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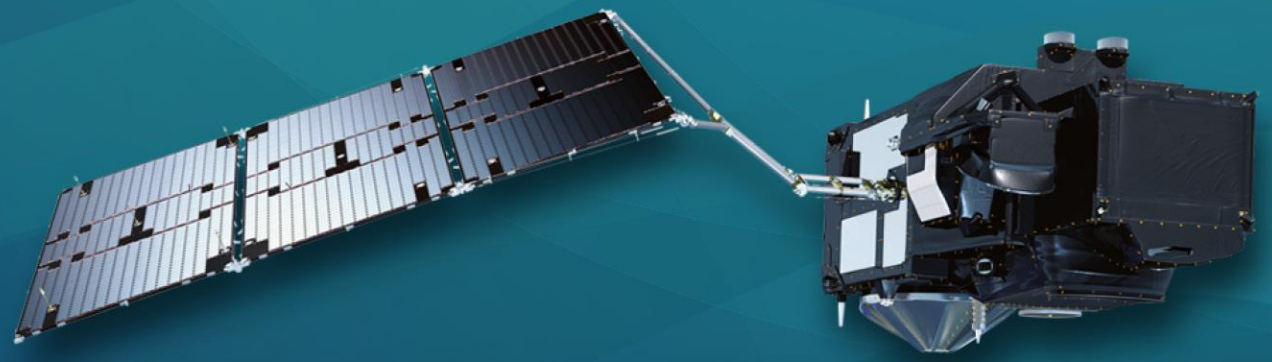


9th Sentinel-3 Validation Team meeting 2026

30 March–01 April 2026 | ESA–ESRIN | Frascati (Rome), Italy

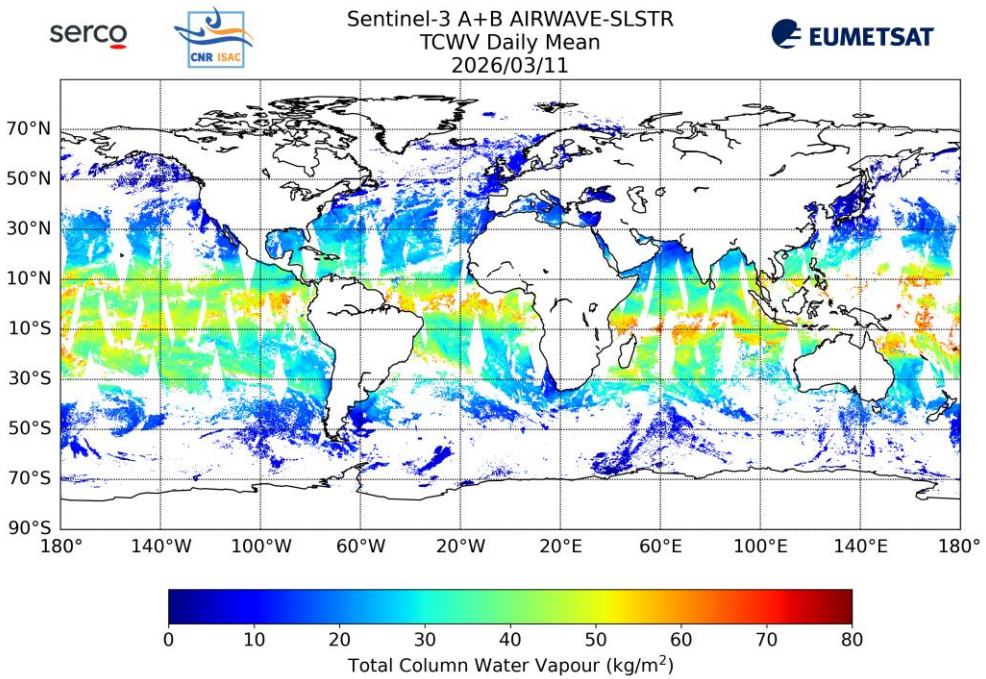
Sentinel 3 AIRWAVE-SLSTR automatic processing and inter-comparison/validation chain

Massimo Valeri[1], Elisa Castelli[2], Riccardo Luciani[1], Stefano Casadio[1], Enzo Papandrea[2], Andrè Achilli[2,3]
1) Serco Italy, 2) CNR-ISAC, 3) University of Bologna

The Advanced Infra-Red WAter Vapour Estimator algorithm

- The **AIRWAVE** algorithm was originally developed for the **(A)ATSR-1/2 instruments** (Casadio et al., 2016; Papandrea et al., 2018; Castelli et al., 2019), retrieving TCWV in **cloud free scenarios** over water surfaces **in day and night** from ATSR-like instruments exploiting the TOA BTs collected from the **nadir and oblique views** of the channels at **10.8 (S8) and 12 µm (S9)**.

- In the frame of EUMETSAT AIRWAVE-SLSTR studies (https://www.eumetsat.int/airwave-slstr-follow-study), the algorithm has been extended to exploit SLSTR observations (Castelli et al., 2025).



SLSTR main characteristics

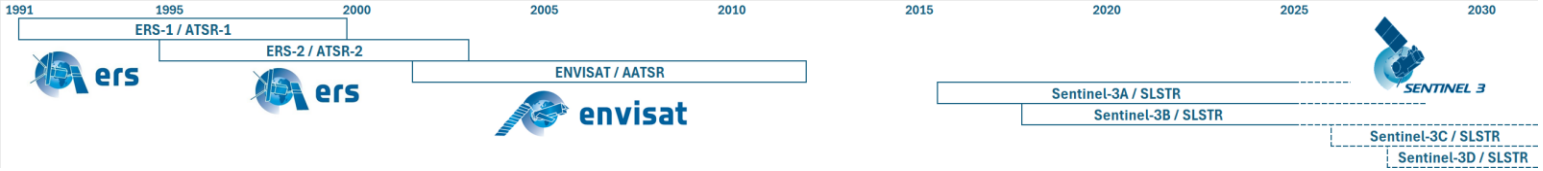
- Swath width: dual view scan
  1400 km (nadir) / **740 km** (backwards)
- Spatial sampling: 500 m (VIS, SWIR)
  1 km (MWIR, TIR)
- Spectrum: 9 channels [0.55 - 12] µm
  + 2 channels for fire detection

Current status

AIRWAVE is now part of the “Scientific Framework – Operational Water Vapour Products from Optical Imagers” EUMETSAT project, whose activities in the first-year focused on:

1. consolidating the retrieval code (e.g., **new SRF treatment**),
2. updating the calculation of **Type B (systematic) errors**,

(1) and (2) lead to the definition of the AIRWAVE version 3 code. (A)ATSR-1/2 missions' L1b data have been reprocessed with AIRWAVE-V3*. This dataset, extended to S3-A/B-SLSTR missions’ data, opens up the possibility of creating a long time series of TCWV over water surfaces in clear-sky conditions during both day and night at a spatial resolution of 1 km^2



** IDEAS-QA4EO - CNR-ISAC/Serco WP “Total Column Water Vapour Essential Climate Variable from (A)ATSR(-1/2) reprocessed L1 data series using AIRWAVE-V3”*

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1. consolidating the retrieval code (e.g., **new SRF treatment**),
2. updating the calculation of **Type B (systematic) errors**,
3. implementing an **automatic retrieval and inter-comparison/validation chain** into WEkEO.

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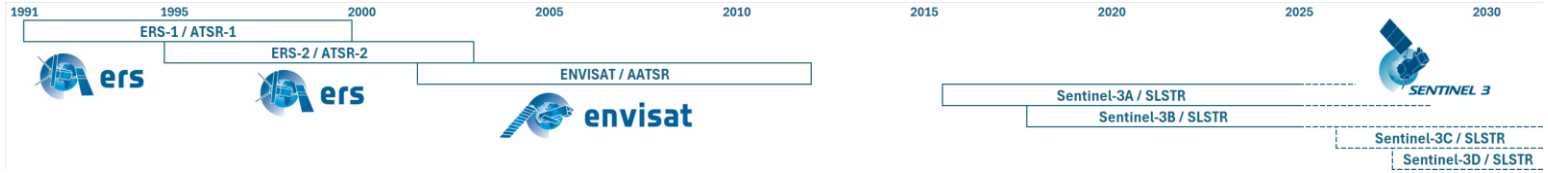
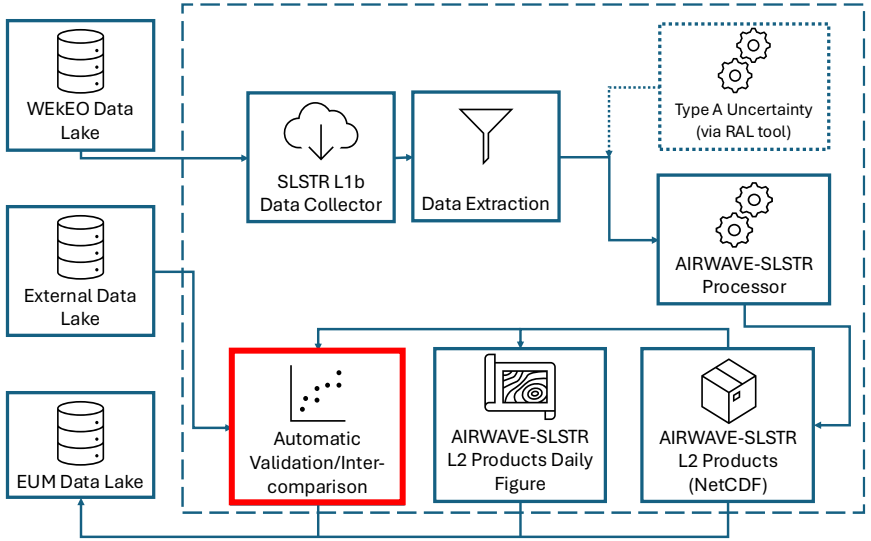




** IDEAS-QA4EO - CNR-ISAC/Serco WP “Total Column Water Vapour Essential Climate Variable from (A)ATSR(-1/2) reprocessed L1 data series using AIRWAVE-V3”*

Inter-comparison against SSMI/S TCWV products

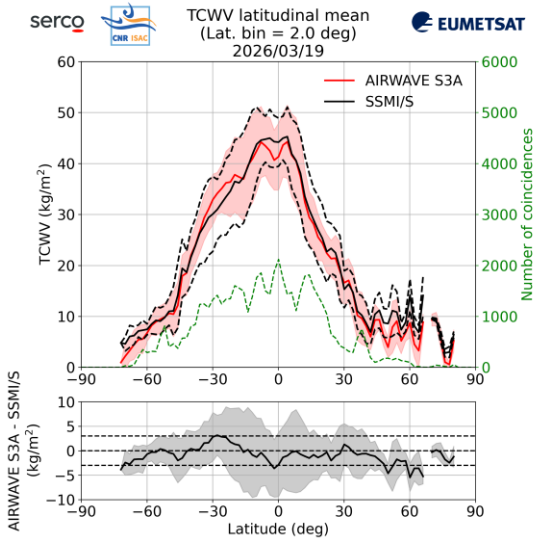
Inter-comparison approach

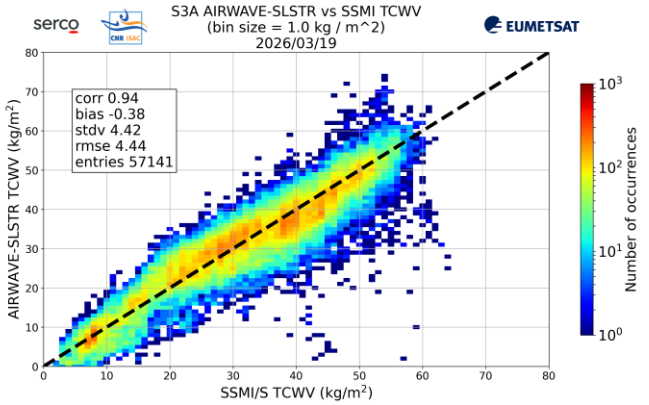
- AIRWAVE-SLSTR TCWV products were re-gridded on the RSS SSMI/S daily products grid (0.25° x 0.25°).
- SSMI/S F17 satellite products are used. Better coverage of S3-A/B mission period and more stable local time of the ascending node (about 18:00).
- We adopted the **classic cloud mask** for filtering out cloudy SLSTR pixels. We evaluated the results as a function of the clear-sky percentage (CSP)

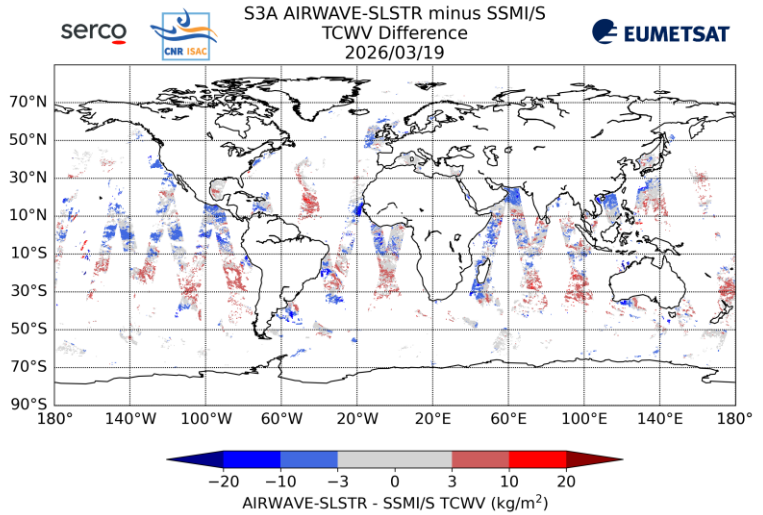
$$CSP_{\text{grid cell}} = \frac{(\text{N of clear pixels over sea})_{\text{grid cell}}}{(\text{Sum of cloudy and clear pixels over sea})_{\text{grid cell}}} * 100$$

- We filtered out SSMI/S pixels with Liquid Water Content > 0, proxy of clouds presence

S3A/19.03.2026







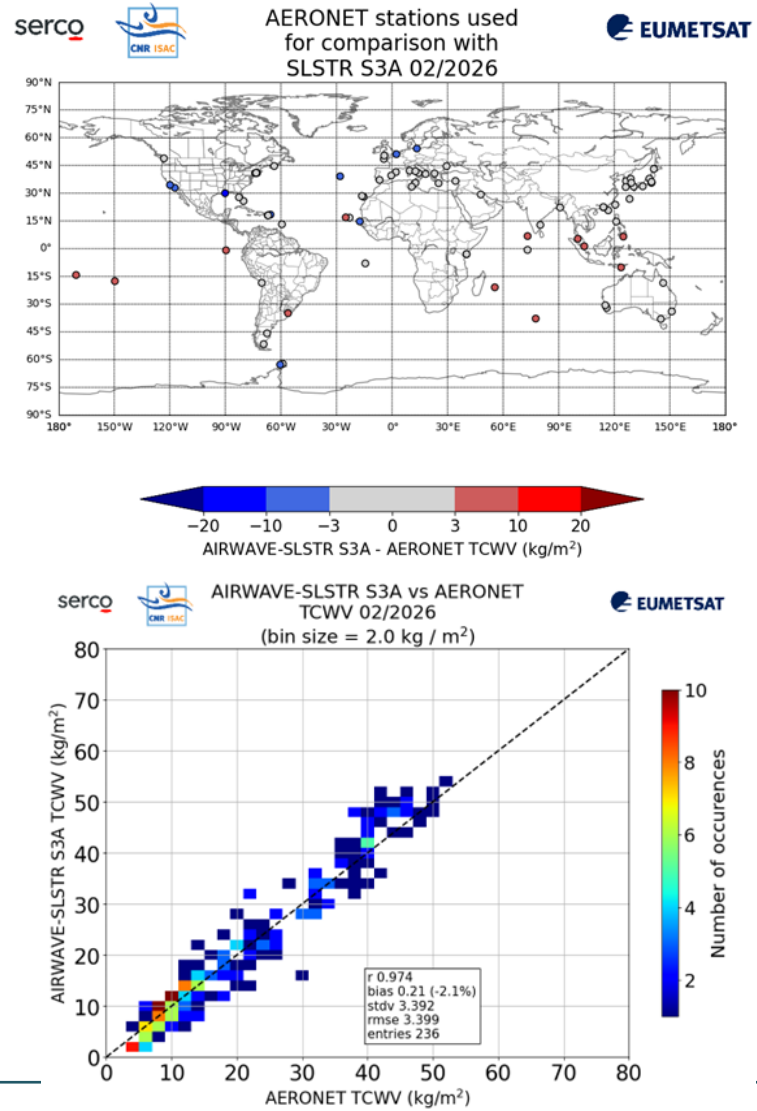
Results are automatically produced on a daily basis. Recently degraded due to major discontinuities in the delivery of RSS SSMI/S products.

Validation against AERONET TCWV products

Validation approach

- For each AERONET station, we calculated the **SEA% coverage** (percentage of sea surface area in a circle of 100 km radius around each station location) exploiting the 1x1 Km resolution "lsmask-world8-var.dist5.5.nc" land/sea mask.
- The AIRWAVE-SLSTR dataset at the **native SLSTR spatial resolution** (1 km) were used.
- We adopted the **classic cloud mask** for filtering out cloudy pixels.
- Co-location criteria: maximum distance (between AERONET station and SLSTR measurement) allowed is **100 km** and maximum time difference is **±30 minutes.**
- The results are evaluated as a function of the clear-sky percentage and SEA%.

SLSTR-A/FEB 2026



Results are automatically produced on a monthly basis

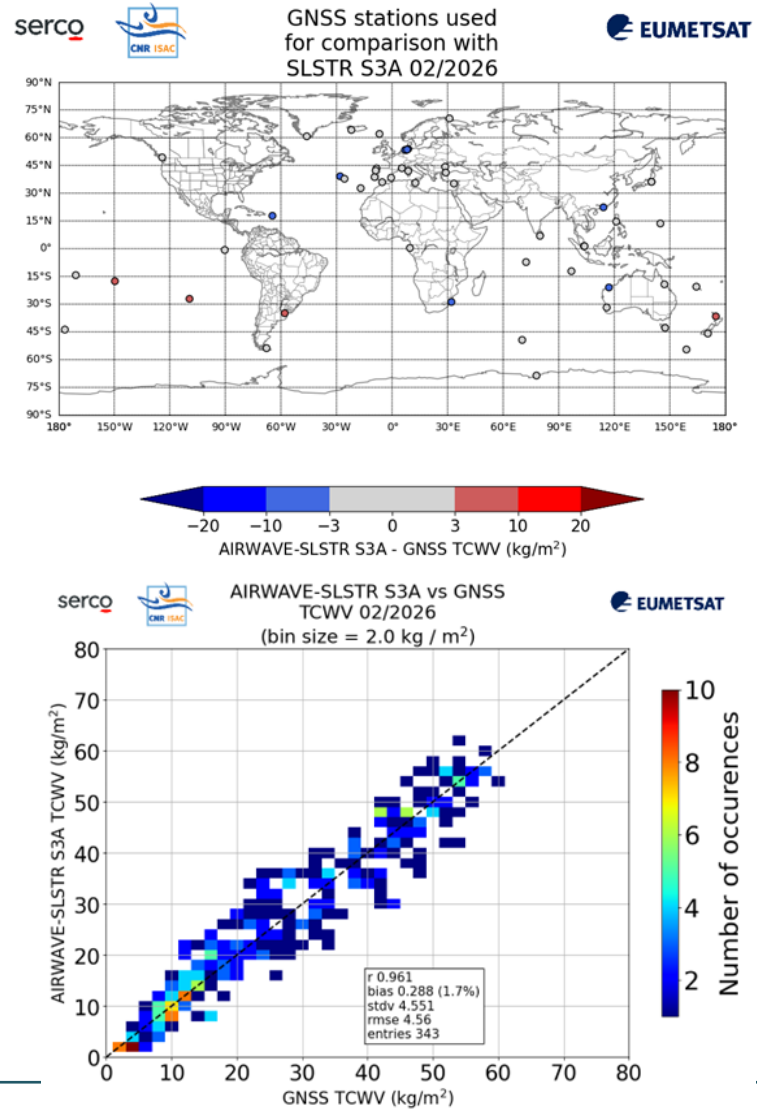
Validation against GNSS TCWV products

Validation approach

- For each GFZ GNSS station, we calculated the **SEA% coverage** (percentage of sea surface area in a circle of 100 km radius around each station location) exploiting the 1x1 Km resolution "lsmask-world8-var.dist5.5.nc" land/sea mask.
- The GNSS TCWV values (*iwv_ztd_met*) are available every 15 minutes
- The AIRWAVE-SLSTR dataset at the **native SLSTR spatial resolution** (1 km) were used.
- We adopted the **classic cloud mask** for filtering out cloudy pixels. We evaluated the results as a function of the clear-sky percentage
- Co-location criteria: maximum distance (between GNSS station and SLSTR measurement) allowed is **100 km** and maximum time difference is **±30 minutes.**

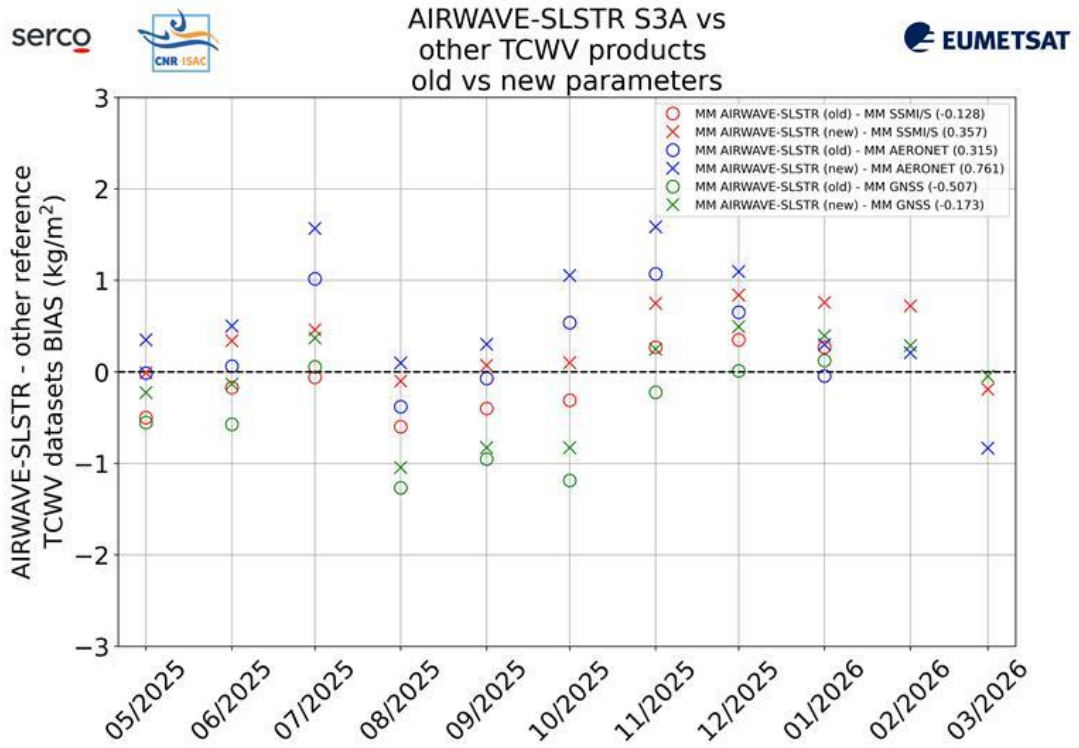
Results are automatically produced on a monthly basis

SLSTR-A/FEB 2026

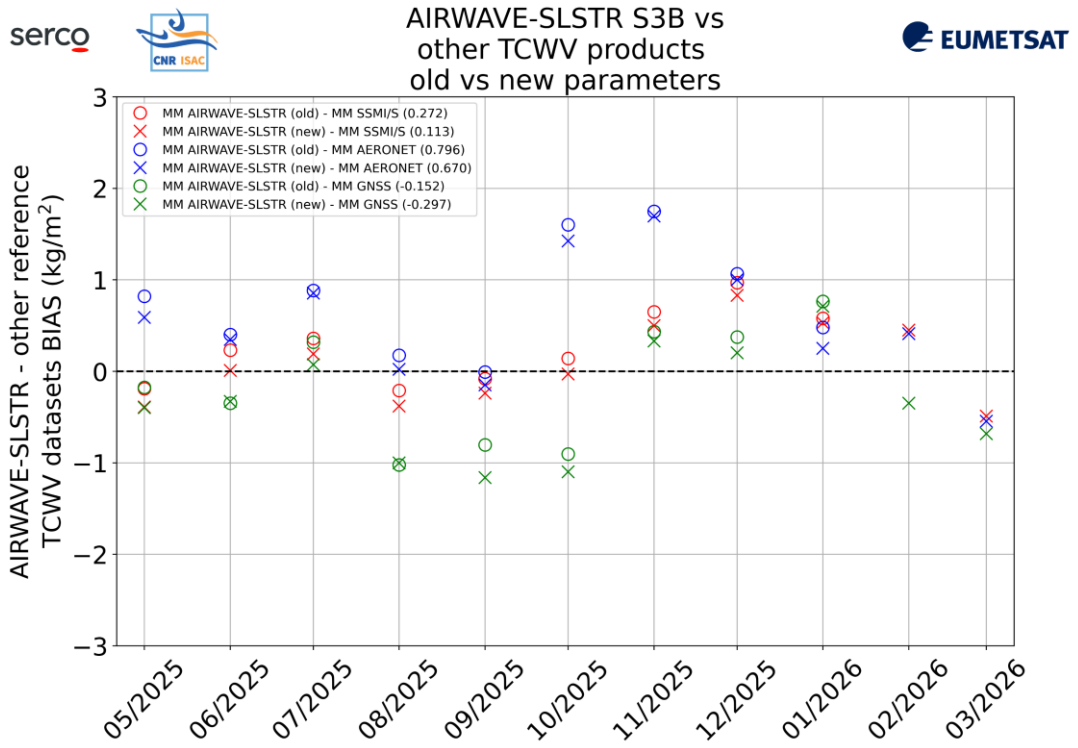


Automatic inter-comparison/validation

S3A



S3B

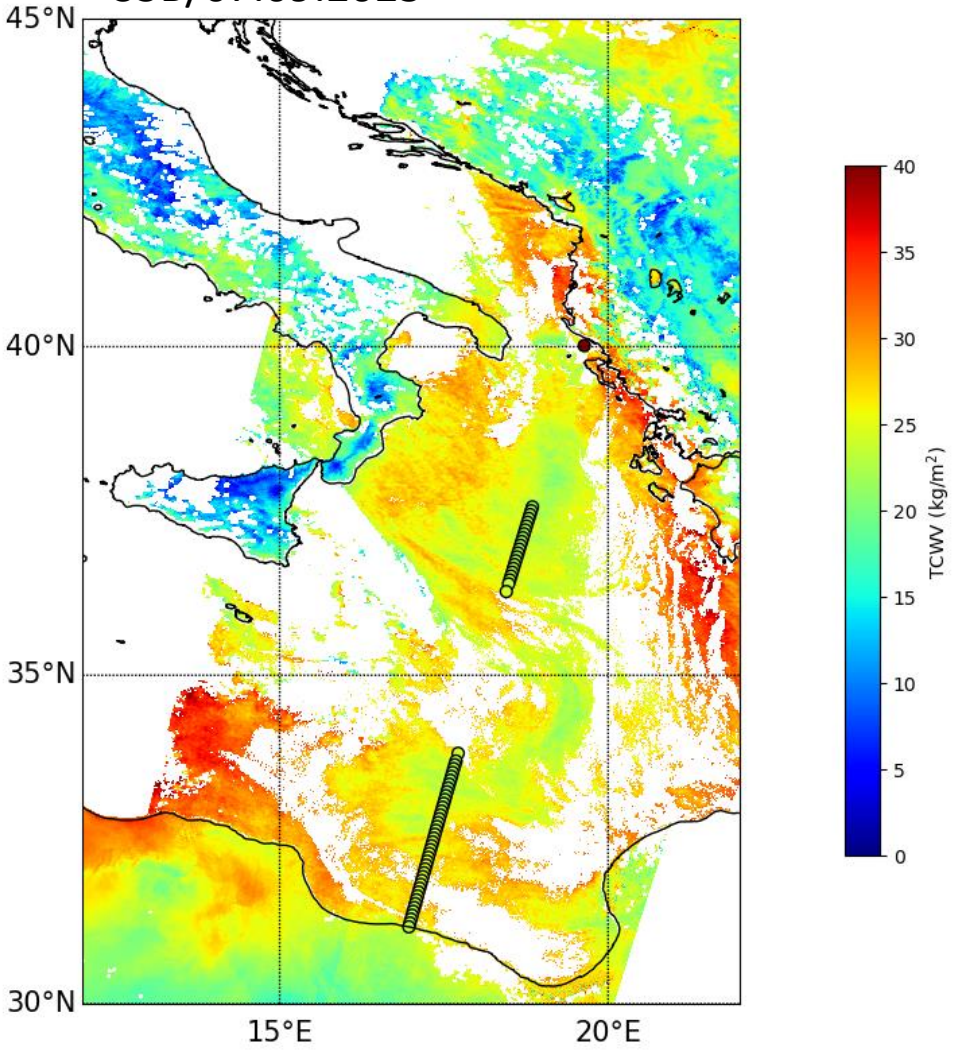


Monthly mean differences between AIRWAVE and the different reference datasets. The results of the inter-comparison/validation exercise are automatically performed on monthly basis (daily basis for SSMI/S and aggregated later)

Sentinel 3 TCWV products

TCWV from Sentinel 3: **AIRWAVE-SLSTR** and **MWR** over water surfaces and **COWa-OLCI** over land

S3B/07.09.2025



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S3B/07.09.2025

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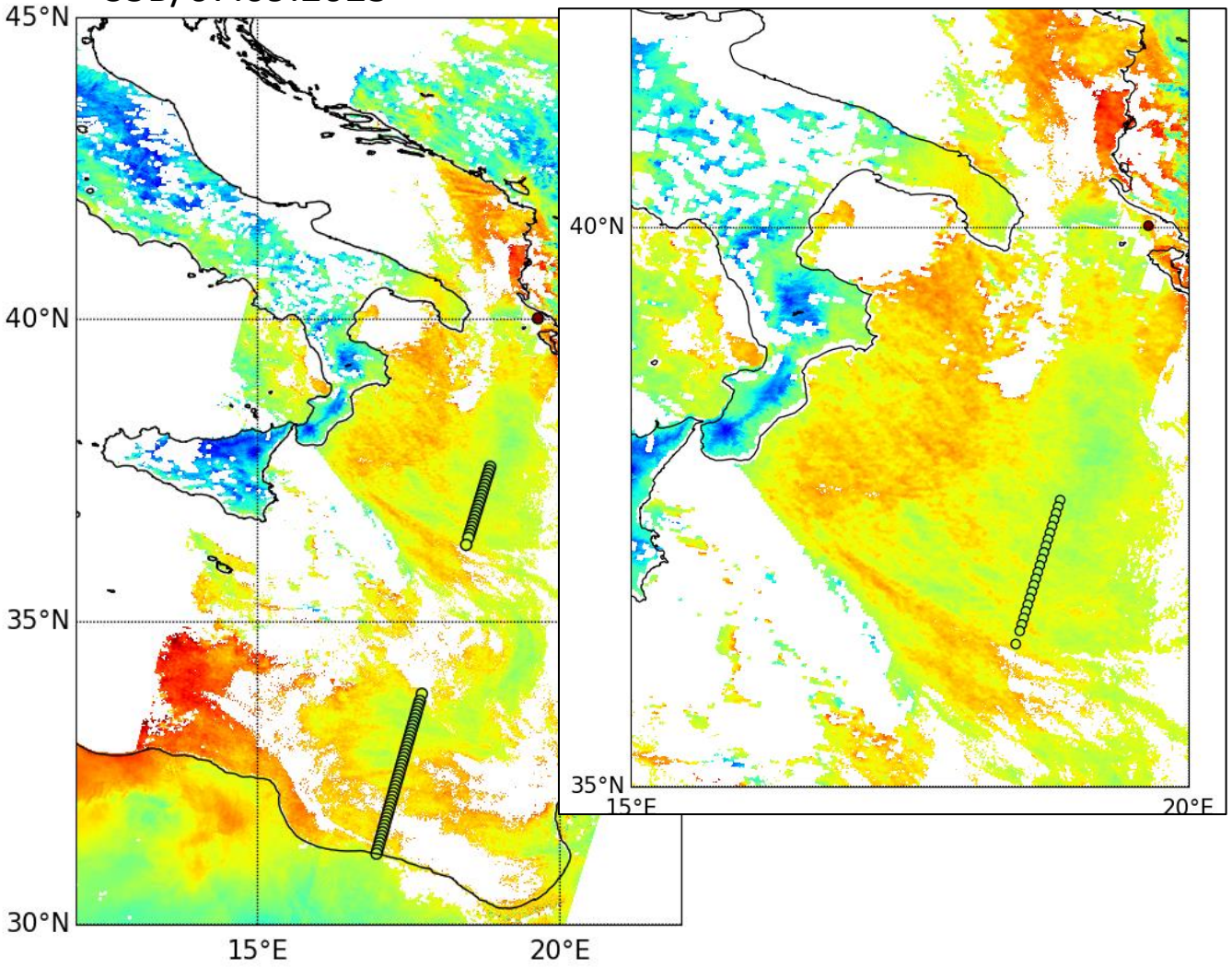

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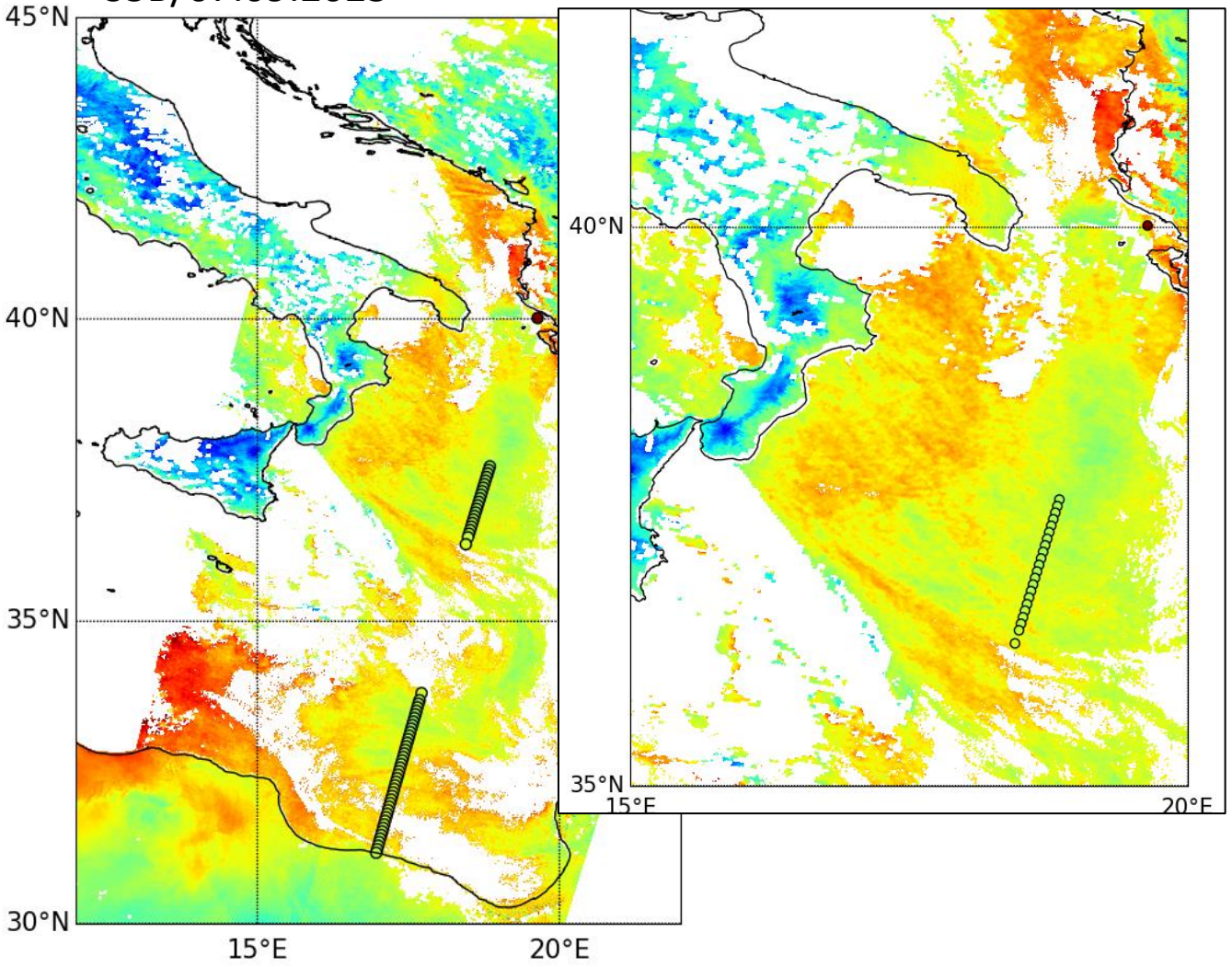

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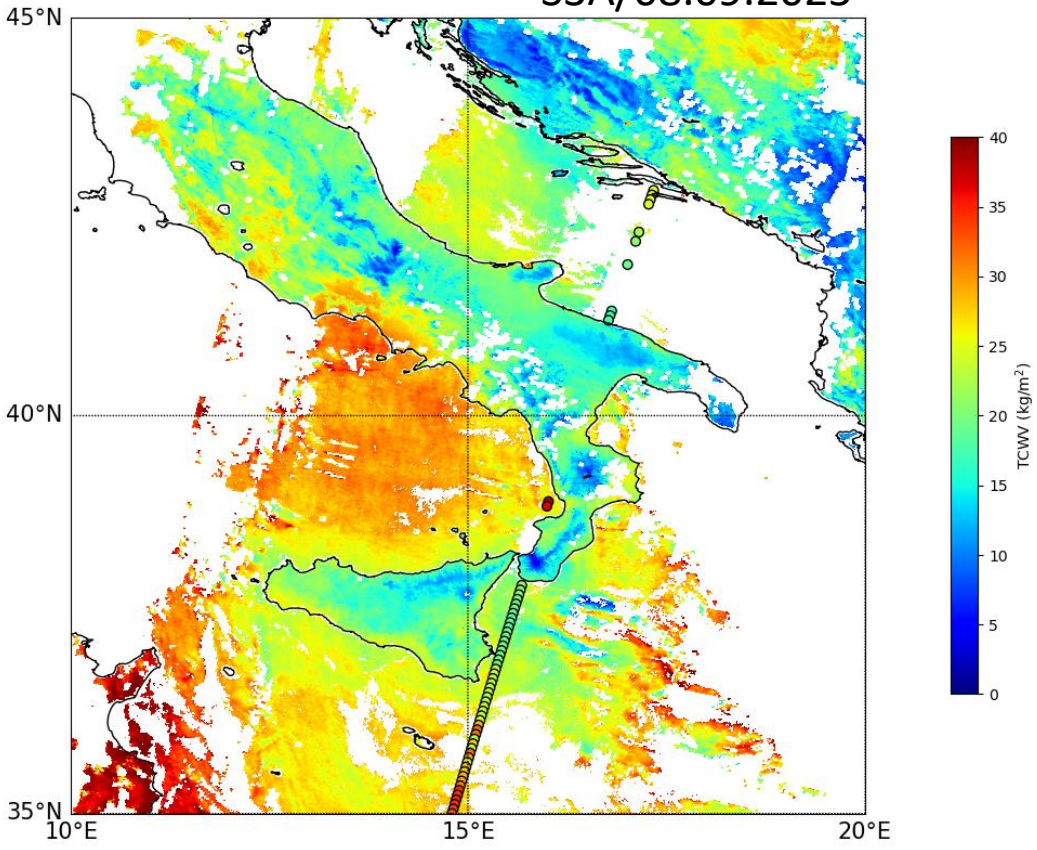

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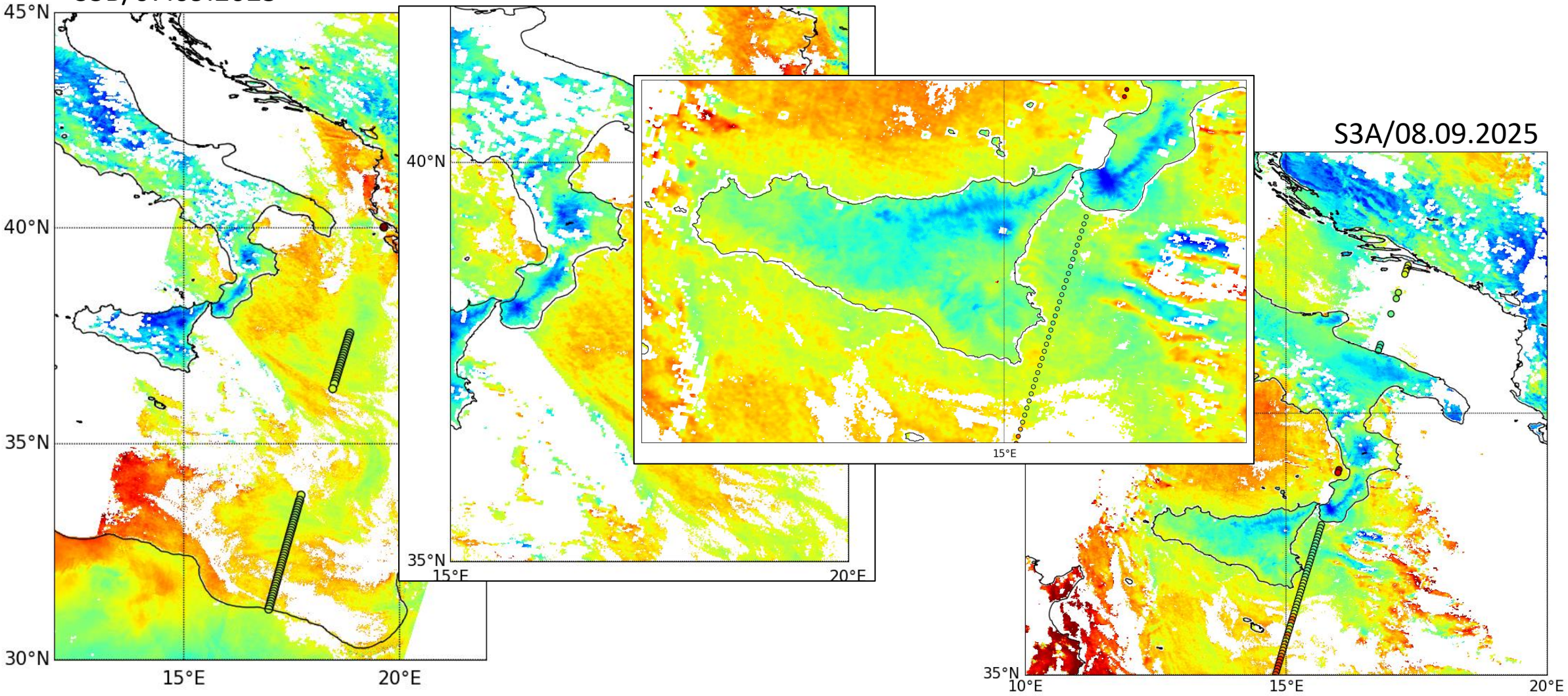
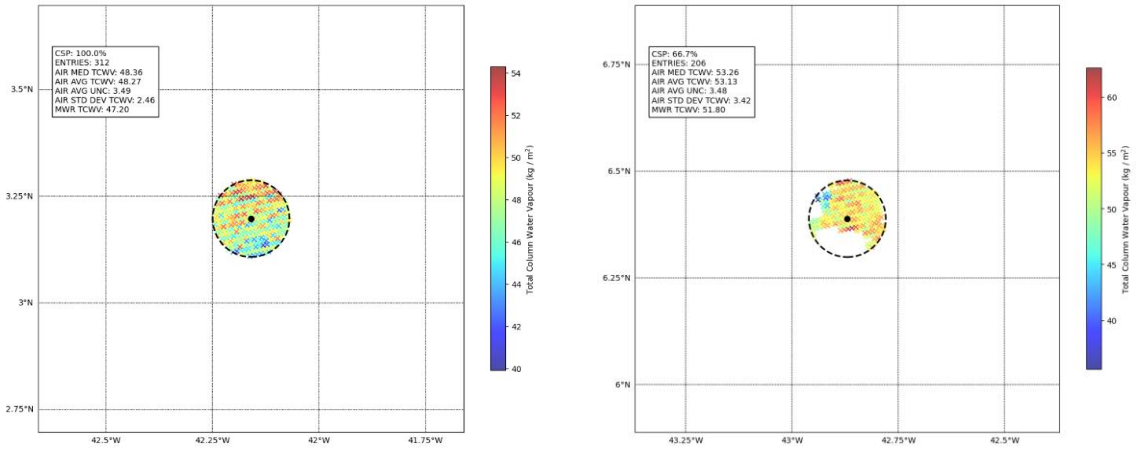
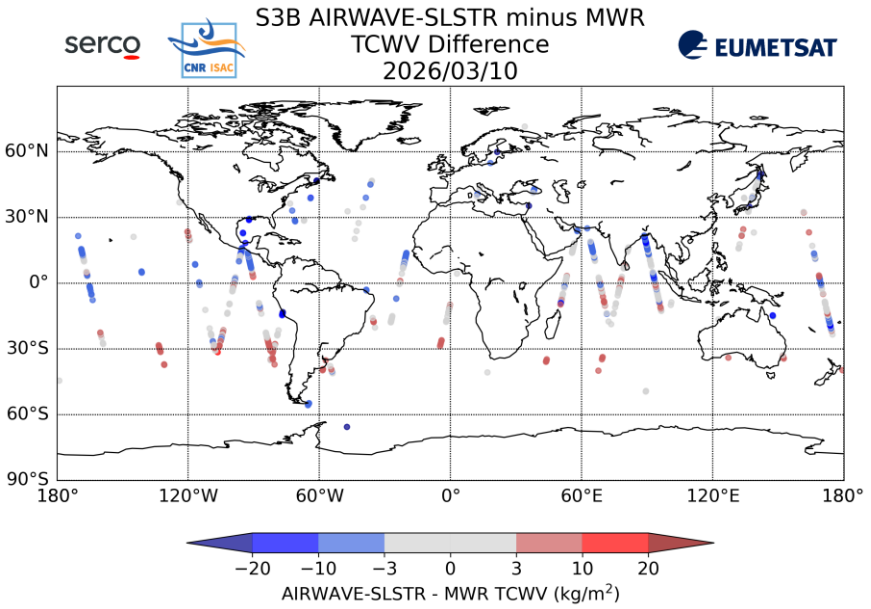


AIRWAVE-SLSTR/MWR inter-comparison

Inter-comparison approach

- We extracted from SRAL L2 products the TCWV values measured using MWR observations.
- We applied a filter on MWR LWC: we excluded matchups with MWR LWC>0, as an indicator of cloud presence, are filtered out.
- The AIRWAVE-SLSTR dataset at the **native SLSTR spatial resolution** (1 km) were used.
- We adopted the **classic cloud mask** for filtering out cloudy pixels. We evaluated the results as a function of the clear-sky percentage
- Co-location criteria: we extract all clear sky AIRWAVE–SLSTR TCWV products within the MWR IFOV, considering a circle of 10 km radius centred on MWR observations coordinates.





Further tests are ongoing. The results will be automatically produced on daily basis soon.

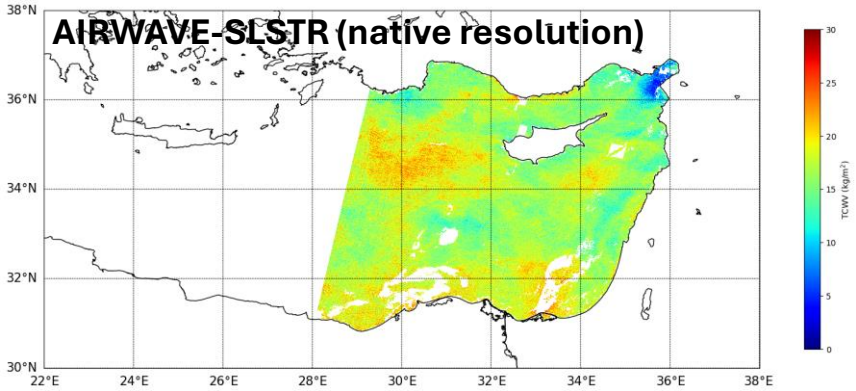
AIRWAVE-SLSTR/COWa-OLCI inter-comparison

Preliminary results

The inter-comparison tool is under development and further tests are ongoing. The results will be automatically produced on daily basis.

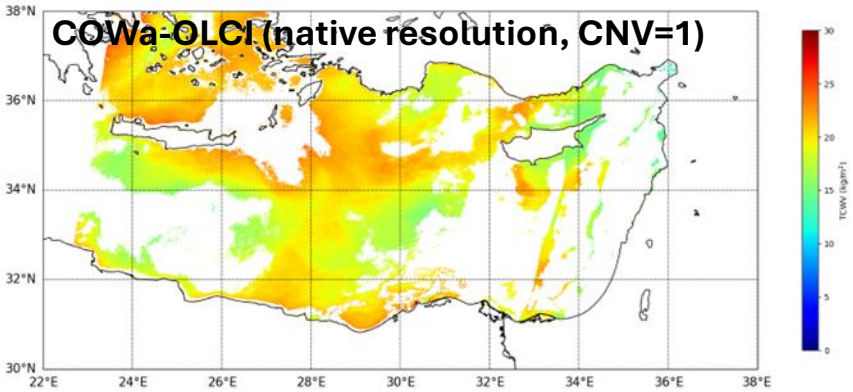
AIRWAVE-SLSTR

- Spatial Resolution: 1 km
- Swath: 740 km (oblique view)
- Flags used:
  - CLOUD = 0 (SLSTR L1b CM)
  - LAND = 0
  - DAY = 1



COWa-OLCI

- Spatial Resolution: 1.2 km
- Swath: 1270 km
- Flags used:
  - IDEPIX_CLOUD = 0
  - IDEPIX_INVALID = 0
  - IDEPIX_LAND = 0
  - DAY = 1 (by default)



AIRWAVE-SLSTR/COWa-OLCI inter-comparison

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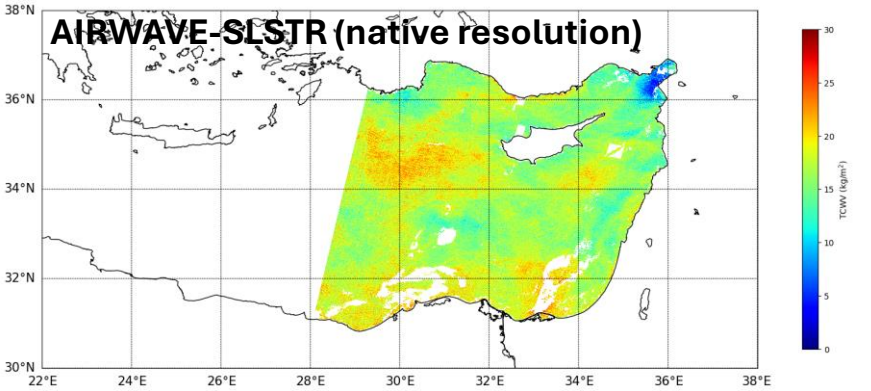

COWa-OLCI

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- Swath: 1270 km
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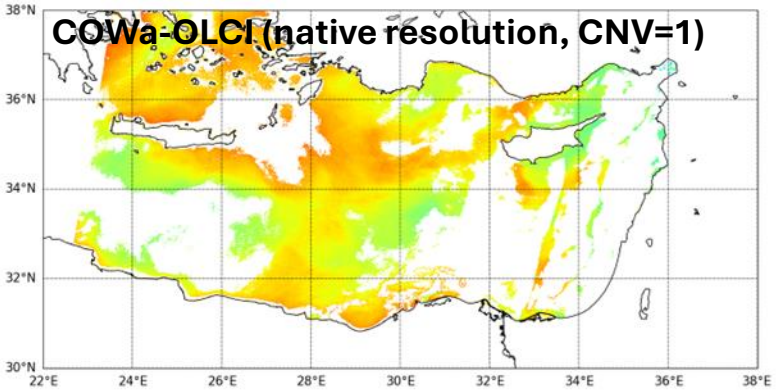
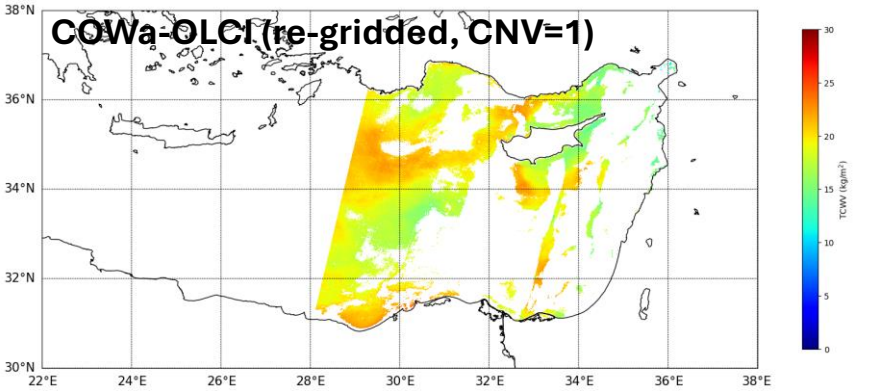
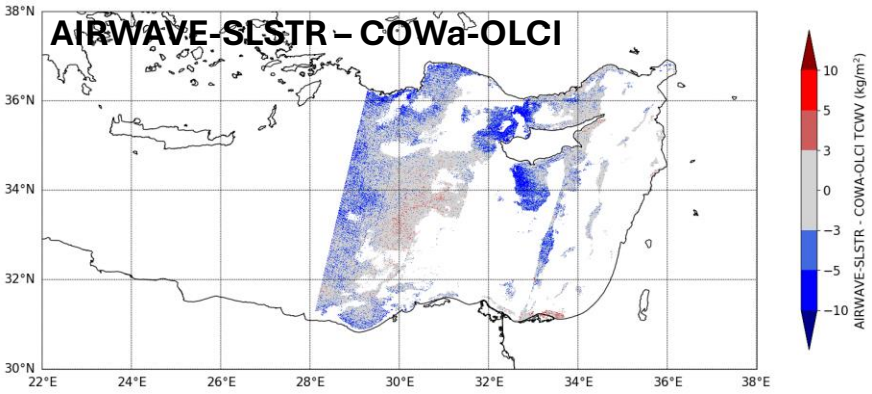
  - IDEPIX_INVALID = 0
  - IDEPIX_LAND = 0
  - DAY = 1 (by default)







- COWa-OLCI products re-gridded on AIRWAVE-SLSTR grid exploiting Python Scipy library numerical tools (griddata, nearest method).
- Pixels where at least one of the cloud mask indicates cloud presence were filtered out
- Only COWa-OLCI pixels where the algorithm reached the convergence (CNV=1) have been considered.

AIRWAVE-SLSTR/COWa-OLCI inter-comparison

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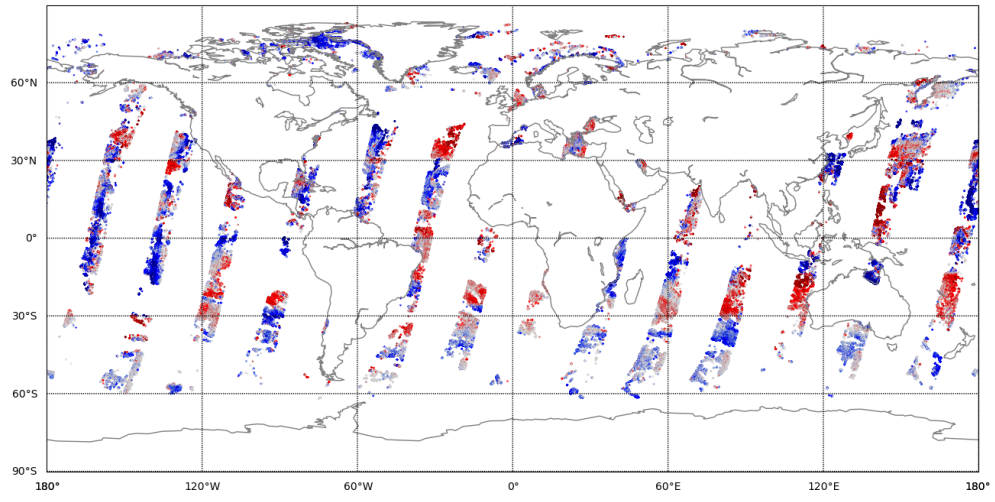
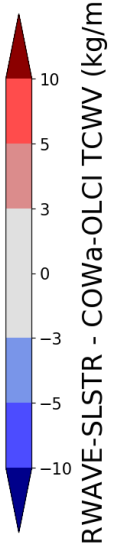
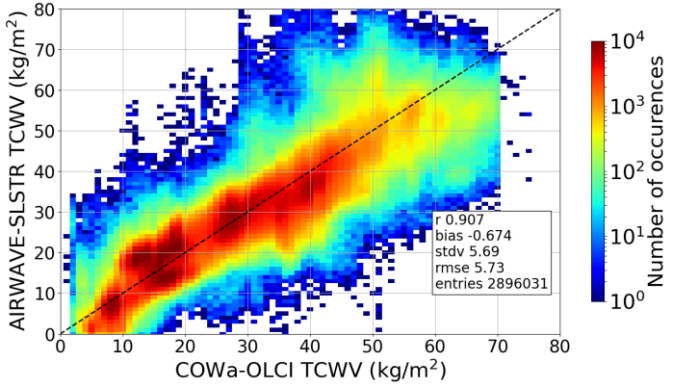
Preliminary results

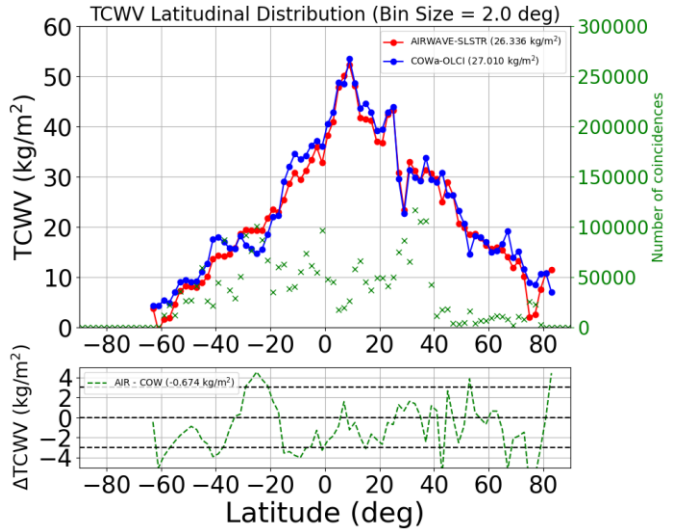
The inter-comparison tool is under development and further tests are ongoing. The results will be automatically produced on daily basis.

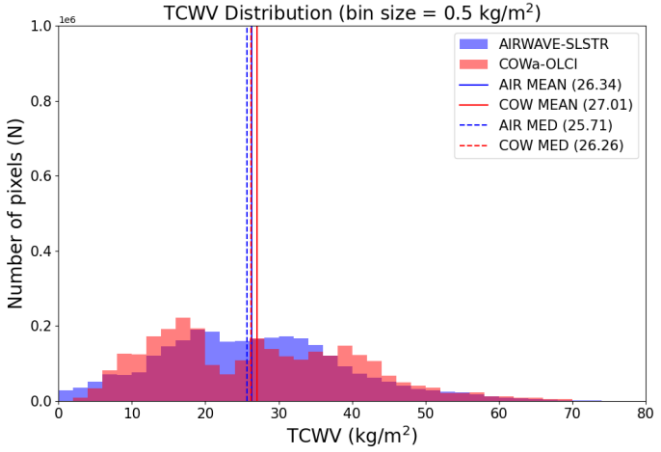
S3B/08.09.2025

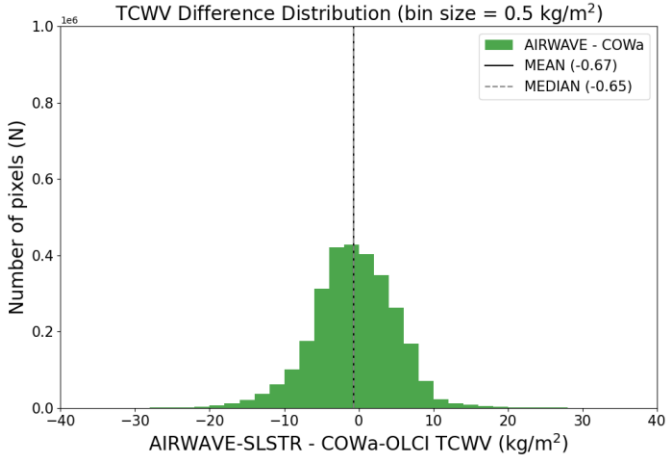












Conclusions and outlook

- Even if not shown today, the algorithm has been improved through the implementation of an **updated, more accurate SRF treatment** and the **computation of new Type B errors**. The AIRWAVE-SLSTR algorithm is now aligned with the latest version (version 3) used for AIRWAVE-(A)ATSR-1/2 reprocessing.
- We **designed and implemented an automatic processing chain** for AIRWAVE-SLSTR TCWV products on WEkEO.
- Together with the processing chain, we also implemented **automatic tools for daily inter-comparison** against RSS SSMI/S daily TCWV products and **monthly validation** against GFZ GNSS and AERONET TCWV data.

- For the future, we planned:
  - **Continuous monitoring** of the already implemented procedures and tools, and of the performance of the AIRWAVE algorithm
  - **Implementation of new automatic tools** for daily inter-comparison against MWR and COWa-OLCI TCWV products
  - **Automatic delivery** of products and inter-comparison/validation results to EUM
  - **Exploitation of Sentinel 3C tandem phase** for further analysis and later extension of automatic processing and inter-comparison/validation chains

Sentinel 3C tandem phase

- In the first AIRWAVE-SLSTR study (2019/2020), we exploited the S3A/S3B tandem phase (July 2018) to evaluate the agreement between the AIRWAVE-SLSTR TCWV products retrieved using the SLSTR-A and –B measurements.
- We observed a bias (SLSTR-A > SLSTR-B) between the two Sentinels of about 0.5 kg/m^2, with higher discrepancies at the tropics and the high latitudes of the SH. No clear dependency on cloud masking, clear sky percentage, or sea coverage.
- Checking the BTs of the two SLSTR, we observed differences that translate into the observed differences in TCWV biases (checked using simulations).
- The bias became quasi-negligible in August and September 2018, and the observed BTs differences have a different behaviour in those months with respect to July, as something has changed in calibration from July to August.

- Since AIRWAVE has been improved in recent years, the idea is to review these results, exploiting the last version of the algorithm (e.g., to assess the impact of the implementation of the more accurate SRF treatment) and exploiting the Sentinel 3C tandem phase for further analysis similar to those previously performed.