DUE GLOBVAPOUR

Product User Guide
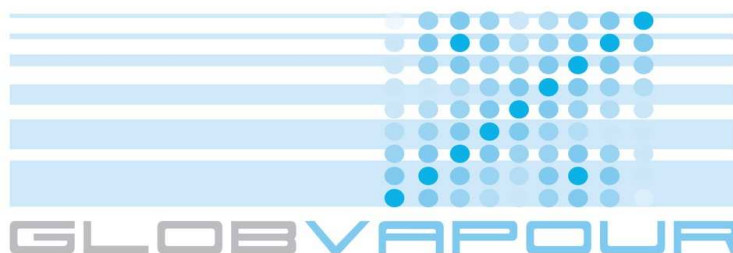
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1 Introduction

The main objective of the ESA DUE GlobVapour project, which started in December 2009 with duration of approximately 2 years, was to provide representative, global long-term coherent water vapour data sets.

The exploitation of synergic capabilities of different EO (ESA and non-ESA) missions allows improved accuracies and enhanced temporal and spatial sampling better than those provided by the single sources. It is envisaged that successful concepts from the project will ensure a sustainable provision of the expected high quality data. The quality of the end products is analysed using various ground based, in-situ and other satellite observations for validation.

The objectives of the ESA DUE GlobVapour project has been:

- ✓ Development of multi-annual global water vapour data sets inclusive error estimates based on carefully calibrated and inter-calibrated radiances.

- ✓ Validation of the water vapour products against ground based, airborne and other satellite based measurements.

- ✓ Assessment of the quality of five different IASI water vapour profile algorithms developed by the project contractors and outside groups for estimating the retrieval method quality.

- ✓ Provision of a complete processing system that can further strengthen operational production of the developed products.

The GlobVapour project provided water vapour satellite products in three phases: the Prototype Products covering 4 month in 2006-2008, released in November 2010, the Test Products covering the years 2006-2008, released in summer 2011 and the Final Products which are described in Table 1-1 with release in January 2011. The current status of this document applies to the Final Products.

Table 1-1. ESA DUE GlobVapour water vapour products.

Sensors	Product	Spatial resolution	Temporal resolution	Time period
SSM/I+MERIS (combined)	TCWV	Global SSM/I above ocean $(0.5°)^2$ MERIS above land $(0.05°)^2$ Additionally: low resolution product $(0.5°)^2$	daily composite (DC), monthly mean (MM)	2003 – 2008 daylight only
GOME/SCIA/ GOME-2	TCWV	Global $(0.5°)^2$	weekly mean (WM), MM	1996 – 2008 daylight only
AATSR	TCWV	Global $(0.05°)^2$	DC, MM	2003 – 2008 full day

The present document provides details about the instruments, retrieval and processing schemes, the validation and the limitation of each data product.

All referenced GlobVapour documents can be ordered through the GlobVapour web page (**www.globvapour.info**). A description of how to get data access and to handle the products is provided in this document.

1.1 Purpose

This document, called Product User Guide, gives an overview about the GlobVapour Final Products and explains the metadata structure as well as how to download the data.

1.2 Definitions, Acronyms and Abbreviations

AATSR	(Advanced) Along Track Scanning Radiometer
AIRS	Atmospheric Infrared Sounder
ANN	Artificial Neural Network
ARM	Atmospheric Radiation Measurement
ATBD	Algorithm Theoretical Basis Document
ATOVS	Advanced TIROS Operational Vertical Sounder
CM	Cloud Mask
CM SAF	Eumetsat SAF on Climate Monitoring
CDO	Climate Data Operators
DMSP	Defense Meteorological Satellite Programme
DWD	Deutscher Wetterdienst
ENVISAT	Environmental Satellite
ERS	European Remote-Sensing Satellite
FUB	Free University of Berlin
GEWEX	Global Energy and Water cycle Experiment
GFS	Global Forecast System
GOME	Global Ozone Monitoring Experiment on ERS-2
GOME-2	Global Ozone Monitoring Experiment on MetOp
GUAN	GCOS Upper Air Network
IR	Infrared
L1	Level 1
L2	Level 2
L3	Level 3
LCWV	Layered Column Water Vapour
LST	Local Solar Time
MERIS	Medium-Resolution Imaging Spectrometer
MODIS	Moderate-Resolution Imaging Spectroradiometer
NIR	Near-Infrared
NWC SAF	Eumetsat SAF on Nowcasting and Very Short-Range Forecasting
O3M SAF	Eumetsat SAF on Ozone and Atmospheric Chemistry Monitoring
RMSE	Root Mean Square Error
RTM	Radiative Transfer Model
SAF	Satellite Application Facility
SCIAMACHY	Scanning Imaging Absorption spectroMeter for Atmospheric CHartography

SSM/I   Special Sensor Microwave/Imager

SSMIS   Special Sensor Microwave Imager and Sounder

SST   Sea Surface Temperature

TB   Brightness Temperature

TCWV   Total Column Water Vapour

TIR   Thermal Infrared

TPW   Total Precipitable Water

1.3 Applicable Documents

[AD-1]   DUE GLOBVAPOUR Technical Specification Document (TSD), issue 1, revision 0, dated 16 April 2010.

1.4 Reference Documents

[RD-1]   DUE GLOBVAPOUR Algorithm Theoretical Basis Document (ATBD) for L2 SSMI, issue 3, revision 0, dated 19 January 2012.

[RD-2]   DUE GLOBVAPOUR Algorithm Theoretical Basis Document (ATBD) for L2 MERIS, issue 3, revision 0, dated 19 January 2012.

[RD-3]   DUE GLOBVAPOUR Algorithm Theoretical Basis Document (ATBD) for L3 Combined SSM/I+MERIS, issue 3, revision 0, dated 19 January 2012.

[RD-4]   DUE GLOBVAPOUR Algorithm Theoretical Basis Document (ATBD) for L2 and L3 GOME+SCIAMACHY, issue 3, revision 0, dated 19 January 2012.

[RD-5]   DUE GLOBVAPOUR Metadata Definition, issue 2, revision 0, dated 19 January 2012.

[RD-6]   DUE GLOBVAPOUR Filename Convention, issue 2, revision 0, dated 19 January 2012.

[RD-7]   NetCDF-CF website (http://cf-pcmdi.llnl.gov/).

[RD-8]   Andersson, A., K. Fennig, C. Klepp, S. Bakan, H. Graßl, and J. Schulz, 2010:
          The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data - HOAPS-3, Earth Syst. Sci. Data, 2, 215-234, doi:10.5194/essd-2-215-2010.

[RD-9]   Andersson, A., C. Klepp, K. Fennig, S. Bakan, H. Graßl, and J. Schulz, 2011:
          Evaluation of HOAPS-3 ocean surface freshwater flux components, Journal of Applied Meteorology and Climatology, 50, 379-398, doi:10.1175/2010JAMC2341.1.

[RD-10]   Andersson, A., C. Klepp, K. Fennig, S. Bakan, H. Grassl, and J. Schulz, 2009: The HOAPS climatology: Essential water cycle components over global oceans derived from satellite data. Accepted by J. Appl. Met. Clim.

[RD-11]   DUE GLOBVAPOUR Product Validation Report (PVR) for GOME/SCIAMACHY/GOME-2, issue 3, revision 0, dated 19 January 2012.

[RD-12]   DUE GLOBVAPOUR Product Validation Report (PVR) for SSM/I+MERIS, issue 3, revision 0, dated 19 January 2012.

[RD-13]   Loyola, D. G., N. Hao, M. Rix, S. Slijkhuis, P. Valks, 2011: Algorithm Theoretical Basis Document for GOME-2 Total Column Products of Ozone, Minor Trace Gases,

and Cloud Properties. DLR/GOME-2/ATBD/01, Iss.2/E.

[RD-14]   Kalakoski, N., T. Wagner, K. Mies, S. Beirle, S.Slijkhuis, D. Loyola (2011) O3M SAF Validation Report, O3M-12, Offline Total Water Vapour, SAF/O3M/FMI/VR/H2O/111

[RD-15]   CDO reference card (https://code.zmaw.de/files/cdo/html/1.5.1/cdo_refcard.pdf)

[RD-16]   DUE GLOBVAPOUR Algorithm Theoretical Basis Document (ATBD) for L2 and L3 (A)ATSR, issue 1, revision 0, dated 19 January 2012.

[RD-17]   NCVIEW home page (http://meteora.ucsd.edu/~pierce/ncview_home_page.html)

[RD-18]   DUE GLOBVAPOUR Technical Note, Validation of AATSR, issue 1, revision 0, dated 12 August 2011.

1.5 Structure of the Document

In section 2, the GlobVapour SSM/I+MERIS based product are described. Section 3 gives a description of the GlobVapour GOME-SCIAMACHY-GOME-2 based data set. The (A)ATSR product is described in section 4. Each section contains information on the instruments used, the retrieval scheme, the validation results and the limitations of the product.

The data description is presented in section 5 and in section 6 it is described how to access the GlobVapour data products. The appendix contents an example of a GlobVapour NetCDF file as well as tables for the explanation of the file name convention.

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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

2   SSM/I+MERIS Based Products

2.1   Product Definition

The combined SSM/I+MERIS total columnar water vapour (TCWV) data product was derived on a global grid over ocean and cloud free land, with a spatial resolution of 0.5° over ice-free ocean (SSM/I) and 0.05° over land and coastal ocean (MERIS). The resulting SSM/I+MERIS L3 products are defined on a rectangular (0.05 x 0.05)° grid and stored in NetCDF files that are fully compliant with the NetCDF Climate Forecast convention. Note that the SSM/I observations are oversampled and that the data set contains daylight observations only.

In order to ease utilisation the SSM/I+MERIS product is distributed on a 0.5°x0.5° grid, with the MERIS product being averaged to match the lower spatial resolution. On request, the project provides the 0.05°x0.05° spatial resolution product. Also, on request the product can be provided with a cloud mask applied to the SSM/I data.

Ocean area with sun glint, where SSM/I observations are not available, is blended with gridded MERIS data. The water vapour of the atmosphere is vertically integrated in a column from surface to 200 hPa, and given in units of kg/m². Both, the SSM/I and MERIS data streams are processed independently and combined afterwards to fit comprise composites and monthly means.

The final products utilise SSM/I data onboard two satellites from the Defense Meteorological Satellite Program (DMSP), namely F13 and F14, for the period 2003 to 2008. Due to a lack of data, the period from August until December only contains F13 data. The SSM/I L2 data set contains descending data which is closer to the overpass times of ENVISAT with MERIS on board (10 am local time). It is based on homogenised L1 data, which provides SSM/I swath-based information on (a.o.) brightness temperature, for four frequencies and for horizontal and vertical polarization (Anderson, 2010).

The MERIS data used for the processing of the final products stems from the 3rd reprocessing of the MERIS L1 archive. The TCWV retrieval is applied to swath-based, normalized radiances in MERIS bands 13, 14 and 15 at 865 nm, 885 nm and 900 nm, respectively, while the cloud screening procedure utilises the full set of MERIS radiances between 400 and 900 nm.

2.2   Instruments and Retrievals

The Special Sensor Microwave Imager (SSM/I) is a linearly polarized passive microwave radiometer system using a conical scanner with a scan angle (satellite view angle with respect to nadir) of ~45°, which corresponds to an earth incidence angle of ~53°. The instrument measures at seven channels on four frequencies (19.35, 22.235, 37.0 and 85.5 GHz). The SSM/I is located onboard the DMSP Satellites. The satellites used for the processing (F13 and F14) have a descending equator crossing time at around 6 and 7 am. Only the descending orbit of SSM/I data is used, because of the temporal time closeness to MERIS.

The retrieval scheme applied on SSM/I full spectrum is a 1D-Var scheme using ERA-Interim and climatological profiles that are spatially and temporally collocated with the satellite observations as background information. The 1D-Var scheme was developed by the Satellite Application Facility for Numerical Weather Prediction (NWP SAF). It solves for atmospheric temperature, atmospheric water vapour, oceanic surface wind speed and either liquid water path or total water content. The 1D-Var output contains a quality flag. The SSM/I input data are recalibrated and homogenized by the SAF on Climate Monitoring (CM SAF).

The MEdium Resolution Imaging Spectrometer (MERIS) is a wide field-of-view imaging pushbroom spectrometer, providing measurements in 15 spectral channels between 400 and 900 nm. The spatial resolution in the reduced resolution mode is (1x1) km and the swath width is

roughly 1150 km. ENVISAT is flying in a sun-synchronous orbit, with a constant equator crossing time of 10:00 LST at descending node.

For the MERIS water vapour product an Artificial Neural Network (ANN) developed at FUB is applied for screening clouds. 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 source of information about TCWV provided by MERIS is the approximated water vapour transmittance in the $\rho\sigma\tau$ absorption band at 900nm. In order to efficiently perform the simulation of the MERIS measurements, the ratio of MERIS bands 14 and 15 is simulated as the ratio of atmospheric transmittance along the light path, corrected for atmospheric scattering at molecules and aerosols.

Detailed information about the L2 retrieval methods for SSM/I and MERIS can be found in the GlobVapour L2 ATBDs (SSM/I: [RD-1], MERIS: [RD-2]).

2.3 Processing Scheme

A processing system for the merged SSM/I+MERIS data product has been developed within the GlobVapour project. It utilises SSM/I L1c and MERIS L1b data to generate a merged SSM/I+MERIS L3 dataset. The retrieval methods for both input data are applied independently. A L2toL3 processor associated to each dataset is responsible to remap the swath-based (L2 SSM/I and MERIS) output data of step one to a global rectangular grid (L3). Daily composites are generated by *overwriting* the grid boxes in chronological order. In this process quality flags are evaluated. Monthly mean and standard deviation is calculated.

The last step is the merging of both L3 datasets (SSM/I: 720 x 360 grid boxes, MERIS: 7200 x 3600) to daily composites and monthly means as the final product with a sampling of 7200 x 3600 grid boxes. Since MERIS provides data only during daytime with a fixed equator crossing time at 10:00 LST, the SSM/I products are created from morning overpasses only as well, in order to provide a consistent combined data set. Also, there are two L2 SSM/I data sets existing: a clear-sky only product (LWP $\leq$ 0.3 kg/m^2) and a all sky product. Both products will be combined with the IR MERIS cloud-free product. The official GlobVapour final product will be the all sky product. The clear sky product can be delivered on request. The two L3 data sources, TCWV from SSM/I above ice-free ocean and MERIS above cloud-free land and sea ice, are eventually merged by oversampling the SSM/I data to the higher MERIS resolution of (0.05)$^\circ$. An additional combined SSM/I+MERIS product with lower resolution (0.5 x 0.5°) is available, too.

The combined SSMI+MERIS data set contain the following variables:

tcwv_bg	Background of the TCWV retrieval, unit: kg/m^2
tcwv_res	TCWV retrieval of SSM/I or MERIS, unit: kg/m^2
tcwv_err	TCWV retrieval error of SSM/I or MERIS, unit: kg/m^2
tcwv_stddev	Standard deviation of the retrieved TCWV, unit: kg/m^2
nobs	Number of observations
flag	GlobVapour Surface Mask 0: land, 1: ocean, 2: clouds, 3: ssmi_scattering, 4: sea_ice, 5: coast, 6: sun_glint, 7: partly_cloudy, 8: partly_sea_ice, 9: 7_and_8_mixed, 99: miss

The SSM/I+MERIS processing scheme is described in detail in the ATBDs for SSM/I L2 [RD-1], MERIS L2 [RD-2], and SSMI+MERIS L3 [RD-3].

2.4 Validation

GlobVapour total columnar water vapour (TCWV) SSM/I+MERIS products have been validated for the final period 2003–2008, using ground-based measurements (radiosonde and microwave radiometer). In addition, inter-comparisons with other satellite-based measurements such as from AIRS (Table 2-1) and ATOVS (Table 2-2) have been proceeded, as well with ground-based measurements, e.g. GUAN radiosonde data (Table 2-3). Comparable to the test product validation, AIRS is used with an applied cloud-mask versus the GlobVapour final products. The comparison versus GUAN above ocean is not reliable because of too few observations.

Comparing SSM/I+MERIS with over land and coastal regions shows a small dry bias over coast (Table 2-3). ATOVS and AIRS show a dry bias for all scenes, being smallest over ocean for ATOVS and smallest over land for AIRS, by reason of the applied AIRS cloud-mask. Versus all validation data sets, SSM/I+MERIS is consistently drier.

Validation method and detailed results can be found in the PVR [RD-12].

Table 2-1: Overall mean intercomparison results for SSMI+MERIS versus AIRS for the final phase (2003-2008).

Surface Type	Valid grid fraction (%)	Bias (kg/m^2)	RMSE (kg/m^2)
Sea/Ocean	17.3 ± 2.0	-(0.66 ± 0.21)	2.29 ± 0.15
Coast	2.7 ± 0.7	-(1.05 ± 0.25)	3.20 ± 0.33
Land	9.7 ± 1.4	-(0.16 ± 0.22)	2.26 ± 0.11

Table 2-2: Overall mean intercomparison results for SSMI+MERIS versus ATOVS for the final phase (2004-2008).

Surface Type	Valid grid fraction (%)	Bias (kg/m^2)	RMSE (kg/m^2)
Sea/Ocean	46.3 ± 1.6	-(0.42 ± 0.37)	2.18 ± 0.21
Coast	8.9 ± 1.3	-(1.09 ± 0.31)	5.07 ± 0.54
Land	18.7 ± 1.5	-(1.05 ± 0.29)	4.75 ± 0.40

Table 2-3: Overall mean intercomparison results for SSMI+MERIS versus GUAN for the final phase (2003-2008).

Surface Type	N_obs	Bias (kg/m^2)	RMSE (kg/m^2)
Sea/Ocean	1.7 ± 1.2	+(1.34 ± 1.48)	1.85 ± 1.60
Coast	12.7 ± 2.7	-(0.47 ± 1.2)	4.27 ± 1.19
Land	34.1 ± 5.2	-(1.27 ± 0.8)	3.93 ± 0.66

2.5 Limitations

The SSM/I+MERIS data set is a morning-only climatology above land and a daytime-only climatology above ocean. There is no correction of the diurnal cycle effect on the retrieved water vapour.

Above ocean, the actual spatial resolution of the L3 products is (0.5 x 0.5)°, while it is (0.05 x 0.05)° above land. In order to provide both data sources within the highly resolved grid, the ocean data is oversampled by a factor of 10.

Neither SSM/I nor MERIS provide reliable estimates of TCWV above ocean in coastal regions. In case of MERIS, this is due to the weak reflectance of the ocean in the near infrared and the resulting uncertainty introduced by the unknown contribution of aerosol scattering and absorption to the signal. In case of SSM/I, the measurements cannot be used in case the relatively large footprint is contaminated by land.

The quality of the MERIS TCWV retrieval is unknown over mountainous and/or ice-covered areas due to uncertainties in cloud detection.

A further restriction arises from the fact that the MERIS retrieval algorithm relies on measurements in the visible channels. For this reason, the TCWV is retrieved from MERIS daytime overpasses over land only.

Another limitation is that the MERIS level 2 water vapour products should only be generated under clear sky conditions. The achieved retrieval accuracy therefore depends to considerable extent on the accuracy of the cloud mask used. The filling of cloud gaps is an unresolved issue. Studies on the so called clear sky bias indicate that cloudy areas should not be filled with values from neighbouring clear sky pixels.

Another issue, not dealt with in this document, is the homogenisation of the radiance time series. The SSM/I time series relies on existing homogenisations, and MERIS stability is not considered as critical due to the relatively short length of the time series.

3 GOME/SCIAMACHY/GOME-2 Based Products

3.1 Instruments and Retrievals

The GOME/SCIAMACHY/GOME-2 family of instruments are nadir-looking spectrometers operating in the UV/VIS/near-IR wavelength region (SCIAMACHY has more extended capabilities as well, which are not considered here). For the retrieval of H_2O, a spectral window around the H_2O absorption lines near 630 nm is used. The retrieval can be employed both over ocean and over land surfaces. The properties of the various instruments are summarised in Table 3-1.

Table 3-1: Satellite instrument properties.

Parameter	GOME	SCIAMACHY	GOME-2
Data Availability	06/1995 – today [1]	07/2002 - today	01/2007 - today
Spectral resolution at 630 nm	0.35 nm	0.4 nm	0.5 nm
Ground Pixel size	320 x 40 km^2	60 x 30 km^2	40 x 80 km^2
Swath Width	960 km	960 km	1920 km
Equator crossing local time	10:30 a.m.	10:00 a.m.	9:30 a.m.
Global Coverage	3 days [1]	6 days	almost daily

[1] no global coverage since June 2003

Detailed information about the L2 retrieval method for GOME-2 can be found in the O3M SAF L2 ATBD [RD-11]. The same algorithms are used for the processing of GOME and SCIAMACHY data at DLR, for details see the GlobVapour ATBD for L2 and L3 [RD-4].

The merged GOME/SCIAMACHY/GOME-2 H_2O data product is available on 720 x 360 grid boxes of 0.5^o x 0.5^o each. The Level 3 dataset is developed for climatological purposes; Level 3 products are available as weekly and monthly means.

3.2 Processing Scheme

The L2 data are remapped on a rectangular grid and averaged in monthly means. The adjustment of the data from the various instruments is in detail described in the ATBD for GOME+SCIAMACHY+GOME2 L2 and L3 [RD-4].

The final data set contains data from the GOME-1 instrument for 1996 to 2002, from the SCIAMACHY instrument for 2003 to 2006 and from the GOME-2 instrument for 2007 and 2008.

The combined GOME/SCIAMACHY/GOME-2 data set contain the following variables:

tcwv_res	TCWV retrieval, unit: kg/m²
tcwv_err	TCWV error
tcwv_stddev	Standard deviation of the retrieved TCWV, unit: kg/m²
nobs	Number of observations
flag	GlobVapour Surface Mask 0: nobs_low, 1: nobs_normal, 2: nobs_high

3.3 Validation

The homogenised GlobVapour total columnar water vapour (TCWV) GOME/SCIA/GOME-2 products have been validated for the final period 1996–2008, using ground-based measurements (radiosonde and microwave radiometer). In addition, inter-comparisons with other satellite-based measurements such as from AIRS (Table 3-2) and ATOVS (Table 3-3) have been proceeded, as well with ground-based measurements, e.g. GUAN radiosonde data (Table 3-4). Comparable to the test product validation, AIRS is used with an applied cloud-mask versus the GlobVapour final products. The comparison versus GUAN above ocean is not reliable because of too few observations.

The GOME products against GUAN radiosondes show a slight dry bias for all scenes, being lowest over sea and highest over land (Table 3-4). A similar picture is found against ATOVS. Versus AIRS, a wet bias is evident over all scenes.

Validation method and detailed results can be found in the PVR [RD-12].

Table 3-2: Overall mean intercomparison results for SCIAMACHY and GOME-2 versus AIRS for the final phase (2003-2008).

Surface Type	Valid grid fraction (%)	Bias (kg/m²)	RMSE (kg/m²)
Sea/Ocean	37.3 ± 14.0	+(2.15 ± 0.74)	5.33 ± 1.10
Coast	9.2 ± 3.1	+(1.67 ± 0.71)	4.48 ± 1.16
Land	14.6 ± 3.8	+(0.16 ± 0.44)	4.06 ± 1.04

Table 3-3: Overall mean intercomparison results for SCIAMACHY and GOME-2 versus ATOVS for the final phase (2004-2008).

Surface Type	Valid grid fraction (%)	Bias (kg/m^2)	RMSE (kg/m^2)
Sea/Ocean	47.4 ± 3.7	+(0.37 ± 0.97)	4.92 ± 0.99
Coast	11.4 ± 1.5	-(0.11 ± 0.67)	4.54 ± 0.76
Land	17.8 ± 1.3	-(2.92 ± 0.68)	5.75 ± 0.75

Table 3-4: Overall mean intercomparison results for SCIAMACHY and GOME-2 versus GUAN for the final phase (2003-2008).

Surface Type	N_obs	Bias (kg/m^2)	RMSE (kg/m^2)
Sea/Ocean	14.6 ± 7.9	-(0.45 ± 1.80)	3.85 ± 1.39
Coast	13.1 ± 11.8	-(1.10 ± 1.35)	4.01 ± 1.56
Land	43.9 ± 16.5	-(0.72 ± 1.10)	4.91 ± 0.77

3.4 Limitation

The GOME/SCIAMACHY/GOME-2 data set is a morning-only climatology (between 9:30 and 10:30 local time) above land and ocean. There is no correction of the diurnal cycle effect on the retrieved water vapour.

The spatial resolution of the different sensors ranges from 320 x 40km² (GOME-1) to 30 x 60 km² (SCIAMACHY) and 80x40km² (GOME-2). The merged GOME/SCIAMACHY/GOME-2 H$_2$O data product is available on 720 x 360 grid boxes of 0.5^o x 0.5^o each.

The L2 data used for this product have been generated for climatological purposes, with a minimum of external data and modelling assumptions. This may lead to larger errors for individual measurements, but provides a dataset independent of other instruments and/or NWP models.

Cloud shielding may yield lower TCWV. A cloud screening algorithm is applied, nevertheless the data may contain a cloud bias, to be characterised in validation. High mountains peaks, as in Himalaya and Andes, cause artefacts in the dataset. An extensive geophysical validation of GOME-2 Level 2 data is given in the O3M SAF validation report [RD-10]. Especially in regions with persistent cloud cover, the number of observations might be small.

For measurements in the Arctic, taken at high solar zenith angles, the overpass time may be shifted to earlier (starting from sunrise); for measurements taken at high solar zenith angle in the Antarctic, time may be later (ending at sunset). The transition from sunrise to 9:30 occurs very rapidly; in the regridded data this is averaged with data at nominal local time. A similar approach is applied to sunset data.

Sunglint may occur over ocean in the tropical regions. The present retrieval method of TCWV does not correct for sunglint. Especially GOME-2, with its broad swath width, experiences more Sunglint than the other instruments do. Sunglint is expected to cause an overestimation of the GOME-2 TCWV.

4 Data Description

4.1 File Format

The ESA DUE GlobVapour data products (L3) undertake grid-based global data with updated GlobVapour metadata information in NetCDF format following the CF-1.4 standard for daily composites as well as weekly or monthly means. Each file provides the following variables: TCWV, TCWV error, quality flag, with the unit kg/m^2 and number of observations. More details, in particular on global attributes, are given in the appendix.

4.2 Filename Convention

For all L3 GlobVapour products, the following file naming convention applies (1. general composition for internal use, with exemplary filename / 2. general composition for external use, with exemplary filename):

1. <INSTR>_<PROC_LEVEL>_<TYPE>_<SAT>_<VAL_TIME>_<PROC_MODE>_<PROC_TIME>
    e.g. SSMI_MERIS_L3_MM_xxx_20070701000000_E_20110504182450.nc

2. GV_<INSTR>_<TYPE>_<VAL_TIME>_<PROC_MODE>_<VERSION>

    e.g. GV_GOMExxxxxxx_WM_20070102_P_1.nc

The first example file contains monthly means of the GlobVapour combined SSM/I and MERIS product for July 2007. It is a final end product, pointed by the 'E' at the PROC_MODE place holder. The second example file contains a weekly mean of the GlobVapour GOME/SCIA/GOME-2 data product for a week in July 2007. The 'P' pointed it as a prototype product, version 1. Non-relevant or empty fields are crossed out with 'x'. The data products with an external filename are generated by the processing system and are available on the ftp server. The L2toL3 data processors have adopted the internal filename convention for internal use.

The mapping to the metadata attributes is also indicated in A2 in Table 0-1 and Table 0-2. More details about the filename convention can be found in the 'Metadata Definition' [RD-5]. Note in this respect that the filename itself is also included as metadata attribute.

Specific information can be gained through the document 'Filename convention' [RD-6] and the tables in the Appendix.

5 Data Access

User services are provided through the ESA DUE GlobVapour web page www.globvapour.info. The user service is managed by the *User Help Desk*, responsible for data requests and technical support. The project web page provides information and documentations about ESA DUE GlobVapour project and its products.

5.1 User Registration and Login

To get data access go to the projects web page, select the button *Products* then scroll to section *Data Access (FTP)*, click [HERE] (Figure 5-1) and register as a User (Figure 5-2).

Figure 5-1. ESA DUE GlobVapour web page.

After filling out the registration form select the button *Register*. This finalises the registration process. You will receive an email with the identifying information to login the ftp server (ftp-cmsaf.dwd.de) via the button on the GlobVapour project page (Figure 5-3).

If the user condition is accepted (Figure 5-3), you would have admission to the ESA DUE GlobVapour data products (Figure 5-4). You are invited to browse the product catalogue, check the data availability and download the data free of charge for scientific purposes.
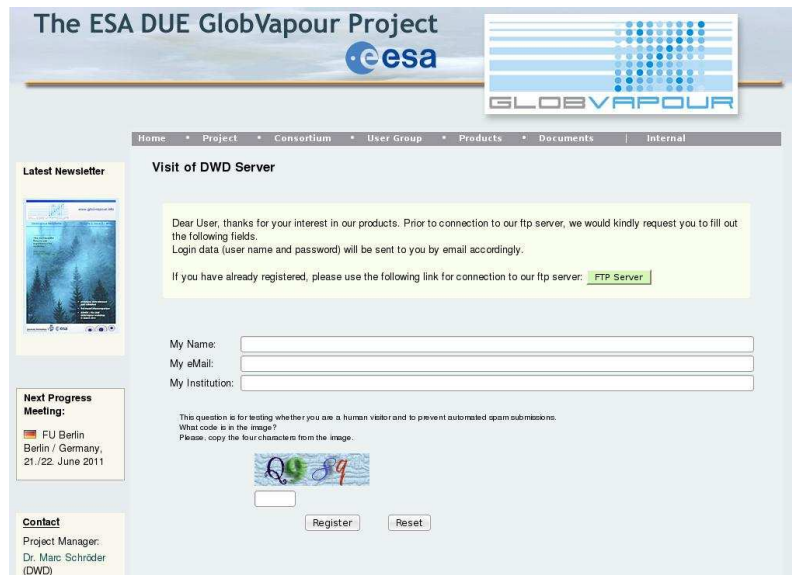
Figure 5-2. ESA DUE GlobVapour data user registration.

Figure 5-3. Copyright note for data use.

5.2 Browse Product Catalogue

The product catalogue is given by the ftp directory structure. Subfolders are available for the data products from AATSR ("/AATSR"), GOME/SCIAMACHY/GOME2 ("/GOME_SCIA_GOME2") and SSMI+MERIS ("/SSMI_MERIS") displayed in Figure 5-4. For the final period (SSMI+MERIS: 2003-2008 and GOME/SCIA/GOME-2: 1996-2008), the SSMI+MERIS data product is available in monthly means (MM) and daily composites (DC), weekly means (WM) and monthly means (MM) are available for GOME/SCIA/GOME-2. An example of the data structure for July 2007 is displayed in Figure 5-7.

Index von ftp://ftp-cmsaf-projects.dwd.de/ESA_GlobVapour/External/Products/

⬆ In den übergeordneten Ordner wechseln

Name	Größe	Zuletzt verändert
📁 AATSR		17.11.2011 09:55:00
📁 GOME_SCIA_GOME2		09.02.2012 16:24:00
📁 SSMI_MERIS		09.02.2012 16:30:00

Figure 5-4. ESA DUE GlobVapour product catalogue: three products are available on ftp server provided by DWD.

For completeness and traceability, the prototype products, test product and final products are available from the ftp server, located in subfolders "/prototype_products", "/test_products" and "/final_products" (Figure 5-5).

The data are available with a spatial resolution of 0.5° per grid box. High resolution data of the combined SSMI+MERIS product (SSMI: 0.5°, MERIS: 0.05°) are available on request. Also, only the SSMI+MERIS product without a cloud-mask for SSMI (marked with 'NO') can be find online. The combined product with a SSMI clear-sky data set (marked with 'CM') is available on request as well (Figure 5-6).

Index von ftp://ftp-cmsaf-projects.dwd.de/ESA_GlobVapour/External/Products/SSMI_MERIS/

⬆ In den übergeordneten Ordner wechseln

Name	Größe	Zuletzt verändert
📁 final_products		10.02.2012 17:17:00
📁 prototype_products		09.02.2012 16:26:00
📁 test_products		09.02.2012 16:25:00

Figure 5-5. ESA DUE GlobVapour product catalogue: up to three versions are available for each GlobVapour product.

Index von ftp://ftp-cmsaf-projects.dwd.de/ESA_GlobVapour/External/Products/SSMI_MERIS/final_products/NO/

⬆ In den übergeordneten Ordner wechseln

Name	Größe	Zuletzt verändert
📁 hires		14.02.2012 17:30:00
📁 lores		10.02.2012 17:44:00

Figure 5-6. ESA DUE GlobVapour product catalogue: the combined SSMI+MERIS product is available with two spatial resolutions (lores: 0.5° global and hires: 0.05° land, 0.5° ocean). There is only one exemplary month in hires online. The whole dataset of the final period can be deliver in high resolution on request.

Figure 5-7. ESA DUE GlobVapour product catalogue for the SSMI+MERIS lores (0.5°) product (07/2007). The filename convention for external filenames explains the name structure.

5.3 Data Handling

Since the GlobVapour data products are following the NetCDF CF-1.4 convention, the handling of the data is easy with official data tools, e.g. Climate Data Operators (CDO).

An overview, the documentation and several tutorials of the handling of CDOs can be find on its web page (https://code.zmaw.de/projects/cdo). The reference card [RD-14] is highly recommended.

Some examples:

`cdo info FNAME`	Dataset information is listed by parameter identifier
`cdo sellonlatbox,lon1,lon2,lat1,lat2 IFNAME OFNAME`	Select a lon/lat box
`cdo pardes FNAME`	Show parameter description
`cdo griddes FNAME`	Show grid description

`ncview` is quick option to display the data graphically. Detailed descriptions about NCVIEW can be found on its web page [RD-15].

5.4 User Feedback

Users of ESA DUE GlobVapour products and services are encouraged to provide feedback. Therefore, users can either contact the GlobVapour *User Help Desk*. Please go to the GlobVapour web page (www.globvapour.info) or send an email to marc.schroeder@dwd.de.

Appendix

A.1 Example of a GlobVapour NetCDF File

In this file, the field Total Column Water Vapour (TCWV) has been defined as NetCDF element 'tcwv', which in turn is declared as standard_name 'atmosphere_water_vapor_content'. The TCWV standard error is defined with this standard_name as well. A quality flag per grid point is implemented. The filename follows a precise file-naming convention. The grid resolution is consistent with the (lat, lon) grid dimensions. Note that, as reflected in the latitude/longitude vectors, the central grid point co-ordinates are used. A final product generated using 'ncgen' with the ASCII template as below has a size of about 2.6 MB.

The example shows the header of a GlobVapour SSMI+MERIS TCWV monthly mean for 01/2008.

```
netcdf SSMI_MERIS_L3_MM_xxx_20080101000000_E_20111122050527 {

dimensions:

        time = UNLIMITED ; // (1 currently)
        lon = 7200 ;
        lat = 3600 ;
variables:

    int time(time) ;
            time:long_name = "time" ;
            time:calender = "standard" ;
            time:units = "days since 1996-01-01 00:00:00" ;
    float lon(lon) ;
            lon:long_name = "longitude" ;
            lon:units = "degrees_east" ;
            lon:standard_name = "longitude" ;
    float lat(lat) ;
            lat:long_name = "latitude" ;
            lat:units = "degrees_north" ;
            lat:standard_name = "latitude" ;
    float tcwv_bg(time, lat, lon) ;
            tcwv_bg:long_name = "Total Column Water Vapour Background"
;
            tcwv_bg:units = "kg m-2" ;
            tcwv_bg:standard_name = "atmosphere_water_vapor_content" ;
            tcwv_bg:_FillValue = -999.f ;
    float tcwv_res(time, lat, lon) ;
            tcwv_res:long_name = "Total Column Water Vapour" ;
            tcwv_res:units = "kg m-2" ;
            tcwv_res:standard_name = "atmosphere_water_vapor_content"
;
            tcwv_res:_FillValue = -999.f ;
    float tcwv_err(time, lat, lon) ;
            tcwv_err:long_name = "Total Column Water Vapour Standard
Deviation" ;
             tcwv_err:units = "kg m-2" ;
             tcwv_err:standard_name = "atmosphere_water_vapor_content"
;
             tcwv_err:_FillValue = -999.f ;
      float tcwv_stddev(time, lat, lon) ;
             tcwv_stddev:long_name = "Total Column Water Vapour
Standard Deviation" ;
```

```
                tcwv_stddev:units = "kg m-2" ;
                tcwv_stddev:standard_name =
"atmosphere_water_vapor_content" ;
                tcwv_stddev:_FillValue = -999.f ;
        int nobs(time, lat, lon) ;
                nobs:long_name = "Number of Observations" ;
                nobs:units = "1" ;
                nobs:_FillValue = -999 ;
        byte flag(time, lat, lon) ;
                flag:long_name = "GlobVapour Flag" ;
                flag:units = "1" ;
                flag:_FillValue = 99b ;
                flag:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b
;
                flag:flag_meanings = "land ocean clouds ssmi_scattering
sea_ice coast sun_glint partly_cloudy partly_sea_ice 7_and_8_mixed" ;
// global attributes:
                :Conventions = "CF-1.4" ;
                :format = "3.63" ;
                :filename =
"SSMI_MERIS_L3_MM_xxx_20080101000000_E_20111122050527.nc" ;
                :timestamp = "20111122050527" ;
                :history = "created on 2011-11-22 05:05:27 UTC" ;
                :institution = "Freie Universitaet Berlin / Deutscher
Wetterdienst" ;
                :filetype = "product" ;
                :title = "GlobVapour - Total Column Water Vapour monthly
mean from SSMI+MERIS" ;
                :parameter = "TCWV" ;
                :validity = "20080101000000" ;
                :source = "satellite observations" ;
                :spatial = "0.05" ;
                :temporal = "monthly" ;
                :version = "1.00" ;
                :references = "GlobVapour web site (www.globvapour.info)"
                :comment = "cloud and daytime only product (SSM/I),
clear-sky and daytime only product (MERIS), validated" ;
                :level = "L3" ;
                :processor = "GlobVapour TCWV SSM/I L2: 1DVAR v2.0
operated in hybrid mode; SSM/I L3: v2.1; MERIS L2: v1.1; MERIS MM: v1.1;
SSM/I+MERIS: v1.1" ;
                :projection = "rectangular grid" ;
                :selection = "descending orbits" ;
                :instrument = "SSM/I-MERIS" ;
                :sat_series = "DMSP-ENVISAT" ;
                :sat_id = "F14+F13, ENV" ;
                :type = "mean" ;
                :bias = "TBD" ;

    data:

    time = 4383 ;
    lon = -179.975, -179.925, -179.875, -179.825, -179.775, -179.725, …

        [etc.]
    }
```

A.2 File Name Convention (external and internal)

Table 0-1: File name fields of the GlobVapour NetCDF-CF products for internal usage.

Field	Description	Size	Value / Format	Metadata attribute
INSTR	Instrument(s) involved in the generation of the (combined) product	11	'GOMExxxxxxx', 'SCIAxxxxxxx', 'GOME+SCIAxx', 'SSMIxxxxxxx', 'MERISxxxxxx', 'SSMI+MERISx', 'ATSRxxxxxx', 'AATSRxxxxxx', 'IASIxxxxxxx', 'SEVIRIxxxxx', 'IASI+SEVIRI'	Related to '**instrument**'
PROC_LEVEL	Processing level	2	'L2', 'L3'	Identical with '**level**'
TYPE [1]	Product type indicating the temporal resolution (3-hourly, daily, weekly, monthly) and type (mean, composite)	2	'3M', 'DM', 'WM', 'MM', 'DC' [2]	Related to '**temporal**' and '**type**'
SAT [3]	Satellite-id involved in the processing	3	'F13', 'N18', etc.	Related to '**satellite-id**'
VAL_TIME [4]	Validity date and time of the GlobVapour file	14	Format YYYYMMDDHHMMSS	Identical with '**validity**'
PROC_MODE	Processing mode associated with the project phase, defining whether the product has been generated in Internal, Prototype, Test or End mode	1	'I', 'P', 'T', 'E'	N/A
PROC_TIME	Processing date and time (at file generation)	14	Format YYYYMMDDHHMMSS	Identical with '**timestamp**'

[1] This is not relevant for L2 products (which are typically orbit based).

[2] Currently, composite products are only foreseen in combination with daily temporal resolution.

[3] This is not relevant for L3 products (which are typically based on data from more than one satellite).

[4] This involves the starting date/time of the validity period. This implies that e.g. for a daily mean, the time '00:00:00' of the particular day is referenced, whereas for a monthly mean the first day of the particular month is specified.

Table 0-2: File name fields of the GlobVapour NetCDF-CF products for distribution to end users.

Field	Description	Size	Value / Format	Metadata attribute
INSTR	Instrument(s) involved in the generation of the (combined) product	11	'GOMExxxxxxx', 'SCIAxxxxxxx', 'GOME+SCIAxx', 'SSMIxxxxxxx', 'MERISxxxxxx', 'SSMI+MERISx', 'ATSRxxxxxx', 'AATSRxxxxxx', 'IASIxxxxxxx', 'SEVIRIxxxxx', 'IASI+SEVIRI'	Related to '**instrument**'
TYPE	Product type indicating the temporal resolution (3-hourly, daily, weekly, monthly) and type (mean, composite)	2	'3M', 'DM', 'WM', 'MM', 'DC' [1]	Related to '**temporal**' and '**type**'
VAL_TIME [2]	Validity date and time of the GlobVapour file	8	Format YYYYMMDD	Related to '**validity**'
PROC_MODE	Processing mode associated with the project phase, defining whether the product has been generated in Prototype, Test or End mode	1	'P', 'T', 'E'	N/A
VERSION	Simple product version, incremented for major changes per processing mode phase	1	Numerical ('0', '1', '2', etc.)	N/A [3]

[1] composite products are only foreseen in combination with daily temporal resolution.

[2] This involves the starting date/time of the validity period. This implies that e.g. for a monthly mean the first day of the particular month is specified.

[3] This is independent of the product '**version**' metadata attribute