Retrieval of ozone profiles from OMPS limb observations

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OMPS instrument and data

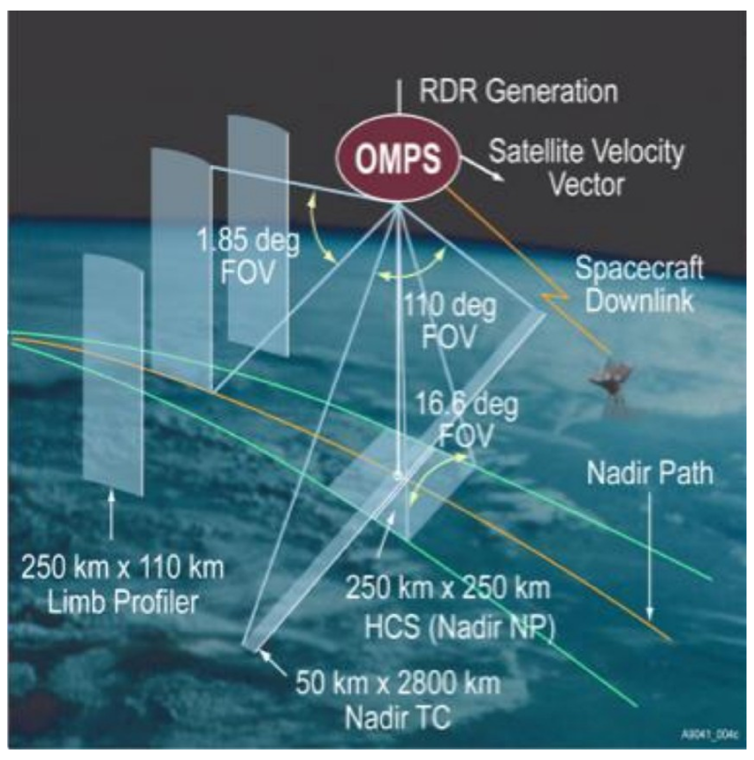


Fig.1 Sketch of the OMPS' geometry of observation

The Ozone Mapper and Profiler Suite (OMPS) instrument was launched at the end of 2011 into a sun-synchronous orbit; it carries three instruments: two nadir viewers and one **Limb Profiler** (LP) [1,2], of our interest. The LP instrument was specifically designed for ozone spectroscopy:

- it exploits a prism disperser;
- it collects radiance from the whole atmospheric range (0-100 km) at the same time by two CCDs, at four different gains; these are then sampled and interpolated to get level 1b data;
- stray light is reduced by means of spectral filters and pre-launch accurate PSFs study.

Spectral Range	280-1000 nm
Spectral Resolution	1 nm (UV) - 30 nm (IR)
Vertical Sampling	1.5 km

OMPS-IUP retrieval scheme set up

SCIATRAN is a software package that includes a coupled radiative transfer model and a retrieval algorithm [3]. Developed for the analysis of SCIAMACHY measurements, it has been adjusted to OMPS limb observations: the main differences between the two instruments for which the retrieval scheme had to be changed are the coarser OMPS' spectral resolution and the different channels in which the radiance is collected. The retrieval is based on the Optimal Estimation technique with Tikhonov regularization; spherical refractive geometry and multiple scattering are accounted for.

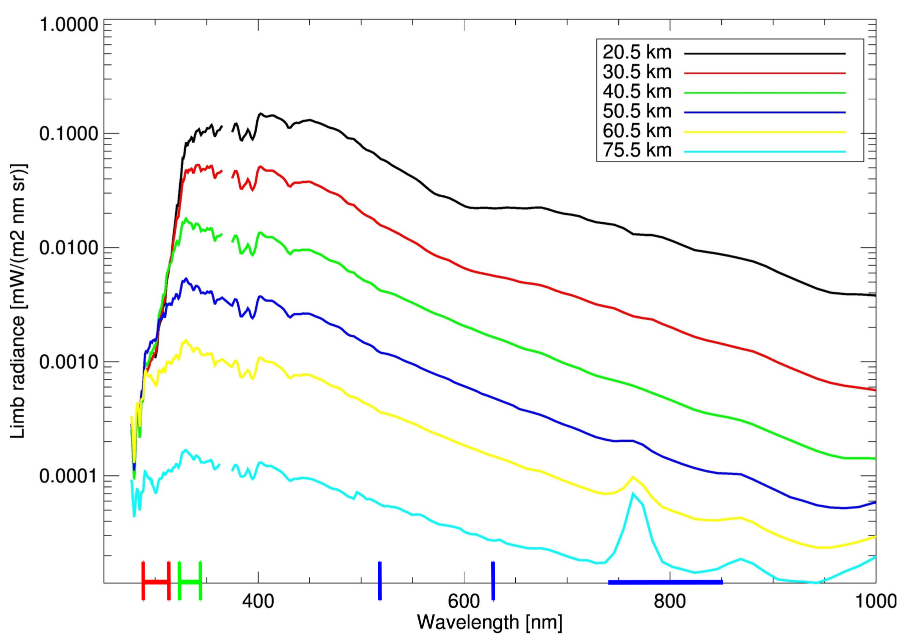


Fig.2 Spectral OMPS radiance at different tangent heights

Measurement vector:

$$y_i = \log\left(I_{TH_i} / I_{TH_n}\right) - P_n$$

where I_{TH_n} is an upper limb radiance used for the normalization (a Tangent Height, TH, between 43 and 63 km depending on the spectral range) and P_n is a subtracted polynomial (in Huggins and Chappuis bands).

Selected wavelengths:

- 2 intervals in Hartley band
- 2 intervals in Huggins band
- Chappuis from 515 nm to 635 nm

Wavelength intervals and the different parameters were adjusted looking at:

- **Ozone weighting functions,** to understand the sensitivity of the radiance at different wavelengths to ozone variations at different altitudes;
- **Fitting residuals,** differences between simulated and measured spectra;

Strong sensitivity is shown to the Tikhonov parameter and to Polynomial subtraction: these parameters had to be chosen carefully. Jumps and unrealistic features in the profiles were avoided, with a particular attention to the junctions between different spectral ranges.

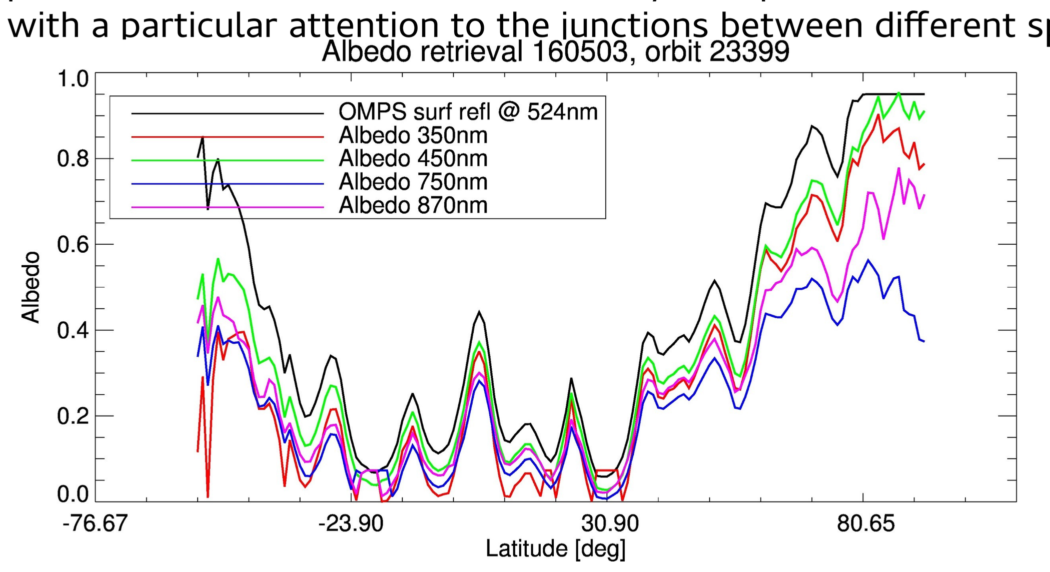


Fig.3 Albedo retrieval results for one orbit and 4 different spectral ranges, in black OMPS official surface reflectance at 524nm

Albedo retrieval is carried out thanks to the sun-normalized radiance provided in the new level 1b data release. THs around 35-40 km are considered and different spectral windows can be exploited, as shown in Fig.3.

Aerosol are accounted for using a climatology profile from a scaled LOWTRAN parametrization; aerosol load affects albedo retrieval: excessive loads lead to unrealistic albedo values.

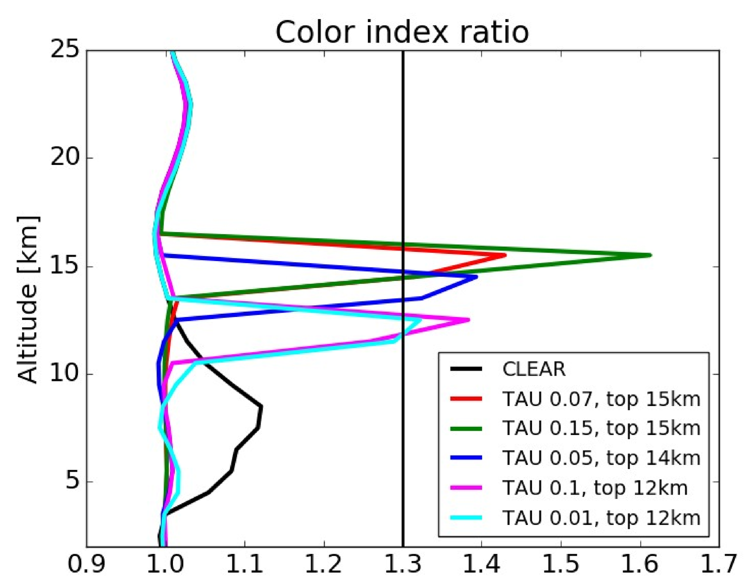


Fig.4 CIR for simulated clouds with different Optical Depths (in the legend OD / km) and altitudes.

A **Cloud flag** is implemented, based on the Color Index Ratio (**CIR**) approach [4]: the ratio of the radiance at 750 nm to the radiance at 1000 nm is firstly computed, the vertical gradient of this ratio is then found. A cloud lead to a peak in the CIR profile, as seen in Fig.4, where simulated cloud profiles are shown: the chosen threshold for the cloud flag is CIR = 1.3.

All the tangent heights below the detected cloud top are rejected. Typical background aerosol extinction is around 10^{-3}.

No **tangent height corrections** are actually implemented but static and dynamic adjustments are provided by NASA team in level 1 data

OMPS-NASA comparison

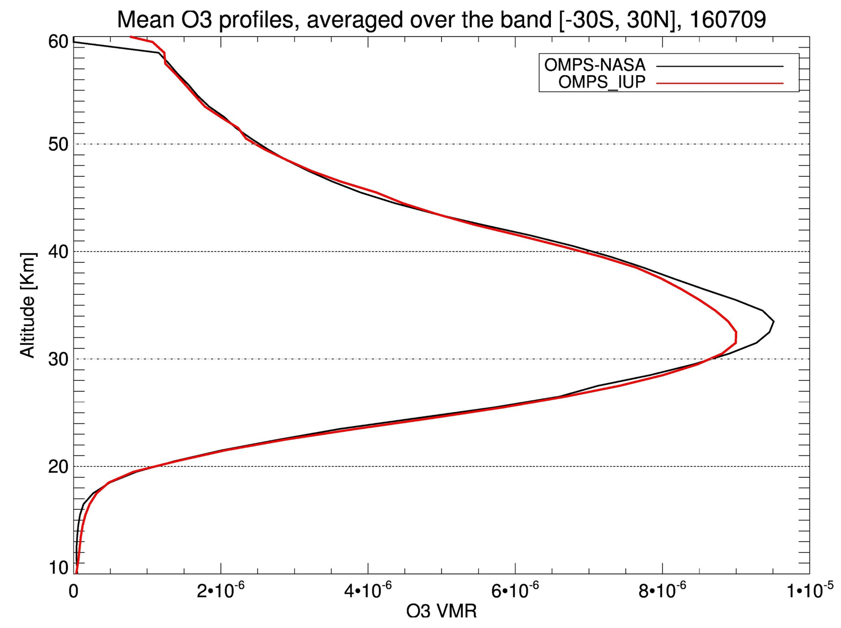


Fig.5 Comparison between NASA and OMPS-IUP retrieved ozone profiles (VMR), averaged over the tropical band for 1 day.

Official OMPS-NASA retrieval is based on the Optimal Estimation technique, but the measurement vector is made out of wavelength doublets and triplets. Upper and lower stratospheric ozone are retrieved separately and then the profiles are merged.

In Fig.5, VMR profiles retrieved on 09-Jul-2016 for both OMPS-IUP and OMPS-NASA are averaged over the tropical band ([30°S, 30°N]). The VMR peak is usually less pronounced for OMPS-IUP retrieval, but relative differences are less then 10% above 20 km.

OMPS-IUP profiles are retrieved starting from 12 up to 60 km, while NASA product starts at 6 km if no clouds are detected.

First MLS and ozonesonde comparisons

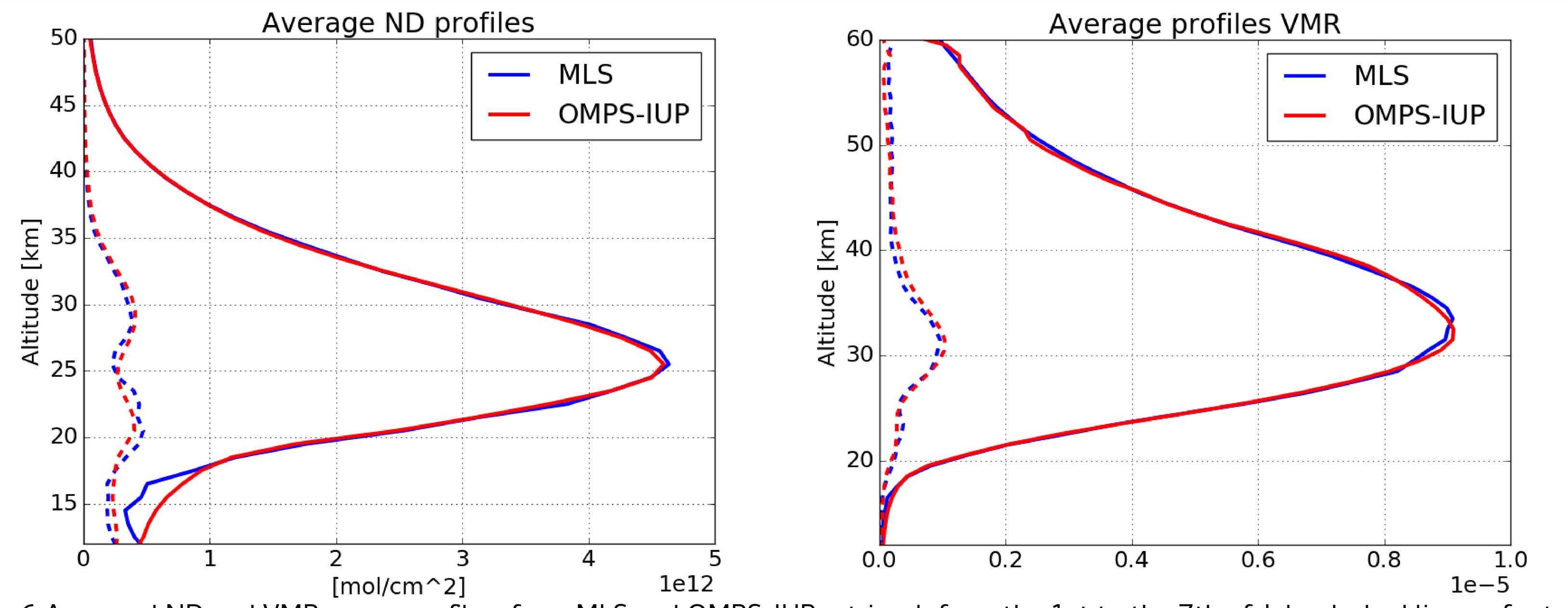
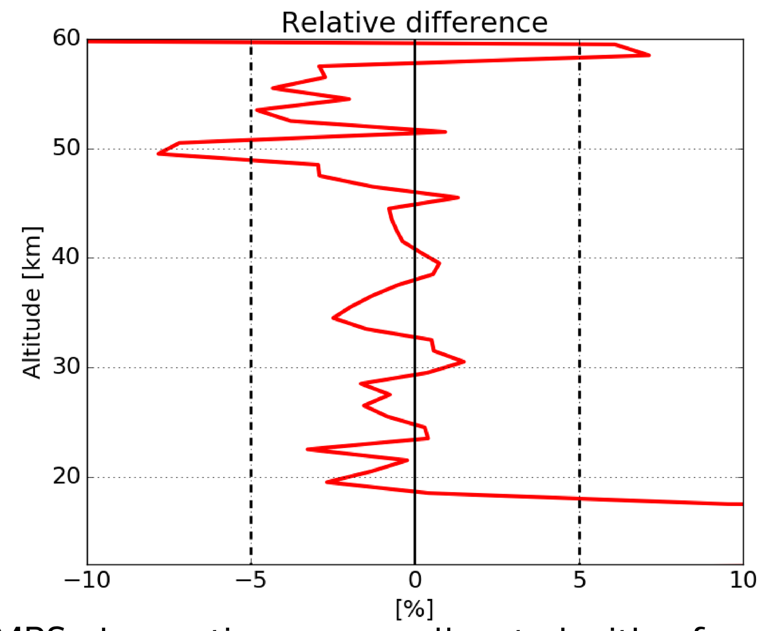


Fig.6 Averaged ND and VMR ozone profiles, from MLS and OMPS-IUP retrieval, from the 1st to the 7th of July; dashed lines refer to the std of the mean. Below, relative difference between OMPS-IUP and MLS profiles, 5% threshold is highlighted in black.



MLS and OMPS observations were collocated over 7 days at the beginning of July 2016, using the following criteria:

± 1° latitude and longitude & ± 6 hours

The profiles are then averaged over the tropical latitudinal band [30°S, 30°N] and shown in Fig.6.

Relative differences are also reported: from 17 up to 47 km OMPS-IUP retrieval is close to MLS within the 5%; a discrepancy of 2-3 km in the VMR profile peak is detected.

OMPS observations were collocated with a few available ozonesondes using the following criteria:

± 5° latitude, ± 10° longitude, ± 24 hours

Data from WOUDC were considered. In Fig.8, a balloon profile launched at Hohenpeissenberg on the 04-May-16, is smoothed using the Averaging Kernels of the retrieval scheme (blue line) and reported together with 19 collocated and averaged OMPS-IUP retrieved profiles (red line). In this case, relative differences (on the right) are less than 5% between 15 km up to the top height of the sonde.

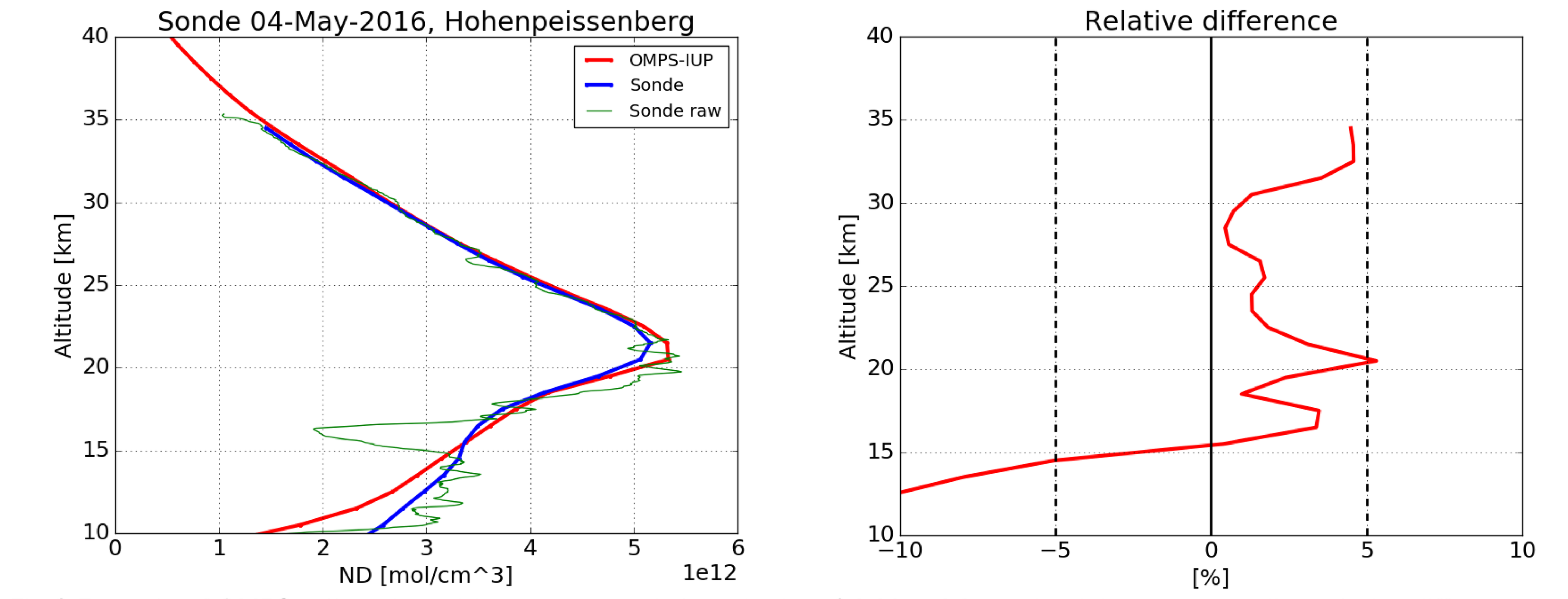


Fig.8 Example of OMPS collocation with an ozonesonde launched on 04-May-16; on the right, corresponding relative differences

Conclusions

The SCIAMACHY retrieval scheme was adjusted to OMPS limb measurements, exploiting spectral ranges in Hartley, Huggins and Chappuis ozone bands, to retrieve profiles between 12 and 60 km. The adjustment was supported by the analysis of ozone weighting functions and fit residuals. The retrieval actually includes a cloud filter and albedo retrieval.

Comparison with OMPS official profiles and MLS reference product were carried out: OMPS-IUP last version shows mean differences (over few test days) below 5% between 17 and 47 km. Extensive validations with MLS and balloon measurements will be performed.

References and Acknowledgements

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