Preliminary assessment of the Arctic Weather Satellite microwave sounder with the ARPEGE global model

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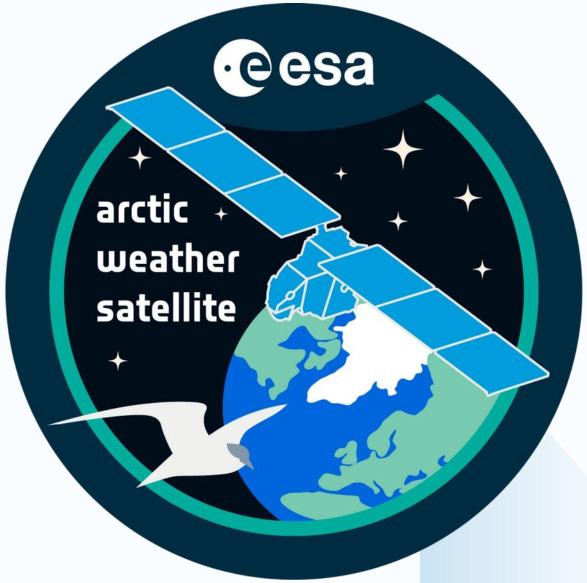
Context

What's AWS

- ESA mission launched in august 2024
- Pathfinder in view of the **EPS-Sterna** constellation
- Study conducted under a scientific initiative managed by EUMETSAT
- Observing System Simulation Experiment (Rivoire et al. 2024, QJRMS)
- **Payload** : micro-wave radiometer with 19 channels distributed in 4 horns
  - 1 window channel
  - 8 Temperature sounding channels
  - 6 Humidity sounding channels
  - 4 **sub-millimetric** channels (ice-clouds)



Outline

1. NWP system and tools used for the evaluation of the data quality

2. Assessment of data quality

3. First assimilation impacts

4. Conclusion and perspectives

NWP systems and tools used for the evaluation of the data quality

ARPEGE : global model of Météo-France

- *Horizontal resolution :* 5 to 24 km
- *Assimilation scheme :* 4D-var with 6-hours windows assimilation

Assimilation route for AWS:

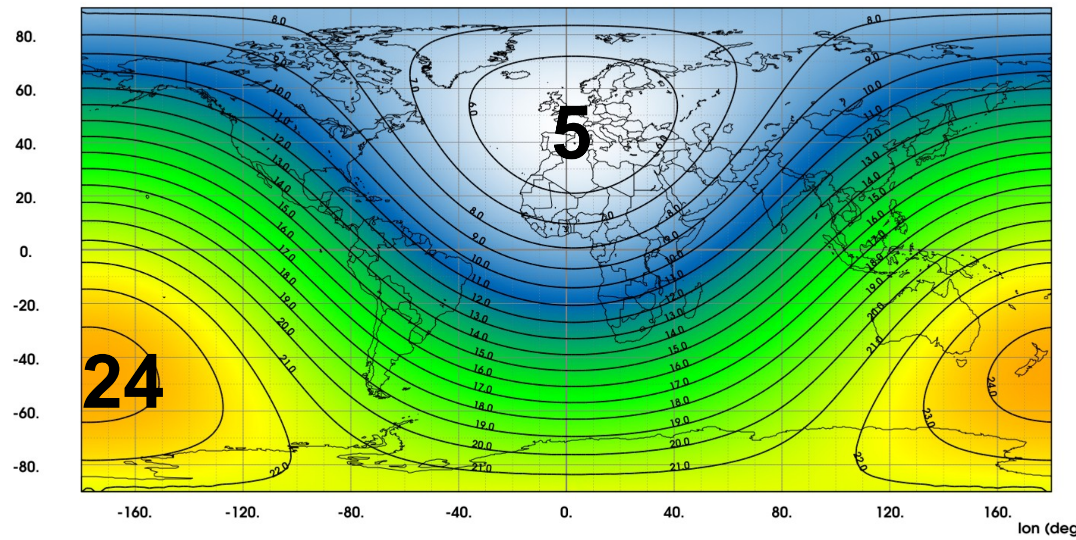
- RTTOV-SCATT 13.0
- Allsky conditions (ECMWF method) like MHS, GMI, MWHS-2 and AMSR2

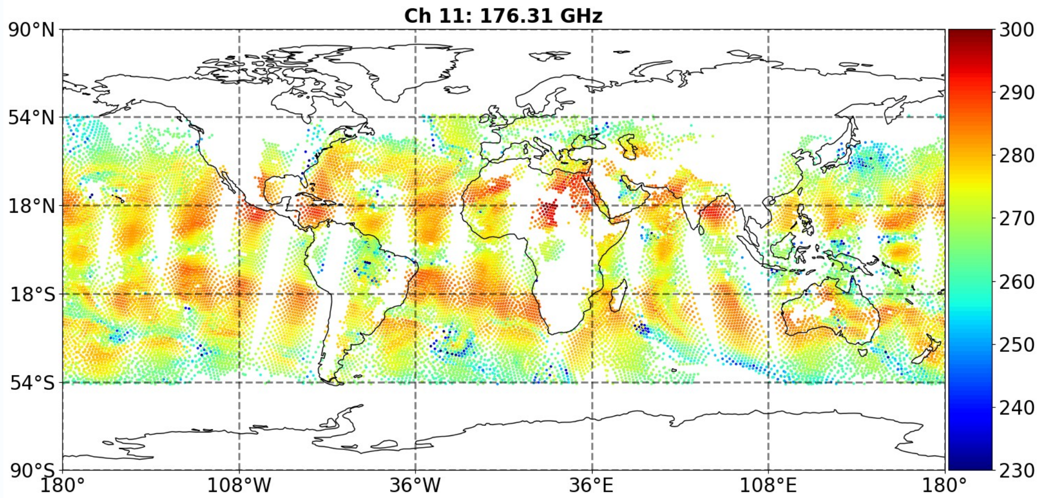
Use of Level1b data available in the EUMETSAT data store

Pre-processing of observations :

- *Remapping*: AAPP tool from NWP-SAF
- *Super-obbing and thining:* average with a 3 x 3 mask to lower noise
- *Quality controls:* including geographic selection in function of the channel sensitivity

ARPEGE resolution





Ch. 11 (176,31 GHz): Observation value on 2025-03-16

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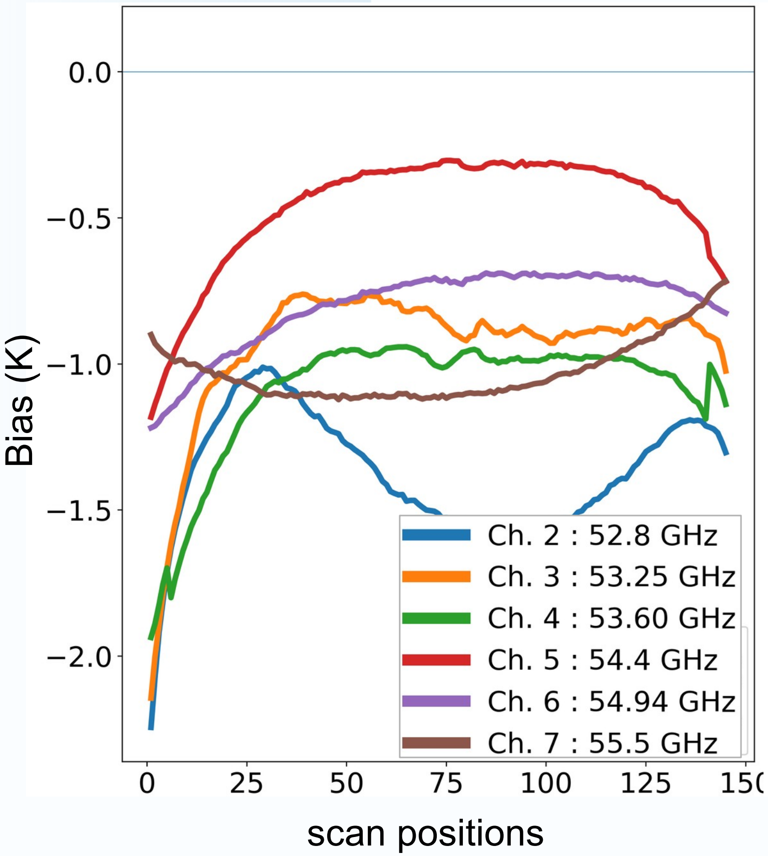
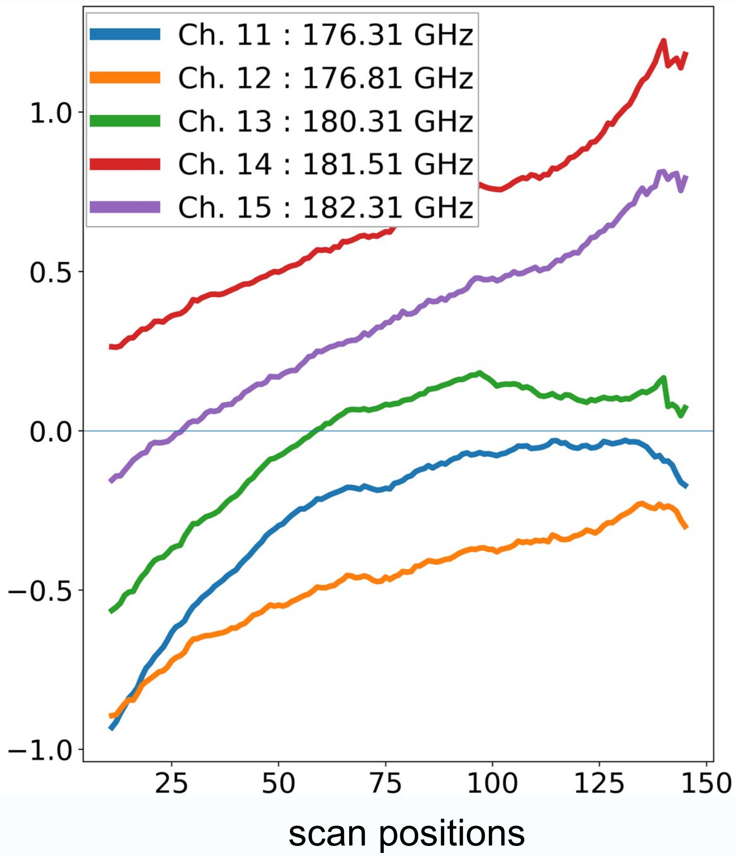
Assessment of quality of data

Monitoring experiments: CTRL: control experiment : AWS monitored
Considered period: from 2025-03-16 to 2025-04-15

Mean of first guess departure as a function of scan position

before bias correction





Before bias correction :

Strong dependencies with scan position :

- **temperature channels :** higher bias on each extremity of the swath
- **humidity channels :** linear dependency with higher bias for the first scan positions.

Assessment of quality of data

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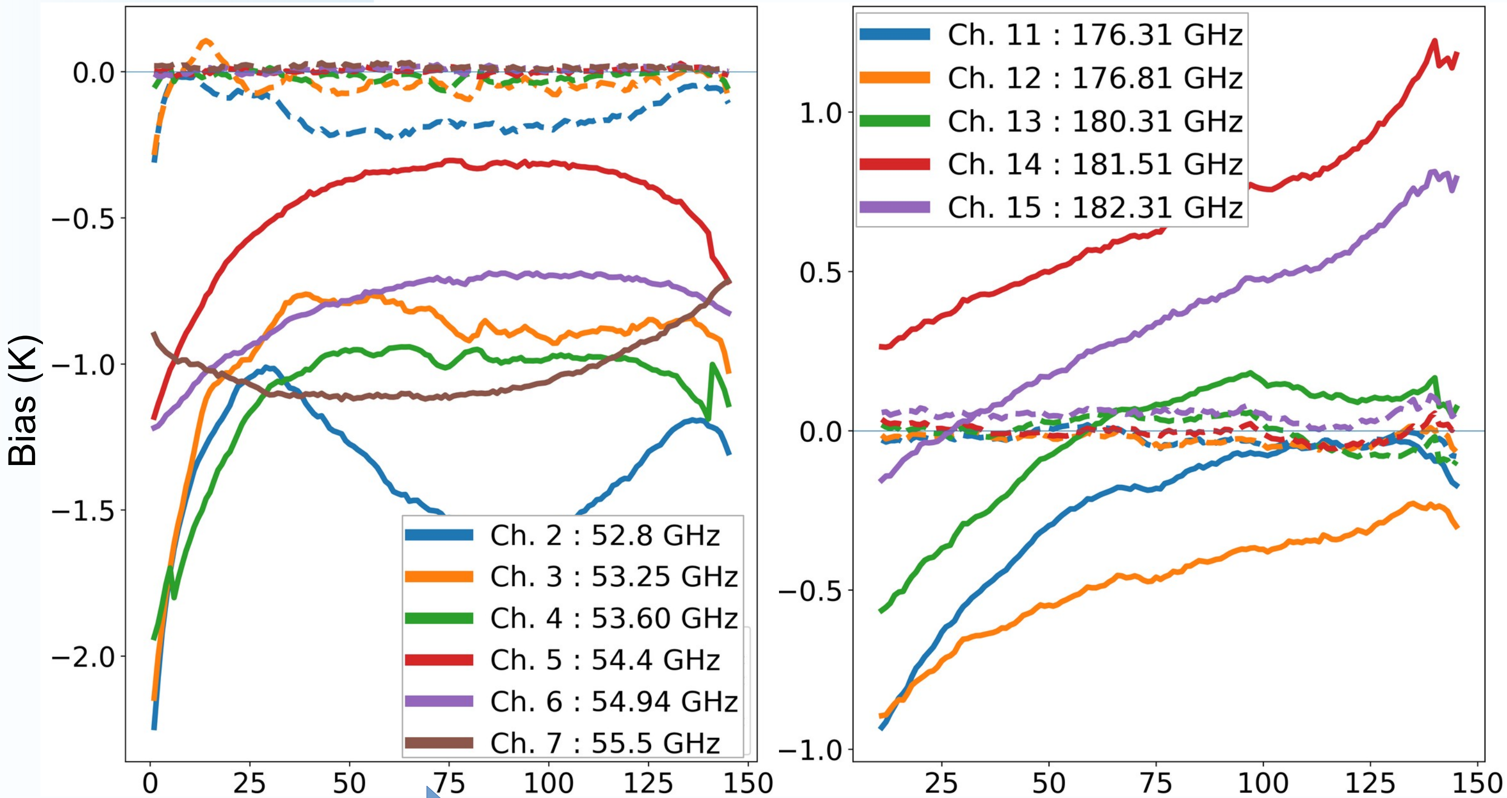
Mean of first guess departure as a function of scan position

before bias correction — after bias correction



Before bias correction :

Strong dependencies with scan position :

- **temperature channels :** higher bias on each extremity of the swath
- **humidity channels :** linear dependency with higher bias for the first scan positions.

After bias correction :

Bias <0,2 K except at the edges of the swath → positions not assimilated

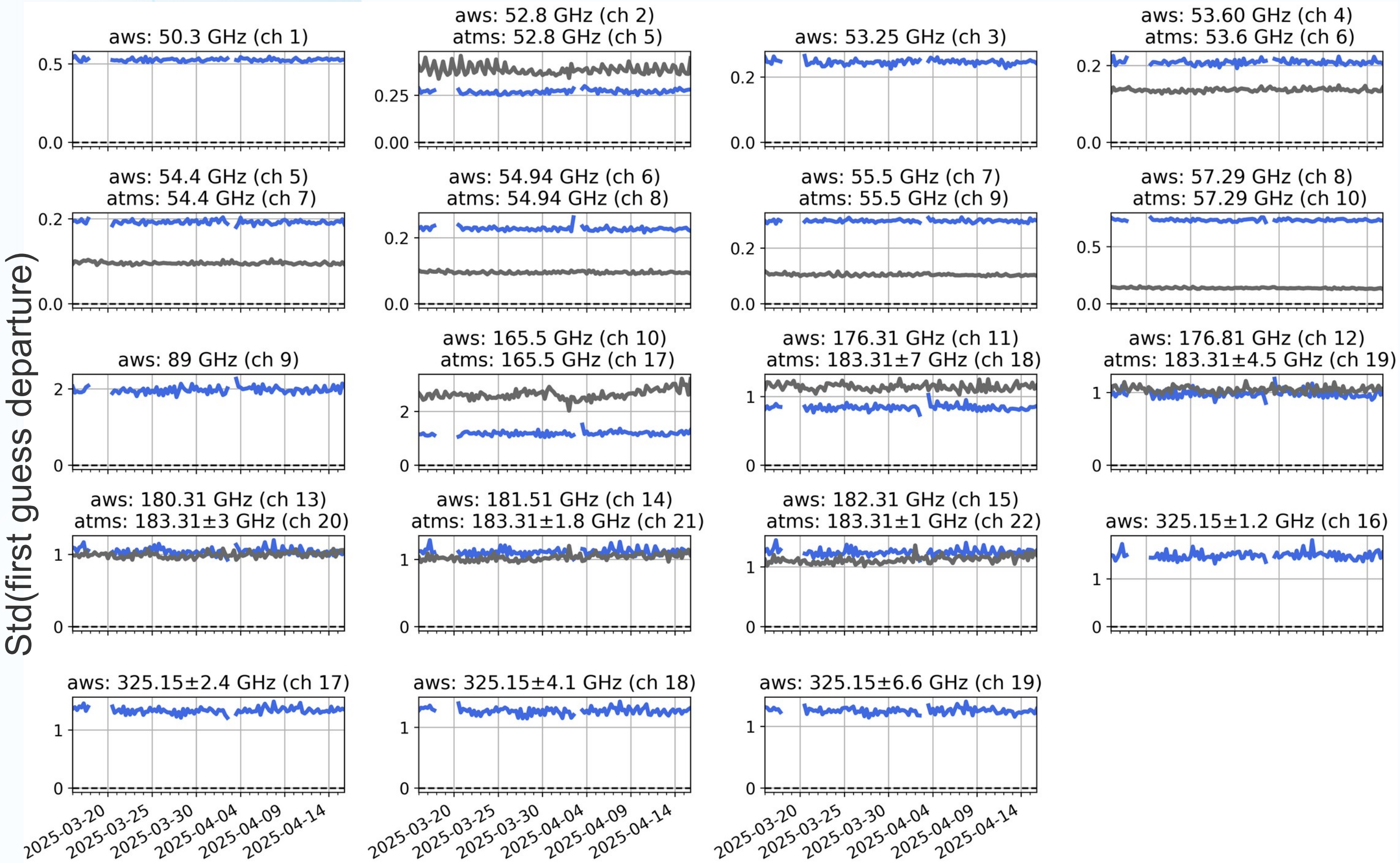
Biases well handled by the variational bias correction

Assessment of quality of data

Standard deviation of first-guess departure after bias correction between 2025-03-16 and 2025-04-15

Comparaison between AWS and ATMS over sea

AWS ATMS



Stable over time

~ 0,2K for T channels and ~1K for Hu channels

- **Temperature channels :** Larger than ATMS
- **Humidity channels :** Comparable to ATMS

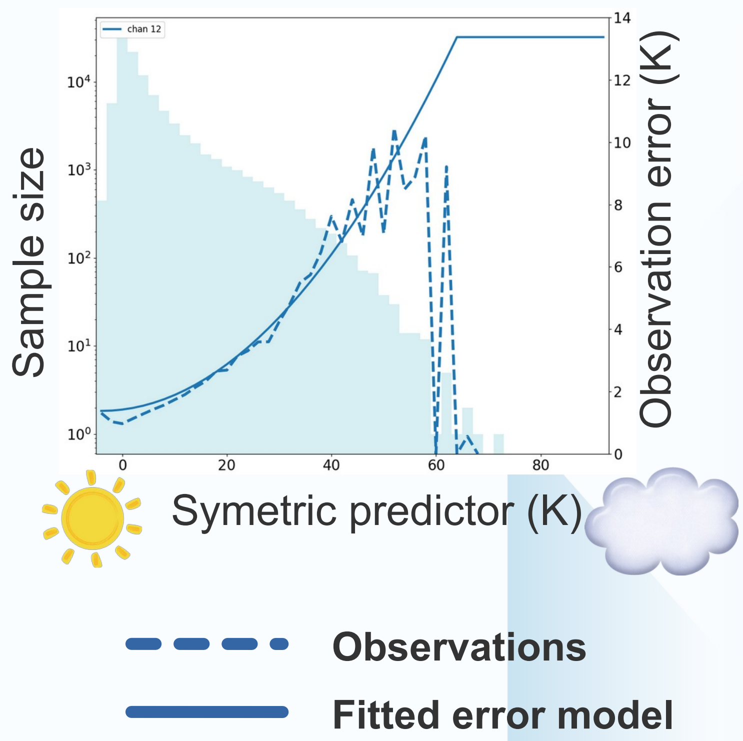
Outline

Preparation to assimilation

Evaluation of observation error models (Geer et Bauer 2011)

- Fitted over real observations over sea and land.
- Different proxys used to determine the cloud amount following Lean et al. (2023) for humidity and temperature channels :
  - A high frequency scattering index for Hu channels : $C_{sym} = \frac{1}{2} x\left(\left(Tb_{191} - Tb_{150}\right) + \left(Obs_{191} - Obs_{150}\right)\right)$
  - A predictor used for AMSU-A : $C_{sym} = \frac{1}{2} x\left(\left|Tb_{50} - Tb_{50\,clear}\right| + \left|Obs_{50} - Tb_{50\,clear}\right|\right)$ (ch52 over land and ch50 over sea)

Ch. 12 (176,81 GHz) over sea



Preparation to assimilation

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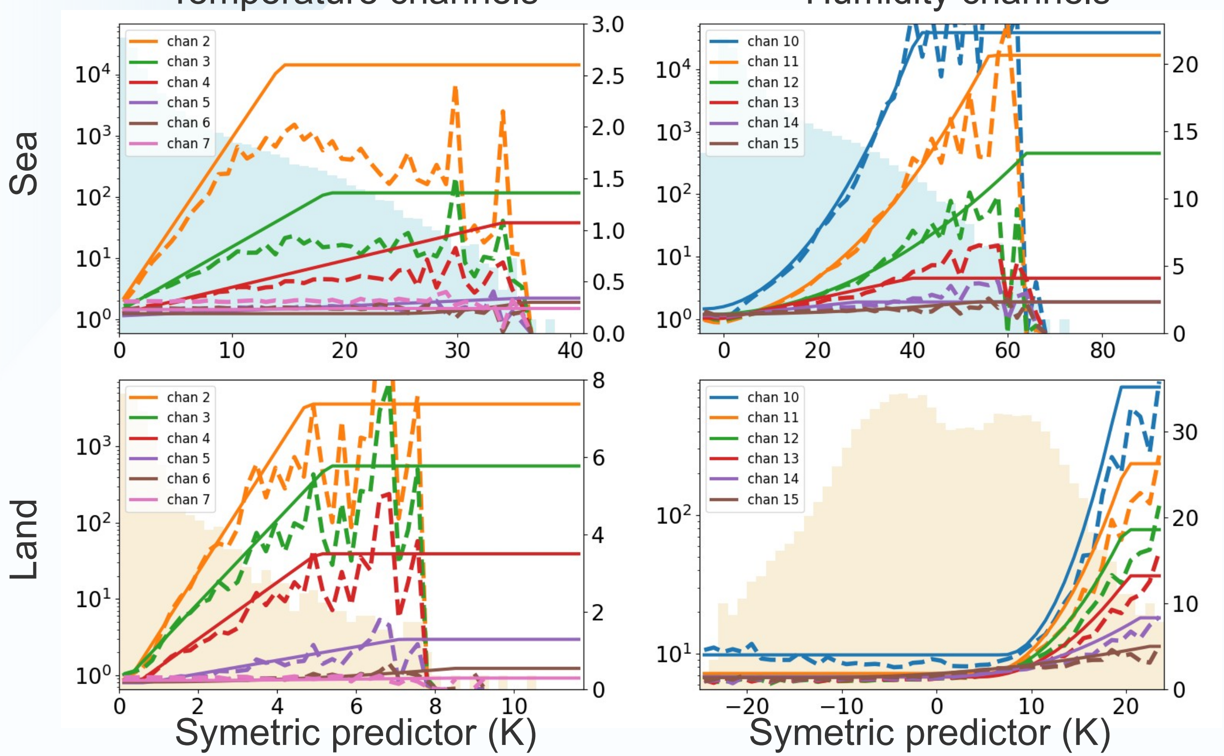
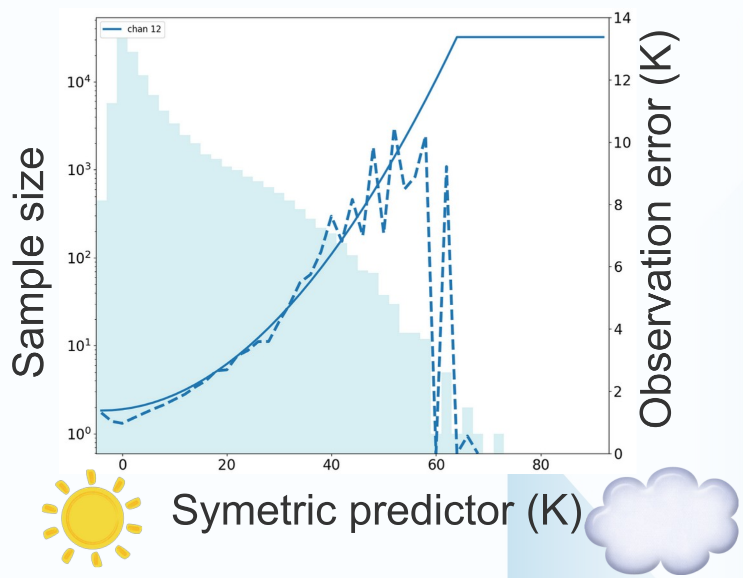


Ch. 12 (176,81 GHz) over land



Larger errors for cloudy areas

Assimilation experiments

Considered period: from 2025-03-16 to 2025-04-15

Assimilation experiments :

ASSIM_T : temperature channels assimilation

ASSIM_Hu : humidity channels assimilation

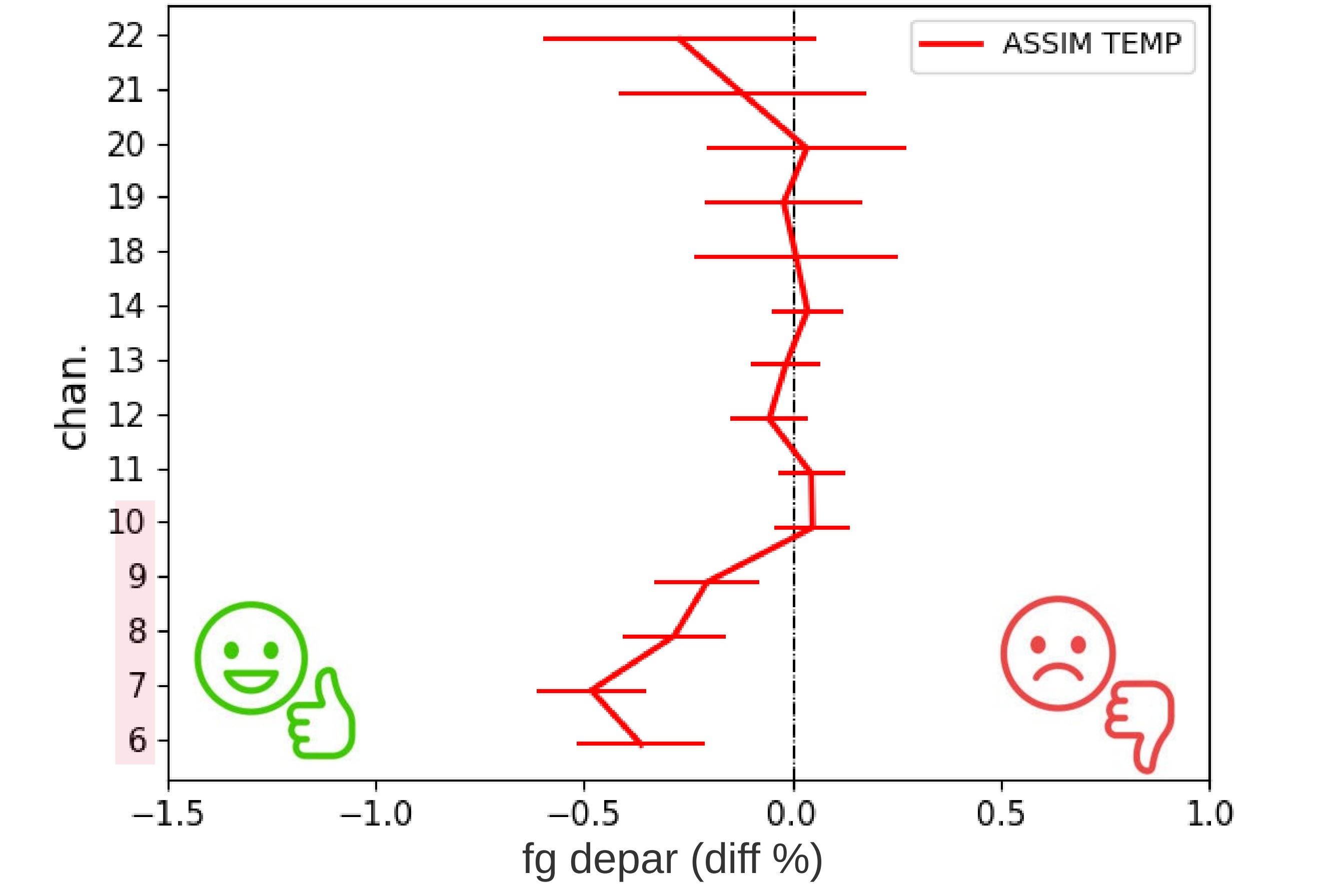
ASSIM_ALL : temperature and humidity channels assimilation

Channel	Frequency
1	50,3
2	52,8
3	53,246
4	53,596
5	54,4
6	54,94
7	55,5
8	57,29
9	89
10	165,5
11	176,311
12	178,811
13	180,311
14	181,511
15	182,311
16	325,15+/-1,2
17	325,15+/-2,4
18	235,15+/-4,1
19	325,15+/-6,6

First assimilation impacts

Short range assimilation impacts (H+6) : exemple of ATMS

Relative difference of the standard deviation of the first guess departure in the North Hemisphere



ASSIM_T

ASSIM_ T : positive impact on temperature channels

First assimilation impacts

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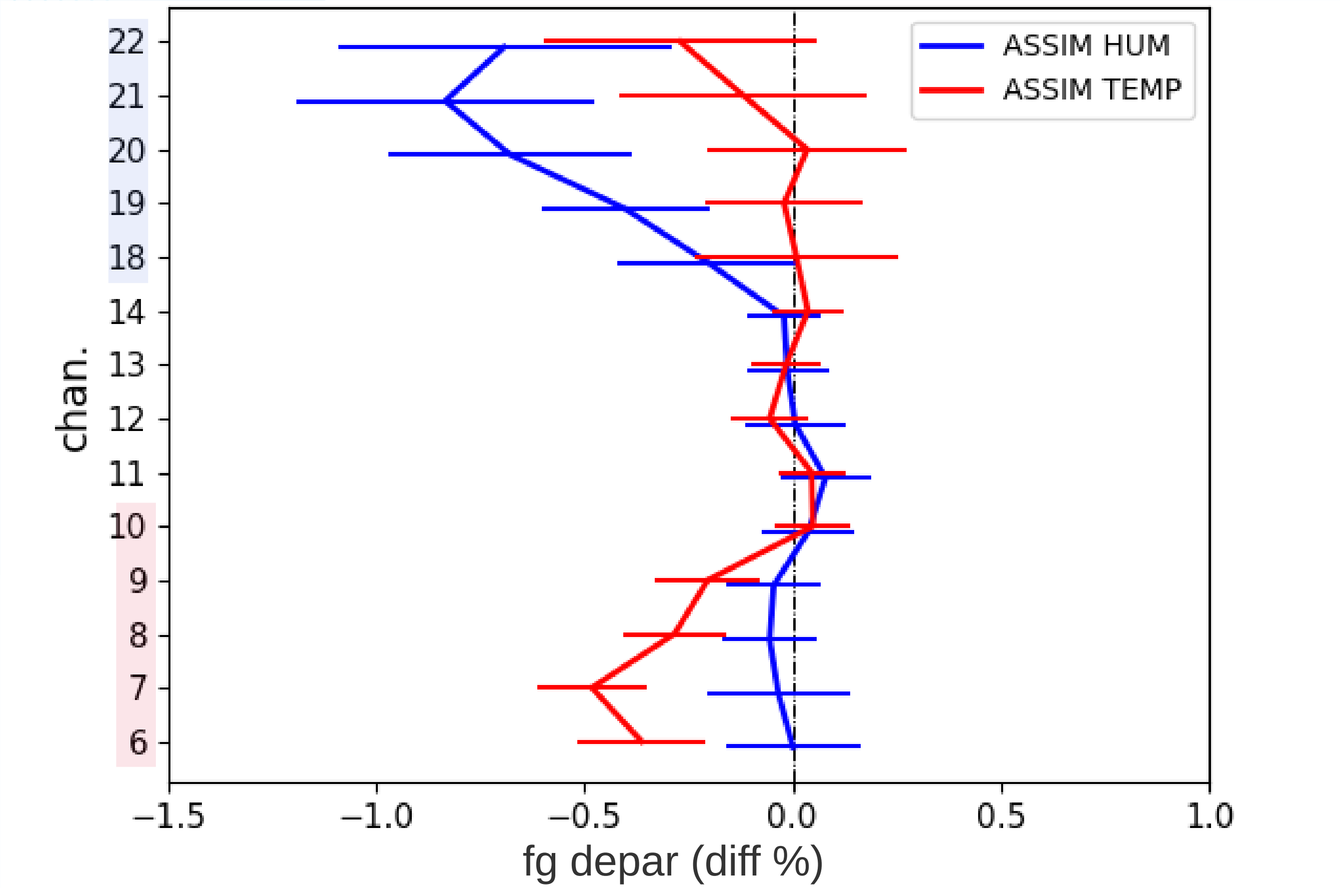

ASSIM_T ASSIM_Hu

ASSIM_ T : positive impact on temperature channel

ASSIM_ Hu : positive impact on humidity channels

First assimilation impacts

Short range assimilation impacts (H+6) : exemple of ATMS

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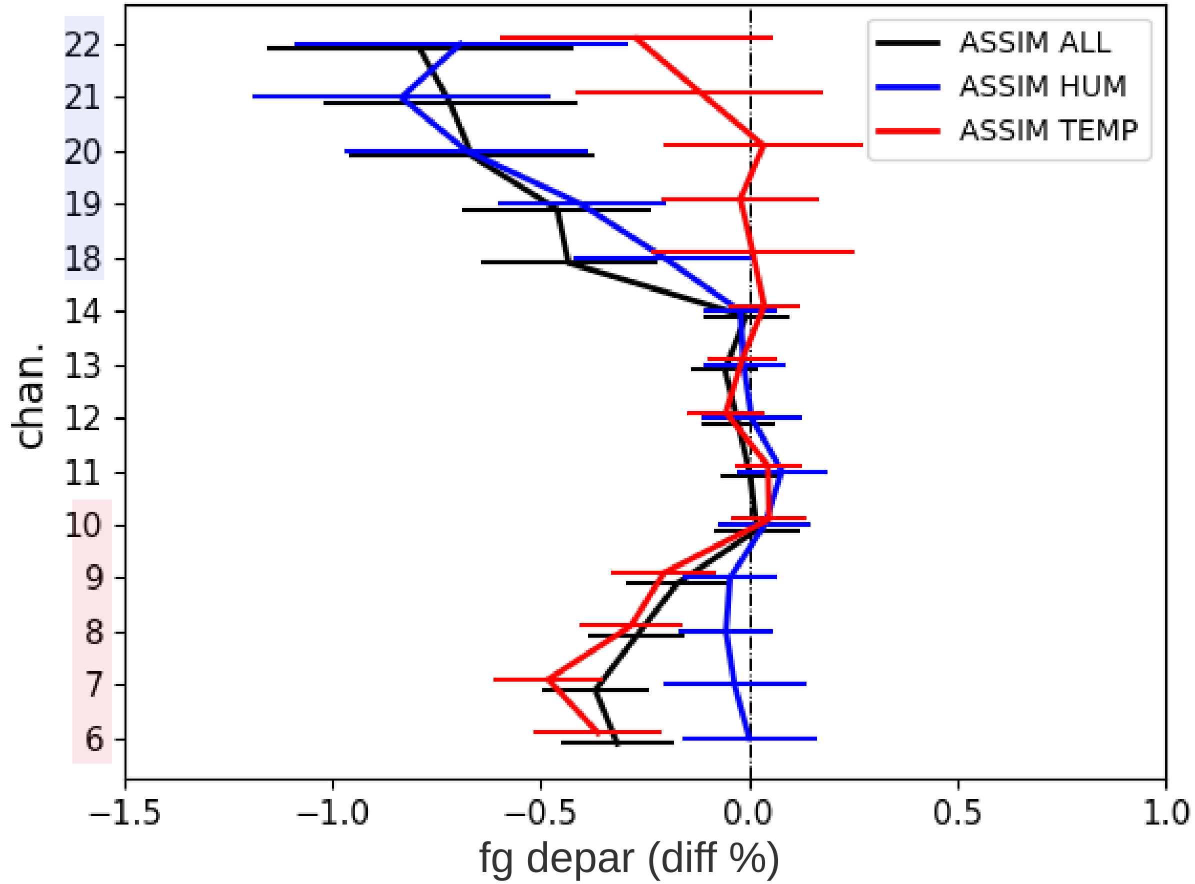


ASSIM_ T : positive impact on temperature channel

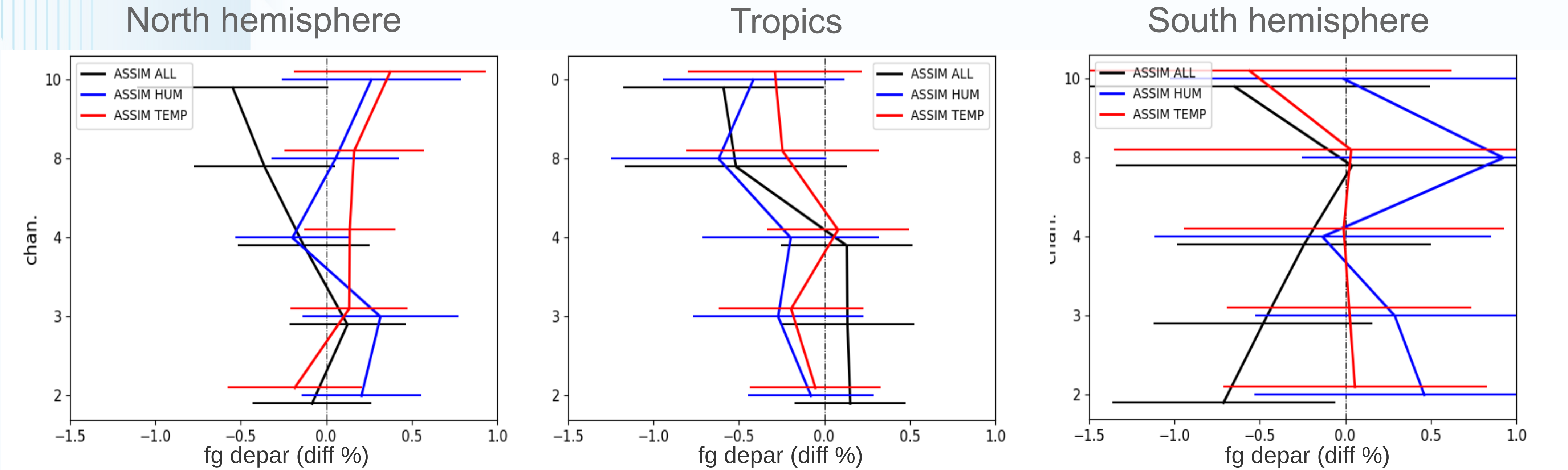
ASSIM_ Hu : positive impact on humidity channel

ASSIM_ ALL : positive synergy between T and Hu channels

ASSIM_T **ASSIM_Hu** **ASSIM_ALL**

First assimilation impacts

Short range assimilation impacts (H+6) : exemple of AHI

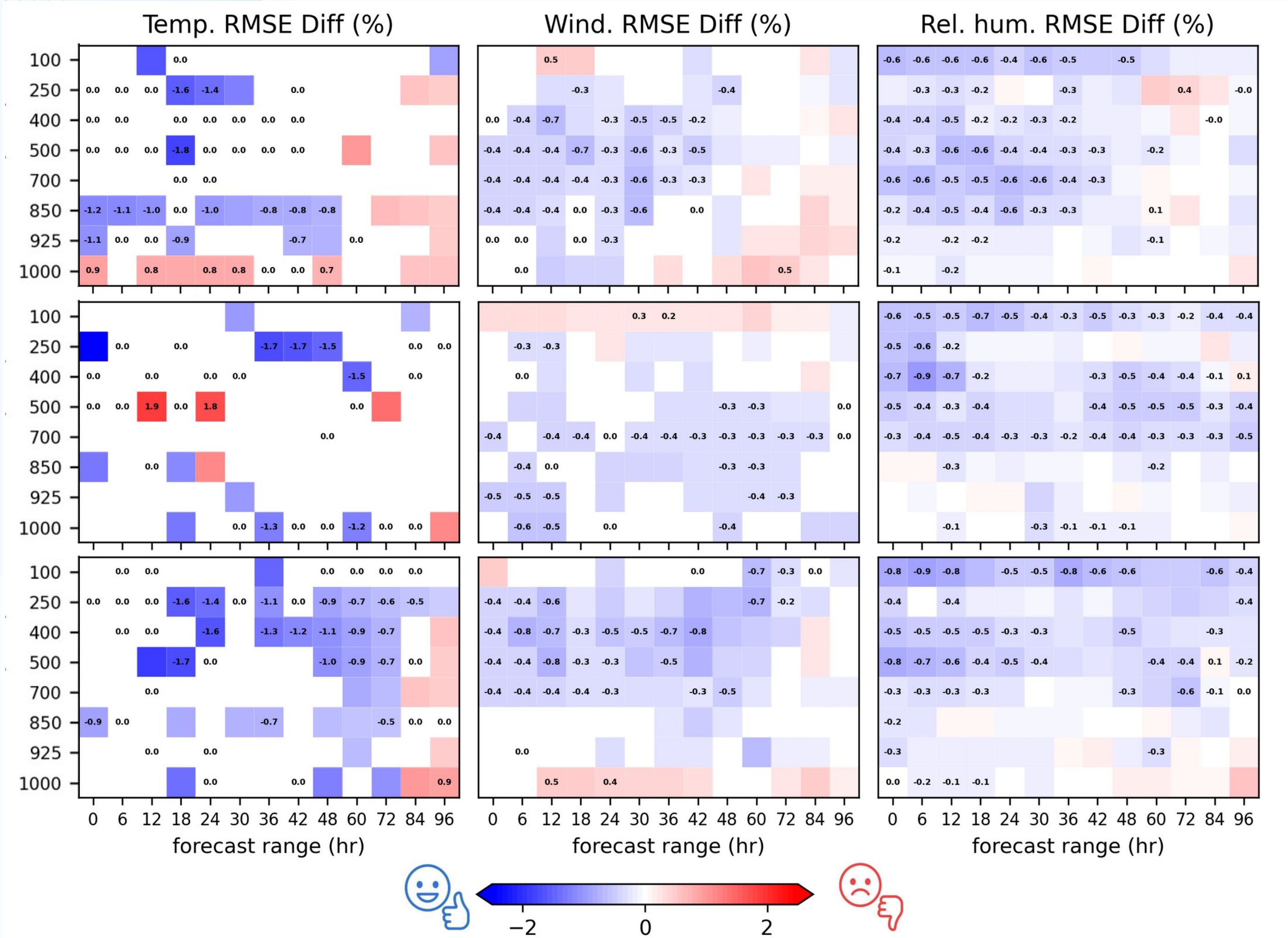


- Positive synergy with other **MW sensors**
- Positive synergy with other **IR sensors**
- **Forecast error reductions** in the short range from both T and Hu channels

First assimilation impacts

Mid range assimilation impacts (until D+4) :

Root Mean Square Error (from 15-03-2025 to 15-04-2025)



Global positive impacts

- **NORTH20 :** some degradations for temperature near the surface but positive impacts upper and for wind and temperature
- **TROPICS :** localized degradation at 500 hPa for temperature but positive impacts especially for humidity.
- **SOUTH20 :** positive impacts for all parameters but some slight degradations for the wind near the surface

Even if some improvements have to be done and the period has to be extended, results are very encouraging

Conclusion and prospectives

Good data quality :

- The data noise and biases are stable over time and comparable to existing instruments like ATMS.
- Scan-dependent biases are relatively strong for humdity channels but can be corrected via VarBC.

First trials of assimilation led to promising results

- Good impact on short range predictions
- Good first results on mid-range predictions but needed to be consolidated

Perspectives :

- Work in progress regarding sub-millimetric channels (325GHz) using SURFEM Ocean.
- Work in progress regarding the adding of the hydrometeors in the control vector of an experimental 4DEnVar for ARPEGE and our regional model AROME.

Bibliography

Geer, A. J. and Bauer, P. (2011). *Observation errors in all-sky data assimilation.* Quarterly Journal of the Royal Meteorological Society, 137, 2024–2037

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