ESA DUE GlobVapour water vapour products: retrieval methods and validation

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

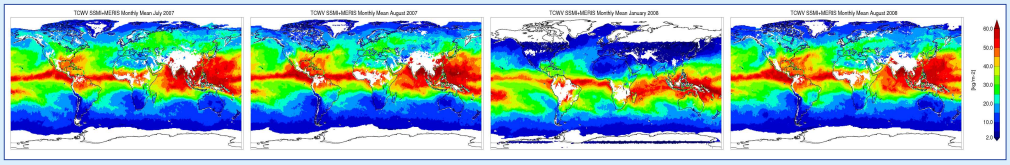
Backgroud

Combined SSM/I+MERIS data product

Product: total columnar water vapour (TCWV) daily composites and monthly means

Region: global; (0.5°)² grid

Time: 07, 08/2007 and 01, 08/2008 already available
01/2006 – 12/2008 available in June 2011



Retrieval Method

Input Data

- SSM/I level 1c data of HOAPS project from CM SAF archive
- MERIS level 1b data from FU Berlin
- MERIS cloud mask from FU Berlin

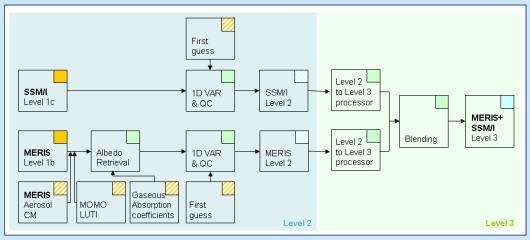


Figure 1. *Flow chart of the combined SSM/I and MERIS processor. Input data is marked orange (orange shaded: higher level input data), products are marked blue (blue shaded: instantaneous level 2 products) and software development is marked green.*

SSM/I 1D Var and Quality Control

The SSM/I 1D-Var retrieval method was developed by the Satellite Application Facility in support of Nowcasting and Very Short-Range Forecasting (NWC SAF). It solves for atmospheric temperature, atmospheric water vapour, oceanic surface wind speed and either liquid water path or total water content and requires as input atmospheric profiles (background profiles) that are spatially and temporally collocated with the satellite observations. The 1D-Var output is marked by a quality flag.

MERIS 1D-Var and Quality Check

For the MERIS water vapour product an Artificial Neural Network (ANN) developed at FUB is applied for screening clouds. Therefore a Cloud Mask (CM) is necessary. The subsequent retrieval of the vertically integrated water vapour content is based on a Newton Secant Method for the iterative matching of measurements and forward simulation above land, coast and ice/snow regions during daytime. The single scattering model is used for the efficient forward simulation.

Level 2 to Level 3 Processor

Level 2 swath-based satellite data are remapped to a global rectangular grid (level 3) with a spatial resolution of

- (0.5°)², resulting in 720 x 360 grid boxes for SSM/I
- (0.05°)², resulting in 7200 x 3600 grid boxes for MERIS

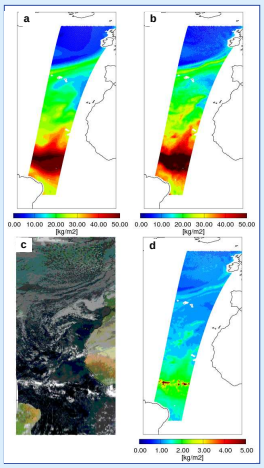
- Daily composites are generated by overwriting the grid boxes in chronologically order.
- Flags are evaluated in order to select good-quality data.
- Monthly mean and standard deviation is calculated.

Blending

The gridded level 3 MERIS and SSM/I products are blended by simply oversampling the SSM/I grid to the MERIS resolution of (0.05°)². The blended data therefore contain

- oversampled, gridded SSM/I data over open ocean
- gridded MERIS data over cloud free land and sea ice
- gridded MERIS data over sun glint, where SSM/I observations are not available.

Results and Validation



SSM/I data product

The total columnar water vapour (TCWV) was derived over ice-free ocean on a spatial resolution of 0.5°. The SSM/I retrieval uses passive microwave measurements, allowing for accurate water vapour retrievals over ocean, where the emissivity of the surface is known accurately, independent of the time of day.

The retrieval scheme applied on SSM/I data is a 1D-Var scheme using climatological profiles (or optionally ERA-Interim) as background information. The SSM/I input data are recalibrated and homogenized by CM SAF. Results of the SSM/I TCWV product are displayed (figure 2) in comparison to model data output and imaged SEVIRI data.

The high resolution of SSM/I satellite data has the advantage of localising spatial variations compared to model data.

Figure 2. *Results of the 1D-Var retrieval: TCWV as calculated from ERA-Interim data (a) and as derived with SSM/I 1D-Var scheme (b) for DMSP-F13 over the Atlantic Ocean. A pseudo-RGB image as derived from SEVIRI measurements (c) and the estimated 1D-Var retrieval uncertainty (d) are shown for the same scene.*

MERIS data product

Since the MERIS retrieval algorithm is based on measurements in the near infrared region, problems occur where the ocean is dark (very little reflection). Hence it can only be used for water vapour retrievals above land surfaces during daytime.

Due to its relatively large footprints and the significant degradation of the retrieval quality when land surface contaminates these footprint, SSM/I cannot be used for the TCWV retrieval in coastal regions. At these grid points, MERIS measurements were used to fill the gaps, accepting a higher uncertainty of the final product. Similar applies to sea ice where MERIS will be used in the combined product.

The MERIS retrieval was modified for coastal regions by applying a new multiple scattering term (figure 3).

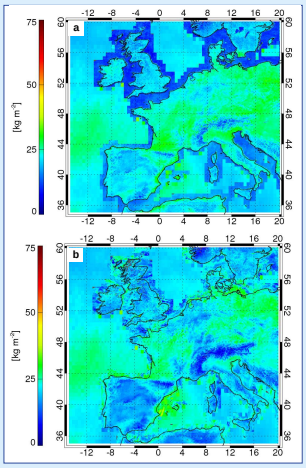


Figure 3. *Results of the MERIS retrieval: the old (a) and new (b) method is displayed for Europe. The improvement for coastal regions is clearly observable.*

Validation of the combined SSM/I+MERIS data product

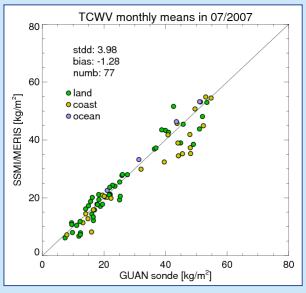
Due to these retrieval characteristics, the final product combines the excellent performances of MERIS and SSM/I water vapour retrievals over land and ocean, respectively.

The validation of the SSM/I and MERIS prototype products against ground based and satellite based TCWV monthly means shows strongly varying results (figure 4). The GUAN radiosonde data are on average more humid, with biases up to -1.7 kg/m². Against ATOVS data a similar bias is found (-1.2 kg/m²). Against AIRS data however it exhibits a positive bias of 0.6 kg/m² whereas against MODIS IR a mixed bias of -0.8 and +0.6 kg/m² for respectively the Terra and Aqua satellite is present. In comparison to MODIS NIR a bias of -0.3 kg/m² is found, which applies only to land observations.

In general, for all prototype months the SSM/I+MERIS level 3 monthly means seem dryer over sea than over land as compared to GUAN, AIRS and MODIS.

All comparisons show a relatively large bias and RMS error for the coastal segment. In particular for the GUAN validation, where the number of observations at the coast is rather large (about a third), these degraded TCWV values disturb the overall picture (figure 5 and 6). The improved MERIS data mentioned above are expected to have a large positive impact in this respect.

Figure 5. *Combined SSM/I+MERIS TCWV prototype month 07/2007 compared to data of GUAN radiosondes network separated for land, coastal and ocean regions.*



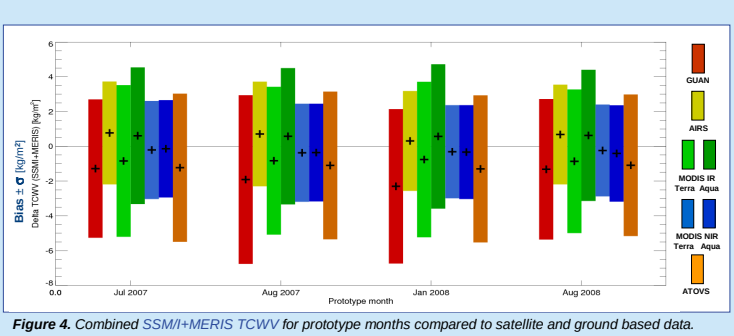


Figure 4. *Combined SSM/I+MERIS TCWV for prototype months compared to satellite and ground based data.*

Surface Type & N_obs	Bias [kg/m²] Jul 07	Aug 07	Jan 08	Aug 08	RMSE [kg/m²] Jul 07	Aug 07	Jan 08	Aug 08
Sea/Ocean 2 - 4 (Dry)	-2.1	-1.3	-3.2	-2.6	2.1	1.3	3.5	3.7
Coast 23 - 29	+3.1	+3.9	+3.9	+2.3	5.5	7.3	6.6	5.0
Land 48 - 68 (Wet)	+0.6	+1.2	+2.0	+1.2	3.5	4.1	4.2	3.8
Overall 77 - 101	-1.3	-1.9	-2.3	-1.3	4.0	4.9	4.9	4.2

Figure 6. *Combined SSM/I+MERIS TCWV prototype months compared to data of GUAN radiosondes network.*

Outlook

The GlobVapour project has following aims, in regard to the combined SSM/I+MERIS data product, for the near future:

The test products (2006 - 2008) are going to be published in June 2011.

The data will be generated with a modified processing system, which includes the modified retrieval schemes for

✓the generation of improved SSM/I data using hybrid
✓the generation of improved MERIS data in the coastal region

The validation of level 3 monthly means will be execute for the full time period (2006 - 2008) with high accuracy.

Additionally, high quality end products are aimed to be obtained by improved validation of level 2 and level 3 data.