Royal Netherlands
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KNMI HARMONIE R&D and operations

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In September 2011 a new supercomputer was installed at KNMI. This has enabled KNMI to start running HARMONIE/AROME in a semi-operational suite from the beginning of December 2011. On average the model outperforms the operational HIRLAM model. During the first year of running HARMONIE the model gives very good guidance in extreme weather, but also a few weaknesses have been identified. Through a combination of physics adjustments and data-assimilation (MODES, MSG, RADAR) these weaknesses are reduced.

1. New supercomputer

In September 2011 the new KNMI super-computer was assembled in the new computer hall that has been constructed. This new computer is a BullX B500 cluster (figure 1), with 4752 processors divided over 396 nodes, delivering a peak performance of 58 teraflop. On this computer we are running HARMONIE on an 800x800x60 2.5 km resolution domain on 46 nodes (see figure 2). The domain is chosen such that the whole life cycle of the most severe convective complexes hitting the Netherlands is taking place within the model domain.

Figure 1. *The KNMI BullX B500 supercomputer*

	HIRLAM D11	HIRLAM H11	HARMONIE
domain	550x726	306x290	800x800
resolution	11km	11km	2.5km
fc-length	+48h	+24h	+48h
fc-interval	6h	3h	3h
nr-proc	132	60	552
wllcl time	960s	200s	4400s

Table 1: *some characteristics of part of the operational KNMI model suite.*

2. HARMONIE performance

The conventional verification scores of HARMONIE are in general a little bit better than for the operational HIRLAM models. The use of hourly boundaries from ECMWF (currently still through an intermediate HIRLAM run) has improved the scores for PMSL substantially. For precipitation the frequency bias is much better in HARMONIE.

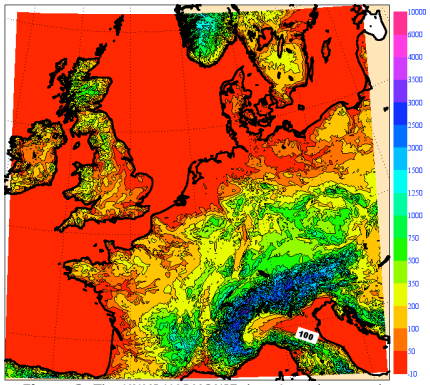

Figure 2. *The KNMI HARMONIE domain and orography*

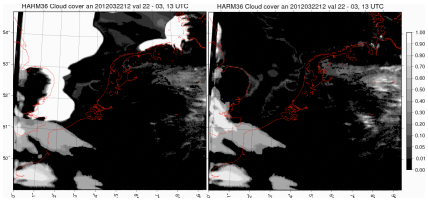

Figure 3. *HARMONIE +1h cloud cover in the reference run (top left) and with application of MSG clouds (top right) and verifying satellite image (bottom) for 22 March 2012, 13 UTC.*

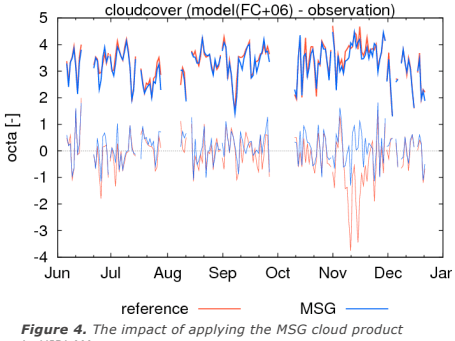

Figure 4. *The impact of applying the MSG cloud product in HIRLAM.*

Especially during high impact weather the model gives additional guidance to the forecasters. The model performs very well when this type of weather is strongly forced. The timing, strength and type of organization of strong convection is described very well by HARMONIE.

3. Overprediction of fog

One important weakness of the current version of HARMONIE is the overprediction of fog and low clouds over the sea. Figure 3 (top left) shows an example of this phenomenon. Between 20 and 29 March 2012 high pressure and relatively warm and moist air over the cold North Sea caused some low clouds and fog to develop on a few days. HARMONIE, however, filled the whole North Sea with widespread and long lasting fog during these days.

Resolving this problem is very important for acceptance of the model by forecasters and for the aviation forecasts for Schiphol Airport, which is situated very close to the coast.

4. Using MSG-clouds

One way of reducing the problematic low clouds and fog is to adjust the initial model state such that clouds and fog are present in the model only where they are observed through satellite and surface observations. The initial profiles of temperature and moisture are adjusted using the MSG cloud mask and cloud top temperatures and synoptic cloud base observations, keeping the virtual temperature constant.

With this adjustment erroneous clouds can be taken out of the model and missing clouds can be included. Figures 3 (top right) and 4 show the impact of this procedure in HARMONIE and HIRLAM respectively.

5. Outlook

HARMONIE is performing very well. Identified weaknesses probably can be reduced significantly through data assimilation. Work is therefore started on assimilating Radar (winds and reflectivities), MODES over a large area, GPS and ASCAT.

The fog and low clouds problems are also attacked through model physics research (vertical diffusion and the statistical cloud scheme) and the application of partial solutions already developed elsewhere.

The new computer also allows for a small ensemble with HARMONIE. The coming year will be used to study the options and setup of such an ensemble.