File Revision Date:
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Data Set Description:

PI:	Andrea PAZMINO (Previous PI: Florence GOUTAIL)
	SAOZ UV-Visible Spectrometer
Site(s):	SALEKHARD 66.533 N 66.667 E 137 m
Measurement Quantities:	O3, NO2

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Reference Articles:

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Vandaele, A. C., C. Fayt, F. Hendrick, C. Hermans, F. Humbled, M. Van Roozendael, M. Gil, M. Navarro, O. Puentedura, M. Yela, G. Braathena, K. Stebelb, K. Tørnkvista, P. Johnston, K. Kreher, F. Goutail, A. Mieville, J.-P. Pommereau, S. Khaikine, A. Richter, H. Oetjen, F. Wittrock, S. Bugarski, U. Frieâ, K. Pfeilsticker, R. Sinreich, T. Wagner, G. Corlett, R. Leigh. An intercomparison campaign of ground-based UV-visible measurements of NO2, BrO, and OClO slant columns. Methods of analysis and results for NO2, Journal of Geophysical Research, 110, D8, D08305, 2005, DOI:10.1029/2004JD005423.

Instrument Description:

The SAOZ is made of a commercial Jobin-Yvon CP200 flat field spectrometer equipped with a holographic grating and a Hamamatsu diode array uncooled detector, with an entrance slit allowing an average resolution of the order of 1 nm in the range 300-600 nm. The first version (SAOZ-512) was using a 200 gr/mm grating associated to a 512 diode array detector and a 25 micron entrance slit and the second one (SAOZ-1024) was using a 360 gr/mm grating associated to a 1024 diode array detector and a 50 micron entrance slit allowing a better oversampling (2 instead of 1). The equipment which is ran in the outside, is placed in a sealed tight and dehydrated box on the top of which a quartz window is mounted in order to look at the zenith sky with a total field of view of 10°. As SAOZ was designed to measure especially in the Polar Regions, sometimes of difficult access, the system is completely automated, maintenance is simple (mechanical shutter).
The instrument is driven by an external computer which records and analyses the spectra in real time. Measurements are performed from sunrise to sunset until a Solar Zenith Angle (SZA) of 94°. The exposure time is adjusted automatically between 0.1s to 60s in order to optimize the signal and the spectra are co-added in memory during a 60s duty cycle. The data from a GPS device is used for SZA and time calculation. The dark current of the detector is measured each time the duration of exposure changes and subtracted. Averages of ozone and NO2 morning and evening vertical columns measured between 86 and 91 SZA are calculated and transmitted in real time to the laboratory through internet. Columns transmitted to NDACC data bank are reprocessed data, only possible after original spectra are received at the laboratory from the remote stations.

Algorithm Description:

A previous version (V1) was delivered to NDACC concerning all data before 2008. A new version of processed algorithm (V2) was developed in 2009. This is the only version now available on NDACC after reprocessing and resubmission of all data in February 2010. The data processing is achieved into 3 steps:

1. Level 0: acquisition of the spectrum and other parameters as GPS location and temperature inside the instrument.

2. Level 1: Spectroscopic analysis using the DOAS technique.
   - Precise wavelength alignment with the use of the Fraunhofer solar absorption lines
   - Division of the actual spectra by a reference spectrum recorded at high sun on a clear and unpolluted day.
   - Monotonic large trends are removed by subtracting the same spectrum smoothed at a broad bandpass (40nm) resulting in an atmospheric differential spectrum, into which narrow features corresponding to absorption by ozone, nitrogen dioxide, O4 (oxygen dimer), water vapour, O2 and OClO, are remaining.
   - Calculation of slant columns by least squares fitting between the signal and the differential cross sections of each absorber in an iterative process in which the contributions of the various species are calculated and removed sequentially. Ozone is measured in the Chappuis visible bands (450-550nm) where the cross sections are weakly dependant of the temperature; nitrogen dioxide in 410-530nm range; O4 in 440-544nm; H2O in one band 500-555nm and O2 around 620nm.

3. Level 2: Conversion of slant columns into total columns using an Air Mass Factor (AMF). The AMF is calculated by modelling the radiative transfer of the sunlight into the atmosphere. In the visible at 500 nm, the average atmospheric scattering layer at 90 SZA is located around 10-12 km, that is below the ozone and nitrogen dioxide peak concentration and above tropospheric clouds. It is dependent of constituent profile, concentration and altitude of peak.
   - Previous version V1: single Air Mass Factor (AMF) using yearly mean profiles for Tropics, Mid-latitudes or Polar regions depending on the station for both ozone and NO2. For Salekhard station, O3 Arctic AMF are calculated from annual average composite profiles from POAM III + SAOZ balloon sonde and for NO2 Arctic AMF calculated from average summer evening composite profiles from POAM III + SAOZ balloon sonde. The AMF is calculated at the centered wavelength of the fitting band: at 510nm for O3 and 470 nm for NO2. At 90deg SZA the “Arctic” AMF are respectively 16.63 for ozone and 16.14 for NO2.
   - Version V2: single AMF for nitrogen dioxide (same as version V1) and daily AMF for ozone calculated by UVSPEC/DISORT radiative transfer model. The model uses a multi-entry data base of O3 AMFs. It is based on the TOMS version 8 (TV8) ozone and temperature profile climatology. The TV8 is a monthly-zonal climatology sorted according to the ozone column. The parameters considered in building the look-up table (LUT) were: wavelength, ground albedo, altitude of the station, and SZA.

<u>Expected Precision/Accuracy of Instrument:</u>

Converting slant columns relative to a given reference spectrum into vertical columns requires the knowledge of the AMF (see above) and the residual amount of constituent still present in the reference spectrum.

The residual amount of constituent present in the reference spectrum is determined by a Bouguer-Langley plot (slant column versus AMF) extrapolated to zero air mass.

   - Previous version V1: annual Bouguer-Langley plot
   - Consolidate data V2: monthly Bouguer-Langley plots. This provides a more precise evaluation of the residual (0.5%)

The precision of the total column measurements at twilight (86 - 91 SZA) is 2 Dobson Unit for ozone and 1.5 10+14 mol/cm2 for NO2.
The accuracy, including uncertainties of cross-sections and their temperature dependencies and that of Air Mass Factors (vertical profiles of the constituent, stratospheric temperature seasonal changes and photochemical changes for NO2) is: ± 4% for ozone (2% cross sections and 2% AMF) and 10% for NO2 (5% cross sections, 5% AMF).
Note: SAOZ AMF does not take into account Pinatubo aerosol perturbation in 1992-1993. The ozone columns for the Pinatubo perturbed period have been removed.

Instrument History:
starting date: 1998/11/04
spectrometer: Jobin Yvon CP200, grating: 200 gr/mm, 300-600nm,
measured FWMH: 1.2nm
detector: NMOS, 512 pixel
entrance slit: 25 microns
instrument n°: 5
Analysis software: L1/L2: SAM V5.9/Igor

There is a problem of data storage during the period 1998/11/4 until 2001/11/14.
Before 2001/11/14 the data were stored on a hard disk and they have been lost during transfert on another support. Only realtime data via Argos are available.
After 2001/11/14 the data are stored on HP diskette and translated into PC compatible data (using LIFUTIL software) in order to be analysed with SAM.

starting date: 2009/09/22
spectrometer: Jobin Yvon CP200, grating: 360 gr/mm, 270-630nm,
measured FWMH: 1.8nm
detector: NMOS, 1024 pixel
entrance slit: 50 microns
instrument n°: 15
Analysis software: L1/L2: SAM V5.9/Igor