COMPARISON OF O3M SAF OFFLINE TOTAL WATER VAPOUR WITH GROUND-BASED AND IN-SITU MEASUREMENTS

Niilo Kalakoski

Finnish meteorological institute, Erik Palménin aukio 1, Helsinki, Finland

Abstract

The offline total water vapour product (OTO/H2O) of the Satellite Application Facility on Ozone and Atmospheric Chemistry Monitoring (O3M SAF) is produced by German Aerospace Center (DLR) during 15-year EUMETSAT Polar System programme using the measurements of the three Metop satellites. H2O/OTO product is based on the radiance spectrum (wavelength region 611-700 nm) of sunlight scattered from the atmosphere by Metop/GOME-2. This paper presents the results of comparison of the latest H2O/OTO product with integrated total water vapour columns from radiosoundings collected in the Integrated Global Radiosonde Archive (IGRA) and real-time integrated atmospheric water vapour from the ground-based GPS network.

INTRODUCTION

The Global Ozone Monitoring Experiment (GOME-2) is a nadir-viewing scanning spectrometer aboard EUMETSATs Metop-A and B satellites launched in October 2006 and September 2012, respectively, followed by third instrument aboard Metop-C, due to be launched in 2018. Metop series forms the space segment of the EUMETSAT Polar System (EPS), expected to operate at least until 2020. GOME-2 is dedicated to observation atmospheric trace gases, mainly to total column ozone content and vertical ozone profiles. Other parameters provided by GOME-2 include total column of nitrogen dioxide, sulphur dioxide, water vapour, bromine oxide and other trace gases, as well as aerosols. The MetOp orbit is sun-synchronous with an equator crossing time of 09:30 local time. Processing, dissemination and archiving of GOME-2 data products is handled by EUMETSAT Satellite Application Facility on Ozone and Atmospheric Chemistry Monitoring (O3M SAF). O3M SAF water vapour product has been processed operationally since March 2010.

In this paper, we present the results of geophysical validation of the GOME-2A and B water vapour total column against radiosonde and ground-based GPS measurements.

GOME-2 WATER VAPOUR PRODUCT

GOME-2 observes solar light reflected from Earth's atmosphere and surface in ultraviolet and visual the spectral range (wavelengths 240-790 nm) with spectral resolution of 0.2-0.4 nm. GOME-2 has spatial resolution of 40x80 km, with swath width of 1920 km, giving it daily global coverage at mid-latitudes. Each 6-second scan cycle consists of a 4.5-second forward scan (24 40x80 km pixels) and a 1.5-second back scan (eight 40x240 km pixels). Both forward- and back-scan pixels are processed and written into data files. At low solar elevations, longer integration times are used thus increasing the pixel size. Additionally, for one day (day 15) in every 29-day observation cycle, instrument measures at narrow swath mode, halving the pixel size to 40x40 km.

GOME-2 water vapour total column product was developed mainly for climatological studies. It uses no external input on the state of the atmosphere. Thus GOME-2 data are fully independent of measurements from other instruments and/or modelling, but at the cost of possible larger errors of

individual measurements. Retrieval uses Differential Optical Absorption Spectroscopy (DOAS) algorithm with 614-683 nm fitting window to retrieve slant column of atmospheric water vapour, followed by Air Mass Factor (AMF) conversion to generate vertical total columns. O_2 absorption in same fitting window is used for determining the air mass correction factor used in retrieval For further information on algorithm and data use, see Algorithm Theoretical Basis Document (Valks et al, 2013a) and Product User Manual (Valks et al, 2013b)

GROUND-BASED DATA SOURCES

Integrated Global Radiosonde Archive (IGRA) is a radiosonde dataset maintained by National Climatic Data Center (NCDC) (http://www.ncdc.noaa.gov/oa/climate/igra/). IGRA contains quality-assured observations from 1500 globally distributed stations with different periods of record from 1960s to present. For the period of this validation, source of the data is NCDC real-time Global Telecommunication System (GTS) dataset.

COSMIC/SuomiNet is a ground-based GPS network designed for real-time remote sensing of atmospheric water vapour. Network provides integrated atmospheric water vapour and total electron content from GPS from globally distributed stations. Precipitable water estimates are provided for each station at 30 minutes time resolution (Ware et al., 2000).

RESULTS AND DISCUSSION

GOME-2 observations were compared to ground-based observations during the period December 13 2012 to July 31 2013. We selected radiosonde data within 3 hours of GOME-2 overpass and with spatial separation within a GOME-2 pixel. GPS observation also also selected to be within GOME-2 a pixel, but due to better time resolution of GPS data, only co-locations with the smallest time difference were chosen. Usually, the time difference between GPS observation and GOME-2 overpass is less than 15 minutes. GOME-2 pixels were screened for heavy cloud cover and for pixels larger than nominal size (back scan pixels and low light conditions). Locations of the co-locations are shown in figure 1.

Scatterplots of the observations are shown in figure 2. Comparisons generally show good agreement between GOME-2 and ground observations. In majority of cases, GOME-2 measurements are within x% from the collocated radiosonde and GPS data. Figure 3 shows the histograms of the relative differences ([GOME-2 – ground] / ground) with medians and 16th and 84th percentiles of the distributions. Statistics of distributions are also shown in table 1. GOME-2A and B show very similar behaviour in these comparisons. Comparisons against sondes show a small dry bias in both cases and comparisons against GPS showing small wet bias. The width of the distribution is also similar in all cases, with standard deviations of 25-30% in all cases. In comparisons with GPS, relatively large number of very large positive relative differences can be seen at low values (Figure 2).

	Median [%]	**16th Percentile [%]**	**84th percentile [%]**	**Co-locations**
GOME-2A vs sonde	-1.70	-27.9	29.9	43455
GOME-2A vs GPS	2.86	-22.5	36.5	9918
GOME-2B vs sonde	-0.27	-25.7	31.5	43974
GOME-2B vs GPS	3.20	-20.9	37.5	8976

Table 1: **Statistics of comparisons.**

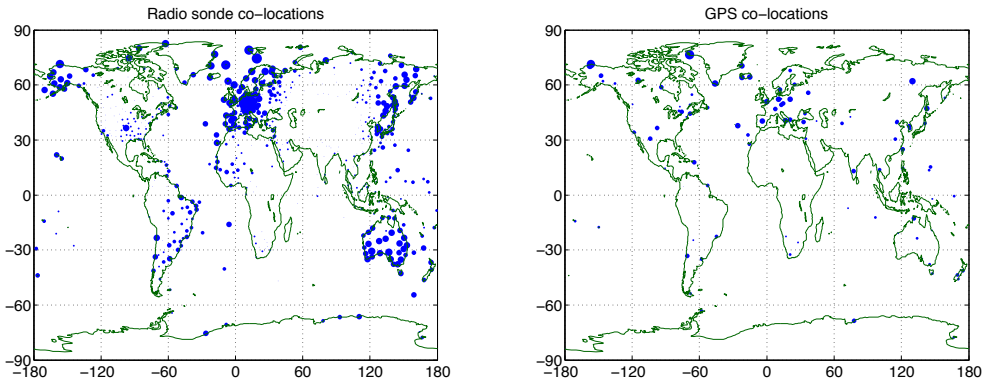

Figure 1: **Locations of co-locations of GOME-2A observations with radiosonde (left) and GPS (right) observations. Size of dots is proportional to the number of observations**

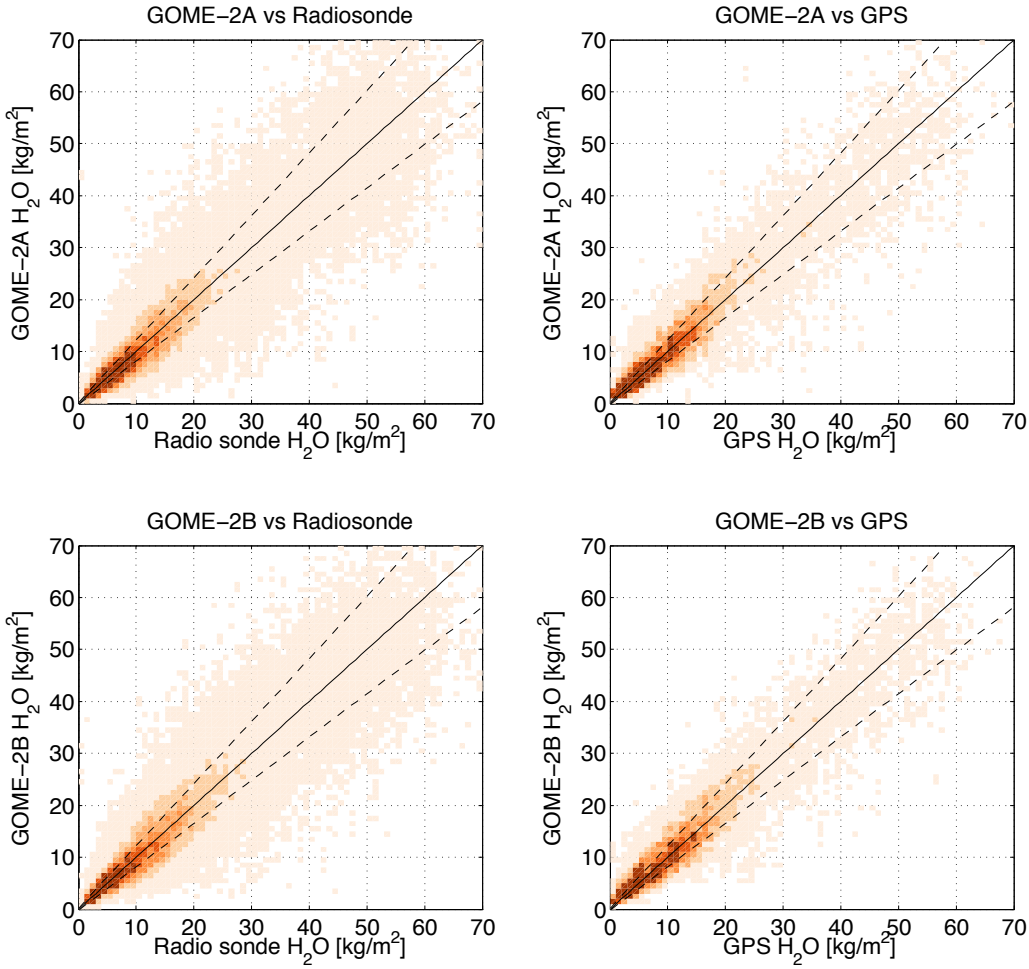

Figure 2: **Scatterplots of GOME-2A (top) and B (bottom) against co-located radiosonde (left) and GPS (right) observations. Solid black line is y=x, dashed black lines are +/1 20% difference lines.**

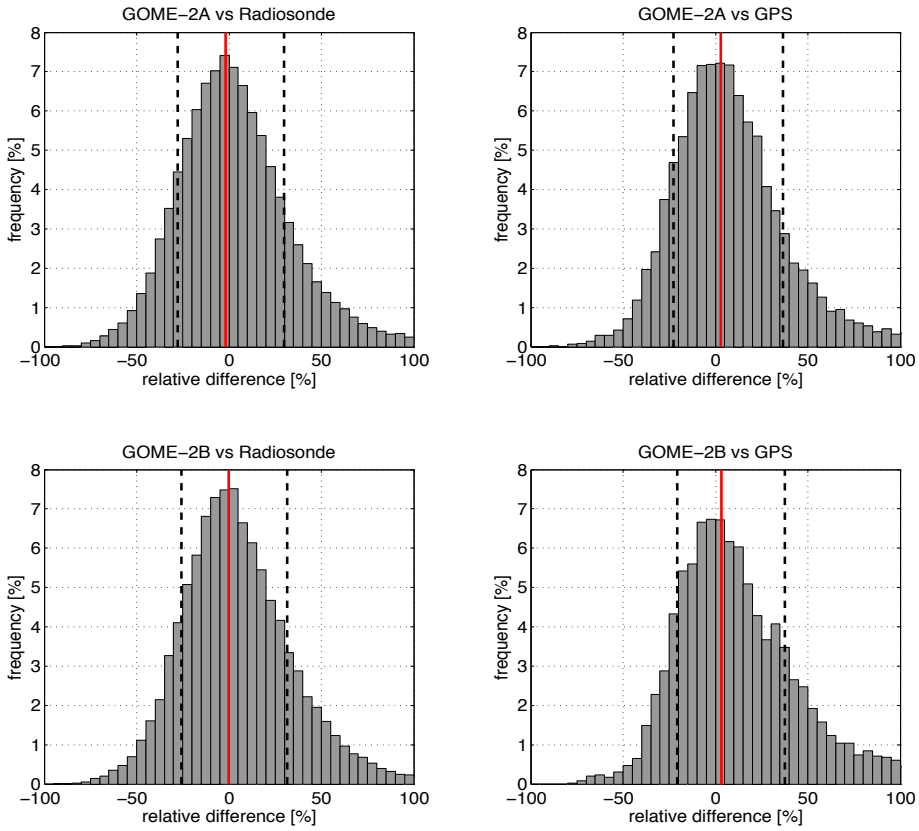

Figure 3: **Histograms of relative difference ([GOME-2 – ground] / ground) of GOME-2A (top) and B (bottom) against co-located radiosonde (left) and GPS (right) observations. Solid red line shows the median of the distribution and dashed lines the 16th and 84th percentiles.**

CONCLUSIONS

Comparisons show good agreement between GOME-2A and B against both radiosonde and GPS observations, with comparisons against radiosondes showing a small (1.7% and 0.3% for GOME-2A and B, respectively) dry bias and comparisons against GPS showing small (2.9% and 3.2%) wet bias. Width of the difference distribution is also very similar for all comparisons (57-59% from 16th to 84th percentiles). GOME-2A and B show very similar behaviour against each other.

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