In this issue

European Centre for Medium-Range Weather Forecasts
Shinfield Park, Reading, Berkshire RG2 9AX, UK
Fax: . . . +44 118 986 9450
Telephone: National . . . 0118 949 9000
International . . . +44 118 949 9000
ECMWF Web site . . . http://www.ecmwf.int

The ECMWF Newsletter is published quarterly and contains articles about new developments and systems at ECMWF. Articles about uses and applications of ECMWF forecasts are also welcome from authors working elsewhere (especially those from Member States and Co-operating States).

The ECMWF Newsletter is not a peer-reviewed publication.

Editor: Bob Riddaway

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Front cover

Inset image: MODIS bands 1, 4, 3 true-colour image of Scandinavia, 19 February, 2003. Picture produced by the MODIS Land Rapid Response Team / NASA. Main image of sea-ice courtesy of Claus Hilberg.

A new Convention for ECMWF

Dominique Marbouty

In the 30th year of existence of ECMWF I am particularly pleased to report that the ECMWF Council, at its extraordinary 62nd session on 22 April 2005, unanimously adopted the Amending Protocol for a new ECMWF Convention. This is a major achievement, as it will open the possibility for new Member States to become party to the Convention.

When the ECMWF Convention was finalised in 1973, it was established as a 'closed' Convention: only the States listed in the Annex to the Convention could become Member States. The first 'victim' of this closed Convention was Iceland, which was forgotten in this list. The only possibility to overcome the situation was the conclusion of a Co-operation Agreement, as foreseen in the Convention, between Iceland and ECMWF in 1980.

The conclusion of Co-operation Agreements was more frequently used since 1994 when several countries from Central Europe wanted to join ECMWF: today we have signed eight co-operation agreements and three are under discussion.

In December 1999, the Council decided that time had come to find ways to open the Convention for new Member States. A first attempt to find a quick solution by simply amending the Annex, without going through the difficult process of amending the Convention, failed. In June 2002 the Council decided that there was no alternative but to amend the Convention itself. As this major task should only be undertaken once in a generation, it was worthwhile taking the opportunity to consider other modifications. This opened a Pandora's box, which took three further years to close.

At the end of this lengthy and difficult process, an agreement has been reached which not only allows new Member States to accede to the Convention, but also:

- Enlarges ECMWF's mission to cover the monitoring of the Earth-system;
- Redefines some decision processes of the Council (voting rights);
- Widens the possibility for externally funded activities (e.g. by the European Union);
- Extends official status to all the official languages of the Member States (on a request-and-pay basis).

Further information about the Convention is available on the Centre's website at:
www.ecmwf.int/about/basic/volume-1/convention_and_protocol/

Before the amended Convention can enter into force, it still has to pass through the acceptance procedures applicable in each Member State. This will probably take a couple of years. There is, however, a clear commitment to successfully complete this process as fast as possible. New Member States will join ECMWF and contribute to its future developments, which will without any doubt be of benefit to the existing and future Member States of ECMWF.

ECMWF's highlights for 2005

Dominique Marbouty

Planning is an important activity at ECMWF. Setting clear plans for our future developments is necessary to allow them to be discussed, agreed and supported by our Member States. The main planning task is the yearly preparation of a programme covering the following four calendar years, which is discussed by the Committees in the autumn before adoption by the Council in December.

The plans for 2005 are a direct implementation of the four-year programme, with the understanding that each implementation will take place only if and when the research results are properly validated and proven beneficial. Here we shall focus on the main activities and targets for 2005, from the users' point of view, keeping in mind that the whole Scientific and Technical Four-Year Programme of Activities 2005-2008 is available on the Centre's website at:

www.ecmwf.int/about/programmatic/

Each year, the most visible milestones are the changes to the operational weather prediction system.

- ◆ The first change has already taken place on 5 April and is described in the usual review starting on this page.
- ◆ A second model change is already under test for implementation in early summer and should include a variational radiance bias correction and the assimilation of rain-affected radiances from SSM/I.
- ◆ The most important change, particularly concerning the consequences for the users, is scheduled in the autumn: it will include increases in vertical resolution from 60 to 91 levels (40 to 62 for the EPS) and in horizontal resolution from 40 to 25 km (80 to 50 for the EPS).
- ◆ Another major change is expected towards the end of the year with the implementation of the unified Ensemble Prediction System. There will be a merging of the medium-range EPS and the monthly forecasting system with a resolution varying in steps from 50 km at the beginning of the forecast to 125 km at the end. At the same time the deterministic forecast will be extended to 15 days.

Important changes are also expected for this year concerning the seasonal forecasting system with the implementation of the system-3 based on a recent cycle of the medium-range forecasting system and the development of products from the multi-model system.

On the computing side, with the Phase-3 of the IBM supercomputer now in operation, a major activity will be the development of grid activities, thanks to two projects funded by the European Union. The first project, SIMDAT, targets the issue of accessing distributed meteorological data with the development of a WMO Virtual Global Information System Centre (V-GISC). The second project, DEISA, is a five-years project to develop and test a grid-computing infrastructure between ECMWF and several large supercomputing sites in Europe. Such technologies, once mature, are expected to become important for the interactions between ECMWF and its Member States.

Reanalysis has been a very successful ECMWF project and is now widely used by the worldwide research community. This activity will continue in 2005 with the start of the interim reanalysis, namely a rerun of ERA-40 for the period 1989 to present, with a more recent cycle of the model. This interim reanalysis will correct or reduce some of the identified deficiencies of ERA-40.

It is very unusual that infrastructure projects find their way to the headlines of ECMWF's plans. From this point of view, 2005 will be exceptional with the completion of the Computer Hall extension, the complete redesign of the access roads and car park, and the start of the construction of a new office building. And for the first time ever, an article is dedicated to these developments in the Newsletter (see page 25).

What might be seen in the future as the most important development in 2005 at ECMWF could well be the start of the GEMS project. With this project developed with major partners in the Member States, ECMWF will contribute to a new mission for the global monitoring of the atmospheric composition (non-reactive gases, reactive gases, aerosols), including reanalyses. It is interesting to note that these developments are fully in line with the amended convention. GEMS is briefly described in a specific article page 17.

Finally, a major activity of ECMWF in 2005 is the preparation of the new strategy for the period 2006–2015 as requested by the Council last year. The goal is to finalise it by the end of the year after extensive discussions with our Member States. It will be built upon the strengths of ECMWF and the need of our societies, that is to:

- ◆ Continue the development of earth system assimilation and modelling;
- ◆ Focus on the prediction of severe weather events;
- ◆ Strengthen collaboration with our Member States and the wide research community.

It will give a special emphasis on the Centre's contribution to THORPEX, as developed in the article at page 4.

These are the highlights of ECMWF plans for 2005. However, one should always keep in mind that the main activity will remain the constant improvement of each component of the forecasting system and the permanent development of the systems and tools necessary for delivering the best possible service to our Member States, 24 hours a day.

Changes to the operational weather prediction system

François Lalaurette

Changes made on 5 April 2005

Cy29r1 has been implemented for the operational medium-range (deterministic and EPS) and monthly forecasts, as well as for the Boundary Conditions Optional Project. This version includes the following changes.

- **Boundary layer scheme** — A new moist boundary layer scheme was implemented that generates more stratocumulus clouds in subtropical highs, and has shown to be better at generating low-level clouds in some anticyclonic conditions such as those found in December over continental Europe.
- **Background error statistics** — A wavelet formulation was introduced in the representation of background error statistics (Jb), the tuning of which has been based on Data Assimilation ensemble runs with a special treatment for ozone statistics.
- **Surface pressure observations** — There was revised use of surface pressure observations: airport hourly reports (METAR) are activated (about 25,000 per day); all surface pressure data are subject to an adaptative bias correction scheme and get a higher weight in the assimilation (reduced observation error assumption); PAOB observations are not used any more.
- **MODIS winds** — MODIS winds from AQUA were activated (previously only winds from TERRA were used) and their observation error was reduced; ten AIRS channels were blacklisted due to their negative impact on stratospheric humidity.
- **Other model changes** — A bug in the first time step of the semi-Lagrangian treatment of the physics was fixed; snow cover tile coupling was revised; a new dissipation source function was introduced for modeling the oceanic wave.
- **Technical changes** — Several technical implementations paving the way for the assimilation of rain, of GPS data and for the variational bias correction of satellite radiances was introduced but not activated yet.

The impact of data assimilation changes on the scaling of EPS initial perturbations was tested and found negligible; therefore scaling parameters were not changed. Also the use of Non-linear Normal Mode Initialisation for the EPS Control and EPS initial perturbations has been discontinued.

The overall impact of these changes has been found to be meteorologically small during the test period (August 2004 to present), although some clear beneficial impact could be seen on occasions for cloud cover.

The production and archiving of bathymetry fields (parameter 219 - ECMWF local GRIB table 2 version 140) in MARS from both the global and European wave models for forecast step 0 have also been be added.

Future changes

Testing of a new model cycle (29r2) will start this spring. Among the new features activated in this cycle are the assimilation of rain-affected SSM/I radiances, changes to the humidity analysis, use of SMHI Baltic sea-ice analysis, changes to the convective scheme and improved Gaussian sampling of singular vectors for the EPS.

New ECMWF web site items

Andy Brady

Monthly Forecast Charts

ECMWF started an experimental programme of monthly forecasting (time range from 10 to 30 days) in March 2002. The monthly forecasting system is operational since October 2004. A selection of ECMWF's monthly forecast charts are now available.

www.ecmwf.int/products/forecasts/d/charts/mofc/forecast/

WMO Predefined EPSgrams

Epsgrams are available for the capital city of each WMO Member. These are updated twice daily and are sorted by alphabetical order. The database of capital cities is still being constructed, particularly for islands, please let us know about possible inaccuracies.

www.ecmwf.int/products/forecasts/d/charts/medium/epsgramswmo

ECMWF 2005 Annual Seminar

The one week seminar on Global Earth-System Monitoring will start on Monday 5 September at 10.00 and finish Friday 9 September at 12.30.

This Seminar will provide a pedagogical review of the science, data requirements and availability, and technical aspects which together will form the foundations of the new European initiatives in Global Earth-System Modelling and Monitoring.

www.ecmwf.int/newsevents/meetings/annual_seminar2005/

Amended ECMWF Convention

At its 62nd (extraordinary) session on 22 April 2005, the Council of the European Centre for Medium-Range Weather Forecasts unanimously adopted the amended ECMWF Convention. The current Convention, which entered into force in 1975, restricts membership to the current 18 Member States. The amendment will enable existing Co-operating States and other new EU Member States to join. Further important amendments to the Convention include updated objectives, reflecting the Centre's already existing contributions to environmental questions, and provision for greater opportunity to carry out optional programmes and activities requested by third parties.

www.ecmwf.int/about/basic/volume-1/convention_and_protocol/amending_convention/

Tenth Workshop on Meteorological Operational Systems

The tenth Workshop on Meteorological Operational Systems will be held from 14 to 18 November 2005. The objective of the workshop is to review the state of the art of meteorological operational systems and to address future trends in: the use and interpretation of medium-range forecast guidance; operational data management systems; meteorological visualisation applications.

www.ecmwf.int/newsevents/meetings/workshops/2005/MOS_10/

SIMDAT and DEISA GRID Projects

ECMWF is currently involved in two European Commission FP6 funded GRID computing projects to investigate and develop technologies for utilising computer, supercomputer and data storage capacity effectively across distant sites. The two main projects are the DEISA project and the SIMDAT project.

www.ecmwf.int/services/grid/

AMMA Project

ECMWF is involved in the EU-funded (FP6) component of the African Monsoon Multidisciplinary Analysis (AMMA) project. One of the tasks is to monitor the observations in the AMMA area.

www.ecmwf.int/research/EU_projects/AMMA/

ECMWF Newsletter

Philippe Bougeault

On 31 December Peter White ceased being editor of the ECMWF Newsletter. Peter joined the Centre in 1997 after a long and productive career at the Met Office. During his eight years as editor he was committed to improving the newsletter content and ensuring that high standards of presentation were maintained. Of course, getting authors to meet deadlines is always a difficult task, but Peter successfully managed this in a firm yet courteous way. Our thanks go to Peter for his contributions to ECMWF and we wish him well for the future.

Bob Riddaway took over as Editor of the Newsletter from 1 February 2005 on his retirement from the Met Office. He has long experience of being involved in publications, and for seven years was editor of the journal *Meteorological Applications*. Also about 20 years ago he spent three years on secondment to ECMWF as Assistant to the Head of Research in the Field of Education and Training.

When a new editor is appointed it is appropriate to review the purpose of the Newsletter. This has now been done. It has been agreed that the aim of the ECMWF Newsletter is to make users of ECMWF products, collaborators with ECMWF and the wider meteorological community aware of new developments at ECMWF and the use that can be made of ECMWF products.

The Newsletter will be published four times a year and will include:

- Features about new developments and systems at ECMWF, case studies of important meteorological events, and uses of ECMWF products.
- News items about:
  - Changes to operational systems and progress with projects and other ongoing activities.
  - New activities, including recent initiatives and decisions of Council and progress with externally funded projects.
- Information about publications, changes to the web site, and plans for ECMWF workshops and the education programme for the coming year.

Staff at ECMWF may submit articles to the Newsletter. Also articles are welcome from people working elsewhere, especially those from Member States and Co-operating States.

Anybody with any queries about the newsletter or would like advice about the submissions process should contact the editor at: Bob.Riddaway@ecmwf.int.

ECMWF and THORPEX: A natural partnership

Philippe Bougeault

At its fourteenth Congress held in 2003, the World Meteorological Organization decided to establish a new ten-year research and development programme, called THORPEX: A Global Atmospheric Research Programme. The aim of THORPEX is to accelerate the improvement in accuracy of 1–14 day high-impact weather forecasts for the benefit of society, the economy and the environment. This aim largely coincides with the mission of ECMWF. Therefore, not surprisingly, the THORPEX International Science Plan has many similarities with the research agenda of ECMWF. Further information about THORPEX, including the Science and Implementation Plans, can be found at:

http://wmo.int.ch/thorpex/.

An important aspect of THORPEX is to facilitate collaboration between the academic community and operational centres. ECMWF expects to benefit from research done by THORPEX scientists, and is keen to contribute to this important initiative. Examples of past and future ECMWF contributions are given below.

Targeted observations

ECMWF participated in the North Atlantic Regional Campaign organized under THORPEX in the Autumn of 2003 (see for example *Leutbecher et al.*, 2005). Various targeting products were provided by ECMWF in order to plan which additional observations would be most useful. It also offered an Internet facility to host the targeting products of all participants and to facilitate all communications and decisions. ECMWF now archives and processes the special observations from this field experiment.

ECMWF scientists are conducting research to evaluate the value of targeted observations taken during the campaign, and to assess the relative merits of the various targeting

Participants in the TIGGE Workshop that was held at ECMWF from 1 to 3 March 2005.

methods (e.g. *Cardinali and Buizza*, 2005). It is intended that ECMWF will make a similar contribution during future THORPEX field campaigns, for instance during the International Polar Year 2007–2008. Also there will be participation in the forthcoming EUCOS initiative to establish operational targeting at the European scale.

THORPEX Interactive Grand Global Ensemble (TIGGE)

THORPEX actively promotes the idea of collecting in a single ensemble a large number of ensemble forecasts issued by several NWP centres. The THORPEX International Research Implementation Plan establishes the TIGGE project as a research and development instrument aiming at:

- Developing the concept of multi-model ensemble.
- Establishing its real value.
- Developing optimal products and verification techniques.
- Developing new software to exchange the data in a flexible and user-friendly way.

ECMWF hosted a TIGGE Workshop from 1 to 3 March 2005. Information about the workshop can be found at:

www.ecmwf.int/newsevents/meetings/workshops/2005/TIGGE/

The workshop brought together representatives of the scientific community working on ensembles, in order to identify and review requirements. The workshop agreed on the scientific questions that need to be addressed in the TIGGE project and on an initial list of data to be exchanged. Although TIGGE will be initially a research project, cooperation will be sought with the operationally oriented North-American Ensemble Forecasting System.

TIGGE is likely to take a two-phase approach. Phase 1 is planned to start early in 2006. This would allow ECMWF (and possibly a limited number of other centres) to collect data from all existing global operational centres with Ensemble Prediction Systems, and redistribute them to the research community in near real time. The functionalities of the MARS system would be used for this process. At the end of Phase 1, demonstration projects would be conducted with real-time dissemination of forecasts to selected users. Also, during Phase 1, software would be developed to archive TIGGE data in a distributed manner and disseminate that data in a user-transparent way using GRID technologies. Taking this approach would allow all interested centres to become a TIGGE Centre in Phase 2. In Phase 2, the concentration of data at one centre would no longer be necessary.

After initial agreement on the definition of the project obtained during the workshop, ECMWF will now produce a technical proposal for the TIGGE infrastructure. It is intended that a decision will be made about the infrastructure and the associated resources by the end of 2005, and to start TIGGE by early 2006. ECMWF will be the main European site for TIGGE, but we expect other sites to be developed in America (possibly NCAR) and Asia (possibly CMA).

Announcement of Opportunity for data archived at operational centres

There exists a wealth of data at operational centres that would be useful for research. The most well known datasets are the reanalyses. However, operational forecasts are also archived, as well as re-forecasts, seasonal forecasts, results of research projects, etc. These data constitute a valuable resource for investigating the scientific questions posed in the THORPEX International Science Plan (for instance the interannual variability of predictability). We want to engage the scientific community in exploiting these data more systematically.

The concept of a THORPEX Announcement of Opportunity for data archived at operational centres is outlined on page 70 of the International Research Implementation Plan. Subject to agreement with all participating centres, a list of available datasets (together with their main characteristics) will be established and regularly updated. In addition a list of priorities for research subjects will be established based on the International Science Plan. Research projects making use of the data will be invited, and the help of the THORPEX Science Committees will be sought in selecting the most promising projects. Investigators involved in these projects will receive help from the operational centres, not only to access the data free of all charges but also to process them efficiently. To assist in this knowledge transfer, the investigators will have an opportunity to interact with designated staff at the operational centres so that they become rapidly aware of any characteristics or limitations of the datasets, which would affect the planned research.

'Nature runs' for OSSEs

The need for and limitations of Observation System Simulation Experiments (OSSEs) were discussed in depth at the First THORPEX International Science Symposium in Montreal in 2004. At NCEP for instance, there is a keen interest in continuing OSSEs as a contribution to planning an optimal observing network. As a result of the discussions in Montreal, ECMWF is now committed to delivering a new series of "nature runs". These are long simulations of the Integrated Forecasting System (IFS) that will serve as a substitute for the truth when investigating the information content of various future observation systems. These nature runs will be made available to the scientific community around mid-2006. The current plan is to produce a 13-month run at T511L91, with 3-hourly output, and T799L91 runs for selected periods totalling two months, with output every 30 minutes. Consultations will now be conducted to determine the exact configuration of the runs and the list of output diagnostics.

FURTHER READING

Cardinali, **C**. and **R**. **Buizza**, 2005: Observation sensitivity to the analysis and forecast: a case study during ATReC targeting campaign. THORPEX Symposium Proceedings, Commission for Atmospheric Science, *WMO TD 1237*.

Leutbecher, **M**., **E**. **Anderson**, **A**. **Beljaars**, **M**. **Hortal**, and **P**. **Janssen**, 2005: Planning of adaptive observations during the Atlantic THORPEX Regional Campaign 2003. *ECMWF Newsletter*, **102**, 16–25.

Note: some elements of this text originate in the address given by Dr. Bougeault at the First THORPEX International Science Symposium, Montreal, 6-10 December 2004.

Sea ice analyses for the Baltic Sea

Matthias Drusch

Concentration of sea ice (CI) is a key parameter in the exchange processes between ocean and atmosphere. It strongly influences albedo, surface fluxes of latent and sensible heat, and surface wind drag. For atmospheric numerical modelling applications and weather forecasting, the CI analysis is a useful product as a comprehensive diagnostic of the ocean-atmosphere system. In addition, the CI analysis has a particular value as the initial state and it can be used to check the quality of the sea surface temperature analysis. Consequently, real-time sea ice products are of fundamental importance for those NWP centres that do not run fully coupled ocean-atmosphere models and/or do not analyse this surface field in-house.

In the operational Integrated Forecast System (IFS) for medium-range forecasts, sea ice concentration and sea surface temperature analyses are based on the corresponding daily 0.5° data sets produced by NCEP (National Centers for Environmental Prediction). Both products are re-sampled from their original regular latitude/longitude grid to the reduced Gaussian model grid using bi-linear interpolation. Technically, the analyses are performed six hours before the atmospheric variational analysis is done. The first guess (i.e. the previous analysis) is only updated when a new analysis is available. CI fields remain constant during the ten-day forecast period. Consequently, there is no feedback from the atmosphere to the ocean.

In the monthly and seasonal forecast systems CI evolves with time. In the current model version, CI is limited to values of 100% or 0%. At every model time step, the presence of sea ice is determined through a threshold algorithm based on modelled SST and a weak relaxation to sea ice climatology. A new treatment of CI has been formulated and is being tested in research mode: Initial CI is obtained from the atmospheric analysis used for the medium-range forecasts as described above. For the first 10 days of the coupled integration the CI is kept constant. After an integration time of one month climatological values of CI derived from ERA40 are used. For days 10 to 31 CI is linearly interpolated between the analysed field and climatology.

At the Swedish Meteorological and Hydrological Institute (SMHI), sea ice concentration, sea ice thickness, and sea surface temperature are analysed operationally for the Baltic Sea twice a week. It was found that significant differences exist between the NCEP and SMHI analyses of CI for the Baltic Sea. Two experiments have been performed to study the impact of these analyses on the medium-range forecast fields:

- CTRL — the control run based on the global NCEP analysis.
- EXP — the experimental run, where the SMHI analysis is used for the Baltic Sea.

The results of these experiments showed that the impact of the high-resolution CI analysis for the Baltic Sea on the medium-range weather forecast on the continental scale is neutral if temperature and geopotential height are analysed. But even for these fields there are indications of minor improvements in the 24-hour forecast and the forecast period covering days four to seven. However, on regional to local scales, the differences in the surface parameters (surface fluxes, temperature, humidity, and planetary boundary layer height) are non-negligible and can influence forecast cloud cover. For a number of practical applications (e.g. icing of ships, fog forecasts, air quality, and dispersion of pollutants) the differences in the planetary boundary layer can be crucial. In the next major upgrade of the operational IFS (cycle 29r2) the SMHI sea ice analysis will replace the NCEP analysis in the Baltic Sea.

Analyses of sea ice concentration

The global NCEP analysis of CI is based on passive microwave observations from the Special Sensor Microwave/Imager (SSM/I). CI is calculated from the daily composite brightness temperature grids following a tie-point algorithm described in *Cavalieri et al.* (1991). In a final step, a number of quality checks are applied and there is polar gap filling. A detailed description of the automated analysis process and the final quality-controlled data set is given in *Grumbine* (1996).

The footprint size of SSM/I, which is ~ 69 × 43 km^2 at 19 GHz, determines the resolution of the NCEP analysis. However, it has been shown (e.g. *Drusch et al.*, 1999) that only 50 % of the information obtained through an individual observation from SSM/I originates from this area. Consequently, SSM/I measurements in coastal areas and small basins are strongly contaminated by land. For the Baltic Sea, with its ragged coastline and a number of small islands, it is almost impossible to find a land-free SSM/I footprint.

The SMHI analysis is done manually by an analyst using AVHRR (Advanced Very High Resolution Radiometer) data and in-situ observations. The final maps are digitised and archived at 1 km (sea ice and thickness) and ~ 10 km (sea surface temperature) resolution. For the applications at ECMWF the high-resolution product has been linearly averaged to the reduced Gaussian model grid.

Sea ice season 2003/2004

The SMHI and NCEP analyses have been compared for the sea ice season 2003/2004 for the entire Baltic Sea and three sub-basins:

- Gulf of Bothnia (GoB, 60.25° N to 65.85° N, 16.5° E to 26.0° E).
- Gulf of Finland (GoF, 59.5° N to 60.6° N, 22.6° E to 30.8° E).
- Gulf of Riga (GoR, 56.9° N to 59.0° N, 21.7° E to 24.8° E).

Time series for mean CI and sea ice extent, as defined by grid boxes containing more than 20 % sea ice, are shown in Figure 1. In general, mean sea ice fractions calculated from the SMHI and NCEP analyses are in reasonable agreement. In all three sub-basins the high-resolution SMHI analysis results in higher concentrations during the peak time of the ice season from mid-February to mid-March. For individual days differences exceeding 20 % can be found for the Gulf of Finland. During the growing and melting seasons, mean sea ice concentration from SMHI tends to be slightly smaller for the Gulf of Riga and the Gulf of Finland. The agreement between both analyses for the Gulf of Bothnia is very high.

The differences in sea ice extent are significantly higher than for the concentrations. In all three sub-regions the sea ice extents can differ by more than 30 %. In general, the NCEP analysis leads to higher ice extents, which is due to the coarse resolution of the SSM/I satellite footprint. For the Gulf of Riga a plateau is obtained for the winter period from mid-February to the end of April. This plateau is an artefact of the interpolation of the coarse-resolution NCEP analysis to the limited number of model grid points in the array defining the Gulf of Riga region. For the Baltic Sea area the differences in sea ice extent and sea ice concentration exceed 10 % and 5 %, respectively.

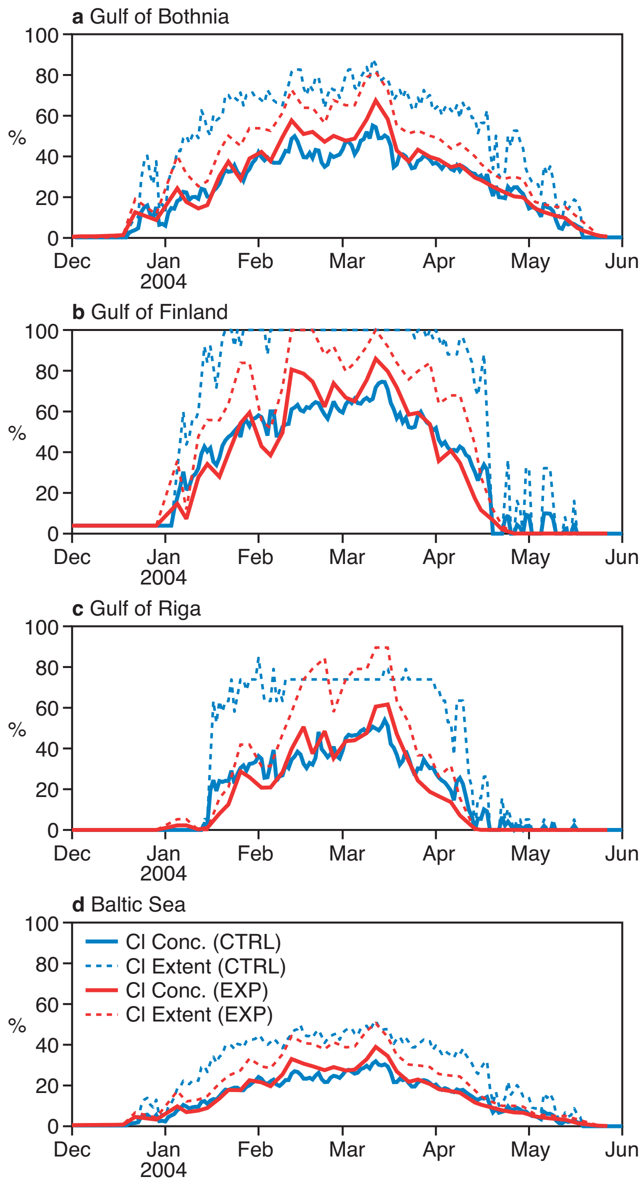

Figure 1 Sea ice extent (solid lines) and sea ice concentration (dashed lines) for winter 2003/2004 for (a) Gulf of Bothnia, (b) Gulf of Finland, (c) Gulf of Riga, and (d) Baltic Sea. Values from CTRL (NCEP analysis) are in blue and from the EXP (SMHI analysis) are in red.

Sea ice concentration for 5–24 January 2004

The results presented in Figure 1 show significant differences between the two CI analyses for the Baltic Sea and the three sub-basins. Consequently the impact of these differences on surface parameters (e.g. turbulent fluxes of sensible and latent heat), the boundary layer, and eventually

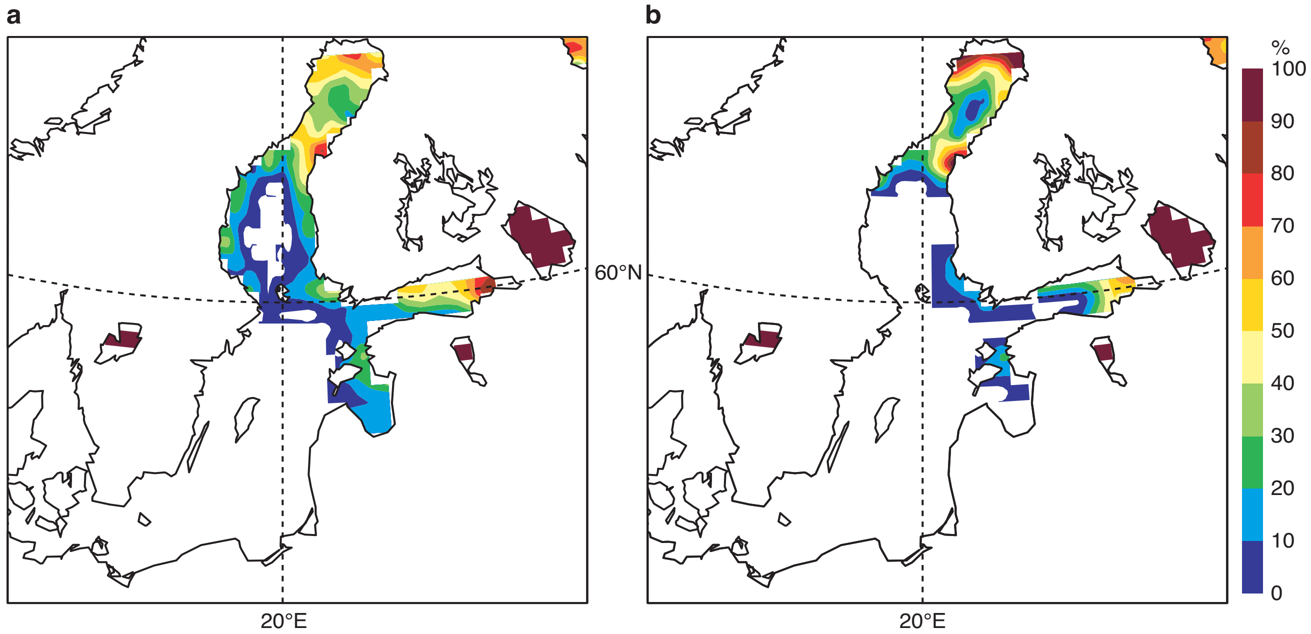

Figure 2 Mean sea ice concentration for the study period 5–24 January 2004: (a) CTRL and (b) EXP.

on the quality of the medium-range weather forecasts has been assessed. The most accurate quantification of the impact on the forecast is obtained using the operational version of the IFS, which includes the full 4D-Var atmospheric data assimilation system. However, these experiments are computationally expensive and therefore the study period is limited to the 20 day period from 5 to 24 January 2004.

In general, the gradients in CI in CTRL are smaller when compared to the corresponding values in EXP (Figure 2). In the northern part of the Gulf of Bothnia the CI in CTRL hardly exceeds 60 % with a maximum value of 78 %. Minimum CI is 28 % in the central northern part. In contrast EXP produces a CI of 97 % along the very northern coastline and a small almost ice free area of 3 %. These differences are primarily due to the coarse resolution of the satellite product and the contamination by land. Significant differences in CI also occur along the eastern coast of Sweden north of 60° N and in the Gulf of Finland, where an overestimation of low CI can be found in CTRL. The same holds for the Gulf of Riga, which is almost ice free in the EXP analysis.

Turbulent surface fluxes

Differences in CI have a direct impact on the turbulent surface fluxes. Figures 3(a) and 3(b) show spatially integrated daily values of latent and sensible heat fluxes from CTRL based on 24-hour forecasts. The time series for the Baltic Sea and the three sub-basins exhibit substantial temporal variability during the study period. The Gulf of Finland and the Gulf of Riga regions are characterized by high upward fluxes of up to 160 Wm^{-2} for latent heat and 180 Wm^{-2} for sensible heat from 7 to 10 January. During this period, a strong spatial gradient in 2 m temperature was present, leaving the Gulf of Riga, the Gulf of Finland, and the very eastern part of the Baltic Sea under the influence of cold air with temperatures below -9 °C.

From the 11th onwards, warm air moved eastward, reducing the surface fluxes. During this part of the study period, the turbulent fluxes in the three sub-basins look similar. From 20 January onwards, the entire Baltic Sea region was under the influence of cold air masses characterized by 2 m temperatures between -4 °C (central part) and -12 °C in the Gulf of Finland. The strong vertical temperature gradient between the ocean and the atmosphere results in fluxes of up to -200 Wm^{-2} (Figure 3(a)). In general, fluxes are smaller in the Gulf of Bothnia and the Gulf of Finland due to the presence of ice.

The differences between CTRL and EXP are presented in Figures 3(c) and 3(d). For the Gulf of Riga, where CI is very low in both analyses, the differences in fluxes do not exceed 3 Wm^{-2} until 15 January. During the last days of the study period, CI increases (Figure 1) and differences up to 55 Wm^{-2} can be found (Figure 3(c)). The most pronounced differences are obtained for the Gulf of Finland, where large fluxes and significant differences in CI are present. The difference of 80 Wm^{-2} in sensible heat flux, which is caused by differences in CI, is comparable to the temporal variability during the study period (Figure 3(a)). For the Gulf of Bothnia area, the two CI analyses result in spatially averaged flux differences of up to 30 Wm^{-2}.

Impact on the planetary boundary layer

21 January has been selected to study the impact of the different sea ice analyses on the planetary boundary layer (PBL). This particular day was characterized by a northerly flow, leaving the Gulf of Bothnia under the influence of cold air with 2 m temperatures varying from -14 to -7 ° C.

The differences in the forecast are studied using data from two grid point: GP1 (64.4° N, 22.4° E) and GP2 (65.1° N, 24.0° E). In CTRL both points are partly ice covered with a CI of 47 % at GP1 and 64 % at GP2. The spatial gradient in CI in EXP is much higher. GP1 is in the centre of the

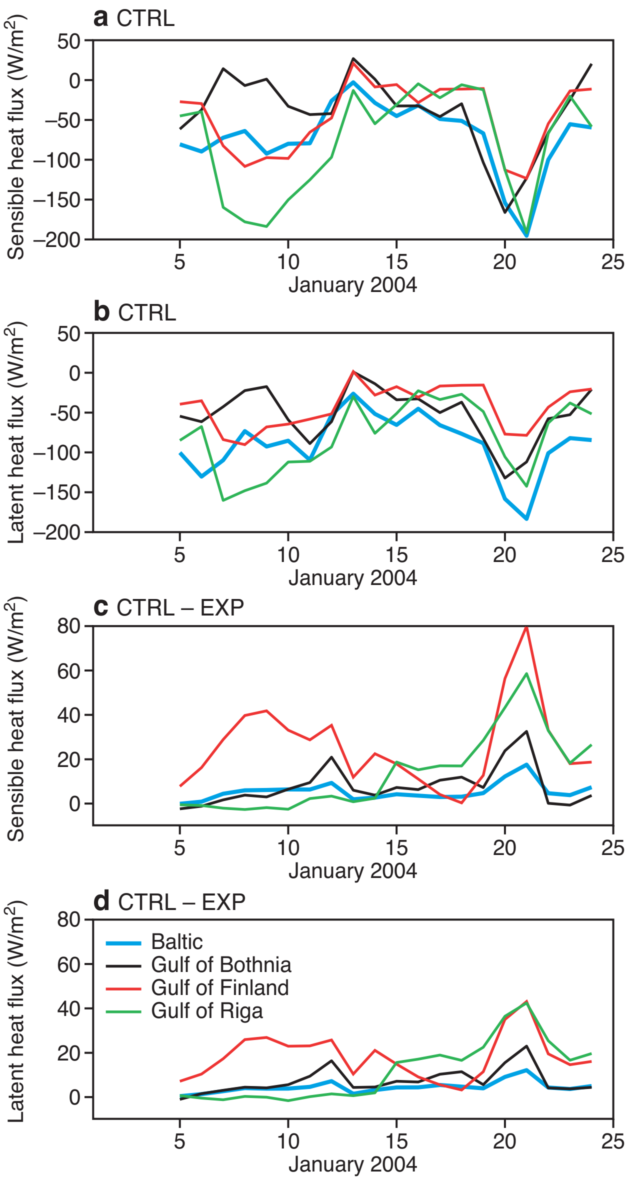

Figure 3 Spatially integrated turbulent surface fluxes for 5–24 January 2004 as computed from the CTRL experiment for (a) sensible heat flux and (b) sensible heat flux. The corresponding differences between CTRL and EXP are shown in (c) and (d). Individual curves represent the Baltic Sea area (blue line), Gulf of Bothnia (black line), Gulf of Finland (red line), and Gulf of Riga (green line).

northern part of the Gulf of Bothnia, which was almost ice free in the high-resolution analysis; GP2 is characterized by almost complete ice coverage of 94 % (Table 1).

Vertical profiles of temperature and specific humidity for the six-hour forecast from 12 UTC on 21 January are shown in Figures 4(a) and 4(b). The differences at GP1 in the vertical profiles are comparatively small. Surface temperature is slightly higher in EXP, since more open water is present. Above 800 hPa, the two curves are almost identical. The most striking difference occurs in the low-level temperature profile at GP2. The CI of 93 % causes a stable boundary layer up to almost 970 hPa. In the presence of 36 % open water in CTRL an unstable structure is created near the surface. The differences in surface temperature are ~ 3 °C (Figure 4(a)).

		GP1 (64.4°N, 22.4°E)		GP2 (65.1°N, 24.0°E)	
Forecast time	**Parameter**	**CTRL**	**EXP**	**CTRL**	**EXP**
18 UTC	CI (%)	47	9	64	94
	PBLH (m)	295	320	216	98
	LCC (%)	6.0	9.2	14.4	14.7
	TCC (%)	6.0	9.2	14.4	14.7
	TCWV (kg m^{-2})	3.44	3.43	3.58	3.57
06 UTC	CI (%)	47	9	64	94
	PBLH (m)	199	196	147	88
	LCC (%)	85.0	78.0	99.0	59.3
	TCC (%)	85.0	78.0	99.0	59.3
	TCWV (kg m^{-2})	2.09	2.17	1.91	1.89

Table 1 Selected surface parameters at two model grid points for 21 and 22 January: Sea ice concentration (CI), planetary boundary layer height (PBLH), low cloud cover (LCC), total cloud cover (TCC), and total column water vapour (TCWV). The table shows data from the 6-hour and 18-hour forecasts. Forecast base time is 12 UTC on 21 January 2004.

In addition, full ice coverage reduces the specific humidity up to a height of 900 hPa. The difference at the surface is almost 0.3 gkg^{-1}.

Atmospheric column water vapour, low cloud cover, and total cloud cover for both grid points are listed in Table 1. For the six-hour forecast (i.e. at 18 UTC) there are hardly any differences between CTRL and EXP in these parameters. The synoptic situation, with a comparably strong northerly flow and extensive cloud fields east of the Gulf of Bothnia, suggests that the lower boundary conditions have little influence on the atmospheric state. In the 18-hour forecast (i.e. at 06 UTC) differences in low-level cloud cover of almost 40 % occur at GP2.

In general, negative differences in downward sensible heat flux result in deeper boundary layers. Areas for which the flux differences are positive are characterized by shallower boundary layers. The differences in PBL height for the two grid points vary from 3 m (06 UTC forecast for GP1) to 118 m (18 UTC forecast for GP2), which is a substantial amount compared to the absolute value of 216 m. Due to the lack of in-situ observations, it is impossible to validate these results. However, it has been demonstrated that local differences in CI affect the boundary layer and cloud cover even in a coarse-resolution global model.

Impact on NWP skill scores

Changes in the turbulent surface fluxes over the Baltic Sea do not necessarily have a direct impact on the atmosphere on larger spatial scales. Effects of changes in sea surface

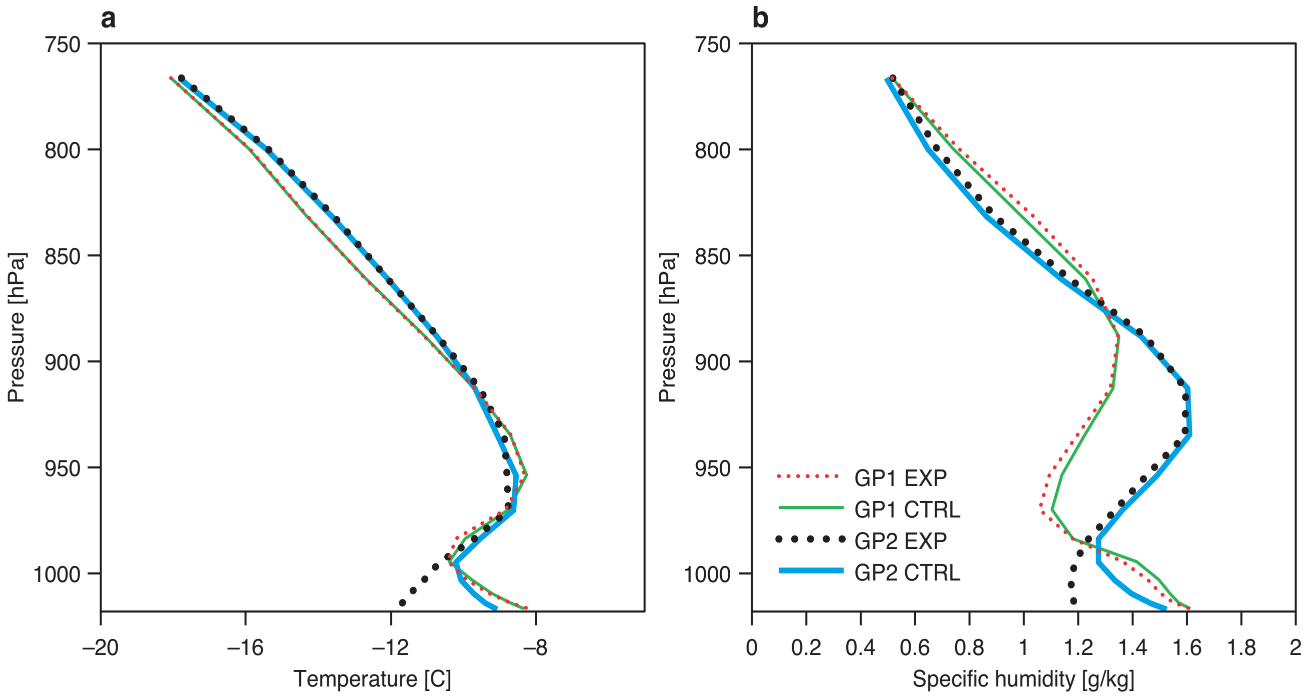

Figure 4 Vertical profiles of (a) temperature and (b) specific humidity for GP1 (64.4° N, 22.4° E, green and dotted red lines) and GP2 (65.1° N, 24.0° E, blue and dotted black lines) from the six-hour forecast from 12 UTC on 21 January 2004. The solid lines show data from the CTRL experiment, the dotted curves refer to the EXP run.

temperature and CI in the Baltic Sea — and consequently in the turbulent fluxes — are superimposed by advective influences. The response of the atmosphere is transported downstream and spatially spread. The dynamic structure of the atmosphere and its upper layers can only be altered in stationary conditions. However, it has to be ensured that the high resolution CI analysis from SMHI does not have an adverse impact on the forecast quality.

The anomaly correlations for 1000 hPa geopotential height for Northern Europe are shown in Figure 5. Again, the differences between CTRL and EXP are small. For forecast days one and two the anomaly correlations for EXP are slightly higher when compared with CTRL. The same holds for the period from days four to eight.

The anomaly correlations presented in Figure 5 suggest a neutral to slightly positive impact of the SMHI analysis on the forecast. Since the actual sample size of twenty forecasts is comparatively small, the evaluation of the forecast impact has been extended to the 500 hPa level. In addition, the t-test and the sign-test have been used to quantify the statistical significance of the differences between CTRL and EXP for forecasts up to 168 hours.

- For the sign-test, CTRL performed significantly worse in five cases; in twenty-three cases the performance has been equal.
- For the t-test, significant changes have been obtained for six cases; in twenty-two cases the performance has been equal.

Although there are indications of a positive impact for days four to seven and for the 24-hour forecast it has to be noted that the results have been derived from a limited number of forecasts. Further testing is necessary to obtain statistically significant results at a higher confidence level.

Should the sea ice field be updated during the forecast period?

Since ECMWF does not run a coupled ocean-sea ice-atmosphere model for the medium-range forecast, the initial sea ice conditions have to be kept constant throughout the forecast range. The SMHI high-resolution analyses can be used to assess the temporal variability during the forecast period.

Figure 6 shows the difference between the CI at the beginning of a ten-day forecast period and the maximum value for the forecast period. For all three sub-basins differences

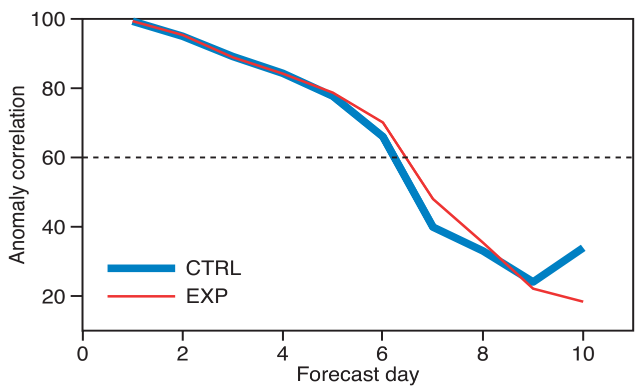

Figure 5 Anomaly correlations for 1000 hPa height for Northern Europe for CTRL (blue line) and EXP (red line). Correlations below 60% (dashed line) are considered not to be useful in weather forecasting.

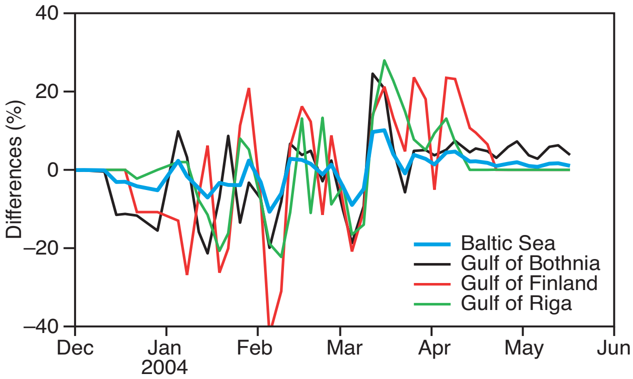

Figure 6 Differences between the mean CI concentration at the beginning of the forecast and the maximum value for the ten-day forecast period for Baltic Sea (blue line), Gulf of Bothnia (black line), Gulf of Finland (red line) and Gulf of Riga (green line). Ice concentrations have been computed from the SMHI high-resolution data set.

exceeding 20 % occur during the 2003/2004 winter season. For the Gulf of Finland a single period with a maximum difference of 40 % has been detected. Based on the absolute values for the differences, mean values of 7.7 % (GoB), 10.6 % (GoF), 7.1 % (GoR), and 3.2 % (Baltic Sea) have been obtained for the season. These differences are comparable with the differences introduced through the two CI analyses. Consequently, significant errors in the surface fluxes can be introduced by not updating the sea ice field. Similar results have been found with high-resolution models for shorter forecast periods of up to 48 hours (*Gustafsson et al.*, 1998). This indicates that it would be desirable to use a coupled sea ice-atmosphere model or to include offline sea ice concentration forecasts as lower boundary conditions.

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The ADM-Aeolus satellite to measure wind profiles from space

David G.H. Tan and Erik Andersson

ECMWF is currently preparing for the arrival of wind profile measurements from the ADM-Aeolus satellite, with expected launch in 2008. The Atmospheric Dynamics Mission (informally known as ADM, but more correctly referred to as Aeolus) is the second of the Earth Explorer Core Missions of the European Space Agency (ESA). For further information see *Stoffelen et al.* (2005) or go to:

www.esa.int/export/esaLP/earthexplorers.html.

ESA has placed a contract with ECMWF to develop the software to produce and deliver two of the mission's official data products:

- Retrieved wind profiles (level 2B data products);
- Aeolus-assisted wind profiles from analyses (level 2C data products).

Part of the software will be portable and made available to the meteorological community at large; this is to facilitate widest possible use of the Aeolus data soon after they first become available. Currently, the algorithm to retrieve representative winds and the portable codes are being developed in collaboration with Météo-France/GAME, KNMI, DLR and LMD/IPSL[1]. After launch, ECMWF will be responsible for monitoring the Aeolus data: assessing their quality, producing the 2B/2C data set routinely, and updating and distributing relevant software for use at other NWP centres.

The objective of Aeolus is to demonstrate, for the first time, the capability of measuring wind profiles from space using a Doppler wind lidar (DWL) on a polar orbiting platform. Aeolus is designed to provide high-quality profiles from the surface up to 30 km, the wind information being single-component in the horizontal direction of the instrument's line-of-sight (HLOS), perpendicular to the satellite track. The viewing geometry is shown in Figure 1. The instrument design includes a Rayleigh channel for detecting molecular scattering and a Mie channel for cloud and aerosol scattering. The combination of the two channels will enable good quality HLOS wind retrievals in 0.5, 1.0 and 2.0 km layers (near the ground, in the free troposphere and in the stratosphere, respectively) except where the view is restricted by thick clouds. Simulated six-hour data coverage is shown in Figure 2. The intention is to have the satellite in orbit from 2008 to at least 2011.

Wind accuracy in numerical weather prediction

An illustration of the accuracy to which the global wind-field is currently known is shown in Figure 3. This shows an estimate of the standard deviation of error in the east-west wind component at 250 hPa (approximately 10 km) in ECMWF analyses. The distribution of errors is a product of atmospheric

1 GAME = Groupe d'Etude de l'Atmosphere Meteorologique, KNMI = Koninklijk Nederlands Meteorologisch Instituut, DLR = Deutsches Zentrum für Luft- und Raumfahrt, LMD/IPSL = Laboratoire de Météorologie Dynamique / Institut Pierre-Simon Laplace

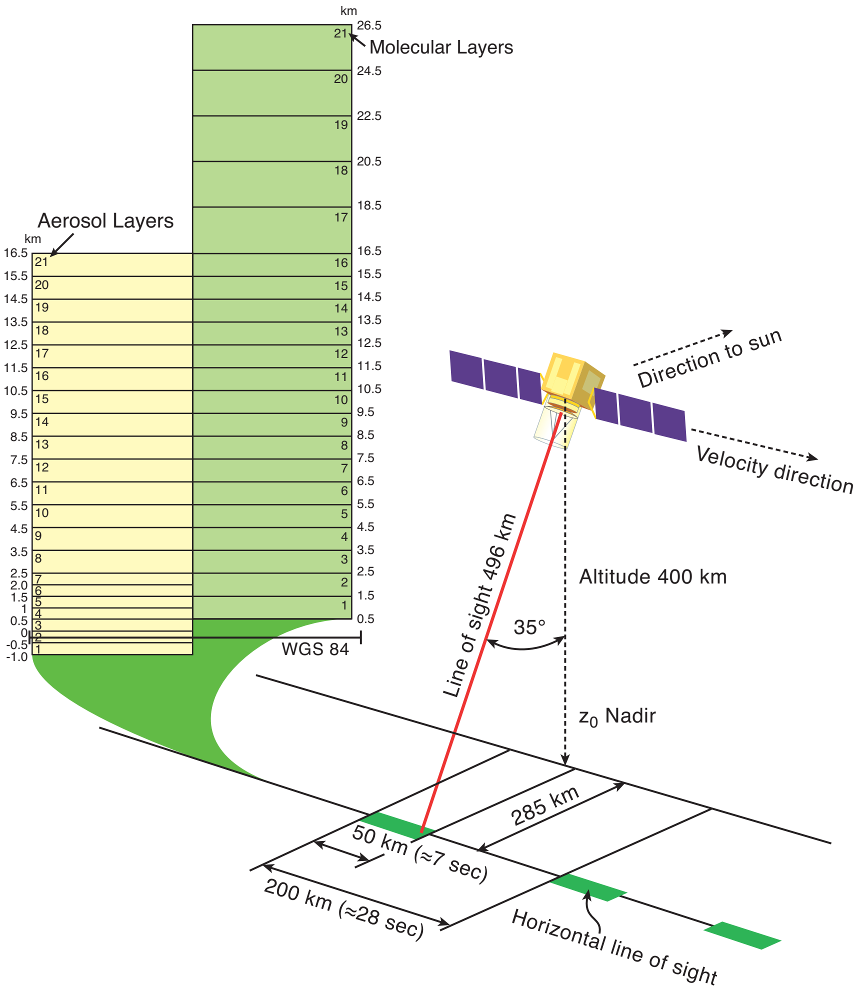

Figure 1 ADM-Aeolus viewing geometry and vertical resolution (Courtesy ESA). Laser light is emitted from the satellite. A small fraction of the light is backscattered and its frequency shift (which is wind-induced) is measured in two channels by the onboard receivers: Mie for aerosol returns and Rayleigh for molecular returns. The combination of the two channels will enable good quality HLOS wind retrievals from 27–30 km to the surface in 0.5, 1.0 and 2.0 km layers as indicated, except where the view is restricted by thick clouds.

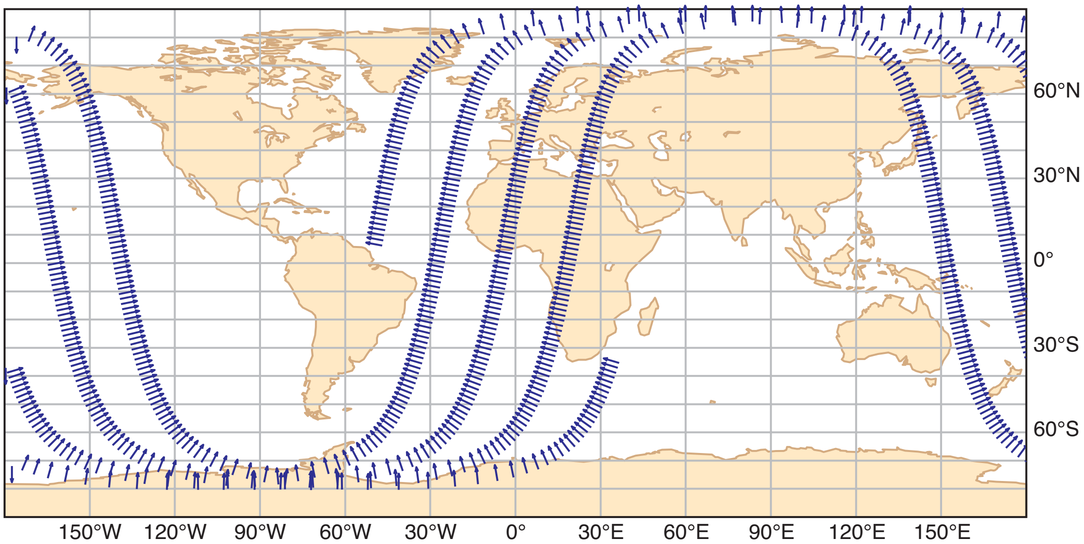

Figure 2 Simulated ADM-Aeolus data coverage and HLOS directions in a six-hour period.

wind variability on the one hand, and the availability of accurate observations, on the other. We see that wind analysis errors are small in data dense areas (e.g. North America, Europe, Japan and Australia) and in regions with little wind variability (e.g. parts of the sub-tropics). Wind errors tend to be large in most parts of the tropics, in the storm-tracks over oceans (e.g. southern oceans, North Pacific, North Atlantic) and along the sub-tropical jet extending from the southern Mediterranean region to northern China. It is in these areas, where current data assimilation systems have relatively high wind uncertainties, that the main analysis impact can be expected from Aeolus wind profile data.

Simulation of Aeolus measurements and their accuracy

The accuracy of the Aeolus wind measurements will not be uniform. The signal-to-noise ratio will primarily depend on the intensity of the backscattered laser light. In the Mie channel the backscattering depends on the presence and thickness of clouds, and the concentration of aerosol, whereas in the Rayleigh channel it depends on the density of air. It is expected that the Aeolus instrument will receive sufficient backscatter from the layers of clear air above clouds, from cloud-top layers, from layers in and below thin clouds, and from layers with sufficient aerosol in the lower parts of the atmosphere.

It is important to consider whether Aeolus will provide significant numbers of high-quality data in the meteorologically most interesting regions, i.e. where incipient storms tend to occur and where storm systems develop. These so-called 'sensitive areas' tend to be associated with high cloud cover (*McNally*, 2002). Therefore, the yield and quality of Aeolus wind profiles has been investigated (*Tan and Andersson*, 2005) through detailed simulations, given realistic cloud distributions and climatological estimates of aerosol concentration.

The simulations of backscatter and instrument performance have been carried out using the LIPAS (Lidar Performance Analysis Simulator) software (*Marseille and Stoffelen*, 2003). Given as input vertical profiles of atmospheric parameters (temperature, pressure, wind speed and direction, cloud fraction and aerosol concentration) LIPAS outputs a simulated Aeolus horizontal line-of-sight (HLOS) wind as well as corresponding estimates of measurement accuracy. The user specifies parameters such as the observation resolution, shot-accumulation length and pulse repetition frequency.

The Aeolus observation accuracy is provided as a sum of observation error and representativity error variances. Thus, LIPAS provides the simulated measurements and their accuracy as required for realistic impact studies. The mission-specified requirement on observation error for the Level-2B HLOS wind component data is set to 1 ms^{-1} below 2 km altitude and 2 ms^{-1} above. After addition of representativity error, Aeolus observations meeting the mission requirements are expected to receive weights comparable to those given to radiosonde and wind profiler wind observations in the ECMWF data assimilation system (*Tan and Andersson*, 2005).

Examples of LIPAS simulations of the expected yield of Aeolus winds are shown in Figure 4. The coloured markers show the percentage of good-quality data; that is those meeting the mission-specified accuracy requirement in terms of random error. This is shown separately for wind retrievals from the Rayleigh (molecular) channel in the mid-troposphere (Figure 4(a)), and for the Mie (aerosol) channel near the surface (Figure 4(b)). These simulations are for the period 10 January to 28 February 2003 and are based on cloud cover as provided by the ECMWF forecast model at full operational resolution (T511, or ~40 km), climatological aerosol distributions, and other meteorological inputs from the ECMWF model. We see that the yield of good data is high (>50 %, green markers) in most regions, even in the storm-tracks in the mid-troposphere. The yield is lower (red markers) mainly in the most persistently cloudy regions (i.e. the ITCZ and at low levels in the storm-tracks). At higher levels (not shown) the yield of good data is near complete.

Impact assessment using ensemble simulations

The global impact of Aeolus data has most recently been investigated through assimilation ensemble experiments (*Tan and Andersson*, 2004). This is a novel approach that is being developed and applied for the first time in these Aeolus simulations. The original assimilation ensemble method (*Fisher*, 2003a) was thus extended to assess the impact of different observations types: simulated Aeolus data and, for calibration purposes, radiosonde plus wind profiler data. This has required the generation of new ensembles that differ in the observations made available to assimilate.

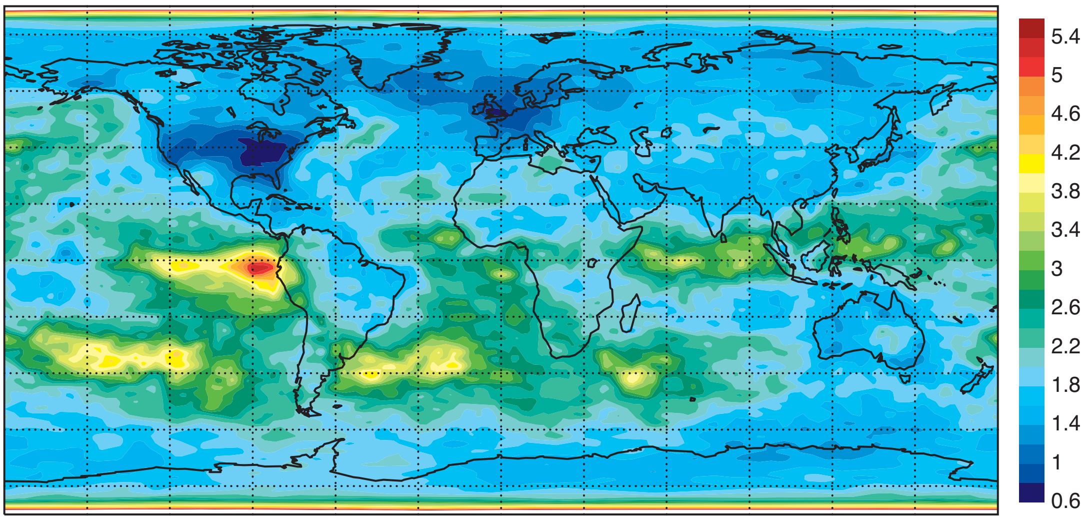

Figure 3 An estimate of wind analysis uncertainty (east-west wind component at 250 hPa, in ms^{-1}) in the Autumn 2001 version of the ECMWF data assimilation system showing maxima in the tropics, and the oceanic storm track regions. Errors tend to be smaller in data-dense regions and where wind variability is less. The estimate is based on the spread between the ten members of an ensemble of assimilations, 1–31 October 2000.

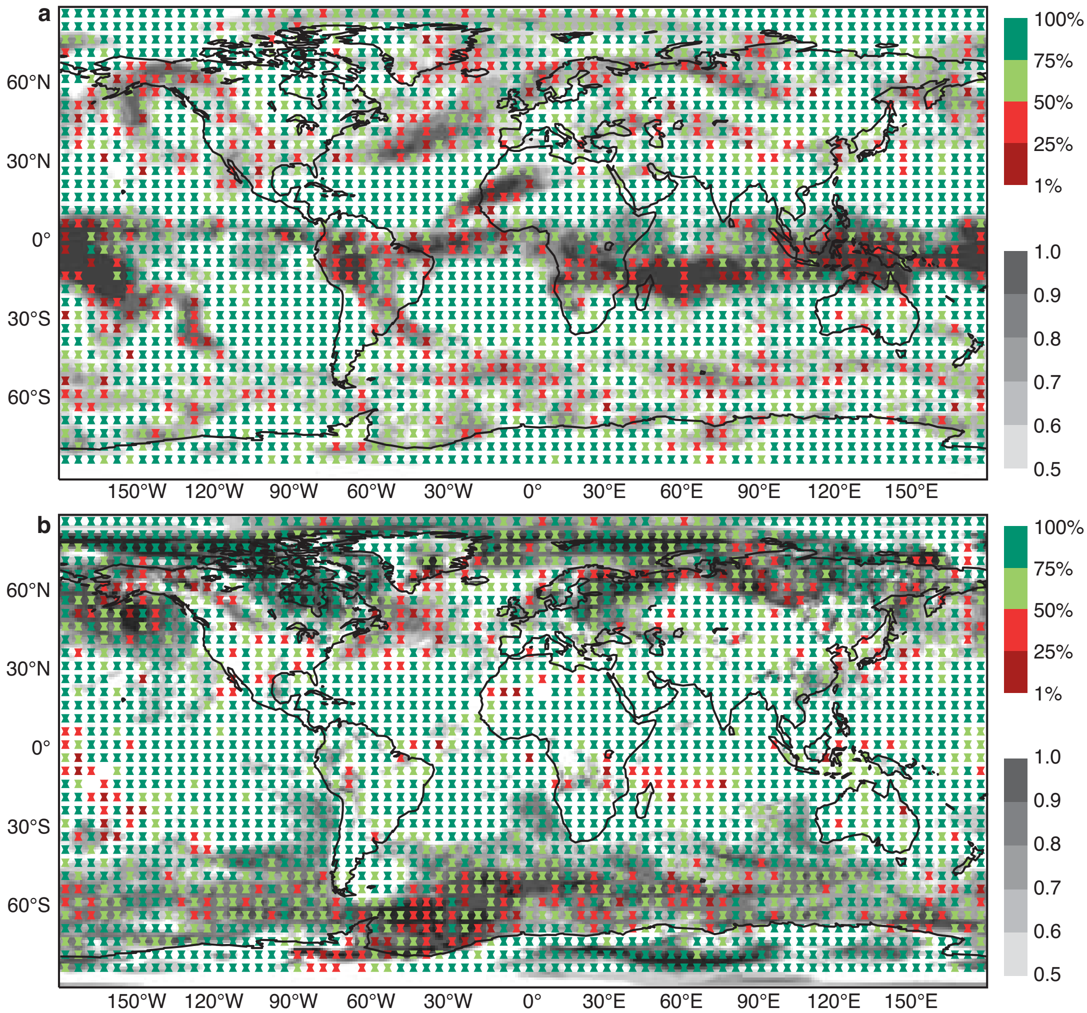

Figure 4 Simulated ADM-Aeolus yield of good-quality data for (a) the Rayleigh (molecular) channel at 4–5 km and (b) for the Mie (aerosol) channel at 0.5–1 km, in terms of percentage of good data in each 5×5 degree box meeting mission requirements as represented by green and red markers (see legend). Based on simulations through the period 10 January to 28 February 2003. Grey shading shows ECMWF cloud cover at (a) 4–6 km and (b) 0–3 km within the study period.

Three ensembles were generated, and each ensemble consisted of four independent members; each member was run for the period 10 January to 28 February 2003. The three ensembles differed in the observations that were assimilated as follows.

- **Control**: All observational data as used in the 2004 ECMWF operational system.
- **Aeolus**: As Control with simulated Aeolus data added.
- **NoSondes**: As Control but radiosondes and wind-profilers were removed.

Statistics, such as the spread within a particular ensemble, were compiled for the period 16 January to 28 February 2003 (to disregard common initial conditions). A beneficial impact of observational data corresponds to a reduction in ensemble spread. Comparison of the Control and NoSondes ensembles permits essential calibration of the results, and facilitates a relative assessment of Aeolus and radiosonde impacts.

Development of the methodology taken here was motivated by two significant advantages over the traditional approach using an Observing System Simulation Experiment (OSSE) for assessing the impact of anticipated data. The first is that the method is based on real observations thus obviating the need to simulate observations other than the anticipated new data (Aeolus in this case). The second is that, whereas OSSE results are difficult to interpret because of uncertainties surrounding the role of simulation biases, the situation is not so severe in the assimilation ensemble approach. This is because the ensemble approach has permitted the development of diagnostics based on relative differences between ensemble members, offering much more scope for cancellation of bias effects.

The results in Figure 5 suggest that the main benefits from Aeolus (compared to Control) for analysed wind fields will be found over ocean regions in both hemispheres and in the tropics, and over parts of central Asia. These regions have been identified as priority areas for improvement. A calibration factor of order 2 is required to obtain values commensurate with actual wind uncertainties in the ECMWF system. The large impact in the tropics is noteworthy. It is likely that the Aeolus wind data will help determine the moisture-convergence at

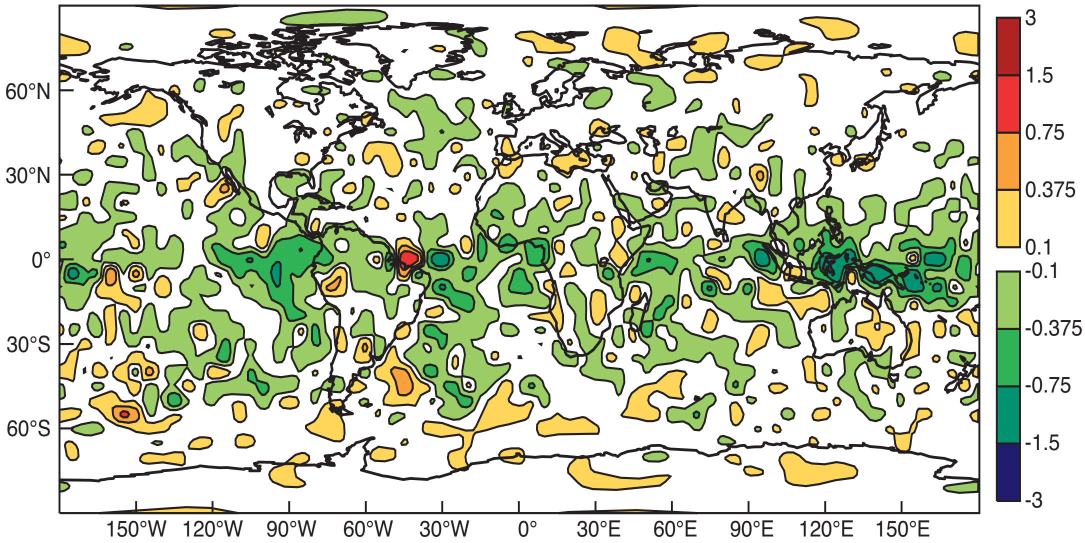

Figure 5 Impact in terms of 200 hPa zonal wind component (ms^{-1}) of ADM-Aeolus wind profile data as deduced from the difference in data assimilation ensemble spread between two ensembles: Control and ADM. Green shading indicates that the ensemble spread (i.e. the analysis error) is reduced using the ADM data, with orange indicating that it is increased (see legend). Shading in the range -0.1 to 0.1 is suppressed.

low levels in the region of the ITCZ, as well as the divergent outflow in the upper troposphere. It is hoped that the Aeolus data will help maintain a more correct intensity of the Hadley circulation than is currently the case at ECMWF in the operational system and ERA-40 climate re-analyses.

Information Content

We have complemented the above result with an assessment in terms of information content. Practical methods for computing information content (degrees of freedom for signal - DFS) in the observations and analyses have recently been developed (*Cardinali et al.*, 2004; *Fisher*, 2003b) within the context of the global 4D-Var assimilation system. The profiling observing systems that Aeolus can most usefully be compared with are the radiosondes and wind profilers. Using the method of *Fisher* (2003b) information content was computed for each of the experiments Control, Aeolus and NoSondes, defined above.

It was found that in terms of wind information in these experiments the radiosondes plus wind profilers provide 3153 DFS and Aeolus provides 2454 DFS (see Table 1). These results are in keeping with the expected quantity, accuracy and coverage of the simulated Aeolus data. Radiosondes and wind profilers provide slightly more information in absolute terms, but require proportionately more observations to achieve this. Aeolus observations provide more information per datum because they are able to contribute information in regions that are currently poorly observed (i.e. over ocean regions in both hemispheres and throughout the tropics).

Data	TEMP+PILOT winds to 55 hPa	ADM-Aeolus line of sight winds
Number of data	74,682	28,979
DFS	3153	2454
Data per DFS	23.7	11.8

Table 1 Information content in TEMP (radiosonde) and PILOT winds and ground-based wind profiler data from the surface to 55 hPa and in simulated ADM-Aeolus single line-of-sight data, in data assimilation experiments with the ECMWF 4D-Var system.

Future work

In the years leading up to the launch of the Atmospheric Dynamics Mission Aeolus, further simulations will be carried out using the new data processing software, currently under development. In particular there will be studies of quality control issues and how to achieve representative along-track averaging in heterogeneous cloud and aerosol conditions. First Aeolus-like atmospheric data will be available in 2006 obtained from an airborne version of the Aeolus Doppler wind lidar to be flown by a DLR team, in ESA-funded campaigns.

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Ensembles-based predictions of climate changes and their impacts (ENSEMBLES Project)

Francisco Doblas-Reyes

Predictions of climate variability and the human impact on climate are inherently probabilistic, due to uncertainties in the initial conditions of forecasts, the representation of key processes within models, and climatic forcing factors. Hence, reliable estimates of climatic risk can be made only through ensemble integrations of Earth system models in which these uncertainties are explicitly incorporated.

The ENSEMBLES project, funded through a five-year contract with the European Commission, aims to provide probabilistic estimates of climatic risk through ensemble integrations of Earth system models in which both initial and model uncertainties are explicitly incorporated. The project, funded since 1 September 2004 under the Commission's Sixth Framework Programme, is a major undertaking among a large number of mainly European institutions. The project has 69 partners, and is being coordinated by the Hadley Centre at the Met Office in the UK.

The project will, for the first time, develop a common ensemble climate forecast system for use across a range of timescales (seasonal, decadal, and longer) and spatial scales (global, regional, and local). This model system will be used to construct integrated scenarios of future climate changes that will provide a basis for quantitative risk assessment of climate changes and climate variability. There will be an emphasis on changes in extremes (e.g. changes in storminess and precipitation and the severity and frequency of drought) and the effects of "surprises," such as the shutdown of the thermohaline circulation.

Important components of the project will be the assessment of three different methods to estimate model uncertainty (i.e. the multi-model, stochastic physics and perturbed parameter approaches) and the extensive validation of the model system. Probability hindcasts made for the twentieth century will be compared against quality-controlled, high-resolution gridded data sets. The exploitation of the results will be maximized by linking the output of the ensemble prediction system to a wide range of applications, such as agriculture and health. In turn, feedback from these impact areas to the climate system will also be addressed.

The project plans to bring together a broad spectrum of international expertise across many disciplines to provide policy-relevant information on climate and climate changes and its interactions with society. To meet the goals of this large project, the work will be carried out using a set of closely connected research themes.

- **Development of the Ensemble Prediction System**. Development and testing of the global ensemble prediction system based on global Earth system models developed in Europe (Theme 1).
- **Production of hindcasts and climate change scenarios**. Production of sets of simulations at seasonal, decadal, and centennial timescales using the global ensemble prediction system (Theme 2A).
- **Production of regional climate change scenarios**. Production of regional climate scenarios for impacts assessments, using a high-resolution regional climate model (RCM) ensemble system and downscaling methods to add value to the global ensemble prediction system (Theme 2B).
- **Development of a high-resolution multi-model ensemble for Europe**. Development of the high-resolution RCM ensemble system for Europe and a third-world region (Theme 3).
- **Understanding the processes**. Advancement of our understanding of the basic science issues, focusing on the processes governing climate variability and change, climate predictability, and the probability of extreme events (Theme 4).
- **Evaluation of the simulations against observations**. Independent, comprehensive evaluation of the ENSEMBLES simulations against observations and analyses (Theme 5).
- **Assessment of impacts**. Assessments of the effects of climate changes by integrating process models of impacts on the global environment into Earth system models, linking impact models to probabilistic scenarios of climate changes, and maximizing skill in the impact models at seasonal and decadal timescales (Theme 6).
- **Scenarios and policy implications**. Adoption of scenarios of greenhouse gas emissions, land-use change, and adaptive capacity with and without greenhouse gas emission reduction policies, and testing the sensitivity of these scenarios to climatic change (Theme 7).
- **Dissemination, education and training**. Provision of support to the ENSEMBLES community in the dissemination of results emerging from the other research themes and from the project as a whole, along with education and training through short courses and exchange programmes (Theme 8).

Partner	Model		Model uncertainty sampling
	Atmosphere	Ocean	
ECMWF	IFS	HOPE	Stochastic physics
ECMWF	IFS	OPA	None
Météo-France (France)	ARPEGE	OPA	None
CERFACS (France)	ARPEGE	OPA	None
Met Office (UK)	GloSea		Perturbed parameters
Met Office (UK)	DePreSys		Perturbed parameters
IfM (Germany)	ECHAM5	MPI-OM1	None

Table 1 List of global coupled models taking part in the comparison between the three methods (multi-model, stochastic physics and perturbed parameters) considered in ENSEMBLES to assess model uncertainty in seasonal and interannual integrations. All the models will contribute to a multi-model ensemble with ensemble hindcasts without stochastic physics or perturbed parameters, while only some of them will sample model uncertainty using the other two methods. CERFACS: Centre Européen pour la Recherche et la Formation Avancée en Calculs Scientifiques, Toulouse. IfM: Institut für Meereswissenschaften, University of Kiel.

It is essential that the research themes are linked together. ENSEMBLES will do this by using the end-to-end approach, based upon a continuous communication between users of climate information and climate scientists. The global and regional climate model ensemble prediction systems developed in Themes 1 and 3 will be used to produce seasonal-decadal hindcasts and climate change scenarios in Themes 2A and 2B, making use of emissions and land-use scenarios from Theme 7, for the assessment of the impacts of climate changes in Theme 6. Theme 7 will also take the first steps toward the integration of the human dimension into the Earth system models. The model results will be analysed to increase our understanding of the processes and feedbacks in Theme 4, and will be evaluated against observations and analyses in Theme 5. Knowledge gained from all these activities will subsequently guide improvements in the ensemble prediction system and will be disseminated to the scientific community, the public, and the stakeholder community through Theme 8.

ECMWF is a highly relevant partner in ENSEMBLES, especially in the production and validation of seasonal and decadal hindcasts, as well as in the management of the project. The activity in Theme 1 involves the development of methods to estimate model uncertainty, for which multi-model, stochastic physics-based and perturbed parameter-based prediction systems will be installed and run at ECMWF. Table 1 summarises the global coupled models that will take part in this experiment. These systems will be used in Theme 2A to create a comprehensive set of seasonal and decadal ensemble hindcasts that correctly samples model uncertainty. These hindcasts will be created, archived and disseminated at ECMWF following a co-ordinated effort that builds on the operational European seasonal forecast multi-model system and on previous EU-funded projects such as DEMETER and ENACT. Detailed validation and comprehensive verification of these hindcasts will be carried out in Themes 4 and 5, respectively. In addition, ECMWF is closely collaborating with partners in Theme 6 to increase the use of climate predictions by end users and to understand their specific needs in an attempt to bridge the gap between users and climate scientists.

In summary, the ENSEMBLES project aims to provide probabilistic estimates of climatic risk through ensemble integrations of Earth system models, and will achieve this by:

- Developing a unique ensemble prediction system based on global and regional Earth system models, validated against quality-controlled, high-resolution gridded data sets for Europe;
- Quantifying and reducing the uncertainty in the representation of physical, chemical, biological, and human-related feedbacks in the Earth system (including water resource, land-use, and air quality issues, and carbon cycle feedbacks);
- Maximizing the exploitation of the results by linking the outputs of the ensemble prediction system to a range of applications, including agriculture, health, food security, energy, water resources, insurance, and weather risk management.

More information on the project is available at
http://www.ensembles-eu.org
or from the project coordinator at
ensemblesfp6@metoffice.gov.uk.

The GEMS project — making a contribution to the environmental monitoring mission of ECMWF

Tony Hollingsworth

The EU's initiative on "Global Monitoring for Environment and Security" (GMES, www.gmes.info) aims to make environmental information more readily available to both providers and users. In addition it will lead to the creation of a "European Shared Information System" for exchanging a wide range of information. The reason for the GMES initiative is that scientists, policy-makers and industry are confronted with volumes of data so large and varied that extracting information for a specific need is very difficult. Something needed to be done to rectify the situation.

As a contribution to the GMES initiative, an EU-funded project, GEMS (Global Earth-system Monitoring using Satellite and in-situ data) has been established to develop a real-time operational assimilation and forecast capability of aerosols, greenhouse gases and reactive gases. The new European operational system will be an extension of current data assimilation and forecast capabilities for Numerical Weather Prediction. It will be used to monitor the composition, dynamics and thermodynamics of the atmosphere and produce medium-range and short-range air-chemistry forecasts.

Satellite data will be a major source of information, and ground-based observations will be used initially for validation and evaluation. The inclusion of these new parameters in data assimilation systems will improve the retrieval of temperature and moisture from infrared sounders. Also the explicit representation of ozone and aerosols in the models will have a positive impact on weather forecasts. The GEMS Project should provide a good step towards fulfilling the new environmental monitoring mission of ECMWF. The main beneficiaries of the GEMS Project will be high-level policy users, operational regional air-quality and environmental forecasters, users of the GMES, and the scientific community.

Objectives and participants

The GEMS forecast capabilities will require sophisticated operational models. In addition global and regional data assimilation systems will be needed to exploit satellite and in-situ data so as to provide initial data ('status assessments') for the forecasts. These operational 'status assessments' are also invaluable for documenting sources, sinks and transports of atmospheric trace constituents. The specific objectives of the GEMS Project are to:

- Develop and implement at ECMWF a validated, comprehensive, and operational global data assimilation/forecast system for atmospheric composition and dynamics, which combines all available remotely sensed and in-situ data. Operational deliverables will include current and forecast three-dimensional global distributions (four times daily with a horizontal resolution of 50–100 km, and vertical resolution of 60 levels between the surface and 65 km) of key atmospheric trace constituents including greenhouse gases, reactive gases and aerosols.
- Provide initial and boundary conditions for operational regional air-quality and 'chemical weather' forecast systems across Europe. This will provide a methodology for assessing the impact of global climate changes on regional air quality. It will also provide improved operational real-time air-quality forecasts.
- Provide a retrospective analysis of all accessible in-situ and remotely sensed data on atmospheric dynamics and composition as validation material for the ENVISAT-EOS era (1999–2007).
- Develop state-of-the-art variational estimates of the sources/sinks, plus inter-continental transports, of many trace gases and aerosols. These estimates will be designed to meet policy-makers' key information requirements relevant to the Kyoto and Montreal Protocols and to the UN Convention on Long-Range Trans-boundary Air Pollution.

The GEMS consortium consists of four categories of participants.

- Sixteen research institutes in seven countries providing expertise in satellite and in-situ observations for assessing/validating models, expertise in developing models and assimilations of tropospheric and stratospheric chemistry and aerosol, and expertise in inversion methods to estimate sources, sinks and transports.
- Ten regional modelling centres in nine countries, most with operational responsibilities for national or regional air-quality forecasts.
- Two environmental protection agencies.
- Two international bodies: ECMWF with extensive experience in exploiting satellite and in-situ data to produce forecasts, and the Institute for Environment and Sustainability of the EU's Joint Research Centre.

The members of the consortium are listed in the Annex.

GEMS strategy

Figure 1 illustrates the main strands of the GEMS strategy to build an integrated operational system for monitoring and forecasting the atmospheric chemistry environment. The building blocks of the separate elements of the system already exist. The schematic also illustrates the scientific interactions between the strands of development, which will develop and mature as the integration of the system proceeds. In formulating the strategy, both scientific and practical considerations were taken into account. The primary scientific goal is to create an architecture which will provide a fully integrated treatment of all aspects of atmospheric composition and dynamics when it becomes operational in the first half of 2009. In doing this full use will be made of the existing infrastructure provided WMO's World Weather Watch and European resources in information technology.

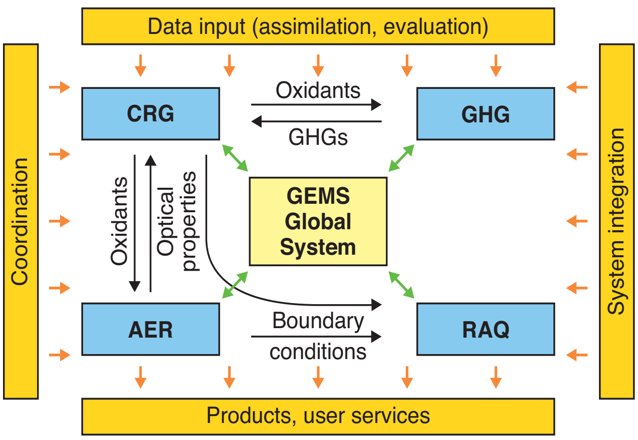

Figure 1 Schematic illustrating the links and the flow of data and information between the main elements of the GEMS system: Greenhouse Gases (GHG), Global Reactive Gases (GRG), Global Aerosol (AER), Regional Air Quality (RAQ) and the global atmospheric assimilation system at ECMWF.

The GEMS strategy is based on a step-wise approach.

- ◆ Establish in parallel, and validate, individual elements of the system in the first half of the period.
- ◆ Merge the individual components in an integrated system, and validate the integrated system.

The operational system for greenhouse gases and for the inference of surface fluxes will be the first such operational system. It will considerably strengthen the already strong European position in international negotiations, because of its transparency and sophistication.

Research systems for assimilation of reactive gases and aerosol have been developed in recent years, but none has the comprehensive use of satellite data, the comprehensive validation mechanisms and the high spatial resolution of the system proposed here. Again the operational global system will be a first, and will maintain and strengthen European leadership in these areas.

The GEMS assessments of the impact of the global composition changes on regional air quality will be based on a range of regional air-quality models using similar assessment protocols. The resulting assessments will be comprehensive and extensive, examining impacts on mean fields and on extreme events.

Links with other initiatives and operational implementation

The aim of the GEMS project is to be scientifically and technically ready to transition the global and regional GEMS systems to operational status by mid-2009, at the end of the project. To ensure successful transition it will be necessary to create institutional arrangements step-wise in the next four years. The actors will include the following.

- ◆ European Commission (e.g. GMES Advisory Committee), European Environment Agency (EEA) and European Space Agency (ESA).
- ◆ National Meteorological Services, together with ECMWF, EUMETSAT and EUMETNET.
- ◆ National Environment and Regional Environment Agencies.
- ◆ Other scientific and technical partners in GEMS and related GMES activities (see http://www.gse-promote.org/).

The institutional arrangements will address issues such as long-term funding, data sharing, and product dissemination funding. There are further challenges in the availability of satellite data beyond 2010. The current ENVISAT/EOS era provides a wealth of observational capability from space, which GEMS will exploit. Beyond 2010, the operational METOP series will provide upper-troposphere measurements of ozone. In addition information about aerosols, land properties and ocean will come from the operational NPOESS series. The main gap in satellite provision is an effective atmospheric chemistry observing capability from space. No such missions are committed beyond the demise of ENVISAT and EOS-AURA. ESA's current priority for a chemistry mission is very low. Missions currently under study could not fly before 2015, even in a favourable funding environment.

A further institutional issue concerns the INSPIRE (Infrastructure for Spatial Information in Europe) initiative being developed by the European Commission. Discussions have begun between EUMETNET and the Commission on the scope of the draft INSPIRE directive in the domains of meteorology and oceanography. The outcome of those discussions will have a direct impact on important aspects of the operational transition.

Another component of GMES is the GEOLAND Integrated Project. This aims to provide products and services associated with the monitoring of land cover and vegetation. By 2009 it is expected that the elements of the GEMS and GEOLAND suites will be run operationally to provide:

- ◆ Real-time global air-quality products.
- ◆ Boundary and initial conditions for regional air-quality models.
- ◆ Quality control of satellite data in near-real-time.
- ◆ Four-dimensional Greenhouse gas fields needed by the inversion teams on a regular basis.

European Centre for Medium-Range Weather Forecasts, UK
Met Office, UK
Centre National de la Recherche Scientifique, France
Commissariat à l'Energie Atomique, France
Max-Planck-Institute for Biogeochemistry, Germany
Max Planck Institut für Meteorologie, Germany
Royal Netherlands Meteorological Institute, Netherlands
Institut d'Aeronomie Spatiale de Belgique, Belgium
Finnish Meteorological Institute, Finland
Danish Meteorological Institute, Denmark
Deutscher Wetterdienst, Germany
University of Bremen, Germany
Universite Pierre et Marie Curie, France
National and Kapodistrian University of Athens, Greece
Météo-France, Centre National de Recherches Météorologiques, France
National University of Ireland, Galway, Ireland
Koninklijk Meteorologisch Instituut – Institut Royal Météorologique, Belgium
ARPA Emilia-Romagna, Italy
Instituto di Scienze dell'Atmosfera e del Clima Consiglio Nazionale delle Ricerche, Italy
Meteorologisk Institutt, Norway
Rheinisches Institut für Umweltforschung Universität Köln, Germany
Joint Research Centre, Institute for Environment and Sustainability, Italy
Institut National de l'Environnement Industriel et des Risques, France
Czech Hydrometeorological Institute, Czech Republic
Irish Environmental Protection Agency, Ireland
Polish Institute of Environmental Protection, Poland
Imperial College of Science, Technology and Medicine, UK

Members of the GEMS Consortium

- Consequential quality control of flask data within a month or two of calibration.

Each individual element of the GEMS and GEOLAND suite may be useful for NWP, and so may be incorporated in the NWP assimilating model and/or in the deterministic and ensemble forecast models. Those elements of the GEMS suite not incorporated in the NWP suite will be run operationally as a stand-alone assimilation/forecast suite for the reasons just cited. From the viewpoint of GCOS (Global Climate Observing System) there may be arguments for operational running of all elements of the GEMS suite at a common resolution.

The initial post-2008 operational configuration of the GEMS assimilation system could have a 50–100 km resolution. The operational configuration will evolve thereafter to realise benefits for the NWP system. On the other hand, some elements of the GEMS suite (e.g. aerosol) could prove of sufficient value to justify implementation in the NWP suite by 2008.

The heat-wave of summer 2003 led to more than 18,000 excess deaths in Europe, partly due to heat-stress and partly due to high ozone levels. The operational GEMS system will provide a major improvement in European capabilities to forecast natural disasters, to monitor the global environment, and to advance the science of atmospheric dynamics and composition. Within the GEMS consortium ECMWF will undertake the global modelling and assimilation tasks. Other partners will use the global fields as boundary conditions for regional air-quality models as part of the regional air-quality forecast tasks. In addition the research partners will address the issues necessary to improve the system, and to assure the quality of the daily global analyses of greenhouse gases, monthly estimates of sources and sinks of carbon dioxide, daily global analyses and forecasts of reactive gases and aerosols, and the provision of boundary conditions for regional air-quality models. The availability of these data will be an important resource for the wider scientific community.

An atlas describing the ERA-40 climate during 1979–2001

Sakari Uppala

Each re-analysis creates a new view of the climate of the earth and its variations. This is based on information provided by the data-assimilation system (model and analysis) and on external information from observations and boundary conditions. Time consistency is a very important consideration for climate studies and, since in the context of re-analysis the data-assimilation is applied with minimum changes through the period, the re-analysis products are more suitable for climate research than the routinely produced operational analyses. Nevertheless, re-analyses are affected by changes to the observing system and in general the quality of re-analysis products is improving with time. The largest change to the observing system happened in 1979, the FGGE year, when new polar orbiting and geostationary satellite systems were introduced, and aspects of the in-situ observing system also improved.

The products from a new re-analysis also improve over older versions due to the development of the data-assimilation process (both the model and the analysis method). This leads to new and higher quality diagnostics of the atmospheric circulation. As described in Newsletter 101, ERA-40 has been an

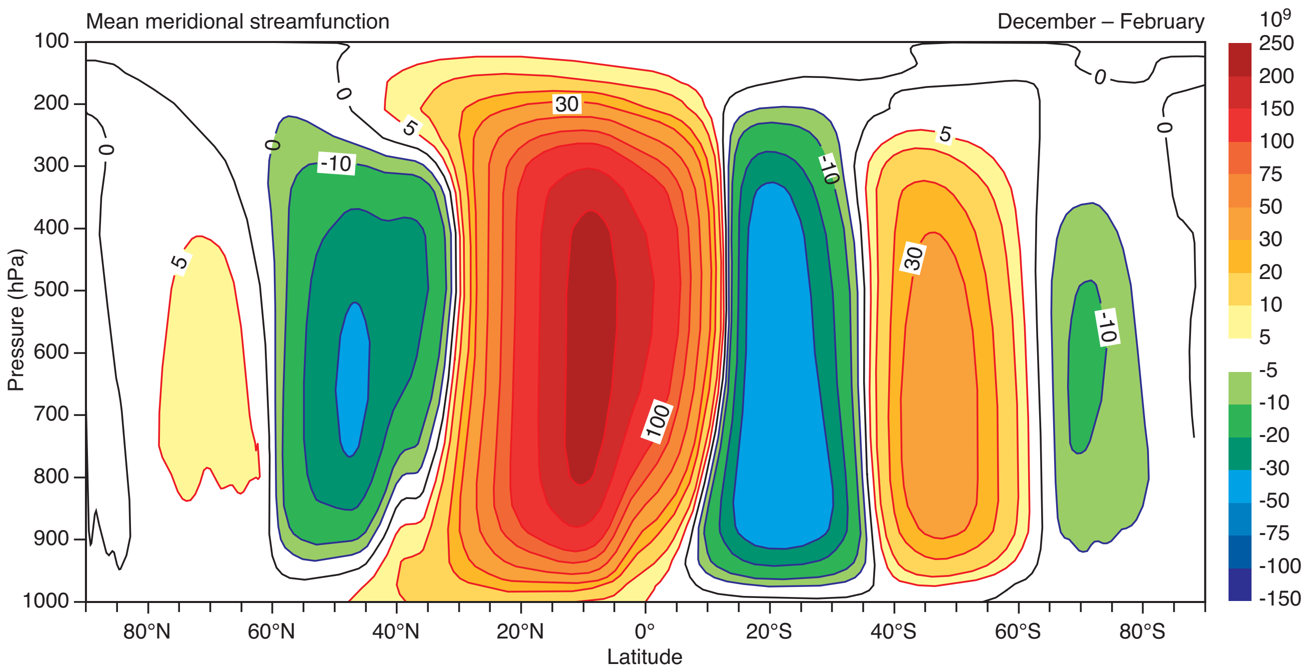

Figure 1 A tropospheric perspective of mean meridional streamfunction (kgs^{-1}) for December-February during 1979–2001.

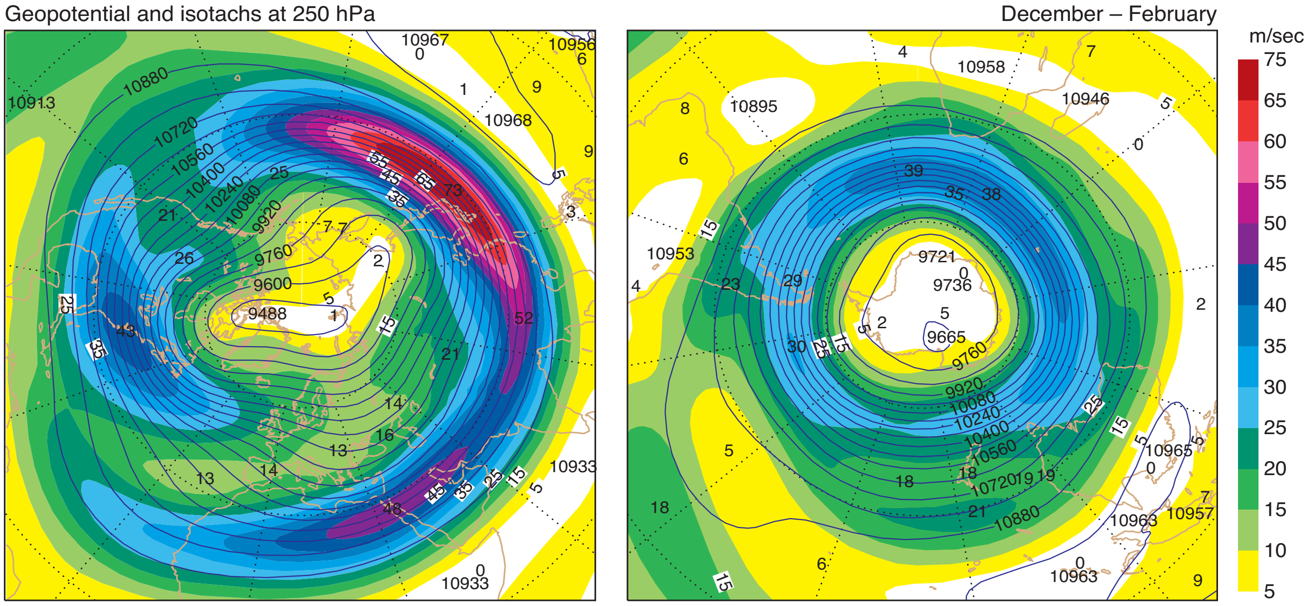

Figure 2 Hemispheric geopotential (gpm) with isotachs (ms^{-1}) at 250 hPa for December-February during 1979–2001.

extensive and successful re-analysis project, whose results are widely used by the research community. More observations have been used than in earlier re-analyses, and satellite radiances have been assimilated directly for the first time.

A new atlas of the general circulation, based on ERA-40, has now been published as No. 19 in the ERA-40 Report Series. It was prepared jointly by Per Kållberg, Adrian Simmons, Sakari Uppala and Sylvie Lamy-Thépaut of ECMWF and Paul Berrisford and Brian Hoskins of the University of Reading, with support from the World Climate Research Programme. The Atlas describes the ERA-40 climate during 1979–2001, the period with the best and most time-consistent product quality for the globe as a whole. It complements the earlier atlases produced for shorter periods (1980–81, 1981–82, the FGGE year 1979–80 and 1979–89) by University of Reading and ECMWF. The ERA-40 climate archive has been used to prepare the Atlas.

The Atlas contains surface and column-integrated fields, and upper-air fields derived on pressure levels, on isentropic levels and on the 2 pvu potential-vorticity level from values on the model's native hybrid levels. Also included are the invariant fields used in the data-assimilation system. The climate of the period 1979-2001 is presented for the four seasons, the annual average and the interannual variability. These products are based on the ERA-40 monthly/diurnal averages together with six-hourly analysis and forecast fields. A selection of time series, showing for example the quasi-biennial oscillation of stratospheric winds, is presented for the full period 1958–2001.

Two sample maps from the Atlas are presented here for December-February. Figure 1 shows the mean meridional mass transport in the troposphere using the zonal mean meridional streamfunction. This gives a measure of how much mass is transported north or south. The stronger Hadley cell and weaker mid-latitude Ferrel cells can be seen.

The mean geopotential and wind at 250 hPa for the two hemispheres are given in Figure 2. The circulation in the Southern Hemisphere is relatively weak and symmetric, while in the Northern Hemisphere the jetstream is strong particularly from North Africa to the East Pacific. A wave number three pattern can be identified in the mean geopotential.

In addition to the printed Atlas, a web version can be found: http://www.ecmwf.int/research/era/ERA-40_Atlas

MERSEA — a project to develop ocean and marine applications

David Anderson and Alberto Troccoli

MERSEA is a large Integrated Project of the EU. It has about 50 partners, started on the 1 April 2004 and it will continue for four years. Its objective is the development of a European system for operational monitoring and forecasting of the ocean physics, biogeochemistry, and ecosystems, on global and regional scales. This will result in an integrated service for global and regional ocean monitoring and forecasting for use by intermediate users and policy makers in support of safe and efficient offshore activities, environmental management, security, and sustainable use of marine resources. The system to be developed will be a key component of the ocean and marine services element of GMES (Global Monitoring for Environment and Security).

The MERSEA ocean monitoring system is envisaged as an operational network that systematically acquires data (e.g. ocean observations from satellites, in situ observations from ocean observing networks, and surface forcing fields from numerical weather prediction agencies). These data from diverse sources will be combined and merged with numerical ocean circulation models to produce best estimates of the actual state of the ocean from which forecasts can be made. That information is then disseminated to enable various users to develop specific applications.

The project work plan is structured on a set of eleven work packages organized in three main modules:

- Observing systems and provision of data;
- Design, development, implementation, integration, evaluation and validation of a co-ordinated set of monitoring and forecasting systems covering the global ocean and the oceans and seas surrounding Europe;
- Development and demonstration of information products, applications and services, in partnership with intermediate users.

Two additional work packages are devoted to the management and co-ordination and to the overall assessment of the project.

The project will develop marine applications addressing the needs of both intermediate and end-users, whether institutional or from the private sector. The specific objectives are to:

- Improve the safety and efficiency of maritime transport and naval operations;
- Enable the sustainable exploitation and management of ocean resources (i.e. offshore oil, gas industry and fisheries);
- More efficiently mitigate the effects of environmental hazards and pollution crisis (i.e. oil spills and harmful algal blooms);
- Contribute to ocean climate variability studies and seasonal climate prediction and the effects on coastal populations;
- Improve national security and reduce public health risks;
- Advance marine research with the aim to better understand the global climate, the ocean and its ecosystems.

There are two Special Focus Experiments dealing with (i) ecosystem modelling in regional and shelf seas and (ii) seasonal and medium-range weather forecasting. There are also specific applications on marine safety which concern improved wave forecasts, offshore operations, ship routing, and oil-spill drift.

The ECMWF contribution, which started 1 April 2005, is mainly through the use of MERSEA intermediate products, more specifically of ocean analyses, in medium-range and seasonal predictions applications, by means of coupled general circulation model experiments. These applications represent a particularly useful source of feedback to the design and development of the MERSEA system.

ECMWF will lead the Special Focus Experiment (SF2): Forecasting the ocean-atmosphere system on daily to seasonal timescales. This is a relatively small but well-focused experiment in which ECMWF will work with three partners: Istituto Nazionale di Geofisica e Vulcanologia (INGV, Italy), Météo-France and GIP MERCATOR OCEAN (France). In addition MERCATOR will be directly involved in the design of the MERSEA system.

Experiments will be carried out in SF2 which complement DEMETER and ENACT; these projects include dealing with multimodel ensembles and ocean data assimilation systems used for seasonal forecasts. The SF2 experiments will test the sensitivity of the coupled model (medium-range and seasonal) to initial conditions as well as to ocean and atmospheric model resolution.

The global high-resolution assimilation system, developed by MERCATOR, will produce the global ocean analyses to be used as initial conditions for the forecasts. These analyses will use the OPA (Océan PArallélisé) ocean model at a resolution of 0.25 degrees. ECMWF will couple this version of the ocean model to the IFS. Coupled integrations covering various timescales and using various ocean/atmospheric resolutions will also be performed. In addition to assessing the impact of resolution on seasonal forecasts, ECMWF will perform a set of experiments using the 0.25 degree ocean model coupled to an atmospheric model of comparable resolution. This should allow the impact of ocean interaction on medium-range atmospheric predictions, such as hurricane tracks, to be assessed.

Migration of ECFS data from TSM to HPSS ("Back-archive")

Jean-Luc Pepin

In 2002 we started to replace ECMWF's Data Handling System (DHS). The old system used IBM's Tivoli Storage Manager (TSM) as its underlying data management software. The new one uses IBM's High Performance Storage System (HPSS) instead. One of the major tasks associated with the replacement of the DHS was to physically migrate the MARS and ECFS data that was stored in the old system into the new system. This had to be done since the format of TSM data is not compatible with that of HPSS. This article describes how the ECFS back-archive was achieved, safely and securely, with the minimum of disruption to the end users of the data.

Back-archiving data needs to be done as transparently as possible for the end users. They should be able to continue accessing their data seamlessly, without interruption, and as far as possible with little or no change to the interface that they use. ECFS was designed with this in mind. We chose the solution that would be the least disruptive to the users by modifying the ECFS server software in order to allow unrestricted access to the data whilst it was being migrated from the TSM system to HPSS.

The back-archive called for around 165 Terabytes of data in about 10 million files to be copied, and as such this was bound to be a lengthy process. We estimated that this exercise would take 12 months, starting at the beginning of 2004.

The existing ECFS TSM data was stored on a set of 16 file systems managed by TSM HSM software. HSM automatically migrates data between a hierarchy of data storage technologies (disk and tape), transparently to the user, and in theory provides unlimited storage space. Nevertheless, we had to split these file systems from time to time because of practical limitations imposed by TSM on the number of files per file system (around 800,000).

These HSM file systems matched several distinct logical data units such as those used by operations, research, member states, internal users and special projects. Some of these logical units were split over multiple file systems, in some cases residing on two separate hosts and all this was totally transparent to the users who, through the ECFS client interface, had a view of this data as a single large remote file system.

By contrast, this data is now stored in HPSS in a small number of "families" (seven at present), as HPSS can cope with a much larger number of files per family. So, for example, the data for internal and member state users are now in the same HPSS family. This will avoid having to physically copy the data of those ECFS users moving between internal and member state status, a process which happens quite frequently.

In order to complete this back-archive in the required timeframe, we had to optimize the process as much as possible. Since most files resided on tapes, we had to copy the files on a tape volume basis. This meant copying all the files in the order they are stored on that tape, instead of copying all the data for a particular user or subtree of the file system directory structure at a time. We had also to run as many streams in parallel as possible and keep the system going 24 hours a day, 7 days a week, whilst recovering from all kind of possible errors. This was done against the background of bringing into production a brand new HPSS version that required the introduction of patches to fix various problems along the way.

It was a major challenge, due to the size of this exercise, to implement this back-archive system so that it could run in a continuous, automated way, with full control and visibility. We chose ECMWF's SMS-CDP utility and an SQL database (MYSQL) as our basic tools for this purpose. We used the HPSS API to write files in the most efficient way. Every SMS task that failed could be rerun as many times as needed without any other manual intervention.

The MYSQL database contained a table for each HSM file system and an entry for each file in that file system. It gave the status of each file in that file system at any particular time (tape volume serial number, "file already copied", "file to be skipped", potential errors, "backup required"). These fields were queried and updated by each SMS task before and after each file was processed.

The initial part of each SMS suite (one per file system) performed the following functions.

- Query the list of tape volumes corresponding to the file system being processed.
- List the contents of each tape.
- Prepare a file in a format ready to be ingested by the SQL database containing the list of all files contained in this file system.
- Load the corresponding MYSQL table.

The last function of the initial section of the SMS suite was to generate the dynamic part of the SMS suite, creating one set of tasks per tape volume.

Before starting the back-archive in earnest, an SMS task was run manually to initialise various flags in the database. Unwanted files were marked with a "skip" flag. Also the "backup" flag was set using regular expressions built from the user responses to the questionnaire in which they were asked to specify which files they wanted copied (or not) and which they also wanted backed up.

Another aspect which complicated the back-archive process was that, in order to minimize the number of files in the HSM system, we had tarred small files into internal ECFS tar files. These were managed by the ECFS software transparently to the user. During this process of back-archiving to HPSS, these files had to be extracted on the fly, entered into a separate MYSQL table and copied in a subsequent step.

We also had to establish a file locking mechanism between the ECFS server (serving the various ECFS client requests) and the back-archive SMS tasks that could run on the same host as the ECFS server or on a different one. This was done in order to guarantee that an ECFS file in the process of being copied was locked until the copy process for this file was complete. Immediately after a file was back-archived, access to this file for an ECFS client would switch from TSM to HPSS, although the source TSM file still existed, since we did not want to destroy the original data until the back-archive had completed successfully.

The files copied over to HPSS retained their original timestamps. This was very useful as it made them prime candidates for rapid migration from disk to tape, avoiding flushing genuine new files from the HPSS disk cache.

A user would know that a file had been back-archived in HPSS only by issuing an "els" command and examining the first character of the line: "b" or "-" for files in HPSS ("b" for files with backup, "-" for files without backup) and "*" for files still in TSM.

Regarding the HPSS system, we had to develop our own set of tools based on the HPSS API. The result was a powerful test bed and all the tools necessary for checking the progress of the back-archive.

Abbreviation	Meaning
API	Applications Program Interface
CDP	Command and Display Program
DHS	Data Handling System
ECFS	ECMWF Centralised File System
HSM	Hierarchical Storage Management
HPSS	High Performance Storage System
MARS	Meteorological Archival and Retrieval System
SQL	Structured Query Language
SMS	Supervisor Monitor Scheduler
TSM	Tivoli Storage Manager

The meaning of the acronyms and abbreviations used in the article.

Last but not least, it was necessary to check that for each TSM file system all the files had been copied over to HPSS. This was time consuming and tedious but an essential exercise to ensure that all required files were eventually copied to HPSS. This reconciliation task was accomplished by using a "recursive walk" of a complete TSM file system. For each file encountered in this way a check was made of the corresponding target in HPSS, whilst querying the corresponding MYSQL table to establish whether the file owner had asked for this file to be skipped.

The exercise lasted roughly ten months (nine months to copy the files and about one month for the reconciliation) during which 5,000 tape volumes were processed, 18,000 SMS tasks were run and no data was lost. The combination of SMS-CDP and MYSQL proved to be an extremely powerful and invaluable tool. Together with the software changes put in place in the current ECFS software, this allowed us to execute the lengthy migration exercise in a way that was almost totally transparent to the end user, well within the time allotted.

Collaboration with the Executive Body of the Convention on Long-Range Transboundary Air Pollution

Manfred Kloeppel

A working arrangement on collaboration between ECMWF and the Executive Body of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) was signed on 26 January 2005.

The CLRTAP entered into force in 1983, creating the essential framework for controlling and reducing the damage to human health and the environment caused by transboundary air pollution. Within the framework of CLRTAP, two Meteorological Synthesizing Centres (MSCs) have the following main tasks:

- The MSC-West in Oslo (run by the Norwegian Meteorological Institute) operates a three-dimensional Eulerian model for sulphur and nitrogen deposition as well as for photochemical oxidants, ozone and atmospheric particles;
- The MSC-East in Moscow is focused on research and modelling of the long-range transport of persistent organic pollutants and heavy metals.

Some of the main points of the agreement are:

- Both Parties will coordinate their activities and procedures.
- The Centre will provide archived data to the MSCs, which will not re-distribute them to third parties without prior consent of the Centre.
- Staff of the MSCs may participate in training courses of the Centre.

More information can be found using the following links.

- ECMWF co-operation agreements: http://www.ecmwf.int/about/basic/volume-1/cooperation_agreements/index.html
- Working arrangement on collaboration with CLRTAP: http://www.ecmwf.int/about/basic/volume-1/cooperation_agreements/CLRTAP.html
- CLRTAP: http://www.unece.org/env/lrtap/welcome.html

Co-operation Agreement with Lithuania

Manfred Kloeppel

A co-operation agreement was signed between ECMWF and Lithuania on 18 March 2005. The agreement will come into force later this year after ratification by the Lithuanian Parliament.

Dominique Marbouty, the Director of the ECMWF, said "All nations now recognise the necessity of improving the quality and accuracy of advance warning of floods, gales and other severe weather events. I am looking forward to closer collaboration with the Lithuanian Hydrometeorological Service in extending the use of our medium-range and seasonal weather forecasts for the benefit of the people of Lithuania. The worldwide leadership of the ECMWF in the field of Numerical Weather Prediction is based on close collaboration with the European scientific community."

Arunas Kundrotas, Minister of Environment of the Republic of Lithuania, said "This Co-operation Agreement is a significant milestone for meteorology in Lithuania. The European

Centre's products will greatly assist the Lithuanian Hydrometeorological Service to fulfil its mission including the protection of life and property. I am confident that both the ECMWF and the Lithuanian Hydrometeorological Service will benefit from their close co-operation in meteorology."

Vytautas Bernadisius, Director of the Lithuanian Hydrometeorological Service, said "The European Centre is the world leader in its area of scientific and technical expertise. The data from its supercomputer system will be vital for improving the overall quality of our forecasting, and for our warning services in advising of the likelihood of extreme weather events. Our meteorological staff will benefit from extending their contacts with their colleagues at the ECMWF. We will be using the Centre's products to extend both the range and the validity of our forecasts to the benefit of the people of Lithuania. We very much welcome this Agreement."

Some of the main points of the agreement are:

- All meteorological information gathered in Lithuania will be provided to the Centre.
- Lithuania can use, free of charge, computer programs and technical information which belong to the Centre.
- The results of studies and research carried out at the Centre will be made available to Lithuania.
- Lithuania will be given access to the training facilities at the Centre.
- The annual contribution of Lithuania to the Centre will be half of the contribution that Lithuania would have to pay if it were a Member state.
- Lithuania will become a member of the ACCS (Advisory Committee of Co-operating States).

More information about the co-operation agreements can be found at:

http://www.ecmwf.int/about/basic/volume-1/cooperation_agreements/

The Centre's Building Programme

Gerd Schultes

When the Centre was established, the Headquarters Agreement foresaw "working accommodation for up to 145 permanent staff plus up to ten visiting scientists (thus allowing at the beginning for an expansion of working accommodation beyond the initial total of 126 staff)." The accommodation provided to this specification came under pressure in the early 1990s due to:

- Increased activity in the fields of Satellite Research, Provision of Data Services, Re-analysis, Seasonal Forecasting and RMDCN.
- Establishment of the Boundary Condition and Prediction of Ocean Waves Projects.
- Increased number of externally funded Special Projects.

Consequently the number of staff and consultants steadily increased to over 200. In addition there are contractors and resident engineers for whom office accommodation has to be provided.

To ease the pressure on office space, a second-hand Portakbin-type building was leased in 1998. The 1998 Audit Report confirmed the need for additional office space and recommended that Council consider replacing the temporary building with a more long-term solution. In December 2001 the Council requested the Director to prepare detailed proposals for additional office accommodation for submission to the Finance Committee and the Council.

At the same meeting in December 2001, the Council discussed the Service Contract with IBM for a new High Performance Computing Facility. As a result, the Council asked the Director to review the Centre's infrastructure requirements to ensure that the Centre was well prepared for the next Invitation to Tender or for an extension of the Service Contract.

Following preparatory meetings with a team of architects, structural engineers and surveyors and discussions in the Finance Committee, the Council, at its session in December 2002, approved the extension of the Computer Hall and the construction of a new Office Building.

Wokingham District Council approved the extension of the Computer Hall in November 2003. In June 2004 the ECMWF Council gave approval for the financial framework for the project.

Work on the extension of the Computer Hall started on 12 July 2004. It is expected that the building will be handed over to the Centre in autumn 2005. The extended Computer Hall will provide additional 750 m^2 of floor space for the installation of computer equipment, a storage area and, as an extension of the current mezzanine, an extra fourteen offices.

After lengthy negotiations Wokingham District Council approved the plans for a new Office Building in September 2004. The new building will be located on the parking area to the south of the Centre's premises and connected to the existing Office Block. As the new building will be located closer to the existing building than originally planned, it will be necessary to re-arrange the road system between the buildings and build a new gatehouse in addition to the construction of a new car park on the land made available by the United Kingdom. This work started in March 2005 with completion expected in July.

Following an Invitation to Tender, it is expected that the Council will authorise the Director to sign a contract for the construction of the new building at its session in June 2005. Construction work would then start in July with an anticipated completion date in autumn 2006. The new Office Building will be a two-storey building with 55 offices, a number of meetings rooms, an open area for receptions and a small gym.

The extensive building programme underway will help ensure that ECMWF has appropriate facilities to support its activities now and in the future.

ECMWF Workshops and Scientific Meetings 2005

Workshop on Representation of Sub-grid Processes Using Stochastic-Dynamic Models (6–8 June 2005)

The workshop explored new ideas in the representation of sub-grid processes in weather and climate models, using computationally-cheap stochastic-dynamic systems. The topics covered included:

- Use of additive or multiplicative noise in the tendency equations, stochastic parameters in conventional parameterisation scheme and stochastic cellular automata schemes;
- Impact of stochastic sub-grid schemes on ensemble forecast skill, and the comparison with multi-model forecast systems;
- Impact of stochastic sub-grid schemes on model systematic errors.

Further details about the programme will be published on: www.ecmwf.int/newsevents/meetings/workshops/2005/Sub-grid_Processes/

ECMWF 2005 Annual Seminar: Global Earth-System Monitoring (5–9 September 2005)

The seminar will provide a review of the science, data requirements and availability, and technical aspects which together will form the foundations on the new European initiative in Global Earth-System Modelling and Monitoring, Subjects to be covered will include:

- Core global assimilation and forecast system, the challenges of both the modelling of greenhouse gases, reactive gases and aerosols, and of assimilating satellite information of these atmospheric constituents;
- Chemical transport and regional air quality models, and the methods for initializing and coupling these to global weather forecast models;
- Links to components of Earth System monitoring such as Land and Ocean;
- Potential international implications of these Earth-System initiatives.

The seminar is open to applicants from all ECMWF Member States and Co-operating States. Applicants from elsewhere should contact ECMWF for further information. Any queries should be addressed to Els Kooij-Connally at seminars@ecmwf.int.

A registration form and further information is available from: www.ecmwf.int/newsevents/meetings/annual_seminar/

ECMWF/NWP-SAF Workshop on Bias Estimation and Correction in Data Assimilation (8–11 November 2005)

The handing of biases in data assimilation is a key element in the effective use of current and future satellite systems. Consequently the workshop will consider:

- The capability to disentangle systematic errors inherent to the instruments, radiative transfer and NWP models;
- The demand for robust design to reduce the adverse effect of systematic errors in data assimilation schemes.

The workshop will also form part of ECMWF's contribution to the activities of the NWP Satellite Application Facility.

Jean-Noël Thépaut and Tom McNally are organising the workshop. Further details about the programme will be published on:

www.ecmwf.int/newsevents/meetings/workshops/2005/NWP_SAF/

10th Workshop on Meteorological Operational Systems (14–18 November 2005)

The objective of the workshop is to review the state of the art of meteorological operational systems and to address future trends in:

- Use and interpretation of medium-range forecast guidance;
- Operational data management systems;
- Meteorological visualisation applications.

The workshop is being organised by Horst Böttger. Further information will be available from:

www.ecmwf.int/newsevents/meetings/workshops/2005/MOS_10/

ECMWF publications

(see http://www.ecmwf.int/publications/library/ecpublications/)

Technical Memoranda

460 **Vidard, A., D.L.T. Anderson** & **M. Balmaseda**: Impact of ocean observation systems on ocean analysis and seasonal forecasts. *April 2005*

459 **Walser, A., M. Arpagus, M. Leutbecher** & **C. Appenzeller**: Impact of moist singular vectors and horizontal resolution on short-range limited-area ensemble forecasts for two European winter storms. *March 2005*

458 **Haines, K., J. Blower, J-P. Drecourt, C. Liu, I. Astin, X. Zhou** and **A. Vidard**: Salinity assimilation using S(T) relationships: Part 1 — theory. *March 2005*

457 **Andersson, E., C. Cardinali, B. Truscott** and **T. Hovberg**: High-frequency AMDAR data – a European aircraft data collection trial and impact assessment. *February 2005*

456 **Lopez, P., A. Benedetti, P. Bauer, M. Janisková** and **M. Köhler**: Experimental 2D-Var assimilation of ARM cloud and precipitation observations. *January 2005*

455 **Tompkins, A.M., C. Cardinali, J-J. Morcrette** & **M. Rodwell**: Influence of aerosol climatology on forecasts of the African Easterly Jet. *March 2005*

454 **Haseler, J.**: Early-delivery Suite. *December 2004*

453 **Tompkins, A.M., A. Diongue, D.J. Parker** and **C.D. Thorncroft**: The African easterly jet in the ECMWF Integrated forecast system: 4D-Var analysis. *December 2004*

452 **Tompkins, A.M., P. Bechtold, A.C.M. Beljaars, A. Benedetti, S. Cheinet, M. Janisková, M. Köhler, P. Lopez** and **J-J. Morcrette**: Moist physical processes in the IFS: Progress and Plans (SAC paper). *December 2004*

447 **Fisher, M.**: On the equivalence between Kalman smoothing and weak-constraint four-dimensional variational data assimilation. *October 2004*

ERA-40 Project Report Series

20 **Li, H., A. Robock, S. Liu, X. Mo** and **P. Viterbo**: Evaluation of reanalysis soil moisture simulations using Updated Chinese soil moisture observations. *November 2004*

18 **Simmons, A.J., P.D. Jones, V. da Costa Bechtold, A.C.M. Beljaars, P.W. Kållberg, S. Saarinen, S.M. Uppala, P. Viterbo** and **N. Wedi**: Comparison of trends and variability in CRU, ERA-40 and NCEP/NCAR analyses of monthly-mean surface air temperature. *July 2004*

Workshop Proceedings

ECMWF/ELDAS Workshop on Land Surface Assimilation. 8–11 November 2004

Special Project allocations 2005–2007

Member State		Institution	Project title	2005		2006		2007	
				HPCF units	Data storage	HPCF units	Data storage	HPCF units	Data storage
Continuation Projects									
Austria	1	Univ. Vienna (Beck, Ahrens)	Alpine regional downscaling of reanalysis data using the LAM ALADIN	1,000	100	1,000	100	X	X
	2	Univ. Innsbruck (Ehrendorfer)	Mesoscale Predictability and Ensemble Prediction	8,000	5	8,000	5	8,000	5
	3	Univ. Innsbruck (Georges)	Analysis of Precipitation in the Northern Peruvian Andes	600	10	600	10	X	X
	4	Univ. Vienna (Haimberger)	Checking the temporal homogeneity of the ERA-40 observational input and analyses using analysis feedback data	2,000	200	1,000	200	X	X
	5	Univ. Graz (Kirchengast)	Climate Monitoring by Advanced Spaceborne Sounding and Atmospheric Modeling	30,000	300	30,000	300	30,000	300
	6	Universitat fur Bodenkultur, Vienna (Kromp-Kolb)	Modelling of Tracer Transport (MoTT)	500	5	500	5	500	5
	7	Univ. Vienna (Steinacker)	Mesoscale Alpine Climatology (VERACLIM)	100	5	X	X	X	X
Denmark	8	DMI (Sattler)	Investigations on LAM ensembles for wind power prediction (WEPS)	50,000	250	50,000	250	50,000	250
France	9	L.A.M.P. (Cautenet)	Chemistry, cloud and radiation interactions in a meteorological model	100	2	100	2	100	2
	10	Mercator-Ocean (de Prada)	MERCATOR	792,000	8,100	900,000	10,000	900,000	10,000
	11	CERFACS (Morel)	PALM: Universal software for data assimilation	10,000	180	10,000	180	10,000	180
	12	CERFACS (Weaver)	Development and application of variational data assimilation with the OPA OGCM	150,000	1,458	150,000	1,800	150,000	1,800
	13	CERFACS (Rogel)	Seasonal to interannual predictability of a coupled ocean-atmosphere model	10,000	150	10,000	150	10,000	150
Germany	14	MPI, Hamburg (Bengtsson)	Numerical experimentation with a coupled ocean/atmosphere model	250,000	4050	280,000	6,000	300,000	7,000
	15	MPI, Hamburg (Bengtsson)	Regional downscaling of ERA40 data and validation of the hydrological cycle	265,000	1,215	350,000	2,200	420,000	3,000

Member State		Institution	Project title	2005		2006		2007	
				HPCF units	Data storage	HPCF units	Data storage	HPCF units	Data storage
Germany	16	Freie Univ. Berlin (Cubasch, Kirchner)	Investigation of systematic tendency changes and their influence on the general circulation simulated with climate models	5,000	800	6,000	1,000	8,000	1,500
	17	ISET (Czisch)	Evaluation of the Global Potential of Energy Towers	100	20	100	20	X	X
	18	D.L.R. (Doernbrack)	Influence of non-hydrostatic gravity waves on the stratospheric flow for fields above Scandinavia	100,000	80	125,000	80	150,000	80
	19	Univ. Munich (Eckhardt)	Validation of trajectory calculations	1,000	80	1,000	90	1,000	100
	20	Univ. Munich (Egger)	Landsurface – Atmosphere interaction	1,500	50	1,500	50	1,500	50
	21	D.L.R. (Gierens)	Ice-supersaturation and cirrus clouds	200,000	100	200,000	100	200,000	100
	22	D.L.R. (Hoinka)	Climatology of the global tropopause	8,000	10	10,000	10	10,000	10
	23	Univ. Munich (Jones)	The impact of tropical cyclones on extratropical predictability	100,000	300	150,000	350	150,000	400
	24	D.L.R. (Keil, Craig)	Ensemble Modelling for the Improvement of Short Range Quantitative Precipitation Forecasts	100,000	80	100,000	80	100,000	80
	25	IMK-IFU (Kuntsmann)	Onset of the Rainy Season in West Africa	10,000	100	X	X	X	X
	26	Leibniz-Institut – Univ. Kiel (Latif)	Seasonal to decadal forecasting with coupled ocean-atmosphere general circulation models	1,056,000	3,240	700,000	6,300	700,000	8,600
	27	MPI-A Heidelberg (Masciadri)	Forecasting of the optical turbulence for Astronomy applications with the MesoNH mesoscale model coupled with ECMWF products	4,000	30	4,000	30	4,000	30
	28	D.L.R. (Mayer)	Remote Sensing of Water and Ice Clouds with Meteosat Second Generation	20,000	20	20,000	20	20,000	20
	29	Alfred Wegener Institute (Rinke)	Sensitivity of HIRHAM	200	50	200	50	200	50
	30	Alfred Wegener Institute (Schollhammer)	Changes in ozone transport: residual circulation and the isentropic transport	200	50	200	50	X	X
	31	MPI, Hamburg (Schultz)	Global Atmospheric Chemistry Modelling	100,000	1,620	120,000	3,000	140,000	4,000
	32	Univ. Koln (Speth)	Interpretation and calculation of energy budgets	100	6	100	6	100	6
	33	Univ. Bremen (Weber)	Chemical and dynamical influences on Decadal Ozone Change (CANDIDOZ)	100	20	100	20	100	20
	34	Univ. Mainz (Wirth)	Water vapour in the upper troposphere	1,000	20	1,000	20	1,000	20

Member State		Institution	Project title	2005		2006		2007	
				HPCF units	Data storage	HPCF units	Data storage	HPCF units	Data storage
Ireland	35	Univ. College Cork, INM (Joergensen, Moehrlen, Garcia Moya)	HONEYMOON – A high resolution numerical wind energy model for on- and offshore forecasting using ensemble predictions	75,000	10	75,000	10	X	X
	36	Met Éireann (Lynch)	Community Climate Change Consortium for Ireland (C4I)	100,000	1,620	100,000	3,000	100,000	4,000
	37	Univ. College Cork, Met Éireann (Moehrlen, McGrath, Joergensen)	Verification of Ensemble Prediction Systems for a new market: Wind Energy	150,000	10	200,000	10	X	X
Italy	38	ISMAR-CNR (Cavaleri)	Evaluation of the performance of the ECMWF meteorological model at high resolution	20,000	150	20,000	150	20,000	150
	39	INGV, Bologna (Manzini)	Middle atmosphere modeling	230,000	1458	250,000	2,100	270,000	2,500
	40	ARPA-SMR, Emilia Romagna & MétéoSwiss (Montani, Arpagus)	Improvements of COSMO limited-area ensemble forecasts	120,000	550	140,000	600	150,000	620
	41	ARPA-SMR, Emilia Romagna & Italian Met. Service (Paccagnella/Montani/Ferri)	Limited area model targeted ensemble prediction system (LAM-TEPS)	90,000	90	100,000	100	120,000	120
Netherlands	42	KNMI (van Oldenborgh, Burgers)	Advanced ocean data assimilation	50,000	100	50,000	100	50,000	100
	43	KNMI (Siebesma)	Large Eddy Simulation (LES) of boundary layer clouds	25,000	30	30,000	40	35,000	50
Norway	44	DNMI (Iversen, Frogner)	REGCLIM: optimal forcing perturbations for the atmosphere	200,000	500	200,000	500	X	X
	45	Univ. Oslo (Isaaksen)	Ozone as a climate gas	15,000	4	15,000	4	15,000	6
Portugal	46	Univ. Lisbon (Soares)	HIPOCAS-SPEC	0	10	0	10	0	10
Spain	47	Univ. Illes Balears (Cuxart)	Study of the Stably stratified Atmospheric Boundary Layer through Large-Eddy simulations and high resolution mesoscale modeling	60,000	100	60,000	100	60,000	100
Sweden	48	SMHI (Undén)	The HIRLAM 6 project	350,000	1,620	500,000	2,500	700,000	3,500
United Kingdom	49	ESSC, Univ. Reading (Bengtsson)	Sensitivity of ERA40 to different observing systems and determination of the Global Water Cycle	325,000	500	400,000	700	550,000	900
	50	Univ. Reading (Hoskins)	Routine back trajectories	5,000	4	5,000	4	5,000	4
	51	Univ. Reading (Hoskins)	Stochastic physics	20,000	90	X	X	X	X
	52	DARC, Univ. Reading (O'Neill)	Assimilation of retrieved products from EOS MLS	300,000	1,000	300,000	1,000	300,000	1,000
	53	BAS, Cambridge (Turner, Lachlan-Cope)	Assessment of ECMWF forecasts over the high-latitude areas of the Southern Hemisphere	0	1	0	1	0	1
JRC	54	JRC-IES (Dentener)	The linkage of climate and air pollution: simulations with the global 2-way nested model TM5	15,000	120	17,000	140	19,000	160

Member State		Institution	Project title	2005		2006		2007	
				HPCF units	Data storage	HPCF units	Data storage	HPCF units	Data storage
New Projects									
Netherlands	1	KNMI (Barkmeijer)	Potential for regime transition in North Atlantic Climate	150,000	500	150,000	500	150,000	500
	2	KNMI (van Velthoven)	Chemical reanalyses and sensitivity studies with the chemistry-transport model TM4	30,000	50	30,000	100	10,000	100
Norway	3	DNMI (Frogner)	NORLAMEPS: Limited Area Ensemble Prediction System for Norway	150,000	400	150,000	400	150,000	400
JRC	4	JRC-IES (Herbette)	NAT-FISH: Modelling the seasonal and inter-annual variability of the northwest African upwelling system	40,000	300	X	X	X	X
Total requested				5,796,500	31,923	6,022,400	44,547	6,068,500	51,974

Member State computer resources 2005

Member State	HPCF (kunits)	Data Storage (Gbytes)
Belgium	2,451	13,525
Denmark	2,062	11,378
Germany	10,911	60,197
Spain	4,014	22,146
France	7,974	43,994
Greece	1,853	10,221
Ireland	1,649	9,098
Italy	6,691	36,914
Luxembourg	1,356	7,481
Netherlands	3,106	17,137
Norway	1,996	11,010

Member State	HPCF (kunits)	Data Storage (Gbytes)
Austria	2,222	12,259
Portugal	1,788	9,865
Switzerland	2,575	14,209
Finland	1,857	10,247
Sweden	2,383	13,147
Turkey	2,208	12,185
United Kingdom	8,154	44,987
Allocated to Special Projects	5,797	31,923
Reserved for Special Projects	1,457	8,077
Total	**72,500**	**400,000**

ECMWF Calendar 2005

May 17-18	Security Representatives' Meeting
May 19-20	Computer Representatives' Meeting
Jun 6-10	Training Course – Use and Interpretation of ECMWF Products
Jun 6-8	Workshop – Representation of Sub-grid Processes Using Stochastic-Dynamic Models
Jun 13–14	Council *(63rd Session)*
Jun 15-17	Forecast Products – Users Meeting
Sep 5-9	Seminar – Global Earth-System Monitoring
Oct 3-5	Scientific Advisory Committee *(34th Session)*
Oct 5-7	Technical Advisory Committee *(35th Session)*
Oct 10-14	Training Course – Use and Interpretation of ECMWF Products (for WMO Members)
Oct 17-18	Finance Committee *(75th Session)*
Oct 21	Advisory Committee on Data Policy *(7th Session)*
Oct 19-20	Policy Advisory Committee *(22nd Session)*
Nov 8-11	Workshop – Bias Estimation and Correction in Data Assimilation (ECMWF/NWP-SAF Workshop)
Nov 14-18	Workshop – Meteorological Operational System *(10th Workshop)*
Dec 6-7	Council *(64th Session)*

TAC Representatives, Computing Representatives and Meteorological Contact Points

Member State	TAC Representative	Computer Representative	Meteorological Contact Point
Belgium	Dr D. Gellens	Mrs L. Frappez	Dr J. Nemeghaire
Denmark	Mr L. Laursen	Mr N. Olsen	Mr G. Larsen
Germany	Mr H. Ladwig	Dr E. Krenzien	Mr D. Meyer
Spain	Mr P. del Rio	Mr E. Monreal	Ms A. Casals Carro
France	Mr B. Strauss	Mrs M. Pithon	Mr J. Clochard
Greece	Mr J. Bassiakos	Major J. Alexiou	Mr I. Papageorgiou, Mr P. Xirakis
Ireland	Mr J. Logue	Mr P. Halton	Mr M. Walsh
Italy	Dr S. Pasquini	Mr G. Tarantino	Dr G. Maresca
Luxembourg	Mr C. Alesch	Mr C. Alesch	Mr C. Alesch
Netherlands	Mr T. Moene	Mr H. de Vries	Mr J. Diepeveen
Norway	Mr J. Sunde	Ms R. Rudsar	Mr P. Evensen
Austria	Dr G. Kaindl	Dr G. Wihl	Dr H. Gmoser
Portugal	Mrs I. Barros Ferreira	Mrs M. da C. Periera Santos, Mr J. Monteiro	Mr F. Prates
Switzerland	Dr S. Sandmeier	Mr P. Roth	Mr R. Mühlebach
Finland	Mrs K. Soini	Mr K. Niemelä	Mr P. Nurmi
Sweden	Mr I. Karro	Mr R. Urrutia	Mr M. Hellgren
Turkey	Mr M. Fatih Büyükkasabbaşi	Mr B. Yagci	Mr M. Kayhan
United Kingdom	Dr A. Dickinson	Mr R. Sharp	Mr A. Radford
Cooperating States			
Croatia	Mr I. Cacic	Mr V. Malović	Mr D. Glasnović
Czech Republic	Mr M. Janoušek	Mr M. Janoušek	
Hungary	Dr E. Antal	Mr I. Ihász	Mr I. Ihász
Iceland	Mr K. G. Bjarnason	Mr K. G. Bjarnason	Mrs S. Karlsdottir
Romania	Dr D. Banciu	Mr C. Soci	Dr E. Cordoneanu, Dr O. Diaconu
Slovenia	Mr J. Jerman	Mr M. Razinger	Mr B. Gregorčič
Serbia / Montenegro	Ms L. Dekic	Mr V. Dimitrijević	
Observers			
Advisory Committee on Data Policy	Mr D. Frömming		
ECOMET	Mr R. Hoenson		
EUMETSAT	Mr M. Rattenborg	Dr K. Holmlund	
Finance Committee	Mrs L. Frachon		
Scientific Advisory Committee	Prof E. Källén		
WMO	Mr M. Jarraud		

Index of past newsletter articles

This is a list of recent articles published in the ECMWF Newsletter series.
Articles are arranged in date order within each subject category. Articles can be accessed on the ECMWF public web site
http://www.ecmwf.int/publications/newsletter/ index.html

Useful names and telephone numbers within ECMWF

Telephone number of an individual at the Centre is:

International: +44 118 949 9 + three digit extension
UK: (0118) 949 9 + three digit extension
Internal: 2 + three digit extension

e.g. the Director's number is:
+44 118 949 9001 (international),
(0118) 949 9001 (UK) and 2001 (internal).

E-mail

The e-mail address of an individual at the Centre is:
firstinitial.lastname@ecmwf.int

e.g. the Director's address is: D.Marbouty@ecmwf.int

For double-barrelled names use a hyphen
e.g. J-N.Name-Name@ecmwf.int

Internet web site

ECMWF's public web site is: http://www.ecmwf.int

	Ext
Director	
Dominique Marbouty	001
Deputy Director & Head of Administration Department	
Gerd Schultes	007
Head of Operations Department	
Walter Zwieflhofer	003
Head of Research Department	
Philippe Bougeault	005
ECMWF switchboard	000
Advisory	
Internet mail addressed to Advisory@ecmwf.int	
Telefax (+44 118 986 9450, marked User Support)	
Computer Division	
Division Head	
Isabella Weger	050
Computer Operations Section Head	
Sylvia Baylis	301
Networking and Computer Security Section Head	
Matteo Dell'Acqua	356
Servers and Desktops Section Head	
Richard Fisker	355
Systems Software Section Head	
Neil Storer	353
User Support Section Head	
Umberto Modigliani	382
User Support Staff	
John Greenaway	385
Paul Dando	381
Dominique Lucas	386
Carsten Maaß	389
Pam Prior	384
Computer Operations	
Call Desk	303
Call Desk email: cdk@ecmwf.int	
Console - Shift Leaders	803
Console fax number ☞44 118 949 9840	
Console email: newops@ecmwf.int	
Fault reporting - Call Desk	303
Registration - Call Desk	303
Service queries - Call Desk	303
Tape Requests - Tape Librarian	315
Software libraries (eclib, nag, etc.)	
John Greenaway	385

	Ext
ECMWF library & documentation distribution	
Els Kooij-Connally	751
Meteorological Division	
Division Head	
Horst Böttger	060
Applications Section Head	
Alfred Hofstadler	400
Data and Services Head	
Baudouin Raoult	404
Graphics Section Head	
Jens Daabeck	375
Operations Section Head	
François Lalaurette	420
Meteorological Analysts	
Antonio Garcia Mendez	424
Federico Grazzini	421
Anna Ghelli	425
Claude Gibert (web products)	111
Laura Ferranti (seasonal forecasts)	601
Meteorological Operations Room	426
Data Division	
Division Head	
Adrian Simmons	700
Data Assimilation Section Head	
Erik Andersson	627
Satellite Section Head	
Jean-Nöel Thépaut	621
Re-Analysis Project (ERA)	
Saki Uppala	366
Probability Forecasting & Diagnostics Division	
Division Head	
Tim Palmer	600
Seasonal Forecasting Head	
David Anderson	706
Model Division	
Division Head	
Martin Miller	070
Numerical Aspects Section Head	
Mariano Hortal	147
Physical Aspects Section Head	
Anton Beljaars	035
Ocean Waves Section Head	
Peter Janssen	116
Education & Training	
Renate Hagedorn	257
GMES Coordinator	
Anthony Hollingsworth	824