SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year	2014
Project Title:	Implementation and validation of radar data-assimilation in the HARMONIE mesoscale weather prediction model.
Computer Project Account:	SPNLVERK
Principal Investigator(s):	Dr. W.T.M. Verkley
Affiliation:	Royal Netherlands Meteorological Institute (KNMI)
Name of ECMWF scientist(s) collaborating to the project (if applicable)	
Start date of the project:	2012
Expected end date:	2014

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		**Current year**	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	300000	24765	300000	0
Data storage capacity	(Gbytes)	400	0	400	0

Summary of project objectives
(10 lines max)

To prepare the ground for operational assimilation of radar data from as many radar stations as is considered useful.

To study the impact of radial wind and reflectivity data from Dutch and foreign radar stations on analyses and forecasts of a test-version of the HARMONIE mesoscale weather forecasting system.

To investigate the influence of quality control on the data used, in particular of the BALTRAD de-aliasing algorithm for radial winds.

Summary of problems encountered (if any)
(20 lines max)

It has been noticed on several occasions that memory problems arise in the data-assimilation system if the amount of radar data is larger than usual. The problem can be solved by thinning the radar data before they are read by the HARMONIE system.

Although the impact of assimilating radar data can be quite substantial, especially if they are assimilated every hour as in a rapid update cycle, the impact cannot yet be said to constitute an improvement.

Due to some misunderstandings concerning the script in which the accounting is set, all of the submitted jobs in the previous year were charged on the regular computing budget.

Summary of results of the current year (from July of previous year to June of current year)

The aim of this special project, which has started in the summer of 2012, is to implement the assimilation of radar data in the mesoscale numerical weather prediction model HARMONIE. The data considered are reflections from precipitating particles (reflectivities) and their velocities in the line of sight (Doppler or radial winds). It was also intended to study the impact of these data on both analysis and forecast.

The work was started with version 36h1_radar of the HARMONIE system, followed by version 37h1.2 and will be continued in the near future with version 38h1.1. The different model versions are all configured for the smaller of the two domains displayed in Fig. 1 and are run at ECMWF. The larger domain in Fig. 1 is used for the model (version 36h1.4) that presently runs operationally at KNMI. The dots in the smaller domain denote the positions of the Dutch and Belgian radars.

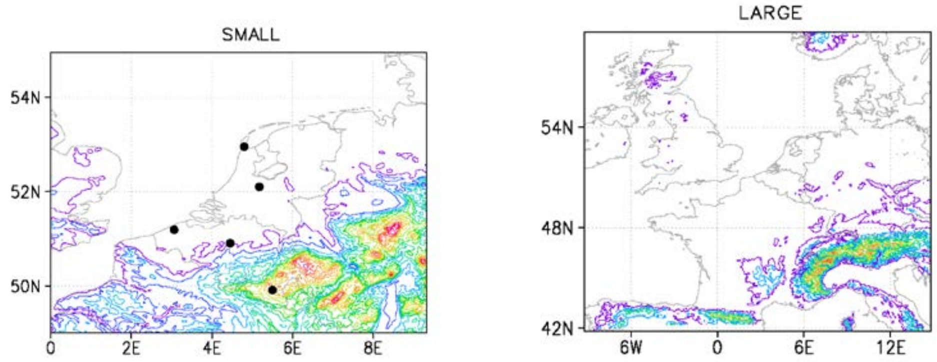

Figure 1 Left: the (small) domain on which the HARMONIE model is run in this study. The horizontal resolution is 300 × 300 grid points, 2.5 km apart. Right: the (large) domain on which the operational version of HARMONIE is run at KNMI. It has a horizontal resolution of 800 × 800 grid points, 2.5 km apart. Both models have 60 η-levels in the vertical.

Most of the work until now has been carried out with radar data in KNMI's own hdf5 format, using CONRAD to convert the data into MF bufr. The converted data are read into the observation database (ODB) by a program called BATOR. A schematic of the corresponding configuration is displayed in Fig. 2.

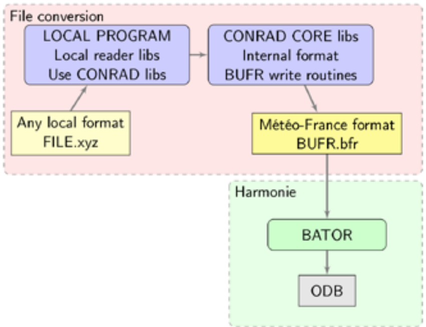

Figure 2 Schematic of the way in which the radar data are presently read by the test version of the HARMONIE weather forecasting system. The local format is KNMI hdf5, for which a local program has been written to read the data. These data are then converted by CONRAD (developed by Martin Grønsleth) into MF bufr, which is then read by BATOR into the observation data base (ODB) of HARMONIE.

This configuration has been used to read volume radar data from the two C-band Doppler weather radars operated by KNMI (De Bilt and Den Helder). Later, the Belgian radars in Jabbeke, Wideumont and Zaventem were added, using the same configuration to read the data. The data are available every five minutes, like the Dutch radars. The Belgian radar data are converted from OPERA hdf5 to KNMI hdf5, using a routine made available by Hidde Leijnse of KNMI, so that they can be processed in the same manner as the Dutch data.

During a substantial period of time within the current project a semi-operational rapid update cycle has been operational for the smaller domain of Fig. 1. In this configuration, set up and maintained by Jan Barkmeijer and run at KNMI, both the Dutch and the Belgian radar-data were assimilated every hour using three-dimensional variational data-assimilation. The system functioned reasonably well although, unfortunately, the data load at times became too high, especially in situations with extensive precipitation. This was solved provisionally by limiting the amount of radar stations and assimilating radial winds only. As we are now able to thin the data (thanks to Hidde Leijnse) a better solution is available.

Several periods of time were studied rather extensively. To the periods already mentioned in the previous report the ten-day period from 8 April 2013 to 17 April 2013 and the twenty-day period from 6 September 2013 to 25 September 2013 were added. In these periods 24 hours forecasts were initiated every day at 12:00 UTC in two configurations: one in which only conventional data are assimilated and one in which radar data are assimilated as well, using three-dimensional variational data-assimilation. In the previous report it was shown how an analysis increment typically evolves, producing small-scale structures very quickly (within an hour). In an idealized experimental set-up, using a two-dimensional doubly-periodic fluid system in which the spectrum was varied using different forms of dissipation, it was shown that the amount of small-scale structure that emerges depends very much on the spectrum of the model state. It was thus concluded that the generation of small-scale structures of analysis increments might be typical for mesoscale models.

If in a 24 hours forecast the radar data are assimilated only at the beginning, then the impact of these data vanishes on a time-scale of about 6 hours. We therefore considered the effect of assimilating radar data more frequently. From the twenty-day period mentioned above we have chosen a particular date and time, 16 September 2013, 12:00 UTC, from which five forecasts of 24 hours were initiated, all using the same first guess at the initial time and the same boundary fields (from ECMWF) at every hour during the forecast. In the first forecast (ref) no data were assimilated except for conventional data at the initial time. The ensuing forecast was free-running apart from using boundary fields at every hour during the forecast. The set-up of the second forecast (dat) was the same as the first, except that conventional data were assimilated every hour. In the third forecast (daa) radial winds from the radar in De Bilt were added. In the fourth forecast (dab) only reflectivities from the same radar were used, using the French technique of converting these data into humidity profiles. In the fifth forecast (dac) both radial winds and reflectivities were added to the conventional data. In Fig. 3 we display the observed rainfall rate and the rainfall rate as produced by the first and second forecast. In Fig. 4 we display the rainfall rates as produced by the forecasts three, four and five. We show the results at analysis time and after six hours into the forecast. It is clear that the accumulation of radar data can cause large differences in the predicted rainfall rate. Unfortunately, the differences are not necessarily improvements as can be seen by comparing the different forecasts with the observed rainfall rates in the first column of Fig. 3. In the poster mentioned at the end of the next section, one can see the rainfall rates at 12, 18 and 24 hours into the forecast.

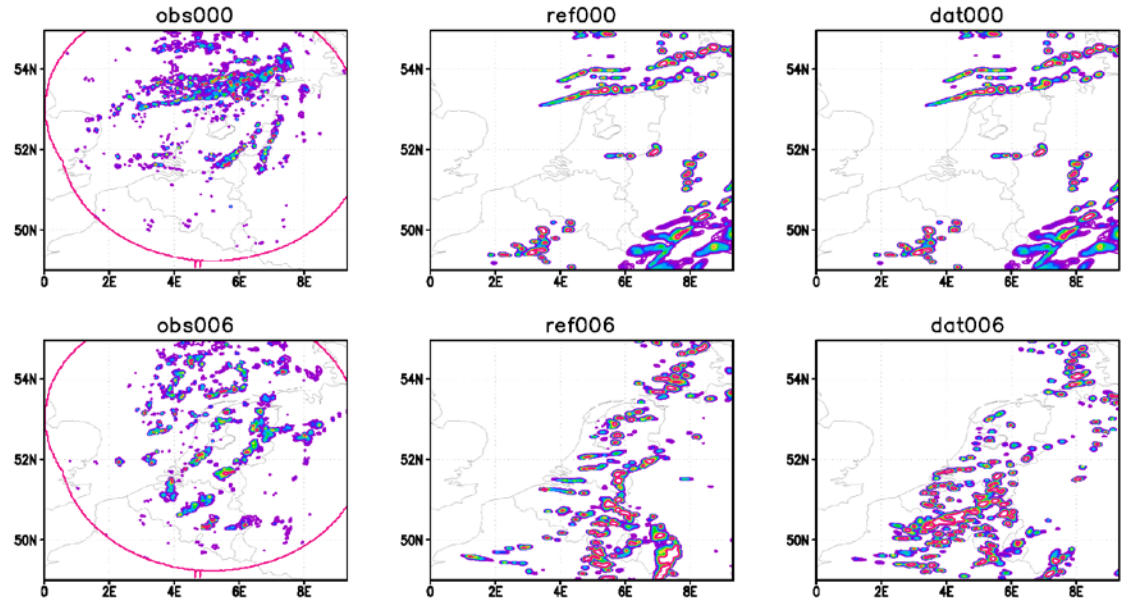

Figure 3. Left column: rainfall rate (in mm/h) as derived in a semi-empirical way from reflectivity data obtained from the Dutch radar stations in De Bilt and Den Helder. Middle and right columns: rainfall rate (in mm/h) produced by the two forecasts ref and dat, respectively. The contour interval is 0.1 mm/h, with blue colours denoting small and red colours denoting high values. The upper and lower column refer to analysis time (16 September 2013, 12:00 UTC) and 6 hours later, respectively. The way in which the different forecasts differ is explained in the text.

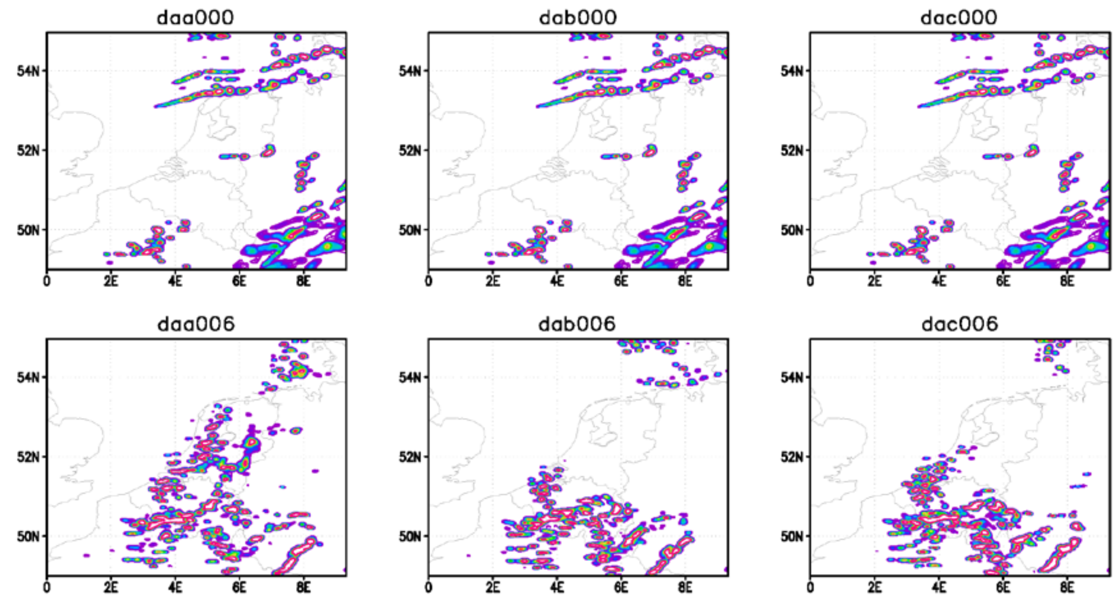

Figure 4 Left, middle and right columns: the rainfall rate in mm/h produced by the forecasts daa, dab and dac, respectively, displayed with the same conventions as the previous figure. More details on the forecasts are given in the text.

Since 16 October 2013 volume radar data from a substantial number of European countries can be downloaded from an OPERA ftp-site. These data are quality controlled and available in OPERA hdf5 every hour. In addition, software has become available to read OPERA hdf5 files directly into the observation data base, i.e., without the need to use

CONRAD to convert local file formats (such as KNMI hdf5) into MF bufr. Martin Ridal from SMHI (Sweden) and Mats Dahlbom from DMI (Denmark) have been instrumental in this development. We have implemented their procedure in our current version 37h1.2 of the HARMONIE system. In the meantime Jan Barkmeijer, in collaboration with Magnus Lindskog from SMHI, has succeeded in using four-dimensional variational data-assimilation in the HARMONIE system on the smaller domain of Fig. 1, using version 37h1.1 of HARMONIE and running the model at KNMI. The effort to assimilate radar data with this system has been successful technically although the data had to be thinned rather drastically by a factor of 4 × 4.

Because of the fact that the radar data from the OPERA ftp-site are already quality controlled, we did not spend much time on this issue. It seems to be more important to obtain insight into the details of the implementation of the radar data assimilation in HARMONIE. We need to find out, for instance, why in the example shown in Figs. 3 and 4, the addition of radar data in the assimilation did not lead to improvement of the predicted rainfall rate. This will be an important issue during the remainder of this project.

List of publications/reports from the project with complete references

During the reporting period two presentations were given on the status of radar data assimilation at KNMI. The first was on 2 December 2013 in Copenhagen during the Harmonie Working Week on Data Assimilation and Observations in HARMONIE, from 2 – 15 December 2013. The presentation can be viewed on:

https://hirlam.org/trac/attachment/wiki/HarmonieWorkingWeek/UseObs201312/status_2013_2.pdf.

The second was on 12 March 2013 in Norrköping during the Harmonie Working Days on Radar Data Assimilation in HARMONIE, from 12 – 14 March 2014. The presentation can be viewed on:

https://hirlam.org/trac/attachment/wiki/HarmonieWorkingWeek/Radar201403/status_2014_wim.pdf.

We also prepared a poster for the 24-th ALADIN Workshop & HIRLAM All Staff Meeting 2014. The meeting was held from 7 – 11 April 2014 in Bucharest, Romania. The poster can be viewed on:

http://www.cnrm.meteo.fr/aladin/IMG/pdf/poster_landscape_asm_03.pdf.

Summary of plans for the continuation of the project

(10 lines max)

Before the end of this project, we wish to reach a situation in which radar data can be assimilated without causing problems such as data overload etc. We will thus have to decide on a thinning strategy also with a view on exploiting more of the radar data that are becoming available from the OPERA ftp-site. It is expected that this goal will be reached within the coming months.

The issue of quality control – apart from checking its consequences for the analysis and forecast of the HARMONIE system – will be left aside, for the moment, as this issue is taken up by the OPERA and BALTRAD communities. The advantage of leaving the quality control to these larger communities is that its implementation will be uniform for all radars of which the data are distributed via the OPERA ftp-site.

The most important problem that needs attention in the immediate future is the lack of positive impact seen until now. At the moment it is not clear why this is the case – it is presumably more than a matter of quality control of the data. A more detailed study of the actual implementation of the data-assimilation system, combined with process studies, are planned to tackle this problem.