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Data Set Description:

PI: Udo Frieß

Instrument: UV-Vis MAX-DOAS

Site(s): Neumayer Station, Antarctica

Measurement Quantities: Ozone, NO2

Data Version description:

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Reference Articles:

Frieß, U., Hollwedel, J., König-Langlo, G., Wagner, T. and Platt, U.: Dynamics and chemistry of tropospheric bromine explosion events in the Antarctic coastal region, J. Geophys. Res., 109, D06305, doi:10.1029/2003JD004133, 2004.

Frieß, U., Kreher, K., Johnston, P. and Platt, U.: Ground-based DOAS measurements of stratospheric trace gases at two Antarctic stations during the 2002 ozone hole period, J. Atmos. Sci., 62(3), 765–777, doi:10.1175/JAS-3319.1, 2005.

Kreher, K., Van Roozendael, M., Hendrick, F., Apituley, A., Dimitropoulou, E., Frieß, U., Richter, A., Wagner, T., Lampel, J., Abuhassan, N., Ang, L., Anguas, M., Bais, A., Benavent, N., Bösch, T., Bognar, K., Borovski, A., Bruchkouski, I., Cede, A., Chan, K. L., Donner, S., Drosoglou, T., Fayt, C., Finkenzeller, H., Garcia-Nieto, D., Gielen, C., Gómez-Martín, L., Hao, N., Henzing, B., Herman, J. R., Hermans, C., Hoque, S., Irie, H., Jin, J., Johnston, P., Khayyam Butt, J., Khokhar, F., Koenig, T. K., Kuhn, J., Kumar, V., Liu, C., Ma, J., Merlaud, A., Mishra, A. K., Müller, M., Navarro-Comas, M., Ostendorf, M., Pazmino, A., Peters, E., Pinardi, G., Pinharanda, M., Piters, A., Platt, U., Postylyakov, O., Prados-Roman, C., Puentedura, O., Querel, R., Saiz-Lopez, A., Schönhardt, A., Schreier, S. F., Seyler, A., Sinha, V., Spinei, E., Strong, K., Tack, F., Tian, X., Tiefengraber, M., Tirpitz, J.-L., van Gent, J., Volkamer, R., Vrekoussis, M., Wang, S., Wang, Z., Wenig, M., Wittrock, F., Xie, P. H., Xu, J., Yela, M., Zhang, C. and Zhao, X.: Intercomparison of NO_2, O_4, O_3 and HCHO slant column measurements by MAX-DOAS and zenith-sky UV–visible spectrometers during CINDI-2, Atmospheric Measurement Techniques, 13(5), 2169–2208, doi:10.5194/amt-13-2169-2020, 2020.

Roozendael, M. V. and Hendrick, F.: Recommendations for total ozone retrieval from NDACC zenith-sky UV-VIS spectrometers, Belgian Institute for Space Aeronomy (BIRA-IASB). [online] Available from: https://uv-vis.aeronomie.be/groundbased/NDACC_UVVIS-WG_O3settings_v2.pdf, 2009.

Roozendael, M. V. and Hendrick, F.: Recommendations for NO_2 column retrieval from NDACC zenith-sky UV-VIS spectrometers, Belgian Institute for Space Aeronomy (BIRA-IASB). [online] Available from: https://uv-vis.aeronomie.be/groundbased/NDACC_UVVIS-WG_NO2settings_v3.pdf 2012.

Roscoe, H. K., Van Roozendael, M., Fayt, C., du Piesanie, A., Abuhassan, N., Adams, C., Akrami, M., Cede, A., Chong, J., Clémer, K., Friess, U., Gil Ojeda, M., Goutail, F., Graves, R., Griesfeller, A., Grossmann, K., Hemerijckx, G., Hendrick, F., Herman, J., Hermans, C., Irie, H., Johnston, P. V., Kanaya, Y., Kreher, K., Leigh, R., Merlaud, A., Mount, G. H., Navarro, M., Oetjen, H., Pazmino, A., Perez-Camacho, M., Peters, E., Pinardi, G., Puentedura, O., Richter, A., Schönhardt, A., Shaiganfar, R., Spinei, E., Strong, K., Takashima, H., Vlemmix, T., Vrekoussis, M., Wagner, T., Wittrock, F., Yela, M., Yilmaz, S., Boersma, F., Hains, J., Kroon, M., Piters, A. and Kim, Y. J.: Intercomparison of slant column measurements of NO_2 and O_4 by MAX-DOAS and zenith-sky UV and visible spectrometers, Atmos. Meas. Tech., 3(6), 1629–1646, doi:10.5194/amt-3-1629-2010, 2010.

Vandaele, A. C., Fayt, C., Hendrick, F., Hermans, C., Humbled, F., Van Roozendael, M., Gil, M., Navarro, M., Puentedura, O., Yela, M., Braathen, G., Stebel, K., Tørnkvist, K., Johnston, P., Kreher, K., Goutail, F., Mieville, A., Pommereau, J.-P., Khaikine, S., Richter, A., Oetjen, H., Wittrock, F., Bugarski, S., Frieß, U., Pfeilsticker, K., Sinreich, R., Wagner, T., Corlett, G. and Leigh, R.: An intercomparison campaign of ground-based UV-visible measurements of NO_2, BrO, and OClO slant columns: Methods of analysis and results for NO_2, J. Geophys. Res., 110(D8), D08305, doi:10.1029/2004JD005423, 2005.

Instrument Description:

The instrument consists of two separate spectrograph/detector units for the UV and Vis wavelength range, located in a single stainless steel housing. The optical parts of the spectrograph are mounted in a 'sandwich' design between 3 and 5mm thick stainless steel plates which ensure a high mechanical stability. All inner parts are blackened using Teflon coating. The housing is evacuated ($p < 10^{-5}$ mBar) and filled with dry argon under slight over-pressure to avoid any freezing or condensation of water onto the cooled detector surfaces. At the fiber bundles exit, the 14 quartz fibers are arranged as columns, serving as entrance slits. The light is dispersed in each spectrograph using concave holographic gratings and is detected with photo diode arrays. The characteristics of both spectrometer units are as follows:

	UV	**Vis**
Grating Manufacturer	Yobin Yvon	American Holographics
Grating Diameter [mm]	70	85
Focal length [mm]	210	160
Aperture ratio	f/3.2	f/2
Grooves/mm	1200	510
Diffraction order	-1	1
Wavelength range [nm]	320 - 420	400 – 650
Average resolution (FWHM) [nm/channel]	0.5/5.0	1.8/7.2

To avoid any changes in the optical adjustments and to improve the detector cooling, the housing is locaded inside a custom build fridge that keeps the system on a stable temperature of +2◦C. The light dispersed by the holographic gratings is detected using photo diode arrays (PDAs) manufactured by Hamamatsu (type ST3904-1024). The detectors are thermoelectrically cooled to a temperature of -35◦C. The dark current signal and electronic offset amount to ≈ 0.25 counts/sec and ≈ 700 counts/scan, respectively.

The instrument was initially equipped with a zenith sky telescope unit, which has been replaced by a multi-axis telescope in 2003. It uses rotatable prisms to observe scattered sunlight at elevation angles of 90°, 20°, 10°, 5°, 2°, 1°, -5° and -20° (the latter two pointing downwards observing light scattered by the snow surface).

Algorithm Description:

Spectra are analysed using the DOASIS software developed at the Institute of Environmental Physics of the University of Heidelberg using a non-linear least squares fitting routine based on the Levenberg-Marquardt algorithm.

Ozone slant column densities are retrieved in the wavelength range between 450 and 550 nm according to the recommendations for total ozone retrieval from NDACC zenith-sky UV-VIS spectrometers (v2) [Roozendael and Hendrick, 2009]. Slant column densities are converted to vertical column densities

according to the NDACC recommendations using the NDACC AMF data base, with the reference SCD being determined using the Langley plot method.
The spectral retrieval of NO_2 dSCDs is performed in the wavelength region between 425 and 490 nm according to the recommendations for NO_2 column retrieval from NDACC zenith-sky UV-VIS spectrometers (v3) [Roozendael and Hendrick, 2012], and converted to VCDs using the NDACC AMF lookup table.

Expected Precision/Accuracy of Instrument:

Average random errors resulting from spectral noise amount to 4.5 DU for the ozone VCD and $3x10^{13}$ molec/cm^2 for the NO_2 VCD. In addition, the accuracy is affected by several systematic error sources. Inaccuracies in the spectral fit, caused by inaccurate cross sections, non-perfect removal of the effects caused by inelastic scattering (Ring effect), wavelength calibration and instrumental artefacts, is expected to lead to an additional uncertainty in the order of 2% for ozone and 5% for NO_2. Although considered in the NDACC AMF lookup tables, uncertainties in the vertical distribution of the trace gases lead to an uncertainty in the airmass factors, which can be estimated to contribute to the VCD error in the order of 4% for ozone and at most 10% for NO_2. Uncertainties in stratospheric photochemistry leads to additional uncertainties of the NO_2 AMF. Furthermore, the uncertainty in the residual trace gas amount of the reference spectrum determined by the Langley plot adds to the error budget with a small contribution of 1-2%. The measurements at Neumayer station in the pristine Antarctic atmosphere is unaffected by tropospheric pollution.

Instrument History:

01/1999:	Installation of the DOAS instrument at Neumayer Station, Antarctica.
03/2003:	Replacement of the Zenith-Sky telescope by a multi-axis Telescope