SMHI

Preparing for and evaluating the AWS data in the Nordic limited-area NWP systems

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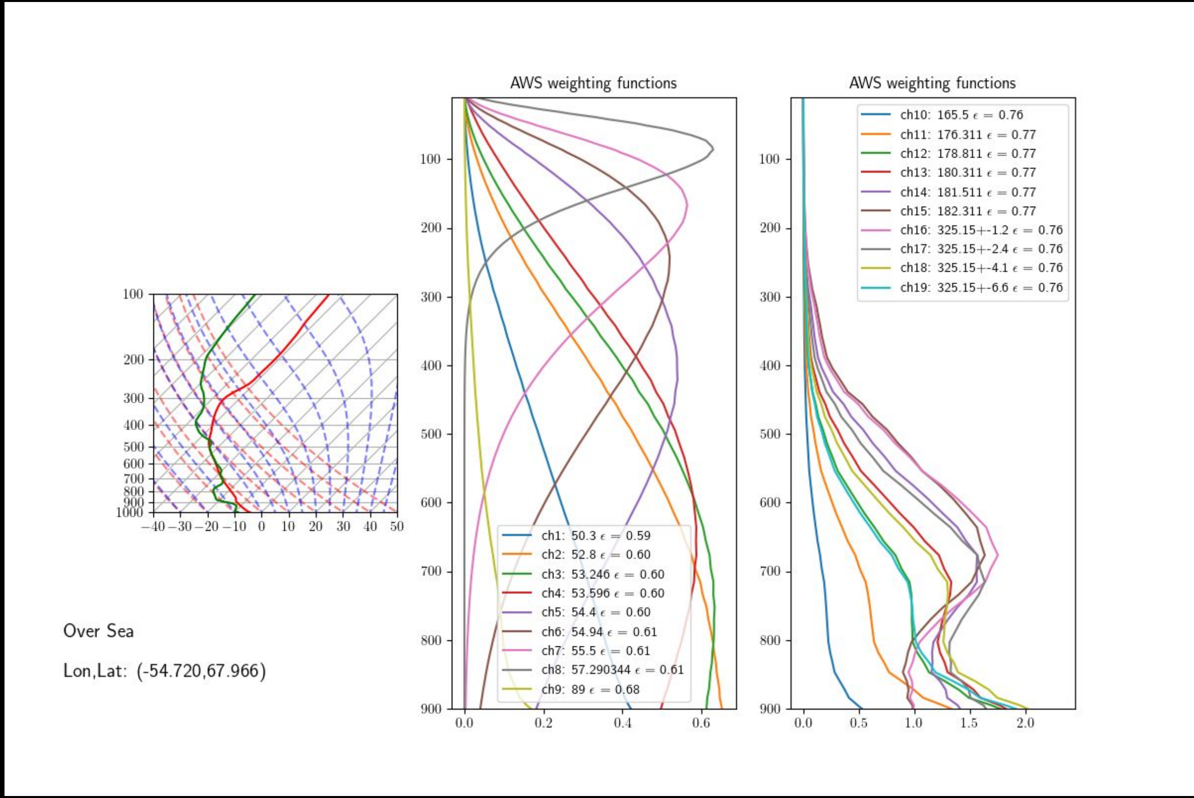
DMI
DTU
CHALMERS
FMI
Meteorologisk institutt

Introduction

- The prototype AWS satellite is scheduled for launch 2024
- Provides MW sounding capability for temperature and humidity important for NWP
- ...and new bands with information on cloud ice
- A possible forerunner for a EUMETSAT constellation giving very frequent updates over the Arctic and high latitudes

Introduction



Introduction

Performance evaluation of Arctic Weather Satellite data

SMHI

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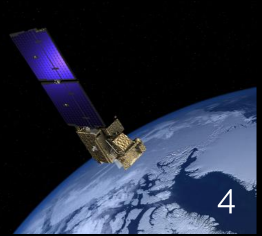
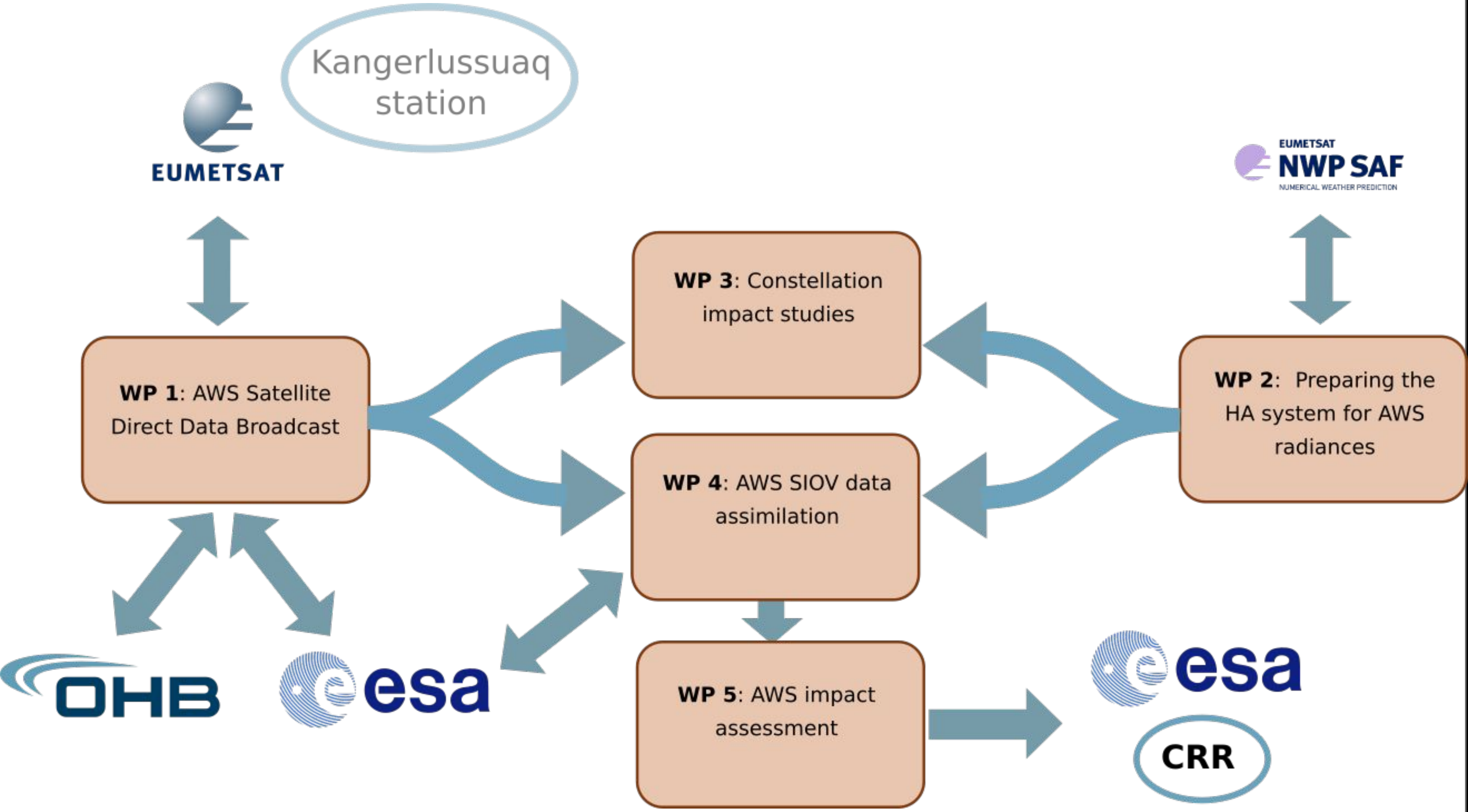




Kangerlussuaq station
EUMETSAT
EUMETSAT NWP SAF
NUMERICAL WEATHER PREDICTION
WP 3: Constellation impact studies
WP 1: AWS Satellite Direct Data Broadcast
WP 2: Preparing the HA system for AWS radiances
WP 4: AWS SIOV data assimilation
WP 5: AWS impact assessment
OHB
esa
esa
CRR

A Nordic AWS Ground Segment

Coverage

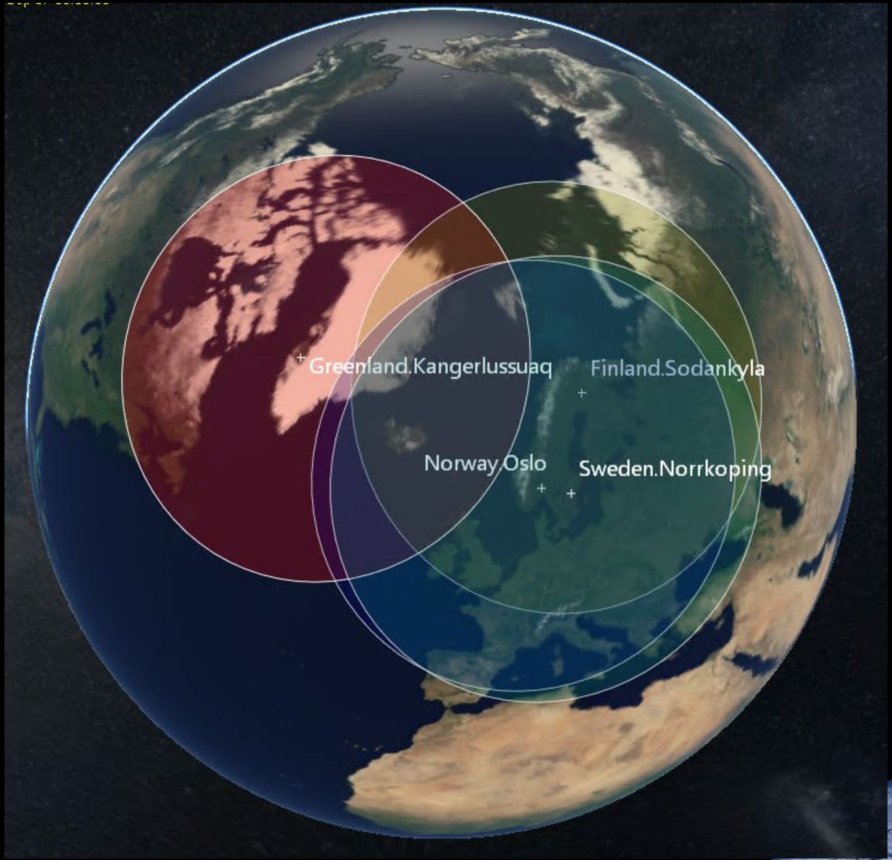
AWS horizons, seen from the four stations

Norrköping

Oslo

Sodankylä

Kangerlussuaq



Reception capability

Simulations over 10 days end of March 2022, assuming LTDN of 10:30, and lowest priority to AWS on all stations:

- Kangerlussuaq: 65 of 114 (57%)
- Sodankylä: 69 of 114 (61%)
- Norrköping: 31 of 104 (30%)
- Receiving **102** out of 146 total passes

Orbit	Satellite	Satellite Acquisition Priorities
Mid-morning	Metop-C	1
	Metop-B	4
Afternoon	NOAA-20 (JPSS-1)	5
	SNPP	2
	FY-3D	7
Early Morning	NOAA-18	6
	NOAA-19	3

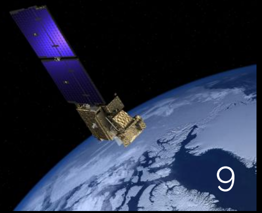
NB! EUMETSAT has committed to ~60% AWS passes for Kangerlussuaq

Reception capability

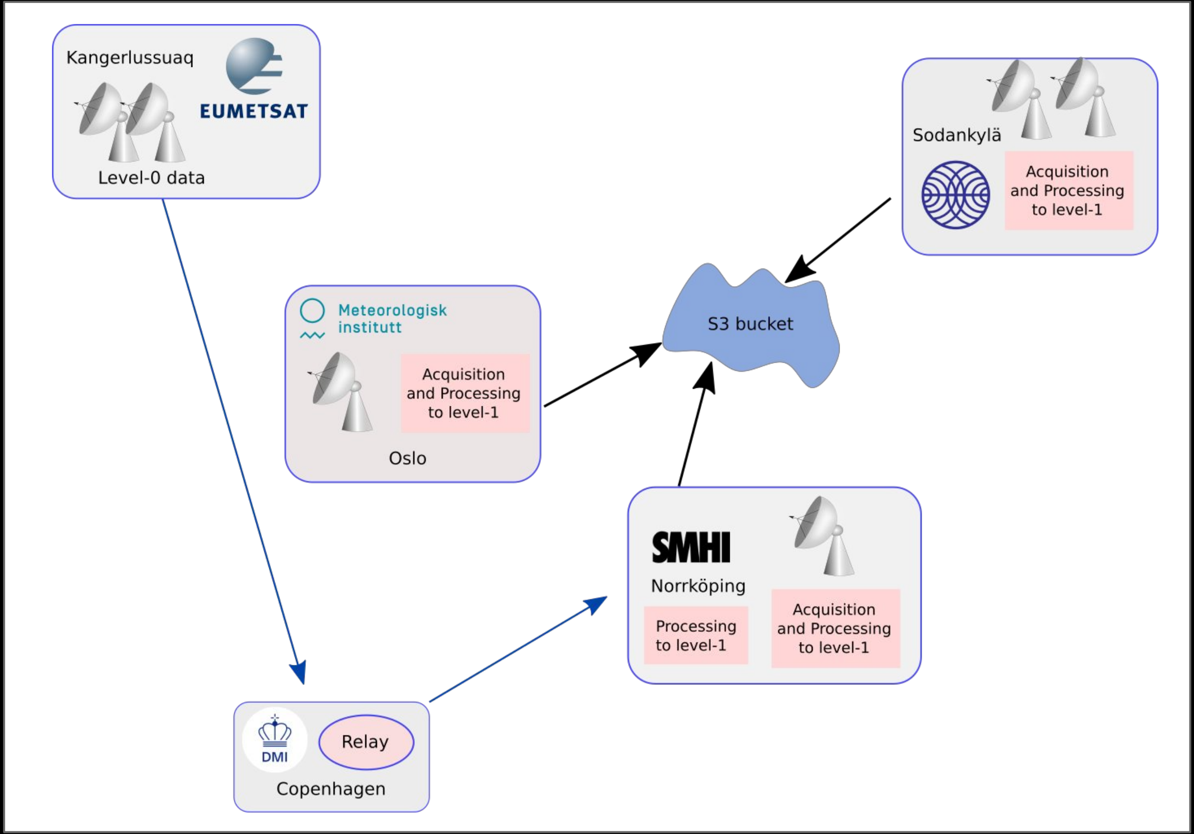
…full priority to AWS in Norrköping but lowest priority in Greenland and Finland:

- Receiving **131** passes out of 146

NB! This requires a full operational data (all polar satellites) exchange in place between Oslo and Norrköping

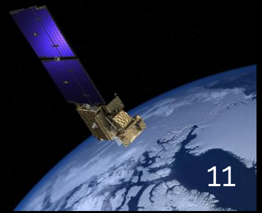


Ground segment - concept



Ground segment - concept

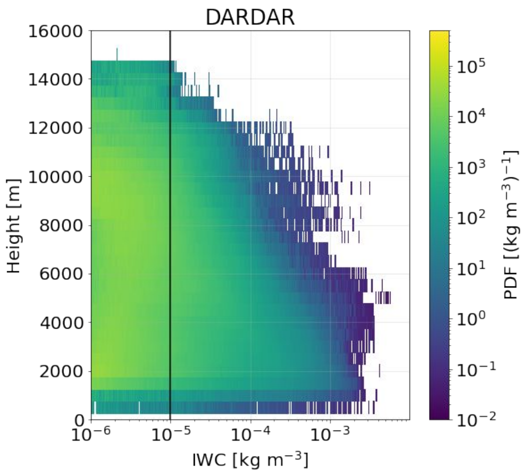
- Level-0 processor integrated at each node in local acquisition system
- Common implementation of level-1 processor with Pytroll SW (same for all 3 Nordic stations)
- Greenland (level-0) data will be sent to DMI and then relayed to SMHI for processing
- All 3 nodes (Norrköping, Oslo and Sodankylä) will post the level-1 data to a S3 bucket

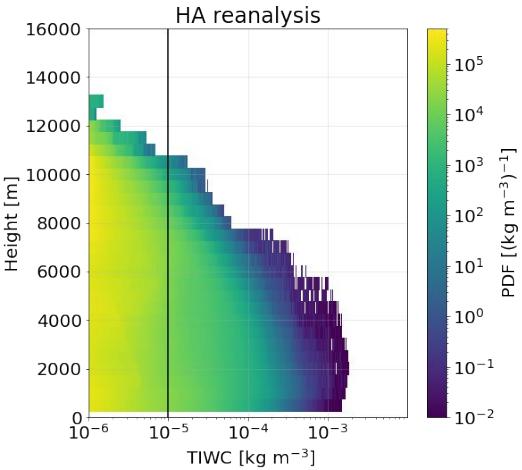


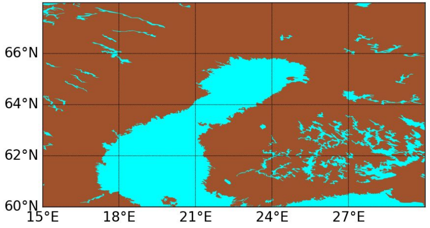
Preparing the NWP model system

- Technical adaptations for AWS
- Focus on low-peaking channels & snow and sea ice
- All-sky preparations
- Footprint operator
- Use of 325 GHz channels

All-sky preparations







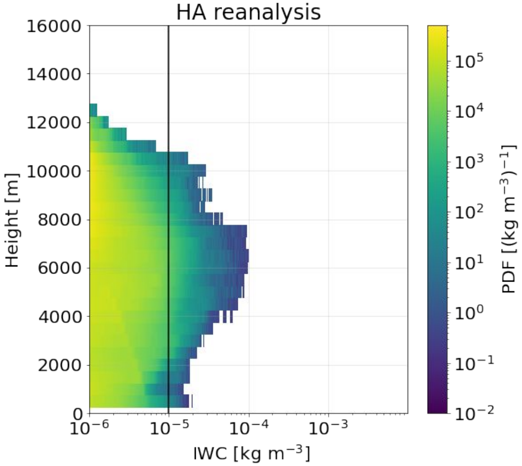
<u>Data (Nov & Dec):</u>

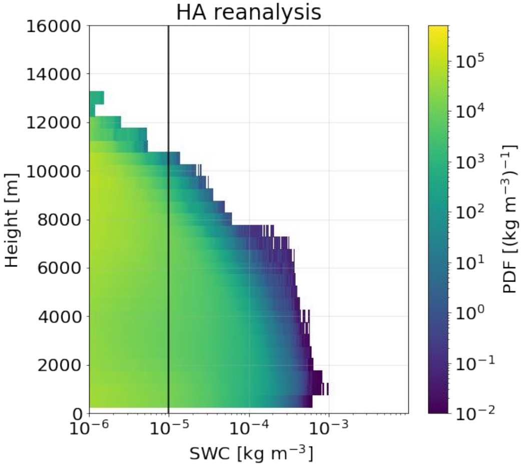
Harmonie Arome 1200 UTC):

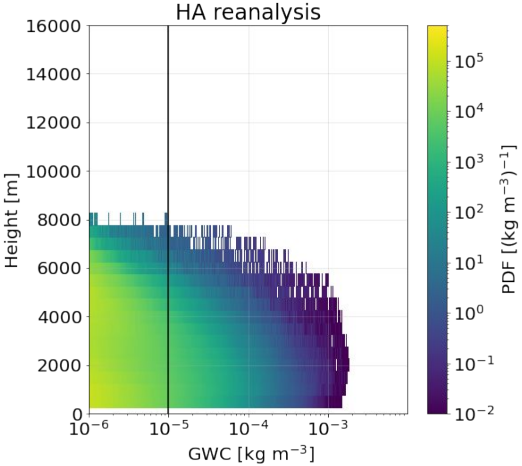
- 2021

DARDAR (1330 UTC):

- 2009-2010, 2015-2017







Settings:

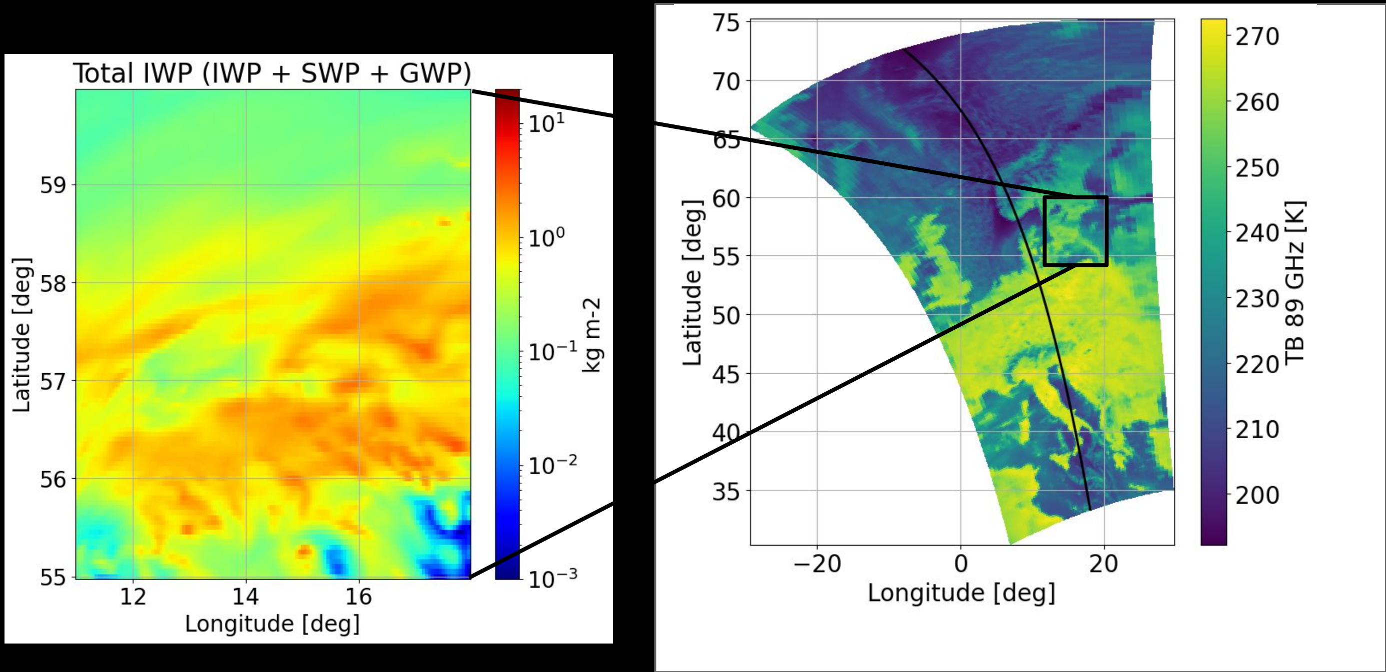
Scene over central and southern Sweden - 12:00 UTC, 1/12-2021

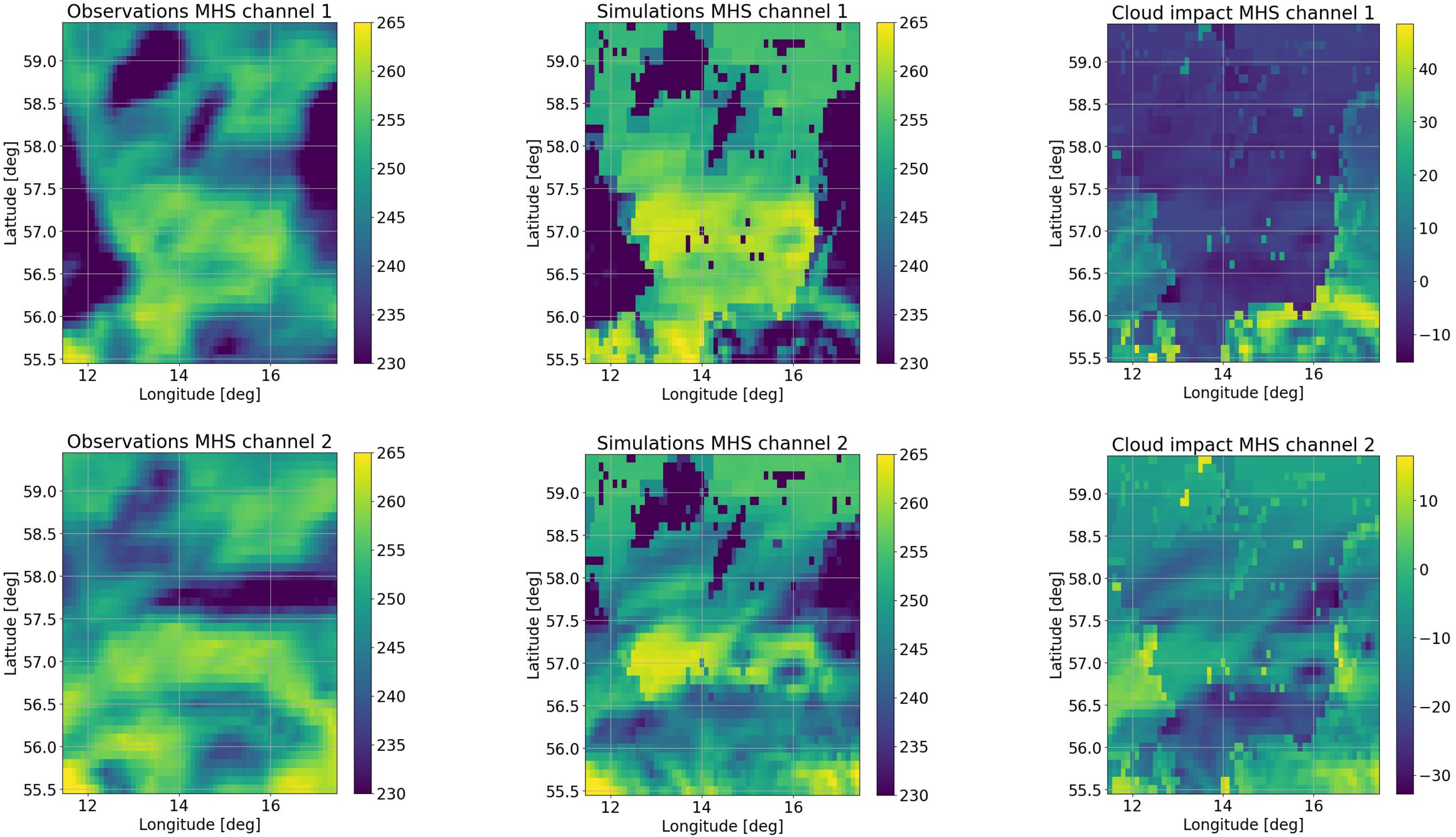
TELSEM over land and FASTEM over sea

Large plate aggregate and particle size distribution D14

NB!

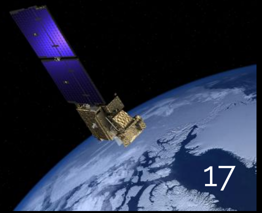
- MHS like simulations at nadir only
- MHS observations at ~20 deg.




Observations MHS channel 1
Simulations MHS channel 1
Cloud impact MHS channel 1
Observations MHS channel 2
Simulations MHS channel 2
Cloud impact MHS channel 2
Lattude [deg]
Latitude [deg]
Longitude [deg]
12
14
16
55.5
56.0
56.5
57.0
57.5
58.0
58.5
59.0
230
235
240
245
250
255
260
265
−10
0
10
20
30
40
−30
−20

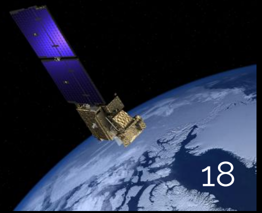
Summary & Outlook

- An ESA project prepares for an early evaluation of the first AWS in the context of regional NWP at high latitudes
- Real-time data over the Nordic region including Greenland will be made available publicly
- The HARMONIE-AROME system is being updated to make the best possible use of AWS data from day-1



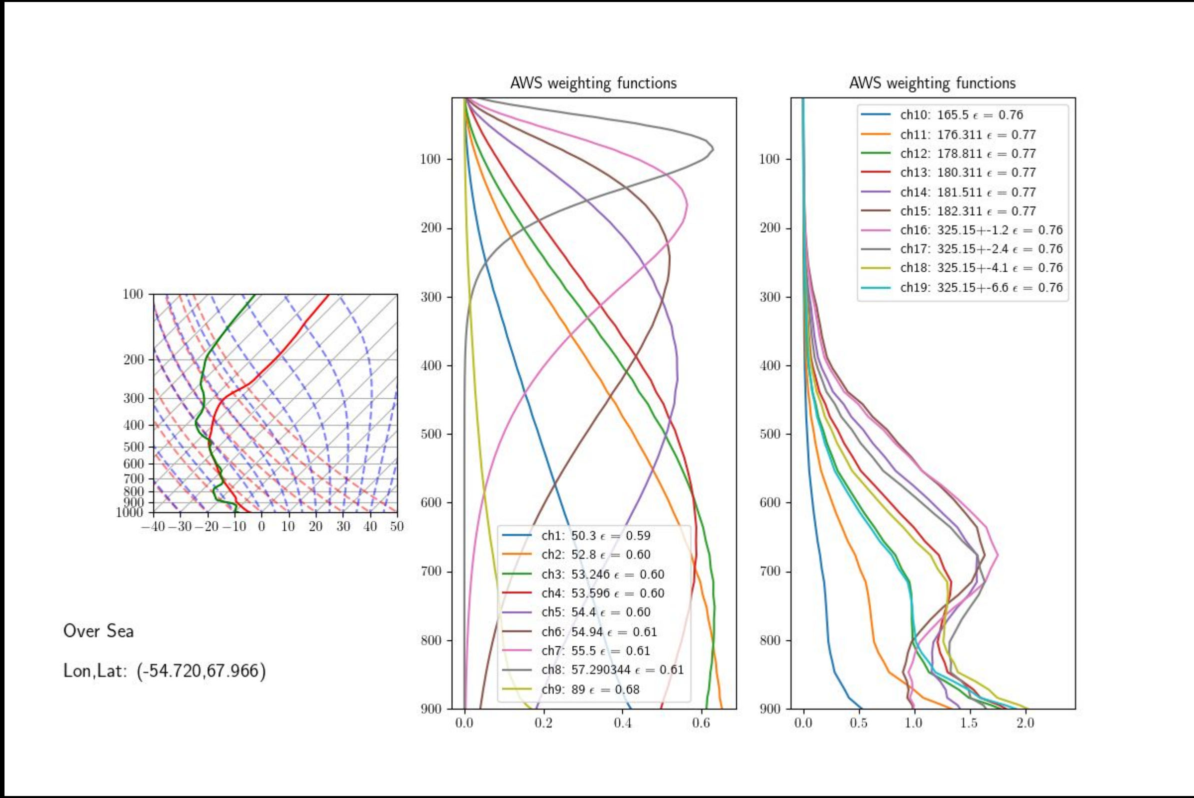
Summary & Outlook

- A EUMETSAT study lead by MET Norway is being launched to prepare for a constellation of AWS's
- Focus on regional NWP and Nowcasting at high latitudes and Arctic:
  - Regional OSSE
  - Nowcasting precipitation

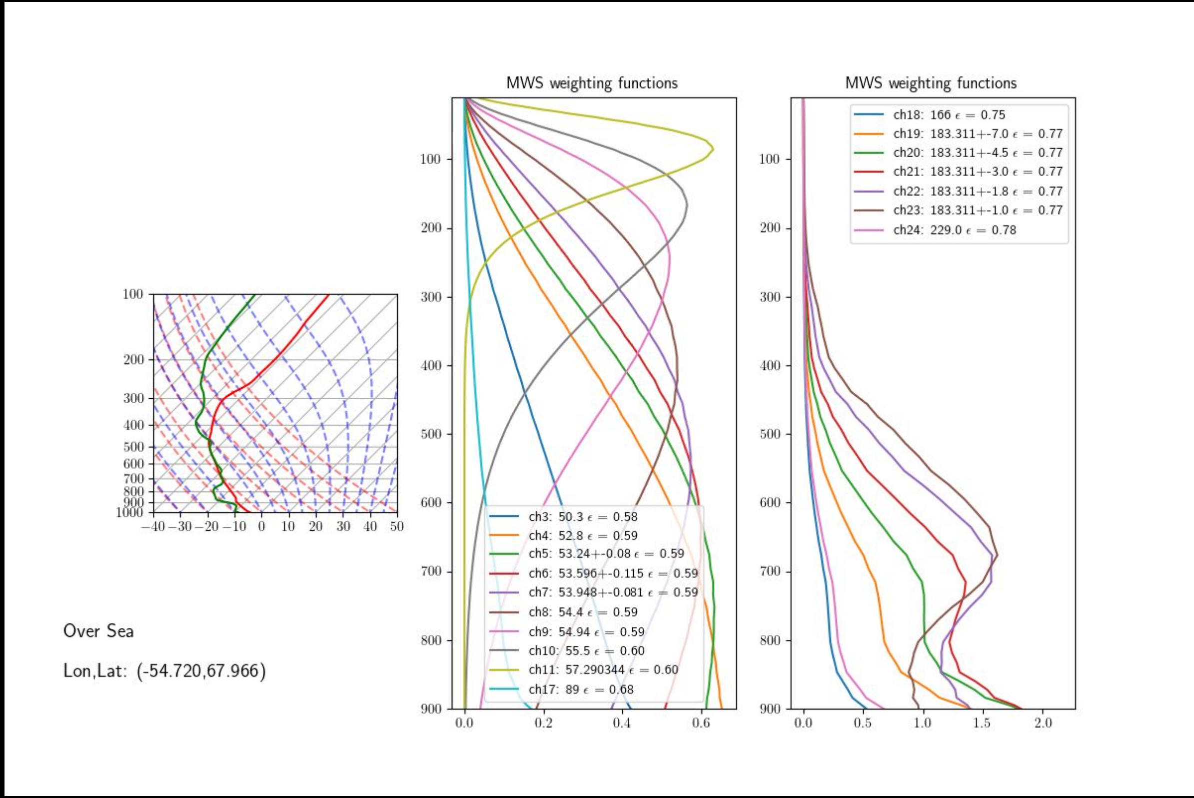


Backup slides

Introduction



Introduction

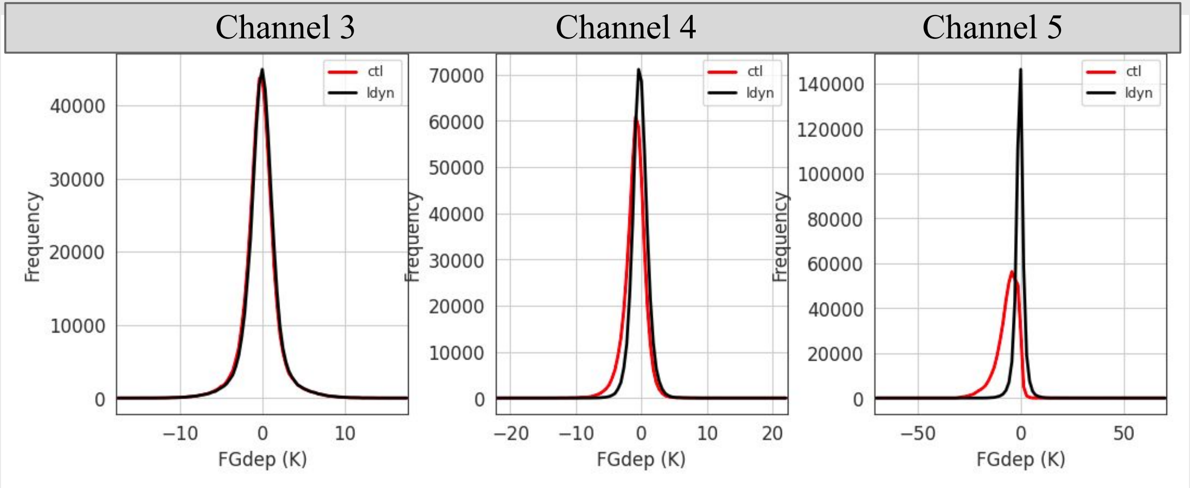


Results
Impact on BT simulations

FG-Departures to Observations

CONTROL
LDYN

Frequency histograms
MHS over sea-ice
(20210110-20210228)



⇛ Reduction of bias and stdev for surface-sensitive channels (MHS channel 4 & 5)

Norwegian Meteorological Institute

Results

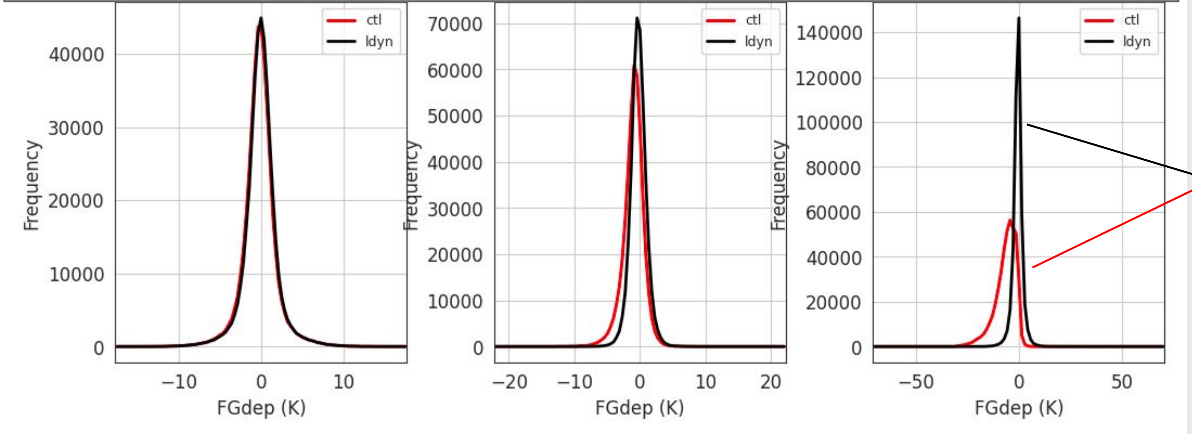
Impact on BT simulations

FG-Departures to Observations

CONTROL
LDYN

Frequency histograms
MHS over sea-ice
(20210110-20210228)

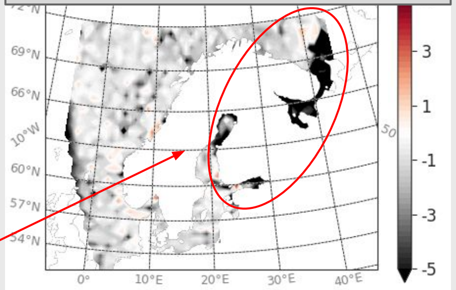
Channel 3 | Channel 4 | Channel 5



Averaged map for MHS over sea
(20210210-20210215)

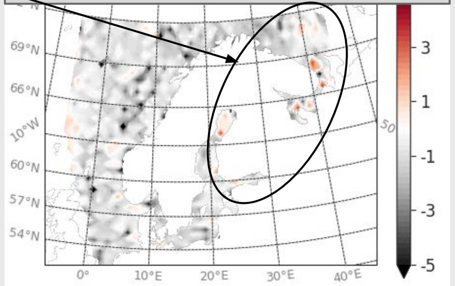
CONTROL

Channel 5



LDYN

Channel 5



⇒ Reduction of bias and stdev for surface-sensitive channels (MHS channel 4 & 5)

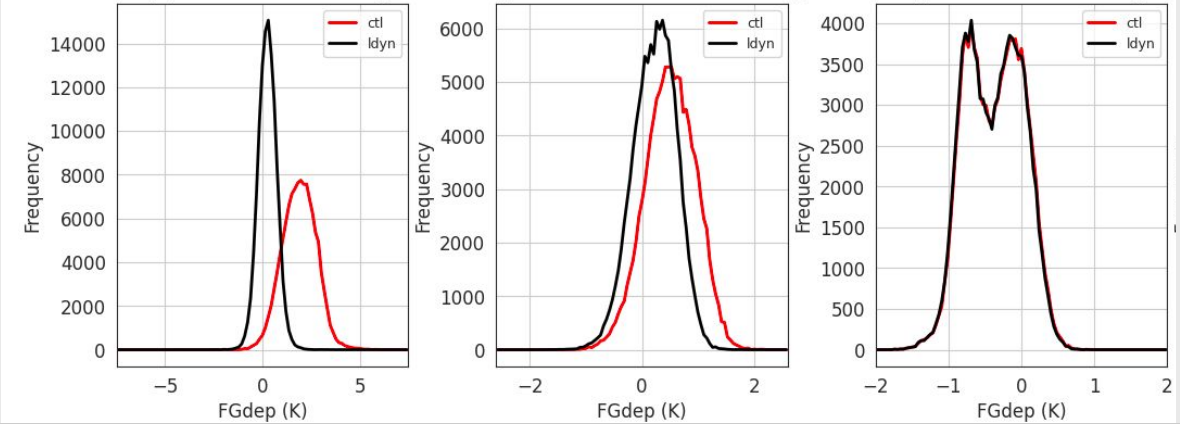
Results
Impact on BT simulations

FG-Departures to Observations

CONTROL
LDYN

Frequency histograms
AMSU-A over land
(20210110-20210228)

Channel 4 | Channel 5 | Channel 6

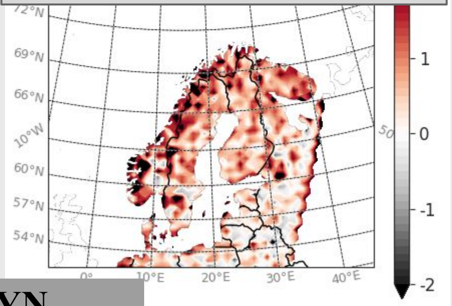


⇒ Reduction of bias and stdev for surface-sensitive channels (AMSU-A channel 4 & 5)

Averaged map for AMSU-A over land
(20210110-20210215)

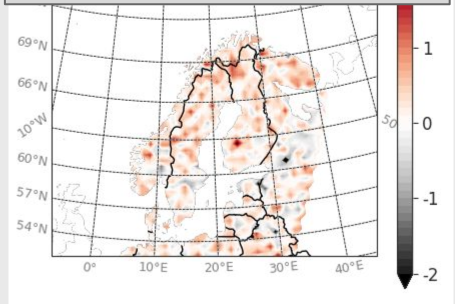
CONTROL

Channel 4



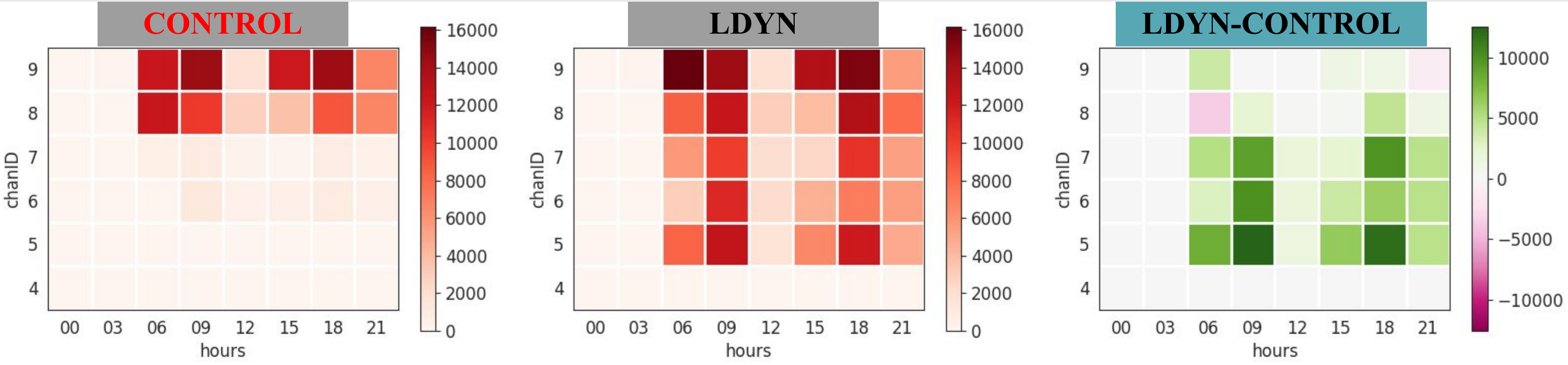
LDYN

Channel 4



Results
Impact on BT simulations

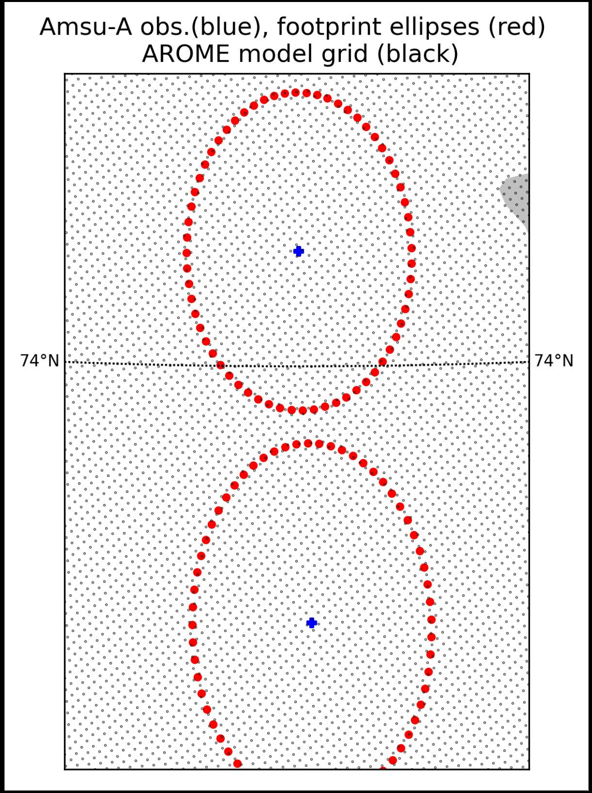
Amount of active AMSU-A observations over land
(20210110-20210228)



=> Better statistics on Fg-Departures increases the amount of observations passing the QC check
=> More than 7000 more AMSU-A observations over land for channels 6 and 7 in LDYN vs CTL (6 weeks)
=> About the same additional amount of observations for surface-sensitive MHS channels

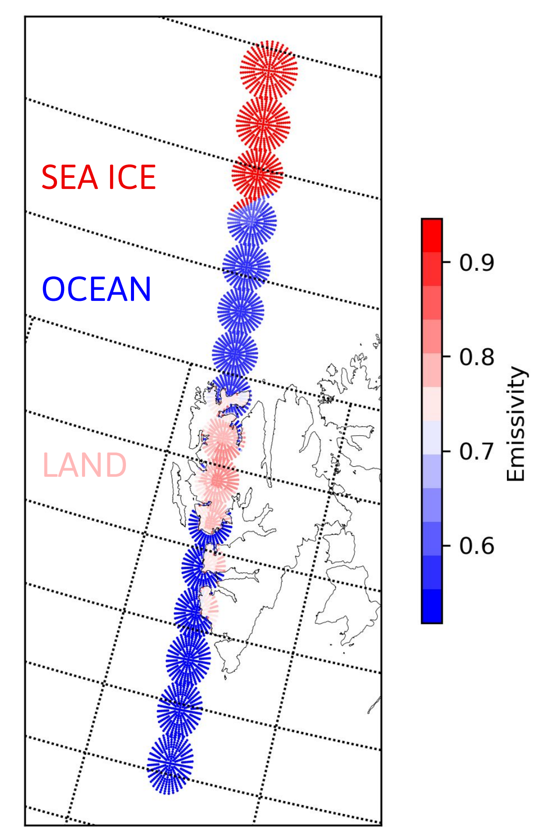
A footprint operator: Improved spatial representation of satellite radiances

- 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



Example: Resolution gap between AMSU-A and HARMONIE-AROME (FOVs at the scan edge)

- The benefit of the AWS footprint operator is expected where the variability in model fields are large
- The footprint representation might also help to take into account sub-footprint heterogeneity e.g:
    - to use more radiance data in LAMs (e.g. low-peaking)
    - to better treat coastal areas in data assimilation
    - to move towards all-surface assimilation
- The AWS footprint operator is going to be tested with 4D-Var framework in order to improve both spatial and temporal representation errors



Example: AMSU-A single scanline and retrieved emissivity

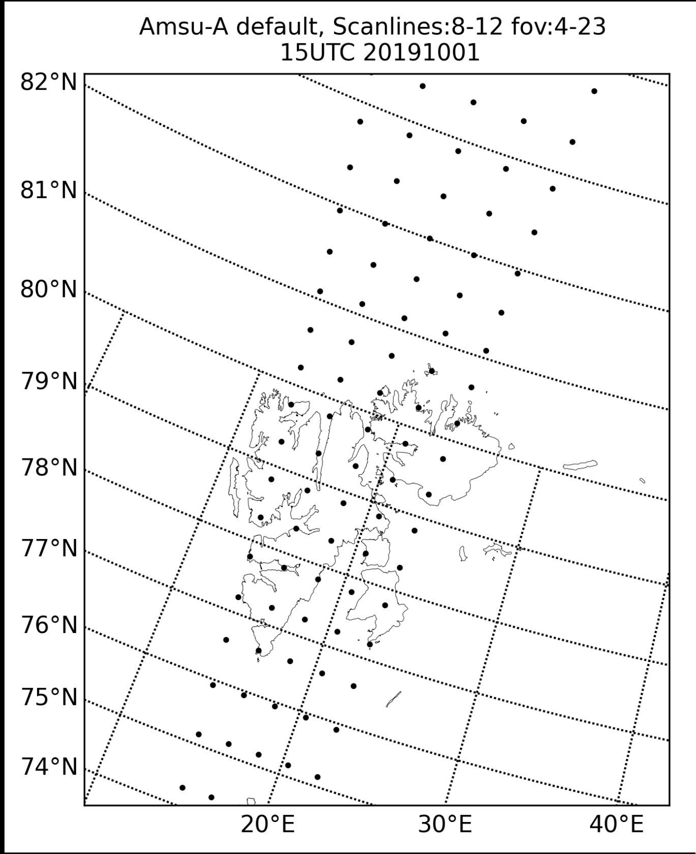
Sub-FOV heterogeneity of radiance observations

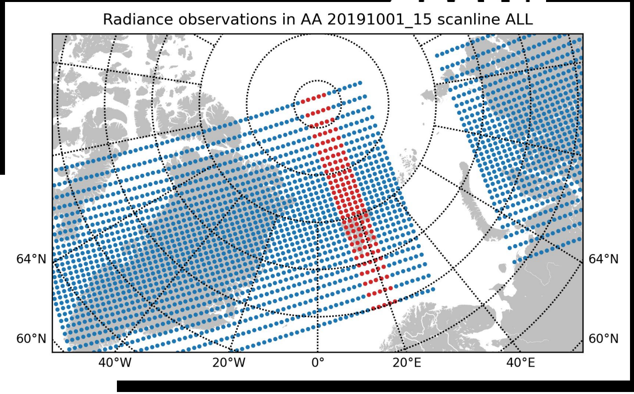
(AMSU-A retrieved emissivity)

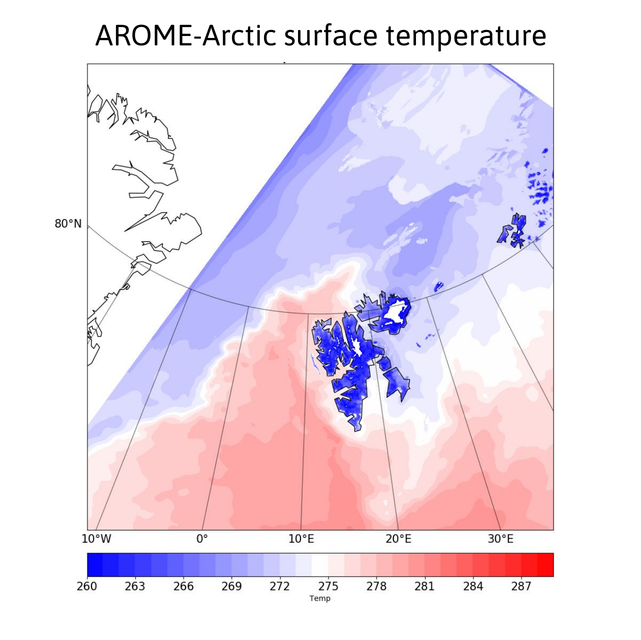
Default case

-

Point observations







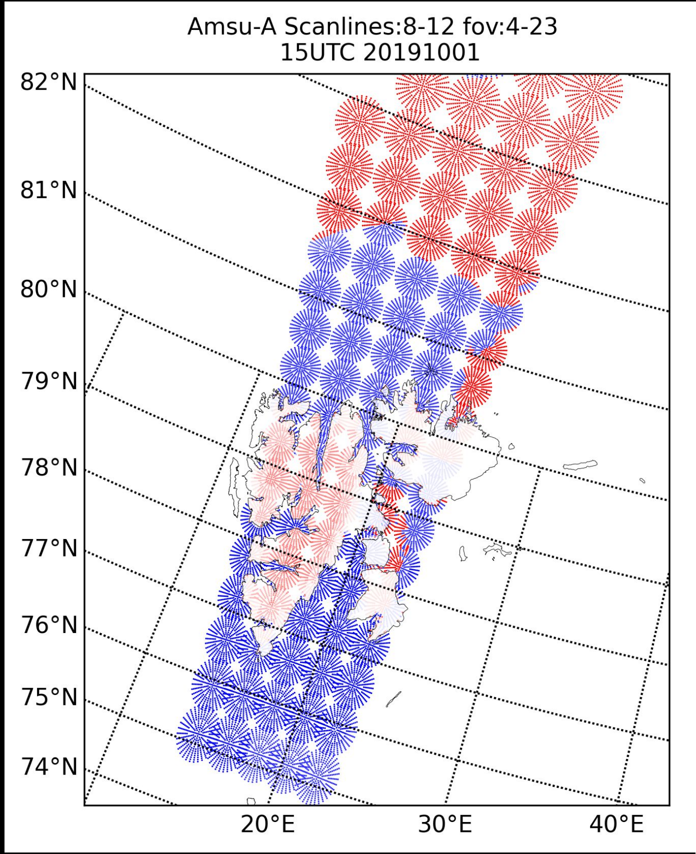
Sub-FOV heterogeneity of radiance observations

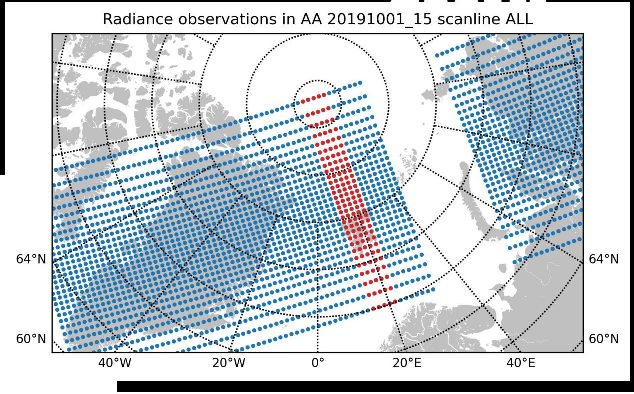
(AMSU-A retrieved emissivity)

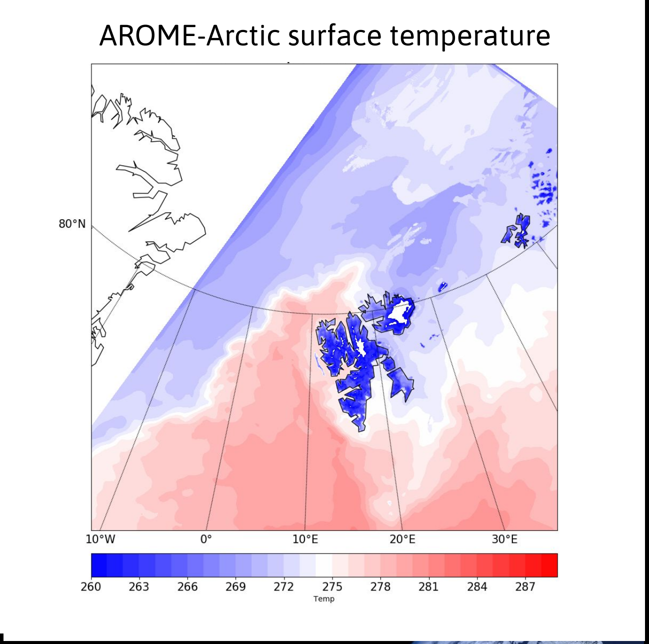
Default case

-

Point observations

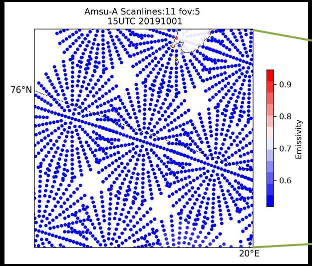


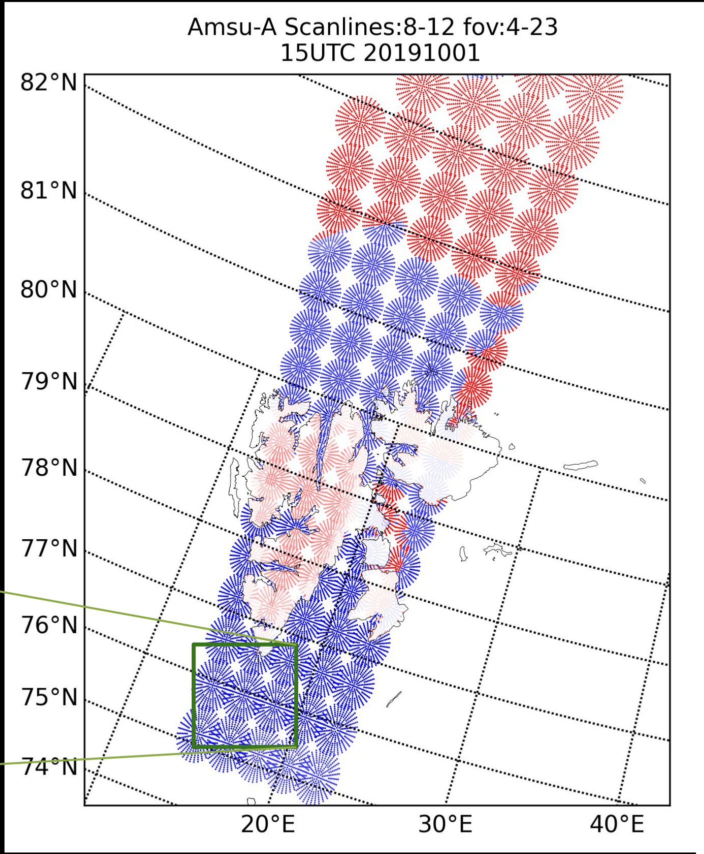


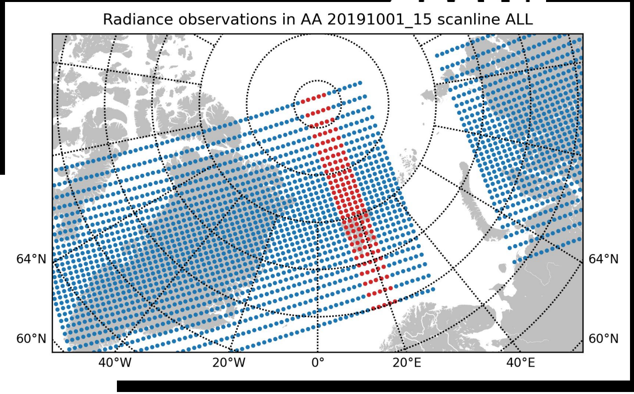


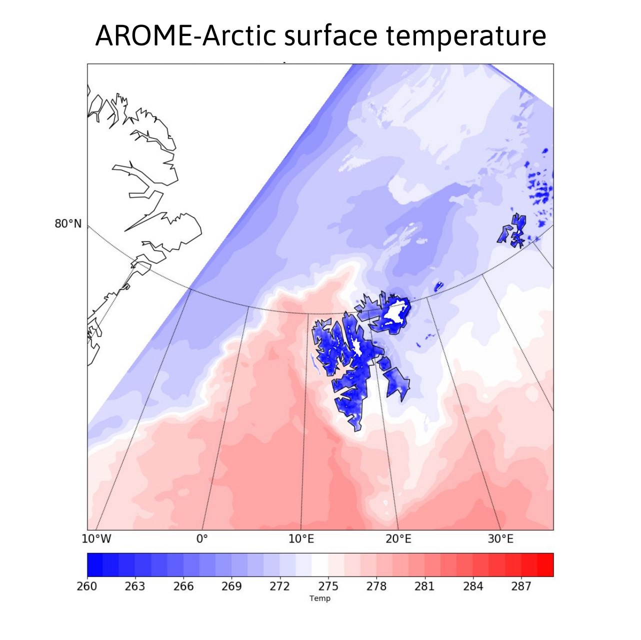
Sub-FOV heterogeneity of radiance observations

(AMSU-A retrieved emissivity)

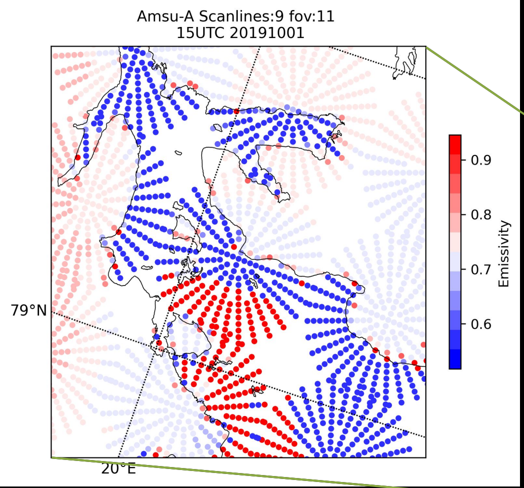


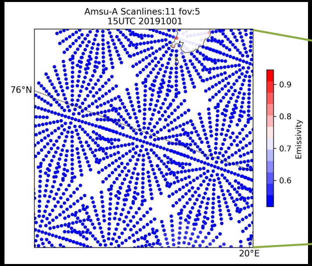


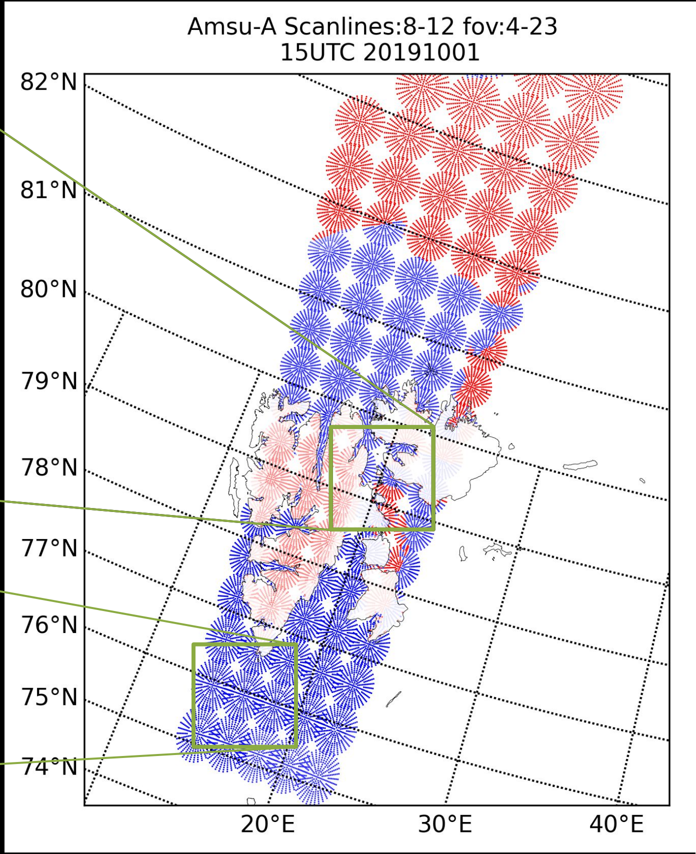


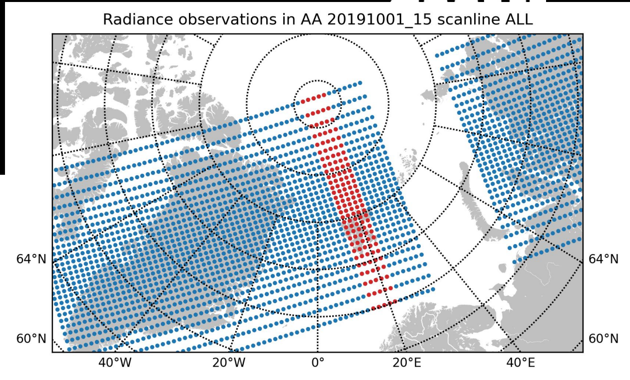


Sub-FOV heterogeneity of radiance observations
(AMSU-A retrieved emissivity)









AROME-Arctic surface temperature