



Norwegian
Meteorological
Institute

Impact of observations on the AROME-Arctic regional model

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Acknowledgment: Niels Bormann & Heather Lawrence

Outline

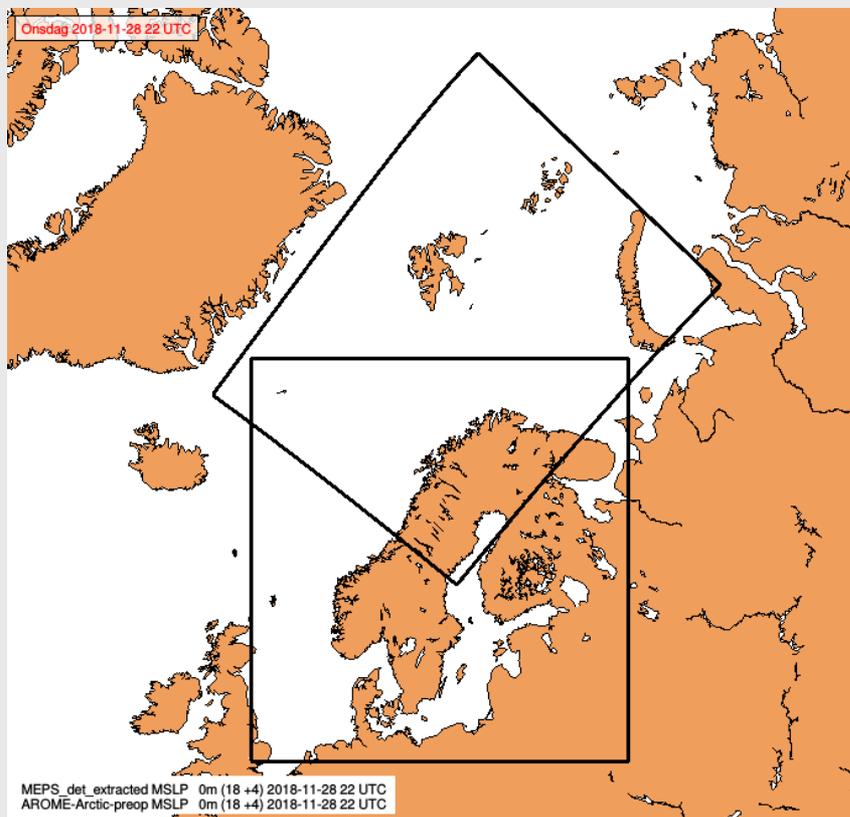
1. **Introduction of the NWP system**
2. **The OSE strategy**
3. **The available observations**
4. **Impact study: 2 Periods**
5. **Concluding remarks**

The DA and NWP system

System setup: (Harmonie cycle 40h1.1.1)

- 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
- Blacklist of conventional observations: IFS decision

- 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 performed two series of Global OSE: Global and Arctic (lat ≥ 60) observations denial.

LBC Options: **LBC1:** Global Control **LBC2:** Global Arctic Obs Denial **LBC3:** Global Obs Denial

Arctic Limited Area Model Assimilation Setups: (a) LAM control (b) LAM Obs Denial

Relative and Total Impact of Observations:

Case 1	Global Control	+	LAM control	vs	Global Control	+	LAM Obs Denial	⇒	Impact of obs in Arctic LAM
Case 2	Global Control	+	LAM Obs Denial	vs	Global Arctic Obs Denial / Global Obs Denial	+	LAM Obs Denial	⇒	Impact of obs through LBC in Arctic LAM
Case 3	Global Control			vs	Global Arctic Obs Denial			⇒	Impact of non-Arctic observations on Arctic (LAM) NWP
Case 4	Global Control	+	LAM Control	vs	Global Arctic Obs Denial / Global Obs Denial	+	LAM Obs Denial	⇒	The Total impact of observations

The Total impact of observations = Impact of obs in Arctic LAM + Impact of obs through LBC in Arctic LAM

Lists of OSE Experiments

Observations	Impact through LAM DA (Case 1)	Impact through LBC (Case 2)	Total impact (Case 4)	Impact of non-Arctic observation (Case 3)
Microwave satellite radiances	<u>X</u>	<u>X</u>	<u>X</u>	X
Microwave temperature sensitive radiances	X	X	X	
Microwave humidity sensitive radiances	X	X	X	
Infrared satellite radiances	<u>X</u>	<u>X</u>	<u>X</u>	
Atmospheric motion vectors (AMV)	X			
Conventional observations	<u>X</u>	<u>X</u>	<u>X</u>	
Radiosonde observations	X	X	X	
Surface pressure observations	X			
SOP1 observations	X			

X indicates tested for both SOP periods

LBC Description

LBC2: Arctic denial experiments	LBC3: Global denial experiments
All microwave satellite radiances	All microwave satellite radiances
All microwave temperature sensitive radiances	
All microwave humidity sensitive radiances	
All infrared satellite radiances	All infrared satellite radiances
All atmospheric motion vectors (AMV)	
All conventional observations	All conventional observations
All radiosonde observations	
All surface pressure observations	
All SOP1 observations	

OSE over SOP1 period

Experiments period: 10 February to 31 March 2018
10 - 14 February warming period

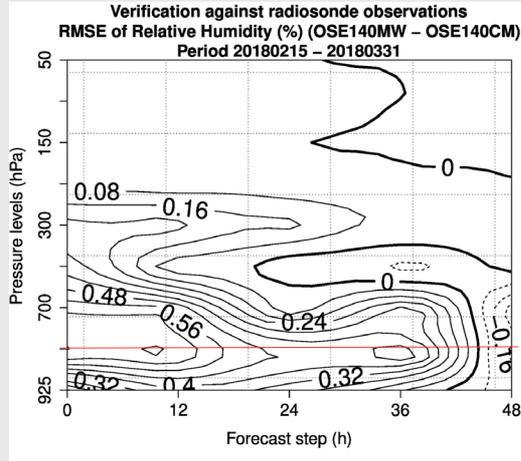
Some of the experiments were stopped with one month verification period due to lack computational

The denial experiments concern only the upper-air assimilation.
The surface assimilation remained untouched

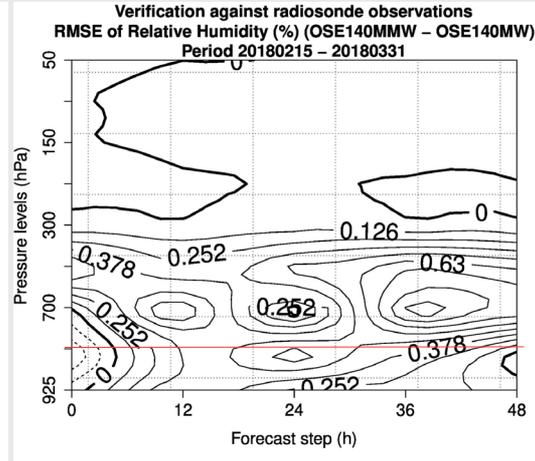
Concentrate mainly on upper-air impact due to presentation time constraint

Relative impact of microwave radiances on AROME-Arctic forecasts

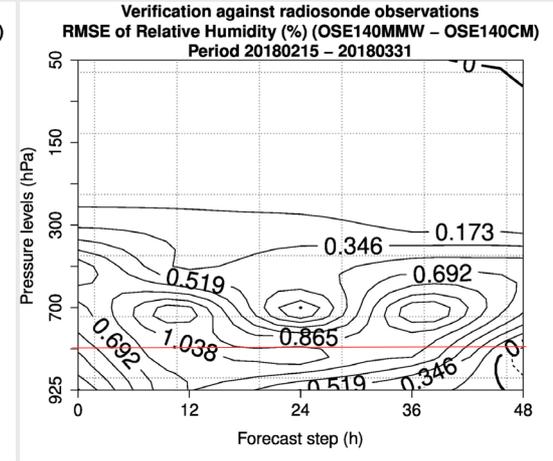
Impact through local DA
(Case 1)



Impact through LBC
(Case 2)



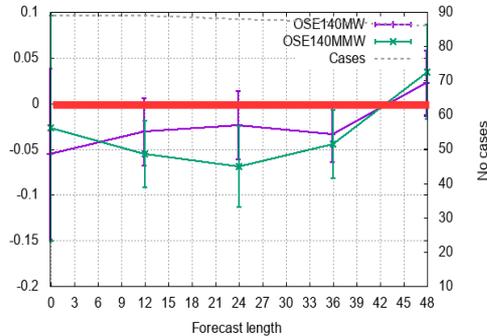
Total impact
(Case 4)



Relative humidity

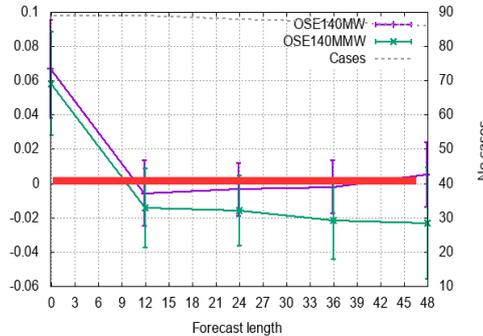
Normalized mean RMSE diff (90% conf) vs OSE140CM
Selection: ALL using 8 stations
Period: 20180215-20180331
Relative humidity 850hPa Hours: 00,12

RH



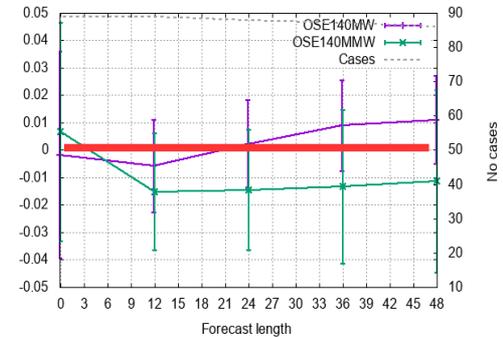
Normalized mean RMSE diff (90% conf) vs OSE140CM
Selection: ALL using 8 stations
Period: 20180215-20180331
Temperature 850hPa Hours: 00,12

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Normalized mean RMSE diff (90% conf) vs OSE140CM
Selection: ALL using 8 stations
Period: 20180215-20180331
Geopotential 850hPa Hours: 00,12

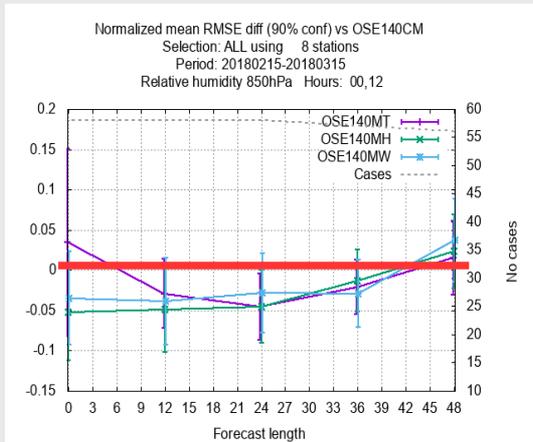
Geo



Significance Test

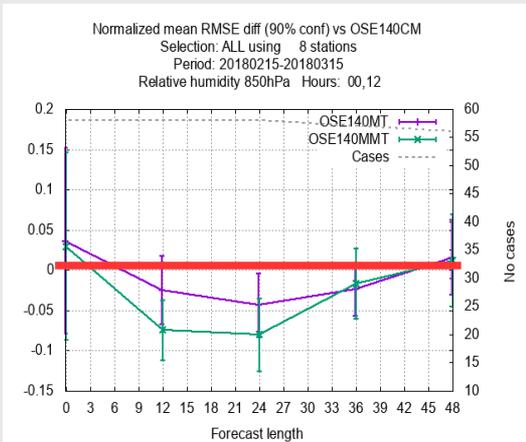
Relative impact of microwave radiances on AROME-Arctic forecasts (relative humidity at 850 hPa)

Impact of Local DA (CASE 1)

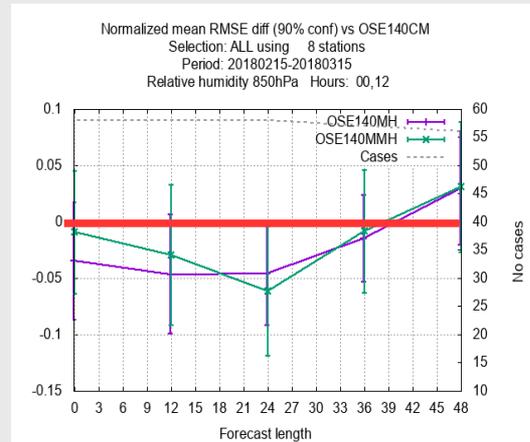


AMSU-A, MHS, ATOVS

Local DA (Case 1) / Total Impact (Case 4) / LBC (Case 2)

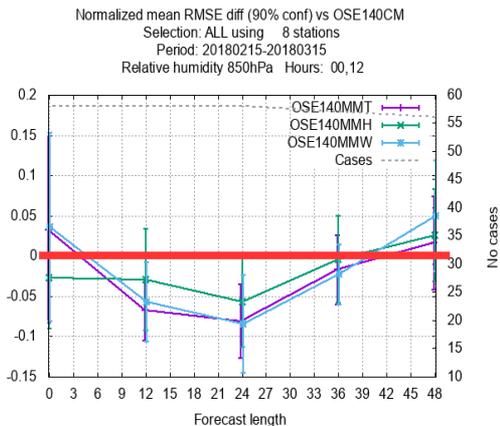


AMSU-A



MHS

Total Impact Comparison (Case 4)



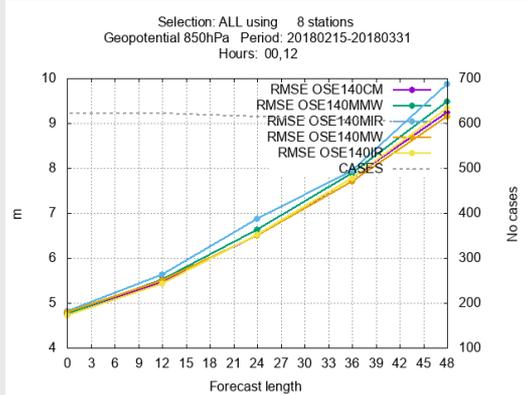
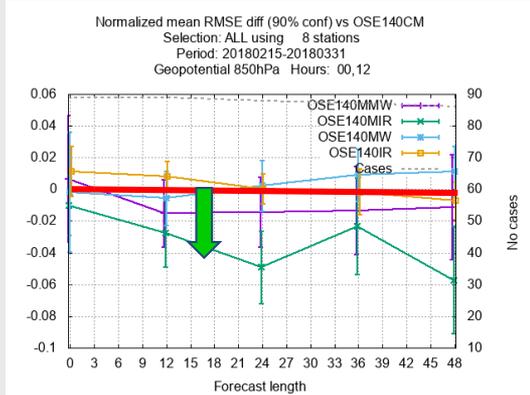
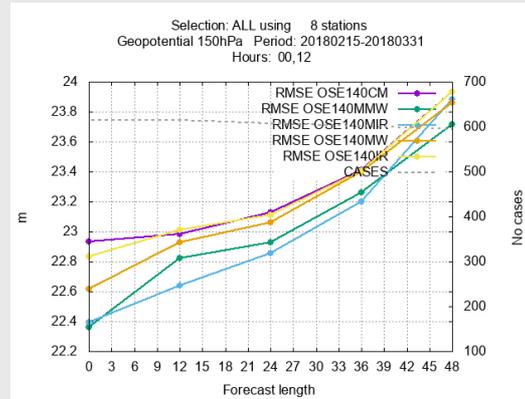
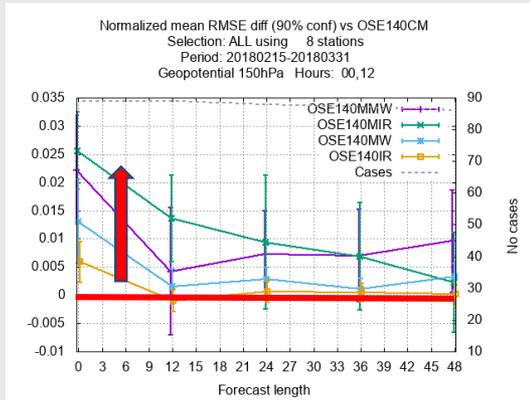
AMSU-A
 MHS
 ATOVS

Note the relatively shorter period – one month

Relative impact of satellite observations

IASI- LDA; IASI total impact;
ATOVS- LDA; ATOVS total impact

Loc MW; Tot MW;
Loc IASI; Tot IASI; Contr



Impact through LBC

IASI:

Positive impact on geopotential in lower troposphere and negative impact in upper-tropo and stratosphere.

ATOVS:

Positive impact on geopotential in lower troposphere and negative impact in upper-tropo and stratosphere.

Relative impact of observations on upper-air during SOP1

Impact through local DA:

AMSU-A:

Humidity: Positive Impact

Geopotential: Neutral Impact

Temperature: Neutral Impact

Wind Speed: Slightly Positive Impact

MHS:

Humidity: Positive Impact

Geopotential: Neutral Impact

Temperature: Neutral Impact

Wind Speed: Slightly positive impact on wind speed slightly negative impact in lower troposphere up to 12h forecast

ATOVS:

Humidity: Positive Impact on humidity below 700 hPa, negative impact at 700 hPa up to 12h

Geopotential: Neutral Impact

Temperature: Positive to neutral impact.

Wind Speed: Slightly Positive Impact

Impact through LBC:

AMSU-A:

Humidity: Positive Impact

Geopotential: Neutral Impact

Temperature: negative impact on upper-tropospheric and positive impact on lower-tropospheric

Wind Speed: Slightly positive impact

MHS:

Humidity: Slightly Positive Impact

Geopotential: Slightly Positive Impact

Temperature: Slightly Positive Impact

Wind Speed: Slightly Positive Impact

ATOVS:

Humidity: Slightly Positive Impact

Geopotential: Neutral Impact

Temperature: Slightly Positive Impact

Wind Speed: Slightly Positive Impact

Total impact:

AMSU-A:

Humidity: Positive Impact

Geopotential: Neutral Impact

Temperature: negative impact on upper-troposphere and positive impact on lower-tropospheric

Wind Speed: Positive - neutral impact

MHS:

Humidity: Positive Impact

Geopotential: Neutral Impact

Temperature: Positive Impact - Neutral

Wind Speed: Positive Impact, slightly negative impact in lower troposphere up to 12h forecast

ATOVS:

Humidity: Slightly Positive Impact

Geopotential: Neutral Impact

Temperature: Slightly Positive Impact

Wind Speed: Slightly Positive Impact

IASI impact (SOP1):

Through local DA:

Humidity: Negative below 850 hPa, positive impact above 850 hPa

Geopotential: Neutral Impact

Temperature: Neutral Impact

Wind Speed: Slightly negative impact in day 1

Through LBC:

Humidity: Negative above 850 hPa, Positive impact below 850 hPa

Geopotential: Negative above 850 hPa, Positive impact below 850 hPa

Temperature: Negative above 500 hPa, Positive impact below 500 hPa

Wind Speed: Slightly positive impact

Total impact:

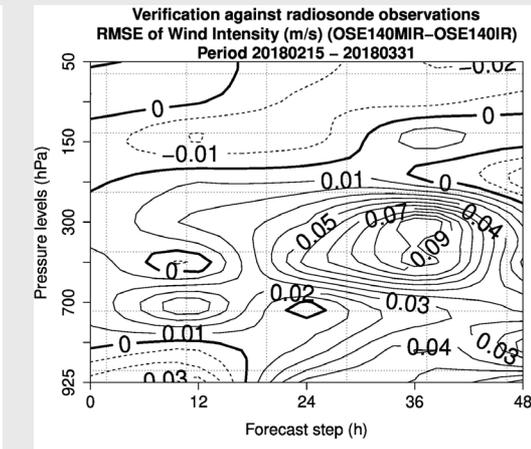
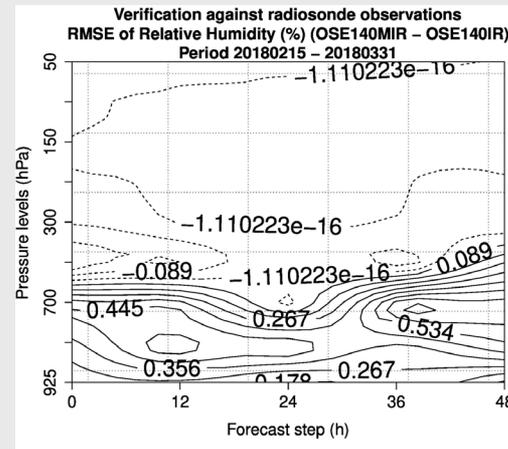
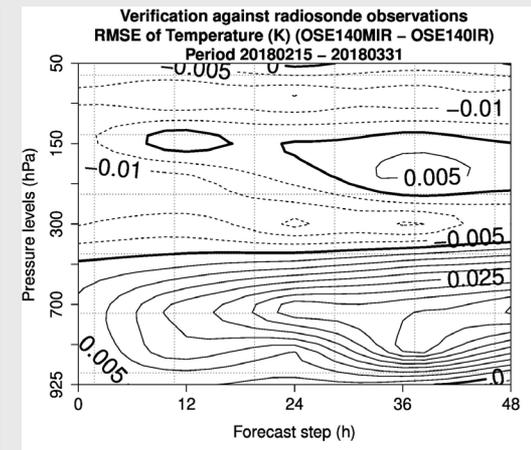
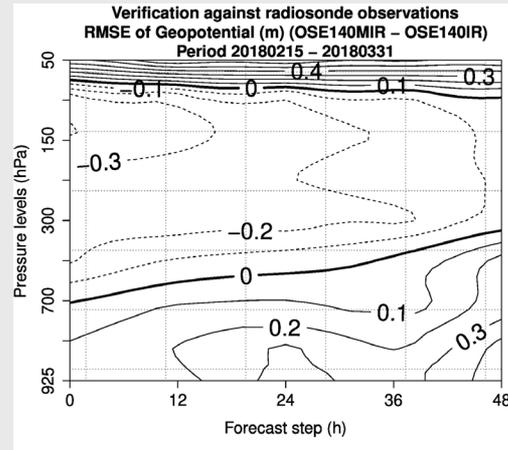
Humidity: Negative above 850 hPa, Positive impact below 850 hPa

Geopotential: Negative above 850 hPa, Positive impact below 850 hPa

Temperature: Negative above 500 hPa, Positive impact below 500 hPa

Wind Speed: Slightly positive impact

Through LBC:



OSE over SOP2 period

Experiments period: 1 July to 25 2018
1 - 4 July warming period

The denial experiments concern only the upper-air assimilation.
The surface assimilation remained untouched

Note the relatively short period due to lack of computational resource

Relative impact of observations on upper-air during SOP2

Impact through local DA:

AMSU-A:

Not checked

MHS:

Not checked

ATOVS:

Humidity: negative impact up to 36h

Geopotential: Neutral Impact

Temperature: Neutral Impact

Wind Speed: Positive impact

Impact through LBC:

AMSU-A:

Not checked

MHS:

Not checked

ATOVS:

Humidity: Positive impact on humidity between 700 - 850 hPa and day-1 and on day-2

Geopotential: Negative impact on upper- tropospheric / stratospheric

Temperature: Positive impact above 500 hPa and negative impact below 500 hPa

Wind Speed: Negative impact on day-1 wind speed

Total impact:

AMSU-A:

Not checked

MHS:

Not checked

ATOVS:

Humidity: Negative impact for day 1, Positive impact for day 2

Geopotential: Slightly positive below 500 hPa and Negative impact above 500 hPa

Temperature: rather negative - neutral impact on lower troposphere

Wind Speed: Positive impact (except for day-1 below 700 hPa up to 24h forecast)

IASI impact (SOP2):

Through local DA:

Humidity: Negative impact below 700 hPa and positive impact above 700 hPa

Geopotential: Neutral Impact

Temperature: Neutral Impact

Wind Speed: Positive impact on day-1 and negative impact on day-2

Through LBC:

Humidity: Positive impact below 700 hPa and negative impact above 700 hPa

Geopotential: Negative impact between 100 & 200 hPa otherwise positive impact

Temperature: Negative - neutral impact

Wind Speed: Slightly positive impact

Total impact:

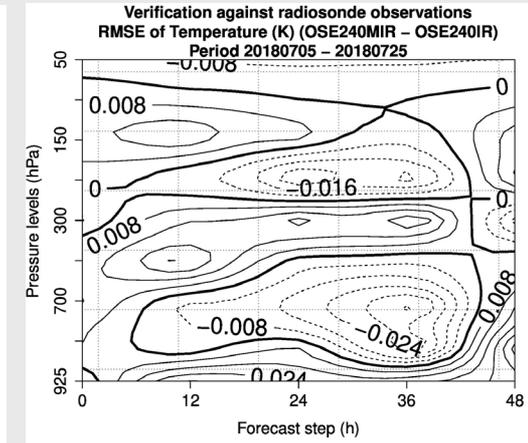
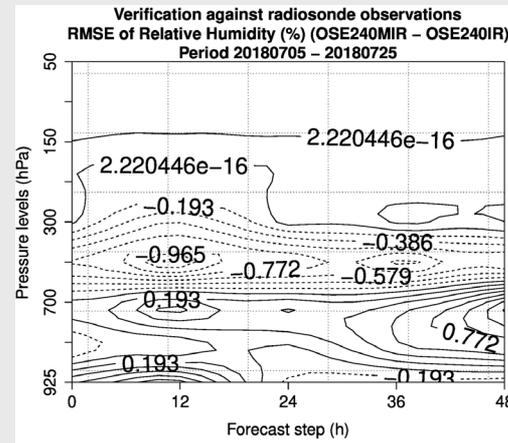
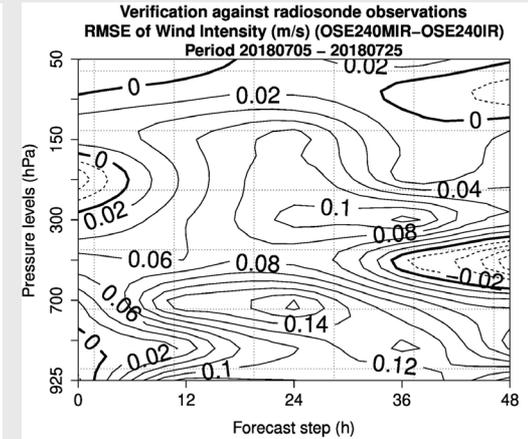
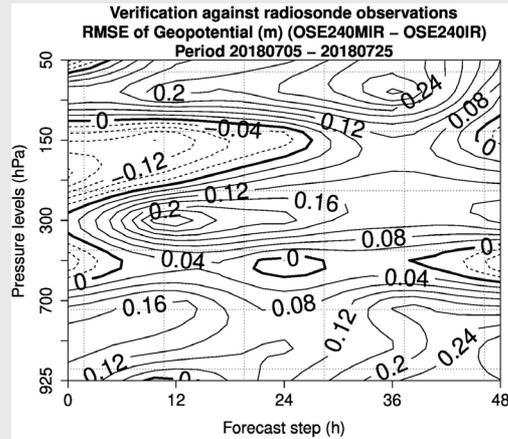
Humidity: Positive impact for day-1 below 700 hPa, otherwise negative impact

Geopotential: Positive impact below 500 hPa and negative impact above 500 hPa

Temperature: Positive impact below 500 hPa and negative impact above 500 hPa

Wind Speed: Slightly positive impact

Through LBC:



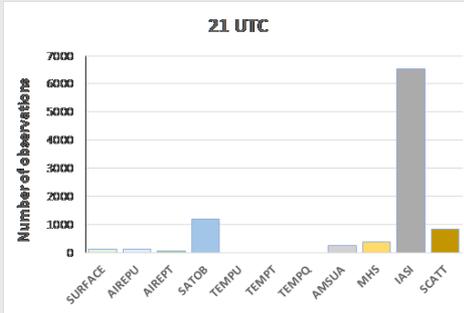
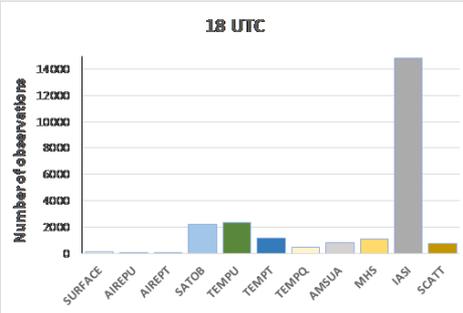
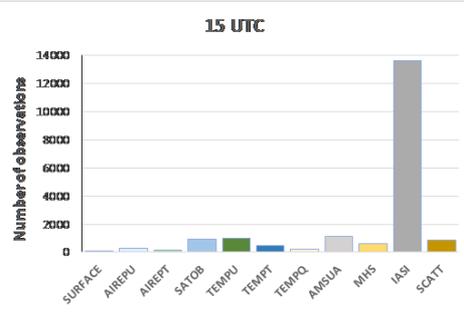
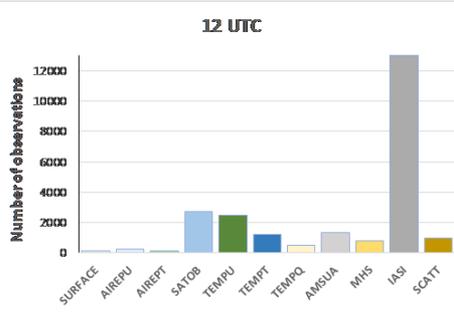
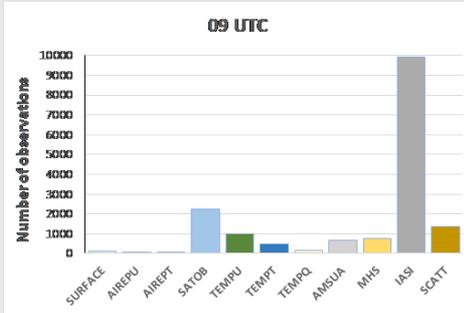
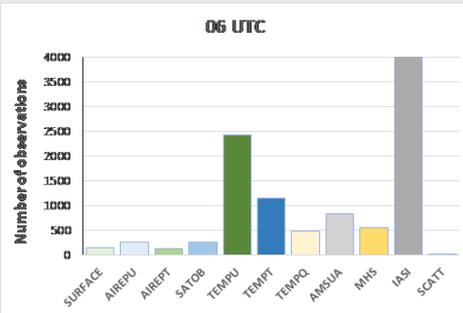
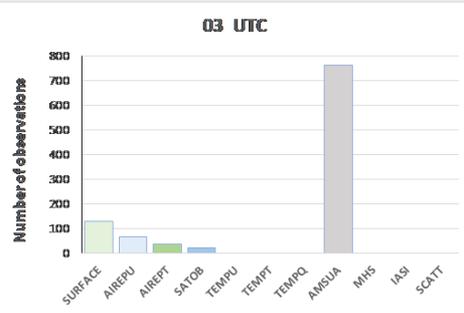
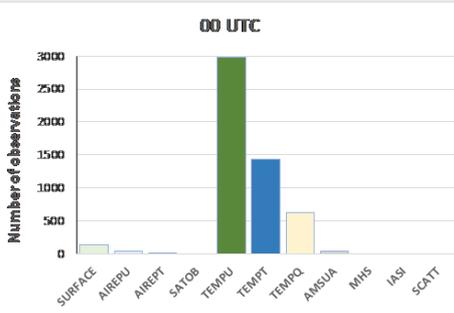
Concluding remarks

- We just published (*Randriamampianina et al., 2019*) results of an OSE study, where each satellite radiance used in this study showed relative positive impact on the AROME-Arctic analysis and forecasts
- The impact of the investigated satellite observations was slightly different during winter (SOP1) and summer (SOP2) periods. Negative and positive impacts were found through both local data assimilation and lateral boundary conditions
 - Ex: not shown, but on top of what was shown, the impact on surface parameters was found larger during SOP1 compared to that during SOP2
- Total impact = impact through local DA + impact through LBC
 - impact through LBC was not yet checked until now

Thank you for your attention!

The available observations

Note the difference in scales in the plots



Case of March 30th, 2018

Observations denial in both global and regional models

SOP1			
Temperature	Wind speed	Relative humidity	Geopotential height
All conventional IR, MW	All conventional IR MW	All conventional MW IR	All conventional IR, MW

Observation denial in regional model

SOP1			
Temperature	Wind speed	Relative humidity	Geopotential height
All conventional IR, MW AMV	All conventional IR Up. Tr: AMV MW Lo. Tr: MW AMV	All conventional AMV, MW IR	All conventional Up. Tr: AMV, IR (d2) MW Lo. Tr.: MW AMV, IR (d1)
SOP2			
All conventional IR, MW, AMV	All conventional IR AMV MW	All conventional AMV, MW IR	All conventional AMV IR, MW

Order of importance

Upper-air forecast

Surface pressure			2m temperature		
Day-1		Day-2	0 - 12 hours	12 - 24 hours	Day-2
MCV CV, PS RS, MW, MMW, MRS AMV IR, MIR, MT S1N		MCV MRS AMV MIR IR, MMW, S1N RS, CV MW MT, MH	MCV CV PS MRS RS MW, MMW IR, MIR, S1N MT, MH AMV	MCV CV MRS PS, MW, MMW IR, MIR RS, S1N AMV MT, MH	MCV, CV MRS, MW IR, S1N MIR, RS, PS MMW, AMV MT, MH
2m relative humidity			2m Specific humidity		
Day-1		Day-2	Day-1		Day-2
MH MMW, MW MRS, RS MT IR, MIR S1N, AMV MCV CV PS		MRS, MT MH, MIR, MCV MW MMW IR, S1N, RS, AMV CV PS	MCV CV MRS MMW, MW, MH, RS MT, S1N, AMV MIR, IR, PS		MCV CV MRS, MIR MW, MT, RS, AMV, PS, IR, S1N MH MMW
10m Wind speed			Total cloud cover		
0 - 12 hours	12 - 24 hours	Day-2	0 - 12 hours	12 - 24 hours	Day-2
MCV CV RS, MRS MT, MH AMV, S1N, MMW IR, MIR PS, MW	MCV MT MH MW, MMW MIR, CV, RS, MRS AMV S1N, IR	MT, MH, MMW MW, MCV, AMV MIR, RS S1N, PS, IR MRS, CV	MCV CV PS, RS, MH, MT MRS, MW MMW, AMV MIR S1N	MCV MMW MRS, AMV MT, RS IR MIR MH, MW	MCV MMW MRS, AMV MW, MT, S1N CV, PS MH, IR, MIR, RS

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 global studies

Experiments performed in Feb-March

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

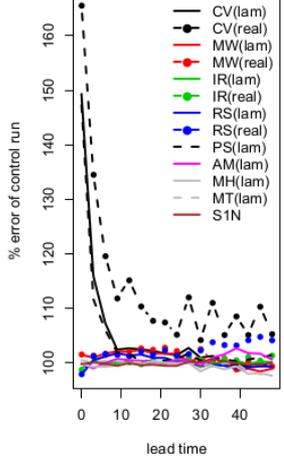
- All microwave satellite radiances
- All microwave temperature sensitive radiances
- All microwave humidity sensitive radiances
- All infrared satellite radiances
- All atmospheric motion vectors (AMV)
- All conventional observations

- All radiosonde observations
- All surface pressure observations

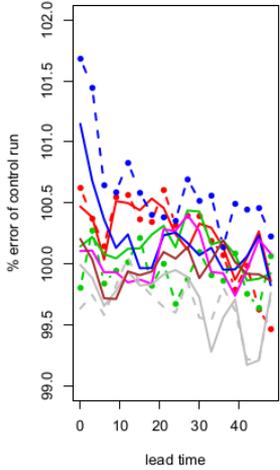
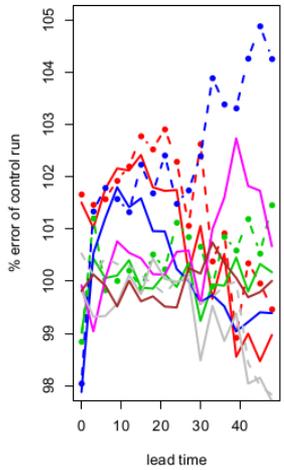
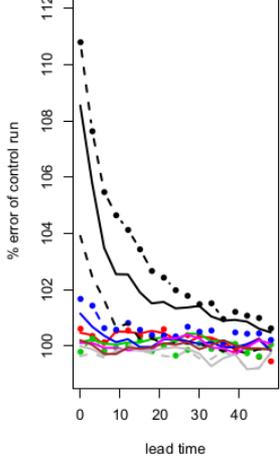
- All SOP1 observations

The experiments in blue were used in our study

Mean Sea Level Pressure



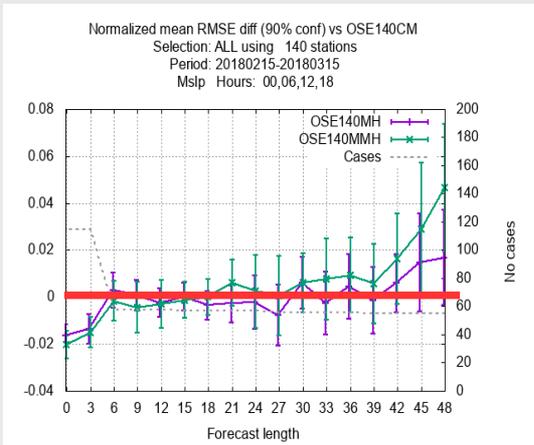
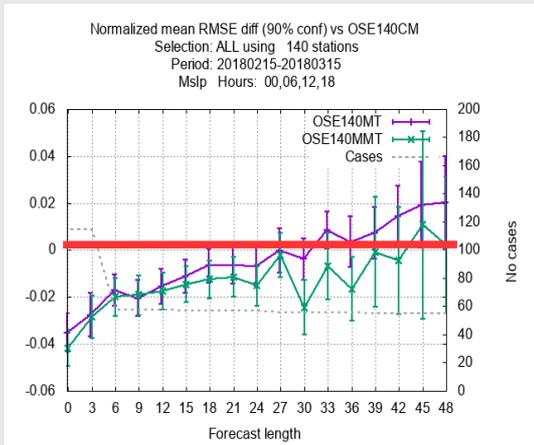
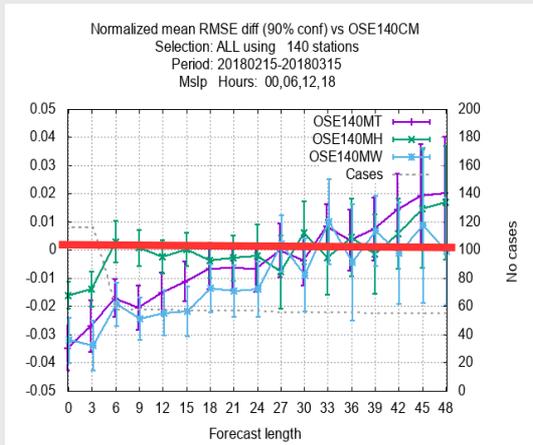
2m air temperature



Relative impact of microwave radiances on AROME-Arctic forecasts (Surface parameters – MSLP)

Note the relatively shorter period – one month

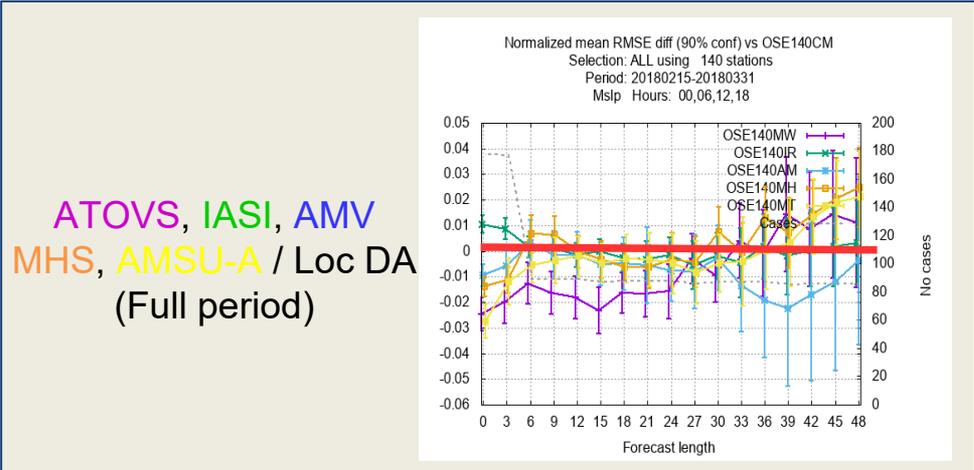
Local DA / total impact / LBC (the difference)



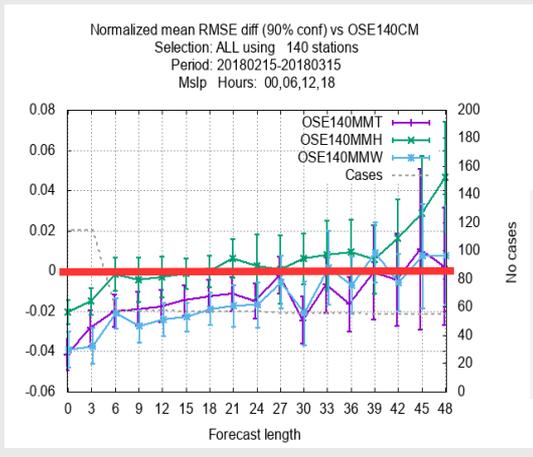
AMSU-A, MHS, ATOVS / Loc DA

AMSU-A / LBC

MHS / LBC



ATOVS, IASI, AMV
MHS, AMSU-A / Loc DA
(Full period)

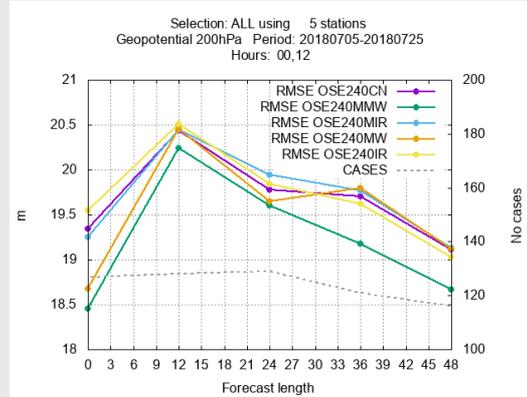
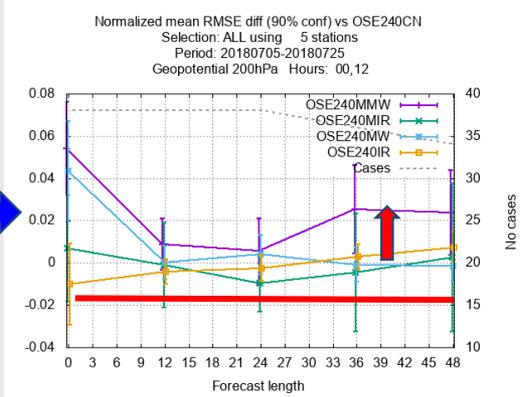


Total impact
AMSU-A
MHS
ATOVS

Relative impact of satellite observations

IASI- LDA; IASI total impact;
 ATOVS- LDA; ATOVS total
 impact

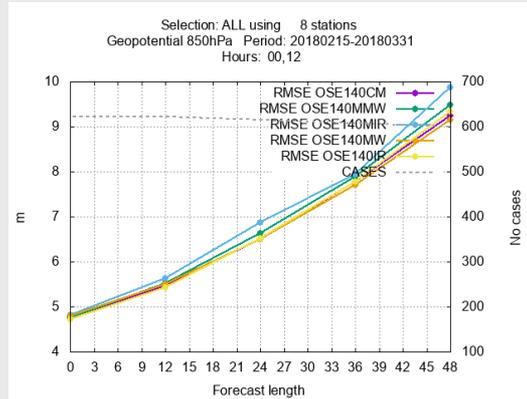
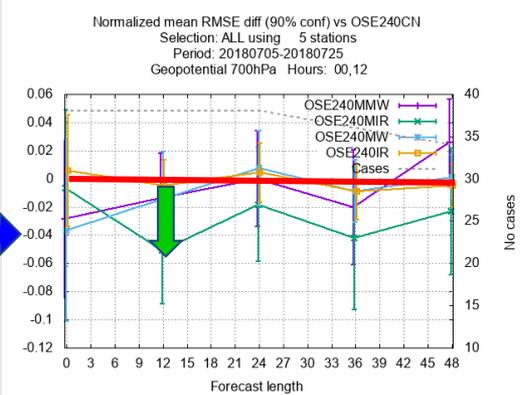
Loc MW; Tot MW;
 Loc IASI; Tot IASI; Contr



Impact through LBC

IASI:

Positive impact on geopotential
 (larger in lower troposphere and
 smaller in upper-tropo and
 stratosphere)



ATOVS:

Rather neutral impact on geopotential
 in lower-troposphere and **negative**
 impact on upper-troposphere /
 stratosphere.

LBC
 ATOVS
 -ve

LBC
 IASI
 +ve