Tropical Tropospheric Ozone observed from GOME_2 and perspectives for TROPOMI

Heue, Klaus-Peter; Hao, Nan; Valks, Pieter; Loyola, Diego ; Miles, Georgina; Siddans, Richard; Rahpoe, Nabiz

The CCD Method

The ozone column above high reaching convective clouds is barely influenced from tropospheric pollution. Therefore the above cloud column is a good approximation for the stratosphere. In the tropics the longitudinal dependency of the stratospheric ozone column is assumed to be low, hence the stratospheric ozone column is estimated based on the above cloud column for the region India to the western Pacific (70°E eastwards to 170°W). This „stratospheric“ column is subtracted from the total column for cloud free pixels (Figure 1). The data are gridded to a 1.25°lat and 2.5° long grid.

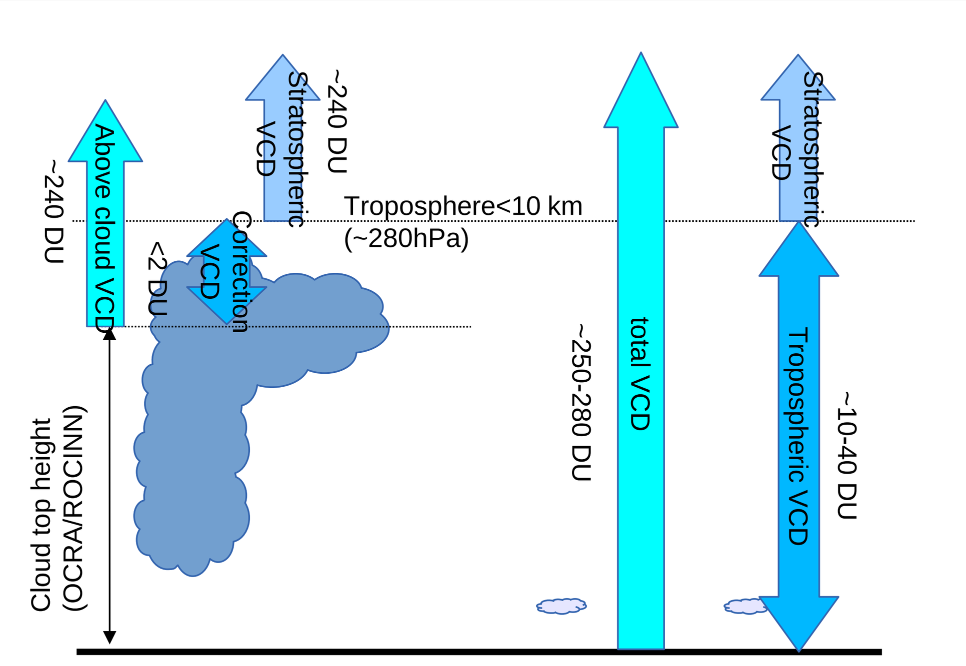

Fig 1: Principle of the convective cloud differential method to retrieve tropospheric ozone column.

Comparison to sondes

The CCD data are compared to the sondes from the SHADOZ network. The sonde data are integrated up to 10 km. The CCD tropospheric columns compare well with the sonde data but are slightly higher. The average deviation is about 2 DU. Also the annual cycle is observed well in most cases (Figure 2).

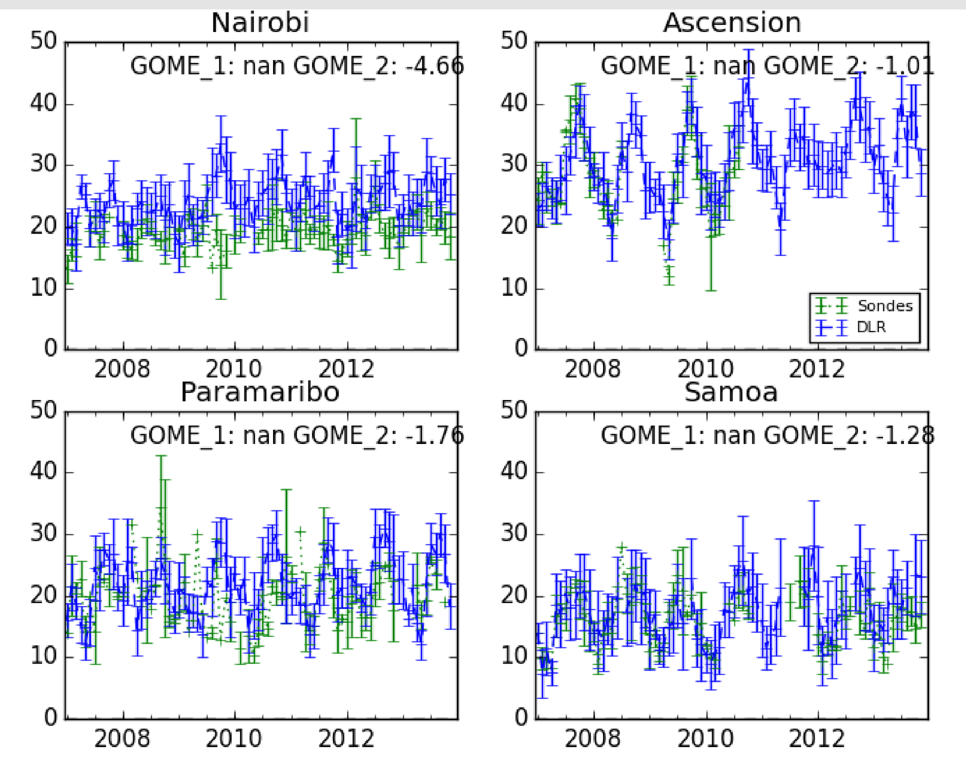

Fig 2: Time series for tropospheric ozone, observed by sondes (green) and GOME_2 on Metop A (blue) for four representative stations.

Comparison to SCIAMACHY, GOME_2, OMI

We compare our CCD tropospheric ozone columns to similar data products e.g. direct profile retrieval from RAL, SCIAMACHY limb-nadir matching, or OMI/MLS (not shown). In most cases the top height of the tropospheric column has to be adjusted. The CCD product integrates up to 10 km while for the SCIAMACHY the tropospheric column is calculated up to the tropical Tropopause (~17km).

For the correction a constant mixing ratio inside the column was assumed and the data where harmonized to a tropospheric column below 10 km by:

$$VCD(10km) = VCD(17km) \times \frac{\Delta P(10km)}{\Delta P(17km)}$$

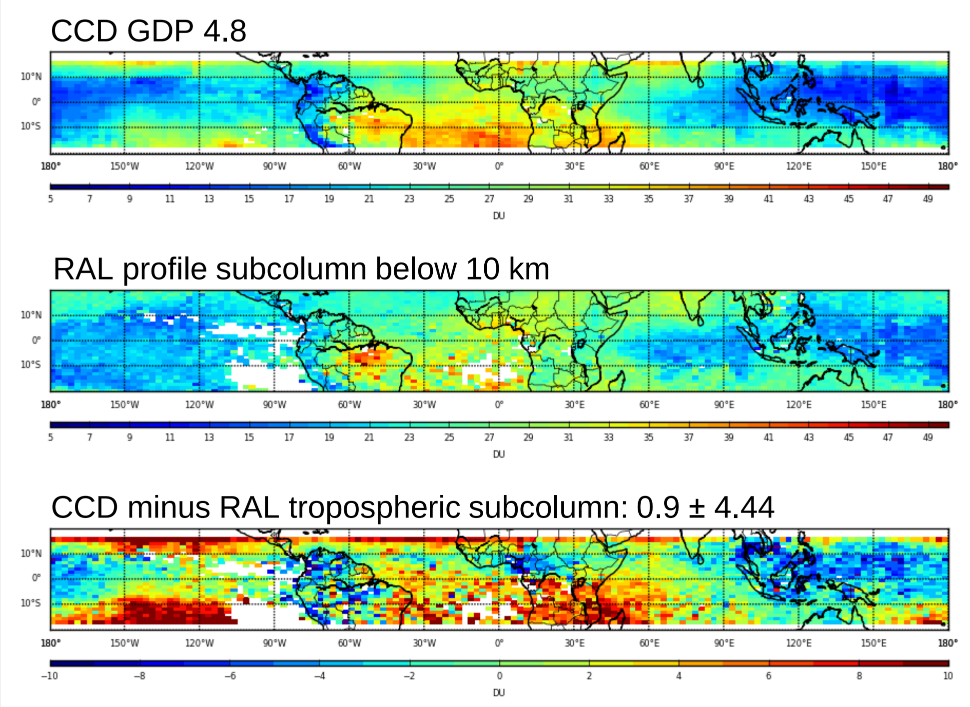

Fig 3: Comparison of GOME _2 CCD data with tropospheric columns below 10 km based on the RAL profile retrieval. Data for Nov 2007

The comparison (for 2007 to 2011) with the RAL profile retrieval shows a slight overestimation (~3 DU) for the summer months (April to September) and an underestimation (-2 DU) in the Winter (DJF). This periodical change in the difference is not yet fully understood. Never the less the general tropospheric ozone distribution patterns look similar (Figure 3), and the standard deviation of the differences is between 3 and 5 DU.

For the SCIAMACHY limb-nadir matching, a different result is found. As for the comparison with the RAL profiles the complete tropics (20°S to 20°N) are included. The CCD data are in most cases higher than the SCIAMACHY, however the difference is typically lower (~2 DU) only for a few outliers the differences reached 5 DU. The standard deviation however, is 6-8 DU as the example in figure 4 shows. Hence the standard deviation is almost twice as high as in the comparison with the RAL retrieval.

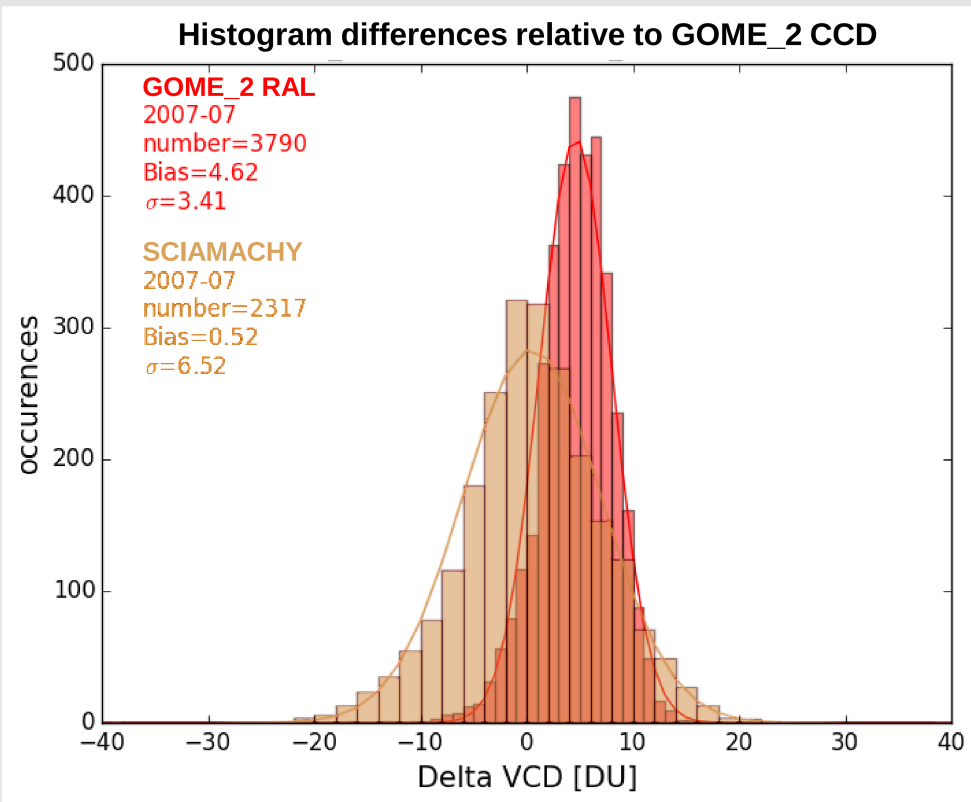

Fig 4: Histogram of the differences between GOME_2 CCD and GOME_2 RAL or SCIAMACHY. For July 2007 the standard deviations are 3.4 and 6.5 DU.

GOME-MLS

The current CCD algorithm limits the tropospheric ozone retrieval to the tropical latitude band. Because only here the assumption of a low longitudinal variation of the stratospheric ozone column is justified.

Because of this limitation a new algorithm was thought of: GOME-MLS. Here the MLS data are subtracted from the GOME_2 total column. The algorithm is adapted from the OMI-MLS algorithm.

A comparison with other global tropospheric data and with sondes shows a good agreement. In general all the measurements of tropospheric ozone deviate from another by up to 10 DU as can bee seen in figure 5.

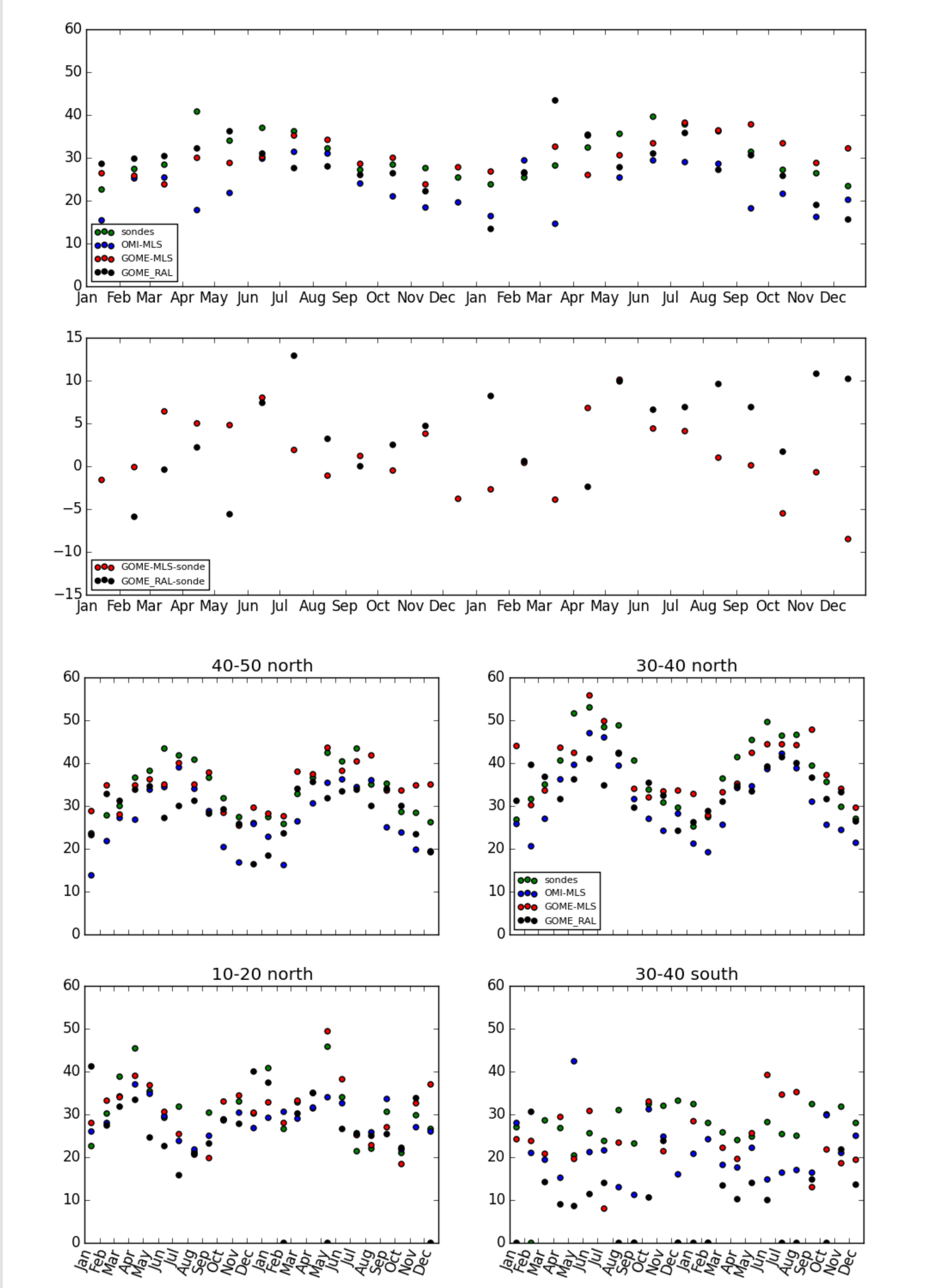

Fig 5 top: Comparison of different ozone column products in DU with the integrated ozone sondes at Hohenpeißenberg for 2007 and 2008.
Bottom: For 10° latitude bands all sondes and collocated satellite observations were averaged.

Perspective for S5P

The new satellite Sentinel 5 Precursor (S5P) will be launched into a sun-synchronous orbit in 2016. The TROPOMI instrument on S5P will have an outstanding resolution of 7x7 km² (compared to 40x80 km² from GOME_2). The resolution of the instrument also limits the resolution of tropospheric ozone retrieval. We tested the spatial resolution for GOME_1 (2.5°x 5°), GOME_2 (1.25°x2.5°) and OMI (0.5°x1°, figure 6). For even finer resolutions artefacts are observed and also the noise increases. Alternatively to the spatial resolution the temporal resolution might be improved. For example for OMI a temporal resolution of about 1 week seems possible, for S5P even better resolutions will be achieved.

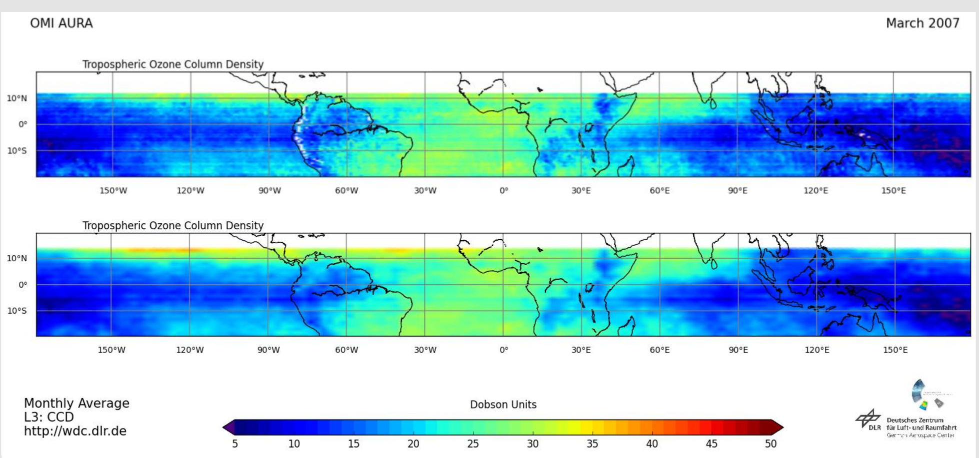

Fig 6: Tropospheric ozone columns from OMI for March 2007 with a fine resolution (top) and low resolution (bottom)

Acknowldgement:
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