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Data Set description:

PI : Dr. Eliane Maillard Barras

Instrument: Stratospheric Ozone MOnitoring RAdiometer SOMORA Ground-based 142 GHz microwave spectrometer

Measurement Quantities:
Ozone VMR profiles

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Reference Articles:

Maillard Barras, E., Haefele, A., Nguyen, L., Tummon, F., Ball, W. T., Rozanov, E. V., Rüfenacht, R., Hocke, K., Bernet, L., Kämpfer, N., Nedoluha, G., and Boyd, I.: Study of the dependence of stratospheric ozone long-term trends on local solar time, Atmos. Chem. Phys. 20, 8453–8471, https://doi.org/10.5194/acp-20-8453-2020, 2020.

Hocke, K., Haefele, A., Le Drian, C., Kaempfer, N., Ruffieux, D., von Clarmann, T., Milz, M., Steck, T., Froidevaux, L., Pumphrey, H.C., Jimenez, C., Walker, K.A., Bernath, P., Timofeyev, Y.M., Polyakov, A.V., Cross-validation of recent satellite and ground-based measurements of ozone and water vapor in the middle atmosphere, in: ESA Atmospheric Science Conference 2006, ed.: ESA, 2006.

Hocke, K., Kämpfer, N., Ruffieux, D., Froidevaux, L., Comparison and synergy of stratospheric ozone measurements by satellite limb sounders and the ground-based microwave radiometer SOMORA, Atmos. Chem. Phys., 7, 4117–4131, 2007. Haefele A, Hocke K, Kämpfer N, Keckhut P, Marchand M, Bekki S, Morel B, Egorova T, Rozanov E, Diurnal changes in middle atmospheric H2O and O3 : Observations in the Alpine region and climate models changes in middle atmospheric H2O and O3 : Observations in the Alpine region and climate models, J. Geophys. Res, vol. 113, 1-13, 2008.

Maillard Barras, E., Haefele, A., Stübi, R., and Ruffieux, D., A method to derive the Site Atmospheric State Best Estimate (SASBE) of ozone profiles from radiosonde and passive microwave data, Atmos. Meas. Tech. Discuss., 8, 3399–3422, 2015, doi:10.5194/amtd-8-3399-2015.

Rodgers, C. D, Characterisation and error analysis of profiles retrieved from remote sensing measurements, J. Geophys. Res., 95, 5587-5595, 1990.

Eriksson, P., Jimenez, C., Buehler, S. A., Qpack, a general tool for instrument simulation and retrieval work, Journal of Quantitative Spectroscopy & Radiative Transfer, 91 47–64. doi: 10.1016/j.jqsrt.2004.05.050, 2005.
Buehler, S. A., Eriksson, P., Kuhn, T., von Engeln, A., and Verdes, C.: ARTS, the Atmospheric Radiative Transfer Simulator, J. Quant. Spectrosc. Radiat. Transfer, 91(1), 65-93, doi:10.1016/j.jqsrt.2004.05.051, 2005.
Calisesi, Y., The Stratospheric Ozone Monitoring Radiometer SOMORA: NDSC application document, Res. Rep. 2003-11, Inst. of Appl. Phys., Univ. of Bern, Bern, Switzerland, 2003.
Calisesi, Y.: Monitoring of stratospheric and mesospheric ozone with a ground-based microwave radiometer: data retrieval, analysis, and applications, Ph.D. thesis, Philosophisch-Naturwissenschaftliche Fakultät, Universität Bern, Bern, Switzerland, 77 pp., available at: http://www.iap.unibe.ch/publications, 2000.

Instrument description:

Developed by the University of Bern (Calisesi, 2000), the SOMORA is a total power microwave radiometer measuring the thermal emission line of ozone at 142.175 GHz. The electromagnetic radiation is measured under an antenna elevation angle of 39° and the brightness temperatures range from 80 to 260 K. The SOMORA is calibrated using a hot load heated and stabilized at 300 K and a cold load at 77 K cooled with liquid nitrogen. A rotating planar mirror is used as a switch between the radiation sources. A Martin-Puplett interferometer (sideband filter) picks out the frequency band around 142 GHz. Outgoing from the front-end part (quasi optics), the signal is amplified and down-converted in frequency to 7.1 GHz by means of a constant-frequency signal (mixer). The signal is further down-converted in two steps (intermediate step at 1.5GHz/1GHz) to the baseband (0-1 GHz). The spectral distribution, i.e. voltage as function of channel or frequency is measured since 10/2010 by an Acquiris Fast-Fourier-Transform spectrometer (FFTS) with 16384 channels distributed over 1GHz bandwidth. Before, two acousto-optical spectrometers (the first AOS with a bandwidth of 1 GHz distributed over 1024 channels and a second AOS, focused on the center of the observed spectrum, with a bandwidth of 50 MHz distributed over 2048 channels) have been used for the spectral detection (Calisesi, 2000).

After 1h integration time, an ozone volume mixing ratio (VMR) profile is retrieved by optimal estimation using ARTS/Qpack, which is a general environment for the radiative transfer simulation (forward model) (Buehler, 2005) and the optimal estimation method (OEM) profile retrieval of Rodgers (Eriksson, 2005). The vertical resolution of the ozone profiles is 8–10 km from 20 to 40 km, increasing to 15-20 km at 60 km.

Summary:

142.175 GHz mm-wave spectrometer with 16384 individual channels; Frequency resolution 61 KHz.
Overall spectrometer bandwidth 1 GHz
Martin-Puplett single sideband filter
SSB noise temperature 2700 K
Automatic N2 filling station for calibration load
Single spectra integration time of 20 sec.
Observation angle 39 degrees elevation

Fully operational since 2000

Location:
Payerne, 46.82N / 6.95E, 491 m. a.s.l.

Calibration:
Triple switched total power with liquid N2 and heated load, elevation scans

Preprocessing :
1 hour integration time for one retrieval, rejection of spectra obtained with atmospheric transmission lower than 0.3
Tropospheric correction with single layer model
Background contribution removal

Forward model:
JPL/HITRAN spectral database
Use of actual NMC T and p profiles and O3 radiosonde measurements

Database:
24 profiles per day, NASA AMES format,
Fully operational and continuous since January 2000 to present

<u>Retrieval algorithm:</u>
Optimal estimation
Layer thickness 2-3 km
Altitude resolution 8-15 km in the range 20 to 60 km altitude
Meas. covariance estimation from wing brightness temperatures standard deviation.
A priori covariance (0.3)^2 to (1.0)^2 diagonal, and 3 km vertical correlation.
Post-processing retrieval every hour by the ARTS/Qpack retrieval software (Eriksson et al., 2005; Buehler et al., 2005).

<u>Accuracy:</u>
Estimated uncertainty for each profile at each retrieved altitude level is reported in the data file.
Expected P=precision, A=accuracy and R=resolution (smoothing)

Alt [km]	P [%]	A [%]	R [km]
20	6	17	9
25	4	12	9
30	4	12	9
35	4	13	11
40	5	15	10
45	6	15	12
50	7	20	15
55	8	20	14
60	8	25	17
65	15	25	17

Validation of profiles for the period 2000-2002 by comparison with with mm-wave radiometer GROMOS (Calisesi et al, 2003).

Validation of profiles for the period 2000-2006 by comparison with AURA/MLS (Hocke et al, 2007).

Validation of profiles for the period 2000-2018 by comparison with mm-wave radiometer (GROMOS) at Bern, with radio-sonde at Payerne, with MLS, MIPAS, and SCIAMACHY instruments (Maillard Barras et al, 2020).

<u>Instrument History:</u>

Operational since January 2000

May 2001:	reparation of the mixer diode
June 2005:	replacement of the front-end
July 2009:	replacement of the GUNN
October 2010:	replacement of the two acousto-optical spectrometers (AOS) by an Acquiris Fast-Fourier-Transform spectrometer (FFTS) for spectral detection.

Homogenisation of the dataset for the 2001, 2005 and 2009 technical interventions, and for the AOS-FFTS update of 2010. Reprocessing of the 2000-2018 dataset in 2019 (retrieval update with monthly

climatological a-priori profiles, Era-i T profiles, variation of the integration time for a constant measurement contribution). https://doi.org/10.5194/acp-20-8453-2020.