ODB User Guide

Sami Saarinen

ECMWF, Reading, UK

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ODB User Guide

Executive summary

You are reading the first edition of ODB User Guide, which is related to the Integrated Forecasting System's (IFS) cycle CY28R2.

ODB stands for Observational DataBase. It is database software to store and retrieve large amounts of meteorological numerical data in an efficient manner while used from within IFS. ODB software mimics relational database queries through its `ODB/SQL` -compiler and accesses data currently via a Fortran90 library interface.

The document tries to explain as comprehensively as possible the concepts behind ODB and provides many examples of how to use the system. Despite being a large document, the intention was not to go into too small details, since they can be easily found in the source code.

The document is divided into ten main sections. In brief, these sections cover the following major items:

1. *ODB at a glance* gives a gentle introduction to what ODB is and how a typical observational database looks like.
2. *Core ODB* explains the core software, and how its data querying, partitioning and packing work.
3. `ODB/SQL` *-language* gives detailed introduction how to use the "heart" of ODB – that is: data querying and filtering.
4. *ODB Fortran90 access layer* gives a tour of the ODB functions i.e. how to manipulate a database and access `ODB/SQL` -queries from a high level language like Fortran90.
5. *Some examples*, which it is useful to browse through almost immediately, since it gives an indication about ODB complexity in a form of complete – yet simple – examples.
6. *ODB interface to IFS* explains how a major ODB application – IFS – is coupled with ODB software.
7. *Database related to IFS* continues with IFS related aspects including data definition layouts for currently recognized (permanent) databases in IFS like `ECMA` and `CCMA` databases.
8. *Guidelines for modifications* covers most of the aspects that need to be remembered in order to modify something in ODB (or ODB to IFS) environment.
9. *Using other database layouts* extends the use of ODB by explaining how to use ODB software with non-IFS related databases.

10. *ODB applications* covers a few useful programs that are built on top of ODB, most notably `BUFR2ODB` and `odbviewer`.

The main sections are followed by appendices, the contents of which is summarized below:

A appendix covers *Environment variables* i.e. almost all you wanted to know about various Unix environment variables affecting ODB execution.

B *Miscellaneous observation type codes* could perhaps be the most important section in this document. Despite being not directly ODB software related, the observation codes are of major importance for a user in ECMWF environment.

C *Variable numbers* is another important reference in order to find out what kind of observations are in the database.

D *Important files for reference* simply lists most frequently referred files in the ODB framework. Thus, it is useful to have them listed in this document Note, however, that some of them are subject to frequent modifications.

E *ODB source files and binary codes* is a supplementary reading for those who want to understand what kind of object libraries drive ODB software and which source files need to compiled to create ODB software.

F *ODB limitations* briefly explains current ODB software limitations and gives some work-arounds.

G *Data sorting* covers a famous `FAQ`[1]: how could I sort my dataset (possibly quickly)? The answer is to use function `KEYSORT` also used inside ODB software.

H *Dr.Hook instrumentation tool* is a little bit out of context for this documentation. However, it provides essential information about ODB performance and produces reliable calling trees upon failures.

Finally, the document contains an extensive glossary, bibliographic references and finishes with an index.

Why have ODB ?

The main reasons to have ODB were as follows:

- Enable large amounts of satellite observations through the ECMWF 4D-Var-system
- Simplify introduction of new observation types
- Manage and control observation processing data flow through data queries
- Have full control over the desired features via source code (ODB/SQL-compiler and Fortran90 library)

[1]Frequently Asked Question

- Replace old `CMA`-file format

Some of the design goals were as follows:

- Design a relational-like database for MPI-parallel data access
- Implement transparent access to observational data through data definition and query language (i.e. `ODB/SQL` -language)
- Bind `ODB/SQL` -compilations into Fortran90 module interface
- Maintain high vectorization efficiency for storing and retrieving observational data
- Introduce well performing and lossless data packing methods
- Enable fast, flexible and configurable I/O management
- Enable MPI-parallel data queries, but also coordinated queries for data shuffling between MPI-tasks
- Allow compatibility with older ODB-databases by re-generating data access libraries directly from database metadata
- Implement such binary format for database files which enables transparent access to data on any (Unix-)platform without explicit or external data conversions

About 95% of the core ODB software is written in C-language, the rest is written in Fortran90. The core library is currently *not* fully thread safe for `OpenMP`, but the interface to IFS has been adapted for safe `OpenMP`-processing via a low-overhead locking mechanism.

The ODB software has purposely been divided into the core part and IFS-interface. The latter is dependent on IFS modules and its environment, whereas the former can also be used for non-observational (but numerical) database accesses.

ODB software itself contains about 3,000 lines of Fortran90 and 45,000 lines of C code. Automatically generated C-code for ECMWF 4D-Var-system from SQL is about 280,000 lines. The separate ODB interface to IFS is about 17,000 lines of Fortran90. Translation from BUFR-format to ODB and back is itself about 65,000 lines of Fortran90.

A short history

ODB has been developed at ECMWF since mid-1998. There was a need to replace the `CMA`-file structure (developed by Drasko Vasiljevic at ECMWF) with a less disk space and memory consuming format and provide more scalable (and parallel) access to ever growing satellite observational data. At the same time an idea of using relational database concepts for easier data selection and filtering was born. The main inspirational spark was absorbed from the reference [B.M91].

A lot of thought was still needed to maintain high vector processing speed, without sacrificing I/O performance, and yet enable high data packing ratios without loss of accuracy.

These special needs in observation handling, software availability and support on various platforms, and high price precluded the use of commercial databases.

The first 4D-Var-system with ODB went into operations at ECMWF with IFS cycle CY22R3 on 27th of June 2000. This system still used `CMA`-files, but only as intermediate ones. That is to say, input observations `BUFR`-data format were translated into `CMA`-files from which it was relatively easy to map observational data into ODB-format, because of the similarities in data structures of `CMA`-files and ODB data layout.

Before June 2000 the ODB software had already been used for nearly a year in the ERA40 reanalysis-project to detect duplicate conventional observations through a database called `PREODB`. In this database, some key information was first picked up from BUFR-messages to aid selection and speed-up duplicate detection before observational data was passed to the re-analysis.

A weak OpenMP-support by means of locking mechanism was added to IFS interface to ODB in early 2001. This enabled multiple OpenMP threads to select and update mutually exclusive observational datasets without observational data sharing conflicts. This scheme was considerably enhanced by replacing costly high-level OpenMP-locks with low-overhead locking in Spring 2004 for cycle CY28R2.

The IFS cycle CY26R1 (29th of April 2003) introduced a major technical change to ECMWF's observation handling system. In this version observations get translated directly from ECMWF `BUFR`-format into an ODB-database, and after analysis are fed back to feedback-BUFR. This facility was developed jointly with Milan Dragosavac (BUFR2ODB-tools) and Drasko Vasiljevic (MAKECMA-replacement in IFS).

Meanwhile the ODB software and especially its separate IFS interface was enhanced so that separate streams of observational groups can be loaded independently and in (job-)parallel mode. This is one of those unique features of ODB which enables nearly endless amounts of observations through the 4D-Var-system. It is now the backbone in providing high observational data volume into ECMWF 4D-Varsystem.

The new observation handling system has now many levels of parallelism: job level (one stream of observation type per job) and program level (both MPI distributed memory and OpenMP shared memory parallelism is available – simultaneously). That is to say, when there are enough processors available, huge amounts of observational data can indeed be processed through the 4D-Var-system.

A typical size of twelve hour 4D-Var observational database has reached 5GB at ECMWF. The data is heavily packed without loss of accuracy, and represents in fact about 15GB of data, had it not been packed. This is a major step forward from earlier days (ca. 1997), when a six hour 4D-Var-system used less than half a gigabyte of *unpacked* data in `CMA`-file format.

You can load the PDF-file or the PostScript-file of this document from ...

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Finally, I would like to thank my family for persistent support in getting this document finished.

Sami Saarinen
ECMWF, Reading, UK
Author of ODB
7th May 2004

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1 ODB at a glance

This section explains some basic ideas behind the ODB software.

1.1 A typical observational database

A typical observational database contains the following items:

- Observation identification information (date, position, station identification)
- Observed values for different observation types, for example: winds, humidities, temperatures per pressure level or geopotential height; or brightness temperatures per satellite channel number
- Various flags indicating quality and validity of an observation, like whether it is active or rejected, or whether the measurement can be trusted etc.
- Departure from observed value (i.e. observed value minus background field, observed value minus analyzed)
- Bias corrections
- Satellite specific information like zenith angle, field of view and so on
- Other important observational processing and meteorological information

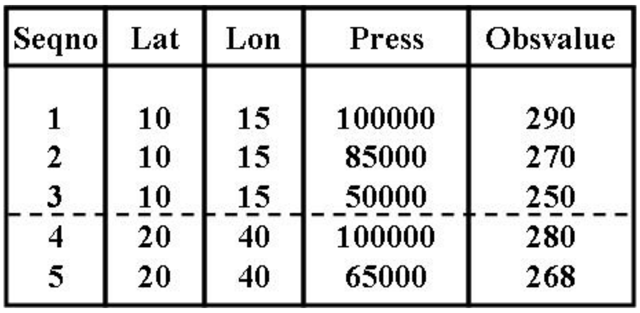
When each of the items have been placed in its appropriate table, the designated columns can be accessed by using their descriptive names. This means that data querying and especially data filtering becomes fairly straightforward. This is where `ODB/SQL` query language compiler plays an important role.

1.2 Data definition

An ODB database is constructed out of basic building blocks called tables. You can think of them as matrices (2D-arrays) with a number of rows and columns containing numerical data. For data querying purposes each table and its columns have a name. Each column also has a number of attributes (the currently implemented ones are datatype and column packing method number).

Such a table would be described in the ODB-system through its data definition and query language `ODB/SQL` as follows:

Figure 1: Observational data in a single table (a matrix or so called flat file)



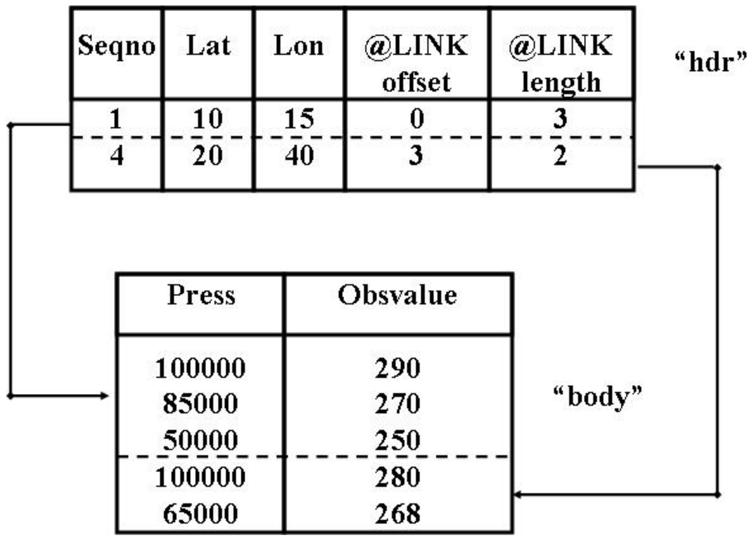
Seqno	Lat	Lon	Press	Obsvalue
1	10	15	100000	290
2	10	15	85000	270
3	10	15	50000	250
4	20	40	100000	280
5	20	40	65000	268

```
    CREATE TABLE mydata AS (
        seqno int ,
        lat pk9real ,
        lon pk9real ,
        press pk9real ,
        obsvalue pk9real ,
    );
```

In practice a (relational) database normally consists of many tables, where data is related to each other normally via one-to-many relationships. Say, for every spatial position a number observational measurements (like air pressure, temperature, wind speed) has taken place. It is then advisable to put positional information into a "parent"-table and the actual observed values into a "child" table and bind these tables together. In ODB the table relations are handled via a link concept (datatype `@LINK`). The `@LINK` is a special column which is present in the parent table and allows one-way referencing from a parent-table to its child-table. In detail, a link is a pair of numbers containing absolute row-offset to a particular child table and the count of consecutive rows in the child-table "belonging" to the parent starting from the offset position.

In this case the data definition is only marginally more complex than above:

Figure 2: Table relations and data normalization in ODB



```
CREATE TABLE hdr AS (
    seqno int ,
    lat pk9real ,
    lon pk9real ,
    body @LINK ,
);

CREATE TABLE body AS (
    press pk9real ,
    obsvalue pk9real ,
);
```

The `@LINK` concept is the main difference between a relational database approach and ODB's hierarchical approach. The genuine relational database engines handle connections between tables through special identification columns (`PRIMARY KEY`s, `FOREIGN KEY`s and `REFERENCES`) which are present (in one form or another) in both parent and their child tables. Furthermore there is a speed-up in data queries by use of pre-calculated indices. All this is not applicable at present in the ODB-system, where child-information (e.g. measurements) can be located instantly by looking at the data behind the `@LINK`-item from its parent-table.

1.3 Data queries

Data queries are probably one of the most important reasons to have ODB. They are an easy way to select desired information from a database and place it in a data matrix for further examination. A data query that selects all aircraft temperature observations (below $-10^{o}Celsius$)in certain region could be as follows:

```
// File query.sql
READONLY; SET $airep = 2; // IFS-tag to denote aircraft obs.
CREATE VIEW query AS
    SELECT lat, lon, obsvalue, an_depar, status.active@body
      FROM hdr, body
    WHERE obstype = $airep
      AND varno@body = $t
      AND obsvalue < -10C  // -10C converted to Kelvin by ODB/SQL
      AND abs(rad2deg(lat)) < 20  // IFS has (lat,lon) in radians
      AND rad2deg(lon) BETWEEN 10W AND 10E  // Note:  West & East
;
```

The language used is `ODB/SQL` – almost a minimum subset of `SQL`.

1.4 Fortran90 access to database

At present ODB software provides access to databases through a Fortran90 library interface, to the underlying C-code. The following small program is an example of how to access the data query above from Fortran90:

```
PROGRAM thefirst
!*** thefirst.F90 ***
USE odb_module
implicit none
INTEGER(4) :: npools, h, rc
INTEGER(4) :: numargs, iargc
character(len=64) dbname, queryname
character(len=64), allocatable :: colnames(:)
rc = ODB_init()
numargs = iargc()
if (numargs /= 2) then
  CALL ODB_abort('thefirst',&
  'Usage: thefirst DBname queryname',numargs)
endif
CALL getarg(1,dbname)    ! Database name
CALL getarg(2,queryname) ! Query name
h = ODB_open(dbname,'READONLY',npools)
write(*,*)'Executing query=',"'//trim(queryname)//'"'
rc = ODB_print(h, queryname, poolno=-1, &
   &           file=trim(queryname)//'.rpt', &
   &           inform_progress=.TRUE.)
rc = ODB_close(h)
rc = ODB_end()
END PROGRAM thefirst
```

Later in the document you will be guided how to create a generic data query program which accepts any data queries for any ODB-database. All that matters is how the data layouts, queries and application program are compiled and linked together. Typical commands applicable to the examples here are (the *DB* denotes here any/generic ODB-database name):

```
$ use odb
$ newodb DB   # or odbcomp DB.ddl
$ odbcomp -lDB query.sql
$ odbf90 thefirst.F90 -lDB -o thefirst.x
$ ./thefirst.x DB query
```

The last line actually executes our first ODB-application executable `thefirst.x`. Output of the query can be found in file `query.rpt`. You may want to browse the output with command:

```
$ b4.x query.rpt
```

1.5 Data access patterns

In ODB, emphasis has been put on storing data column-wise in order to perform efficient (often stride-one) data extraction. This enables rapid retrieval of consecutive cells of data with genuine stride one access to data column elements. This is also the usual data access pattern in 4D-Var, so it must be efficient. You could also think of these fetches as vectorized database-to-memory -transfers. Column-wise ordering is also a prerequisite for implementing lossless packing methods in ODB, which pack a whole column of data in one go, usually in a vectorized manner.

One drawback in predefined column-wise ordering is that data insertion between two existing rows (or cells, for that matter) can be very inefficient. The same holds for row deletion. Therefore, we usually do not to do that in ODB, but generate a complete database from the input data by appending data to the end of existing tables in one single sweep. However, data flow in observation handling never requires physical removal of particular data rows (or cells) while performing complex tasks as required by 4D-Var. Unwanted rows are simply explicitly marked as rejected via status-flags introduced in the data layout. Flags must then be used in the data queries to eliminate undesired rows from data retrievals.

Genuine database engines normally store data row-wise rather than column-wise and keep data rows in a kind of tree structure thus enabling flexible insertion and deletion without much trouble. This approach, however, prohibits stride one access to column data and destroy chances for any good vectorization when lots of data cells are requested. These are features, which must not be neglected in modern meteological software implementations.

1.6 Data partitioning : pool concept

Another thing that makes ODB unique is its suitability for distributed memory (i.e. MPI-) parallelization. This has been achieved by a simple data partitioning strategy. The tables (and associated data in their child and sibling tables) get split horizontally (row-wise) so that (for example) the first 1000 rows belong to partition#1, the next 1000 rows (say) to partition#2 and so on. In ODB terminology such partitions are called pools. Pools are allocated for each parallel MPI-task in a round-robin fashion so that each processor becomes solely responsible for that partition with exclusive access to its own data pools only. That is to say, no other MPI-task can modify data on a pool that it does not own.

Each data pool to be dealt with is a separate, but at the same time a complete chunk of a full observational dataset. Each MPI-task can manipulate its own partition as it likes without knowing what some other MPI-tasks are doing with their own data pools at the same time. Pools have no connections with each other, so for example data queries are truly local on a per pool basis. Furthermore, each MPI-task owns one or more pools and can perform truly local queries over its own datasets without interfering with the neighboring MPI-tasks. In this way there are no worries about global integrity of data and the pool concept actually implements a kind of databases within a database. This is the key factor in order to process the huge volumes of observational data in the current and future 4D-Var-system in a real(istic) time.

The ODB software can also query and deliver data in a parallel manner. This is accomplished by the Fortran90 interface layer, which explicitly communicates (or even replicates) observations from the owner MPI-task into remote task(s), if necessary. If data was replicated in this way (e.g. a flight path of an aircraft), the rule is that only locally owned data can be updated back to database. Whereas if an individual set of observations gets shuffled over to a remote MPI-task (and only one remote task) then this MPI-task is allowed to update data. This is the only exception, where a pool can be by modified remote MPI-task.

1.7 Availability of the ODB software

ODB software can be made available to ECMWF member state users as source code. A user can simply compile and install ODB software from "tarball" i.e. source code distribution tarfile. This procedure is explained more in appendix E.

ODB is now available in both big and little endian versions for Unix-platforms. It has been tested (or is operational) on the following platforms: Fujitsu VPPs, Silicon Graphics, IBM/RS6000 Power3 and Power4 series, Pentium/Linux (with Portland `pgf90`-compiler). It has also been compiled for the following platforms: NEC SX, HP-PA, Sun Solaris, Compaq.

It is important to note that ODB databases created (say) on big-endian machines can still be read and updated (say) on little-endian machines (and vice versa). This is possible due to a built-in endian-detection procedure in ODB, which flips bytes as necessary upon loading data.

2 Core ODB

This section explains how the core of the ODB software works in greater detail.

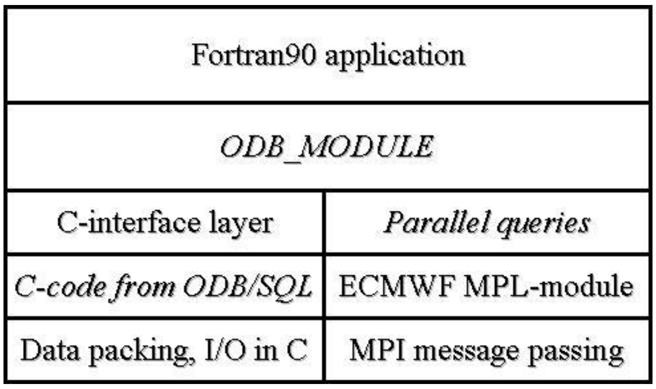
2.1 Introduction to ODB software layers

The ODB software is layered as shown in figure 3. It implements embedded access to databases without client-server intervention. Data can currently be accessed only through a Fortran90 interface layer (described more detail in section 4).

Underneath is found a C-software layer which connects to database queries. And they are in fact `ODB/SQL` -language transformed into C-code. This generated C-code performs the actual data unpacking and (in many cases) calls I/O-routines to download data on-demand.

Data delivery from parallel queries is handled through the ECMWF message passing library (MPL), called by Fortran90 interface layer. The ECMWF MPL-library in turn calls standard MPI message passing interface library, or alternatively an equivalent library meant for non-parallel runs (`libmpi_serial.a`).

Figure 3: Software layers in ODB



Fortran90 application	
ODB_MODULE	
C-interface layer	*Parallel queries*
C-code from ODB/SQL	ECMWF MPL-module
Data packing, I/O in C	MPI message passing

Database queries are processed by using `ODB/SQL` -language. Firstly, the `ODB/SQL` -compiler translates data layouts into C-code to provide true access to database files. Then it generates C-code for each SQL-query in order to facilitate fast data extraction and update. Queries are bound to C-layer from which data propagates back to the Fortran90 layer and user-space. The C-layer is also responsible for transparent packing and unpacking of column data, where applicable.

All database I/O in ODB is done by using either standard C or Unix system I/O. The I/O can be done on demand i.e. a whole data table is brought into memory only when needed and kept there as long as possible[2]. Each column in a table gets unpacked only when it is referred to for the first time.

The smallest chunk of data that is currently read in is a single table from one pool (I/O-method#1). That is to say, the whole table of a particular pool (partition) is read into memory regardless of how many columns need to be accessed.

The latest versions of ODB software also support I/O-method#4, which is designed to have more efficient I/O, but uses more more memory. In this method data is read and distributed from *all* tables (by default) when opening the database (see function `ODB_open`), even if you are not going to access some tables[3]. Unless you have a lot of memory to spare and/or multiple processors involved, you may have a problem when postprocessing ODB data from 4D-Var-run. However, there are two ways under development to circumvent this "built-it" problem when using I/O-method#4 on low-memory systems.

Since availability of memory can be an issue, the future releases of ODB software will see an alternative I/O-scheme (called Direct Column Access or DCA-method), which will allow extraction of a particular column through a seek-and-read operation rather than reading the whole table.

2.2 `ODB/SQL` compilation system

Observational data (or any numerical data for that matter) needs to be introduced to ODB through its Data Definition Layout or DDL-file. This is a text file containing possible parameter declarations (`SET`) or datatype (or Bitfield) definitions and most importantly table definitions.

Tables and their named columns i.e. data definition are the cornerstone of databases. It enables us to refer to data items by their "nice" (user-friendly) names and perform data queries in a relatively easy manner. These queries (also known as SQL-queries[4]), enable us to extract desired data cells from database which satisfy certain conditions. Once extracted, they can be copied into an analysis program and be modified and re-written back to the database. Alternatively an extraction can be input to a graphical user interface program for plotting positions and their values (say) in a different color or marker.

Here is an example of a data definition, say a DDL-file `DB.ddl`:

[2]Not applicable to I/O-method#4, though, see discussion below

[3]To prevent this from happening refer to environment variable `ODB_CONSIDER_TABLES` (see p.190)

[4]SQL stands for Structured Query Language

```
SET $n = 1;

CREATE TYPE mytype_t AS (
  first_bit bit1 ,
  second_bit bit1 ,
);

CREATE TABLE mytable AS (
  a int ,
  b[$n] double , // defines b_1
  s string ,
  x mytype_t ,
);
```

A data query is expressed in English-like text, which clearly asks to SELECT column items FROM a subset of database tables, WHERE certain constraints apply. The outcome of a query is a sub-matrix containing typically much less data (columns) than was in the originating tables. Also, not all data rows are included, since the constraint-filter (WHERE-condition) restricts the extraction size to contain only the desired rows. Optionally the sub-matrix can also be sorted with respect to one or more result columns (ascending or descending order) before it is presented to the analysis program.

Here is an example of a data query, say a SQL-file `query.sql`:

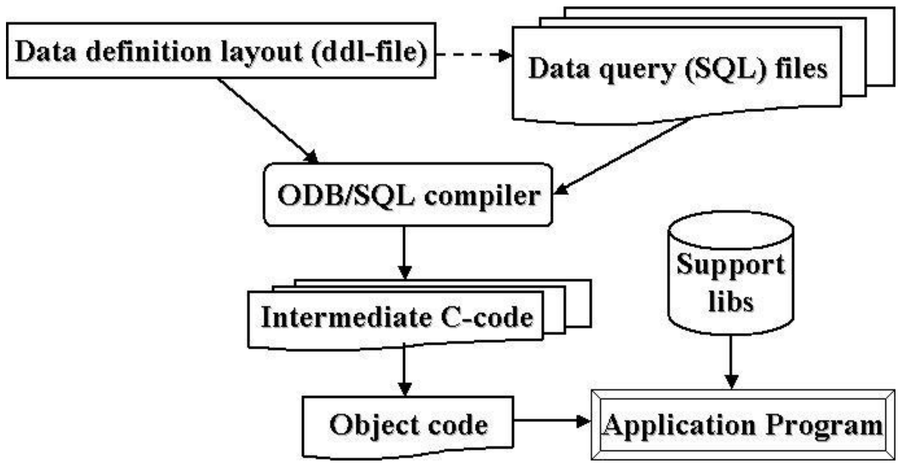
```
CREATE VIEW query AS
  SELECT b[1], x.second_bit, s
  FROM mytable
  WHERE a > 10;
```

2.2.1 How the `ODB/SQL` -compilation system works ?

The user supplies a DDL-file which will be compiled using the `ODB/SQL` -compiler. This compilation produces a pre-processed DDL-file i.e. `ddl_`-file (also known as DDL underscore-file). Compilation also produces a bunch of automatically generated C-codes: the main driver code, a header-file, and one C-file for each table. And all these for each particular database.

The next step is to create data queries. This is done by supplying one or more SQL-files, where data queries are expressed through `ODB/SQL` language. As long as the DDL underscore-file is available, SQL-files can be compiled into C-code. These C-files will then be compiled with a native C-compiler and put into an object library named after the database name (for example the library `libDB.a` for database `DB`).

Figure 4: `ODB/SQL` compilation system



Once an object library for a particular database is present, your application can gain access to database data through the ODB core library. This library connects the application program to database objects that have just been created and its built-in `ODB/SQL` -query engine to be driven.

A typical outcome of such a process is that a Fortran90 program receives a subset of data (sub-matrix), which can be manipulated and possibly even updated back to the database.

The `ODB/SQL` -compilation program (executable `odb98.x`) has been wrapped into a script `odbcomp`. Its purpose is to hide all technical details to make compilation to look like an easy task.

When compiling data layouts (for our imaginary database, DB), we need to invoke the compiler as follows:

```
$ odbcomp DB.ddl
```

This produces the pre-requisite files, as explained above. Furthermore, the data queries need to be compiled as follows:

```
$ odbcomp -lDB query.sql
```

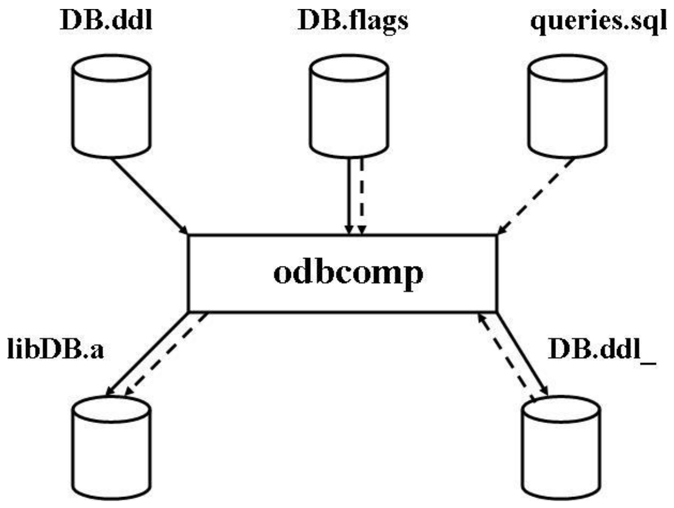
Here the file `query.sql` contains one or more CREATE VIEW-statements. If there is only one data query present, it is preferable to name the query file prefix after the view name (with `.sql`-suffix) and use lowercase letters in the filename.

If you want to compile several queries, you can supply them one after another, as follows:

```
$ odbcomp -lDB query1.sql query2.sql ...  queryN.sql
```

The command `odbcomp` concatenates them together and then invokes the `ODB/SQL` -compiler executable.

Figure 5: Using `odbcomp` -command to compile data layouts and SQL-queries



After all compilations have been performed, the library file `libDB.a` is up to date and in principle ready for linking with the application program and its support (core) libraries.

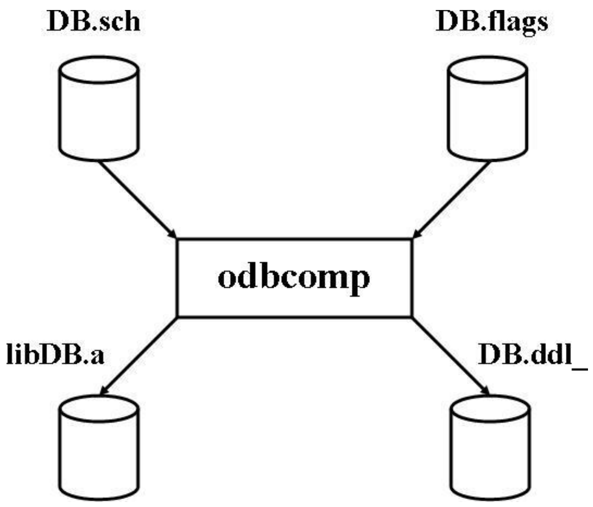
However, one thing is not clear. How do the objects from the support libraries link to this particular library (`libDB.a`)? When the core library was created there may not have been any knowledge of this database name and therefore not even dummy calls to this could have been present.

This dilemma is now solved through a special add-on file called `_odb_glue.c`. It is a crucial bridge between the ODB core libraries and the previously unknown database libraries. It is generated automatically from `static.h`-file when compiling our database `DB` by overriding standard `static.c`-file which is part of the core library. Once this object gets "glued" between the application and the database `DB`, all works fine.

If a particular database becomes standard on a particular site, it should be made permanent. Such a database is called a "recognized" or "permanent" database in ODB parlance.

A permanent (or recognized) database can be overridden (possibly) with some other data layout, but still with the same name. This actually happens all the time when dealing with post-processing requests of ODB. A typical situation: 4D-Var has performed its tasks and the user wants to access conventional data. At ECMWF this can be accomplished by restoring the database from the archive into a user disk and re-creating database access libraries specific

Figure 6: Using `odbcompsch` -command to re-create ODB data access library



to this database (`DB`) from its metadata – in particular using files `DB.sch` and `DB.flags`. The latter is optional, but then it is preferred to have access to the standard `ODB_COMPILER_FLAGS` (see p.**??**) , normally found in file `$ODB_SYSPATH/odb98.flags`.

This reconstruction of libraries is very convenient, since our database can be of any age and yet with the latest software release we are able to recover it without any data conversions. The only thing that is needed is to re-create its data access library (like `libDB.a`). To re-create the access library, treat the file `DB.sch` (a schema file) as if that was your data definition `DB.ddl`-file and create DDL underscore-file with:

```
$ odbcomp DB.sch
```

The rest (data queries, linkage with application) goes as explained earlier.

2.3 Data partitioning

We have touched on ODB data partitioning earlier in this document. This subsection is explains it more formally and in detail.

2.3.1 TABLE hierarchy and `@LINK`s

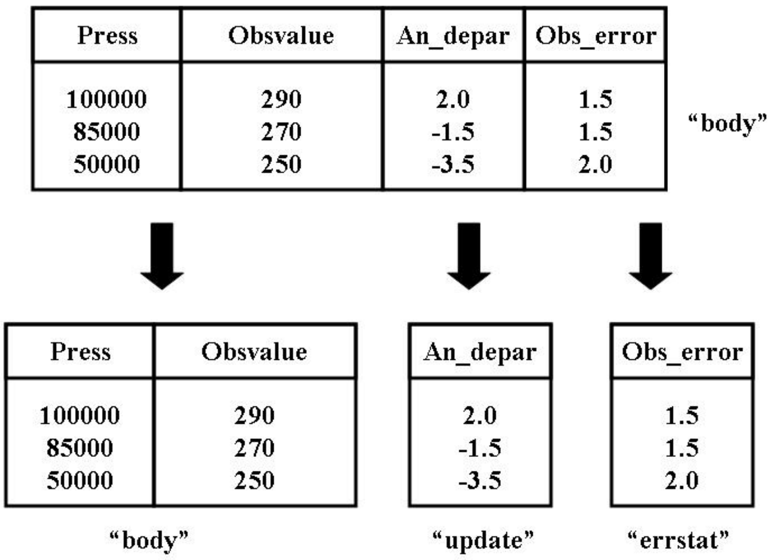
There are in fact three forms of data partitioning in ODB. The first one is to split data between tables by means of data normalization.

In the second way, two or more tables can be said to be aligned if they are split vertically. A special form of this alignment is one-to-one (or one-looper) relationship between tables.

Finally, the third way is to split tables horizontally and place datasets into separate pools.

2.3.2 Aligned tables

Figure 7: Vertical data partitioning



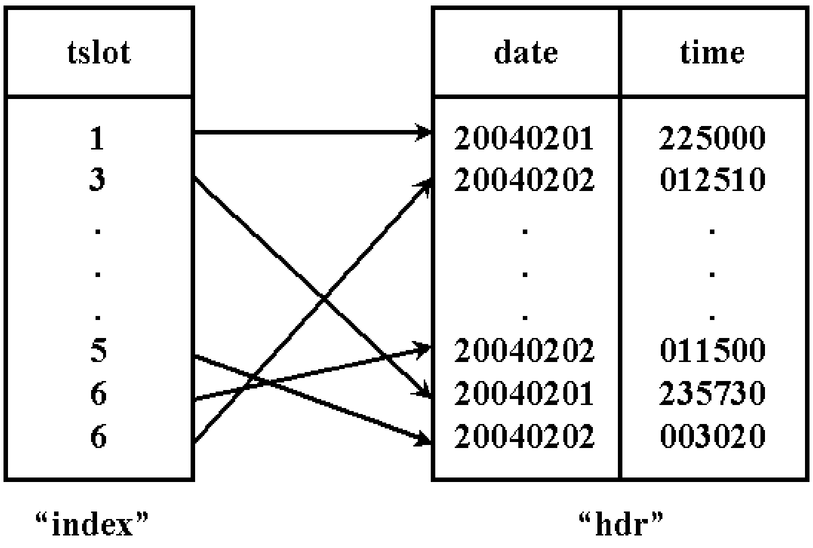
If you have lots of columns in one table, you may want to move some columns into another table and still make sure that that these two tables retain the same order and have the same number of data rows. In order to achieve this, you need to align the newly created table (also known as "slave" table) with the original table (known as "master" table) where the columns came from.

Table alignment is just a soft assumption and is not forced by ODB. That is to say, the user application must ensure that the master and its slave tables have the same amount of data rows and that rows are one-to-one aligned (horizontally thinking) together, before attempting any SQL-requests.

When alignment conditions are fully met, the `ODB/SQL` query optimizer treats the aligned tables as if they were "glued" together into single quantity, that is – one big super-table with a large number of columns.

2.3.3 One-to-one relationship tables (one-loopers)

Figure 8: One-to-one relationship between two tables, where data rows are not in the same order



Sometimes there is a need to have two (or more) tables which are meant to be aligned, but without them having the same number of rows and their rows are not necessarily in the same order as the master table. Such tables are called "one-loopers" (one-to-one -link between rows of the tables) in ODB terminology.

These are very useful. Suppose we have a master table containing full information about positions and observation types. Some observation types however have some additional information specific to this type only. Ultimately you want to exclude them from the master table, since these cell entries are present only for a subset of observation types.

Another example is when two tables have the same number of rows, but in different order. Strictly speaking this does not meet the criterion of being fully aligned tables. Say, the first table contains positional information about observations in more or less random order. The second table contains timeslot information about these positions and is sorted with respect to timeslot number. Clearly what is wanted is to be able to load positional information without considering date and time sorting. Using one-loopers will accomplish this.

2.3.4 Data splitting through pools

A table can be split into multiple tables by assigning upon creation a chunk of consecutive rows into separate partitions. These are called pools in ODB termilogy and form horizontal data partitioning.

Figure 9: One-to-one relationship between tables, where not all tables have matching row present in the "sibling" table(s)

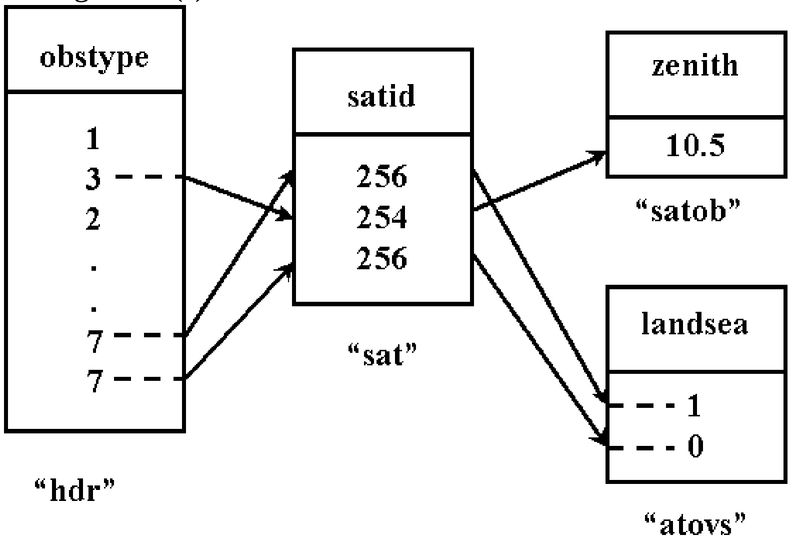
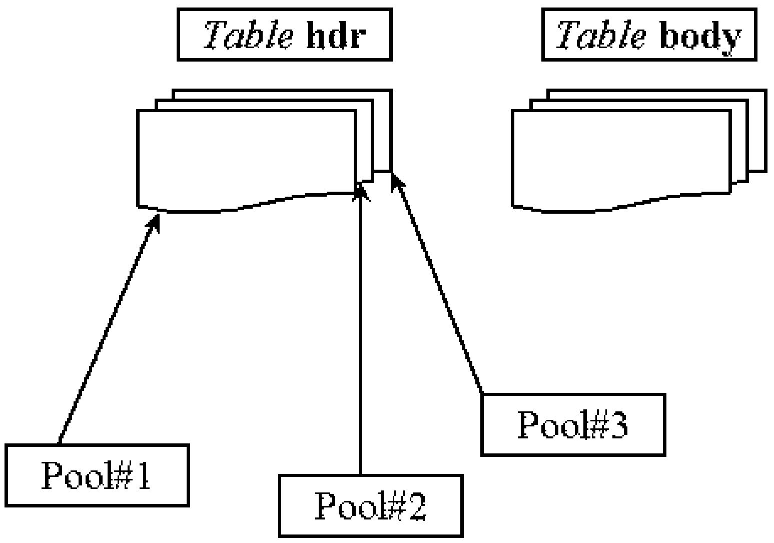


Figure 10: Horizontal data partitioning



This pool concept helps management of large numbers of observations, since a minimum of one pool at a time can exist in memory. Each pool could also be geographically assigned, so that a particular area of interest could be found in one (or a set of) pools.

Pools also come to the rescue when it comes to parallel data querying. Each MPI-task is assigned to its unique set of pools (in a round-robin fashion) and only those tasks can access and modify data on their pools.

2.4 Missing data indicator

When some cells have no value, their data are said to be missing. Unlike commercial database engines, ODB stores a special value (`$mdi`) into those cells to indicate no value. Presently, the missing data value is recommended to be `-$mdi` for double precision floating point numbers and `+$mdi` for integer quantities. However, users must ensure that these values are inserted explicitly in the application program.

You can query data that is not missing by applying the following WHERE-condition in the request:

```
SET $mdi = 2147483647; // The default
SELECT x,y
  FROM t
  WHERE abs(z) != abs($mdi);
```

This would correspond to the following query in commercial systems and is also available (recommended way) in the latest ODB-release:

```
SELECT x,y
  FROM t
  WHERE z IS NOT NULL;
```

2.5 Data packing

The way data columns are stored in an ODB database makes them suitable for good packing and usually without loss of accuracy[5]. Packing ratios of 3 to 4 are not uncommon.

This packing is called internal packing and is transparent to the user. When data columns are requested, their tables are first read in as a whole, columns remaining still in a packed form, in memory. Particular columns are then unpacked on demand, as needed.

Columns can also be repacked, if requested, but this would lead to unnecessary performance degradation. Constant unpacking and packing may lead into memory fragmentation and in fact higher memory usage – completely opposite effect to what was originally anticipated.

It is easy to suggest packing of a column: just define a column to be one of the packed integral type: normally `pk1int` for integers and `pk9real` 64-bit floating point numbers.

[5]There are lossy packing methods available, too

Data packing in ODB can also be external. This means that each table file is subject to `gzip`'ping (or related) when table-files are written out to disk. Reverse (for example `gunzip`) is applied automatically when table data is fetched into memory. To control whether to use external packing or not is down to `IOASSIGN`-file for a particular database.

External packing usually leads another 10% additional packing when it comes to disk space usage. However, the future direct column access (`dca`) requires no external packing, since backward seek-operations are very difficult and slow to implement, when a file is externally packed.

From cycle CY26R3 onwards all external packing is removed from ECMWF scripts to accomodate future needs with direct column access. Consequently databases are marginally larger, but faster to access.

2.6 Database files

An ODB database contains two types of files: metadata and actual binary data files.

Metadata is usually stored in text-format in order to use it for various data filtering (Perl or similar) and to be able to fix unforeseen problems manually. Metadata resides in directory `ODB_SRCPATH_dbname`.

The actual data is placed into logical files named after *database_name.table_name.pool_-number*. This normally gets translated (mapped) via IOASSIGN into files *$DBDIR/pool_-number/table_name*.

This however has its own problems in terms of number of files. The most recent I/O-optimization in ODB has addressed this issue and by choosing I/O-method#4 via

```
$ export ODB_IO_METHOD=4
```

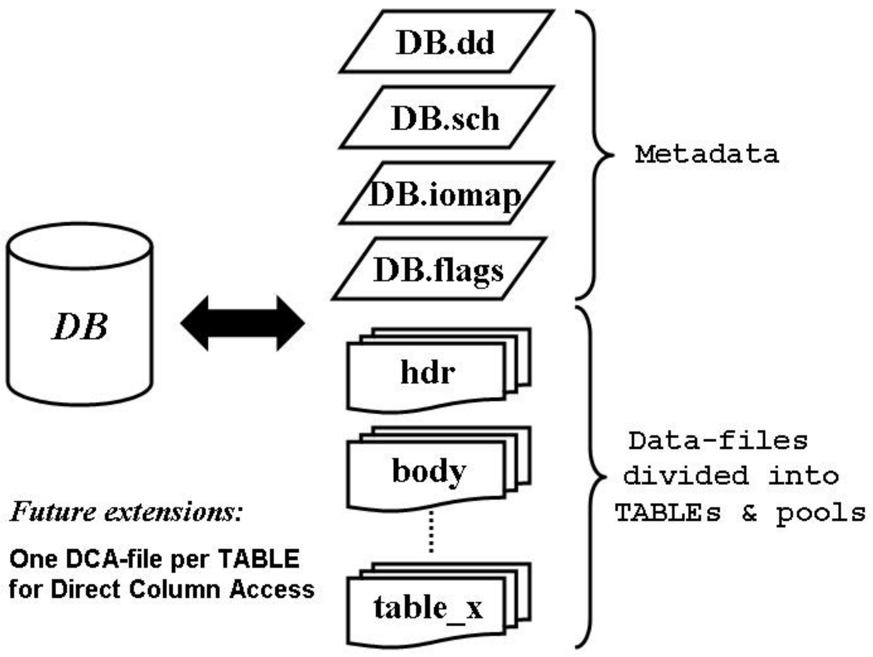
By default concatenated files of 32MB will be created. Tables are said to be concatenated horizontally (HC32-file format). One or more (up to `ODB_IO_GRPSIZE`) similar table-files from adjacent pools are concatenated together into a single physical file until 32MB limit (or `ODB_IO_FILESIZE`) is reached.

The root directory for binary data can be different from metadata. This is because this enables data to be placed on the systems memory resident file system, whereas less frequently accessed metadata is on disk.

Metadata files are as follows:

DB.dd Data description file. The main and originally the only metadata file. Can be used to re-create the data layout in absence of DB.sch (a file, which is absent only in very old ODB databases).

Figure 11: Database files


DB.dd
DB.sch
DB.iomap
DB.flags
Metadata
DB
hdr
body
table_x
Data-files divided into TABLEs & pools
Future extensions:
One DCA-file per TABLE for Direct Column Access

DB.sch Schema file. Nearly a carbon copy of original DDL-file, except some missing items and renaming of derived datatypes (Bitfields).

DB.flags Supplementary information for the `ODB/SQL` -compiler. This is a relatively new file and introduced because there was a need to propagate database specific `ODB_-COMPILER_FLAGS`-files in case the default file (`odb98.flags`) was missing or had changed radically since the database was created.

DB.iomap Information about horizontal concatenation. Available to I/O-method#4 only.

The latest version of ODB software generates so called direct column access- or `dca`-files. These allow potentially faster (and direct) access to ODB-column data without need to read (nearly) all files in memory. This could improve dramatically the postprocessing speed from even large ODB databases.

2.6.1 File mapping via ioassign

ODB always opens files using their logical names. These names are mapped into physical names via IOASSIGN-file, which also supplies suggestions for I/O-buffering sizes and whether data need to be read/written through Unix-pipe (e.g. `gzip`).

Here is a example of `IOASSIGN-file` for database our artificial database `DB` with two tables:

```
DB $ODB_SRCPATH_DB/DB.dd 1 0 0 0 0 0 0 0 0
DB.sch $ODB_SRCPATH_DB/DB.sch 1 0 0 0 0 0 0 0 0
DB.flags $ODB_SRCPATH_DB/DB.flags 1 0 0 0 0 0 0 0 0
DB.iomap $ODB_SRCPATH_DB/DB.iomap 1 0 0 0 0 0 0 0 0
DB.hdr.dca $ODB_SRCPATH_DB/dca/hdr.dca 1 0 0 0 0 0 0 0 0
DB.body.dca $ODB_SRCPATH_DB/dca/body.dca 1 0 0 0 0 0 0 0 0
DB.hdr.%d $ODB_DATAPATH_DB/%d/hdr 1 8388608 8388608 8388608 8388608 0 0 0 32
DB.body.%d $ODB_DATAPATH_DB/%d/body 1 8388608 8388608 8388608 8388608 0 0 0 32
```

3 ODB/SQL -language

ODB/SQL is a language to manage observational databases. It is a minimum subset of international standard SQL used to manipulate genuine relational databases. SQL stands for Structured Query Language and is pronounced as *sequel* or *es-kjuu-el*.

Normally ODB/SQL is used in a semi-interactive way, because ODB/SQL is a compiler that translates particular user defined text files into C-code for native compilation and linking with application program. Application programs must currently be written in Fortran90, although low-level access routines are all coded in C.

You can arrange the use of ODB/SQL to look a like interactive session (see odbviewer,p. 185).

ODB/SQL is currently capable of handling the following tasks:

- *Data definition* : To define structure and organization of data to be stored and relationships between the items.
- *Data retrieval* : To define data queries in order retrieve (normally) a subset of data items.

What ODB/SQL is currently *not* capable of doing is as follows (see also [N.W02]):

- *Data manipulation* : To add, update, remove or modify data one needs to use Fortran90 access layer of ODB. This situation is subject to change in future releases, where more direct manipulation may become available in one form or another.
- *Access control* : To be able to restrict the user's ability to retrieve, add or modify data by protecting unauthorized access. However, with Fortran90 access layer, an ODB database can be opened in READONLY-mode, which truly protects from accidental loss or damage of data.
- *Data sharing* : Sharing of a database by concurrent users without interfering each other. This is again already possible for READONLY-databases.
- *Data integrity* : To protect the database from corruption due to inconsistent updates or during system failures. In ODB its important to make sure that @LINK's between tables stay correct and table alignments are not violated, when making data queries.

3.1 ODB/SQL : language summary

The following subsection summarizes ODB/SQL language in BNF (Backus Naur Form). The notational conventions used are as follows:

- SQL keywords appear in `UPPERCASE`, but can now also be supplied in lowercase. (Mixed case keywords are not yet accepted by `ODB/SQL` compiler).
- Syntax elements are specified in *italics*.
- The notation *item_list* denotes a single *item* or a list of comma separated *items*.
- Vertical bars (`|`) indicate a choice between two or more alternative syntax elements.
- Square brackets (`[]`) indicate an optional syntax element enclosed within them.
- Curly brackets (`{}`) indicate a choice among required syntax elements enclosed within them.

The `ODB/SQL` -language is currently divided into two parts: data definition language and SQL-query processor. The former defines data definition layout i.e. what elements (tables, columns, datatypes) comprise a particular database. The latter implements data query motor in order to search in particular columns of a database satisfying certain conditions.

The data definition layout is normally placed in a database specific file with a suffix `.ddl`. It is recommended to put a single data query per file with a suffix `.sql`. To avoid confusion, the query filename should be named after the viewname (the label `CREATE VIEW`-keyword).

3.1.1 `ODB/SQL` operators and keywords

The following operators are available in `ODB/SQL` -language:

Table 1: ODB/SQL operators

Operator or expression	**Meaning**
`@`	When appears after *colname* (or *colname*.*memname*) signifies the specific *table_name* in concern
`,`	List separator
as	One of the following : {`AS	=	:`} A separator between keyword headers `CREATE TYPE`, `CREATE TABLE` or `CREATE VIEW` and rest of the respective statements
`+`	Add
`-`	Subtract
`*`	Multiply, except when after the `SELECT` or `FROM`-clause, in which case instructs choose all applicable columns or search from all available tables, respectively

continued on next page . . .

Table 1: ODB/SQL operators ... *continued*

Operator or expression	**Meaning**
`/`	Divide
`%`	Modulo operator i.e. $x\%y$ or $mod(x,y)$
`** , ^`	Power operator i.e. x^y or $pow(x,y)$
`SET ... = ...`	Assignment operator (see `SET`-variables)
`= , ==`	Equal-to
`<> , != , /=`	Not-equal-to
`<`	Less-than
`<=`	Less-than-or-equal-to
`>`	Greater-than
`>=`	Greater-than-or-equal-to
`< ... <`	Combined greater-than this, but less-than that
`> ... >`	Same as previous, but reversed
`<= ... <`	Combined greater-than-or-equal-to this, but less-than that
`>= ... >`	Same as previous, but reversed
`< ... <=`	Combined greater-than this, but less-than-or-equal-to that
`> ... >=`	Same as previous, but reversed
`NOT , !`	Logical `NOT`
`&& , AND`	Logical `AND`
`|| , OR`	Logical `OR`
`IN`	Test if a *colexpr* has values in a *list*
`NOT IN`	Test if a *colexpr* has no values in a *list*
`BETWEEN ... AND ...`	Test whether *colexpr* is between two other *colexpr*essions (with border values included) :
`LIKE , RLIKE`	Tests whether a *string colname* contains particular characters in unix-regular expression fashion
`NOT LIKE , NOT RLIKE`	Same as previous, but tests whether doesn't have any such characters
`IS NULL`	A shorthand to test whether $abs(colexpr)$ is $abs(\$mdi)$
`IS NOT NULL`	A shorthand to test whether $abs(colexpr)$ is not $abs(\$mdi)$

There are no reserved keywords in `ODB/SQL` that could not be used as column or table names.

Table 2: ODB/SQL keywords

Keywords	**Meaning**
`ALIGN`	Defines table alignment in which two or more tables should have the same number of rows and appear in the same row-order (horizontal data partitioning)
`RESET ALIGN`	Resets any previous table alignments
`ONELOOPER`	Defines tables which have one-to-one relationship
`RESET ONELOOPER`	Resets any previous one-to-one relationship definitions
`SET`	Sets initial value for a scalar variable
`AS`	See previous table
`CREATE TYPE`	Creates user defined data type (merely `Bitfield`)
`CREATE TABLE`	Creates data layout for *table_name*
`READONLY`	Defines that subsequent *select_column*'s should not be updatable
`UPDATED`	Defines that subsequent *select_column*'s should be updatable (this is the default)
`CREATE VIEW`	Defines *query_name*
`SELECT`	Select desired columns
`SELECT ALL`	Synonym to previous
`SELECT DISTINCT`	Select columns with distinct (unique) values only
`SELECT UNIQUE`	Synonym to previous
`UNIQUEBY`	Value in selected columns must pass uniqueness criteria
`FROM`	Selects *table_name*'s in concern
`WHERE`	Invokes *where_condition*
`BETWEEN`	See previous table
`IN, NOT IN`	See previous table
`NOT, AND, OR`	See previous table
`IS NULL`	See previous table
`IS NOT NULL`	See previous table
`ORDERBY, ORDER BY`	Sorts *select_column*'s
`SORTBY, SORT BY`	The same as `ORDERBY`
`ASC`	Invokes ascending sorting (the default) for a *sort_column*
`DESC`	Invokes descending sorting for a *sort_column*
`ABS`	Takes an absolute of a *sort_column* before invoking either ascending or descending sort

Keywords can be typed in UPPERCASE (recommended) or lowercase letters. No mixed case is currently allowed.

3.1.2 Language element syntax

The following language element syntax is used in the subsequent subsections:

Table 3: ODB/SQL language element syntax

Language element	**Syntax**
initial_value	*64_bit_floating_point_number*
scalar_expr	...
regular_expr	`"`*unix_regular_expression*`"`
user_datatype_t	*name*
typedef_item	*memname* `bit`*integer_number_1..32*
target_datatype	*accepted_datatypes*
accepted_datatypes	...
table_name	*name*
tabledef_item	*name datatype* `[READONLY|UPDATED]`
query_name	*name*
colname	*name*
column_name	{*colname* | *colname***@***table_name*}
select_column	{*column_name* | *bitfield_member*}
memname	*name*
bitfield_member	{*colname***.***memname* | *colname***.***memname***@***table_name*}
column_regular_expr	`"/`*unix_regex_against_column_names*`/[i]"`
uniqueby_column	*column_name*
sort_column	

3.2 Data definition layout

3.2.1 CREATE TYPE

The `CREATE TYPE` (or deprecated `TYPEDEF`) creates user defined datatypes. In ODB parlance this means introduction of a new type, which occupies an unsigned integer word and has member fields consisting of varying length of bits. The total bit occupancy cannot therefore exceed 32 bits. In addition each, so called `Bitfield`-member has its own unique name to make referencing to them possible in data queries.

The idea of having this kind of user defined bit pattern is that we can effectively save space by packing small integer-like numbers into one word. And yet they all have their own name identifier.

```
CREATE TYPE[|TYPEDEF] user_datatype_t as
       ( typedef_item_list )
;
```

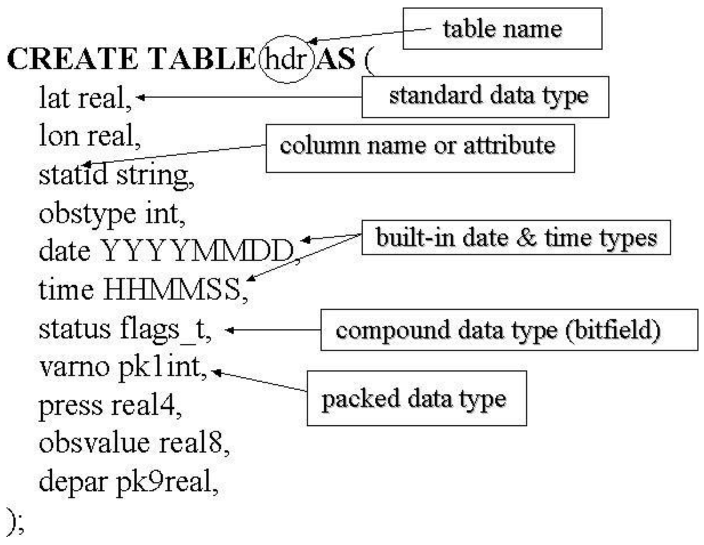
Another form of type definition available in `ODB/SQL` is type aliasing. Sometimes, perhaps to improve readability, a user wants to call some basic type with a user defined name, which can be more descriptive. Type aliasing has nothing to do with bit pattern definition (i.e. you can alias even a floating point type into your own type name) and is accomplished as follows:

```
CREATE TYPE[|TYPEDEF] user_datatype_t as target_datatype ;
```

3.2.2 CREATE TABLE

```
CREATE TABLE table_name as
       ( tabledef_item_list )
;
```

Figure 12: Components in CREATE TABLE statement



```
CREATE TABLE hdr AS (
   lat real,
   lon real,
   statid string,
   obstype int,
   date YYYYMMDD,
   time HHMMSS,
   status flags_t,
   varno pk1int,
   press real4,
   obsvalue real8,
   depar pk9real,
);
```

3.3 Data queries

3.3.1 CREATE VIEW

The data query syntax is as follows:

```
[SET  $var [= {initial_value | scalar_expr}] ;]

// This is a comment line
--  This is a comment line, too

[READONLY ;]  // read/only-mode for subsequent queries
[UPDATED ;]   // ... or all columns will be updatable (the default)

[CREATE VIEW query_name as]
   SELECT [ALL|DISTINCT]
      {select_column_list | column_regular_expr_list | *}
   [{UNIQUE BY|UNIQUEBY}  uniqueby_column_list]
   FROM  {table_name_list | *}
   [WHERE  where_condition]
   [{ORDER BY|ORDERBY|SORT BY|SORTBY} sort_column_list]
;
```

The `CREATE VIEW` can now be omitted and a query can start from `SELECT`-clause directly, but only if it is possible to determine the viewname from the SQL-filename[6].

3.3.2 SELECT-clause

```
SELECT [ALL|DISTINCT]
      {select_column_list | regular_expr_list | *}
```

3.3.3 UNIQUE BY-clause

```
{UNIQUE BY|UNIQUEBY}  uniqueby_column_list
```

[6]Please note that not all scripts in our IFS environment are adapted to cope with this “omission” of `CREATE VIEW`-statement and consequently compilations may fail. It is a good practice to include `CREATE VIEW` since improves readability

3.3.4 FROM-clause

`FROM` {*table_name_list* | *}

3.3.5 WHERE-condition

`WHERE` *where_condition*

3.3.6 ORDER BY-clause

{`ORDER BY|ORDERBY|SORT BY|SORTBY`} *sort_item_list*

The `ORDER BY`-clause allows you to sort the query output with respect to one or more columns found in the `SELECT`-clause. In the latest version a particular sorting column does not have to be present in the `SELECT`-clause, instead it will be added automatically into the list of `SELECT`'able-columns.

Output columns can be sorted in ascending or descending order. Ascending is the default and chosen by the keyword `ASC`. Descending is alternative and denoted by the keyword `DESC`. In addition sorting can be based on absolute value (i.e. ignoring sign) of the column. This is useful for instance if you have to sort with respect to analysis departure values, which can be positive or negative and yet the absolute value determines their significance. This sorting can be chosen by supplying function keyword `ABS()` around the column name. See examples below ... which I don't have yet, ugh

You can also use `SORT BY` as a synonym. It is not necessary to have whitespace before the `BY`-keyword, but you can use `ORDERBY` or `SORTBY` written together.

3.3.7 Parameterized queries

Parameterized queries are ordinary `ODB/SQL` -queries, where some of the constants in `WHERE`-condition are replaced by `SET`-variables. In this way the application program can change the predefined default values and the same query can be re-used over and over again. It is illegal to use undefined parameters in a `WHERE`-condition.

Normal query

```
CREATE VIEW abc AS
SELECT x,y,z
FROM t1, t2
WHERE a > 1;
```

$\rightarrow$

Parameterized query

```
SET $value = 1;
CREATE VIEW abc AS
SELECT x,y,z
FROM t1, t2
WHERE a > $value;
```

There is no limit in number of parameters (i.e. `SET`-variables) that can be used in a `WHERE`-condition. One can change the values of parameters through ODB Fortran90 layer by calling function `ODB_setval` (see page ...).

3.3.8 SET-variables

`SET` *$var* [= {*initial_value* | *scalar_expr*}] ;

Note that a `SET`-variable can also be defined for data queries (see parameterized queries). In that case their viaibility is limited to subsequent data query (queries) only. In the following, a variable `$x` is set *after* the first data query and is therefore visible (and applicable) to the second query only. Any attempt to use the variable in the first query would lead to SQL compilation failure, unless variable was already defined in the data definition layout phase.

Illegal use of `$x`

```
CREATE VIEW first AS
  SELECT a,b,c
  FROM t
  WHERE z < $x // Wrong !!
  -- $x not yet defined
;

SET $x = 1;

CREATE VIEW second AS
  SELECT a,b,c
  FROM t
  WHERE z < $x
;
```

Correct use of `$x`

```
SET $x = 1; -- Moved here!

CREATE VIEW first AS
  SELECT a,b,c
  FROM t
  WHERE z < $x // Now OK!
;

CREATE VIEW second AS
  SELECT a,b,c
  FROM t
  WHERE z < $x
;
```

3.4 Miscellaneous `ODB/SQL` language elements

3.4.1 RESET ALIGN-statement

```
RESET  ALIGN;
```

3.4.2 RESET ONELOOPER-statement

```
RESET  ONELOOPER;
```

3.4.3 ALIGN-statement

```
ALIGN( table_name_list ) ;
```

3.4.4 ONELOOPER-statement

```
ONELOOPER( table_name_list ) ;
```

3.4.5 Preprocessing keywords

`ODB/SQL` has limited capability to emulate the C-preprocessor (`CPP`). Only the following statements are currently supported:

```
#include "filename"
#include 'filename'

#define NAME

#ifdef NAME
    conditional_ddl_or_sql_line(s)
#endif
```

Please note that the hash-character (#) must start from the first column of a line, but can follow any number of whitespace (`TAB`s or `SPACE`s) before the preprocessing keyword.

3.4.6 Comment lines

```
// Double-slash starts a comment
-- Double-dash followed by a blank also starts a comment
CREATE TABLE hdr AS //← A comment start and ends here  →
( a int ,  --  also a comment (until end of line)
  -- A blank after the double-dash is crucial !!
```

3.5 Built-in functions

Presently built-in functions can only be used in `WHERE`-statement. Currently implemented functions are shown in the following table:

Table 4: ODB/SQL built-in functions

Function	**Description**
`tdiff(tgdate, tgtime, andate, antime)`	Time difference in seconds (*tgdate,tgtime*) are target times from which the nominal analysis timestamp (*andate,antime*) is getting subtracted from
`twindow(tgdate, tgtime, andate, antime, lmargin, rmargin`	Time window (range) selection around the nominal analysis timestamp. Arguments as in `tdiff`, but in addition (*lmargin, rmargin*) denote left and right offsets in seconds from the nominal analysis timestamp
`cos(x)`	Cosine (where *x* is in degrees)
`sin(x)`	Sine (where *x* is in degrees)
`tan(x)`	Tangent (where *x* is in degrees)
`acos(x)`	Arc cosine (the result is in degrees)
`asin(x)`	Arc sine (the result is in degrees)
`atan(x)`	Arc tangent (the result is in degrees)
`atan2(x,y)`	Arc tangent of two variables (the result in degrees)
`exp(x)`	Exponent
`ldexp(x,n)`	$x2^n$
`cosh(x)`	Hyperbolic cosine
`sinh(x)`	Hyperbolic sine
`tanh(x)`	Hyperbolic tangent
`int(x), trunc(x)`	Truncate to integer
`nint(x)`	Round-up to integer
`uint(x)`	Convert to unsigned integer
`float(x)`	Convert to 32-bit floating point number
`dble(x)`	Convert to 64-bit floating point number
`floor(x)`	Calculate floor value
`ceil(x)`	Calculate ceiling value
`abs(x)`	Absolute value
`max(x,y)`	Maximum value of two arguments
`min(x,y)`	Minimum value of two arguments
`touch(x)`	No-op (a dummy operation) function on *x* in order to force loading of the variables found in expression. Always returns 1, though
`maxcount(x)`	Returns 1, when the row count (per pool) does not exceed value of *x*
`maxrows(x)`	Returns the current row count (per pool)
`ibits(x,pos,len)`	Extract *len* bits from *word* offset pos
`mod(x,y) or x%y`	x modulo y with floating point numbers accepted
`pow(x,y) or x**y or x^y`	x power of y (x^y)

continued on next page . . .

Table 4: ODB/SQL built-in functions ... *continued*

Function	**Description**
`sqrt(x)`	Square root ($\sqrt{x}$)
`log(x),ln(x)`	Natural logarithm
`log10(x),lg(x)`	Base-10 logarithm
`deg2rad(x), degrees(x)`	Convert degrees to radians
`rad2deg(x), radians(x)`	Convert radians to degrees
`circle(x,x0,y,y0,r)`	Returns 1, if the point (*x*,*y*) is inside (or on) the (planar) circle with origin at (*x0*,*y0*) and radius *r*
`rad(lat0, lon0, angle, lat, lon)`	Returns 1, if the (*lat*,*lon*) is inside the great-circle (of any radius) with origin (*lat0*,*lon0*), and view *angle* (in degrees)
`distance(lat1, lon1, lat2, lon2)`	Distance (expressed in kilometres) between two positions (*lat1*,*lon1*) and (*lat2*,*lon2*) along a great-circle of the Earth ($R = 6371$km)
`km(lat1, lon1, lat2, lon2)`	Synonym of `distance`-function
`dist(lat1, lon1, lat2, lon2)`	Synonym of `distance`-function, but the result expressed in metres
`paral(PEvar, targetPE)`	Special shuffle function (more ???)

4 ODB Fortran90 access layer

Unlike in conventional relational databases, the data manipulation (data insertion, update, removal) has currently been organized under the shelter of the Fortran90 layer. This is a set of Fortran90 module based user callable functions. Data layout creation and making queries has been left to the non-Fortran90 layer i.e. ODB/SQL at present.

There are reasons for having the Fortran90 access library. The ODB was originally designed to be used from within IFS 4DVAR system only, which is solely written in Fortran90 language. Therefore it was natural to be able to access database using a Fortran90 subroutine layer rather than something else.

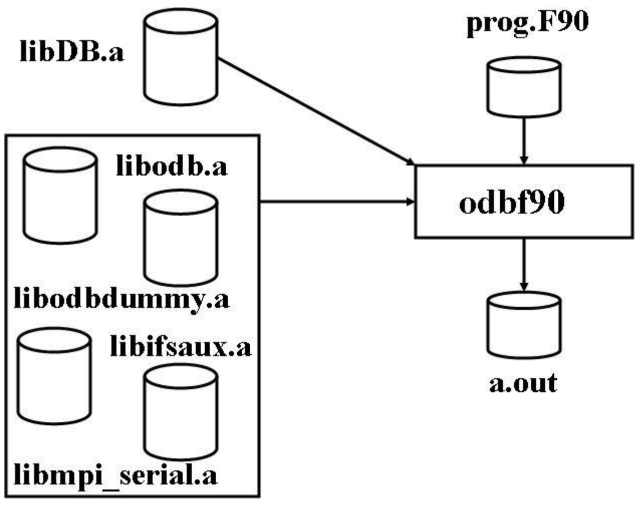
As discussed before the ODB software layers underneath are mostly written in C; also the ODB/SQL compilation produces C-code to be linked with the user application. Therefore it would be rather simple to extend the access ODB from C/C++ in the future. Also implementing a client-server access to the ODB is a feasible option.

4.1 Compiling and linking ODB-access programs

An application using the ODB Fortran90 layer can be compiled into a sequential or parallel program. How it relates to your application is described in the following two subsections.

4.1.1 Creating sequential Fortran90 programs

Figure 13: Using the `odbf90` -command to build a sequential executable



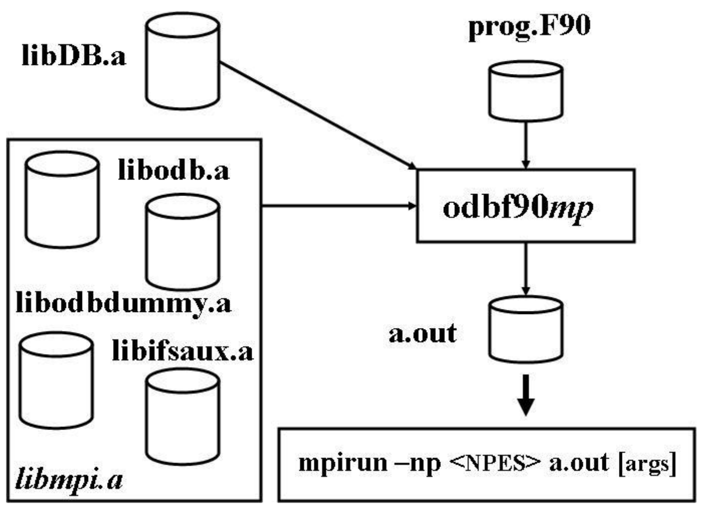
In the sequential ODB-access the MPI-library layer has been replaced with a dummy `MPI`-layer which effectively disables any distributed memory data handling through the message passing interface.

The advantage of using just a single processor executable is that one does not have worry about existence of parallel message passing subsystem nor how it schedules its jobs.

The disadvantage is that multiprocessor access to the partitioned (multipool) database is denied and thus making data queries and extraction potentially much slower than is necessary.

4.1.2 Creating MPI-parallel Fortran90 programs

Figure 14: Using the `odbf90mp` -command to build a MPI-parallel executable



By enabling MPI-parallelism in ODB-access, the application program can simultaneously access different partitions (pools) of data. In this approach the native (and normally system specific high performance) `MPI`-library takes over. You only need to worry about how your parallel job gets resources and is scheduled. Script `mpirun` helps in this respect. This is the default mode for IFS 4D-Var-runs, and thus ODB takes full benefit of this parallel feature by piggy-backing on top of `MPI`.

4.2 Description of the ODB Fortran90 functions

In order to access ODB Fortran90 from your source code, you need to specify the following USE-statement in your Fortran90 program or subroutine:

```
SUBROUTINE mysub(...)
...
USE odb_module
...
implicit none
...
END SUBROUTINE mysub
```

The `USE odb_module` statement declares all prototypes of ODB Fortran90 layer and thus gives extra protection against possible misuse of arguments.

Thorough description about the functions and their argument lists is given in the following subsections. The source files reside under the directories `$SRC/odb/module` or `$SRC/odb/include`. To summarize, the most commonly used functions are described in the table 5.

```
SUBROUTINE mysub(...)
...
USE odb_module
...
implicit none
...
INTEGER(4) :: nrows, ncols, nra
REAL(8), ALLOCATABLE :: x(:,:)
character(len=64) queryname
...
queryname = 'query' ! Based on CREATE VIEW query AS SELECT ...
do jp=myproc,npools,nproc
  rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp)
  ALLOCATE(x(nra,0:ncols))
  rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
  ... ! Work with "x" (access data, update, etc.)
  rc = ODB_put(h,queryname,x,nrows,ncols,poolno=jp)
  DEALLOCATE(x)
  rc = ODB_cancel(h,queryname,poolno=jp)
  ...
enddo
...
END SUBROUTINE mysub
```

After `ODB_select`, the user normally allocates memory for a data matrix, where the subsequent `ODB_get` will place the data. After `ODB_put` this space must be released by the user. The following illustrates the usage. It serves also as a skeleton program for all ODB data extractions and updates which involve just one table. Please note that the type of the

Table 5: Most important ODB Fortran90 functions.

Purpose	**Function name**	Source **.F90/.h**-file
Initialize ODB processing	`ODB_init` (4.2.10)	`odb.F90`
Open database	`ODB_open` (4.2.11)	`odb.F90`
Add more pools	`ODB_addpools` (4.2.1)	`odb.F90`
Register SQL-query	`ODB_addview` (4.2.2)	`odb.F90`
Execute SQL-query	`ODB_select` (4.2.16)	`odb.F90`
Fetch data behind the SQL	`ODB_get` (4.2.6)	`fodb.h`
Update data back to database	`ODB_put` (4.2.13)	`fodb.h`
Unselect (cancel) the query	`ODB_cancel` (4.2.3)	`odb.F90`
Execute SQL and place the result into a file	`ODB_print` (4.2.12)	`odbprint.F90`
Remove table(s) of a pool from memory	`ODB_swapout` (4.2.18)	`odb.F90`
Release the whole pool from memory	`ODB_release` (4.2.14)	`odb.F90`
Get column names/types of view/table	`ODB_getnames` (4.2.7)	`odbutil.F90`
Get column index number for column(s) of view/table	`ODB_varindex` (4.2.20)	`odbutil.F90`
Get view/table size/dimension information	`ODB_getsize` (4.2.8)	`odb.F90`
Get current value of parameterized $-variable	`ODB_getval` (4.2.9)	`odbutil.F90`
Change the value of parameterized $-variable	`ODB_setval` (4.2.17)	`odbutil.F90`
Test existence of parameterized $-variable	`ODB_varexist` (4.2.19)	`odbutil.F90`
Remove data from a table	`ODB_remove` (4.2.15)	`odb.F90`
Close database	`ODB_close` (4.2.4)	`odb.F90`
Finish with ODB	`ODB_end` (4.2.5)	`odb.F90`

ALLOCATABLE Fortran90-matrix (variable `x`, which will contain the data) must be either `REAL(8)` or `INTEGER(4)`[7]. Call to `ODB_get` will abort if any columns in the associated SQL-query contain floating point (or `string`) types, but variable `x` was declared as `INTEGER(4)`. You can find the datatypes of every column by using function `ODB_getnames`, but safest and easiest is to use `REAL(8)` type all the time.

The following sections explain ODB data manipulation functions in greater detail. For easier navigation, the routines are found in alphabetical rather than in functional order.

4.2.1 ODB_addpools

Usage of the function `ODB_addpools` is as follows:

[7]INTEGER(4) will be phased out in the future versions of the ODB software

```
rc = ODB_addpools ( handle, pool_excess &
&                 , [old_npools], [maxpoolno] )
```

This function adds more pools (pool_excess) – globally – to the existing database and returns total number of pools after the addition. The function is global i.e. all participating MPI-tasks must call it. Furthermore, no outstanding data queries must be in progress i.e. they all must have been completed (ODB_cancel should have been called).

The parameters denote :

rc	INTEGER(4) Return code, which upon successful completion will be ≥ 0
handle	INTEGER(4),INTENT(IN) Database handle as returned by ODB_open
pool_excess	INTEGER(4),INTENT(IN) The number of new pools to be added – globally, not per MPI-task
old_npools	INTEGER(4),INTENT(**OUT**),*OPTIONAL* Returns global number of pools before the addition
maxpoolno	INTEGER(4),INTENT(**OUT**),*OPTIONAL* Specifies the highest pool number used in data queries. The reason for using this parameter is that we may know the total amount of pools containing meaningful data is (say) old_npools and we want to stick with this. However, if the number of MPI-tasks used for this run is larger than old_npools, then we must add pool_excess number of "phoney" pools (which we may not necessarily contain any data), so that the total number of pools is at least equal to MPI-tasks. Then we set maxpoolno to be equal to old_npools and ODB will never search (in this run) beyond this pool number (on the database pointed to by the handle). Consequently the "phoney" pools are also never processed

Examples:

```
! Get the current number of pools by adding none
INTEGER(4) :: rc, handle, npools
rc = ODB_addpools(handle, 0, old_npools=npools)

! Now add 3 extra pools, but limit the maximum
! pool number to be used in data queries
rc = ODB_addpools(handle, 3, maxpoolno=npools)
```

```
! Just add 1 pool; no limits for data queries
rc = ODB_addpools(handle, 1)
```

4.2.2 ODB_addview

Usage of the function `ODB_addview` is as follows:

```
rc = ODB_addview ( handle, dtname &
&                , [viewfile], [select], [uniqueby], [from], [where] &
&                , [orderby], [sortby], [query], [set], [abort] )
```

Registers `SQL`-query `dtname` into the running `ODB` application so that subsequent query execution in ODB_select can take place. Note that in the later releases of `ODB`-software it is not necessary to use ODB_addview anymore, since when ODB_select is applied first time to `dtname`, it will issue an automatic ODB_addview Note also that this function is applicable straight away to *all* participating pools i.e. no `poolno` parameter is available. (Please note that the dynamic linking mode is a deprecated feature and is not actively supported in the `ODB` software anymore).

The parameters denote :

`rc`	`INTEGER(4)` Return code. A positive number indicates successful completion. It also defines the internal view number for this data query, which can be used to refer the query in the future `ODB` software releases instead of character string `dtname`.
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`viewfile`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only* (i.e. when `ODB_STATIC_LINKING` is set to 0). In dynamic mode you can supply `SQL`-query file (say `dtname.sql`) and the system will compile and dynamically link it into the currently running executable by using shareable object linking mechanism

`select`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. Instead of using `SQL`-query file, you will be able to supply the `SELECT` ... `FROM` etc. statements directly through this Fortran90 interface and they will be put into file `dtname.sql` and compiled like in the case of parameter `viewfile` above
`uniqueby`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply (`ODB`/SQL-specific) `UNIQUEBY` keyword with this parameter.
`from`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply `FROM` keyword with this parameter. Assumes that `SELECT` is also present
`where`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply (an optional) `WHERE` keyword with this parameter. The routine checks that `SELECT` and `FROM` have also been supplied
`orderby`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply (an optional) `ORDERBY` keyword with this parameter. You cannot use both `ORDERBY` and `SORTBY` simultaneously
`sortby`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply (an optional and `ODB`/SQL-specific) `SORTBY` keyword with this parameter. This parameter is mutually exclusive with `ORDERBY`
`query`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. You can supply the whole `SQL`-query string (without `CREATE VIEW dtname`) and thus simplify the subroutine call. It will be placed into file `dtname.sql` and compiled similarly as discussed in the context of parameter `viewfile`
`set(:)`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* *This parameter is applicable in dynamic linking mode only*. For parameterized queries you can supply an array of `SET`-variable definitions. Due to a Fortran90 restriction each of such character elements in the array must have exactly the same length
`abort`	`LOGICAL,INTENT(IN),`*`OPTIONAL`* By default if view registration fails, `ODB` aborts the program. By setting

this parameter to .FALSE., abort is prevented. This option is useful to check existence (availability) of a particular query

Examples:

```
! Register view 'queryname' to the running program
! Abort if not found (the default)
INTEGER(4) :: rc, handle
rc = ODB_addview(handle, 'queryname')

! The same as previous, but do not abort if fails to register
rc = ODB_addview(handle, 'queryname', abort=.FALSE.)
```

4.2.3 ODB_cancel

Usage of the function ODB_cancel is as follows:

```
rc = ODB_cancel ( handle, dtname &
&              , [poolno] )
```

This function the opposite of ODB_select i.e. it deallocates all internal index space reserved for the query dtname. After calling this routine you cannot access (fetch through ODB_get) the data belonging to this query unless you re-execute its counterpart ODB_select again. The parameters denote :

rc	INTEGER(4) Return code, which upon successful completion will be ≥ 0
handle	INTEGER(4),INTENT(IN) Database handle as returned by ODB_open
dtname	CHARACTER(LEN=*),INTENT(IN) Query name (in lower case letter) as specified in the CREATE VIEW-statement. Usually points also to the SQL-query file dtname.sql; sometimes even to database specific file *$dbname*_dtname.sql
poolno	INTEGER(4),INTENT(IN),*OPTIONAL* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned

Examples:

```
! De-activate data 'query' and release its internal index space
! All participating pools
! Can be re-activated upon next ODB_select
! (No need to re-invoke ODB_addview, though)
INTEGER(4) :: rc, handle
rc = ODB_cancel(handle, 'query')

! Cancel pool number 7 only
rc = ODB_cancel(handle, 'query', poolno=7)
```

4.2.4 ODB_close

Usage of the function `ODB_close` is as follows:

```
rc = ODB_close ( handle, [save] )
```

This function closes connection to the opened database and optionally updates associated data into the disk-media The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion will be ≥ 0
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`save`	`LOGICAL,INTENT(IN),`*`OPTIONAL`* If this parameter is present and was set to `.TRUE.`, and if database was *not* opened in '`READONLY`'-mode, then the routine will update database tables and associated metadata to disk-media before closing the connection to the database pointed to by the `handle`. In any other circumstances, or if this option is not present, the database is not be saved to disk. At the end of the call internal data structures related to this database-handle will also be wiped out from memory

`Examples`:

```
! Close database WITHOUT saving (the default)
INTEGER(4) :: handle, rc
rc = ODB_close(handle)

! Save changes (assume not a read-only database) and close
rc = ODB_close(handle, save=.TRUE.)
```

4.2.5 ODB_end

Usage of the function `ODB_end` is as follows:

```
rc = ODB_end ()
```

Finishes `ODB`-processing by closing connections to all databases that are still open and terminates `MPI`-parallel processing. Because of this, the program may also terminate, but this is a system specific behaviour. Anyway, this should be the last function call in your program.

The parameters denote :

rc	`INTEGER(4)` Return code, with value of 0 indicating success

`Examples`:

```
! Finish with ODB and end parallel processing
! Note: This call may terminate your program
!       on some platforms, so don't expect to
!       perform any operations after this call !
INTEGER(4) :: rc
rc = ODB_end()
```

4.2.6 ODB_get

Usage of the function `ODB_get` is as follows:

```
rc = ODB_get ( handle, dtname, d, nrows &
&           , [ncols], [poolno], [colget], [colpack], [index] &
&           , [sorted] )
```

This function copies data from database, `SQL`-query or tablename `dtname`, into the user supplied dynamically allocated data array/matrix `d`. Currently *`DATATYPE`* of the array has to be either `INTEGER(4)` or `REAL(8)`. In the subsequent release we may have to stick with `REAL(8)` datatype only.

The data is a complete `TABLE` of a *particular* pool, or result of `SQL`-query `dtname` executed through the function `ODB_select`

The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion returns the number of rows actually put into array `d`
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`d(:,0:)`	`DATATYPE,INTENT(INOUT)` Array or data matrix, where the outcome of the `SQL`-request (or whole table) `dtname` will copied. Note that the columns start at zero, since some internal information needs to stored for subsequent `ODB_put`
`nrows`	`INTEGER(4),INTENT(INOUT)` Upon return indicates number of rows actually copied into the data matrix `d`. The value can be $<$ the value upon input, depending on the nature of `SQL`-request; for example some duplicates may have been eliminated due to `SELECT DISTINCT`-statement in `CREATE VIEW`
`ncols`	`INTEGER(4),INTENT(INOUT),OPTIONAL` Upon return indicates number of columns actually copied into the data matrix `d`. The value can be $<$ the value upon input, depending on the nature of `SQL`-request; for example some ghost-columns may have been eliminated before copying data to the array (not yet implemented)
`poolno`	`INTEGER(4),INTENT(IN),OPTIONAL` The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned
`colget(:)`	`LOGICAL,INTENT(IN),OPTIONAL` Optionally only a subset of columns of the matrix `d` could be filled/copied by supplying `.TRUE.`-values in a logical-vector (of length $\geq$ `ncols`). This parameter has nothing to do with the famous toothpaste, `I` think
`colpack(:)`	`LOGICAL,INTENT(IN),OPTIONAL` Selective (internal) column packing can be requested at the end of the function. Purpose of this option is to allow memory saving by packing associated column data internally just before returning from ODB_get. However, its use probably leads into serious memory fragmentation and performance degradation, if used too frequently. If used, the length of this logical-vector has to be $\geq$ `ncols`

index(:)	INTEGER(4),INTENT(**OUT**),*OPTIONAL* When SQL-request asks data to be delivered in ordered manner (i.e. using ORDERBY (or SORTBY) -statements), the physical sort of the data matrix d can be prevented by supplying index-vector of length $\geq$ nrows, where the ordering information will be stored. This means that ordered data access needs to be performed via d(index(j),icol), and not directly through d(j,icol)
sorted	LOGICAL,INTENT(IN),*OPTIONAL* Possible use of ORDERBY (or SORTBY) -statements can be ignored by using this optional parameter and setting it to .FALSE.

Examples:

```
! A prime example of ODB-usage :
!   Execute data query, allocate matrix and load it with data
!
! Please note that you need column#0 for internal info

INTEGER(4) :: rc, handle
INTEGER(4) :: nrows, ncols, nra, poolno
REAL(8), allocatable :: x(:,:)

poolno = -1
rc = ODB_select(handle,'query',nrows,ncols,nra=nra,poolno=poolno)

allocate(x(nra,0:ncols))
rc = ODB_get(handle,'query',x,nrows,ncols=ncols,poolno=poolno)

do jrows=1,nrows
  do jcols=1,ncols
    print *,x(jrows,jcols)
  enddo
enddo
```

4.2.7 ODB_getnames

Usage of the function ODB_getnames is as follows:

```
rc = ODB_getnames ( handle, dtname, mode &
&                 , [outnames] )
```

This is a multipurpose function, which returns table names, view (data query) names, or data column names or their types, depending on `mode` associated with the database behind its `handle`. This function is a close relative to ODB_varindex, which returns data column indices per their names.

This function is typically called twice in succession. The first call is invoked without the `outnames`-parameter to get the dimension of the information (i.e. size for `outnames`), stored in the return code `rc`. The second call will be called with `outnames` correctly dimensioned as from previous return code.

The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion will be ≥ 0
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`mode`	`CHARACTER(LEN=*),INTENT(IN)` A character string, which determines the type of information the function should return in character array `outnames`. The `mode` can be as follows:

mode	**Returned info**
’datatype’, ’type’, ’ctype’	Internal `ODB` datatype
’ftndatatype’, ’ftntype’	Fortran90 datatype
’varname’, ’name’	Fully qualified column names (like `obstype@hdr`)
’tablename’, ’table’	Returns all the table names (when `dtname` is ’`*`’)
’viewname’, ’view’	Returns all those SQLs that have been registered directly or indirectly via `ODB_addview`

`outnames(:)`	`CHARACTER(LEN=*),INTENT(`**`OUT`**`),`*`OPTIONAL`* Character string vector containing the information requested by the `mode`

`Examples`:

```
! Please make sure a single character array
! element is large enough, say 128 characters
INTEGER(4) :: handle, ninfo
CHARACTER(LEN=128), allocatable :: clinfo(:)

! Get column names (in a form 'colname@tablename')
ninfo = ODB_getnames(handle,'queryname','name')
allocate(clinfo(ninfo))
ninfo = ODB_getnames(handle,'queryname','name',&
      &              outnames=clinfo)
do j=1,ninfo
  print *,'column name#',j,' = ',trim(clinfo(j))
enddo
deallocate(clinfo)

! Get table names
ninfo = ODB_getnames(handle,'*','table')
allocate(clinfo(ninfo))
ninfo = ODB_getnames(handle,'*','table',&
      &              outnames=clinfo)

! Get registered view names
ninfo = ODB_getnames(handle,'*','view')
allocate(clinfo(ninfo))
ninfo = ODB_getnames(handle,'*','view',&
      &              outnames=clinfo)
```

4.2.8 ODB_getsize

Usage of the function `ODB_getsize` is as follows:

```
rc = ODB_getsize ( handle, dtname, nrows, ncols &
&              , [nra], [poolno] )
```

This function returns the number of rows (`nrows`) and columns (`ncols`) behind the data query or table `dtname`.

The parameters denote :

`rc`	`INTEGER(4)` Return code which upon successful completion return value ≥ 0, which is the same as the `nrows`

handle	INTEGER(4),INTENT(IN) Database handle as returned by ODB_open
dtname	CHARACTER(LEN=*),INTENT(IN) This parameter is normally a tablename (a character string beginning with @-sign) or SQL-request (viewname). In case of SQL-request, this routine just returns the dimensions of the latest query, if still active i.e. ODB_cancel had not been called since the previous ODB_select on dtname
nrows	INTEGER(4),INTENT(**OUT**) The number of rows behind the dtname
ncols	INTEGER(4),INTENT(**OUT**) The number of columns behind the dtname
nra	INTEGER(4),INTENT(**OUT**),*OPTIONAL* Optimal number of rows that ought to be allocated for subsequent data matrix in order to reduce memory bank conflicts on vector machines or cache-line misses on RISC-architectures. The value is guaranteed to be $\geq$ nrows, but the exact value is computer platform dependent.
poolno	INTEGER(4),INTENT(IN),*OPTIONAL* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned

Examples:

```
! Get current size of table '@hdr' at pool number 9
INTEGER(4) :: rc, handle
INTEGER(4) :: nrows, ncols
rc = ODB_getsize(handle,'@hdr',nrows,ncols,poolno=9)

! The same as previous, but for all (locally owned) pools
rc = ODB_getsize(handle,'@hdr',nrows,ncols)
! -- or :
rc = ODB_getsize(handle,'@hdr',nrows,ncols,poolno=-1)

! Get dimensions of currently active data 'query' i.e.
! such query on which ODB_select has been executed,
! but not yet ODB_cancel
rc = ODB_getsize(handle,'query',nrows,ncols)

! The same as previous, but get optimal leading dimension
! for allocations, too
INTEGER(4) :: nlda
REAL(8),allocatable :: array(:,:)
rc = ODB_getsize(handle,'query',nrows,ncols,nra=nlda)
allocate(array(nlda,0:ncols))
```

4.2.9 ODB_getval

Usage of the function `ODB_getval` is as follows:

```
value = ODB_getval ( handle, varname &
&                  , [viewname] )
```

Returns the current value of $-variable `varname` which can optionally belong to `SQL`-query `viewname` only. Unlike its counterpart function `ODB_setval` (see 4.2.17), this function always returns type `REAL(8)` `value`.

The parameters denote :

value	`REAL(8)` The current value of the $-variable `varname`.
handle	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
varname	`CHARACTER(LEN=*),INTENT(IN)` The $-variable as speficied via `SET`-statement either in data definition layout (ddl-file) or `SQL`-query. In the latter case, the `viewname` must be present
viewname	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* The optional `SQL`-query name

Examples:

```
! Get the number of updates as defined in the layout
INTEGER(4) :: handle
INTEGER(4) :: imxupd
imxupd = ODB_getval(handle,'$nmxupd')

! Given the following data query:
```

```
SET $flp = 1.234;
CREATE VIEW jackpot AS
  SELECT etc. ...

! Get floating point parameter value associated with it
REAL(8) :: value
value = ODB_getval(handle, '$flp', viewname='jackpot')
```

4.2.10 ODB_init

Usage of the function `ODB_init` is as follows:

```
rc = ODB_init ( [myproc], [nproc], [pid], [tid], [ntid] )
```

Initializes `ODB` processing for Fortran90 interface and creates the necessary `MPI`-processes and OpenMP-threads, if necessary. This is normally the very first call to `ODB`-library. The source code resides in module file `$SRC/odb/module/odb.F90` The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion returns zero
`myproc`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Process id as returned by the `ECMWF MPL`-library. The value should always be between range 1..**`nproc`**
`nproc`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Number of `MPI`-processes allocated by the `ECMWF MPL`-library
`pid`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Unix process id of the caller
`tid`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* OpenMP thread id as returned by the `ECMWF OML`-library. The value should always be in the range 1 . . . **`ntid`**
`ntid`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Number of OpenMP-threads allocated

`Examples`:

```
! Initialize ODB and (possibly) parallel processing
INTEGER(4) :: rc
rc = ODB_init()

! Get parallel processing parameters, too
INTEGER(4) :: myproc, nproc    ! MPI (MPL)
INTEGER(4) :: numthreads, tid ! OpenMP (OML) threads
INTEGER(4) :: pid              ! Unix process id of the caller
rc = ODB_init(myproc=myproc, nproc=nproc, &
   &          ntid=numthreads, tid=tid, pid=pid)
```

4.2.11 ODB_open

Usage of the function `ODB_open` is as follows:

```
handle = ODB_open ( dbname, status, npools &
&                 , [old_npools], [maxpoolno] )
```

Opens connection to a database `dbname` with opening mode `status`. If the database is new, then `npools` will be allocated. If the database was previously present, the function optionally returns how many pools there were just before ODB_open. Another optional argument `maxpoolno` indicates the actual maximum pool number to be used for data access. This can be less than `npools`. If function ODB_init had not been called yet, ODB_open will take care of doing so.

The parameters denote :

`handle`	`INTEGER(4)` Database handle. Upon successful return this value must be ≥ 1. This parameter acts like a virtual unit number for opened database and must be passed as the first argument to most of the `ODB` Fortran90 layer's functions
`dbname`	`CHARACTER(LEN=*),INTENT(IN)` Database name to be opened. This character string has to be a valid database name i.e. start with capital letters `[A-Z]` and contain thereafter only capital letters or numbers i.e. `[A-Z0-9]`. No underscores are accepted
`status`	`CHARACTER(LEN=*),INTENT(IN)` Opening mode. Three different modes are accepted: '`NEW`' for opening a new database, '`OLD`' for opening an existing database for update,

	and ’`READONLY`’ for opening an existing database which cannot be updated (even accidentally)
`npools`	`INTEGER(4),INTENT(IN`**`OUT`**`)` Number of pools in database. For new databases this defines how many pools (i.e. partitions) need to be created. The number can be increased later on by calling ODB_addpools-function. For existing database it just returns number of pools present. These may have been adjusted by an internal call to ODB_addpools, since `npools` is always rounded up to the nearest number of `MPI`-processors in use
`old_npools`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Existing number of pools before ODB_open was issued. For a new database this would be zero. For an existing database the `npools` may have already been adjusted by an internal call to ODB_addpools
`maxpoolno`	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Indicates how many pools will be used to perform data queries. The original `npools` may have been smaller than the number of `MPI`-processors in use, therefore ODB_addpools-function is called, which makes `npools` larger than the true number of partitions. The excess of these "dummy" partitions will not be created nor accessed when the database was opened with `status`=’READONLY’. The `maxpoolno` indicates therefore the true number of pools that contain any data

`Examples`:

```
! Create new database with 4 pools
! Any existing data will be removed
INTEGER(4) :: handle, npools
npools = 4
handle = ODB_open('MYDB','NEW',npools)

! Open and existing or create a new database,
! if it doesn't exist; thus "npools" may need to be set
npools = 4
handle = ODB_open('MYDB','UNKNOWN',npools)
print *,'Number of pools is : ',npools

! Open an existing database
! If database doesn't exist, the program will abort
npools = 0
handle = ODB_open('DATABAAZ','OLD',npools)
print *,'Number of pools is : ',npools
```

```
! Open an existing database for read-only access
! Database must be an existing one
npools = 0
handle = ODB_open('DATABAAZ','READONLY',npools)
print *,'Number of pools is : ',npools
```

4.2.12 ODB_print

Usage of the function `ODB_print` is as follows:

```
rc = ODB_print ( handle, dtname &
&            , [file], [poolno], [maxpoolno], [setvars], [values] &
&            , [pevar], [replicate_pe], [show_db_index] &
&            , [inform_progress], [open_file], [close_file] &
&            , [append_mode] )
```

Function ODB_print enables `SQL`-query to be executed , get data and place it into a result file. Thus this function is a very quick way to create an output file from a data query without need to call ODB_addview, ODB_select, allocate array, ODB_get and ODB_cancel.

The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion will be ≥ 0
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`file`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* The file name where to write the outcome of the query. If not supplied, then defaults to "*dtname*`.rpt`"
`poolno`	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned

maxpoolno	INTEGER(4),INTENT(IN),*OPTIONAL*
setvars(:)	CHARACTER(LEN=*),INTENT(IN),*OPTIONAL* The same as in ODB_select
values(:)	REAL(8),INTENT(IN),*OPTIONAL* The same as in ODB_select
pevar	CHARACTER(LEN=*),INTENT(IN),*OPTIONAL* The same as in ODB_select
replicate_pe	INTEGER(4),INTENT(IN),*OPTIONAL* The same as in ODB_select
show_db_index	LOGICAL,INTENT(IN),*OPTIONAL* Flag to indicate whether to show internal database index (the "famous" 0^{th} column). By default it is not shown
inform_progress	LOGICAL,INTENT(IN),*OPTIONAL* If .TRUE., then the first MPI-task will display a rudimentary text-based progress-bar to assure that ODB-software is really doing something
open_file	LOGICAL,INTENT(IN),*OPTIONAL* Flag to indicate whether to open the file. Useful only when looping over many pools. See examples. By default .TRUE.
close_file	LOGICAL,INTENT(IN),*OPTIONAL* Flag to indicate whether to close the file. Useful only when looping over many pools. See examples. By default .TRUE.
append_mode	LOGICAL,INTENT(IN),*OPTIONAL* Flag to indicate whether to open the file in append-mode (concatenation). Useful only when you want to merge results from multiple invocations of ODB_print – or even multiple runs of an application program using ODB_print By default .FALSE.

Examples:

```
!-- Execute SQL and put the result into file 'query.rpt'
!   All pools involved
INTEGER(4) :: rc, handle
rc = ODB_print(handle, 'query')

!-- Loop over the pools
```

```
!   Open the file upon first pool, close upon last
!   Assume just participating MPI-task
INTEGER(4) :: jp, npools
do jp=1,npools
  rc = ODB_print(handle, 'query', poolno=jp, &
     &           file='result.rpt', &
     &           open_file = (jp == 1), &
     &           close_file = (jp == npools))
enddo ! do jp=1,npools

!-- Append results from two ODB_print's into one file
rc = ODB_print(handle, 'query1',&
   &           file='total.rpt')  ! Create

rc = ODB_print(handle, 'query2',&
   &           file='total.rpt', &
   &           append_mode=.TRUE.)  ! Append

!-- Show progress bar for curiosity
rc = ODB_print(handle, 'query', &
   &           inform_progress=.TRUE.)
```

4.2.13 ODB_put

Usage of the function `ODB_put` is as follows:

```
rc = ODB_put ( handle, dtname, d, nrows &
&            , [ncols], [poolno], [colput], [colpack], [sorted] )
```

This function copies data from user supplied working array/matrix `d` back into database internal cache. Currently the *DATATYPE* of the array has to be either `INTEGER(4)` or `REAL(8)`, but as indicated in the counterpart function's `ODB_get` description, this may change in the future. See more from function `ODB_get` (4.2.6)

Note that this function does not perform any `I`/O-operations, thus database files are not yet updated. You need to issue a function `ODB_swapout`, `ODB_store`, `ODB_release` or `ODB_close` tophysically update the database on disk. Thus, one can use ODB_put also for `READONLY`-databases, and it will then update only the in-memory data structures. This could be sometimes useful. One may want to extract data via `SQL` and perform temporary (in-memory) update for some items in the query. Then another query will be launched using the modified – now in-memory values. And yet nothing ends up on disk, since database was protected from permanent updates.

The parameters denote :

`rc`	`INTEGER(4)` Return code, which upon successful completion returns the number of rows actually put from array `d` back into database internal cache
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`d(:,0:)`	*`DATATYPE`*`,INTENT(IN`**`OUT`**`)` The data array to be copied back into database internal cache
`nrows`	`INTEGER(4),INTENT(IN)` The number of rows to be copied
`ncols`	`INTEGER(4),INTENT(IN`**`OUT`**`),`*`OPTIONAL`* Upon input the number of columns to be copied. Upon output indicates how many columns actually copied.
`poolno`	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned
`colput(:)`	`LOGICAL,INTENT(IN),`*`OPTIONAL`* Similar to `colget`-parameter in function `ODB_get`. That is to say, optionally only subset of columns can be passed back to database. A logical-vector of length $\geq$ `ncols`
`colpack(:)`	`LOGICAL,INTENT(IN),`*`OPTIONAL`* The same as `colpack`-parameter in function `ODB_get`.
`sorted`	`LOGICAL,INTENT(IN),`*`OPTIONAL`* When set to `.TRUE.`, enforces physical sorting of data array `d` with respect to column#0 before passing data columns into database. Normally not supplied since the system automatically detects the need for sorting (for example, in case of putting back local data which stemmed from multiple pools)

Examples:

```
! Update database (in-memory), deallocate data matrix and
! finally de-activate the data query

INTEGER(4) :: rc, handle
INTEGER(4) :: nrows, ncols, nra, poolno
REAL(8), allocatable :: x(:,:)

poolno = -1
rc = ODB_put(handle,'query',x,nrows,ncols=ncols,poolno=poolno)
deallocate(x)

rc = ODB_cancel(handle,'query',poolno=poolno)
```

4.2.14 ODB_release

Usage of the function `ODB_release` is as follows:

```
rc = ODB_release ( handle, [poolno] )
```

Removes all data associated with `poolno` from memory. Unlike its sibling routine `ODB_-swapout`, this routine only has an effect when the database has been opened in `ODB_-open` with status '`READONLY`'. This routine also works for I/O-method#4 (see `ODB_IO_-METHOD` (see p.191)), but then there is no way to request data back into memory, unlike if function `ODB_swapout` with I/O-method#4, unless ODB_close followed by ODB_open are invoked again.

If no explicit pool number is given and if database has been opened in '`READONLY`'-mode, then all pools will be removed from memory.

The parameters denote :

rc	`INTEGER(4)` Return code, which upon successful completion will be ≥ 0
handle	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
poolno	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned

Examples:

```
! Remove every pool of data from memory (without saves to disk)
INTEGER(4) :: rc, handle
rc = ODB_release(handle)

! Remove the first pool of every MPI-task
! i.e. pool number 'myproc' from memory
INTEGER(4) :: myproc
rc = ODB_init(myproc=myproc)
...
rc = ODB_release(handle, poolno=myproc)
```

4.2.15 ODB_remove

Usage of the function `ODB_remove` is as follows:

```
rc = ODB_remove ( handle, dtname &
&               , [poolno] )
```

This function removes data behind the table `dtname` and marks it empty for subsequent database operations. If the pool number `poolno` is missing, then *all* the similar tables given in `dtname` will be removed.

Warning: use this function only if you know exactly what you are doing or you may severely destroy the integrity of your database.

The parameters denote :

`rc`	`INTEGER(4)` Upon successful return this value indicates the number of bytes removed
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Table name (begins with (@-sign) to which the removal operation will be applied. Unlike in many other functions, you presently cannot use the '`*`'-syntax to indicate all table, nor refer to `SQL`-queries. That makes use of this dangerous function less attractive i.e. you really need to convince yourself whether it is a good idea to call this function at all !

poolno	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned

Examples:

```
! Remove permanently table '@zztop' from database
! All pools
INTEGER(4) :: rc, handle
rc = ODB_remove(handle,'@zztop')

! The same as previous, but only pool number 13 will be removed
rc = ODB_remove(handle,'@zztop', poolno=13)
```

4.2.16 ODB_select

Usage of the function `ODB_select` is as follows:

```
rc = ODB_select ( handle, dtname, nrows, ncols &
&              , [nra], [poolno], [setvars], [values], [pevar], [replicate_pe] &
&              , [sync] )
```

This function executes `SQL` (data query) *dtname* which was previously registered by ODB_-addview function. It returns number of rows and columns to be allocated before ODB_get can be issued. Return code ≥ 0 denotes *local* number of rows for parallel queries. For *non-parallel* queries this number equals to *nrows*

The parameters denote :

rc	`INTEGER(4)` Return code which upon successful completion return value ≥ 0. For non-parallel queries value indicates how many rows satisfied the `WHERE`-condition and the return code should be equal to `nrows`. For parallel queries the value indicates how many rows from *local* pools satisfied the `WHERE`-condition; thus the sum of return codes on every `MPI`-processor would give value found in `nrows`.
handle	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`

dtname	`CHARACTER(LEN=*),INTENT(IN)` `SQL`-query name (lower case) or `TABLE` name (begins with @-sign). In the latter case reverts the call to function `ODB_getsize`
nrows	`INTENT(4),INTENT(`**`OUT`**`)` Number of rows that satisfy this query
ncols	`INTEGER(4),INTENT(`**`OUT`**`)` Number of columns that satisfy this query
nra	`INTEGER(4),INTENT(`**`OUT`**`),`*`OPTIONAL`* Optimal number of rows that ought to be allocated for subsequent data matrix in order to reduce memory bank conflicts or cache-line misses. The value is guaranteed to be $\geq$ `nrows`, but the exact value is computer platform depend.
poolno	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned
pevar	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* Applicable for `MPI`-parallel data shuffle. More later ...
replicate_pe	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* Applicable for replicated `MPI`-parallel queries only. If set to -1, then data obtained from local processors/pools will be replicated on every processor upon `ODB_get`. If set to a value in the range of 1..**`nproc`**, then only the processor in the range will receive the replicated data
setvars(:)	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* For parameterized queries and used in connection with the `values`-parameter. Attempts to override the value of `$`-variable present in the data query `dtname`
values(:)	`REAL(8),INTENT(IN),`*`OPTIONAL`* Supplies new values for a set of dollar-variables present in the data query `dtname`. Variable-list is supplied via `setvars`. The lifetime of the new value is duration of the `SQL`-query only. You need to use `ODB_setval` to change the value of a dollar-variable permanently
sync	`LOGICAL,INTENT(IN),`*`OPTIONAL`* If `TRUE`, then synchronizes queries from every `MPI`-processor

`Examples`:

```
! Execute data query on pool number 17 only
! and get dimensions for data matrix allocation
INTEGER(4) :: rc, handle
INTEGER(4) :: nrows, ncols, nra
rc = ODB_select(handle,'query',nrows,ncols,nra=nra,poolno=17)

! Invoke parameterized query, where '$tslot' is
! referred in WHERE-statement, by looping over 4D-Var timeslots
CHARACTER(LEN=32) :: clsetvar(1)
REAL(8) :: vals(size(clsetvar))
INTEGER(4) :: tslot
clsetvar(1) = '$tslot'
do tslot=1,25
  vals(1) = tslot
  rc = ODB_select(handle,'query',nrows,ncols, &
     &            setvars=clsetvar(1:1), values=vals(1:1))
  ... allocate data matrix
  ... fill data matrix with data and work with it
  ... dellocate data matrix
  rc = ODB_cancel(handle,'query')
enddo ! do tslot=1,25

! Invoke parallel data query to collect global view
! on every MPI-task (all tasks and pools involved)
rc = ODB_select(handle,'query',nrows,ncols,nra=nra,&
   &            replicate_PE=-1)

! Invoke parallel shuffle against loop-variable '$loop'
rc = ODB_select(handle,'query',nrows,ncols,nra=nra,&
   &            pevar='$loop')
```

4.2.17 ODB_setval

Usage of the function `ODB_setval` is as follows:

```
oldvalue = ODB_setval ( handle, varname, newvalue &
&                     , [viewname] )
```

Re-defines the value $-variable `varname` by `newvalue` and apply it optionally to `SQL`-query `viewname` only.

The *DATATYPE* can be either REAL(8) or INTEGER(4), or types which will be automatically casted into these two basic types.

See also function ODB_getval at 4.2.9

The parameters denote :

oldvalue	*DATATYPE* Returns the previous value, or 0 if variable was not defined
handle	INTEGER(4),INTENT(IN) Database handle as returned by ODB_open
varname	CHARACTER(LEN=*),INTENT(IN) The $-variable as speficied via SET-statement either in data definition layout (ddl-file) or SQL-query. In the latter case, the viewname must be present
newvalue	*DATATYPE*,INTENT(IN) The new value to be assigned
viewname	CHARACTER(LEN=*),INTENT(IN),*OPTIONAL* The optional SQL-query name

Examples:

```
! Change desired timeslot number to 2 (globally)
INTEGER(4) :: handle, idummy
INTEGER(4) :: ioldvalue
ioldvalue = ODB_setval(handle,'$tslot',2)

! And now restore the old value
! The "idummy" becomes 2
idummy = ODB_setval(handle,'$tslot',ioldvalue)

! Set floating point value to 3.14 in view 'jeffpot'
REAL(8), parameter :: pi_approx = 3.14d0
REAL(8) :: oldvalue
oldvalue = ODB_setval(handle,'$pi',pi_approx, &
         &             viewname='jeffpot')
```

4.2.18 ODB_swapout

Usage of the function ODB_swapout is as follows:

```
rc = ODB_swapout ( handle, dtname &
&                , [poolno], [save] )
```

This function removes ODB data from memory by optionally saving it to disk, if save-option was set to .TRUE..

The dtname denotes the table name, SQL-query name or '*', where to remove the associated data from memory. When SQL-query is specified, then all tables accessed via this query will be removed from memory. In particular with '*', *all* tables brought into memory will be removed.

This used to be an effective way of interleaving data in memory between subsequent data pools so that data in two or more pools never needed to coexist. This is useful especially when performing post-processing on systems with limited amount of memory. While it still works fine for I/O-method#1, this function is now being superceded by ODB_release, which also works for the new I/O-method#4 (see more on ODB_IO_METHOD from A) The parameters denote :

rc	INTEGER(4) Return code, which upon successful completion will be ≥ 0
handle	INTEGER(4),INTENT(IN) Database handle as returned by ODB_open
dtname	CHARACTER(LEN=*),INTENT(IN) Query name (in lower case letter) as specified in the CREATE VIEW-statement. Usually points also to the SQL-query file dtname.sql; sometimes even to database specific file *$dbname*_dtname.sql
poolno	INTEGER(4),INTENT(IN),*OPTIONAL* The pool number. If omitted, the default $= -1$ will be assumed i.e. all applicable pools owned by the particular MPI-task will be scanned
save	LOGICAL,INTENT(IN),*OPTIONAL* If this parameter is present and was set to .TRUE., and if database was *not* opened in 'READONLY'-mode, then the routine will update tables associated with the dtname

Examples:

```
! Remove table '@errstat' (all pools) from memory without saves
INTEGER(4) :: rc, handle
rc = ODB_swapout(handle, '@errstat')
```

```
! The same as the previous, but apply to pool#9 and save changes
rc = ODB_swapout(handle, '@errstat', poolno=9, save=.TRUE.)

! Remove all those tables from memory, which are present
! in data query 'queryname'
rc = ODB_swapout(handle, 'queryname')
```

4.2.19 ODB_varexist

Usage of the function `ODB_varexist` is as follows:

```
exist = ODB_varexist ( handle, varname &
&                    , [viewname] )
```

You can test the presence of a particular $-variable `varname`, which can optionally belong to `SQL`-query `viewname`.

See also for related functions `ODB_getval` (4.2.9) and `ODB_setval` (4.2.17).

The parameters denote :

`exist`	`LOGICAL` If the $-variable`varname` is present, returns `.TRUE.`, otherwise `.FALSE.`
`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`varname`	`CHARACTER(LEN=*),INTENT(IN)` The $-variable as speficied via `SET`-statement either in data definition layout (ddl-file) or `SQL`-query. In the latter case, the `viewname` must be present
`viewname`	`CHARACTER(LEN=*),INTENT(IN),`*`OPTIONAL`* The optional `SQL`-query name

`Examples`:

```
! Check whether the parameter '$mdi' has been defined at all
INTEGER(4) :: handle
REAL(8) :: value
if (ODB_varexist(handle, '$mdi')) then
  value = ODB_getval(handle, '$mdi')
  print *,'Parameter $mdi is present. The current value = ',value
else
  print *,'Parameter $mdi is NOT present'
endif
```

4.2.20 ODB_varindex

Usage of the function `ODB_varindex` is as follows:

```
rc = ODB_varindex ( handle, dtname, names, idx )
```

This function helps you to avoid using hardcoded column index numbers when accessing data in matrices returned by ODB_get. It helps you to find out the column indices (`idx`) of the given (fully qualified) column names (`names`). If some column name is not part of data query (or table) `dtname`, the corresponding element in `idx` has value zero (0).

The parameters denote :

`handle`	`INTEGER(4),INTENT(IN)` Database handle as returned by `ODB_open`
`dtname`	`CHARACTER(LEN=*),INTENT(IN)` Query name (in lower case letter) as specified in the `CREATE VIEW`-statement. Usually points also to the SQL-query file `dtname.sql`; sometimes even to database specific file *$dbname*_`dtname.sql`
`names(:)`	`CHARACTER(LEN=*),INTENT(IN)` Fully qualified array of column names, like '`obstype@hdr`'. Please note that `@LINK`-information must be given as follows: For `table.offset` enter `LINKOFFSET(table)`, and for `table.len` enter `LINKLEN(table)`. In addition both are *case sensitive*, i.e. `LINKOFFSET` and `LINKLEN` must be entered in capital letters
`idx(:)`	`INTEGER(4),INTENT(`**`OUT`**`)` Column index numbers to be used to address the second dimension (i.e. column) of data matrices returned from ODB_get. Each individual value must be ≥ 1, or otherwise the particular column name specified in its corresponding `idx`-entry has no match in `dtname`. The dimension of `idx` must be at least the same of length of the `names`-vector

`Examples`:

```
! Given the following data query:
CREATE VIEW query AS
  SELECT a,b,c
    FROM table;

! Find out column indices for {c,b,a} in this order
! Should print out : 3, 2, 1
INTEGER(4) :: rc, handle
CHARACTER(LEN=128) :: names(3)
INTEGER(4) :: idx(size(names))
names(1) = 'c@table'
names(2) = 'b@table'
names(3) = 'a@table'
rc = ODB_varindex(handle,'query',names,idx)
print *,'idx(:) = ',idx(:)
```

5 Some examples

In the following few sections we explain how to

- Initialize ODB environment on Unix-level
- Create new, empty database
- Populate database with data
- Make SQL-queries to retrieve data records
- Add more records if certain records didn't already exist there
- Update existing records
- Archive and remove database from disk

The aim of this exercise is to give a firm understanding how ODB works in practice and what steps need to be taken to store, query and update the database.

The example is an oversimplified simulator to perform synop pressure bias correction at station level, where initially no station or bias information was present. After running 4D-Var for a number of days, such a station level bias correction knowledge gradually builds up. Data is based upon this knowledge and is put into ODB database in order to be able to retrieve and control its data properly. No more ad-hoc data files are necessary and online/offline queries can be made to monitor validity of such data at any given moment.

5.1 Initialization of ODB environment

In order to run examples in this document, you need to initialize the ODB environment properly. The initialization scripts shown are applicable for ECMWF Linux desktop environment.

Under the Korn-shell the user needs to give the following commands:

```
$ export ODB_VERSION=latest
$ .    /vol/odb/ODBDIR/use_odb.sh
```

If you are C-shell (or `tcsh`) user, you need to give the following commands:

```
% setenv ODB_VERSION latest
% source  /vol/odb/ODBDIR/use_odb
```

Since the `latest`-version is the default, and since ECMWF has `use`-command available[8], the easiest way of get going (in either of the shell-environments) is in fact to issue simply a command:

```
use odb
```

5.2 Creating a new database

In this subsection you will be introduced to the following ODB Fortran90 interface functions:

- `ODB_init` : Initialize ODB (and parallel, if applicable) environment
- `ODB_open` : Open and create new database
- `ODB_close` : Save (meta)data upon closing otherwise empty database
- `ODB_end` : Finish with ODB (and terminate parallel processing)

Before creating a new database, you need to specify its data layout. This needs to be placed in file `$dbname.ddl`, where `$dbname` is your choice for database name. The name has to start with a capital letter (`[A-Z]`), optionally followed by capital letters or numbers (i.e. `[A-Z0-9]` No underscores are accepted at present. Also the length of the database name must be no more than 64 characters.

You need to choose whether you want to use one of the recognized database names (i.e. permanent database names) or invent your own database name. This is an important factor, since ODB (mainly) supports static linkage (see `ODB_STATIC_LINKING` (see p.194)), where certain most commonly used database names are automatically bound to the ODB compilation system.

There is however a relatively new workaround method explained in 9.2, which allows you to define any database name (and even override the existing permanent ones) on-the-fly and still perform a static linkage.

In this section we assume a completely new database name and call it `DB`. Its layout is shown here:

```
// Database DB: file DB.ddl

SET $mdi = 2147483647;

CREATE TABLE hdr (
```

[8]The `use`-command is just a small script to make life easier

```
  seqno   pk1int,
  date    YYYYMMDD,
  time    HHMMSS,
  statid  string,
  lat     pk9real,
  lon     pk9real,
  body   @LINK,
);

CREATE TABLE body (
  entryno   pk1int,
  varno     pk1int,
  press     pk9real,
  obsvalue  pk9real,
  depar     pk9real,
  obs_error pk9real,
  bias      pk9real,
);
```

It consists of two tables `hdr` and `body`. Table `hdr` can is considered as parent-table since it has a `@LINK`to its child-table `body`. Both tables have a few columns containing mixed 4-byte integer, 64-bit floating point and fixed 8-byte character data. The column names `seqno` and `entryno` can be considered as a kind of key entries, which we try to keep unique. This uniqueness fact is not mentioned anywhere in the data layout, but when we start to populate them with data (see 5.3), it will become clearer.

If you already are familiar with genuine relational databases, the database schema (i.e. data layout) could look like as follows ([Feh02]):

```
-- Database DB: file DB.inp

CREATE TABLE hdr (
  seqno   INTEGER NOT NULL UNIQUE,
  date    DATE,
  time    TIME,
  statid  CHAR(8),
  lat     DOUBLE,
  lon     DOUBLE,
--
  PRIMARY KEY (seqno)
);

CREATE TABLE body (
  entryno   SMALLINT NOT NULL,
  varno     INTEGER,
  press     DOUBLE,
  obsvalue  DOUBLE,
  depar     DOUBLE,
  obs_error DOUBLE,
  bias      DOUBLE,
--
  seqno     INTEGER NOT NULL,
  PRIMARY KEY (seqno,entryno),
  CONSTRAINT hdr2body
    FOREIGN KEY(seqno)
    REFERENCES hdr(seqno)
);
```

The compilation of the ODB database layout `DB.ddl` can be accomplished as follows:

```
$ newodb DB
```

If database `DB` was already in the list of recognized database names, the compilation would have been:

```
$ odbcomp DB.ddl
```

Outcome of this compilation process is explained more in 9.2 and **??**. The bottom line is that you have got now a library `libDB.a`, which becomes a backbone for your database access of this particular (nothing else) database `DB`.

The next stage is to create a program `createdb.F90` which will handle creation of any (i.e. generic) ODB database. Since we have chosen to oversimplify the matters, this program does nothing else but creates a new and empty database. In a normal situation we would be doing both: a database creation and its population with data. The program is as follows:

```
PROGRAM createdb
!*** createdb.F90 ***
USE odb_module
implicit none
INTEGER(4) :: myproc,nproc,npools,h
INTEGER(4) :: nrows, ncols, nra, rc
character(len=64) dbname
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname) ! Database name
npools = 1 ! Change this to a desired number
h = ODB_open(dbname,'NEW',npools)
rc = ODB_close(h,save=.TRUE.)
rc = ODB_end()
END PROGRAM createdb
```

To run this program, you need to execute the following commands (but make sure you have initialized your ODB environment first, see 5.1):

```
# Go to directory where DB.ddl sits
#   This will become (by default) your database directory
cd /my/DB

# (1) Compile database DB (once in the lifetime):
newodb DB

# (2) Run setup to get the IOASSIGN right:
./DB.setup > DB.IOASSIGN
export IOASSIGN=‘pwd‘/DB.IOASSIGN

# (3) Make sure database directories get right:
export ODB_DATAPATH_DB=‘pwd‘
export ODB_SRCPATH_DB=‘pwd‘

# (4) Compile and link Fortran90 application:
odbf90 createdb.F90 -lDB -o createdb.x

# (5) Run the application
./createdb.x DB
```

If you change the data layout (`DB.ddl`), you need to redo all steps from 1...5. However, if you just change the Fortran90 application, you just redo the steps 4 and 5. If you decide to relocate the database destination directory, you have to make sure your `IOASSIGN`-file reflects this change, and environment variables `ODB_DATAPATH` (see p.190) and `ODB_-SRCPATH` (see p.194) get adjusted, too.

The output listing for this example is shown next. You can see that database has been created and it has a certain number of pools. Line numbers are not part of the real output. Nothing much exciting:

```
  1: MPL_INIT : MPL_METHOD=JP_BLOCKING_BUFFERED
  2: MPL_INIT : MAILBOX SIZE=     1000000
  3: MPL_BUFFER_METHOD:  2   540680269
  4: >>> Assuming static linking mode
  5: ***Warning: Poolmasking ignored altogether
  6:  OPEN_DB: handle= 1
  7:  DataBase-name="DB"
  8:  inuse ?  T
  9:  newdb ?  T
 10:  readonly ?  F
 11:  no. of global pools =  1
 global max poolno =  1
 no. of local pools =  1
 sequence no. scaling factor =  1073741824
 max. no. of rows per pool =  1073741823
 I/O-method =  1
 iounit =  0
 ntables =  2
*** newio.c:init_IOs() ***
   ODB_WRITE_EMPTY_FILES=0
     ODB_CONSIDER_TABLES=*
      ODB_IO_KEEP_INCORE=1
         ODB_IO_FILESIZE=32 MB
          ODB_IO_BUFSIZE=1048576 bytes
          ODB_IO_GRPSIZE=1 (or max no. of pools)
          ODB_IO_PROFILE=0
          ODB_IO_VERBOSE=0
           ODB_IO_METHOD=1
             ODB_IO_LOCK=0
*********************
 END of OPEN_DB
```

5.3 Populating with data

We intend to populate the database tables with some initial data. You will be introduced to the following ODB Fortran90 interface functions in this subsection:

- `ODB_open` : Open an existing database
- `ODB_getval` : Find out the value of a parameterized variable
- `ODB_getsize` : Inquire existing table dimensions
- `ODB_put` : Append full data rows directly to a table
- `ODB_close` : Save data and close database

If we were using standard relational database engines, we would simply type in the following stream of SQL-commands :

```
INSERT INTO hdr
(seqno,      date,    time,       statid,    lat,    lon)
VALUES
(    1,  20010101, 100000,    "   07027", 49.18, -0.45),
(    2,  20010101, 130000,    "   07061", 49.82,  3.20),
(    3,  20010101, 130000,    "   07075", 49.78,  4.63);

INSERT INTO body
(entryno, varno,    press,  obsvalue,    depar, obs_error, seqno)
VALUES
(    1,      110,    657.05, 98530.00,   -85.86,     69.03,     1),
(    2,       39,  98530.00,   282.70,     1.80,      1.95,     1),
(    1,      110,    990.47, 98480.00,  -221.59,     69.09,     2),
(    2,       39,  98480.00,   279.80,     1.06,      1.95,     2),
(    1,      110,   1451.38, 98250.00,  -123.32,     69.36,     3);
```

Unfortunately these are not available in `ODB/SQL` -language as yet, so we need to put some more effort. We have two choices to supply data to ODB database:

1. Let a Fortran90 program to feed data to ODB
2. Pass text datafile(s) to ODB via `simulobs2odb`-utility

We will cover here only the more labourous way i.e. using ODB Fortran90 interface. An alternative, a completely novel approach in connection with simulated observations will be covered in section 10.4. In this approach the nearly free formatted text datafiles containing desired values are passed into a script (`simulobs2odb`), which further down pre-processes the data so that the ODB-application `odbsimulobs` can take over and populate the database directly from these text files.

An ODB Fortran90 application `populate.F90` , which is able to feed our database, could look something like:

```
PROGRAM populate
!*** populate.F90 ***
USE odb_module
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
REAL(8) mdi ! Missing data indicator ("NULL")
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, rc
character(len=64) dbname, tblname
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname)    ! Database name
npools = 0 ! Gets true value from ODB_open()
h = ODB_open(dbname,'OLD',npools)
mdi = abs(ODB_getval(h, '$mdi'))
jp = 1 ! Here: Populate poolno#1 only for now
if (myproc == mod(jp-1,nproc)+1) then
  tblname = '@hdr' ! Note '@'-sign in front of
```

```
    rc = ODB_getsize(h,tblname,nrows,ncols,poolno=jp)
    nrows = 3 ! Three new rows for TABLE hdr
    ALLOCATE(x(nrows,0:ncols))
    !              seqno       date     time     statid  ...
    !                ...      lat        lon  body.offset  body.len
    x(1,1:ncols) = (/1d0,20010101d0,100000d0,8H   07027, &
                   &       49.18d0,  -0.45d0,      0d0,          2d0/)
    x(2,1:ncols) = (/2d0,20010101d0,130000d0,8H   07061, &
                   &       49.82d0,   3.20d0,      2d0,          2d0/)
    x(3,1:ncols) = (/3d0,20010101d0,130000d0,8H   07075, &
                   &       49.78d0,   4.63d0,      4d0,          1d0/)
    ! Note: the following APPENDs after the existing data
    rc = ODB_put(h,tblname,x,nrows,ncols,poolno=jp)
    DEALLOCATE(x)
    tblname = '@body' ! Note '@'-sign in front of
    rc = ODB_getsize(h,tblname,nrows,ncols,poolno=jp)
    nrows = 5 ! Five new rows for TABLE body
    ALLOCATE(x(nrows,0:ncols))
    ! entryno, varno,     press,  obsvalue,    depar, obs_error, bias
    x(1,1:ncols) = &
      (/1d0,   110d0,  657.05d0,98530.00d0, -85.86d0,   69.03d0, -mdi/)
    x(2,1:ncols) = &
      (/2d0,    39d0,98530.00d0,  282.70d0,   1.80d0,    1.95d0, -mdi/)
    x(3,1:ncols) = &
      (/1d0,   110d0,  990.47d0,98480.00d0,-221.59d0,   69.09d0, -mdi/)
    x(4,1:ncols) = &
      (/2d0,    39d0,98480.00d0,  279.80d0,   1.06d0,    1.95d0, -mdi/)
    x(5,1:ncols) = &
      (/1d0,   110d0, 1451.38d0,98250.00d0,-123.32d0,   69.36d0, -mdi/)
    ! Note: the following APPENDs after the existing data
    rc = ODB_put(h,tblname,x,nrows,ncols,poolno=jp)
    DEALLOCATE(x)
  endif
  rc = ODB_close(h,save=.TRUE.)
  rc = ODB_end()
  END PROGRAM populate
```

To run this program, you need to execute the following commands (we assume that you have already successfully performed the steps 1..3 as shown in 5.2):

```
# (4) Compile and link Fortran90 application:
odbf90 populate.F90 -lDB -o populate.x

# (5) Run the application
./populate.x DB
```

The output listing for this example is shown next. It is pretty much similar compared to the database creation output earlier (5.2), but shows that database has been opened as an existing one (line#9). Line numbers are not part of the real output:

```
 1: MPL_INIT : MPL_METHOD=JP_BLOCKING_BUFFERED
 2: MPL_INIT : MAILBOX SIZE=     1000000
 3: MPL_BUFFER_METHOD:  2   540680269
 4: >>> Assuming static linking mode
 5: ***Warning: Poolmasking ignored altogether
 6:  OPEN_DB: handle= 1
 7:  DataBase-name="DB"
 8:  inuse ?  T
 9:  newdb ?  F
10:  readonly ?  F
11:  no. of global pools =  1
12:  global max poolno =  1
13:  no. of local pools =  1
14:  sequence no. scaling factor =  1073741824
15:  max. no. of rows per pool =  1073741823
16:  I/O-method =  1
17:  iounit =  0
18:  ntables =  2
19: *** newio.c:init_IOs() ***
20:    ODB_WRITE_EMPTY_FILES=0
21:      ODB_CONSIDER_TABLES=*
22:       ODB_IO_KEEP_INCORE=1
23:          ODB_IO_FILESIZE=32 MB
24:           ODB_IO_BUFSIZE=1048576 bytes
25:           ODB_IO_GRPSIZE=1 (or max no. of pools)
26:           ODB_IO_PROFILE=0
27:           ODB_IO_VERBOSE=0
28:            ODB_IO_METHOD=1
29:              ODB_IO_LOCK=0
30: *********************
31:  END of OPEN_DB
```

This example was for illustration purposes only and in practice you would like to read data from an input file and pass it to ODB. However, this has now been made automatic by introduction of `simulobs2odb`-utility.

5.4 Simple data querying

This subsection introduces the following ODB Fortran90 interface functions:

- `ODB_open` : Open an existing database for '`READONLY`'-access

- `ODB_addview` : Register the query
- `ODB_getnames` : Find out column names in the query
- `ODB_select` : Execute and find out allocation dimensions of the request
- `ODB_get` : Fetch data satisfying the request into the user space
- `ODB_cancel` : Deactivate the query and free internal indices
- `ODB_release` : Remove a data pool from memory (without saves)
- `ODB_swapout` : Remove particular table(s) and pool from memory
- `ODB_close` : Close database without saving it

In this example we continue working with the database created and populated in the previous sections. A logical continuation is to check that the data fed into database is what we would expect. The next thing is to show some more complicated queries and that all these queries can be accomplished by using the generic data query processing program `querydata.F90` as follows:

```
PROGRAM querydata
!*** querydata.F90 ***
USE odb_module
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, nra, rc
INTEGER(4) :: numargs, iargc, jque, jr, jc, nc
character(len=64) dbname, queryname
character(len=64), allocatable :: colnames(:)
rc = ODB_init(myproc=myproc,nproc=nproc)
numargs = iargc()
if (numargs < 1) then
  CALL ODB_abort('querydata',&
  'Usage: querydata DBname [query1 [query2] ...]',numargs)
endif
CALL getarg(1,dbname)    ! Database name
do jque=2,numargs
  CALL getarg(jque,queryname) ! Query name
  npools = 0 ! Gets true value from ODB_open()
  h = ODB_open(dbname,'READONLY',npools)
  write(*,*)'Exec query#',jque-1,'="'//trim(queryname)//'"'
  rc = ODB_addview(h,queryname) ! Not necessary anymore
  nc = ODB_getnames(h,queryname,'name')
  ALLOCATE(colnames(nc))
  nc = ODB_getnames(h,queryname,'name',colnames)
  do jp=myproc,npools,nproc ! Round-robin, "my" pools only
    rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp)
```

```
      if (nrows > 0) then
        ALLOCATE(x(nra,0:ncols))
        rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
        write(*,'((3a20))') (trim(colnames(jc)),jc=1,nc)
        do jr=1,nrows
          write(*,'(1p,(5x,3(1x,g20.10)))') x(jr,1:ncols)
        enddo
        DEALLOCATE(x)
      endif
      rc = ODB_cancel(h,queryname,poolno=jp)
      ! The following is the same as the less preferred
      ! rc = ODB_swapout(h,'*',poolno=jp)
      rc = ODB_release(h,poolno=jp)
    enddo ! do jp=myproc,npools,nproc
    DEALLOCATE(colnames)
    rc = ODB_close(h)
  enddo ! do jque=2,numargs
  rc = ODB_end()
  END PROGRAM querydata
```

Compilation and linking of this generic query processor program can be performed similarly to the data populator-program 5.3. The *queryname* denotes the SQL-request in the corresponding `CREATE VIEW`-statement(s) shown later:

```
# (1) Compile-only Fortran90 application:
odbf90 -c querydata.F90

# (2) Introduce new SQL-query:
odbcomp -lDB queryname.sql

# (3) (Re-)link Fortran90 application:
odbf90 querydata.o -lDB -o querydata.x

# (4) Run the application
./querydata.x DB queryname
```

When you apply new query, you need to repeat the steps 2...4. To check that the data fed into the database is what we expect it to be, we start with simple queries like `querydata1.sql` :

```
CREATE VIEW querydata1 AS SELECT * FROM hdr;
```

or `querydata2.sql`:

```
CREATE VIEW querydata2 AS SELECT * FROM body;
```

They ask for *all* columns (and thus '*') from single tables. In terms of genuine database engine, these queries would have been exactly identical, if the engine supported the `CREATE VIEW`-statements. Otherwise they should have been just queries forwarded directly to their client-server, like :

```
SELECT * FROM hdr;
SELECT * FROM body;
```

From the output of these queries we can judge that the database has been loaded correctly. You can also see what commands were used to produce desired result:

```
$ odbf90 -c querydata.F90
$ odbcomp -lDB querydata1.sql
$ odbf90 querydata.o -lDB -o querydata.x
$ ./querydata.x DB querydata1
...
 END of OPEN_DB
 Exec query# 1 ="querydata1"
           seqno@hdr            date@hdr             time@hdr
          statid@hdr             lat@hdr              lon@hdr
LINKOFFSET(body)@hdr   LINKLEN(body)@hdr
           1.000000000         20010101.00          100000.0000
          6.0135615738-154      49.18000000         -0.4500000000
           0.000000000         2.000000000
           2.000000000         20010101.00          130000.0000
          6.0135615738-154      49.82000000          3.200000000
           2.000000000         2.000000000
           3.000000000         20010101.00          130000.0000
          6.0135615738-154      49.78000000          4.630000000
           4.000000000         1.000000000
$ odbcomp -lDB querydata2.sql
$ odbf90 querydata.o -lDB -o querydata.x
$ ./querydata.x DB querydata2
...
 END of OPEN_DB
 Exec query# 2 ="querydata2"
        entryno@body          varno@body           press@body
       obsvalue@body          depar@body       obs_error@body
           bias@body
           1.000000000         110.0000000          657.0500000
           98530.00000        -85.86000000          69.03000000
```

```
            0.000000000
            2.000000000         39.00000000         98530.00000
            282.7000000         1.800000000         1.950000000
            0.000000000
            1.000000000         110.0000000         990.4700000
            98480.00000        -221.5900000         69.09000000
            0.000000000
            2.000000000         39.00000000         98480.00000
            279.8000000         1.060000000         1.950000000
            0.000000000
            1.000000000         110.0000000         1451.380000
            98250.00000        -123.3200000         69.36000000
            0.000000000
```

Note that you can also execute *both* queries in a single program invocation. Refer to the next output to see how that can be done. This is useful if you have a number of queries that you want to execute in a batch mode:

```
$ odbf90 -c querydata.F90
$ odbcomp -lDB querydata1.sql querydata2.sql
$ odbf90 querydata.o -lDB -o querydata.x
$ ./querydata.x DB querydata1 querydata2
...
 Exec query# 1 ="querydata1"
           seqno@hdr             date@hdr            time@hdr
          statid@hdr              lat@hdr             lon@hdr
LINKOFFSET(body)@hdr   LINKLEN(body)@hdr
            1.000000000         20010101.00         100000.0000
          6.0135615738-154      49.18000000       -0.4500000000
            0.000000000         2.000000000
            2.000000000         20010101.00         130000.0000
          6.0135615738-154      49.82000000         3.200000000
            2.000000000         2.000000000
            3.000000000         20010101.00         130000.0000
          6.0135615738-154      49.78000000         4.630000000
            4.000000000         1.000000000
...
 Exec query# 2 ="querydata2"
        entryno@body          varno@body          press@body
       obsvalue@body          depar@body      obs_error@body
           bias@body
            1.000000000         110.0000000         657.0500000
            98530.00000        -85.86000000         69.03000000
            0.000000000
            2.000000000         39.00000000         98530.00000
            282.7000000         1.800000000         1.950000000
            0.000000000
            1.000000000          110.0000000          990.4700000
            98480.00000         -221.5900000          69.09000000
            0.000000000
            2.000000000          39.00000000          98480.00000
            279.8000000          1.060000000          1.950000000
            0.000000000
            1.000000000          110.0000000          1451.380000
            98250.00000         -123.3200000          69.36000000
            0.000000000
```

Note that the station id (`statid`-column) has been printed improperly. This is because it is stored as 64-bit floating point number, but is in fact an 8-byte character string. By having more targeted format-statement we could have fixed this problem. We could have used function `ODB_getnames` to resolve the type of any column and made format-statements more type-sensitive. However, it is maybe easier to use `ODB_print` for now to resolve formatting problems.

5.5 More complicated requests

We continue our description of data queries, but move on into somewhat more complex queries. We use the same program `querydata.F90` from the previous subsection. You should always remember to ask only such column entries that you really need, since the `ODB/SQL` -query language is presently not very remarkable and is not for example yet capable of processing subqueries or aggregate functions. These features present in standard SQL often reduce the number of output rows dramatically. For example, asking for all columns as in the previous example is normally an overkill and waste of computer resources. And when you use more tables (the `FROM`-clause), the table joins will can produce too much information to be analyzed properly,

Here are a few examples of queries , which produce more targeted output:

```
CREATE VIEW cx1 AS
     SELECT lat, lon
       FROM hdr;

CREATE VIEW cx2 AS
     SELECT date, time
       FROM hdr
      WHERE seqno = 2;
```

The first view (`cx1`) pulls out all latitudes and longitudes from table `hdr`. The second view (`cx2`) gives date and time information, but under the condition that the sequence number (`seqno`) is equal to two.

```
CREATE VIEW cx3 AS
     SELECT press, obsvalue
       FROM hdr,body // Natural join
      WHERE seqno = 2;
```

The third example (cx3) shows our first table join. In the ODB/SQL we normally do not have to worry about about getting a huge number of rows as output due to potential cartesian product: the number of rows in the parent table hdr times the number of rows in the child table body. This is because of the special @LINK-column structure, which automatically recognizes the parent-child relation (hierarchy). In a genuine relational databases this would be called natural join and would require (at least) that seqno would be present in both tables as a controlling key. Note also that we ask columns (in SELECT) solely belonging to table body, whereas the WHERE-condition refers to other table hdr. This shows once again that we do not have to specify the columns found in WHERE-conditions in the SELECT-clause, too.

```
CREATE VIEW cx4 AS
     SELECT seqno, "*@body"
       FROM hdr,body // Natural join
      WHERE statid = '07027'
        AND varno = 110
;
```

The fourth query (cx4) asks for all columns found in body-table under a character a string condition. The column statid is a right justified character string. In ODB/SQL the WHERE-condition automatically right-adjusts any constant character expression by padding as many blanks in *front* of that the string would finally occupy the maximum 8 characters. This is quite different to what the genuine relational database engines do: there character strings are by default assumed to be left-justified. Furthermore, this query also shows how to use the AND-condition to effectively eliminate the number of rows in output.

```
CREATE VIEW cx5 AS
     SELECT seqno, date, time,
            varno, obsvalue@body
       FROM hdr,body // Natural join
      WHERE (statid RLIKE '070.*' AND varno = 39)
         OR seqno = 3
;
```

The final case (`cx5`) shows how to use the `OR`-condition and regular expression (`LIKE`) in finding out a character string match for a station identifier. The regular expression is a Unix-like regular expression. Without using the `OR`-condition we would have got only such entries, which contained temperatures (`varno` equal to 39), since the last `hdr`-row (`seqno` equal to 3) `body`-table entries didn't have any temperatures. But use of the `OR`-condition gave us also the data associated with the last `hdr`-row.

When we run these queries, the program produces the following output :

```
$ odbf90 -c querydata.F90
$ odbcomp -lDB complex.sql
$ odbf90 querydata.o -lDB -o querydata.x
$ ./querydata.x DB cx1 cx2 cx3 cx4 cx5
...
 Exec query# 1 ="cx1"
            lat@hdr              lon@hdr
          49.18000000        -0.4500000000
          49.82000000          3.200000000
          49.78000000          4.630000000
...
 Exec query# 2 ="cx2"
           date@hdr             time@hdr
          20010101.00          130000.0000
...
 Exec query# 3 ="cx3"
         press@body       obsvalue@body
          990.4700000          98480.00000
          98480.00000          279.8000000
...
 Exec query# 4 ="cx4"
          seqno@hdr        entryno@body          varno@body
         press@body       obsvalue@body          depar@body
     obs_error@body           bias@body
          1.000000000          1.000000000          110.0000000
          657.0500000          98530.00000         -85.86000000
          69.03000000          0.000000000
...
 Exec query# 5 ="cx5"
          seqno@hdr            date@hdr            time@hdr
         varno@body       obsvalue@body
          1.000000000          20010101.00          100000.0000
          39.00000000          282.7000000
          2.000000000          20010101.00          130000.0000
          39.00000000          279.8000000
          3.000000000          20010101.00          130000.0000
          110.0000000          98250.00000
```

Using traditional database engines, the queries involving joins and more complex `WHERE`-condition (`cx3` .. `cx5`) should have been written as follows :

```
-- cx3
SELECT press, obsvalue         --       SELECT press, obsvalue
  FROM hdr NATURAL JOIN body   -- or:     FROM hdr,body
 WHERE hdr.seqno = 2;          --        WHERE hdr.seqno = body.seqno
                               --          AND hdr.seqno = 2;

-- cx4
SELECT seqno, body.*
  FROM hdr NATURAL JOIN body
 WHERE statid = '   07027'
   AND varno = 110;

-- cx5
SELECT seqno, date, time,
       varno, body.obsvalue
  FROM hdr NATURAL JOIN body
 WHERE (statid LIKE '   070%' AND varno = 39)
    OR hdr.seqno = 3;
```

5.6 Using parameterized queries

In this subsection we perform a series of parameterized queries. They are ordinary `ODB/SQL` -queries except that the constant values in the `WHERE`-condition are parameterized using $-variables, and whose current value can be altered from within ODB Fortran90 layer. This is very useful, since we can effectively execute different requests using the same `ODB/SQL` -query definition. You will learn about how to

- `ODB_getval` : Get the existing value of a parameterized variable
- `ODB_setval` : Alter the value of a parameterized variable
- `ODB_select` : Temporarily change the values of parameterized variables

For parameterized queries we need to modify our previous program a little in order to be able to change the parameter values on-the-fly. For simplicity we also removed the loop over input arguments. The first program `paramquery1.F90` looks as follows:

```
PROGRAM paramquery1
!*** paramquery1.F90 ***
USE odb_module
```

```
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
REAL(8) newvalue, oldvalue
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, nra, rc
INTEGER(4) :: jr, jc, nc
character(len=64) dbname, queryname, varname, cval
character(len=64), allocatable :: colnames(:)
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname)    ! Database name
CALL getarg(2,queryname) ! Query name
CALL getarg(3,varname)   ! $-variable name without '$'
CALL getarg(4,cval)      ! REAL value of $-variable
read(cval,*) newvalue
npools = 0 ! Gets true value from ODB_open()
h = ODB_open(dbname,'READONLY',npools)
rc = ODB_addview(h,queryname) ! Not necessary anymore
oldvalue = ODB_setval(h,'$'//varname,newvalue,viewname=queryname)
write(*,*) myproc,': oldvalue,newvalue >',oldvalue,newvalue
nc = ODB_getnames(h,queryname,'name')
ALLOCATE(colnames(nc))
nc = ODB_getnames(h,queryname,'name',colnames)
write(*,*) myproc,': Exec query="'//trim(queryname)//'"'
do jp=myproc,npools,nproc ! Round-robin, "my" pools only
  rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp)
  if (nrows > 0) then
    ALLOCATE(x(nra,0:ncols))
    rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
    write(*,'((3a20))') (trim(colnames(jc)),jc=1,nc)
    do jr=1,nrows
      write(*,'(1p,(5x,3(1x,g20.10)))') x(jr,1:ncols)
    enddo
    DEALLOCATE(x)
  endif
  rc = ODB_cancel(h,queryname,poolno=jp)
  ! The following is the same as the less preferred
  ! rc = ODB_swapout(h,'*',poolno=jp)
  rc = ODB_release(h,poolno=jp)
enddo
DEALLOCATE(colnames)
oldvalue = ODB_getval(h,'$'//varname,viewname=queryname)
write(*,*) myproc,': oldvalue at end >',oldvalue
rc = ODB_close(h)
rc = ODB_end()
END PROGRAM paramquery1
```

We could also refrain from calling function `ODB_setval` and let the function `ODB_select` to alter the parameter value for the duration when the SQL is executed. Such a program

(paramquery2.F90) is as follows:

```
PROGRAM paramquery2
!*** paramquery2.F90 ***
USE odb_module
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
REAL(8) newvalue, oldvalue
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, nra, rc
INTEGER(4) :: jr, jc, nc
character(len=64) dbname, queryname, varname, cval
character(len=64), allocatable :: colnames(:)
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname)     ! Database name
CALL getarg(2,queryname) ! Query name
CALL getarg(3,varname)   ! $-variable name without '$'
CALL getarg(4,cval)      ! REAL value of $-variable
read(cval,*) newvalue
npools = 0 ! Gets true value from ODB_open()
h = ODB_open(dbname,'READONLY',npools)
rc = ODB_addview(h,queryname) ! Not necessary anymore
oldvalue = ODB_getval(h,'$'//varname,viewname=queryname)
write(*,*) myproc,': oldvalue at begin >',oldvalue
nc = ODB_getnames(h,queryname,'name')
ALLOCATE(colnames(nc))
nc = ODB_getnames(h,queryname,'name',colnames)
write(*,*) myproc,': Exec query="'//trim(queryname)//'"'
do jp=myproc,npools,nproc ! Round-robin, "my" pools only
  rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp,&
     &     setvars=(/'$'//varname/), values=(/newvalue/))
  if (nrows > 0) then
    ALLOCATE(x(nra,0:ncols))
    rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
    write(*,'((3a20))') (trim(colnames(jc)),jc=1,nc)
    do jr=1,nrows
      write(*,'(1p,(5x,3(1x,g20.10)))') x(jr,1:ncols)
    enddo
    DEALLOCATE(x)
  endif
  rc = ODB_cancel(h,queryname,poolno=jp)
  ! The following is the same as the less preferred
  ! rc = ODB_swapout(h,'*',poolno=jp)
  rc = ODB_release(h,poolno=jp)
enddo
DEALLOCATE(colnames)
oldvalue = ODB_getval(h,'$'//varname,viewname=queryname)
write(*,*) myproc,': oldvalue at end >',oldvalue
```

```
rc = ODB_close(h)
rc = ODB_end()
END PROGRAM paramquery2
```

We use the following, a slightly artificial parameterized query and during the execution we vary the value of sequence number (`$seqno`) between 1 and 3:

```
// A parameterized query

SET $seqno = 0;

CREATE VIEW paramquery AS
     SELECT seqno@hdr, entryno, depar
       FROM hdr,body
      WHERE seqno = $seqno
;
```

After running the parameterized query with different parameter values, the first program `paramquery1.F90` produces the following output :

```
$ odbf90 -c paramquery1.F90
$ odbcomp -lDB paramquery.sql
$ odbf90 paramquery1.o -lDB -o paramquery1.x
$ ./paramquery1.x DB paramquery seqno 1
...
 END of OPEN_DB
 1 : oldvalue,newvalue > 0.000000000000000000E+00 1.00000000000000000
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           1.000000000          1.000000000         -85.86000000
           1.000000000          2.000000000          1.800000000
 1 : oldvalue at end > 1.00000000000000000
$ ./paramquery1.x DB paramquery seqno 2
...
 END of OPEN_DB
 1 : oldvalue,newvalue > 0.000000000000000000E+00 2.00000000000000000
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           2.000000000          1.000000000         -221.5900000
           2.000000000          2.000000000          1.060000000
 1 : oldvalue at end > 2.00000000000000000
$ ./paramquery1.x DB paramquery seqno 3
...
 END of OPEN_DB
 1 : oldvalue,newvalue > 0.000000000000000000E+00 3.00000000000000000
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           3.000000000          1.000000000          -123.3200000
 1 : oldvalue at end > 3.00000000000000000
```

The second program (`paramquery2.F90`) produces similar output . Note, that the `oldvalue`-variable (i.e. the parameterized variable) retains its value throughout the program unlike in the first example. This is because its get changed only temporarily by the `ODB_select`:

```
$ odbf90 -c paramquery2.F90
$ odbcomp -lDB paramquery.sql
$ odbf90 paramquery2.o -lDB -o paramquery2.x
$ ./paramquery2.x DB paramquery seqno 1
...
 END of OPEN_DB
 1 : oldvalue at begin > 0.000000000000000000E+00
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           1.000000000          1.000000000          -85.86000000
           1.000000000          2.000000000           1.800000000
 1 : oldvalue at end > 0.000000000000000000E+00
$ ./paramquery2.x DB paramquery seqno 2
...
 END of OPEN_DB
 1 : oldvalue at begin > 0.000000000000000000E+00
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           2.000000000          1.000000000          -221.5900000
           2.000000000          2.000000000           1.060000000
 1 : oldvalue at end > 0.000000000000000000E+00
$ ./paramquery2.x DB paramquery seqno 3
...
 END of OPEN_DB
 1 : oldvalue at begin > 0.000000000000000000E+00
 1 : Exec query="paramquery"
           seqno@hdr        entryno@body          depar@body
           3.000000000          1.000000000          -123.3200000
 1 : oldvalue at end > 0.000000000000000000E+00
```

In the following is shown how queries would look like in a genuine relational databases (like MySQL), you would need to use @-variable instead of $-variable and the parameterized SQL-file would look like:

```
-- Set parameter
SET @seqno = 0;

-- Increase @seqno by 1
SET @seqno = @seqno + 1;

-- paramquery
SELECT hdr.seqno, entryno, depar
  FROM hdr NATURAL JOIN body
 WHERE hdr.seqno = @seqno;

-- Increase @seqno by 1 etc.
```

5.7 Updating database

Very often it is necessary to modify some values in the database. Modification can be unconditional or conditional. That former means we change column entry values regardless of its and any other columns' existing value. On the other hand the latter means we want to fulfil in essence some `WHERE`-condition, before updates takes place.

Using genuine relational database engines we could make single value updates using the following commands (the last SQL is used for verification purposes only):

```
-- 1st update
UPDATE body SET bias=0;

-- 2nd update
UPDATE body SET bias=30
       WHERE varno = 110;

-- 3rd update
UPDATE hdr NATURAL JOIN body
       SET bias=abs(0.25*depar)
       WHERE time = 100000
         AND varno != 39;

-- To verify changes
SELECT statid,varno,depar,bias
  FROM hdr NATURAL JOIN body;
```

The `ODB/SQL` doesn't currently support the `UPDATE`-statement and all updates need to be performed by using the `CREATE VIEW`-mechanism. This allows to execute the SQL, bring the associated data to user space (Fortran90 program), apply modifications and pass modified columns back to database using function `ODB_put`. In fact this mechanism, albeit requiring a Fortran90 program, is much richer than the `UPDATE`-statement shown before, because we can make multi-value updates. That is to say, a single column (say `bias` at table `body`) is not restricted in getting constant values, or just values that stem from some other variable, but can have *any* values supplied by the application program possibly through a complex algorithm.

In this example you will learn how to

- `ODB_open` : Open a database in ’`UNKNOWN`’-mode
- `ODB_select` : Execute and find out allocation dimensions of the request
- `ODB_get` : Fetch data satisfying the request into the user space
- `ODB_put` : Propagate modifications back to the database using the active request (view)
- `ODB_cancel` : Deactivate the query and free internal indices
- `ODB_close` : Save updated data and close the database

Note that this example demonstrates how to use `ODB_select` without `ODB_addview`, since in the latest version of the ODB software the `ODB_select` (also `ODB_getnames` and `ODB_varindex`) calls `ODB_addview` automatically if the SQL-query has not yet been registered. In the dynamic linking platforms, the use of `ODB_addview` is still needed, if one wants to re-introduce the same queries over again while running the application.

We intend to simulate the `UPDATE`-statements shown before to prove that the action available for database engines can take place by using proper collaboration with `ODB/SQL` -statements and the ODB Fortran90 application.

At first sight it would sound easier to launch `UPDATE`-statements similar to the ones available in the genuine database engines’ client-server environment than using an embedded approach by means of ODB Fortran90 application. However, when an application, like IFS 4D-Var is already present, and is MPI-parallelized and performs very complicated calculations before updating database values, then the approach available through the ODB software becomes viable.

Now pay consider the 0^{th} column of the array allocated for `ODB_get`. This is so called control-column and contains internal information for ODB to perform updates through function `ODB_put`. The column zero consists of composite numbers denoting the pool (partition) and row index number, where the data originated from. That is to say, you can safely sort the array with respect to any data column and the function `ODB_put` finds its way to propagate data back to the database.

To drive the updates in this example, we need a set of `CREATE VIEW`-statements They are shown in the following :

```
// For 1st update
CREATE VIEW update_1 AS
     SELECT bias
       FROM body;

// For 2nd update
CREATE VIEW update_2 AS
     SELECT bias
       FROM body
      WHERE varno = 110;

// For 3rd update
CREATE VIEW update_3 AS
     SELECT bias,
            depar READONLY
       FROM hdr, body
      WHERE time = 100000
        AND varno != 39;

// To verify changes
CREATE VIEW verify AS
     SELECT time,varno,depar,bias
       FROM hdr,body;
```

Note in the third update the use of `READONLY`-keyword. This is `ODB/SQL` -language specific and prevents a Fortran90 application from performing updates to this column (`depar`). We could have achieve the same by using the `colput(:)` logical vector in the call to function `ODB_put`. The ODB Fortran90 application is fine-tuned for these queries and could look as follows :

```
PROGRAM updatedb
!*** updatedb.F90 ***
USE odb_module
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, nra, rc
INTEGER(4) :: jupd, jr, jc, nc
character(len=64) :: dbname, verify, upd(3) = &
             & (/'update_1','update_2','update_3'/)
character(len=64), allocatable :: colnames(:)
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname)    ! Database name
npools = 0 ! Gets true value from ODB_open()
h = ODB_open(dbname,'UNKNOWN',npools)
verify = 'verify'
```

```
nc = ODB_getnames(h,verify,'name')
ALLOCATE(colnames(nc))
nc = ODB_getnames(h,verify,'name',colnames)
jp = -1 ! Here: We apply for all pools in one go
do jupd=1,size(upd)
  !-- Update#<jupd>
  write(*,*)'Exec update#',jupd
  rc = ODB_select(h,upd(jupd),nrows,ncols,nra=nra,poolno=jp)
  ALLOCATE(x(nra,0:ncols))
  rc = ODB_get(h,upd(jupd),x,nrows,ncols,poolno=jp)
  !-- Perform the update
  CALL update(jupd,x,nrows,ncols,nra)
  ! The following would update data in memory, not on disk
  rc = ODB_put(h,upd(jupd),x,nrows,ncols,poolno=jp)
  DEALLOCATE(x)
  rc = ODB_cancel(h,upd(jupd),poolno=jp)
  !-- Verify changes (... which are not on disk yet, though)
  write(*,*)'Exec verify'
  rc = ODB_select(h,verify,nrows,ncols,nra=nra,poolno=jp)
  ALLOCATE(x(nra,0:ncols))
  rc = ODB_get(h,verify,x,nrows,ncols,poolno=jp)
  write(*,'((4a15))') (trim(colnames(jc)),jc=1,nc)
  do jr=1,nrows
     write(*,'(1p,(5x,4(1x,g15.8)))') x(jr,1:ncols)
  enddo
  DEALLOCATE(x)
  rc = ODB_cancel(h,verify,poolno=jp)
enddo
DEALLOCATE(colnames)
rc = ODB_close(h,save=.TRUE.) ! Goes to disk only now
rc = ODB_end()

CONTAINS

SUBROUTINE update(kupd,x,nrows,ncols,nra)
implicit none
INTEGER(4), intent(in) :: kupd,nrows,ncols,nra
REAL(8), intent(inout) :: x(nra,0:ncols)
if (kupd == 1) then
  x(1:nrows,1) =  0 ! UPDATE body SET bias=0;
else if (kupd == 2) then
  x(1:nrows,1) = 30 ! UPDATE body SET bias=30 WHERE ...
else if (kupd == 3) then ! ... SET bias=abs(0.25*depar)
  x(1:nrows,1) = abs(0.25*x(1:nrows,2))
endif
END SUBROUTINE update

END PROGRAM updatedb
```

When we run the program (again: after appropriate compilations), the output will be as follows:

```
$ odbcomp -lDB update.sql
$ odbf90 -c updatedb.F90
$ odbf90 updatedb.o -lDB -o updatedb.x
$ ./updatedb.x DB
...
 OPEN_DB: handle= 1
 DataBase-name="DB"
...
 newdb ?  F
 readonly ?  F
 no. of global pools =  1
...
 END of OPEN_DB
 Exec update# 1
 Exec verify
       time@hdr     varno@body     depar@body      bias@body
        100000.00      110.00000      -85.860000      0.0000000
        100000.00      39.000000       1.8000000      0.0000000
        130000.00      110.00000     -221.59000       0.0000000
        130000.00      39.000000       1.0600000      0.0000000
        130000.00      110.00000     -123.32000       0.0000000
 Exec update# 2
 Exec verify
       time@hdr     varno@body     depar@body      bias@body
        100000.00      110.00000      -85.860000      30.000000
        100000.00      39.000000       1.8000000      0.0000000
        130000.00      110.00000     -221.59000       30.000000
        130000.00      39.000000       1.0600000      0.0000000
        130000.00      110.00000     -123.32000       30.000000
 Exec update# 3
 Exec verify
       time@hdr     varno@body     depar@body      bias@body
        100000.00      110.00000      -85.860000      21.465000
        100000.00      39.000000       1.8000000      0.0000000
        130000.00      110.00000     -221.59000       30.000000
        130000.00      39.000000       1.0600000      0.0000000
        130000.00      110.00000     -123.32000       30.000000
```

Note that we verify the changes after every call to function `ODB_put`. Furthermore, it is important to note that changes from calling function `ODB_put` go to disk only after `ODB_close`, `ODB_swapout` or `ODB_release`, all with `save`-option set to `TRUE`.

5.8 Adding more data

The last ODB Fortran90 example shows how to create a program and a set of queries which would add new data rows to the database, if they didn't already exist there. As a practical case, consider that you want to a new synoptic station, but you are not quite sure whether you already have this station in the database. And you want to avoid duplicate definitions. You will learn a few new function in this subsection and just how to find out via `ODB_varindex` the column index belonging to a particular set of columns. The use of this function improves portability and makes your program more generic.

We start with a query, which will be used to test whether a synop station `07088` already exists in database. If it doesn't, the associated will be appended to database. However, if it does exist, we will modify `depar` and `bias` column values of the corresponding surface pressure. The SQL-request looks as follows:

```
// To check for existence of a station ident

SET $all = 0;

READONLY;
CREATE VIEW checkupd AS
     SELECT "*@hdr", varno, depar,
            bias UPDATED
       FROM hdr,body
      WHERE (statid = '07088' AND varno = 110)
         OR $all
;
```

The subroutine `feedrow.F90` used by the main program is as follows. We had to use `ODB_remove`-technique, because there is a bug in the current ODB software, when this kind of append is requested:

```
SUBROUTINE feedrow(h,tblname,poolno,nd,d)
USE odb_module
implicit none
INTEGER(4), intent(in) :: h,poolno,nd
REAL(8),intent(in) :: d(nd)
character(len=*),intent(in) :: tblname
INTEGER(4) :: nrows, ncols, jp, rc
REAL(8), ALLOCATABLE :: x(:,:)
jp = poolno
rc = ODB_getsize(h,tblname,nrows,ncols,poolno=jp)
if (ncols/=nd) CALL ODB_abort('feedrow>'//trim(tblname),'ncols/=nd',ncols-nd)
```

```
ALLOCATE(x(nrows+1,0:ncols))
rc = ODB_get(h,tblname,x,nrows,ncols,poolno=jp)
x(nrows+1,1:ncols) = d(1:nd)
rc = ODB_remove(h,tblname,poolno=jp)
rc = ODB_put(h,tblname,x,nrows+1,ncols,poolno=jp)
DEALLOCATE(x)
END SUBROUTINE feedrow
```

Please note that you currently cannot parametrize character strings in your `WHERE`-condition. The program `appenddb.F90` looks as follows:

```
PROGRAM appenddb
!*** appenddb.F90 ***
USE odb_module
implicit none
REAL(8), ALLOCATABLE :: x(:,:)
REAL(8) bodyoffset, bodylen, bias, all, seqno
INTEGER(4) :: myproc,nproc,npools,jp,h
INTEGER(4) :: nrows, ncols, nra, rc
INTEGER(4) :: nrows_body, ncols_body
INTEGER(4) :: jupd, jr, jc, nc, idx(1)
character(len=64) :: dbname, queryname, tblname, chbias(1)
character(len=64), allocatable :: colnames(:)
rc = ODB_init(myproc=myproc,nproc=nproc)
CALL getarg(1,dbname)    ! Database name
npools = 0 ! Gets true value from ODB_open()
h = ODB_open(dbname,'OLD',npools)
queryname = 'checkupd'
jp = 1 ! Here: We apply for pool#1 only
write(*,*)'=== Check existence'
rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp)
bias = 10; nc = ncols
if (nrows == 0) then
  rc = ODB_cancel(h,queryname,poolno=jp)
  write(*,*)'==> Station did not exist; adding it now'
  !** Get the total length of @body so far
  rc = ODB_getsize(h,'@body',nrows_body,ncols_body,poolno=jp)
  bodyoffset = nrows_body ! The existing max. rows
  bodylen    = 1 ! We will only add one new row into '@body'
  !**  Get the next free sequence number
  rc = ODB_getsize(h,'@hdr',nrows,ncols,poolno=jp)
  seqno = nrows + 1 ! Next free sequence number
  CALL feedrow(h,'@hdr',jp,ncols, &
!              seqno       date     time     statid  ...
!                ...      lat        lon  body.offset body.len
           & (/seqno,20010101d0,140000d0,8H   07088, &
           &          59.18d0,  -7.45d0,  bodyoffset, bodylen/))
  CALL feedrow(h,'@body',jp,ncols_body, &
! entryno, varno,     press,  obsvalue,    depar, obs_error, bias
  & (/1d0, 110d0,  857.05d0,99530.00d0, -88.90d0,   80.03d0, bias/))
else ! Was present ==> we update the bias by increasing by it 1% + bias
  write(*,*)'==> Station did indeed exist; just updating the bias'
  chbias(1) = 'bias@body' ; idx(1) = 0
  rc = ODB_varindex(h,queryname,chbias(:),idx=idx(:))
  if (idx(1) == 0) CALL ODB_abort('appenddb','Bias column not present',-1)
  ALLOCATE(x(nra,0:ncols))
  rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
  x(1:nrows,idx(1)) = x(1:nrows,idx(1))*0.01 + bias ! Updated bias
  rc = ODB_put(h,queryname,x,nrows,ncols,poolno=jp)
  DEALLOCATE(x)
  rc = ODB_cancel(h,queryname,poolno=jp)
endif
write(*,*)'=== Verifying contents'
ALLOCATE(colnames(nc))
nc = ODB_getnames(h,queryname,'name',colnames)
all = 1 ! Ask for *all* rows now
rc = ODB_select(h,queryname,nrows,ncols,nra=nra,poolno=jp,&
   &     setvars=(/'$all'/), values=(/all/))
ALLOCATE(x(nra,0:ncols))
rc = ODB_get(h,queryname,x,nrows,ncols,poolno=jp)
write(*,'((3a20))') (trim(colnames(jc)),jc=1,nc)
do jr=1,nrows
  write(*,'(1p,(5x,3(1x,g20.10)))') x(jr,1:ncols)
enddo
DEALLOCATE(x)
rc = ODB_cancel(h,queryname,poolno=jp)
DEALLOCATE(colnames)
rc = ODB_close(h,save=.TRUE.) ! Goes to disk only now
rc = ODB_end()
END PROGRAM appenddb
```

The output listing , when the synop station was not yet in database is as follows:

```
$ odbcomp -lDB checkupd.sql
$ odbf90 -c appenddb.F90 feedrow.F90
$ odbf90 appenddb.o feedrow.o -lDB -o appenddb.x
$ ./createdb.x DB  # Re-create the database to ensure ...
$ ./populate.x DB  # ... a fresh start
$ ./appenddb.x DB  # this is the *first* run; station not there
...
 END of OPEN_DB
 === Check existence
 ==> Station did not exist; adding it now
 === Verifying contents
```

```
           seqno@hdr             date@hdr             time@hdr
          statid@hdr              lat@hdr              lon@hdr
LINKOFFSET(body)@hdr   LINKLEN(body)@hdr           varno@body
          depar@body            bias@body
           1.000000000           20010101.00           100000.0000
          6.0135615738-154       49.18000000         -0.4500000000
           0.000000000           2.000000000           110.0000000
          -85.86000000           0.000000000
           1.000000000           20010101.00           100000.0000
          6.0135615738-154       49.18000000         -0.4500000000
           0.000000000           2.000000000           39.00000000
           1.800000000           0.000000000
           2.000000000           20010101.00           130000.0000
          6.0135615738-154       49.82000000           3.200000000
           2.000000000           2.000000000           110.0000000
          -221.5900000           0.000000000
           2.000000000           20010101.00           130000.0000
          6.0135615738-154       49.82000000           3.200000000
           2.000000000           2.000000000           39.00000000
           1.060000000           0.000000000
           3.000000000           20010101.00           130000.0000
          6.0135615738-154       49.78000000           4.630000000
           4.000000000           1.000000000           110.0000000
          -123.3200000           0.000000000
           4.000000000           20010101.00           140000.0000
          6.0135615738-154       59.18000000          -7.450000000
           5.000000000           1.000000000           110.0000000
          -88.90000000           10.00000000
```

The second output shows how `bias`-column gets updated when the synop station in concern was previously already in database. We repeat only the changed parts of output:

```
$ ./appenddb.x DB  # this is the *second* run; station already there
...
 END of OPEN_DB
 === Check existence
 ==> Station did indeed exist; just updating the bias
 === Verifying contents
           seqno@hdr             date@hdr             time@hdr
          statid@hdr              lat@hdr              lon@hdr
LINKOFFSET(body)@hdr   LINKLEN(body)@hdr           varno@body
          depar@body            bias@body
...(unchanged)...
           4.000000000           20010101.00           140000.0000
          6.0135615738-154       59.18000000          -7.450000000
           5.000000000           1.000000000           110.0000000
          -88.90000000           10.10000000
```

5.9 Archiving and removing database

The final subsection in this section illustrates how to archive and remove ODB database in the file system level, and how possibly to re-introduce a database on some other place and/or machine.

The default location of the database is the current directory. You can change this by defining either database specific environment variables

- `ODB_DATAPATH_$dbname` (see p.191) for data files
- `ODB_SRCPATH_$dbname` (see p.194) for metadata

or use the generic location definition variables

- `ODB_DATAPATH` (see p.190) for data files
- `ODB_SRCPATH` (see p.194) for metadata

The former definition takes precedence, if specified. If none of these are defined, the ODB software will decide to use the current directory during `ODB_open`. You need have access to data directories, and very often also the right to write/update files.

It is recommended to label the root database directory to start with the database name, followed by optional qualifiers, like observational group, time of analysis, and so on. For example, ECMWF's IFS system creates large AIRS ECMA-database into root directory prefixed with `$WDIR/ECMA.airs`, where the `$WDIR` denotes the working directory for particular `$BASETIME` i.e. analysis period.

Since ODB database is normally located under a single root directory, it is easy to back it up, create a tarfile, remove it or transfer it to another machine.

Suppose one has a database `DB` again located under the directory `/local/disk/DB`. In order to create tarfile and remove it, one only needs to do the following (the `mycomp$` denotes the command line prompt on "my"-machine):

```
mycomp$   cd /local/disk
mycomp$   tar -cvf DB.tar DB
mycomp$   rm -rf DB
```

You can untar your database on some other machine and start working with it by:

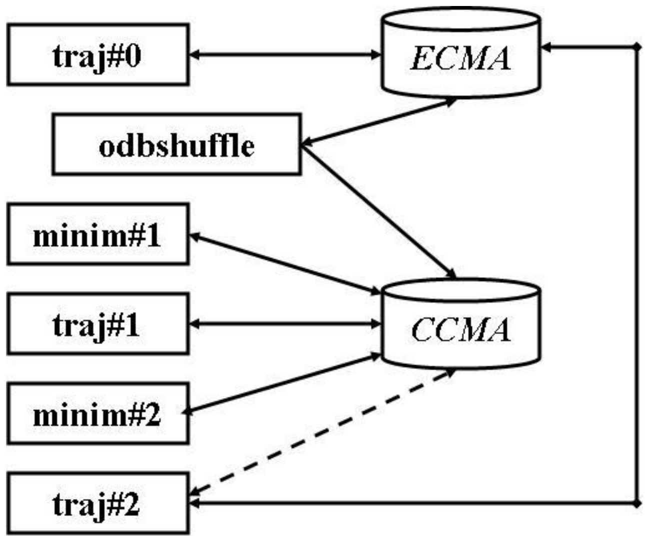
```
mycomp$   rcp /local/disk/DB.tar username@host:/remote/dir/
mycomp$   rlogin host -l username
host$     cd /remote/dir/
host$     tar -xvf DB.tar
host$     cd DB
host$     export ODB_DATAPATH_DB=/remote/dir/DB
host$     export ODB_SRCPATH_DB=/remote/dir/DB
```

6 ODB interface to IFS

The IFS analysis uses two different database layouts called ECMA and CCMA. In addition, some pre- and postprocessing utilities may benefit from utilizing the ECMASCR layout. So far we have decided to have exactly the same layout in the ECMASCR than in the ECMA, but this is generally up to the user what to do with the ECMASCR. You can find more about these database layouts from section 7.

The analysis is divided into several steps. The first step is called Screening or the First trajectory (i.e. traj#0). It uses the ECMA layout to screen all observations in order to mask out bad or undesired observations. After Screening the remaining observations are transferred into the CCMA layout. This is a subset of the ECMA database both in terms of volume and the number of tables and columns.

Figure 15: The program flow in the 4D-Var-system at ECMWF



The CCMA database is used all through the Minimization process, except that in the Final trajectory, the ECMA steps in again, if needed. Currently ECMWF uses the ECMA database for the Final trajectory run.

6.1 Architecture

The interface between IFS and ODB is indirect. That is to say, IFS sees ODB via Fortran90 module `yomdb`, which resides in the file `$SRC/ifs/module/yomdb.F90`. This module essentially defines data structures, where observational data is copied from each SQL-

Figure 16: Observational data flow at ECMWF

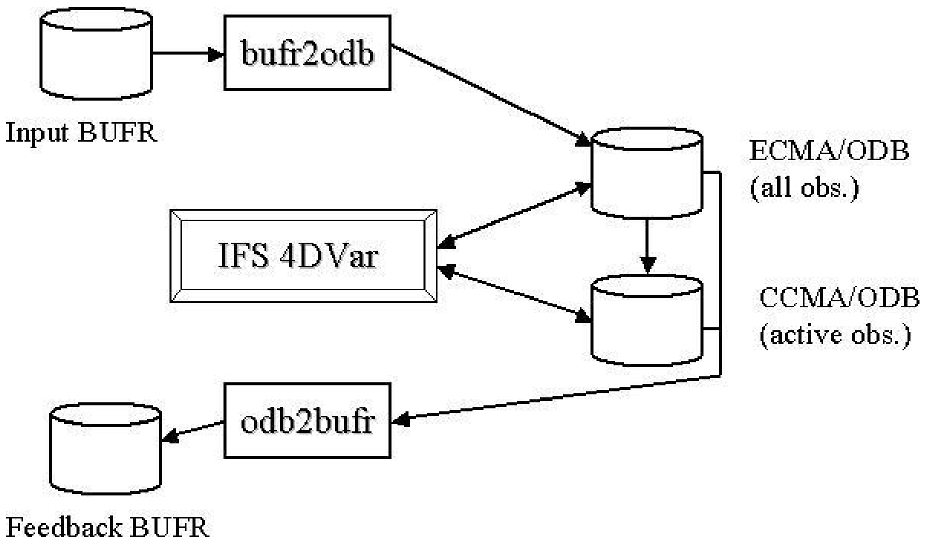
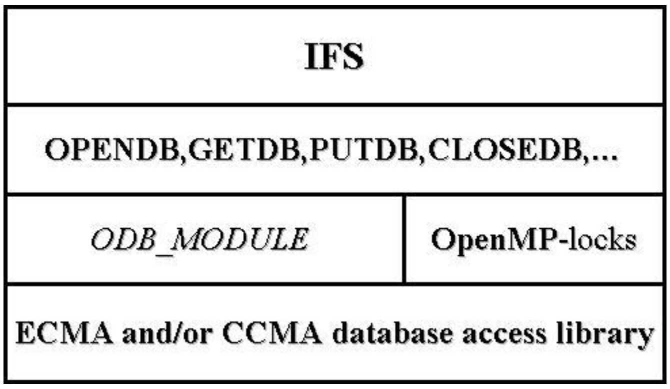


Figure 17: Software layers in ODB and IFS interface


IFS
OPENDB,GETDB,PUTDB,CLOSEDB,...
ODB_MODULE
OpenMP-locks
ECMA and/or CCMA database access library

query. The module file includes another important file, `$SRC/ifs/common/yomdb_-vars.h`, where the observational data arrays are defined for use by data structure `o_(it)` (i.e. one element for each OpenMP-thread `it`. Most of the symbols found in that file are pre-processing macro-symbols, which get filtered through the file `$SRC/ifs/common/yomdb_-defs.h`, while the Fortran90 routines include them via `$SRC/ifs/common/openmp_-obs.h`. The latter file also includes the file `$SRC/ifs/common/itdef.h`.

6.2 Observational arrays, MDB-variables and MLNK-pointers

Data is transferred between ODB and IFS using observational arrays described in the following table. The basic idea is that the ODB interface layer to IFS fills these arrays with data that had just been extracted from a database. IFS then accesses and often modifies these arrays before passing them back to the database via the interface layer (see also figure 18).

Table 6: Observational arrays in the ODB interface to IFS

Array name	Description	Datatype
`ROBHDR`	Data from `hdr`-related tables	REAL(8)
`MOBHDR`	The same as `ROBHDR`, but contains only INTEGER columns	INTEGER(4)
`ROBODY`	Data from `body`-related tables	REAL(8)
`MOBODY`	The same as `ROBODY`, but contains only INTEGER columns	INTEGER(4)
`ROBSU`	Usually similar to `ROBHDR`, but used only in setup/special routines	REAL(8)
`MOBSU`	The same as `ROBSU`, but contains only INTEGER columns	INTEGER(4)
`ROBDDR`	Array for`ddrs`-table data for convenience	REAL(8)
`SATHDR`	Satellite specific `hdr`-information	REAL(8)
`SATPRED`	Satellite predictor `hdr`-info, is often aliased to `SATHDR`	REAL(8)
`SATBODY`	Satellite specific `body`-information	REAL(8)
`MLNKH2B`	Runtime link between `hdr` and `body` related information extracted via ODB/SQL	INTEGER(4)

Advance warning: please note that all the INTEGER-arrays (except `MLNKH2B`) are subject to be removed from the ODB/IFS-interface in the near future release, since they can hold only 31-bits of control word information in the zeroth column. The increase in the number of observations and pools require the use of 63-bit control word information. This can be achieved by removing references to these arrays while removing ODB-functions `ODB_iget` and `ODB_iput` – the INTEGER(4) equivalents of `ODB_get` and `ODB_put`, respectively.

The MDB-variables and MLNK-pointers (see more in section 7) are used to address the particular column of the observational arrays in IFS. The values for the MDB/MLNK-pointers are registered once in the routine `INITMDB` and their values get *dynamically* assigned to a column number in the routine `MAPVARDB` for each OpenMP-thread. This means that they get fresh values in every call to `GETDB` and are reset back to a missing (or purposely a bad) value in PUTDB, so that if they are referred outside the GETDB–PUTDB -block, the program will crash and normally produce a traceback.

All @LINK-entries have use MLNK-pointers, which have two elements: offset and length. For a @LINK column entry child@parent, the MLNK-pointers from master table (parent) to child table (child) would be:

1. MLNK_PARENT2CHILD(1) denotes the offset (child.offset@parent)
2. MLNK_PARENT2CHILD(2) denotes the length (child.len@parent)

Internally the ODB software knows the offset to child-table as LINKOFFSET(child)@parent (or just LINKOFFSET(child) when unique), and the length respectively as LINKLEN(child)@parent (or LINKLEN(child)). These notations need to be used in functions like ODB_varindex, when searching the column number for the given @LINK-object (i.e. offset and/or length).

6.3 The main interface functions

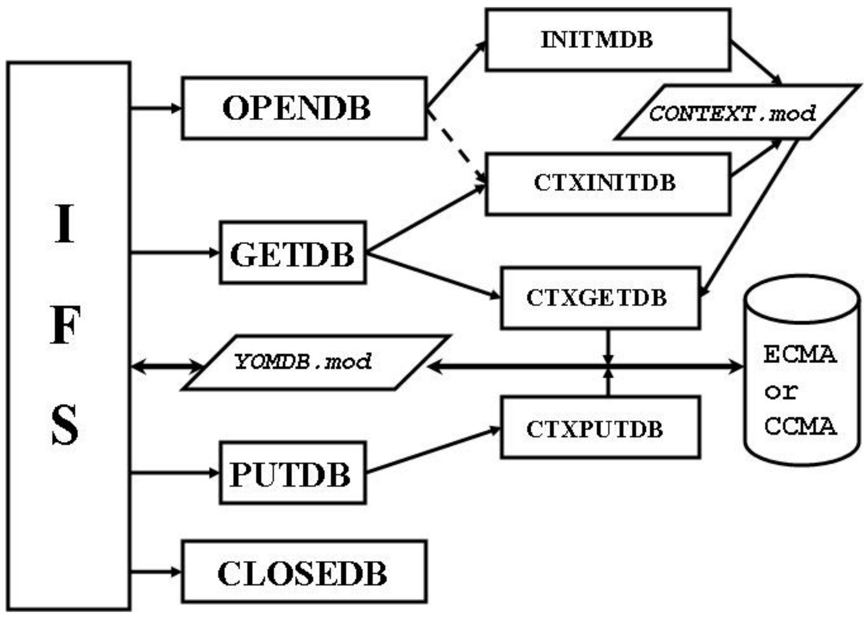
The IFS accesses database(s) without calling the ODB core functions directly. This interface layer passes data from ODB internal data structures into observational arrays for use by IFS. There are a few advantages of coding this way:

1. IFS does not depend directly on ODB-modules i.e. can be compiled without referencing to ODB software,
2. IFS often needs simultaneous access to multiple data queries at once (ROBHDR, ROBODY, ...), therefore the interface is coded to allow access *retrievals* – that is: multiple SQL data queries,
3. Underlying change in ODB core libraries does not (normally) affect IFS code.

The interface layer between ODB and IFS consists of the following subroutines:

- OPENDB : Open database (p.117)
- SETACTIVEDB : Change currently active database (p.118)
- INITMDB : Initialize MDB-pointer addresses (p.119)
- CTXINITDB : Initialize mapping of retrivals to data queries (SQL) (p.119)
- GETDB : Execute a set of SQLs (i.e. a retrieval) and get data to observational arrays for use by IFS (p.121)
- PUTDB : Pass data from observational arrays back to in-memory database arrays (p.123)
- CLOSEDB : Close currently active database with or without updating it (p.125)

Figure 18: Interfacing and transferring data between IFS and ODB



These routines are associated with the module `yomdb` and another module `context`, which is resides in the file `$SRC/odb/module/context.F90`.

In addition there is observational data shuffle routine `SHUFFLEDB`, which can transform data between two different database, like ECMA and CCMA. Its source code resides in the file `$SRC/odb/cma2odb/shuffledb.F90`. Other routines to be discussed: `$SRC/odb/cma2odb/sw` , `$SRC/odb/cma2odb/store.F90`, `$SRC/odb/cma2odb/load.F90` and `$SRC/odb/lib/m` `obsdata.F90`.

6.3.1 OPENDB

Usage of the subroutine `OPENDB` is as follows:

```
CALL  OPENDB ( CDNAME, CDSTAT, KINFO, KINFOLEN )
```

Subroutine `OPENDB` opens a connection to one of the known databases (see 7). Up to `JP-MAXSIMDB` can be opened simultaneously for the `ODB` interface to `IFS`. Routine `OPENDB` is a wrapper routine built on the top of ODB_open. Another purpose is to initialize the `IFS` interface layer. It also makes sure that data retrievals under OpenMP-locks get done properly i.e. it initializes the derived datatype array `o_(:)` from the module `yomdb`

(see $SRC/ifs/module/yomdb.F90). The source file resides in $SRC/odb/cma2odb/opendb.F9
. The parameters denote :

CDNAME	CHARACTER(LEN=*),INTENT(IN) Database name. Currently recognized names are ECMA, CCMA and ECMASCR
CDSTAT	CHARACTER(LEN=*),INTENT(IN) Opening mode. Allowed values are 'NEW', 'OLD' and 'READONLY'
KINFO(KINFOLEN)	INTEGER(4),INTENT(IN**OUT**) Integer information vector To supply or return useful information the length (KINFOLEN) should be set to 2. In that case the first element (KINFO(1)) contains the number of pools and the second element (KINFO(2)) contains (upon return) the value of the maximum number of updates specified in the data layout (the parameter $nmxupd)
KINFOLEN	INTEGER(4),INTENT(IN) Number of elements in KINFO-vector

Examples:

```
INTEGER(4) :: info(2)
CALL OPENDB('ECMA', 'OLD', info, size(info))
CALL OPENDB('CCMA', 'NEW', info, size(info))
CALL OPENDB('ECMASCR', 'READONLY', info, size(info))
```

6.3.2 SETACTIVEDB

Usage of the subroutine SETACTIVEDB is as follows:

```
CALL  SETACTIVEDB ( CDNAME )
```

This changes the currently active database, which is the database to which all subsequent GETDB, PUTDB etc. calls will be targeted. The source file resides in $SRC/odb/cma2odb/setactivedb
. The parameters denote :

CDNAME	CHARACTER(LEN=*),INTENT(IN) The name of database which is to become the currently active database

Examples:

```
!-- Set active database to ECMA and work with it
CALL SETACTIVEDB('ECMA')

!-- Now work with CCMA database for a change
CALL SETACTIVEDB('CCMA')
```

6.3.3 INITMDB

Usage of the subroutine `INITMDB` is as follows:

```
CALL INITMDB ( KNMXUPD )
```

The purpose of this routine is to map the `MDB` column address variables into data layout variables of the recognized databases. This routine can be found from `$SRC/odb/cma2odb/initmdb.F9`
. It is used in association with the (generic) data layout file `$SRC/odb/ddl/cma.h` for the `ECMA`, `ECMASCR` and `CCMA` databases. The parameters denote :

KNMXUPD	INTEGER(4),INTENT(IN) Supplies the actual number of updates. The value must be less or equal than `$NMXUPD` defined in `$SRC/odb/ddl/cma.h`

Examples:

```
INTEGER(4) :: imxupd
imxupd = 2 ! Maximum number of updates in this run
CALL INITMDB(imxupd)
```

6.3.4 CTXINITDB

Usage of the subroutine `CTXINITDB` is as follows:

CALL CTXINITDB (CDNAME, CDRETR, KVERSION, KNMXUPD)

This routine defines all recognized data retrievals to be used in GETDB and PUTDB and maps them into the given set of SQL-query files, that reside under the directory $SRC/odb/ddl/. Retrievals are identified from GETDB and PUTDB by their name (CDNAME) and version number (KVERSION). The source file resides in $SRC/odb/cma2odb/ctxinitdb.F90. The parameters denote :

CDNAME	CHARACTER(LEN=*),INTENT(IN) Database name. Currently supported names are ECMA, CCMA and ECMASCR
CDRETR	CHARACTER(LEN=*),INTENT(IN) Retrieval name
KVERSION	INTEGER(4),INTENT(IN) Retrieval version number. This number is often the same as the current (minimization or trajectory) update number
KNMXUPD	INTEGER(4),INTENT(IN) The actual number of minimizations to be performed (or trajectory updates) in the current 4D-Var-run

Examples:

```
! The very first time (in opendb.F90 for example)

integer(4) :: imxupd
imxupd = <max. no. of updates in this run>
CALL CTXINITDB(cdname, ' ', 0, imxupd)

! or normally (like in getdb.F90)

character(len=*),intent(in) :: cdretr
integer(4), intent(in)      :: kversion
integer(4) :: imxupd
imxupd = <max. no. of updates in this run>
CALL CTXINITDB('ECMA', cdretr, kversion, imxupd)
```

6.3.5 GETDB

Usage of the subroutine GETDB is as follows:

```
CALL  GETDB ( CDRETR, KVERSION, KRET, KINFO, KINFOLEN &
&             , PINFO, KPINFOLEN, KSET, KTSLOT, KPOOLNO &
&             , KOBSTYPE, KCODETYPE, KSENSOR )
```

Subroutine GETDB executes one or more SQL-queries for the active database under the cover of the ODB to IFS interface. The routine copies data for each OpenMP-thread to observational arrays declared in module yomdb. For each context i.e. (retrieval,version)-pair for there must be a set of SQL-queries available. Initialization of contexts is done in routine CTXGETDB. The source file resides in $SRC/odb/cma2odb/getdb.F90 . The parameters denote :

CDRETR	CHARACTER(LEN=*),INTENT(IN) Retrieval name initialized in subroutine CTXGETDB. This parameter with KVERSION determines which SQL-queries will be invoked
KVERSION	INTEGER(4),INTENT(IN) Retrieval version number
KRET	INTEGER(4),INTENT(IN**OUT**) Return code, which (if non-negative) denotes number of rows placed in the *first* observational array in the sequence of SQL-queries executed. That is to say, it is mostly the number of rows in ROBHDR-array
KINFO(KINFOLEN)	INTEGER(4),INTENT(IN**OUT**) Integer information vector. Its length (KINFOLEN) should normally be set to zero (0). However, if non-zero, then the elements are interpreted as follows: The KINFO(1) denotes parameterized variable $hdr_min, the KINFO(2) variable $hdr_max, and the KINFO(3) variable $all. These variables are only used in a very few SQL-queries
KINFOLEN	INTEGER(4),INTENT(IN) Number of elements in the integer information vector KINFO. Normally zero

PINFO(KPINFOLEN)	REAL(8),INTENT(IN**OUT**) Auxiliary information vector. Not used at the moment, but could in the future contain (say) station identification information or some other information, which requires 8-bytes of storage
KPINFOLEN	INTEGER(4),INTENT(IN) Number of elements in the real information vector PINFO. Normally zero
KSET	INTEGER(4),INTENT(IN) A set number as calculated in the IFS routine ECSET. Refers to the parameterized variable $kset, and if present in the SQL's WHERE-condition, the value of KSET will temporarely replace the default value, for the current OpenMP-thread only. If set to a missing data value (MDIDB) or a non-positive number, then the default value of parameterized variable $kset does not get changed at all, unless the value is -1, which denotes any set number
KTSLOT	INTEGER(4),INTENT(IN) The 4D-Var timeslot number. Refers to the parameterized variable $tslot, and if present in the SQL's WHERE-condition, the value of KTSLOT will temporarily replace the default value, for the current OpenMP-thread only. If set to a missing data value (MDIDB) or a non-positive number, then the default value of parameterized variable $tslot does not get changed at all, unless the value is -1, which denotes any timeslot number
KPOOLNO	INTEGER(4),INTENT(IN) The pool number to which the SQLs are to be applied. Usually all pools are scanned, which corresponds to the value of -1
KOBSTYPE	INTEGER(4),INTENT(IN) The particular (CMA) observation type (see table B.2). Refers to the parameterized variable $obstype, and if present in the SQL's WHERE-condition, the value of KOBSTYPE will temporarily replace the default value, for the current OpenMP-thread only. If set to a missing data value (MDIDB) or a non-positive number, then the default value of parameterized variable $obstype does not get changed at all, unless the value is -1, which denotes any observation type

KCODETYPE	`INTEGER(4),INTENT(IN)` The particular (`CMA`) observation codetype. Refers to the parameterized variable `$codetype`, and if present in the `SQL`'s `WHERE`-condition, the value of `KCODETYPE` will temporarily replace the default value, for the current OpenMP-thread only. If set to a missing data value (`MDIDB`) or a non-positive number, then the default value of parameterized variable `$codetype` does not get changed at all, unless the value is -1, which denotes any observation codetype
KSENSOR	`INTEGER(4),INTENT(IN)` The particular satellite sensor number (see table B.4.1). Refers to the parameterized variable `$sensor`, and if present in the `SQL`'s `WHERE`-condition, the value of `KSENSOR` will temporarily replace the default value, for the current OpenMP-thread only. If set to a missing data value (`MDIDB`) or a negative number, then the default value of parameterized variable `$sensor` does not get changed at all, unless the value is -1, which denotes any sensor

Examples:

```
INTEGER(4) :: iversion, iret, info(0)
INTEGER(4) :: iset, itimeslot, ipoolno, icma_obstype
INTEGER(4) :: icma_codetype, isensor
REAL(8) :: zinfo(0)

iversion = 0         ! version (or sometimes update) number
iset = MDIDB         ! set number N/A
itimeslot = -1       ! All
ipoolno = 2          ! Scan pool number 2 only
icma_obstype = 7     ! SATEM
icma_codetype = 210  ! ATOVS
isensor = 11         ! AIRS-data

CALL GETDB('RETRIEVAL_NAME', iversion, iret, info, 0, zinfo, 0, &
   & iset, itimeslot, ipoolno, icma_obstype, icma_codetype, isensor)
```

6.3.6 PUTDB

Usage of the subroutine `PUTDB` is as follows:

```
CALL  PUTDB ( CDRETR, KVERSION, KRET, KINFO, KINFOLEN &
&                , PINFO, KPINFOLEN )
```

This routine updates the database by copying data in observational arrays back to the desired cells in the database tables (that are held in memory). In practice only those columns are updated, which were not under `READONLY`-condition of the corresponding `SQL`-queries of the retrieval. Parameters denote the same as in the counterpart routine `GETDB`. The source file resides in file `$SRC/odb/cma2odb/putdb.F90` The parameters denote :

`CDRETR`	`CHARACTER(LEN=*),INTENT(IN)` Retrieval name initialized in subroutine `CTXINITDB`. This parameter with `KVERSION` determines which `SQL`-queries will be invoked
`KVERSION`	`INTEGER(4),INTENT(IN)` Retrieval version number
`KRET`	`INTEGER(4),INTENT(INOUT)` Return code
`KINFO(KINFOLEN)`	`INTEGER(4),INTENT(INOUT)` Integer information vector
`KINFOLEN`	`INTEGER(4),INTENT(IN)` Number of elements in the integer information vector `KINFO`
`PINFO(KPINFOLEN)`	`REAL(8),INTENT(INOUT)` Real information vector
`KPINFOLEN`	`INTEGER(4),INTENT(IN)` Number of elements in the real information vector `PINFO`

Examples:

```
INTEGER(4) :: iversion, iret, info(0)
REAL(8) :: zinfo(0)
iversion = 0
CALL PUTDB('RETRIEVAL_NAME', iversion, iret, info, 0, zinfo, 0)
```

6.3.7 CLOSEDB

Usage of the subroutine `CLOSEDB` is as follows:

```
CALL  CLOSEDB ( LDSAVE )
```

This subroutine closes connection to the currently active `ODB` database. The source file resides in `$SRC/odb/cma2odb/closedb.F90` The parameters denote :

LDSAVE	LOGICAL,INTENT(IN)

Examples:

```
! Close database with possible updates going to disk
CALL CLOSEDB(.TRUE.)

! Close database without updating changes
CALL CLOSEDB(.FALSE.)
```

6.4 Additional interface functions

There are a few other interface functions one should be aware of. In some situations it maybe essential to understand how the routine `$SRC/odb/cma2odb/ctxgetdb.F90` works, therefore we start from this subroutine.

6.4.1 CTXGETDB

Usage of the subroutine `CTXGETDB` is as follows:

```
CALL  CTXGETDB ( KHANDLE, KCTXID, LDEXECV, KEXECV &
&             , KSET, KTSLOT, KPOOLNO, KOBSTYPE, KCODETYPE &
&            , KSENSOR, KHDR_MIN, KHDR_MAX, KALL, KRETCODE )
```

Routine `CTXGETDB` is one of the most important "slave"-routines in `ODB` interface to `IFS`. It invokes executions of (normally) multiple SQLs related to the current retrieval and allocates all the necessary observational arrays as instructed by the routine `CTXINITDB`. The routine is called from `GETDB` and its source code resides in `$SRC/odb/cma2odb/ctxgetdb.F90` . The parameters denote :

KEXECV	INTEGER(4),INTENT(IN) The number of SQLs to be executed, at most
LDEXECV(KEXECV)	LOGICAL,INTENT(IN) Flag vector to indicates that particular SQL needs (or needs not) to be executed
KHANDLE	INTEGER(4),INTENT(IN) Database handle
KCTXID	INTEGER(4),INTENT(IN) Context id as defined in CTXINITDB (and returned by routine CTXID)
KSET	INTEGER(4),INTENT(IN) Observational set number as defined in IFS routine ECSET ($SRC/ifs/var/ecset.F90) or -1 to take all sets in one go, or MDIDB when not applicable
KTSLOT	INTEGER(4),INTENT(IN) 4D-Var-timeslot number in concern, or -1 for all timeslots, or MDIDB when not applicable
KPOOLNO	INTEGER(4),INTENT(IN) Apply requests to particular pool number only, or -1 for all pools
KOBSTYPE	INTEGER(4),INTENT(IN) Particular CMA observation type in concern, or either -1 for any observation type, or MDIDB when not applicable
KCODETYPE	INTEGER(4),INTENT(IN) Particular CMA codetype in concern, or either -1 for any codetype, or MDIDB when not applicable
KSENSOR	INTEGER(4),INTENT(IN) Satellite sensor indicator, or either -1 for any sensor number, or MDIDB when not applicable
KHDR_MIN	INTEGER(4),INTENT(IN) Special case: refers to retrieved minimum row number, which is usually related to table @hdr (thus the naming convention). Used with SQL WHERE-condition like `$hdr_min <= #hdr <= $hdr_max`

KHDR_MAX	`INTEGER(4),INTENT(IN)` The same as previous one, but refers to maximum row number
KALL	`INTEGER(4),INTENT(IN)` Used in some data shuffle routines to indicate whether to filter out (in `SQL`) all observations (=1) or just the active, `CCMA`-related ones (=0). In addition MeteoFrance sometime uses the value 2
KRETCODE	`INTEGER(4),INTENT(`**`OUT`**`)` Return code to indicate how many rows retrieved for the principal data query (usually `@hdr`-related)

6.4.2 CTXPUTDB

Usage of the subroutine `CTXPUTDB` is as follows:

```
CALL  CTXPUTDB ( KHANDLE, KCTXID, KRETCODE )
```

Routine `CTXPUTDB` is the counterpart to `CTXGETDB` and is called from `PUTDB`. The routine is responsible for passing data from allocated observational arrays back to in-memory database data structures. After this it deallocates these arrays. The source file resides in `$SRC/odb/cma2odb/ctxputdb.F90`. The parameters denote :

KHANDLE	`INTEGER(4),INTENT(IN)` Database handle
KCTXID	`INTEGER(4),INTENT(IN)` Context id
KRETCODE	`INTEGER(4),INTENT(`**`OUT`**`)` Return code

6.4.3 GETATDB

Usage of the subroutine `GETATDB` is as follows:

```
CALL  GETATDB ( CDRETR, KSET, KINFO, KINFOLEN )
```

The purpose of subroutine `GETATDB` is to get a full database table directly. It is related to subroutine `GETDB`, but accesses no data queries. The retrieved full table is placed in one of the observational arrays, like `ROBHDR`, depending on table name. The source file resides in `$SRC/odb/cma2odb/getatdb.F90`. The parameters denote :

`CDRETR`	`CHARACTER(LEN=*),INTENT(IN)` Lowercase table name starting with a character "@"
`KSET`	`INTEGER(4),INTENT(IN)` Used currently as incremental update number to refer to table name `@update`
`KINFOLEN`	`INTEGER(4),INTENT(IN)` Number of elements in the integer information vector `KINFO`. Usually the length needs to be 2
`KINFO(KINFOLEN)`	`INTEGER(4),INTENT(IN`**`OUT`**`)` Integer information vector `KINFO` The first element returns number of pools in database. The second element returns maximum number of updates applicable to this run

Examples:

```
INTEGER(4) :: info(2)

info(1) = <no. of rows needed for array> ! Here: ROBHDR
info(2) = <pool number in concern>       ! Cannot be -1

!-- Allocate ROBHDR (see GETATDB-code for why ROBHDR)
CALL GETATDB('@HDR', -1, info, 2)

!-- Now ROBHDR has been allocated and it has dimensions
!   info(1) x ( 1 + no. of columns in '@hdr'-table )

!-- Look at the PUTATDB-example for the rest !
```

6.4.4 PUTATDB

Usage of the subroutine `PUTATDB` is as follows:

```
CALL  PUTATDB ( CDRETR, KSET, KINFO, KINFOLEN )
```

Routine PUTATDB either creates a database table by fully populating it with data from appropriate observational array, or appends new data rows to the existing table. This routine is the counterpart of GETATDB and related to PUTDB, except that no data queries (SQLs) are accessed. The source file resides in `$SRC/odb/cma2odb/putatdb.F90`. The parameters denote :

CDRETR	CHARACTER(LEN=*),INTENT(IN) Lowercase table name with character "@" prepended into the string
KSET	INTEGER(4),INTENT(IN) Used currently as incremental update number to refer to table name @update
KINFOLEN	INTEGER(4),INTENT(IN) Number of elements in the integer information vector KINFO.
KINFO(KINFOLEN)	INTEGER(4),INTENT(IN**OUT**) Integer information vector KINFO

Examples:

```
!-- See GETATDB-example
...

!-- Fill ROBHDR somehow
...

!-- Pass ROBHDR to ODB and deallocate it
CALL PUTATDB('@HDR', -1, info, 2)
```

6.4.5 MAPVARDB

Usage of the subroutine MAPVARDB is as follows:

```
CALL  MAPVARDB ( KVIEWS, CDNAME, KSIZE )
```

Routine MAPVARDB assigns column entry numbers into all (OpenMP-thread specific) MDB-pointers present in data queries CDNAME. It is important to understand that the routine INITMDB (called upon OPENDB) ensures that mapping between every column entry name of a database and MDB-pointer addresses is established. Thss makes a constant re-assignment of MDB-pointer values possible, whenever the next SQL-query will be launched from within CTXGETDB (called by GETDB). The source file resides in $SRC/odb/cma2odb/mapvardb.F90 . The parameters denote :

KVIEWS	INTEGER(4),INTENT(IN) Number of data queries or SQLs (i.e. views) in CDNAME
CDNAME(KVIEWS)	CHARACTER(LEN=*),INTENT(IN) Data query names as per CREATE VIEW for each SQL
KSIZE(KVIEWS)	INTEGER(4),INTENT(IN) Number of columns in each data query CDNAME

6.4.6 UNMAPDB

Usage of the subroutine UNMAPDB is as follows:

```
CALL  UNMAPDB ( IT )
```

Routine UNMAPDB resets all MDB-pointers for a given OpenMP-thread (IT) back to undefined state. A counterpart routine to MAPVARDB. The source file resides in $SRC/odb/cma2odb/unmapdb
. The parameters denote :

IT	INTEGER(4),INTENT(IN) The OpenMP (OML) thread id. A number between 1 and maximum number of OpenMP-threads

6.4.7 SWAPOUTDB

Usage of the subroutine SWAPOUTDB is as follows:

```
CALL  SWAPOUTDB ( CDNAME, KPOOLNO, LLSAVE )
```

Routine SWAPOUTDB us used to remove database in-memory pool (or all local pools) from memory with possible update to disk. Please note that due to inadequacies when ODB_-IO_METHOD (see p.191) is 4, then this routine does nothing due to limitations in this I/O-method – currently. The source file resides in $SRC/odb/cma2odb/swapoutdb.F90 . The parameters denote :

CDNAME	`CHARACTER(LEN=*),INTENT(IN)` Data query or database table name
KPOOLNO	`INTEGER(4),INTENT(IN)` Pool number in concern. Use -1 to include all local pools
LLSAVE	`LOGICAL,INTENT(IN)` Flag for indicating saving the contents of in-memory database to disk before data pools are removed from memory

Examples:

```
!-- Swap the whole database ECMA out of memory without saving changes
CALL SWAPOUTDB('ECMA',-1,.FALSE.)

!-- Release database CCMA, pool number 5 from memory
!   Save changes to disk
CALL SWAPOUTDB('CCMA', 5,.TRUE.)
```

6.4.8 STOREDB

Usage of the subroutine `STOREDB` is as follows:

```
CALL  STOREDB ( KPOOLNO )
```

Routine `STOREDB` is the counterpart of `LOADDB` routine. It is used to store current in-memory database into disk. However, the same as in `LOADDB` limitation applies here: if `ODB_IO_METHOD` (see p.191) is 4, then this routine does nothing due to limitations in this I/O-method, currently. The source file resides in `$SRC/odb/cma2odb/storedb.F90` . The parameters denote :

KPOOLNO	`INTEGER(4),INTENT(IN)` Pool number in concern. If set to -1, then all (locally owned) pools will be loaded into memory

Examples:

```
!-- Save all pools from ECMA-database into disk
CALL SETACTIVEDB('ECMA')
CALL STOREDB(-1)

!-- Store only pool number 7 from the current database
CALL STOREDB(7)
```

6.4.9 LOADDB

Usage of the subroutine LOADDB is as follows:

```
CALL  LOADDB ( KPOOLNO )
```

Routine LOADDB is rarely used as opposed to its counterpart STOREDB. The routine is a high-level implementation of ODB-function ODB_load to load particular (or all) locally owned pools from disk into memory. However, there is an exception: if ODB_IO_METHOD (see p.191) is 4, then this routine does nothing due to limitations in this I/O-method, currently. The source file resides in $SRC/odb/cma2odb/loaddb.F90. The parameters denote :

KPOOLNO	INTEGER(4),INTENT(IN) Pool number in concern. If set to -1, then all (locally owned) pools will be loaded into memory

Examples:

```
!-- Load database CCMA, pool number 3 into memory
CALL SETACTIVEDB('CCMA')
CALL LOADDB(3)
```

6.5 Shuffling observations between two databases

The following subroutines are mainly used when database CCMA is created from database ECMA. Routines involved in this context are $SRC/odb/cma2odb/shuffledb.F90 and $SRC/odb/cma2odb/xchangedatadb.F90.

Furthermore information accumulated during the 4D-Var-minimization process needs to be passed back from CCMA to ECMA with driver routine $SRC/odb/cma2odb/matchupdb.F90 being called.

6.5.1 SHUFFLEDB

Usage of the subroutine SHUFFLEDB is as follows:

```
CALL  SHUFFLEDB ( CDNAME_IN, CDNAME_OUT, KALL, KANDAT &
&                 , KANTIM, KNMXUPD )
```

Routine SHUFFLEDB is an important driver-routine to perform observational data shuffling (e.g. ECMA to CCMA translation) in concert with routine XCHANGEDATADB. The source file resides in $SRC/odb/cma2odb/shuffledb.F90. The parameters denote :

CDNAME_IN	CHARACTER(LEN=*),INTENT(IN) Input database name
CDNAME_OUT	CHARACTER(LEN=*),INTENT(IN) Output database name
KALL	INTEGER(4),INTENT(IN) Integer flag to indicate whether to include all observations (=1) or just active ones (=0). The latter one is the usual case when creating CCMA from ECMA
KANDAT	INTEGER(4),INTENT(IN) Analysis date
KANTIM	INTEGER(4),INTENT(IN) Analysis time
KNMXUPD	INTEGER(4),INTENT(IN) Maximum number of updates applicable to this run

6.5.2 XCHANGEDATADB

Usage of the subroutine XCHANGEDATADB is as follows:

```
CALL XCHANGEDATADB ( CDWHAT, CDTABLE, CDVIEW, CDNAME_-
IN &
&                          , CDNAME_OUT, KHANDLE_IN, KHANDLE_-
OUT, KALL, KTYPE &
&                  , KPOOLS, KPOOLIDS )
```

Routine XCHANGEDATADB is an important "slave"-routine, when creating ("shuffling") CCMA-database out of ECMA. It is almost generic, that is to say, it collects all still active observations from the ECMA-database and passes them via observational arrays down to the CCMA-database. The routine is called from SHUFFLEDB and its source file resides in $SRC/odb/cma2odb/xchangedatadb.F90. The parameters denote :

CDWHAT	CHARACTER(LEN=*),INTENT(IN) The case to be handled

CDTABLE	CHARACTER(LEN=*),INTENT(IN) Database table in concern
CDVIEW	CHARACTER(LEN=*),INTENT(IN) Data query to be used
CDNAME_IN	CHARACTER(LEN=*),INTENT(IN) Input database name (usually ECMA)
CDNAME_OUT	CHARACTER(LEN=*),INTENT(IN) Output database name (usually CCMA)
KHANDLE_IN	INTEGER(4),INTENT(IN) Input database handle
KHANDLE_OUT	INTEGER(4),INTENT(IN) Output database handle
KALL	INTEGER(4),INTENT(IN) Transform all observations. Normally =0, but can =1 when used in creating ECMA-database from ECMASCR
KTYPE	INTEGER(4),INTENT(IN) Special satellite specific case
KPOOLS	INTEGER(4),INTENT(IN) Number of (local) pools involved
KPOOLIDS(KPOOLS)	INTEGER(4),INTENT(IN) Local pool numbers

6.5.3 MATCHUPDB

Usage of the subroutine MATCHUPDB is as follows:

```
CALL  MATCHUPDB ( NUM_TIME_SLOTS, LDFINTRAJ_ECMA &
&                    , LD_INTERNAL_ODB2ECMA, KNMXUPD )
```

Routine MATCHUPDB is used to feed all the essential information gathered during 4D-Var-minimization process in CCMA-database back to ECMA-database. The parameters denote :

NUM_TIME_SLOTS	INTEGER(4),INTENT(IN) Number of timeslots to be matched up

KNMXUPD	`INTEGER(4),INTENT(IN)` Number of updates applicable
LDFINTRAJ_ECMA	`LOGICAL,INTENT(IN)` Flag for final trajectory
LD_INTERNAL_ODB2ECMA	`LOGICAL,INTENT(IN)` Obsolescent. Used to trigger `ECMA`-file creation out of `ECMA`/ODB-database internally i.e. when database was still in memory, and thus saving some crucial computer resources

7 Databases related to IFS

Currently there are two databases which are directly connected for use by IFS (databases ECMA and CCMA) and one indirectly connected (database ECMASCR).

The database ECMA contains all observations to be used in a 4D-Var analysis. These are the observations converted from external sources like BUFR-files or ASCII text files into ODB. The very first step (traj#0) of the 4D-Var suite screens observations found in ECMA to select a suitable set for the subsequent 4D-Var minimization process. These so called active observations are placed into a separate database called CCMA. Both databases are distributed between MPI-tasks so that every task will process roughly the same number of observations in each timeslot of 4D-Var.

The database ECMASCR is meant to be a temporary database, which is normally supposed to have exactly the same data layout as the ECMA. But this similarity can of course be altered to suit local needs. The purpose of this "replica" of ECMA is allow observations to be fed into the ECMASCR-database as soon as they arrive and then ECMASCR is converted ("shuffled") to ECMA-database to get load balancing of observations between MPI-tasks in subsequent 4D-Var-run. However, this processing is nowadays rarely exercised at ECMWF due to its high cost in terms of processing time, memory and disk requirement. Our (near) load balancing of ECMA is a result of quick examination and timeslotting of BUFR-data before it is decoded into the database.

To add your own database either an automatically recognized (permament) database or on a temporary basis, see section 9.2 for details.

7.1 Table hierarchies

In order to interpret the data layout entries used in IFS related databases, you need to understand the table hierarchies currently employed. Figures 19 and 20 show these hierarchies in database ECMA which is nearly the same (with less tables) for CCMA. Figure 19 is for all observation types and figure 20 for satellite specific tables.

In the satellite data hierarchy all satellite specific tables communicate via an intermediate table sat. This table also contains the INTEGER-equivalent of satellite id, that is satid@sat. Its value should always be the same as ident@hdr for convenience.

Note that not all observation types share satellite table information. When this is the case, the corresponding @LINK-length (see 6.2) is set to zero.

7.2 User defined datatypes

Before introducing database tables and column entries currently used in ECMA and CCMA, we need to describe the associated user defined datatypes also known in ODB/SQL -jargon

Figure 19: Generic database table hierarchy in IFS

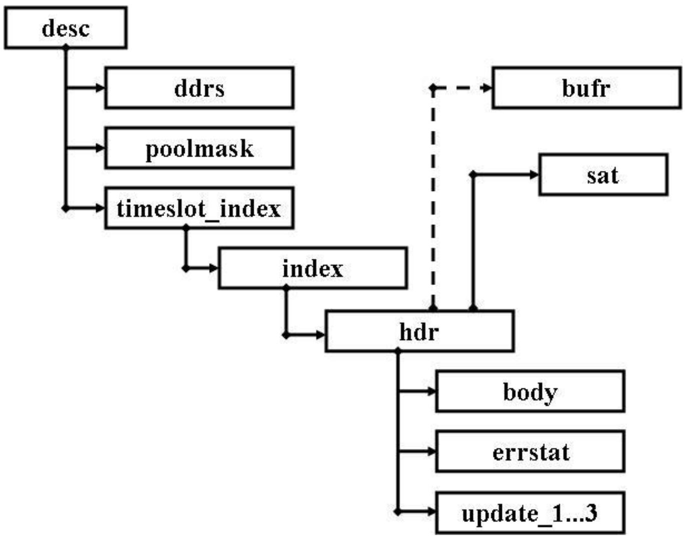
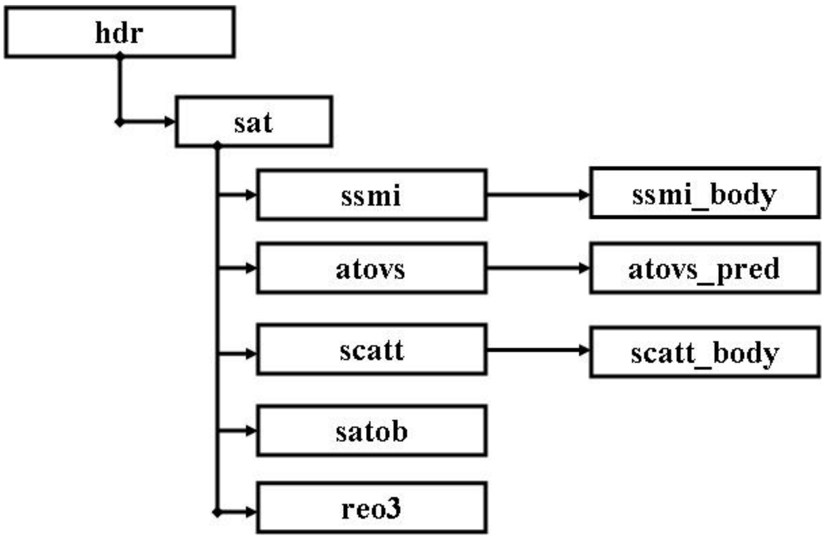


Figure 20: Satellite database table hierarchy in IFS



as `Bitfields`. The data layout definition for the IFS code benefits from a number of user defined datatypes. They are explained in the following subsections.

There can be up to 32-bits (assigned from right to left) per user defined datatype. Each member of particular datatype can be referred to in the `ODB/SQL` as *col_entry.member@table*.

For instance, the observation characteristics column entry's *obschar* member *codetype* can be referred to as *obschar.codetype* or with the fully qualified definition *obschar.codetype@hdr*. All type definitions explained here can be found from file `$SRC/odb/ddl/cma.h`.

7.2.1 Observation characteristics

Observation characteristics contains the following four member fields:

Table 7: Data members for user defined datatype `obschar_t`

Member name	Bit range	Description
codetype	0–9	Observation code type
instype	10–19	Instrument type
retrtype	20–25	Retrieval type
datagroup	26–31	Data processing group

And its – now obsolete – type definition was as follows:

```
CREATE TYPE obschar_t AS (
        codetype bit10,
        instype bit10,
        retrtype bit6,
        datagroup bit6
);
```

Note that this datatype has been removed, since we were running out of bits available for the *datagroup*-member and because it is more convenient to refer to *codetype* as a separate column entry. Therefore, in the releases of IFS from `CY28R2` onwards shows separate column entries in the `hdr`-table called *codetype*, *insttype*[9], *retrtype* and *areatype* (not *datagroup*!) with no *obschar*-word anymore.

7.2.2 Analysis datum flags

[9]Two "t"'s, i.e. not *instype*!

Table 8: Data members for user defined datatype `datum_flag_t`

Member name	**Bit range**	**Description**
final	0–3	Final flag
fg	4–7	First guess flag
depar	8–11	Departure flag
varQC	12–15	Variational quality control flag
blacklist	16–19	Blacklist flag
		Metéo-France: d'utilisation par analyse ...
ups	20	... de pression de surface
uvt	21	... de vent et temperature
uhu	22	... d'humidite
ut2	23	... d'utilisation par analyse de temperature a 2m
uh2	24	... d'humidite a 2m
uv1	25	... de vent a 10m
urr	26	... de precipitations
usn	27	... de neige
usst	28	... de temperature de surface de la mer
	29–31	Unused bits

7.2.3 Report/datum status flags

Table 9: Data members for user defined datatype `status_t`

Member name	**Bit range**	**Description**
active	0	Active flag
passive	1	Passive flag
rejected	2	Rejected flag
blacklisted	3	Blacklisted flag
		Not for database `CCMA`:
		Blacklist failcode bits, fails in ...
monthly	4	... monthly monitoring part of Blacklist
constant	5	... constant part
experimental	6	... experimental part
whitelist	7	Whitelisted (i.e. un-Blacklisted)
	4–31	Unused for database `CCMA`
	8–31	Unused for database `ECMA`/`ECMASCR`

Its type definition is implemented as follows:

```
CREATE TYPE status_t AS (
        active bit1,
        passive bit1,
        rejected bit1,
        blacklisted bit1,
#ifdef ECMA
        // BLACKLIST FAILCODE BITS
        monthly bit1,
        constant bit1,
        experimental bit1,
        whitelist bit1,
#endif /* ECMA */
);
```

7.2.4 Report RDB-flags

These flags are defined for each report (`hdr`-table row).

Table 10: Data members for user defined datatype `report_-rdbflag_t`

Member name	Bit range	Description
lat_humon	0	
lat_QCsub	1	
lat_override	2	
lat_flag	3–4	
lat_HQC_flag	5	
lon_humon	6	
lon_QCsub	7	
lon_override	8	
lon_flag	9–10	
lon_HQC_flag	11	
date_humon	12	
date_QCsub	13	
date_override	14	
date_flag	15–16	
date_HQC_flag	17	
time_humon	18	
time_QCsub	19	
time_override	20	
time_flag	21-22	
time_HQC_flag	23	

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Table 10: Datatype `report_rdbflag_t` . . . *continued*

Member name	**Bit range**	**Description**
stalt_humon	24	
stalt_QCsub	25	
stalt_override	26	
stalt_flag	27–28	
stalt_HQC_flag	29	
	30–31	Unused bits

7.2.5 Datum RDB-flags

These flags are defined for each datum (`body`-table row).

Table 11: Data members for user defined datatype `datum_rdbflag_t`

Member name	**Bit range**	**Description**
press_humon	0	
press_QCsub	1	
press_override	2	
press_flag	3–4	
press_HQC_flag	5	
press_judged_prev_-an	6–7	
press_used_prev_an	8	
_press_unused_6	9–14	Alignment bits (unused)
varno_humon	15	
varno_QCsub	16	
varno_override	17	
varno_flag	18–19	
varno_HQC_flag	20	
varno_judged_prev_-an	21–22	
varno_used_prev_an	23	
	24–31	Unused bits

7.2.6 TEMP/PILOT level flags

These flags are applicable for TEMP/PILOT `body`-entries only. They are not present in `CCMA`-database.

Table 12: Data members for user defined datatype `level_t`

Member name	Bit range	Description
id	0–8	TEMP/PILOT level identification
maxwind	9	Maximum wind level
tropopause	10	Tropopause
D_part	11	D-part
C_part	12	C-part
B_part	13	B-part
A_part	14	A-part
surface	15	Surface level
signwind	16	Significant wind level
signtemp	17	Significant temperature level
	18–31	Unused bits

7.2.7 Report event#1 flags

Table 13: Data members for user defined datatype `report_event1_t`

Member name	Bit range	Description
no_data	0	No data available
all_rejected	1	All rejected
bad_practice	2	Bad reporting practice
rdb_rejected	3	Rejected in RDB
rdb_activated	4	Activated in RDB
whitelist_activated	5	Activated via whitelist
horipos_outrange	6	Horizontal position out of range
vertpos_outrange	7	Vertical position out of range
time_outrange	8	Time out of range
redundant	9	Redundant report
land	10	Land observation
sea	11	Sea observation
stalt_missing	12	Station altitude
modsurf_stalt_dis-tance	13	Surface modified due to *stalt*
namelist_rejected	14	Rejected via NAMELIST
QC_failed	15	Quality control failure
	16–31	Unused bits

7.2.8 Report event#2 flags

These flags are not generic, but differ from one observation type to another. Therefore it is easier to alias it to 32-bit (packed) integer `pk1int` as follows:

```
CREATE TYPE report_event2_t = pk1int;
```

7.2.9 Report blacklist flags

When set, these bits indicate which column entry/entries in table `hdr` (or related, like `atovs`) were responsible for causing blacklisting to occur. So the last column in the next table should be read as "Blacklisting caused by" followed by the text in the column.

In practice these column entries are present in the IF-conditions of the Blacklist language definition file that resulted blacklisting of current report.

Table 14: Data members for user defined datatype `report_-blacklist_t`

Member name	Bit range	Description
obstype	0	Observation type
statid	1	Station identifier
codetype	2	CMA codetype
instype	3	Instrument type
date	4	Measurement date
time	5	Measurement time
lat	6	Latitude
lon	7	Longitude
stalt	8	Station altitude
scanpos	9	Scan position
retrtype	10	Retrieval type
QI_1	11	Quality indicator 1 (satob)
QI_2	12	Quality indicator 2 (satob)
QI_3	13	Quality indicator 3 (satob)
modoro	14	Model orography
lsmask	15	Land sea mask (either 0 or 1)
rlsmask	16	Land sea mask (real; 0.0 .. 1.0)
modPS	17	Model pressure
modTS	18	Model surface temperature
modT2M	19	Model 2 metre temperature
modtop	20	Model top pressure
sensor	21	Sensor id
fov	22	Field of view
satza	23	Satellite zenith angle

continued on next page . . .

Table 14: Datatype `report_blacklist_t` *... continued*

Member name	Bit range	Description
andate	24	Analysis date
antime	25	Analysis time
	26–31	Unused bits

7.2.10 Datum blacklist flags

When set, these bits indicate which column entry/entries in table `body` were responsible for causing blacklisting to occur. So the last column in the next table should be read as "Blacklisting caused by" followed by the text in the column. In practice these column entries are present in the IF-condition(s) of the Blacklist definition file resulting blacklisting of current datum.

Table 15: Data members for user defined datatype `datum_blacklist_t`

Member name	Bit range	Description
varno	0	Variable number
vertco_type	1	Vertical coordinate type
press	2	Pressure level/channel number
press_rl	3	Reference pressure level
ppcode	4	SYNOP pressure code
obsvalue	5	Observed value
fg_depar	6	First guess departure
obs_error	7	Observation error
fg_error	8	First guess error
winchan_dep	9	Window channel departure
obs_t	10	???
	11–31	Unused bits

7.2.11 Variable presence flags

This flag can be used to indicate (roughly) what kind of variable numbers (*varno*) are present in the `body`-table belonging to this observation spot. Note, that this entry is relatively new and may not always be correctly filled. When matured, it should speed up SQL-queries requiring `body`-entries, since scan of `body`-related tables can be reduced to bare minimum by requesting these `hdr`-flags in the SQL-query.

The last column indicates presence of (any) *varno@body* belonging to particular category.

Table 16: Data members for user defined datatype `varno_-presence_t`

Member name	Bit range	Description
other	0	For non-categorized variable number
ps	1	Surface pressure
wind	2	Wind-components
t	3	Temperature
z	4	Geopotential
rh	5	Relative humidity
q	6	Specific humidity
obs2m	7	2 meter observations
snow	8	Snow analysis related observations
rain	9	Rain
rawbt	10	Brightness temperature
rawra	11	Raw radiance
ozone	12	Ozone
dz	13	Thickness
pwc	14	PWC
time_period	15	Time period (of rain)
	16–31	Unused bits

7.2.12 Datum event#1 flags

These are `body`-table related events and they describe reason why certain body-enty has been rejected – or even activated.

Table 17: Data members for user defined datatype `datum_event1_t`

Member name	Bit range	Description
vertco_missing	0	Vertical coordinate missing
obsvalue_missing	1	Observed value missing
fg_missing	2	First guess value missing
rdb_rejected	3	Rejected due to `rdbflags`
rdb_activated	4	Activated due to `rdbflags`
whitelist_activated	5	Activated due to whitelisting
bad_practice	6	Bad reporting practice
vertpos_outrange	7	Vertical position out of range
reflevel_outrange	8	Reference level out of range
fg2big	9	First guess too big
depar2big	10	Analysis departure too big

continued on next page . . .

Table 17: Datatype `datum_event1_t` ...*continued*

Member name	Bit range	Description
obs_error2big	11	Observation error too big
datum_redundant	12	Redundant body entry
level_redundant	13	Reduntant level information
land	14	Land point
sea	15	Sea point
not_analysis_varno	16	Not an analysis variable
duplicate	17	Duplicate body entry
levels2many	18	Too many levels
multilevel_check	19	Multilevel check failed
level_selection bit1	20	Level selection ???
vertco_consistency	21	Vertical consistency failed ??
vertco_type_changed	22	Vertical coordinate type has changed
namelist_rejected	23	Rejection via `NAMELIST`
combined_flagging	24	Combined flagging
report_rejected	25	Whole report is rejected
varQC_performed	26	Variational quality control has been performed
contam_cld_flag	27	Cloud contamination
contam_rain_flag	28	Rain contamination
	29–31	Unused bits

7.2.13 Datum event#2 flags

These flags are not generic, but differ from observation type to another. Therefore it is easier to alias it to 32-bit (packed) integer `pk1int` as follows:

```
CREATE TYPE datum_event2_t = pk1int;
```

7.3 Database ECMA

Database `ECMA` is the backbone for IFS interfacing with ODB. It contains all observations from (possibly pre-thinned) BUFR-file (or external ASCII text file). The following subsections list all column entries for each table with their description and corresponding MDB/MLNK-pointers, which are used to reference these columns in IFS. The definitive order of the column entries is *not* necessarily the same as in data definition layout file. Please consult the `$SRC/odb/ddl.ECMA/ECMA.ddl` and all files it includes.

7.3.1 Table `desc`

This table holds descriptive data for each database. With one data row definition for each pool. By examining its columns, you can find our whether the database has been used operationally (`expver` equals to right justified `'0001'`), what is the analysis timestamp concerned, when the database was created or last modified, who was the creator and modifier. Furthermore, one can find how many trajectory updates are expected from this database (i.e. how many `update`-tables are containing non-missing data) and whether positional coordinates `(lat,lon)` are already in radians or still in degrees. In addition there are links to a few tables below the table hierarchy.

Table 18: Database table `desc`

Column entry	**Type**	**Description**	**Column pointer(s)**
expver	string	Experiment version	MDB_EXPVER_AT_DESC
andate	`YYYYMMDD`	Analysis date	MDB_ANDATE_AT_DESC
antime	`HHMMSS`	Analysis time	MDB_ANTIME_AT_DESC
creadate	`YYYYMMDD`	DB creation date	MDB_CREADATE_AT_DESC
creatime	`HHMMSS`	DB creation time	MDB_CREATIME_AT_DESC
creaby	string	User who created database	MDB_CREABY_AT_DESC
moddate	`YYYYMMDD`	DB modification date	MDB_MODDATE_AT_DESC
modtime	`HHMMSS`	DB modification time	MDB_MODTIME_AT_DESC
modby	string	User who modified database	MDB_MODBY_AT_DESC
mxup_traj	pk1int	Max. no. of trajectory updates	MDB_MXUP_TRAJ_AT_DESC
latlon_rad	pk1int	Flag for `(lat,lon)` being in radians	MDB_LATLON_RAD_AT_DESC
		Offsets & lengths to ...	
ddrs	`@LINK`	`ddrs`	MLNK_DESC2DDRS
poolmask	`@LINK`	`poolmask`	MLNK_DESC2POOLMASK
timeslot_index	`@LINK`	`timeslot_index`	MLNK_DESC2TIMESLOT_INDEX

7.3.2 Table `ddrs`

This table contains Data Description Records for analysis and is still in a little-bit old fashioned format: data needs to be accessed nearly as a bulk data, rather than referring to column entries with their natural names.

Table 19: Database table `ddrs`

Column entry	**Type**	**Description**	**Column pointer(s)**
ddrno	pk1int	CMA DDR-block number	MDB_DDRNO_AT_DDRS

continued on next page . . .

Table 19: Database table `ddrs` ... *continued*

Column entry	Type	Description	Column pointer(s)
wordno	pk1int	Word number within DDR-block	MDB_WORDNO_AT_DDRS
bulkdata	pk9real	DDR-data as in former CMA-files	MDB_BULKDATA_AT_DDRS

7.3.3 Table `poolmask`

This table contains data distribution information for use by poolmasked data access. This information is useful, since you can also find how particular observational groups are split between data pools, or how much data a particular timeslot has in terms of location or measurement information.

Table 20: Database table `poolmask`

Column entry	Type	Description	Column pointer(s)
tslot	pk1int	Timeslot number	MDB_TSLOT_AT_POOLMASK
obstype	pk1int	observation type (CMA)	MDB_OBSTYPE_AT_POOLMASK
codetype	pk1int	codetype (CMA)	MDB_CODETYPE_AT_POOLMASK
sensor	pk1int	Satellite sensor	MDB_SENSOR_AT_POOLMASK
bufrtype	pk1int	BUFR type	MDB_BUFRTYPE_AT_POOLMASK
subtype	pk1int	BUFR subtype	MDB_SUBTYPE_AT_POOLMASK
satinst	pk1int	WMO satellite instrument	MDB_SATINST_AT_POOLMASK
poolno	pk1int	Pool number	MDB_POOLNO_AT_POOLMASK
hdr_count	pk1int	Count of spots/pixels	MDB_HDR_COUNT_AT_POOLMASK
body_count	pk1int	Count of body entries	MDB_BODY_COUNT_AT_POOL-MASK
max_bodylen	pk1int	Max. no. of bodies	MDB_MAX_BODYLEN_AT_POOL-MASK

The count of spots/pixels refers to the number of different observation locations both in space `(lat,lon)` and measurement time `(date,time)`. The count of body entries tells you the number of individual measurements in terms of (say) wind component, temperatures, humidities etc.

7.3.4 Table timeslot_index

This table enables direct access to timeslot-based data without need to scan the whole index or hdr tables for that purpose. Optimally this table should contain only as many rows per pool as there are observational timeslots specified for the particular 4D-Var-run.

Table 21: Database table timeslot_index

Column entry	Type	Description	Column pointer(s)
timeslot	pk1int	Timeslot number	MDB_TIMESLOT_AT_TIMESLOT_IN-DEX
index	@LINK	Offset&length to index	MLNK_TIMESLOT_INDEX2INDEX

In order to make any use of this table (and speeding up SQLs), its child table (index) must already have been sorted with respect to its column tslot@index.

7.3.5 Table index

This table controls timeslot information and enables shuffle and matchup procedures to work correctly. This is to say, the table is used for complicated parallel data shuffles between MPI-tasks when feeding information back and forth between ECMA and CCMA databases. Another purpose is to keep track of *kset*'s and pointers to IFS EC- and GOM-arrays.

Table 22: Database table index

Column entry	Type	Description	Column pointer(s)
target	pk1int	Report "owner" pool in ECMA	MDB_TARGET_AT_INDEX
procid	pk1int	Destination pool for CCMA	MDB_PROCID_AT_INDEX
tslot	pk1int	Timeslot number	MDB_TSLOT_AT_INDEX
kset	pk1int	*kset* as from ECSET	MDB_KSET_AT_INDEX
abnob	pk1int	ECxxx-array pointer	MDB_ABNOB_AT_INDEX
mapomm	pk1int	GOMxxx-array pointer	MDB_MAPOMM_AT_INDEX
hdr	@LINK	Offset&length to hdr	MLNK_INDEX2HDR

As explained earlier in 7.3.4, this table needs to be sorted with respect to its column tslot@index to be efficient.

7.3.6 Table `hdr`

This table contains location and time information for every observation spot/pixel. It is also known as report data and has links down the line to its `body`-related tables and the satellite specific intermediate-table `sat`. Note also that if the observation type is not satellite data, then the `@LINK`-length to `sat`-table is zero.

Another important point is to note that positional coordinates `(lat,lon)` are normally expressed in radians, unless you examine database just after creating it from BUFR-file, in which case they are in degrees. The value of column entry `latlon_rad@desc` shows the conversion status.

Table 23: Database table `hdr`

Column entry	**Type**	**Description**	**Column pointer(s)**
seqno	pk1int	Observation sequence number	MDBONM
obstype	pk1int	(CMA) Observation type	MDBOTP
codetype	pk1int	Observation (CMA) code type	MDB_CODETYPE_AT_HDR
insttype	pk1int	Observation instrument type	MDB_INSTTYPE_AT_HDR
retrtype	pk1int	Observation retrieval type	MDB_RETRTYPE_AT_HDR
areatype	pk1int	Observation area type	MDB_AREATYPE_AT_HDR
zone	pk9int	??? check MF ???	MDB_ZONE_AT_HDR
date	`YYYYMMDD`	Observation date	MDBDAT
time	`HHMMSS`	Exact observation time	MDBETM
status	status_t	Report's status	MDBRST
event1	report_event1_t	Report's events (part 1), see **??**	MDBREV1
sortbox	pk1int	Sorting box	MDBBOX
sitedep	pk1int	Site dependent integer	MDBSTD
source	string	Source id of obs. (re-analysis)	MDB_SOURCE_AT_HDR
statid	string	Station id in character form	MDBSID
ident	pk1int	Numeric `statid` or zero	MDB_IDENT_AT_HDR
lat	pk9real	Latitude (normally in radians)	MDBLAT
lon	pk9real	Longitude (normally in radians)	MDBLON
stalt	pk9real	Station altitude	MDBALT
modoro	pk9real	Model's orography	MDBMOR
trlat	pk9real	Transformed `lat`	MDBTLA
trlon	pk9real	Transformed `lon`	MDBTLO
instspec	instrm_t	Inst. spec. word positions	MDBINS
anemoht	pk9real	Height of anemometer	MDBHOAN{S|D|T|P}
baroht	pk9real	Height of barometre	MDBHOBA{S|D|T|P}
sensor	pk1int	Satellite sensor indicator	MDBSSIA
numlev	pk1int	No. of distinct pressure levels	MDB_NUMLEV_AT_HDR
numactiveb	pk1int	No. of active body entries	MDB_NUMACTIVEB_AT_HDR

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Table 23: Database table `hdr` . . . *continued*

Column entry	**Type**	**Description**	**Column pointer(s)**
checksum	pk9real	Sum of `obsvalue`'s in `body`-table that are not missing data	MDB_CHECKSUM_AT_HDR
varno_presence	varno_presence_t	Variable presence flag	MDB_VARNO_PRESENCE_AT_HDR
rdbflag	report_rdbflag_t	Report's flags	MDBRFL
subtype	pk1int	BUFR-subtype	MDB_SUBTYPE_AT_HDR
bufrtype	pk1int	BUFR-type	MDB_BUFRTYPE_AT_HDR
satinst	pk1int	Satellite instrument in BUFR/WMO	MDB_SATINST_AT_HDR
satname[2]	string	Extended satellite name (i.e. two word, up to 16 bytes)	MDB_SATNAME_AT_HDR(2)
sat	`@LINK`	Link to `sat`	
body	`@LINK`	Link to `body`	
errstat	`@LINK`	Link to `errstat`	
update[:]	`@LINK`	Link to `$NMXUPD` `update`-tables	
		Not in database `CCMA`	
thinningkey[$NUMTHBOX]	pk9real	Thinning key	MDB_THINNINGKEY_AT_HDR(:)
thinningtimekey	pk9real	Thinning time key	MDB_THINNINGTIMEKEY_AT_HDR
blacklist	report_blacklist_t	Report's blacklist events	MDBRBLE
event2	report_event2_t	Report events (part 2)	MDBREV2
bufr	`@LINK`	Link to BUFR-data	
subsetno	pk9int	BUFR-multisubset no. (=0 for single)	MDB_SUBSETNO_AT_HDR
station_type	pk1int	SYNOP/SHIPs (whether DRIBU)	MDB_STATION_TYPE_AT_HDR
sonde_type	pk1int	For TEMP bias correction	MDB_SONDE_TYPE_AT_HDR
satem_instdata	pk1int	Instrument data used in processing old-SATEM	MDB_SATEM_INSTDATA_AT_HDR
satem_dataproc	pk1int	Data processing technique used for old-SATEM	MDB_SATEM_DATAPROC_AT_HDR

Note, that its data rows can appear in any order, since its parent table (`index`) (and grandparent (`timeslot_index`) have arranged `@LINK`-offsets in such a way that timeslot access is will be direct.

7.3.7 Table `body`

This table contains the actual measurement information accompanied with first guess and analysis departure values (once calculated) and analysis status flag information.

Table 24: Database table `body`

Column entry	Type	Description	Column pointer(s)
varno	pk1int	Variable number	MDBVNM
vertco_type	pk1int	Vertical coordinate type	MDBVCO
anflag	datum_flag_t	Observation flags, see 7.2.2	MDBFLG
status	status_t	Observation status, see 7.2.3	MDBDSTA
event1	datum_event1_t	Observation events (part 1), see **??**	MDBDEV1
entryno	pk1int	Entry sequence number	MDBESQN
press	pk9real	Vert. coord. (pressure, channel no.)	MDBPPP
press_rl	pk9real	Vert. coord. reference level	MDBPRL
obsvalue	pk9real	Observed value of variable	MDBVAR
aux[$NUMAUX]	pk9real	Auxiliary observed values. For u-wind component aux[1] contains wind speed (`ff`) and aux[2] contains wind direction (`dd`). For v-wind component values are just reversed.	MDB_AUX_AT_BODY(:)
biascorr	pk9real	Bias correction	MDB{TORB|TORBA|SSRB}
rdbflag	datum_-rdbflag_t	Observation RDB-flags, see **??**	MDBRDFL
an_depar	pk9real	Observed minus Analysed value	MDBOMN
fg_depar	pk9real	Observed minus First guess value	MDBOMF
fg_check_1	pk9real	First guess check no. 1	MDBFGC1
fg_check_2	pk9real	First guess check no. 2	MDBFGC2
cld_fg_depar	pk9real	FG departure for cloudy radiances	MDB_CLD_FG_DEPAR_AT_BODY
surfemiss	pk9real	Surface emissivity	MDB_SURFEMISS_AT_BODY
csr_pclear	pk9real	% of clear pixels in mean CSR	MDB_CSR_PCLEAR_AT_BODY
csr_pcloudy	pk9real	% of cloudy pixels in mean CSR	MDB_CSR_PCLOUDY_AT_BODY
rank_cld	pk9real	Channel ranking for cloud detection	MDB_RANK_CLD_AT_BODY
rank_an	pk9real	Channel ranking for analysis	MDB_RANK_AN_AT_BODY
		Metéo-France/CANARI-only	
mf_vertco_type	pk1int	Vertical coordinate type	MDBRBVC
mf_log_p	pk9real	Pressure used in CANARI ($log(p)$)	MDBRBPIO
mf_stddev	pk9real	Obs. std dev at bottom layer	MDBRBOE
		Not in database `CCMA`	
blacklist	datum_black-list_t	Observation blacklist events	MDBDBLE
event2	datum_event2_t	Datum events (part 2)	MDBDEV2

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Table 24: Database table `body` . . . *continued*

Column entry	Type	Description	Column pointer(s)
ppcode	pk1int	Synop pressure code	MDBSYPC
level	level_t	Pilot level id	MDB{TELID|PILID}

7.3.8 Table `errstat`

This table contains observation error statistics.

Table 25: Database table `errstat`

Column entry	Type	Description	Column pointer(s)
final_obs_error	pk9real	Final observation error	MDBFOE
obs_error	pk9real	Observation error	MDBOER
repres_error	pk9real	Representativeness error	MDBRER
pers_error	pk9real	Persistence error	MDBPER
fg_error	pk9real	First guess error	MDBFGE

7.3.9 The `update`-tables

There are a total of `$NMXUPD` `update`-tables [10], one table for each 4D-Var-update. They all have identical column entries. These intermediate departures for each update $IUPD \leq$ `MXUP_-TRAJ` are:

Table 26: Database table `update`

Column entry	Type	Description	Column pointer(s)
initial	pk9real	obs. minus initial value	MDBIOM0(*IUPD*)
hires	pk9real	obs. minus high res. value	MDBIFC1(*IUPD*)
lores	pk9real	obs. minus low res. value	MDBIFC2(*IUPD*)
final	pk9real	obs. minus final value	MDBIOMN(*IUPD*)

[10]Expanded into tablenames `update_1`, `update_2` and so on

7.3.10 Table `sat`

This table acts as a "middle-man" between table `hdr` and satellite specific (header-)information tables. See figure 20. Note that not all satellite specific table information is present in both ECMA and CCMA.

Table 27: Database table `sat`

Column entry	Type	Description	Column pointer(s)
satid	pk1int	Integer equivalent of `statid@hdr` or zero. Should also equal to `ident@hdr`	MDB_SATID_AT_SAT
		Offsets & lengths to ...	
reo3	`@LINK`	`reo3`	MLNK_SAT2REO3
satob	`@LINK`	`satob`	MLNK_SAT2SATOB
satem	`@LINK`	`satem`	MLNK_SAT2SATEM
scatt	`@LINK`	`scatt`	MLNK_SAT2SCATT
ssmi	`@LINK`	`ssmi`	MLNK_SAT2SSMI
atovs	`@LINK`	`atovs`	MLNK_SAT2ATOVS

7.3.11 Table `reo3`

This table contains ozone specific header-information. Table is one-to-one (one-looper) aligned with respect to the `sat`-table.

Table 28: Database table `reo3`

Column entry	Type	Description	Column pointer(s)
instrument_type	pk1int	Satellite instrument[11]	MDBRO3IT
product_type	pk1int	Product type for retr. atm. gases	MDBRO3PT
lat_fov-corner[1:4]	pk9real	Latitude field of view corner 1-4	MDBRO3LA1..4
lon_fov-corner[1:4]	pk9real	Longitude field of view corner 1-4	MDBRO3LO1..4
solar_elevation	pk9real	Solar elevation	MDBRO3SOE
fov	pk1int	Field of view number	MDBRO3FOV
cloud_cover	pk9real	Cloud cover	MDBRO3CLC
cloud_top_press	pk9real	Pressure at top of cloud	MDBRO3CP

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[11]Satellite instrument word `instrument_type@hdr` should be replicated into `sensor@hdr` in order to have to have more generic SQL's

Table 28: Database table `reo3` . . . *continued*

Column entry	Type	Description	Column pointer(s)
quality_retrieval	pk1int	Quality of retrieval	MDBRO3QR
number_layers	pk1int	Number of retrieved layers	MDBRO3NL

7.3.12 Table `satob`

This table contains SATOB-specific header-information. Variable `$mx_satob_weight` is currently set to 43 (used to be 50), but should in fact reflect the value used in prevailing `RTTOV`-implementation. This variable must have the same (or larger) value as Fortran90 variable `JPMX_SATOB_WEIGHT` in file `$SRC/ifs/module/parcma.F90`.

Note that the dimension of column entry `weight[:]` is actually defined via SET-variable `$mx_satob_weight`. Dimension of `MDB_WEIGHT_AT_SATOB(:)` is `JPMX_SATOB_-WEIGHT`.

Table 29: Database table `satob`

Column entry	Type	Description	Column pointer(s)
comp_method	pk1int	Cloud motion comp. method[12]	MDBSBCMM
instdata	pk1int	Ins. data used in proc.	MDBSBIUP
dataproc	pk1int	Data proc. technique used	MDBSBDPT
QI[3]	pk1int	Three quality indicators	MDBSBQI1..3
segment_size_x	pk9real	Resolution, x-direction	MDB_SEGMENT_SIZE_X_AT_SATOB
segment_size_y	pk9real	Resolution, y-direction	MDB_SEGMENT_SIZE_Y_AT_SATOB
chan_freq	pk9real	Sat. chann. centre freq. [Hz]	MDB_CHAN_FREQ_AT_SATOB
tb	pk9real	Coldest cluster temperature	MDB_TB_AT_SATOB
t	pk9real	Temperature at SATOB p	MDB_T_AT_SATOB
zenith	pk9real	Satellite zenith angle	MDB_ZENITH_AT_SATOB
shear	pk9real	Diff. in speed 50hPa above/below	MDB_SHEAR_AT_SATOB
t200	pk9real	200hPa temperature	MDB_T200_AT_SATOB
t500	pk9real	500hPa temperature	MDB_T500_AT_SATOB
top_mean_t	pk9real	Mean temp. between 80hPa & p	MDB_TOP_MEAN_T_AT_SATOB
top_wv	pk9real	Integrated WV above p	MDB_TOP_WV_AT_SATOB
dt_by_dp	pk9real	Diff in temp. 50hPa above/below	MDB_DT_BY_DP_AT_SATOB
p_best	pk9real	"Best fit" pressure p	MDB_P_BEST_AT_SATOB

continued on next page . . .

[12]Note: Cloud motion computational method word should be replicated into `sensor@hdr` to be able to have more generic SQL's

Table 29: Database table `satob` *... continued*

Column entry	**Type**	**Description**	**Column pointer(s)**
u_best	pk9real	U at "best fit" p	MDB_U_BEST_AT_SATOB
v_best	pk9real	V at "best fit" p	MDB_V_BEST_AT_SATOB
p_old	pk9real	Originally assigned pressure	MDB_P_OLD_AT_SATOB
u_old	pk9real	U at old pressure	MDB_U_OLD_AT_SATOB
v_old	pk9real	V at old pressure	MDB_V_OLD_AT_SATOB
weight[:]	pk9real	Weights for obs oper.	MDB_WEIGHT_AT_SATOB(:)

7.3.13 Table `scatt`

This table contains scatterometer specific header-information.

Table 30: Database table `scatt`

Column entry	**Type**	**Description**	**Column pointer(s)**
track	pk1int	Satellite track	MDBSCSAT
cellno	pk1int	Cell number	MDBSCCNO
prodflag	pk1int	Product flag	MDBSCPFL
uwi_esa[2]	pk1int	UWI ESA FLAG (2×12-bits)	MDB_UWI_ESA_AT_SCATT(2)
scatt_body	`@LINK`	Offset&length to `scatt_body`	MLNK_SCATT2SCATT_BODY

7.3.14 Table `scatt_body`

This table contains scatterometer specific body-information and is aligned with respect to generic (scatterometer specific) information in *body*-table.

Table 31: Database table `scatt_body`

Column entry	**Type**	**Description**	**Column pointer(s)**
azimuth	pk9real	Beam azimuth angle	MDBSCBAA
incidence	pk9real	Beam incidence angle	MDBSCBIA
Kp	pk9real	Instrument/Antenna Noise	MDBSCKP
invresid_1	pk9real	Inv. resid. of 1^{st} solution	MDBSCIRF
invresid_2	pk9real	Inv. resid. of 2^{nd} solution	MDBSCIRS
dirskill	pk9real	Directional skill	MDBSCDIS
mpc	pk1int	Missing packet counter	MDB_MPC_AT_SCATT_BODY

continued on next page ...

Table 31: Database table `scatt_body` *... continued*

Column entry	Type	Description	Column pointer(s)
wvc_qf	pk1int	Wind vector cell quality flag	MDB_WVC_QF_AT_SCATT_BODY
nretr_amb	pk1int	No. of retrieved ambiguities	MDB_NRETR_AMB_AT_SCATT_-BODY

7.3.15 Table `ssmi`

This table is currently undergoing a major revision. Look out for changes in future releases.

Table 32: Database table `ssmi`

Column entry	Type	Description	Column pointer(s)
orbit	pk1int	Orbit number	MDBORNO
scanline	pk1int	Scan line number	MDBSLNO
scanpos	pk1int	Position number along scan	MDBPNAS
typesurf	pk1int	Type of surface	MDBTOS
vertsign	pk1int	Vertical significance	MDBVSG
zenith	pk9real	Zenith angle	MDBZAN
iterno_conv_-1dvar	pk1int	No. of iterations for convergence	MDB1DNIT
failure_1dvar	pk1int	Failure indicator	MDB1DFIN
surfpress[1]	pk9real	Surface pressure	MDB_SURFPRESS_AT_SSMI(1)
skintemp[1]	pk9real	Skin temperature	MDB_SKINTEMP_AT_SSMI(1)
u10m[1]	pk9real	u-component of 10 metre wind	MDB_U10M_AT_SSMI(1)
v10m[1]	pk9real	v-component of 10 metre wind	MDB_V10M_AT_SSMI(1)
prec_st[2]	pk9real	Surface strat. precip. ???	MDB_PREC_ST_AT_SSMI(1:2)
prec_cv[2]	pk9real	Surface conv. precip. ???	MDB_PREC_CV_AT_SSMI(1:2)
ssmi_body	`@LINK`	Offset & length to table ... `ssmi_body`	MLNK_SSMI2SSMI_BODY

7.3.16 Table `ssmi_body`

Table 33: Database table `ssmi_body`

Column entry	Type	Description	Column pointer(s)
radcost	pk9real	1dvar radiance cost	MDB_RADCOST_AT_SSMI_BODY

continued on next page ...

Table 33: Database table `ssmi_body` *. . . continued*

Column entry	**Type**	**Description**	**Column pointer(s)**
rad_cost	pk9real	Cost fraction Jo_1/Jo_n	MDB_RAD_COST_AT_SSMI_BODY
rad_obs	pk9real	Radiance observation	MDB_RAD_OBS_AT_SSMI_BODY
rad_fg_depar	pk9real	Radiance first guess departure	MDB_RAD_FG_DEPAR_AT_SSMI_-BODY
rad_an_depar	pk9real	Radiance analysis departure	MDB_RAD_AN_DEPAR_AT_SSMI_-BODY
rad_obs_err	pk9real	Radiance obs. error	MDB_RAD_OBS_ERR_AT_SSMI_-BODY
rad_bias	pk9real	Radiance bias	MDB_RAD_BIAS_AT_SSMI_BODY
frequency	pk9real	Channel centre frequency	MDBSSCCF
bandwidth	pk9real	Channel bandwidth	MDBSSCBW
polarisation	pk9real	Antenna polarisation	MDBSSANP
press	pk9real	Model level pressure	MDB1DVPS
temp[2]	pk9real	Model level temperature(s)	MDB1DVBT, MDB1DVAT
q[2]	pk9real	Model level specific humidity(-ies)	MDB1DVBQ, MDB1DVAQ,
rain[2]	pk9real	Liquid precipitation flux	MDB_RAIN_AT_SSMI_BODY(1:2)
snow[2]	pk9real	Frozen precipitation flux	MDB_SNOW_AT_SSMI_BODY(1:2)
clw[2]	pk9real	Cloud water	MDB_CLW_AT_SSMI_BODY(1:2)
ciw[2]	pk9real	Cloud ice	MDB_CIW_AT_SSMI_BODY(1:2)
cc[2]	pk9real	Cloud cover	MDB_CC_AT_SSMI_BODY(1:2)

7.3.17 Table `atovs`

Table 34: Database table `atovs`

Column entry	**Type**	**Description**	**Column pointer(s)**
scanline	pk1int	Scan line number	MDBSCLA
fov	pk1int	Field of view number	MDBFOVA
station_height	pk9real	Height of station	MDBSTHA
zenith	pk9real	Satellite zenith angle	MDBSAZA
bearing_az-imuth	pk9real	Bearing or azimuth	MDBSABA
solar_zenith	pk9real	Solar zenith angle	MDBSOZA
solar_azimuth	pk9real	Solar azimuth	MDBSOBA
cldptop[1:3]	pk9real	Cloud top press. from HIRS	MDB_CLDPTOP1..3_AT_ATOVS
cldne[1:3]	pk9real	Cloud emissivity from HIRS	MDB_CLDNE1..3_AT_ATOVS
vertsign[3:4]	pk1int	Vertical significance	MDBVS3..4A
landsea	pk1int	Land/Sea qualifier	MDBLSQA
landsurf_height	pk9real	Height of land surface	MDBHLSA
skintemp	pk9real	Skin temperature	MDBSKTA
press_2	pk9real	Pressure 2	MDBPP2A

continued on next page . . .

Table 34: Database table `atovs` . . . *continued*

Column entry	Type	Description	Column pointer(s)
iterno_1dvar	pk1int	1DVAR iteration number	MDB1DITA
error_1dvar	pk1int	1DVAR error(s)	MDB1DERA
channel_-1dvar_0	pk1int	1DVAR sat. channel(s) used	MDB1DCUA
channel_-1dvar_1	pk1int	1DVAR sat. channel(s) used (cont.)	MDB1DCU1A
presat_flags	pk1int	PRESAT summary flags	MDB1DPFA
iterno_conv_-1dvar	pk1int	1DVAR no. of iter. for convergence	MDB11DINA
failure_1dvar	pk1int	1DVAR failure indicator	MDB11DFIA
landsea_obs	pk1int	Land/sea surface from obs. report	MDB_LANDSEA_OBS_AT_ATOVS
atovs_pred	`@LINK`	Offset&length to `atovs_-pred`	MLNK_ATOVS2ATOVS_PRED

7.3.18 Table `atovs_pred`

In the following table the dimension (i.e. number of columns) for the item `skintemp` is the number of updates (`$NMXUPD`).

Table 35: Database table `atovs_pred`

Column entry	Type	Description	Column pointer(s)
predictor[16]	pk9real	Sixteen predictors	MDB1BCP1..16A
skintemp[:]	pk9real	Skin temperature per update	MDB1BCPTS1(:)

7.3.19 Table `bufr`

This table contains raw BUFR-data in bulk 4-byte chunks.

Table 36: Database table `bufr`

Column entry	Type	Description	Column pointer(s)
data	bufr	BUFR-data, 4-bytes per element	MDB_MSG_AT_BUFR

7.4 Database ECMASCR

Database ECMASCR has the same hierachy as ECMA (see figure **??**).

The ECMASCR should have the same layout as ECMA. It purpose, if used at all, is to allow creation of "raw" ECMA-database, where observation distribution between pools or MPI-tasks is not perfect. The program odbshuffle can create a more balanced database ECMA from ECMASCR.

7.5 Database CCMA

The CCMA is a stripped down version of database ECMA. It contains fewer tables and column entries than ECMA. In essence it contains only active observations after IFS Screening process for use by 4D-Var minimization. Only the following tables are available for database CCMA:

Table name	**Differs from** ECMA **?**
desc	NO
ddrs	NO
poolmask	NO
timeslot_index	NO
index	NO
hdr	**YES**
sat	**YES**
reo3	NO
satob	NO
atovs	**YES**
atovs_pred	NO
body	**YES**
errstat	NO
update-tables	NO

Only the tables which differ from ECMA are explained in the next subsections. For tables that do not differ, please refer directly to ECMA-tables in 7.3.

7.5.1 Table hdr

The column entries are the same as described in 7.3.6, apart from those available for ECMA only. Also some flags have less members for CCMA database, see for example 7.2.3.

7.5.2 Table sat

This table acts as a "middle-man" between table hdr and satellite specific (header-)information tables. Only the following entries are available for CCMA:

Table 37: Database table `sat`

Column entry	Type	Description	Column pointer(s)
satid	pk1int	Integer equivalent of `statid@hdr` or zero Should also equal to `ident@hdr`	MDB_SATID_AT_SAT
		Offsets & lengths to ...	
reo3	`@LINK`	`reo3`	MLNK_SAT2REO3
satob	`@LINK`	`satob`	MLNK_SAT2SATOB
atovs	`@LINK`	`atovs`	MLNK_SAT2ATOVS

7.5.3 Table `atovs`

Only the following entries are available for `CCMA`:

Table 38: Database table `atovs`

Column entry	Type	Description	Column pointer(s)
scanline	pk1int	Scan line number	MDBSCLA
fov	pk1int	Field of view number	MDBFOVA
atovs_pred	`@LINK`	Offset&length to `atovs_pred`	MLNK_ATOVS2ATOVS_PRED

7.5.4 Table `body`

The column entries are the same as described in 7.3.7, apart from those available for `ECMA` only. Also some flags have less members for `CCMA` database, see for example 7.2.3.

8 Guidelines for modifications

This section gives guidance on how to modify items in the ODB interface to IFS. Discussion in this section relates to database ECMA and CCMA only. The section covers how to

- add a column entry (page 165),
- modify a column entry (page 166),
- remove a column entry (page 167),
- add an array of column entries (page 167),
- modify an existing data query (page 168),
- add a data query (page 169),
- add a new retrieval (page 170),
- modify an existing retrieval (page 173),
- add a new table (page 173)

8.1 A checklist

Before going into too much detail it maybe useful to summarize through a checklist what needs to be done when a new column entry has to be added, so that the IFS-code will be able to access this new data from ODB. This the most common situation that user needs to address. The checklist presented here paves the way to successfully accomplish this task.

Our example shows how to add a column entry `xyz@body` i.e. an entry called `xyz` to table `body` and how to access this data column from IFS-code with the MDB-pointer `MDB_XYZ_AT_BODY`, the data which has been requested to IFS through SQL data queries. The database used in this checklist if the `ECMA`, but it could as well been the `CCMA`, in which case you need to substitute the word `ECMA` with `CCMA`.

Table 39: A checklist how to add a new column entry

Step#	Need to do	Action
1	Add the column entry **xyz@body**	Edit file odb/ddl/cma.h
2	Introduce the MDB-pointer **MDB_XYZ_AT_BODY**	Edit files ifs/common/yomdb_defs.h and ifs/common/yomdb_vars.h
3	Create a connection between the column entry and the MDB-pointer	Edit file odb/cma2odb/initmdb.F90

continued on next page . . .

Table 39: A checklist how to add a new column entry ...*continued*

Step#	Need to do	Action
4	Add (normally) two data queries	Create files odb/ddl/testhdr.sql and odb/ddl/testbody.sql
5	Create symbolic links	Make symbolic links from odb/ddl.*ECMA*/testhdr.sql and odb/ddl.*ECMA*/testbody.sql to the previous data query files under odb/ddl
6	Introduce a new retrieval by setting the *context name* to 'TESTHDR' and its viewnames to 'testhdr' and 'testbody', respectively to match the SQL-queries	Edit file odb/cma2odb/ctxinitdb.F90
7	Add statements **USE yomdb** and **#include "openmp_obs.h"** to enable access to the database	Edit the IFS-routine which needs access to observations
8	Extract data from ODB to observational arrays by adding calls to **GETDB('TESTHDR',...)** after which you will be able to access the new data column via **ROBODY(...,MDB_XYZ_AT_BODY)**	Continue editing the IFS-routine
9	Call **PUTDB('TESTHDR',...)** to put data back to the database	Further continue editing the IFS-routine

8.2 Important files and directories

The basic files and directories you need to become familiar with are as follows

- data queries (SQL) or data definition layout for a particular database, you need to look at directories `$SRC/odb/ddl` and `$SRC/odb/ddl.`*`dbname`*, where *dbname* can for example be database `ECMA`,
- ODB to IFS interface go to directory `$SRC/odb/cma2odb` (and sometimes `$SRC/odb/tools`) and also be aware of `$SRC/ifs/common` and possibly file `$SRC/ifs/module/yomdb.F90`,

- `BUFR2ODB`-software (or `ODB2BUFR`) please refer to files under `$SRC/odb/bufr2odb` and (possibly) directory `$SRC/odb/tools`.

It is important to note that ODB to IFS interface revolves mainly around the following files and directories:

- files under directories `$SRC/odb/ddl` and `$SRC/odb/ddl.`*`dbname`*, of which most notable is `$SRC/odb/ddl/cma.h`,
- files `$SRC/ifs/common/yomdb_defs.h` and `$SRC/ifs/common/yomdb_-vars.h`,
- files `$SRC/odb/cma2odb/initmdb.F90`, `$SRC/odb/cma2odb/ctxinitdb.F90`, `$SRC/odb/cma2odb/getdb.F90`, `$SRC/odb/cma2odb/putdb.F90`, `$SRC/odb/cma2odb/getatdb.F90`, `$SRC/odb/cma2odb/putatdb.F90`, and very seldom `$SRC/odb/cma2odb/xchangedatadb.F90`,
- main programs in directory `$SRC/odb/tools`,
- and sometimes files in directories `$SRC/ifs/module`, `$SRC/ifs/obs_-preproc`, `$SRC/ifs/pp_obs` and `$SRC/ifs/var` in order to modify subtle things in IFS observation handling.

These are usually the only files and directories one needs to worry about. If the core ODB software needs amending, then one needs to look at directories `$SRC/odb/module`, `$SRC/odb/lib` and `$SRC/odb/aux`, or `$SRC/odb/compiler` for `ODB/SQL` -compiler source code.

8.3 Adding a column entry

Suppose you need to add a new column entry **xyz** to table **body**. You need to do the following to get modifications to the ODB interface to IFS:

1. Choose the datatype for the new column entry. Normally it is

   - *pk9real* for (64-bit) floating point numbers
   - *pk1int* for (32-bit) integers[13]
   - *string* for character strings (element size is 8 bytes)
   - `YYYYMMDD` for dates in format `YYYY` (year), `MM` (month) and `DD` (day)
   - `HHMMSS` for times in format `HH` (hours), `MM` (minutes) and `SS` (seconds)

[13]Do not use 64-bit integers yet!

2. Insert line (say datatype is *pk9real*) with description
   xyz pk9real, // description
   in file `$SRC/odb/ddl/cma.h` after the line
   CREATE TABLE body

3. Choose the name of the corresponding MDB-pointer.
   The recommended name would be (assuming it fits into 31 characters):
   MDB_XYZ_AT_BODY

4. Insert the following line at the end of file `$SRC/ifs/common/yomdb_defs.h`:
   #define MDB_XYZ_AT_BODY o_(it)%mdb_xyz_at_body

5. Insert the following line at the end of file `$SRC/ifs/common/yomdb_vars.h`:
   INTEGER_M :: mdb_xyz_at_body ! 'xyz@body'

6. Insert the following line in alphabetically conforming location
   in file `$SRC/odb/cma2odb/initmdb.F90`:
   CALL cmdb_REG('xyz@body', 'MDB_xyz_AT_body', MDB_XYZ_AT_BODY, it, rc)

Note that the case of the letters in steps 4–6 must be exactly like shown, otherwise C-preprocessor will not pick up correct translation for `MDB_XYZ_AT_BODY`.

Since this new entry is now available, you may want to modify or even add a new SQL, too. This is explained in the next sections. All these changes will trigger recompilation of libraries `libifs.a`, `libodbport.a`, `libECMA.a`, `libECMASCR.a` and `libCCMA.a`.

8.4 Modifying a column entry

This is probably simplest thing to do, but probably happens also very seldom. A typical situation might be to rename an existing column name to something more descriptive and then standardize on this new definition.

Modifications start by editing and changing data definition layout include-file `$SRC/odb/ddl/cma.h` – in case of databases `CCMA`, `ECMA` and `ECMASCR`. Otherwise check the file with `ddl`-suffix in database directory, like the file `PREODB.ddl` in `$SRC/odb/ddl.PREODB` for database `PREODB`.

Then proceed with changes to the MDB-pointer mapping from file `$SRC/odb/cma2odb/initmdb.F90` : search for the old column name and rename it. After this also adjust `$SRC/ifs/common/yomdb_-vars.h` and `$SRC/ifs/common/yomdb_defs.h` accordingly. Finally modify any SQL-files under `$SRC/odb/ddl` to accomodate the modified column entry over the old one.

An example...ugh ?

8.5 Removing a column entry

To remove a column entry just edit the file `$SRC/odb/ddl/cma.h`, search for the column name to be eliminated and delete it. After this it is necessary to remove column's MDB-pointer mapping from file `$SRC/odb/cma2odb/initmdb.F90`.

Furthermore it is desirable to clean the column up from files `$SRC/ifs/common/yomdb_vars.h` and `$SRC/ifs/common/yomdb_defs.h`, too.

The final check is ensure that no SQL-file refers to this obsolescent entry anymore; so files with `sql`-suffix under directory `$SRC/odb/ddl` need to be checked. And that is all.

An example...ugh ?

8.6 Adding an array of column entries

Suppose one needs to add three new column entries, this time into table **hdr**. And all these column entries share the same characteristics, so they could be viewed as array of column entries, say **key[3]**. Since this is equivalent to adding manually three single column entries **key_1**, **key_2** and **key_3**, one should understand instructions explained already in 8.3. But there is a more convenient way to do the modification, when multiple (array) columns are concerned:

1. Choose the datatype for the column entries (as in 8.3)
2. Insert line (say datatype is *pk9real*)
   key[3] pk9real, // description
   into file `$SRC/odb/ddl/cma.h` in the appropriate place after line
   CREATE TABLE hdr
   Note that this was just a shorthand notation to the following:
   key_1 pk9real, // description
   key_2 pk9real, // description
   key_3 pk9real, // description
3. Choose the name of the corresponding MDB-pointer, which should now also be an array, as follows:
   MDB_KEY_AT_HDR(3)
4. Insert the following line at the end of file `$SRC/ifs/common/yomdb_defs.h`:
   #define MDB_KEY_AT_HDR o_(it)%mdb_key_at_hdr
5. Insert the following line at the end of file `$SRC/ifs/common/yomdb_vars.h`:
   INTEGER_M :: mdb_key_at_hdr(3) ! 'key[3]@hdr'
6. Insert the following line in alphabetically correct location
   in file `$SRC/odb/cma2odb/initmdb.F90`:

CALL cmdb_VECREG('key@hdr', 'MDB_key_AT_hdr', MDB_KEY_AT_HDR, 1, 3, it, rc)
This will initialize all 3 entries in one sweep and is identical with the following:
CALL cmdb_REG('key_1@hdr', 'MDB_key_AT_hdr(1)', MDB_KEY_AT_HDR(1), it, rc)
CALL cmdb_REG('key_2@hdr', 'MDB_key_AT_hdr(2)', MDB_KEY_AT_HDR(2), it, rc)
CALL cmdb_REG('key_3@hdr', 'MDB_key_AT_hdr(3)', MDB_KEY_AT_HDR(3), it, rc)

8.7 Modifying an existing data query

To see the effect of your new column entry as described in 8.3, you may just want to modify existing SQLs. All SQLs are situated under directory `$SRC/odb/ddl`, independently whether they belong to databases `ECMA` or `CCMA` or so. Database specific SQLs are found under `$SRC/odb/ddl.ECMA` (for `ECMA` in this case), but are all symbolic links to the physical SQL-files under `$SRC/odb/ddl`.

Before adding reference to the new entry `xyz@hdr` in the SQL, you should answer the following questions:

- In which SQL-file(s) this entry should be put ?
- Is the new entry a floating point/string or an integer/bitmap column ?

In this particular case it seems that you want to pass values of the new entry `xyz@hdr` into the `ROBHDR`, or solely to the `MOBHDR` if it is an integer/bitmap value. In some rare cases `SATHDR` or `SATPRED` may also be relevant.

Suppose it is *both* `ROBHDR` and `MOBHDR` that are involved. In this case we nearly always fill `ROBHDR` by calling *ODB_get*, and then we copy `N` first columns of `ROBHDR` into `MOBHDR`. (Pending `CTXINITDB` definitions explained in 8.9) (Please see `CTXGETDB` and `INTCOLDB`). These first columns of SQL have to be genuinely integer/bitmap-valued or integer overflow/underflow or floating point exception will occur. If any integer valued columns are found *after* N^{th} column, the check performed by routine `INTCOLDB`, will ensure program will abort.

Bearing in mind these limitations, you indeed need to know what your column datatype is that you are about to add into the existing SQL. Therefore there are two possibilities:

1. If you have the entry **seqno** present (recommended), it must be always the first entry in the header and body data queries (in order to get the variable `MLNKH2B` right)
2. If the datatype is integer-kind, add column at the beginning, but only after entry **seqno**, if that is present
3. If the datatype is floating point-kind, then add the column at the end of **SELECT**-statement's list of column entries (after the integer-kinds)

In this particular example of **xyz@hdr**, the change would be as follows, when datatype is *pk9real*:

Original SQL	Modified SQL

CREATE VIEW testhdr AS
SELECT seqno, obstype,
lat, lon
FROM index, hdr
WHERE tslot = 1
	CREATE VIEW testhdr AS
	SELECT seqno, obstype,
	lat, lon, $\boxed{\textbf{xyz}}$
	FROM index, hdr
	WHERE tslot = 1

and as follows, when datatype is *pk1int*:

Original SQL	Modified SQL

CREATE VIEW testhdr AS
SELECT seqno, obstype,
lat, lon
FROM index, hdr
WHERE tslot = 1
	CREATE VIEW testhdr AS
	SELECT seqno, $\boxed{\textbf{xyz}}$, obstype,
	lat, lon,
	FROM index, hdr
	WHERE tslot = 1

8.8 Adding a new data query

A new set of SQLs typically needs to be added for a new retrieval associated with a new pair of `GETDB` and `PUTDB` calls inserted into IFS. Since SQLs could be generic i.e. used by both `ECMA` and `CCMA`, it is strongly advised to create them under `$SRC/odb/ddl` directory.

Under the ECMWF's ClearCase version handling system adding new SQLs to ODB IFS -interface obeys the following guidelines:

1. Go to `/ccvobs/odb/ddl` :

   ```
   % cd /ccvobs/odb/ddl
   ```

2. Add and edit SQL file :

   ```
   % addfile -f newfile.sql
   ```

3. Go to database `ECMA` specific directory (becomes current directory) :

```
% cd /ccvobs/odb/ddl.ECMA
```

4. Check-out current directory (`cleartool`-command alias is normally `ct`) :

```
% ct co -nc .
```

5. Create relative *ClearCase* symbolic link to SQL-file :

```
% ct ln -s ../ddl/newfile.sql .
```

6. Check-in current directory directory :

```
% ct ci -nc .
```

If SQLs are also related to `CCMA`, you have to repeat steps 3–6 under directory the `/ccvobs/odb/ddl.CCM` too.

If this is not in ClearCase, then replace in the previous `/ccvobs` with `$SRC`, ignore steps 4 and 6, replace `addfile` with your preferred editor command, and finally replace `ct ln` with regular symbolic link command `ln`.

8.9 Adding a new retrieval

To do this you need to modify file `$SRC/odb/cma2odb/ctxinitdb.F90`. A typical case is where four SQLs get assigned to one new retrieval. The first SQL is normally a driving force to fill `ROBHDR` and the third SQL drives `ROBODY` filling. The second and the fourth one are normally for `MOBHDR` and `MOBODY`, respectively. Typically they do not get their values by executing SQL (*ODB-select* followed by *ODB_get*) to fill the arrays, but copy the `N` first columns out of corresponding `ROBHDR` and `ROBODY` – as described in 8.7.

Here is the outline of what you should add to routine `$SRC/odb/cma2odb/ctxinitdb.F90` :

1. Decide if this retrieval is meant for database `ECMA` or `CCMA` or both, or has some other condition to get initialized. If it is for only, say, `ECMA`, make use of predefined flag `LLECMA`
2. Suppose you need to add one new retrieval called `HIPHOP`, version zero (0). It will be bound to SQLs explained in 8.7, 4 views are involved, but 2 of them share data with their master (e.g. `MOBHDR` $\rightarrow$ `ROBHDR`). In most of the cases you just need to add the following piece of code (at the bottom of the source file, just before end of internal subroutine `delayed_init`):

```
if (LLECMA) then
  CALL next_context('HIPHOP', version=0, nviews=4)
  do it=1,inumt
    ctx(idctx,it)%view(1)%name  = 'testhdr' ! SQL-name
    ctx(idctx,it)%view(1)%ncase = JPCASE_ROBHDR

    ctx(idctx,it)%view(2)%name  = 'testhdr'
    ctx(idctx,it)%view(2)%ncase = JPCASE_MOBHDR
    ctx(idctx,it)%view(2)%execute = .FALSE.
    ctx(idctx,it)%view(2)%shared_index = 1 ! Ref. to view(1)
    ctx(idctx,it)%view(2)%mlnkh2b = 4      ! Ref. to view(4)

    ctx(idctx,it)%view(3)%name  = 'testbody' ! SQL-name
    ctx(idctx,it)%view(3)%ncase = JPCASE_ROBODY

    ctx(idctx,it)%view(4)%name  = 'testbody'
    ctx(idctx,it)%view(4)%ncase = JPCASE_MOBODY
    ctx(idctx,it)%view(4)%execute = .FALSE.
    ctx(idctx,it)%view(4)%shared_index = 3  ! Ref. to view(3)
  enddo
endif
```

After this one can add the following new `GETDB` and `PUTDB` calls to IFS to get some action:

```
SUBROUTINE hiphop(...)
USE YOMDB
...
implicit none
INTEGER(kind=JPRM) :: info(0)
REAL(kind=JPRB)    :: zinfo(0)
...
INTERFACE
#include "getdb.h"
#include "putdb.h"
END INTERFACE
...
#include "openmp_obs.h"
!-- begin : the very first executable statement
!-- Execute SQLs
iret=0
iversion=0
CALL GETDB('HIPHOP',iversion,iret, &
          & info, size(info), zinfo, size(zinfo), &
          & -1, -1, -1, -1, -1, -1)
```

```
if (iret > 0) then
  !-- Do something with ROBHDR, MOBHDR, ROBODY & MOBODY
endif
...
!-- Update back to (in-memory) database
!   (usually the last thing in the file)
CALL PUTDB('HIPHOP',iversion,iret, &
          & info, size(info), zinfo, size(zinfo))
END SUBROUTINE hiphop
```

Subroutine `HIPHOP` executes SQLs to retrieve data into arrays `ROBHDR` etc. There are two important points. Firstly, this is OpenMP-thread-safe i.e. the observational arrays are filled per OpenMP-thread and this subroutine can be called safely from within an OpenMP-loop. Secondly, the way we define the retrieval in subroutine `CTXINITDB` did not impose any MPI-parallelism i.e. observational arrays are filled using only local observational data [14]. That is to say, from data pools belonging to the owner MPI-task.

The first point means that you can have *many* retrievals open simultaneously as long as there is only one per OpenMP-thread. To top up the second point, it is also possible to retrieve observational data globally. For example, you may want to view a global flight path and not care about how the aircraft observations were distributed across MPI-tasks or data pools. To accomplish this you just need to add *one* line into `CTXINITDB` after beginning of your `do it=1,inumt`-loop:

```
     do it=1,inumt
       ctx(idctx,it)%replicate_PE = -1 ← add this line
       ctx(idctx,it)%view(1)
```

This is very convenient but also currently very expensive. You essentially ask for data to be replicated across MPI-tasks. Not only is the volume of data much larger than the locally owned data, but also extra operations need to be performed by the core ODB library to communicate data between MPI-tasks. So only use this option if you *really* need it.

The characteristics of the function *ODB_put* (called indirectly by the routine `PUTDB`) are such that in case of replicated views, the update is applied only to local data. That is to say, you can modify as much as you like remote data in your observational arrays, but *ODB_put* will not put these modifications back to their remote MPI-tasks. This stems from the fact that *ODB_put* does not perform any message passing between MPI-tasks (when `replicate_PE` was set to -1), whereas data gathering phase (*ODB_get*) involves message passing for replicated views.

[14]The variable `replicate_PE` was *not* set to -1

It is important to note that replicated views can only work correctly if your program runs in single threaded OpenMP-mode, that is to say: do not use replicated retrievals, if the calling subroutine is in an OpenMP-loop.

8.10 Modifying an existing retrieval

Usually this involves modifications to routine `$SRC/odb/cma2odb/ctxinitdb.F90` only, and rarely to `$SRC/odb/cma2odb/getdb.F90`.

An example...ugh?

8.11 Adding a new table

To add a new table, you often need to modify many files, since it may affect several functions in the ODB interface to IFS. Luckily it is very seldom that new tables need to be introduced, since it is preferable to use the existing ones.

Anyway, here is one recipe for doing the modification. Suppose the table name is called **abcd**. It all starts by modifying our usual data layout file `$SRC/odb/ddl/cma.h`. Decide how the table to be added needs to be related with respect to other tables and add `@LINK`to this new table from parent-to-be table as follows:

```
        abcd @LINK ,
```

Then proceed by adding the table definition. Usually it suffices to add this at the end of data layout file. Do something like this:

```
CREATE TABLE abcd (
        col_1 pk1int , // description for column#1
        col_2 pk9real , // description for column#2
        col_3 string ,// description for column#3
);
```

Decide whether this table needs to be visible to the `CCMA`-database at all. If not, then encapsulate the previous table definition with the conditional block:

```
#ifdef ECMA
// table definition here (visible to ECMA & ECMASCR only)
#endif
```

After this modify the file `$SRC/odb/cma2odb/ctxinitdb.F90` in order to add the new table in the list of "recognized" tables (variable `tables`) and possibly add some retrievals as explained before. Also new data queries are probably needed, or at least existing one may need to refer to the new table (`FROM`-clause).

The rest is quite mechanical: all the columns in the new table are completely unknown to the ODB interface to IFS and the system needs to be told about these. So follow instructions in section 8.3.

Finally, this new table may be loaded outside the ODB interface to IFS[15]. Otherwise routine `$SRC/odb/cma2odb/putatdb.F90` needs to be understood, but is out of the scope of this document ;-)

[15]Some external ODB-program which directly fills up the table – and makes a correct parental `@LINK`

9 Using other database layouts

This section describes other recognized (i.e. permanent) databases, how to create your own databases which may or may not have anything to do with observation handling, and how to create permanent database layouts which will be automatically recognized by the ODB software without "work-arounds".

Currently the recognized databases are `CCMA`, `ECMA` and `ECMASCR` described in the previous chapter, and also database `PREODB` – mostly for historical reasons. The latter one is described below.

9.1 Database PREODB

This was the very first ODB-database – already well before the ODB software went operational at ECMWF.

At ECMWF this database was used to feed `ERA40`-reanalysis with conventional observations. The main application was to perform duplicate data checking on `PREODB` prior to analysis, since observations in this database were derived from many sources (meteorological institutes and organizations) around the world and there were lots of potential duplicate observations which, if entered to the analysis, would have completely destroyed its quality.

There is over 200GB of online data in `PREODB` that covers ERA-40 assimilation from September 1957 till December 2001. Data are split into 6 hourly time-windows. When duplicate checking was performed, only the most trusted observations (and a unique set among duplicates) were selected for the ERA-40 3D-FGAT-analysis.

Database `PREODB` contains only four tables: `desc`, `hdr`, `body` and `bufr`. The end result of duplicate checking procedure actually uses mainly tables `hdr` and `body` to pull out the right `BUFR`-messages for ERA-40 analysis. A typical SQL was as follows (say, for 19780202, 12UTC):

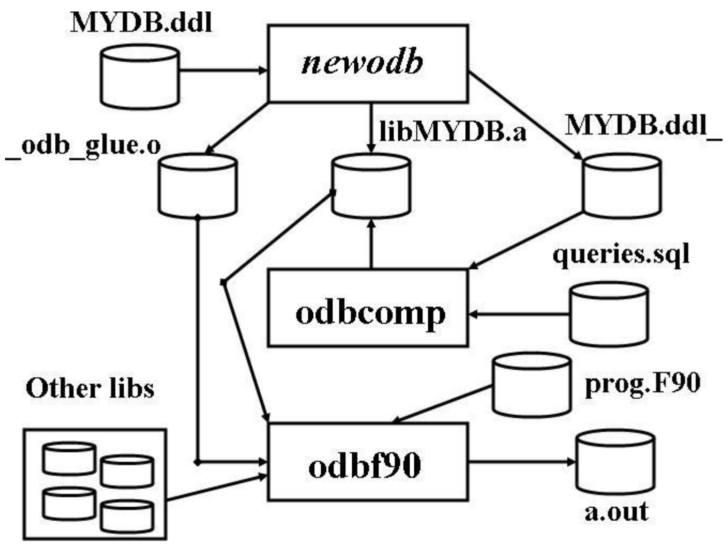
```
SET $andate = 19780202;
SET $antime = 120000;
CREATE VIEW query AS
    SELECT msg@bufr
    UNIQUEBY seqno, andate, antime
      FROM desc, hdr, body, bufr
    WHERE andate = $andate
      AND antime = $antime
      AND duplseqno[1] == 0
;
```

The key element was the item `duplseqno[1] == 0` in the WHERE-condition, since it indicidated whether the selected observation (BUFR-message) was either free from duplicates or was the most trusted observation to be selected into the analysis. Details of how duplicate checking is performed can be seen from figures 22 and 23[16].

9.2 User defined, temporary databases

In the latest ODB software release it is possible to introduce user defined database layouts into the system relatively easily. This is especially true for the interactive ODB environment.

Figure 21: Use `newodb` -command to create your own database library



User defined database differ from permanent databases in such a way that the ODB software has built-in (apriori) knowledge of permanent databases, whereas user defined databases need to be explicitly introduced to the software on-the-fly (technically speaking: through the file `_odb_glue.o`).

The easiest way to introduce user defined database is to

1. Decide the name of your database (say `MYDB`)[17]
2. Create data definition layout file `MYDB.ddl` containing at least table definition(s) and linking structure between tables

[16]Kindly supplied by Vanda Da Costa Bechtold, ECMWF

[17]Must start with a letter `[A-Z]` optionally followed by letter(s) `[A-Z]` and/or number(s) `[0-9]`. No underscores, lowercase letters or blanks allowed

3. Create database specific library `libMYDB.a` by using command:

```
% newodb MYDB
```

4. Supply SQL-file(s) associated with this database and compile them into library `libMYDB.a` as follows (say you have only two queries):

```
% odbcomp -lMYDB query1.sql query2.sql
```

5. Compile (or just re-link) your ODB-application program via command:

```
% odbf90 myprog.F90 -lMYDB -o myprog.x
```

6. Run

```
% ./myprog.x [optional_input_parameters]
```

When your need to supply another set of SQL-files (and disregard the ones supplied in step#4), you just have to repeat the procedure from step#4. That is to say re-compilation of new set of SQLs is necessary as well as re-linking of the ODB-application program.

The command `newodb` is in fact merger of two separate commands. The following

```
$ odbcomp MYDB.ddl
$ create_odbglue MYDB
```

is an equivalent (or a short-hand) notation for

```
% newodb MYDB
```

In fact the command `newodb` is the preferred way to access permanent databases, too. So if you need to deal with two or more databases, you should still use the `newodb`-command. There can be a practical situation to extract from usually a large `ECMA`-database (i.e. permanent database) data into a much smaller database `MYDB` in order to create a more manageable "subset" or work-database. Yet your ODB-application needs to be aware of that. The command dialogue is simply:

```
$ newodb ECMA.sch MYDB.ddl
# Queries associated with database MYDB
$ odbcomp -lMYDB query1.sql query2.sql
# A query associated with database ECMA
$ odbcomp -lECMA extract.sql
$ odbf90 myprog.F90 -lECMA -lMYDB -o myprog.x
```

Note that we used ECMA.sch, not ECMA.ddl-file for data layout file of the permanent database, since we assume that this database exists (i.e. database files accompanied its metadata). Actually, we may not have a trace (clue) of the original ECMA.ddl-file at all[18].

Note also that we compiled two sets of queries: one for database ECMA and the other for MYDB. And then in the linking of the ODB-application we supply both database libraries. Note that the single command

```
% newodb ECMA.sch MYDB.ddl
```

could have been replaced with the following (now three) lines:

```
$ odbcomp ECMA.sch
$ odbcomp MYDB.ddl
$ create_odbglue ECMA MYDB
```

Naturally the one-liner looks more appealing.

9.3 Adding new databases in permanent basis

It maybe necessary to create a new database layout and make it a permanent database in the same manner as database ECMA. Lets call the new database DB. This is what you need to do, if you are under the ECMWF's ClearCase system [19]:

1. Go to /ccvobs/odb :

   ```
   % cd /ccvobs/odb
   ```

2. Create new (ClearCase) directory for database DB :

   ```
   % ct mkdir ddl.DB
   ```

3. Change (ClearCase) protections :

   ```
   % ct protect -chown rdx -chgrp rd -chmod 555 ddl.DB
   ```

After this you must create data definition layout file (DB.ddl) under /ccvobs/odb/ddl.DB and SQL-files *still* under generic place /ccvobs/odb/ddl. See more chapter 8.

[18] On some very old ODB-databases, like PREODB even its PREODB.sch does not exist, but we can always re-create it from the data dictionary file PREODB.dd using utility dd2ddl.x

[19] if not, then replace /ccvobs with $SRC

Figure 22: Duplicate checking with PREODB, part#1

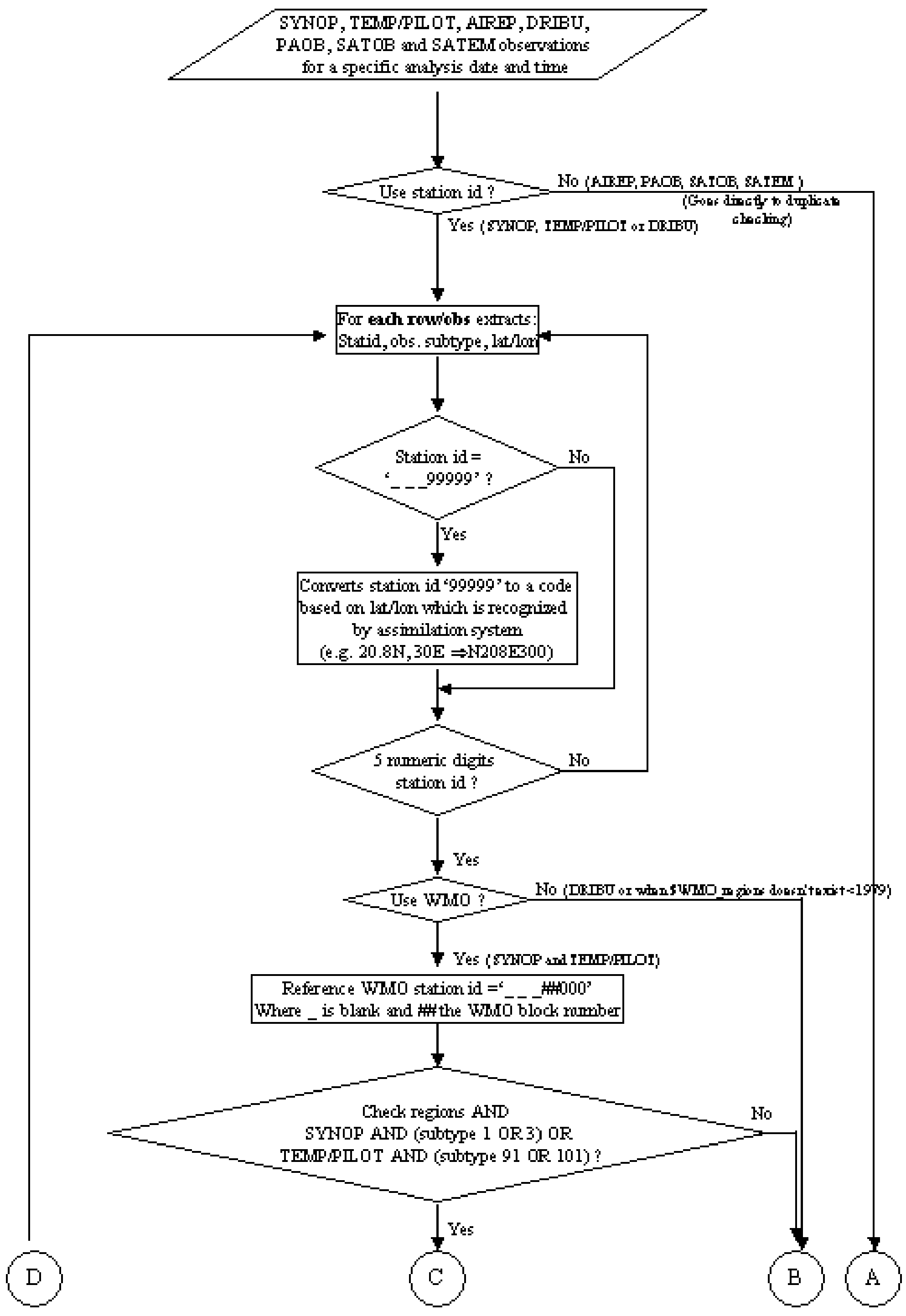
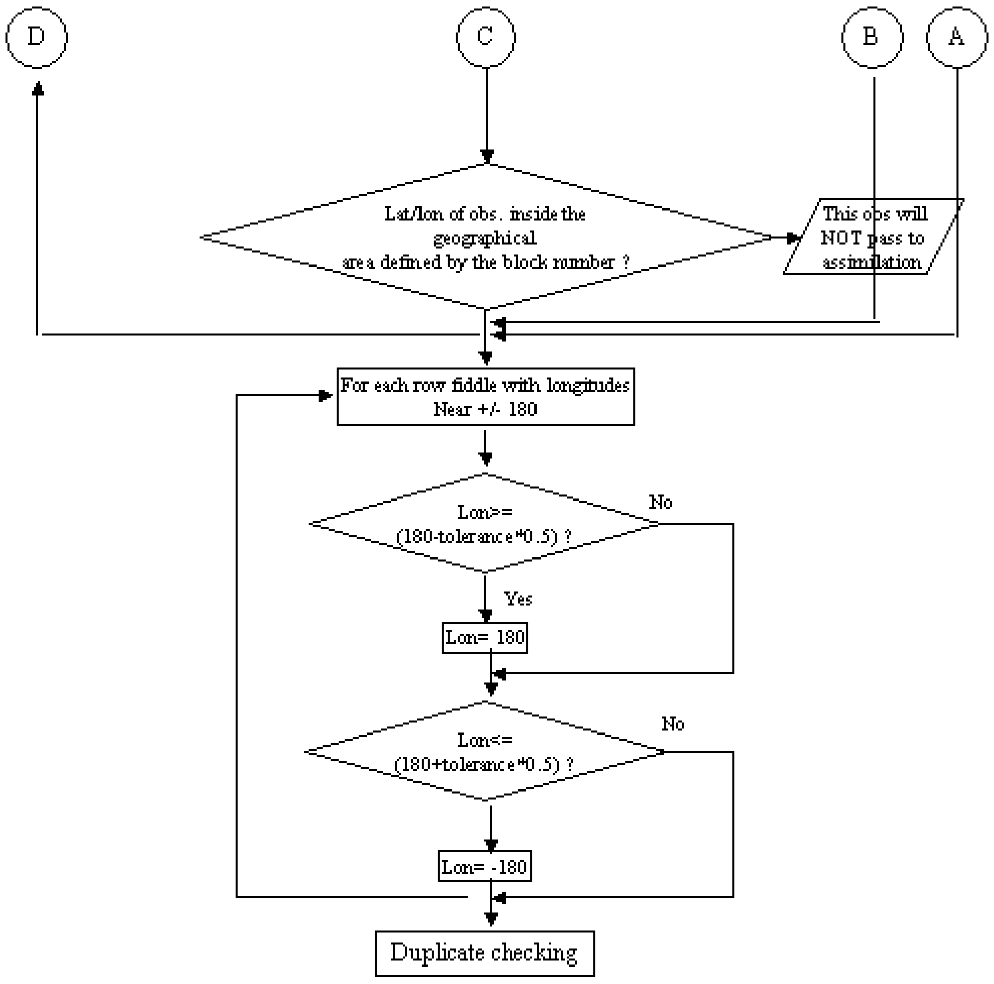

SYNOP, TEMP/PILOT, AIREP, DRIBU, PAOB, SATOB and SATEM observations for a specific analysis date and time
Use station id ?
No (AIREP, PAOB, SATOB, SATEM)
(Goes directly to duplicate checking)
Yes (SYNOP, TEMP/PILOT or DRIBU)
For **each row/obs** extracts: Statid, obs. subtype, lat/lon
Station id = '_ _ _99999' ?
No
Yes
Converts station id '99999' to a code based on lat/lon which is recognized by assimilation system (e.g. 20.8N, 30E ⇒N208E300)
5 numeric digits station id ?
No
Yes
Use WMO ?
No (DRIBU or when $WMO_regions doesn't exist <1979)
Yes (SYNOP and TEMP/PILOT)
Reference WMO station id ='_ _ _##000' Where _ is blank and ## the WMO block number
Check regions AND SYNOP AND (subtype 1 OR 3) OR TEMP/PILOT AND (subtype 91 OR 101) ?
No
Yes
D
C
B
A

Figure 23: Duplicate checking with PREODB, part#2

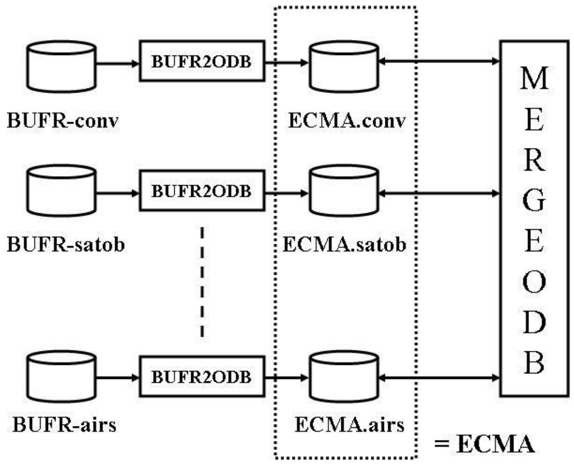

D
C
B
A
Lat/lon of obs. inside the geographical area defined by the block number ?
This obs will NOT pass to assimilation
For each row fiddle with longitudes Near +/- 180
Lon>= (180-tolerance*0.5) ?
No
Yes
Lon= 180
Lon<= (180+tolerance*0.5) ?
No
Lon= -180
Duplicate checking

10 ODB applications

Apart from user ODB-applications, there are a few ODB-applications that are capable of retrieving data automatically from ODB, or being able to create a database from user input (either from `BUFR` or text files). In addition there is a test version of an ODB-to-NetCDF translator.

10.1 BUFR2ODB

Figure 24: BUFR to ODB/ECMA translation procedure



This decodes observations in BUFR-format and translates them into ODB databases `ECMA` or `ECMASCR`. BUFR-messages are expanded from the Input_file and required parameters are written into ODB format . Usage of the command *bufr2odb* is as follows:

```
bufr2odb    -i input_file [-p add_pool]
            [-s npools] [-n] [-d thinning] [-l dbname]
```

The options denote :

`-i input_-file`	Input BUFR-file prefix. A suffix *".poolno"* will be added, so the actual BUFR-files to be opened will be *input_file*.1, *input_file*.2, etc.
`-p add_pool`	Add *add_pool* number of new pools on the top of existing. Default is 0.
`-n`	New database will be created regardless whether old one already exists.

`-s npools`	Number of pools required for new database.
`-d thinning`	Rudimentary thinning. By default the *thinning*-parameter is set to 1 i.e. every observational position will be included. However, if *thinning* $>$ 1, only every *thinning*'th spot will be passed to database.
`-l dbname`	Database name. By default it is `ECMA`, but it also could be `ECMASCR`.

The following environment variables are honoured:

Environment variable	Description	Default value
NUM_MESS	No. of BUFR messages to process	-1
ODB_IO_METHOD	Choose I/O-method : 1 or 4	1

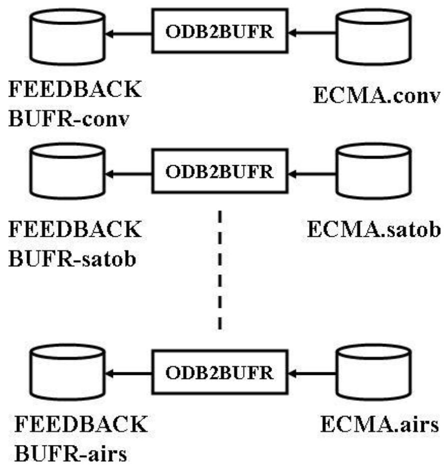
This program only loads the required (known) BUFR-subtypes. Valid BUFR subtype to be handled are:

BUFR subtype	Name
1	SYNOP LAND
3	SYNOP LAND (AUTOMATIC)
9	SYNOP SHIP (ABBREVIATED)
11	SYNOP SHIP
13	SYNOP SHIP (AUTOMATIC)
19	SYNOP SHIP (REDUCED)
21	SURFACE BUOY
22	SURFACE BATHY
23	SURFACE TESAC
51	TOVS 120 KM RESOLUTION
52	TOVS 80 KM RESOLUTION
53	RTOVS
54	TOVS1C(CALIBRATED IN ECMWF)
55	ATOVS (CALIBRATED IN UK MET OFFICE)
57	AIRS
65	SATEM
75	DMSP SATEM
82	SATOB WINDS
83	SATOB WINDS
87	HIGH DENSITY WINDS
89	GEOSTATIONARY RADIANCES
91	PILOT LAND

92	PILOT SHIP
95	WIND PROFILER
96	WIND PROFILER
101	TEMP LAND
102	TEMP SHIP
103	TEMP DROP
104	ROCOB LAND
105	ROCOB SHIP
106	TEMP MOBILE
122	WIND SCATTEROMETER DATA ERS
127	SSMI /T-1 BRIGHTNESS TEMPERATURE
137	QSCAT WINDS
206	SBUV - OZONE , ENVISAT
142	AIREP
144	AMDAR
145	ACAR
164	PAOB

10.2 ODB2BUFR

Figure 25: ODB/ECMA to feedback-BUFR translation procedure



A program to read `ECMA` (or `ECMASCR`) ODB-database and create BUFR feedback. This program creates new style analysis feedback files. There are four files created with the following file extensions:

.main	containing original bufr observations and summary quality control
.qc	containing analysis variables and quality control information
.fos	containing analysis variables and first order statistics information
.dep	containing analysis variables and anlysis departures information

A suffix *".poolno"* will be added at the end of these extensions . Usage of the command *odb2bufr* is as follows:

```
odb2bufr    -o output_file [-l dbname] [-u nupdates] [-I
            inc_subtype] [-E exc_subtype] [-B basetime] [-
            T time_window]
```

The options denote :

`-o output_-file`	Output BUFR-file prefix. A suffix *".poolno"* will be added, so the actual (series of) BUFR-files written will be *output_-file*.main.1, *output_file*.qc.1, *output_file*.fos.1, *output_file*.dep.1, *output_file*.main.2, *output_file*.qc.2, *output_file*.fos.2, *output_-file*.dep.2, etc.
`-l dbname`	Database name. By default it is `ECMA`, but it also could be `EC-MASCR`.
`-u nupdates`	Number of updates. IFS scripts normally are set from environment variable `$MXUP_TRAJ`.
`-T time_win-dow`	Time window (in hours) to which apply the BUFR-feedback creation. By default = 6. Time window starts from given *basetime*.
`-B basetime`	Basetime for time-windowed BUFR-feedback creation. Must be in format `YYYYMMDDHH`, e.g. for 12UTC on 1st of April 2003 basetime would be 2003040112. If not given, BUFR-feedback will be created for *all* data found in the ODB-database, which may/may not be against archive policy.
`-I inc_sub-type`	Only these subtypes will be processed. Option can/should appear multiple times. Value for *inc_subtype* should generally be between 1 and 255 (both inclusive), but value 0 ensures that *all* subtypes not in exclusion list via *-E*-option will be processed.
`-E exc_sub-type`	These subtypes will *not* be processed unless subsequent *-I*-option overrides. Value for *exc_subtype* should be between 1 and 255.

The same subtypes are supported as in `bufr2odb`. The following environment variables are honoured:

Environment variable	Description	Default value
SUMMARY	Produce *.main*-part	true
QC	Produce *.qc*-part	true
FOS	Produce *.fos*-part	true
DEP	Produce *.dep*-part	true
MXUP_TRAJ	Maximum no. of updates	N/A

10.3 ODB-viewer

The ODB-viewer was originally designed to be just a debugging tool to cross-check that database contains desired data items. However, it has evolved into a more mature product, which enables a textual report to be produced for each data query. And if latitude and longitude information is present, then data coverage plot can be produced (using Magics software).

To start ODB-viewer do the following (after typing "`use odb`"):

```
$ cd CCMA
$ odbviewer -f CCMA.sch CCMA
```

When the prompt comes, you just type a view name (say *myview* – without any suffix). An editor session (using your preferred editor through the `ODB_EDITOR` environment variable) opens a window to a file `myview.sql` for you to edit. There you specify column and table names and `WHERE`-condition to extract data. Come out from editor and ODB-viewer will actually compile and execute the query. A new window will be opened and a textual result of your query appears. From that window, by choosing `Plot` and `Coverage plot` you can visualize the data coverage.

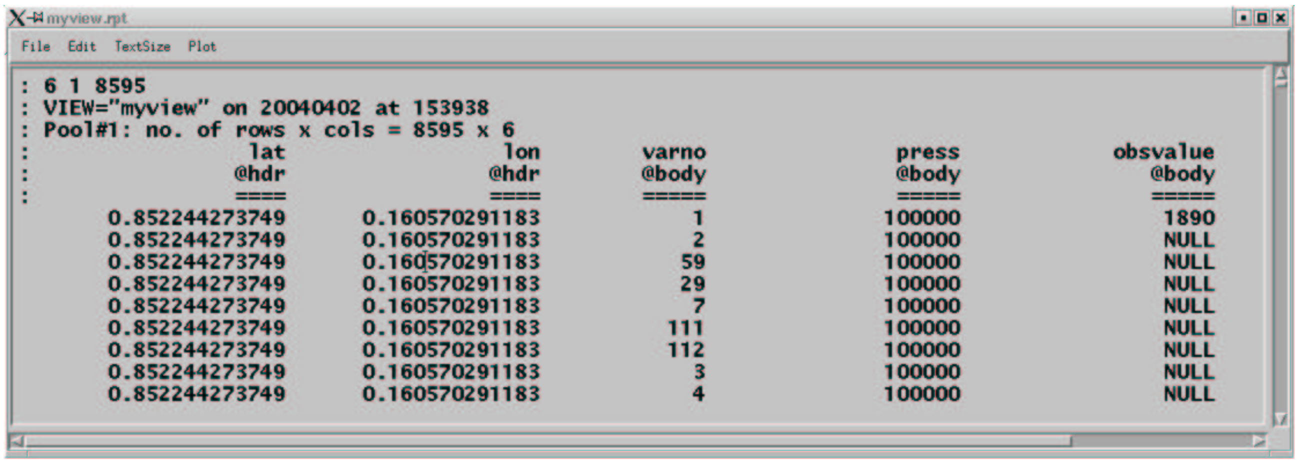
The next thing is to modify you query or launch another query. And the same thing happens over again. Pressing ctrl-D (end of file) or typing a period-character (`.`) terminates ODB-viewer session.

10.4 simulobs2odb

In the latest ODB version there is a prototype version for loading a database directly from a text file. This can be a useful option when developing software or loading own databases and BUFR-definitions (for example) are not yet fixed.

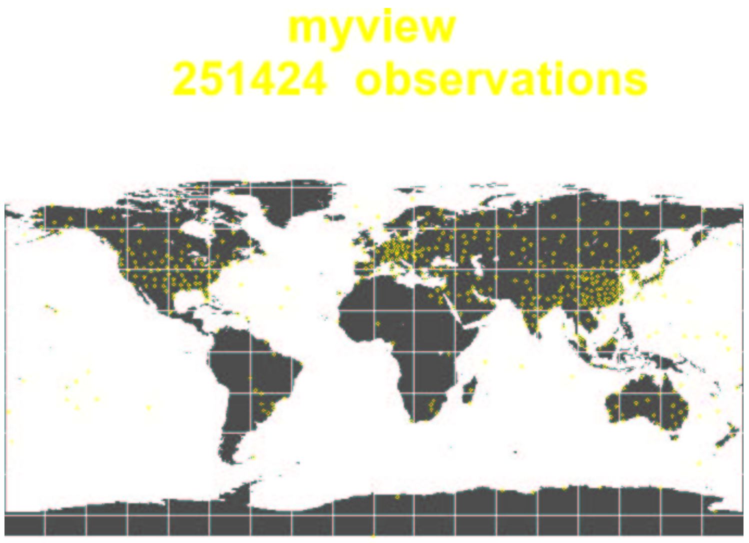
This prototype has already been used successfully in migrating radio-occultation observations into the IFS code (by Sean Healy, ECMWF) before their BUFR-layout was even decided.

Figure 26: An example of ODBVIEWER-report output



```
: 6 1 8595
: VIEW="myview" on 20040402 at 153938
: Pool#1: no. of rows x cols = 8595 x 6
:                 lat               lon      varno          press      obsvalue
:                @hdr              @hdr      @body          @body         @body
:                ====              ====      =====          =====         =====
       0.852244273749    0.160570291183          1         100000          1890
       0.852244273749    0.160570291183          2         100000          NULL
       0.852244273749    0.160570291183         59         100000          NULL
       0.852244273749    0.160570291183         29         100000          NULL
       0.852244273749    0.160570291183          7         100000          NULL
       0.852244273749    0.160570291183        111         100000          NULL
       0.852244273749    0.160570291183        112         100000          NULL
       0.852244273749    0.160570291183          3         100000          NULL
       0.852244273749    0.160570291183          4         100000          NULL
```

Figure 27: An example of ODBVIEWER-report coverage plot



10.5 odb2netcdf

Another prototype has also been tested. It allows a pre-compiled SQL data query to extract data from a database and write it into NetCDF format complying ??? specifications from ...

10.6 odb2mysql

Similar to the `odb2netcdf`-program, it is possible to extract data from ODB into a popular relational MySQL-database. This software is still under development.

A Environment variables

This appendix describes every environment variable used directly or indirectly by the ODB software.

ODB-specific environment variables

Environment variables listed here are given in alphabetical order.

ODB_CATCH_SIGNALS

It is possible to catch error conditions through the ODB software by setting this environment variable to 1. This means, that when some unexpected memory violation occurs, the ODB system tries to catch signals sent by the Unix-system and produce a traceback in order to pin-point the file name and line number, where the error occurred.

See also `ODB_ERRTRA` (see p.191) and `ODB_TRACE_PROC` (see p.195) .

This environment variable has become obsolete in CY28R2 due to introduction of Dr.Hook, which has a more robust way of catching errors.

ODB_CCMA_CREATE_DIRECT

This variable is used in connection with ECMWF's 4D-Var-system. If set to 1, it tells the system to create directly the `CCMA`-database from the `ECMA`-database while IFS/Screening is still running, thus saving some important I/O-time. During development it is sometimes necessary to decouple the direct CCMA creation. Also some memory savings (in expense of higher I/O-cost) can be achieved, when this variable is set to 0 (which is also the default). See also routine `$SRC/ifs/var/writeoba.F90` .

ODB_CCMA_IGNORE_TSLOTS

When this variable is set to 1 during the `CCMA`-database creation, you can opt for ignoring 4D-Var timeslot information. This would produce a geographically load balanced database disregarding time information. See also routine `$SRC/ifs/var/writeoba.F90` .

ODB_CCMA_OBS_RANDOMIZE

When the `CCMA`-database is created, a geographical mapping of observational areas is performed. Each area contains approximately the same number of observations taking into account the cost of calculations. Sometimes it is hard to predict the cost and post-mapping (of observations) needs to performed. This environment variable allows randomization of the original "good" geographical mapping by redistributing observations in a round-robin fashion across all available data pools.

Set this to 1 if you want the randomization, otherwise set to 0. The default value is computer platform specific.

ODB_CONSIDER_TABLES

This variable is used only in connection with `ODB_IO_METHOD` (see p.191) . This environment variable sets ("considers") which database tables will actually be read in when `ODB_open` or `ODB_close` calls routine `MSGPASS_OBSDATA` (in `$SRC/odb/lib/msgpass_-obsdata.F90`) with I/O-method equal to #4.

If not defined, then *all* TABLEs will be processed. This corresponds to condition:

```
$ export ODB_CONSIDER_TABLES="*"
```

Processing all TABLEs maybe an overkill for some post-processing applications, where just by looking at the SQL-query's `FROM`-list one could determine the list of necessary TABLEs. If you know in advance that you will definitely should process only (say) TABLE `hdr` and `body`, then you need to give list of TABLEs as a slash (/) separated list as follows:

```
$ export ODB_CONSIDER_TABLES="/hdr/body/"
```

If you want to work with all tables, but not (say) `bufr`-table, you can specify this as follows:

```
$ export ODB_CONSIDER_TABLES='*   except   /bufr/'
```

ODB_CTX_DEBUG

Prints one line of information to `stderr` every time any subroutine in the ODB interface to IFS is entered or exited. This allows you to keep track of when and what kind of retrievals are executed and possible to understand erroneous situations.

This variable is by default turned off i.e. corresponds to value of 0. You can activate it for a particular MPI-task (1..`nproc`) or for all MPI-tasks in one go by setting it to -1. If running with more than one `OpenMP`-threads, a line of information for each thread is printed.

See also `ODB_ERRTRA` (see p.191) and `ODB_TRACE_PROC` (see p.195) .

ODB_DATAPATH

The generic root directory for database binary files. Usually the same as `ODB_-SRCPATH` (see p.194) , but if different, then it indicates that binary files are possibly stored on a different disk file system to the metadata.

If not defined, defaults to the current directory. See also `ODB_DATAPATH_$dbname` (see p.191) .

ODB_DATAPATH_$dbname

Database specific root directory for database binary files. When the location of the root directory is determined in `ODB_open`, this is the environment variable which will be interpreted first, just before `ODB_DATAPATH` (see p.190) .

ODB_FLPCHECK

When this variable is set to 1, the ODB software will check that upon reading/unpacking or writing/packing every floating point column has got IEEE 754 conformant numbers. By default set to 0 i.e. turned OFF, and should stay like this, since the checking may increase execution time considerably. See also `ODB_INTCHECK` (see p.191) .

ODB_ERRTRA

Attempt to activate subroutine/function call traceback writing in case of an error condition. The default value is 0 and no traceback will be written. Any other value activates traceback.

See also how to activate signal handler in ODB via `ODB_CATCH_SIGNALS` (see p.189) . For more comprehensive debugging try `ODB_TRACE_PROC` (see p.195) or with IFS `ODB_CTX_DEBUG` (see p.190) .

This environment variable has become obsolete in CY28R2 due to introduction of Dr.Hook, which has a more robust way of printing tracebacks.

ODB_IGNORE_POOLMASKING

By default value is 1 and indicates that any poolmasking (i.e. selection of active pools on temporary basis) should be skipped. Set this option to 0 to allow poolmasking to be enabled. Note that the use of this option does not affect what has been defined through the variable ODB_PERMANENT_POOLMASK

.

ODB_INTCHECK

When set to 1, this variable tries to guard against integer overflows. Can be very expensive when turned ON (=1). See also `ODB_FLPCHECK` (see p.191) for floating point checks. The default is 0.

ODB_IO_FILESIZE

Defines an approximate maximum allowed filesize in megabytes for concatenated `HC32`-format files. See also for I/O-method#4 in `ODB_IO_METHOD` (see p.191) .

ODB_IO_METHOD

Chooses the format of ODB database binary files and the way data will be scheduled to the application program. This applies to all database TABLE-files i.e. you cannot choose an I/O-method on a per TABLE-basis.

ODB currently supports four I/O-methods, of which only two (method#1 and #4) are properly tested and considered robust. The I/O-methods are

1 The default value. Creates one file per every TABLE on a pool basis. Uses the CMA I/O-routines with the standard C I/O-library (i.e. `fopen`, `fread`, `fwrite` and `fclose`).

2 The same as method#1, but after file opening bypasses the standard C I/O-library by using system I/O-routines (`read` and `fwrite`) directly. *Not very well tested.*

3 `qtar` method, where an external ODB-specific utility (similar to `tar`) is invoked to store and extract data. One `QTAR`-file per pool is created i.e. all TABLEs will be saved into a single file on a pool basis. Reduces number of files considerably, but can be slow due to regular invocations of the external tool, and is also *not very well tested.*

4 This is the `HC32`-format file, where "HC" stands for horizontal concatenation and "32" stands for 32-bits and means that a single file in this scheme can span up to 4GB in size. This I/O-method is switched on as default in ECMWF scripts from IFS cycle CY26R1 onwards, since it offers substantial reduction in the number of TABLE-files produced. In this method each similar TABLE-file for a number of consecutive pools are essentially concatenated together to achieve the maximum configured filesize given via `ODB_IO_FILESIZE` (see p.191) .

   The drawback of using this method is that *all* the required TABLEs (as specified via `ODB_CONSIDER_TABLES` (see p.190) need to be loaded into the (distributed) memory during the `ODB_open`. This may currently crash the post-processing application for a large database, unless sufficient number of parallel MPI-processors and/or enough memory is available. There is a work-around for this problem: utility `hcat` can split the database TABLE-files by essentially transforming `HC32`-format files into format used by I/O-method#1. Other means to solve this memory problem are under development. One of the most prominent ways is to load data pools in chunks, when post-processing. This requires the use of environment variable `ODB_PERMANENT_POOLMASK` (see p.193) .

See also `ODB_IO_FILESIZE` (see p.191) , `ODB_IO_GRPSIZE` (see p.**??**) , `ODB_-WRITE_EMPTY_FILE` (see p.196) , `ODB_PACKING` (see p.192) , `ODB_PERMANENT_-POOLMASK` (see p.193) and `ODB_CONSIDER_TABLES` (see p.190)

ODB_PACKING

By default ODB data files are internally packed. That is to say, the ODB packing algorithm is applied to every column of each TABLE before data is written to disk. There can be some situations – especially during development – when one wants to turn packing off, or use just a fixed packing method.

This environment variable can have the following values

-1 The default i.e. packing is ON and every packable column gets packed before it is written to disk.

0 Turns packing OFF i.e. data turns out to disk as big-endian binary, where floating point number follow IEEE 754 standard.

n Packing method is set to a fixed number (*n*), which has to be between `1-255`, with currently recognized packing methods being `1, 2, 5, 9, 11-19, 21-29`. By using fixed packing method you will ask ALL packable columns to get compressed.

In addition to this environment variable, particular packing methods can be mapped to use alternative packing method. See more detail under `ODB_PACKING_MAP_$n` (see p.193) .

ODB_PACKING_MAP_$n

This variable enables you to map an existing packing method to use some other recognized packing method or to turn OFF packing. When should this advanced feature be used? Suppose you do not trust some newly developed packing method and want to turn that off, but leave columns using other packing methods untouched. Then you can switch off the suspected packing method, or map it to use another, perhaps a more robust or one with better packing capabilities.

An example: Suppose you want to switch off a newly invented packing method#50 and map another packing method#60 to use the existing (robust) method#3. You would define:

```
$ export ODB_PACKING_MAP_50=0
$ export ODB_PACKING_MAP_60=3
```

See also `ODB_PACKING` (see p.192) .

ODB_PERMANENT_POOLMASK

This option enables you to select a permanent set of pools to work with. This can be useful in post-processing a large amount of observations spread over many pools – and when the I/O-method had been set to 4. The use of this environment variable essentially limits the pool range(s) that an ODB application can access. You can choose a single pool, a pool range or many pool ranges. The following example illustrates different usages:

```
# Work with pool#10 only
$ export ODB_PERMANENT_POOLMASK=10

# Work with pools 5 to 7 only
$ export ODB_PERMANENT_POOLMASK="5-7"
$ export ODB_PERMANENT_POOLMASK="5,6,7"

# Work with pools 1, 5-7 and 10-12 only
$ export ODB_PERMANENT_POOLMASK="1,5-7,10-12"
```

See also `ODB_IGNORE_POOLMASKING` (see p.191)

ODB_REPRODUCIBLE_SEQNO

This environment variable instructs ECMWF's `MERGEODB`-process to generate unique sequence numbers for each observation across MPI-tasks. There are a few different approaches, of which number 2 is the default at ECMWF.

ODB_SRCPATH

Generic location of database metadata. If not defined, defaults to `"."` i.e. the current directory while in function `ODB_open`. See also `ODB_DATAPATH` (see p.190) .

ODB_SRCPATH_$dbname

The location of database metadata for the specific database `$dbname`. When the location of metadata directory is determined in `ODB_open`, this is the first environment variable to be checked, and if it has not been defined, then `ODB_SRCPATH` (see p.194) will be checked.

ODB_STATIC_LINKING

Enables (=1) or disables (=0) static linking mode. If static linking mode is OFF, then any database layout (even not a recognized/permanent one) gets loaded into the running executable during the runtime. Also SQL-queries can be supplied during the runtime, making the ODB-system very flexible.

The ODB was developed on SGI (Silicon Graphics) and dynamic linking worked (works) perfectly there for years, but unfortunately the mode doesn't work as expected on IBM-systems, making the interactive ODB-system quite painful to use. This discrepancy will be addressed in the future by adding an interpretitive-like query processing system, which would make ODB data requests independed of platform specific dynamic linking features.

Currently dynamic linking is a *deprecated* feature and should be avoided.

ODB_TEST_INDEX_RANGE

For every SQL-query while in `ODB_select`, the ODB builds a list of indices in order to gather data to user arrays while `ODB_get` is called. If you suspect that this index structure may have been corrupted, you can turn ON the range checking by setting this variable to 1. Activating this option will increase CPU-time consumption considerably.

ODB_TRACE_PROC

You can obtain very detailed information about ODB data transactions. You can choose to set this variable to 0 and you get no information (the default), or to *n* and you get information from MPI-task number *n*, or set it to -1 and every MPI-task produces information.

Information is written to files – one for each MPI-task – as defined through the variable `ODB_TRACE_FILE` (see p.195) . Information can be flushed to this file at every `ODB_TRACE_FLUSH_FREQ` (see p.195) written lines.

ODB_TRACE_FILE

When ODB tracing is turned ON as described in `ODB_TRACE_PROC` (see p.195) , you must define the output file for every MPI-task needing this information. This can be accomplished by setting this environment variable. In the following, the MPI-task is referred via `%d` and use of environment variables to be parsed by the ODB software, are accepted. For example:

```
$ export ODB_TRACE_PROC=-1
$ export ODB_TRACE_FILE=/specific/path/filename.%d

# or just for the first MPI-task

$ export ODB_TRACE_PROC=1
$ export ODB_TRACE_FILE=$WDIR/filename.%d
```

Trace transactions are written out by default for every line i.e. by using linebuffering mode. If you want less frequent output i.e. more efficient tracing, you can use variable `ODB_TRACE_FLUSH_FREQ` (see p.195) .

ODB_TRACE_FLUSH_FREQ

Chooses the frequency of how often a number of trace transaction information will be written to `ODB_TRACE_FILE` (see p.195) , when `ODB_TRACE_PROC` (see p.195) is ON. The default is to flush after every line, but you can override this; for example every 1000 lines:

```
$ export ODB_TRACE_FLUSH_FREQ=1000
```

ODB_WRITE_EMPTY_FILES

The default value is 0 and indicidates that when a TABLE does not contain any data rows, writing the file will be automatically switched off. When attempting to read such a non-existent file, the ODB system will automatically set the number of rows to zero.

If you still want to write zero rows of data, you can do it by setting this environment variable to 1. The file itself will not be completely empty, but will contain a few bytes of header information only.

B Miscellaneous observation type codes

This appendix lists all relevant BUFR and CMA type codes and satellite sensor identifications used in IFS.

B.1 BUFR observation types and its (ECMWF) subtypes

The following table summarizes the recognized BUFR subtypes (ECMWF local numbering) and whether they are currently fed into database `ECMA` (or `ECMASCR`) through the `BUFR2ODB`-procedure.

Table 41: BUFR-types and subtypes

bufrtype@hdr		**subtype@hdr**		**Supported by**
No.	**Name**	**No.**	**Name**	**BUFR2ODB ?**
0	Land surface	1	Land SYNOP	$\surd$
		3	Automatic land SYNOP	$\surd$
		140	METAR	$\surd$
1	Sea surface	9	SHIP abbreviated	$\surd$
		11	SHIP 1	$\surd$
		13	Automatic SHIP	$\surd$
		19	Reduced SHIP	$\surd$
		21	DRIBU	$\surd$
		22	BATHY	$\surd$
		23	TESAC	$\surd$
2	Upper-air soundings	91	Land PILOT	$\surd$
		92	SHIP PILOT	$\surd$
		95	Wind profiler (USA)	$\surd$
		96	European & Japanese wind profilers[20]	$\surd$
		101	Land TEMP	$\surd$
		102	SHIP TEMP	$\surd$
		103	DROP TEMP	$\surd$
		106	Mobile TEMP	$\surd$
3	Satellite soundings	51	High-resolution TOVS 120km	($\surd$)[21]
		53	RTOVS	
		54	TOVS-1B	
		55	ATOVS	$\surd$

continued on next page . . .

[20] European and Japanese wind profilers distinguished from each other by their station identifier
[21] Phased out in CY28R2

Table 41: BUFR-types and subtypes ... *continued*

bufrtype@hdr		**subtype@hdr**		**Supported by**
No.	**Name**	**No.**	**Name**	**BUFR2ODB ?**
		61	Low-level temperature SATEM	√
		62	High-level temperature SATEM	√
		63	PWC SATEM	√
		65	Merged SATEM	√
		71	Low-level temperature TOVS	√
		72	High-level temperature TOVS	√
		73	PWC TOVS	√
		75	Merged TOVS	√
4	AIREP	142	AIREP	√
		143	COLBA	√
		144	AMDAR	√
		145	ACARS	√
5	SATOB	82	Temperature and wind	√
		83	Wind only	√
		84	Surface temperature	
		85	Clouds temperature	
		86	High-resolution VIS wind	
		87	AMV + quality control ??	√
12	ERS/SSMI	8	ERS 1	
		122	ERS 2 Wind scatterometer	√
		127	SSM/I BT	√
253	PAOB	164	PAOB	√
?	MODIS, GEOS, AIRS, ...			
?	??	89	Geostationary radiances	√
?	??	57	Radiances	√
?	??	189	Geostationary radiances	√

For more information, see BUFR Reference Manual by Milan Dragosavac (ECMWF) at `http://www.ecmwf.int/products/data/software/bufr_reference_manual.pdf`.

B.2 CMA observation types and its codetypes

The following table summarizes the recognized CMA observation types and codetypes used in IFS, and also whether they are currently fed into database `ECMA` (or `ECMASCR`) through the `BUFR2ODB`-procedure.

Table 42: CMA observation types and codetypes

obstype@hdr		**codetype@hdr**	
No.	**Name**	**No.**	**Name**
1	SYNOP	11	Manual land station
		14	Automatic land station
		21	SHIP
		22	SHIP abbreviated
		23	SHRED
		24	Automatic SHIP
		140	METAR
2	AIREP	41	CODAR
		141	Aircraft
		142	Simulated
		144	AMDAR
		145	ACARS
		241	COLBA
3	SATOB	88	SATOB
		89	High-resolution VIS wind
		90	AMV
		188	SST as DRIBU
4	DRIBU	63	BATHY
		64	TESAC
		160	ERS as DRIBU
		165	DRIBU
5	TEMP	35	Land
		36	SHIP
		37	Mobile
		39	Land ROCOB
		40	SHIP ROCOB
		135	DROP
		137	Simulated
6	PILOT	32	Land
		33	SHIP
		34	Wind profilers
7	SATEM	86	GTS SATEM (500km)
		184	High-res. simulated DWL TOVS
		185	High-res. simulated DWL SATEM
		186	High-res. SATEM (250km)
		200	GTS BUFR SATEM 250km
		201	GTS BUFR SATEM Clear Radiance

continued on next page . . .

Table 42: CMA observation types and codetypes ... *continued*

obstype@hdr		codetype@hdr	
No.	**Name**	**No.**	**Name**
		202	GTS BUFR retrieved profiles/ clear radiances
		210	ATOVS
		211	RTOVS
		212	TOVS
		215	SSMI
8	PAOB	180	PAOB
9	Scatterometer	8	Scatterometer 1
		122	Scatterometer 2
		210	Scatterometer 3

B.3 Mapping between CMA and BUFR types

B.3.1 Mapping from CMA to BUFR types

Please note that going from CMA-world to BUFR-world, there is not always corresponding BUFR-codes available.

Table 43: CMA obs.types mapped into BUFR types

CMA-world		BUFR-world	
obstype@hdr	**codetype@hdr**	**bufrtype@hdr**	**subtype@hdr**
1	11	0	1, 9
	14	0	3, 4
	21	1	9, 11
	22	–	–
	23	1	19
	24	1	13
2	41	–	–
	141	4	142
	142	–	–
	144	4	144
	145	4	145
	241	4	143

continued on next page ...

Table 43: CMA obs.types mapped into BUFR types *. . . continued*

CMA-world		BUFR-world	
obstype@hdr	**codetype@hdr**	**bufrtype@hdr**	**subtype@hdr**
3	88	5	82–85
	89	5	86
	90	5	87
	188	–	–
4	63	1	23
	64	1	22
	160	–	–
	165	1	2
5	35	2	101
	36	2	102
	37	2	106
	39	2	104
	40	2	105
	135	2	103
	137	–	–
6	32	2	91
	33	2	92
	34	2	95
7	86	3	61–63, 65
	184	–	–
	185	–	–
	186	3	71–73, 75
	200	–	–
	201	–	–
	202	–	–
	210	3	54, 89 ??
	211	3	53
	212	3	0, 51
	215	12	127
8	180	253	164
9	8	12	8
	122	12	122
	210	??	??

B.3.2 Mapping from BUFR to CMA types

Table 44: BUFR obs.types mapped into CMA types

BUFR-world		CMA-world	
bufrtype@hdr	**subtype@hdr**	**obstype@hdr**	**codetype@hdr**
0	1	1	11
	3	1	14 ??
	4	1	14 ??
	9	1	11
	140	1	140
1	9, 11	1	21
	13	1	24
	19	1	23
	22	4	64
	23	4	63
2	91	6	32
	92	6	33
	95	6	34
	96	6	131
	96	6	134
	101	5	35
	102	5	36
	103	5	135
	104	5	39
	105	5	40
	106	5	37
3	0	7	212
	51	7	212
	53	7	211
	54	7	210
	61–63, 65	7	86
	71–73, 75	7	186
4	142	2	141
	143	2	241
	144	2	144
	145	2	145
5	82–85	3	88
	86	3	89
	87	3	90
	89	7	210
12	8	9	8
	122	9	122
	127	7	125

continued on next page ...

Table 44: BUFR obs.types mapped into CMA types *. . . continued*

BUFR-world		CMA-world	
bufrtype@hdr	**subtype@hdr**	**obstype@hdr**	**codetype@hdr**
253	164	8	180

B.4 Satellite identification codes

See also file `$SRC/ifs/module/yomtvradF90`.

B.4.1 Satellite sensor

Table 45: SATOB computational methods

Variable label	Index	Name (CHSENSOR)	Channel offset	Channel count	By default perform cloudy RTCALC
`MSENSOR_HIRS`	0	`HIRS`	0	20	`YES`
`MSENSOR_MSU`	1	`MSU`	20	4	`YES`
`MSENSOR_SSU`	2	`SSU`	24	3	`NO`
`MSENSOR_AMSUA`	3	`AMSUA`	27	15	`YES`
`MSENSOR_AMSUB`	4	`AMSUB`	42	5	`NO`
`MSENSOR_SSMI`	6	`SSMI`	0	7	`YES`
`MSENSOR_VTPR1`	7	`VTPR1`	0	8	`YES`
`MSENSOR_VTPR2`	8	`VTPR2`	8	8	`YES`
`MSENSOR_AIRS`	11	`AIRS`	0	2378	`YES`
`MSENSOR_METEOSAT`	20	`METEOSAT`	0	2	`YES`
`MSENSOR_MSG`	21	`MSG`	0	8	`NO`
`MSENSOR_GOESIMG`	22	`GOESIMG`	0	4	`NO`

B.4.2 SATOB computational methods

Table 46: SATOB computational methods

Variable label	**Index**	**Name (CHMETHOD)**
MMETHOD_WVCL	0	WVCL
MMETHOD_IR	1	IR
MMETHOD_VIS	2	VIS
MMETHOD_WVMIX	3	WVMIX
MMETHOD_COM_SPEC	4	COM_CHAN
MMETHOD_WVMW	5	WVMW

B.4.3 Geostationary satellite names

Table 47: Geostationary satellite names

Variable label	**Index**	**Name (CHGEOSATN)**
MGEOSATN_METEOSAT	0	METEOSAT
MGEOSATN_GMS	1	GMS
MGEOSATN_GOES	2	GOES
MGEOSATN_MSG	3	MSG
MGEOSATN_INDSAT	4	INDSAT
MGEOSATN_MODIS	7	MODIS

B.4.4 Satellite series

Table 48: Satellite series

Variable label	**Index**	**Name (CHSERIES)**
MSERIES_NOAA	1	NOAA
MSERIES_DMSP	2	DMSP
MSERIES_METEOSAT	3	METEOSAT
MSERIES_GOES	4	GOES
MSERIES_GMS	5	GMS
MSERIES_NASA	6	NASA

C Variable numbers

This appendix describes all known observation variable numbers (`varnobody`) and how they map into various variable number mnemonics found in ODB file `$SRC/odb/ddl/varno.h` (see also D.1) and to IFS-variable `NVNUMB` (initialized in `$SRC/ifs/setup/suvnmb.F90`).

Table 49: Observation variable numbers

NVNUMB index	varno@body	ODB mnemonic	Description	Units [or **WMO code**]
1	3	$u	u-component of wind	m/s
2	4	$v	v-component of wind	m/s
3	1	$z	Geopotential (Z)	$(m/s)^2$
4	57	$dz	Thickness (DZ)	$(m/s)^2$
5	29	$rh	Relative humidity (RH)	Numeric
6	9	$pwc	Precipitable water content (PWC)	kg/m^2
7	58	$rh2m	2metre relative humidity (RH_{2m})	Numeric
8	2	$t	Upper air temperature (T)	K
9	59	$td	Upper air dew point (T_d)	K
10	39	$t2m	2metre temperature (T_{2m})	K
11	40	$td2m	2metre dew point (T_{d2m})	K
12	11	$ts	Surface temperature (T_s)	K
13	30	$ptend	Pressure tendency (p_t)	$Pa/3h$
14	60	$w	Past weather (W)	[4561]
15	61	$ww	Present weather (WW)	[4677]
16	62	$vv	Visibility (V)	[4300]
17	63	$ch	Type of high clouds (C_H)	[0509]
18	64	$cm	Type of middle clouds (C_M)	[0515]
19	65	$cl	Type of low clouds (C_L)	[0513]
20	66	$nh	Cloud base height (N_h)	m
21	67	$nn	Low cloud amount (N)	[2700]
22	68	$hshs	Additional cloud group height (h_sh_s)	m
23	69	$c	Additional cloud group type(C)	[0500]
24	70	$ns	Additional cloud group amount (N_s)	[2700]
25	71	$sdepth	Snow depth (S_d)	m
26	72	$e	State of ground (E)	[0901]
27	73	$tgtg	Ground temperature (T_gT_g)	K
28	74	$spsp1	Special phenomena#1 (S_pS_p)	[3778]

continued on next page . . .

Table 49: Observation variable numbers ... *continued*

NVNUMB index	**varno@body**	**ODB mnemonic**	**Description**	**Units** [or **WMO code**]
29	75	\$spsp2	Special phenomena#2 (s_ps_p)	[3778]
30	76	\$rs	Ice code type (R_s)	[3551]
31	77	\$eses	Ice thickness (E_sE_s)	[1751]
32	78	\$is	Ice (I_s)	[1751]
33	79	\$trtr	Time period of rain information (t_rt_r)	h
34	80	\$rr	6h rain amount	kg/m^2
35	81	\$jj	Maximum temperature (JJ)	K
36	82	\$vs	Ship speed (V_s)	m/s
37	83	\$ds	Ship direction (D_s)	Degree
38	84	\$hwhw	Wave height (H_wH_w)	m
39	85	\$pwpw	Wave period (P_wP_w)	s
40	86	\$dwdw	Wave direction (D_wD_w)	Degree
41	87	\$gclg	General cloud group	[20012]
42	88	\$rhlc	Relative humidity from low clouds	Numeric
43	89	\$rhmc	Relative humidity from middle clouds	Numeric
44	90	\$rhhc	Relative humidity from high clouds	Numeric
45	91	\$n	Total cloud amount	[20011]
46	92	\$sfall	6h snowfall	m
47	110	\$ps	Surface pressure (p_s)	Pa
48	111	\$dd	Wind direction	Degree
49	112	\$ff	Wind force	m/s
50	119	\$rawbt	Brightness temperature (T_b)	K
51	120	\$rawra	Raw radiance	K
52	121	\$satcl	Cloud amount from satellite	%
53	122	\$scatss	Backscatter (σ_0)	dB
54	5	\$du	Wind shear u-component ($\partial u/\partial z$)	$1/s$
55	6	\$dv	Wind shear v-component ($\partial v/\partial z$)	$1/s$
56	41	\$u10m	10metre u-component of wind (u_{10m})	m/s
57	42	\$v10m	10metre v-component of wind (v_{10m})	m/s
58	19	\$rhlay	Layer relative humidity	Numeric
59	200	\$auxil	Auxiliary variable	Numeric

continued on next page ...

Table 49: Observation variable numbers ... *continued*

NVNUMB index	**varno@body**	**ODB mnemonic**	**Description**	**Units** [or **WMO code**]
60	123	$cllqw	Cloud liquid water (Q_l)	kg/kg
61	124	$scatdd	Ambiguous v-component	m/s
62	125	$scatff	Ambiguous u-component	m/s
63	7	$q	Specific humidity (Q)	kg/kg
64	126	$scatwd	Ambiguous wind direction	Degree
65	127	$scatws	Ambiguous wind speed	m/s
66	8	$vsp	Vertical speed	m/s
67	56	$vt	Virtual temperature (T_v)	K
68	130	$o3lay	Ozone layer density	kg/m^2
69	156	$height	Generic height	m
70	215		SSM/I 1DVAR multilevel variable	

It is not very difficult to add new variable numbers. This can be accomplished as follows: ...

D Important files for reference

This appendix contains listings of some important files referred in this document.

D.1 Database layouts

$SRC/odb/ddl.CCMA/CCMA.ddl

```
#define CCMA

#include "cma.h"
```

$SRC/odb/ddl.ECMA/ECMA.ddl

```
#define ECMA

#include "cma.h"
```

$SRC/odb/ddl.ECMASCR/ECMASCR.ddl

```
#define ECMASCR
#define ECMA

#include "cma.h"
```

$SRC/odb/ddl/cma.h

```
//
//  Data layout (schema) for CY28R2
//
//  ECMASCR & ECMA table hierarchy:
//
//       1  desc
//       2  +---> ddrs
//       3  +---> poolmask
//       4  +---> timeslot_index
//       5  |     +---> index
//       6  |     |     +---> hdr
//       7  |     |     |     +---> sat
//       8  |     |     |     |     +---> reo3
//       9  v     v     v     v     +---> satob
//      10  |     |     |     |     +---> scatt
//      11  |     |     |     |     |     +---> scatt_body
//      12  |     |     |     |     +---> ssmi
//      13  |     |     |     |     |     +---> ssmi_body
//      14  |     |     |     |     +---> atovs
//      15  |     |     |     |     |     +---> atovs_pred
//     16  |     |     |     +---> bufr
//     17  |     |     |     +---> body
//     18  |     |     |     +---> errstat
//     19  |     |     |     +---> update_1
//     20  |     |     |     +---> update_2
//     21  |     |     |     +---> update_3
//
//  CCMA table hierarchy:
//
//
//      1  desc
//      2  +---> ddrs
//      3  +---> poolmask
//      4  +---> timeslot_index
//      5  |     +---> index
//      6  |     |     +---> hdr
//      7  |     |     |     +---> sat
//      8  |     |     |     |     +---> reo3
//      9  |     |     |     |     +---> satob
//     10  v     v     v     v     +---> atovs
//     11  |     |     |     |     |     +---> atovs_pred
//     12  |     |     |     +---> body
//     13  |     |     |     +---> errstat
//     14  |     |     |     +---> update_1
//     15  |     |     |     +---> update_2
//     16  |     |     |     +---> update_3
//
// Variables
//

SET  $NMXUPD = 3; // Maximum number of updates supported with this layout
SET  $NUMAUX = 2; // No. of auxiliary obsvalue's per body; aux1 ==> aux[$NUMAUX]
SET  $NUMTHBOX = 3; // No. of thinning boxes (see also ifs/module/yomdb.F90)


// Aligned tables (contain the same no. of rows when requested over the @LINK)
RESET ALIGN;
ALIGN(body,errstat,update[1:$NMXUPD],scatt_body,ssmi_body);
ALIGN(atovs,atovs_pred);

// @LINKs with maximum jump of one ("one-loopers")
// Rows in these tables have one-to-one correspondence over the @LINK
RESET ONELOOPER;
ONELOOPER(index,hdr);
ONELOOPER(hdr,sat);
ONELOOPER(sat,atovs,ssmi,scatt,satob,reo3);

// Define shared links (new option; not available through command line)
// (these aren't working properly ... yet (as of 29/8/2001 SS)
//SHAREDLINK(body,errstat,update[1:$NMXUPD]);

#include "mdi.h"
#include "obstype.h"
#include "varno.h"
#include "vertco_type.h"
#include "ppcode.h"
#include "sensor.h"

SET  $BG = 1;
SET  $ADJ = 2;

//
```

```
// Type definitions
//

//CREATE TYPE obschar_t AS (
//  codetype bit10,                          // OBS. CODE TYPE
//  instype bit10,                           // INS. TYPE
//  retrtype bit6,                           // RETRIEVAL TYPE
//  datagroup bit6,                          // DATA PROCESSING GROUP
//);

CREATE TYPE report_rdbflag_t AS (
  lat_humon bit1,
  lat_QCsub bit1,
  lat_override bit1,
  lat_flag bit2,
  lat_HQC_flag bit1,
  lon_humon bit1,
  lon_QCsub bit1,
  lon_override bit1,
  lon_flag bit2,
  lon_HQC_flag bit1,
  date_humon bit1,
  date_QCsub bit1,
  date_override bit1,
  date_flag bit2,
  date_HQC_flag bit1,
  time_humon bit1,
  time_QCsub bit1,
  time_override bit1,
  time_flag bit2,
  time_HQC_flag bit1,
  stalt_humon bit1,
  stalt_QCsub bit1,
  stalt_override bit1,
  stalt_flag bit2,
  stalt_HQC_flag bit1,
);

CREATE TYPE status_t AS (
  active bit1,                             // ACTIVE FLAG
  passive bit1,                            // PASSIVE FLAG
  rejected bit1,                           // REJECTED FLAG
  blacklisted bit1,                        // BLACKLISTED
#ifdef ECMA
  // BLACKLIST FAILCODE BITS
  monthly bit1,
  constant bit1,
  experimental bit1,
  whitelist bit1,
#endif /* ECMA */
);

CREATE TYPE instrm_t = pk1int;

CREATE TYPE datum_rdbflag_t AS (
  press_humon bit1,
  press_QCsub bit1,
  press_override bit1,
  press_flag bit2,
  press_HQC_flag bit1,
  press_judged_prev_an bit2,
  press_used_prev_an bit1,
  _press_unused_6 bit6,
  varno_humon bit1,
  varno_QCsub bit1,
  varno_override bit1,
  varno_flag bit2,
  varno_HQC_flag bit1,
  varno_judged_prev_an bit2,
  varno_used_prev_an bit1,
//  _varno_unused_6 bit6,
);

CREATE TYPE datum_flag_t AS (
  final bit4,                 // FINAL FLAG
  fg bit4,                    // FIRST GUESS FLAG
  depar bit4,                 // DEPARTURE FLAG
  varQC bit4,                 // VARIATIONAL QUALITY FLAG
  blacklist bit4,             // BLACKLIST FLAG
  ups bit1,                   // d'utilisation par analyse de pression de surface
  uvt bit1,                   // d'utilisation par analyse de vent et temperature
  uhu bit1,                   // d'utilisation par analyse d'humidite
  ut2 bit1,                   // d'utilisation par analyse de temperat ure a 2m
  uh2 bit1,                   // d'utilisation par analyse d'humidite a 2m
  uv1 bit1,                   // d'utilisation par analyse de vent a 10m
  urr bit1,                   // d'utilisation par analyse de precipitations
  usn bit1,                   // d'utilisation par analyse de neige
  usst bit1,                  // d'utilisation par analyse de temperature de surface de la mer
);

#ifdef ECMA
CREATE TYPE level_t AS (
  id bit9,                    // PILOT LEV. ID.
  maxwind bit1,               // MAX WIND LEVEL
  tropopause bit1,            // TROPOPAUSE
  D_part bit1,                // D PART
  C_part bit1,                // C PART
  B_part bit1,                // B PART
  A_part bit1,                // A PART
  surface bit1,               // SURFACE LEVEL
  signwind bit1,              // SIGNIFICANT WIND LEVEL
  signtemp bit1,              // SIGNIFICANT TEMPR. LEVEL
);
#endif /* ECMA */

CREATE TYPE report_event1_t AS (
  no_data bit1,
  all_rejected bit1,
  bad_practice bit1,
  rdb_rejected bit1,
  rdb_activated bit1,
  whitelist_activated bit1,
  horipos_outrange bit1,
  vertpos_outrange bit1,
  time_outrange bit1,
  redundant bit1,
  land bit1,
  sea bit1,
  stalt_missing bit1,
  modsurf_stalt_distance bit1,
  namelist_rejected bit1,
  QC_failed bit1,
);
```

```
#ifdef ECMA
CREATE TYPE report_event2_t = pk1int;

CREATE TYPE report_blacklist_t AS (
  obstype bit1,
  statid bit1,
  codetype bit1,
  instype bit1,
  date bit1,
  time bit1,
  lat bit1,
  lon bit1,
  stalt bit1,
  scanpos bit1,
  retrtype bit1,
  QI_1 bit1,
  QI_2 bit1,
  QI_3 bit1,
  modoro bit1,
  lsmask bit1,
  rlsmask bit1,
  modPS bit1,
  modTS bit1,
  modT2M bit1,
  modtop bit1,
  sensor bit1,
  fov bit1,
  satza bit1,
  andate bit1,
  antime bit1,
);
#endif /* ECMA */

CREATE TYPE datum_event1_t AS (
  vertco_missing bit1,
  obsvalue_missing bit1,
  fg_missing bit1,
  rdb_rejected bit1,
  rdb_activated bit1,
  whitelist_activated bit1,
  bad_practice bit1,
  vertpos_outrange bit1,
  reflevel_outrange bit1,
  fg2big bit1,
  depar2big bit1,
  obs_error2big bit1,
  datum_redundant bit1,
  level_redundant bit1,
  land bit1,
  sea bit1,
  not_analysis_varno bit1,
  duplicate bit1,
  levels2many bit1,
  multilevel_check bit1,
  level_selection bit1,
  vertco_consistency bit1,
  vertco_type_changed bit1,
  namelist_rejected bit1,
  combined_flagging bit1,
  report_rejected bit1,
  varQC_performed bit1,
  contam_cld_flag bit1,  // cloud contamination
  contam_rain_flag bit1, // rain contamination
);

#ifdef ECMA
CREATE TYPE datum_event2_t = pk1int;

CREATE TYPE datum_blacklist_t AS (
  varno bit1,
  vertco_type bit1,
  press bit1,
  press_rl bit1,
  ppcode bit1,
  obsvalue bit1,
  fg_depar bit1,
  obs_error bit1,
  fg_error bit1,
  winchan_dep bit1,
  obs_t bit1,
);
#endif /* ECMA */

CREATE TYPE varno_presence_t AS (
                      // presence of (any) ...
  other bit1,         //   bit#0 for non-categorized variable no.
  ps bit1,            //   1  : surface pressure
  wind bit1,          //   2  : wind-components
  t bit1,             //   3  : temperature
  z bit1,             //   4  : geopotential
  rh bit1,            //   5  : relative humidity
  q bit1,             //   6  : specific humidity
  obs2m bit1,         //   7  : 2m observations
  snow bit1,          //   8  : snow obs.
  rain bit1,          //   9  : rain (liquid/solid)
  rawbt bit1,         //   10 : brightness temperature
  rawra bit1,         //   11 : raw radiance
  ozone bit1,         //   12 : ozone
  dz bit1,            //   13 : thickness
  pwc bit1,           //   14 : pwc
  time_period bit1,   //   15 : time period (of rain etc.)
);

//
// Table definitions (now in a more logical order)
//

CREATE TABLE desc AS (
  expver string,
  andate YYYYMMDD,
  antime HHMMSS,

  // creation date, time and created by whom (username)
  creadate YYYYMMDD,
  creatime HHMMSS,
  creaby   string,

  // modification date, time and modified by whom (username)
  moddate YYYYMMDD,
  modtime HHMMSS,
  modby   string,

  // max. no. of updates for this database (= $MXUP_TRAJ)
  mxup_traj pk1int,
  ddrs @LINK,
  poolmask @LINK,
  timeslot_index @LINK,

  latlon_rad pk1int, // ==1 if (lat,lon) is in radians, ==0 if in degrees
);

CREATE TABLE ddrs AS (
  ddrno pk1int,
  wordno pk1int,
  bulkdata pk9real,
);

CREATE TABLE poolmask AS (
  tslot pk1int,
  obstype pk1int,
  codetype pk1int,
  sensor pk1int,
  bufrtype pk1int,
  subtype pk1int,
  satinst pk1int,
  poolno pk1int,
  hdr_count pk1int,
  body_count pk1int,
  max_bodylen pk1int,
);

CREATE TABLE timeslot_index AS ( // More direct access to time slot data
  timeslot pk1int,
  index @LINK,
);

CREATE TABLE index AS (
  target pk1int,
  procid pk1int,  // normally the same as pool number, too
  tslot pk1int,
  kset pk1int,
  abnob pk1int,
  mapomm pk1int,
  hdr @LINK,
);

CREATE TABLE hdr AS (
  seqno pk1int,                     // OBSERVATION SEQUENCE
  obstype pk1int,                   // OBSERVATION TYPE
//  obschar OBSCHAR_t,              // OBSERVATION CHARACTERISTICS
  codetype pk1int,                  // OBSERVATION CODE TYPE
  insttype pk1int,                  // OBSERVATION INSTRUMENT TYPE
  retrtype pk1int,                  // OBSERVATION RETRIEVAL TYPE
  areatype pk1int,                  // OBSERVATION AREA TYPE
  zone pk9int,                      // Used by Meteo France
  date YYYYMMDD,                    // OBS. DATE
  time HHMMSS,                      // OBS. EXACT TIME
  status STATUS_t,                  // REPORT'S STATUS
  event1 REPORT_EVENT1_t,           // REPORT'S EVENTS (PART 1)
  sortbox pk1int,                   // SORTING BOX
  sitedep pk1int,                   // site dependent
  source string,                    // Source ID of obs. (CHARACTER*8) : Re-analysis purposes
  statid string,                    // STATION ID (CHARACTER*8)
  ident pk1int,                     // Integer equivalent of STATION ID (or zero)
  lat pk9real,                      // LATITUDE
  lon pk9real,                       // LONGITUDE
  stalt pk9real,                     // ALTITUDE
  modoro pk9real,                    // MODEL'S OROGRAPHY
  trlat pk9real,                     // TRANSFORMED LAT.
  trlon pk9real,                     // TRANSFORMED LON.
  instspec INSTRM_t,                 // INST. SPEC. WORD POSITIONS
  anemoht pk9real,                   // HEIGHT OF ANEMOMETER
  baroht pk9real,                    // HEIGHT OF BAROMETRE
  sensor pk1int,                     // SATELLITE SENSOR INDICATOR
  numlev pk1int,                     // No. of distinct pressure levels in bodies
  numactiveb pk1int,                 // No. of active body entries (i.e. status.active@body == 1)
  checksum pk9real,                  // A check sum of obsvalues where press and
                                     //   obsvalue is not NULL
  varno_presence varno_presence_t,   // Variable presence flag
  sat @LINK,
  body @LINK,
  errstat @LINK,
  update[1:$NMXUPD] @LINK,
  rdbflag REPORT_RDBFLAG_t,          // REPORT'S FLAGS
  subtype pk1int,                    // BUFR subtype for reference
  bufrtype pk1int,                   // BUFR-type
  satinst pk1int,                    // Satellite sensor/instrument in BUFR/WMO-world
  satname[2] string,                 // Satellite name (2 words, up to 16 bytes)
#ifdef ECMA
  thinningkey[$NUMTHBOX] pk9real,    // Thinning key
  thinningtimekey pk9real,           // Thinning time key
  blacklist REPORT_BLACKLIST_t,      // REPORT'S BLACKLIST EVENTS
  event2 REPORT_EVENT2_t,            // REPORT EVENTS (PART 2) WORD POS.
  bufr @LINK,                        // Link to BUFR-data
  subsetno pk9int,                   // Multisubset number in BUFR-msg (=0 for single subset)
  station_type pk1int,               // SYNOP/SHIPS (needed to find out if DRIBU)
  sonde_type pk1int,                 // In order to do bias corr. of TEMPs
  satem_instdata pk1int,             // INS. DATA USED IN PROC. for old-SATEM
  satem_dataproc pk1int,             // DATA PROC. TECHNIQUE USED for old-SATEM
#endif /* ECMA */
);

#ifdef ECMA
CREATE TABLE bufr AS (
  msg bufr, // Just a set of 4-byte sequences after each other
);
#endif

CREATE TABLE sat AS (
  satid pk1int,                         // Integer equivalent to statid@hdr or 0; same as ident@hdr
  atovs @LINK,
  reo3  @LINK,
  satob @LINK,
#ifdef ECMA
  scatt @LINK,
  ssmi @LINK,
#endif /* ECMA */
);


CREATE TABLE reo3 AS (
  instrument_type pk1int,               // SATELLITE INSTRUMENT
  product_type pk1int,                  // PRODUCT TYPE FOR RETRIEVED ATMOSPHERIC GASES
  lat_fovcorner[1:4] pk9real,           // LATITUDE FIELD OF VIEW CORNER 1-4
  lon_fovcorner[1:4] pk9real,           // LONGITUDE FIELD OF VIEW CORNER 1-4
  solar_elevation pk9real,              // SOLAR ELEVATION
  fov pk1int,                           // FIELD OF VIEW NUMBER
  cloud_cover pk9real,                  // CLOUD COVER
  cloud_top_press pk9real,              // PRESSURE AT TOP OF CLOUD
  quality_retrieval pk1int,             // QUALITY OF RETRIEVAL
  number_layers pk1int,                 // NUMBER OF RETRIEVED LAYERS
);


-- The following depends on RTTOV, so watch for it!
SET $mx_satob_weight = 43;

CREATE TABLE satob AS (
  comp_method pk1int,                   // CLOUD MOTION COMP. METHOD
  instdata pk1int,                      // INS. DATA USED IN PROC.
  dataproc pk1int,                      // DATA PROC. TECHNIQUE USED
  QI[3] pk1int,                         // Quality indicators
  segment_size_x pk9real,               // RESOLUTION, x-direction
  segment_size_y pk9real,               // RESOLUTION, y-direction
  chan_freq pk9real,                    // Satellite Channel Centre Frequency [Hz] (02197) for subtype=8
  tb pk9real,                           // Coldest cluster temperature
  t pk9real,                            // Temperature at SATOB p
  zenith pk9real,                       // Satellite zenith angle
  shear pk9real,                        // Diff. in speed 50hPa above/below
  t200 pk9real,                         // 200 hPa temperature
  t500 pk9real,                         // 500 hPa temperature
  top_mean_t pk9real,                   // Mean temperature between 80 hPa & p
  top_wv pk9real,                       // Integrated WV above p
  dt_by_dp pk9real,                     // Diff in temp. 50hPa above/below
  p_best pk9real,                       // "Best fit" pressure
  u_best pk9real,                       // U at "best fit" pressure
  v_best pk9real,                       // V at "best fit" pressuree
  p_old pk9real,                        // Originally assigned pressure
  u_old pk9real,                        // U at old pressure
  v_old pk9real,                        // V at old pressure
  weight[$mx_satob_weight] pk9real,     // Weight for obs operator (note hardwiring - see jpmx_satob_wei
);

CREATE TABLE atovs AS (
#ifdef ECMA
  scanline pk1int,                      // SCAN LINE NUMBER
  fov pk1int,                           // FIELD OF VIEW NUMBER
  station_height pk9real,               // HEIGHT OF STATION
  zenith pk9real,                       // SATELLITE ZENITH ANGLE
  bearing_azimuth pk9real,              // BEARING OR AZIMUTH
  solar_zenith pk9real,                 // SOLAR ZENITH ANGLE
  solar_azimuth pk9real,                // SOLAR AZIMUTH
  cldptop[1:3] pk9real,                 // CLOUD TOP PRESS. FROM HIRS RADIANCES
  cldne[1:3] pk9real,                   // CLOUD EMISSIVITY FROM HIRS RADIANCES
  vertsign[3:4] pk1int,
  landsea pk1int,                       // LAND/SEA QUALIFIER
  landsurf_height pk9real,              // HEIGHT OF LAND SURFACE
  skintemp pk9real,                     // SKIN TEMPERATURE
  press[2:2] pk9real,
  iterno_1dvar pk1int,                  // 1D VAR ITERATION NUMBER
  error_1dvar pk1int,                   // 1D VAR ERROR(S)
  channel_1dvar[0:1] pk1int,
  presat_flags pk1int,                  // PRESAT SUMMARY FLAGS
  iterno_conv_1dvar pk1int,             // 1D VAR NO. OF ITER. FOR CONVERGENCE
  failure_1dvar pk1int,                 // 1D VAR FAILURE INDICATOR
  landsea_obs pk1int,                   //  land/sea surface from obs report
#endif /* ECMA */
#ifdef CCMA
  fov pk1int,                           // FIELD OF VIEW NUMBER
  zenith pk9real,                       // SATELLITE ZENITH ANGLE
#endif /* CCMA */
  atovs_pred @LINK,
);

CREATE TABLE atovs_pred AS (
  predictor[16] pk9real,
  skintemp[$NMXUPD] pk9real,            // SKIN TEMPERATURE, per NRESUPD
);

#ifdef ECMA
CREATE TABLE scatt AS (
  track pk1int,                         // SATELLITE TRACK
  cellno pk1int,                        // CELL NO.
  prodflag pk1int,                      // PRODUCT FLAG
  uwi_esa[2] pk1int,                    // UWI ESA FLAG (2 x actually 12 bit words)
  scatt_body @LINK,
);
#endif /* ECMA */


#ifdef ECMA
CREATE TABLE ssmi AS (
  orbit pk1int,             // ORBIT NO.
  scanline pk1int,          // SCAN LINE NO.
  scanpos pk1int,           // POSITION NUMBER ALONG SCAN
  typesurf pk1int,          // TYPE OF SURFACE
  vertsign pk1int,          // VERTICAL SIGNIFICANCE
  zenith pk9real,           // ZENITH ANGLE
  iterno_conv_1dvar pk1int,// NO. OF ITERATIONS
  failure_1dvar pk1int,     // FAILURE INDICATOR

  surfpress[1] pk9real,     // from slev, SFC PRESSURE
  skintemp[1] pk9real,      // from slev, SKIN TEMPERATURE
  u10m[1] pk9real,          // from slev, U-WIND 10M
  v10m[1] pk9real,          // from slev, V-WIND 10M
  prec_st[2] pk9real,       // new      , SFC STRAT. PRECIP.
  prec_cv[2] pk9real,       // new      , SFC CONV. PRECIP.

  ssmi_body @LINK,
);
#endif /* ECMA */


CREATE TABLE body AS (
  varno pk1int,                         // VARIABLE NUMBER
  vertco_type pk1int,                   // VERTICAL COORDINATE TYPE
  anflag DATUM_FLAG_t,                  // OBSERVATION FLAGS
  status STATUS_t,                      // OBSERVATION STATUS
  event1 DATUM_EVENT1_t,                // OBSERVATION EVENTS (PART 1)
  entryno pk1int,                       // ENTRY SQ. NO.
  press pk9real,                        // VERTICAL COORDINATE REFERENCE 1
  press_rl pk9real,                     // VERTICAL COORDINATE REFERENCE 2
  obsvalue pk9real,                     // OBSERVED VARIABLE
  aux[$NUMAUX] pk9real,                 // Auxiliary obsvalues;
                                        //   say aux[1:2] := (ff,dd) foreach u or v,
                                        //   or aux_1 i.e. aux[1] could be Td for T & vice versa
  biascorr pk9real,                     // RADIANCE BIAS CORRECTION
  rdbflag DATUM_RDBFLAG_t,              // OBSERVATION FLAGS (RDB)
#ifdef ECMA
  blacklist DATUM_BLACKLIST_t,          // OBSERVATION BLACKLIST EVENTS
  event2 DATUM_EVENT2_t,                // DATUM EVENTS (PART 2) WORD POS.
  ppcode pk1int,                      // PRESSURE CODE
  level LEVEL_t,                      // PILOT LEVEL ID.
#endif /* ECMA */
  an_depar pk9real,                   // OBSERVED MINUS ANALYSED VALUE
  fg_depar pk9real,                   // OBSERVED MINUS FIRST GUESS VALUE
  fg_check[2] pk9real,
  an_sens_obs pk9real,                // analysis sensitivity to the obs
// The following 4 entries will be moved into @atovs_body-table, when it becomes available
  cld_fg_depar pk9real,               //  FG departure for cloudy radiances
  surfemiss pk9real,                  //  surface emissivity
  csr_pclear pk9real,                 //  percentage of clear pixels in mean CSR
  csr_pcloudy pk9real,                //  percentage of cloudy pixels in mean CSR

  rank_cld pk9real,                   // channel ranking for cloud detection
  rank_an pk9real,                    // channel ranking for analysis
#ifdef CANARI
  mf_vertco_type pk1int,              // vertical coordinate type
  mf_log_p pk9real,                   // pressure used in CANARI (Log P)
  mf_stddev pk9real,                  // obs. std dev at bottom layer
#endif /* CANARI */
);

CREATE TABLE errstat AS (
  final_obs_error pk9real,            // FINAL OBSERVATION ERROR
  obs_error pk9real,                  // OBSERVATION ERROR
  repres_error pk9real,               // REPRESENTATIVENESS ERROR
  pers_error pk9real,                 // PERSISTENCE ERROR
  fg_error pk9real,                   // FIRST GUESS ERROR
);

// The following declares up to $NMXUPD update-tables with
// the naming convention update_1, update_2, ..., update_<$NMXUPD>.
// Each of them has got exactly the same attributes.
// Note: It is up to the software to decide how many of these tables will
// actually be filled !!

CREATE TABLE update[1:$NMXUPD] AS (
  initial pk9real,           // OBS. MINUS UPD. U INITIAL VALUE
  hires pk9real,             // OBS. MINUS UPD. U HIGH RES. VALUE
  lores pk9real,             // OBS. MINUS UPD. U LOW RES. VALUE
  final pk9real,             // OBS. MINUS UPD. U FINAL VALUE
);


#ifdef ECMA
CREATE TABLE ssmi_body AS (
  radcost pk9real,         // 1D VAR RADIANCE COST
  rad_cost pk9real,        // new, COST FRACTION Jo_1/Jo_n
  rad_obs      pk9real,    // new, RADIANCE OBSERVATION
  rad_fg_depar pk9real,    // new, RADIANCE FG DEPARTURE
  rad_an_depar pk9real,    // new, RADIANCE AN DEPARTURE
  rad_obs_err  pk9real,    // new, RADIANCE OBS. ERROR
  rad_bias     pk9real,    // new, RADIANCE BIAS
  frequency pk9real,       // CHANNEL CENTRE FREQUENCY
  bandwidth pk9real,       // CHANNEL BAND WIDTH
  polarisation pk9real,    // ANTENNA POLARISATION

  press pk9real,           // from mlev, PRESSURE
  temp[2] pk9real,         // from mlev, TEMPERATURE
  q[2] pk9real,            // from mlev, SPEC. HUMIDITY
  rain[2] pk9real,         // new      , LIQUID PRECIP FLUX
  snow[2] pk9real,         // new      , FROZEN PRECIP FLUX.
  clw[2] pk9real,          // new      , CLOUD WATER MIX. RATIO
  ciw[2] pk9real,          // new      , CLOUD ICE MIX. RATIO
  cc [2] pk9real,          // new      , CLOUD COVER, PROF.
);
#endif /* ECMA */


#ifdef ECMA
CREATE TABLE scatt_body AS (
  azimuth pk9real,                     // BEAM AZIMUTH ANGLE
  incidence pk9real,                   // BEAM INCIDENCE ANGLE
  Kp pk9real,                          // Kp (INSTRUMENT NOISE; Antenna Noise)
  invresid[2] pk9real,
  dirskill pk9real,                    // DIRECTIONAL SKILL
  mpc pk1int,                          // MISSING PACKET COUNTER
  wvc_qf pk1int,                       // WIND VECTOR CELL QUALITY FLAG
  nretr_amb pk1int,                    // NUMBER OF RETRIEVED AMBIGUITIES
);
#endif /* ECMA */
```

$SRC/odb/ddl/mdi.h

```
SET $MDI = 2147483647; // Absolute value of the Missing Data Indicator
```

$SRC/odb/ddl/obstype.h

```
// CMA observation types (obstype@hdr) :

SET  $SYNOP = 1;
SET  $AIREP = 2;
SET  $SATOB = 3;
SET  $DRIBU = 4;
SET  $BUYO  = 4;
SET  $TEMP  = 5;
SET  $PILOT = 6;
SET  $SATEM = 7;
SET  $PAOB  = 8;
SET  $SCATT = 9;

// CMA codetypes (used to be in obschar.codetype@hdr) for $SATEM :

SET  $REO3 = 206;
SET  $ATOVS = 210;
SET  $RTOVS = 211;
SET  $TOVS = 212;
SET  $SSMI = 215;

SET $satem500 = 86;
SET $satem250 = 186;
SET $rad1c = 210;
```

$SRC/odb/ddl/ppcode.h

```
// Synop pressure codes (ppcode@body) :

SET $psealev  = 0;      // press@body is SEA LEVEL PRESSURE
SET $pstalev  = 1; //      "        STATION LEVEL PRESSURE
SET $g850hpa  = 2; //      "  850MB GEOPOTENTIAL
SET $g700hpa  = 3; //      "  700MB GEOPOTENTIAL
SET $p500gpm  = 4; //      "  500GPM PRESSURE
SET $p1000gpm = 5; //      "  1000GPM PRESSURE
SET $p2000gpm = 6; //      "  2000GPM PRESSURE
SET $p3000gpm = 7; //      "  3000GPM PRESSURE
SET $p4000gpm = 8; //      "  4000GPM PRESSURE
SET $g900hpa  = 9; //      "  900MB GEOPOTENTIAL
SET $g1000hpa = 10; //      "  1000MB GEOPOTENTIAL
SET $g500hpa  = 11; //      "  500MB GEOPOTENTIAL
SET $g925hpa  = 12; //      "  925MB GEOPOTENTIAL
```

$SRC/odb/ddl/sensor.h

```
// sensor id's (sensor@hdr) :

SET $hirs      =  0;
SET $msu       =  1;
SET $ssu       =  2;
SET $amsua     =  3;
SET $amsub     =  4;
SET $meteosat  = 20;
```

$SRC/odb/ddl/varno.h

```
// Variable numbers (varno@body) :

SET $u = 3; // UPPER AIR U COMPONENT   = NVNUMB(  1)
SET $v = 4; // UPPER AIR V COMPONENT   = NVNUMB(  2)
SET $z = 1; // GEOPOTENTIAL            = NVNUMB(  3)
SET $dz = 57; // THICKNESS               = NVNUMB(  4)
SET $rh = 29; // UPPER AIR REL. HUMIDITY = NVNUMB(  5)
SET $pwc = 9; // PWC                     = NVNUMB(  6)
SET $rh2m = 58; // 2M REL. HUMIDITY        = NVNUMB(  7)
SET $t = 2; // UPPER AIR TEMPERATURE   = NVNUMB(  8)
SET $td = 59; // UPPER AIR DEW POINT     = NVNUMB(  9)
SET $t2m = 39; // 2M TEMPERATURE          = NVNUMB( 10)
SET $td2m = 40; // 2M DEW POINT            = NVNUMB( 11)
SET $ts = 11; // SURFACE TEMPERATURE     = NVNUMB( 12)
SET $ptend = 30; // PRESSURE TENDENCY       = NVNUMB( 13)
SET $w = 60; // PAST WEATHER (W)        = NVNUMB( 14)
SET $ww = 61; // PRESENT WEATHER (WW)    = NVNUMB( 15)
SET $vv = 62; // VISIBILITY              = NVNUMB( 16)
SET $ch = 63; // TYPE OF HIGH CLOUDS (Ch)= NVNUMB( 17)
SET $cm = 64; // TYPE OF MIDDLE CLOUDS (Cm) = NVNUMB( 18)
SET $cl = 65; // TYPE OF LOW CLOUDS (Cl) = NVNUMB( 19)
SET $nh = 66; // CLOUD BASE HEIGHT (Nh)  = NVNUMB( 20)
SET $nn = 67; // LOW CLOUD AMOUNT (N)    = NVNUMB( 21)
SET $hshs = 68; // ADDITIONAL CLOUD GROUP HEIGHT (hh) = NVNUMB( 22)
SET $c = 69; // ADDITIONAL CLOUD GROUP TYPE (C) = NVNUMB( 23)
SET $ns = 70; // ADDITIONAL CLOUD GROUP AMOUNT (Ns) = NVNUMB( 24)
SET $sdepth = 71; // SNOW DEPTH              = NVNUMB( 25)
SET $e = 72; // STATE OF GROUND (E)     = NVNUMB( 26)
SET $tgtg = 73; // GROUND TEMPERATURE (TgTg) = NVNUMB( 27)
SET $spsp1 = 74; // SPECIAL PHENOMENA (SpSp)#1 = NVNUMB( 28)
SET $spsp2 = 75; // SPECIAL PHENOMENA (SpSp)#2 = NVNUMB( 29)
SET $rs = 76; // ICE CODE TYPE (Rs)      = NVNUMB( 30)
SET $eses = 77; // ICE THICKNESS (EsEs)    = NVNUMB( 31)
SET $is = 78; // ICE (Is)                = NVNUMB( 32)
SET $trtr = 79; // ORIGINAL TIME PERIOD OF RAIN OBS. (TrTr) = NVNUMB( 33)
SET $rr = 80; // 6HR RAIN (LIQUID PART)  = NVNUMB( 34)
SET $jj = 81; // MAX. TEMPERATURE (JJ)   = NVNUMB( 35)
SET $vs = 82; // SHIP SPEED (Vs)         = NVNUMB( 36)
SET $ds = 83; // SHIP DIRECTION (Ds)     = NVNUMB( 37)
SET $hwhw = 84; // WAVE HEIGHT             = NVNUMB( 38)
SET $pwpw = 85; // WAVE PERIOD             = NVNUMB( 39)
SET $dwdw = 86; // WAVE DIRECTION          = NVNUMB( 40)
SET $gclg = 87; // GENERAL CLOUD GROUP     = NVNUMB( 41)
SET $rhlc = 88; // REL. HUMIDITY FROM LOW CLOUDS    = NVNUMB( 42)
SET $rhmc = 89; // REL. HUMIDITY FROM MIDDLE CLOUDS = NVNUMB( 43)
SET $rhhc = 90; // REL. HUMIDITY FROM HIGH CLOUDS   = NVNUMB( 44)
SET $n = 91; // TOTAL AMOUNT OF CLOUDS  = NVNUMB( 45)
SET $sfall = 92; // 6HR SNOWFALL (SOLID PART OF RAIN) = NVNUMB( 46)
SET $ps = 110; // SURFACE PRESSURE        = NVNUMB( 47)
SET $dd = 111; // WIND DIRECTION          = NVNUMB( 48)
SET $ff = 112; // WIND FORCE              = NVNUMB( 49)
SET $rawbt = 119; // BRIGHTNESS TEMPERATURE  = NVNUMB( 50)
SET $rawra = 120; // RAW RADIANCE            = NVNUMB( 51)
SET $satcl = 121; // CLOUD AMOUNT FROM SATELLITE = NVNUMB( 52)
SET $scatss = 122; // SIGMA 0 = NVNUMB( 53)
SET $du = 5; // WIND SHEAR (DU) = NVNUMB( 54)
SET $dv = 6; // WIND SHEAR (DV) = NVNUMB( 55)
SET $u10m = 41; // 10M U COMPONENT = NVNUMB( 56)
SET $v10m = 42; // 10M V COMPONENT = NVNUMB( 57)
SET $rhlay = 19; // LAYER REL. HUMIDITY = NVNUMB( 58)
SET $auxil = 200; // AUX. VARIABLE = NVNUMB( 59)
SET $cllqw = 123; // CLOUD LIQUID WATER = NVNUMB( 60)
SET $scatdd = 124; // AMBIGUOUS V COMPONENT = NVNUMB( 61)
SET $scatff = 125; // AMBIGUOUS U COMPONENT = NVNUMB( 62)
SET $q = 7; // SPECIFIC HUMIDITY (Q) = NVNUMB( 63)
SET $scatwd = 126; // AMBIGUOUS WIND DIRECTION = NVNUMB( 64)
SET $scatws = 127; // AMBIGUOUS WIND SPEED     = NVNUMB( 65)
SET $vsp = 8; // VERTICAL SPEED = NVNUMB( 66)
SET $vt = 56; // VIRTUAL TEMPERATURE = NVNUMB( 67)
SET $o3lay = 206; // LAYER OZONE = NVNUMB( 68)
SET $height = 156; // HEIGHT = NVNUMB( 69)
```

$SRC/odb/ddl/vertco_type.h

```
// Vertical coordinate types (vertco_type@body) :

SET $pressure = 1; // press@body is pressure (in Pa)
SET $gpheight = 2; // press@body is geopotential height
SET $tovs_cha = 3;
SET $scat_cha = 4;
```

$SRC/odb/ddl.PREODB/PREODB.ddl

```
//
// === TYPE and TABLE definitions for the ERA-40 PREODB ===
//
// As of 28-Sep-1999 : by ECMWF/ERA-40 group
//
//
// The present TABLE hierarchy
// ===========================
//
//
//
//                  +--> bufr
//                  |
//                  ^
//                  |
//    desc --> hdr --+--> body
//
//

//
// === Global $-variables ===
//

#include "mdi.h"
#include "obstype.h"
#include "varno.h"
#include "vertco_type.h"
#include "ppcode.h"

// For fixed dimensioning of some arrays in data layout :

SET $MAXDESC = 10;         // No. of string-words (x8 bytes) per fulldesc
SET $MAXDUPL = 16;         // Max. no. of different duplicate criterias (<= 32)

//
// === TYPE definitions ===
//

TYPEDEF FLAG_t AS (
invalid bit1,

invalid_date bit1,
invalid_time bit1,

invalid_lat bit1,
invalid_lon bit1,
invalid_stalt bit1,

invalid_statid  bit1,
invalid_bufr bit1,

passive bit1,

duplicate bit1,

_reserved bit6,

dupl[$MAXDUPL]  bit1,
);

TYPEDEF obschar_t = (
  codetype bit9,                      // OBS. CODE TYPE
  instype bit10,                      // INS. TYPE
  retrtype bit6,                      // RETRIEVAL TYPE
  geoarea bit6,                       // GEOGRAPHICAL AREA
);

//
// === TABLE definitions ===
//

CREATE TABLE desc AS (
source string,
version pk9int,
acl pk9int,  // Access control list (0=no, 0>has restrictions)

andate YYYYMMDD,
antime HHMMSS,

creadate YYYYMMDD,
creatime HHMMSS,
creaby string,

moddate YYYYMMDD,
modtime HHMMSS,
modby string,

// Links
hdr @LINK,

// Make sure the $MAXDESC equals to no. of "fulldesc_" -entries
fulldesc[$MAXDESC] string,
);

CREATE TABLE hdr AS (
  sortbox pk9int,// Box-id pre-calculated from (lat,lon) on 1x1 grid

  subclass pk9int,                    // 2ndry source

  seqno int,                          // OBSERVATION SEQUENCE

  obstype pk2int,                     // OBSERVATION TYPE (CMA)
  obschar OBSCHAR_t,                  // OBSERVATION CHARACTERISTICS (CMA)

  RDBtype pk5int,                     // RDB-type (BUFR)
  subtype pk5int,                     // Sub-type (BUFR)
  bufrtype pk5int,                    // BUFR-type (BUFR)

  date YYYYMMDD,                      // OBS. DATE
  time HHMMSS,                        // OBS. EXACT TIME

  statid string,                      // STATION ID
  lat real4,                          // LATITUDE (in degrees: -90..+90)
  lon real4,                          // LONGITUDE (in degrees: -180..+180)
  stalt pk9real,                      // ALTITUDE

  flag FLAG_t,                        // PREODB-flags
  numlev pk5int,// No. of distinct pressure levels in bodies

  duplseqno[$MAXDUPL] pk9int,         // If > 0, seqno of the duplicate

// Links
body @LINK,
bufr @LINK,
);

CREATE TABLE body AS (
  varno pk5int,                          // VARIABLE NUMBER
  press real8,                           // VERTICAL COORDINATE (pressure or geop. ht)
  obsvalue real8,                        // OBSERVED VARIABLE
  aux1 pk9real,                          // Derived quantity: WSPEED, WDIR, etc..
  vertco_type pk5int,                    // VERTICAL COORDINATE TYPE
  ppcode pk9int,                         // SYNOP PRESSURE CODE
);

CREATE TABLE bufr AS (
msg bufr,
);
```

D.2 ODB interface to IFS

$SRC/ifs/module/yomdb.F90

```
MODULE YOMDB

USE PARKIND1  ,ONLY : JPIM     ,JPRB

USE PARCMA, ONLY : JPMXUP, JPXTSL, JPMX_SATOB_WEIGHT
USE YOMOML
IMPLICIT NONE
SAVE
PUBLIC
LOGICAL :: LODB = .TRUE.
CHARACTER(LEN=*), PARAMETER :: CLEVELDB = '28R2'
INTEGER(KIND=JPIM)       , PARAMETER :: MDIDB = 2147483647
!-- UNDEFDB moved to /cc/rd/odb/module/odbshared.F90 on 20-Mar-2002 by SS
!   since it is not anymore needed directly from within IFS
!!INTEGER_M       , PARAMETER :: UNDEFDB = -1953789045 ! "ODB_UNDEF" ; same as 0x8B8B8B8B
INTEGER(KIND=JPIM)       , PARAMETER :: JPMAXTSLDB = JPXTSL
INTEGER(KIND=JPIM), PRIVATE :: i, j
INTEGER(KIND=JPIM), PARAMETER :: JPMAXSIMVIEWS = 16
INTEGER(KIND=JPIM), PARAMETER :: JP_MAXDESC = 10
INTEGER(KIND=JPIM), PARAMETER :: JP_MAXDUPL = 16
INTEGER(KIND=JPIM), PARAMETER :: JP_NUMAUX   = 2 ! Must be the same as $NUMAUX in odb/ddl/cma.h
INTEGER(KIND=JPIM), PARAMETER :: JP_NUMTHBOX = 3 ! Must be the same as $NUMTHBOX in odb/ddl/cma.h
!*** Disable UNMAPDB-function
LOGICAL :: LUNMAPDB_DO = .TRUE.
!***  Database handles
INTEGER(KIND=JPIM),PARAMETER :: JPMAXSIMDB = 5   ! Max. no. of simultaneously opened DBs
INTEGER(KIND=JPIM)           :: NUMSIMDB  =  0   ! No. of presently opened DBs
INTEGER(KIND=JPIM) :: NHANDLEDB(JPMAXSIMDB) = (/( 0, i=1,JPMAXSIMDB)/)
INTEGER(KIND=JPIM) :: NPOOLSDB(JPMAXSIMDB)  = (/( 0, i=1,JPMAXSIMDB)/)
INTEGER(KIND=JPIM) :: NACTIVEDB = 0 ! Index to NHANDLEDB() for active DB
CHARACTER(LEN= 20) :: COPENDB(JPMAXSIMDB)   = (/(' ', i=1,JPMAXSIMDB)/)
CHARACTER(LEN= 20) :: CSTATUSDB(JPMAXSIMDB) = (/(' ', i=1,JPMAXSIMDB)/)
CHARACTER(LEN= 20) :: CACTIVEDB   = ' ' ! Say 'BUFRBASE', 'ECMA' or 'CCMA'
!***  NPOOLS_* for most common databases
INTEGER(KIND=JPIM) :: NPOOLS_CCMA    = 0
INTEGER(KIND=JPIM) :: NPOOLS_ECMA    = 0
INTEGER(KIND=JPIM) :: NPOOLS_ECMASCR = 0
!***  Miscellaneous
LOGICAL :: L_DEBUG   = .FALSE.
LOGICAL :: L_SWAPOUT = .FALSE.
LOGICAL :: L_CANARI  = .FALSE.
LOGICAL :: L_CANALT  = .FALSE.
LOGICAL :: L_REDUC   = .FALSE.
LOGICAL :: L_DEGREES = .FALSE.
LOGICAL :: L_ACTIVE  = .FALSE.

TYPE yomdb_t
SEQUENCE
#include "yomdb_vars.h"
END TYPE yomdb_t

TYPE(yomdb_t), allocatable :: o_(:)

END MODULE YOMDB
```

$SRC/ifs/common/openmp_obs.h

```
#include "yomdb_defs.h"
#include "itdef.h"
```

$SRC/ifs/common/yomdb_vars.h

```
!*** Note: MAKE SURE ALL VARIABLES ARE IN lowercase !!
!    Please make sure that variable lengths do not exceed 31 chars (a F90-std limit) !
!    If you want to know what is what, please look at /cc/rd/odb/cma2odb/initmdb.F90
CHARACTER(LEN=128) :: cactiveretr
logical :: lactiveretr
logical :: allocated_satpred
!***  Observational array lengths
INTEGER(KIND=JPIM) :: nrows_robhdr
INTEGER(KIND=JPIM) :: ncols_robhdr
INTEGER(KIND=JPIM) :: nrows_satpred
INTEGER(KIND=JPIM) :: ncols_satpred
INTEGER(KIND=JPIM) :: nrows_satbody
INTEGER(KIND=JPIM) :: ncols_satbody
INTEGER(KIND=JPIM) :: nrows_sathdr
INTEGER(KIND=JPIM) :: ncols_sathdr
INTEGER(KIND=JPIM) :: nrows_mobody
INTEGER(KIND=JPIM) :: ncols_mobody
INTEGER(KIND=JPIM) :: nrows_mobhdr
INTEGER(KIND=JPIM) :: ncols_mobhdr
INTEGER(KIND=JPIM) :: nrows_robody
INTEGER(KIND=JPIM) :: ncols_robody
INTEGER(KIND=JPIM) :: nrows_mobsu
INTEGER(KIND=JPIM) :: ncols_mobsu
INTEGER(KIND=JPIM) :: nrows_robsu
INTEGER(KIND=JPIM) :: ncols_robsu
INTEGER(KIND=JPIM) :: nrows_robddr
INTEGER(KIND=JPIM) :: ncols_robddr
!***  observational arrays
REAL(KIND=JPRB)   , pointer :: robhdr(:,:)
REAL(KIND=JPRB)    , pointer :: satpred(:,:)
REAL(KIND=JPRB)    , pointer :: satbody(:,:)
REAL(KIND=JPRB)    , pointer :: sathdr(:,:) ! sometimes TARGET
INTEGER(KIND=JPIM), pointer :: mobody(:,:)
INTEGER(KIND=JPIM), pointer :: mobhdr(:,:)
REAL(KIND=JPRB)    , pointer :: robody(:,:)
!***  for obs-setup retrievals obs_boxes, obatabs, mkglobstab, suobarea, ecset, smtov
INTEGER(KIND=JPIM), pointer :: mobsu(:,:)
REAL(KIND=JPRB),     pointer :: robsu(:,:)
!***  link between header & body
INTEGER(KIND=JPIM), pointer :: mlnkh2b(:)
!***  ddrs
REAL(KIND=JPRB), pointer :: robddr(:,:)
!*** dynamic mdb-pointers
INTEGER(KIND=JPIM) :: mdb_ddrno_at_ddrs  ! 'ddrno@ddrs'
INTEGER(KIND=JPIM) :: mdb_wordno_at_ddrs  ! 'wordno@ddrs'
INTEGER(KIND=JPIM) :: mdb_bulkdata_at_ddrs  ! 'bulkdata@ddrs'
INTEGER(KIND=JPIM) :: mdb_andate_at_desc  ! 'andate@desc'
INTEGER(KIND=JPIM) :: mdb_antime_at_desc  ! 'antime@desc'
INTEGER(KIND=JPIM) :: mdb_expver_at_desc ! 'expver@desc'
INTEGER(KIND=JPIM) :: mlnk_desc2ddrs(2)
INTEGER(KIND=JPIM) :: mdbonm ! 'seqno@hdr'
INTEGER(KIND=JPIM) :: mdbotp ! 'obstype@hdr'
!INTEGER_M :: mdboch ! 'obschar@hdr'
INTEGER(KIND=JPIM) :: mdbdat ! 'date@hdr'
INTEGER(KIND=JPIM) :: mdbetm ! 'time@hdr'
INTEGER(KIND=JPIM) :: mdbrfl ! 'rdbflag@hdr'
INTEGER(KIND=JPIM) :: mdbrst ! 'status@hdr'
INTEGER(KIND=JPIM) :: mdbrev1 ! 'event1@hdr'
INTEGER(KIND=JPIM) :: mdbrble ! 'blacklist@hdr'
INTEGER(KIND=JPIM) :: mdbbox ! 'sortbox@hdr'
INTEGER(KIND=JPIM) :: mdbstd ! 'sitedep@hdr'
INTEGER(KIND=JPIM) :: mdbsid ! 'statid@hdr'
INTEGER(KIND=JPIM) :: mdblat ! 'lat@hdr'
INTEGER(KIND=JPIM) :: mdblon ! 'lon@hdr'
INTEGER(KIND=JPIM) :: mdbalt ! 'stalt@hdr'
INTEGER(KIND=JPIM) :: mdbmor ! 'modoro@hdr'
INTEGER(KIND=JPIM) :: mdbtla ! 'trlat@hdr'
INTEGER(KIND=JPIM) :: mdbtlo ! 'trlon@hdr'
INTEGER(KIND=JPIM) :: mdbins ! 'instspec@hdr'
INTEGER(KIND=JPIM) :: mdbrev2 ! 'event2@hdr'
INTEGER(KIND=JPIM) :: mdbhoans ! 'anemoht@hdr'
INTEGER(KIND=JPIM) :: mdbhoand ! 'anemoht@hdr'
INTEGER(KIND=JPIM) :: mdbhoant ! 'anemoht@hdr'
INTEGER(KIND=JPIM) :: mdbhoanp ! 'anemoht@hdr'
INTEGER(KIND=JPIM) :: mdbhobas ! 'baroht@hdr'
INTEGER(KIND=JPIM) :: mdbhobad ! 'baroht@hdr'
INTEGER(KIND=JPIM) :: mdbhobat ! 'baroht@hdr'
INTEGER(KIND=JPIM) :: mdbhobap ! 'baroht@hdr'
INTEGER(KIND=JPIM) :: mdbsbcmm ! 'comp_method@satob'
INTEGER(KIND=JPIM) :: mdbsbiup ! 'instdata@satob'
INTEGER(KIND=JPIM) :: mdbsbdpt ! 'dataproc@satob'
INTEGER(KIND=JPIM) :: mdbsbqi1 ! 'qi_1@satob'
INTEGER(KIND=JPIM) :: mdbsbqi2 ! 'qi_2@satob'
INTEGER(KIND=JPIM) :: mdbsbqi3 ! 'qi_3@satob'
INTEGER(KIND=JPIM) ::   mdb_tb_at_satob ! 'tb@satob'
INTEGER(KIND=JPIM) ::   mdb_t_at_satob ! 't@satob'
INTEGER(KIND=JPIM) ::   mdb_zenith_at_satob ! 'zenith@satob'
INTEGER(KIND=JPIM) ::   mdb_shear_at_satob ! 'shear@satob'
INTEGER(KIND=JPIM) ::   mdb_t200_at_satob  ! 't200@satob'
INTEGER(KIND=JPIM) ::   mdb_t500_at_satob ! 't500@satob'
INTEGER(KIND=JPIM) ::   mdb_top_mean_t_at_satob ! 'top_mean_t@satob'
INTEGER(KIND=JPIM) ::   mdb_top_wv_at_satob ! 'top_wv@satob'
INTEGER(KIND=JPIM) ::   mdb_dt_by_dp_at_satob ! 'dt_by_dp@satob'
INTEGER(KIND=JPIM) ::   mdb_p_best_at_satob ! 'p_best@satob'
INTEGER(KIND=JPIM) ::   mdb_u_best_at_satob ! 'u_best@satob'
INTEGER(KIND=JPIM) ::   mdb_v_best_at_satob ! 'v_best@satob'
INTEGER(KIND=JPIM) ::   mdb_p_old_at_satob ! 'p_old@satob'
INTEGER(KIND=JPIM) ::   mdb_u_old_at_satob ! 'u_old@satob'
INTEGER(KIND=JPIM) ::   mdb_v_old_at_satob ! 'v_old@satob'
INTEGER(KIND=JPIM) ::   mdb_weight_at_satob(jpmx_satob_weight) ! 'weight@satob'
INTEGER(KIND=JPIM) :: mdbssia ! 'sensor@hdr'
INTEGER(KIND=JPIM) :: mdbscla ! 'scanline@atovs'
INTEGER(KIND=JPIM) :: mdbfova ! 'fov@atovs'
INTEGER(KIND=JPIM) :: mdbstha ! 'station_height@atovs'
INTEGER(KIND=JPIM) :: mdbsaza ! 'zenith@atovs'
INTEGER(KIND=JPIM) :: mdbsaba ! 'bearing_azimuth@atovs'
INTEGER(KIND=JPIM) :: mdbsoza ! 'solar_zenith@atovs'
INTEGER(KIND=JPIM) :: mdbsoba ! 'solar_azimuth@atovs'
INTEGER(KIND=JPIM) :: mdbvs3a ! 'vertsign_3@atovs'
INTEGER(KIND=JPIM) :: mdblsqa ! 'landsea@atovs'
INTEGER(KIND=JPIM) :: mdbhlsa ! 'landsurf_height@atovs'
INTEGER(KIND=JPIM) :: mdbskta ! 'skintemp@atovs'
INTEGER(KIND=JPIM) :: mdbpp2a ! 'press_2@atovs'
INTEGER(KIND=JPIM) :: mdbvs4a ! 'vertsign_4@atovs'
INTEGER(KIND=JPIM) :: mdb1dita ! 'iterno_1dvar@atovs'
INTEGER(KIND=JPIM) :: mdb1dera ! 'error_1dvar@atovs'
INTEGER(KIND=JPIM) :: mdb1dcua ! 'channel_1dvar_0@atovs'
INTEGER(KIND=JPIM) :: mdb1dcu1a ! 'channel_1dvar_1@atovs'
INTEGER(KIND=JPIM) :: mdb1dpfa ! 'presat_flags@atovs'
INTEGER(KIND=JPIM) :: mdb11dina ! 'iterno_conv_1dvar@atovs'
INTEGER(KIND=JPIM) :: mdb11dfia ! 'failure_1dvar@atovs'
INTEGER(KIND=JPIM) :: mdb1bcp1a ! 'predictor_1@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp2a ! 'predictor_2@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp3a ! 'predictor_3@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp4a ! 'predictor_4@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp5a ! 'predictor_5@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp6a ! 'predictor_6@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp7a ! 'predictor_7@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp8a ! 'predictor_8@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp9a ! 'predictor_9@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp10a ! 'predictor_10@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp11a ! 'predictor_11@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp12a ! 'predictor_12@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp13a ! 'predictor_13@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp14a ! 'predictor_14@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp15a ! 'predictor_15@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcp16a ! 'predictor_16@atovs_pred'
INTEGER(KIND=JPIM) :: mdb1bcpts1(jpmxup) ! skintemp[$NMXUPD]@atovs_pred
INTEGER(KIND=JPIM) :: mdbscsat ! 'track@scatt'
INTEGER(KIND=JPIM) :: mdbsccno ! 'cellno@scatt'
INTEGER(KIND=JPIM) :: mdbscpfl ! 'prodflag@scatt'
INTEGER(KIND=JPIM) :: mdborno ! 'orbit@ssmi'
INTEGER(KIND=JPIM) :: mdbslno ! 'scanline@ssmi'
INTEGER(KIND=JPIM) :: mdbpnas ! 'scanpos@ssmi'
INTEGER(KIND=JPIM) :: mdbtos ! 'typesurf@ssmi'
INTEGER(KIND=JPIM) :: mdbvsg ! 'vertsign@ssmi'
INTEGER(KIND=JPIM) :: mdbzan ! 'zenith@ssmi'
INTEGER(KIND=JPIM) :: mdb1dnit ! 'iterno_conv_1dvar@ssmi'
INTEGER(KIND=JPIM) :: mdb1dfin ! 'failure_1dvar@ssmi'
INTEGER(KIND=JPIM) :: mdb1bps ! 'surfpress_1@ssmi'
INTEGER(KIND=JPIM) :: mdb1bsts ! 'skintemp_1@ssmi'
INTEGER(KIND=JPIM) :: mdb1bsus ! 'u10m_1@ssmi'
INTEGER(KIND=JPIM) :: mdb1bsvs ! 'v10m_1@ssmi'
INTEGER(KIND=JPIM) :: mdb1dvps ! 'press@ssmi_body'
INTEGER(KIND=JPIM) :: mdb1dvbt ! 'temp_1@ssmi_body'
INTEGER(KIND=JPIM) :: mdb1dvat ! 'temp_2@ssmi_body'
INTEGER(KIND=JPIM) :: mdb1dvbq ! 'q_1@ssmi_body'
INTEGER(KIND=JPIM) :: mdb1dvaq ! 'q_2@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_procid_at_index  ! 'procid@index'
INTEGER(KIND=JPIM) :: mdb_target_at_index  ! 'target@index'
INTEGER(KIND=JPIM) :: mdb_kset_at_index  ! 'kset@index'
INTEGER(KIND=JPIM) :: mdb_tslot_at_index  ! 'tslot@index'
INTEGER(KIND=JPIM) :: mdb_abnob_at_index  ! 'abnob@index'
INTEGER(KIND=JPIM) :: mdb_mapomm_at_index ! 'mapomm@index'
INTEGER(KIND=JPIM) :: mdb_ident_at_hdr ! 'ident@hdr'
INTEGER(KIND=JPIM) :: mdb_thinningkey_at_hdr(jp_numthbox) ! 'thinningkey@hdr'
INTEGER(KIND=JPIM) :: mdb_thinningtimekey_at_hdr ! 'thinningtimekey@hdr'
INTEGER(KIND=JPIM) :: mlnk_index2hdr(2)
INTEGER(KIND=JPIM) :: mlnk_hdr2body(2)
INTEGER(KIND=JPIM) :: mlnk_hdr2update(2,jpmxup)
INTEGER(KIND=JPIM) :: mlnk_hdr2errstat(2)
INTEGER(KIND=JPIM) :: mlnk_hdr2sat(2)
INTEGER(KIND=JPIM) :: mlnk_sat2atovs(2)
INTEGER(KIND=JPIM) :: mlnk_sat2reo3(2)
INTEGER(KIND=JPIM) :: mlnk_sat2ssmi(2)
INTEGER(KIND=JPIM) :: mlnk_sat2scatt(2)
INTEGER(KIND=JPIM) :: mlnk_sat2satob(2)
INTEGER(KIND=JPIM) :: mlnk_atovs2atovs_pred(2)
INTEGER(KIND=JPIM) :: mlnk_ssmi2ssmi_body(2)
INTEGER(KIND=JPIM) :: mlnk_scatt2scatt_body(2)
INTEGER(KIND=JPIM) :: mdbvnm ! 'varno@body'
INTEGER(KIND=JPIM) :: mdbvco ! 'vertco_type@body'
INTEGER(KIND=JPIM) :: mdbrdfl ! 'rdbflag@body'
INTEGER(KIND=JPIM) :: mdbflg ! 'anflag@body'
INTEGER(KIND=JPIM) :: mdbdsta ! 'status@body'
INTEGER(KIND=JPIM) :: mdbdev1 ! 'event1@body'
INTEGER(KIND=JPIM) :: mdbdble ! 'blacklist@body'
INTEGER(KIND=JPIM) :: mdbesqn ! 'entryno@body'
INTEGER(KIND=JPIM) :: mdbppp ! 'press@body'
INTEGER(KIND=JPIM) :: mdbprl ! 'press_rl@body'
INTEGER(KIND=JPIM) :: mdbvar ! 'obsvalue@body'
INTEGER(KIND=JPIM) :: mdbomn ! 'an_depar@body'
INTEGER(KIND=JPIM) :: mdbomf ! 'fg_depar@body'
INTEGER(KIND=JPIM) :: mdbaso ! 'an_sens_obs@body'
INTEGER(KIND=JPIM) :: mdbfoe ! 'final_obs_error@errstat'
INTEGER(KIND=JPIM) :: mdboer ! 'obs_error@errstat'
INTEGER(KIND=JPIM) :: mdbrer ! 'repres_error@errstat'
INTEGER(KIND=JPIM) :: mdbper ! 'pers_error@errstat'
INTEGER(KIND=JPIM) :: mdbfge ! 'fg_error@errstat'
INTEGER(KIND=JPIM) :: mdbfgc1 ! 'fg_check_1@body'
INTEGER(KIND=JPIM) :: mdbfgc2 ! 'fg_check_2@body'
INTEGER(KIND=JPIM) ::    mdbiom0(jpmxup) ! initial@update[$NMXUPD]
INTEGER(KIND=JPIM) ::    mdbifc1(jpmxup) ! hires@update[$NMXUPD]
INTEGER(KIND=JPIM) ::    mdbifc2(jpmxup) ! lores@update[$NMXUPD]
INTEGER(KIND=JPIM) ::    mdbiomn(jpmxup) ! final@update[$NMXUPD]
INTEGER(KIND=JPIM) :: mdbrbvc ! 'mf_vertco_type@body'
INTEGER(KIND=JPIM) :: mdbrbpio ! 'mf_log_p@body'
INTEGER(KIND=JPIM) :: mdbrboe ! 'mf_stddev@body'
INTEGER(KIND=JPIM) :: mdbdev2 ! 'event2@body'
INTEGER(KIND=JPIM) :: mdbsypc ! 'ppcode@body'
INTEGER(KIND=JPIM) :: mdbtelid ! 'level@body'
INTEGER(KIND=JPIM) :: mdbpilid ! 'level@body'
INTEGER(KIND=JPIM) :: mdbtorb ! 'biascorr@body'
INTEGER(KIND=JPIM) :: mdbtorba ! 'biascorr@body'
INTEGER(KIND=JPIM) :: mdbssrb ! 'biascorr@body'
INTEGER(KIND=JPIM) :: mdbs1dvc ! 'radcost@ssmi_body'
INTEGER(KIND=JPIM) :: mdbsscf ! 'frequency@ssmi_body'
INTEGER(KIND=JPIM) :: mdbsscbw ! 'bandwidth@ssmi_body'
INTEGER(KIND=JPIM) :: mdbssanp ! 'polarisation@ssmi_body'
INTEGER(KIND=JPIM) :: mdbscbaa ! 'azimuth@scatt_body'
INTEGER(KIND=JPIM) :: mdbscbia ! 'incidence@scatt_body'
INTEGER(KIND=JPIM) :: mdbsckp ! 'kp@scatt_body'
INTEGER(KIND=JPIM) :: mdbscirf ! 'invresid_1@scatt_body'
INTEGER(KIND=JPIM) :: mdbscirs ! 'invresid_2@scatt_body'
INTEGER(KIND=JPIM) :: mdbscdis ! 'dirskill@scatt_body'
INTEGER(KIND=JPIM) ::   mdb_satid_at_sat  ! 'satid@sat'
INTEGER(KIND=JPIM) ::   mdb_cldptop1_at_atovs  ! 'cldptop1@atovs'
INTEGER(KIND=JPIM) ::   mdb_cldne1_at_atovs  ! 'cldne1@atovs'
INTEGER(KIND=JPIM) ::   mdb_cldptop2_at_atovs  ! 'cldptop2@atovs'
INTEGER(KIND=JPIM) ::   mdb_cldne2_at_atovs  ! 'cldne2@atovs'
INTEGER(KIND=JPIM) ::   mdb_cldptop3_at_atovs  ! 'cldptop3@atovs'
INTEGER(KIND=JPIM) ::   mdb_cldne3_at_atovs  ! 'cldne3@atovs'
INTEGER(KIND=JPIM) :: mdbro3it ! 'instrument_type@reo3'
INTEGER(KIND=JPIM) :: mdbro3pt ! 'product_type@reo3'
INTEGER(KIND=JPIM) :: mdbro3la1 ! 'lat_fovcorner_1@reo3'
INTEGER(KIND=JPIM) :: mdbro3lo1 ! 'lon_fovcorner_1@reo3'
INTEGER(KIND=JPIM) :: mdbro3la2 ! 'lat_fovcorner_2@reo3'
INTEGER(KIND=JPIM) :: mdbro3lo2 ! 'lon_fovcorner_2@reo3'
INTEGER(KIND=JPIM) :: mdbro3la3 ! 'lat_fovcorner_3@reo3'
INTEGER(KIND=JPIM) :: mdbro3lo3 ! 'lon_fovcorner_3@reo3'
INTEGER(KIND=JPIM) :: mdbro3la4 ! 'lat_fovcorner_4@reo3'
INTEGER(KIND=JPIM) :: mdbro3lo4 ! 'lon_fovcorner_4@reo3'
INTEGER(KIND=JPIM) :: mdbro3soe ! 'solar_elevation@reo3'
INTEGER(KIND=JPIM) :: mdbro3fov ! 'fov@reo3'
INTEGER(KIND=JPIM) :: mdbro3clc ! 'cloud_cover@reo3'
INTEGER(KIND=JPIM) :: mdbro3cp ! 'cloud_top_press@reo3'
INTEGER(KIND=JPIM) :: mdbro3qr ! 'quality_retrieval@reo3'
INTEGER(KIND=JPIM) :: mdbro3nl ! 'number_layers@reo3'
INTEGER(KIND=JPIM) :: mdb_source_at_desc    ! 'source@desc'
INTEGER(KIND=JPIM) :: mdb_version_at_desc   ! 'version@desc'
INTEGER(KIND=JPIM) :: mdb_acl_at_desc       ! 'acl@desc'
INTEGER(KIND=JPIM) :: mdb_creadate_at_desc  ! 'creadate@desc'
INTEGER(KIND=JPIM) :: mdb_creatime_at_desc  ! 'creatime@desc'
INTEGER(KIND=JPIM) :: mdb_creaby_at_desc    ! 'creaby@desc'
INTEGER(KIND=JPIM) :: mdb_moddate_at_desc   ! 'moddate@desc'
INTEGER(KIND=JPIM) :: mdb_modtime_at_desc   ! 'modtime@desc'
INTEGER(KIND=JPIM) :: mdb_modby_at_desc     ! 'modby@desc'
INTEGER(KIND=JPIM) :: mdb_fulldesc_at_desc(jp_maxdesc)  ! 'fulldesc@desc'
INTEGER(KIND=JPIM) :: mlnk_desc2hdr(2)
INTEGER(KIND=JPIM) :: mlnk_hdr2bufr(2)
INTEGER(KIND=JPIM) :: mdb_subclass_at_hdr  ! 'subclass@hdr'
INTEGER(KIND=JPIM) :: mdb_rdbtype_at_hdr   ! 'rdbtype@hdr'
INTEGER(KIND=JPIM) :: mdb_subtype_at_hdr   ! 'subtype@hdr'
INTEGER(KIND=JPIM) :: mdb_bufrtype_at_hdr  ! 'bufrtype@hdr'
INTEGER(KIND=JPIM) :: mdb_flag_at_hdr      ! 'flag@hdr'
INTEGER(KIND=JPIM) :: mdb_numlev_at_hdr    ! 'numlev@hdr'
INTEGER(KIND=JPIM) :: mdb_numactiveb_at_hdr ! 'numactiveb@hdr'
INTEGER(KIND=JPIM) :: mdb_duplseqno_at_hdr(jp_maxdupl)  ! 'duplseqno@hdr'
INTEGER(KIND=JPIM) :: mdb_msg_at_bufr      ! 'msg@bufr'
INTEGER(KIND=JPIM) :: mdb_thinbox_at_hdr   ! 'thinbox@hdr'
INTEGER(KIND=JPIM) :: mdb_msec_at_hdr      ! 'msec@hdr'
INTEGER(KIND=JPIM) :: mdb_satid_at_hdr     ! 'satid@hdr'
INTEGER(KIND=JPIM) :: mdb_orbit_at_hdr     ! 'orbit@hdr'
INTEGER(KIND=JPIM) :: mdb_fov_at_hdr       ! 'fov@hdr'
INTEGER(KIND=JPIM) :: mdb_scanline_at_hdr  ! 'scanline@hdr'
INTEGER(KIND=JPIM) :: mdb_zenith_at_hdr    ! 'zenith@hdr'
INTEGER(KIND=JPIM) :: mlnk_hdr2inbufr(2)
INTEGER(KIND=JPIM) :: mdb_msg_at_inbufr    ! 'msg@inbufr'
INTEGER(KIND=JPIM) :: mlnk_hdr2outbufr(2)
INTEGER(KIND=JPIM) :: mdb_msg_at_outbufr   ! 'msg@outbufr'
INTEGER(KIND=JPIM) :: mdb_varno_presence_at_hdr ! 'varno_presence@hdr'
!*** New items added due to direct BUFR2ODB conversion
INTEGER(KIND=JPIM) :: mdb_station_type_at_hdr ! 'station_type@hdr'
INTEGER(KIND=JPIM) :: mdb_sonde_type_at_hdr ! 'sonde_type@hdr'
INTEGER(KIND=JPIM) :: mdb_uwi_esa_at_scatt(2) ! 'uwi_esa@scatt'
INTEGER(KIND=JPIM) :: mdb_mpc_at_scatt_body ! 'mpc@scatt_body'
INTEGER(KIND=JPIM) :: mdb_wvc_qf_at_scatt_body ! 'wvc_qf@scatt_body'
INTEGER(KIND=JPIM) :: mdb_nretr_amb_at_scatt_body ! 'nretr_amb@scatt_body'
INTEGER(KIND=JPIM) :: mdb_subsetno_at_hdr ! 'subsetno@hdr'
!*** New items added due to Poolmasking
INTEGER(KIND=JPIM) :: mlnk_desc2poolmask(2)
INTEGER(KIND=JPIM) :: mdb_poolno_at_poolmask ! 'poolno@poolmask'
INTEGER(KIND=JPIM) :: mdb_obstype_at_poolmask ! 'obstype@poolmask'
INTEGER(KIND=JPIM) :: mdb_codetype_at_poolmask ! 'codetype@poolmask'
INTEGER(KIND=JPIM) :: mdb_sensor_at_poolmask ! 'sensor@poolmask'
INTEGER(KIND=JPIM) :: mdb_tslot_at_poolmask ! 'tslot@poolmask'
INTEGER(KIND=JPIM) :: mdb_subtype_at_poolmask ! 'subtype@poolmask'
INTEGER(KIND=JPIM) :: mdb_bufrtype_at_poolmask ! 'bufrtype@poolmask'
INTEGER(KIND=JPIM) :: mdb_hdr_count_at_poolmask ! 'hdr_count@poolmask'
INTEGER(KIND=JPIM) :: mdb_body_count_at_poolmask ! 'body_count@poolmask'
INTEGER(KIND=JPIM) :: mdb_max_bodylen_at_poolmask ! 'max_bodylen@poolmask'
!*** New items added due to introduction of 'timeslot_index'-table
INTEGER(KIND=JPIM) :: mdb_timeslot_at_timeslot_index ! 'timeslot@timeslot_index'
INTEGER(KIND=JPIM) :: mlnk_desc2timeslot_index(2)
INTEGER(KIND=JPIM) :: mlnk_timeslot_index2index(2)
!*** Commonly needed subwords/members of 'obschar.*@hdr'
!INTEGER_M :: mdb_obschar_d_codetype_at_hdr  ! 'obschar.codetype@hdr' ! 'obschar_d_codetype@hdr'
!INTEGER_M :: mdb_obschar_d_instype_at_hdr   ! 'obschar.instype@hdr' ! 'obschar_d_instype@hdr'
!INTEGER_M :: mdb_obschar_d_retrtype_at_hdr  ! 'obschar.retrtype@hdr' ! 'obschar_d_retrtype@hdr'
!INTEGER_M :: mdb_obschar_d_datagroup_at_hdr ! 'obschar.datagroup@hdr' ! 'obschar_d_datagroup@hdr'
!*** obschar is replaced by 4 new entries
INTEGER(KIND=JPIM) :: mdb_codetype_at_hdr ! 'codetype@hdr'
INTEGER(KIND=JPIM) :: mdb_insttype_at_hdr ! 'insttype@hdr'
INTEGER(KIND=JPIM) :: mdb_retrtype_at_hdr ! 'retrtype@hdr'
INTEGER(KIND=JPIM) :: mdb_areatype_at_hdr ! 'areatype@hdr'
!*** Additional @satob entries requested by Niels Bormann  [20/11/2001]
INTEGER(KIND=JPIM) :: mdb_segment_size_x_at_satob ! 'segment_size_x@satob'
INTEGER(KIND=JPIM) :: mdb_segment_size_y_at_satob ! 'segment_size_y@satob'
!*** New item(s)
INTEGER(KIND=JPIM) :: mdb_zone_at_hdr ! 'zone@hdr'
INTEGER(KIND=JPIM) :: mdb_satinst_at_hdr      ! 'satinst@hdr'
INTEGER(KIND=JPIM) :: mdb_satinst_at_poolmask ! 'satinst@hpoolmask'
INTEGER(KIND=JPIM) :: mdb_satname_at_hdr(2)      ! 'satname@hdr'
!*** New @satob table item suggested by Niels Bormann [7/11/2002]
INTEGER(KIND=JPIM) :: mdb_chan_freq_at_satob ! 'chan_freq@satob'
!*** New @body & @atovs entries proposed by Christina Koepken [26/11/2002]
INTEGER(KIND=JPIM) :: mdb_landsea_obs_at_atovs ! 'landsea_obs@atovs'
INTEGER(KIND=JPIM) :: mdb_cld_fg_depar_at_body ! 'cld_fg_depar@body'
INTEGER(KIND=JPIM) :: mdb_surfemiss_at_body ! 'surfemiss@body'
INTEGER(KIND=JPIM) :: mdb_csr_pclear_at_body ! 'csr_pclear@body'
INTEGER(KIND=JPIM) :: mdb_csr_pcloudy_at_body ! 'csr_pcloudy@body'
!*** New @body entries proposed by Tony McNally [29/11/2002]
INTEGER(KIND=JPIM) :: mdb_rank_cld_at_body ! 'rank_cld@body'
INTEGER(KIND=JPIM) :: mdb_rank_an_at_body  ! 'rank_an@body'
!*** New @desc & @hdr entries pushed in by Sami Saarinen [17/02/2004]
INTEGER(KIND=JPIM) :: mdb_mxup_traj_at_desc ! 'mxup_traj@desc'
INTEGER(KIND=JPIM) :: mdb_source_at_hdr     ! 'source@hdr'
!*** Table @satem removed and items moved into @hdr with different names
!    (for old SATEM) by Sami Saarinen [26/6/2003]
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INTEGER(KIND=JPIM) :: mdb_satem_dataproc_at_hdr ! 'satem_dataproc@hdr'
INTEGER(KIND=JPIM) :: mdb_satem_instdata_at_hdr ! 'satem_instdata@hdr'
!*** MDB_AUX1_AT_BODY obsolete (except PREODB)
!    Elsewhere replaced by (vector) of MDB_AUX_AT_BODY [23/1/04 SS]
INTEGER(KIND=JPIM) :: mdb_aux_at_body(jp_numaux)  ! 'aux@body'
INTEGER(KIND=JPIM) :: mdb_aux1_at_body  ! 'aux1@body'
!*** latlon_rad@desc added to flag whether (lat,lon) are in radians or not [23/1/04 SS]
INTEGER(KIND=JPIM) ::  mdb_latlon_rad_at_desc ! 'latlon_rad@desc'
!*** SSM/I reorganization (Peter Bauer/Sami Saarinen) [11/3/04]
INTEGER(KIND=JPIM) :: mdb_prec_st_at_ssmi(2) ! 'prec_st[2]@ssmi'
INTEGER(KIND=JPIM) :: mdb_prec_cv_at_ssmi(2) ! 'prec_cv[2]@ssmi'
INTEGER(KIND=JPIM) :: mdb_rain_at_ssmi_body(2) ! 'rain[2]@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_snow_at_ssmi_body(2) ! 'snow[2]@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_clw_at_ssmi_body(2) ! 'clw[2]@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_ciw_at_ssmi_body(2) ! 'ciw[2]@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_cc_at_ssmi_body(2) ! 'cc[2]@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_cost_at_ssmi_body ! 'rad_cost@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_obs_at_ssmi_body ! 'rad_obs@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_fg_depar_at_ssmi_body ! 'rad_fg_depar@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_an_depar_at_ssmi_body ! 'rad_an_depar@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_obs_err_at_ssmi_body ! 'rad_obs_err@ssmi_body'
INTEGER(KIND=JPIM) :: mdb_rad_bias_at_ssmi_body ! 'rad_bias@ssmi_body'
!*** checksum@hdr-word added to get over reproducibility problems for good [18/3/04 SS]
!    contains the SUM(obsvalue) WHERE press IS NOT NULL and obsvalue IS NOT NULL
!    just after bufr2odb (in mergeodb; routine odb/cma2odb/update_obsdb.F90)
INTEGER(KIND=JPIM) :: mdb_checksum_at_hdr ! 'checksum@hdr'
```

$SRC/ifs/common/yomdb_defs.h

```
!*** Note: make sure that the variable to be redefined is in UPPERCASE
!      and MAKE SURE THAT THE REDEFINITION (o_(it)%...) IS IN lowercase !!
!    If you want to know what is what, please look at /cc/rd/odb/cma2odb/initmdb.F90
#define CACTIVERETR o_(it)%cactiveretr
#define LACTIVERETR o_(it)%lactiveretr
!***  Observational array lengths
#define ALLOCATED_SATPRED o_(it)%allocated_satpred
#define NROWS_ROBHDR o_(it)%nrows_robhdr
#define NCOLS_ROBHDR o_(it)%ncols_robhdr
#define NROWS_SATPRED o_(it)%nrows_satpred
#define NCOLS_SATPRED o_(it)%ncols_satpred
#define NROWS_SATBODY o_(it)%nrows_satbody
#define NCOLS_SATBODY o_(it)%ncols_satbody
#define NROWS_SATHDR o_(it)%nrows_sathdr
#define NCOLS_SATHDR o_(it)%ncols_sathdr
#define NROWS_MOBODY o_(it)%nrows_mobody
#define NCOLS_MOBODY o_(it)%ncols_mobody
#define NROWS_MOBHDR o_(it)%nrows_mobhdr
#define NCOLS_MOBHDR o_(it)%ncols_mobhdr
#define NROWS_ROBODY o_(it)%nrows_robody
#define NCOLS_ROBODY o_(it)%ncols_robody
#define NROWS_MOBSU o_(it)%nrows_mobsu
#define NCOLS_MOBSU o_(it)%ncols_mobsu
#define NROWS_ROBSU o_(it)%nrows_robsu
#define NCOLS_ROBSU o_(it)%ncols_robsu
#define NROWS_ROBDDR o_(it)%nrows_robddr
#define NCOLS_ROBDDR o_(it)%ncols_robddr
!*** Observational arrays and link arrays
#define ROBHDR o_(it)%robhdr
#define SATPRED o_(it)%satpred
```

```
#define SATBODY o_(it)%satbody
#define SATHDR o_(it)%sathdr
#define MOBODY o_(it)%mobody
#define MOBHDR o_(it)%mobhdr
#define ROBODY o_(it)%robody
#define MOBSU o_(it)%mobsu
#define ROBSU o_(it)%robsu
#define MLNKH2B o_(it)%mlnkh2b
#define ROBDDR o_(it)%robddr
!*** Dynamic MDB-pointers to address obs. array columns
#define MDB_DDRNO_AT_DDRS o_(it)%mdb_ddrno_at_ddrs
#define MDB_WORDNO_AT_DDRS o_(it)%mdb_wordno_at_ddrs
#define MDB_BULKDATA_AT_DDRS o_(it)%mdb_bulkdata_at_ddrs
#define MDB_ANDATE_AT_DESC o_(it)%mdb_andate_at_desc
#define MDB_ANTIME_AT_DESC o_(it)%mdb_antime_at_desc
#define MDB_EXPVER_AT_DESC o_(it)%mdb_expver_at_desc
#define MLNK_DESC2DDRS o_(it)%mlnk_desc2ddrs
#define MDBONM o_(it)%mdbonm
#define MDBOTP o_(it)%mdbotp
#define MDBOCH o_(it)%mdboch
#define MDBDAT o_(it)%mdbdat
#define MDBETM o_(it)%mdbetm
#define MDBRFL o_(it)%mdbrfl
#define MDBRST o_(it)%mdbrst
#define MDBREV1 o_(it)%mdbrev1
#define MDBRBLE o_(it)%mdbrble
#define MDBBOX o_(it)%mdbbox
#define MDBSTD o_(it)%mdbstd
#define MDBSID o_(it)%mdbsid
#define MDBLAT o_(it)%mdblat
#define MDBLON o_(it)%mdblon
#define MDBALT o_(it)%mdbalt
#define MDBMOR o_(it)%mdbmor
#define MDBTLA o_(it)%mdbtla
#define MDBTLO o_(it)%mdbtlo
#define MDBINS o_(it)%mdbins
#define MDBREV2 o_(it)%mdbrev2
#define MDBHOANS o_(it)%mdbhoans
#define MDBHOAND o_(it)%mdbhoand
#define MDBHOANT o_(it)%mdbhoant
#define MDBHOANP o_(it)%mdbhoanp
#define MDBHOBAS o_(it)%mdbhobas
#define MDBHOBAD o_(it)%mdbhobad
#define MDBHOBAT o_(it)%mdbhobat
#define MDBHOBAP o_(it)%mdbhobap
#define MDBSBCMM o_(it)%mdbsbcmm
#define MDBSBIUP o_(it)%mdbsbiup
#define MDBSBDPT o_(it)%mdbsbdpt
#define MDBSBQI1 o_(it)%mdbsbqi1
#define MDBSBQI2 o_(it)%mdbsbqi2
#define MDBSBQI3 o_(it)%mdbsbqi3
#define MDB_TB_AT_SATOB o_(it)%mdb_tb_at_satob
#define MDB_T_AT_SATOB o_(it)%mdb_t_at_satob
#define MDB_CHAN_FREQ_AT_SATOB o_(it)%mdb_chan_freq_at_satob
#define MDB_ZENITH_AT_SATOB o_(it)%mdb_zenith_at_satob
#define MDB_SHEAR_AT_SATOB o_(it)%mdb_shear_at_satob
#define MDB_T200_AT_SATOB o_(it)%mdb_t200_at_satob
#define MDB_T500_AT_SATOB o_(it)%mdb_t500_at_satob
#define MDB_TOP_MEAN_T_AT_SATOB o_(it)%mdb_top_mean_t_at_satob
#define MDB_TOP_WV_AT_SATOB o_(it)%mdb_top_wv_at_satob
#define MDB_DT_BY_DP_AT_SATOB o_(it)%mdb_dt_by_dp_at_satob
#define MDB_P_BEST_AT_SATOB o_(it)%mdb_p_best_at_satob
```

```
#define MDB_U_BEST_AT_SATOB o_(it)%mdb_u_best_at_satob
#define MDB_V_BEST_AT_SATOB o_(it)%mdb_v_best_at_satob
#define MDB_P_OLD_AT_SATOB o_(it)%mdb_p_old_at_satob
#define MDB_U_OLD_AT_SATOB o_(it)%mdb_u_old_at_satob
#define MDB_V_OLD_AT_SATOB o_(it)%mdb_v_old_at_satob
#define MDB_WEIGHT_AT_SATOB o_(it)%mdb_weight_at_satob
#define MDBSSIA o_(it)%mdbssia
#define MDBSCLA o_(it)%mdbscla
#define MDBFOVA o_(it)%mdbfova
#define MDBSTHA o_(it)%mdbstha
#define MDBSAZA o_(it)%mdbsaza
#define MDBSABA o_(it)%mdbsaba
#define MDBSOZA o_(it)%mdbsoza
#define MDBSOBA o_(it)%mdbsoba
#define MDBVS3A o_(it)%mdbvs3a
#define MDBLSQA o_(it)%mdblsqa
#define MDBHLSA o_(it)%mdbhlsa
#define MDBSKTA o_(it)%mdbskta
#define MDBPP2A o_(it)%mdbpp2a
#define MDBVS4A o_(it)%mdbvs4a
#define MDB1DITA o_(it)%mdb1dita
#define MDB1DERA o_(it)%mdb1dera
#define MDB1DCUA o_(it)%mdb1dcua
#define MDB1DCU1A o_(it)%mdb1dcu1a
#define MDB1DPFA o_(it)%mdb1dpfa
#define MDB11DINA o_(it)%mdb11dina
#define MDB11DFIA o_(it)%mdb11dfia
#define MDB1BCP1A o_(it)%mdb1bcp1a
#define MDB1BCP2A o_(it)%mdb1bcp2a
#define MDB1BCP3A o_(it)%mdb1bcp3a
#define MDB1BCP4A o_(it)%mdb1bcp4a
#define MDB1BCP5A o_(it)%mdb1bcp5a
#define MDB1BCP6A o_(it)%mdb1bcp6a
#define MDB1BCP7A o_(it)%mdb1bcp7a
#define MDB1BCP8A o_(it)%mdb1bcp8a
#define MDB1BCP9A o_(it)%mdb1bcp9a
#define MDB1BCP10A o_(it)%mdb1bcp10a
#define MDB1BCP11A o_(it)%mdb1bcp11a
#define MDB1BCP12A o_(it)%mdb1bcp12a
#define MDB1BCP13A o_(it)%mdb1bcp13a
#define MDB1BCP14A o_(it)%mdb1bcp14a
#define MDB1BCP15A o_(it)%mdb1bcp15a
#define MDB1BCP16A o_(it)%mdb1bcp16a
#define MDB1BCPTS1 o_(it)%mdb1bcpts1
#define MDBSCSAT o_(it)%mdbscsat
#define MDBSCCNO o_(it)%mdbsccno
#define MDBSCPFL o_(it)%mdbscpfl
#define MDBORNO o_(it)%mdborno
#define MDBSLNO o_(it)%mdbslno
#define MDBPNAS o_(it)%mdbpnas
#define MDBTOS o_(it)%mdbtos
#define MDBVSG o_(it)%mdbvsg
#define MDBZAN o_(it)%mdbzan
#define MDB1DNIT o_(it)%mdb1dnit
#define MDB1DFIN o_(it)%mdb1dfin
#define MDB1BPS o_(it)%mdb1bps
#define MDB1BSTS o_(it)%mdb1bsts
#define MDB1BSUS o_(it)%mdb1bsus
#define MDB1BSVS o_(it)%mdb1bsvs
#define MDB1DVPS o_(it)%mdb1dvps
#define MDB1DVBT o_(it)%mdb1dvbt
#define MDB1DVAT o_(it)%mdb1dvat
```

```
#define MDB1DVBQ o_(it)%mdb1dvbq
#define MDB1DVAQ o_(it)%mdb1dvaq
#define MDB_PROCID_AT_INDEX o_(it)%mdb_procid_at_index
#define MDB_TARGET_AT_INDEX o_(it)%mdb_target_at_index
#define MDB_KSET_AT_INDEX o_(it)%mdb_kset_at_index
#define MDB_TSLOT_AT_INDEX o_(it)%mdb_tslot_at_index
#define MDB_ABNOB_AT_INDEX o_(it)%mdb_abnob_at_index
#define MDB_MAPOMM_AT_INDEX o_(it)%mdb_mapomm_at_index
#define MDB_IDENT_AT_HDR o_(it)%mdb_ident_at_hdr
#define MLNK_INDEX2HDR o_(it)%mlnk_index2hdr
#define MLNK_HDR2BODY o_(it)%mlnk_hdr2body
#define MLNK_HDR2UPDATE o_(it)%mlnk_hdr2update
#define MLNK_HDR2ERRSTAT o_(it)%mlnk_hdr2errstat
#define MLNK_HDR2SAT o_(it)%mlnk_hdr2sat
#define MLNK_SAT2ATOVS o_(it)%mlnk_sat2atovs
#define MLNK_SAT2REO3 o_(it)%mlnk_sat2reo3
#define MLNK_SAT2SSMI o_(it)%mlnk_sat2ssmi
#define MLNK_SAT2SCATT o_(it)%mlnk_sat2scatt
#define MLNK_SAT2SATOB o_(it)%mlnk_sat2satob
#define MLNK_ATOVS2ATOVS_PRED o_(it)%mlnk_atovs2atovs_pred
#define MLNK_SSMI2SSMI_BODY o_(it)%mlnk_ssmi2ssmi_body
#define MLNK_SCATT2SCATT_BODY o_(it)%mlnk_scatt2scatt_body
#define MDBVNM o_(it)%mdbvnm
#define MDBVCO o_(it)%mdbvco
#define MDBRDFL o_(it)%mdbrdfl
#define MDBFLG o_(it)%mdbflg
#define MDBDSTA o_(it)%mdbdsta
#define MDBDEV1 o_(it)%mdbdev1
#define MDBDBLE o_(it)%mdbdble
#define MDBESQN o_(it)%mdbesqn
#define MDBPPP o_(it)%mdbppp
#define MDBPRL o_(it)%mdbprl
#define MDBVAR o_(it)%mdbvar
#define MDBASO o_(it)%mdbaso
#define MDBOMN o_(it)%mdbomn
#define MDBOMF o_(it)%mdbomf
#define MDBFOE o_(it)%mdbfoe
#define MDBOER o_(it)%mdboer
#define MDBRER o_(it)%mdbrer
#define MDBPER o_(it)%mdbper
#define MDBFGE o_(it)%mdbfge
#define MDBFGC1 o_(it)%mdbfgc1
#define MDBFGC2 o_(it)%mdbfgc2
#define MDBIOM0 o_(it)%mdbiom0
#define MDBIFC1 o_(it)%mdbifc1
#define MDBIFC2 o_(it)%mdbifc2
#define MDBIOMN o_(it)%mdbiomn
#define MDBRBVC o_(it)%mdbrbvc
#define MDBRBPIO o_(it)%mdbrbpio
#define MDBRBOE o_(it)%mdbrboe
#define MDBDEV2 o_(it)%mdbdev2
#define MDBSYPC o_(it)%mdbsypc
#define MDBTELID o_(it)%mdbtelid
#define MDBPILID o_(it)%mdbpilid
#define MDBTORB o_(it)%mdbtorb
#define MDBTORBA o_(it)%mdbtorba
#define MDBSSRB o_(it)%mdbssrb
#define MDBS1DVC o_(it)%mdbs1dvc
#define MDBSSCCF o_(it)%mdbssccf
#define MDBSSCBW o_(it)%mdbsscbw
#define MDBSSANP o_(it)%mdbssanp
#define MDBSCBAA o_(it)%mdbscbaa
```

```
#define MDBSCBIA o_(it)%mdbscbia
#define MDBSCKP o_(it)%mdbsckp
#define MDBSCIRF o_(it)%mdbscirf
#define MDBSCIRS o_(it)%mdbscirs
#define MDBSCDIS o_(it)%mdbscdis
#define MDB_SATID_AT_SAT o_(it)%mdb_satid_at_sat
#define MDB_CLDPTOP1_AT_ATOVS o_(it)%mdb_cldptop1_at_atovs
#define MDB_CLDNE1_AT_ATOVS o_(it)%mdb_cldne1_at_atovs
#define MDB_CLDPTOP2_AT_ATOVS o_(it)%mdb_cldptop2_at_atovs
#define MDB_CLDNE2_AT_ATOVS o_(it)%mdb_cldne2_at_atovs
#define MDB_CLDPTOP3_AT_ATOVS o_(it)%mdb_cldptop3_at_atovs
#define MDB_CLDNE3_AT_ATOVS o_(it)%mdb_cldne3_at_atovs
#define   MDBRO3IT  o_(it)%mdbro3it
#define   MDBRO3PT  o_(it)%mdbro3pt
#define  MDBRO3LA1  o_(it)%mdbro3la1
#define  MDBRO3LO1  o_(it)%mdbro3lo1
#define  MDBRO3LA2  o_(it)%mdbro3la2
#define  MDBRO3LO2  o_(it)%mdbro3lo2
#define  MDBRO3LA3  o_(it)%mdbro3la3
#define  MDBRO3LO3  o_(it)%mdbro3lo3
#define  MDBRO3LA4  o_(it)%mdbro3la4
#define  MDBRO3LO4  o_(it)%mdbro3lo4
#define  MDBRO3SOE  o_(it)%mdbro3soe
#define  MDBRO3FOV  o_(it)%mdbro3fov
#define  MDBRO3CLC  o_(it)%mdbro3clc
#define   MDBRO3CP  o_(it)%mdbro3cp
#define   MDBRO3QR  o_(it)%mdbro3qr
#define   MDBRO3NL  o_(it)%mdbro3nl
#define MDB_SOURCE_AT_DESC    o_(it)%mdb_source_at_desc
#define MDB_VERSION_AT_DESC   o_(it)%mdb_version_at_desc
#define MDB_ACL_AT_DESC       o_(it)%mdb_acl_at_desc
#define MDB_CREADATE_AT_DESC  o_(it)%mdb_creadate_at_desc
#define MDB_CREATIME_AT_DESC  o_(it)%mdb_creatime_at_desc
#define MDB_CREABY_AT_DESC    o_(it)%mdb_creaby_at_desc
#define MDB_MODDATE_AT_DESC   o_(it)%mdb_moddate_at_desc
#define MDB_MODTIME_AT_DESC   o_(it)%mdb_modtime_at_desc
#define MDB_MODBY_AT_DESC     o_(it)%mdb_modby_at_desc
#define MDB_FULLDESC_AT_DESC  o_(it)%mdb_fulldesc_at_desc
#define MLNK_DESC2HDR         o_(it)%mlnk_desc2hdr
#define MLNK_HDR2BUFR         o_(it)%mlnk_hdr2bufr
#define MDB_SUBCLASS_AT_HDR   o_(it)%mdb_subclass_at_hdr
#define MDB_RDBTYPE_AT_HDR    o_(it)%mdb_rdbtype_at_hdr
#define MDB_SUBTYPE_AT_HDR    o_(it)%mdb_subtype_at_hdr
#define MDB_BUFRTYPE_AT_HDR   o_(it)%mdb_bufrtype_at_hdr
#define MDB_FLAG_AT_HDR       o_(it)%mdb_flag_at_hdr
#define MDB_NUMLEV_AT_HDR     o_(it)%mdb_numlev_at_hdr
#define MDB_NUMACTIVEB_AT_HDR o_(it)%mdb_numactiveb_at_hdr
#define MDB_DUPLSEQNO_AT_HDR  o_(it)%mdb_duplseqno_at_hdr
#define MDB_MSG_AT_BUFR       o_(it)%mdb_msg_at_bufr
#define MDB_THINBOX_AT_HDR    o_(it)%mdb_thinbox_at_hdr
#define MDB_MSEC_AT_HDR       o_(it)%mdb_msec_at_hdr
#define MDB_SATID_AT_HDR      o_(it)%mdb_satid_at_hdr
#define MDB_ORBIT_AT_HDR      o_(it)%mdb_orbit_at_hdr
#define MDB_FOV_AT_HDR        o_(it)%mdb_fov_at_hdr
#define MDB_SCANLINE_AT_HDR   o_(it)%mdb_scanline_at_hdr
#define MDB_ZENITH_AT_HDR     o_(it)%mdb_zenith_at_hdr
#define MLNK_HDR2INBUFR       o_(it)%mlnk_hdr2inbufr
#define MDB_MSG_AT_INBUFR     o_(it)%mdb_msg_at_inbufr
#define MLNK_HDR2OUTBUFR      o_(it)%mlnk_hdr2outbufr
#define MDB_MSG_AT_OUTBUFR    o_(it)%mdb_msg_at_outbufr
#define MDB_VARNO_PRESENCE_AT_HDR o_(it)%mdb_varno_presence_at_hdr
!*** New items added due to direct BUFR2ODB conversion
```

```
#define MDB_STATION_TYPE_AT_HDR      o_(it)%mdb_station_type_at_hdr
#define MDB_SONDE_TYPE_AT_HDR        o_(it)%mdb_sonde_type_at_hdr
#define MDB_UWI_ESA_AT_SCATT         o_(it)%mdb_uwi_esa_at_scatt
#define MDB_MPC_AT_SCATT_BODY        o_(it)%mdb_mpc_at_scatt_body
#define MDB_WVC_QF_AT_SCATT_BODY     o_(it)%mdb_wvc_qf_at_scatt_body
#define MDB_NRETR_AMB_AT_SCATT_BODY  o_(it)%mdb_nretr_amb_at_scatt_body
#define MDB_SUBSETNO_AT_HDR          o_(it)%mdb_subsetno_at_hdr
!*** New items added due to Poolmasking
#define MLNK_DESC2POOLMASK        o_(it)%mlnk_desc2poolmask
#define MDB_POOLNO_AT_POOLMASK    o_(it)%mdb_poolno_at_poolmask
#define MDB_OBSTYPE_AT_POOLMASK   o_(it)%mdb_obstype_at_poolmask
#define MDB_CODETYPE_AT_POOLMASK  o_(it)%mdb_codetype_at_poolmask
#define MDB_SENSOR_AT_POOLMASK    o_(it)%mdb_sensor_at_poolmask
#define MDB_TSLOT_AT_POOLMASK     o_(it)%mdb_tslot_at_poolmask
#define MDB_SUBTYPE_AT_POOLMASK   o_(it)%mdb_subtype_at_poolmask
#define MDB_BUFRTYPE_AT_POOLMASK  o_(it)%mdb_bufrtype_at_poolmask
#define MDB_HDR_COUNT_AT_POOLMASK     o_(it)%mdb_hdr_count_at_poolmask
#define MDB_BODY_COUNT_AT_POOLMASK    o_(it)%mdb_body_count_at_poolmask
#define MDB_MAX_BODYLEN_AT_POOLMASK   o_(it)%mdb_max_bodylen_at_poolmask
!*** New items added due to introduction of 'timeslot_index'-table
#define MDB_TIMESLOT_AT_TIMESLOT_INDEX   o_(it)%mdb_timeslot_at_timeslot_index
#define MLNK_DESC2TIMESLOT_INDEX         o_(it)%mlnk_desc2timeslot_index
#define MLNK_TIMESLOT_INDEX2INDEX        o_(it)%mlnk_timeslot_index2index
!*** Commonly needed subwords/members of 'obschar.*@hdr'
!    Please make sure that their length does not exceed 31 chars !
!#define MDB_OBSCHAR_D_CODETYPE_AT_HDR   o_(it)%mdb_obschar_d_codetype_at_hdr
!#define MDB_OBSCHAR_D_INSTYPE_AT_HDR    o_(it)%mdb_obschar_d_instype_at_hdr
!#define MDB_OBSCHAR_D_RETRTYPE_AT_HDR   o_(it)%mdb_obschar_d_retrtype_at_hdr
!#define MDB_OBSCHAR_D_DATAGROUP_AT_HDR  o_(it)%mdb_obschar_d_datagroup_at_hdr
!*** OBSCHAR is replaced by 4 new entries
#define MDB_CODETYPE_AT_HDR   o_(it)%mdb_codetype_at_hdr
#define MDB_INSTTYPE_AT_HDR   o_(it)%mdb_insttype_at_hdr
#define MDB_RETRTYPE_AT_HDR   o_(it)%mdb_retrtype_at_hdr
#define MDB_AREATYPE_AT_HDR   o_(it)%mdb_areatype_at_hdr
!*** Additional @satob entries requested by Niels Bormann  [20/11/2001]
#define MDB_SEGMENT_SIZE_X_AT_SATOB     o_(it)%mdb_segment_size_x_at_satob
#define MDB_SEGMENT_SIZE_Y_AT_SATOB     o_(it)%mdb_segment_size_y_at_satob
!*** New item(s)
#define MDB_ZONE_AT_HDR                 o_(it)%mdb_zone_at_hdr
#define MDB_SATINST_AT_HDR      o_(it)%mdb_satinst_at_hdr
#define MDB_SATINST_AT_POOLMASK o_(it)%mdb_satinst_at_poolmask
#define MDB_SATNAME_AT_HDR      o_(it)%mdb_satname_at_hdr
!*** New @satob table item suggested by Niels Bormann [7/11/2002]
#define MDB_CHAN_FREQ_AT_SATOB o_(it)%mdb_chan_freq_at_satob
!*** New @body & @atovs entries proposed by Christina Koepken [26/11/2002]
#define MDB_LANDSEA_OBS_AT_ATOVS o_(it)%mdb_landsea_obs_at_atovs
#define MDB_CLD_FG_DEPAR_AT_BODY o_(it)%mdb_cld_fg_depar_at_body
#define MDB_SURFEMISS_AT_BODY    o_(it)%mdb_surfemiss_at_body
#define MDB_CSR_PCLEAR_AT_BODY   o_(it)%mdb_csr_pclear_at_body
#define MDB_CSR_PCLOUDY_AT_BODY  o_(it)%mdb_csr_pcloudy_at_body
!*** New @body entries proposed by Tony McNally [29/11/2002]
#define MDB_RANK_CLD_AT_BODY     o_(it)%mdb_rank_cld_at_body
#define MDB_RANK_AN_AT_BODY      o_(it)%mdb_rank_an_at_body
!*** New @desc & @hdr entries pushed in by Sami Saarinen [17/02/2004]
#define MDB_MXUP_TRAJ_AT_DESC    o_(it)%mdb_mxup_traj_at_desc
#define MDB_SOURCE_AT_HDR        o_(it)%mdb_source_at_hdr
!*** New items added for storing thinning keys
#define MDB_THINNINGKEY_AT_HDR       o_(it)%mdb_thinningkey_at_hdr
#define MDB_THINNINGTIMEKEY_AT_HDR       o_(it)%mdb_thinningtimekey_at_hdr
!*** Table @satem removed and items moved into @hdr with different names
!    (for old SATEM) by Sami Saarinen [26/6/2003]
#define MDB_SATEM_DATAPROC_AT_HDR        o_(it)%mdb_satem_dataproc_at_hdr
```

```
#define MDB_SATEM_INSTDATA_AT_HDR         o_(it)%mdb_satem_instdata_at_hdr
!*** MDB_AUX1_AT_BODY obsolete (except PREODB)
!    Elsewhere replaced by (vector) of MDB_AUX_AT_BODY [23/1/04 SS]
#define MDB_AUX_AT_BODY o_(it)%mdb_aux_at_body
#define MDB_AUX1_AT_BODY o_(it)%mdb_aux1_at_body
!*** latlon_rad@desc added to flag whether (lat,lon) are in radians or not [23/1/04 SS]
#define MDB_LATLON_RAD_AT_DESC    o_(it)%mdb_latlon_rad_at_desc
!*** SSM/I reorganization (Peter Bauer/Sami Saarinen) [11/3/04]
#define MDB_PREC_ST_AT_SSMI o_(it)%mdb_prec_st_at_ssmi
#define MDB_PREC_CV_AT_SSMI o_(it)%mdb_prec_cv_at_ssmi
#define MDB_RAIN_AT_SSMI_BODY o_(it)%mdb_rain_at_ssmi_body
#define MDB_SNOW_AT_SSMI_BODY o_(it)%mdb_snow_at_ssmi_body
#define MDB_CLW_AT_SSMI_BODY o_(it)%mdb_clw_at_ssmi_body
#define MDB_CIW_AT_SSMI_BODY o_(it)%mdb_ciw_at_ssmi_body
#define MDB_CC_AT_SSMI_BODY o_(it)%mdb_cc_at_ssmi_body
#define MDB_RAD_COST_AT_SSMI_BODY o_(it)%mdb_rad_cost_at_ssmi_body
#define MDB_RAD_OBS_AT_SSMI_BODY o_(it)%mdb_rad_obs_at_ssmi_body
#define MDB_RAD_FG_DEPAR_AT_SSMI_BODY o_(it)%mdb_rad_fg_depar_at_ssmi_body
#define MDB_RAD_AN_DEPAR_AT_SSMI_BODY o_(it)%mdb_rad_an_depar_at_ssmi_body
#define MDB_RAD_OBS_ERR_AT_SSMI_BODY o_(it)%mdb_rad_obs_err_at_ssmi_body
#define MDB_RAD_BIAS_AT_SSMI_BODY o_(it)%mdb_rad_bias_at_ssmi_body
!*** checksum@hdr-word added to get over reproducibility problems for good [18/3/04 SS]
#define MDB_CHECKSUM_AT_HDR o_(it)%mdb_checksum_at_hdr
```

$SRC/ifs/common/itdef.h

```
#define it it_
INTEGER(KIND=JPIM) :: it
it = OML_MY_THREAD()
```

$SRC/ifs/common/inumtdef.h

```
#define inumt inumt_
INTEGER(KIND=JPIM) :: inumt
#include "itdef.h"
inumt = OML_MAX_THREADS()
```

E ODB source files and binary objects

This appendix gives an overview of the ODB source files, which libraries are involved and how to build standalone ODB object binaries from a source code "tarball" – that is, the ODB source code distribution tarfile.

E.1 ODB source file organization and libraries

ODB software is split into many libraries, some of which are very big in terms of object size (order of tens of megabytes). That is because we want to avoid linking unnecessary libraries together and be able to re-create, say, database libraries on-the-fly from database metadata (see more in xxx).

The following libraries are involved:

Library name	**Object description**
`libodbsqlcompiler.a`	ODB/SQL-compiler
`libodb.a`	The core ODB
`libodbport.a`	ODB interface to IFS & `BUFR2ODB`/`ODB2BUFR`
`libodbmain.a`	ODB-tools and other miscellaneous main programs
`libodbdummy.a`	Dummy objects
`libCCMA.a`	Database `CCMA` objects (as built from std source)
`libECMA.a`	Database `ECMA` objects
`libECMASCR.a`	Database `ECMASCR` objects
`libPREODB.a`	Database `PREODB` objects
`libifs.a`	IFS
`libifsaux.a`	IFSAUX
`libobstat.a`	OBSTAT (Observation statistics)
`libobsproc.a`	OBSPROC (becoming obsolete)
`libobsort.a`	OBSORT (becoming obsolete)
`libmpi_serial.a`	Serial (non-parallel) MPI-library
`libemos.a`	64-bit real, 32-bit integer EMOSLIB (000240)
`libec.a`	64-bit real, 32-bit integer ECLIB (y2k timer only)

Also source code selected for these libraries follows certain conventions which should not be broken. The following table lists the libraries.

Table 50: ODB source codes and dependencies per library

Library name	**Source files (all under $SRC/odb/)**	**Dependency directories ($VPATH)**
`libodbsqlcompiler.a`	compiler/*.l , compiler/*.y , compiler/*.c	$SRC/odb/include
`libodb.a`	module/*.F90 , lib/[a-z]*.F90 , lib/[a-z]*.c , aux/[a-z]*.F90 , aux/[a-z]*.c	$SRC/ifsaux/include , $SRC/ifsaux/module , $SRC/odb/include , $SRC/odb/module , $SRC/odb/interface
`libodbport.a`	cma2odb/*.F90 , bufr2odb/*.F90 , preodb/[a-z]*.F90	As for `libodb.a` plus : $SRC/ifs/common , $SRC/ifs/module , $SRC/obsproc/module , $SRC/obsort/module
`libodbmain.a`	tools/[A-Z]*.F90 , tools/*.c	As for `libodb.a` and `libodbport.a`
`libodbdummy.a`	lib/[A-Z]*.F90 , lib/[A-Z]*.c	As for `libodb.a`

Table 51: Source codes & dependencies per permanent (recognized) database libraries

Library name	**Source files (all under $SRC/odb/)**	**Dependency directories ($VPATH)**
`libCCMA.a`	ddl.CCMA/CCMA.ddl , ddl.CCMA/*.sql	$SRC/odb/ddl.CCMA
`libECMA.a`	ddl.ECMA/ECMA.ddl , ddl.ECMA/*.sql	$SRC/odb/ddl.ECMA
`libECMASCR.a`	ddl.ECMASCR/ECMASCR.ddl , ddl.ECMASCR/*.sql	$SRC/odb/ddl.ECMASCR
`libPREODB.a`	ddl.PREODB/PREODB.ddl , ddl.PREODB/*.sql	$SRC/odb/ddl.PREODB

The next table is valid for a standalone ODB build only. There we build also some additional libraries (like EMOS and ECLIB), since they may not be available, accessible or up-to-date in the installation site.

E.2 Building ODB binaries

ODB can be distributed and built without building the whole `libifs.a`. We still, however, need the prerequisite libraries like `libifsaux.a` and some selected modules from `lib-ifs.a`. Also some crucial setup routines are still needed from libraries `libobsproc.a` and `libobsort.a`, but this is subject to change in the near future[22].

How to build ODB software from a tarfile ?

Assuming you have `gunzip`'ped the ODB source code distribution tarfile (say, the file `odb_CY28R2.tar.gz`). Copy it to the place where you have some `0.5GB` of disk space and untar it. Then run `configure` and `make` as follows (assuming Korn-shell):

```
$ cp odb_CY28R2.tar.gz /your/disk
$ cd /your/disk
$ gunzip < odb_CY28R2.tar.gz | tar -xf -
$ cd odb_CY28R2
$ export ARCH=xxxx
$ ./configure
$ make 2>&1 | tee log.make
```

If you had run this in C-shell (`csh` or `tcsh`), the to achieve the same log-file, the last command should be:

```
% make |& tee log.make
```

where *xxxx* is ARCH-name as described in table below. Also, please have a look at `odb/scripts/make.`
for `$ARCH` *xxxx*.

Be aware that compilation may take well over one hour unless you lower optimization levels.

The label "CY28R2" may vary, depending on shipped version or included features.

You do not need EMOSLIB & ECLIB from ECMWF to satisfy all external references, since there are all the necessary entries found under odb/extras/.

The same holds for MPI, if you don't have one, the odb/extras/mpi_serial can be "kicked in" (change is possibly needed in file odb/scripts/make.xxxx).

[22] Almost all the necessary functions `libobsproc.a` have already been moved to `libifs.a` and observation `libobsort.a` awaits for similar "treatment" – that is, some source code from OBSORT will be moved under ODB

For one plotting utility you need MAGICS from ECMWF – or you just rely on default dummies (=> no plots produced).

Before running ./configure, make sure your ARCH setting is set to one of the following (B=Big Endian, L=Little Endian):

ARCH	**Platform**	**Endian**	**Status**
rs6000	IBM RS6000 Power3	B	Tested
ibm_power4	IBM RS6000 Power4	B	Tested
linux	Pentium/Linux	L	Tested, byte swap ok.
linuxg95	Pentium/Linux with Gnu95	L	Compiles, doesn’t link yet
sgimips	SGI MIPS R10000	B	Compiles
vpp5000	Fujitsu VPP5000	B	To be tested
hppa	HP-UX 11	B	Compiles, doesn’t link yet
decalpha	Compaq/Dec Alpha	L	Compiles, but needs /bin/sh -> /bin/ksh

At the moment ODB has not been thoroughly tested on all platforms. To add a new platform, you need to add a file "make.<platform>" under `odb/scripts`-directory. See for example the files `make.linux`, `make.rs6000` or `make.ibm_power4`.

The ODB software was originally developed on SGI-system (`sgimips`) and it ran many years on Fujitsu VPP5000 & VPP700(E) vector-machines at ECMWF, so we have available their file ("make.<platform>") as well, but we cannot (anymore) test them properly.

The ODB software should also run okay on Sun Solaris, HP-UX, Dec/Compaq Alpha and on the new Cray SV2-systems, and NEC SX (with some tweaking).

All systems must be either big or little endians and follow the IEEE-754 floating point arithmetic standard.

Installation directory

For the ODB administrator, it is preferred to do the following when installing the standalone ODB software:

```
$ export ARCH=xxxx
$ export ODB_DIR=/your/odb/root/path
$ export ODB_VERSION=mytest
$ make INSTALL_DIR=$ODB_DIR/$ARCH/$ODB_VERSION install
```

As result you will have an ODB installation ’mytest’ for machine ’xxxx’ under directory $ODB_DIR/$ARCH/$ODB_VERSION. Under this directory you will see subdirectories: lib/, bin/, include/ and module/. They contain libraries, binaries and scripts, various include files and F90 module files, respectively.

Environment initialization

Things could be wrapped into a script. But in essence the following things must be set to gain access to the installed software (note: you may have to modify scripts use_odb.sh/use_odb to suit local requirements):

```
$ export ARCH=xxxx
$ export ODB_DIR=/your/odb/root/path
$ export ODB_VERSION=mytest
$ .  $ODB_DIR/$ARCH/$ODB_VERSION/bin/use_odb.sh
```

or in C-shell (csh/tcsh):

```
% setenv ARCH xxxx
% setenv ODB_DIR /your/odb/root/path
% setenv ODB_VERSION mytest
% source $ODB_DIR/$ARCH/$ODB_VERSION/bin/use_odb
```

Running examples

(This will be completed later)

F ODB limitations

There are a few limitations in ODB that user needs to be aware of.

F.1 Column entry size

Each column entry can hold a maximum 8-bytes of information. This means that any attempt to store character strings greater than 8 bytes per element are subject to failure. In such circumstances multiple column entries must be allocated, or character (or byte) data needs to be spread across multiple rows. The latter is bad for executing SQL. However BUFR-data – 4 or 8 bytes per element for example – can safely be spread across multiple rows, since the SQL's `WHERE`-condition practically never needs to be applied to BUFR-data itself.

F.2 Maximum number of rows per request

A serious limitation could be hit in practice[23]. The control (0^{th}) column of data matrix in *ODB_get* is a made up of compound numbers which must accomodate the pool number and row number from where data was extracted. For increasing the number of pools (say $>>$ 100, like at ECMWF), the maximum number of rows per request that fit into the control column gets smaller and smaller, being approximately 2147483647 divided by the largest possible pool number.

In future releases this limitation will be fixed by allowing functions `ODB_get` and `ODB_put` not to operate with other than `REAL(8)` data matrices. This gives 63-bits rather than 31-bits for the control column information.

F.3 Character string limit

The number of bytes in a single cell (an element of a column) is exactly 8 bytes. This limitation is likely to stay like this, since functions `ODB_get` and `ODB_put` can deal at most with 8-byte elements (cells). If you need more than eight bytes for your character string, you can specify multiples of eight as follows:

```
CREATE TABLE tbl (
        str[10] string , //
);
```

[23]Before ODB software is changed

This definition will create 10 `string`-columns (fields from `str_1@tbl` to `str_10@tbl`), each having 8 bytes for character data. And yet functions `ODB_get` and `ODB_put` work as usual.

G Data sorting

G.0.1 KEYSORT

Usage of the subroutine KEYSORT is as follows:

```
CALL  KEYSORT ( RC, A, N, [KEY], [MULTIKEY] &
&                , [METHOD], [INDEX], [INIT], [TRANSPOSED] )
```

This is ECMWF's multi-key sort, which is using fast and vectorizable radix-sort method for reordering the data. This function is used everywhere in IFS what comes to observation ordering. It is also the cornerstone for performing ORDERBY-statement in ODB/SQL. Source code is located in the module file `$SRC/ifsaux/module/ecsort.F90`. To use this function you need to issue the following statement in your Fortran90 program:
`USE ecsort` This function uses rsort32()-function underneath to perform the fast sorting. This utility is located under `$SRC/ifsaux/utilities/rsort32.c` and duplicated in file `$SRC/odb/lib/rsort32_odb.c`. The parameters denote :

RC	`INTEGER(4),INTENT(`**`OUT`**`)` Return code, which upon success should return `n`
A(:,:),A(:)	`REAL(4),INTENT(IN`**`OUT`**`)` The array or vector to be sorted. If optional argument `index` is present, then physical reordering is not performed.
N	`INTEGER(4),INTENT(IN)` Number of rows to be sorted, when `transposed`-parameter is not given or is set to (default) value .FALSE.. In this case must be $\leq$ leading dimension of array `a`. If `transposed`-parameter is set to .TRUE., then denotes number of columns. In this case must be $\leq$ than number of columns in array `a`.
KEY	`INTEGER(4),INTENT(IN),`*`OPTIONAL`* The column number of array `a` to be used as primary key for sorting (when `transposed`=.FALSE.). (if `transposed`=.TRUE., then the row number of `a`). The value must be either positive number between $1 \ldots n$ and sorting will be ascending, or negative number between $-n \ldots -1$ and sorting will return a descending sequence. This parameter is mutually exclusive with parameter `multikey` and they should not be used simultaneously. Also, if array `a` is a vector, then use of this parameter is not applicable and will result an error.

MULTIKEY(:)	INTEGER(4),INTENT(IN),*OPTIONAL* This parameter should be used when multiple sorting keys (columns) needs to be applied to array a. The first value multikey(1) denotes the most significant key and the last element denotes the least significant key. Negative numbers are also accepted, as with parameter key. Sorting is performed in a series of calls to rsort32, starting from least significant column down to the most significant key. No check is performed whether the same key is supplied more than once. This parameter is mutually exclusive with parameter key and they should not be used simultaneously. Also, if array a is a vector, then use of this parameter is not applicable and will result an error.
METHOD	INTEGER(4),INTENT(IN),*OPTIONAL* Change of sorting method. Applicable only for the situation where array a is a vector. Possible choices are (1) radix sort (the default) or (2) heap sort. The multikey-sorting always uses radix sort.
INDEX(:)	INTEGER(4),INTENT(IN**OUT**),TARGET,*OPTIONAL* Instead of performing physical sort of array a, the routine can return just index to the sorted order. This parameter is initialized with values $1 \ldots n$, if parameter init is not set (or is set to .TRUE.). If init is set to .FALSE., then user can supply her own initial ordering (values $1 \ldots n$, but in predefined order). This is useful if one wants to perform a series of keysort-calls after each other, each changing the index-vector.
INIT	LOGICAL,INTENT(IN),*OPTIONAL* When this parameter is not present or present and set to .TRUE., it will initialize index-vector (if present) with values $1 \ldots n$.
TRANSPOSED	LOGICAL,INTENT(IN),*OPTIONAL* You can supply array a as a transposed array without actually transposing it first. This swaps the meaning of rows and columns with each other. The end result is the same. Since this is by far much less economical way of accessing data (stride is now leading dimension of a), it is not recommended to set this parameter to .TRUE.. The default value is .FALSE.

H Dr.Hook instrumentation tool

Dr.Hook is a simple, low-overhead instrumentation tool, which allows you to keep track of dynamic calling tree of a program and print it in the event of failure. It can also gather performance profiling information on a per subroutine basis, which can be useful in estimating computational costs.

The name Dr.Hook stems from Fujitsu VPP's hook-function – a compiler option which allowed routines to be intercepted upon entry and exit by a user defined "hook"-function. The Dr.Hook-environment, unlike Fujitsu's system, is meant to be portable across all Unix-systems, controlled by environment variables without need to recompile or relink.

In the recent years it has become more difficult to get reliable traceback upon failure. One reason is our complex environment and use of multiple MPI-tasks and OpenMP-threads. Error messages from such processes are often lost or can be quite misleading. As result much extra time has to be put into debugging. We wanted to reduce this laborous debugging and instead (or in addition to) offer a more direct way of trapping errors.

Since the CY28 of IFS was a cleaning cycle, it was decided to insert automatically calls to `DR_HOOK()`-function while entering and leaving any IFS/ARPEGE related subroutine, a few thousand in total. This way the Dr.Hook-environment could keep track of dynamic calling tree and upon failure produce informative Dr.Hook-traceback.

As result of these calls we can hopefully fix programming errors much quicker than before without need to add extra print statements or wonder for several days what may have gone wrong.

A nice "by-product" of Dr.Hook-instrumentation is that we can also collect profiling information on resources we spend in each instrumented routine. That is to say, we can collect routine call-counts, wall & CPU-times, chase for memory peaks, check paging activities and so on. Furthermore we can produce a user-friendly report at the end of execution per each MPI-task spread across every computional OpenMP-thread, if necessary.

A recent addition (CY28R1) to Dr.Hook system is possibility to obtain MFlop/s-rates per OpenMP-thread and MPI-task on the IBM Power4 machine. This greatly helps us to understand computational costs in IFS/ARPEGE and may even aid benchmarking.

Dr.Hook is currently callable from both Fortran90 and C-routines.

Instrumentation

Every instrumented routine (here: just a generic SUBR) has the following coding norm:

- at the top of the routine: enable access to `YOMHOOK`-module

```
USE YOMHOOK, ONLY : LHOOK, DR_HOOK
```

- at the beginning of the routine (before the first executable statement)

```
REAL(KIND=JPRB) ::  ZHOOK_HANDLE
IF (LHOOK) CALL DR_HOOK('SUBR',0,ZHOOK_HANDLE)
```

- just before `END`- or before *any* `RETURN`- or `CONTAINS`-statements you *must* call

```
IF (LHOOK) CALL DR_HOOK('SUBR',1,ZHOOK_HANDLE)
```

The first call to `DR_HOOK()` adjusts the current dynamic calling tree by adding a new member to it. The last call to `DR_HOOK()` removes routine `'SUBR'` from this instantaneous calling tree.

If in addition performance profiling is on, then the Dr.Hook-system collects exact (as opposed to sampled) performance profile on behalf of routine `'SUBR'` and its descendants while in this routine.

If the `SUBR` is a Fortran90 module procedure, then the name will contain the MODULE-name followed by a colon before the routine name (for example: `'GFL_SUBS:DEFINE_-GFL_COMP'`).

It is important to note that the variable `ZHOOK_HANDLE` must be a local (stack) variable – i.e. not a `SAVE`d variable. Its size has to be 8-bytes and the subroutine prototype requires it to be a `REAL(8)` floating point number. Upon return from the first `DR_HOOK()`-call it contains the address information to the Dr.Hook internal data structure, where accounting information for this particular routine (and of this OpenMP-thread) is kept. The last call to `DR_HOOK()` in the routine will use the value of variable `ZHOOK_HANDLE` as an address to locate and update the routine's accounting records.

If `ZHOOK_HANDLE` gets overwritten between these two calls to `DR_HOOK()`, then the second call will pick this it up immediately and raise an abort. This is an indication of either a genuine (stack variable) overwrite, or more often that some descendant routine has `RETURN`ed before calling second time its `DR_HOOK()`. The latter case is easy to fix: just search for alternative exits and `RETURN`-statements from the descendant routines and check whether any path to the second call of `DR_HOOK()` exists at all.

The logical variable `LHOOK` is by default set to `.TRUE.` in module `YOMHOOK`. When the very first call to `DR_HOOK()` takes place in a program, then all Dr.Hook-environment variables are examined. If it turns out that Dr.Hook-facility was not turned on, then the logical variable `LHOOK` is set to `.FALSE.` and any further dynamic calling tree processing will be disabled.

In the future there will be available a checker-program to ensure that `DR_HOOK()` calls are entered correctly.

Environment variables

Environment variables are used to activate and drive Dr.Hook features. By default – if no variables are set – Dr.Hook facility is turned off. All values (except filenames) are case insensitive in the following table.

Table 52: Dr.Hook environment variables

Variable	Description	Values & remarks
DR_HOOK	Enable/disable Dr.Hook	`true` or 1 activates Dr.Hook `false` or 0 is the default
DR_HOOK_OPT	A comma-separated list of:	
	`calls` or `count`	Traceback contains call counts
	`cputime` or `cpu`	Traceback contains CPU-times
	`walltime` or `wall`	Traceback contains wall clock times
	`times` or `time`	Union of `cputime` and `walltime`
	`heap` or `hwm`	Heap memory high water mark per routine
	`stack` or `stk`	Stack size monitoring per routine
	`rss`	Resident set size monitoring
	`paging` or `pag`	Paging activity monitoring per routine
	`memory` or `mem`	Union of `heap`, `stack`, `rss` & `paging`
	`all`	Union of `memory` and `times`
	`prof` or `wallprof`	Activates wall clock time based profiling Implies also `calls` and `walltime` Deactivates `cpuprof`
	`cpuprof`	Activates CPU-time based profiling Implies also `calls` and `cputime` Deactivates `wallprof`
	`hpmprof` or `hpm` or `mflops`	Activates MFlop/s profiling Implies `wallprof`
	`trim`	Allow case insensitive input of routine name Very expensive! Don't use this!
	`self`	Include Dr.Hook in the profile output, too
	`noself`	Exclude Dr.Hook altogether from the profile By default Dr.Hook overhead *is always*,

continued on next page . . .

Table 52: Dr.Hook environment variables . . . *continued*

Variable	Description	Values & remarks
		accounted for, but not printed in the profile output
	`nosize` or `nosizeinfo`	Do not display size-information
	`noprop` or `nopropagate`	Do not propagate signals outside Dr.Hook
	`cluster` or `clusterid`	Display cluster-id information
DR_HOOK_HPMSTOP	Stops `HPM`-counting for the given routine after *ncalls* if *mflops*-rate has not been achieved	Set this to value *ncalls* or *ncalls,mflops*

Currently the options `DR_HOOK_OPT="stack,paging,mflops"` are only available for IBM Power4 machines, but ports to Cray X1 (for example) are underway. As of writing this document, Cray X1 hardware performance monitor for obtaining MFlop/s-rates has just been implemented.

In addition the following environment variables are also available to Dr.Hook:

Table 53: More Dr.Hook environment variables

Variable	Description	Values & remarks
DR_HOOK_PROFILE	Filename(s) for the profile	One profile-file per MPI-task Use full path with `.%d` for MPL-task: `/path/file.%d`, `%d` = 1..$*NPES* The default: `drhook.prof.%d` If the suffix (`.%d`) is missing, it will be added automatically
DR_HOOK_PROFILE_PROC	MPL-task that produces profile	The default = -1 i.e. all MPL-tasks
DR_HOOK_PROFILE_LIMIT	Routines that consume at least this many percentages of (self-)time resources will appear in the profile	The default = -10.0 (!)
DR_HOOK_CATCH_SIGNALS	A comma separated list of *additional* signals to be caught	The default = 0 i.e. no effect. Value = -1 activates all possible signals
DR_HOOK_IGNORE_SIGNALS	A comma separated list of signals *not* to be caught	The default = 0 i.e. no effect. Value = -1 deactivates all possible signals

continued on next page . . .

Table 53: More Dr.Hook environment variables ... *continued*

Variable	Description	Values & remarks
DR_HOOK_HASHBITS	No. bits for hashing algorithm	The default = 15 i.e. allocates a hash data structure of 2^{15} elements. Between 1..24. Increase only if you have thousands of routines to monitor

Caught signals

The following table shows what Unix-signals are caught by Dr.Hook-system. Please note that signal `SIGXPU` (i.e. CPU-time exceeded) does not produce any profiling output, since it would cause Dr.Hook to catch `SIGXPU` infinitely, since there is no CPU-time left! Otherwise the profile is written even if a signal has been caught, since we believe it still can contain valuable information.

Signal name	Description	Remarks
SIGABRT	Abort execution	
SIGBUS	Bus error	
SIGSEGV	Segmentation violation	
SIGILL	Illegal instruction	
SIGEMT	EMT instruction	N/A on Linux
SIGSTKFLT	Stack fault	Linux only; from 28R2 onwards
SIGFPE	Floating-point exception	
SIGTRAP	Trace trap	Should be switched off when debugging
SIGINT	Interrupt	
SIGQUIT	Quit	
SIGTERM	Termination	
SIGIO	I/O now possible	
SIGXCPU	CPU limit exceeded	Ignores `atexit()` i.e. no profiling
SIGSYS	Bad system call	

For actual signal numbers, please refer to your `man signal`-command or have look at your Unix-system's include file `/usr/include/signal.h` (often in `/usr/include/sys/signal.h`). These are needed if you want to use environment variables `DR_HOOK_CATCH_SIGNALS` or `DR_HOOK_IGNORE_SIGNALS` to activate/deactivate some signals.

Very often catching a `SIGSEGV` means serious memory overwrite, a `SIGBUS` that some subroutine argument is missing or stack is corrupted, a `SIGILL` means that illegal instruction is executed, a `SIGFPU` means a floating point arithmetic on uninitialized or invalid numbers, a `SIGINT` means that control-C is pressed (for interactive jobs), and so on.

Overhead

When the dynamic calling tree is activated (but nothing else) the overhead of `DR_HOOK()`-calls seem to be around 1% in the current IFS/ARPEGE configurations on ECMWF's IBM Power4. This seems to be a low price to pay for enabling correct tracebacks, and thus reducing need for extensive debugging and head-lice scratching!

When the wall clock time profiling is on, overheads seem to be around 2%. And if the MFlop/s-rate counters are activated, the overhead is still bearable 10-15%. And all these extra profiling options can be turned on via environment variables, without need to recompile or relink anything. Please note that the `HPM`-overhead can now be effectively minimized by setting environment value `DR_HOOK_HPMSTOP` to (say) `20,500000`. This means: stop calling `HPM`-counters for any given routine after 20 calls unless routines performance exceeds 500000 Mflop/s (500GigaFlop/s!).

Some auxiliary routines

You can activate Dr.Hook's signal catching feature to be able to produce at least system specific traceback more reliably by calling routine `C_DRHOOK_INIT_SIGNALS()`:

```
      CALL C_DRHOOK_INIT_SIGNALS(1)
```

This instructs Dr.Hook's signal handling functions to be on the top of the list of the functions to be called in the event of failure. And if Dr.Hook-facility was turned off you will not get its dynamic calling tree, but a system specific traceback, which may or may not be accurate. See for example `ifs/setup/sumpini.F90`.

When Dr.Hook has been activated, you can print an instantaneous calling tree at any moment to a Fortran I/O-unit by calling routine `C_DRHOOK_PRINT()`:

```
 INTEGER(4)          :: IOUNIT, ITID, IOPT, INDENT
 INTEGER(4),EXTERNAL :: get_thread_id
 IOUNIT   = 0                  ! Fortran I/O-unit , say stderr
 ITID     = get_thread_id( )   ! 1 .. # of OpenMP-threads
 IOPT     = 2                  ! Print current calling tree
 INDENT   = 0                  ! Indentation; modified during the call
 CALL C_DRHOOK_PRINT(IOUNIT, ITID, IOPT, INDENT)
! The variable INDENT now equals to no. of routines seen in the traceback
```

C-interface

Also C-routines can be instrumented under Dr.Hook-system. The interface (in CY28R2) to C is as follows:

```
#include "drhook.h" /* from "ifsaux/include/drhook.h" */

void subname()
{
  /* Variable declarations */

  { /* Begin block (optional) */
    /* The following ia like the first call to DR_HOOK() in Fortran90 */

    DRHOOK_START(subname);

    /* or as a constant (compile-time evaluable) character string:
       DRHOOK_START_BY_STRING("subname");
    */

    /* The first actual executable statement */

    /* The body of the routine "subname" goes here */

    /* The last thing ;
       the zero (0) below can be replaced with some size-information,
       like the number of bytes processed or so */

    DRHOOK_END(0);
  } /* End block (optional, if the Begin block also omitted) */
  return;
}
```

You can see examples in files `odb/lib/codb.c` and `odb/include/codb.h`. Note that symbols `DRHOOK_START`, `DRHOOK_START_BY_STRING` and `DRHOOK_END` are all simple and cheap C-macros, which take care of declaring the Fortran90 `ZHOOK_HANDLE`-equivalent inside the macros.

Source code and libraries

In CY28R2, Dr.Hook resides in IFSAUX, files `ifsaux/support/drhook.c` and include file
`ifsaux/include/drhook.h` and is therefore naturally built into library `libifsaux.a`.
The Fortran90-part resides in files `ifsaux/module/yomhook.F90` and `ifsaux/support/dr_-hook_*.F90`.

Timers and memory routines needed are found mostly under the `ifsaux/utilities/`-directory. Some other resource related routines are still found (for historical reasons) under `odb/aux/util_ccode.c`, but can also be found in file `ifsaux/utilities/util_-timers.c` in CY28R2.

Dummies for `HPM` (High Performance Monitoring) for IBM are found under `odb/lib/Dummies.c`, in case you hit problems with unsatisfied externals.

On an IBM Power4 machine in order to activate the `HPM`-feature, you need to compile the file
`ifsaux/support/drhook.c` with option `-DHPM` and link executable either with dummies
(`-lodbdummy` i.e. no runtime `HPM`) or with `HPM`-libraries (at ECMWF called `$LIBHPM`)
`-L/usr/pmapi/lib -lpmapi`.

Enhancements

After CY28R2 we will investigate ways to incorporate profiling of data movement. That is to say, we want to get clearer picture on amounts of data transferred across MPI-processes and to be able to trace I/O-bottlenecks. This has been partially done via GSTATS-subroutine (in IFSAUX).

Furthermore we want to be able to show the filename of the routine being called. This is important especially for C-routines, where there maybe several routines sitting the same file making searching process more difficult.

The Fortran90-interface to `DR_HOOK()` contains two more arguments: size information (an `INTEGER(4)`) and the (source) filename parameters. In fact, the C-interface in cycle CY28R1 already contains this functionality and some ODB C-routines already benefit from these two extra arguments. As an example, you could pass the number of bytes retrieved from a database, or decide that you want to see how many rows of data satisfy a particular SQL-query condition. In both cases you could also opt for source filename of the routine in concern.

The basic Dr.Hook without fancy MFlop/s-monitors, but with traceback feature, will run at least on the following machines in CY28R2: IBM Power4 & Power3, Pentium/Linux and Silicon Graphics. We still have to check how Fujitsu VPP5000 version will behave. Port to Cray X1 is nearly completed and it is now already possible to easily compare this machine's performance with IBM Power4 rather realistically.

Known bugs or features

Dr.Hook-system cannot handle recursive function calls correctly i.e. profiling information for such routines (and calling tree before the routine) will be incorrect. This will be fixed in the future. Meantime, remove Dr.Hook from potentially recursive routines.

When a failure occurs on a non-master OpenMP-thread (i.e. > 1), the dynamic calling tree incorrecty prints the full current calling tree of the master-thread before proceeding to print thread's own tree. Although this doesn't matter too much, you will still see slightly misleading traceback and duplicate output of some routines that were active in both master and slave thread during failure.

The signal SIGIOT was mistakenly typed as SIGIO. The SIGIOT normally equals to SIGABRT. If you belive that this incorrect coding causes problems and you want to remove SIGIO (normally #29) from the list of Dr.Hook-catchable signals, you can ignore this signal via environment variable as follows (Korn-shell):

```
$ export DR_HOOK_IGNORE_SIGNALS=29
```

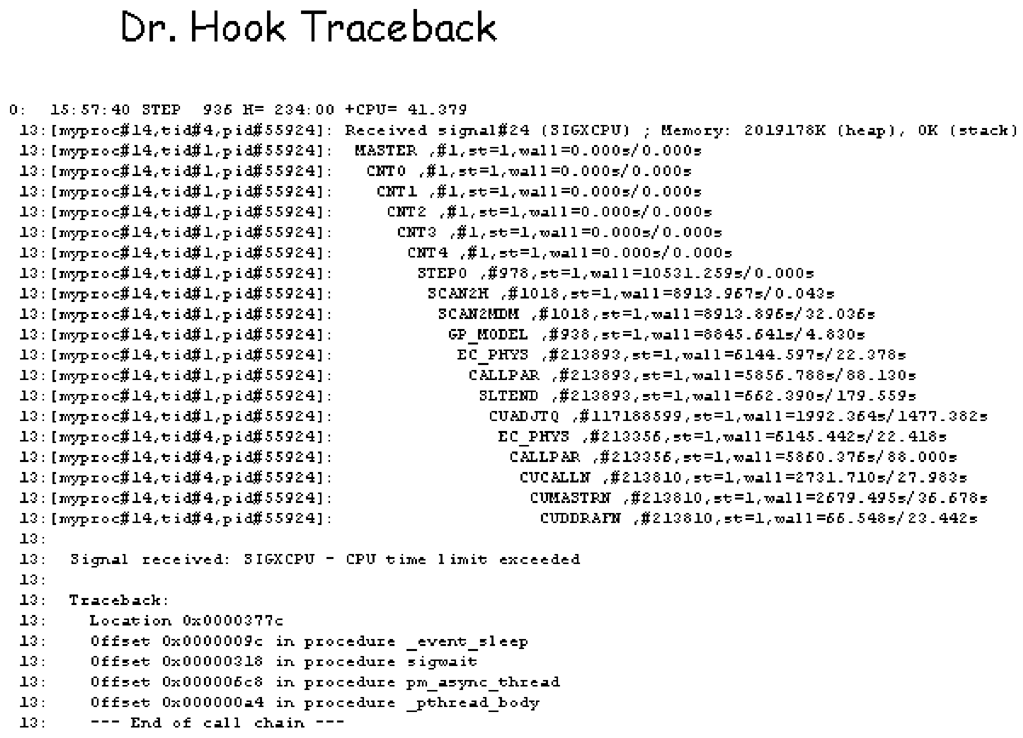
This bug has now been fixed in CY28R2.

Acknowledgements

Thanks to Bob Walkup from IBM Watson Research for information about how to read the HPM-counters on IBM Power4 machine.

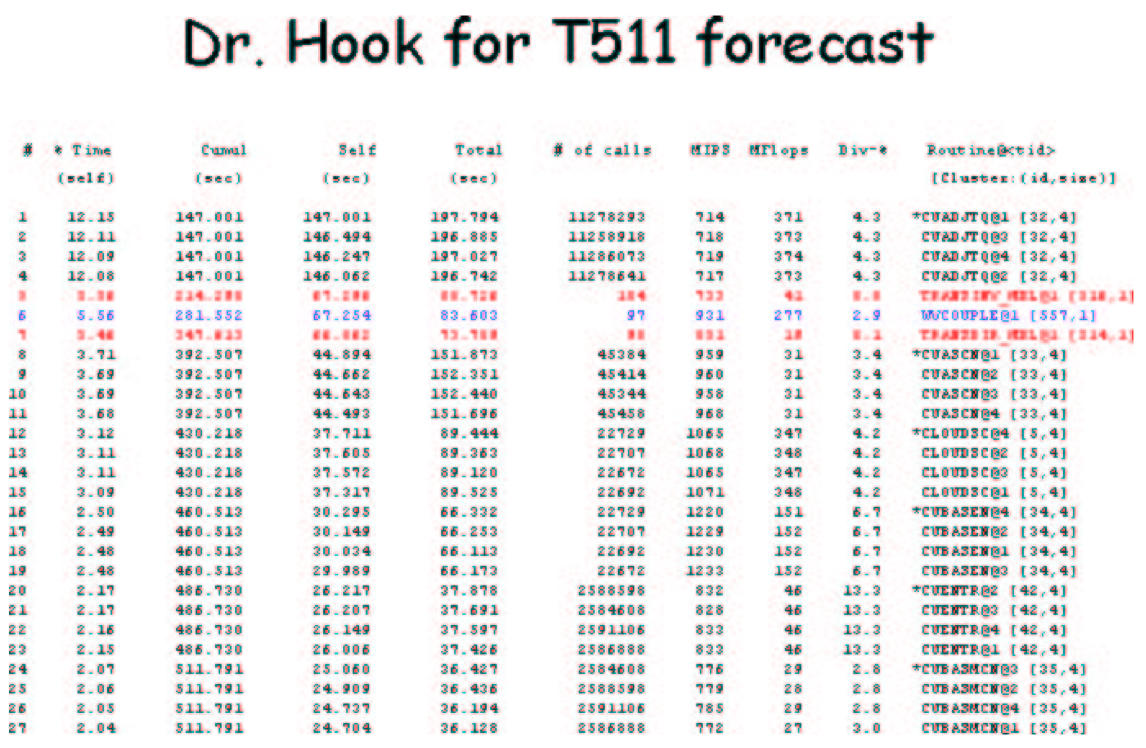
Thanks to Bob Carruthers from Cray UK for supplying HPM-counters for Cray X1 machines.

Examples of Dr.Hook output from IFS:



Dr. Hook Traceback

```
0:  15:57:40 STEP  936 H= 234:00 +CPU= 41.379
 13:[myproc#14,tid#4,pid#55924]: Received signal#24 (SIGXCPU) ; Memory: 2019178K (heap), 0K (stack)
 13:[myproc#14,tid#1,pid#55924]:  MASTER ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:   CNT0 ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:    CNT1 ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:     CNT2 ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:      CNT3 ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:       CNT4 ,#1,st=1,wall=0.000s/0.000s
 13:[myproc#14,tid#1,pid#55924]:        STEP0 ,#978,st=1,wall=10531.259s/0.000s
 13:[myproc#14,tid#1,pid#55924]:         SCAN2H ,#1018,st=1,wall=8913.967s/0.043s
 13:[myproc#14,tid#1,pid#55924]:          SCAN2MDM ,#1018,st=1,wall=8913.896s/32.036s
 13:[myproc#14,tid#1,pid#55924]:           GP_MODEL ,#938,st=1,wall=8845.641s/4.830s
 13:[myproc#14,tid#1,pid#55924]:            EC_PHYS ,#213893,st=1,wall=6144.597s/22.378s
 13:[myproc#14,tid#1,pid#55924]:             CALLPAR ,#213893,st=1,wall=5856.788s/88.130s
 13:[myproc#14,tid#1,pid#55924]:              SLTEND ,#213893,st=1,wall=662.390s/179.559s
 13:[myproc#14,tid#1,pid#55924]:               CUADJTQ ,#117188599,st=1,wall=1992.364s/1477.382s
 13:[myproc#14,tid#4,pid#55924]:                EC_PHYS ,#213356,st=1,wall=6145.442s/22.418s
 13:[myproc#14,tid#4,pid#55924]:                 CALLPAR ,#213356,st=1,wall=5860.376s/88.000s
 13:[myproc#14,tid#4,pid#55924]:                  CUCALLN ,#213810,st=1,wall=2731.710s/27.983s
 13:[myproc#14,tid#4,pid#55924]:                   CUMASTRN ,#213810,st=1,wall=2679.495s/36.678s
 13:[myproc#14,tid#4,pid#55924]:                    CUDDRAFN ,#213810,st=1,wall=66.548s/23.442s
 13:
 13:  Signal received: SIGXCPU - CPU time limit exceeded
 13:
 13:  Traceback:
 13:    Location 0x0000377c
 13:    Offset 0x0000009c in procedure _event_sleep
 13:    Offset 0x00000318 in procedure sigwait
 13:    Offset 0x000006c8 in procedure pm_async_thread
 13:    Offset 0x000000a4 in procedure _pthread_body
 13:    --- End of call chain ---
```



Dr. Hook for T511 forecast

```
 #   * Time      Cumul       Self       Total     # of calls   MIPS  MFlops  Div-*   Routine@<tid>
     (self)      (sec)       (sec)      (sec)                                         [Cluster:(id,size)]

 1   12.15     147.001     147.001    197.794     11278293     714    371    4.3   *CUADJTQ@1 [32,4]
 2   12.11     147.001     146.494    196.885     11258918     718    373    4.3    CUADJTQ@3 [32,4]
 3   12.09     147.001     146.247    197.027     11286073     719    374    4.3    CUADJTQ@4 [32,4]
 4   12.08     147.001     146.062    196.742     11278641     717    373    4.3    CUADJTQ@2 [32,4]
 5   [illegible] [illegible] [illegible] [illegible]  184     733    [illegible] [illegible]  TRANSINV_MDL@1 [illegible]
 6    5.56     281.552      67.254     83.603           97     931    277    2.9    WVCOUPLE@1 [557,1]
 7   [illegible] [illegible] [illegible] [illegible]  [illegible] [illegible] [illegible] [illegible]  TRANSDIR_MDL@1 [illegible]
 8    3.71     392.507      44.894    151.873        45384     959     31    3.4   *CUASCN@1 [33,4]
 9    3.69     392.507      44.662    152.351        45414     960     31    3.4    CUASCN@2 [33,4]
10    3.69     392.507      44.643    152.440        45344     958     31    3.4    CUASCN@3 [33,4]
11    3.68     392.507      44.493    151.696        45458     968     31    3.4    CUASCN@4 [33,4]
12    3.12     430.218      37.711     89.444        22729    1065    347    4.2   *CLOUDSC@4 [5,4]
13    3.11     430.218      37.605     89.363        22707    1068    348    4.2    CLOUDSC@2 [5,4]
14    3.11     430.218      37.572     89.120        22672    1065    347    4.2    CLOUDSC@3 [5,4]
15    3.09     430.218      37.317     89.525        22692    1071    348    4.2    CLOUDSC@1 [5,4]
16    2.50     460.513      30.295     66.332        22729    1220    151    6.7   *CUBASEN@4 [34,4]
17    2.49     460.513      30.149     66.253        22707    1229    152    6.7    CUBASEN@2 [34,4]
18    2.48     460.513      30.034     66.113        22692    1230    152    6.7    CUBASEN@1 [34,4]
19    2.48     460.513      29.989     66.173        22672    1233    152    6.7    CUBASEN@3 [34,4]
20    2.17     486.730      26.217     37.878      2588598     832     46   13.3   *CUENTR@2 [42,4]
21    2.17     486.730      26.207     37.691      2584608     828     46   13.3    CUENTR@3 [42,4]
22    2.16     486.730      26.149     37.597      2591106     833     46   13.3    CUENTR@4 [42,4]
23    2.15     486.730      26.006     37.426      2586888     833     46   13.3    CUENTR@1 [42,4]
24    2.07     511.791      25.060     36.427      2584608     776     29    2.8   *CUBASMCN@3 [35,4]
25    2.06     511.791      24.909     36.436      2588598     779     28    2.8    CUBASMCN@2 [35,4]
26    2.05     511.791      24.737     36.194      2591106     785     29    2.8    CUBASMCN@4 [35,4]
27    2.04     511.791      24.704     36.128      2586888     772     27    3.0    CUBASMCN@1 [35,4]
```

Glossary

This appendix provides a short description of acronyms used. Some of them are not directly used in the document, but are closely related to high performance computing, databases, observation processing, satellites or 4D-Var analysis – thus worth mentioning.

1D-Var	One Dimensional Variational Assimilation (usually the vertical profile).
3D-FGAT	3D-Var with first guess at appropriate time.
3D-Var	Three Dimensional Variational Assimilation.
4D-Var	Four Dimensional Variational Assimilation (includes time as fourth dimension).
ACARS	Aircraft Communication Addressing and Reporting System.
Active data	All data that contribute (have a non-zero weight) in the analysis.
AD	Adjoint (the transpose of the tangent-linear operator).
AIREP	Aircraft weather report.
AIRS	Atmospheric Infrared Sounder.
AMDAR	Aircraft Meterological Data Acquisition and Relay.
AMSU (-A, -B)	Advanced Microwave Sounding Unit (AMSU-A, AMSU-B).
AMV	Atmospheric Motion Vectors (SATOBS).
Analysis variables	.
AQUA	NASA's Earth Observation system (EOS) mission to study water vapour and cloud.
ARPEGE	Action de Recherche Petite Echelle Grande Echelle (a collaboration with ECMWFs IFS code development).
ASCII	American Standard Code for Information Interchange.
ATOVS	Advanced TOVS.
Background	Prior information, often in the form of climatology or (better) a short-range forecast.
BATHY	Report of bathythermal observation.
Bias	Mean error.

Bit	Stands for binary digit, or a number that can have only two values: 0 or 1.
Blacklist	A set of instructions defining which observations not to use.
BUFR	WMO Code for Binary Universal Form for data Representation.
BUFR2ODB	A conversion software package to translate BUFR-data into ODB-format (database ECMA in particular) prior to 4D-Var-analysis. See also ODB2BUFR.
Byte	Eight bits and can hold a value from 0 to 255 (i.e. $2^8 - 1$), or -128 to 127.

CCMA	ODB-database name for used observations (Compressed Central Memory Array).
/ccvobs	Root directory for files under ClearCase version handling system at ECMWF.
ClearCase	Software version handling system in use at ECMWF to manage source code modifications.
COH	Comprehensive Observation Handling. See as/see also MAKECMA.
Control variable	The set of variables that are adjusted (analyzed) during variational assimilation.
Cost function	The "objective function" measuring the distance (or misfit) to observations and prior information.
CPU	Central Processing Unit.

DDL	Data Definition Language or Layout.
Departure	The difference between observation and model fields (either background or analysis).
DMSP	Defense Meteorological Satellite Program (USA).
Dr.Hook	A portable instrumentation tool developed at ECMWF, which enables reliable traceback upon failure and produces per subroutine, per OpenMP-thread profiling information about resource usages, like wall-clock time, CPU-time and on some computer platforms even MFlops- and MIPS-rates.
DRIBU	WMO code for drifting buyos.

ECMA	ODB-database name for all used and monitored observations (Extended Central Memory Array).
ECMASCR	Normally the same as ECMA-database, but used as a temporary database.
ECMWF	European Centre for Medium-Range Weather Forecasts.
ENVISAT	Environmental Satellite (ESA).
ERA-15	ECMWF Re-Analysis for 15 years.
ERA-40	ECMWF Re-Analysis for 40 years.
ESA	European Space Agency.
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites.
First guess	Starting point for an iterative process (such as the minimization of the variational cost function). First guess can be different from the Background.
FDB	Fields DataBase.
Fragmentation	Operating systems allocate disc space in chunks as they create and expand files. When files are purged, these chunks are released for re-use. Over time the disc space may end up "fragmented" into many small pieces, which can slow the performance and the reliability of the system. The same analogy holds for performance degradation of a program, which constantly allocates and de-allocates memory during the execution: free space becomes fragmented.
Gigabyte	A gigabyte (GB) is a measure of memory space equal to 1,024 megabytes or 1,073,741,824 (i.e. 2^{30}) bytes.
GOES	U.S. programme of geostationary satellites.
GPS	Global Positioning System.
GRIB	Gridded data in Binary Form (a WMO code).
HIRS	High Resolution Infra-Red Sounder.

HPM	High Performance Monitor – a process or computer hardware that enables to measure MFlops-rates, thus to monitor application performance.
IASI	Infrared Atmospheric Sounding Interferometer.
IFS	Integrated Forecasting System.
Increment	The initial-condition correction (w.r.t. the Background) computed by assimilation system.
Incremental	A technique in which the control variable is the increment rather than the ful initial state – the increment may be at reduced resolution to save computational cost.
I/O	Input and/or output operation.
IR	Infrared.
Jacobian	Matrix of first derivatives.
Jb	The background term in variational assimilation.
Jc	Constraints added as additional terms to the variational cost function.
Jo	Rge observation term in variational assimilation.
Kilobyte	A kilobyte (KB) is is a memory space measure equal 1,024, or 2^{10} bytes.
L31, L60, L90, ...	31, 60, 90, ... levels in ECMWF's forecasting models (its vertical discretization).
MAGICS	Meteorological Applications Graphics Integrated Colour System.
MAKECMA	An observation pre- and postprocessing software (now obsolescent at ECMWF) to create files in CMA-format holding 4D-Var-analysis observation data. Also known as OBSPROC or COH.
MAP	Mesoscale Alpine Programme.
MARS	Meteorological Archival and Retrieval System.

MATCHUP	A software to update ECMA ODB-database with 4D-Var-information from CCMA ODB-database.
Megabyte	A megabyte (`MB`) is a memory space measure equal to 1,048,576 (1024×1024), or 2^{20} bytes. 1,024 megabytes is a gigabyte.
MERGEODB	A software to merge multiple ECMA ODB-databases (which were split per satellite sensor in BUFR2ODB) into one large virtual database to give impression for 4D-Var about single database view only. This process is normally embedded into IFS-code and is run just before any observation processing begins in a 4D-Var-run.
METVIEW	Generalized data access, manipulation and visualization system for meteorological data.
MF, M-F	Meteo-France.
MFlops	Megaflops per second, millions of floating point operations per second. A performance measure to show how efficient a particular computer is on numerically intensive applications.
Minimization	An iterative algorithm to find the minimum of a function (e.g. `M1QN3` and Conjugate Gradient).
MIPAS	Michelson Interferometer for Passive Atmospheric Sounding.
MIPS	Millions of instructions per second. Another measure about computer performance in particular in scalar intensive computations.
MKCMARPL	An abbreviation for MAKECMA replacement. A large set of subroutines in IFS-code to preprocess observations, before they actually enter into analysis. Used to be a separate software package called MAKECMA (also known as OBSPROC or COH) before BUFR2ODB software was available.
Model variables	The predictive variables of the forecast model (e.g. lnP_s, T_v, `VO`, `Div`, O_3, C_{lw}, Ci, C_a and the surface variables).
MODIS	Moderate Resolution Imaging Spectroradiometer.
MPI	Message Passing Interface, a system dependent software library, which can be used in parallel meteorological application programs. Also denotes Max Planck Institute.
MPI I/O	Message Passing Interface, I/O-extension.

MPL	Message Passign Library is a software layer on top of MPI developed at ECMWF.
MSG	METEOSAT Second Generation.
MSLP	Mean Sea Level Pressure.
MSU	Microwave Sounding Unit.

NCAR	U.S. National Centre for Atmospheric Research.
NESDIS	National Environmental Satellite, Data and Information Service, USA.
NOAA	National Oceanic and Atmospheric Administration, USA.

Observation operator	The calculations required to go from model variables to the equivalents of the observed quantities. Includes horizontal and vertical interpolation to the observation locations. In 4D-Var the forecast model can usefully be seen as part of the observation operator.
Observed variables	Observed quantities such as T, u, v, u_{10m}, v_{10m}, rh_{2m}, P_s, `IR` and microwave radiances, `TCWV` etc..
OBSPROC	See MAKECMA.
ODB	Observational DataBase is a database software developed at ECMWF to manage large amount of (especially) satellite observations through the 4D-Var system in efficient manner. Its core parts consist of ODB/SQL data query engine and Fortran90 interface layer.
ODBSHUFFLE	A software, which translates active observational data from ECMA into CCMA ODB-database for use by 4D-Var minimization process.
ODB2ECMA	A conversion software package to translate ECMA ODB-database back to so called feedback BUFR-format after 4D-Var completion.
ODB/SQL	A very-subset of SQL-language and is applicable to ODB software only to perform data queries from its databases.
OI	Optimum Interpolation.
OML	OpenMP support library developed at ECMWF to allow OpenMP-multithreaded computation in high-performance meteorological applications.

OpenMP	A portable application program interface aimed at parallel programs on shared-memory machines.
OSE	Observing System Experiment.
PAOB	WMO code for surface pressure pseudo-observations (from Australia).
Passive data	Data that are processed for monitoring purposes, but not actively used in the assimilation – observation minus background departures are computed.
PILOT	Upper-wind report from a fixed land station.
Preconditioning	A technique that makes it faster/easier/less expensive to minimize the variational cost-function by incorporating some knowledge about its shape (its second derivative).
PREODB	ODB-database for ERA-40 created from input (conventional) BUFR-data from various data sources in order to perform easier duplicate checking with ODB software before input data actually gets selected for re-analysis. Contains over 40 years and more than 200GB of ODB-data online, split into 6 hourly time windows. ERA-40 assimilation has used PREODB from September 1957 till December 2001. Also the very first ODB-application/implementation.
PREPIFS	Software to PREPare IFS research experiments and eventually submit them to run on a supercomputer.
QC	Quality Control.
QuikScat	NASA's dedicated mission to fly the SeaWinds scatterometer.
RDB	Reports Data Base.
REO3	Retrieved ozone layers.
Rejected data	The data that will not be used actively in the assimilation.
RISC	Reduced Instruction Set Computer.
RTOVS	Replacement TOVS.

RT-codes	Radiative Transfer code (e.g. `RTTOV`, `OPTRAN`, `RTI-ASI`, `SYNSATRAD`, ...), providing the observation operator for infrared and microwave radiances.
RTTOV	RT model for TOVS, ATOVS and several other atmospheric sounders.
SATOB	WMO code for Satellite Observation report (Cloud track winds).
SBUV	Solar Backscatter Ultraviolet Radiometer.
SCIAMACHY	Scanning Imaging Absorption Spectrometer for Atmospheric Cartography.
Schema	.
Screening	A set of quality control and data selection procedures prior to the analysis (uses the Background).
SQL	Structured Query Language is international standard for making data queries from (especially) relational databases. See also ODB/SQL.
$SRC	Root directory of the source code in this document. At ECMWF this refers to directory `/ccvobs`, when source files are under ClearCase software version handling system. Otherwise it can be any file system holding a sub-tree of directories and sourcefiles.
SSM/I, SSMI	Special Sensor Microwave Imager.
SSMIS	Special Sensor Microwave /Imager Sounder.
SST	Sea Surface Temperature.
SSU	Stratospheric Sounding Unit.
SYNOP	WMO code for upper air observations.
TCWV	Total Column Water Vapour.
TEMP	WMO code for surface weather observations.
Terabyte	A terabyte (TB) is a measure of memory space equal to 1,024 gigabytes or 1,099,511,627,776 (i.e. 2^{40}) bytes.
Thinning	A procedure to reduce the density of data to be comparable with the model resolution.
TL	Tangent Linear – the linear model that best approcimates the corresponding non-linear model for a goven atmospheric state.
TOVS	TIROS Operational Vertical Sounder.

Trajectory	A time sequence of atmospheric states (produced by the non-linear forecast model), around which perturbations are propagated by the TL model.
TRMM	Tropical Rainfall Measuring Mission.
UTC	Universal Time Coordinated.
UV	Ultraviolet.
VarQC	Variational Quality Control.
WMO	World Meteorological Organization based in Geneva, Switzerland.

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