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Data Set description:

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Instrument : GROund-based Millimeter-wave Ozone Spectrometer GROMOS

Measurement Quantities : Ozone profiles

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Instrument description:

The GROMOS instrument is a triple switched 142 GHz total power radiometer (Clancy and Muhleman [1993]), observing at an elevation angle of 40 degrees in the north-east direction. GROMOS is located in Bern, and is an updated version of the older instrument described in Lobsiger and Künzi [1984], Lobsiger and Künzi [1986], Lobsiger [1987] and Zommerfelds et al. [1989].

The instrument consists of a sub-harmonically pumped Schottky waveguide mixer, with an IF section at 3.7 GHz using low noise amplifiers. An off-axis parabolic mirror produces a beam width of 1.9 FWHM. The beam is directed with a flat rotating mirror to the different calibration loads and the atmosphere.

The main differences between the GROMOS and the older instrument are the use of a Martin-Puplett interferometer for the rejection of the image band contribution, the change of the optical path, improvement of the IF electronics and an automatic liquid nitrogen filling station for the calibration load. Additionally the receiver is operated at room temperature in order to increase the operationality and reliability and exhibits a system noise temperature of 3000 K (SSB). The new configuration is operational since November 1994 (Peter and Kämpfer [1995]).The filter frequencies of the spectrometer with an overall bandwidth of 1.2 GHz are not equally spaced and have resolutions ranging from 100 MHz at the line wings to 200 KHz at the line center. A higher spectral resolution is needed towards the line center due to the increased information content per unit of frequency near the line center of the pressure broadened rotational transition at 142.175 GHz. In order to treat the spectral intensities as values of an ideal delta function filter, the effective filter center frequencies have been determined by folding the filter response with a typical ozone spectrum resulting in frequency pairs which are not exactly symmetric around the line center. Therefore we use the unfolded spectrum for the profile calculation, which has additionally the advantage that possible undulations can be better isolated. The given overall bandwidth and resolution permits to determine ozone profiles in the altitude range of 15 to 70 km. Sufficient signal to noise ratio for one hour integration time is obtained for the medium resolution channels giving the information on ozone volume mixing ratio for the stratospheric region. For mesospheric observations longer integration times are required (typicaly 2 hours).

<u>Summary:</u>
142.175 GHz mm-wave spectrometer with 46 individual channels. Bandwidths range from 100 MHz to 200 KHz. Overall spectrometer bandwidth 1.2 GHz Martin-Puplett single sideband filter (since 1994). SSB noise temperature 3000 K (uncooled) Automatic N_2 filling station for calibration load. Single spectra integration time of 3 min.Observation angle 40 degrees elevation, variable. Fully operational since 1994.

Location : Bern, 47N / 7E, 560 m. a.s.l., close to NDACC station
Jungfraujoch (70 km from Bern), where parallel measurements of chlorine monoxyde are performed (Gerber and Kämpfer, [1994])

Calibration : Triple switched total power with liquid N_2 and heated load, elevation scans

Preprocessing : 2 hour integration time for one retrieval, rejection of spectra obtained with atmospheric transmission lower than 0.3
Modelling of SSB filter broadband response
Tropospheric correction with single layer model
Background contribution removal

Forward model : JPL/HITRAN spectral database
Validation of forward models by participating in NDSC and ESA intercomparisons
Use of actual NMC T and p profiles and O_3 radiosonde measurements from the nearby met. inst. Payerne (a priori update below 25 km)

Database : 12 profiles per day, NASA Ames format, 14kByte/day

Continuous observations with gaps since 1990
Fully operational and continuous since Nov. 1994 to present.
Since 2009: 48 profiles per day, HDF GEOMS format

Retrieval algorithm:
Optimal estimation, including coincident estimation of offset between filter arrays. Layer thickness 2-3 km (Rodgers [1976], [1990])
Altitude resolution 8-15 km in the range 20 to 60 km altitude
Meas. covariance estimation from spectral residuals, wing brightness temperatures and system noise temperature. A priori covariance (0.5)^2 to (1.5)^2, diagonal
Post-processing retrieval for every two hours. Since 2004, the ARTS/Qpack retrieval software is used (Eriksson et al., 2005; Buehler et al., 2005).

Accuracy:
Estimation with error analysis as in Connor et al. 1991/95. The errors are altitude dependent.
Estimations given below, with P=precision, A=accuracy and R=resolution (smoothing)

Alt [km]	P [%]	A [%]	R [km]
15	15	30	-
20	5	12	12
25	4	6	10
30	4	6	9
35	4	5	10
40	5	7	10
45	6	8	12
50	8	10	12
55	10	11	14
60	12	13	15
65	15	16	-
70	20	21	-

Validation with Radiosonde and Lidar within ESMOS (European Stratospheric Monitoring Stations) 1990
Validation during winter 94/95 within SESAME (Second European Strat. Arctic and Midlat. Exp.). Mean dev. from Lidar Hohenpeissenberg and Haute Provence 10 %, rms 10 %
Comparison with Umkehr (Peter and al., [1995])
Comparison with balloon-borne ozone soundings at Payerne
Comparison with 3-D model and Lidar in progress

Instrument History:
Continuous millimeter-wave measurements of the ozone distribution over Bern are performed using GROMOS since November 1994. Since then, several interruption periods occurred where the instrument was revised, as in September 1995, November 1996, August 1997 and November 1997. Even if the instrument has essentially remained the same since it became operational in November 1994, this is not the case for the retrieval algorithm which underwent several changes in 1997. The estimation of a possible offset between two different filter-arrays was included in the retrieval, as well as the introduction of the system noise temperature as a parameter for the estimation of the measurement covariance matrix. The whole data-set was reprocessed using this updated algorithm, leading to a new homogenized version of the GROMOS data. In August 1999, a long-term drift in the hot calibration load temperature was noticed. The amplitude of the drift was of about 3 K in 5 years. In order to correct the data for this drift, all the spectra since January 1997 were recalibrated and reprocessed. The changes in total ozone induced by this correction are less than 3 % in comparison to the previous data. The new data set is now available at NDACC. In 2009, a high-resolution digital Fourier transform spectrometer replaced the old 49 channel filterbank.