The Advanced Infra-Red WAter Vapour Estimator-v3 (AIRWAVE-v3) TCWV dataset from clear-sky over water (A)ATSR-1/2 measurements

E. Castelli[1], E. Papandrea[1], M. Valeri[2], A. Achilli[1,3], S. Casadio[2], A. Cofano[2], B. M. Dinelli[1], S. Pinori[2]

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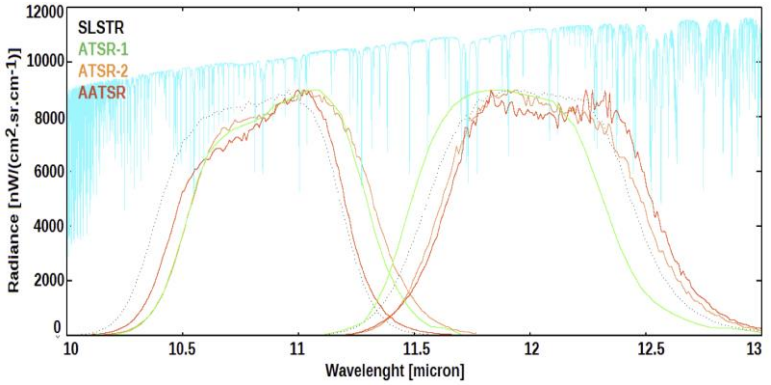
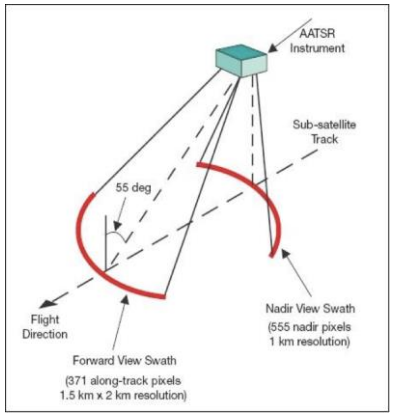
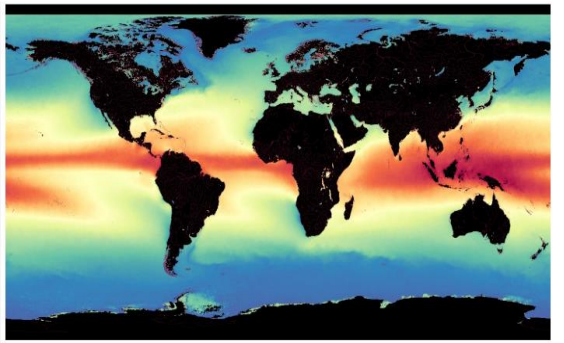
Rationale 1/2

During ESA ALTS phase 1 & 2 projects, we retrieved the TCWV from ATSR-like instruments exploiting the TOA BT collected from the nadir and forward views of the channels at 11 and 12 microns with the AIRWAVE algorithm.

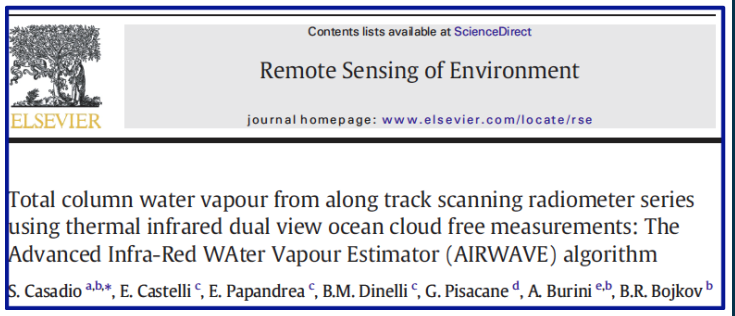
The algorithm exploits a set of retrieval parameters calculated off-line with a Radiative Transfer Model (RTM) specifically developed to simulate the radiance measured by ATSR in the TIR channels.







1991-2012 average TCWV global field at coarse resolution



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Total column water vapour from along track scanning radiometer series using thermal infrared dual view ocean cloud free measurements: The Advanced Infra-Red WAter Vapour Estimator (AIRWAVE) algorithm

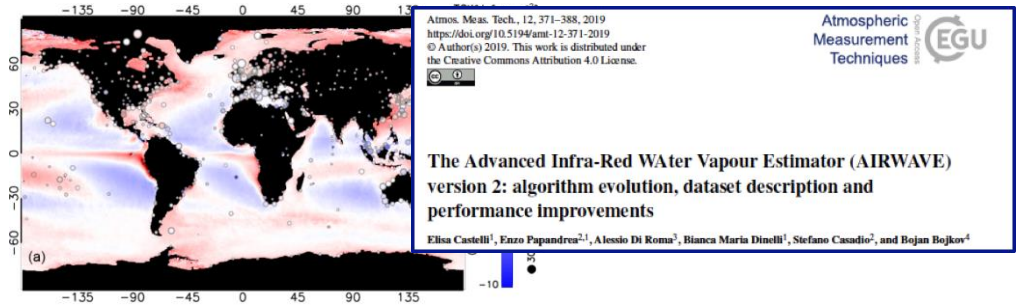
S. Casadio [a,b,*], E. Castelli [c], E. Papandrea [c], B.M. Dinelli [c], G. Pisacane [d], A. Burini [e,b], B.R. Bojkov [b]

The AIRWAVE algorithm was applied to the ATSR missions: ATSR-1/ERS-1 (1991-1996), ATSR-2/ERS-2 (1995-2003) and AATSR/ENVISAT (2002-2012)

Two versions of AIRWAVE dataset: the first one (V1), which uses constant parameters over the globe and an improved version (V2), which accounts for the atmospheric variability at different latitudes and the associated seasonality.

Rationale 2/2

A reduced version of the AIRWAVE V1 dataset has been included in the first version of the G-VAP GEWEX archive, the AIRWAVE V2 has been selected for inclusion in the second version.

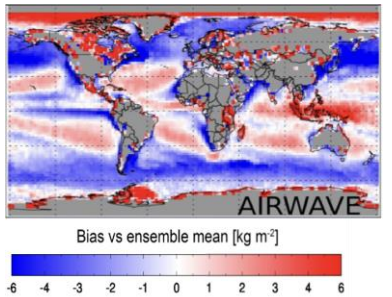


Atmos. Meas. Tech., 12, 371–388, 2019
https://doi.org/10.5194/amt-12-371-2019

Atmospheric Measurement Techniques

The Advanced Infra-Red WAter Vapour Estimator (AIRWAVE) version 2: algorithm evolution, dataset description and performance improvements

Elisa Castelli[1], Enzo Papandrea[2,1], Alessio Di Roma[3], Bianca Maria Dinelli[1], Stefano Casadio[2], and Bojan Bojkov[4]



The GEWEX Water Vapor Assessment archive of water vapour products from satellite observations and reanalyses

Marc Schröder[1], Maarit Lockhoff[1], Frank Fell[2], John Forsythe[3], Tim Trent[4,5], Ralf Bennartz[6,7], Eva Borbas[7], Michael G. Bosilovich[8], Elisa Castelli[9], Hans Hersbach[10], Misako Kachi[11], Shinya Kobayashi[12], E. Robert Kursinski[13], Diego Loyola[14], Carl Mears[15], Rene Preusker[16], William B. Rossow[17], and Suranjana Saha[18]

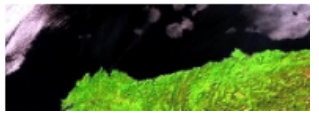
Recently, a new reprocessing of ATSR Level 1b files has become available. The improvements in reprocessed Level 1b files and on the RTM used for the calculation of AIRWAVE retrieval parameters motivate the production of a new AIRWAVE dataset named V3.

News / Envisat AATSR 4th Reprocessing...

Envisat AATSR 4th Reprocessing data now available

26 Jan 2023

The 4th Reprocessing of the AATSR instrument L1B data stemming from the Envisat satellite have now been released to users following successful quality assessment.

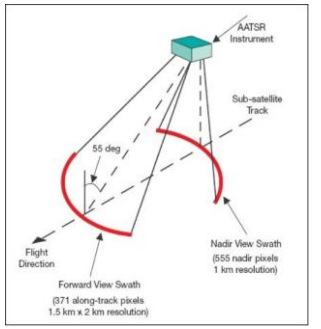


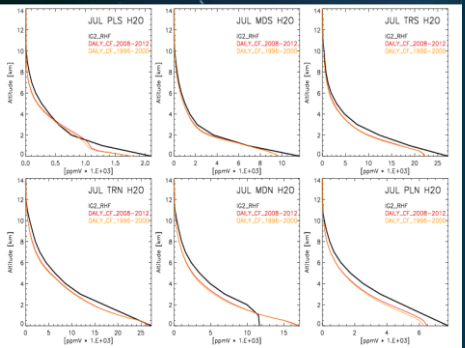
IDEAS-QA4EO

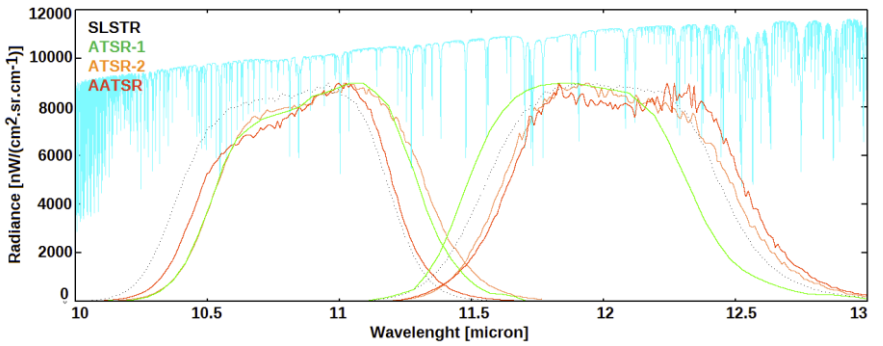
Set up the AIRWAVE V3 retrieval chain using updated retrieval parameters and
Run the retrieval code over the ATSRs missions to produce the AIRWAVE V3 dataset. Validation with satellite and ground-based data

AIRWAVE code

AIRWAVE (Advanced Infra-Red Water Vapour Estimator)
using
BTs at 11 and 12 µm channels in **FORWARD** and **NADIR** view
acquired in cloud free scenarios over seas in day and night
+
Calculations from **Radiative Transfer Forward Models**
+
Sea surface Emissivity database
10.7488/ds/162







Total Column Water Vapour (TCWV) from ATSR Series at very high spatial resolution (1 km x 1 km)

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

$$\Phi_{NAD} = \frac{\ln\left(\frac{J_{NAD_1}^{\lambda_1}}{J_{NAD_2}^{\lambda_2}}\right) - E_{NAD} - \Delta\tau_{CO2} - const}{\Delta\sigma_{NAD}} \qquad \alpha = \frac{1}{1 - \frac{\Delta\sigma_{FWD}}{\delta \cdot \Delta\sigma_{NAD}}} \qquad \beta = \frac{1}{1 - \frac{\delta \cdot \Delta\sigma_{NAD}}{\Delta\sigma_{FWD}}} \qquad G_{FWD} \approx \delta \cdot G_{NAD}$$

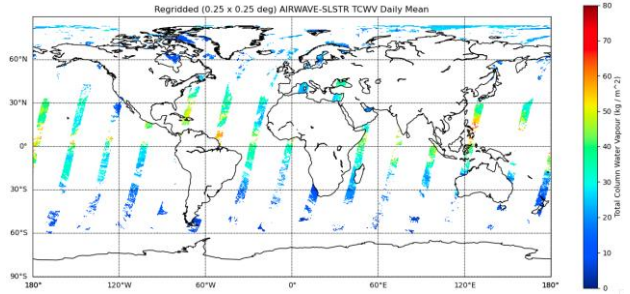
Main advantages: Use of RTM calculations no empirical adjustments, Fast retrieval

Code Updates and first tests

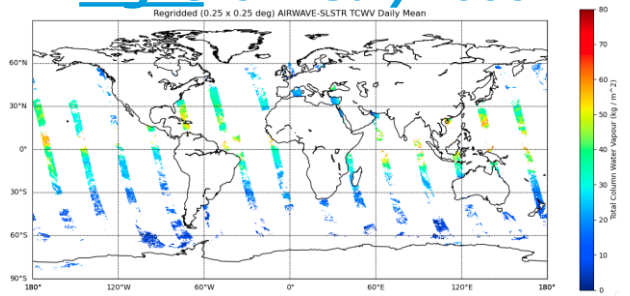
Adaption of the code for directly handling (A)ATSR-(1/2) L1b data / Preparation of the routine for producing the L2 products in NetCDF format

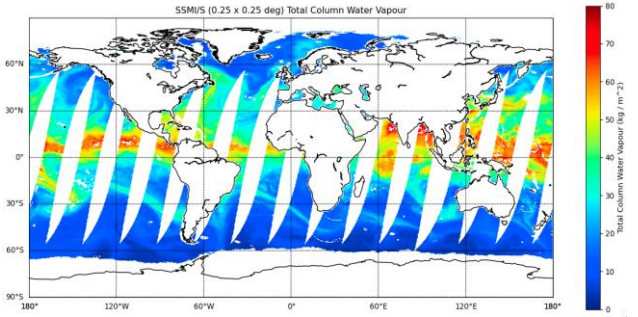
3 NAS containing (A)ATSR-(1/2) L1b data have been delivered by ESA

Preliminary tests exploiting (A)ATSR-(1/2) L1b data representative of the 3 missions and inter-comparison against co-located SSMI/S TCWV products



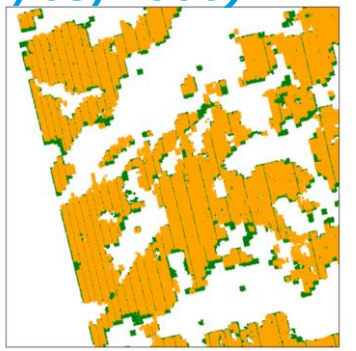
AIRWAVEv3 retrieved TCWV for day and night for 1 July 2006.





SSMI/S retrieved TCWV for 1 July 2006.

AATSR pixels position in L1B 3rd and 4th reprocessing at nadir (01/03/2006)

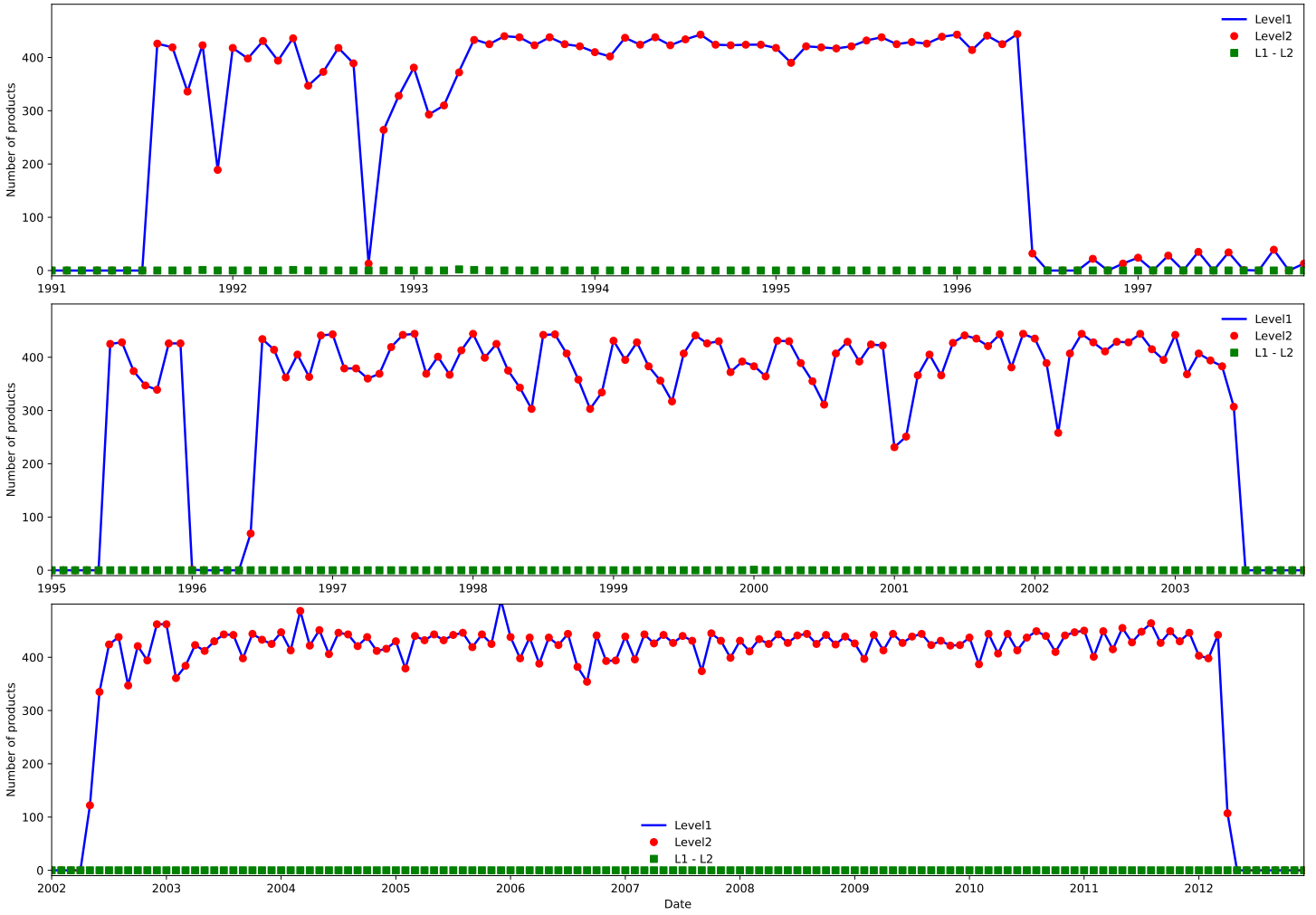


3 Nas with L1B data connected at ISAC server

File Name	tcwv.nc			
Element name	Description	Range or value	T	D
Rows	Along track grid size			
Columns	Across track grid size	512		
<common global attributes>	Common global attributes	See Table 10		
Tcwv	Integrated water vapour column above the current pixel	[-4.29492e+06; 4.29502e+06]	I32	rows columns
Units	UDUNITS unit name	Kg / m²		1
scale_factor	Scaling factor used in decoding packed data	0.002		1
add_offset	Offset used to in decoding packed data	50		1
_FillValue	Value indicating missing data	-2147483648		1
tcwv_tpA	Type A error estimate for integrated water vapour column above the current pixel	[0; 5.08]	u8	rows columns
Units	UDUNITS unit name	Kg / m²		1
scale_factor	Scaling factor used in decoding packed data	0.002		1
add_offset	Offset used to in decoding packed data	0		1
_FillValue	Value indicating missing data	255		1
tcwv_tpB NOTE: not used in this current version	Type B error estimate for integrated water vapour column above the current pixel	[0]	u8	rows columns
Flg	AIRWAVE Level 2 masks	See Table 11	u8	rows columns
Latitude	Latitude of detector FOV centre on the earth's surface	[-90; 90]	i32	rows columns
Standard_name	CF standard name	latitude		1
Units	UDUNITS unit name	degrees_north		1
scale_factor	Scaling factor used in decoding packed data	1e-6		1
add_offset	Offset used to in decoding packed data	0		1
_FillValue	Value indicating missing data	-2147483648		1
Longitude	Longitude of detector FOV centre on the earth's surface	[-180; 180]	i32	rows columns
Standard_name	CF standard name	longitude		1
Units	UDUNITS unit name	degrees_east		1
scale_factor	Scaling factor used in decoding packed data	1e-6		1
add_offset	Offset used to in decoding packed data	0		1
_FillValue	Value indicating missing data	-214748364		1

Structure of AIRWAVEv3 Netcdf file

Massive processing:



ERS-1/ATSR-1
(23390 products, 3.6 TB)

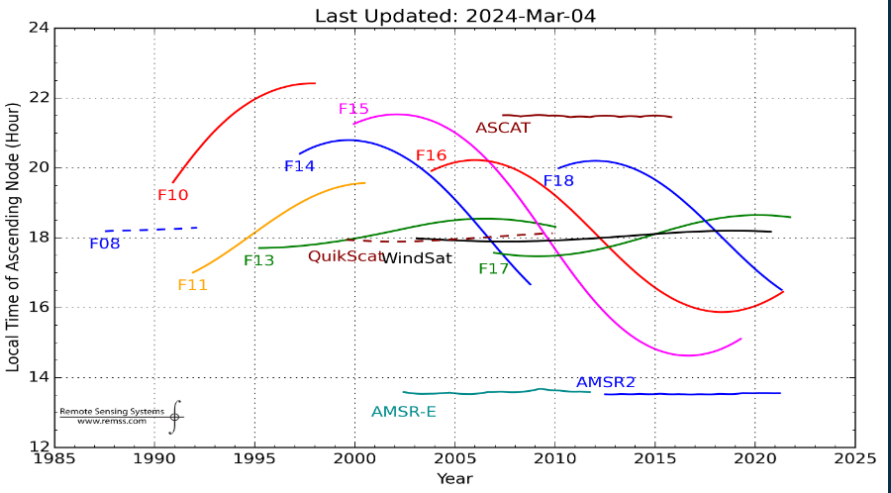
ERS-2/ATSR-2
(35926 products, 5.6 TB)

ENVISAT/AATSR
(50547 products, 8.1 TB)

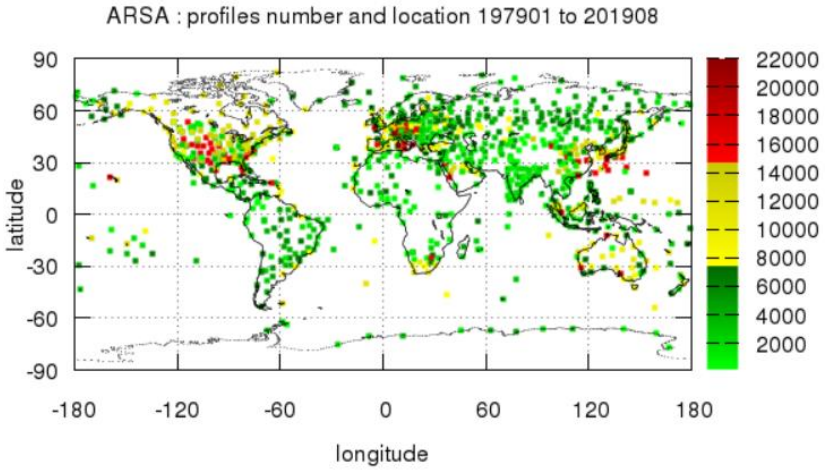
AIRWAVE V3 Validation

The validation of the AIRWAVE V3 TCWV dataset was performed against

- **Satellite-based TCWV products:**
  We used the **SSM/I F13 V7 satellite products**, time period (**1995-2009**) overlaps with the measurements of all three ATSR instruments.
  The spatial grid used for the comparison at SSM/I resolution (**0.25° x 0.25°**), AIRWAVE TCWVs have been aggregated to this grid.
  We used only pixels with more than **2%** of the area covered by AIRWAVE values.

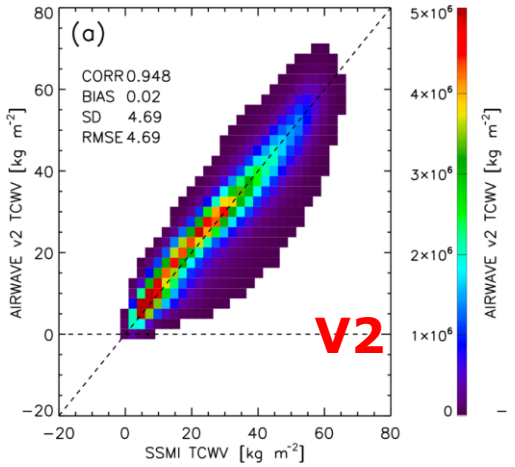


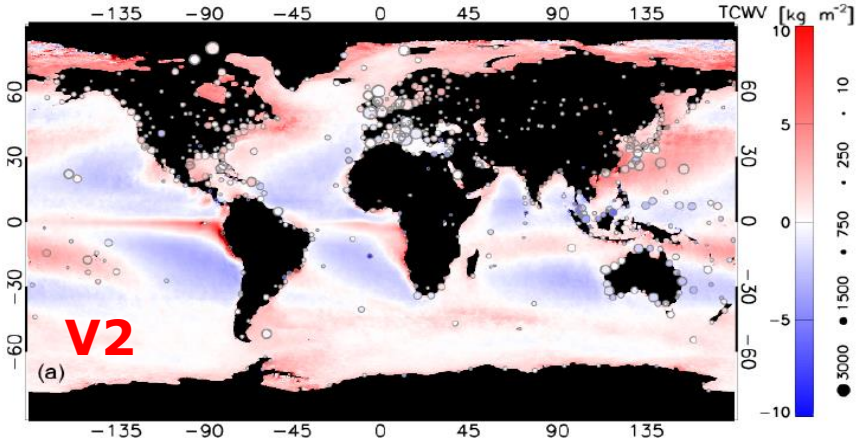
- **Radiosonde TCWV data:**
  The **ARSA TCWV products** was previously obtained by integrating the humidity profile across the entire pressure range.
  AIRWAVE products (at their native resolution of 1 km) located **within a radius of 100 km around the coastal stations' position** have been averaged with collocated radiosonde measurements.
  We used only matchups with more than **2%** of the water area covered by AIRWAVE values.

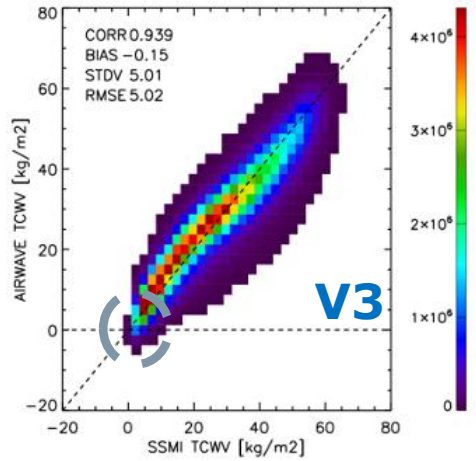


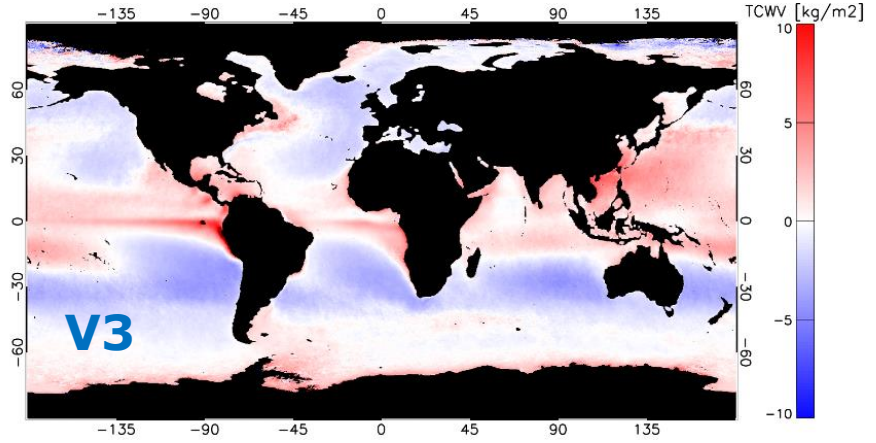
AIRWAVE V3 Validation

AIRWAVE v2 vs v3 considering SSM/I as a reference:









Similar performances but …

- Differences in the bias distribution especially in the north pole
- Negative values found
- Different number of valid points with respect to AIRWAVE v2 and v1

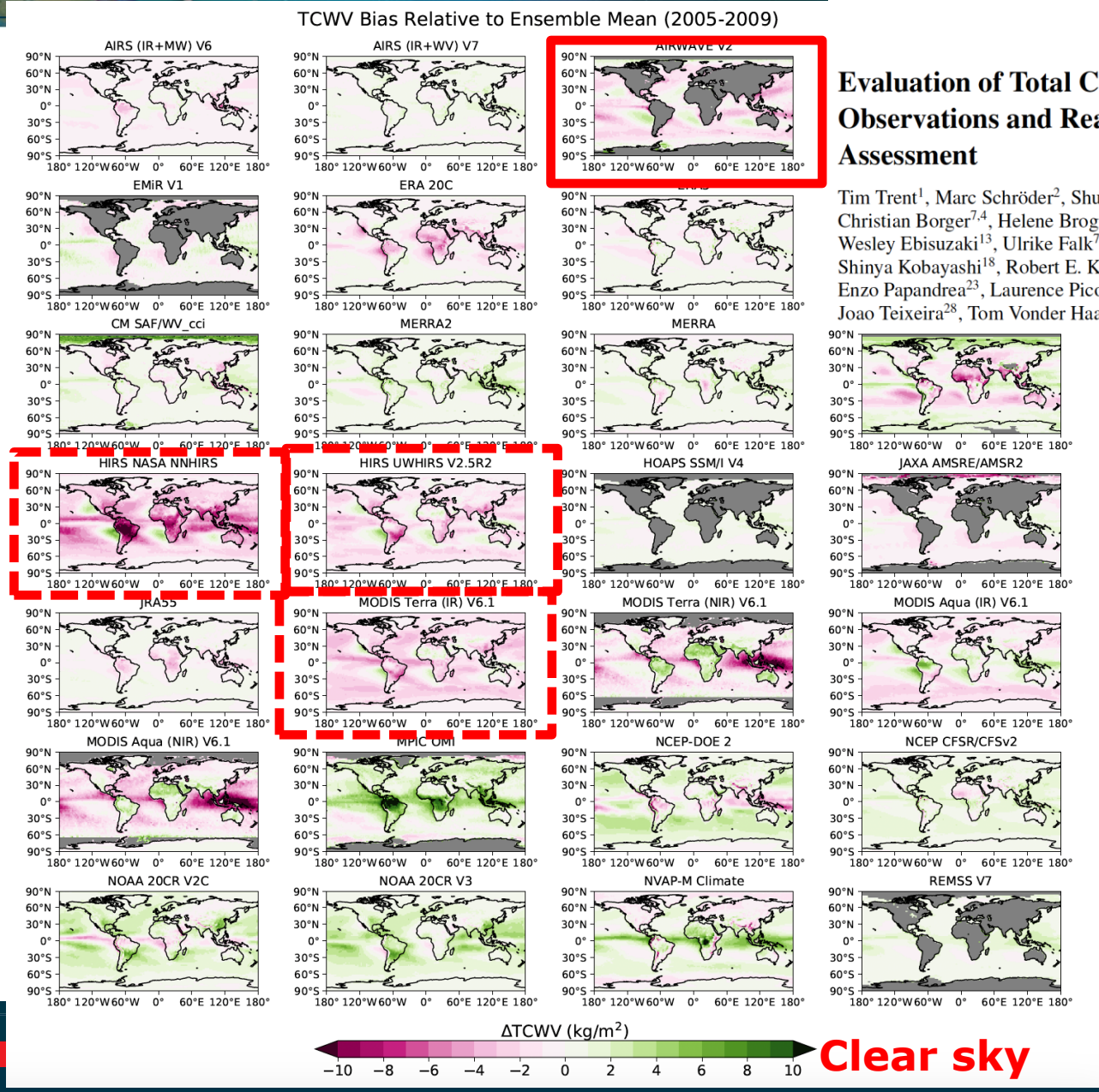
  Cloud effect? Land/Sea mask effect?

		N (10^5)	
Instrument	**Scenario**	**V3**	**V2 & V1**
All	**Global**	2980	3110
All	**Equator**	1505	1160
All	**Mid-Latitude**	1312	1380
All	**Polar**	163	170
ATSR-1	**Global**	210	190
ATSR-2	**Global**	1319	1390
AATSR	**Global**	1451	1520

https://doi.org/10.5194/egusphere-2023-2808
Preprint. Discussion started: 29 November 2023

G-VAP V2 archive:

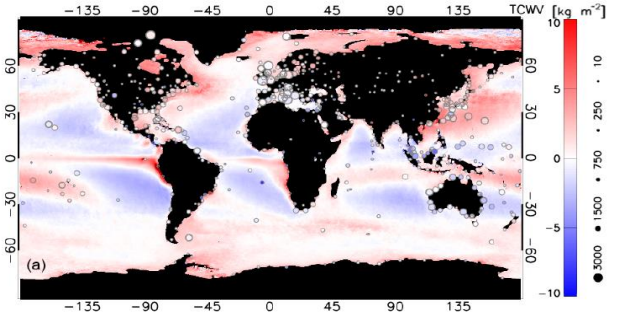
Similar patterns in the difference when using IR measurements



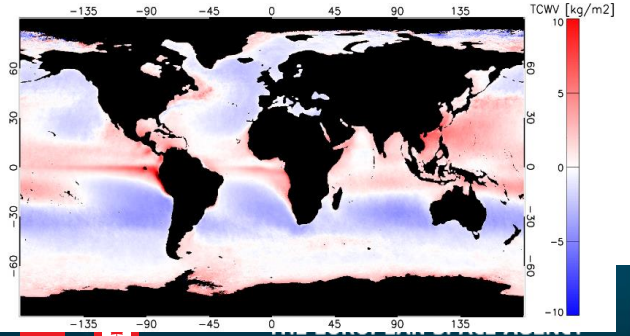
Evaluation of Total Column Water Vapour Products from Satellite Observations and Reanalyses within the GEWEX Water Vapor Assessment

Tim Trent[1], Marc Schröder[2], Shu-Peng Ho[3], Steffen Beirle[4], Ralf Bennartz[5], Eva Borbas[6], Christian Borger[7,4], Helene Brogniez[8], Xavier Calbet[9], Elisa Castelli[10], Gilbert P. Compo[11,12], Wesley Ebisuzaki[13], Ulrike Falk[7], Frank Fell[14], John Forsythe[15], Hans Hersbach[16], Misako Kachi[17], Shinya Kobayashi[18], Robert E. Kursinski[19], Diego Loyola[20], Zhengzao Luo[21], Johannes K. Nielsen[22], Enzo Papandrea[23], Laurence Picon[24], Rene Preusker[25], Anthony Reale[3], Lei Shi[26], Laura Slivinski[27], Joao Teixeira[28], Tom Vonder Haar[29], and Thomas Wagner[4]

AIRWAVE V2

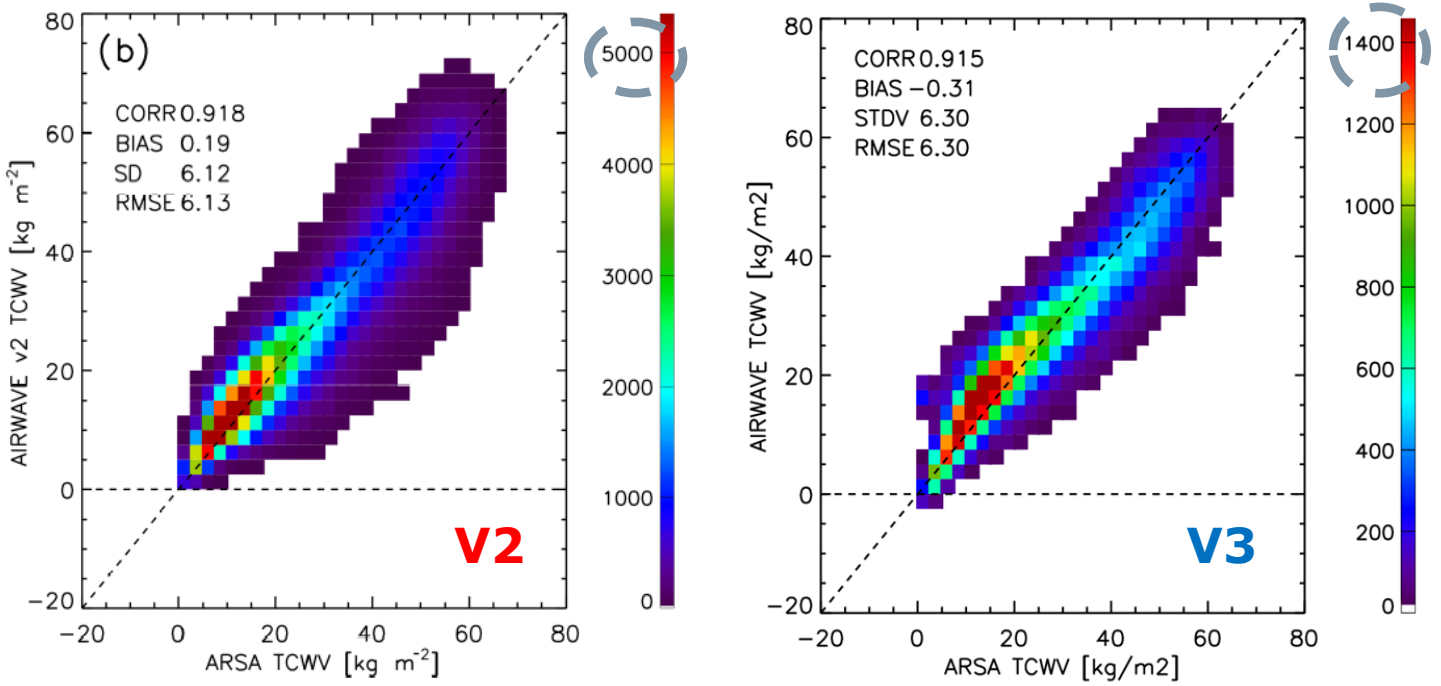


AIRWAVE V3



AIRWAVE V3 Validation

AIRWAVE v2 vs v3 considering ARSA as a reference:



Similar performances but …

- Differences in the bias distribution especially in the north pole
- Slightly negative values found
- Different number of valid points with respect to AIRWAVE v2 and v1
  - Cloud effect?
  - Land/Sea mask effect?

		N (10^5)	
Instrument	**Scenario**	**V3**	**V2 & V1**
All	**Global**	1.84	3.01
All	**Equator**	0.59	0.87
All	**Mid-Latitude**	1.08	1.8
All	**Polar**	0.17	0.35
ATSR-1	**Global**	0.12	0.48
ATSR-2	**Global**	0.75	1.00
AATSR	**Global**	0.96	1.53

Conclusions

ESA produced the 4th reanalysis of (A)ATSR(-1/2) L1B data

In the frame of ESA ALTS contracts, we developed and applied the AIRWAVE code to retrieve TCWV from (A)ATSR(-1/2) infra-red BTs

The new reprocessing of L1B data gave the possibility of retrieving a new AIRWAVE TCWV dataset (Version 3). In the frame of this activity, the code has been upgraded and new retrieval parameters have been calculated.

We reprocessed the whole (A)ATSR(-1/2) archive and validate the results against SSM/I and ARSA.

The validation exercise highlight the still good quality of the new dataset.

The mean bias is about -0.15 kg/m^2 in comparison to SSM/I and -0.31 kg/m^2 with respect to ARSA

The AIRWAVE V3 dataset with 20 years of data can be used for scientific and climate studies