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,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 12 years of OMPS-LP data (2012–2023) 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].

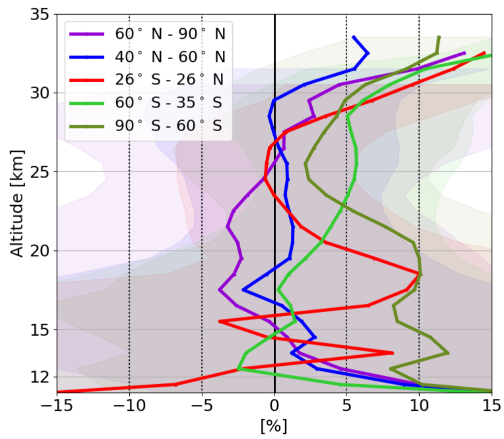

***Figure 1:** Relative differences between collocated OMPS-LP retrievals and ozonesonde profiles as a function of altitude in several latitude bands, 2012-2021 data.*

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 2012-2021, 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 (SCIA+OMPS), which covers the period 2003-2021, 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 32 km in spring are shown. An evident asymmetry at northern mid and high latitudes is visible, with the strongest recovery over the Canadian sector and negative values over Siberia. This feature was studied with the TOMCAT chemistry transport model, which can well reproduce this feature, as shown in Fig. 2 on the right. The investigation showed that the main atmospheric driver of this asymmetry is the change in the mean position of the polar vortex and it is related to long-term variations in atmospheric wave activity.

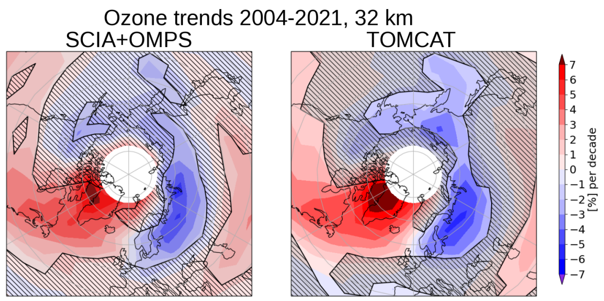

Figure 2: *Longitudinally resolved ozone linear changes in % per decade at 32 km over the period 2003-2021 in spring (MA) from the SCIA+OMPS merged data set and TOMCAT simulation. Dashed areas indicate non-significant values.*

A known issue that has been improved in the last months, is the OMPS-LP drift with respect to independent data sets, e.g. MLS, which particularly affected altitudes above 35 km. An improved version of the satellite data team was released last year by the NASA, including improved pointing and calibration corrections. A re-processing of the OMPS-LP time series was performed in the last months and the long-term drift was strongly reduced as shown in Fig. 3. Here the drift between OMPS-LP and MLS time series is shown as a function of altitude and latitude, in terms of % per decade, over 2012-2021: in the left panel for the old OMPS-LP dataset (v2.5) and in the right panel after the recent re-processing.

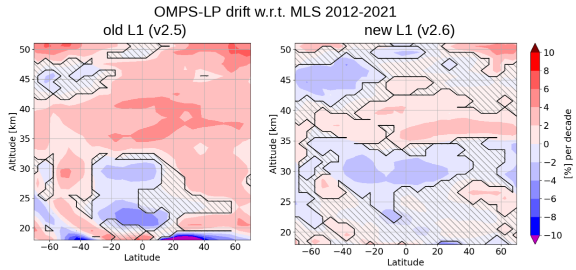

Figure 3: *OMPS-LP drift in % per decade w.r.t. MLS ozone data for the old and new data version.*

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.

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DFG Subject Area

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