# 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.
- Extensive validation of the results against independent data sets (satellite and ground based) and discussion of the temporal evolution of the biases.
- 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.
- Geophysical studies of the ozone changes, by using a chemistry transport model to investigate dynamics- and chemistry-related drivers.

The importance of ozone as a trace gas in the atmosphere is mainly related to its stratospheric layer, which absorbs biologically harmful ultraviolet (UV) radiation. Despite the progresses in the understanding of the ozone chemistry in the stratosphere, 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 of chlorine-containing ozone-depleting substances (ODS) and greenhouse gases. Current predictions of the long term impact of the increasing $CO_2$ concentration coupled with the removal of 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, the expected decrease in the lower tropical stratosphere is controversial.

Such studies require long-term reliable data sets. During the last few decades, several remote sensing observation techniques have been used to derive ozone concentrations from the troposphere up to the mesosphere. In particular, the limb scattering technique is able to provide vertical profiles of ozone with high vertical resolution and good coverage on daily basis. One of the instruments performing such measurements was the SCanning Imaging Absorption spectroMeter for Atmospheric CHartographY (SCIAMACHY), operative between 2002 and 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 sets by merging the OMPS-LP and SCIAMACHY time series. In the first years of the project, we processed 9 years of OMPS-LP data (2012–2020) and performed a validation of the retrieved data set against independent observations, e.g. ozonesondes. A description of our retrieval algorithm and validation can be found in [1].

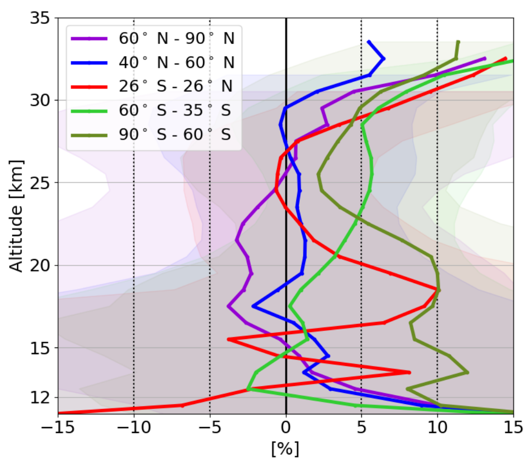


***Figure 1:** Relative differences between collocated OMPS-LP retrievals and ozonesonde profiles as a function of altitude in several latitude bands, 2012-2019 data.*

Several versions of the retrieval scheme have been implemented, the last one including pointing corrections provided by the NASA team, including improved settings for the lower stratosphere and polar regions. In Fig. 1 we show the zonally averaged relative differences between collocated ozonesondes and OMPS-LP profiles, computed over 2012-2019, in several latitude bands. As we can see, the general agreement between the two satellite data sets is good, with differences extensively within $\pm$ 10% between 12 and 30 km. The largest discrepancies are found in the lower stratosphere, in particular in the tropics, where both the ozone amount and the instrument sensitivity are low. A positive bias is also visible in the southern polar region below 20 km.

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 systematic offsets 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 2003-2020, 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]. In Fig. 2 longitudinally resolved ozone trends at 38 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. This feature was studied with the aim of TOMCAT chemistry transport model to better understand the main atmospheric drivers of these observed trends. This gave clues that the asymmetry is related to changes in atmospheric dynamics, e.g. the mean position of the polar vortex.

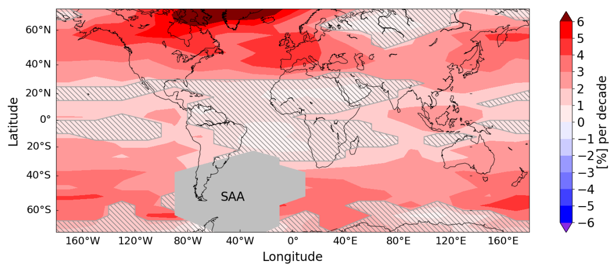


***Figure 2:*** *Longitudinally resolved ozone linear changes in % per decade at 38 km over the period 2003-2020 from the SCIAMACHY/OMPS-LP merged data set. Dashed areas indicate non-significant values.*

A known issue that has to be checked in the next months, is the OMPS-LP drift with respect to independent data sets, e.g. MLS. This drift has been identified during the last years and it particularly affects altitudes above 35 km. In Fig. 3 the drift between OMPS-LP and MLS time series is shown as a function of altitude and latitude, in terms of % per decade, over 2012-2020. Investigations from the NASA team have struggled to better understand the cause of this drift and a collaboration with their team is ongoing. Presently, an improved version of L1G data by the NASA team is in preparation, which will be released at the end of the summer. The results from the processing of the first sub-set of the new L1G data are promising, and the re-processing of the OMPS-LP time series is planned.

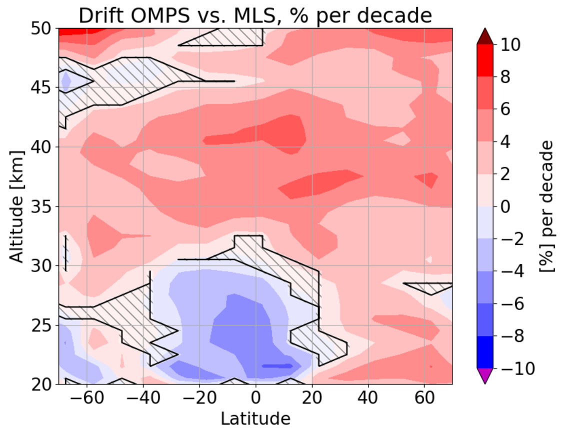


***Figure 3:*** *OMPS-LP drift in % per decade w.r.t. MLS ozone data.*

## WWW

https://www.iup.uni-bremen.de/LRRT/home.html

## 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.

[3] J.P. Burrows, E. Hölzle, APH Goede, et al., (1995), *SCIAMACHY−Scanning imaging absorption spectrometer for atmospheric chartography*, **35**, 445-451.

[4] J. Jaross, P.K. Bhartia, C. Grace and K. Mark, (2014), *OMPS Limb Profiler instrument performance assessment*, **119**, 4399-4412.

[5] I. Petropavlovskikh, S. Godin-Beekmann, D. Hubert et al., (2019), *Sparc/io3c/gaw report on long-term ozone trends and uncertainties in the stratosphere*.

[6] WMO, (2018), *Scientific Assessment of Ozone Depletion 2018, Global Ozone Research and Monitoring Project Report 58*.

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## DFG Subject Area

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