Ozone profiles from limb observations

Retrieval of stratospheric ozone profiles from OMPS observations in limb geometry

C. Arosio, A. Rozanov, J.P. Burrows, *Institut für Umweltphysik (IUP), Universität Bremen*

In Short

- Retrieval of stratospheric ozone profiles from measurements of scattered solar light performed by the OMPS Limb Profiler instrument.
- Improvement of the quality of the retrieval settings, fixing issues found after the first data processing.
- Processing of the whole series of OMPS observations, from the beginning of the mission (2012) till mid 2019.
- Extensive validation of the results against independent data sets (satellite and ground based) and discussion of the temporal evolution of the biases.
- Merging of OMPS ozone time series with the SCIAMACHY one (2002–2012), in order to get a consistent longitudinally resolved time series over the last 15 years. Then merge with SAGE II record (1984–2005) to assess ozone trends over the last 35 years.

The importance of ozone as trace gas in the atmosphere is mainly related to its stratospheric layer that absorbs strong Ultraviolet (UV) radiation heating this atmospheric region and acting as a protective layer against biologically harmful radiation. As a greenhouse gas, it also plays an important role in the climate change (IPCC 5th report [5]).

After decades of studies related to ozone chemistry in the stratosphere, the reactions involving this molecule are generally well understood nowadays. Still, there are several issues to be clarified, related to the expected ozone recovery after the Montreal protocol adoption, to long term ozone trends and stratospheric responses to changes in tropospheric temperatures. Current predictions of the long term impact of global warming coupled with the removal of ozone depleting substances indicate a colder stratosphere and an increase in stratospheric ozone, a so-called super recovery. Global positive trends have been reported by many studies, as recently described by [6] [7]. However, if in the latter studies a statistically significant trend in the upper stratosphere is shown, [3] and other authors pointed out an unexpected decadal negative trend in the ozone abundance in the upper tropical stratosphere.

All these kinds of studies, require long-term reliable data sets, both from ground based instruments and from satellite observations. During the last few decades, several different remote sensing observation techniques have been used to derive ozone concentrations from the troposphere up to the mesosphere. A relatively new technique, the limb scatter of sunlight, is able to provide vertical profiles of ozone density with high vertical resolution and good coverage on a daily basis. One of the instruments capable of performing limb scanning in the shortwave spectral range was the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY), operative between March 2002 and April 2012 [2]. At the end of 2011, just some months before the end of SCIAMACHY lifetime, the Ozone Mapping and Profiler Suite (OMPS) instrument, similar in the concept to SCIAMACHY, was launched and it is still operative [4].

The main aim of this project is the processing of 7 years of OMPS limb observations, in order to retrieve stratospheric ozone profiles. It represents a continuation of the hbk00045 project focused on the retrieval of ozone distributions from SCIAMACHY limb measurements and inherits from it the general methodology. The final objective of the study is the creation of a consolidated ozone data set, employing a similar retrieval scheme used for the processing of SCIAMACHY data, so that the merging of the OMPS time series with the SCIAMACHY one is expected to be done in the most optimal way.

During the first 9 months of the project we processed 5 years of OMPS data (2012–2016) and performed a validation of the retrieved data set against independent observations, such as measurements from the satellite instrument Microwave Limb Sounder (MLS). A description of our retrieval algorithm and of the validation can be found in [1]. In Fig. 1 we present the zonally averaged relative differences between MLS and OMPS profiles, calculated considering 2016 data, as a function of latitude and altitude. As we can see, the general agreement between the two satellite data sets is good with differences within $\pm$ 10% between 20 and 55 km. A strong discrepancy is found in the lower stratosphere, in particular in the tropics, where both the ozone amount and the instrument sensitivity are low. In addition we can notice hemispheric asymmetry of the differences, that indicate the need of additional pointing corrections depending on latitude. A discrepancy between the first 2 years of retrieved profiles and the last 3 was also detected and related

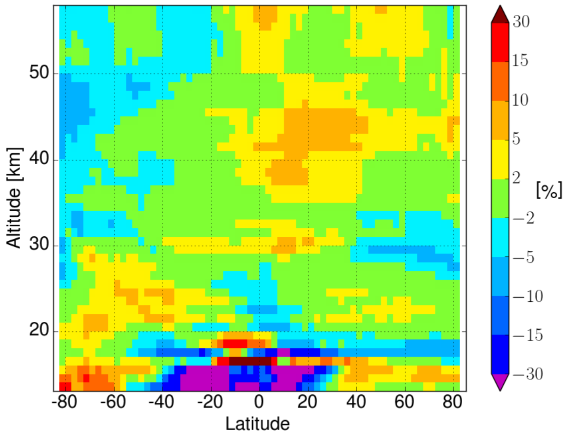

Figure 1: *Relative differences between collocated OMPS-LP retrievals and MLS profiles plotted in 2.5° latitude bins as a function of altitude, 2016 data set.*

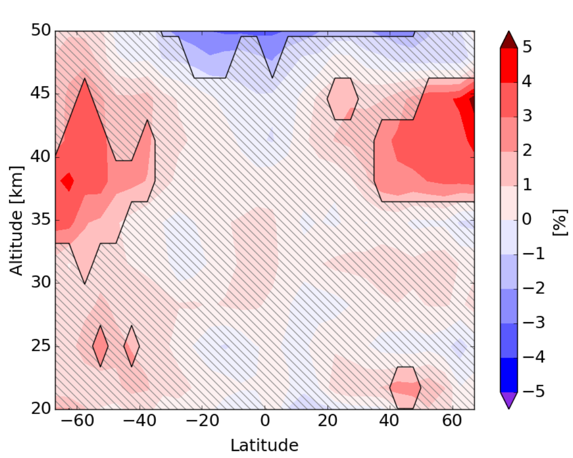

Figure 2: *Zonal linear long-term ozone variations over 2003–2016 period in % per decade, after merging SCIAMACHY and OMPS data sets. Dashed areas indicate non-significant trends.*

to a changing in UV radiance occurred at the end of 2013. To tackle these problems an improved retrieval version has already been tested and the plan is to re-process the whole time series using this version. In addition, an extension of the processed time series till the beginning of 2019 and the merging with the SCIAMACHY time series will result in more than 15 years of ozone record.

After the first processing of OMPS time series we performed a merging with the SCIAMACHY data set. Since the overlap time of the two mission is of only 3 months, we used the MLS record to remove the systematic offset between the two instruments and then joined the time series. We considered monthly averaged values binned every 5° latitude and 20° longitude. Using the merged data set, which covers the period 2003-2016, we applied a standard multi-linear regression approach to compute ozone long-term variations. In Fig. 2 we show the ozone linear trends in % per decade as a function of latitude and altitude, dashed ares indicate non-significant trends. As we can see, significant variations are found only at mid- and high-latitudes in the upper stratosphere. This recovering of ozone concentration is related by several studies also to the positive effects of the Montreal Protocol in reducing the emission of halogen-containing ozone-depleting substances.

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More Information

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