The ALARO implementation at SMHI

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Current SMHI configuration

System overview

The SMHI HARMONIE system is based on CY35t1. The forecasting system is run in a 6 h data assimilation cycle on a Linux-cluster. Each cycle includes both data assimilation and a short-range forecast. The system is run with 60 vertical levels and 5.5 km horizontal resolution over an area covering Scandinavia, as illustrated in Fig. 1.

The data assimilation consists of 3D-Var analysis and of OI based CANARI surface analysis, including blending of ECMWF SST fields. For the upper-air analysis, background error statistics is derived from forecasts differences of an ensemble of ALARO forecasts. These are downscaled from an ECMWF data assimilation ensemble experiment. In 3D-Var we utilize conventional types of observations and ATOVS AMSU-A satellite data. AMSU-A channels 5-10 are used and these are subject to variational bias correction (VarBC). To mitigate the effects due to spurious wrap-around of assimilation increments due to a narrow extension zone, no observations closer to lateral boundaries than 250 km are used, as is illustrated for NOAA 18 AMSU-A channel 10 data in Fig. 1.

The forecast model is run in hydrostatic mode utilizing ALARO physics parameterization. The maximum forecast range is 36 hours. Lateral boundary conditions are taken from the most recently available ECMWF forecasts. To reduce imbalances in the initial state, an incremental DFI is applied, before the forecast model integration is started.

Recent improvements

The rather poor results obtained with the SMHI ALARO configuration one year ago have now been improved. One important reason for the improvement is the introduction of a proper use of DFI in our configuration. Other relatively recent improvements are:

- Introduction of incremental DFI.
- Utilization of ECMWF SST analyses in CANARI surface data assimilation.
- Utilization of AMSU-A satellite information together with VarBC.

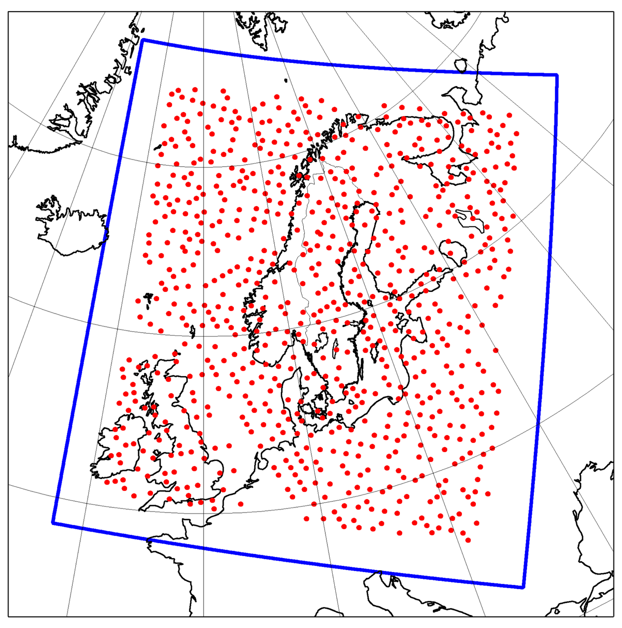

Fig.1: Model domain (blue frame) and NOAA 18 AMSU-A channel 10 data coverage for 20090210 00 UTC (red dots).

Results and planned developments

Problems during winter

The SMHI ALARO forecast of the cold 2010 winter months have been of poor quality. SMHI operational HIRLAM forecasts over similar areas and at 11 (E11) and 5.5 (G05) km horizontal resolution are better. This is illustrated in Fig. 2a in terms of scores for verification of 2 m temperature and Mean Sea level Pressure (MSLP) forecasts against observations. There is a clear positive bias in the ALARO forecasts and the RMS scores are worse for ALARO. This positive ALARO temperature bias can be seen in the lower troposphere, up to roughly 600 hPa. Above 600 hPa the ALARO bias becomes negative or close to zero. Recent changes in SLDH has reduced this “wiggle”.

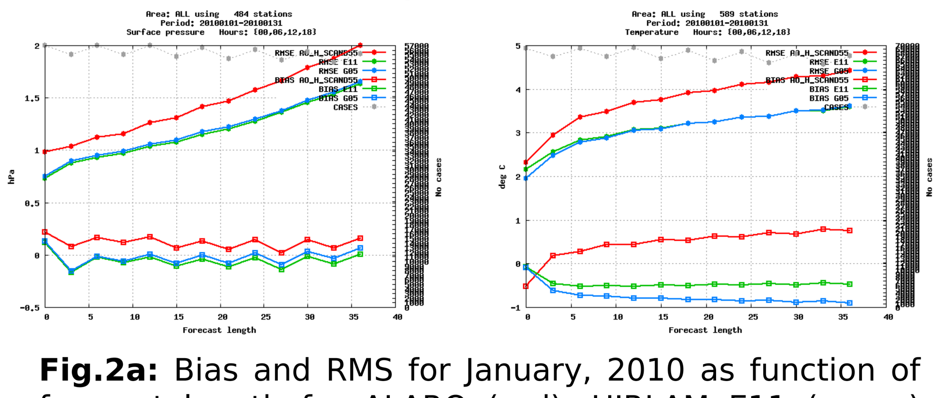

Fig.2a: Bias and RMS for January, 2010 as function of forecast length for ALARO (red), HIRLAM E11 (green) and HIRLAM G05 (blue). Left is for MSLP (unit: hPa) and right for 2 metre temperature (unit: K).

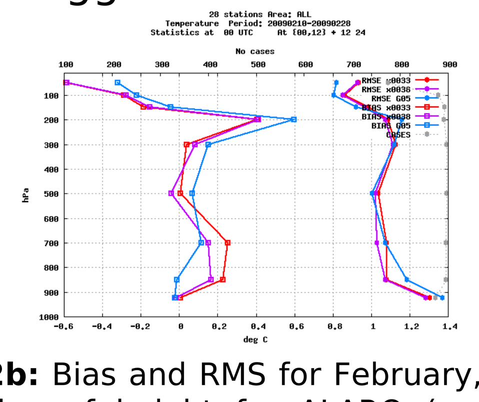

Fig.2b: Bias and RMS for February, 2009 as function of height for ALARO (red/purple), and HIRLAM G05 (blue). The purple ALARO is with corrected SLHD settings.

The problem of representing low winter surface temperatures is a known deficiency in the version of ISBA used in ALARO. Fig 3 shows the difference between HIRLAM G05, AROME 2.5km and ALARO respectively. Both HIRLAM and AROME with different versions of ISBA has less pronounced problems.

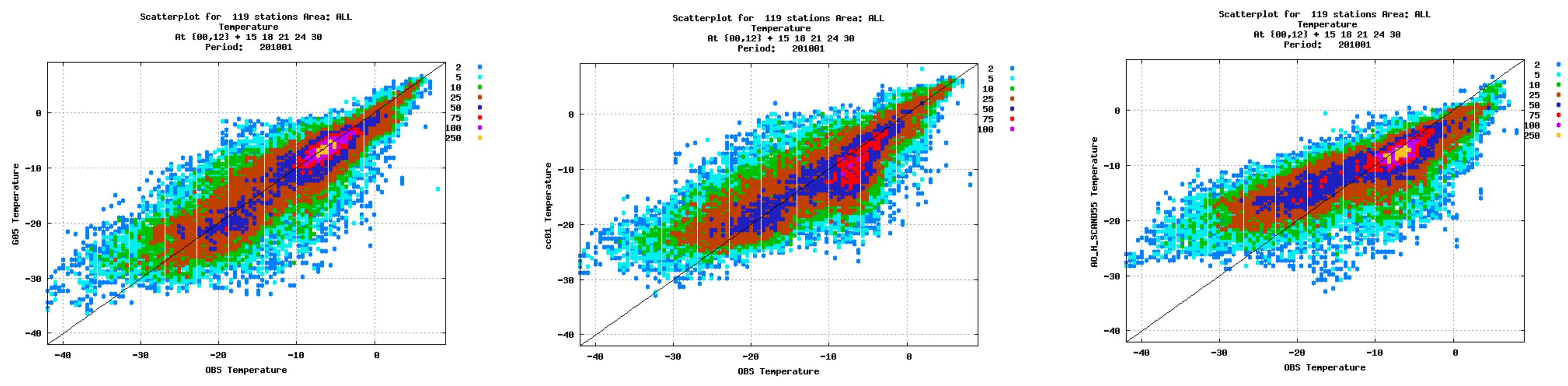

Fig.3:T2m temperatures for (from left to right) HIRLAM, AROME and ALARO for January 2010.

Positive impact of assimilating AMSU-A data

In a parallel experiment for 20090211 to 20090302 a run with assimilation of conventional types of observations only (CRL) have been compared with a run utilizing in addition ATOVS AMSU-A channel 5-10 radiances. A positive impact on forecast quality is obtained from the satellite data, as is shown in Fig. 4 (left) for temperature verification scores. VarBC is applied for the satellite data and the functionality is demonstrated in Fig 4 (right).

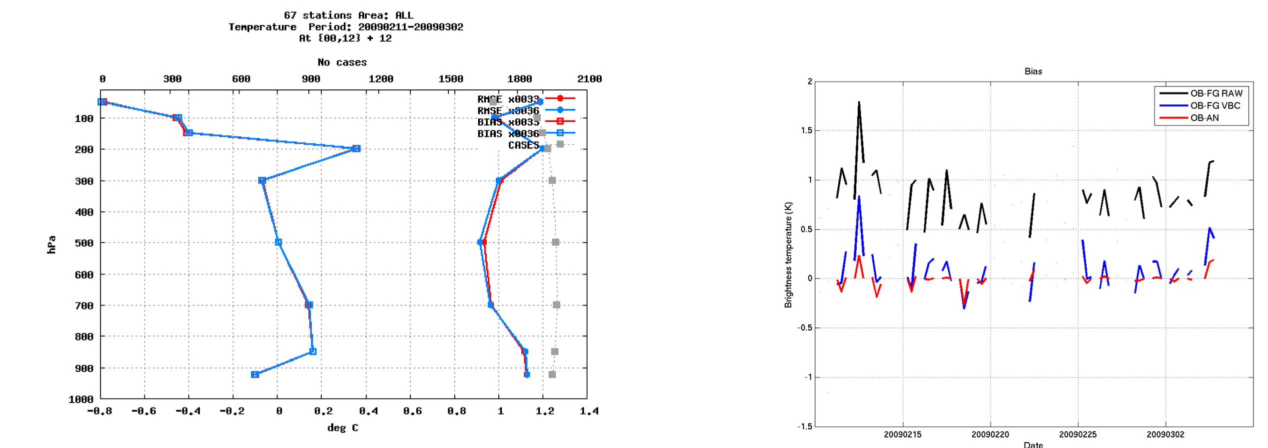

Fig.4: Temperature forecast verification scores (unit: K) for the period 20090211 to 20090302 (left). Bias and RMS as function of vertical level for CRL (red) and SAT (blue). To the right the time-series of AMSU-A channel 10 departures (unit: K) from NOAA 16 are shown for the same period. for the period. Black curve is for raw observation minus background, blue curve is for bias corrected observation minus background and red curve for bias corrected observation minus analysis.

First results with SMHI ALARO 4D-VAR

Some first results have been obtained with multi-incremental ALARO 4D-Var over SMHI ALARO model domain, utilizing 2 outer loop iterations. 4D-Var analysis increments (applied at half model resolution), at the beginning and the centre of the 6 h assimilation time window are shown and compared with 3D-Var analysis increments in Fig 5. For both 4D-Var (3D-Var) the background state is a 3 h (6 h) forecast launched from the previous 3D-Var analysis.

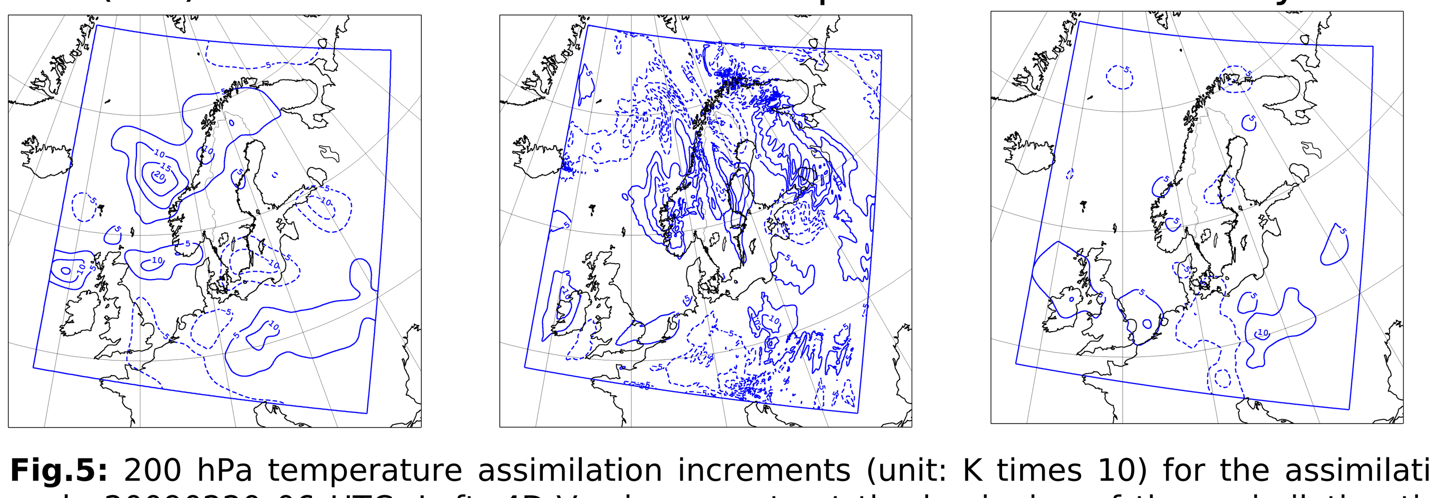

Fig.5: 200 hPa temperature assimilation increments (unit: K times 10) for the assimilation cycle 20090220 06 UTC. Left: 4D-Var increments at the beginning of the assimilation time window (03 UTC). Middle: 4D-Var increments propagated to the centre of the assimilation time window (06 UTC). Right: 3D-Var increments.

SMHI future plans

SMHI near future plans will focus on understanding and reducing the MSLP and temperature biases. We will take an active part in the development of ALARO-1 by further improvements of e.g. the Rasch-Kristiansen scheme and the coupling to SURFEX. Assimilation work will initially aim at introducing assimilating AMSU-B observations and more types of surface observations. More extensive meteorological evaluation and further improvement of ALARO 4D-Var is also planned. Efforts will be put on enabling surface assimilation with SURFEX together with ALARO utilizing CY36t1.