

File Revision Date:

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Data Set Description:

PI: Dr. Giovanni Muscari
Instrument: Stony Brook Ground-Based Millimeter-wave Spectrometer (GBMS)
Site(s): Thule Air Base (Pituffik), Greenland
Measurement Quantities: Nitric Acid profile

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Instrument Description:

The Instrument is a mm-wave heterodyne spectrometer (GBMS) observing rotational lines emitted by stratospheric trace gases at frequencies between 230 and 280 GHz (tunable). It employs a high sensitivity cryogenically cooled SIS (Superconductor-Insulator-Superconductor) tunnel junction mixer, followed by two Acousto-Optical Spectrometers (AOSs). One with a spectral window of 600 MHz and a resolution of 1.2 MHz and a second with a passband of 50 MHz and a resolution of ~65 kHz (used only for measurements of O₃ and CO). The HNO₃ spectrum observed by the GBMS is characterized by a cluster of lines centered at 269.20 GHz strongly blended by pressure broadening. An integration time of 3-5 hours is typically needed for the weak HNO₃ emission spectra to be observed with a satisfactory S/N ratio. Taking advantage of the pressure broadening of the observed lines, the GBMS bandwidth and resolution allow the retrieval of HNO₃ mixing ratio vertical profiles between ~15 and ~50 km.

Algorithm Description:

Mixing ratio vertical profile are retrieved using an Optimal Estimation method. The a priori profile variance ranges from 0.5 ppbv to 1.5 ppbv and a correlation between gas concentrations at different altitudes is considered (correlation length = 5 km). The covariance matrix of the measurement vector is diagonal with all the diagonal elements equal. The value of the diagonal elements is used as an adjustable parameter for optimizing the retrieval sensitivity (Fiorucci et al., 2012).

Expected Precision/Accuracy of Instrument:

The GBMS HNO₃ retrieved vertical profiles are recommended for scientific use in the altitude range between 17 and 45 km. Estimated uncertainty for each profile at each retrieved altitude level is reported in the data file. These errors are estimated by adding in quadrature the uncertainties due to forward parameters, instrumental calibration and spectral noise. Errors related to calibration procedure and to forward model parameters (which have both systematic and random component) add up to the larger of 15% or 0.2 ppbv (de Zafra et al., 1997, Muscari et al., 2002, Fiorucci et al., 2012). Measurements noise (random) is computed following Connor (1995) and is about 0.15 ppbv. The smoothing error is not included in this estimate since it can be removed in comparison with higher resolution data sets convolving the higher resolution profiles with the GBMS Averaging Kernels. According to the GBMS Averaging Kernel the HNO₃ retrieved profiles have a vertical resolution (FWHM of the Averaging kernels) that varies from 9 to 14 km.

Instrument History:

The GBMS was designed and built at the Physics and Astronomy Department of the State University of New York at Stony Brook in the early 90's (de Zafra, 1995; Parrish et al., 1988), and has been regularly operated at a variety of sites, at polar and mid-latitudes, since then. Although the instrument has undergone several minor upgrading since it started operating, the only significant change is the replacement of filterbanks with an Acousto-Optical Spectrometer after the South Pole field campaign in 1995. Until 2008 the GBMS HNO₃ data were analyzed using an iterative Matrix Inversion technique (MI) (Twomey, 1977) employing a smoothing algorithm to constraint the solution and essentially immune to the a priori profile used to start the iteration. In 2009 the retrieval algorithm has been upgraded from the Matrix Inversion to the Optimal Estimation (Rodgers, 1976) and the whole GBMS HNO₃ data set (from 1993 to date) has been reprocessed producing a version 2 of the data.

Field campaigns:

Amundsen-Scott Base, South Pole:	April 1993 - January 1994 March 1995 - November 1995 May 1999 - July 1999
Thule Air Base (Pituffik, 76.5°N, 68.8°W), Greenland:	Jan-Mar 2002 Jan-Mar 2003
Testa Grigia, Italian Alps (45.9°N, 7.7°E, 3500 m a.s.l.):	regular winter campaigns from November 2004 to March 2007
Thule Air Base (Pituffik, 76.5°N, 68.8°W), Greenland:	Jan-Mar 2009 Jan-Mar 2010 Jan-Mar 2011 Jan-Mar 2012