

File Revision Date:

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Data Set Description:

PI: Margarita Yela González  
Instrument: UV-visible spectrometer  
Site(s): Ushuaia, Argentina (54.82°S, 68.32°W)  
Measurement Quantities: O3 and NO2 total

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#### Instrument Description:

NEVAIII is a house-made instrument developed for continuous operation in Antarctica. The instrument consists of a grating spectrometers measuring in visible (400-550 nm) spectral range. It's based on a HAMAMATSU S7031-1008 (256 rows × 1024 pixels) CCD sensor. The read-out electronics is designed and developed at INTA, achieving a typical CCD operating at -40°C. The spectrograph is a HORIBA Micro HR (Czerny-Turner) holding a 1200 grooves/mm holographic grating. The system is located in a housing stabilized at 23°C. Gas Nitrogen is supplied to keep the CCD humidity inside below 5 %. Depolarized light

reaches the spectrograph through a 10 m fused silica fiber bundle. The optical telescope is designed to stand 1° field of view. Tilt telescope movement is controlled by thermally-controlled stepping motors. Measurements were performed in a continuous mode whenever SZA < 98°. NEVAIII was operating in zenith mode around twilight (SZA > 80° at dawn and SZA > 70° at dusk) and in off-axis mode the rest of the day.

Spectrometer named EVA is based on a Jobin-Yvon H20 monochromator with a ruled grating of 1200 grooves/mm and a photomultiplier tube Hamamatsu R212-UH blue enhanced as detector. Spectral resolution is 1nm FWHM and the sampling path is 0.1nm in the range 430–450 nm. A full spectrum is taken in 1.7 s. and 30 spectra per measurement are accumulated to improve the signal to noise 25 ratio. The instrument is located outdoors in a thermostatised housing. Light reaches the spectrograph by a 45° angle mirror. The instrument takes one measurement per 0.5° of SZA between 88° and 92°. NO<sub>2</sub> from the scanning EVA spectrometer is retrieved in the 433–448.5 nm range. The instrument is in operation since the time when it was installed without any significant change.

#### Algorithm Description:

NO<sub>2</sub> and ozone vertical and/or slant column densities are retrieved by the method of differential optical absorption spectroscopy. In the following description, we concentrate more particularly on the NDACC products, NO<sub>2</sub> and ozone total columns

#### NO<sub>2</sub> and ozone total columns

Optical depths calculated as the log of the ratio of a reference high sun spectrum with the measured spectrum are fitted to laboratory cross-sections using a least square method. Stretching and shifting are taken into account for the fit. Ring is corrected by including a pseudo-cross section in the fitting process. Cross-sections of NO<sub>2</sub>, O<sub>3</sub>, O<sub>4</sub>, H<sub>2</sub>O, and Rayleigh are included in the analysis. The amount in the reference spectra are estimated by Langley plots (O<sub>3</sub>) and iterative approximation using twilight am and pm (NO<sub>2</sub>). Dark current is calculated from the integration time accounting by interpixel variability. DC measurements are carried out under routine basis by an electronic shutter located close to the optics. NO<sub>2</sub> is analyzed in the 425-490 nm spectral window, and ozone from 470 to 535 nm, using the spectral analysis software suite (LANA) developed at INTA.

The DOAS settings for the NO<sub>2</sub> column retrieval follows the NDACC UV/Vis Working Group recommendations (Van Roozendael and Hendrick, 2012) whenever possible. Absorption cross sections O<sub>3</sub>, NO<sub>2</sub>, H<sub>2</sub>O and O<sub>4</sub> have been also included in the analysis. Raman scattering cross section was generated by the Win-DOAS package (Fayt and Van Roozendael, 2001), calculated from Raman theory. Finally, the inverse of the reference spectrum was included as a pseudo cross section to account for stray light inside the spectrograph and the residual dark current of the detector. The air mass factor (AMF) used for the conversion of the NO<sub>2</sub> slant columns to vertical columns is the NDACC NO<sub>2</sub> standard AMF, available on the NDACC UV-Vis web page (<http://ndacc-uvvis-wg.aeronomie.be/>) and based on the Lambert et al., 1999 and 2000 climatology of the NO<sub>2</sub> profiles.

For ozone columns, look-up tables of AMFs based on the TOMS V8 O<sub>3</sub> profile climatology are used (see also Hendrick et al., 2011). Mean twilight vertical columns are obtained by averaging individual measurements between 86 and 91° SZA.

#### Expected Precision/Accuracy of Instrument:

A/NO<sub>2</sub> and ozone total columns

Random errors are dominated by the uncertainties related to the slant column spectral fit and the calculations of the Air Mass factors (AMFs). The random errors associated to the spectral fit are due to detector noise, instrumental imperfections, as well as errors or unknowns in the signal modeling. The main sources of uncertainty in the AMF calculation are related to the choice of the radiative transfer model settings, i.e. the O<sub>3</sub> and NO<sub>2</sub> vertical profiles, the aerosol extinction profile, the cloud conditions, and in case of NO<sub>2</sub>, the inclusion or not of the rapid twilight photochemistry. In case of significant tropospheric pollution, additional errors can be introduced for NO<sub>2</sub>.

The uncertainties of the O<sub>3</sub> and NO<sub>2</sub> cross sections used in the spectral fit and the uncertainty on the determination of the residual amount of O<sub>3</sub> and NO<sub>2</sub> in the reference spectra by using the Langley-plot technique dominate the systematic error budget. Typical fitting errors range from 1–2 % under clear skies and 2–3% in cloudy conditions.

The estimated overall errors in the individual measurements are, on average, approximately 16 % for NO<sub>2</sub> (1-2 % fit analysis; 2 % cross-sections; 2 % reference spectrum; 10 % AMF; 2 % stratospheric temperature). Systematic 4%, random, 11% .In the case of NO<sub>2</sub>, much larger errors can be obtained when tropospheric NO<sub>2</sub> is produced or transported above the station.

For O<sub>3</sub>, 4 % for AMF calculate, 1-2% fit analysis, uncertainties of absorption cross- sections and their temperature dependencies, 3% for O<sub>3</sub>, residual column 2%. Systematic 5%, random 6%. 11%

Instrument History:

Starting date EVA: 1.2.1995

Ending date: -

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Starting date NEVAIII: 1.11.2015

Ending date:-

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In 2017 Ushuaia was joined NDACC.

Zenith measurements of column NO<sub>2</sub> since 1994 with a grating scanning monochromator. Since 2015, MAX-DOAS system have been operating. Older system will continue to take measurements until 2020 in order to overlap with those by the MAX-DOAS systems. In 2017 it was joined NDACC. Data from 1994 to 2016 not yet archived