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Absorption cross-sections of ozone in the ultraviolet and visible spectral regions: Status report 2015

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ABSTRACT

The activity "Absorption Cross-Sections of Ozone" (ACSO) started in 2008 as a joint initiative of the International Ozone Commission (IO3C), the World Meteorological Organization (WMO) and the IGACO ("Integrated Global Atmospheric Chemistry Observations") O_3/UV subgroup to study, evaluate, and recommend the most suitable ozone absorption cross-section laboratory data to be used in atmospheric ozone measurements. The evaluation was basically restricted to ozone absorption

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cross-sections in the UV range with particular focus on the Huggins band. Up until now, the data of Bass and Paur published in 1985 (BP, 1985) are still officially recommended for such measurements. During the last decade it became obvious that BP (1985) cross-section data have deficits for use in advanced space-borne ozone measurements. At the same time, it was recognized that the origin of systematic differences in ground-based measurements of ozone required further investigation, in particular whether the BP (1985) cross-section data might contribute to these differences.

In ACSO, different sets of laboratory ozone absorption cross-section data (including their dependence on temperature) of the group of Reims (France) (Brion et al., 1993, 1998, 1992, 1995, abbreviated as BDM, 1995) and those of Serdyuchenko et al. (2014), and Gorshelev et al. (2014), (abbreviated as SER, 2014) were examined for use in atmospheric ozone measurements in the Huggins band.

In conclusion, ACSO recommends:

(a) The spectroscopic data of BP (1985) should no longer be used for retrieval of atmospheric ozone measurements.
(b) For retrieval of ground-based instruments of total ozone and ozone profile measurements by the Umkehr method performed by Brewer and Dobson instruments data of SER (2014) are recommended to be used. When SER (2014) is used, the difference between total ozone measurements of Brewer and Dobson instruments are very small and the difference between Dobson measurements at AD and CD wavelength pairs are diminished.
(c) For ground-based Light Detection and Ranging (LIDAR) measurements the use of BDM (1995) or SER (2014) is recommended.
(d) For satellite retrieval the presently widely used data of BDM (1995) should be used because SER (2014) seems less suitable for retrievals that use wavelengths close to 300 nm due to a deficiency in the signal-to-noise ratio in the SER (2014) dataset.

The work of ACSO also showed:

- The need to continue laboratory cross-section measurements of ozone of highest quality. The importance of careful characterization of the uncertainties of the laboratory measurements.
- The need to extend the scope of such studies to other wavelength ranges (particularly to cover not only the Huggins band but also the comparison with the mid-infrared region).
- The need for regular cooperation of experts in spectral laboratory measurements and specialists in atmospheric (ozone) measurements.

1. Introduction

1.1. The international ACSO initiative (2008–2015)

This report presents the results of the "Absorption Cross-Sections of Ozone" (ACSO) activity, created in 2008 as a joint initiative of the International Ozone Commission (IO3C), the World Meteorological Organization (WMO), and the IGACO ("Integrated Global Atmospheric Chemistry Observations") O3/UV Subgroup.

The official mandate of the ACSO initiative, chaired by *Johannes Orphal* (KIT, Karlsruhe, Germany), together with *Johanna Tamminen* (FMI, Helsinki, Finland), *Johannes Staehelin* (ETH Zurich, Switzerland) and *Geir Braathen* (WMO, Geneva, Switzerland) constituting the ACSO Steering Committee, was created with the task of producing a critical intercomparison of existing ozone absorption cross-sections and their impact on atmospheric ozone retrievals from the ground and satellites. If necessary, a new standard for reference ozone absorption cross-sections should be recommended, and its implementation for all atmospheric measurements of ozone would have to be initiated. Finally, a report with all the findings and recommendations of ACSO would need to be prepared.

The full ACSO group was established in 2008 with a large participation of leading experts from three different communities: (1) ground-based ozone measurements (e.g. Dobson, Brewer, Umkehr, LIDAR and Differential Optical Absorption Spectroscopy (DOAS) methods, including the Network for the Detection of Atmospheric Composition Change (NDACC) network), (2) satellite instruments for atmospheric ozone measurements (e.g. Total Ozone Mapping Spectrometer (TOMS), Solar Backscatter Ultraviolet Radiometer (SBUV), Stratospheric Aerosol and Gas Experiment (SAGE), Global Ozone Monitoring Experiment (GOME)/SCanning Imaging Absorption spectroMeter for Atmospheric Cartography (SCIAMACHY), Ozone Monitoring Instrument (OMI), etc.), and (3) the laboratory community where currently new reference data are being produced. The work was done in two phases. In the first phase, three dedicated workshops were held at WMO in 2009, 2010, and 2011 in which the set of temperature-dependent ultraviolet–visible absorption cross-sections of ozone measured and published by a group of scientists from Reims (France) in the mid-1990s, usually referred to as BDM [1–4] was mostly considered to replace the presently recommended dataset from Bass and Paur [5,6]. In the second phase in 2013, the novel absorption cross-sections of ozone published by Gorshelev et al. [7], Serdyuchenko et al. [8] became available and an additional workshop was arranged at WMO in 2013. The Final Report (ACSO Status Report 2015) was prepared in 2014–2015 and officially released as "WMO – GAW Report No. 218".

1.2. Scientific background

Atmospheric ozone is presently measured from the ground and space by a large number of methods (see e.g. Ref. [9] and references therein) most of them making use of interaction of (solar) radiation with ozone including many different wavelength ranges. Absorption cross-sections of ozone are an essential parameter for the determination of atmospheric ozone concentrations from ultraviolet and visible spectra. While satellite measurements provide global coverage, measurements from the ground are essential to validate satellite ozone measurements and ensure their long-term stability and, therefore, it is desirable to use the same laboratory spectroscopic data for ground-based and satellite measurements in order to minimize error sources for the comparison. Since the discovery of the strong absorption band of ozone in the ultraviolet by *Hartley* in 1880, and the following measurements