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A Consortium for COnvection-scale modelling
Research and Development

Advances in the use of observations in ACCORD

Antonín Bučánek and ACCORD upper-air data assimilation colleagues

47th EWGLAM and 32th SRNWP meeting, 22-25 September 2025
Norrköping, Sweden

Outline

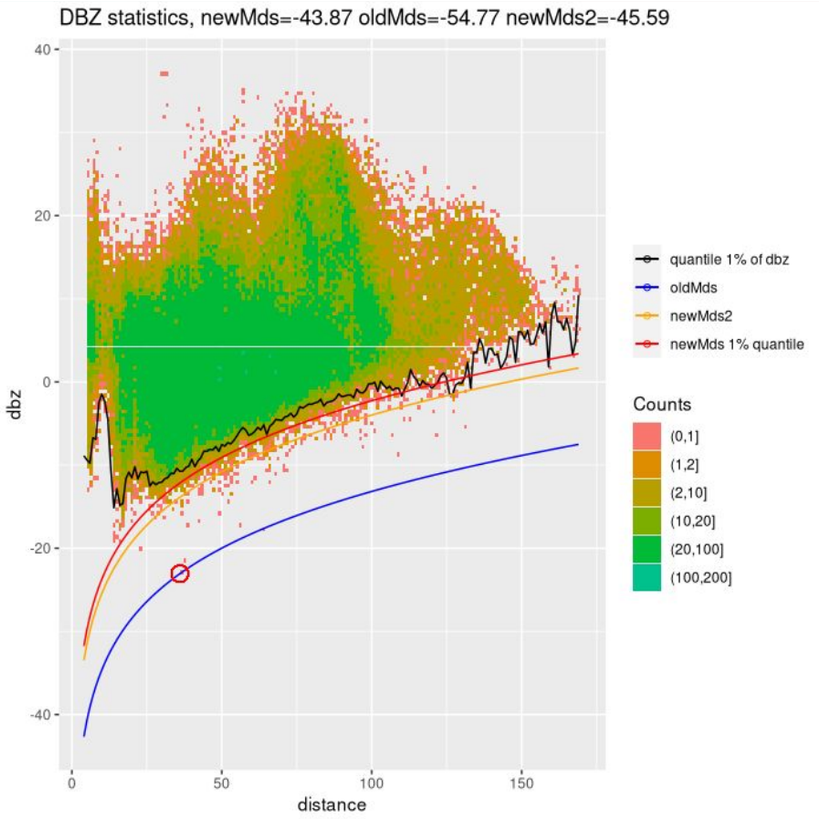
- Radar reflectivity & wind dealiasing
- GNSS-derived data
- Satellite datasets in clear-sky mode:
  - Polar satellites
    - Lambertian vs Specular reflection assumptions (microwave)
    - Assimilation of AWS
    - CrIS and IASI assimilation and inter-channel correlations
  - Geostationary satellites
    - SEVIRI horizontal error correlations
    - SEVIRI use in polar regions
- All-sky assimilation
- MTG Lightning Imager
- Conclusions

**"How AI Sees a Weather Nerd's Journey:
From the Earth to the Sky and Back"**

- **We start on the ground** – where the wind lies and weather stations tattletale (AWS and wind dealiasing).
- **Up we go** – GNSS signals bending like they're dodging taxes.
- **Still clear?** – Polar satellites checking in with their best guesses (and some questionable assumptions about how shiny the Earth is).
- **Microwaves get philosophical** – Lambertian vs Specular: flat Earth vs disco ball.
- **Satellites, assemble!** – CrIS, IASI, SEVIRI… and their complicated inter-channel drama.
- **Geostationary spies** – always watching, even where they're not supposed to (looking at you, SEVIRI in the polar regions).
- **Clouds crash the party** – All-sky assimilation: because real weather isn't always clear.
- **When lightning strikes** – MTG Lightning Imager joins the plot with some flash.
- **And back to Earth** – conclusions drawn, data assimilated, sanity… questionable.

Towards improved radar reflectivity assimilation

- Refinement of Bayesian inversion
  - **Operational in Czechia** since May 2025
  - **New radars** assimilated in **AROME-RUC (AT)**
    - Hochficht (Austria), Southern Poland (to compensate for lack of Czech radars), Bolzano (Italy), Corsica (France)
- **Improved preprocessing** of radar data
  - Less restrictive, now handles missing metadata
  - Resolved issue with multiple elevation angles for same scan level in OPERA for Hungarian radars (BATOR)
  - Improved estimation of minimum detection thresholds of radars – **removed lowest 1% DBZ values** (BATOR)
- Ongoing implementation among ACCORD members
- Experimentation with radar data provided via **ARCUS vs. NIMBUS** (OPERA streams)

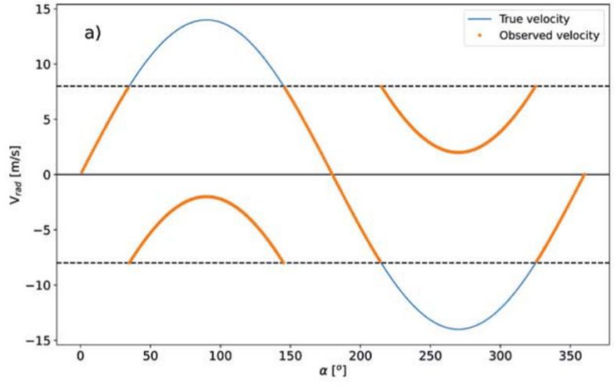


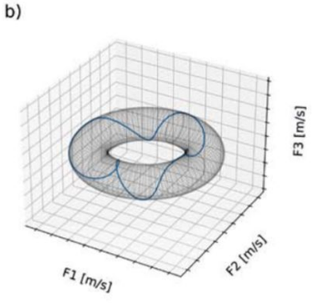
Histogram of observed DBZ from the DEDRS radar at 0.5° elevation on 7 December 2024 at 00 UTC. The blue line represents the old method of computing the detection threshold, while the red line shows the new algorithm.

G. Haase, M. Ridal (SMHI), J. Sánchez-Arriola (AEMET), M. Dahlbom (DMI), M. Nestiak (SMHU), A. Bucanek, A. Trojakova (CHMI), L. Magyar (Hungaromet), F. Meier (GeoSphere Austria)

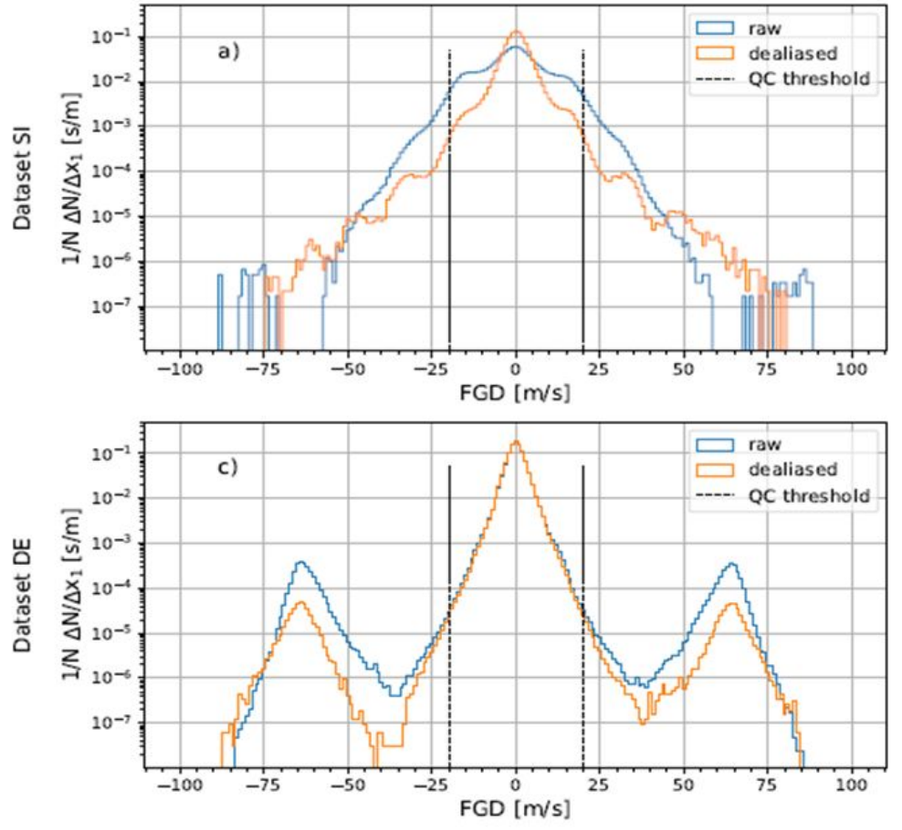
Doppler velocities dealiasing for use in NWP

- Refined **torus mapping** dealiasing
  - variational method
  - assumes a linear field in zonal and meridional wind speeds
- Correctly dealiases more than **90% of radial winds**
- **Reasonable quality** for data assimilation after the additional QC
- Available in HOOF tool (Homogenization Of Opera File)





Idealized wind observations from a Doppler radar with Nyquist velocity of 8 ms−1.
a) Azimuth dependence of observed and true radial wind velocities.
b) Same velocities mapped onto a torus surface



First guess departure distribution of radial winds over one year. The comparison is between raw and de-aliased datasets for SI (upper panel) and DE (lower panel).

Smerkol, P., Švagelj, V., Zgonc, A. & Strajnar, B. (2025). Validation of torus mapping dealiasing method on Doppler velocities for use in numerical weather prediction. Meteorologische Zeitschrift, 08

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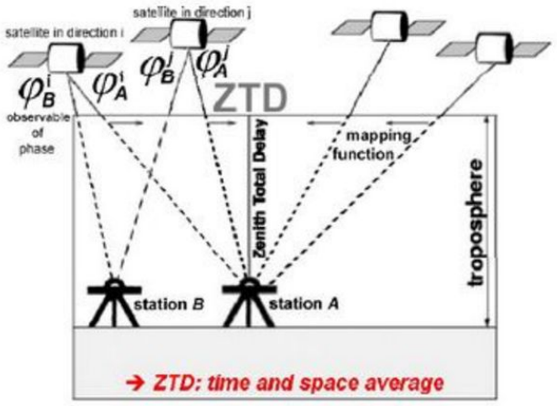
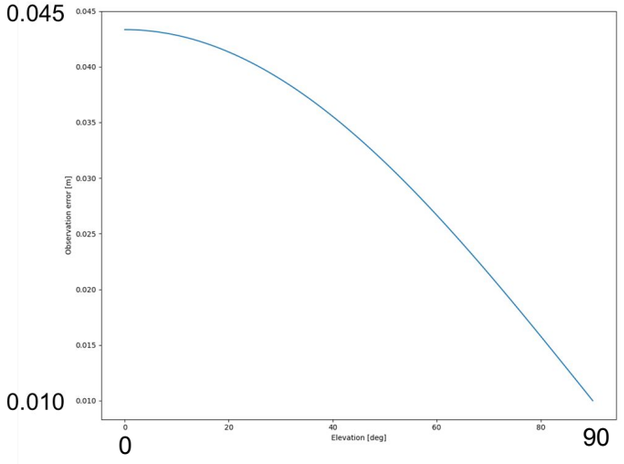
GNSS - derived data

- **GNSS Zenith Total Delays (ZTD)**
  - Ongoing implementation within ACCORD members
  - Newly operational at SHMÚ
  - Preoperational at UWC-W
  - Hourly and sub-hourly Nowcasting testing at AEMET

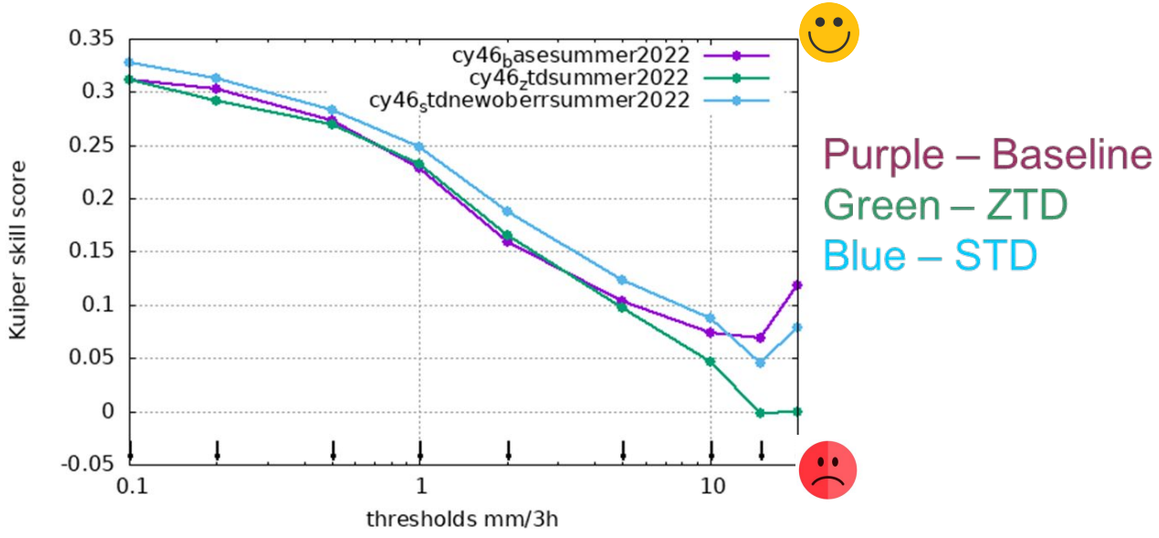
- **GNSS Slant Total Delays (STD)**
  - 8x more obs of similar quality as ZTD
  - The observation error depend on elevation angle
  - STD is showing the most pronounced **improvement in Summer**

- **GNSS ZTD gradients**
  - Observation operator developed at Meteo-France
  - Nearby model profiles used for gradient estimation
  - Impact studies are ongoing





STD observation error as a function of elevation angle of the satellite

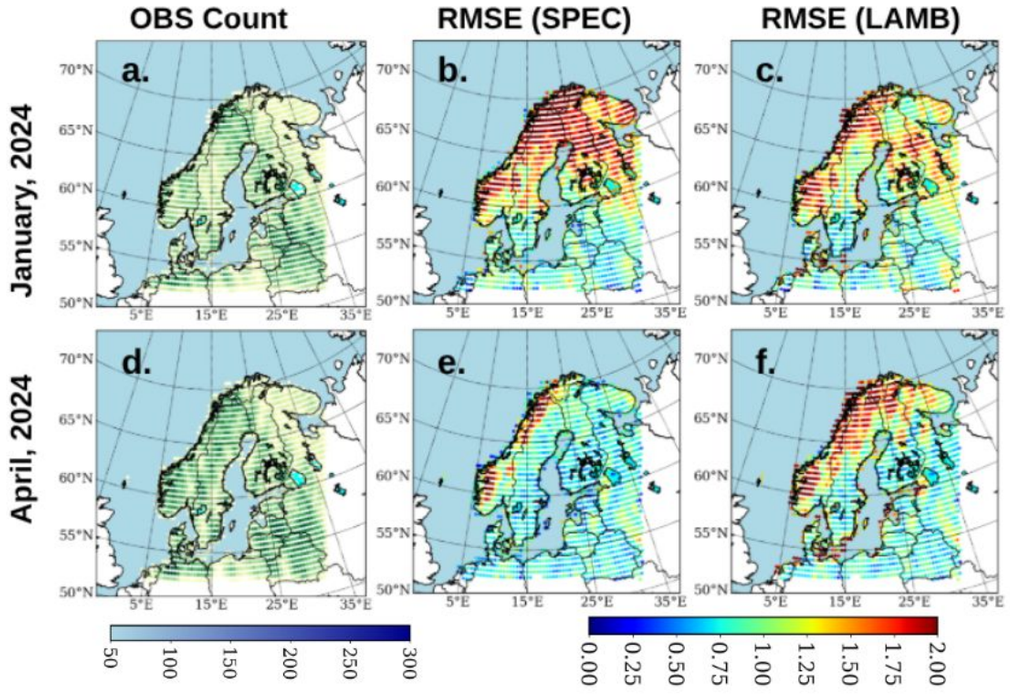


Precipitation Kuiper skill score for the summer experiment (10 Aug - 9 Sep 2022)

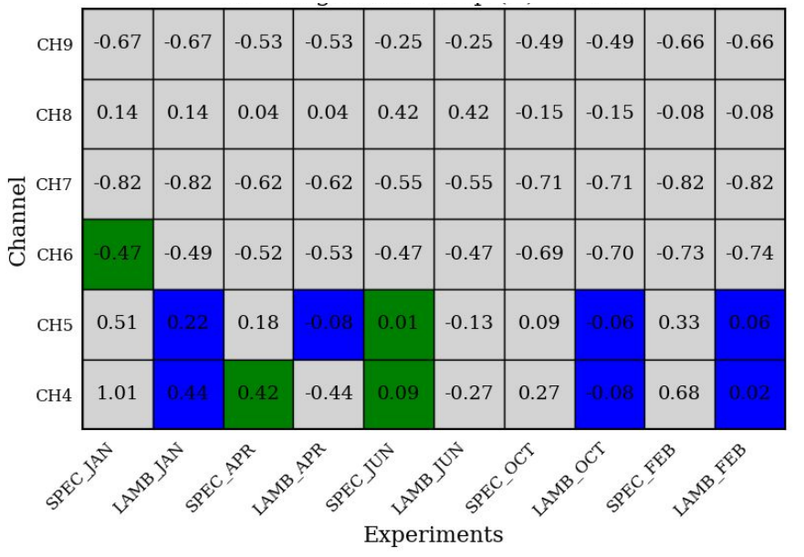
M. Ridal (SMHI), S. DeHaan (KNMI), P. Moll (Meteo-France) & F. Hdidou (DMN)

Study of improved reflection assumptions

- Investigation of surface-sensitive clear-sky microwave radiances using **Lambertian and specular reflection** over land, snow, and icy-water surfaces.



Available **MW observations** and **RMSE of first guess departure** in terms of Brightness Temperature (K) computed **using SPEC and LAMB method** (AMSU-A channel 5).



AMSU-A **channel-wise mean first-guess departure** (K) over land from SPEC and LAMB experiments over five months. Means calculated from all assimilation cycles. Green cells: **SPEC performed better**; blue cells: **LAMB performed better**.

Swapan Mallick (SMHI), Magnus Lindskog (SMHI) and Stephanie Guedj (MET Norway)

Assimilation of AWS in AROME-Arctic with the dynamic emissivity

- **Arctic Weather Satellite (AWS)** launched in **August 2024**, declared operational in **June 2025**
- AWS data over land and sea ice assimilated using **dynamically retrieved emissivity** from **channels 1** (50 GHz) and **9** (89 GHz, Fig. 1).
- Assimilation trials in preop **AROME-Arctic** at Met Norway show **small positive impact** (Fig. 2), with further tuning ongoing.
- Pre-operational implementation expected in the coming weeks.

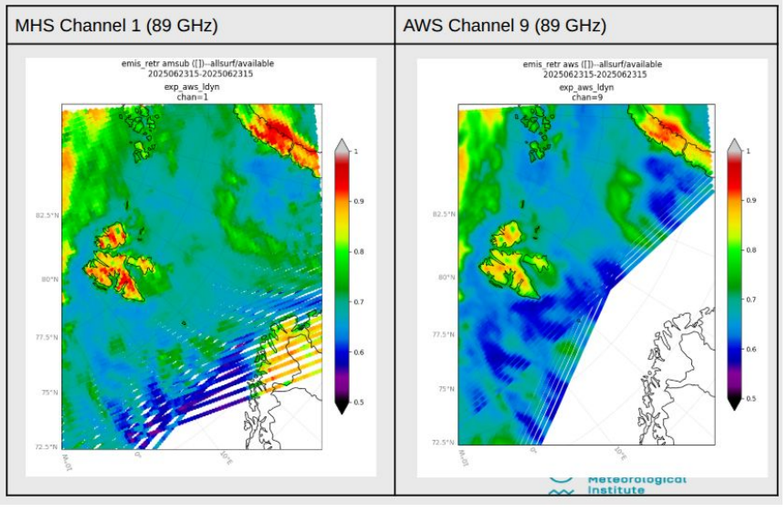


Fig. 1: Maps of retrieved emissivity at 89 Ghz

Channel Selection & QC

- **Channel 4-7 (T)** + **11-15 (Q)** used in **clear-sky** over land/sea-ice & ocean
- **Superobbing T channels** (3×3) in AAPP
- Coastal and high-altitude observations rejected
- **Clear-sky threshold:** FGD < **0.7 K**
- Dynamic emissivity (atlas fallback)
- **Channel 8 blocklisted** (out of spec)
- Window & 325 Ghz channels monitored

CTL = preop version of AA
EXP = CTL + AWS

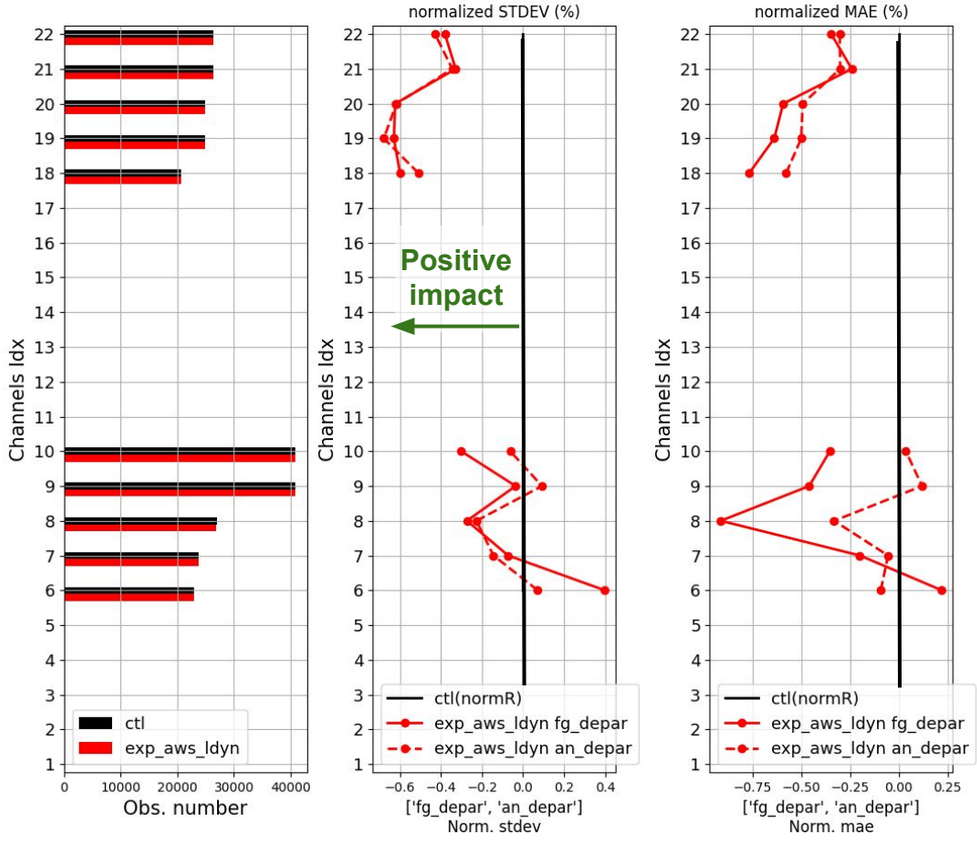


Fig. 2: Normalized first-guess and analyse departures to ATMS active observations (1-20 July 2025)

Stephanie Guedj and Per Dahlgren (MET Norway)

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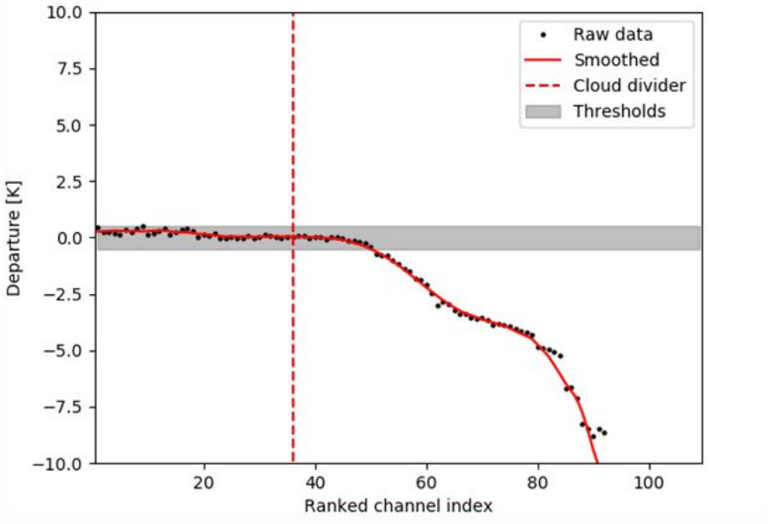
Progress in the assimilation of infrared radiances in AEMET

- **Infrared instrument/satellite**: IASI/METOP-B and C, and CrIS/NOAA-20 and 21
- **Active/Passive**: 53/135 channels for IASI and 40/85 for CrIS
- Increase in the **passive** channels to improve **cloud detection scheme**
- Use of Infrared radiance **cloud detection diagnostic tool** in (**ACCORD-NWP/AccordDaTools**) to check the performance of cloud detection scheme (McNally and Watts, 2003)

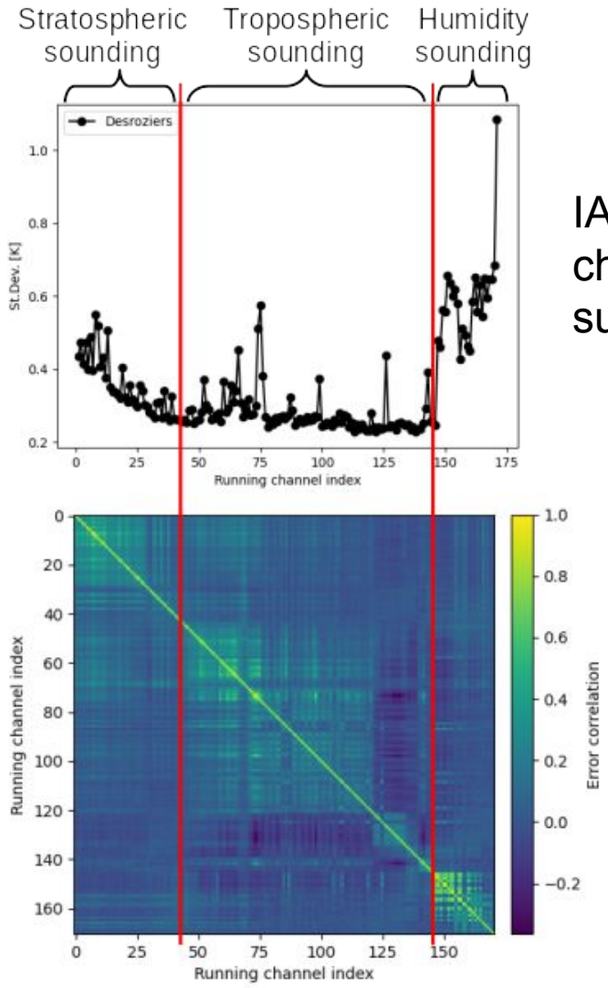


Ob-fg departures vs ranked channel index for a NOAA-20 CrIS sounding

- These changes showed a positive impact, and they are running in the **pre-op suite**

Diagnosis of observation error covariance in infrared sounder data

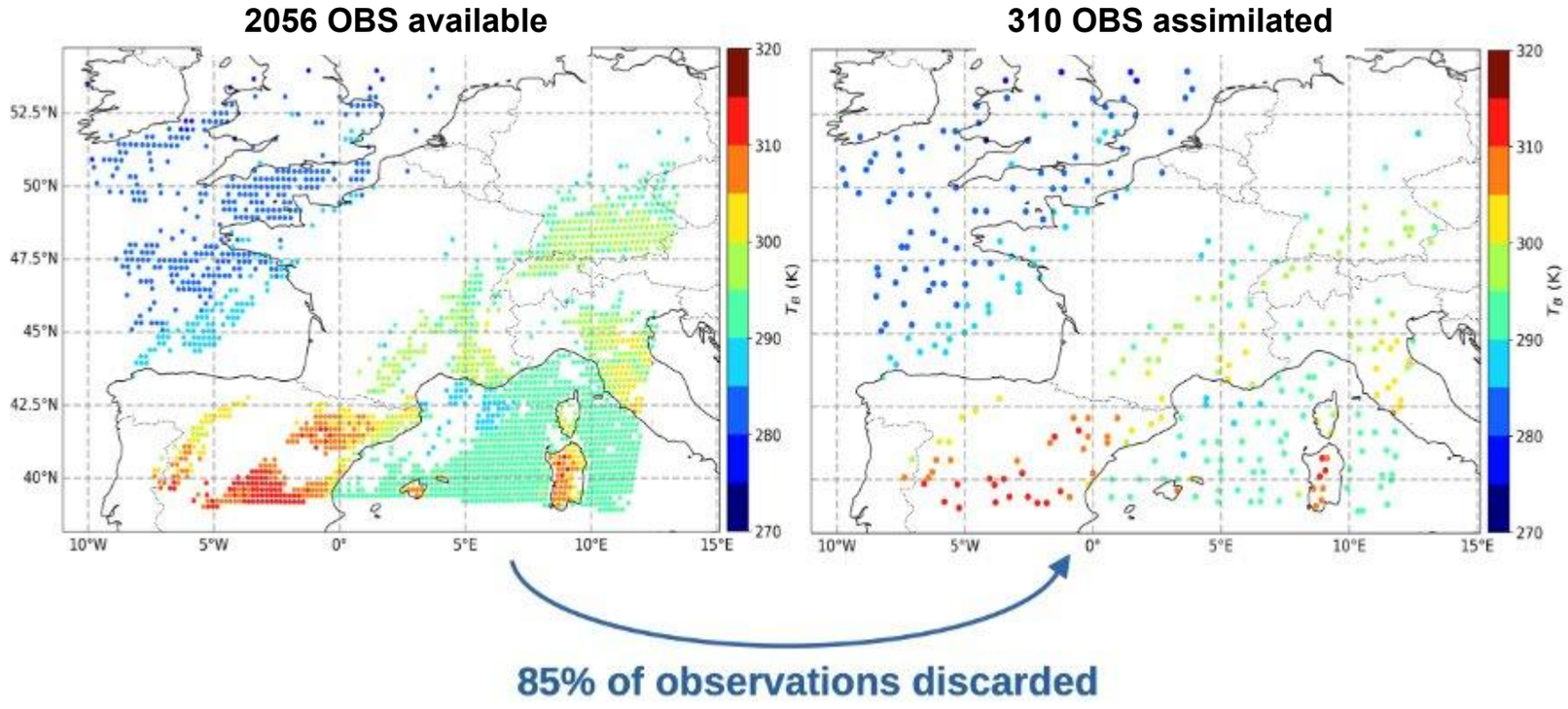
- **Current operational use** in Harmonie-Arome (FI) includes
  - 55 channels from IASI (Metop-B, Metop-C)
  - 40 channels from CrIS (NOAA-20)
- **Aim to increase active channels** by up to **171 from IASI** and **125 from CrIS**
- Performance gains from additional channels depend on accurate observation error statistics
  - Full inter-channel (spectral) observation error covariance is essential
  - Observation errors estimated using the Desroziers diagnostic tool and a 30-day sample from a Nordic limited-area domain
  - Figures show the diagnosed error standard deviations and the inter-channel correlation matrix for IASI

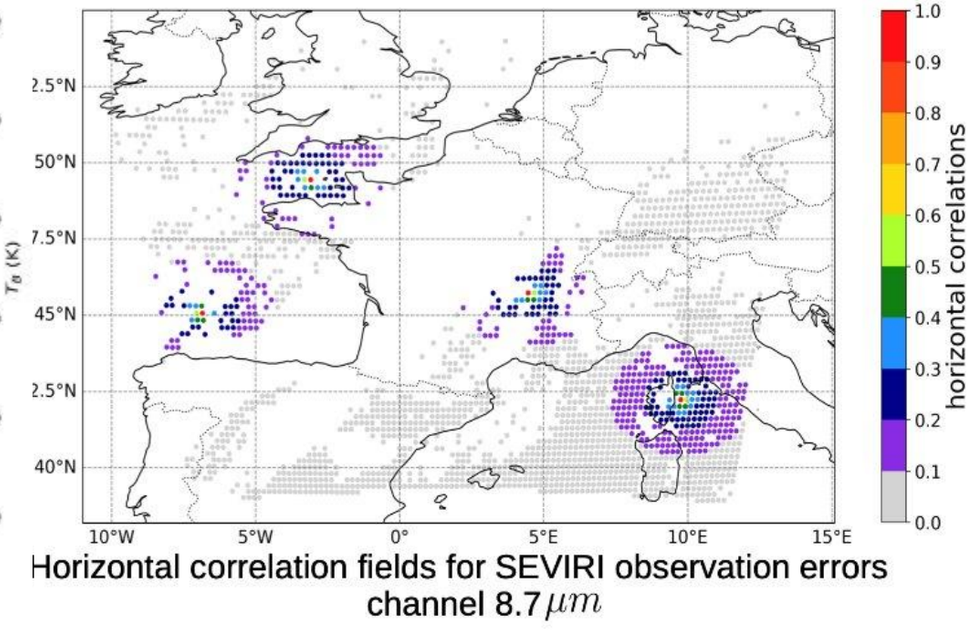


IASI-171 channel subset

Towards the introduction of observation error horizontal correlations in AROME

Example with MSG/SEVIRI data in an experimental framework (one single processor, low resolution of 10 km, 3DVar):





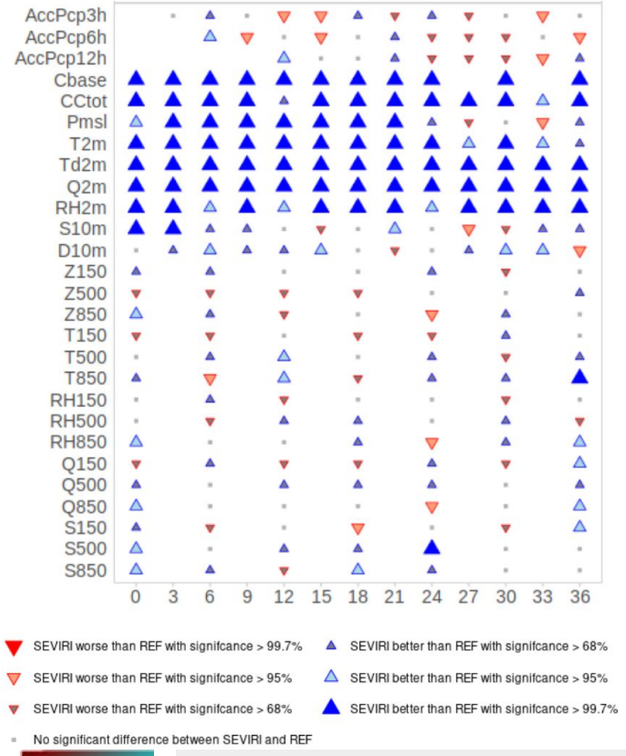
Buey et al., to be submitted for QJRMS

- Results show no degradation of the minimization convergence and an impact on analysis increments
- Next steps: implement in a parallel environment to assess the impact in a cycled near-operational framework

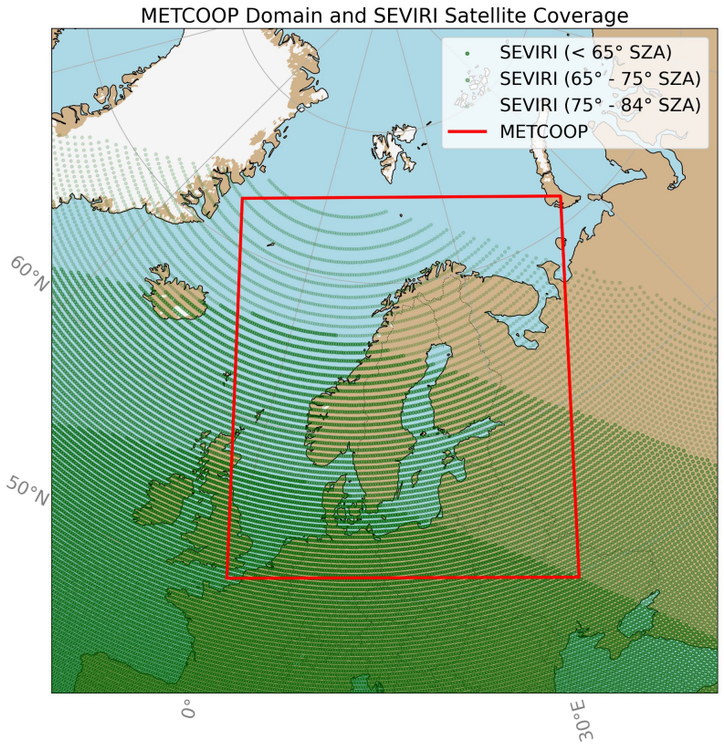
Thomas Buey, Oliver Guillet, Olivier Audouin, Nadia Fourrié (Météo-France)

Extending SEVIRI Satellite Coverage in MetCoOp

- **SEVIRI** rarely used **in the Nordic region** due to large satellite zenith angles (SZA)
- Assimilation of **water vapour channels WV062 & WV073** in HARMONIE-AROME 3DVAR **up to 84° SZA**



- **Alternative set of radiative transfer coefficients** (v9 instead of v7) in clear-sky mode (filtering by NWCSAF software)
- **Findings**:
  - Strong increase in data coverage across the MetCoOp domain
  - **Significant improvements** in near-surface temperature, humidity, MSLP, and cloud fields
  - Benefits strongest **in the first 24h** of forecasts
- **Conclusion**: Even at extreme viewing angles, some of SEVIRI channels can be used to improve short-range forecasts in MetCoOp.



Schönach, D., Eresmaa, R., & Järvinen, H. (2025). Assimilation of SEVIRI Water Vapour Radiances in HARMONIE-AROME at Large Satellite Zenith Angles. Tellus A: Dynamic Meteorology and Oceanography, 77(1)

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All-sky assimilation in CLAEF1k

Ongoing work on all-sky assimilation for IASI, SEVIRI (VIS & IR) following ECMWF route

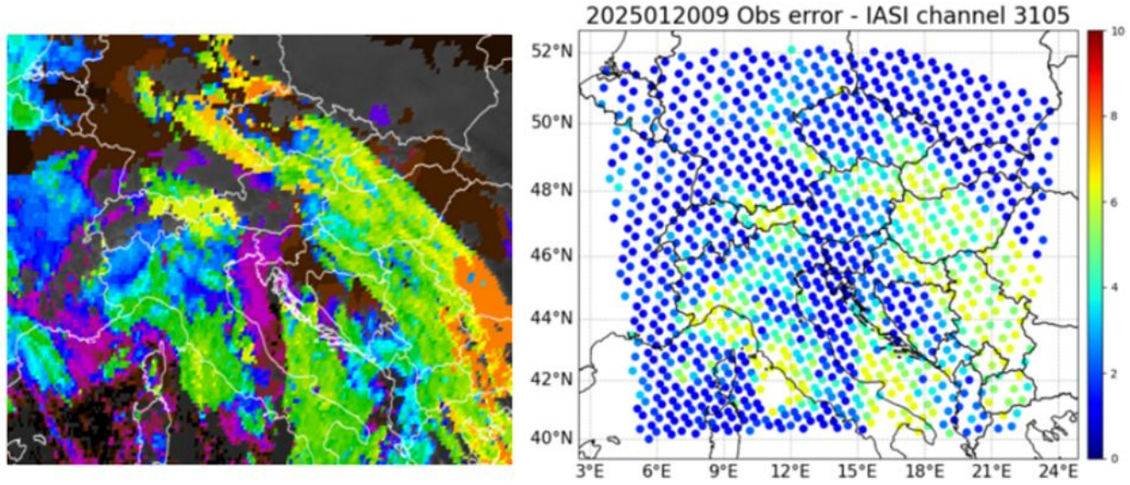
- 3DEnVar with hydrometeors

Error Estimation **Inspired by Okamoto** method

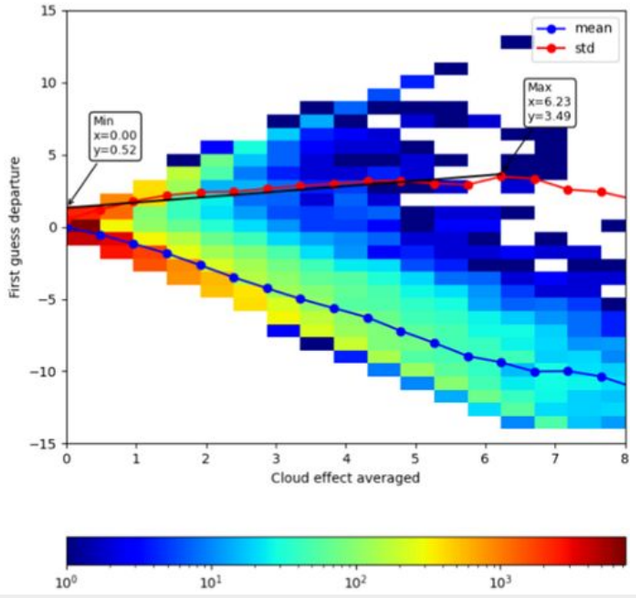
- Observation errors scale **linearly with cloud effect**, up to predefined maximum

IASI experiments

- Assimilated in **passive mode** (1 month period)
- Careful QC rejecting data strongly affected by high thick clouds or by surface contamination, etc.
- First-guess departures used to estimate error bounds for 4 channels
- **Large biases** observed
- To address increasing bias **a New cloud-based predictor** added to **VARBC**



Case 20.01.2025.: EumetView Cloud top height product (left), modeled observation error values for IASI channel 3105 (right)



Histogram of first-guess departures vs. cloud effect,

- mean (**blue**),
- standard deviation (**red**),
- and linear fit (**black**) for observation error estimation

S. Panežić (DHMZ), A. Neduncheran, F. Meier (GeoSphere Austria), B. Strajnar (ARSO)

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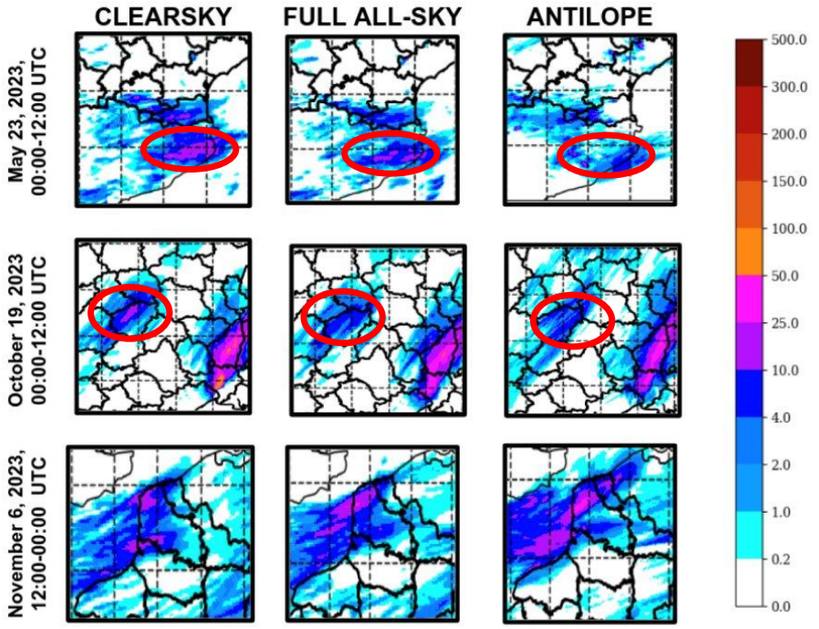
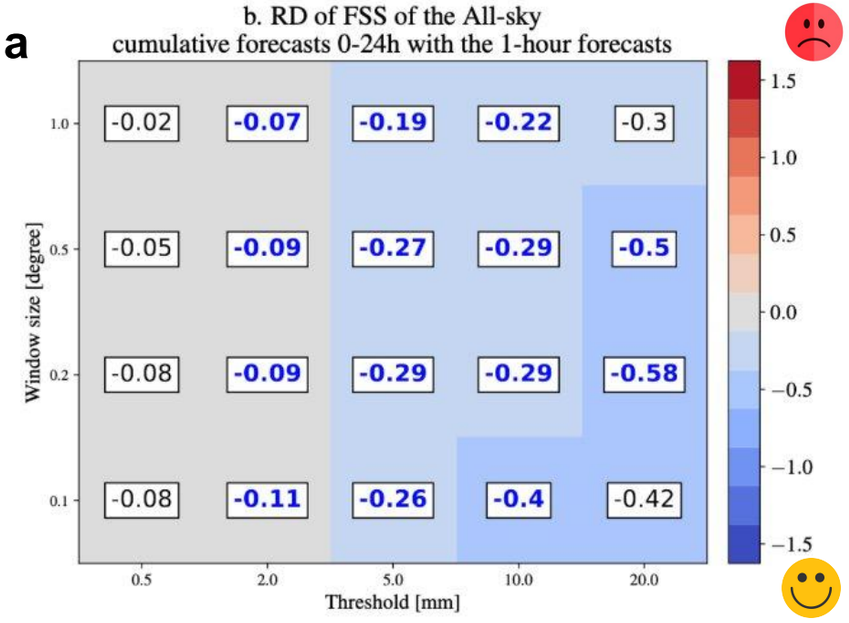
Direct assimilation of passive microwave cloudy and precipitating observations in AROME- France

- As for ground-based radar reflectivities and lighting observations, **the addition of hydrometeors within the control vector** allows to directly assimilate passive microwave observations in cloudy and precipitating areas using **the allsky route of ECMWF** (already used for the global model ARPEGE).

Impact on case studies



Impact for a 1-month period



Chardon--Legrand et al., under review for QJRMS

- Limited to MHS/MWHS2/GMI/AMSR2 for now, larger impact expected with a larger constellation (AMSUA, ATMS, SSMIS, MWRI, AWS and the upcoming MWS/MWI/ICI/AMSR3).

Elisa Chardon--Legrand, Mary Borderies, Philippe Chambon, Hélène Dumas (Météo-France)

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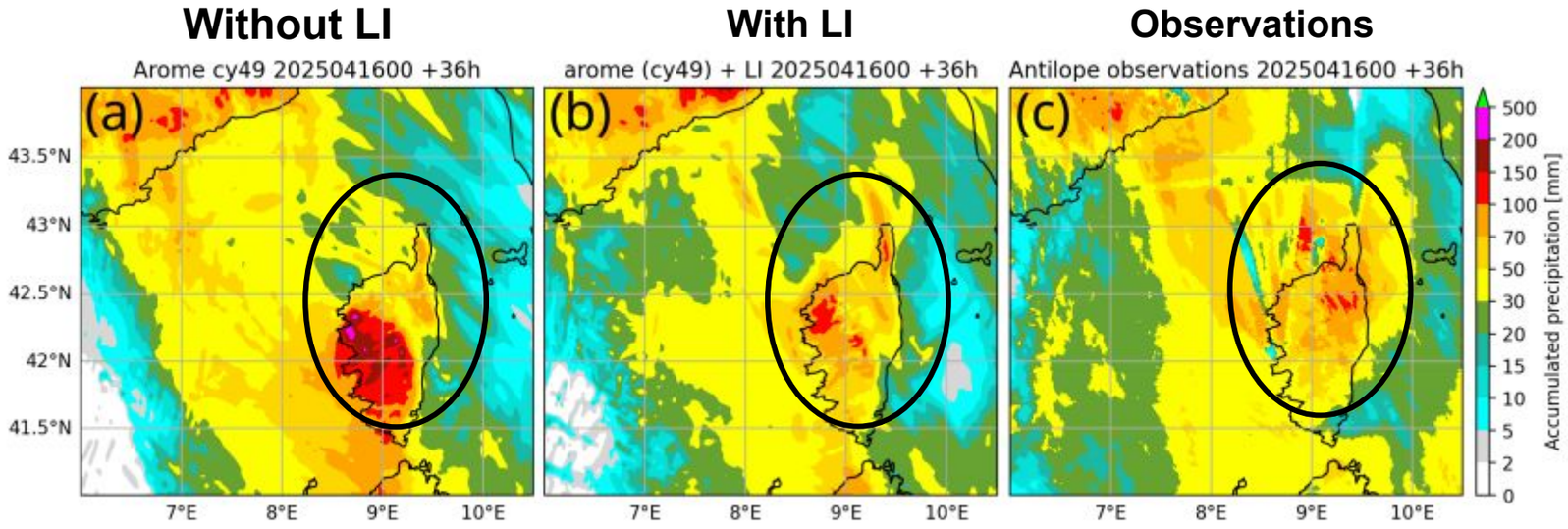
Assimilation of MTG Lightning Imager observations in AROME-France

- The **Accumulated Flash Area product of MTG/LI** is assimilated in the 4DEnVar system of Météo-France, **with hydrometeors in the control vector.**
- Neutral impact, except on short range forecasts for high precipitation threshold (> 10mm in 3h).



- Clear benefit on this precipitating event in which the +36h accumulated rainfall was overestimated in the experiment without LI observations.

Pauline Combarnous, Maud Martet (Météo-France)

Conclusions

- Continued development and observational studies are underway, supported by collaboration among ACCORD members.

- Notable improvements obtained by assimilating observations using ensemble-variational methods, particularly with feedback applied to hydrometeors (e.g., cloudy and precipitating microwave radiances, lightning observations).

- Research is ongoing to enhance all-sky assimilation, focusing on broader data usage, better representation of observation errors and their correlations, and improved modeling of surface characteristics.

Thank you for your attention!

Foto: Carl Johans park, Norrköping, May 2024
Cactus planting 2024
Cactus planting 2025
(tradition since 1926)