Use and impact of ATOVS in the DMI-HIRLAM regional weather model
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Introduction

The HIRLAM (High Resolution Limited Area Model) 3D-VAR (three-dimensional variational) data assimilation system (Gustafsson et al., 2001; Lindskog et al., 2001) has been used operationally at DMI since October 2001. A major reason for changing from the former OI (Optimum Interpolation) data assimilation system was to be able to make better use of satellite brightness radiances data. At DMI experiments with use of locally received ATOVS AMSU-A data has been ongoing since 2001 (Amstrup, 2003; Schyberg et al., 2003). Based on this, use of locally received NOAA16 AMSU-A data (channels 1-10) was made operational December 2002, and use of locally received as well as EARS (EUMETSAT ATOS Transmission Service) NOAA16 and NOAA17 AMSU-A data (channels 1-10) has been operational since September 2nd 2003.

DMI-HIRLAM

The DMI-HIRLAM system is a 3 dimensional variational assimilation system covering four regions. The largest region is based on lateral boundaries from ECMWF (European Centre for Medium-Range Weather Forecasts), whereas the inner models are based on lateral boundary input from the sourrounding model. All models have 40 vertical levels reaching 10 hPa.

In the operational DMI-HIRLAM 3D-VAR system the following observation types (and observation quantities) are used. SYNOP (pressure), DRIBU (pressure), SHIP (pressure), TEMP (temperature, wind and specific humidity), PILOT (wind), AIRBE (temperature and wind), NOAA16 and NOAA17 AMSU-A data (brightness temperature) and QuikScat (surface wind).

Data flow

The AMSU-A data used are received via HRPT (High-Rate Picture Transmission) which have been precossed by AAP (ATOVS and AHVRR Processing Package), provided via EUMETSAT) to level 1c. The level 1c data are either received via local equipment or via EARS. The level 1c data are processed into BUFR code which is used in the 3D-VAR analysis system. The analysis system consists of observation preprocessing, screening of observations and minimization of a cost function.

Forward model and data usage

The forward model presently used at DMI to calculate model derived brightness temperatures for ATOVS data is RRTov7 (Radiative Transfer model for TOVS, release 7) developed in the Numerical Weather Prediction SAF (Satellite Application Facility) project set up by EUMETSAT. As DMI-HIRLAM reach only 10 hPa the radiative transfer equation integration is using a climatological model above this height.

Data is presently rejected over land and ice, and a cloud clearing based on the total cloud liquid water content is made since the effect of precipitatable particles is not modelled in the radiative transfer model. The data are subsequently thinned to 0.9" for NOAA16 and NOAA17 data separately.

Data sources

Three data sources are available for the assimilation system: distribution via NOAA/NCEP, locally received and retrieved through EARS. The first source is received too late for use in the regional model. The second source is having a limited coverage, determined by the location of the stations (in our case at Kangeralussuaq (Greenland) and Smiibsholm (Denmark). The third source (EARS) has a coverage determined by the amount of connected receiver stations and delivers data within 30 minutes (see www.eumetsat.de/en/dmps/atovs.html). In the operational DMI-HIRLAM system both locally received and EARS data are used.

Bias-correction and error statistics.

For bias-correction 7 predictors from the background model (model first guess) are used: 1) a constant displacement, 2) thickness between 100 hPa and 300 hPa, 3) thickness between 200 hPa and 500 hPa, 4) the surface temperature, 5) the integrated water vapor content per area from the surface up to the top of the atmosphere, 6) the surface temperature and 7) the surface temperature. The examination that was done for NOAA16 data (Schyberg et al., 2003) showed that the scatter of the difference between observed and modelled brightness temperature varied significantly as a function of latitude. Accordingly, there are separate bias-correctio coefficients for three latitude bands: 1) up to 50°N, 2) between 50°N and 65°N and 3) north of 65°N. The bias-correction coefficients used operationally at DMI for the NOAA17 data were originally based on passive runs from October 19th to November 12th 2002. For NOAA16 data the bias-correction coefficients were based on data from the full month of April 2002. New bias estimates are based on 271 days of data from 2003. This has decreased the bias slightly.

Results

An assimilation experiment has been made in the DMI-HIRLAM system to visualize the impact of the added data. Figure 2 shows the amount of data before and after screening for land, ice and cloud contamination, and thinning for August 23rd 2003, 15:00 UTC. Due to summer data are used far to the north. More data (in the south-western Atlantic) could be used in case of better ground station coverage.

Figure 2: NOAA16/NOAA17 data used (#: 2064) for analysis cycle 03082315 (G4B).

Figure 3 shows results from observation verification using an EWGLAM (European Working Group on Limited Area Model) station list for an OSE (Observing System Experiment) experiment in September 2003. The rms-scores are slightly better for most variables for the run including AMSU-A data and the impact from using AMSU-A data is positive. See (Amstrup, 2003) for further results from an OSE impact study for January and February 2003. Similar experiments in the winter season gives a more consistent positive impact.

Conclusion and future work

ATOVS AMSU-A data have been assimilated into the regional DMI-HIRLAM model, with data coming from both two local receiver stations and coming from the EUMETSAT Transmission Service. Use of NOAA16 and NOAA17 ATOVS AMSU-A data has a positive impact in the DMI-HIRLAM limited area models based on standard observation verification scores, in particular in the winter season. In the summer season, the impact is largest on mslp scores (not shown).

New bias estimators have not improved the forecasts dramatically, but a slight improvement is found in particular in mean sea level pressure for a testrun in a June/July period.

Plans are in the future to make use of data points also over ice (especially relevant for the Greenland region), and land, either by applying an emissivity scheme or by using only channels not reaching the surface. Furthermore the upper boundary for DMI-HIRLAM should be changed from the present climatological model to data from ECMWF, and the processing should be prepared for AMSU-B and other available sounder instruments.

References