Tropical Tropospheric Ozone from GOME_2 and extension to the extra tropics

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The convective cloud differential method

- Total ozone column is dominated by the stratospheric column (up to 90%).
- Dense clouds shield the tropospheric column from satellite observations.
- The above cloud column is a good approximation for the stratosphere.
- In the tropics the longitudinal dependency of the stratospheric ozone column is low.
- The stratosphere is estimated based on the above cloud column for the region between 70°E and 170°W. Here low ozone concentration above deep convective clouds are observed.
- Correction term corrects for varying cloud altitudes.
- Harmonized to 10 km (280 hPa, close to the average cloud altitude).
- The harmonized above cloud columns are averaged over a month for certain latitude bins (1.25°) to "stratospheric" columns.
- To gain the tropical tropospheric ozone column (TTOC) the stratospheric column is subtracted from the total column for cloud free pixels, monthly averaged and gridded to 1.25° x 2.5° resolution (1).

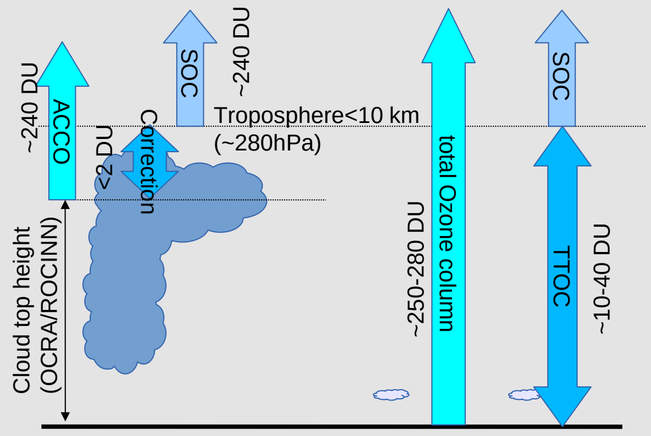

Fig 1: Principle of the convective cloud differential method to retrieve Tropospheric ozone columns.

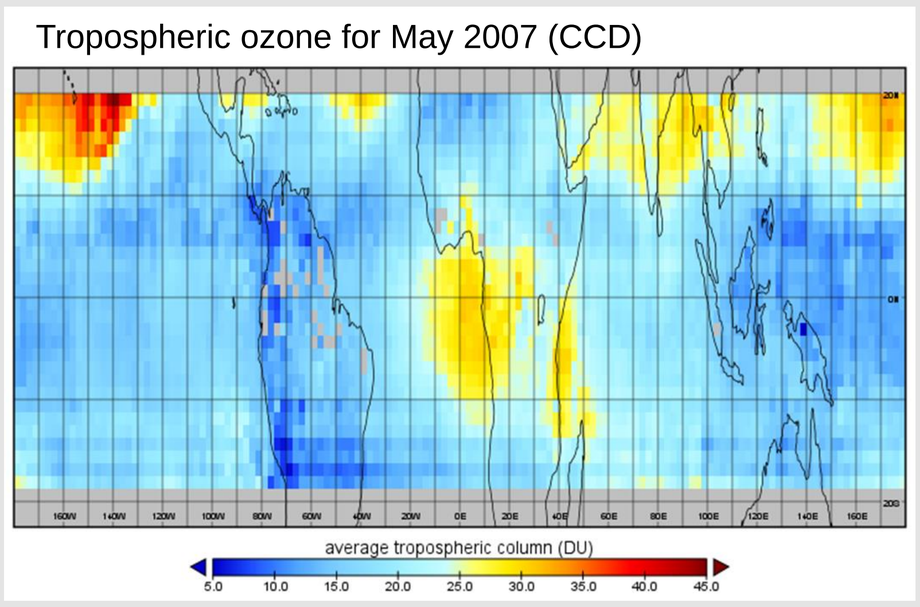

Fig 2: Example result for GOME_2 CCD tropospheric ozone column.

The data

- O3MSAF operational O_3 total column (GDP-4.8, poster Hao et al.)
- Cloud data (OCRA-ROCINN)
- GOME_2 (A and B) TTOC until June 2016 for the O3M SAF project.
- Available at: http://o3msaf.fmi.fi/products/oto_o3tropo_cs.html
- Validation of the data, see poster by Delcloo et al.
- Similar data product within ESA's CCI-ozone, the GODFIT-v3 data from GOME_1, SCIAMACHY, OMI and GOME_2 (A and B).
- The TTOCs from the different sensors were harmonized to SCIAMACHY.
- Derived trends (2) in the TTOC from a multilinear fit, including seasonal term and the indices for ENSO, QBO, Solar activity.
- In general the tropospheric ozone in the tropics increases by 0.7 DU / decade. We also calculated the trends on a regional basis (5°x5°).

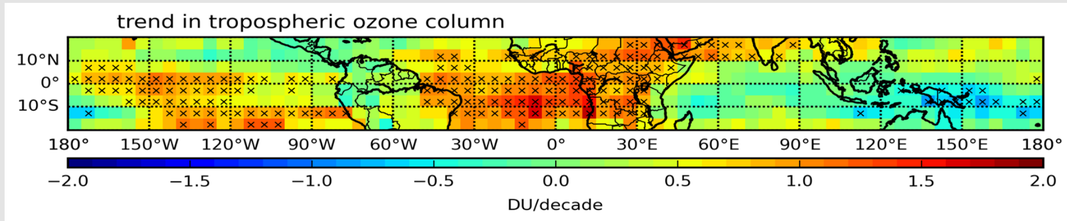

Fig 3: Distribution of trends in tropospheric ozone columns, significant trends are indicated by a crosses. In most parts of the tropics the TTOC seems to increase, only over New Guinea and the Pacific a significant negative trend is found.

GOME_2 MLS

Besides the success of the convective cloud differential method to retrieve the tropospheric ozone column, it is limited to tropics (20°S to 20°N). Therefore we are investigating methods to calculate the tropospheric ozone column also in subtropical to mid latitude.

Following the well established OMI-MLS (3) data product we worked on a combination of GOME_2 total columns with stratospheric columns retrieved from the MLS stratospheric ozone profiles. The principle algorithm is as follows:

- Integrate the MLS mixing ratio between the tropopause and 0.5hPa
- Grid daily MLS stratospheric columns and interpolate linear for missing grid cells
- Grid daily cloud free total GOME_2 data
- Subtract daily MLS stratospheric column from daily GOME_2 total column
- Monthly average daily tropospheric data

Issues to be addressed:

- MLS data do not include tropopause altitudes in mid or polar latitudes
- Comparison to CCD shows varying discrepancy depending on the season
- GOME _2 and MLS have to be harmonized prior to subtraction, requires a longer period of GOME2 MLS data
- Estimate the uncertainty that results from the different overpass times and the daily ozone cycle in the upper stratosphere, first estimates ~1-2 DU

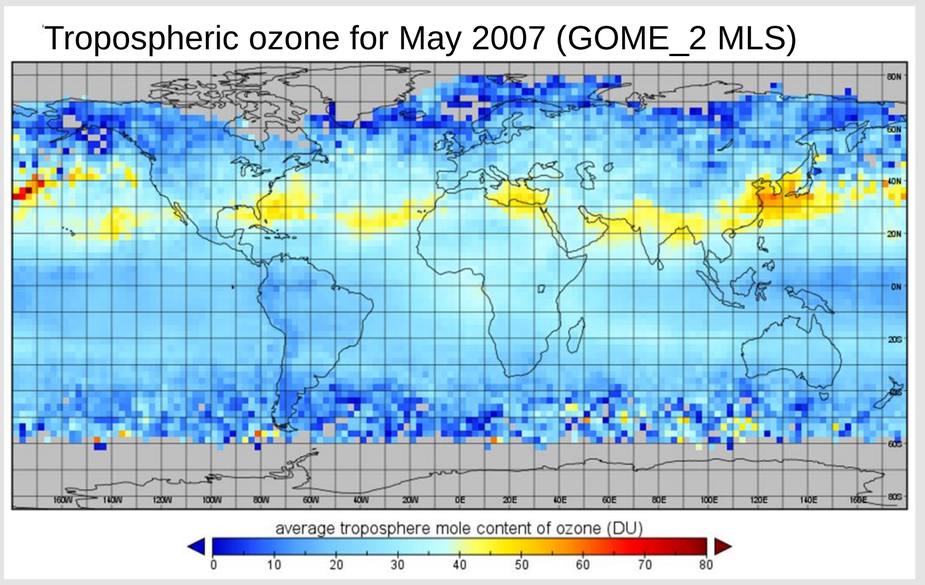

Fig 4: Example result for GOME_2 MLS tropospheric ozone column. Some enhancements e.g. eastern Mediterranean, northern India or east Asia are clearly visible.

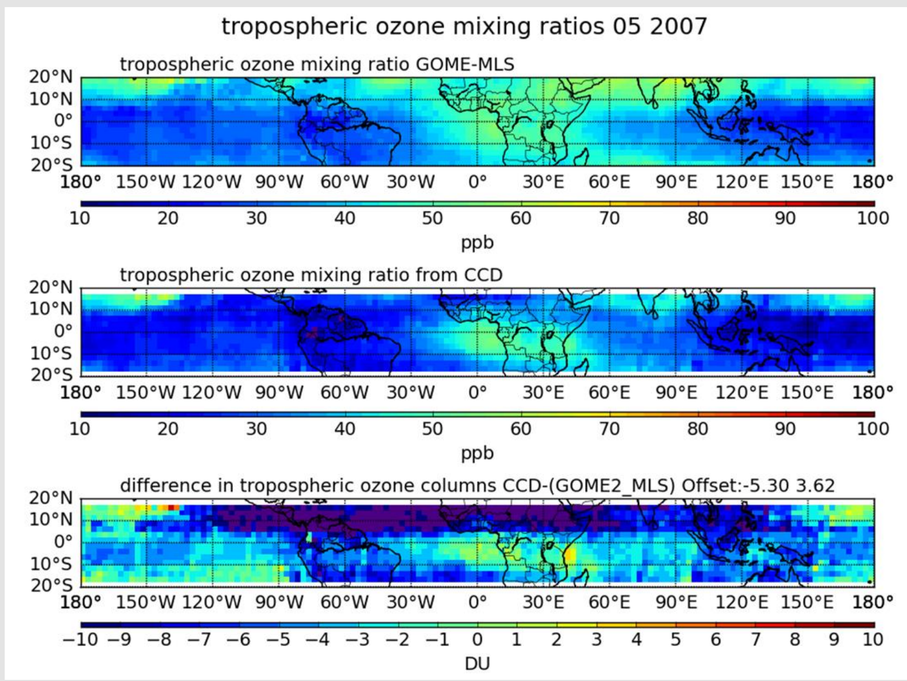

Fig 5: Comparison between GOME_2 MLS and GOME_2 CCD for May 2007. To compensate for different altitude ranges (280 hPa and ~100 hPa) the average tropospheric mixing ratio is compared instead of the columns. The difference (bottom) shows the integrated difference up to the tropopause (~100 hPa). The differences might be related to enhanced ozone mixing ratios in the upper tropopause.

References: (1) Valks, P., Hao, N., Gimeno Garcia, S., Loyola, D., Dameris, M., Jöckel, P., and Delcloo, A.: Tropical tropospheric column ozone retrieval for GOME-2, Atmos. Meas. Tech., 7, 2513-2530, doi:10.5194/amt-7-2513-2014, 2014.
(2) Heue, K.-P., Coldewey-Egbers, M., Delcloo, A., Lerot, C., Loyola, D., Valks, P., and van Roozendael, M.: Trends of tropical tropospheric ozone from twenty years of European satellite measurements and perspectives for Sentinel-5 Precursor, Atmos. Meas. Tech. Discuss., doi:10.5194/amt-2016-139, in review, 2016.
(3) Ziemke, J. R., S. Chandra, B. N. Duncan, L. Froidevaux, P. K. Bhartia, P. F. Levelt, and J. W. Waters, Tropospheric ozone determined from Aura OMI and MLS: Evaluation of measurements and comparison with the Global Modeling Initiative's Chemical Transport Model, J. Geophys. Res., 111, D19303, doi:10.1029/2006JD007089, 2006.

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