An Observing System Simulation Experiment:
Uncertainty estimation of emissivity retriaval over sea-ice and land

Roger Randriamampianina on behalf of

Máté Mile
Stephanie Guedj
Roohollah Azad
Harald Schyberg

The Norwegian Meteorological Institute

The project Arctic-Passion (arctic-passion.eu)

WP3

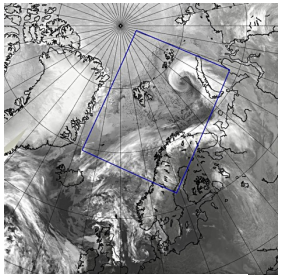
Model-based impact assessments

The objective of the Arctic OSSE

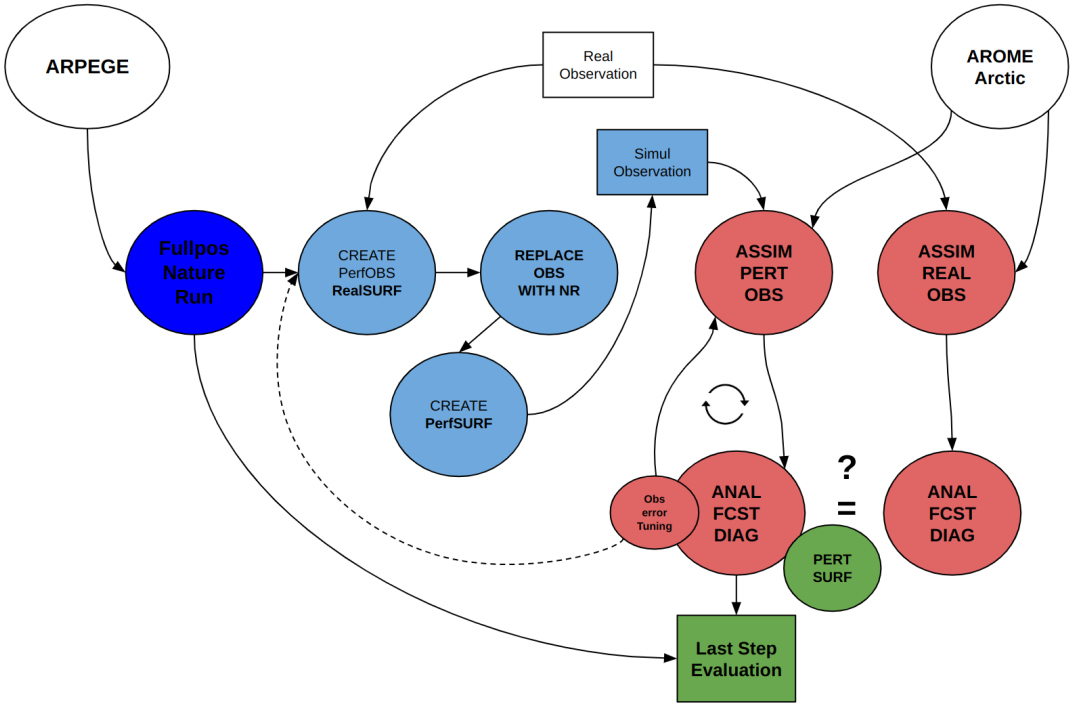
- **Satellite observations, especially microwave radiance observations, are crucial** for NWP over high latitudes
- The observing system simulation experiments (OSSEs) are designed to **estimate the impact** of new observing systems or new components of the NWP data assimilation.

- The objective is to provide information on the value of the improvement of **modelling the surface contribution** to the observation.
- Many different sub tasks can be considered, but here **the surface emissivity contribution of microwave satellite observations** are primarily aimed.

The OSSE structure aiming “perfect surface description”

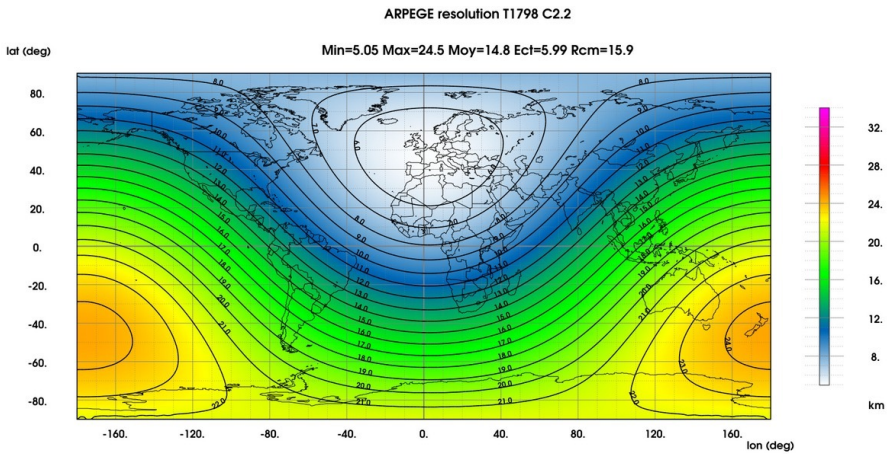


- Nature Run: Pre-processed ARPEGE forecasts
- Create perfect observations and perfect emissivity
- Perturb observations
- Calibration
- Perturb emissivity and Evaluation



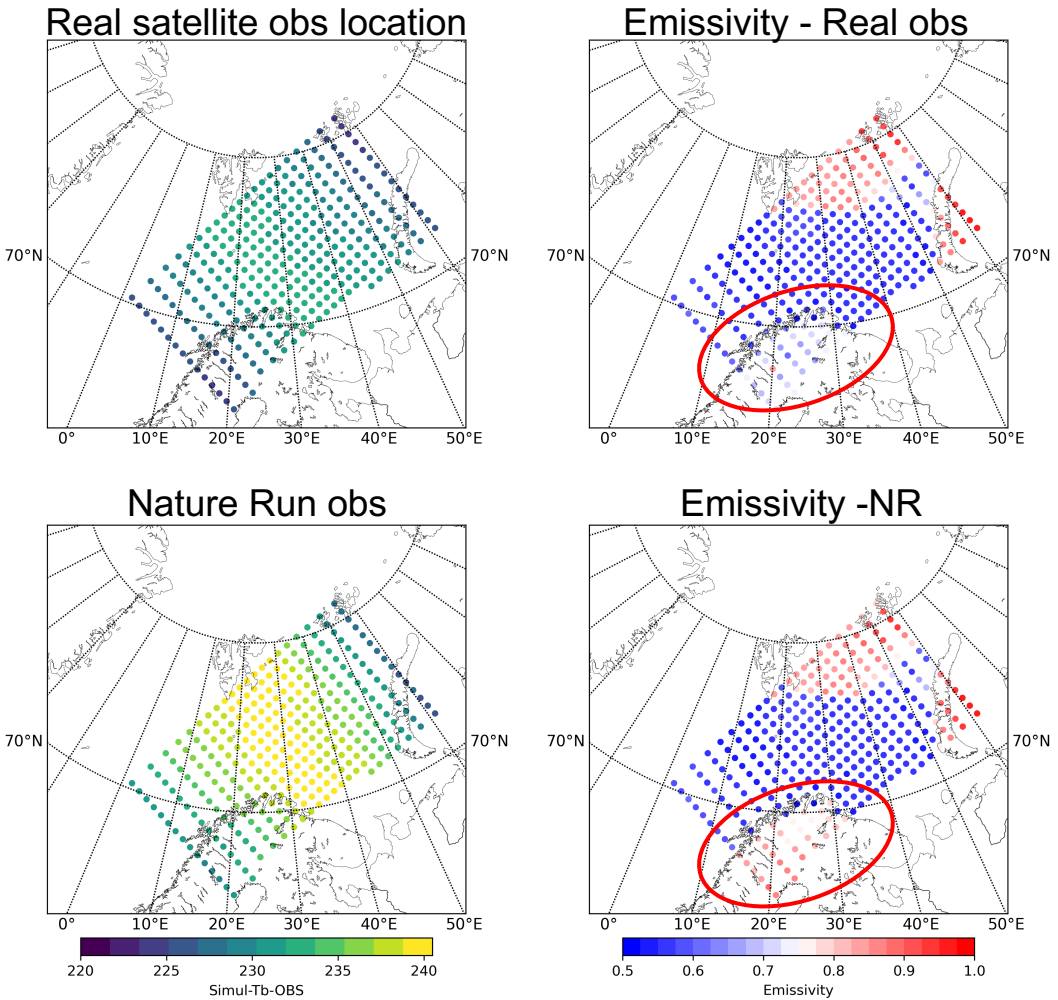
The Nature Run

- Kindly provided by Météo-France, ARPEGE (Action de Recherche Petite Echelle Grande Echelle) forecast files for our OSSE experiments.
- HARMONIE-AROME is generally driven by IFS boundary conditions and ARPEGE can be considered as an independent, continuous dataset as the OSSE truth.
- **In OSSE, we use NR-based observations for assimilation and model verification as well!**



The real vs. simulated quantities

- An example: ATMS ch6 (53,596+/-0.115 GHz)
- Metadata is the same
- Observed values are replaced by Nature Run
- Dynamical emissivity retrieval is used e.g., to determine emissivity over land (highlighted area)

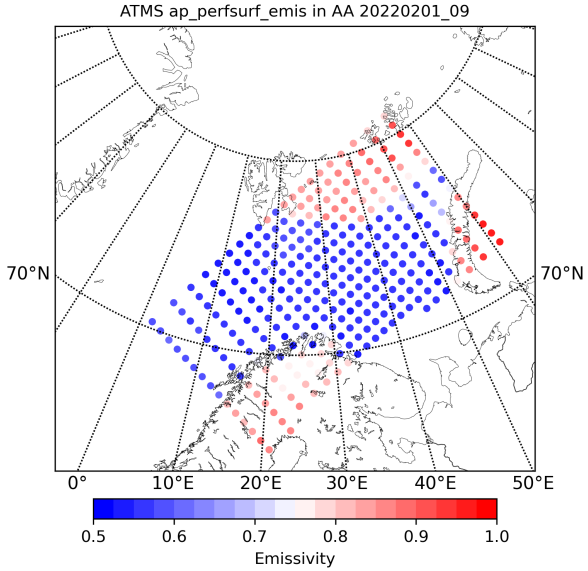


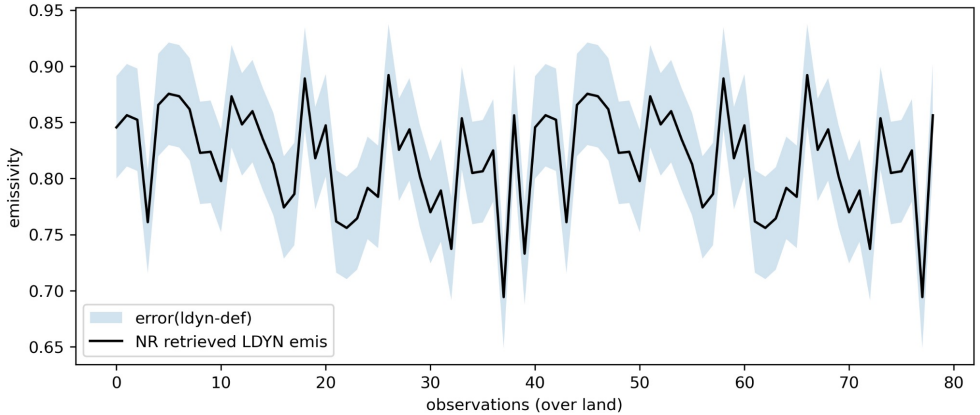
(Current) perturbations of surface emissivity

- The calibration is done through perturbation of observations and **not the emissivity**.
  - Emissivity perturbations are introduced after the calibration.

- For instance, it influences the simulated ATMS observations **over land and sea ice only**

- The uncertainty in emissivity: STDV of LDYN and LATLAS emissivity differences

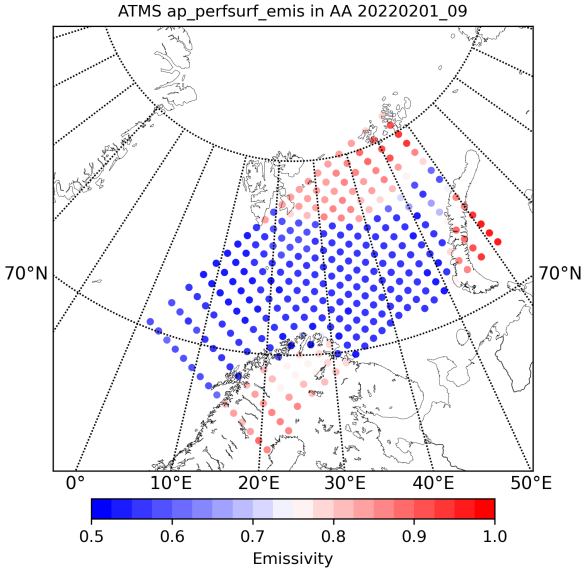


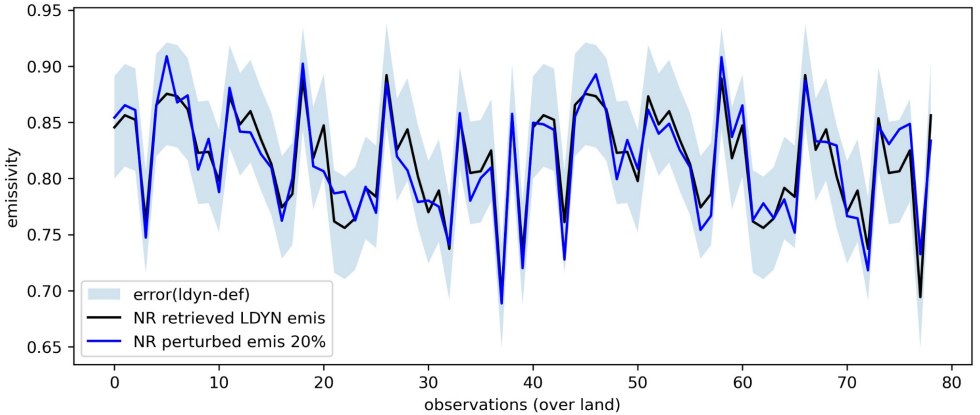


(Current) perturbations of surface emissivity

- The generated normally distributed random number is scaled by the assumed uncertainty in emissivity

- An additional factor is also applied (for scaling) assuming that a potential development cannot address the total error in surface description. See 20% factor on the figure.

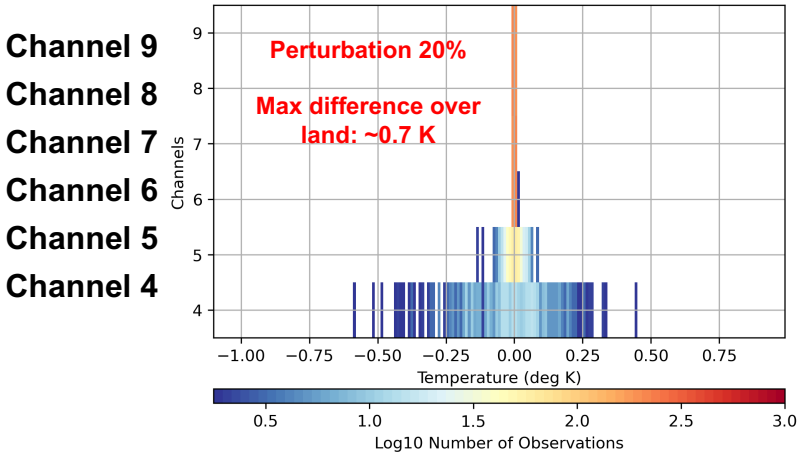




The impact of emissivity perturbations on actual data

- In a case study, the perturbed emissivity is introduced into a real assimilation runs assessing the impact on model-equivalent Tb. Note, that emissivity is perturbed over sea-ice and land and it is unperturbed over open sea.

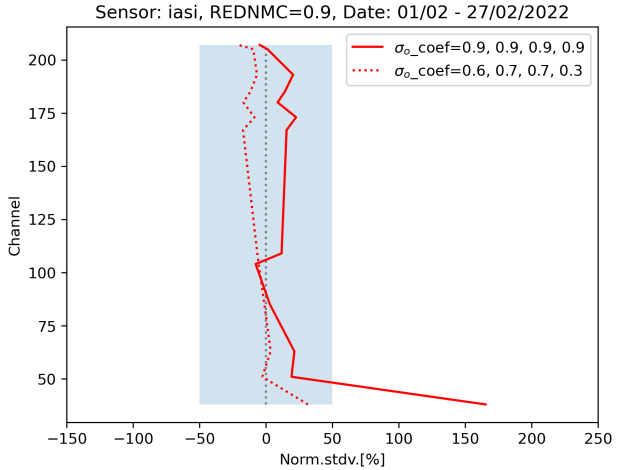
- The difference between AMSU-A simulated Tbs are shown here with and without perturbed emissivity (20% factor) over land. The largest obtained difference is around 0.12 K for Channel 5 and ~0.7 K for Channel 4

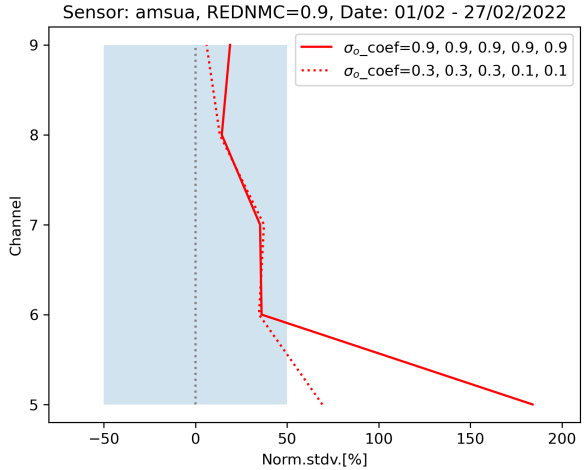


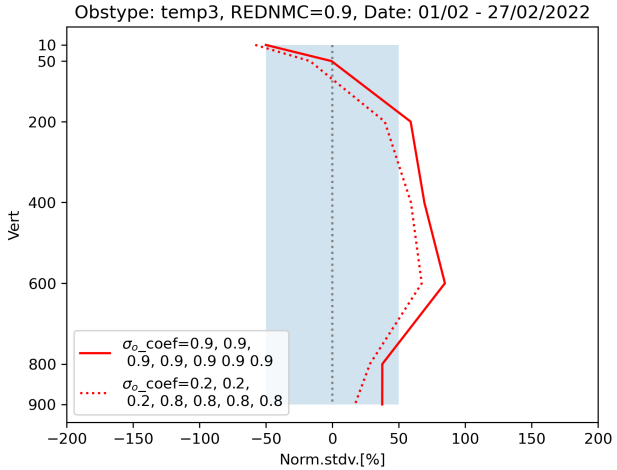
The calibration of OSSE system

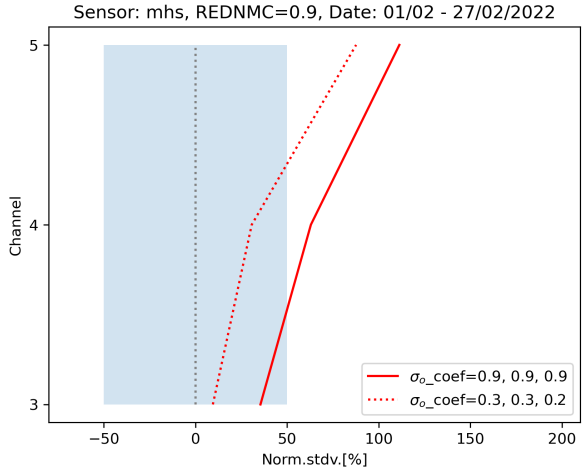
- The OSSE framework was calibrated on a winter period (February 2022), but the evaluation was carried out on a summer and winter period as well

- The assigned observation errors of the OSSE is generally much smaller than the real ones in order to come closer to the impact of the real NWP system









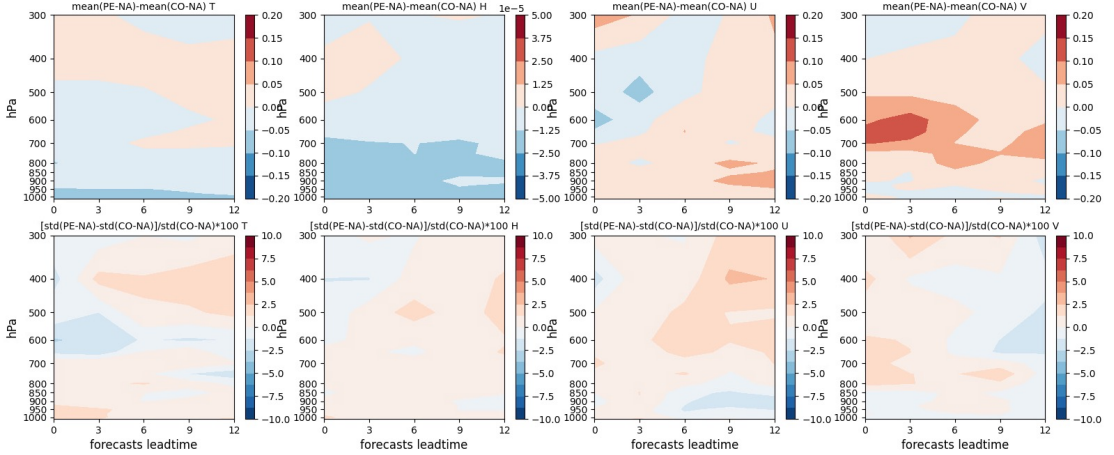
The OSSE evaluation

- Assuming the OSSE is calibrated i.e., providing the same or similar impact than the operational AA system, the evaluation can be carried out.
- Performed OSSE runs:
  - A control OSSE experiment using perfect i.e., unperturbed emissivity
  - And another OSSE experiment with perturbed emissivity values
  - Long forecasts are performed at 06 and 18 UTC to have comparable number of data and active instruments.

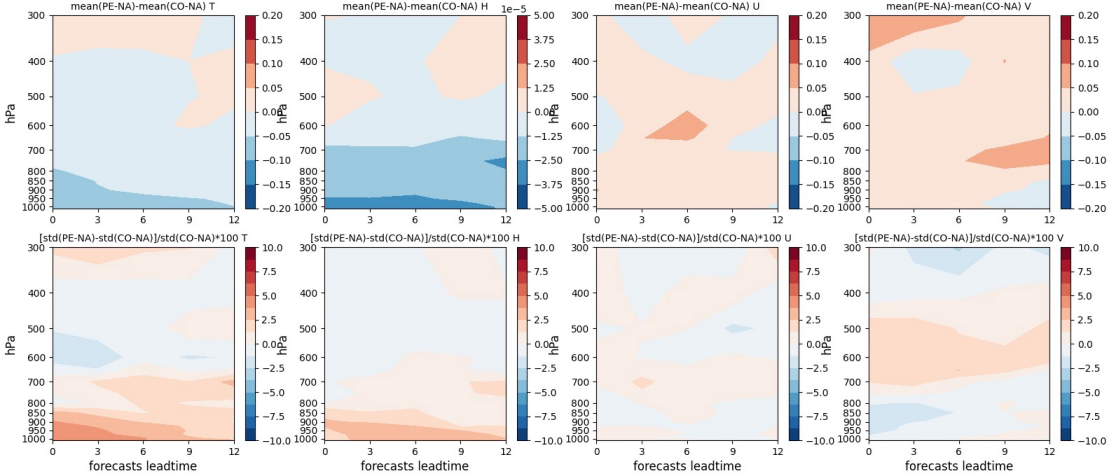
The evaluation of OSSE system

- Control run (perfect emissivity) vs. Perturbed emissivity runs (20% scaling)
- Summer period, verification scores over land, forecasts initialised at 06 and 18 UTC are shown here
- Bias and STDV for Temperature, Spec. Humidity, U-, and V-component of wind

06 land aug2021



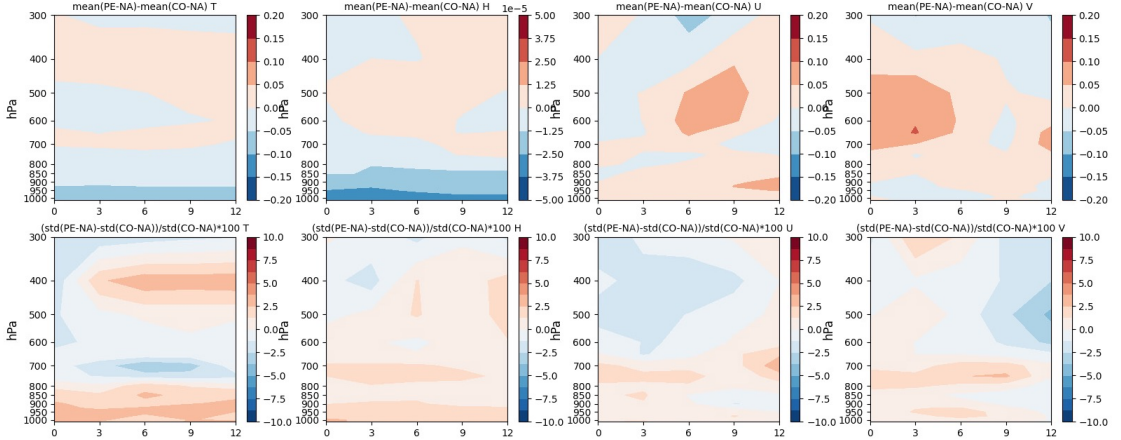
18 land aug2021



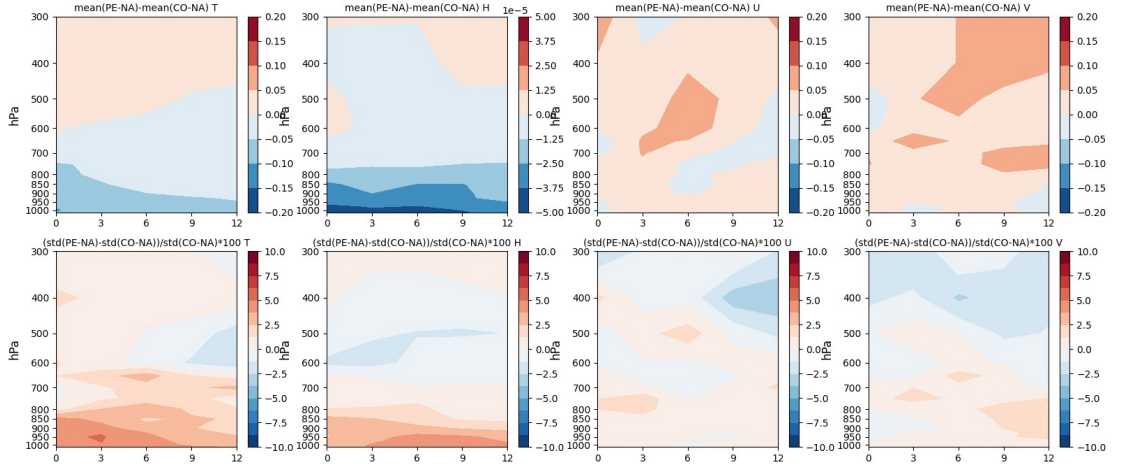
The evaluation of OSSE system

- Control run (perfect emissivity) vs. Perturbed emissivity runs (**50% scaling**)
- Summer period, verification scores over land, forecasts initialised at 06 and 18 UTC are shown here
- Bias and STDV for Temperature, Spec. Humidity, U-, and V-component of wind

06 land_pert50 aug2021



18 land_pert50 aug2021



Conclusions

- An Arctic OSSE was studied focusing on microwave radiance observations and the uncertainties in current surface emissivity.
- Highlighting e.g., 18 UTC AA runs
  - Eliminating **20%** of the uncertainty in emissivity description:
    - **3-5%** in Temp. and **2-3%** improvement in Humi. forecasts up to 6-9 hours can be gained
  - Eliminating **50%** of the uncertainty in emissivity description:
    - **5-7%** in Temp. and **3-4%** improvement in Humi. forecasts up to 6-9 hours can be gained
- Further possibilities
  - Sea ice representation is quite different in ARPEGE and HARMONIE-AROME and it's currently not well taken into account - ongoing work with evaluation of improved sea ice representation
  - Other perturbation techniques, strategies
  - "Perfect surface temperature" instead of "perfect surface emissivity"
  - The use of footprint observation operator

Thanks for your attention!

Question?

ARCTIC
PASSION

Meteorologisk
institutt