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Use of retrieved wind data in the HARMONIE-AROME data assimilation system

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Acknowledgements: Norwegian Space Centre

14th INTERNATIONAL WINDS WORKSHOP, April 23 - 27, 2018 Jeju City, South Korea

Outline

- The NWP systems configuration

- Activities related to wind data

- Impact of retrieved wind data in the analysis system

- Impact of retrieved wind data on the forecast system

- Summary

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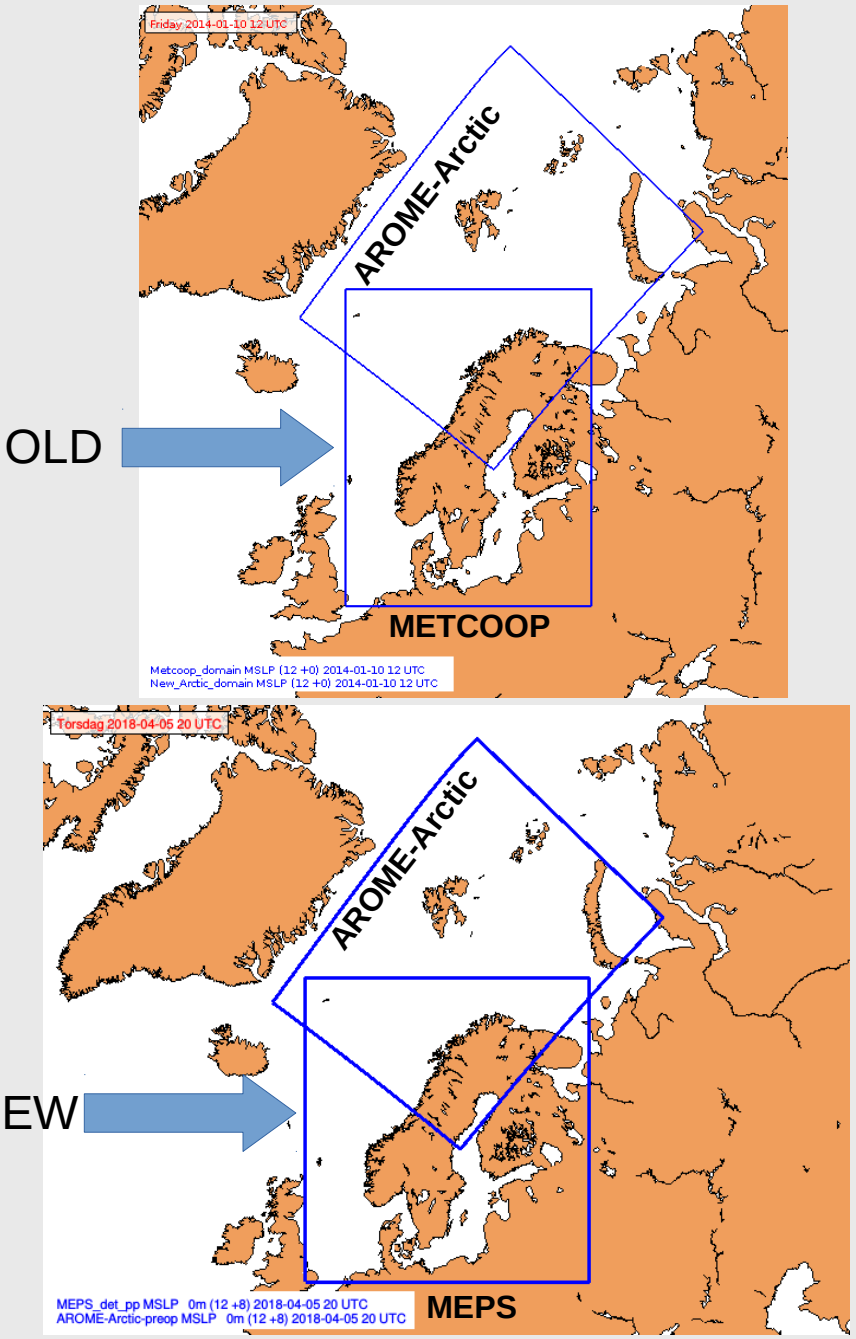
The NWP systems configuration

Operational/experimental domains



Experimental setup

Model cycle: (Harmonie cycle 38h1.1)

- Domain: AROME-Arctic/METCOOP (750x960)
- Model level definition: 65 level
- Horizontal resolution 2.5 km
- Non-hydrostatic dynamic
- Physical parametrisation: HARMONIE-AROME
- Data assimilation: 3D-VAR

  OI for surface
- 3-hourly cycling
- Lateral boundary conditions: ECMWF
- Using all observations from MARS archive
- Background error statistics computed as mean over 4 seasons
- Observations: Conventional, ATOVS, IASI, Polar and Geo AMVs

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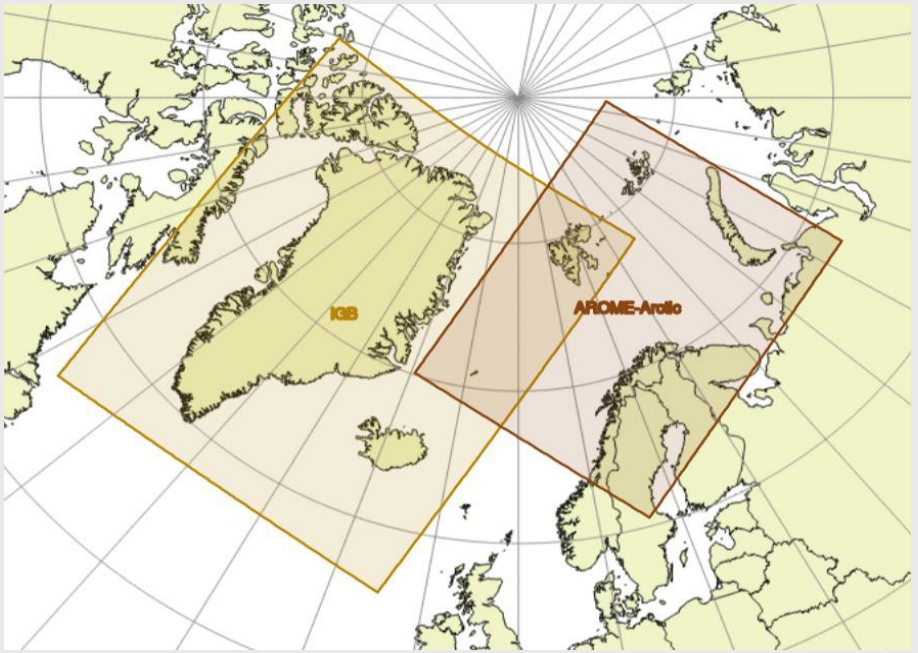
Activities related to retrieved wind data

- **Two regional reanalysis Projects:**
  - Copernicus Regional Arctic and European Reanalysis

Source:http://www.euro-cordex.net/060374/index.php.en

Model: ALADIN, 5.5km resolution
period: early 80's – 2021



Model: HARMONIE-AROME, 2.5km resolution
period: 1997 – 2021

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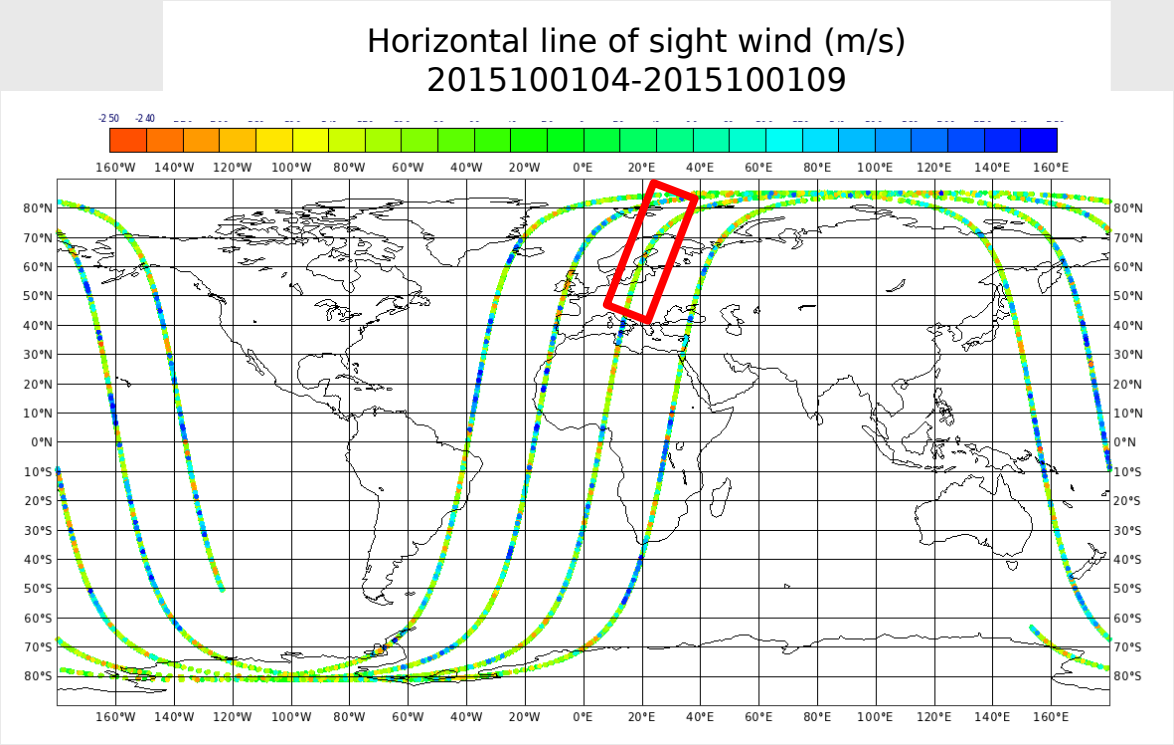
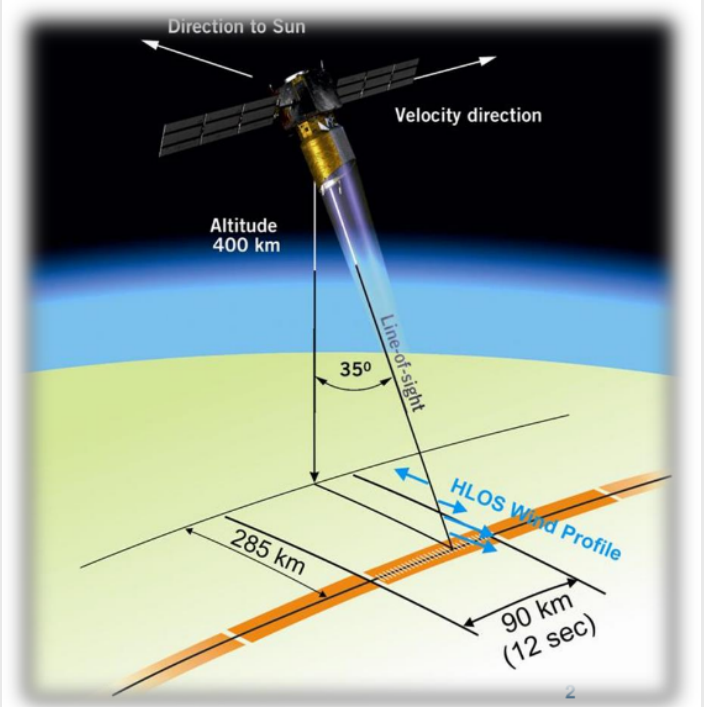
Activities related to wind retrievals

External projects:

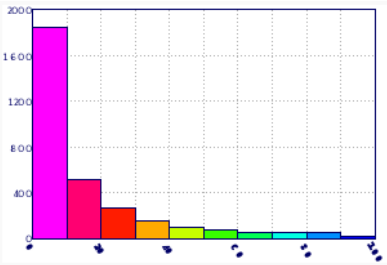
PRODEX: CAL/VAL with Aeolus HLOS





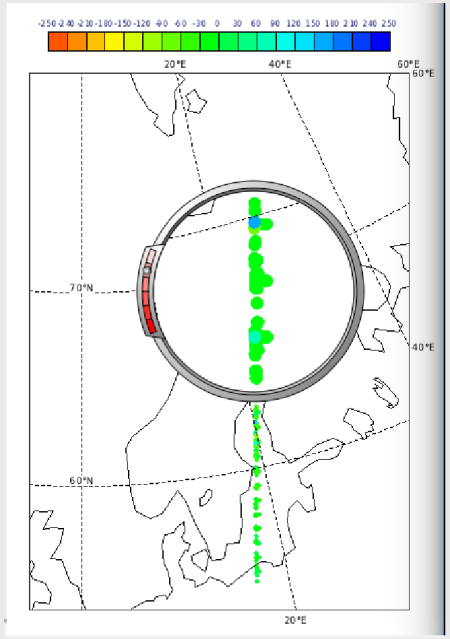
Statistics (for data in visible area)	
Points	3456
Minimum	0.49
Maximum	323.36
Average	30.0175
Stdev	52.1615
Skewness	2.87756
Kurtosis	8.70407

Histogram (for data in visible area)

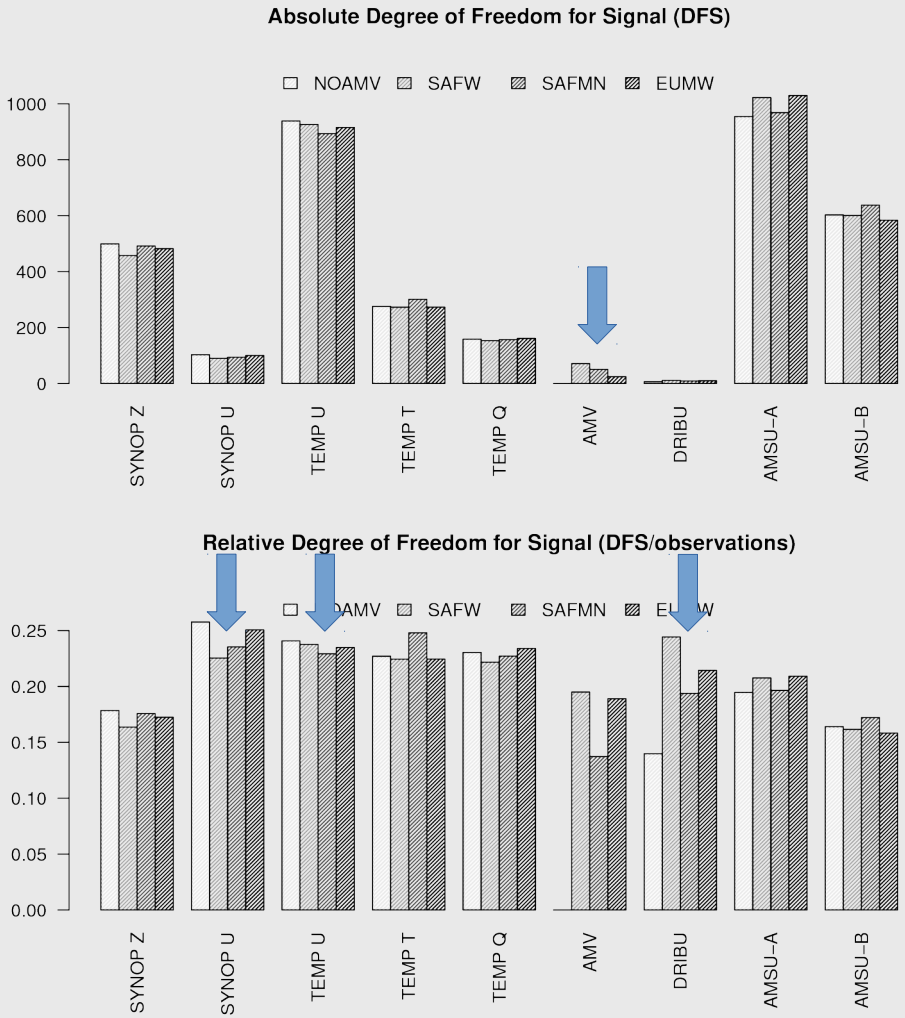


HLOS wind error

This is work in progress.
HARMONIE-AROME DA (CY43)
system is used as tool for comparison



Impact of retrieved wind (geowinds) in the analyses



Assimilation of the Geowind data reduces the influence of the surface (ex. wind and Dribu) observations on the analysis

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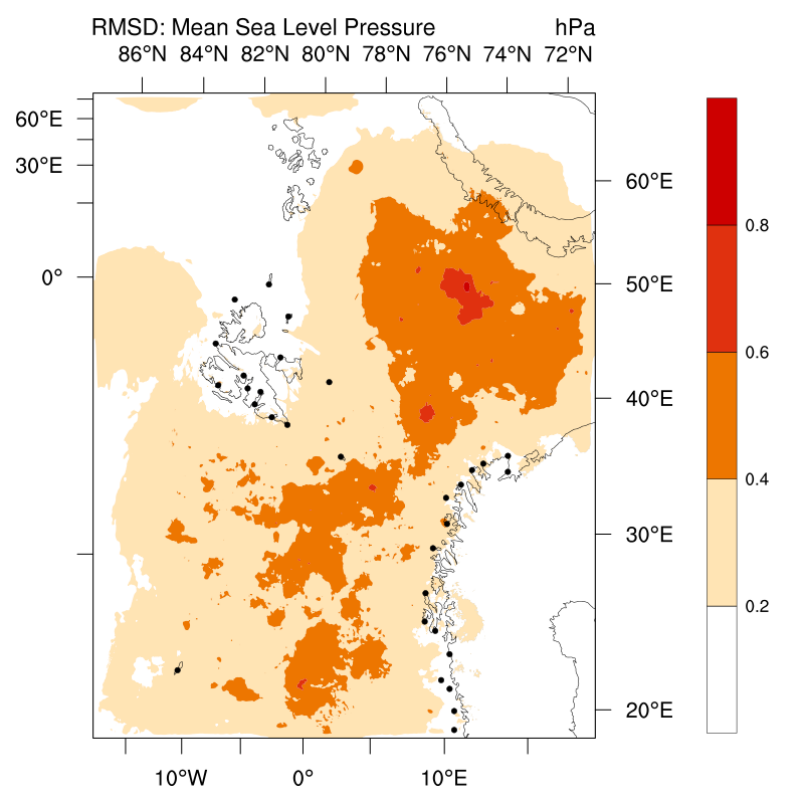
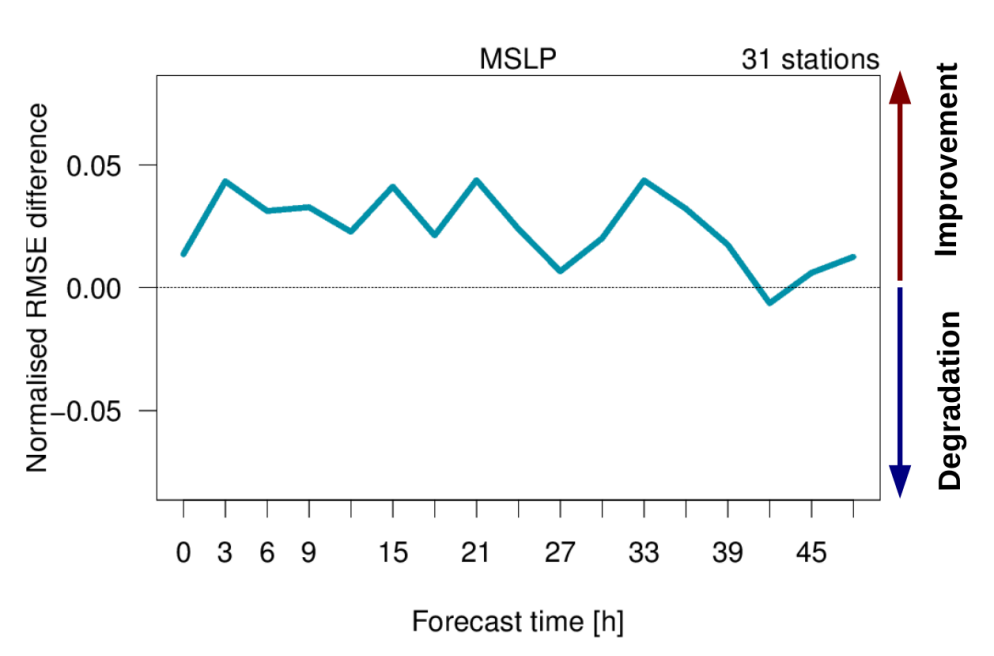
Impact of ASCAT wind data on analyses and forecasts

ASCAT data has slightly positive impact on MSLP and wind speed



Mean RMS difference of MSLP between AA-REF and AA-SCAT experiments in the analysis (+00h forecast) averaged over March 2013.



More about ASCAT impact:
Valkonen et al (2017) "Assimilating Advanced Scatterometer Winds in a High-Resolution Limited Area Model Over Northern Europe," *IEEE JSTARS,* doi: 10.1109/JSTARS.2016.2602889

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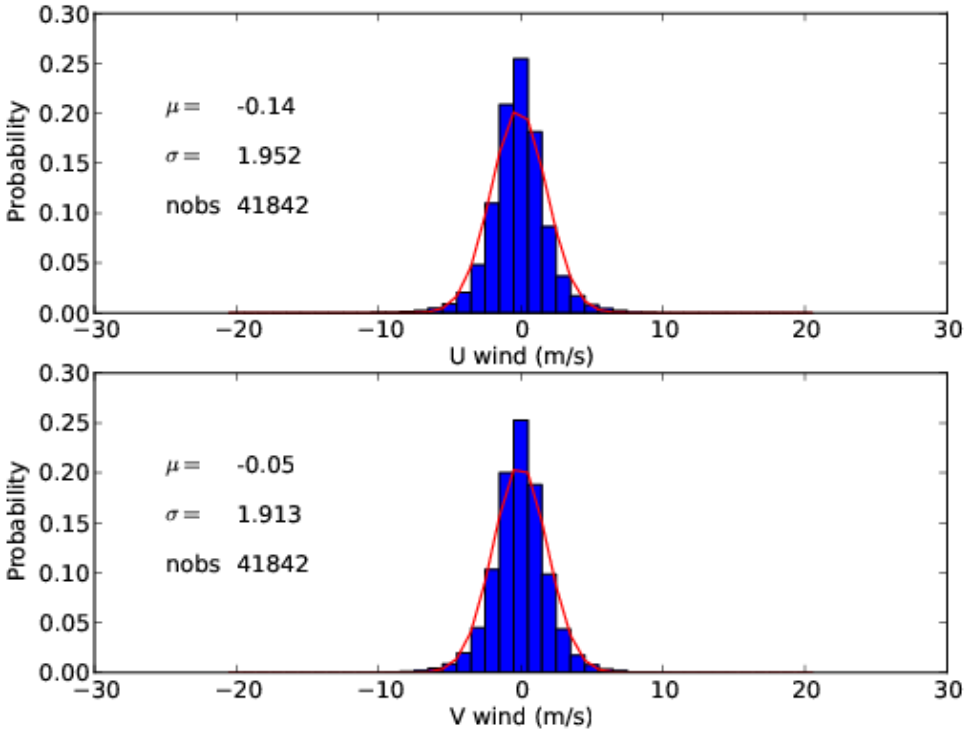
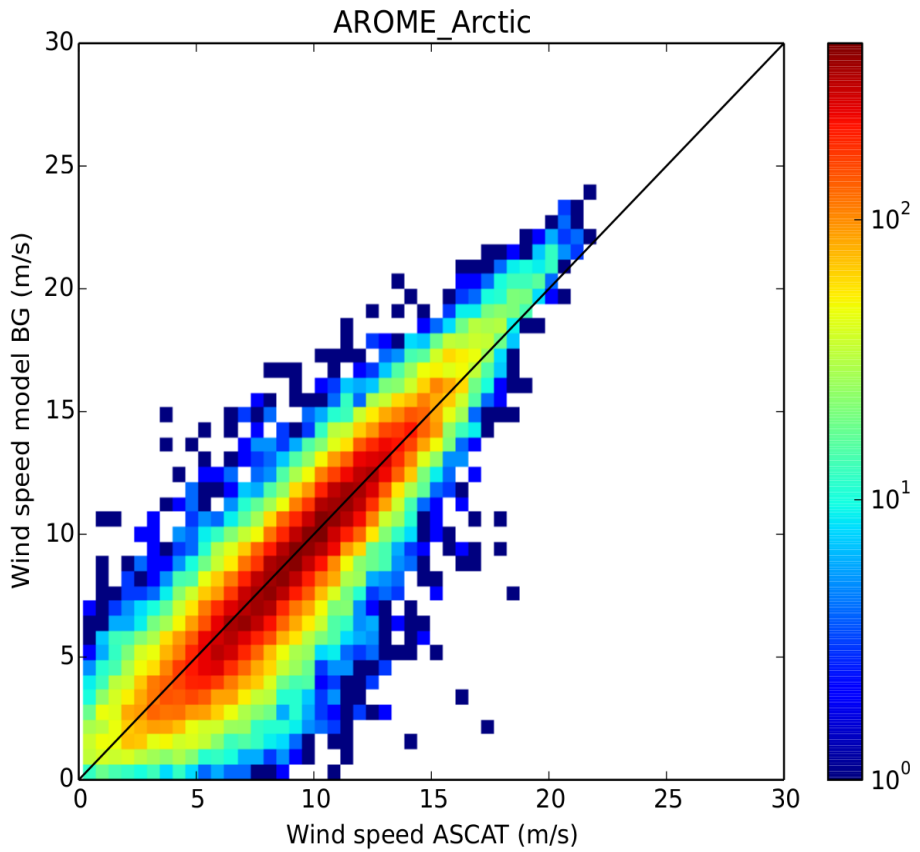
ASCAT data usage in the operational setup



Background departure distribution for ASCAT zonal (upper panel) and meridional (lower panel) wind components in the daily runs of AROME-Arctic in January 2016.



Density scatter plot for absolute wind speed (m/s) calculated from the wind components for the assimilated ASCAT data and the background equivalent in the observation space in the AROME-Arctic system in January 2016

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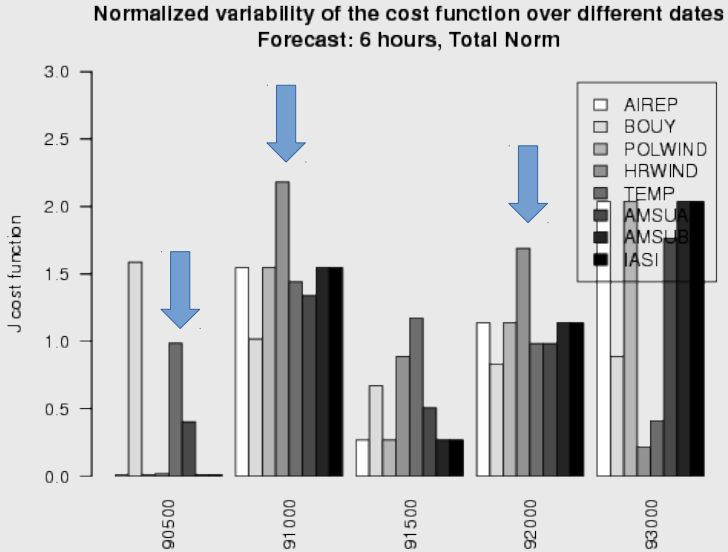
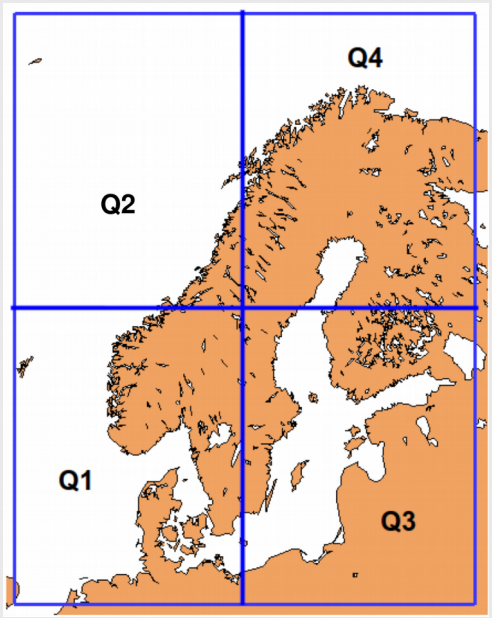
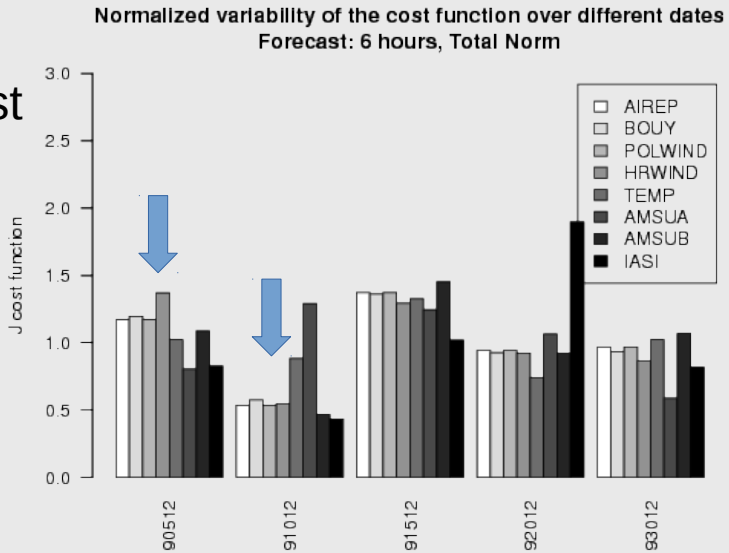
Sensitivity of the forecasts to the used observations sing Moist Total Energy Norm (MTEN) *(Storto and Randriamampianina, 2010)*

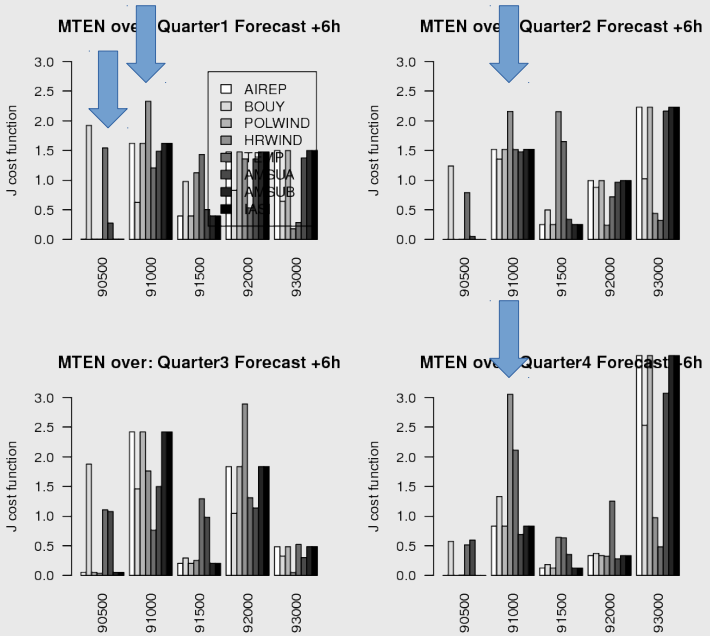


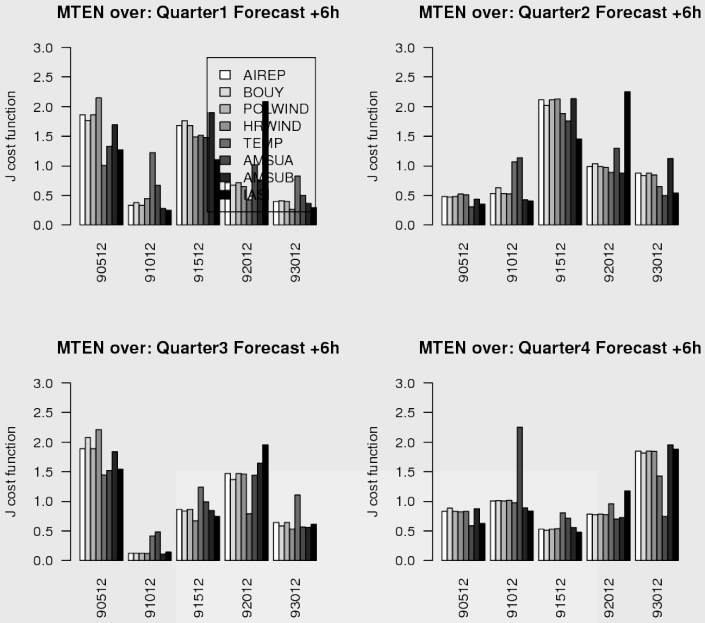
The sensitivity of the forecast system with respect to the withdrawn observations from the analysis system



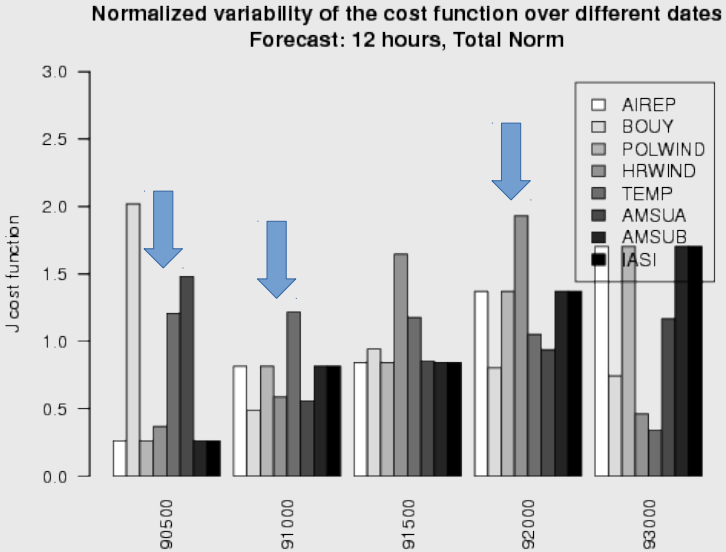
Clear impact of AMV data on 6 hour forecast for some cases







Sensitivity of the forecasts to the used observations sing Moist Total Energy Norm (MTEN) *(Storto and Randriamampianina, 2010)*



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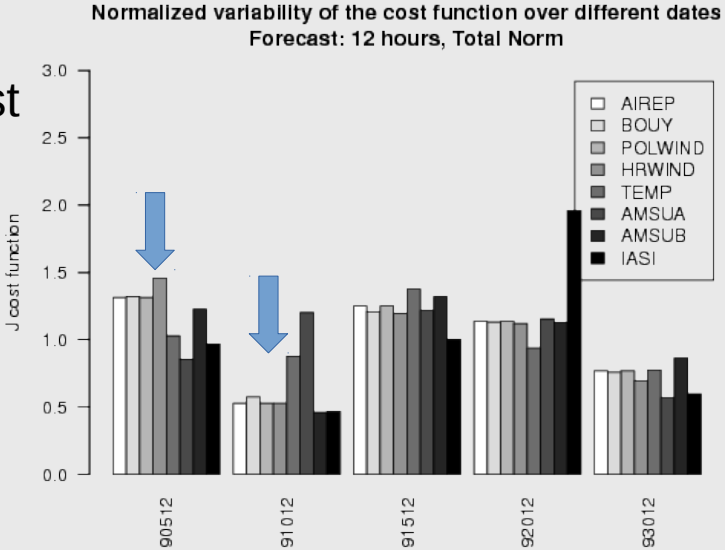
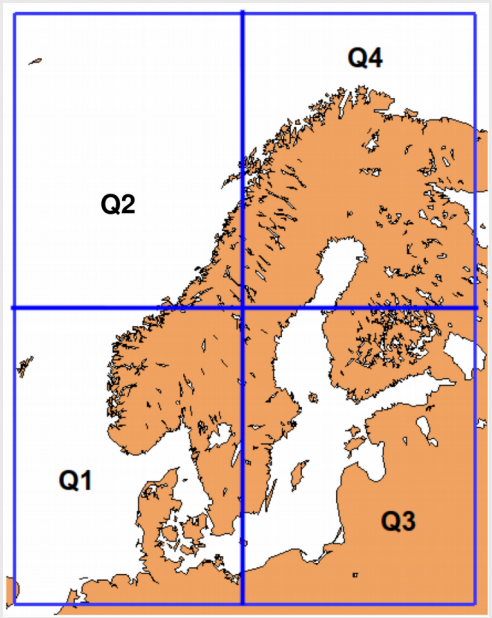
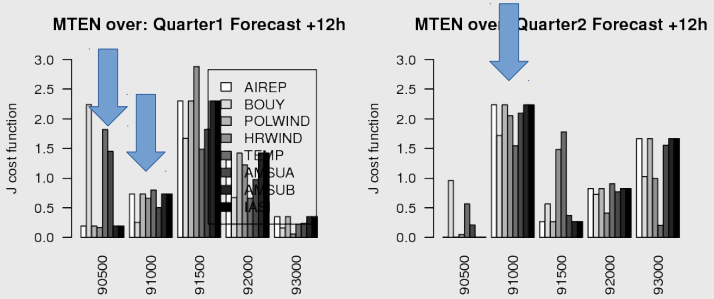
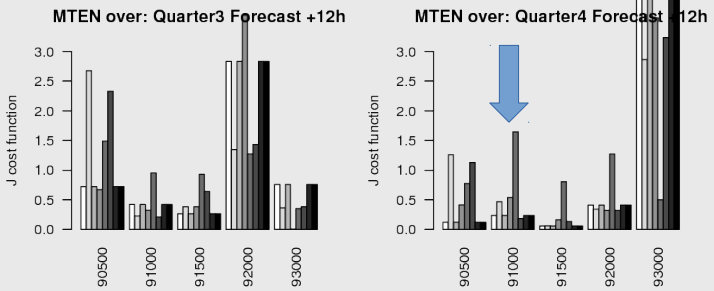
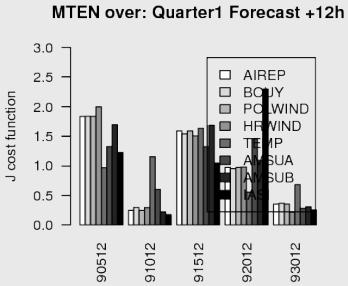


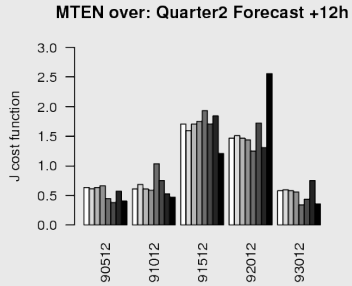


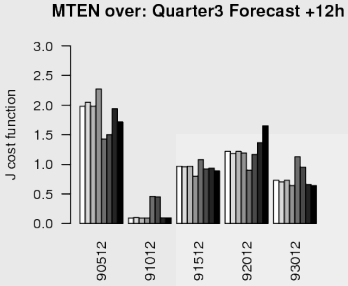


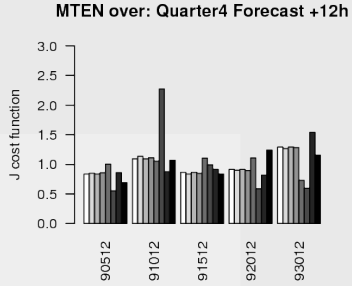


Clear impact of AMV data on 12 hour forecast for some cases

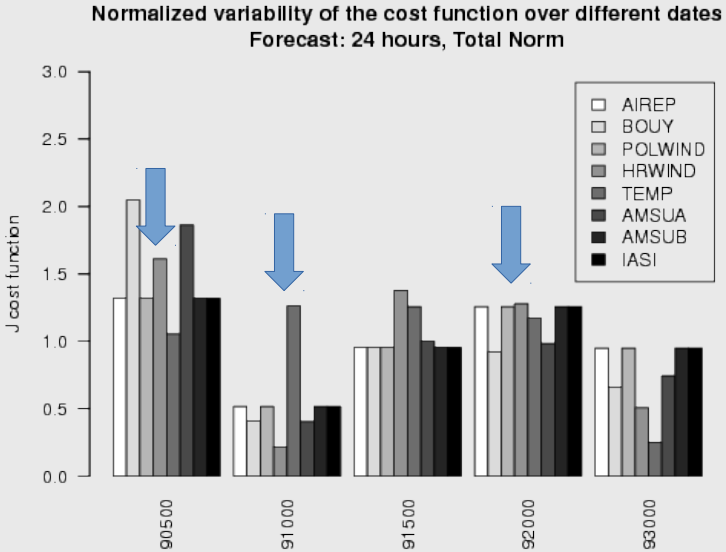




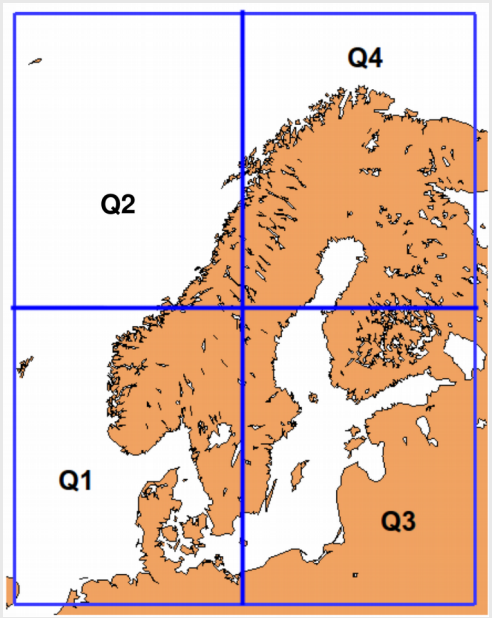


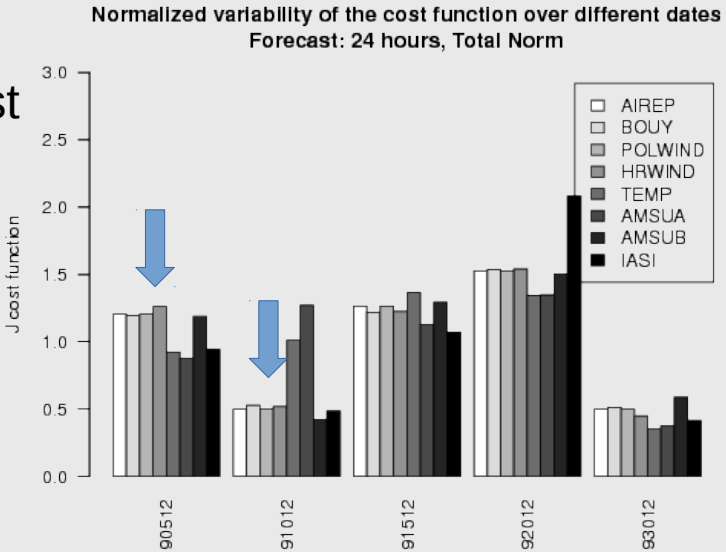


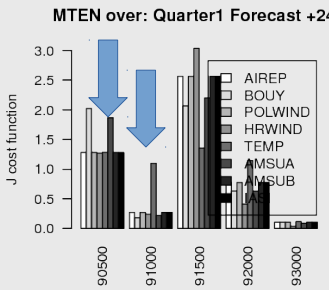
Sensitivity of the forecasts to the used observations sing Moist Total Energy Norm (MTEN) *(Storto and Randriamampianina, 2010)*

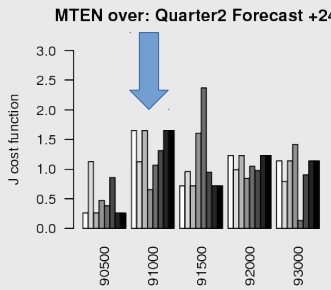


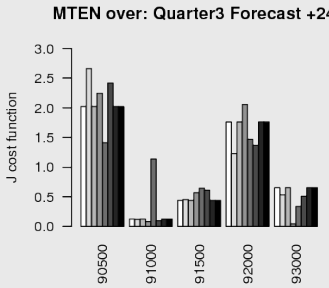
The sensitivity of the forecast system with respect to the withdrawn observations from the analysis system

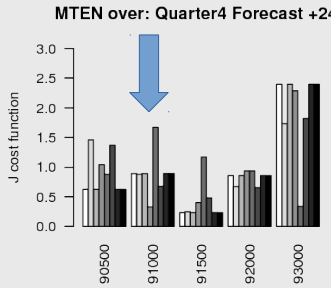




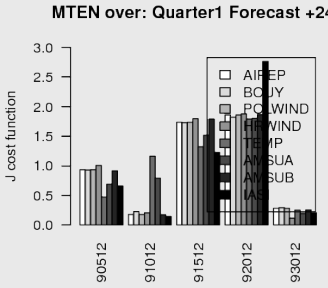


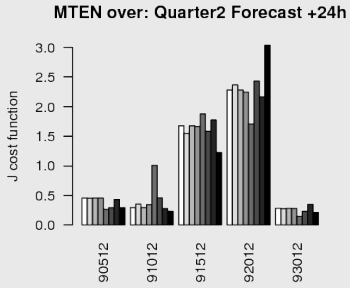


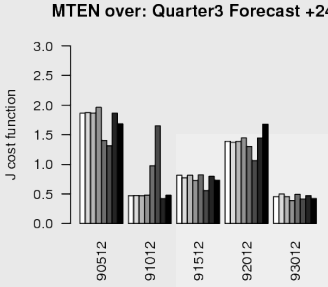


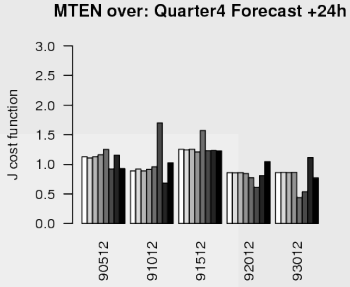


Clear impact of AMV data on 24 hour forecast for some cases

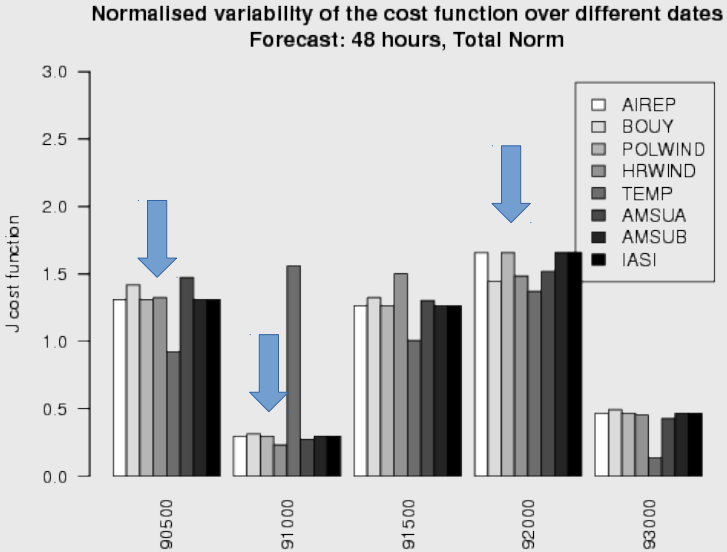




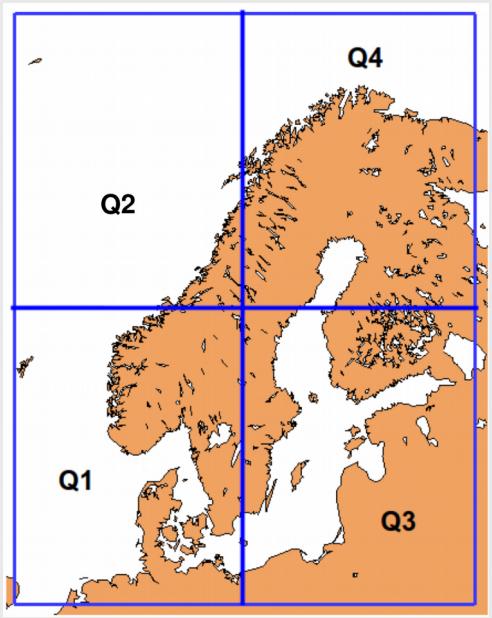


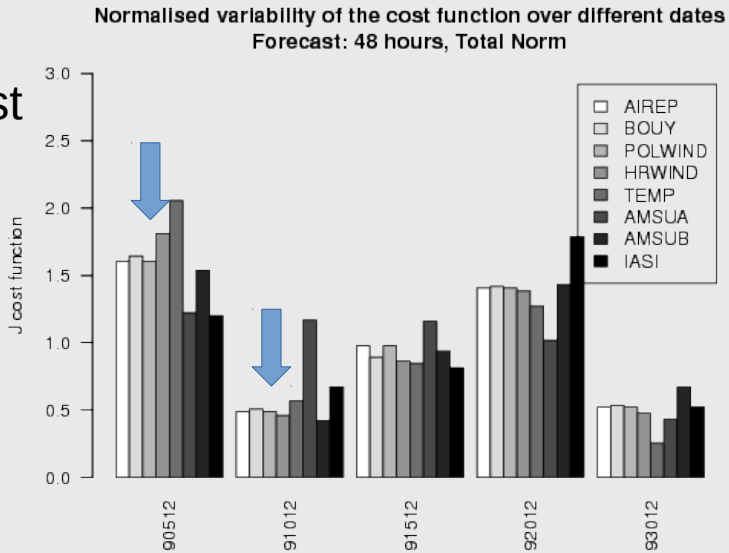


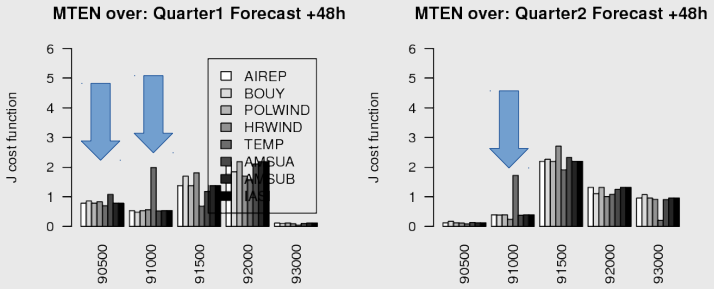
Sensitivity of the forecasts to the used observations sing Moist Total Energy Norm (MTEN) *(Storto and Randriamampianina, 2010)*

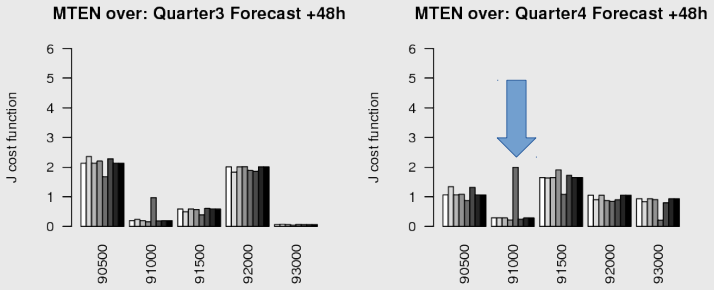


The sensitivity of the forecast system with respect to the withdrawn observations from the analysis system

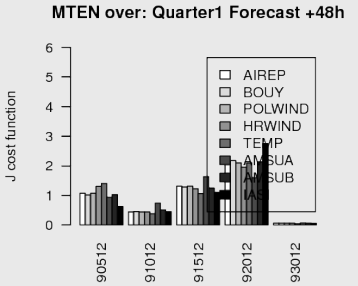


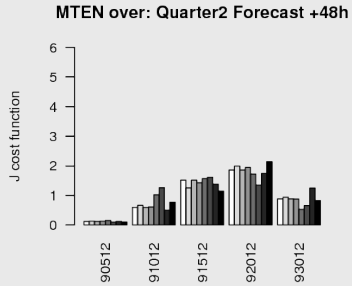


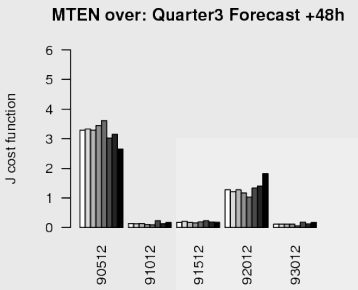


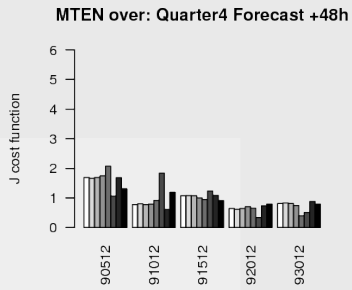


Clear impact of AMV data on 48 hour forecast for some cases

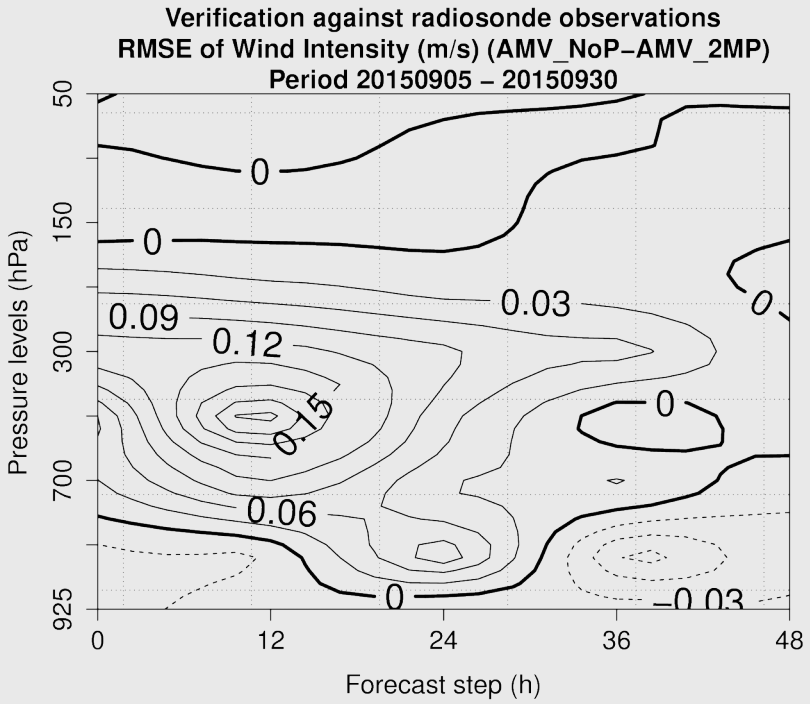


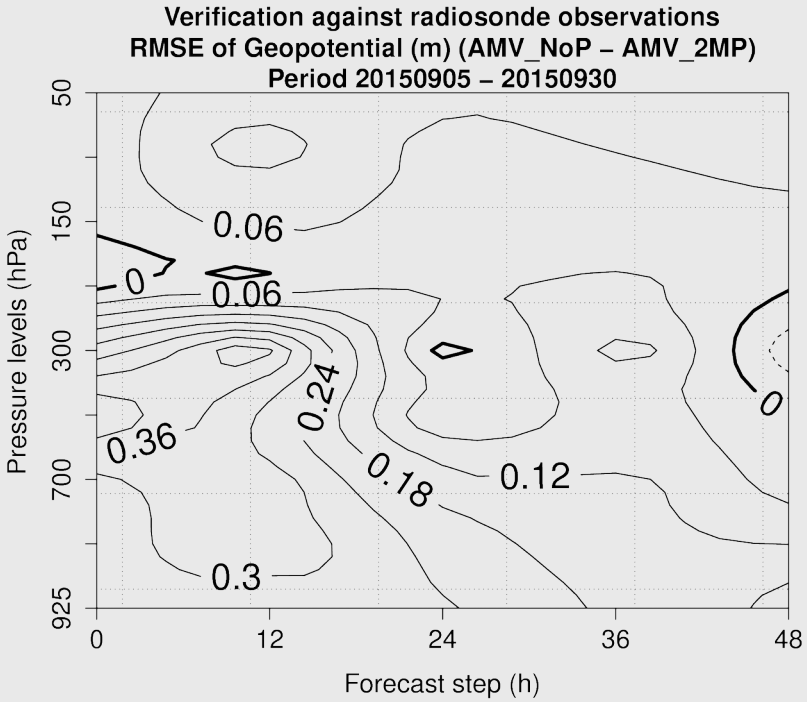


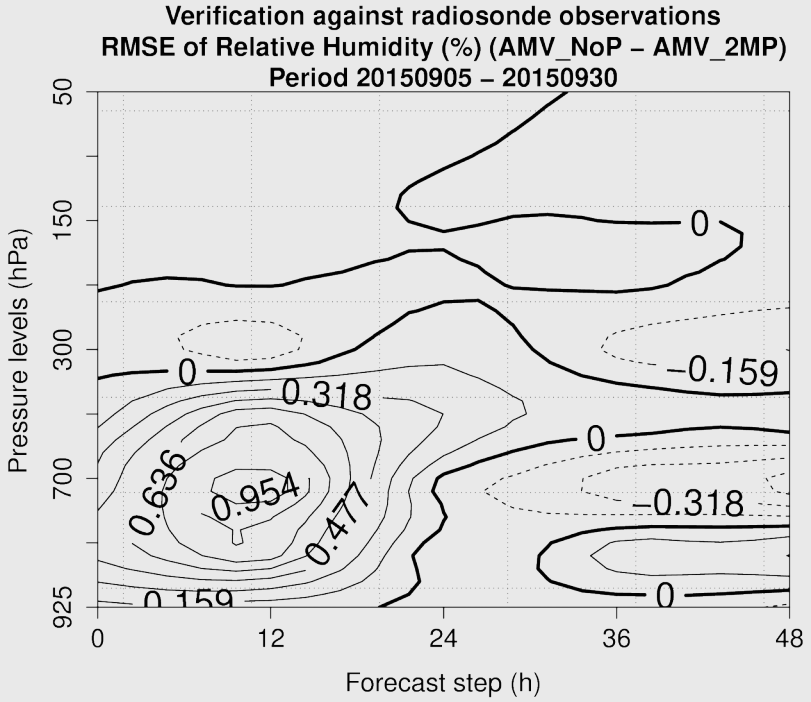




Impact of polar AMV on forecasts







Test period 1: 2015 Jul. 1-31; 4 days warming
period 2: 2015 Sept. 1-30

Similar impact was found for both periods over the Arctic

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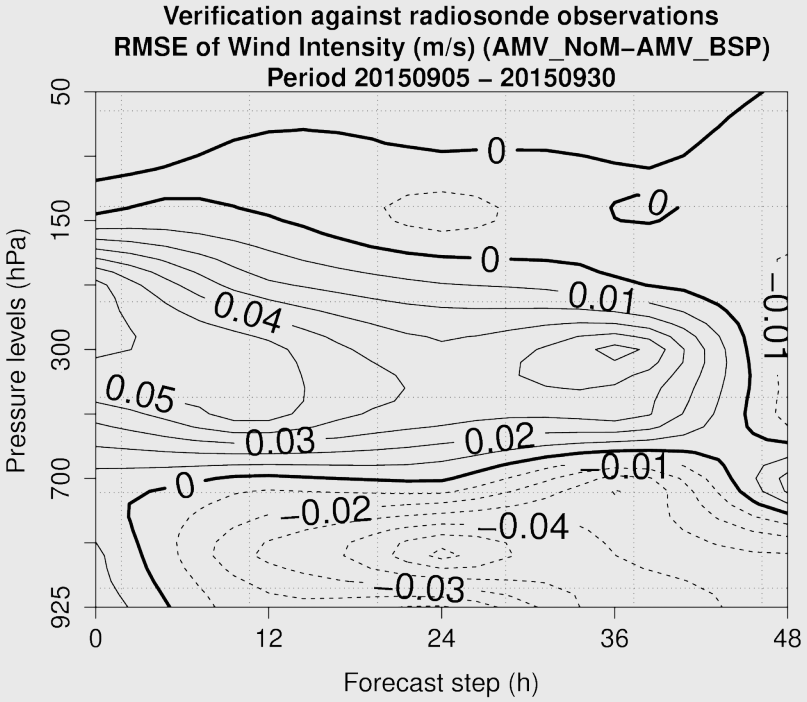
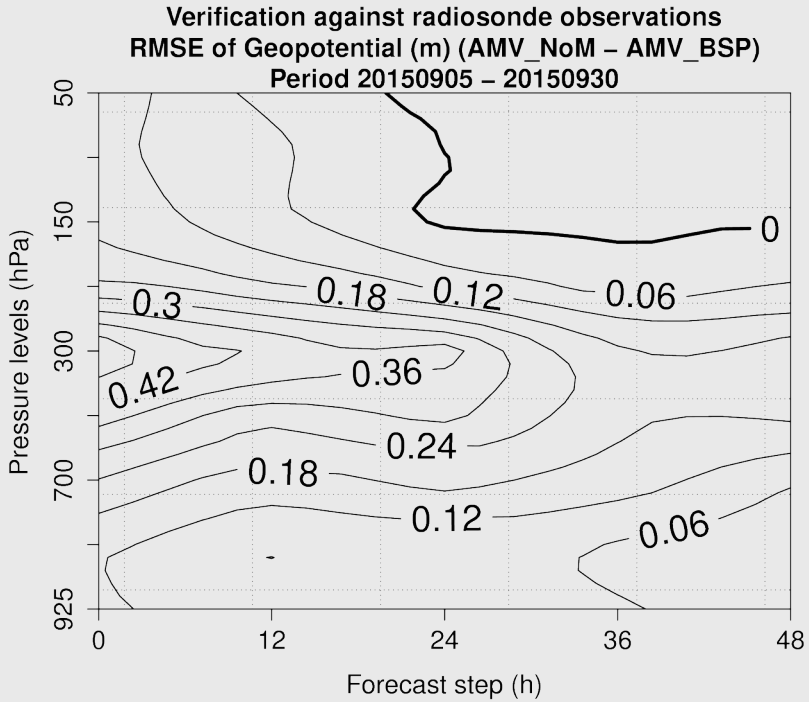
Impact of combined polar and geo-winds

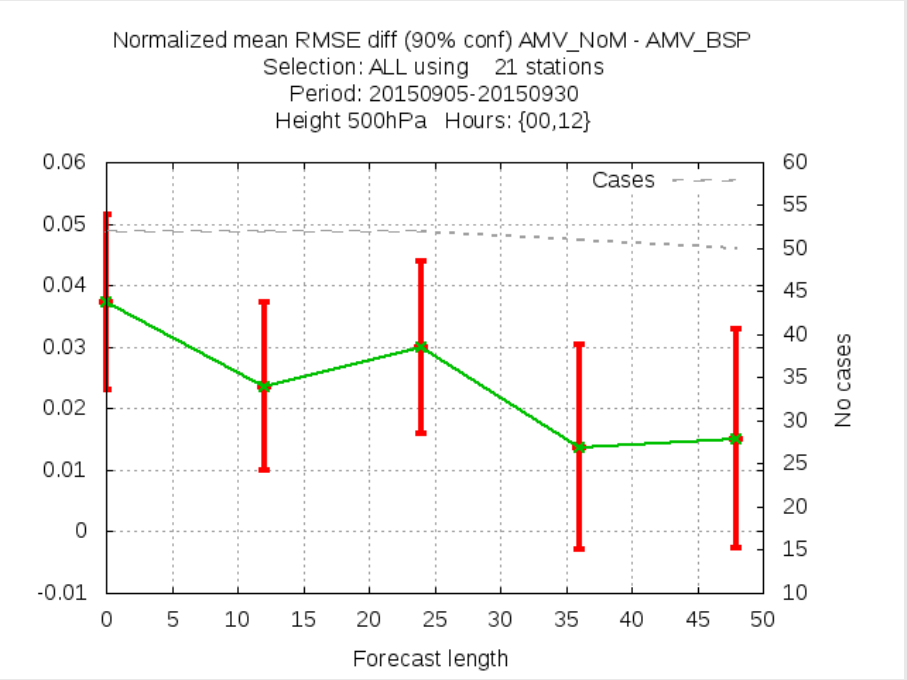




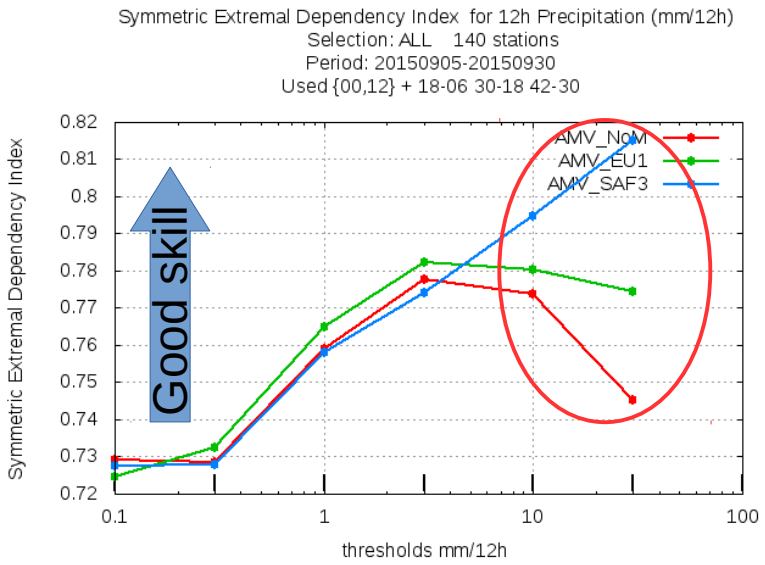
Impact over the MetCoOp model domain

Test period 1: 2015 Jul. 1-31; 4 days warming
period 2: 2015 Sept. 1-30

Significant impact on geopotential

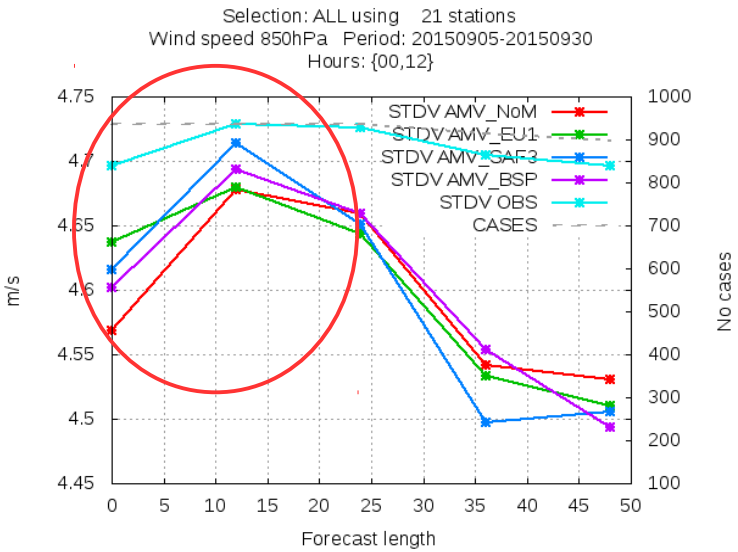


Impact of individual wind product



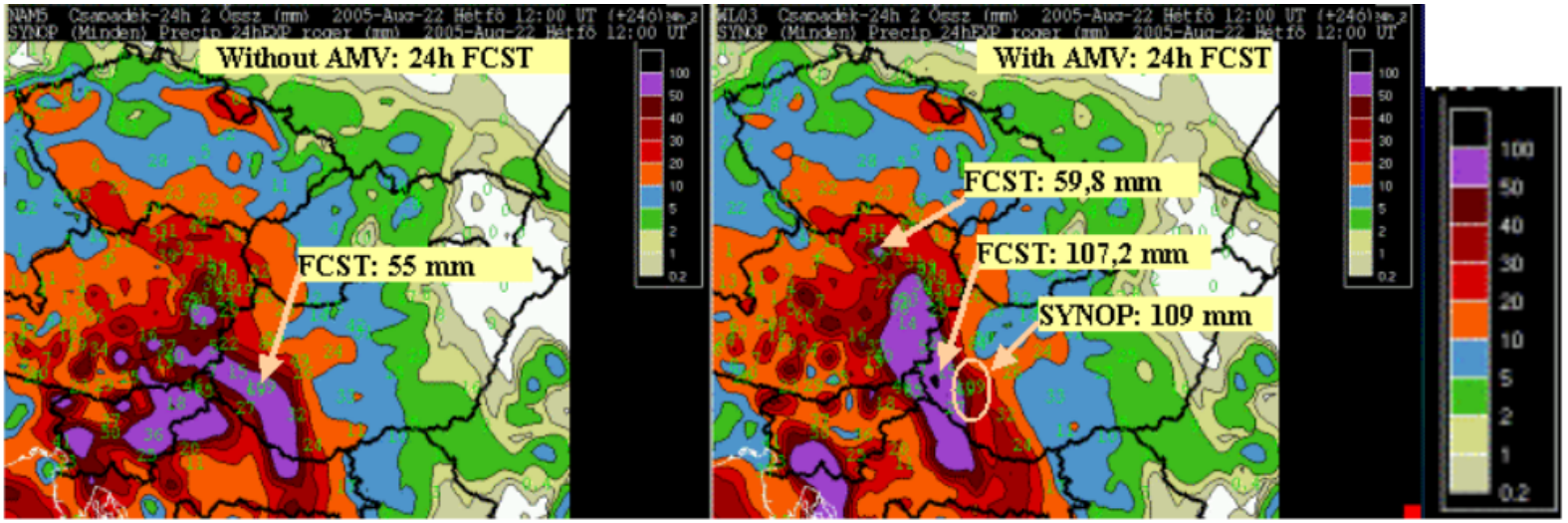
12-h accum. Precipitation

Red – control without AMV
Green – with GeoEUMET
Blue – with GeoSAF (HRW)



Wind speed at 850 hPa

Red – control without AMV
Green – with GeoEUMET
Blue – with GeoSAF (HRW)
Magenta – with GeoSAF and Polar Wind

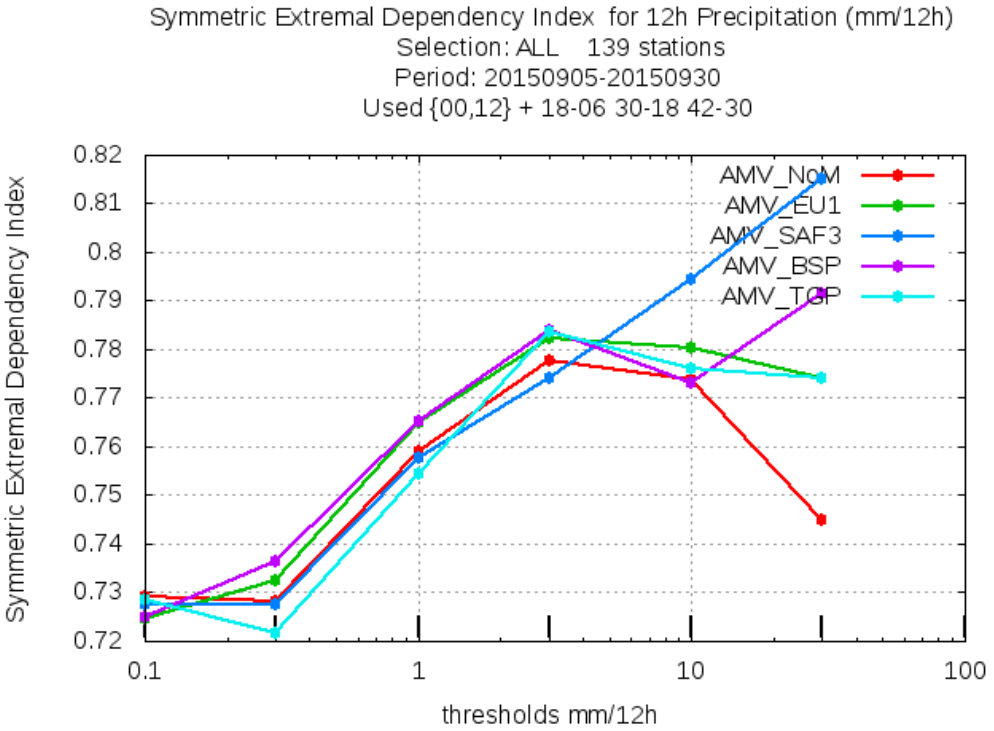


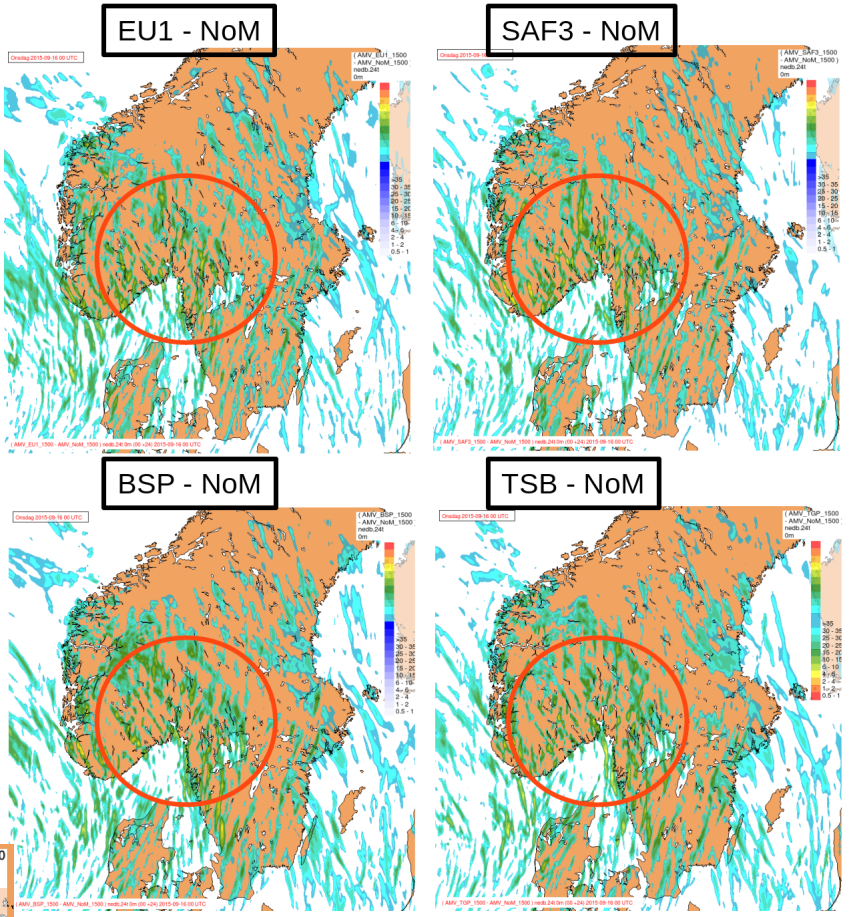
Old experiment showing the same impact on precipitation

Impact of Geowind on Aladin (Hungarian Met Service)

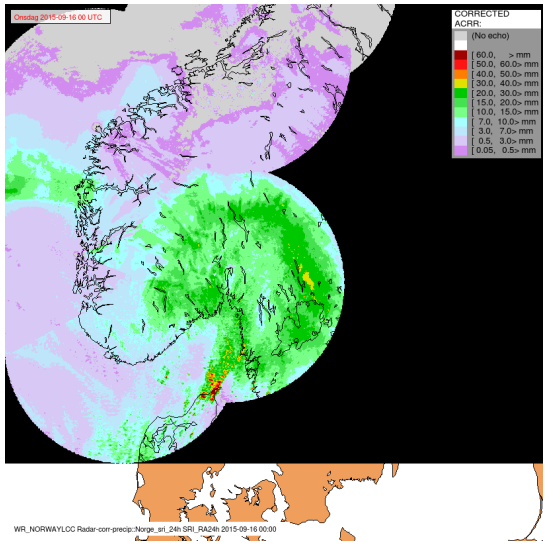
24-hour acumulated precipitation

Impact of individual AMV on 12h and 24h accumulated precip

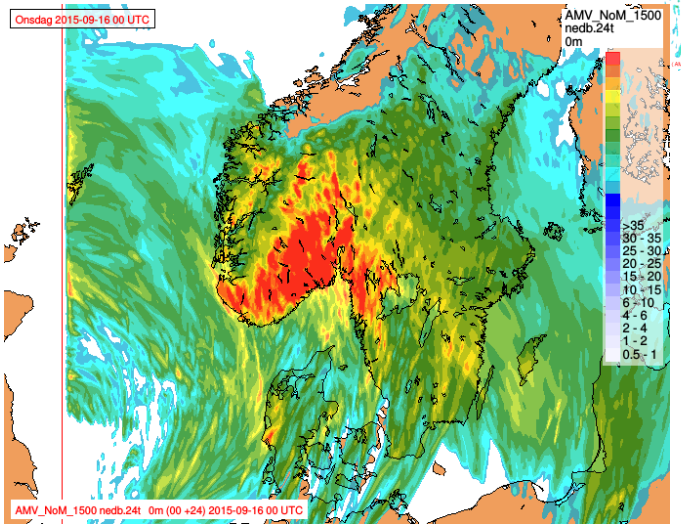




Radar observation



NoM forecast

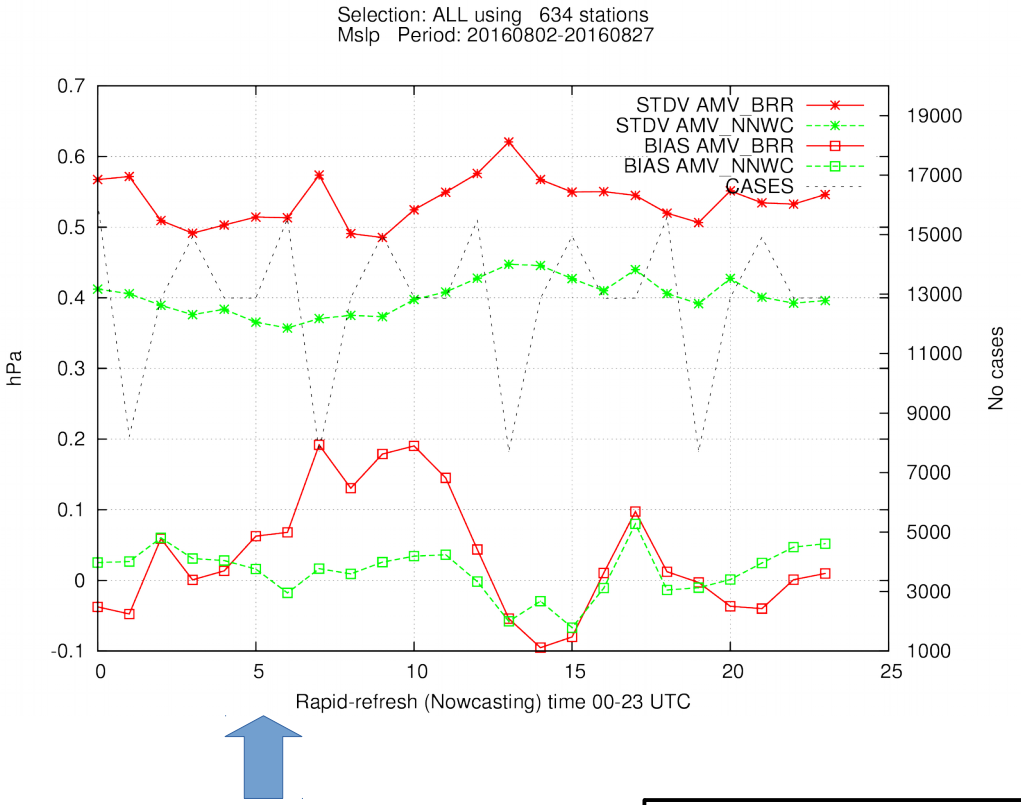


24-hours accumulated precipitation

NoM – control without AMV
EU1 – with GeoEUMET
SAF3 – with GeoSAF (HRW)
BSP – with GeoSAF and Polar Wind
TSB – with All winds

Impact of GeoSAF (HRW) on rapid restart (RR) (Nowcasting using only GeoSAF)

Rapid restart using a 3 hourly cycled 3DVar (imitating the operational system) short-range forecasts (varying from 2 to 7 hours depending on the nowcasting time) as first-guess

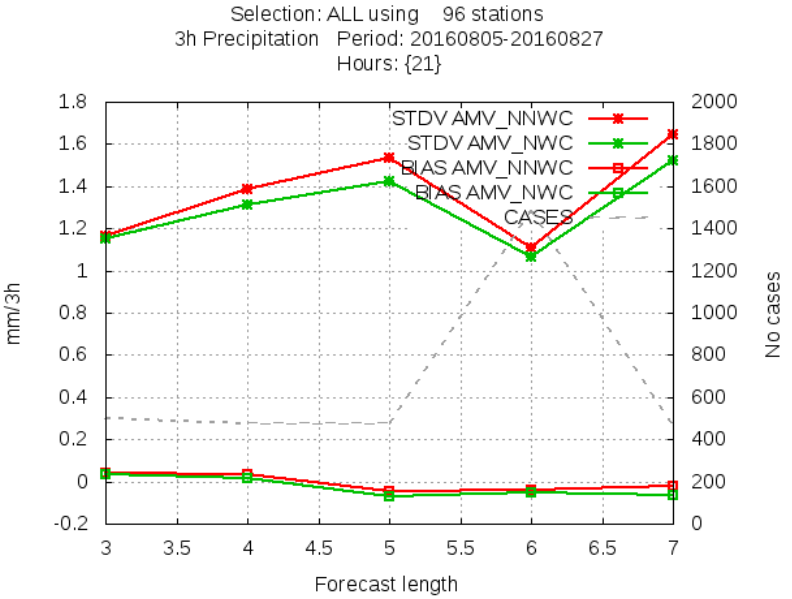


Mean sea level pressure

Red – different short-range fcast valid at now time
Green – RR analysis (now time)

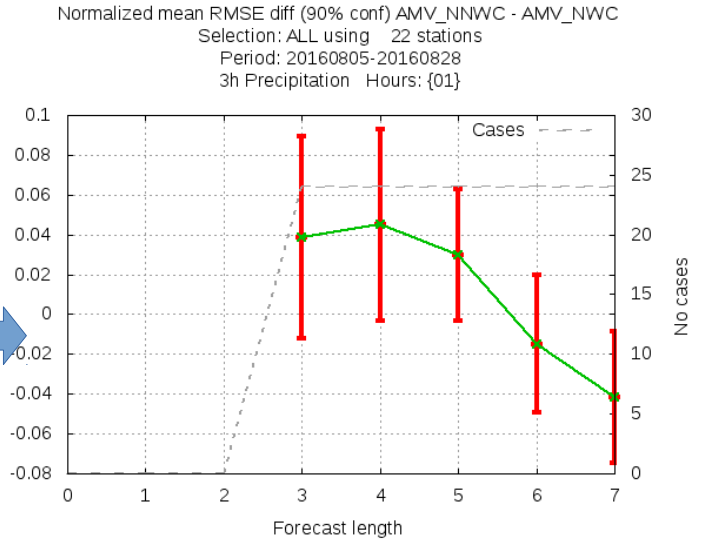
3-h accum. Precipitation fcast

without AMV – with AMV



Mean sea level pressure

Red – control without AMV
Green – with GeoSAF (HRW)



Summary (1)

- We have now few projects dealing with different retrieved wind data.
- **ASCAT** have slightly positive impact on the analyses and forecasts of the Harmonie-Arome.
- **Geostationary AMV** have moderate positive rather than neutral impact on AROME-MetCoOp upper-air analyses and forecasts. The impact on the intense precipitation is clearly positive.
- The impact of the **polar winds** on the analyses and forecasts of the AROME-Arctic is clearly positive for both surface and upper-air variables.
- Using the **polar winds together with the HRW** significantly improved the accuracy of the analyses and forecasts of the AROME-MetCoOp model for both surface and upper-air levels.
- Using all **the three available wind data sets together** did not provide further clear improvement.
  – loss of accuracy in forecasts of precipitation, for example.
  – we probably have a redundancy problem with geostationary AMV data in the assimilation system.

Summary (2)

- Through **DFS** computation, **AMV data influence the analysis system** so that the surface observations show slightly less relative influence.
- The **sensitivity of the model to the AMV data** is slightly higher than that of the other observing systems used the analysis in case of non-stationary or intense weather phenomena.
- Taking into account the timeliness of the geostationary and polar winds,
  – The geostationary winds (HRW) was tested in the 1-hourly non cycling **rapid-refresh (RR) system,** where
  – Comparable impact as on the 3-hourly cycling DA;
  – Positive impact on forecasts of precipitation and cloudiness.

More about this study: https://www.met.no/publikasjoner/met-report/met-report-2017/_/attachment/download/f73796bf-5916-4eca-841f-5d8315455c13:80e930cb50b76b794672c2949c0b37c624f4d6d9/met-report-04-2017.pdf

Decisions:

==> The polar wind data are now finally included in the pre-operational Arome-Arctic model, which is under validation now.

==> The Geowind data will be tested in the nowcasting MetCoOp system.

Thank you for your attention!