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# Atmospheric remote-sensing reference data: Temperature-dependent absorption cross section spectra of ozone in the 235 - 795 nm range obtained with GOME-2 spectrometers

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The GOME-2 instrument is part of the core payload of the MetOp satellite series, which forms the space segment of the EUMETSAT Polar System EPS. Three identical GOME-2 spectrometers were commissioned as flight models for the MetOp satellite series. They are designed as scanning double spectrometers performing simultaneous observations in the 235 to 795 nm range of the extraterrestrial solar irradiance and of the up –welling earthshine in nadir viewing geometry. Primary target parameters are total column densities and vertical profiles of ozone and $NO_2$. For these two gases reference spectra were measured on-ground and under representative in-flight conditions with the individual GOME-2 flight models in three independent campaigns using a mobile absorption spectroscopy set-up called CATGAS (Calibration Apparatus for Trace Gas Absorption Spectroscopy). This set-up had been dedicatedly designed for this purpose at the Institute of Environmental Physics at the University of Bremen.

Temperature dependent absorption spectra were obtained at 203K, 223K, 243K, 273K, and 293K covering the instrument's observational range from 235 to 795nm completely. Up to 12 different combinations of optical pathlength and $O_3$ concentrations were used to cover the range of 7 orders of magnitude, over which the ozone cross section varies within the observational range. A special focus was on the Huggins bands, as these are important for atmospheric retrieval and also on simultaneous measurement of the Huggins and Chappuis bands to enable intercalibration of these two bands. Based on normalisation to unit integrated absorption of electronic bands the relative temperature dependence of the ozone spectrum was determined. Among the

three campaigns it agrees accurately as well as with the literature data available at the selected wavelengths of 253.65 nm, 289.36 nm, 296.73 nm, 302.15 nm, and 334.15 nm. For the temperature dependence of the ozone cross section in the range of 425 to 430 nm an upper limit estimate of no more than 10% decrease with falling temperature was found in disagreement with one previous publication. At the same time a clear increase of amplitude of differential absorption cross section at 426 nm of 13% with falling temperature was determined. At 604.61nm at the top of the Chappuis band a slight increase of cross section with falling temperature of $\approx$1% is found in agreement with three previous publications and in disagreement with one most recent one. By the aforementioned normalisation the series of temperature dependent spectra within the series were already on the correct *relative* scale. They were then placed on an absolute scale of absorption cross sections by scaling the whole series in a least squares approach to literature data using only absolute determinations performed at wavelengths 253.65 nm, 289.36 nm, 296.73 nm, 302.15 nm, 334.15 nm and 604.61 nm and at various temperatures between 200 and 300K. At high concentrations of ozone evidence was found for a continuous background absorption, which does not belong to $O_3$ and which is visible in the region of smallest ozone cross sections between the Huggins and Chappuis bands. It could have its origin either in a gas phase absorber like a $O_3/O_3$ or $O_3/O_2$ dimer or in an interaction between $O_3$ and molecular layers of water on windows or mirrors. From simultaneously measured spectra covering the Huggins and Chappuis bands the ratios of integrated absorption cross sections were determined between the different regions providing a robust means for intercomparison of cross section in these regions.