AIRWAVE-SLSTR: an algorithm to retrieve TCWV from SLSTR measurements over water surfaces

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(A)ATSR series

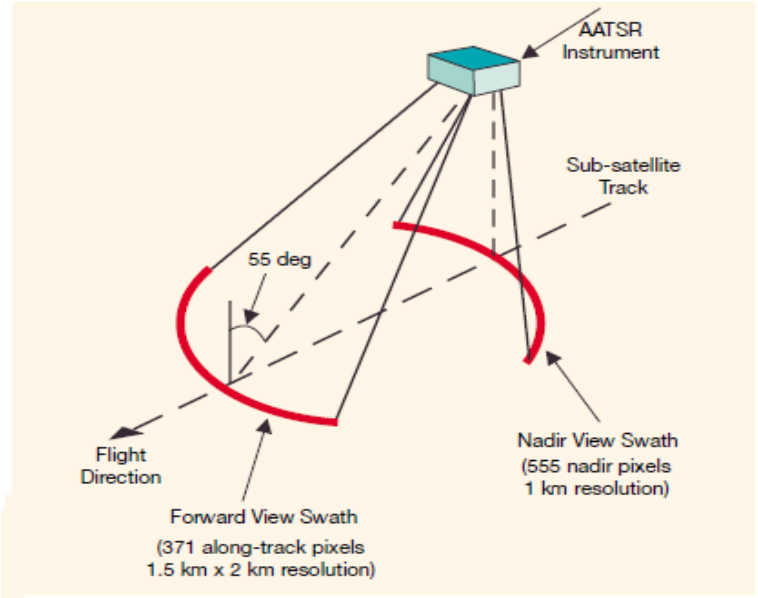
- The ATSR (Along Track Scanning Radiometer) series of instruments (ATSR-1 on ERS-1, ATSR-2 on ERS-2 and AATSR on ENVISAT) were designed to measure the Sea Surface Temperature
- They have measured continuously from 1991 to 2012
- A similar instrument (SLSTR) is now on board Sentinel 3
- The instruments measure the Earth radiation on several spectral bands with two viewing geometries: Nadir and Slant (~50 deg)

Table 1. ATSR-2 and AATSR spectral channels (the first three channels listed were not present in ATSR-1)

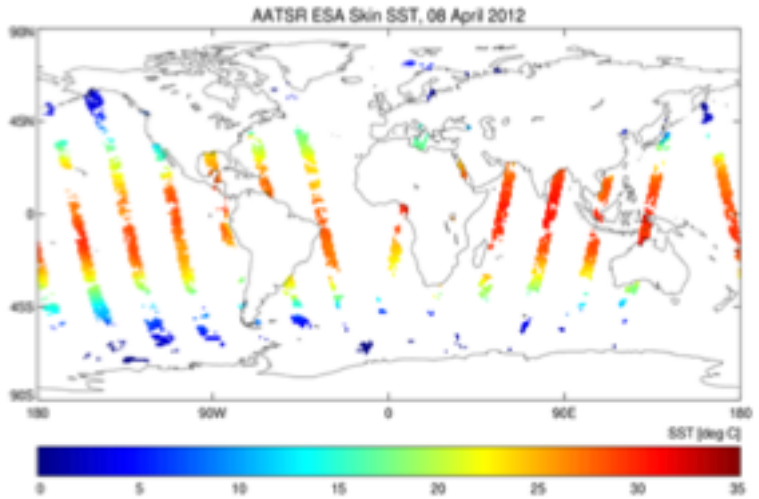
Channel	Centre Wavelength	Bandwidth	Primary Application
0.55 µm	0.555 µm	20 nm	Chlorophyll
0.66 µm	0.659 µm	20 nm	Vegetation Index
0.87 µm	0.865 µm	20 nm	Vegetation Index
1.6 µm	1.61 µm	0.3 µm	Cloud Clearing
3.7 µm	3.70 µm	0.3 µm	SST
11 µm	10.85µm	1.0 µm	SST
12 µm	12.00 µm	1.0 µm	SST

AATSR on ENVISAT

(A)ATSR viewing geometries



The channels of (A)ATSR at **11** and **12** µm were used to measure the Sea Surface Temperature (1 km x 1 km resolution).



The Advanced Infra-Red WAter Vapour Estimator (AIRWAVE) Algorithm

- Developed for the retrieval of TCWV (Total Column of Water Vapor) from the ATSR missions.
- The algorithm exploits the TIR channels (11 and 12 µm) of ATSR-like instruments and the dual viewing geometries to infer the TCWV in clear sky over water surfaces, both in day and night conditions

$$\mathbf{TCWV} = \alpha\, \Phi_{NAD} + \beta\, \Phi_{FWD}$$

- The algorithm makes use of a set of tabulated parameters calculated with a Radiative transfer Model (RTM) specifically developed to reproduce ATSR measurements and a sea emissivity database.

$$\Phi_{NAD} = \frac{\ln\left(\frac{J_{NAD_1}^{\lambda_1}}{J_{NAD_2}^{\lambda_2}}\right) - E_{NAD} - \Delta\tau_{CO2} - const}{\Delta\sigma_{NAD}}$$

$$\alpha = \frac{1}{1 - \frac{\Delta\sigma_{FWD}}{\delta \cdot \Delta\sigma_{NAD}}} \qquad \beta = \frac{1}{1 - \frac{\delta \cdot \Delta\sigma_{NAD}}{\Delta\sigma_{FWD}}} \qquad G_{FWD} \approx \delta \cdot G_{NAD}$$

radiances emissivity scaled water vapour cross section

RTM parameters

AIRWAVE performance evaluation on ATSR dataset

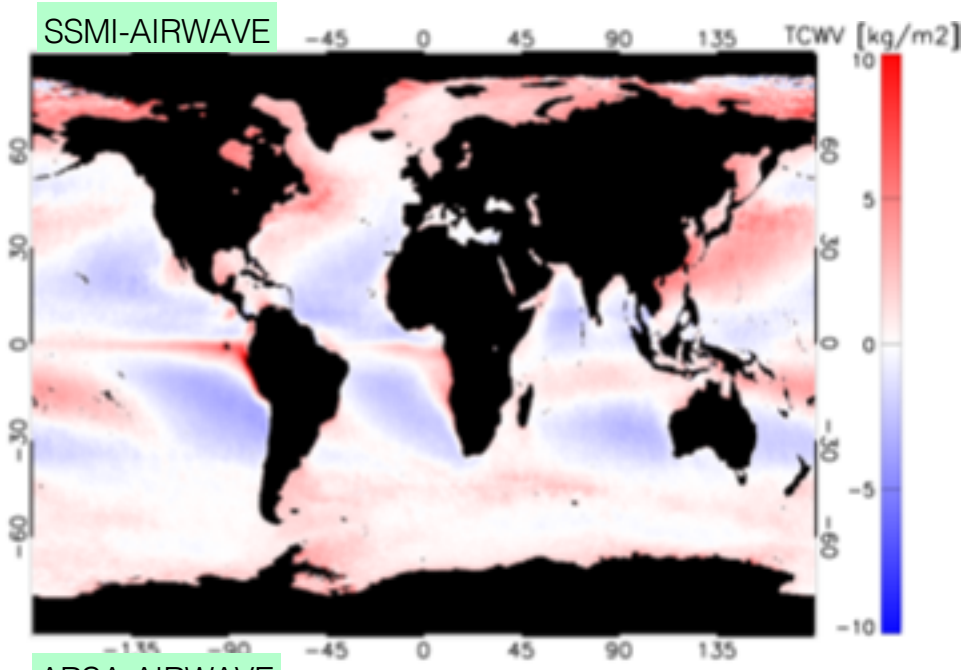
Full mission processed

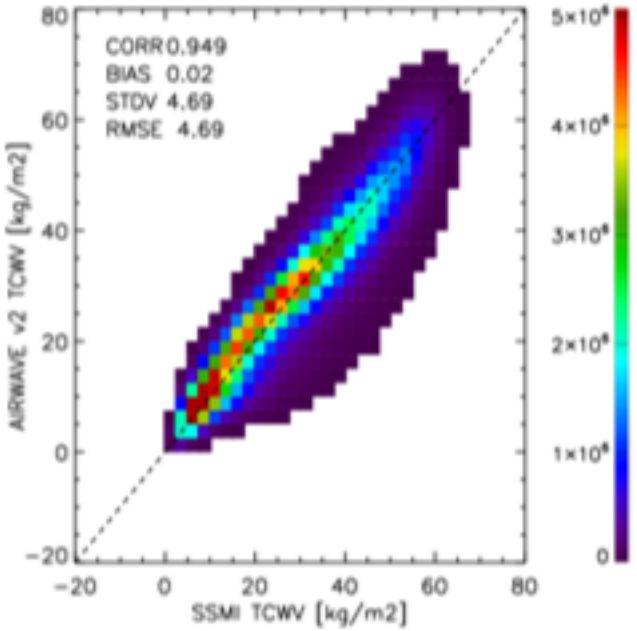
ATSR-1, ATSR-2, AATSR

1991-2012

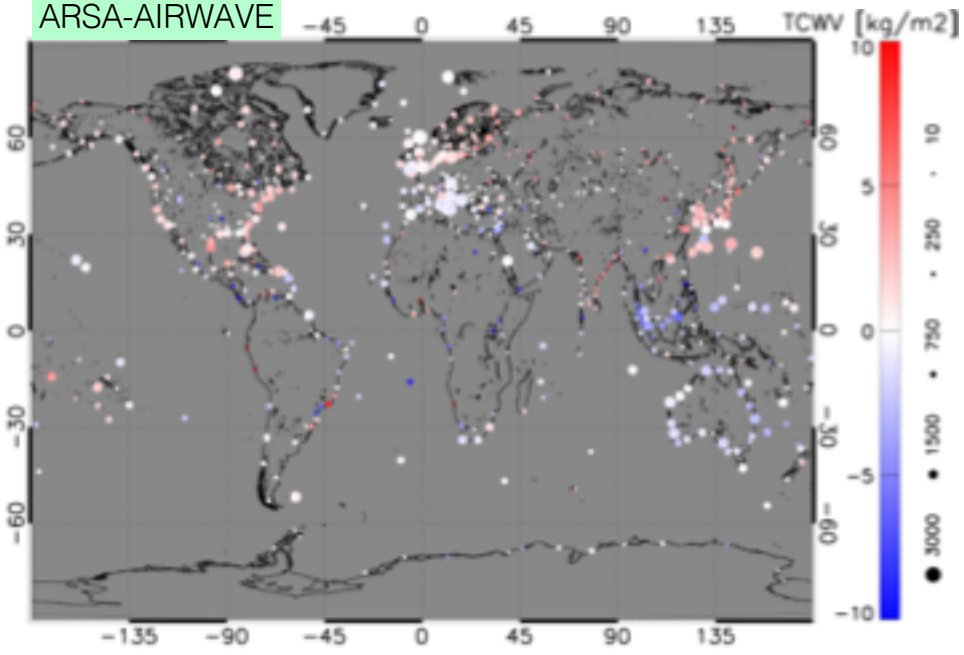
AIWAVE v2 performances evaluated vs SSM/I (F13 satellite) and ARSA radiosondes dataset

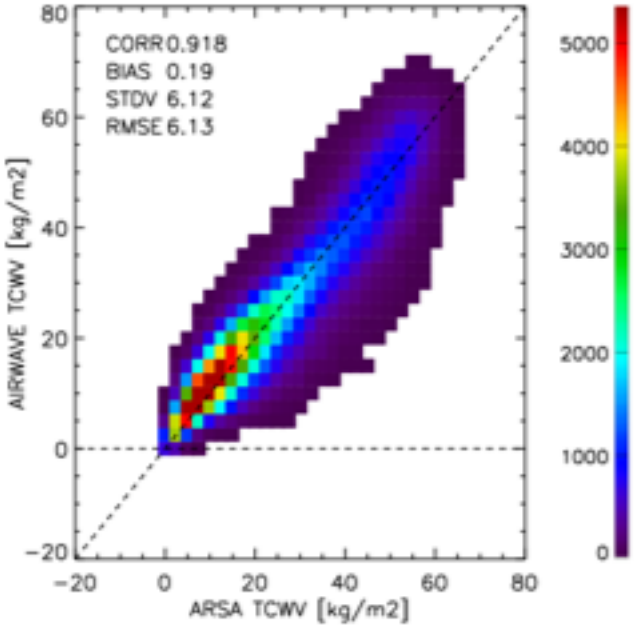
SSMI-AIRWAVE

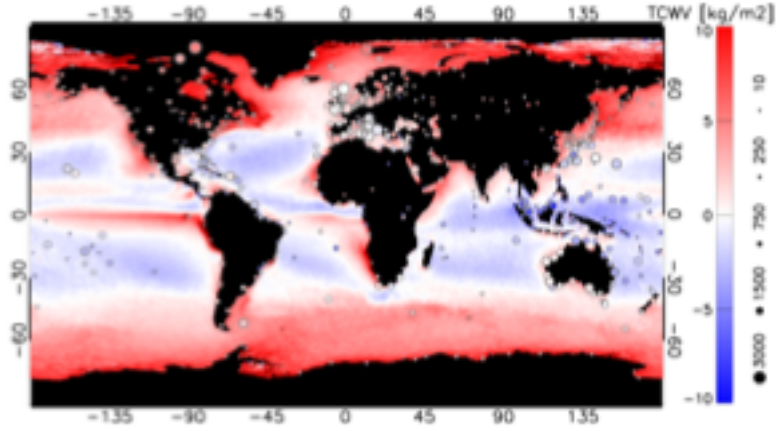




ARSA-AIRWAVE







AIRWAVE for SLSTR

EUMETSAT

- ATSR instrument series stopped working after the ENVISAT failure
- Since 2016 replaced by the Sentinel 3 – Sea and Land Surface Temperature Radiometer (SLSTR) instrument
- Can AIRWAVE be applied to SLSTR measurements?
  - Project funded by EUMETSAT (Contract No.: EUM/CO/19/4600002222/Bbo)
  - **AIRWAVE-SLSTR: an algorithm to retrieve TCWV from SLSTR measurements over water surfaces**
- The goal of the project is to develop a AIRWAVE version for SLSTR to produce a new Sentinel 3 level 2 product (TCWV over water surfaces)

AIRWAVE-SLSTR project

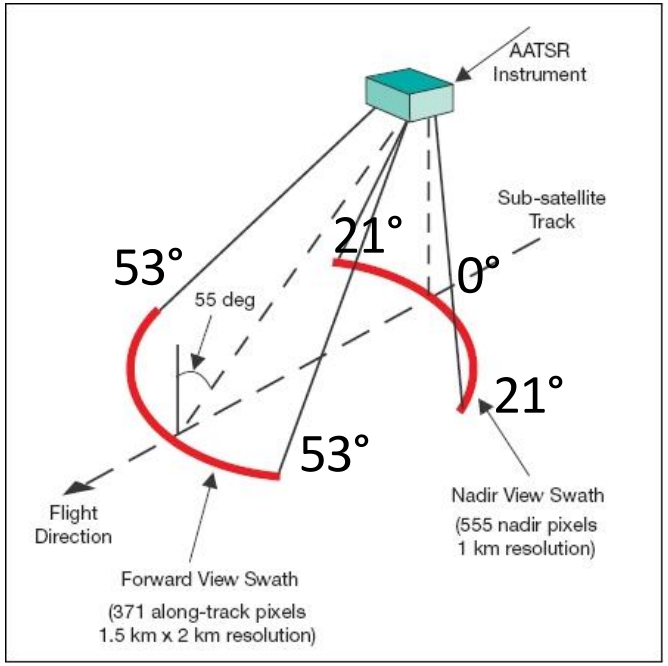
- the project tasks are:
  - Scientific studies for the new code development
  - Prototyping and versioning of the code
  - Error estimation of the obtained TCWV
  - Validation of the obtained TCWV
  - Development of quality flags for the TCWV
  - Public outreach (this talk is an example!)

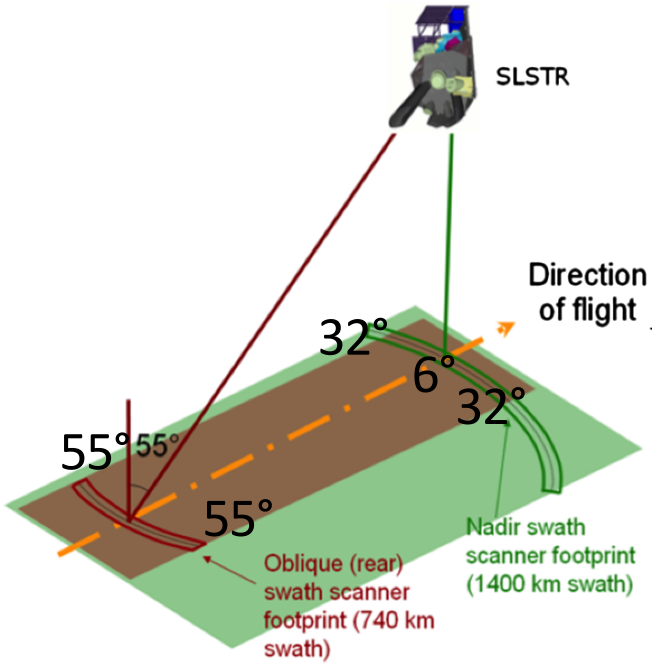
AIRWAVE-SLSTR

EUMETSAT

ATSR / SLSTR differences

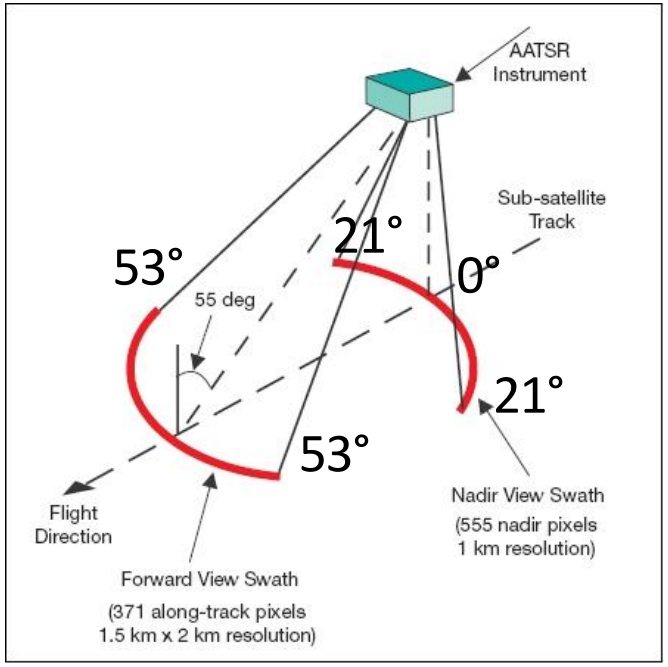
- Both instruments on a Polar Orbit and dual view

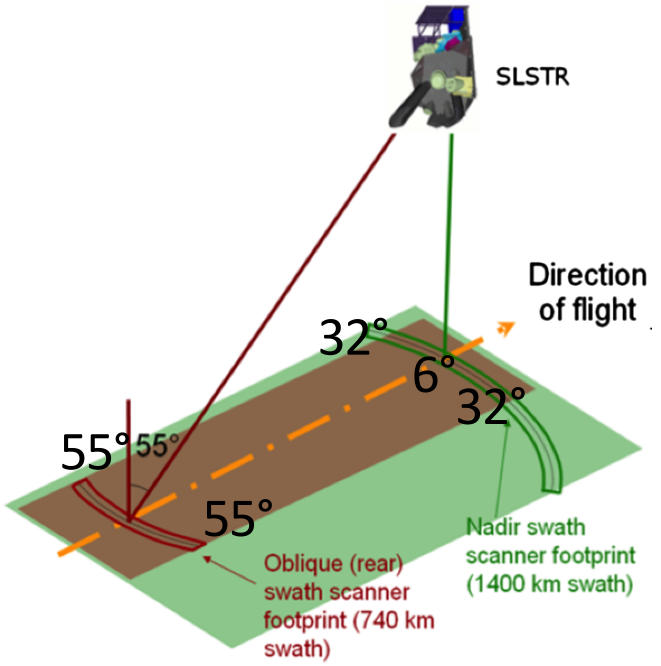




ATSR / SLSTR differences

	ATSR	SLSTR
Viewing geometries	nadir/forward	nadir/oblique (backward)
Across track positions	512 both nadir and forward	1500 nadir; 900 oblique
Filter functions (11 and 12 um)		





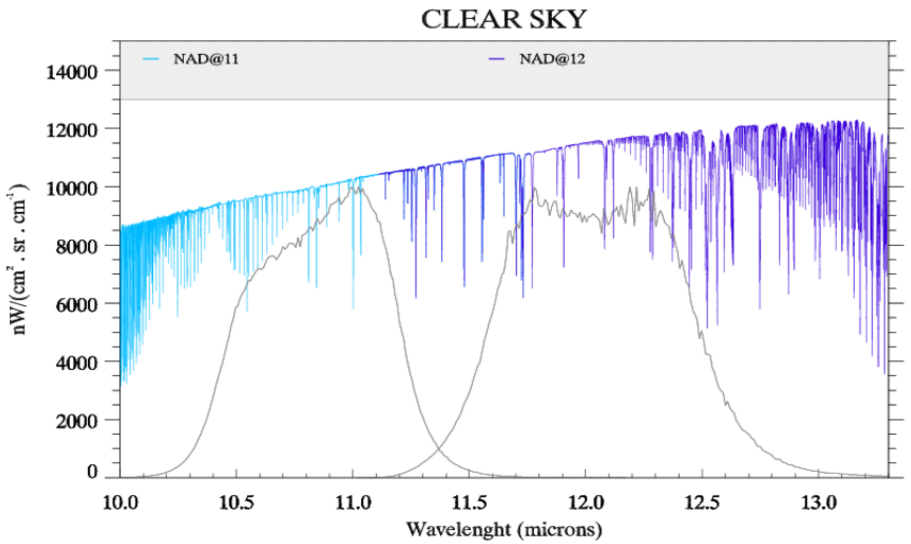
Algorithm updates: atmosphere for parameters calculation

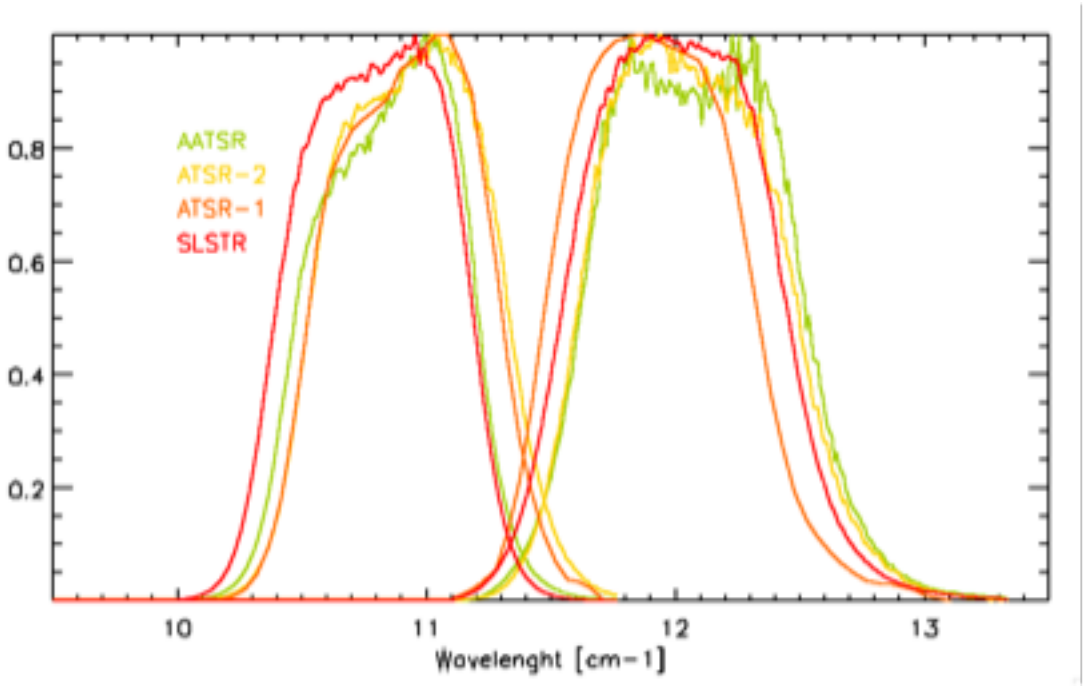
- For the ATSR series we used a climatological database developed for MIPAS/ENVISAT that covers the time span 2002 to 2012
- But the atmosphere has changed, especially CO_2 and CFCs
- We are developing a more accurate climatology with

1) CO_2 and CFCs trends applied to the IG2 profiles to derive the values for the SLSTR mission
2) T , P, H_2O and O_3 ECMWF profiles (monthly means of daily means) from 0 to about 48 km
3) ECMWF Sea Surface Temperature

Algorithm updates: filter functions for parameters calculation

- Each ATSR instrument had a different filter functions
- SLSTR filter functions different, especially for the channel at 11 microns



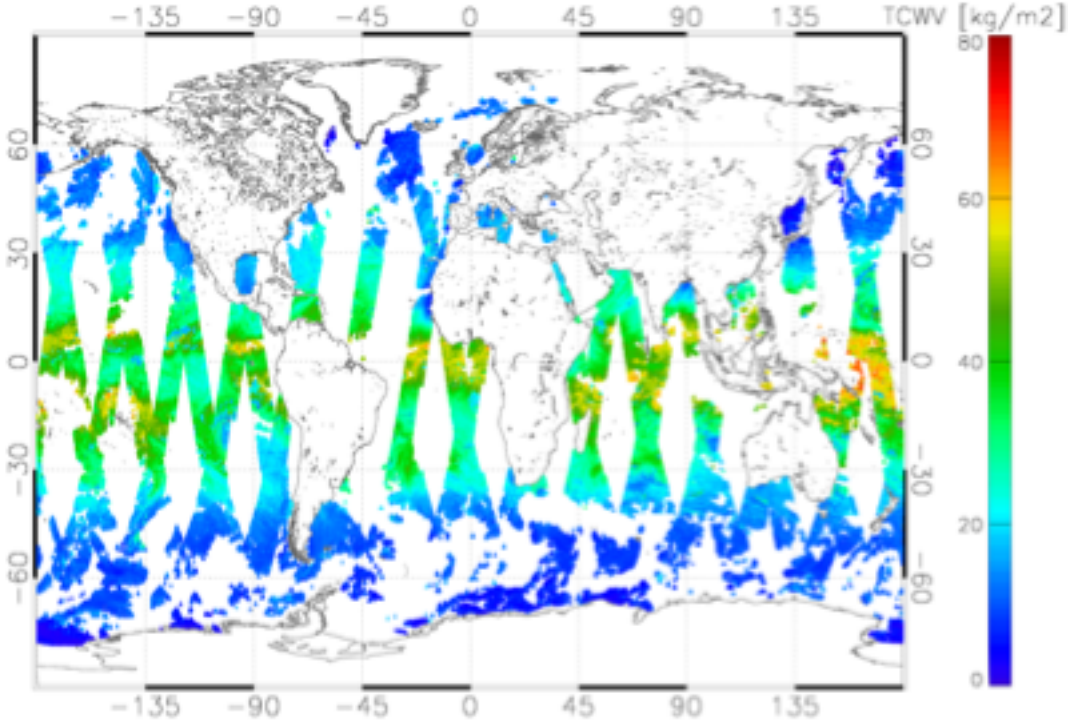


Preliminary tests
Application of AIRWAVEv2 to SLSTR measurements

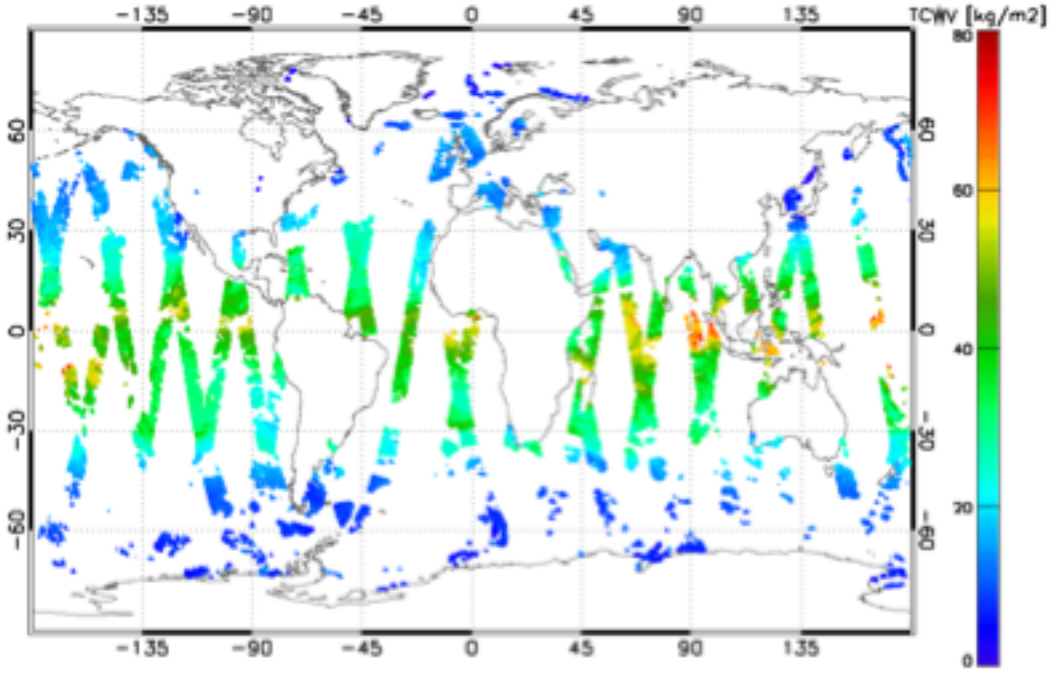
- To test the feasibility of using AIRWAVEv2 on SLSTR data we applied the algorithm to three days of SLSTR data (JAN, APR, JUL 2017).
- The computing time for the analysis of each day is about 2 h.
- The random error due to the TIR channels noise (about 0.02K) is about 3-5% depending on the observed scenario
  - To be compared to 4-7 % for AATSR and ATSR-2 (0.037K noise) and 9-15% for ATSR-1 (0.1K noise).
- To judge the quality we will show a comparison with SSMI (F17/18:00) data for the same days used in our analysis.

Preliminary tests
Application of AIRWAVEv2 to SLSTR measurements

SLSTR – January 2017

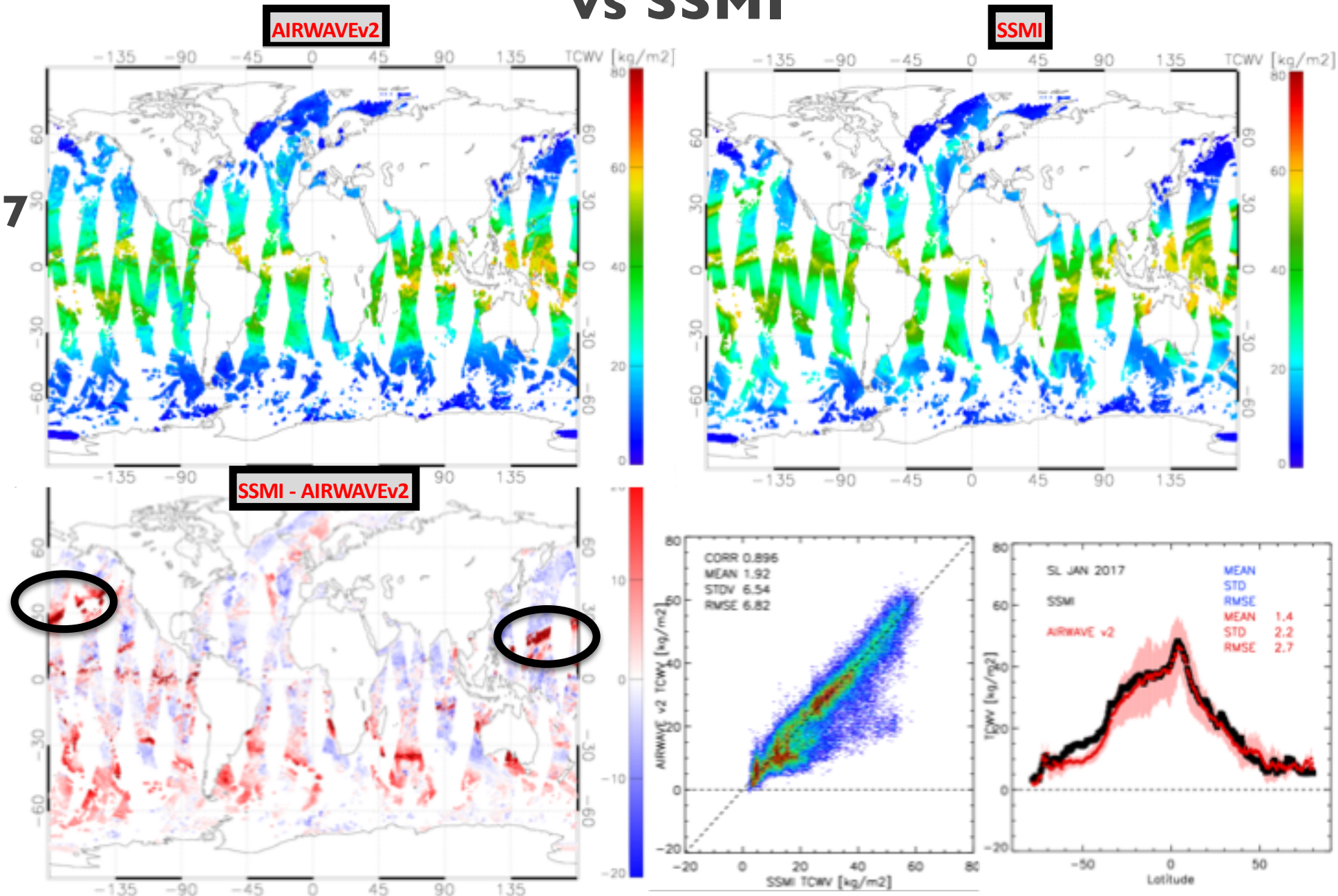


ATSR – January 2003



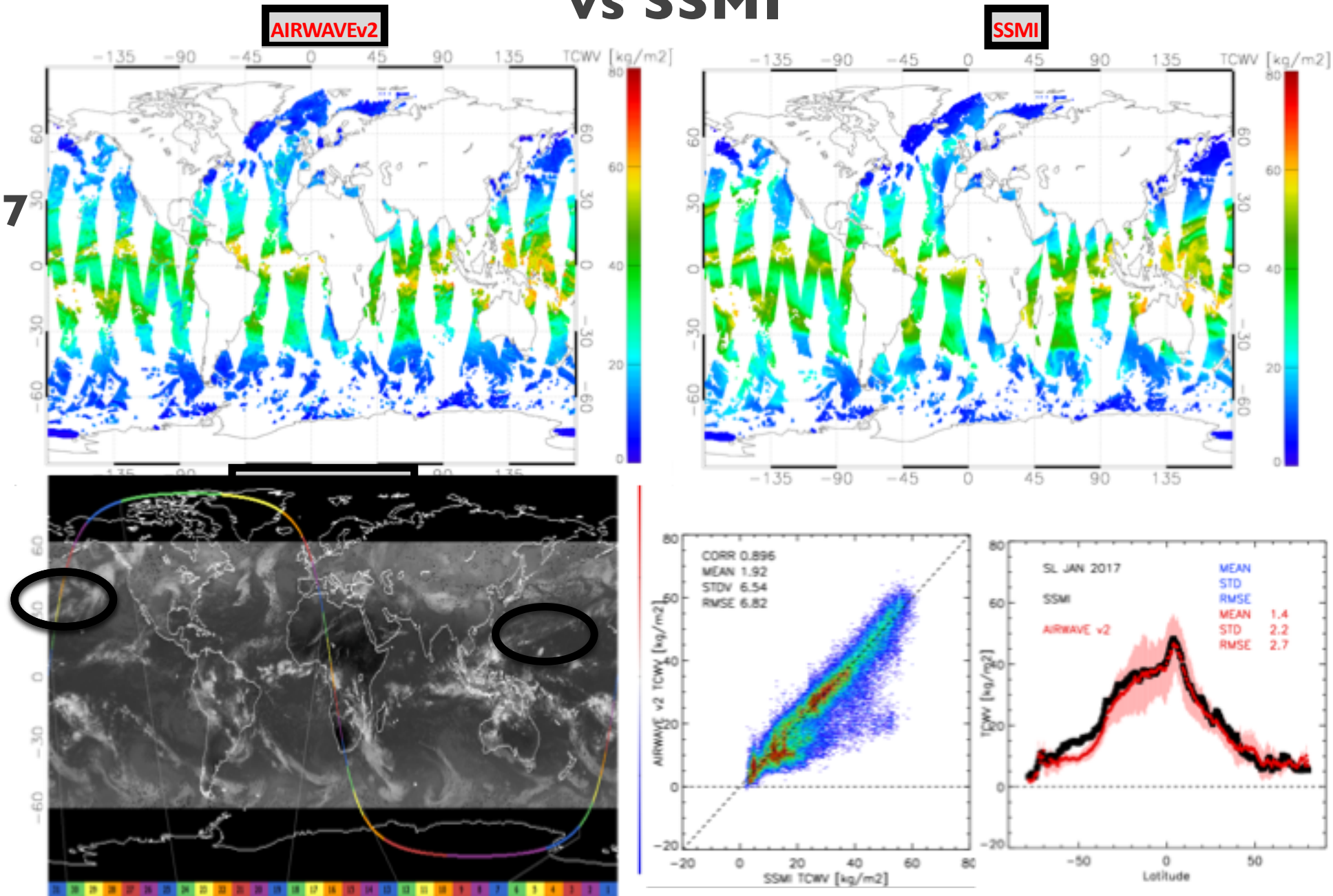
AIRWAVE v2: application to SLSTR measurements: Results vs SSMI

JAN 2017



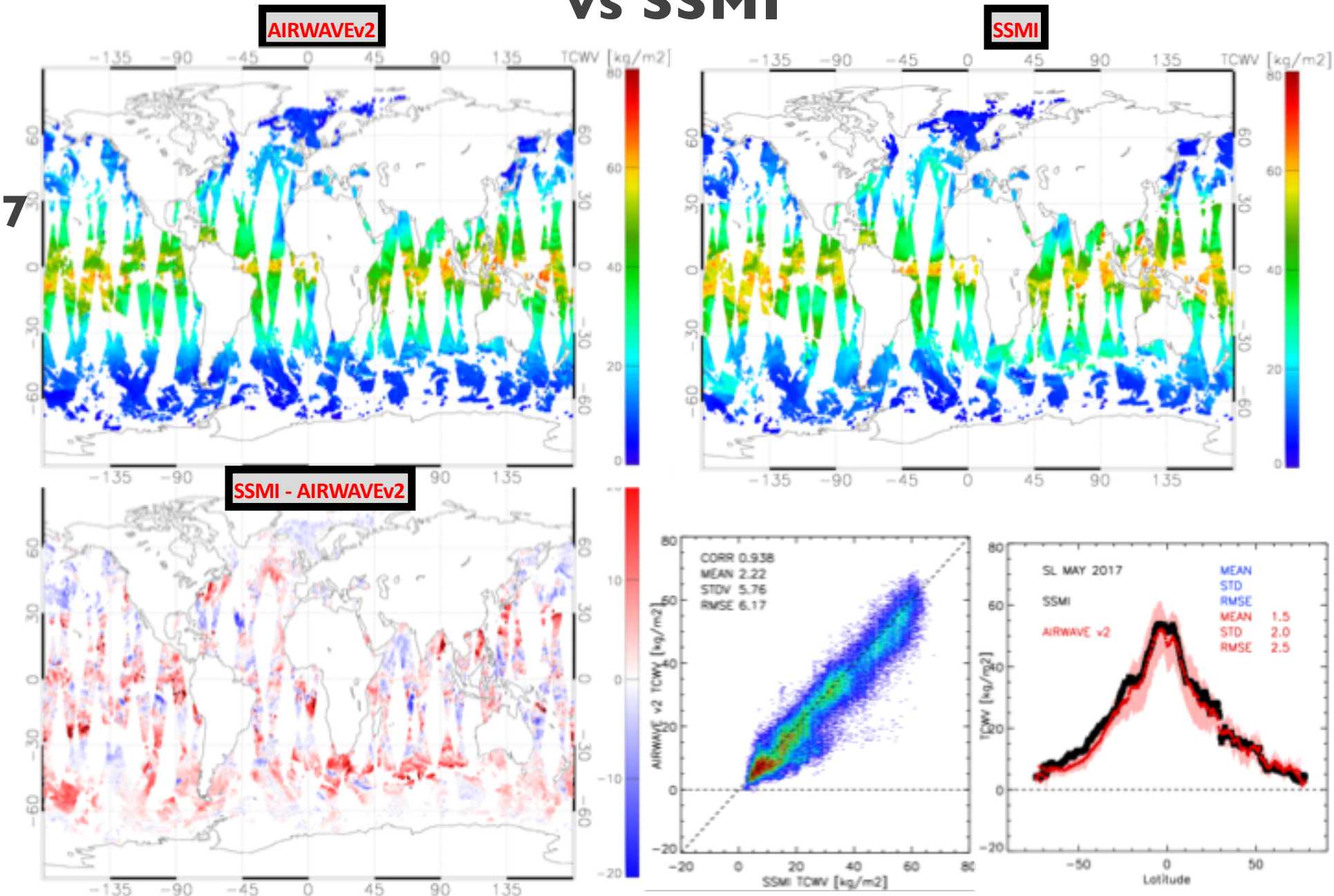
AIRWAVE v2: application to SLSTR measurements: Results vs SSMI

JAN 2017



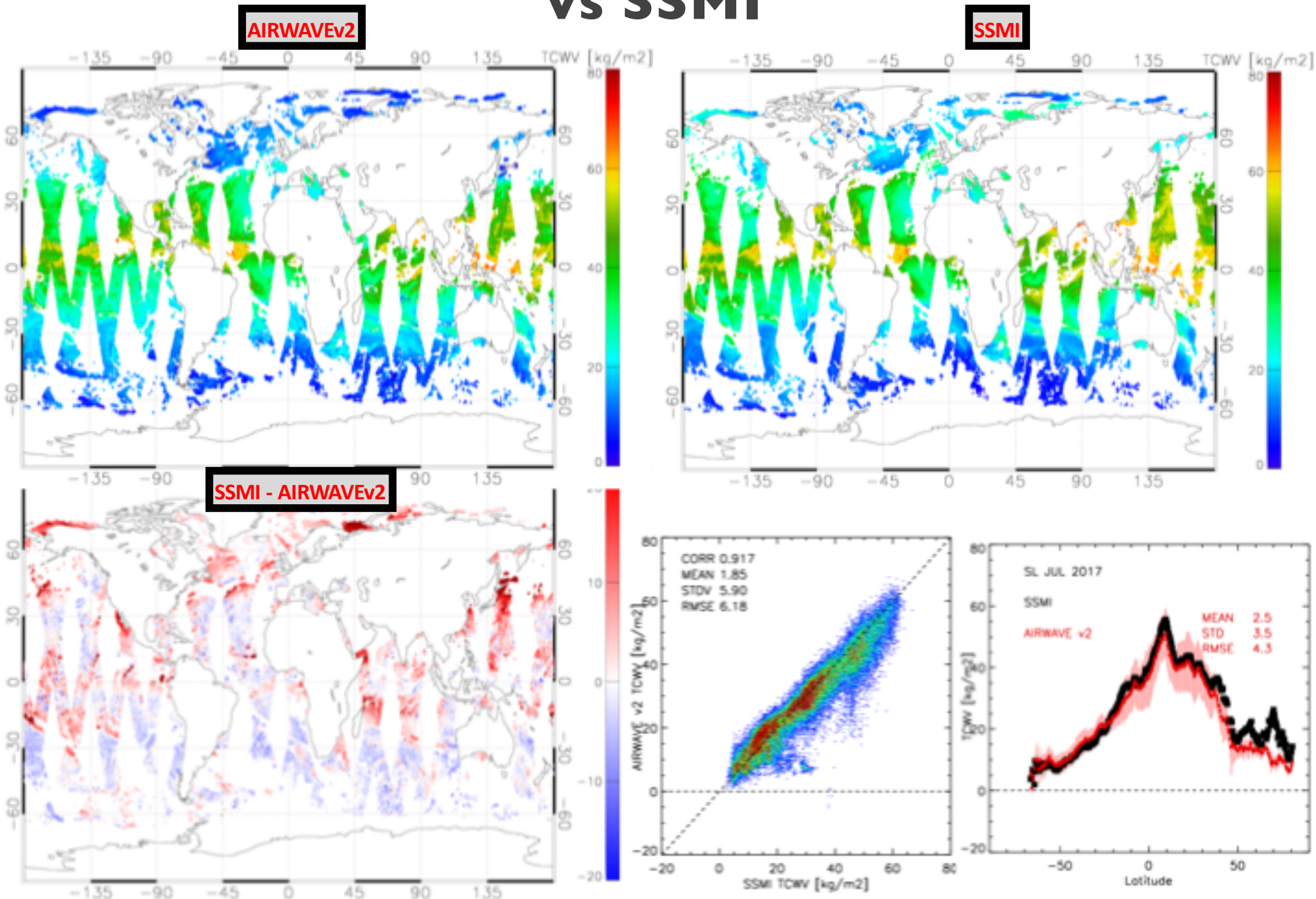
AIRWAVE v2: application to SLSTR measurements: Results vs SSMI

APR 2017



AIRWAVE v2: application to SLSTR measurements: Results vs SSMI

JUL 2017



Conclusions

- In the frame of an EUMETSAT contract we started to develop the AIRWAVE-SLSTR code
- The final goal of the project is to produce a validated algorithm to produce the Sentinel 3 TCWV level 2 product completely characterized (all error sources identified and characterised, quality of data easily defined)
- Preliminary tests show that the TCWV from SLSTR will be of similar or better quality of the TCWV data from the ATSR instrument series (1991-2012)
- The joint use of ATSR and SLSTR data can be used for scientific studies on the variability and trends of the water vapor distribution in atmosphere (TCWV is one of the Essential Climate Variable)