



Norwegian
Meteorological
Institute

Impact of observations in HARMONIE-AROME DA during the YOPP SOP1 period

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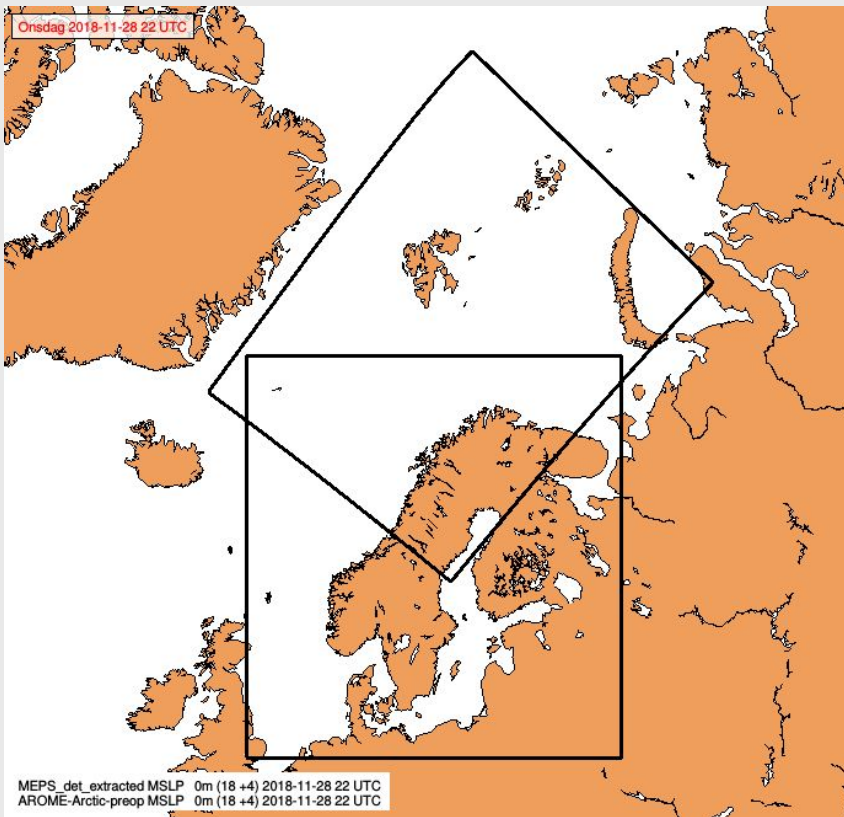
Acknowledgment: Niels Bormann & Heather Lawrence

29th ALADIN Workshop & HIRLAM All Staff Meeting 1-4/04/2019, Madrid, Spain

Outline

- Introduction of the NWP system
- The OSE strategy
- The available observations
- Impact study
- Preliminary conclusions

The DA and NWP system



System setup: (Harmonie cycle 40h1.1.1)

- METCOOP & AROME-Arctic
- Model level definition: 65 level
- Horizontal resolution 2.5 km
- Non-hydrostatic dynamic
- Physical parametrization: Harmonie-AROME
- Data assimilation: 3D-VAR
OI for surface
- 3-hourly cycling
- Lateral boundary conditions: ECMWF
- Observations: Conventional, satellite
- Satellite: AMSU-A, MHS, IASI, Scatterometer (L2), AMV

- Large scale information taken into account using spectral mixing between first-guess and LBC

OSE experiments in Alertness

Alertness **task 2.5**: In frame of the **APPLICATE** project ECMWF is running OSE experiments and sharing with us the results to be used as lateral boundary conditions (LBCs).

They run two series of OSE: with global and Arctic (lat ≥ 60) observations denial.

Scenarios: **(1)Global control LBC1** **(2)Global Arctic denial LBC2** **(3)Global denial LBC3** **4) LAM control** **(5) LAM denial**

Relative impact of observations:

Case 1: LBC1 + (4) vs LBC1 + (5) => impact of obs in LAM

Case 2: LBC1 + (5) vs LBC2/LBC3+ (5) => impact of obs through LBC in LAM

Case 3: **Global** vs **Arctic** denial => impact of non-Arctic observations in Arctic (LAM)NWP

BUT: LBC1 + (4) vs LBC2/LBC3 + (5) shows the real impact of observations

Global denial experiments

Experiments performed in Jan-Feb

Global denial (LBC), the following observations were taken out from the DA:

- All microwave satellite radiances
 - All infrared satellite radiances
 - All atmospheric motion vectors (AMV)
 - All conventional observations
 - ~~- GNSS RO~~
- **Control run using all observation is common in both studies**

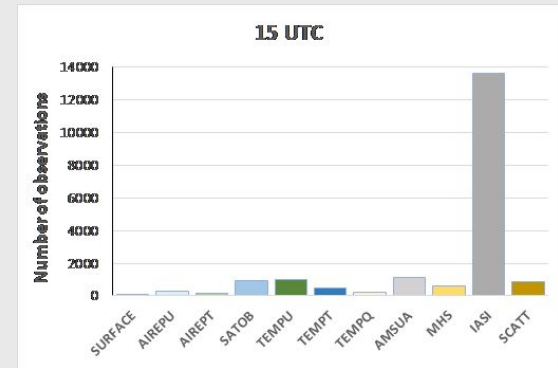
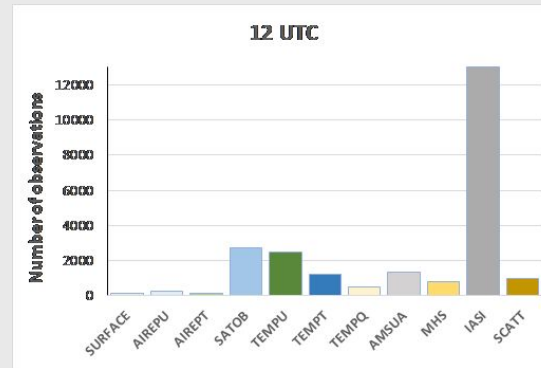
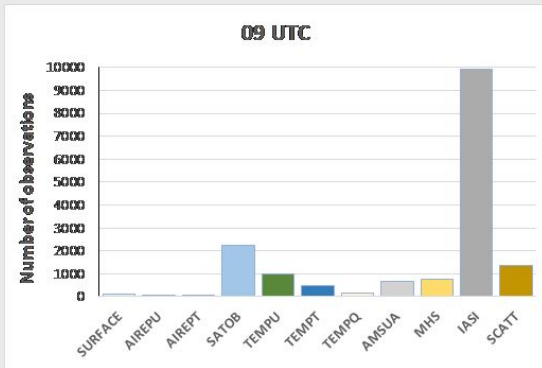
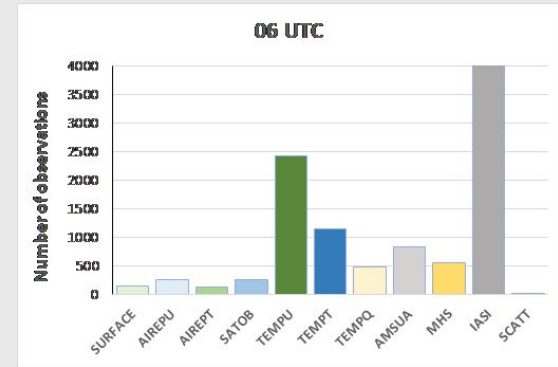
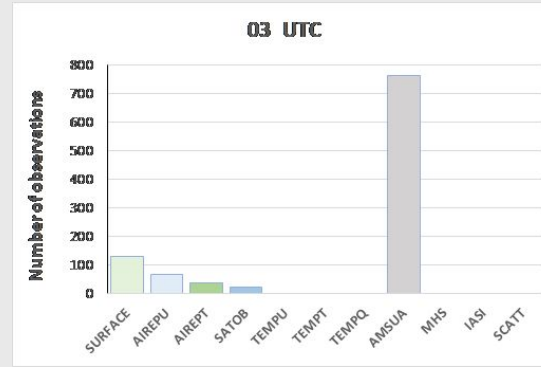
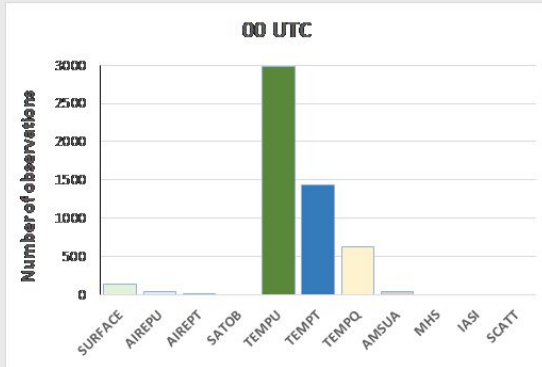
Experiments performed in Feb-March

Arctic denial (LBC), the following observations were taken out from DA:

- All microwave satellite radiances
 - All microwave temperature sensitive radiances
 - All microwave humidity sensitive radiances
 - All infrared satellite radiances
 - All atmospheric motion vectors (AMV)
 - All conventional observations
-
- All radiosonde observations
 - All surface pressure observations
-
- All SOP1 observations

The available observations

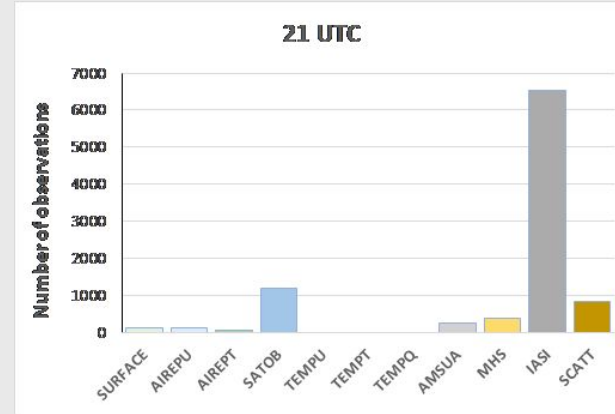
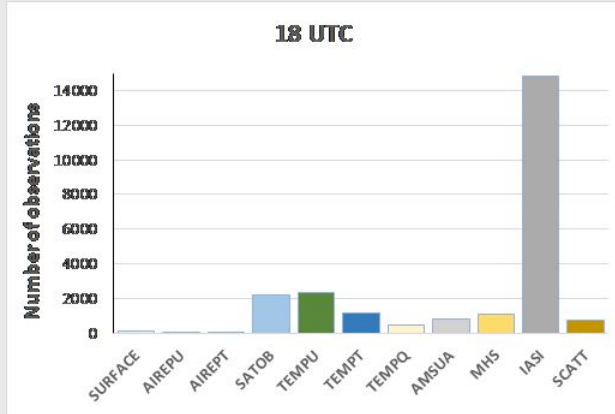
Note the difference in scales in the plots



Case of March 30th, 2018

The available observations

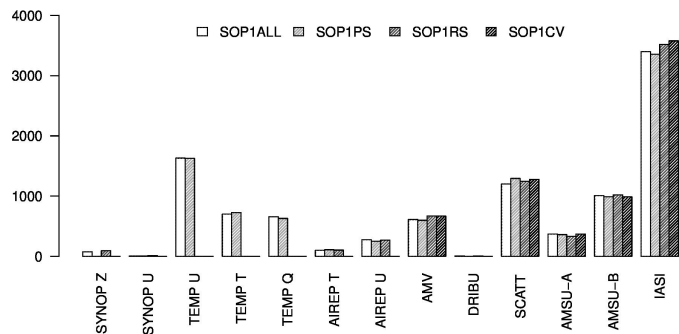
Note the difference in scales in the plots



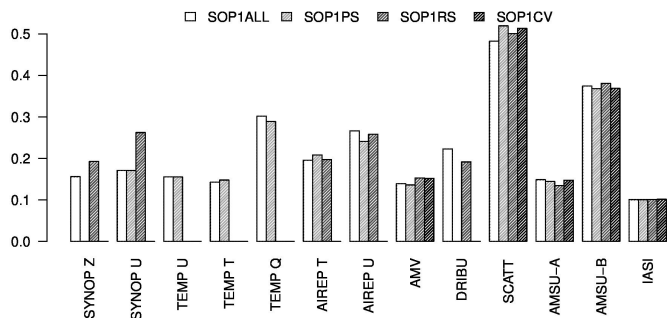
Case of March 30th, 2018

Sensitivity of the AROME-Arctic analyses to the observations using Degrees of Freedom for Signals (DFS)

Absolute Degree of Freedom for Signal (DFS)



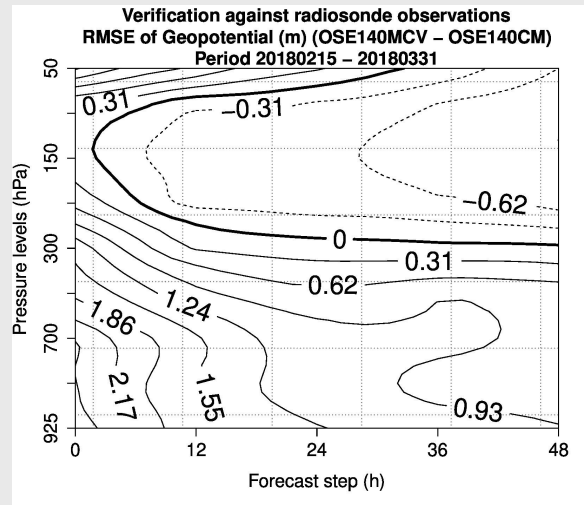
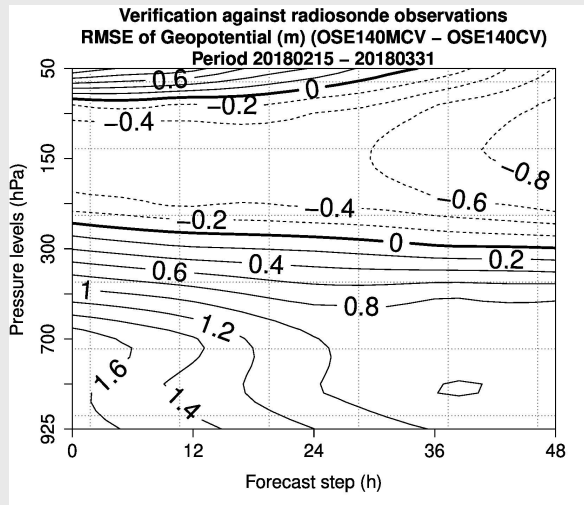
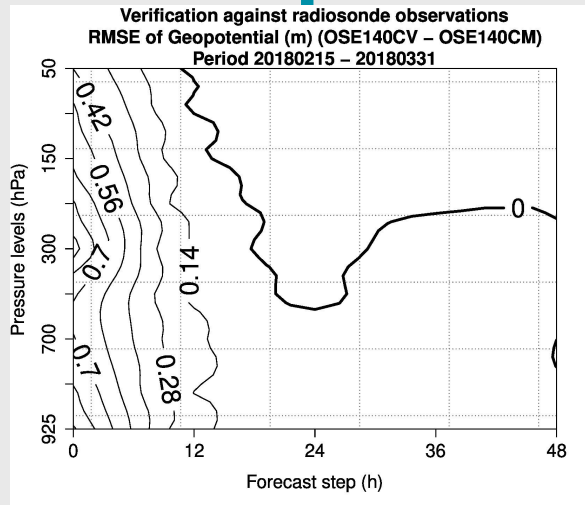
Relative Degree of Freedom for Signal (DFS/observations)



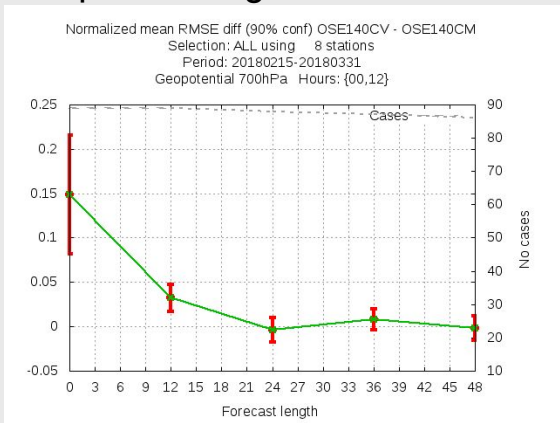
Where: SOP1ALL: analysis with all observations
 SOP1PS: analysis without surface pressure
 SOP1RS: analysis without radiosondes
 SOP1CV: analysis without all conv observations

The following data (analyses) were used in this computation:
 2018030100, 2018030506, 2018031012, 2018031518

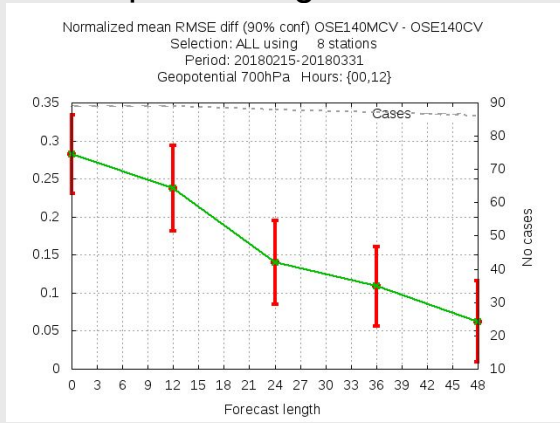
Impact of conventional observations



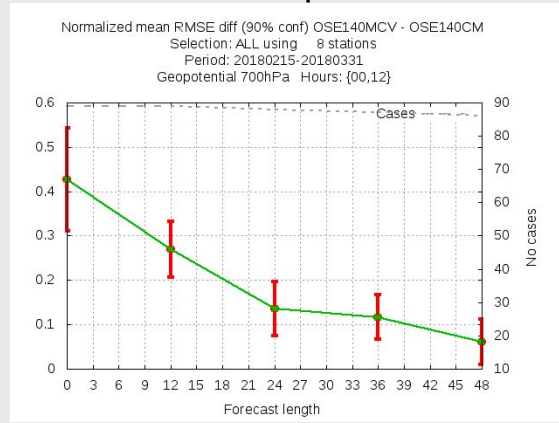
Impact through LAM assim



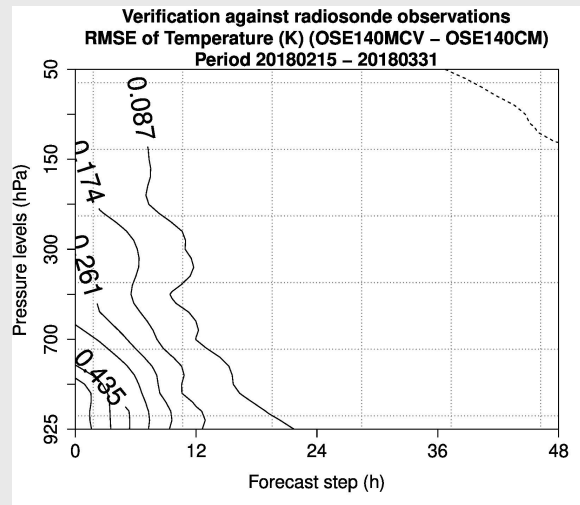
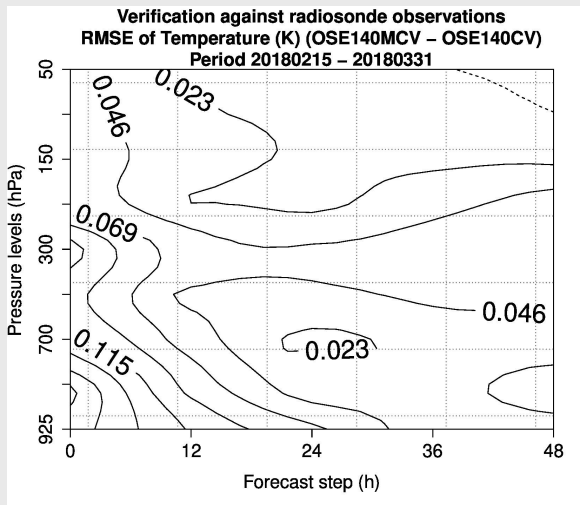
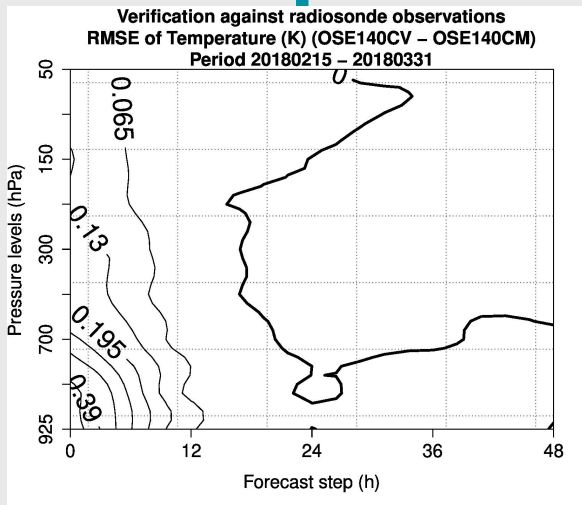
Impact through LBC



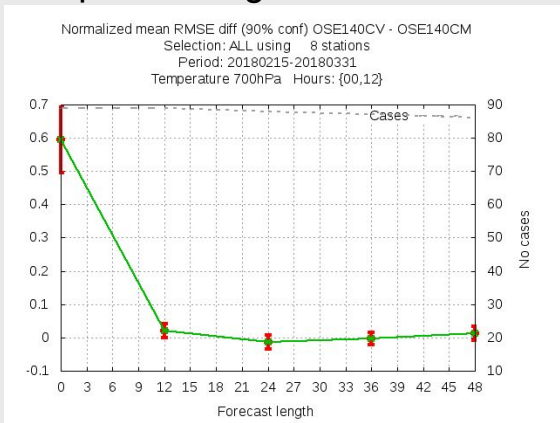
Real impact



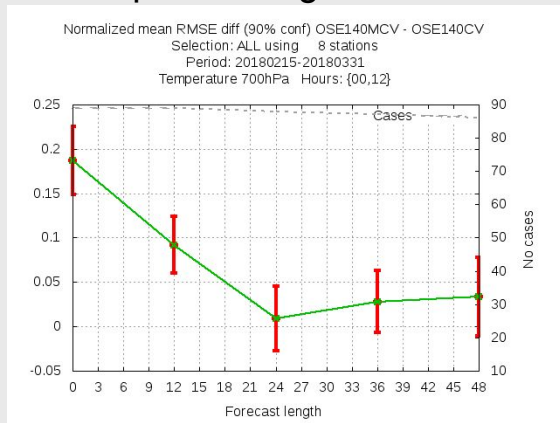
Impact of conventional observations



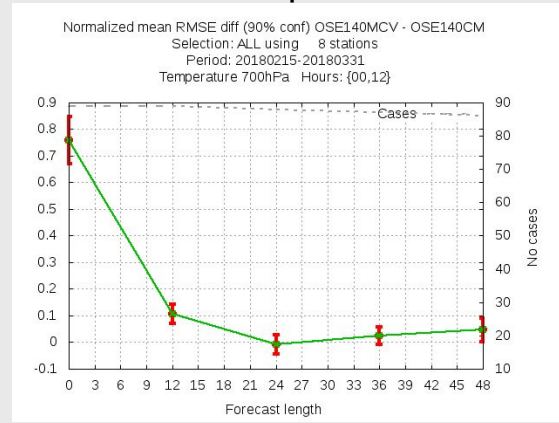
Impact through LAM assim



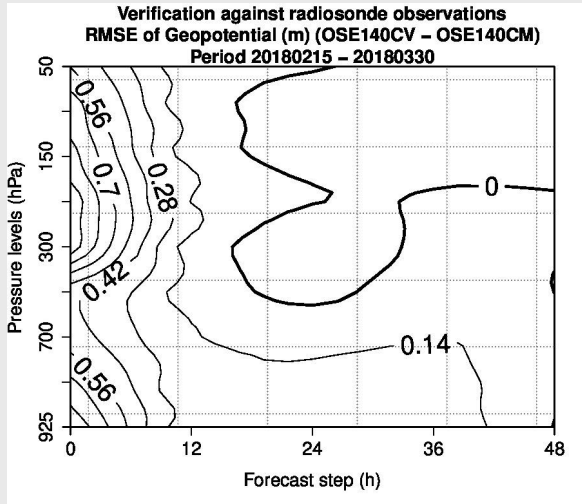
Impact through LBC



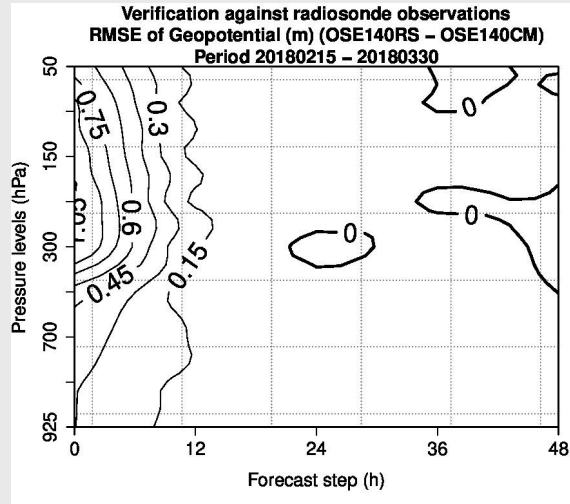
Real impact



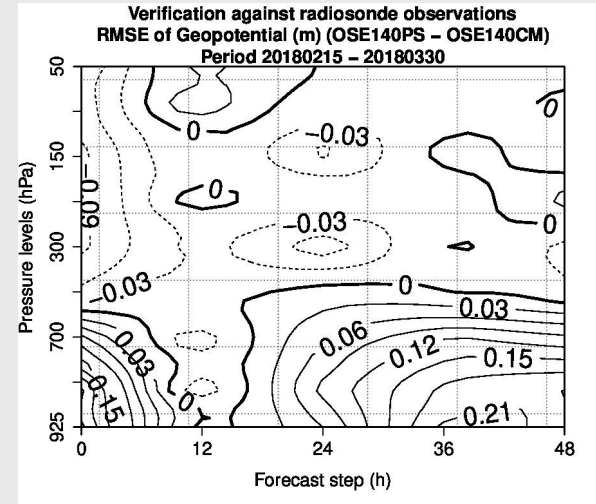
Impact of conventional observations



Significant up to 12 hours
All Conventional



Significant up to 12 hours
All radiosondes

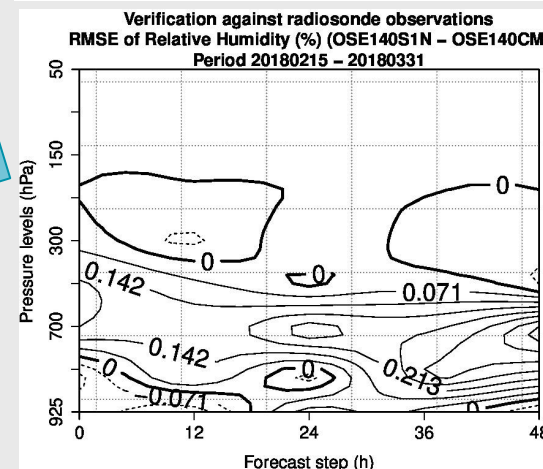
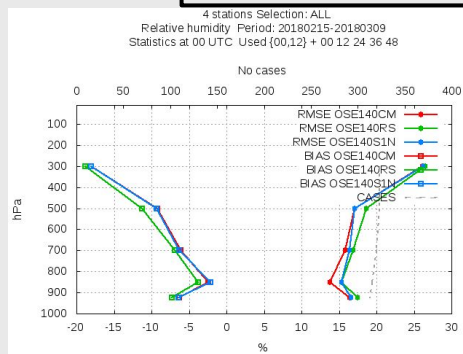
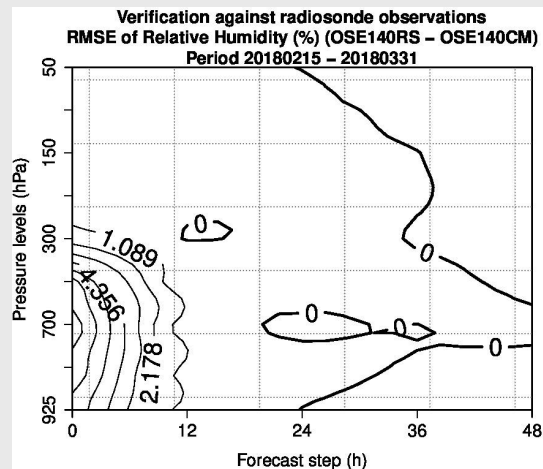
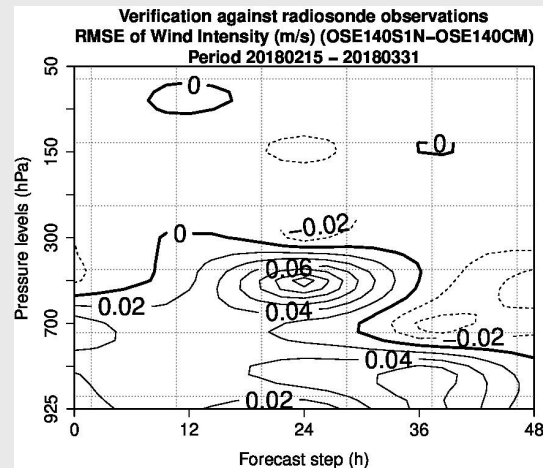
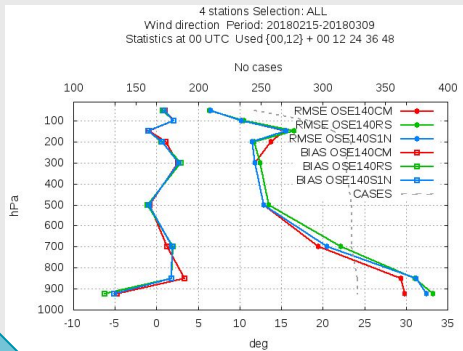
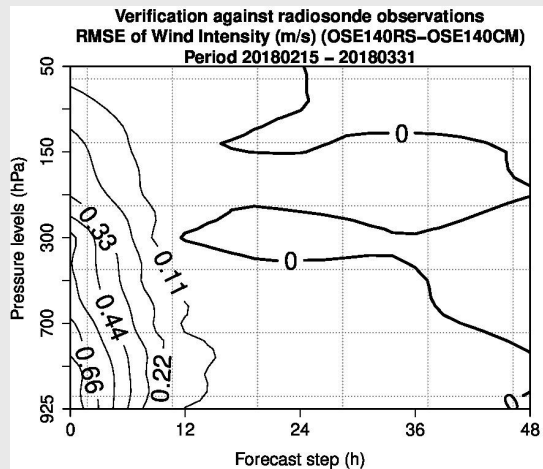


not significant
All surface pressure

These are “experiments without minus with” the observations

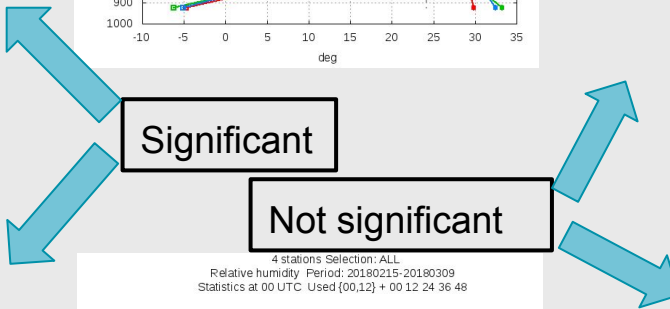
Impact of the SOP1 observations

Note the difference in the amplitude in the scores

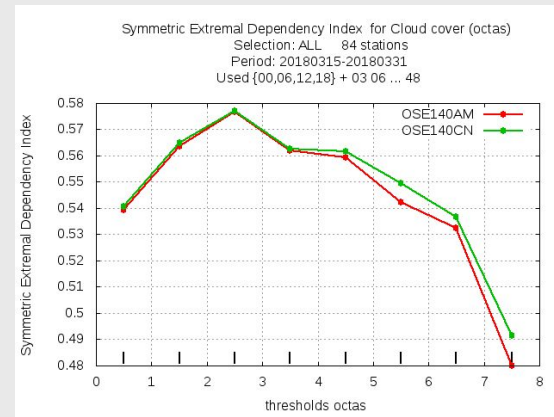
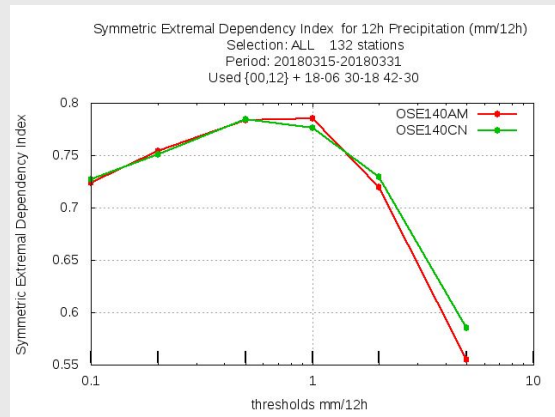
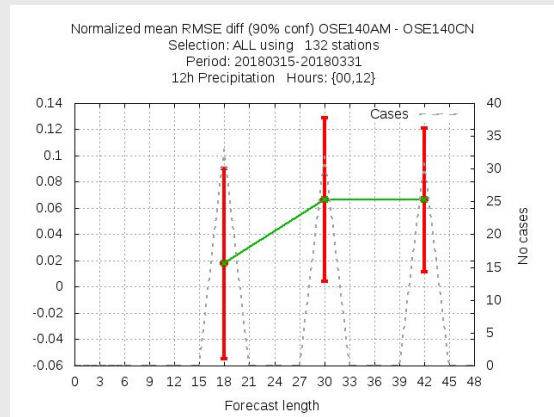
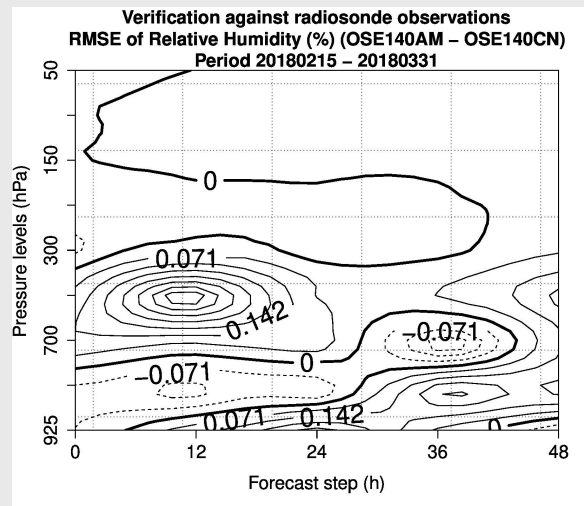
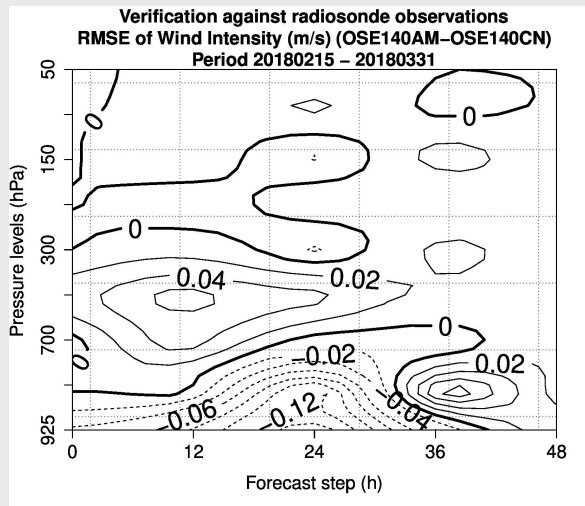
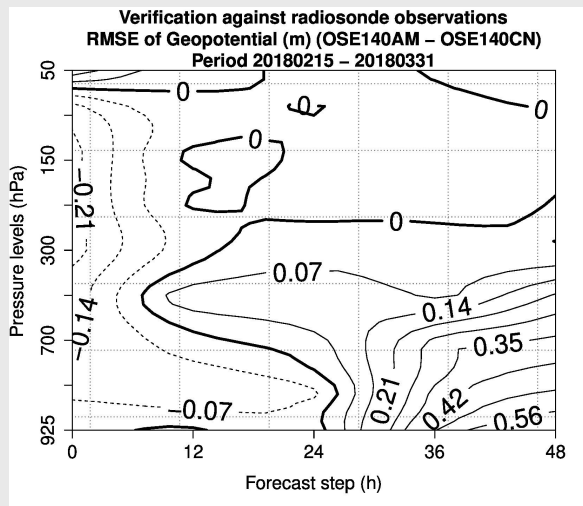


Significant

Not significant

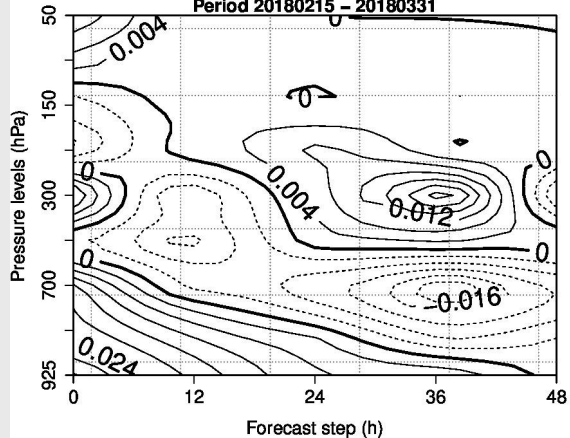


Impact of atmospheric motion vectors (AMV)

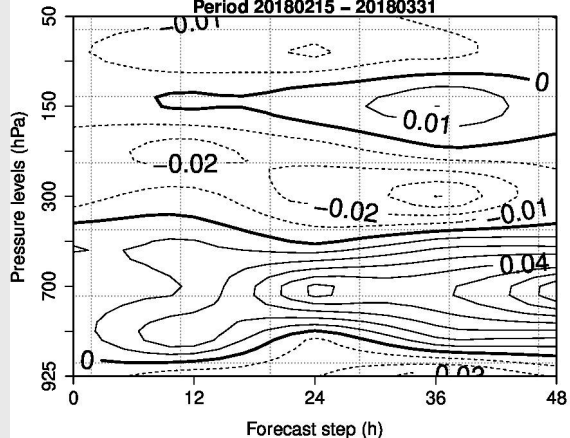


Impact of infrared (IASI) radiance

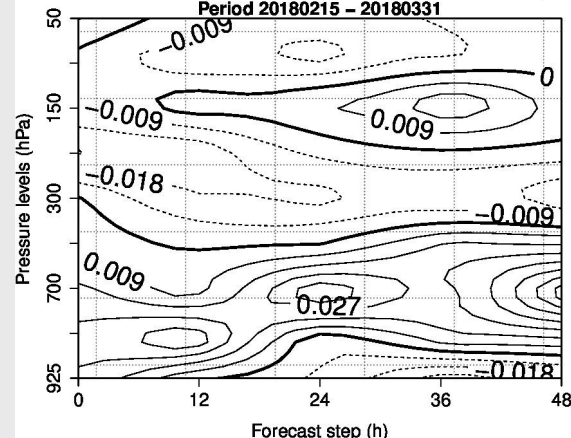
Verification against radiosonde observations
RMSE of Temperature (K) (OSE140IR - OSE140CN)
Period 20180215 - 20180331



Verification against radiosonde observations
RMSE of Temperature (K) (OSE140MIR - OSE140IR)
Period 20180215 - 20180331

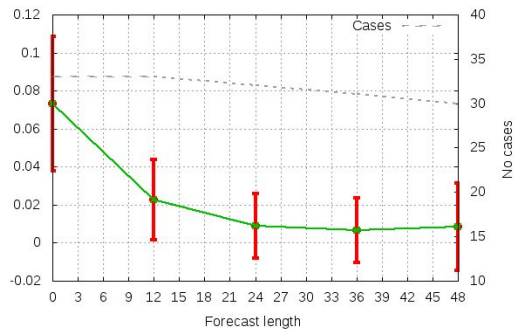


Verification against radiosonde observations
RMSE of Temperature (K) (OSE140MIR - OSE140CN)
Period 20180215 - 20180331



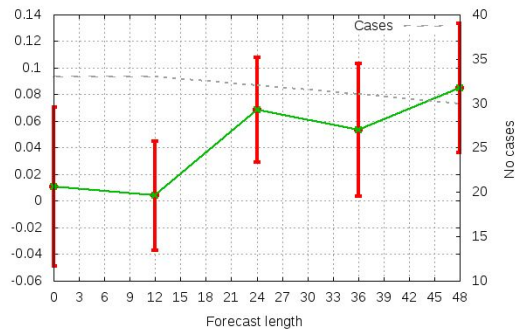
Impact through LAM assim

Normalized mean RMSE diff (90% conf) OSE140IR - OSE140CN
Selection: ALL using 8 stations
Period: 20180315-20180331
Temperature 925hPa Hours: {00,12}



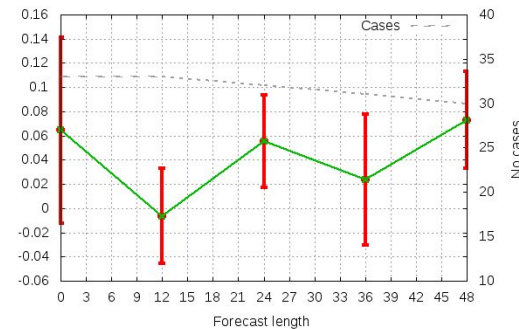
Impact through LBC

Normalized mean RMSE diff (90% conf) OSE140MIR - OSE140IR
Selection: ALL using 8 stations
Period: 20180315-20180331
Temperature 700hPa Hours: {00,12}

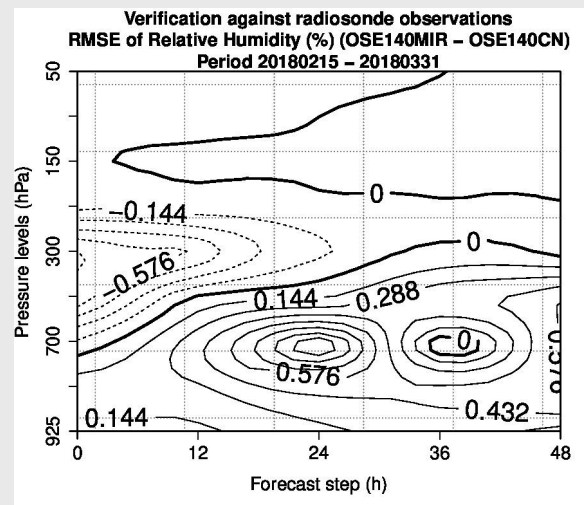
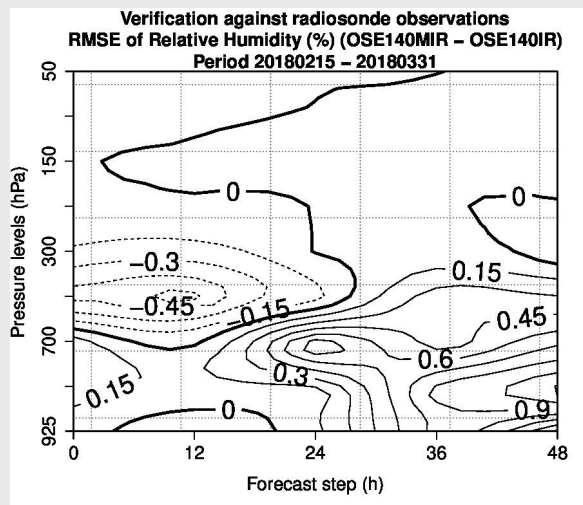
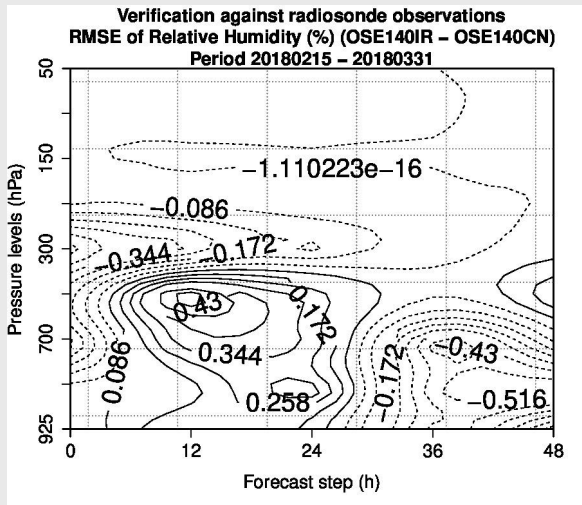


Real impact

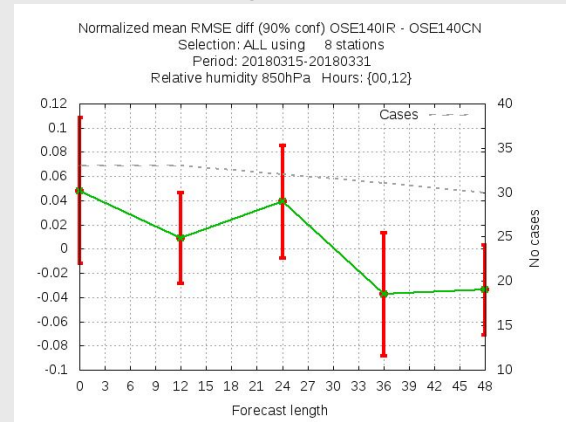
Normalized mean RMSE diff (90% conf) OSE140MIR - OSE140CN
Selection: ALL using 8 stations
Period: 20180315-20180331
Temperature 700hPa Hours: {00,12}



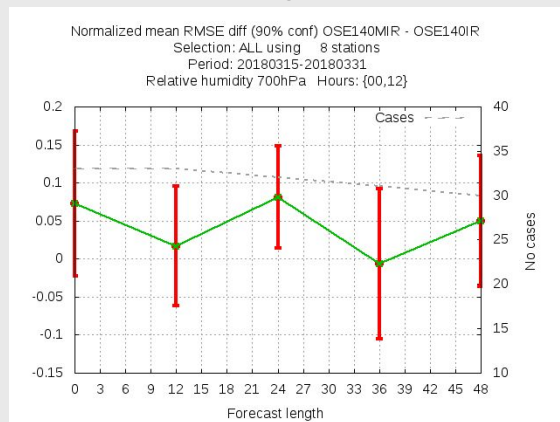
Impact of infrared (IASI) radiance



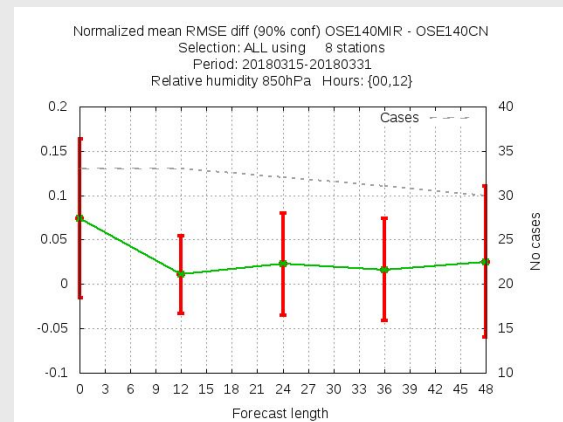
Impact through LAM assim



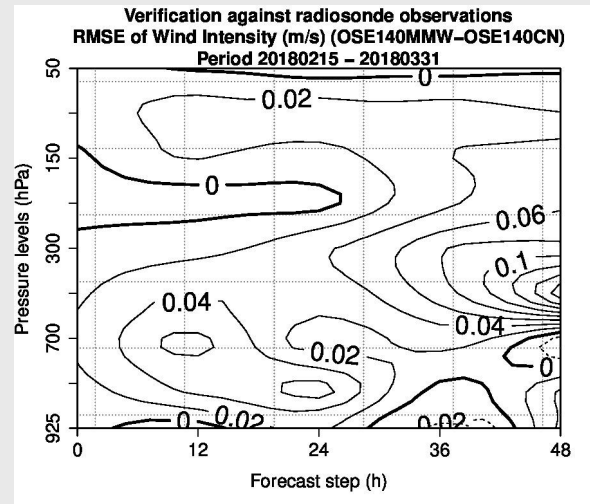
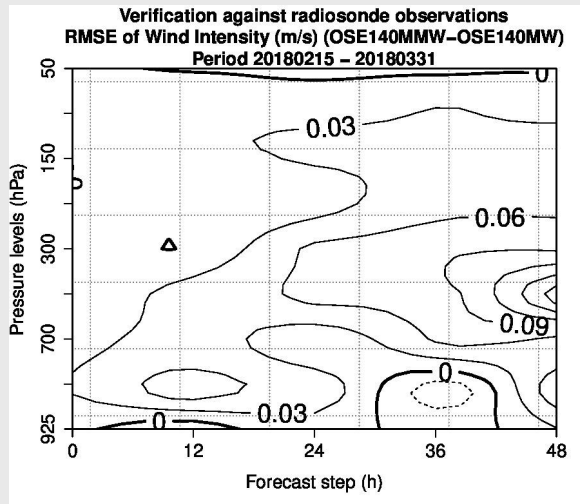
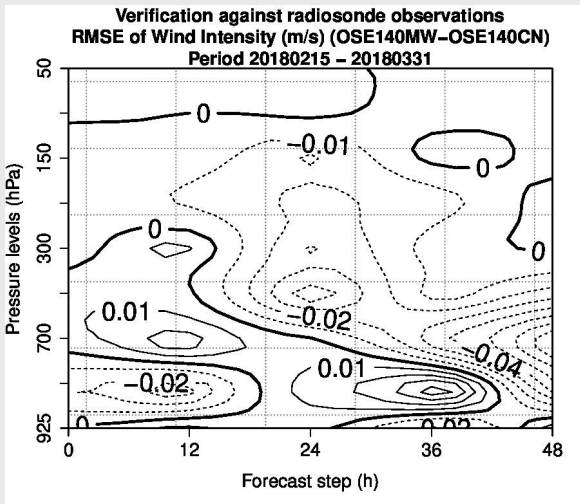
Impact through LBC



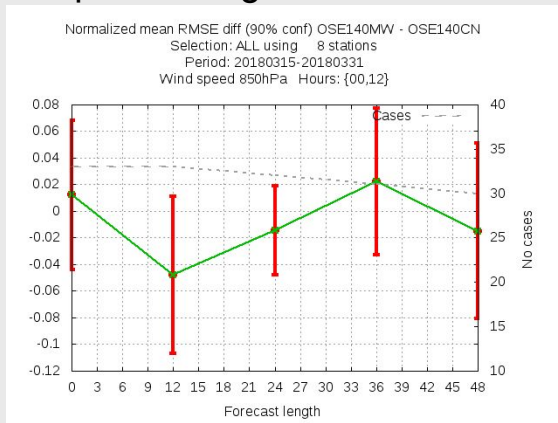
Real impact



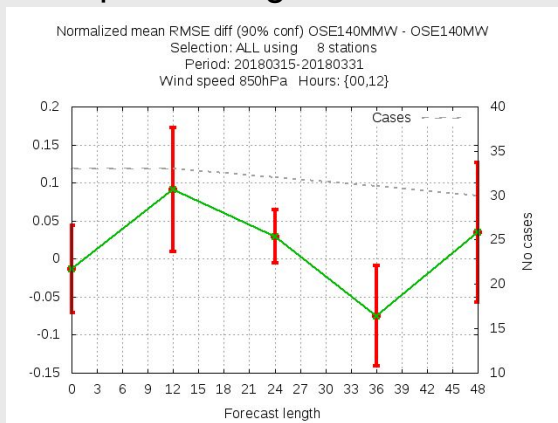
Impact of microwave radiances



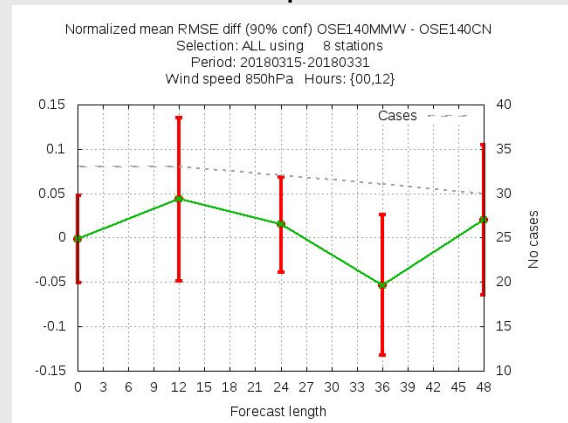
Impact through LAM assim



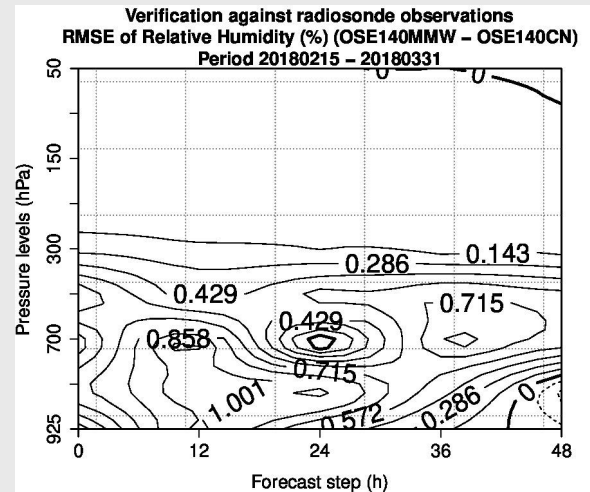
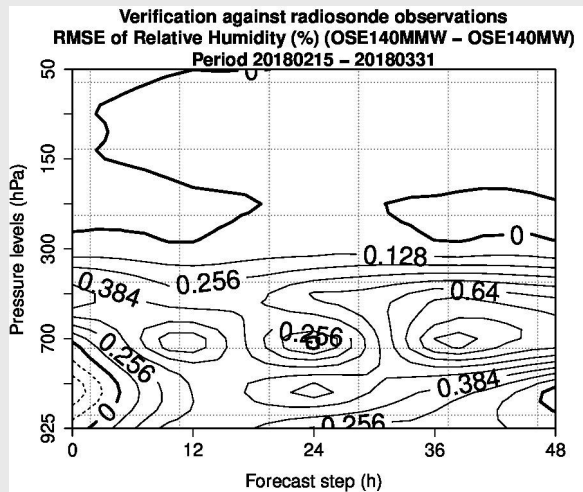
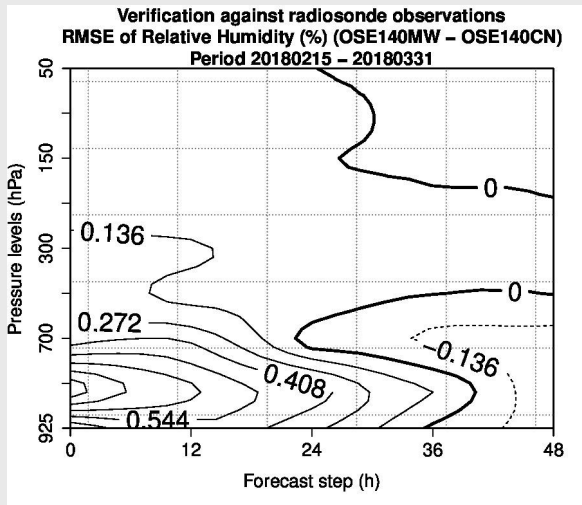
Impact through LBC



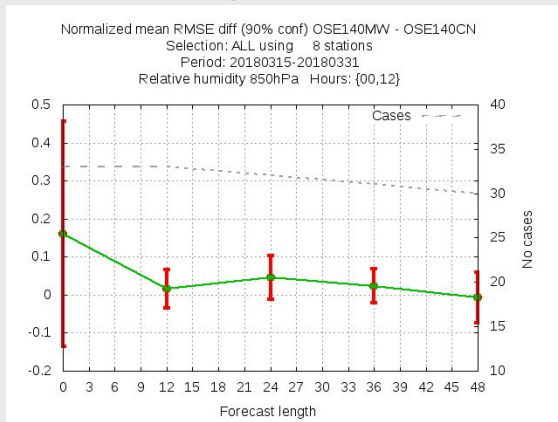
Real impact



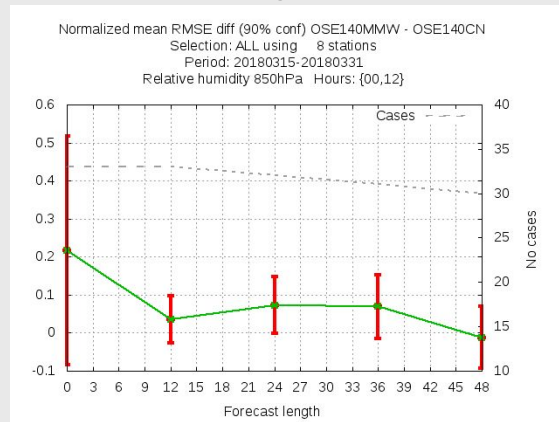
Impact of microwave radiances



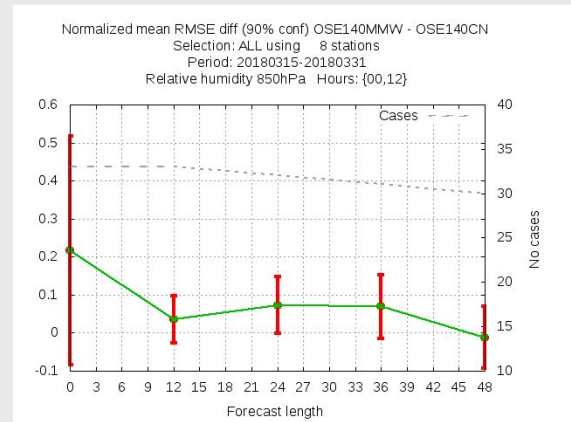
Impact through LAM assim



Impact through LBC



Real impact



Large scale spectral mixing

4.1 LSMIXBC

This method modifies the first guess, \hat{x}_b , before doing the 3DVAR analysis. The large scales from the coupling system are combined with the small scales from the first guess:

$$\hat{x}_b^{mixed}(m, n, lev) = w_{BC} \hat{x}_{ls}(m, n, lev) + (1 - w_{BC}) \hat{x}_b(m, n, lev) \quad (1)$$

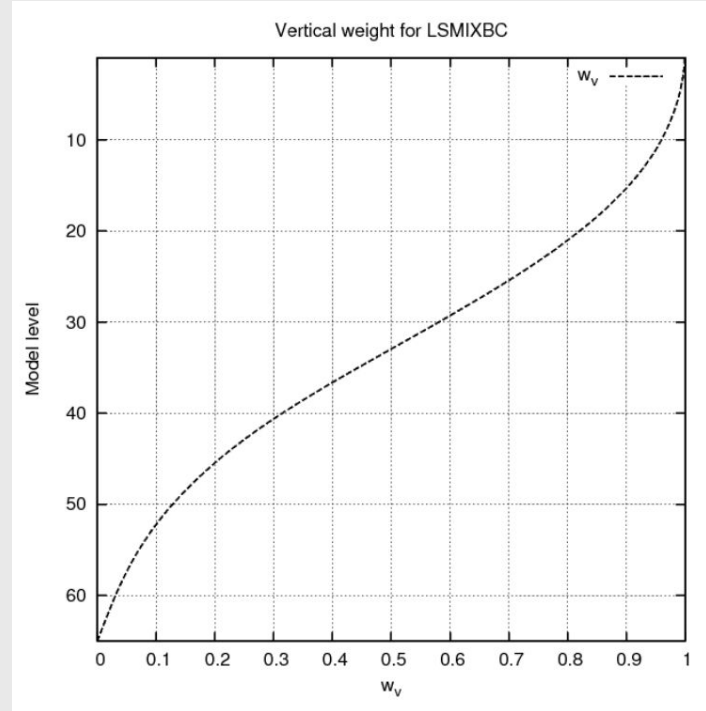
where (m,n) are wave-numbers, *lev* is vertical level and w_{BC} a weighting function for the boundary condition (BC) fields. Each wave-number pair (m,n) is linked to a total wave-number k^* by:

$$k^* = \sqrt{M_{max}N_{max} \left[\left(\frac{m}{M_{max}} \right)^2 + \left(\frac{n}{N_{max}} \right)^2 \right]} \quad (2)$$

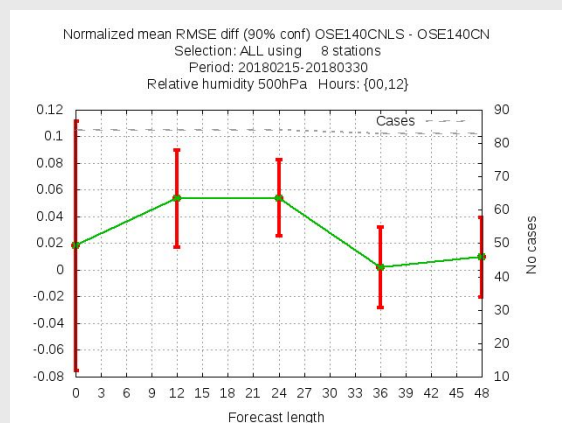
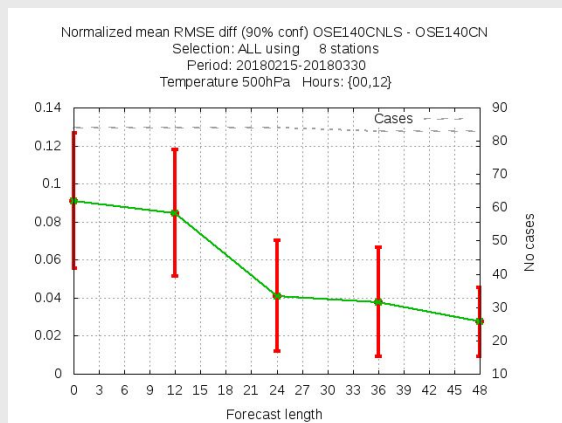
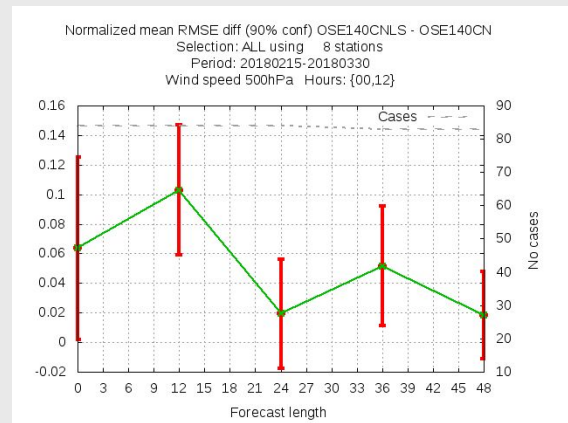
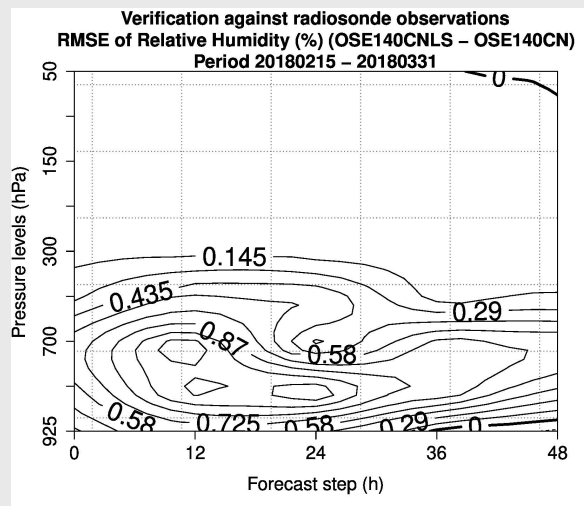
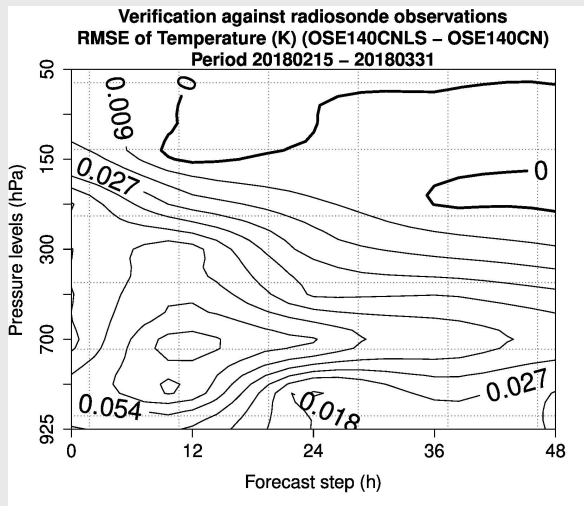
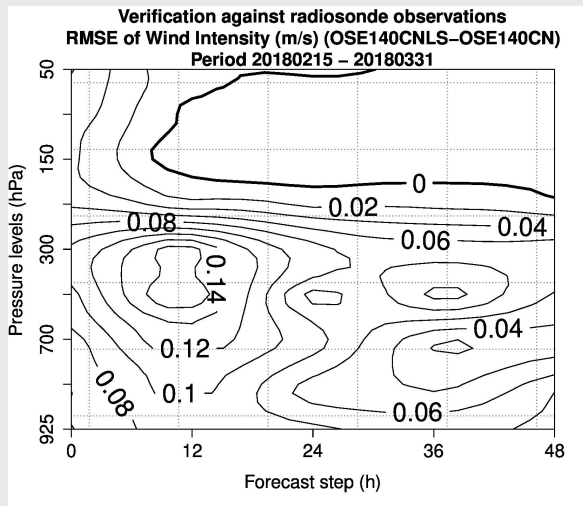
The weighting function in equation 1 consists of a horizontal and vertical part:

$$w_{BC} = w_h w_v \quad (3)$$

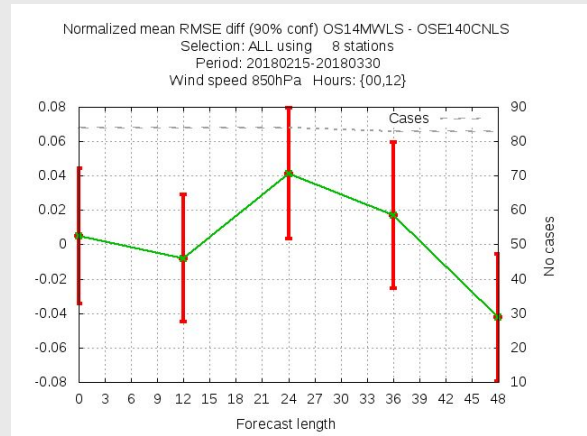
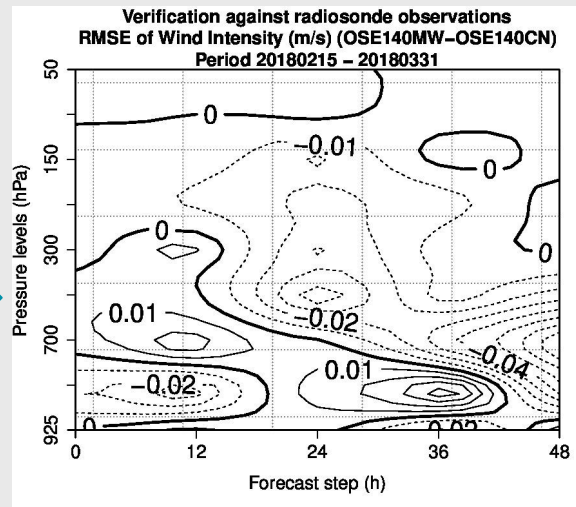
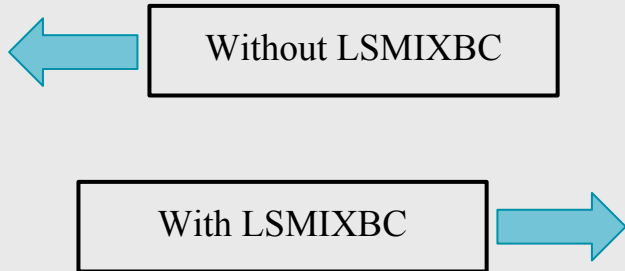
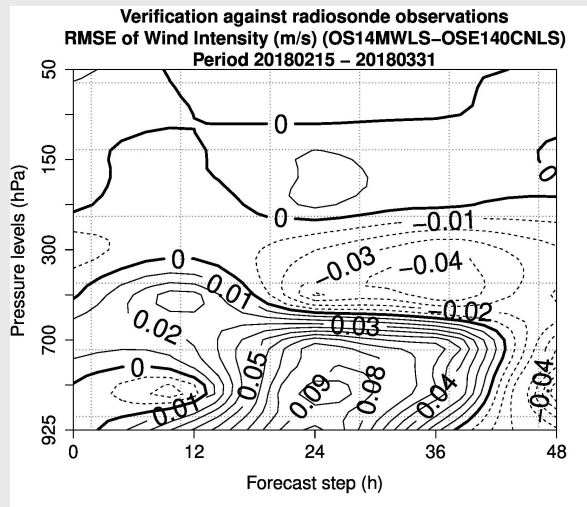
w_h depends on a cut-off wave-number that is computed by dividing the regional model resolution in degrees, R_{own} , with the host model resolution in degrees, R_{ls}



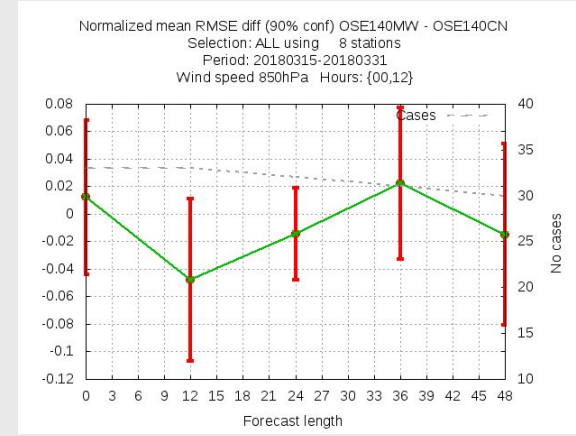
Impact of large scale mixing (without - with)



The relative Impact of observations



The impact of observations is not the same in a system with and without LSMIXBC



(Preliminary) Conclusions

- We use the operational setting in this study, although the relative impact of observations on our analyses and forecasts is relatively higher.
- (Large) significant positive impact of the conventional observations was observed through both LAM DA and LBC.
- The impact of radiosonde observations on (V, T, Geo) analyses and forecasts is significantly positive up to 12 hour forecast.
- A slightly positive and not significant impact of the SOP1 observations was observed.
- The impact of AMV through both LAM DA and LBC is positive. Positive and significant impact of AMV is also observed in some surface parameters.
- We observed positive impact of IASI radiance on analyses and forecasts gained through both LAM DA and LBC.
- Different impact of the microwave radiances on analyses and forecasts was found through LAM DA and LBC.
 - while the impact on temperature and geopotential was found to be slightly negative through LAM DA, the impact through LBC was found to be slightly positive
 - The impact on wind and humidity was found slightly positive through both LAM DA and LBC.

Thank you for your attention!