Ozone profiles from limb observations

Retrieval of stratospheric ozone profiles from OMPS observations in limb geometry

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In Short

- Retrieval of stratospheric ozone profiles from measurements of scattered solar radiation performed by the OMPS Limb Profiler instrument.
- Processing of the whole time series of OMPS observations, from the beginning of the mission.
- Extensive validation of the results against independent data sets (satellite and ground based) and discussion of the temporal evolution of the biases w.r.t. independent measurements.
- Merging of the OMPS ozone time series (2012–present) with the SCIAMACHY one (2002–2012) to get a consistent longitudinally resolved data set and study long-term ozone changes.

The importance of ozone as a trace gas in the atmosphere is mainly related to its stratospheric layer. It absorbs biologically harmful ultraviolet (UV) radiation and heats this atmospheric region. Despite the progresses in understanding the stratosphere chemistry, there are several issues to be clarified, related to the expected ozone recovery after the Montreal protocol adoption, and the stratospheric response to changes in tropospheric temperatures and anthropogenic emissions. Current predictions of the long term impact of the increasing CO_2 concentration coupled with the removal of chlorine-containing ozone-depleting substances (ODS) indicate a colder stratosphere and an increase in stratospheric ozone. Global positive trends have been reported by many studies, as recently described by [6] and [5]. However, although a statistically significant trend in the upper stratosphere is confirmed, some studies pointed out an unexpected decadal negative trend in ozone abundance in the middle tropical stratosphere, and the expected decrease in the lower tropical stratosphere is controversial. In addition, no statistically significant trends in the total column ozone have been so far detected.

Such studies require long-term reliable data sets, from both ground-based instruments and satellite platforms. During the last few decades, several 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 with high vertical resolution and good coverage on daily basis. One of the instruments 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 [3]. At the end of 2011, some months before the end of SCIAMACHY lifetime, the Ozone Mapping and Profiler Suite - Limb Profiler (OMPS-LP) instrument [4], similar in the concept to SCIAMACHY, was launched and is still operative.

The main aim of this project is the processing of OMPS-LP observations to retrieve stratospheric ozone profiles. It is a continuation of the hbk00045 project focused on the ozone retrieval from SCIAMACHY limb measurements and inherits from it the general methodology. We employ a similar retrieval scheme used for the processing of SCIAMACHY data, with the aim to create a consolidated ozone data set by merging the OMPS-LP and SCIAMACHY time series. In the first years of the project, we processed 8 years of OMPS-LP data (2012–2019) and performed a validation of the retrieved data set against independent observations, e.g. measurements from the satellite instrument Microwave Limb Sounder (MLS). A description of our retrieval algorithm and validation can be found in [1].

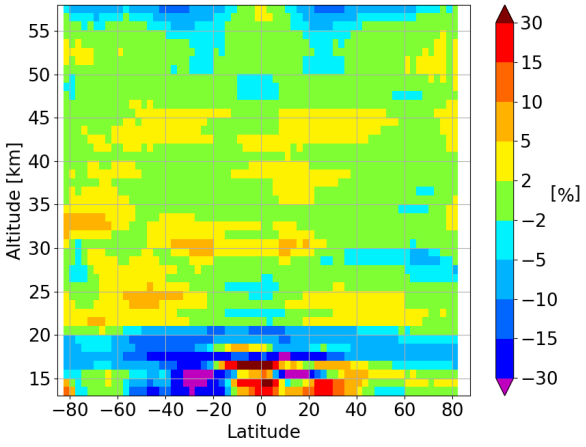

***Figure 1:** Relative differences between collocated OMPS-LP retrievals and MLS profiles averaged in 2.5° latitude bins as a function of altitude, 2016 data set.*

Several versions of the retrieval scheme have been implemented, the last one including pointing corrections provided by the NASA team. In Fig. 1 we show the zonally averaged relative differences between collocated MLS and OMPS-LP profiles, computed over 2016, as a function of latitude and alti-

tude. As we can see, the general agreement between the two satellite data sets is good with differences extensively within ± 5% between 20 and 55 km. Larger discrepancies are found in the lower stratosphere, in particular in the tropics, where both the ozone amount and the instrument sensitivity are low. Work is ongoing to take into account the presence of polar mesospheric clouds in the polar region during summer. Additional work is also needed to improve the quality in the lower stratosphere and update the time series including 2020. The merging with SCIAMACHY results in more than 18 years of ozone record.

Using the current version of the OMPS-LP time series, we performed a merging with the SCIAMACHY data set. Since the overlap time of the two missions is less than 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 2003-2018, we applied a standard multi-linear regression approach to compute long-term ozone variations. The merging approaches and the trend results are presented in [2]. Fig. 2 shows the resulting ozone linear trends in % per decade as a function of latitude and altitude; dashed areas indicate non-significant trends.

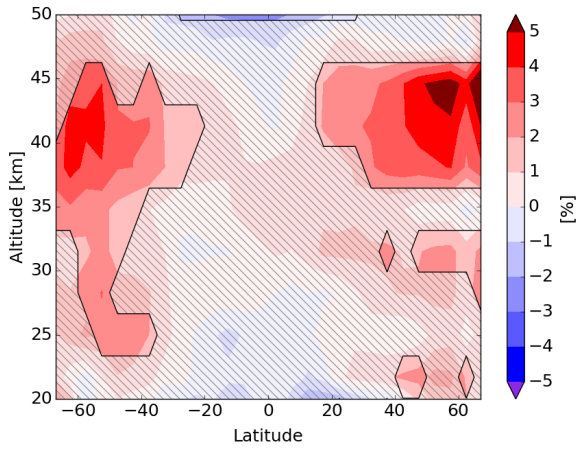

Figure 2: *Zonal linear long-term ozone variations over 2003–2018 in % per decade, after merging SCIAMACHY and OMPS-LP data sets. Dashed areas indicate non-significant values.*

Significant values are found only at mid and high latitudes in the upper stratosphere. The ozone recovery is related also to the positive effects of the Montreal Protocol in reducing the emission of halogen-containing ODS. Negative but non-significant values are found in the lower tropical stratosphere, whereas in the middle tropical stratosphere an oscillating short-term variation has been identified and discussed in [2].

A remarkable longitudinal asymmetry is found not only in the lower stratosphere but also around 40 km. In Fig. 3 longitudinally resolved ozone trends at 41 km are reported. The most important feature is the asymmetry at northern mid and high latitudes, with the strongest recovery over the Canadian sector and non-significant values over Siberia. The causes of this pattern are still under investigation, even though related to changes in the atmospheric dynamics.

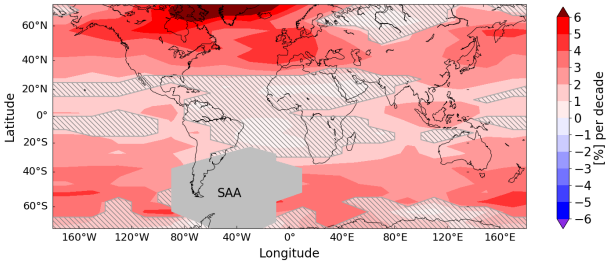

Figure 3: *Longitudinally resolved ozone linear changes in % per decade at 41 km over the period 2003-2018 from the SCIAMACHY/OMPS-LP merged data set. Dashed areas indicate non-significant values.*

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http://www.iup.physik.uni-bremen.de

More Information

[1] C. Arosio, A. Rozanov, E. Malinina et al., (2018), *Retrieval of ozone profiles from OMPS limb scattering observations*, doi:10.5194/amt-11-2135-2018.

[2] C. Arosio, A. Rozanov, E. Malinina et al., (2019), *Merging of ozone profiles from SCIAMACHY, OMPS and SAGE II observations to study stratospheric ozone changes*, doi:10.5194/acp-19-767-2019.

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