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Alertness

APPLICATE.eu
Advanced prediction in polar regions and beyond

The relative impact of observations in regional NWP model

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Outline

- Motivation
- Observing System Experiment design
- Impact of the Arctic observations on the AROME-Arctic analyses
- Impact of mid-latitude and Arctic observations on the AROME-Arctic surface forecasts
- Impact of mid-latitude and Arctic observations on the AROME-Arctic upper-air forecasts
- Concluding remarks

Motivation

- In the Alertness project (2018-2021) we were originally planning to perform Observing System Experiments (OSE) at its final phase.
- Laurence et al. (2019) and Bormann et al. (2019) (ECMWF) conducted a global model with, respectively, Arctic and global OSEs in the framework of the APPLICATE project, and kindly provided us almost all their results to be used as lateral boundary conditions (LBCs) in our study.
- We decided to join this effort and performed the parallel OSEs

The Upper Air OSE

Experiments and naming: **G**= global NWP system, **R**= Regional NWP system , **all**= all observations, **noXX**= observation type XX is removed, **SOP1**= YOPP Special Observing Period 1, **SOP2**= YOPP Special Observing Period 2.

MW= microwave radiances, **MT**= microwave temperature sensitive radiances, **MH**= microwave humidity sensitive radiances, **IR**= Infrared radiances, **AM**= Atmospheric Motion Vectors, **CV**= all conventional observations, **RS**= all radiosonde observations, **PS**= all surface pressure observations, **S1**= all additional SOP1 observations.
The **Gall/Rall** experiment indicates for example the regional experiments in which all observations are assimilated in regional DA, which uses as LBCs the global experiment in which all observations are used. **GnoMW/RnoMW** indicates the regional experiment used while no MW sensitive observations are used either in the regional nor north of 60 N in the global DA.

Control

Regional denial experiments

Global denial experiments

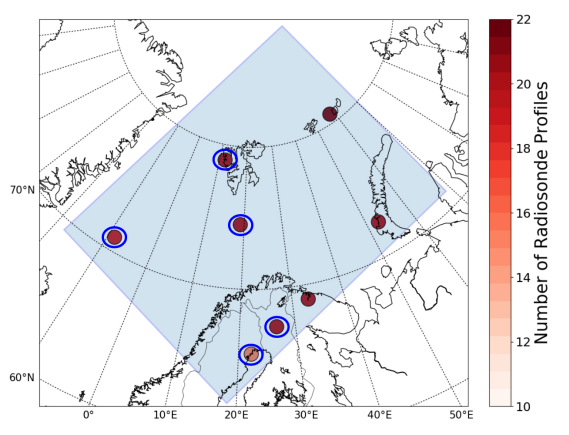
Global experiments used as LBC for regional experiments	Regional experiments	Observations
Gall	Rall	All obs included
Gall	RnoXX	**XX observations removed for SOP1**: MW, MT, MH, IR, AM, CV, RS, PS, S1 **XX observations removed for SOP2**: MW, IR, CV, AM
(Arctic) GnoXX	RnoXX	**XX observations removed for SOP1**: MW, MT, MH, IR, AM, CV, RS **XX removed for SOP2**: MW, IR, CV
(Global) GnoXX	RnoXX	**XX removed for SOP1**: MW, IR, AM, CV

The estimated relative impacts:

-- Through the regional DA: Gall(Arctic)/Rall and Gall(Arctic)/RnoXX
-- Through the LBCs : Gall(Arctic)/RnoXX and GnoXX(Arctic)/RnoXX
-- Total Arctic obs impact: Gall(Arctic)/Rall and GnoXX(Arctic)/RnoXX
-- Impact of mid-latitude obs: GallnoXX(Arctic)/RnoXX and GnoXX(global)/RnoXX

The AROME-Arctic model

- Model upper-air physics: HARMONIE-AROME
- Model surface physics: SURFEX
- Upper-air assimilation: 3D-Var
- Surface assimilation: Optimum interpolation (OI)
- Update strategy: 3 hourly cycling (00, 03, 06, 09, 12, 15, 18, 21 UTC)
- Lateral boundary condition: ECMWF (in this study every 3 hour)
- Used model version: 40h1.2
- Forecast lengths: Long forecast (48 hours) twice a day (00, 12 UTC) for verification purposes
- Winter period (SOP1): 10 February - 31 March 2018
- Summer period (SOP2): 1 - 25 July 2018



The AROME-Arctic model domain with the available radiosonde stations counted during the summer (SOP2) study. Marked stations are those providing additional observations during the YOPP SOPs

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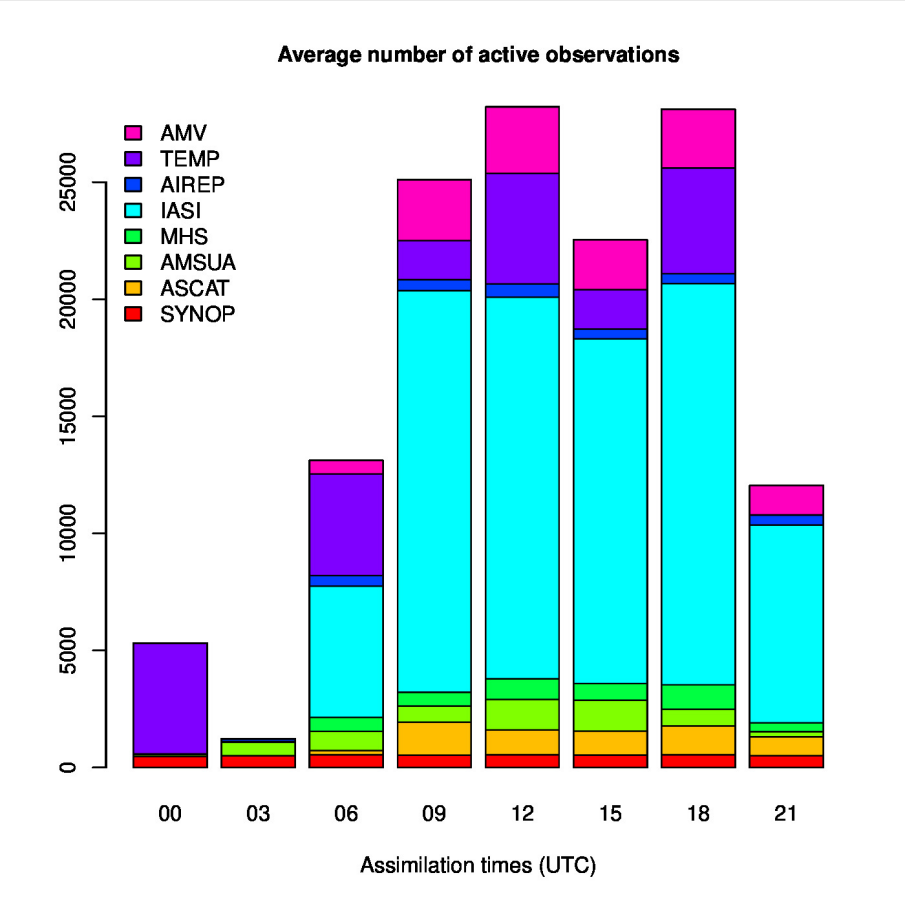
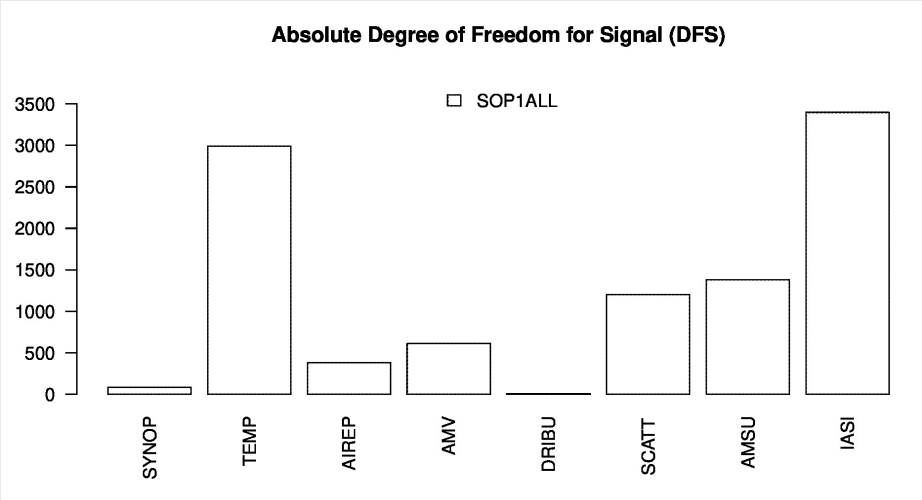
Arctic observations and their impact in DA

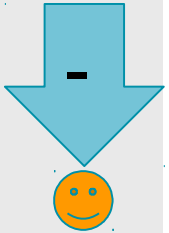


A ten-day averaged number of the assimilated observations per observation type

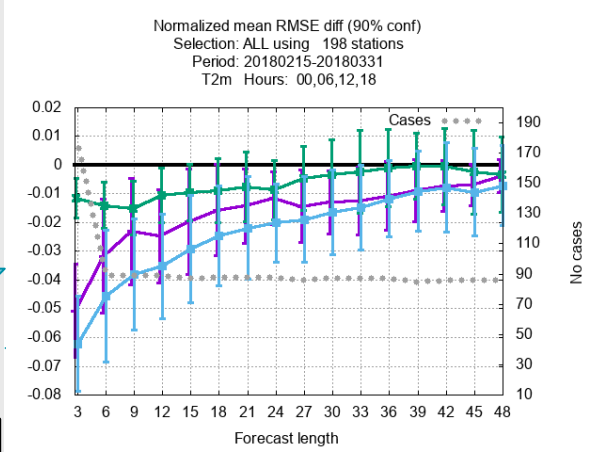
Averaged DFS over four distant assimilation times

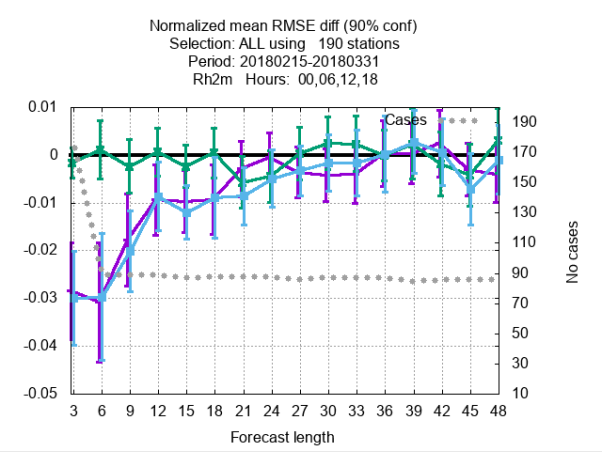


Impact of Arctic observations on the surface fields



SOP1

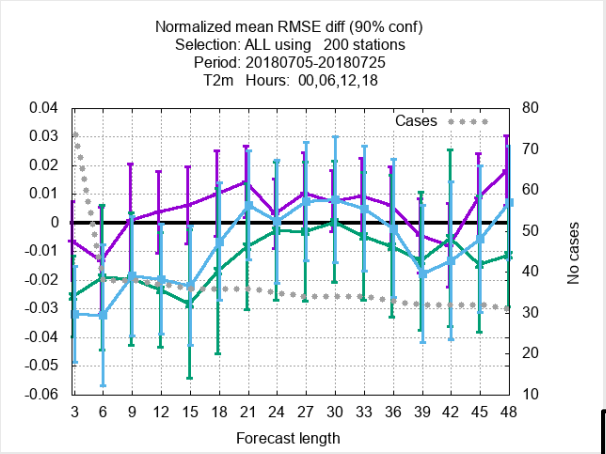




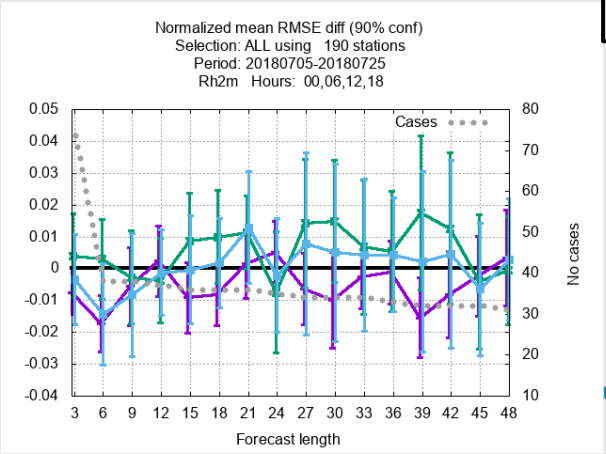
Conventional

Impact through:
Regional DA
LBCs
and
Total impact

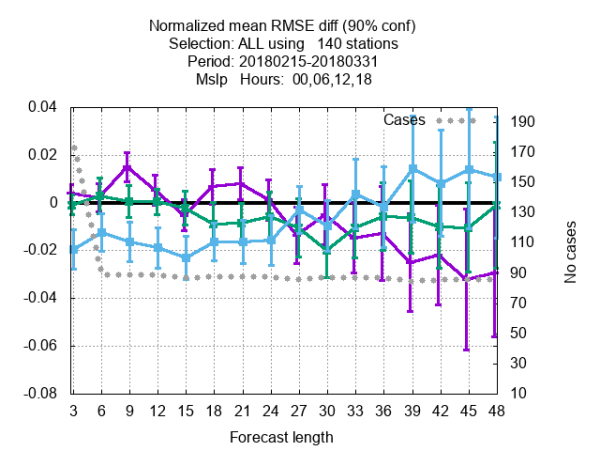
Microwave
ATOVS

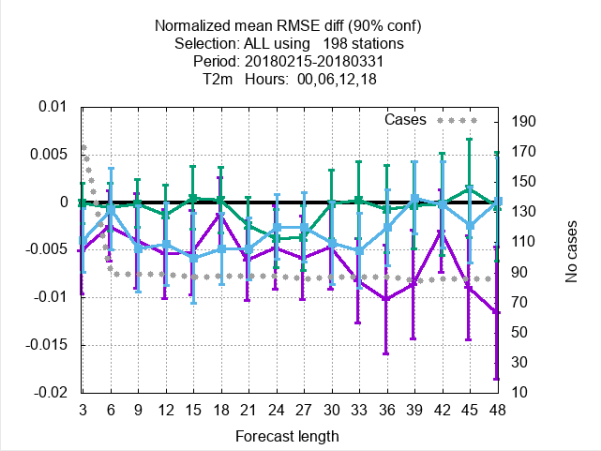


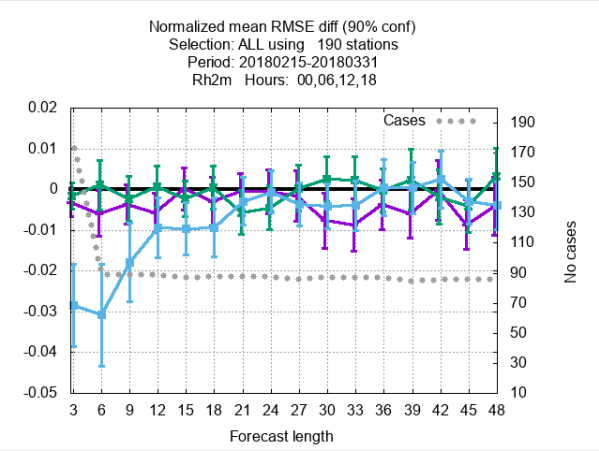
SOP2

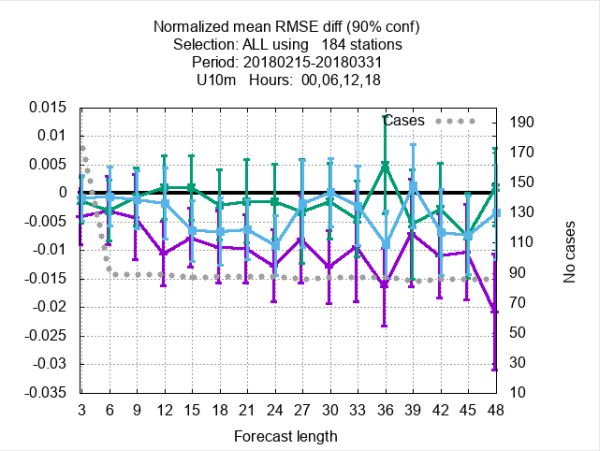


Impact of Arctic and mid-latitude MW on the surface fields









-- Impact of Arctic MW observations through regional DA
-- Impact of Arctic MW observations through LBCs
-- Impact of mid-latitude MW observations through LBCs

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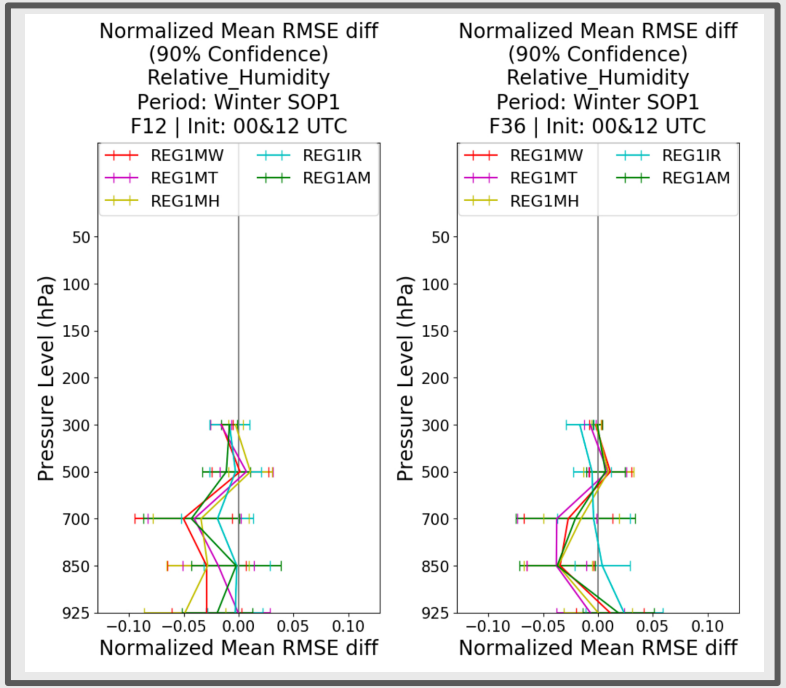
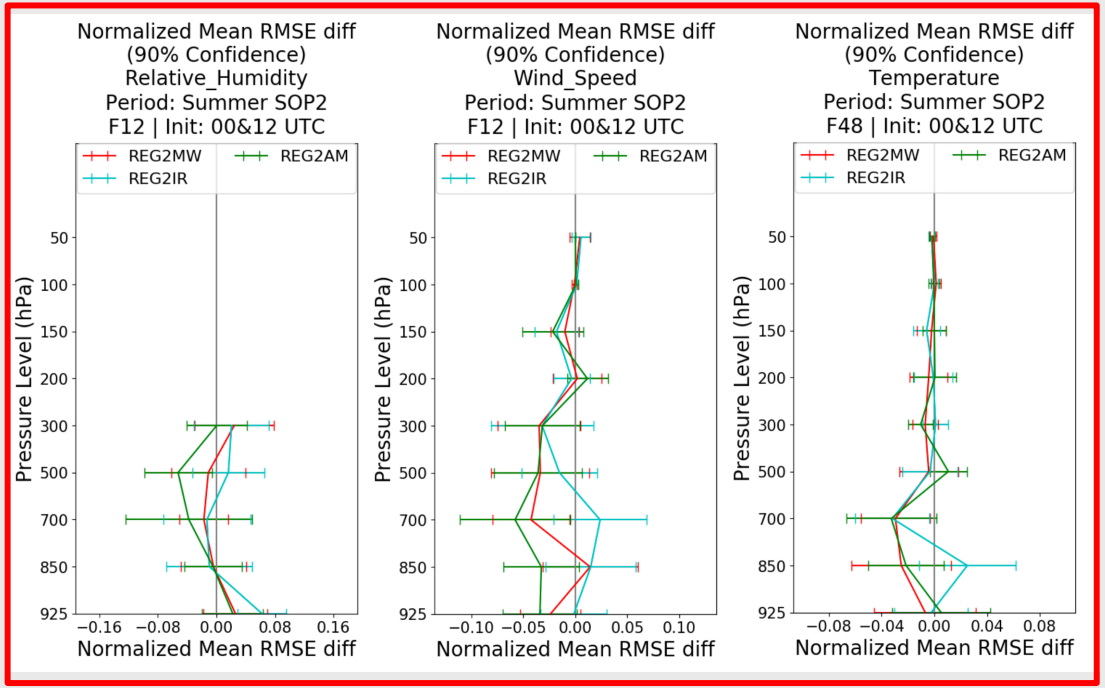
Impact Arctic satellite obs on upper-air through Regional DA

- Satellite observations impact on longer forecast ranges
- Almost all tested observations have positive impact on short range humidity during winter (SOP1), while a smaller impact was observed during summer (SOP2)

SOP1 (Winter)

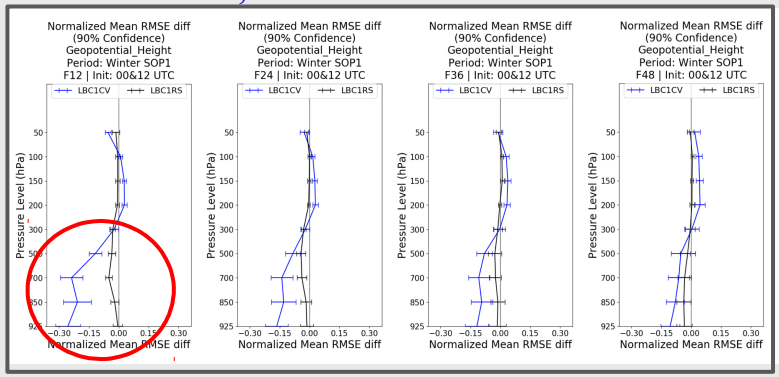
SOP2 (Summer)



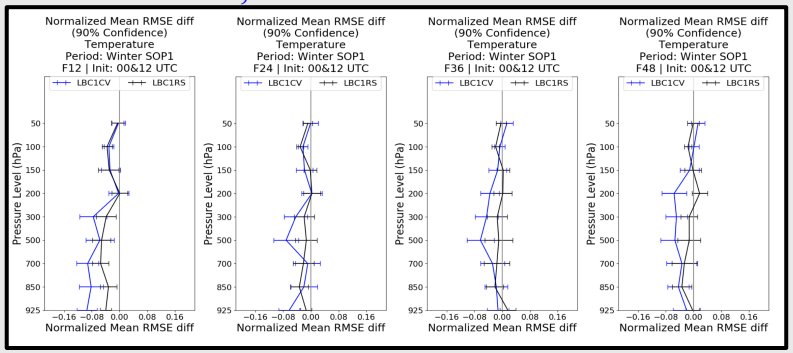


Impact of Arctic obs through LBCs

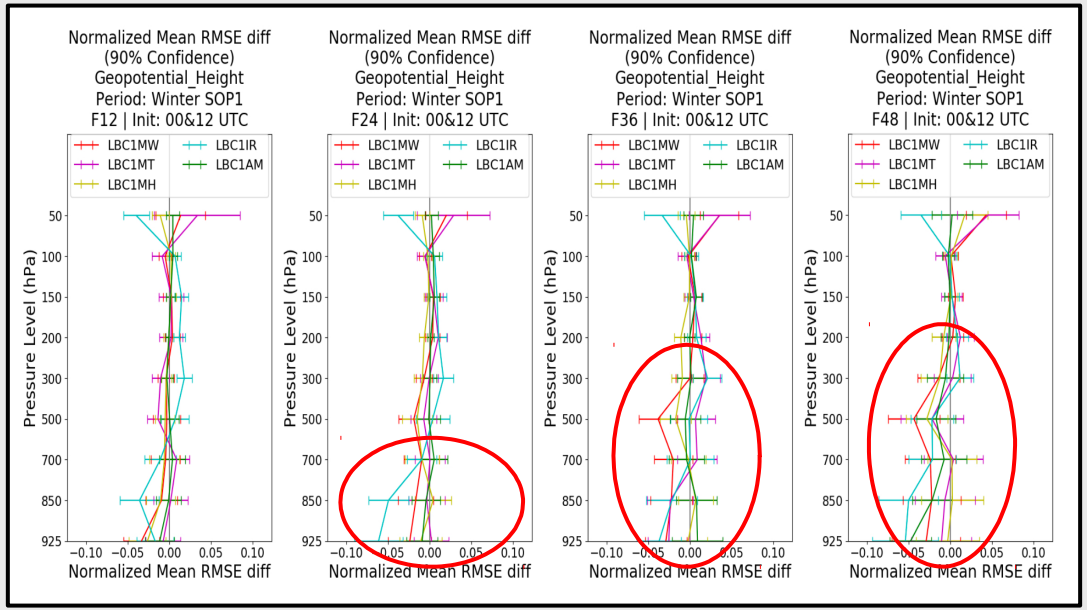
Conventional, Radiosonde



Conventional, Radiosonde



ATOVS, IASI, AMSU-A, MHS, AMV



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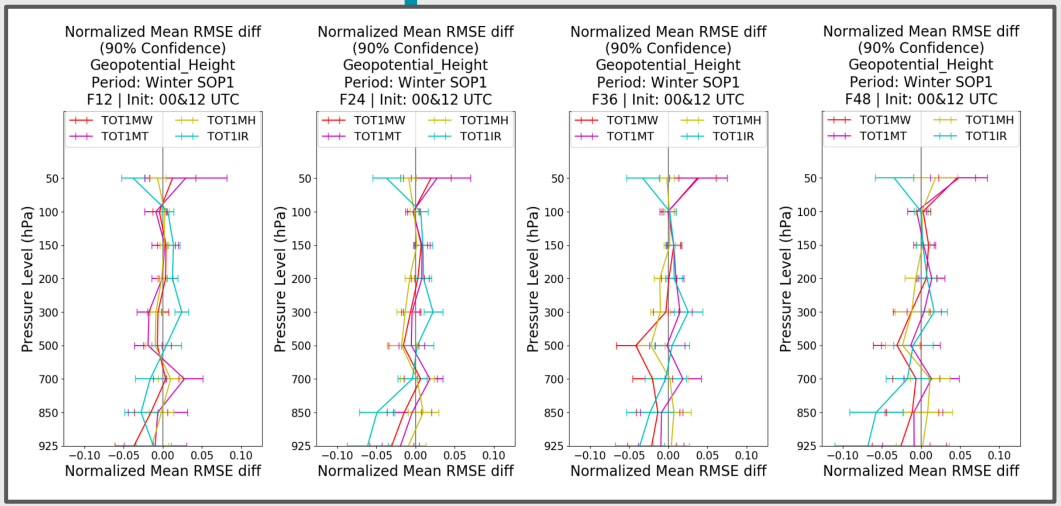
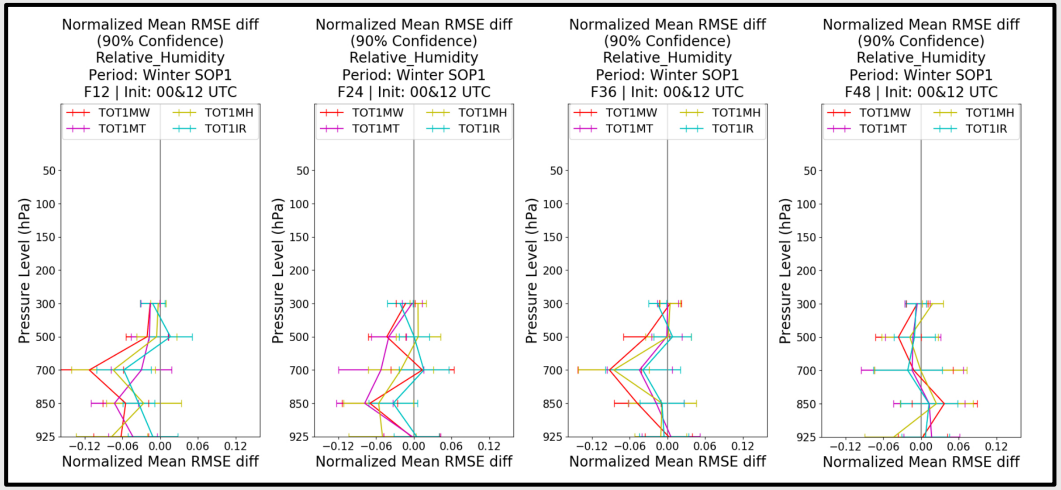
Total impact of the Arctic observations





- IASI radiances (light blue)provide good impact on geopotential in the lower troposphere, and the use of both temperature and humidity sensitive microwave data (red) have complementary impact on the upper troposphere.
- All microwave radiance data (red, violet, yellow) separate or together provide good impact on the tropospheric humidity fields.

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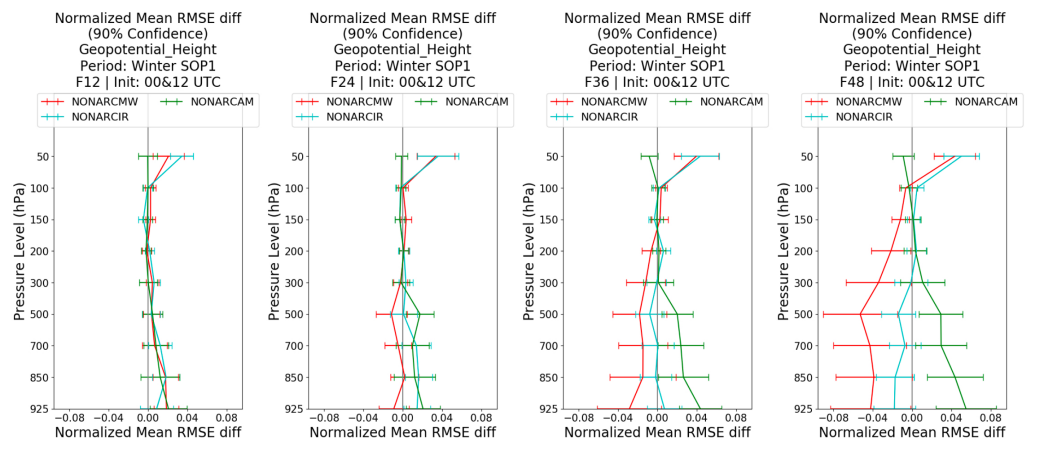
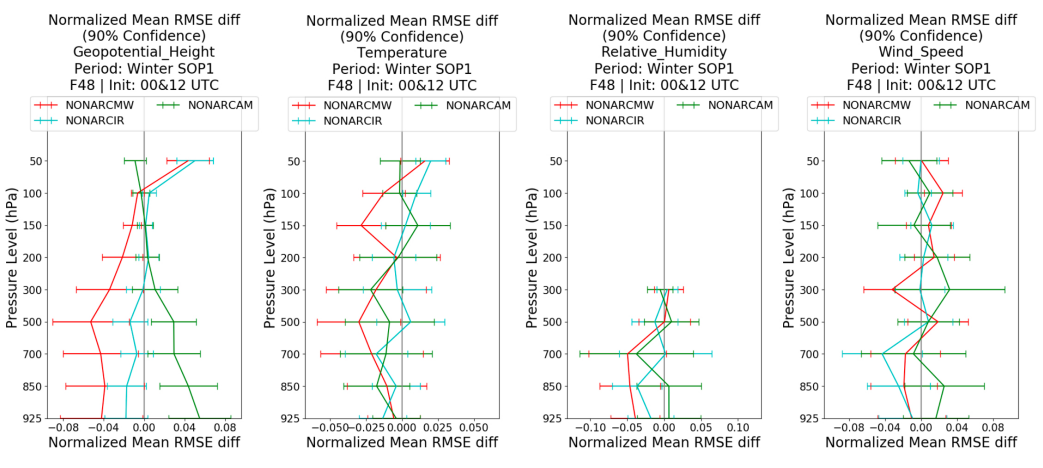
Impact of mid-latitude satellite obs





- The impact of mid-latitude satellite observations is remarkable on day-2 forecasts of the AROME-Arctic.
- All microwave radiance data (red) provide the best positive impact, especially on the 48 hour forecasts.
- Such impacts are observed on the forecasts of geopotential, temperature and relative humidity.

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Concluding remarks(1)

- More satellite observations are available in the Arctic for assimilation compared to conventional ones.
- The DFS diagnostic showed that both radiosonde and IASI data are the most contributing observations in the AROME-Arctic DA, followed by microwave, and scatterometer data.
- Arctic observations impact the quality of the AROME-Arctic forecasts both through regional DA and through LBCs.
- The total impacts of observations on the surface fields are dominated by the impacts through regional DA (e.g. winter case), while in the upper-air the total impacts are dominated by the impacts through LBCs.
- Mid-latitude observations impact the quality of day-2 AROME-Arctic forecasts through LBCs.
- The conventional observations are the most impacting observations, followed by the IASI radiances. The microwave radiances are third impacting observations over our region of interest.

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Concluding remarks(2)

- Only a relative fraction of the available satellite observations (AMSU-A, MHS, IASI) (Metop-A&B, NOAA-18&19) were used in this study.

- We use the similar dataset (plus earlier MSU, AMSU-A, AMSU-B) in the ongoing Copernicus Arctic (CARRA) and European (CERRA) reanalysis production systems.

- We are adding more IASI, AMSU-A&MHS, and ATMS, MWHS-2 and CrIS data using Metop-C, NOAA-20, JPSS and FY-3D. This way we closed the gap of both microwave and infrared radiance data at early morning assimilation times.

- Under the Alertness project we are improving the presentation of the sea ice cover by implementing an assimilation approach and improved interaction between surface and upper-air DA systems.

- For more details see Randriamampianina et al. 2021, Q. J. R. Meteorol. Soc., https://doi.org/10.1002/qj.4018.

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Thank you for your attention!