Look-up tables of ground-based UV-vis O_3 column averaging kernels based on the TV8 ozone profile climatology

François Hendrick and Michel Van Roozendael (BIRA-IASB)
Contact: franch@oma.be

1. Introduction

A climatology of O_3 column averaging kernels has been developed with the aim to consolidate and better characterize the time-series of total ozone measurements produced by UV-vis and SAOZ spectrometers from the NDACC network. Column averaging kernels are needed for satellite total ozone validation in order to compare the sensitivity of the ground-based and space-borne instruments to the ozone vertical profile. Enhancing the usability of the correlative data sets is also the main reason why standard guidelines for data reporting like GEOMS (Global Earth Observation Metadata Standard; see http://avdc.gsfc.nasa.gov/index.php?site=1178067684) recommend to include metadata like averaging kernels in data files. We describe a new multi-entry database of ground-based UV-vis O_3 column averaging kernels applicable at the global scale. It is complementary to the O_3 air mass factor (AMF) climatology recently developed in order to homogenize the NDACC UV-vis O_3 column data sets.

2. Description

The proposed database of O_3 column averaging kernels is based on the theoretical work of *Eskes and Boersma (2003)* and has been generated using the UVSPEC/DISORT radiative transfer model (*Hendrick et al., 2006*) and the TOMS version 8 (TV8) ozone and temperature profile climatology (*Barthia et al., 2004*). The TV8 is a monthly-zonal climatology sorted according to the ozone column. It has been widely used for the retrieval of global total ozone fields from recent US and European UV-VIS nadir sounders (e.g. *Barthia et al., 2004, Coldewey-Egbers et al., 2005, Van Roozendael et al., 2006, Eskes et al., 2005*). In addition to the TV8 profiles, the parameters considered in building the look-up tables (LUTs) are: wavelength, ground albedo, and SZA. Table 1 summarizes these different parameters and their corresponding values.

Parameter	**Values**
TOMS v8.0 O_3 and temperature climatology	- Latitude: 85°S to 85°N step 10° - Month: 1 (Jan) to 12 (Dec) step 1 - Ozone: 125 to 575 DU step 50 DU (TOMS O_3 grid)
Wavelength	440 to 580 nm step 35 nm
Surface albedo	0 and 1
SZA	90° (SZA representative of ground-based UV-vis measurements at twilight)
Aerosols	Aerosol extinction profile corresponding to background conditions and constructed from the aerosol model of *Shettle (1989)* included in UVSPEC/DISORT

Table 1: Parameters of the look-up table and their corresponding values.

The climatology consists of 18 look-up tables (size: 1.3 MB each), each of them corresponding to one TOMS latitude (table #1: 85°S…table #18: 85°N). An interpolation routine has been developed in order to extract appropriately parameterized O_3 column averaging kernels for the different NDACC stations. This routine is written in FORTRAN 77 and a DOS executable has been created. The source code is also available for compilation on LINUX machines. In addition, a global monthly climatology of the surface albedo is coupled to the interpolation routine so that realistic albedo values can be obtained in a transparent way. This albedo climatology is extracted from the GOME surface albedo database developed by *Koelemeijer et al.* (2003). It consists of 12 look-up tables, one for each month of the year. The wavelength corresponding to these tables is 494 nm and albedo values are given for grid-cells of 1° x 1° (latitude: -89.5° to 89.5°; longitude: -179.5° to 179.5°).

3. How to use the O_3 column averaging kernel climatology?

The zip file of the version 2.0 of the extraction routine contains 54 files: 18 O_3 column averaging kernel look-up tables (size: 1.3 MB each), 18 O_3 vertical profile look-up tables (size: 1.3 MB each), 12 surface albedo look-up tables (size: 1.1 MB each), a DOS executable (‘o3_avk_interpolation_v2_0_dos’), the source code in FORTRAN 77 (‘o3_avk_interpolation_v2_0.for’), two input files for selecting parameter values, and two output files (one for the averaging kernels and one for the corresponding O_3 vertical profiles). All the files should be located in the same directory for a proper use of the climatology. In the file ‘input_file_o3_avk.dat’, the user can enter values for wavelength, latitude, longitude, and surface albedo. Regarding the albedo, the user must give a value to a flag in order to determine whether he wants to use the albedo climatology (flag=1) or not (flag=2). The user has also to define the name of the file with year, day numbers, and corresponding O_3 vertical columns in Dobson unit (here called ‘Day_O3_col.dat’; maximum number of lines in this file: 500000). The resulting O_3 column averaging kernels are stored in a file called ‘o3_avk_output.dat’. In version 2.0, the corresponding O_3 vertical profiles in VMR or molec/cm^3 units are also extracted. The main goal is to make available the a priori profiles needed for the smoothing of correlative data (model or satellite vertical profiles) needed for direct comparison according to the Rodgers optimal estimation formalism (Rodgers, 2000):

$$\mathbf{C_s} = \mathbf{C_a} + \mathbf{A}^{\mathbf{T}} (\mathbf{x_c} - \mathbf{x_a}) \; . \qquad (1)$$

where $\mathbf{A}$ is the ground-based UV-visible column averaging kernel, $\mathbf{x_a}$ is the a priori profile used for the calculation of averaging kernels, $\mathbf{C_a}$ is the corresponding vertical column, $\mathbf{x_c}$ is the correlative profile (e.g. model or satellite profiles), $\mathbf{C_s}$ is the smoothed or convolved correlative vertical column.

4. References

Barthia, P. K., C. G. Wellemeyer, S. L. Taylor, N. Nath, and A. Gopolan, Solar Backscatter (SBUV) Version 8 profile algorithm, Proceedings of the Quadrennial Ozone Symposium 2004, edited by C. Zerefos, pp. 295-296, Athens, Greece, ISBN, 960-630-103-6, 2004.

Coldewey-Egbers, M., M. Weber, L. N. Lamsal, R. de Beek, M. Buchwitz, and J. P. Burrows, Total ozone retrieval from GOME UV spectral data using the weighting function DOAS approach, *Atmos. Chem. Phys., 5*, 1015–1025, 2005.

Eskes, H. J., and K. F. Boersma, Averaging kernels for DOAS total-column satellite retrievals, Atmos. Chem. Phys., 3, 1285-1291, 2003.

Eskes, H. J., R. J. van der A, E. J. Brinksma, J. P. Veefkind, J. F. de Haan, and P. J. M. Valks, Retrieval and validation of ozone columns derived from measurements of SCIAMACHY on Envisat, Atmos. Chem. Phys. Discuss., 5, 4429–4475, 2005.

Hendrick, F., M. Van Roozendael, A. Kylling, A. Petritoli, S. Sanghavi, R. Schofield, C. von Friedeburg, F. Wittrock, and M. De Mazière, Intercomparison exercise between different radiative transfer models used for the interpretation of ground-based zenith-sky and multi-axis DOAS observations, Atm. Chem. Phys., 6, 93-108, 2006.

Koelemeijer, R. B. A., J. F. de Haan, and P. Stammes, A database of spectral surface reflectivity in the range 335-772 nm derived from 5.5 years of GOME observations, J. Geophys. Res., 108 (D2), doi 10.1029/2002JD002429, 2003

Rodgers, C. D.: Inverse Methods for Atmospheric Sounding, Theory and Practice. World Scientific Publishing, Singapore-NewJersey-London-Hong Kong, 2000.

Shettle, E. P., Models of aerosols, clouds, and precipitation for atmospheric propagation studies, AGARD Conference Proceedings No. 454: Atmospheric propagation in the UV, visible, IR and mm-region and related system aspects, 1989.

Van Roozendael, M., D. Loyola, R. Spurr, D. Balis, J-C. Lambert, Y. Livschitz, P. Valks, T. Ruppert, P. Kenter, C. Fayt and C. Zehner, Ten years of GOME/ERS-2 total ozone data—The new GOME data Processor (GDP) version 4: 1 Algorithm description, *J. Geophys. Res.* 111, D14311, doi:10.1029/2005JD006375, 2006.