

File Revision Date:

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Data Set Description:

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Instrument Ground-based 110 GHz microwave spectrometer
Site(s): Mauna Loa, Hawaii
Lauder, New Zealand
Measurement Quantities: Mixing ratio profile of O3

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Reference Articles:

Parrish, A., B.J. Connor, J.J. Tsou, I.S. McDermid, and W.P. Chu: "Ground-based Microwave Monitoring of Stratospheric Ozone", J. Geophys. Res., Vol 97 (D2), p.2541-2546, February 20, 1992.

Parrish, A.: "Millimeter-wave Remote-Sensing of Ozone and Trace Constituents in the Stratosphere", Proceedings of the IEEE, 82 (12), p.1915-1929, December, 1994.

Connor, B.J., A. Parrish, J.J. Tsou, and M.P. McCormick: "Error Analysis for the Ground-based Microwave Ozone Measurements During STOIC", J. Geophys. Res., Vol 100 (D5), p.9283-9291, May 20, 1995.

Boyd, I. S., A. D. Parrish, L. Froidevaux, T. von Clarmann, E. Kyro"la", J. M. Russell III, and J. M. Zawodny (2007), Ground-based microwave ozone radiometer measurements compared with Aura-MLS v2.2 and other instruments at two Network for Detection of Atmospheric Composition Change sites, J. Geophys. Res., 112, D24S33, doi: 10.1029/2007JD008720.

Parrish, A., et al., Diurnal variations of stratospheric ozone measured by ground-based microwave remote sensing at the Mauna Loa NDACC site: measurement validation and GEOSCCM model comparison, *Atmos. Chem. Phys.*, 14, 7255–7272, 2014

Nedoluha, G. E., et al., Unusual stratospheric ozone anomalies observed in 22 years of measurements from Lauder, New Zealand, *Atmos. Chem. Phys.*, 15, 6817–6826, 2015

Instrument Description:

The instrument is a microwave spectrometer observing atmospheric thermal emission at 110.8 GHz from the ground. It consists of a cryogenic heterodyne receiver and multi-channel spectrometer, and records the spectral lineshape of an ozone rotational transition every 20 minutes at about 10 to 20 degrees elevation. Observations continue 24 hours a day whenever weather permits. An ozone mixing ratio profile as a function of pressure can be retrieved from each of the ozone spectra obtained. Averages of the spectral data over 6 hour periods are processed routinely

Algorithm Description:

An ozone mixing ratio profile (ppmv) from 56hPa to 0.05hPa (or 20 - 68 km) is retrieved for every 6 hour period (although actual integration times may vary from 40 minutes to 6 hours depending on atmospheric conditions), using a semiempirical optimal estimation retrieval method. For every 24 hour continuous observation, up to four ozone profiles (two for daytime and two for nighttime) per day result, and are reported to the NDSC database. We have also generated hourly retrievals for the Mauna Loa time-series for studies of diurnal ozone variability that are available on request.

Expected Precision/Accuracy of Instrument:

The general expected precision is 4 - 6%, and accuracy 5 - 9%, for nighttime ozone profiles and daytime ozone profiles in the stratosphere. The accuracy of ozone profiles in the lower mesosphere could go up to 12 - 17% for nighttime profiles and 17 - 22% for daytime profiles. The precision, accuracy, and vertical resolution for each ozone profile at each retrieved pressure level are reported in the data set.

Notes on Version 6 Processing:

This version incorporates corrections to the spectral baseline based on measurements of this baseline made regularly through the timeseries of both instruments. For the instrument at Mauna Loa the spectral baseline has remained largely unchanged through the timeseries, and the effect on the retrievals is small compared with the previous processing versions. For the instrument at Lauder there were significant changes to the baseline during 1994-1995 and 2003-2004, as described below, resulting in steps in the timeseries in earlier versions. These biases are reduced in this processing version to the extent that we no longer suggest applying offsets to the ozone profiles.

Notes on Version 5 Processing:

This version incorporates several changes over Version 4 - most significantly the extension of the forward model from ~80 km to ~110 km - which fixes the problem present in the v4 datasets (especially Mauna Loa) above about 60 km (see below).

Other changes include:

Improved characterization of the individual filters; New temperature profiles consisting of a composite of NCEP/NCAR reanalysis, NCEP, Lidar average or climatology, and MSISE-00 model profiles are used in the forward model. Analysis of the various temperature measurements has been undertaken to attempt to ensure homogeneity of the temperature time-series.

Known Issues with Version 5 dataset

Changes in the spectral baseline characteristics are apparent in the Lauder time-series, and are not currently accounted for. The most obvious changes in the spectral baseline occur during the period when the Lauder instrument was tested and serviced at the Table Mountain Facility during 1994 to 1995, and after the receiver failed in 2003. Between 1994 and 1995 there is a step of the order of 4 to 6% in the ozone retrieval at the lowest reported altitudes (56 hPa and 42 hPa). After the instrument was repaired in 2004, a step in the time-series is present between 42 and 18 hPa. Boyd et al. [2007] have determined approximate offsets based on averaging before and after differences between the Lauder MWR and ozonesonde, lidar, and GOMOS during this period. For the purposes of time-series analysis, therefore, data at these levels should be used with caution. Work is currently being undertaken to attempt to better characterize the spectral baselines of both instruments, and this is expected to be implemented in the upcoming version 6 level processing.

Notes on Version 4 Processing:

This is a uniformly processed dataset with the exception of the period September 1993 to October 1994 at Lauder which contains less spectral information near the line center, resulting in higher retrieval errors at high altitudes. At low altitudes (56 hPa and, to a much lesser extent, 42hPa) there is a small drift in the retrieved ozone values due to changing characteristics of the spectral baseline with time.

This version contains a problem which mostly affects the Mauna Loa measurements above about 60 km, resulting in ozone retrievals that are too high at 75 km and too low at 65 km. This is due to a combination of the filter configuration of the instrument at Mauna Loa and the altitude range covered by the forward model.

The filter configurations in the Lauder and Mauna Loa instruments are essentially identical except for one important difference. Included in the filter sets in both instruments is a pair of filters located at offsets of + and - 125 kHz from the ozone line center, with bandwidths of 50 kHz. That is, they pass signal primarily between -150 and - 100 kHz, and between +100 and +150 kHz with respect to the line center, but reject most of the signal from the line center itself. In the Mauna Loa instrument only, there is one additional channel that has a bandwidth of 250 kHz and is centered on the line center. That channel dominantly sees signal from the "core" of the line that is mostly missed by the channels at +/- 125 kHz.

This version uses a 36 level model during the retrieval, with the highest level at .01 hPa, or about 80 km. In reality, the Mauna Loa instrument sees the signal contributed by ozone above that level, if there is any, but the Lauder instrument mostly does not see that contribution, because it lacks the central channel. Above about 75 km the pressure broadening of ozone is smaller than the Doppler broadening so the measurement can't distinguish where the signal is coming from above that altitude. The retrieved profile at .01 hPa is therefore influenced by any ozone above, which makes the measured

signal in the line core larger than the amount calculated from the a priori by the forward model. The Mauna Loa retrieval therefore tends to overestimate the ozone amount at .01 hPa, (with a corresponding over-compensation at 0.1 hPa) and to do so more than the Lauder one, because the latter mostly does not see the line core signal.

Version 4 ozone measurements above about 60 km should not be used for comparison purposes at Mauna Loa.

Measurement History:

First instrument:

July 1989	-	June 1992	:	Table Mountain, CA
July 1992	-	August 1992	:	Observatory of Haute Provence, France
October 1992	-	October 1994	:	Lauder, New Zealand
November 1994	-	March 1995	:	Table Mountain, CA (instrumentation test)
April 1995	-	November 200	:	Lauder, New Zealand
December 2003	-	April 2004	:	Amherst, MA (receiver repair and upgrade)
May 2004	-	October 2016	:	Lauder, New Zealand

Second instrument:

August 1994	-	July 1995	:	Table Mountain, CA (instrumentation test)
August 1995	-	May 2015	:	Mauna Loa, HI

Instrument was replaced/updated and resumed operation in January 2016