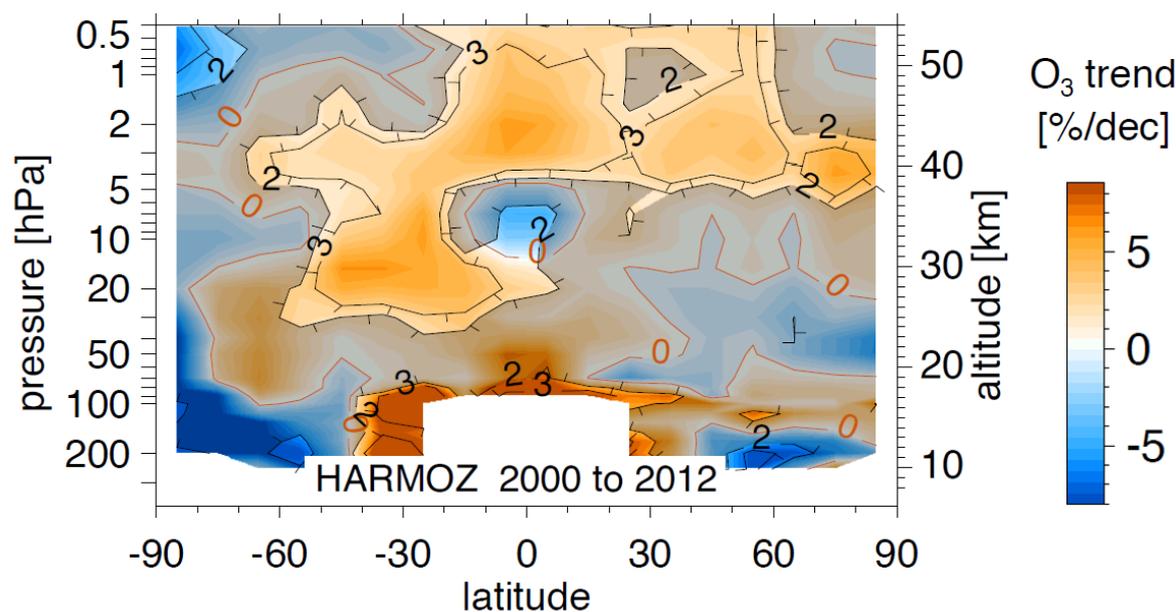


climate change initiative

→ OZONE NEWSLETTER

Issue 6 | July 2015

Ozone trends in %/decade since 2000 derived from the HARMOZ data set. Adapted from Figure 2.10 of the WMO Scientific Assessment of Ozone Depletion: 2014. *More on page 3...*



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Project overview

Ozone is one of the atmospheric Essential Climate Variables. It impacts the radiation budget of the Earth, interacts with atmospheric dynamics and climate, and influences chemically other radiatively active species. The Ozone_cci project aims at generating state-of-the-art and fully traceable long-term data records of ozone measurements from all relevant ESA, EUMETSAT and Third Party Missions. These data are needed to better assess the ozone variability at all scales, and improve our understanding of the fate of our protective ozone layer in a changing climate.

Building on the work realized in the first phase of the CCI programme, which culminated with the delivery in late 2013 of the first version of the ozone “Climate Research Data Package”, Ozone_cci Phase-2 focuses on extending and improving the data products to better match requirements formulated by the science user community.

This includes the extension in time of the data products to produce multi-decadal series of harmonized and consistent ozone

data suitable to assess long-term changes in the vertical distribution of ozone. In particular efforts concentrate on improving the accuracy of the products in the upper troposphere / lower stratosphere (UT/LS), and in the mesosphere which are both critical altitude regions in terms of ozone-climate feedbacks.

In the following, we summarize the main achievements of the project and present some of the most significant realizations. This covers the generation of new

reference time-series of ozone products derived from the successive GOME, SCIAMACHY, GOME-2 and OMI sensors complemented by the thermal infrared IASI instrument. Also addressed is the extension of the HARMOZ ozone profile which currently represents the most comprehensive data set for characterizing the stratospheric ozone variability in the years 2000.

All these data products are freely available from the project web-site.



Main achievements

In the second phase of the programme, the focus and ambition of Ozone_cci is to produce a fully harmonised data base of ozone measurements derived from all ESA and ESA Third Party Missions, and to demonstrate the added-value of these data as an input for chemistry-climate research and development.

The following achievements have been attained so far:

1. Total ozone data sets from all currently available backscatter nadir spectral UV-Vis sensors, i.e. GOME, SCIAMACHY, GOME-2 and OMI, have been reprocessed (Lerot et al., 2014) and the resulting harmonized product used for long-term trend analysis in the WMO Scientific Assessment of Ozone Depletion: 2014.

2. Ozone profile data covering 20 years of observations by the GOME, SCIAMACHY and GOME-2 instruments have been fully reprocessed. This data

set of unprecedented accuracy and consistency (Miles et al., 2015; Keppens et al., 2015) has been selected for inclusion in the 2015 ECMWF reanalysis ERA5.

3. The HARMOZ data base of ozone profiles (Sofieva et al., 2013) assembled from all ENVISAT and ESA TPM limb sensors available since 2000 has been further extended with data from the US MLS sensor, and work is ongoing to improve the data accuracy and long-term consistency of these data in the UT/LS and in the mesosphere. The HARMOZ product has also been included in the WMO

Scientific Assessment of Ozone Depletion: 2014.

Ozone_cci data products have been extensively documented following GCOS/CCI rules (see project documents available on www.esa-ozone-cci.org) and validated against GCOS and user requirements as formulated in the URD and documented in the PVIR.

All products distributed to the international scientific community follow a GCOS-compliant NetCDF-CF format.

New ozone data products: the Ozone_cci Climate Research Data Package (CRDP Aug. 2015)

The CRDP Aug. 2015 is the second version of the Ozone_cci data package. It contains extended data sets of total ozone, nadir ozone profiles and limb ozone profiles from all ESA and ESA TPM sensors. In Phase-2 a strong emphasis is put on deriving improved tropospheric and UT/LS ozone products from both nadir and limb sensors.

Product ID		Product level	Years Processed																					
			95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	
<i>Total column data products</i>																								
TC_GOME		L2/L3M																						
TC_SCIAMACHY		L2/L3M																						
TC_GOME2		L2/L3M																						
TC_OMI		L2/L3M																						
<i>Tropospheric column data products</i>																								
TTOC_GOME2		L2																						
LNTOC_SCIAMACHY		L2																						
<i>Nadir profile data products</i>																								
NP_GOME		L2																						
NP_SCIAMACHY		L2																						
NP_GOME2		L2																						
NP_IASI		L2																						
<i>Limb profile data products</i>																								
LP_SCIAMACHY		L2/L3																						
LP_MIPAS		L2/L3																						
LP_GOMOS		L2/L3																						
LP_OSIRIS		L2/L3																						
LP_SMR		L2/L3																						
LP_ACE		L2/L3																						
LP_MLS		L2																						
Comments:																								
L2/L3: Level-2/ Level-3 data sets																								
L3M: Merged Level-3 data sets																								
 Processed and available on the project web site Processed but still under evaluation																								

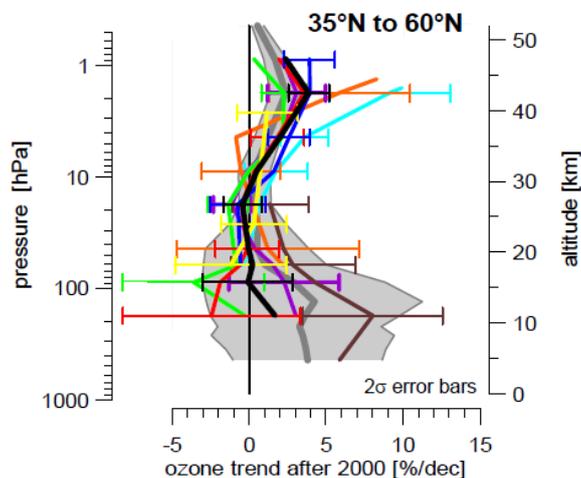


The Scientific Assessment of Ozone Depletion: 2014

Following the discovery of the Antarctic ozone hole in 1985, an international agreement known as Montreal Protocol was reached in 1987 to progressively phase out the use of ozone-depleting chemicals. Conducted under the auspices of the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), the Scientific Assessment of Ozone Depletion periodically update governments on the latest scientific findings related to the ozone layer. The recently published Scientific Assessment of Ozone Depletion: 2014, contains the most up-to-date understanding of ozone depletion. It reflects the thinking of hundreds of international scientific experts who contributed to its preparation and review. Among them, 11 scientists of the Ozone_cci project provided their contribution as lead author, coauthor or contributor. Several Ozone_cci data sets were included in the report, in particular the reprocessed total ozone data series and the HARMOZ limb profiles. The latter were used to infer ozone trends after 2000 showing clear evidences for an ozone recovery in the upper-stratosphere at 40 km of altitude (see figure, adapted from Figure 2.11 of the 2014 WMO Ozone Assessment report).

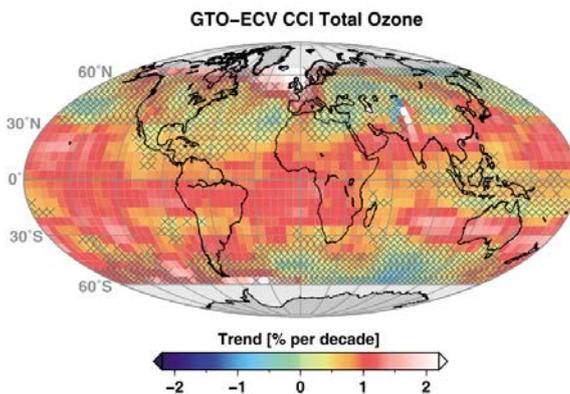
For more details see www.wmo.int/pages/prog/arep/gaw/ozone_2014/full_report_TOC.html.

SBUV-NASA, GOZCARDS, SAGE II V7.0, HARMOZ, NDACC lidar, mwave, FTIR, Umkehr, Sondes, average, CCMVal-2



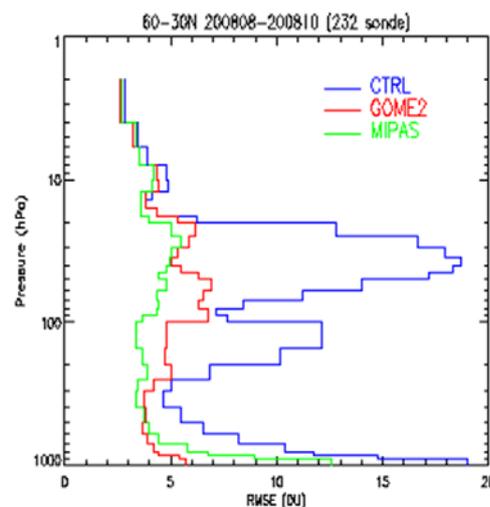
A new health check of the ozone layer

In a study recently published in Geophysical Research Letters (see [Coldewey-Egbers et al., 2015](#)) a new perspective on the current state of the ozone layer has been derived using the merged total ozone data record (GTO-ECV) recently released in the framework of the ESA Climate Change Initiative. Based on a multivariate regression analysis covering the 1995-2013 period, various aspects of ozone change and variability are disentangled on global and regional scales (see figure). This enables the monitoring of the effectiveness of the Montreal Protocol. Given dominant natural variability the expected mid-latitude onset of ozone recovery is still not significant and on estimates that 5 additional years of observations would be needed for an unequivocal detection. A regional increase identified in the tropics is a likely manifestation of a long-term change in El Niño-Southern Oscillation intensity over the last two decades induced by strong El Niño in 1997/1998 and strong La Niña in 2010/2011.



Integration of Ozone_cci products in the ECMWF ERA5 system

As part of the ongoing ERA-CLIM project aiming at generating a new version of the ECMWF reanalysis (ERA5) covering the period from 1979 until present, a round-robin exercise has been recently performed to assess the respective merits of several ozone data sets as an input to the long-term data assimilation system. 6 ozone data sets available from the Ozone_cci project have been included in the exercise: total ozone columns from GOME, SCIAMACHY and GOME-2, ozone profiles from GOME and GOME-2 and stratospheric ozone profiles from MIPAS. Their effect on the assimilation system has been extensively tested over a 4 months period in 2008 demonstrating a positive impact on the resulting ozone fields, which are brought into better agreement with reference data sets (see figure). As a result of the experiment, Ozone_cci data sets from GOME, SCIAMACHY, GOME-2 and MIPAS sensors are recommended for inclusion in ERA5 (Dragani, unpublished result).





Peer-reviewed scientific publications

Selected publications resulting from Ozone_cci data sets and/or activities.

- Adams, C., A. E. Bourassa, V. Sofieva, et al., **Assessment of Odin-OSIRIS ozone measurements from 2001 to the present using MLS, GOMOS, and ozone sondes**, *Atmos. Meas. Tech.*, 7, 49-64, doi:10.5194/amt-7-49-2014, 2014.
- Chiou, E. W., P. K. Bhartia, R. D. McPeters, et al., **Comparison of profile total ozone from SBUV (v8.6) with GOME-type and ground-based total ozone for a 16-year period (1996 to 2011)**, *Atmos. Meas. Tech.*, 7, 1681-1692, doi:10.5194/amt-7-1681-2014, 2014.
- Coldewey-Egbers, M., D. G. Loyola, M. Koukouli, et al., **The GOME-type Total Ozone Essential Climate Variable (GTO-ECV) data record from the ESA Climate Change Initiative**, *Atmos. Meas. Tech. Discuss.*, 8, 1-46, 2015.
- Coldewey-Egbers, M., Loyola R., D. G., Braesicke, P., et al., **A new health check of the ozone layer at global and regional scales**, *Geophysical Research Letters*, doi:10.1002/2014GL060212, 2014.
- Dameris, M. and P. Jöckel, **Numerical modeling of climate-chemistry connections: Recent developments and future challenges**, *Atmosphere*, 4, 132-156, doi: 10.3390/atmos4020132, 2013.
- Dameris, M. and D. Loyola, **Recent and future evolution of the stratospheric ozone layer**, Chapter 45 in *Atmospheric Physics, Background-Methods-Trends*, Ed. U. Schumann, Springer Heidelberg New York Dordrecht London, ISBN 978-3-642-30182-7, doi: 10.1007/978-3-642-30183-4, pp.747-761, 2012.
- Ebojic, F., von Savigny, C., Ladstätter-Weißmayer, et al., **Tropospheric column amount of ozone retrieved from SCIAMACHY limb-nadir-matching observations**, *Atmos. Meas. Tech.*, 7, 2073-2096, doi:10.5194/amt-7-2073-2014, 2014.
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- Gebhardt, C., Rozanov, A., Hommel, R., et al., **Stratospheric ozone trends and variability as seen by SCIAMACHY during the last decade**, *Atmos. Chem. Phys.*, 14, 831-846, doi:10.5194/acp-14-831-2014, 2014.
- Keppens, A., Lambert, J.-C., Granville, J., et al., **Round-robin evaluation of nadir ozone profile retrievals: methodology and application to MetOp-A GOME-2**, *Atmos. Meas. Tech.*, 8, 2093-2120, doi:10.5194/amt-8-2093-2015, 2015.
- Koukouli, M., D. Balis, I. Zyrididou, C., et al., **Validating the new GOME/ERS-2, SCIAMACHY/Envisat and GOME-2/MetOp-A homogeneous total ozone climate data record developed as part of the ESA Climate Change Initiative**, *J. Geophys. Res.*, under review (2015).
- Kyrölä, E., M. Laine, V. Sofieva, et al., **Combined SAGE II-GOMOS ozone profile data set 1984-2011 and trend analysis of the vertical distribution of ozone**, *Atmos. Chem. Phys.*, 13, 10645-10658, doi:10.5194/acp-13-10645-2013, 2013.
- Laeng, A., Hubert, D., Verhoelst, T., et al., **The ozone climate change initiative: Comparison of four Level-2 processors for the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS)**, *Remote Sens. Environ.*, dx.doi.org/10.1016/j.rse.2014.12.013, 2015.
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- Loyola, D., and M. Coldewey-Egbers, **Multi-sensor data merging with stacked neural networks for the creation of satellite long-term climate data records**, *EURASIP Journal on Advances in Signal Processing*, vol. 2012, no. 1, 2012.
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