File Revision Date:

October 11, 2025

Data Set Description:

PI:	Akira Mizuno
Instrument:	Rikubetsu Millimeter-wave Radiometer (Rikubetsu MWR)
Site(s):	Rikubetsu, Japan
Measurement Quantities:	Mixing ratio profile of O3
Data Version description:	Ver. 2: Latest version. Times are given in UT, bug-fix for Ver.1.
	Ver. 1: Times are given in the local time.

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Data License:

Reference Articles:

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Mizuno, A., T. Nagahama, A. Morihira, H. Ogawa, N. Mizuno, Y. Yonekura, H. Yamamoto, H. Nakane, and Y. Fukui, "Millimeter-wave radiometer for the measurement of stratospheric ClO using a superconductive (SIS) receiver installed in the southern hemisphere", International Journal of Infrared and Millimeter Waves, 23, 981–995. doi:10.1023/A:1019618917005, 2002

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Ohyama H, S. Kawakami, K. Shiomi, and K. Miyagawa, "Retrievals of total and tropospheric ozone from GOSAT thermal infrared spectral radiances", IEEE Transactions on Geoscience and Remote Sensing 50, 1770–1784. doi:10.1109/TGRS.2011.2170178, 2012

Asayama, S., Y. Hasegawa, A. Mizuno, H. Ogawa, and T. Onishi, "A Novel Compact Low Loss Waveguide Image Rejection Filter Based on a Backward Coupler with Band Pass Filters for 100 GHz Band", Journal of Infrared, Millimeter, and Terahertz Waves, 36, 445-454, doi: 10.1007/s10762-015-0148-6, 2015

Ohyama, H., T. Nagahama, A. Mizuno, H. Nakane, and H. Ogawa, "Observations of stratospheric and mesospheric O3 with a millimeter-wave radiometer at Rikubetsu, Japan", Earth, Planets and Space, 68, article id.34, doi: 10.1186/s40623-016-0406-4, 2016

Instrument Description:

Rikubetsu MWR is a ground-based spectroscopic radiometer observing the ozone emission line of the rotational transition 6_{15} - 6_{06} at 110.836 GHz. The front-end of the radiometer is a cryogenically cooled superconductive (SIS) mixer system with a waveguide-type image rejection filter (Asayma et al. 2015) to achieve single-sideband operation. A digital fast Fourier transform spectrometer (FFTS) is employed as the backend spectrometer with a bandwidth of 1 GHz and a resolution of 67 kHz. Observations basically continue 24 hours a day. The elevation switching method (Mizuno et al. 2002) is adopted for the observations. The intensity scale is calibrated at almost every minute by using two different intensity reference radiators, hot-load blackbody at ambient temperature and cold-load blackbody at liquid nitrogen temperature. The correction for tropospheric absorption by water vapor is performed based on the "sky-tipping" procedure (Ulich et al. 1980) at every 8 minutes. The observed data are recorded almost every one minutes and averaged over one-hour period for retrieval analysis of the vertical profiles of ozone mixing ratio.

Algorithm Description:

An optimal estimation method is adopted for retrieval of the vertical profile of ozone mixing ratio. The retrieval program is based on an algorithm developed by Ohyama et al. (2012) which is originally applied to space-borne ozone spectra in the thermal infrared region. We retrieved the ozone profile for one-hour averaged spectra, and bad data are eliminated before the average. The selection criteria are that the elevation angles between 15 deg and 40 deg and that tropospheric opacity between 0.05 and 0.40. Also, averaged spectral data with rms noise greater than 0.15K are excluded for the retrieval analysis.

The ozone retrieval has sensitivity between ~21 and 58 km corresponding to the area where the measurement response calculated from the averaging kernel is greater than 0.8 (Ohyama et al. 2016). The vertical resolution ranges from 7 to 10 km in the stratosphere and increases gradually to approximately 15–18 km at an altitude of 60 km.

The vertical profiles of temperature and pressure applied to the retrieval analysis are interpolated at the location of Rikubetsu observatory from the MERRA2 reanalysis data for an altitude below 0.1hPa and from the CIRA-86 empirical model atmosphere for above 0.1hPa. As the a priori profile, we used the daytime or nighttime MLS O3 climatology over all altitudes. The daytime a priori is applied to the mm-wave spectral data obtained at a solar zenith angle below 98 deg, and the nighttime a priori was vice versa.

L0/L1: L0 raw data, consisting of sky measurements and hot-cold calibration data are stored on a disk array, in the laboratory of Atmospheric Science group, ISEE, Nagoya University and yearly datasets are saved in compact hard disks as backups.

Expected Precision/Accuracy of Instrument:

The results of comparison with the three space-based instruments, SBUV/2, SABER, and MLS, are as follows. The MWR ozone mixing ratios were negatively biased by ~10 % with a standard deviation of 5–9 % above 35 km compared to the SABER data, and were positively biased by ~10 % with a standard deviation of 5–8 % below 35 km compared to the SBUV/2 data. These biases were consistent with the validation results of the SABER and SBUV/2 data shown in the earlier literature. The retrieved ozone mixing ratios at individual levels agreed with the MLS version 3.3 or 3.4 data with an average difference better than ±5 % and a standard deviation of 4–9 %. Please see Ohyama et al. (2016) for more detailed discussion on the breakdown of error sources and their effects.

Instrument History:

Present instrument:

Dec. 15, 2013 –

- Frontend Mixer: DSB SIS mixer + waveguide image-band rejection filter
- Backend spectrometer: Digital FFT spectrometer with 1 GHz BW & 61 kHz resolution
- Cold load: radio absorber immersed liquid nitrogen measuring directly from the top of a glass Dewar

Ozone profile data derived from the observations after 15 Dec. 2013 are submitted to NDACC DHF. The retrieved results before this date are not uploaded to NDACC DHF, although the Rikubetsu MWR had been in operation since 1999. That is because the calibration and correction procedures for conversion to the brightness temperature scale were not completely self-contained in the previous instrumental setup and partially depended on the total column measurements by external instruments such as ozone sonde at Sapporo and the Brewer spectrometer in Rikubetsu. Details of the calibration and correction procedures are explained in Ohyama et al. (2016). If you want to access the un-uploaded retrieval data obtained before 15 Dec. 2013, please contact PI or visit the website,
https://fxp.nies.go.jp/public/XoOQQAeiWQFAznMB_ZdscOGZe9xE25ODVE5Mv7-Pooey.

Minor changes and troubles after Dec.15, 2013:

Apr 8, 2022 – Oct 13, 2022:

- Observation was suspended due to malfunction of a signal oscillator for IF circuit.

Oct.14, 2022

- Repair and change the IF circuit configuration to reduce the number of signal oscillators.

Dec. 24, 2022 – Apr. 9, 2023:

- Observation was suspended due to malfunction of a signal oscillator and liquid nitrogen generator.

Apr. 22, 2023 – Dec. 27, 2023:

- The cryogenic refrigerator became unstable, making it impossible to carry out continuous steady-state observations.

Jan. 31, 2024 –

- Observation was suspended due to fatal damage of the compressor for the cryogenic refrigerator.

Previous instrumental setup before 15 Dec. 2013:

Sep. 1, 2013 – Dec. 14, 2013

- Frontend Mixer: DSB SIS mixer + waveguide image-band rejection filter

- Backend spectrometer: Acousto-optical spectrometer (AOS) with 1 GHz BW & 505 kHz resolution
- Cold load: radio absorber immersed liquid nitrogen measuring directly from the top of a glass Dewar

Nov. 25, 2008 – Jul. 25, 2013

- Frontend Mixer: 2SB SIS mixer (Asayama et al. 2004)
- Backend spectrometer: Acousto-optical spectrometer (AOS) with 1 GHz BW & 505 kHz resolution
- Cold load: radio absorber immersed liquid nitrogen measuring directly from the top of a glass Dewar

Oct. 27, 2005 – Nov. 19, 2008

- Frontend Mixer: 2SB SIS mixer (Asayama et al. 2004)
- Backend spectrometer: Acousto-optical spectrometer (AOS) with 1 GHz BW & 505 kHz resolution
- Cold load: Radio absorber immersed liquid nitrogen measuring through the wall of a polystyrene vessel

Nov. 1, 1999 – Sep. 28, 2005

- Frontend Mixer: Tunable SIS mixer adjusted SSB response by waveguide backshort position (Ogawa et al. 1990)
- Backend spectrometer: Acousto-optical spectrometer (AOS) with 0.5 GHz BW & 244 kHz resolution
- Cold load: Radio absorber immersed liquid nitrogen measuring through the wall of a polystyrene vessel