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ALGOM
GOMOS Level 2 algorithm evolution studies

Validation and Alternative Retrievals of GOMOS Ozone Profiles in the UTLS Altitude Region

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Abstract

In this paper, we discuss the quality of the operational Global Ozone Monitoring by Occultation of Stars (GOMOS) ozone profiles in the upper troposphere—lower stratosphere (UTLS) altitude region, and show recent results of an alternative retrieval algorithm that is designed in particular for processing the GOMOS measurements for UTLS applications. The retrievals are performed using the one-step algorithm, where the spectral and the vertical inversions of the two-step algorithm are executed simultaneously. The preliminary results show drastic improvement of the quality of the GOMOS profiles in the UTLS region when compared against ozone soundings from NDACC (Network for the Detection of Atmospheric Composition Change). To further evaluate the novel UTLS dataset, we perform a comparison against OSIRIS ozone dataset, which has previously shown reliable results in the UTLS.

Introduction

GOMOS is a satellite instrument onboard ENVISAT spacecraft that was in operation 2002—2012. During the mission, GOMOS observed about 400 000 nighttime vertical profiles of ozone, NO_2, NO_3, aerosol extinctions and other species. GOMOS was mainly designed for studying the nighttime ozone between 15–100 km altitude. Less attention has been paid to analyze ozone in the UTLS altitude region. This is one aim of the ESA funded ALGOM project.

GOMOS ozone profiles depend strongly on aerosol model below 22 km. The aerosol model of Version 6 (second order polynomial) results typically 10–40% higher ozone at 10–20 km compared to the other possible aerosol models (see Figure 1).

Here we use the GOMOS one-step algorithm, where some of the approximations of the operational algorithm can be avoided and the prior and the measurement errors are treated together. The main difference of the two retrieval algorithms comes from the use of the prior information. In the one-step algorithm, the prior given to one constituent affects the other constituent too. The opposite is true for the operational algorithm, where the prior takes place only in the vertical inversion and is given for every constituent separately. However, in one-step algorithm we cannot set the so-called target resolution, which makes operational dataset user-friendly and easy to use in, e.g., time-series analysis and validation studies.

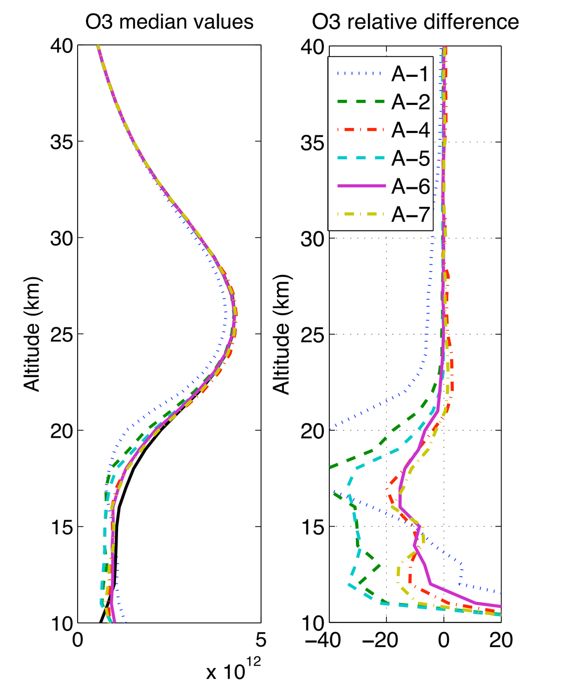

Figure 1. Left: Ozone profiles using different aerosol models. Right: Difference with respect to V6 aerosol model. From Tamminen et.al. ACP, 2010.

Validation of operational GOMOS dataset using NDACC soundings

In order to validate GOMOS profiles, we use the ozone soundings from different NDACC stations (Network for the Detection of Atmospheric Composition Change, http://www.ndsc.ncep.noaa.gov/). Figure 2 shows the relative difference (RD) between GOMOS ozone profiles and the ozone sounding data at different altitudes from all the stations. In order to separate the tropospheric and stratospheric components, the RD was plotted as a function of the altitude relative to the tropopause (Figure 2, center). Below the tropopause, a large ozone over-estimation (median RD larger than 30%) by GOMOS can be observed. Removing the GOMOS data with uncertainty larger than 75% or 50% does not reduce the large median RD values observed below the tropopause. When only the 12 brightest stars are taken into account (right panel in Figure 2), the difference between GOMOS IPF v6 and the ozone soundings becomes even larger (median RD up to about 100%).

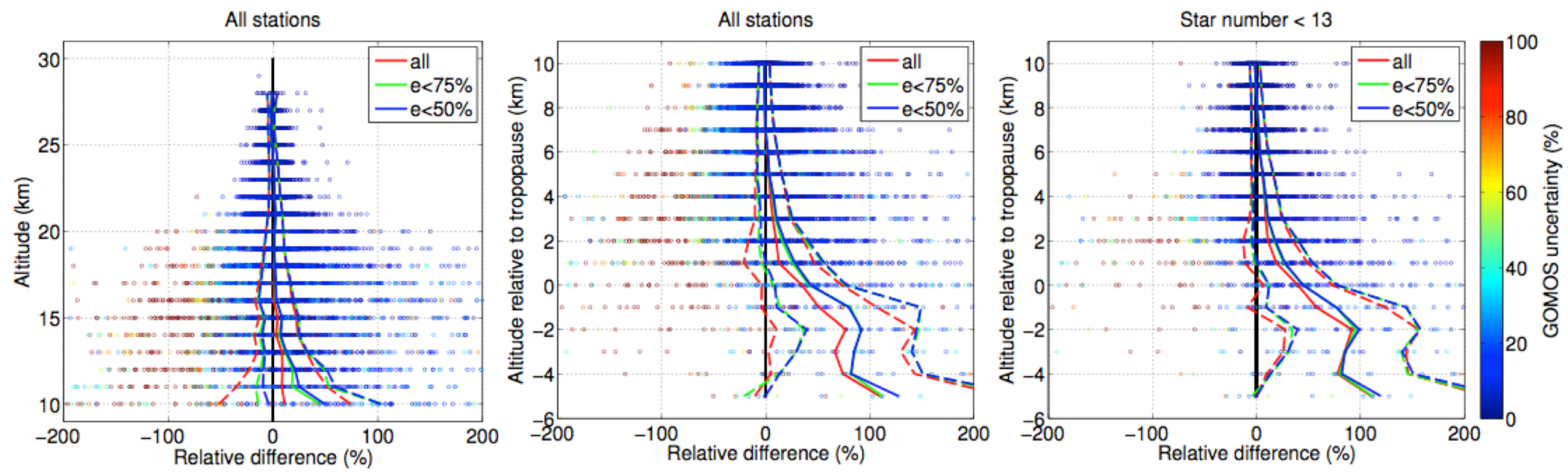

Figure 2. Percentage relative difference from collocations with all NDACC stations as a function of altitude (left panel) and altitude relative to the tropopause (centre) and for the 12 brightest stars (right). The color code of the points corresponds to the uncertainty of the GOMOS ozone retrieval. The lines indicate the median (continuous) and its standard deviation (dashed) when the GOMOS uncertainties are smaller than 100% (red), 75% (green) and 50% (blue).

Validation of GOMOS one-step retrievals

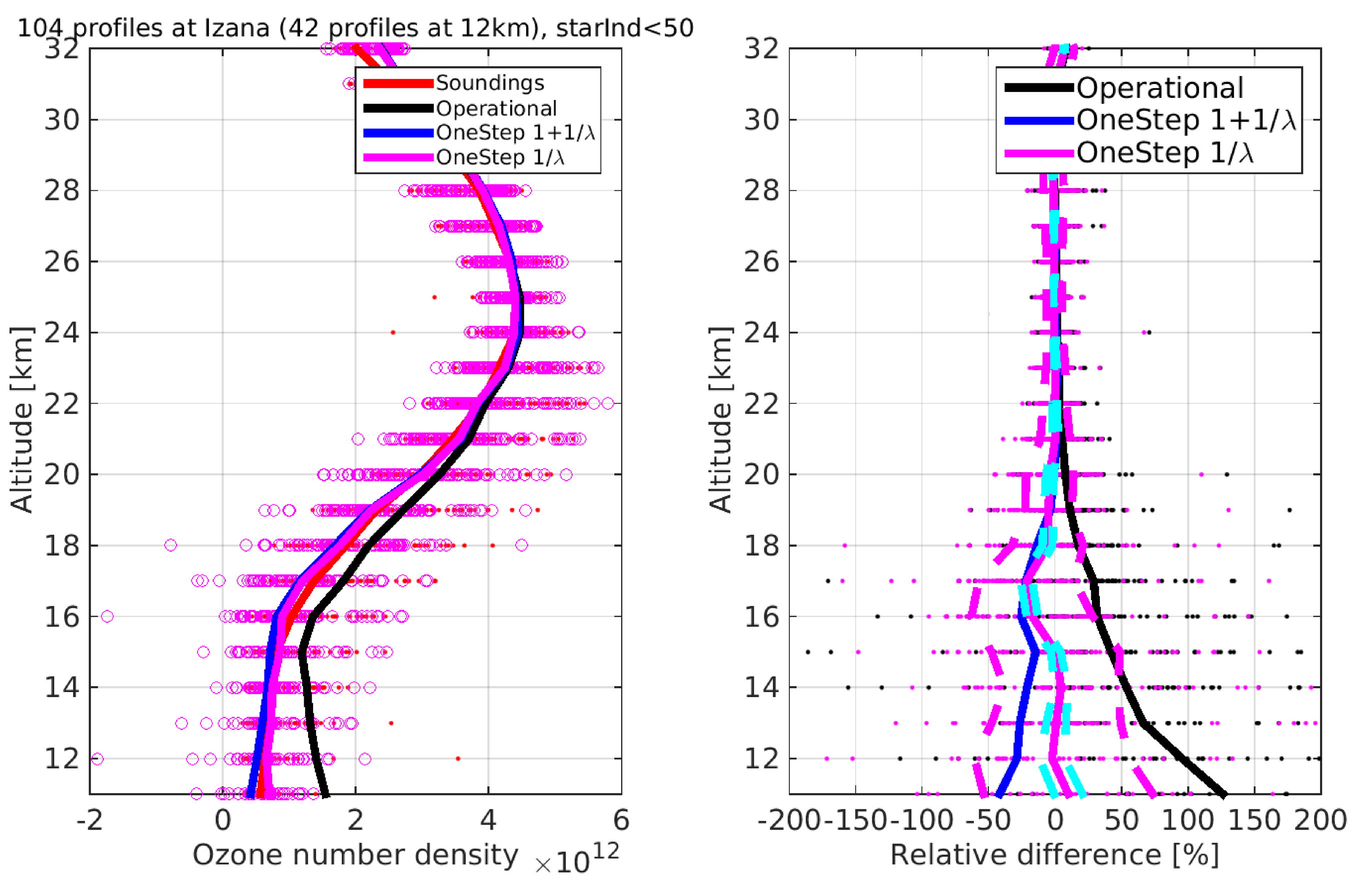

Figure 3. Comparisons at Izaña. Right: ozone profiles. Left: Relative differences. Magenta dashed lines show the median ± the standard deviation of the relative differences (for 1/λ). Cyan dashed lines show the median ± median GOMOS error estimates, given by the one-step algorithm.

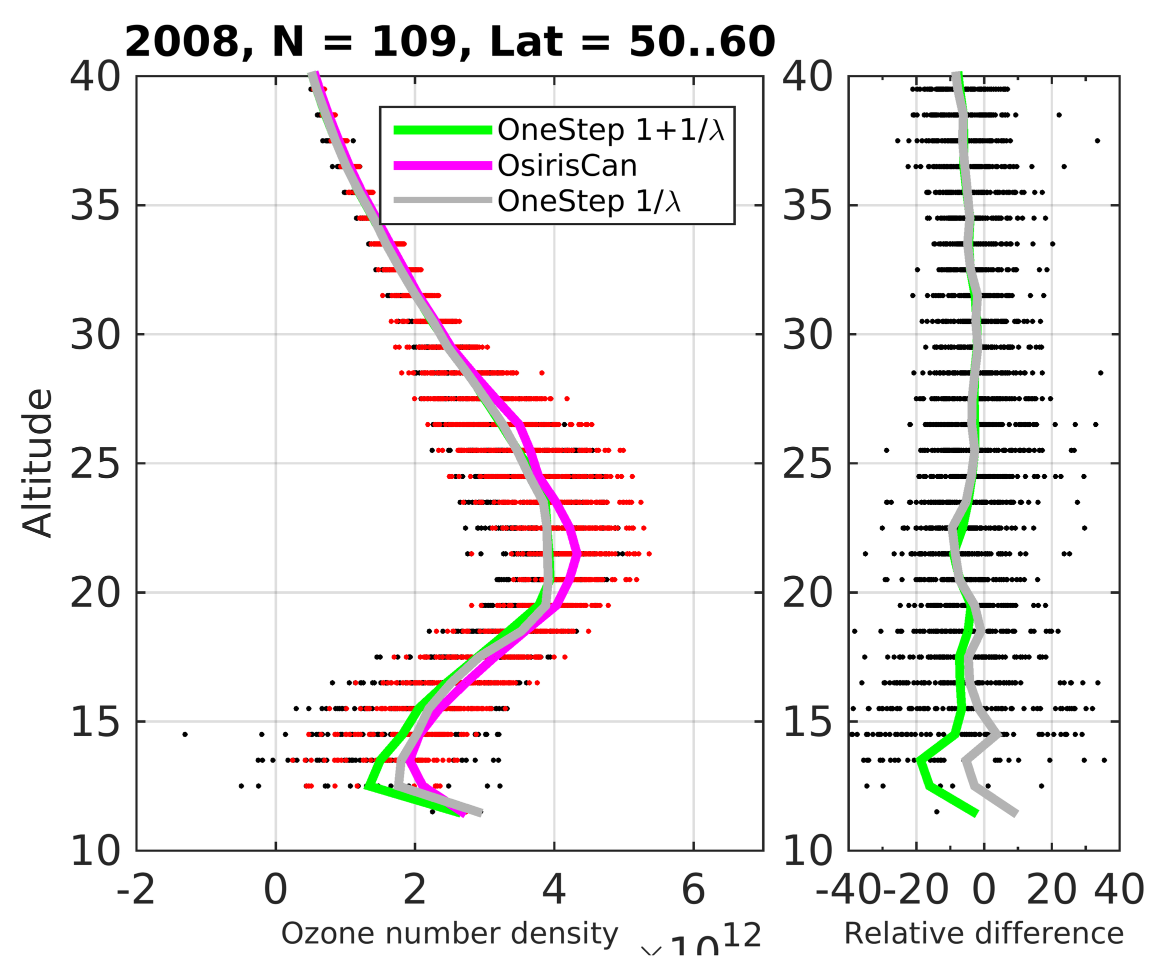

Figure 4. Comparison against OSIRIS at 50°N—60°N. Right: ozone profiles. Left: Relative differences. Grey and green dashed lines show the median ± the standard deviation of the relative differences for 1/λ and 1+1/λ, respectively.

Figure 3 shows how the situation can be improved using GOMOS one-step algorithm with two different aerosol models. Figure 3 shows validation results using 104 profiles at Izaña NDACC station (Canary Islands). We can see that the improvement of the data quality is drastic — GOMOS one-step with 1/λ aerosol model gives essentially the same results as soundings where as with operational profiles show the median relative difference up to 125%. We note that the main effect seen in Figure 3 comes from the change of the aerosol model. The same effect can be obtained with a setup, where strong aerosol smoothness priors were used. However, this setup fails when clear aerosol layer exists.

One of the best ways to get an overall idea of the quality a satellite-borne dataset is to compare it against another global satellite-borne dataset. One of the best global dataset of UTLS ozone is produced by OSIRIS. From Figure 4 and the animations below we note that the agreement with OSIRIS is substantially better with one-step than with IPF v6. The improvement of quality is most pronounced in the tropics. Both aerosol models, 1/λ and 1+1/λ, provide similar results. Although some differences are observed, it cannot be concluded which one of them is closer to the OSIRIS UTLS ozone data. See animations:

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https://dl.dropboxusercontent.com/u/35228286/ALGOMTN/OneOverLambda.gif