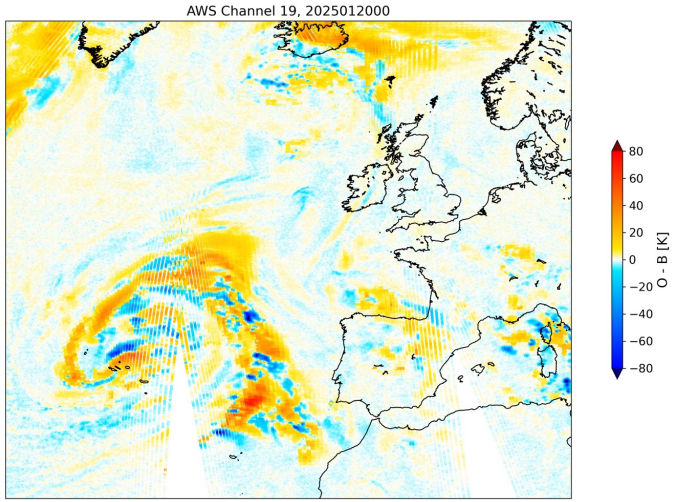
Evaluation of the Arctic Weather Satellite in the ECMWF System

Cal/val and assimilation results



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Thanks to: Marijana Crepulja, Alan Geer, Emma Turner, Patrick Eriksson

ECMWF

ECMWF analysis of AWS data

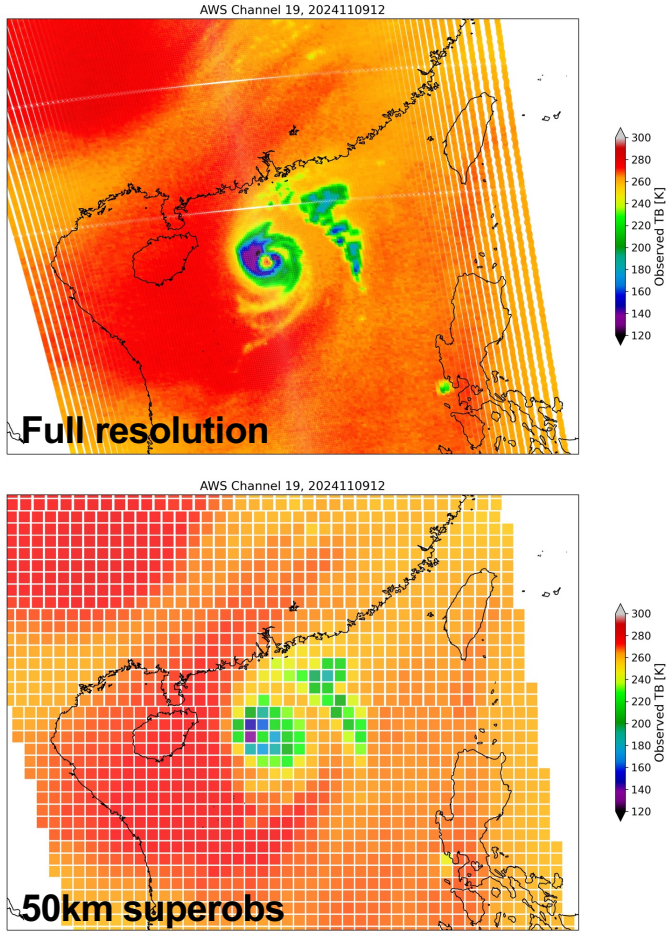
Data processing:

- Ingest L1B in NetCDF and convert to BUFR internally
- BUFR data superobbed to **50km** resolution per horn
- *Horns matched together on common grid*

All-sky processing follows example of AMSU-A, MHS, etc.

Cal/val analysis removes heavily cloud-affected scenes and surface-sensitive channels over land

Analysis covers January to April 2025



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Orbital coverage of MW sounders

Equator Crossing Time (ECT) is well-covered at:

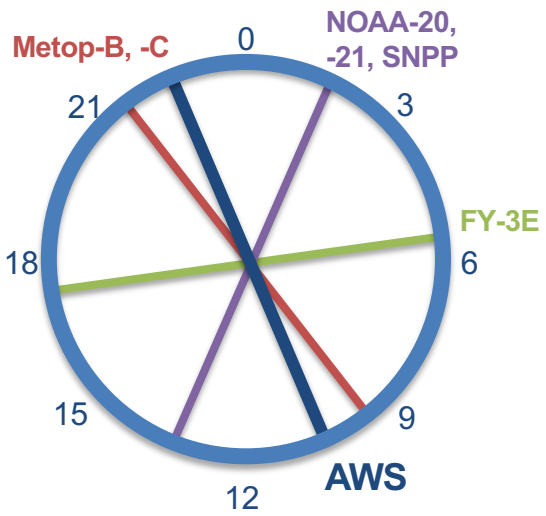
- 9:30 by Metop-B, -C (& NOAA-19)
- 1:30 by SNPP, NOAA-20, -21

Some orbits have drifted over time or occupy a unique slot:

- 5:30 for FY-3E
- 2:50 for FY-3D
- 7:15 for NOAA-15
- 10:45 for NOAA-18

We will lose POES (NOAA-15/18/19) in ***June this year*** → losing 3 AMSU-As & 1 MHS

AWS launched into 10:30 ECT orbit



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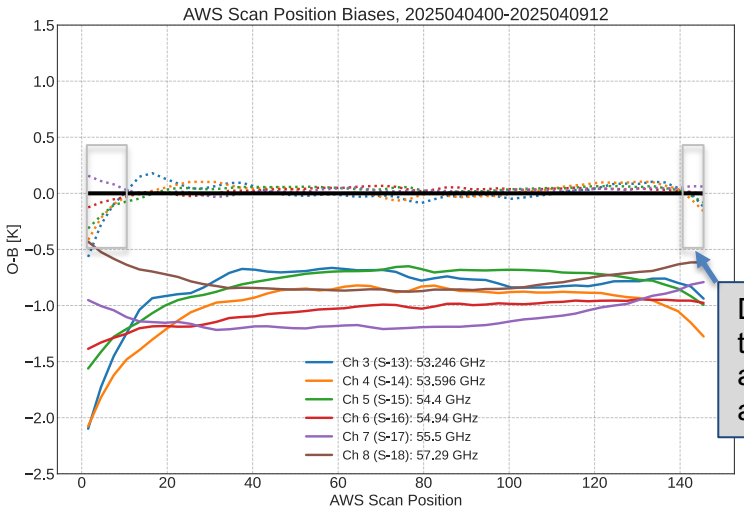
Biases vs. the background

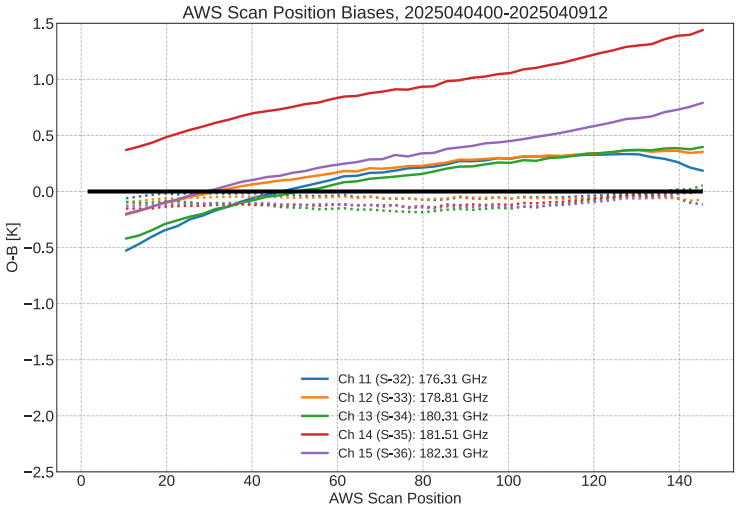
Against IFS, we see biases of roughly -1.5 to +1.0 K for sounder channels

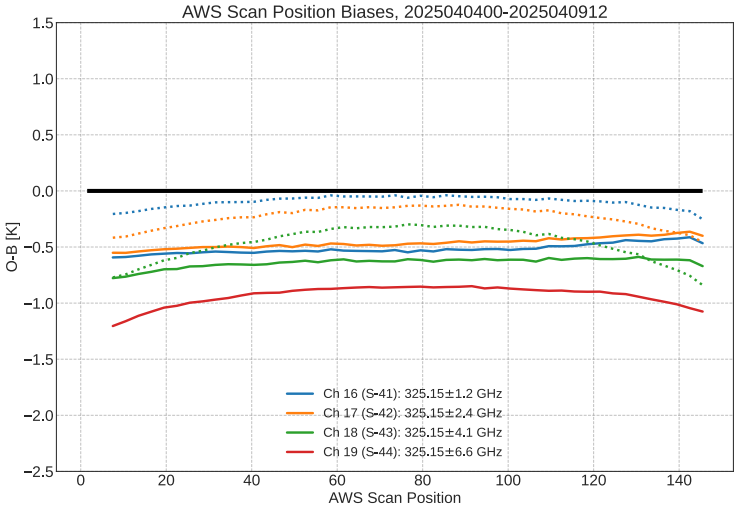
Variational bias correction (VarBC) handles the bias structures well, except for horn 1 at edge of swath



Due to biases, these positions are not yet assimilated

Dotted = after bias correction





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Temperature sounding

Std(O-B) provides reference for noise performance

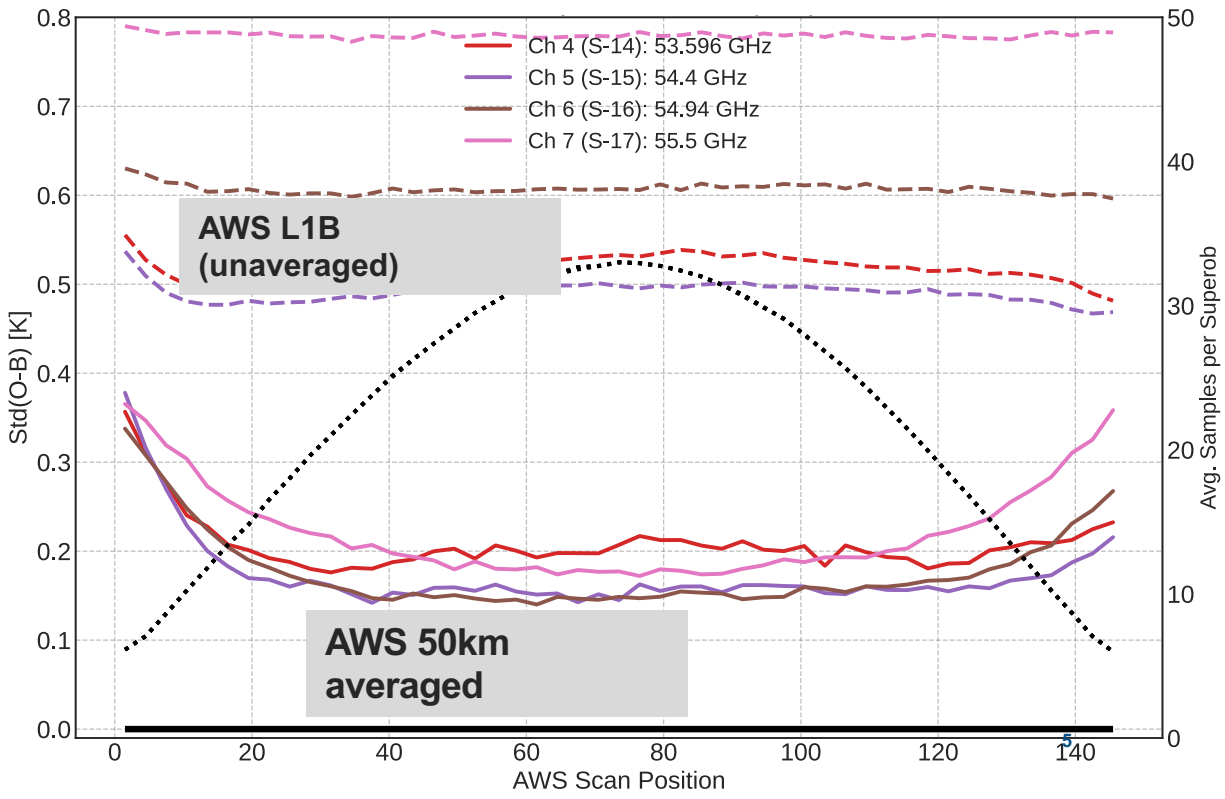
NWP background errors typically ~0.1K

After superobbing, performance is suitable for assimilation

Compare to pre-launch NEDT:

Ch.	NEDT (3dB)	NEDT (sample =*1.73)
4	0.31	0.54
5	0.32	0.55
6	0.36	0.62
7	0.45	0.78

Ch 8 not shown – out of spec and not assimilated



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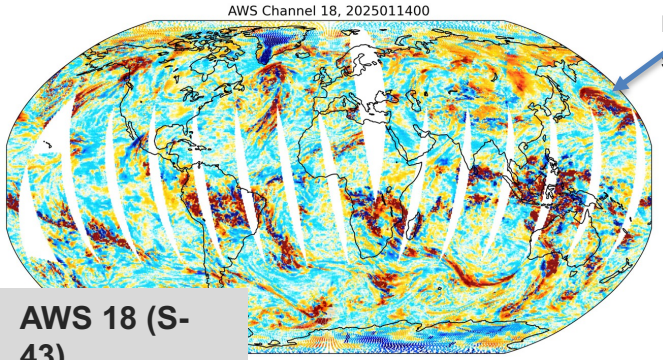
Humidity sounding

Humidity channels' performance is acceptable for assimilation

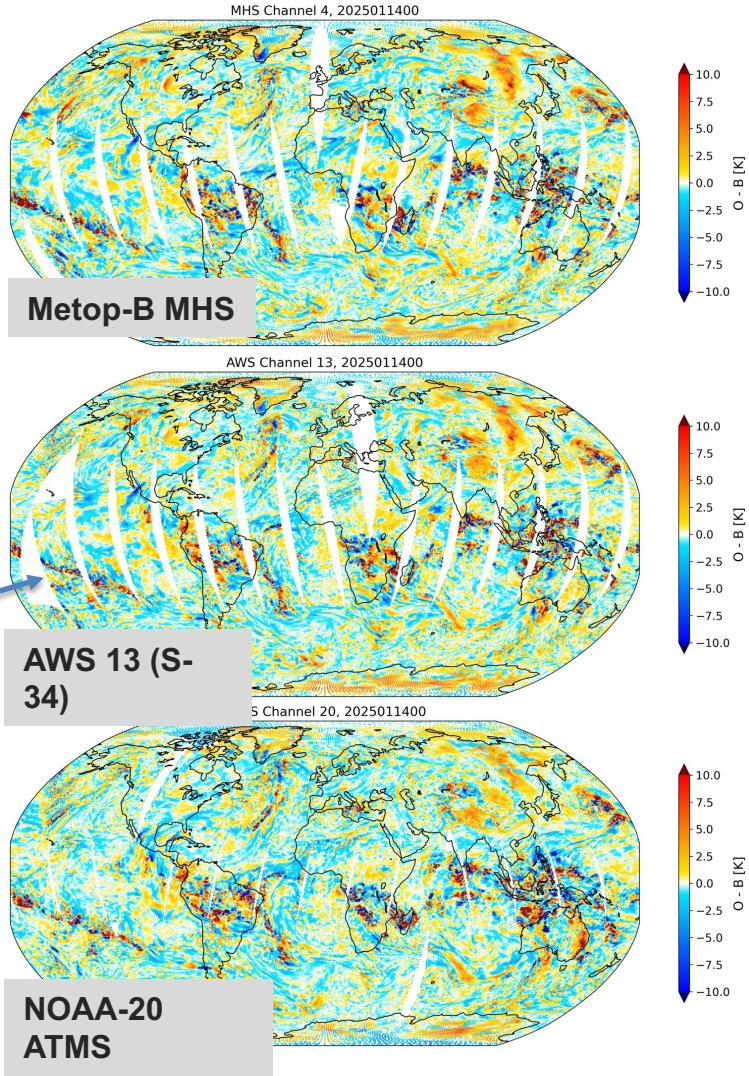
- O-B shown after bias correction
- Comparable quality to ATMS & MHS



AWS 18 (S-43)

Sub-mm provides much larger cloud signals

183±3 GHz equivalents



Metop-B MHS

AWS 13 (S-34)

NOAA-20 ATMS

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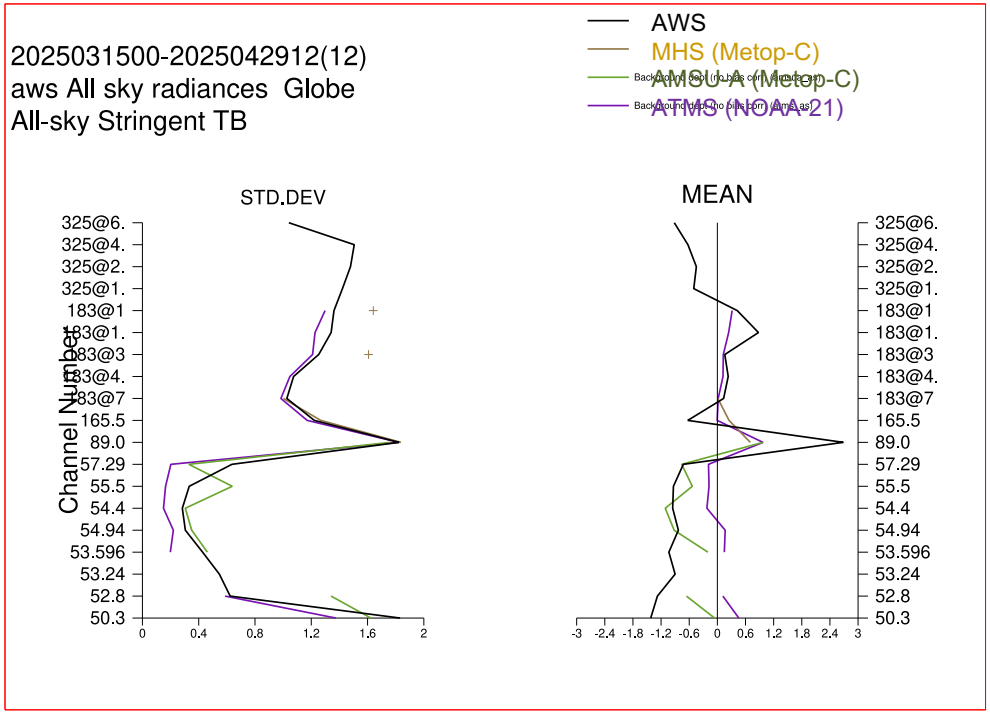
Biases vs. the background

Compared to other sounders, AWS exhibits mean biases of a similar magnitude

Quick comparison against similar instruments is a strength of NWP-based cal/val



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Assimilation trials: Setup

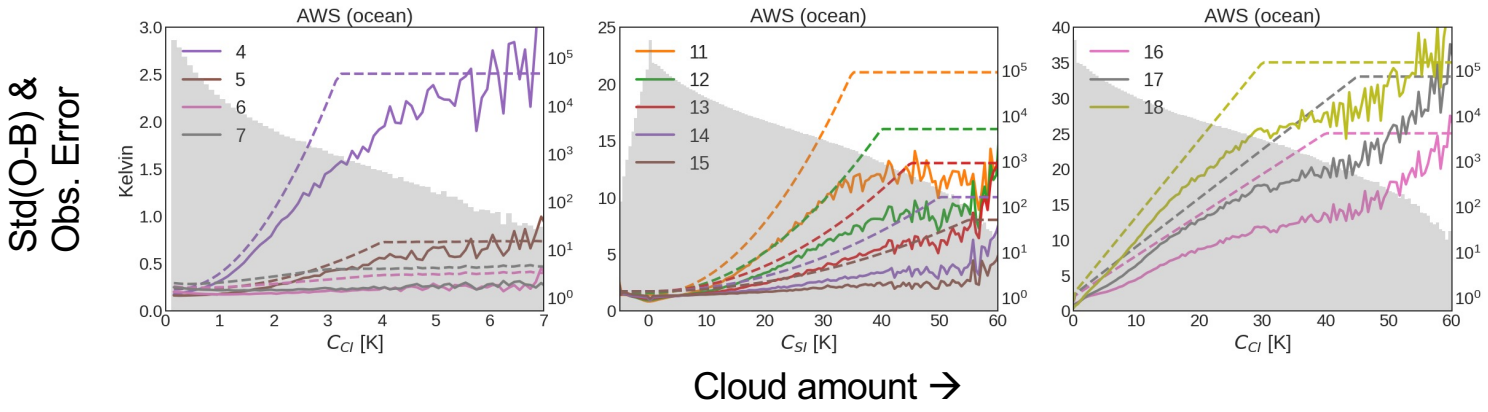
- *29km model resolution*
- *IFS Cycle 49r1 (current)*
- *10 days of "spin-up"*
- *Results from Jan 1st through April*

Experiments:

- Full observing system *but POES (NOAA-15/18/19) removed*
- Add in NOAA-19 (AWS-similar channels only)
- **Activate AWS**

  → Channels 4-7 & 11-18 as below

All-sky observation error models for AWS → Larger errors in cloud



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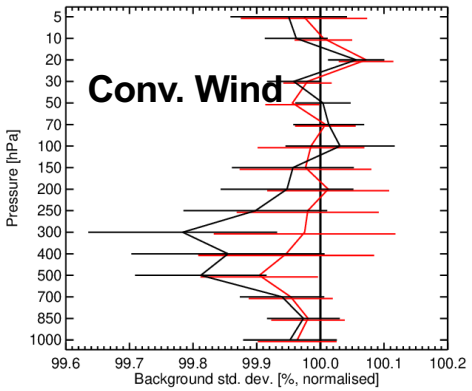
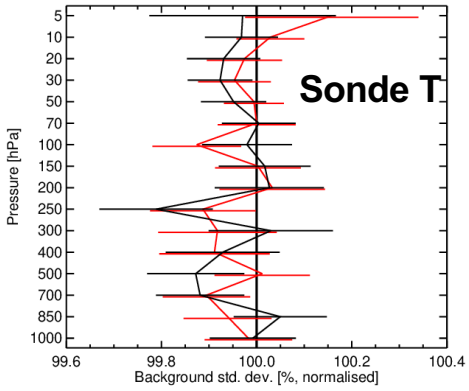
Assimilation trials

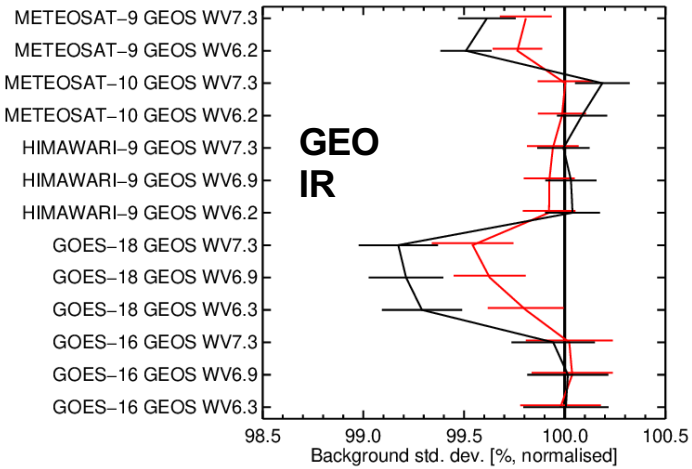
Improved std(O-B) → better short-range forecast

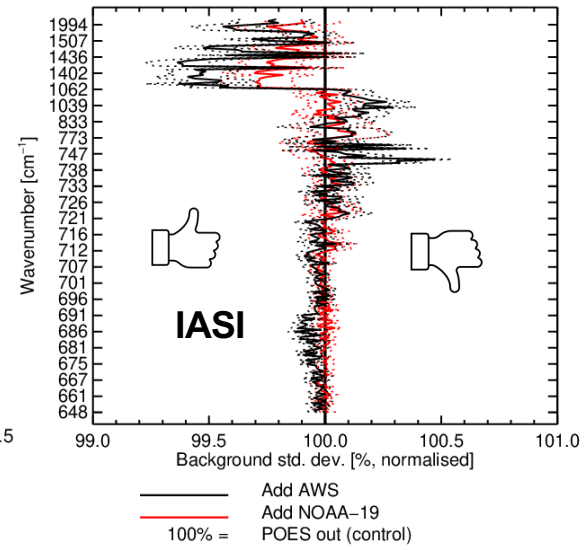
Humidity improved particularly in regions where AWS orbit fills a 'gap'

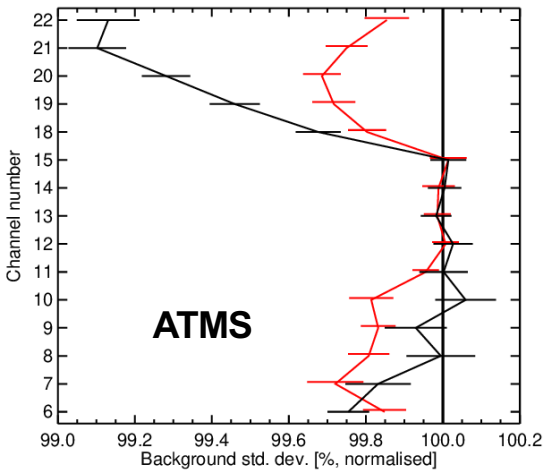
*Impact of **AWS** slightly larger than **NOAA-19***











*NOAA-19 AMSU-A (5,6,9) & MHS (4,5)

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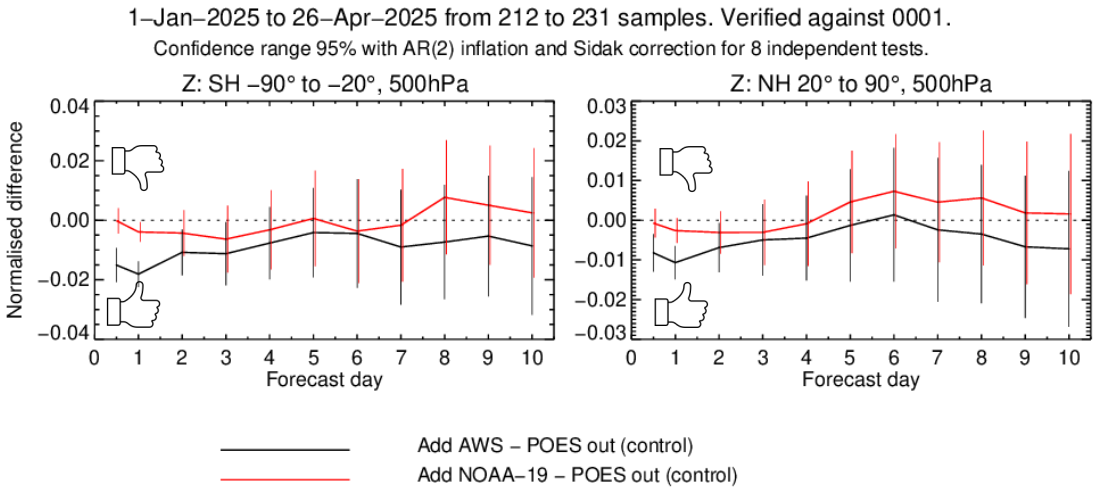
Assimilation trials

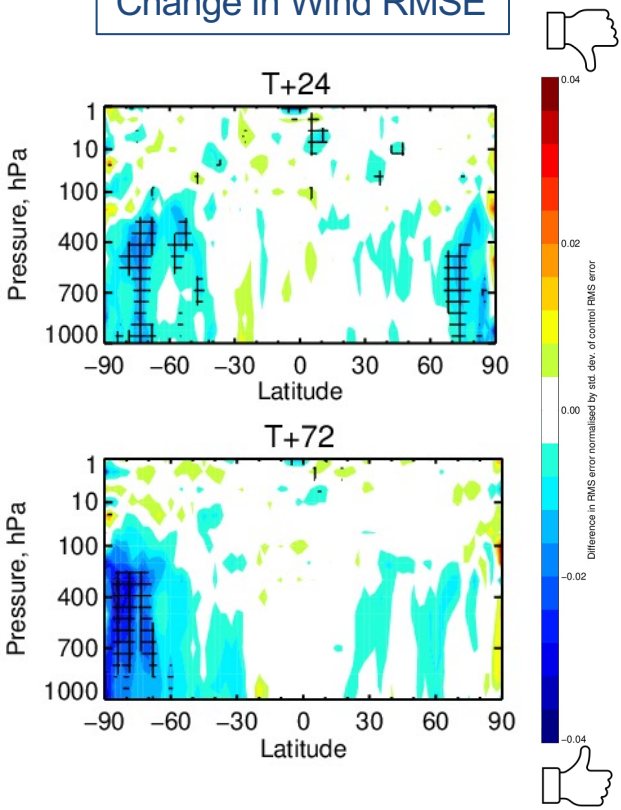
Results look promising with ~4 months

Verified against operational analysis



Change in Z 500 RMSE

Change in Wind RMSE



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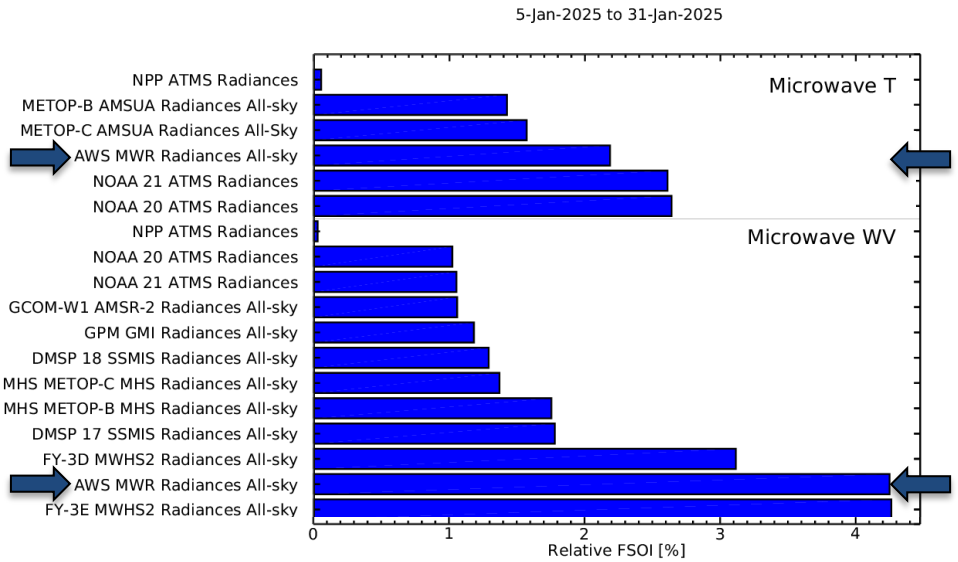
Assimilation trials

Forecast sensitivity to observation impact (**FSOI**) quantifies *24hr forecast error reduction per observation*

AWS has similar FSOI as FY-3E MWHS2 for humidity

Impact between ATMS and AMSU-A for temperature

- *Like FY-3E, AWS likely sees greater FSOI due to filling an orbital 'gap' for MW sounding*



Relative FSOI from MW instruments
(100% for full observing system)
Blue = positive impact

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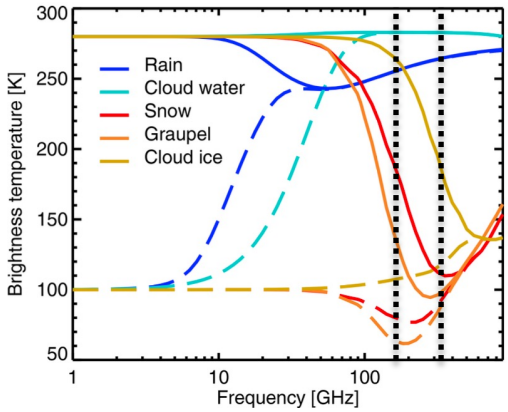
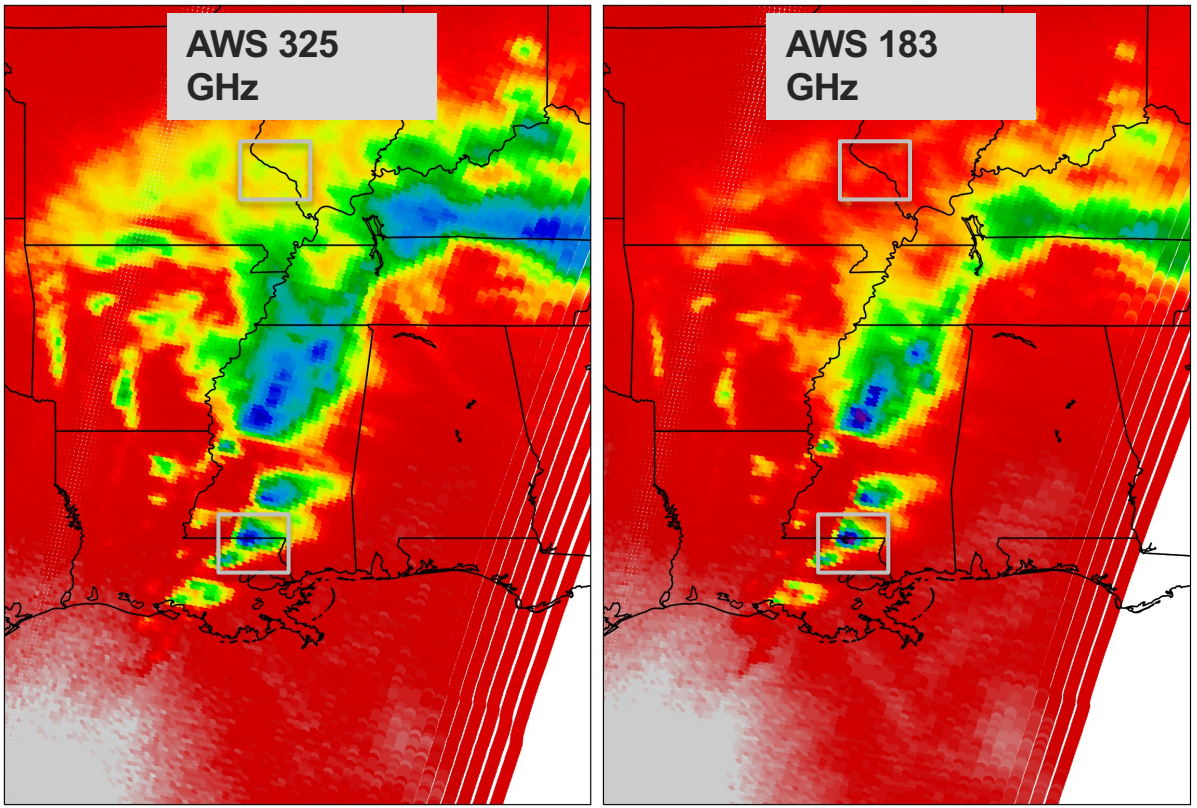
Conclusions

- **Data quality of most AWS channels is sufficient for successful assimilation**
  - Impact on short-range forecast is in line with (AMSU-A + MWHS-2)
  - OSE against NOAA-19 shows comparable or greater impact on forecasts
  - Sub-mm channels can already be assimilated
- ECMWF aims to put AWS into operations soon
- The AWS orbit is a strength for NWP and bodes well for EPS-Sterna impact
- Plenty of work to do on exploiting 325 GHz channels, but initial evaluations with RTTOV-SCATT show good agreement with observations (see also poster 3p.02 by Katie Lean)

Bonus – 325 vs. 183 GHz



From *Geer et al. (2021)*



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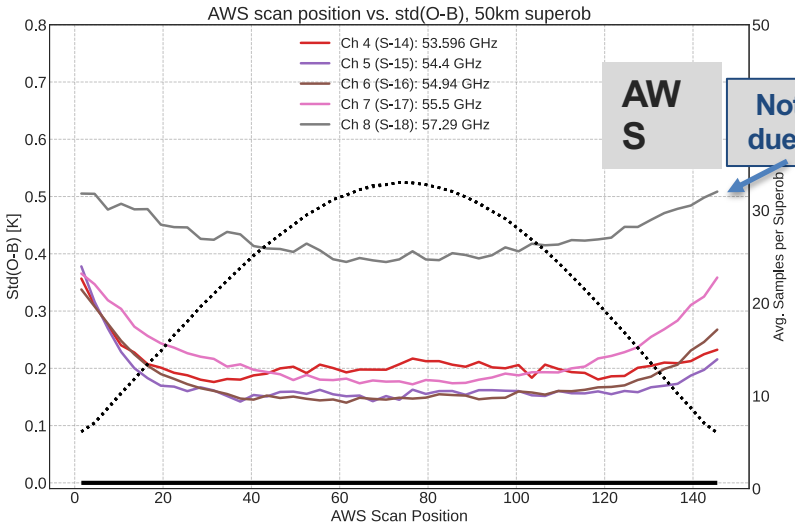
Backup slides

Temperature sounding

→ *Compare to AMSU-A*

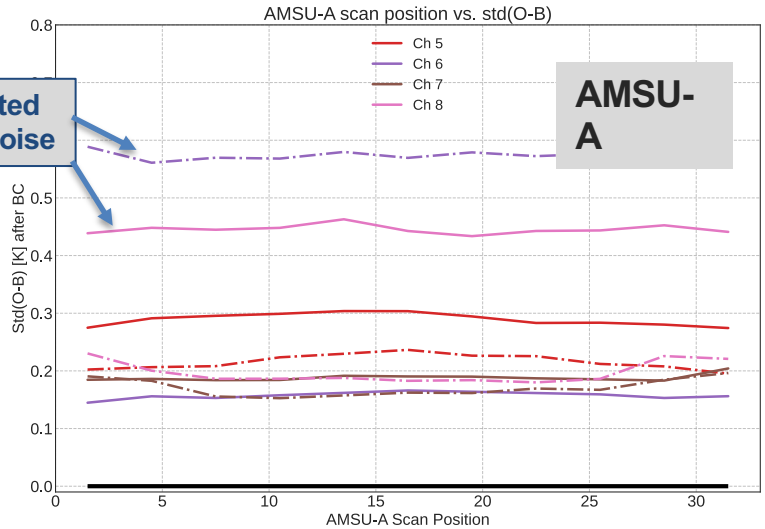
After averaging, AWS channels 4-7 performance is similar to AMSU-A → sufficient for assimilation

But footprints and integration times are quite different



AWS

Not assimilated due to high noise



AMSU-A

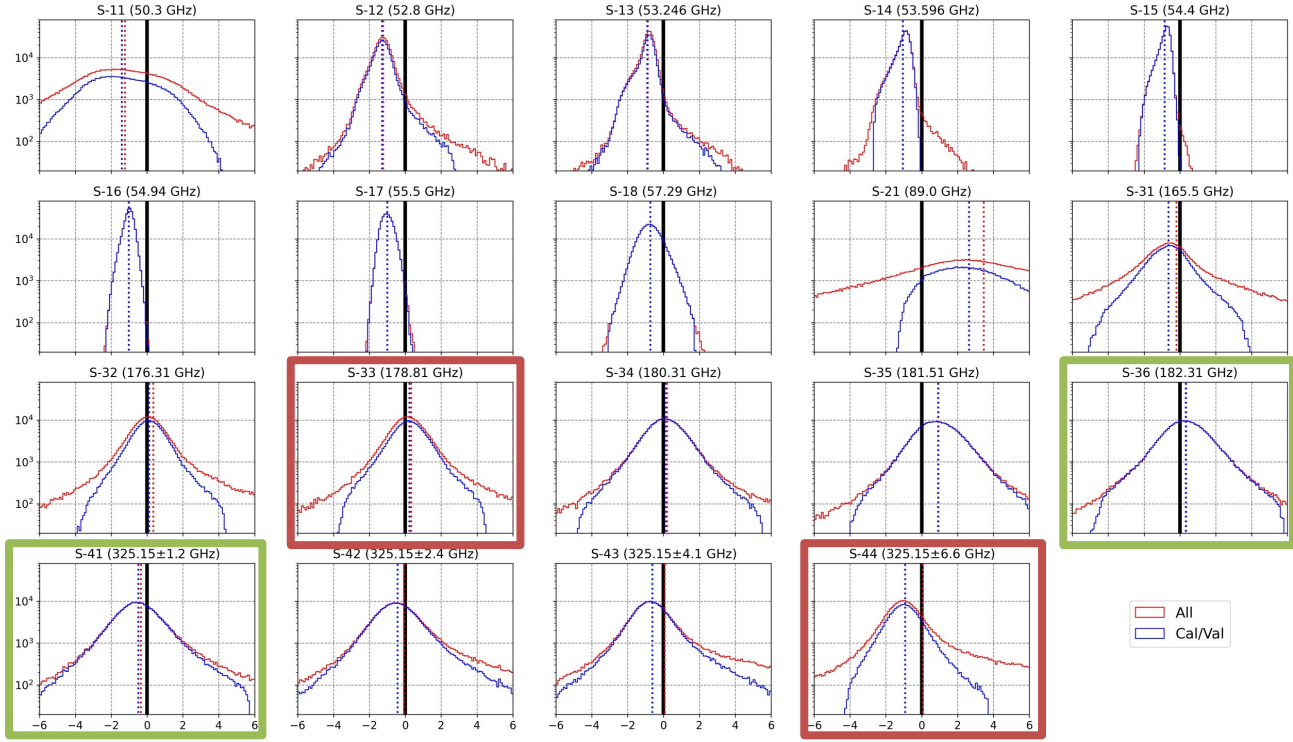
Metop-B = Dash-dot
Metop-C = Solid

ECMWF

Biases vs. the background

O-B PDFs relatively Gaussian

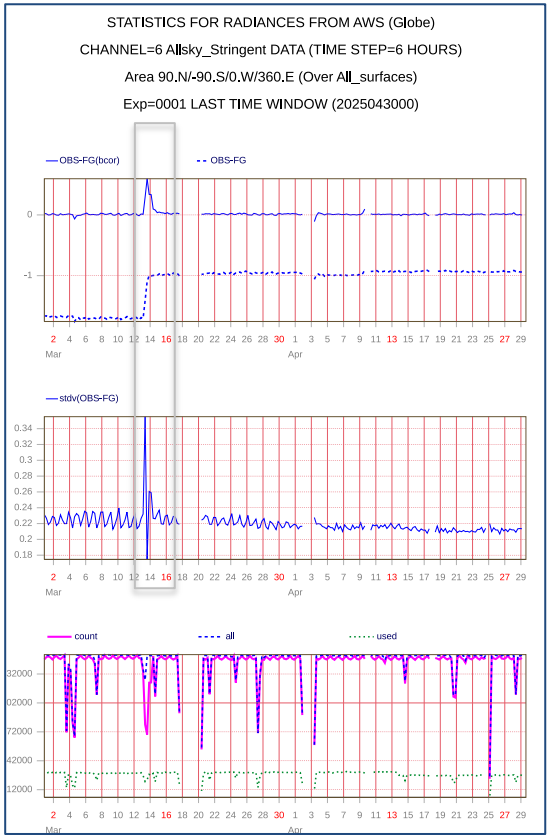
- Cal/val sample (blue) removes largest outliers
- Matched 183/325 channels show very similar behaviour
  - High-peaking
  - Low-peaking

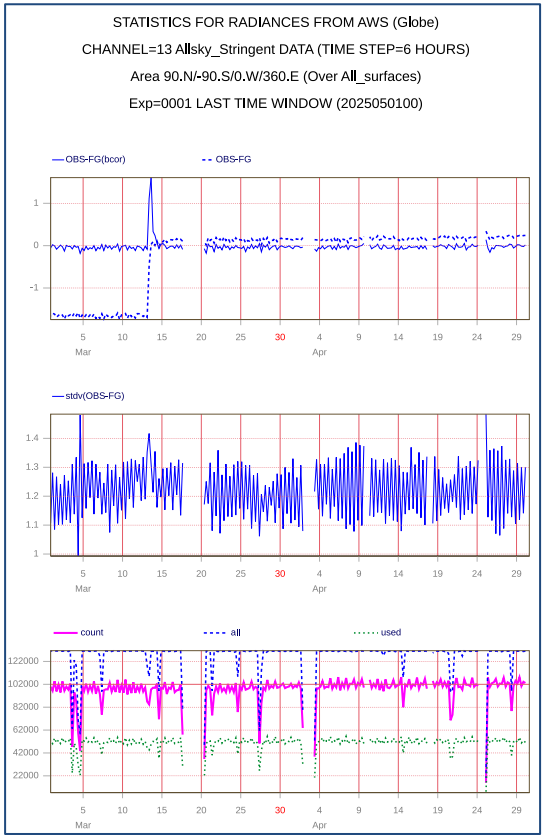


Data from 28th March, over sea only

ECMWF

Biases vs. the background





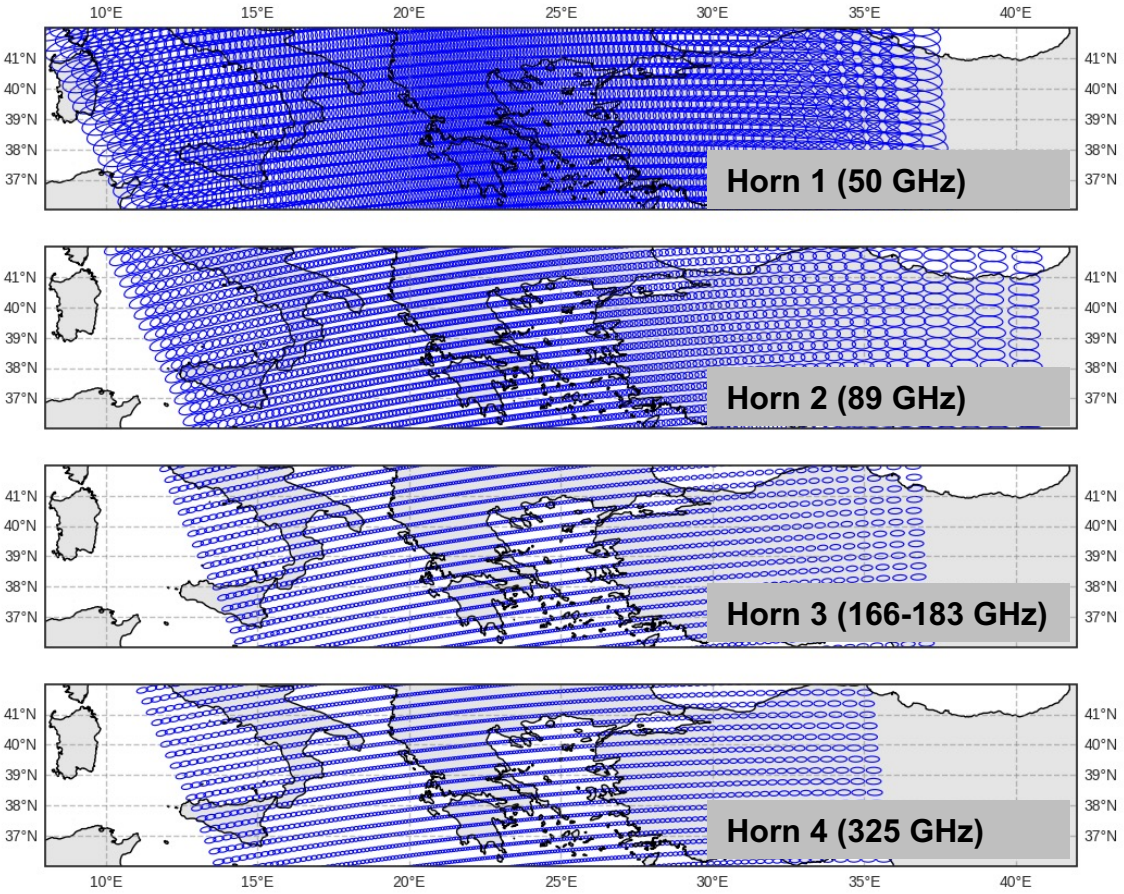
ECMWF monitoring AWS performance in NRT since December

→ Data publicly released in mid April

→ Note calibration change in March

→ Early feedback to ESA & EUMETSAT on calibration biases against IFS

ECMWF



FOVs for all 145 scan positions plotted
*Only every **5th** scan line plotted for clarity*

AWS unique scan patterns

- Separate geolocation per feedhorn needs to be dealt with
- Edge of swath varies significantly between channels
- Heavy spatial over-sampling

ECMWF

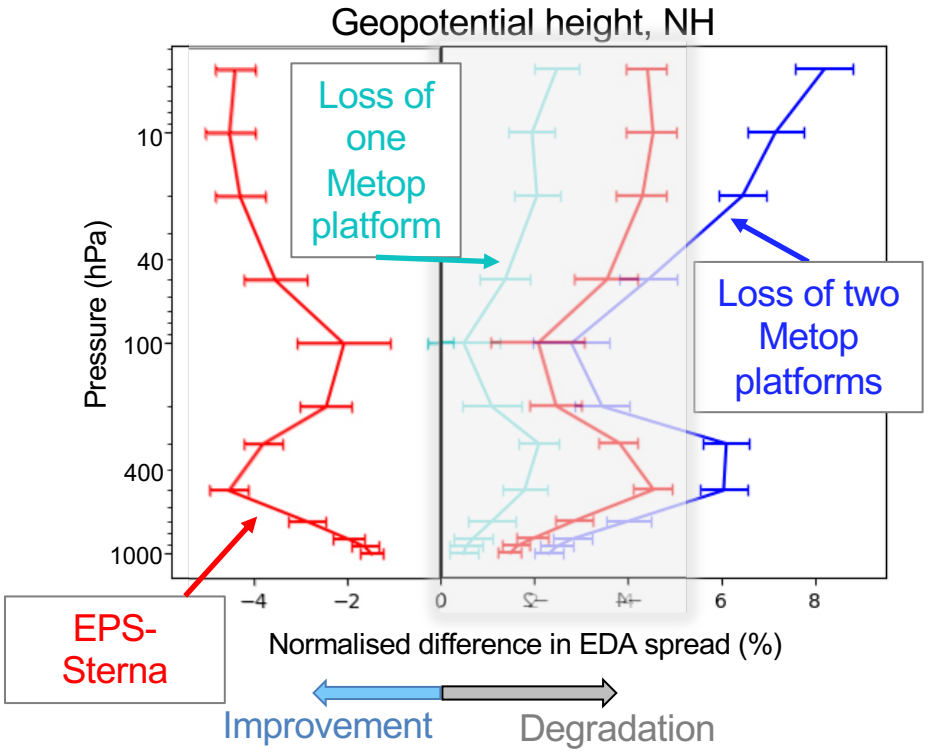
Earlier study on EPS-Sterna expected impact

Study led by Katie Lean (ECMWF) used specified instrument characteristics to estimate potential EPS-Sterna impact in NWP

Importantly, this assumed 0.60 to 0.65 K sample NEDT for 50 GHz channels

AWS now exhibits roughly 0.5 to 0.7 K sample NEDT for these channels

→ *If AWS biases are stable and correctable by NWP bias correction schemes, we should be able to realise the simulated impact from this study*



EPS-Sterna spread reductions larger than opposite spread increase for One Metop denial but smaller than Two Metops denial

Lean et al. (Feb 2025): https://rmets.onlinelibrary.wiley.com/doi/full/10.1002/qj.4939