ILMATIETEEN LAITOS
METEOROLOGISKA INSTITUTET
FINNISH METEOROLOGICAL INSTITUTE

SRNWP at FMI in 2023

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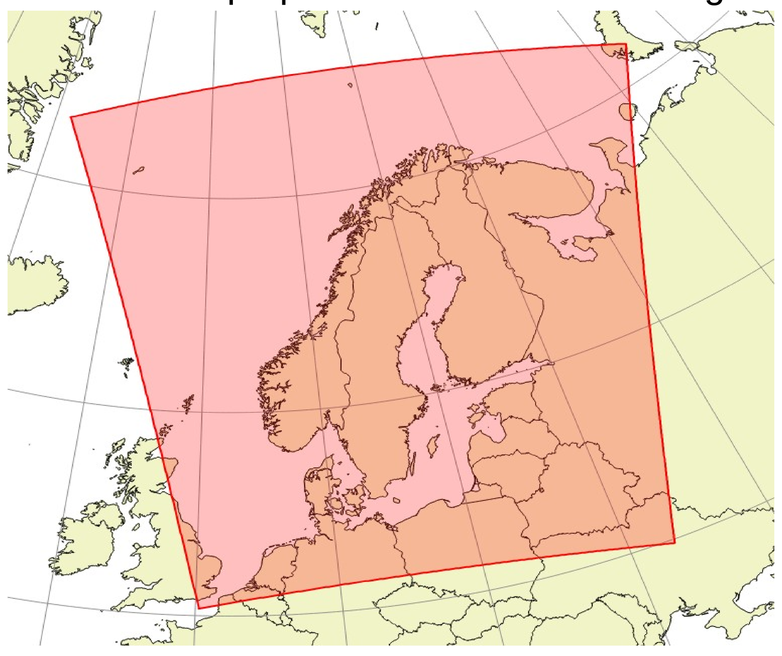
Operations

As a member of a Nordic **MetCoOp** cooperation with Norway, Sweden, and Estonia, FMI participates in developing and running a common high resolution (2,5 km) ensemble prediction system called **MEPS,** based on non-hydrostatic convection-permitting **Harmonie-Arome,** developed in a code cooperation with Météo-France and ALADIN. Operational ensemble forecast is updated every hour and it runs out to 66 hours. In addition, a HARMONIE-AROME-based nowcasting system **MNWC** is run hourly and produces 12 hour forecasts.

Forecast production within MetCoOp is distributed among the participating institutes.

Model Integration area
The MetCoOp operational domain coverage



Research

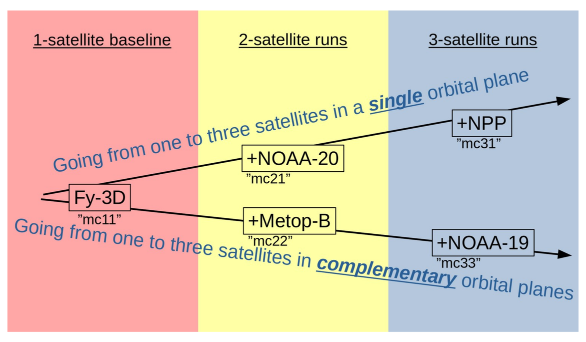
The main research topics, mostly related to numerical weather modelling (NWP) within the context of ACCORD, are as follows:

- Limited area weather forecast models (LAM)
- Short range rapid update weather forecasting (nowcasting)
- Ensemble prediction systems in numerical weather prediction (EPS)
- Weather forecast model data assimilation
  - satellites
  - snow
  - lake surface temperature
- Radiation and the effect of aerosols in NWP
- Forecast quality assurance
- Renewable energy power production estimation
- Icing phenomena in wind power production
- Urban meteorology
- High performance computing (HPC) in meteorology

Evaluating the impact of microwave-sounding satellite data

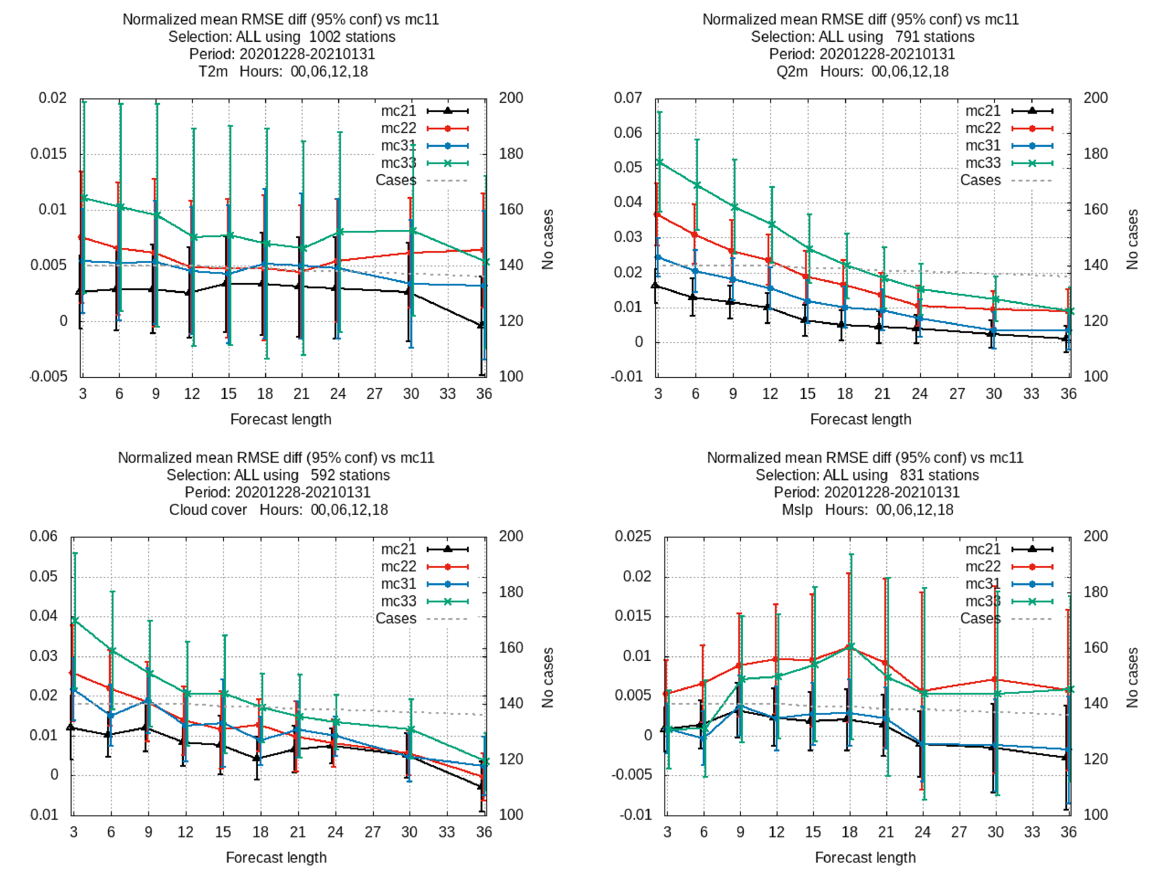
Background
The short-range forecast impact of a constellation of future Arctic Weather Satellites (AWS) is estimated in the context of European Space Agency -funded research project. The approach is to quantify the incremental benefit that is achieved now from adding the currently-operating microwave–sounding satellites into the assimilation system one by one.

Experiment setup
- The impacts of bringing new satellites either into one single orbital plane or into complementary orbital planes are compared
- 42-day experiment using 4D-Var data assimilation in the operational MetCoOp 2.5 km grid
- A winter period 28th December 2020 – 7th February 2021 is chosen so that satellite orbits of NOAA-19, NOAA-20, and Metop-B are as homogeneously distributed as possible (noting the drifting orbit of NOAA-19)
- Five experiment runs with varying use of satellites with microwave sounders
- The use of microwave sounders is as similar to the current operational use as possible
- 4D-Var analysis is done every three hours and a 36-hour forecast every six hours (from 00, 06, 12, and 18 UTC analyses)



The setup of the satellite constellation impact study in the MetCoOp operational domain

Preliminary results after 35/42 days
- In surface-based verification of temperature, humidity, and cloud cover, each new satellite brings benefit out to at least +24-hour forecast lead time
- In surface pressure, there is some benefit from the 2nd satellite, but no further benefit from the 3rd.
- It is more beneficial to put two satellites into complementary orbits than three satellites into a single orbit
- The additional impact from the 3rd satellite is approximately 50% of that from the 2nd satellite
- No conclusive impacts in upper-air forecast parameters, but there are non-significant improvements in lower-tropospheric temperature and humidity

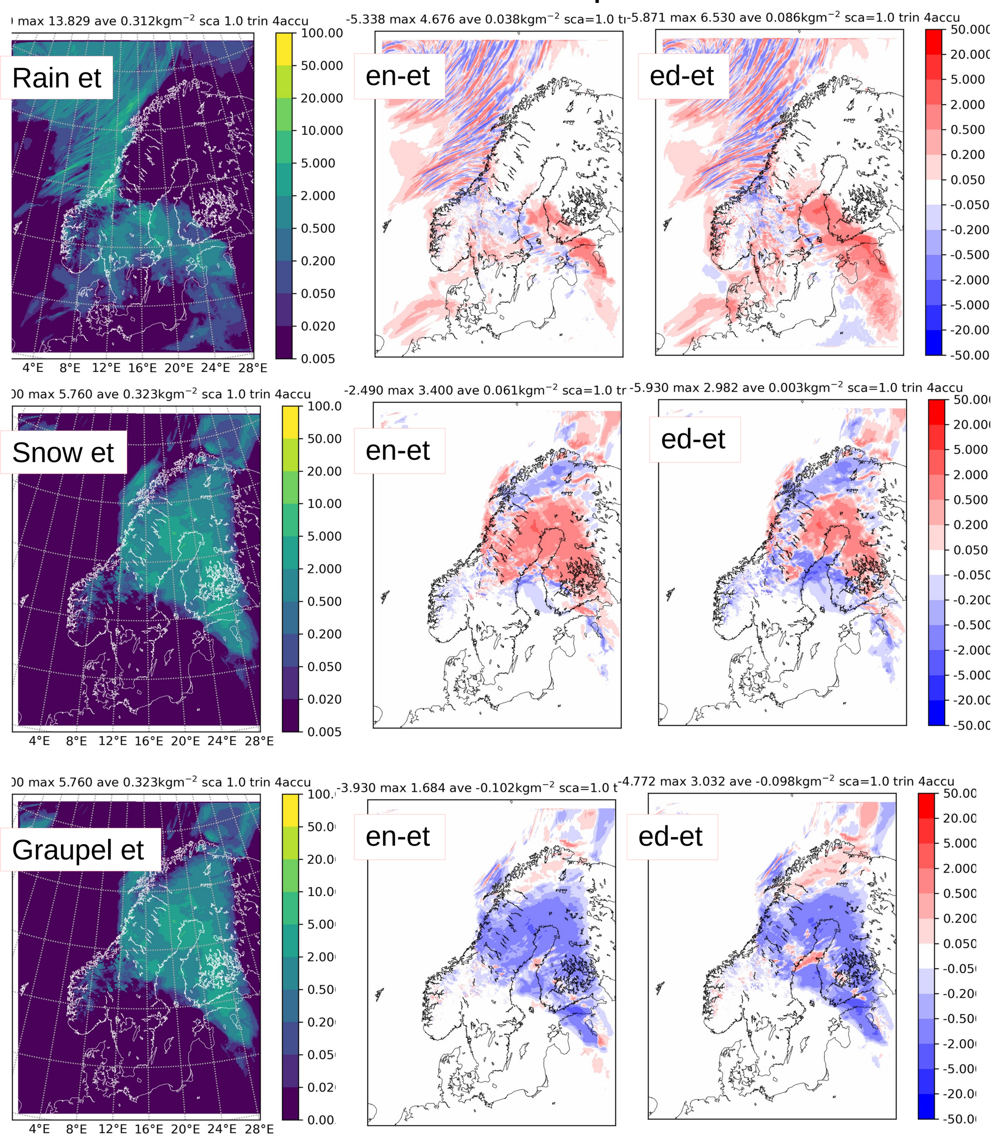


Relative improvement over the 1-satellite baseline in the other four experiment runs. The comparison is in terms of the root-mean-square of forecast error in 2-meter temperature, specific humidity, cloud cover, and mean sea level pressure.

Dust and weather 3000 km apart

HARMONIE-AROME experiments with 14 near-real-time (n.r.t.) aerosol species from Copernicus Atmosphere Monitoring Service (CAMS) were run for the case of February 2021 Saharan dust intrusion to Finland. Impacts to radiation and precipitation type distribution were seen. Modelling uncertainties increased when n.r.t. aerosols were allowed to influence cloud-aerosol-radiation processes.

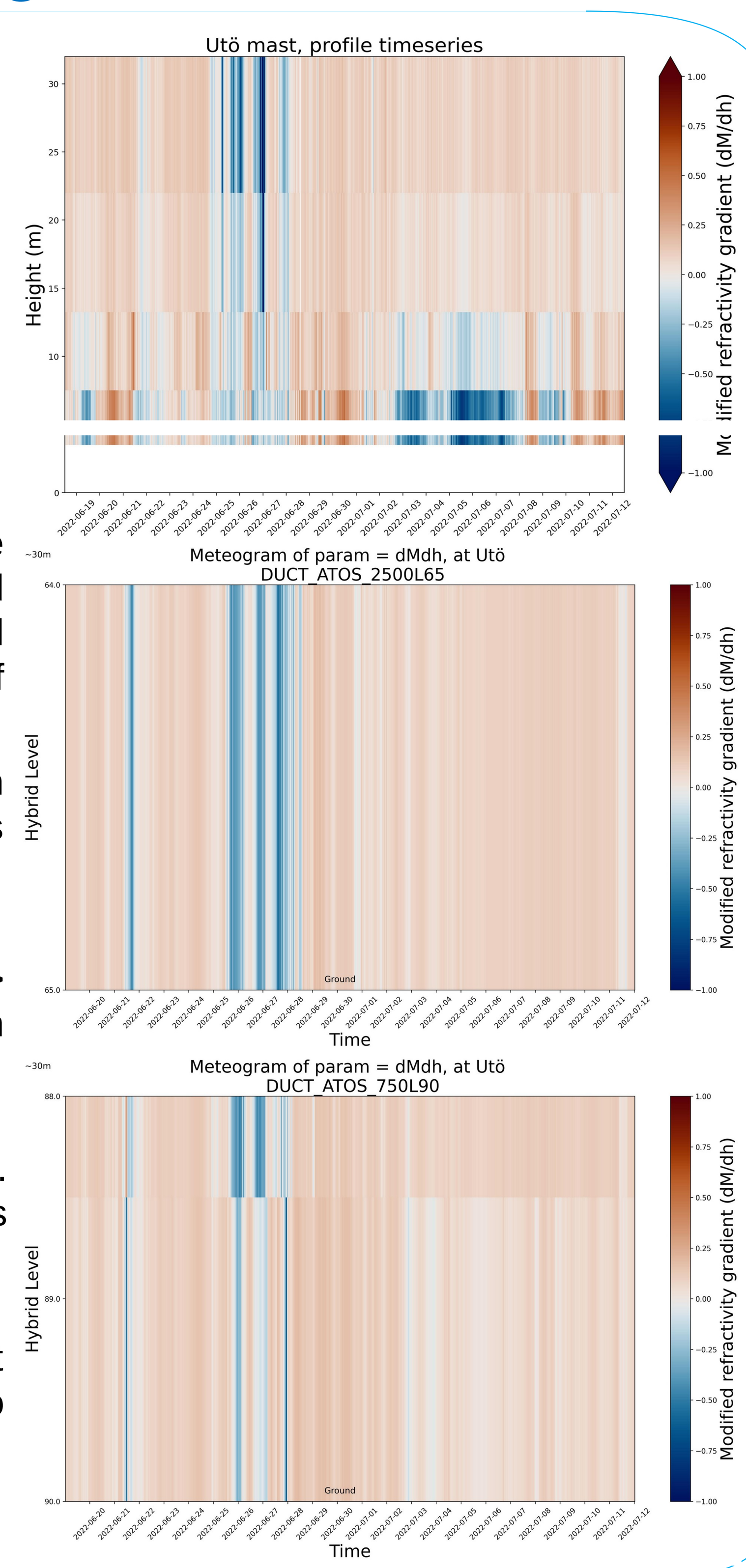
Default experiment with climatological aerosol (et), that does not influence cloud microphysics, was compared to experiments with all n.r.t. species (en) and with only dust (ed). They show different distribution of rain, snow and graupel while the total precipitation was only little affected. In particular, in the experiment with only dust included, the relative amount of rain increased at the expense of solid precipitation over areas that were mostly affected by dust. The effect is related to the way dust is treated by the cloud microphysics parametrizations of the model and requires further evaluation.



Forecasts valid at 2021022300+12, accumulated precipitation (kg/m2) 00-12 : upper row rain, middle snow, lower graupel. From left to right using default climatological aerosols that do not influence cloud microphysics (et); difference n.r.t.-default (en-et); difference dust only and default (ed-et).

Forecasting ducting conditions

Timeseries of vertical profile of Modified refractivity gradient. Calculated based on observations (top), and with two model resolutions 2500m + 65 levels (middle), and 750m + 90 levels (bottom).



What is ducting?
Anomalous signal propagation, especially in form of electromagnetic wave ducting, is a phenomenon affecting the use of radar and radio communication in the atmosphere. Ducting causes radio interference or can lead to radar detection range far greater than usual, both cases are important for many civilian and military applications. Ducting can occur if the vertical gradient of refractivity index of the atmosphere turns into negative. In such condition the radar/radio signal is bent towards the ground and the electromagnetic signal gets trapped into quasihorizontal layer. This cannot be strait measured, but from the behavior of signal propagation it can detect for instance as noise in radar image.

Refractivity index is dependent on atmospheric density and composition. Therefore, the atmospheric pressure, temperature, and humidity are the main interactive parameters. Conditions that affect the formation of ducting layer are: 1.) if humidity decrease strongly upwards, and/or 2.) if temperature inversion is present.

Methods
Refractivity index can be forecasted with NWP models. We utilized the Harmonie-AROME model for these experiments, varying horizontal resolution (2500m -> 750m) and the number of vertical levels (65 -> 90). The results were compared against traditional observations. In addition, we had mast observations with high vertical resolution close to sea surface (4m, 7m, 12m, 22m, 32m).

Results
The modified refractivity gradients were calculated based on model data and measurements. The figures show the vertical time-series from the mast location. The negative (blueish) values indicate the possibility of ducting layer to occur. The main differences are due to models ability to produce realistic enough profiles of temperature close to surface. The temporal accuracy is better higher up (~30m) from the ground where the model temperature is closer to observed.

Conclusions and future plans
Overall the results show that the vertical resolution of the weather model had more impact on results, compared to horizontal resolution. Our next step is to test how more rapid update of the weather model SST will affect on temperature values close to ground. And because the resolution is still very course, we aim to test methods to add more layers closer the ground.