Introduction

The DMI-HIRLAM (High Resolution Limited Area Model) 3D-VAR (three dimensional variational) data assimilation and forecasting system (Gustafsson et al., 2003; Lindskog et al., 2001) has been modified to use ATOVS AMSU-A radiance data over sea-ice and land in addition to the operationally used data over oceans (Amstrup, 2003; Schyberg et al., 2003). The extended use of data requires calculation of new bias statistics for each surface type, and type of proper error covariance matrices.

DMI-HIRLAM

The DMI-HIRLAM system is a 3 dimensional variational assimilation system covering. The present work has employed regions seen in figure 1, whereas the present operational system (since 14th June 2004) covers two regions. DMI-HIRLAM/15 corresponds to G but it is a 20 m resolution and DMI-HIRLAM/058 covering northern Europe in 0.05° resolution. 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 surrounding model. All models have 40 vertical levels reaching 10 hPa, above which a climatological model is used.

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), AIREP (temperature and wind), NOAA15 and NOAA16 AMSU-A data (brightness temperature) and QuickSat data (surface wind).

Figure 1: DMI-HIRLAM domains used in this experiment. See (Sass, et al., 2002) for further details on the DMI-HIRLAM system. The AMSU-A data used are received via both local equipment and via EARS (EUMETSAT ATOS Transmision Service).

Forward model and emissivity

The forward model presently used at DMI to calculate model derived brightness temperatures for ATOVS data is RTTOV (Radiative Transfer model for TOVS; release 7) developed in the Numerical Weather Prediction SAT (Satellite Application Facility) project setup by EUMETSAT. As DMI-HIRLAM reaches up to 10 hPa, the radiative transfer equation integration is using a climatological model above this height. Experiments are made with RTTOV8 - see poster by B. Amstrup.

Data is rejected over land and sea-ice, and a cloud clearing based on the total cloud liquid water content is made. The data are subsequently thinned to 0.5° for NOAA15 and NOAA16 data separately.

Each observation is categorized to be over either ocean, sea-ice or land based on the HIRLAM masking. In this experiment observations over land and sea-ice are assigned constant values of emissivity, respectively \( \varepsilon_{\text{land}} = 0.95 \) and \( \varepsilon_{\text{sea-ice}} = 0.85 \). These values are assigned based on previous works (e.g. (Hewison and Engblom, 1999)), but should be handled with great care as the emissivity value changes with e.g. sea-ice type/age and land surface humidity. Only data over ocean and sea-ice is used in this experiment.

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 1000 hPa and 300 hPa, 2) thickness between 200 hPa and 50 hPa, 4) the surface integrated water vapor content per area from the surface up to the top of the atmosphere, 5) the square of the observation zenith angle and 7) the observation zenith angle. An early study (Schyberg et al., 2003) showed latitude dependency of the bias. Accordingly, there are separate bias-correction coefficients for three latitude bands: 1) up to 57°N, 2) between 57°N and 65°N, and 3) north of 65°N.

The bias estimation scheme has been applied for the three surface types simultaneously giving a set of predictor coefficients for each satellite (NOAA-15 and NOAA-16), surface type and latitude band. A time-span of four months (June to September 2003) has been used. The coefficients have been determined for both the experiment values of emissivity and an additional test with \( \varepsilon_{\text{sea-ice}} = 0.50 \) to test the system sensitivity. The change in emissivity only resulted in minor changes of the coefficients.

The observation error covariance matrix has been chosen diagonal with the same values for NOAA15 and NOAA16. Over oceans the values for channel 1-3 ("surface channels") are so large that effectively only channels 4-10 are used. Over sea-ice further channels 4-6 are given low weight due to strong surface contamination - see table 1.

<table>
<thead>
<tr>
<th>Channel</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Error - ocean (K)</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.70</td>
<td>0.70</td>
<td>0.40</td>
<td>0.35</td>
</tr>
<tr>
<td>Error - sea-ice (K)</td>
<td>0.01</td>
<td>0.00</td>
<td>0.00</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.70</td>
<td>0.70</td>
<td>0.40</td>
<td>0.35</td>
</tr>
</tbody>
</table>

Results

An assimilation experiment has been made in the DMI-HIRLAM system to visualize the impact of the added sea-ice data (land data is still in early testing).

References


