Total Column Water Vapour from Along Track Scanning Radiometer series: the design and application of Advanced Infra-Red Water Vapour Estimator (AIRWAVE) tool

S. Casadio [1,2], E. Castelli [3], E. Papandrea[3], B.M. Dinelli[3], A. Burini[4,2], B. Bojkov [2]

[1] Serco, Italy, [2] ESA-ESRIN, [3] ISAC-CNR, Italy, [4] Rheagroup, Belgium, Italy

Introduction

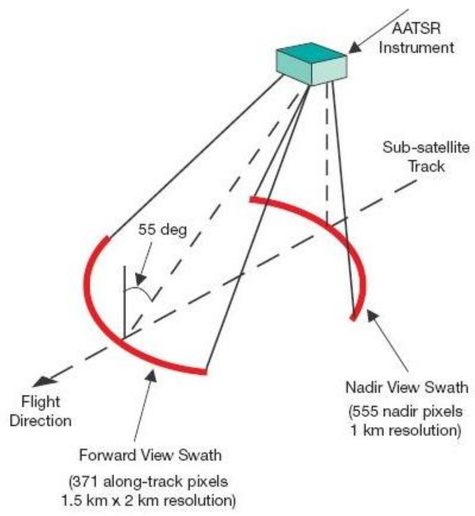
Total Column Water Vapour (TCWV) global distribution is a key parameter for climate analysis and weather monitoring. We have designed a new algorithm that enables an accurate and precise estimate TCWV using the Thermal Infra-Red (TIR) channels of all the Along Track Scanning Radiometer (ATSR) series of instruments. The new algorithm, called Advanced Infra-Red Water Vapour Estimator (AIRWAVE) has been developed in the frame of the ESA contract 'ATSR Long Term Stability (ALTS)' in the optic of a better exploitation of the (A)ATSR instruments and can be easily adapted to work with the Sea and Land Surface Temperature Radiometer (SLSTR) on board the Copernicus Sentinel 3.

AIRWAVE algorithm description

The retrieval method does not require any tuning or adjustments to independent water vapour datasets. It makes use of:

- calculations from a radiative transfer model that was specifically developed to simulate ATSR radiances;
- information on instrumental parameters;
- sea surface spectral emissivity.

The algorithm is based on the relation between the IR radiance at TOA observed by ATSR @ 11 and 12 μm and the atmospheric optical depth (mainly due to H_2O and CO_2). It assumes that TCWV is the same when using Forward and Nadir views.



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

$$\Phi_{NAD} = \frac{\ln\left(\frac{J^{\lambda_1}_{NAD_1}}{J^{\lambda_2}_{NAD_2}}\right) - E_{NAD} - \Delta\tau_{CO_2} - C}{\Delta\sigma_{NAD}}$$

radiance; emissivity; CO_2 opt. depth; constant; scaled H_2O cross section

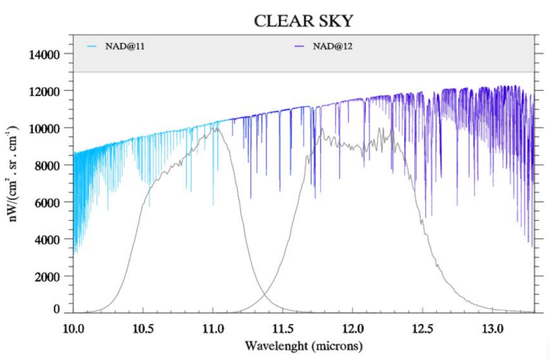
$$\alpha = \frac{1}{1 - \frac{\Delta\sigma_{FWD}}{\delta \cdot \Delta\sigma_{NAD}}} \qquad \beta = \frac{1}{1 - \frac{\delta \cdot \Delta\sigma_{NAD}}{\Delta\sigma_{FWD}}}$$

$$G_{FWD} \approx \delta \cdot G_{NAD}$$

G is the ratio between the radiance contribution at TOA given by the atmosphere and the surface.

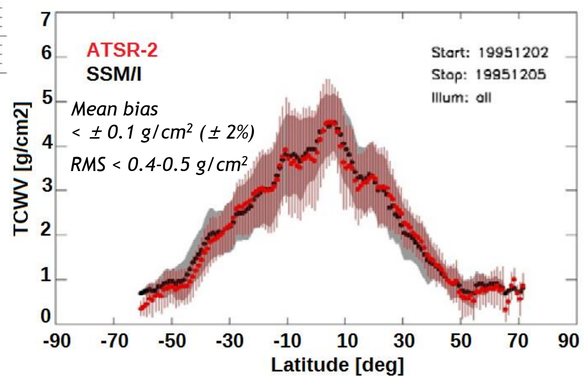
E is calculated from an emissivity database, while the other terms were obtained using a radiative transfer forward model (RTM).

The RTM was developed from the BB_Clouds MIPAS forward model and used to produce the input for the DISORT solver. High resolution spectra convoluted with ATSR filter functions to simulate BTs at 11-12 μm.



Left: clear sky spectrum for Nadir view for 11 and 12 bands. The AATSR filter functions are also showed.

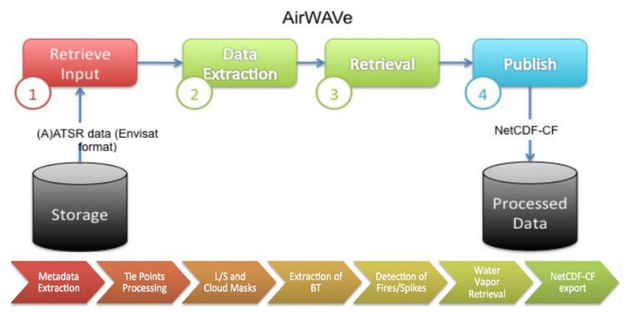
Below: SSM/I - ATSR-2 three days comparison.



Software Design and Integration into GPOD

The AIRWAVE-PP is based on Python 2.7.6 with netCDF v.4.5.3, CODA v.2.11 and HDF5 v.1.8.14 libraries enabled. The processing flow can be summarised as:

1. A query reflecting user input (time specified or full mission) is sent to the G-POD catalogue and the list of (A)ATSR files is returned by the catalogue query and retrieved from the storage.
2. The extraction of (A)ATSR L1 data in Envisat Format is performed by the reading modules of AIRWAVE. During this phase, Cloud masks and Land masks are decoded and applied to specific bands in order to select the candidates for the Water Vapour and Reflectance (TOA).



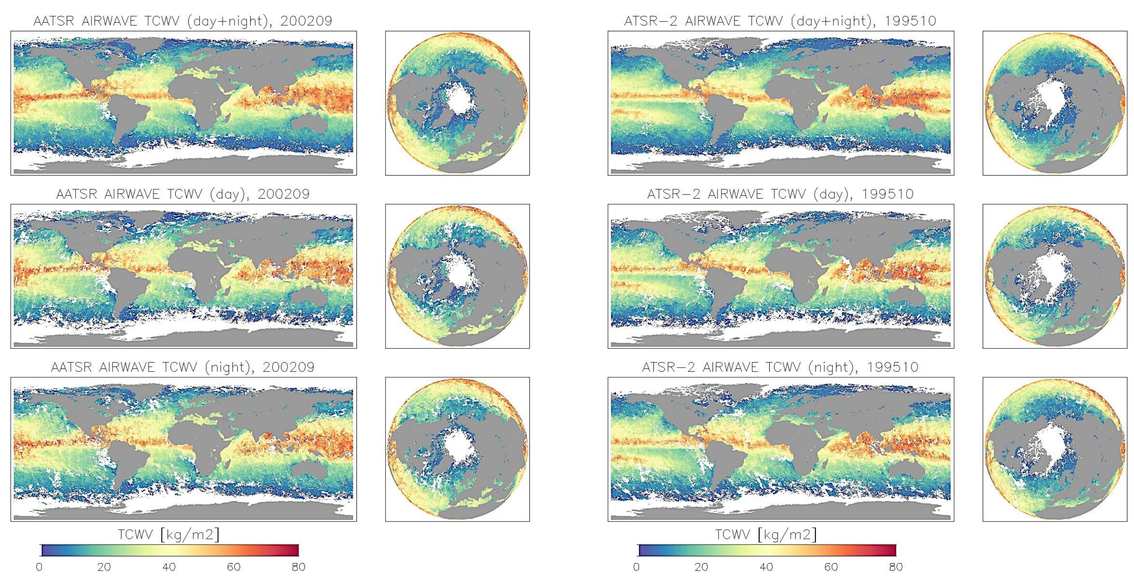
AIRWAVE-PP has been successfully integrated into GPOD and made available to users in the GPOD service portfolio. Users can trigger the AIRWAVE processor through a graphic interface a number of basic options can be selected, such as start_time and stop_time, Area of Interest, processing nodes and input dataset. The output data format is netCDF-4 with HDF-5 compression enabled. The Climate Forecast naming convention has been applied, where possible.

The bulk processing of ATSR heritage mission

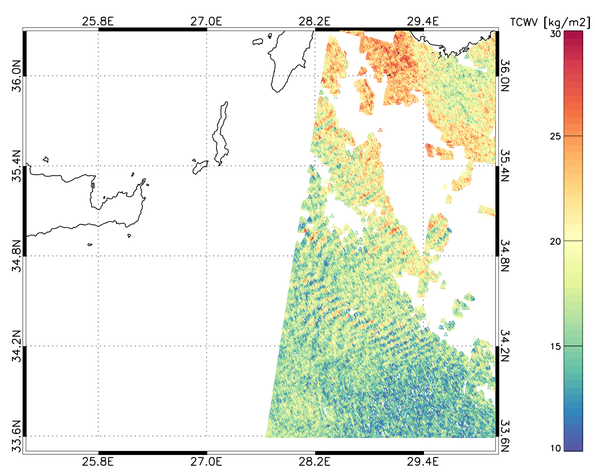
The input dataset is made of about 20 years of data with more than 80000 orbits to be processed, for the total amount of more than 50 TB of data.

With the objective of a fast and easy validation of the AIRWAVE product, a "SSMI-like" sub-product is processed at the same resolution and cell-grid of the SSMI sensor series (NOAA). The SSMI-like product cell size is 0.25x0.25 deg.

Results



Monthly Maps for the SSMI-like AIRWAVE product: Sept. 2009 AATSR (left) and Oct. 1995 ATSR-2 (right)



Karpathos, Kassos, Rhodes and the eastern side of Crete.

Left: Lee wave observed in the 15/05/2008 AIRWAVE product.

Right: 800 hPa vertical velocity simulated (Miglietta et al., Atm. Res., 102-121, 2013).

S. Casadio et al., "Total Column Water Vapor from Along Track Scanning Radiometer Series Using Thermal Infrared Dual View Measurements for Cloud Free Scenes: the Advanced Infra-Red Water Vapor Estimator (AIRWAVE) Algorithm", Remote Sensing of Environment (under review)

Stefano Casadio, Serco c/o ESA-ESRIN, Via Galilei, Frascati, Italy, stefano.casadio@esa.int