Total Column Water Vapour product from the GOME, SCIAMACHY and GOME-2 Instruments

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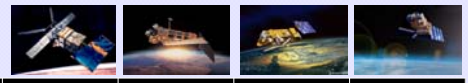
Introduction

Water vapour is one of the most important atmospheric constituents and has a strong impact on the Earth's radiative balance. Uncertainties in the water vapor feedback constitute one major uncertainty in the prediction of climate change. Thus, the knowledge of the effective distribution of ***Total Column Water Vapour (TCWV)*** is fundamental for weather monitoring as well as for the evaluation of climate models. The observations of the spectrometers ***GOME***, ***SCIAMACHY*** and ***GOME-2*** allow retrieving water vapour from 1996 till today. These instruments lay the foundation for a consistent long-term data record of water vapour observations, which will be further extended by the ***GOME-2/MetOp-C*** mission, planned for launch in 2018.

Satellite instruments:



Properties:

Instruments	GOME-1 ERS-2	SCIAMACHY ENVISAT	GOME-2 METOP-A	GOME-2 METOP-B
Data period	06/1995-07/2011	08/2002-04/2012	01/2007-present	12/2012-present
Spectral Coverage	240 - 790 nm	240 - 2380 nm	240 - 790 nm	240 - 790 nm
Ground pixel size	320 x 40 km²	60 x 30 km²	40 x 80 km² - 40 x 40 km² (*)	40 x 80 km²
Swath width	960 km	960 km	1920 km – 960 km (*)	1920 km
Equator crossing time	10:30 a.m.	10:00 a. m.	9:30 a.m.	9:30 a.m.
Global coverage	3 days (**)	6 days	almost daily	almost daily

(*) GOME-2A tandem operation since 15th July 2013; (**) GOME global coverage lost in June 2003

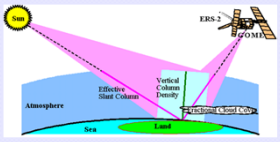
Water Vapour retrieval algorithm

The operational water vapour product is generated at the German Aerospace Centre (DLR) using the Level-1-to-2 GOME Data Processor (GDP). The algorithm is described in Wagner et al. (2003).

The H_2O slant column density (SCD) is computed with a classical ***Differential Optical Absorption Spectroscopy*** (DOAS) method performed in the wavelength interval 614-683 nm. A correction for the non-linearity effects arising from the limited spectral resolution of the instruments is applied.

The simultaneously retrieved ***O_2 SCD*** is used for the calculation of the Air Mass Factor and the conversion from slant to ***vertical column density (VCD)***. The atmospheric modeling is deliberately kept to a minimum.

$$VCD(H_2O) = \frac{SCD(H_2O)}{AMF(H_2O)} \approx \frac{SCD(H_2O)}{SCD(O_2)/VCD(O_2)}$$

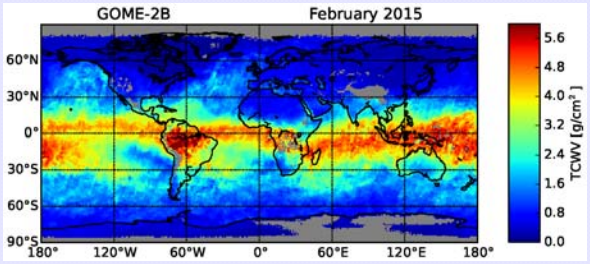


The different profile shapes for H_2O and O_2 lead to correction factors, depending on:

- Solar geometry (large SZA)
- Line of sight geometry (towards the edges of the swath)
- Surface albedo

Cloud-free observations are selected based on the effective cloud fraction and O_2 SCD.

The operational DLR/MPI-C water vapour product



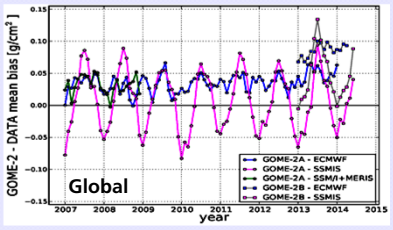
Monthly mean total column water vapour from GOME-2/MetOp-B in February 2015

The GOME-2 TCWV products have been collocated and compared with independent satellite measurements and model data (Grossi et al., 2015):

- ***ERA-Interim reanalysis data from ECMWF***
- ***SSM/I and SSMIS (Microwave) from GlobVapour and REMSS***
- ***MERIS (Optical Imagers) from GlobVapour***

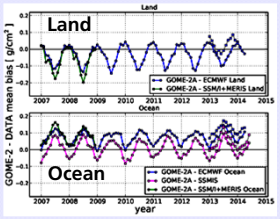
Global mean biases as small as 0.05 g/cm² are found between GOME-2A and all other data sets.

Recent comparisons with ground-based and in-situ measurements can be found in Kalakoski et al. (2015).



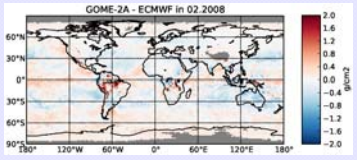
Monthly mean TCWV bias between GOME-2 and ECMWF ERA-Interim reanalysis, SSMIS F16 satellite and combined SSM/I+MERIS data sets for the period January 2007 - June 2014.

GOME-2A - ECMWF ERA-Interim	
BIAS =	0.035 +/- 0.014 g/cm²
GOME-2A – SSMIS (Ocean)	
BIAS =	0.005 +/- 0.045 g/cm²
GOME-2A – SSM/I+MERIS	
BIAS =	0.032 +/- 0.014 g/cm²
GOME-2B - ECMWF ERA-Interim	
BIAS =	0.086 +/- 0.010 g/cm²
GOME-2B – SSMIS (Ocean)	
BIAS =	0.047 +/- 0.040 g/cm²



Comparison with ERA-Interim reanalysis

The ***ECMWF ERA-Interim*** data set present a small positive global mean bias with respect to the GOME-2 product for the period 2007-2014, with opposite behavior over ocean and land. Larger regional differences are observed over ocean and land areas with ***high humidity*** or a relatively ***high surface albedo***.

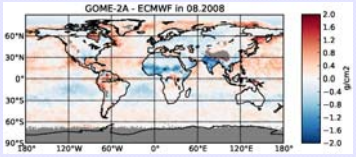


Differences between the monthly mean TCWV from GOME-2A and ERA-Interim reanalysis in February 2008.

Mean Bias = 0.017 g/cm²

Differences between the monthly mean TCWV from GOME-2A and ERA-Interim reanalysis in August 2008.

Mean Bias = 0.044 g/cm²

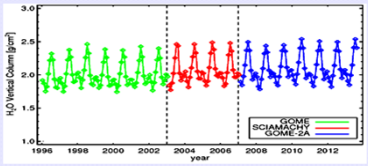


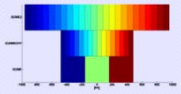
Ongoing projects

Line of sight dependence and BRDF : reduce the Scan Angle Dependency in GOME-type data by taking into account the influence of a ***Bidirectional Reflectance Distribution Function (BRDF)*** in the AMF calculation (ocean: Cox-Munk, land: BPDF 'NDVI').

Evaluation of spatial and temporal sampling errors: simulate satellite measurements by mapping the complete ERA-Interim data set in the footprints of the real satellite.

The 'Climate' data set: in order to assess long-term trends in GOME / SCIAMACHY / GOME-2 data sets, their spatial resolution is artificially degraded to one common resolution for a common swath width. This will reduce e.g. differences between data sets due to cloud filtering at different spatial resolutions.





GOME/SCIAMACHY/GOME-2 Time Series

GOME, SCIAMACHY and GOME-2 data and documentation

O3M SAF

GOME, SCIAMACHY and GOME-2 water vapour products, plus detailed information and documentation are available at:

atmos.caf.dlr.de

wdc.dlr.de/sensors

o3msaf.fmi.fi

EUMETSAT

References

Cox, C. and W. H. Munk: *Measurements of the roughness of the sea surface from photographs of the sun's glitter*, J. Opt. Soc. Am., 44, 838–850, 1954.
Dee, D. P. et al.: *The ERA-Interim reanalysis: Configuration and performance of the data assimilation system.* Quart. J. Roy. Meteor. Soc., 137, 553–597, 2011.
DUE GLOBVAPOUR *Technical Specification Document (TSD)*, issue 1, revision 0, 16 April 2010.
Grossi, M., Valks, P., Loyola, D., Aberle, B., Slijkhuis, S., Wagner, T., Beirle, S., and Lang, R.: *Total column water vapour measurements from GOME-2 MetOp-A and MetOp-B*, Atmos. Meas. Tech., 8, 1111-1133, doi:10.5194/amt-8-1111-2015, 2015.
Grossi, M., Kalakoski, N., and Valks, P.: *O3M SAF ORR Validation Report, Offline Total Water Vapour*, SAF/O3M/DLR/ORR/H2O, Issue 01/2013, 1–29, 2013.
Kalakoski , N., Kujanpää, J., Sofieva, V., Tamminen, J., Grossi, M., and Valks, P.: *Comparison of GOME-2/MetOp total column water vapour with ground-based and in-situ measurements*, amt-2014-292, 2014.
Maignan, F., Bréon, F.-M., Fédèle, E. and Bouvier. M.: *Polarized reflectances of natural surfaces: Spaceborne measurements and analytical modeling*. Rem. Sen. Env., 113(12):2642-2650, 2009.
Wagner, T., Heland, J., Zoeger, M. and Platt, U.: *A fast H_2O total column density product from GOME-Validation with in-situ aircraft measurements*, *Atmos. Chem. Phys.*, 3, 651-663, 2003.
Wagner, T., Beirle, S., Grzegorski, M., and Platt, U.: *Global trends (1996–2003) of total column precipitable water observed by Global Ozone Monitoring Experiment (GOME) on ERS-2 and their relation to near-surface temperature*, J. Geophys. Res. 111, D12102, doi:10.1029/2005JD006523, 2006.
Wentz, F. J.: *A well-calibrated ocean algorithm for SSMI*, J. Geophys. Res., 102, No. C4, 8703–8718, 1997.

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