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PREPARING FOR AND EVALUATING THE ARCTIC WEATHER SATELLITE DATA IN THE NORDIC LIMITED-AREA NUMERICAL WEATHER PREDICTION SYSTEMS

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CHALMERS UNIVERSITY OF TECHNOLOGY

DMI

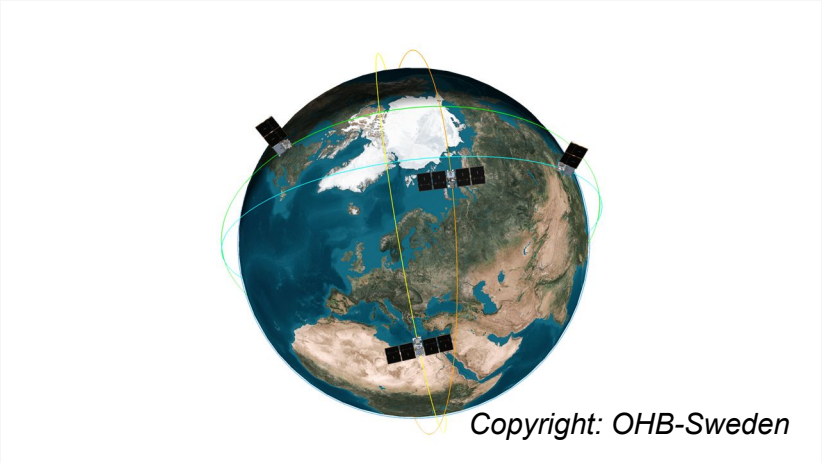
Meteorologisk institutt

Structure

- The Arctic Weather Satellite (AWS)
- ESA AWS project overview
- Preparation of the regional numerical weather prediction (NWP) system
- Constellation impact studies
- Results
- Conclusions

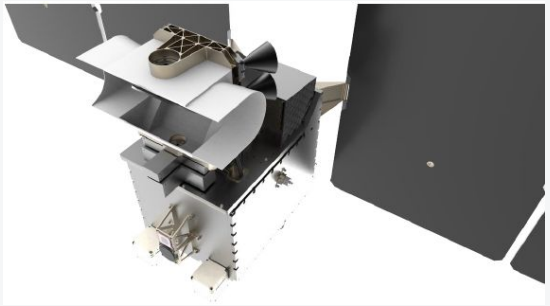
EPS-Sterna

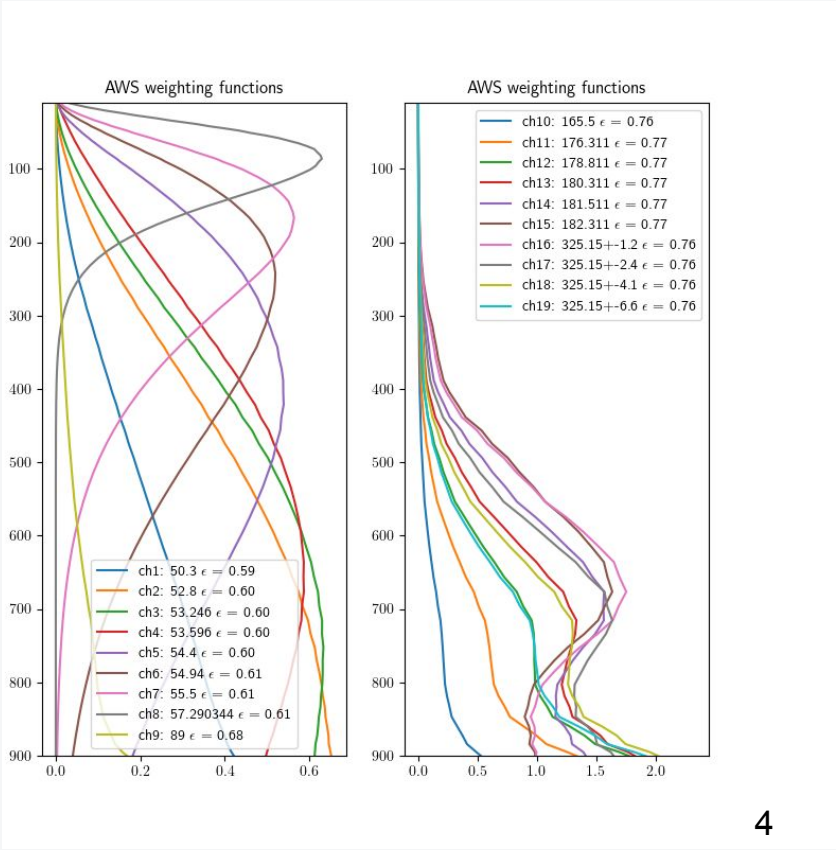
- 6 satellites in 3 different orbital planes
- Complementing the Metop & JPSS
- Giving high temporal coverage - down to ~30 minute over the Arctic

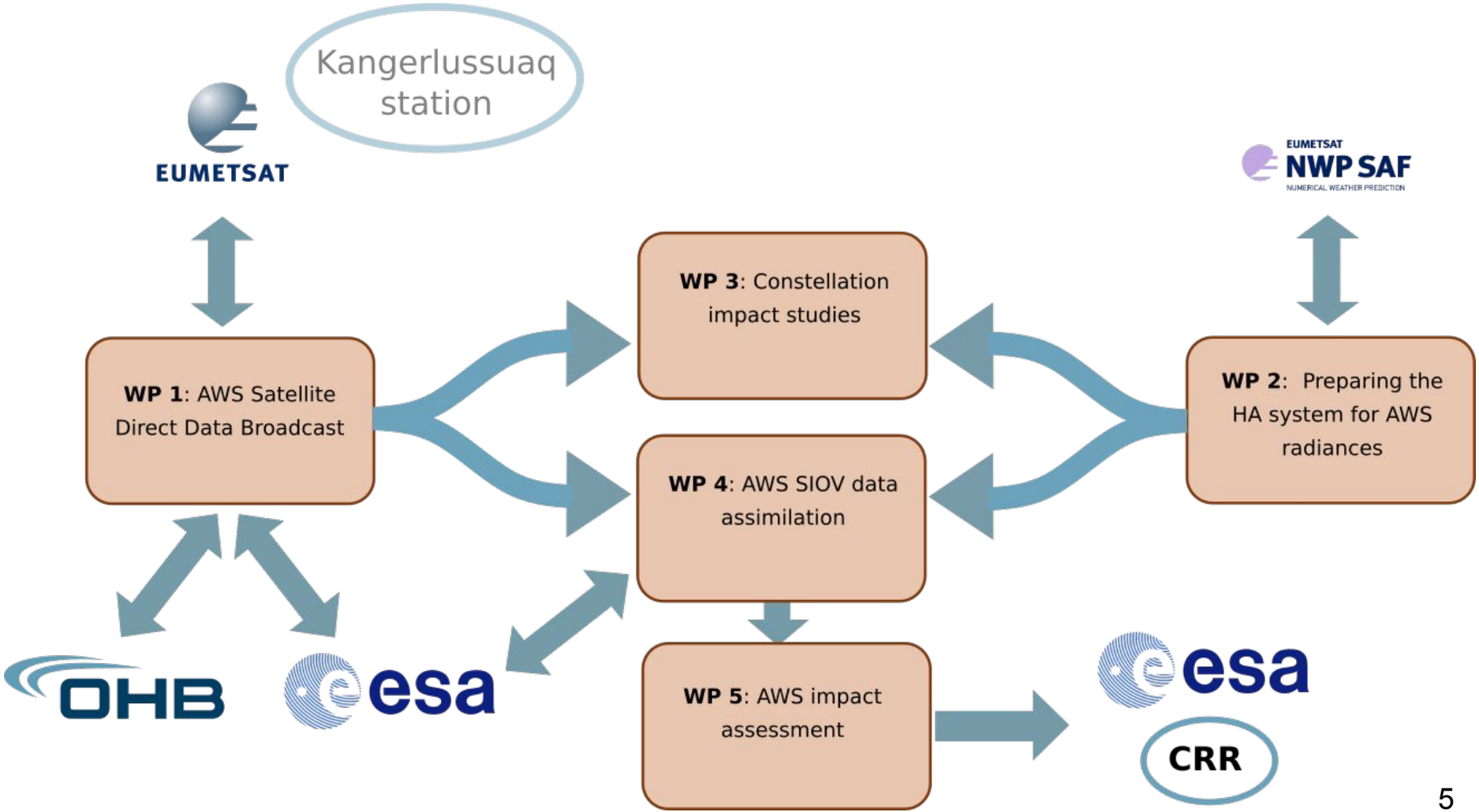


The AWS instrument

- Passive Microwave Radiometer
- Cross-track scanner (~2000 km swath)
- Strong heritage to MHS/AMSU-A and ATMS (and MWS)
- 19 channels for temperature and humidity sounding + clouds
- 4 new sub-mm bands around 325 GHz for humidity sounding and clouds






Kangerlussuaq station
EUMETSAT
EUMETSAT NWP SAF
NUMERICAL WEATHER PREDICTION
WP 1: AWS Satellite Direct Data Broadcast
WP 3: Constellation impact studies
WP 4: AWS SIOV data assimilation
WP 2: Preparing the HA system for AWS radiances
WP 5: AWS impact assessment
OHB
esa
esa
CRR

Nordic ground Segment Coverage

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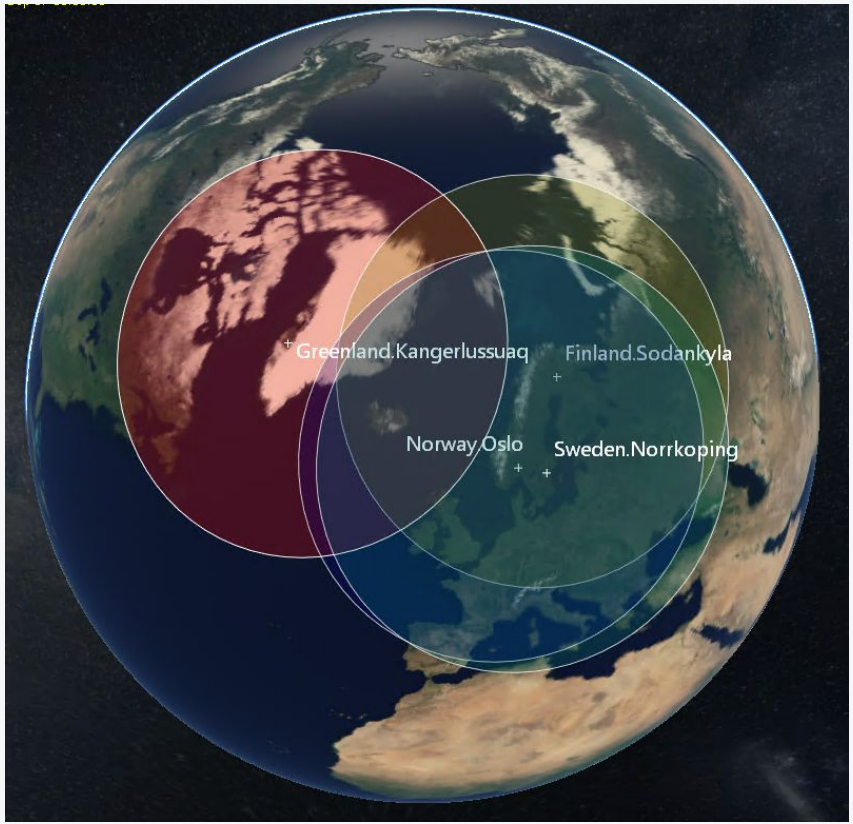
AWS horizons, seen from the four stations

Norrköping

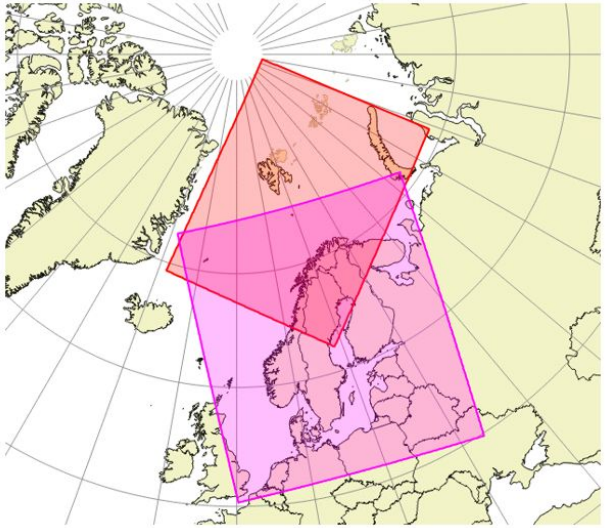
Oslo

Kangerlussuaq

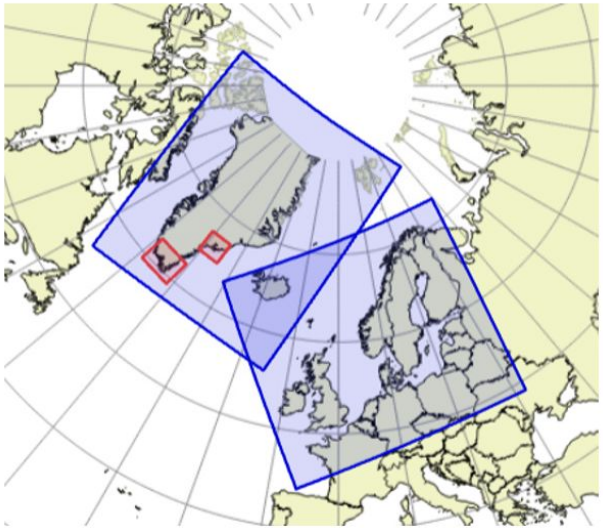
Sodankylä



The HARMONIE-AROME regional numerical weather prediction (NWP) system and Nordic domains



MetCoOp and Arome-Arctic



Danish/Icelandic operational

Planned UWC-west domains

65 vertical model levels, 2.5 km horizontal grid-distance, data-assimilation using 3D-Var or 4D-Var

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Preparing The HARMONIE-AROME NWP system for AWS data

- Technical preparation for reading and processing of AWS data.
- Enhanced use of low-peaking microwave channels.
- Representation of satellite footprint in model equivalent.
- Towards all-sky assimilation.
- Use of 325 GHz channel.

Surface-sensitive data

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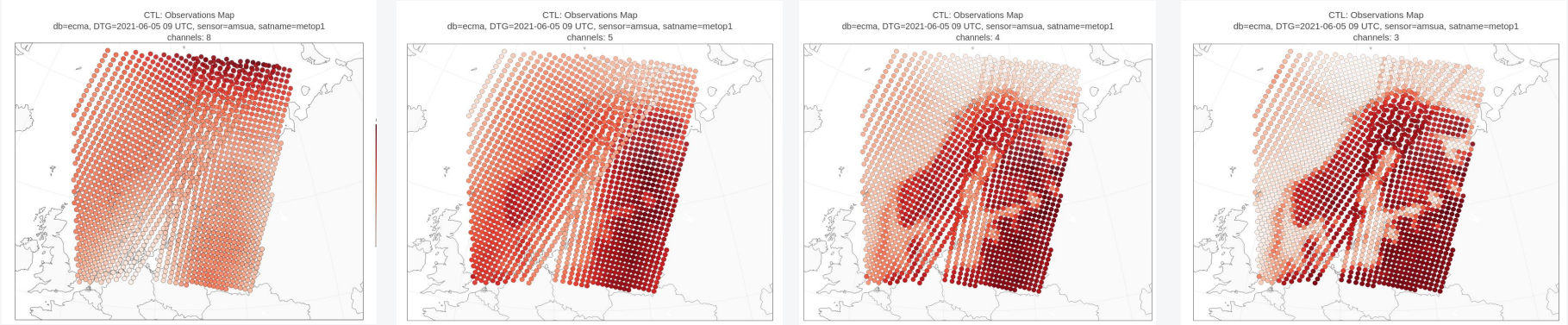
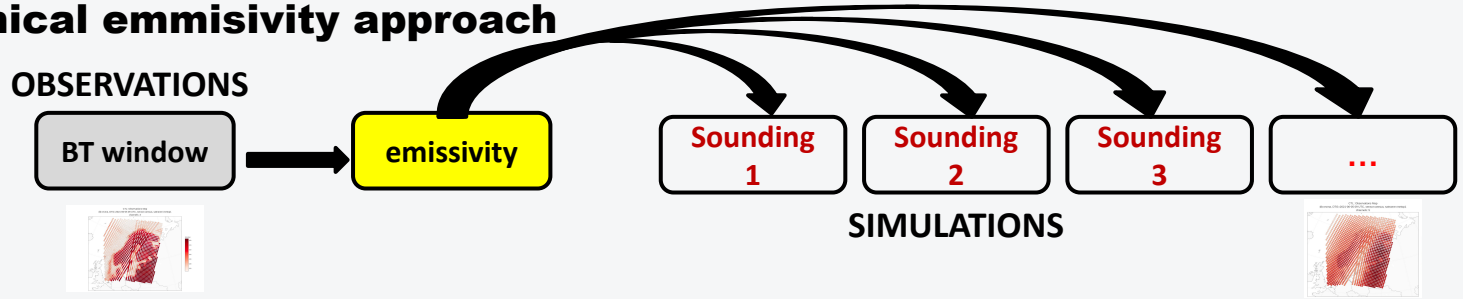
For low-peaking channels, the mixed signal coming from both the atmosphere and the surface **requires an adequate representation of the surface temperature & emissivity in radiance space.**

AMSU-A ch 9 *Sounding (~8km)* … AMSU-A ch 5 *Sounding (~4km)* AMSU-A ch 4 *Sounding (~1km)* AMSU-A ch 3 *Window*



The peak of the channel weighting functions decreases in altitude (reduction of atmospheric absorption)

Dynamical emmisivity approach



Representing satellite radiance footprint

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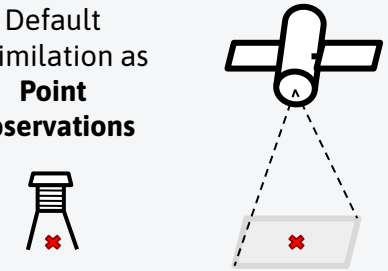
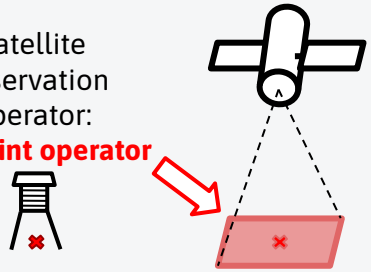
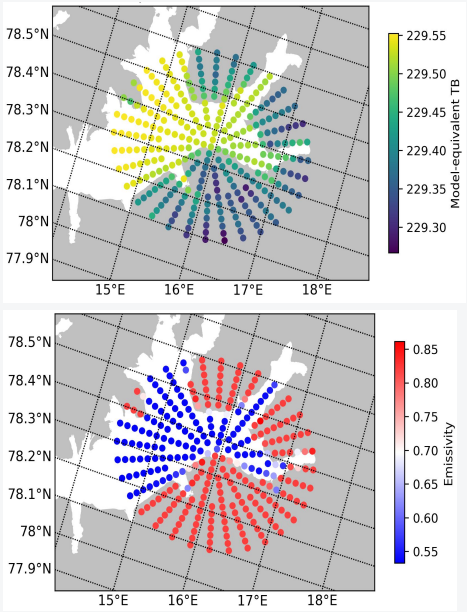
Default assimilation as **Point observations**



Satellite observation operator: **Footprint operator**



- If using AWS radiances as point observations, the HARMONIE-AROME data assimilation will suffer spatial representation errors.
- A footprint operator can improve the high-resolution data assimilation by computing an averaged model equivalent under the satellite footprint.
- The footprint representation help to take into account sub-footprint heterogeneity.



Simulated Tb and retrieved emissivity over mixed surface

Impact of enhanced used of low-peaking channels

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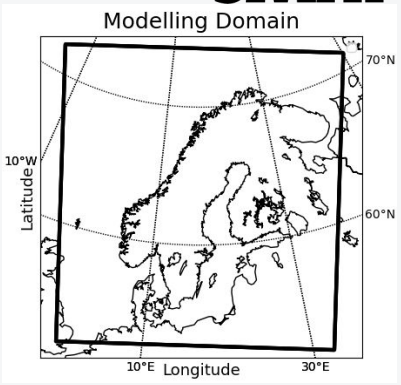
Two sets of parallel experiments of Nordic domain to evaluate the effect of low peaking channels. One in 3D-Var and one in 4D-Var framework. Period: February 2021. Forecasts up to 36h.

CRL: reference experiment using conventional and various types of satellite-based observations

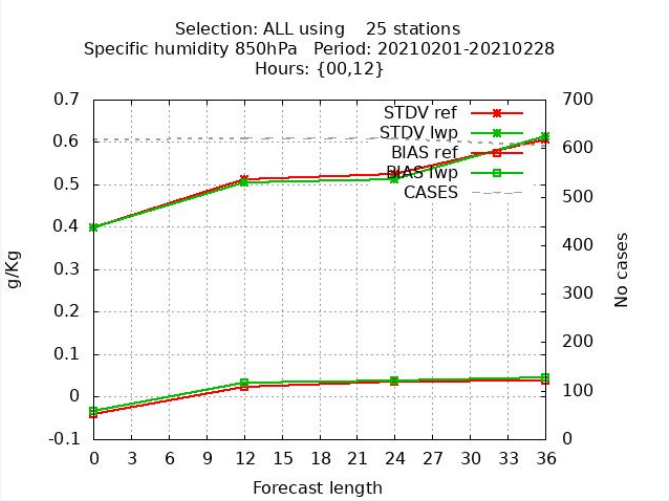
EXP: low peaking channel experiment using dynamic emissivities over land and sea-ice, in which which also channel 5 is used both for AMSU-A and MHS

Results show a slightly positive impact from use of low peaking channels on forecasted humidity and winds (4D-Var). Results obtained for both short (1-3 h, see below) and long forecast ranges.



Standard deviations and bias for verification of 4D-Var based forecasts at 850 hPa against radiosondes.

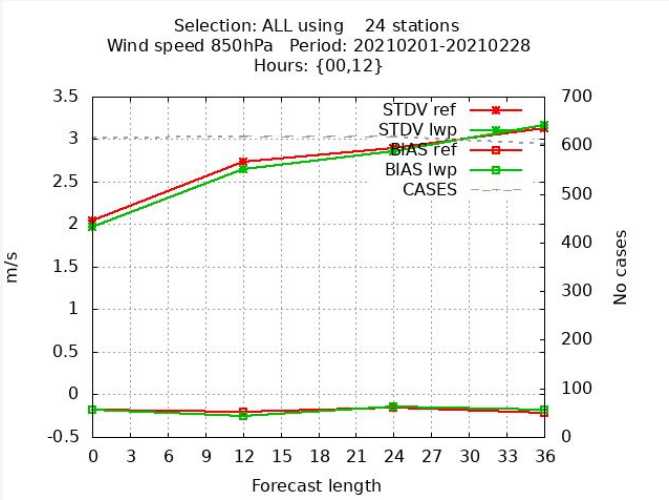
Specific humidity



CRL

EXP

Wind speed



Towards all-sky

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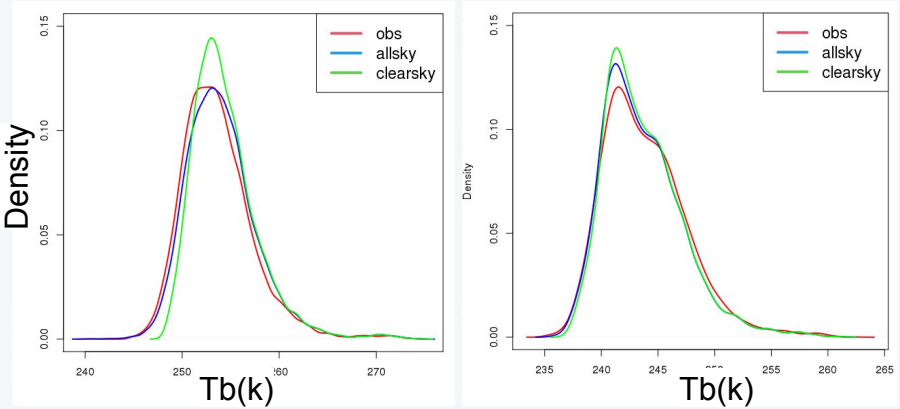
Activation and evaluation of all-sky functionality in HARMONIE-AROME on-going, starting with the MHS instrument. Adaptations towards HARMONIE-AROME micro-physics.

HARMONIE-AROME all-sky

All-weather radiances from MHS assimilated in Harmonie-Arome 3DVAR with ECMWF all-sky approach using rttov_scatt observation operator, no hydrometeors in the control variables so all-sky assimilation will change temperature and humidity fields.

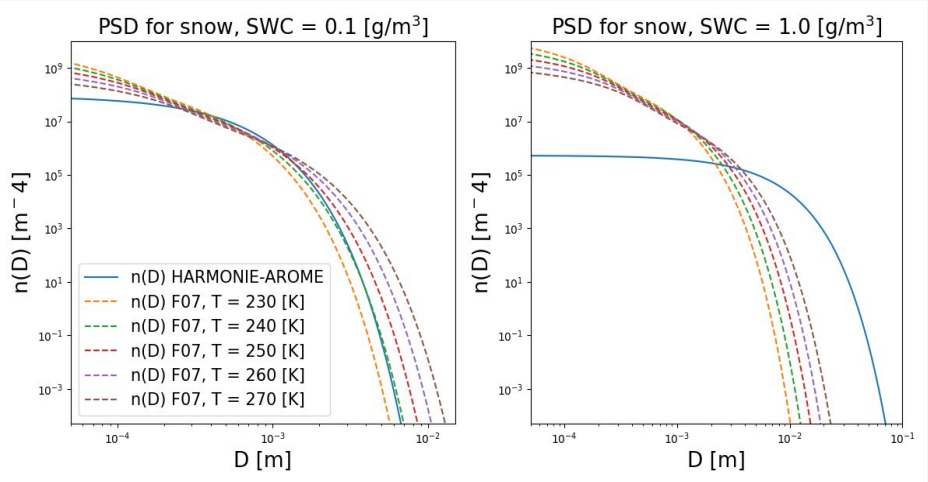
Observed (red), model allsky (blue), and model clear-sky (green) brightness temperature for MHS channel 3 and 4.



On-going investigation of the importance of particle size distributions (PSD) of hydrometeors in all-sky assimilation

Comparison of RTTOV and HARMONIE-AROME snow particle size distributions

F07: PSD used in RTTOVv13 (Field et al. 2007)



Using heritage MW sounders to demonstrate the benefit of multiple satellites in regional NWP

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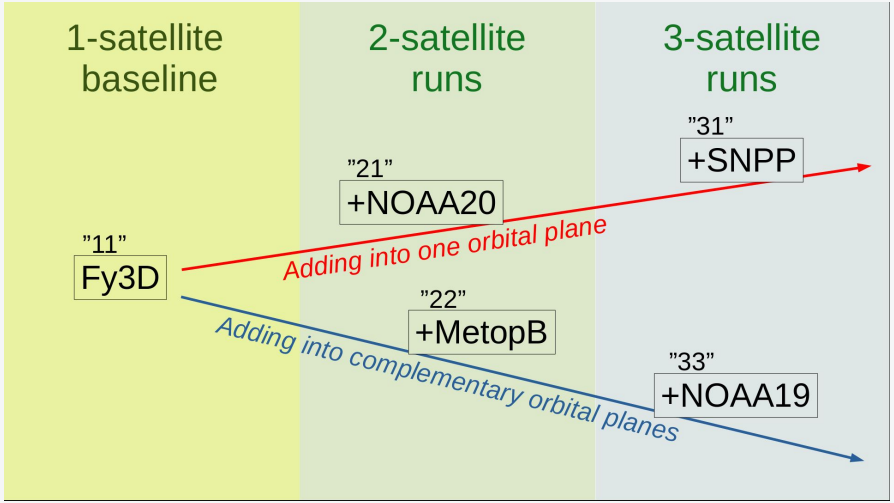
Objective: Quantify the incremental benefit from adding MW-sounding satellites one-by-one either into *one single orbital plane* or into *complementary orbital planes*



We will produce two streams of 8-week experiments using 4D-Var data assimilation:

1) A winter period 14 Dec 2020 – 7 Feb 2021 using the MetCoOp operational domain
2) A summer period 15 Jun 2020 – 9 Aug 2020 using the Arome-Arctic operational domain

The five experiments in each stream are all in production at present

Summary

- Within an ESA-funded project, the HARMONIE-AROME regional NWP system is being prepared for assimilation of AWS data.
- The nordic ground segment include the four receiver stations of Kangerlussuaq, Oslo, Sodankylä and Norrköping.
- Project results regarding enhanced use of low peaking channels from MW instruments have been proven beneficial and already reached operations. Further enhancements are ongoing.
- Constellation impact studies are in production.