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Results of the validation of the AIRWAVE-SLSTR TCWV product and follow-on study

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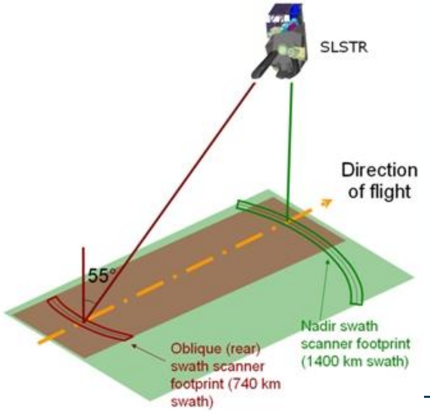
AIRWAVE – SLSTR: The Algorithm

The main objective of the AIRWAVE-SLSTR project was to extend the Advanced Infra-Red WAter Vapour Estimator (AIRWAVE) algorithm (Casadio et al., 2016; Castelli et al., 2019) to the SLSTR instrument to create a prototype for a future operational Copernicus Sentinel 3 SLSTR Level-2 Total Column Water Vapour (TCWV) product.

AIRWAVE has the unique capability to retrieve the TCWV over all the water surfaces of the Earth for cloud-free scenarios using the SLSTR TIR channels (at 10.8 and 12.0 µm) only and, therefore, in both day- and night-time.



SLSTR main characteristics

- Swath width: dual view scan, 1 400 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

AIRWAVE – SLSTR: Validation Approach

The validation was performed using 4 months of AIRWAVE – SLSTR TCWV S3-A data (January, April, July, and October 2018) and 1 month of S3-B data (July 2018) with respect to:

- the SSMI/S daily TCWV product (https://www.remss.com/), and
- the TCWV product retrieved from the Coastal Integrated Global Radiosonde Archive (IGRA) stations atmospheric soundings

A preliminary validation with respect to the EMiR-MWR TCWV product was performed using a reduced dataset (2 days per month for the months of December 2016, and January, February, March, and April 2017).

AIRWAVE – SLSTR vs SSMI/S (1/2)

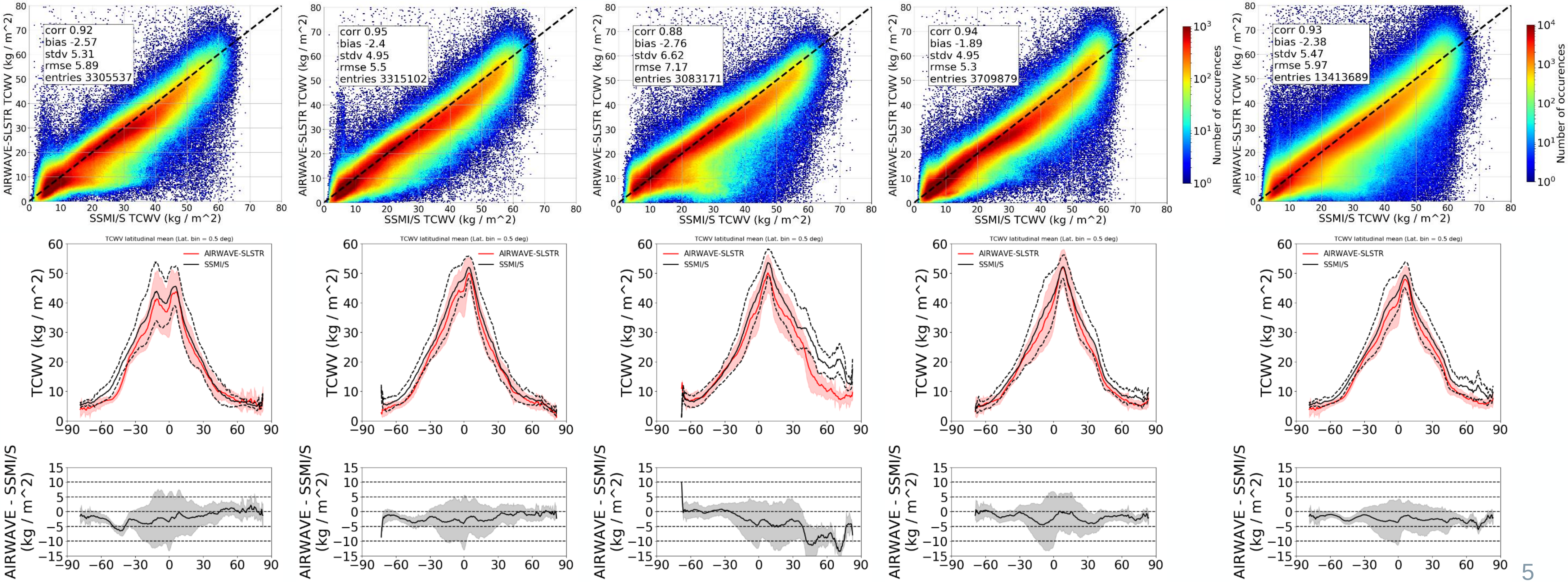
AIRWAVE-SLSTR TCWV products (originally retrieved at SLSTR L1 grid space resolution) were re-gridded on 0.25° x 0.25° grid (SSMI/S spatial resolution), we calculated the AIRWAVE daily means field (day and night separately) and then, we computed the daily mean differences with respect to SSMI/S TCWV data.

We used the SSMI/S F17 satellite products because they properly cover the entire S3 SLSTR mission period. Furthermore, the local time of the ascending node of the F17 satellite (about 18:00) is more stable in comparison to other available SSMI/S satellites.

We used the Bayesian cloud mask to filter out the SLSTR observations flagged as cloudy.

AIRWAVE – SLSTR vs SSMI/S (2/2)

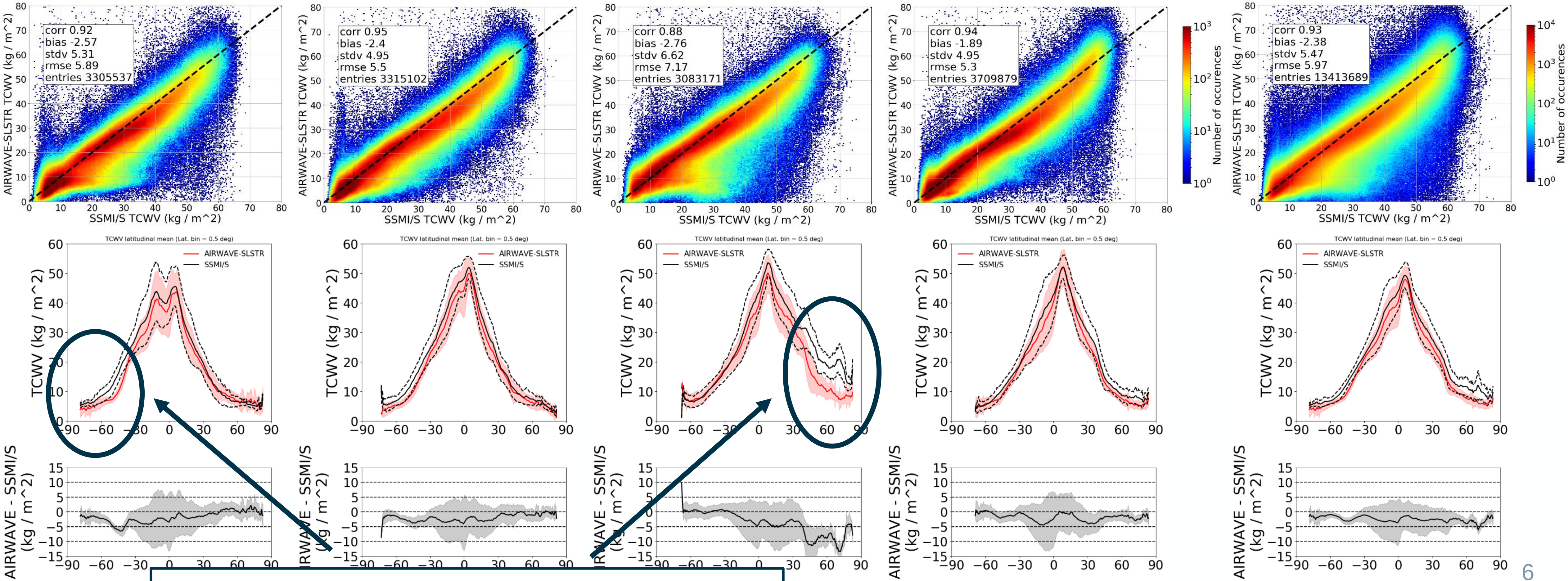
JANUARY | APRIL | JULY | OCTOBER | 4 MONTHS



AIRWAVE – SLSTR vs SSMI/S (2/2)

Generally good agreement

JANUARY | APRIL | JULY | OCTOBER | 4 MONTHS

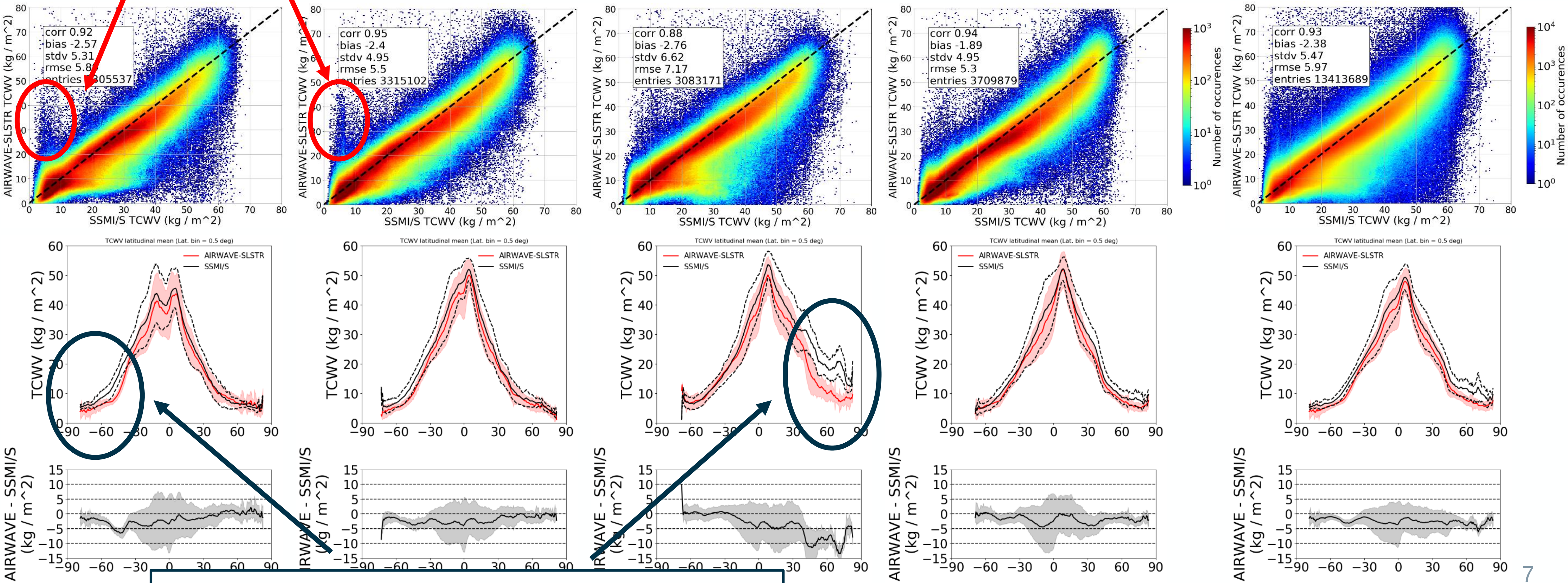


Worst agreement in the summer hemisphere

Structures due to the less than perfect cloud filtering

AIRWAVE – SLSTR vs SSMI/S (2/2)

Generally good agreement



Worst agreement in the summer hemisphere

AIRWAVE – SLSTR vs coastal IGRA stations (1/2)

- The same AIRWAVE - SLSTR dataset but at the native SLSTR spatial resolution (1 km) were used.
- Maximum distance (between IGRA station and SLSTR measurement) allowed is 100 km.
- We adopted a filter on IGRA station coverage (SEA%, percentage of sea surface area in a circle of 150 km radius around each station location). The mask is calculated using the 1 x 1 Km resolution “lsmask-world8-var.dist5.5.nc” dataset (ftp.cgd.ucar.edu).
  Only stations with SEA% > 5% are considered (509 coastal stations, see Figure).

AIRWAVE – SLSTR vs coastal IGRA stations (2/2)

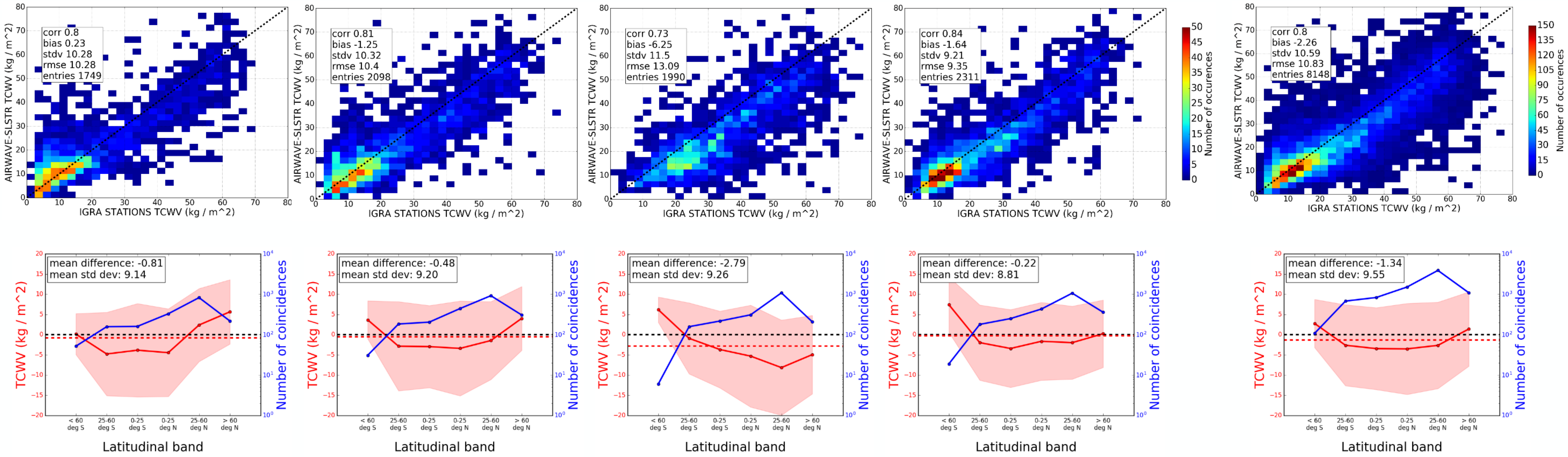
JANUARY

APRIL

JULY

OCTOBER

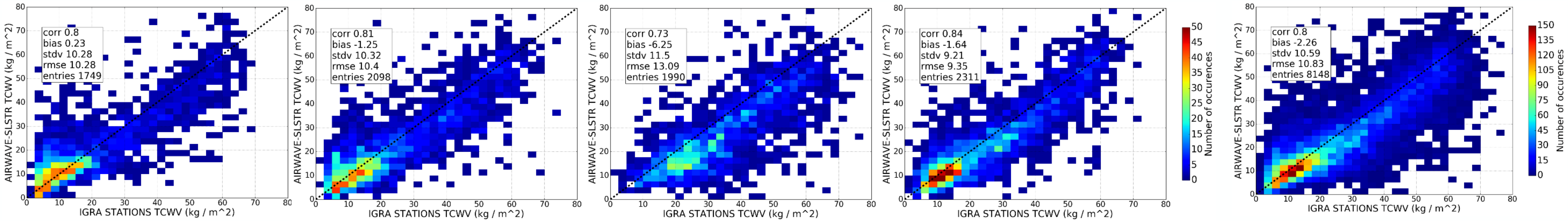
4 MONTHS

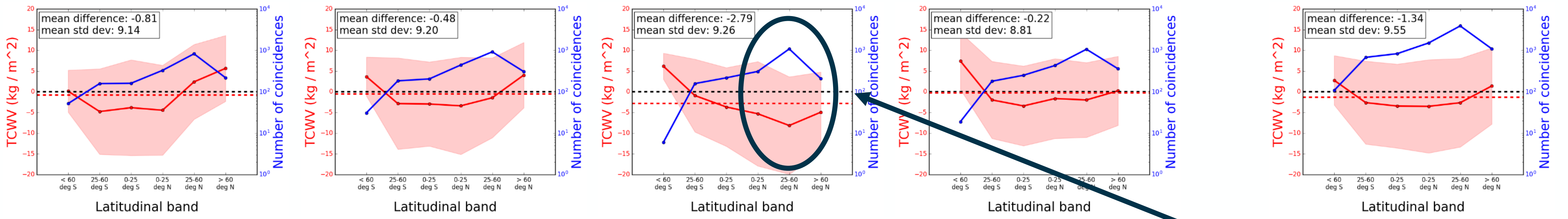


AIRWAVE – SLSTR vs coastal IGRA stations (2/2)

Generally good agreement. Dry bias slightly lower than with SSMI/S

JANUARY | APRIL | JULY | OCTOBER | 4 MONTHS





Worst agreement in July at the mid-latitudes of the NH

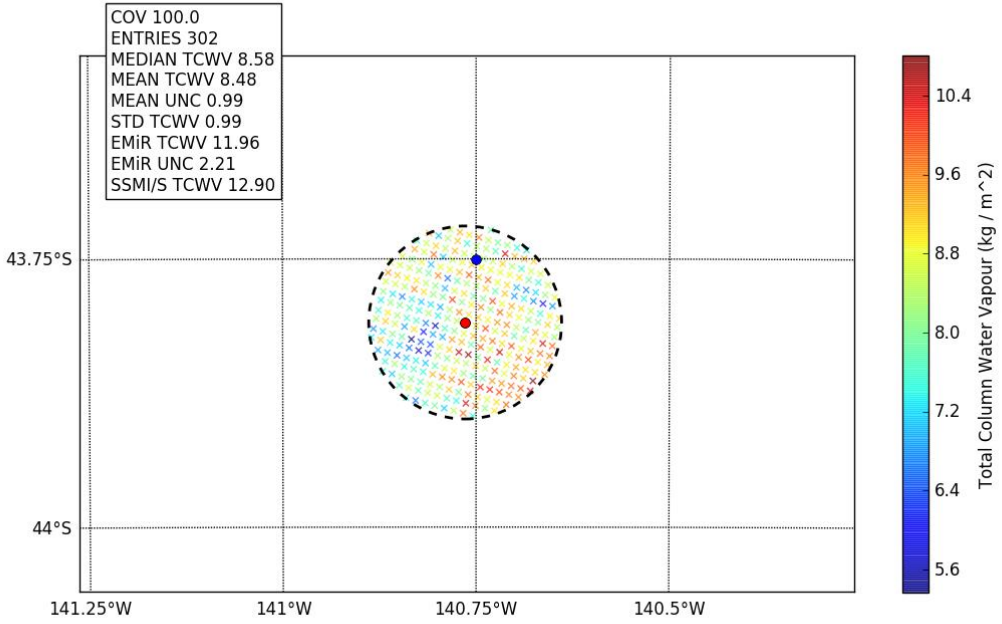
AIRWAVE – SLSTR vs EMiR – MWR (1/3)

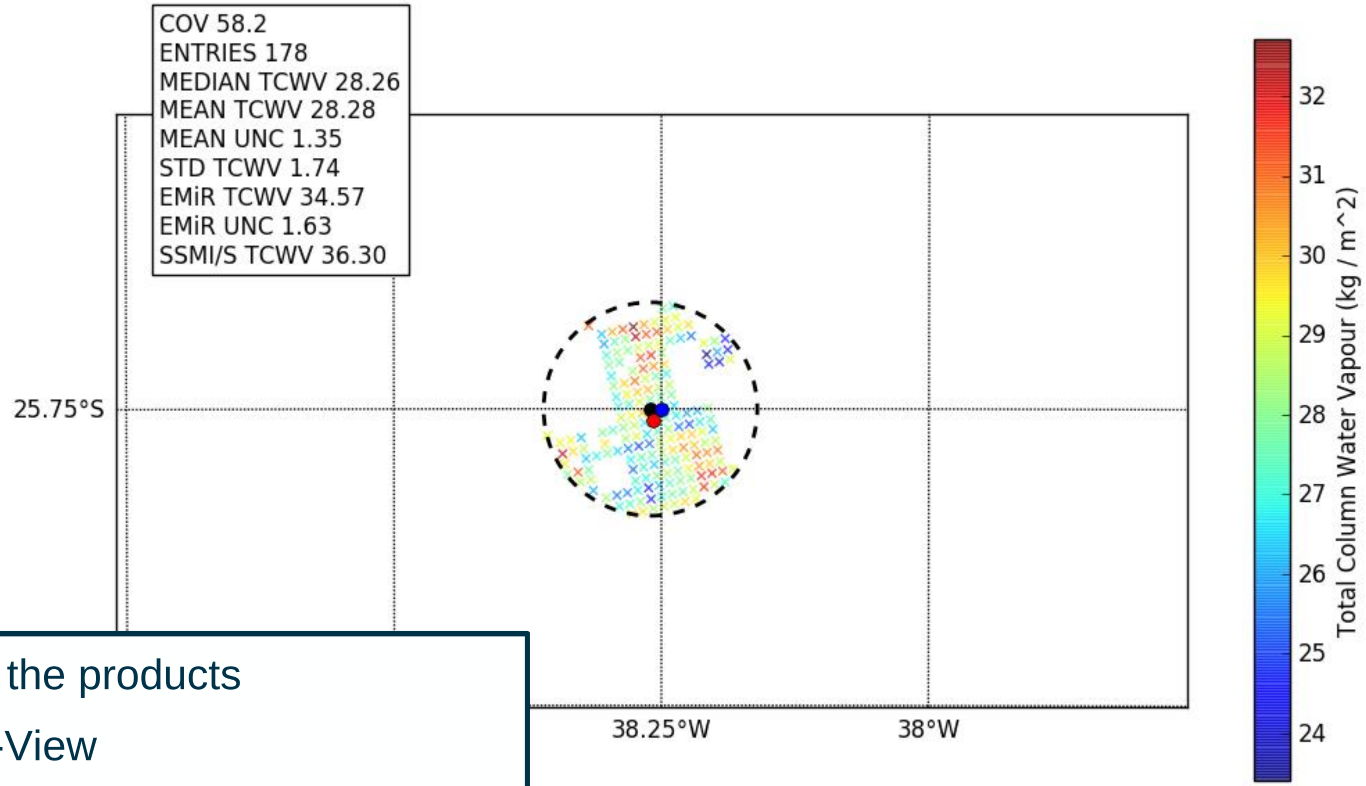
The SLSTR L1b data were processed using the AIRWAVE version 2 algorithm configuration. For the period analysed in this part of the exercise, in the SLSTR L1b, the classic cloud mask is only available.

To increase the inter-comparison significance, we used only not-overlapping EMiR-MWR data selecting half of the available products.

To define a “reference”, we introduced SSMI/S (F17 satellite data) in the inter-comparison exercise. We extract the SSMI/S product corresponding to the grid point within the MWR IFOV (if it exists).

AIRWAVE – SLSTR vs EMiR – MWR (2/3)

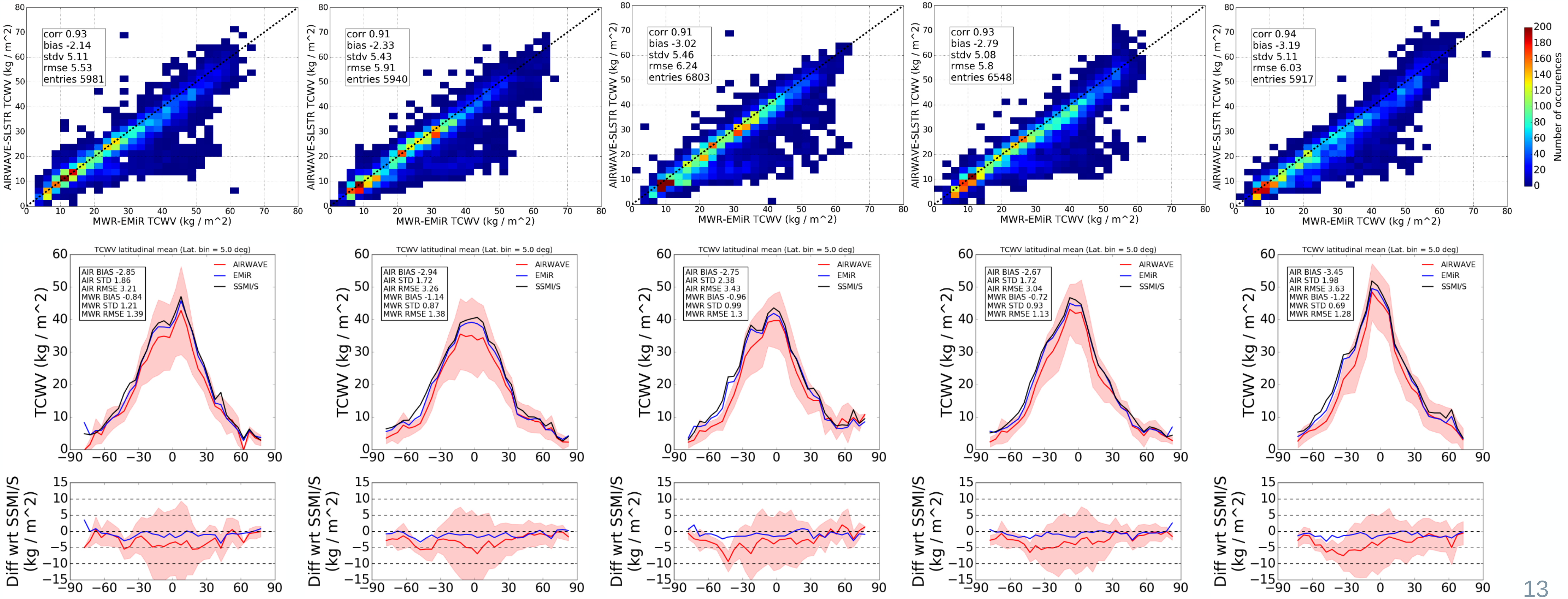




- **Red dot**: Barycentre of the geographical distribution of the products
- **Black dot**: Centre of the MWR Instantaneous Field-Of-View
- **Blue dot**: Grid point (0.25 deg x 0.25 deg) of the SSMI/S product
- **Dashed line**: Approximation of the MWR Instantaneous Field-Of-View
- $$\mathbf{COV_{IFOV}} = \frac{(\text{N of clear−sky AIRWAVE products over sea})_{IFOV}}{(\text{Sum of cloudy and clear−sky AIRWAVE products over sea})_{IFOV}} 100 *$$

AIRWAVE – SLSTR vs EMiR – MWR (3/3)

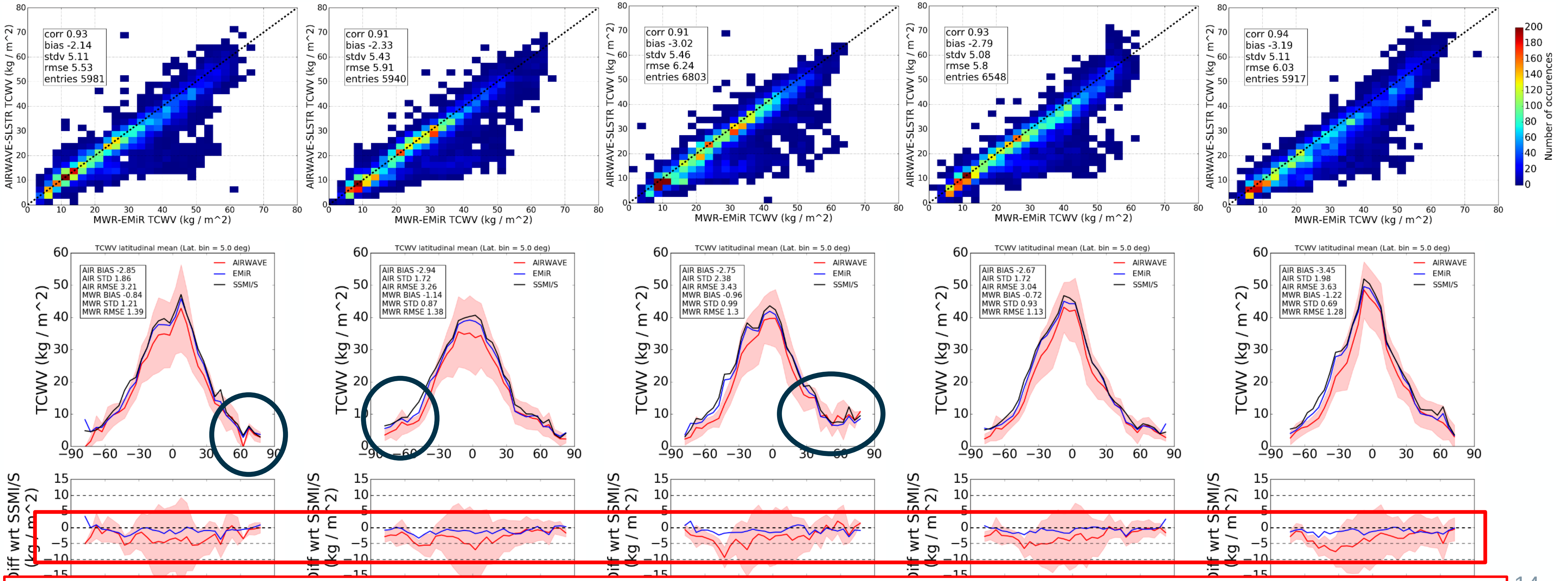
DEC 2016 | JAN 2017 | FEB 2017 | MAR 2017 | APR 2017



AIRWAVE – SLSTR vs EMiR – MWR (3/3)

AIRWAVE TCWV products correctly reproduce the major part of the features of the EMiR – MWR and SSMI/S distributions

DEC 2016 | JAN 2017 | FEB 2017 | MAR 2017 | APR 2017



Overall good agreement. AIRWAVE products are generally lower TCWV than both EMiR-MWR and SSMI/S products

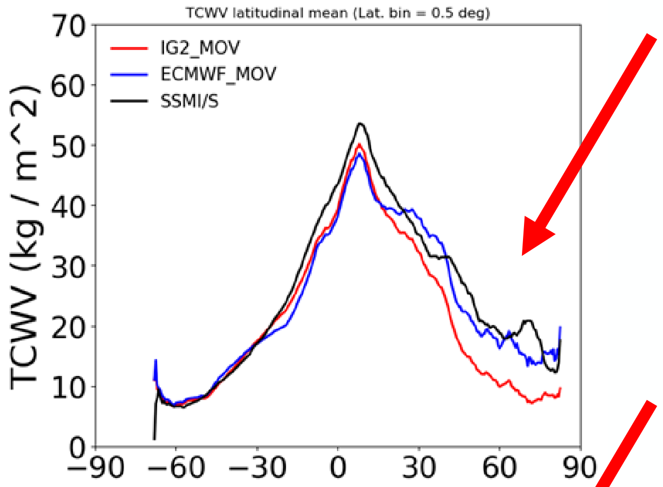
AIRWAVE – SLSTR: Outcomes

- We observed a generally good agreement between the AIRWAVE-SLSTR TCWV product and similar products retrieved from the SSMI/S (mean bias of -2.4 kg/m2), EMiR – MWR (-2.7 kg/m2) and IGRA stations (-2.3 kg/m2) observations.
- Larger dry bias wrt SSMI/S in the summer hemisphere (confirmed by several tests on other years).
- Regarding the IGRA TCWV products, we observed a dry bias slightly lower than with SSMI/S with higher values in July at the mid-latitudes of the NH.
- Even if not shown in this presentation, we observed a better agreement using the Bayesian cloud mask (wrt the classic cloud mask).
- AIRWAVE – SLSTR TCWV products correctly reproduces the major part of the features of the similar distributions obtained with MW measurements, even if AIRWAVE products generally produces lower TCWV than both EMiR-MWR and SSMI/S products (different atmospheric penetration of the MW in comparison with the TIR channels).
- More recently, we processed one year of S3-A SLSTR L1b data (May 2020 to April 2021, available upon request). The validation wrt SSMI/S products confirmed the results highlighted in the previous exercises.

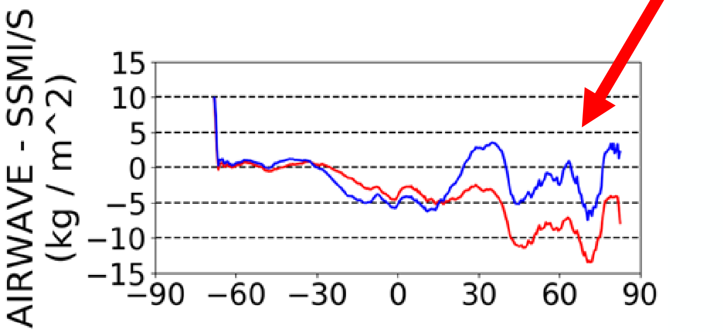
AIRWAVE – SLSTR: Outcomes

- Preliminary tests have shown a better agreement wrt both SSMI/S and IGRA TCWV products using a new set of parameters based on the ECMWF climatology (ERA-Interim).

July 2018 AIRWAVE – SLSTR TCWV latitudinal distributions retrieved using the parameters computed with the IG2 (red line) and the ECMWF (blue line) climatology. SSMI/S distribution is also reported (black line).



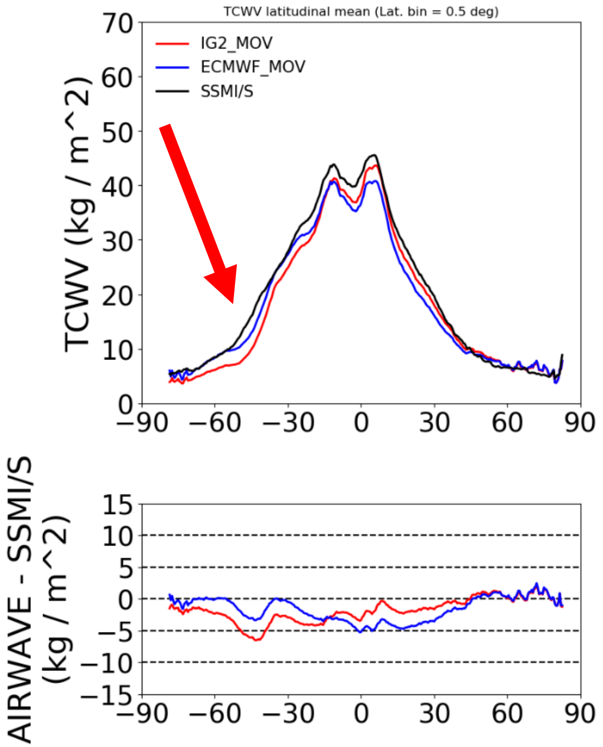
Corresponding differences with respect to the SSMI/S TCWV distribution.



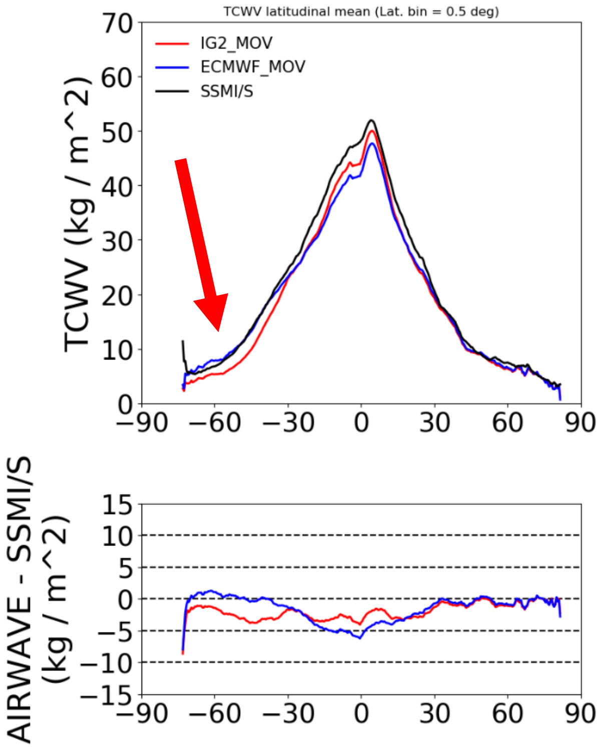
AIRWAVE – SLSTR: Outcomes

- Preliminary tests have shown a better agreement wrt both SSMI/S and IGRA TCWV products using a new set of parameters based on the ECMWF climatology (ERA-Interim).

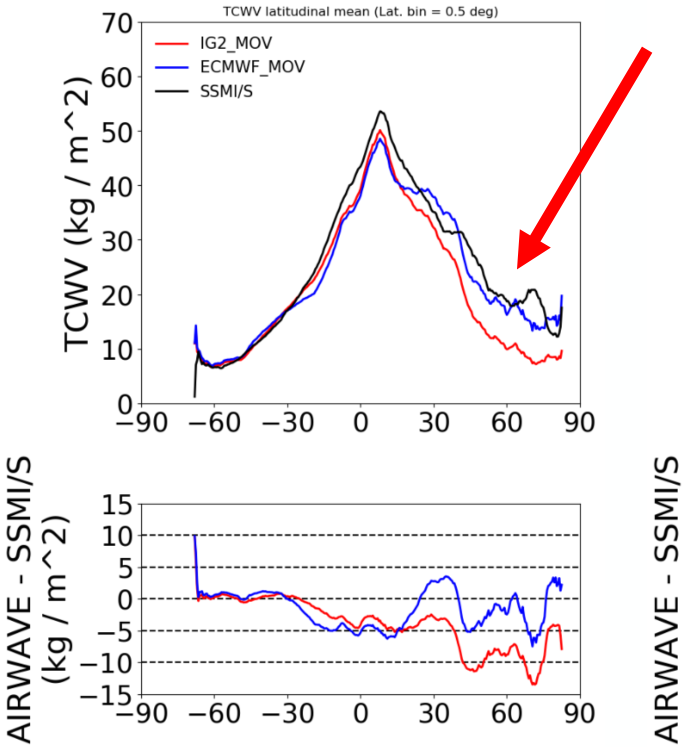
JAN 2018



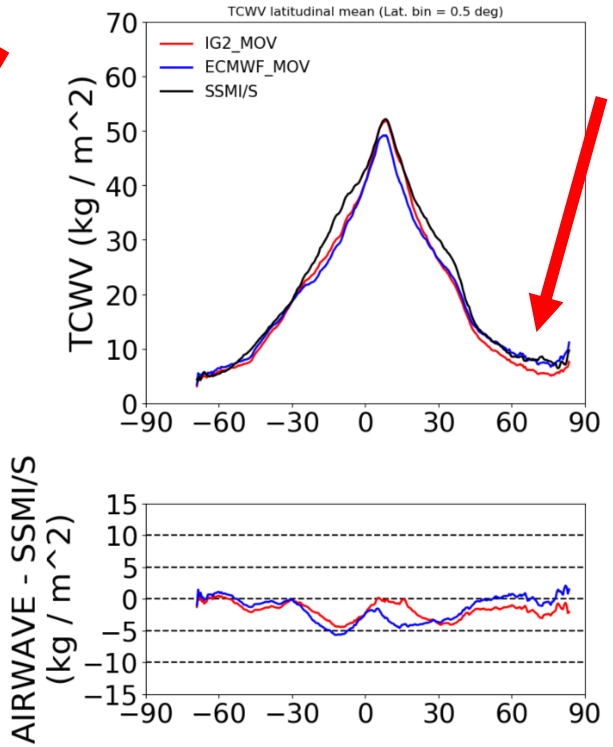
APR 2018



JUL 2018



OCT 2018



AIRWAVE – SLSTR Follow-On Study

- In the frame of the new **AIRWAVE-SLSTR Follow-On Study,** a project funded by EUMETSAT (EUM/CO/22/4600002675/BBo) started in July 2022, we will use the findings and outcomes of the original AIRWAVE-SLSTR study as a starting point to address the known AIRWAVE-SLSTR product limitations.

- The main goal of this project is to refine and improve the AIRWAVE-SLSTR algorithm to achieve a more accurate and robust TCWV product from Sentinel-3 SLSTR, particularly in challenging areas such as at high latitudes and in the Summer hemisphere.

AIRWAVE – SLSTR Follow-On Study

This objective will be achieved through:

- **The computation of new retrieval parameters.**
  We will implement the new spectroscopic data (HITRAN2020) and continuum version (MT_CKD3.6) into the RTM to compute a new set of retrieval parameters. Furthermore, the new set will be computed by exploiting a new temperature and water vapour climatology based on ECMWF reanalysis data over water surfaces for the years covered by the S3 mission.

- **Extensive validation and performance analysis.**
  We will continue to validate the obtained products through the inter-comparison of our TCWV against SSMI/S, IGRA and AMTROC-MWR TCWV products. Furthermore, we try to include in the validation exercise also the COWa-OLCI TCWV products. The validation exercise will be performed using a new validation dataset containing 12 months of S3-A data and 4 months of S3-B AIRWAVE -SLSTR TCWV data.

Thank you for your attention!

From the AIRWAVE-SLSTR team