

Towards operational use of satellite radiances in an Arctic mesoscale model

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Introduction

This study was done in frame of an EU-funded project ACCESS (Arctic Climate Change, Economy and Society), where MET Norway, among other tasks have to deal as well with the following: 1) to describe the present *short-range* monitoring and forecasting capabilities in the Arctic; and 2) Identify the key factors limiting the monitoring and forecasting capabilities, and give recommendations for key areas to improve the forecasting capabilities.

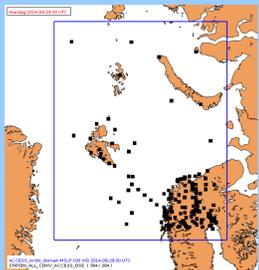
Regarding the task 1) described above, the performance of both the ECMWF and the HIRLAM (operational at study time) have been monitored. As results of such a monitoring, a decrease of NWP model accuracy was found towards the north Pole.

As results taken from the monitoring study, the following hypotheses can take place: 1) Deficiency in description of the physical process in the NWP model; 2) Predictability issues related to the initial condition; 3) The observing networks available in Arctic. The network of conventional observations is sparse in the Arctic, in particular coverage of aircraft observations and radiosonde data. It is important to describe the full 3-D initial state of the atmosphere to provide good forecasts, and the lack of such upper-air data is a difference from the observing system over land at lower latitudes. There is good coverage of satellite data from polar-orbiting satellites at high latitudes, where for instance sensors with temperature and moisture sounding capabilities are available.

We have chosen to do our studies with the HARMONIE-AROME NWP model (AROME-Arctic), which is a version of the operational regional NWP model MET Norway.

The experimental AROME-Arctic model

System setup: (Harmonie cycle 38h1.1)
Domain: 750x960 grid points; **Horizontal resolution:** 2.5 km; **Model level definition:** 65 level;
Non-hydrostatic dynamic; **Physical parametrisation:** AROME/mezo-NH; **Assimilation strategy:** 3-hourly cycling;
Lateral boundary conditions: hourly ECMWF; **Surface data assimilation:** Optimum interpolation; **Upper-air data assimilation:** 3D-VAR; Background error statistics computed as mean over 4 seasons.
Tested observations: Surface (SYNOP, DRIBU), Radiosondes, Aircraft, ATOVS (AMSU-A, AMSU-B/MHS) and IASI



The experimental AROME-Arctic domain with all conventional observations. This is a case of 12 UTC, December 2013.

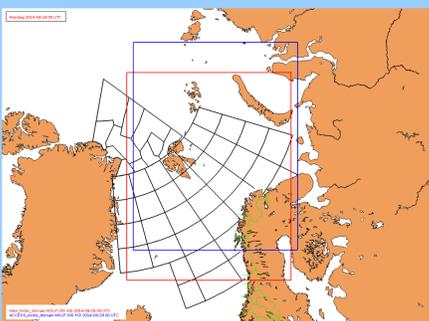
Radiances assimilation:

- AMSU-A : Channels 5 - 10;
 - AMSU-B/MHS: Channels 3 - 5;
 - IASI : 65 Active channels
- 38, 51, 63, 85, 87, 104, 109, 167, 173, 180, 185, 193, 199, 205, 207, 212, 224, 230, 236, 239, 242, 243, 249, 252, 265, 275, 294, 296, 306, 333, 337, 345, 352, 386, 389, 432, 2701, 2819, 2910, 2919, 2991, 2993, 3002, 3008, 3014, 3027, 3069, 3087, 3098, 3207, 3228, 3281, 3309, 3322, 3339, 3438, 3442, 3484, 3491, 3499, 3506, 3575, 3582, 3658, 4032

The operational AROME-Arctic model

System setup: (Harmonie cycle 38h1.2)
Main characteristics are the same as shown in experimental case above. A simple sea-ice scheme is used to support the surface physics.

Implemented observations: Surface (SYNOP, DRIBU), Radiosondes, Aircraft, ATOVS (AMSU-A, AMSU-B/MHS) IASI, ASCAT, GPS ZTD, Radar reflectivity (soon).



The experimental (blue line) and operational (red line) AROME-Arctic domains.

Radiances assimilation:

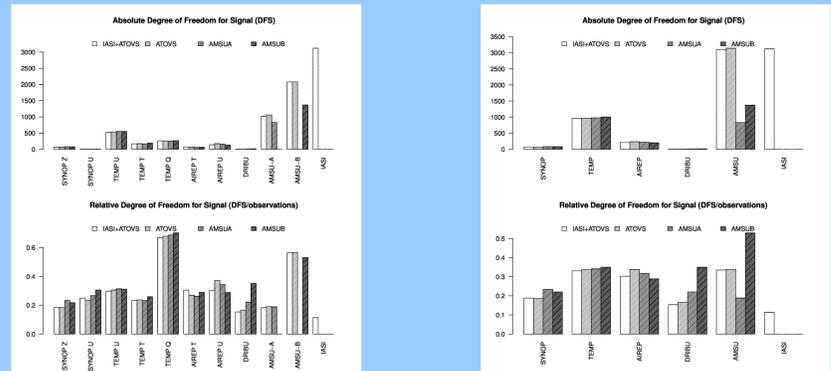
- AMSU-A : Channels 5 - 9;
 - AMSU-B/MHS: Channels 3 - 5;
 - IASI : 55 Active channels
- 38, 51, 63, 85, 104, 109, 167, 173, 180, 185, 193, 199, 205, 207, 212, 224, 230, 236, 239, 242, 243, 249, 296, 333, 337, 345, 352, 386, 389, 432, 2701, 2819, 2910, 2919, 2991, 2993, 3002, 3008, 3014, 3098, 3207, 3228, 3281, 3309, 3322, 3438, 3442, 3484, 3491, 3499, 3506, 3575, 3582, 3658, 4032

Observing System Experiments (OSE)

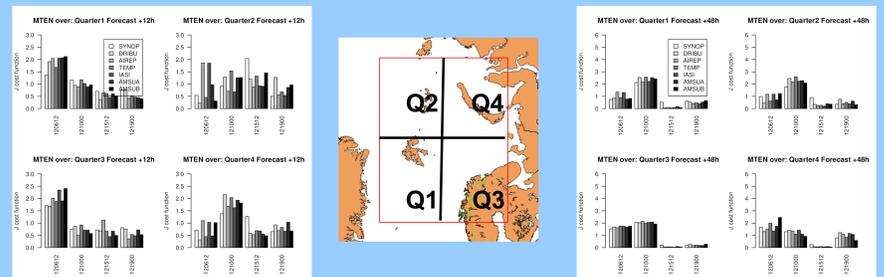
The following experiments were conducted:

- ARCREP** – Downscaling of the ECMWF fields without assimilation;
- ARCSURF** – Only surface analysis is used;
- ARCAIREP** – Surface and upper-air assimilation with conventional observations *without* aircraft data;
- ARCCONV** – Surface and upper-air assimilation with full conventional observations;
- ARCAMSUAN** – System with added ATOVS-AMSU-A radiances;
- ARCAMSUB** – System with added ATOVS-AMSU-B/MHS radiances;
- ARCATOVN** – System with added both ATOVS radiances;
- ARCIASI** – System with further added IASI radiances.

Sensitivity of the AROME-Arctic analyses to the observations using Degrees of Freedom for Signals (DFS) (Chapnik et al. 2006)

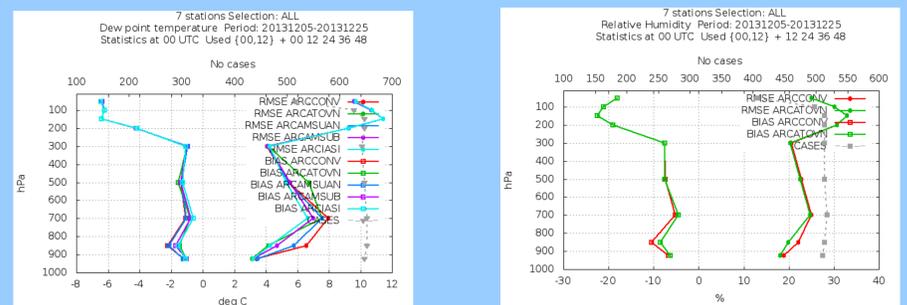


Sensitivity of the AROME-Arctic forecasts to the observations using Moist Total Energy Norm (MTEN) (Storto and Randriamampianina, 2010)

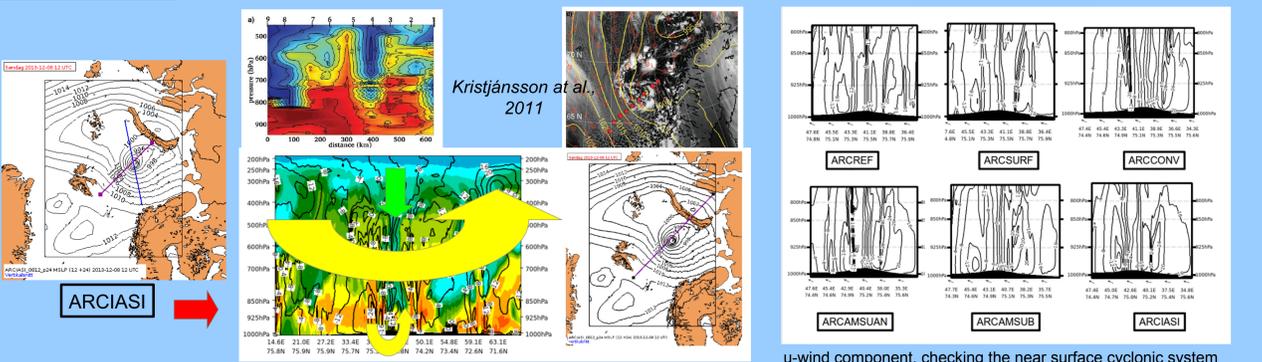
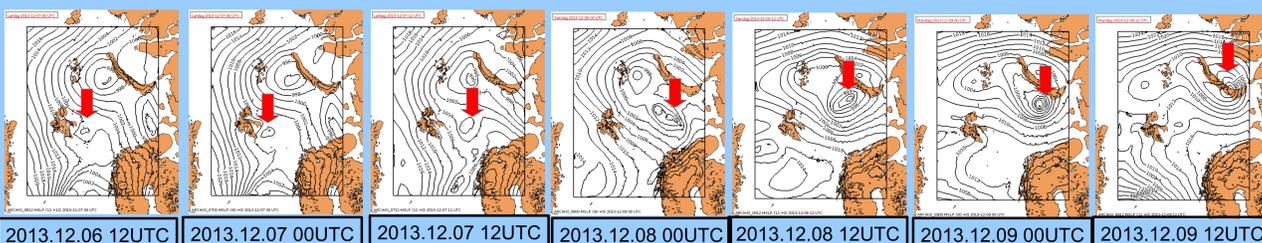


Sensitivity of the forecasts to the "withdrawn" observations from the analysis

Impact of radiances on the AROME-Arctic forecasts comparison against radiosonde observations



Case study: Polar low Dec. 8th, 2013



Concluding remarks

- Downscaling of global model cannot give reliable mesoscale forecasts in Arctic;
- Buoy play important role in adjusting the analyses, and also have considerable influence on the forecasts especially on areas, where conventional observations are sparse (*not shown here*);
- Use of satellite observations is necessary for reliable analyses and forecasts in Arctic;
- IASI radiances are needed for an efficient forecasting of polar low;
- Using the HARMONIE system, regional data assimilation influences mainly the tropospheric levels.

References

- <http://www.access-eu.org/>
Chapnik B, Desroziers G, Rabier F, Talagrand O. 2006. Diagnosis and tuning of observational error in a quasi-operational data assimilation setting. *Q. J. R. Meteorol. Soc.* **132**: 543–565.
Storto A, Randriamampianina R. 2010. The relative impact of meteorological observations in the Norwegian regional model as determined using an energy norm-based approach. *Atmos. Sci. Lett.* **11**: 51–58.
Kristjánsson et al. 2011. The Norwegian IPY-THORPEX: Polar lows and Arctic fronts during the 2008 Andøya campaign. *Bull. Amer. Meteor. Soc.*, **92**, 1443–1466.