File Revision Date:
November 12th, 2024

Data Set Description:

PI:	Gerald Nedoluha
Instrument:	Ground-based 278 GHz microwave spectrometer
Site(s):	Mauna Kea, Hawaii - moved to Mauna Loa in September 2015, returned to Mauna Kea in June 2018 Scott Base, Antarctica
Measurement Quantities:	Mixing ratio profile of ClO

Contact Information:

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DOI: At this time, no DOIs have been assigned to any of the Mauna Kea or Scott Base datasets housed in NDACC. However, data license type would be expected to be CC-0 (most open).

Reference Articles:

Parrish A., R.L. deZafra, P.M. Solomon, and J.W. Barrett, 1988: "A ground-based technique for millimeter wave spectroscopic observations of stratospheric trace constituents", Radio Science, Vol. 23, pp. 106-118.

Solomon P., J. Barrett, B. Connor, S. Zoonematkermai, A. Parrish, A. Lee, J. Pyle and M. Chipperfield, 2000: "Seasonal observations of chlorine monoxide over Antarctica during the 1996-1998 ozone holes and comparison with the SLIMCAT three-dimensional model", JGR 105, D23, 28,979-29001.

Connor Brian, Jim Barrett, Tom Mooney, 2005: "Error Estimates for Mauna Kea ClO, 1992-2004", Internal memorandum.

Nedoluha, G. E., et al., 2011: "Ground-based measurements of ClO from Mauna Kea and intercomparisons with Aura and UARS MLS", J. Geophys. Res., 116, D02307, doi:10.1029/2010JD014732.

Nedoluha, G. E. et al., 2016: "20 years of ClO measurements in the Antarctic lower stratosphere", Atmos. Chem. Phys., 16, 10725-10734, doi: 10.5194/acp-16-10725-2016.

Nedoluha, G. E., et al., (2020): “Initial Results and Diurnal Variations Measured by a new Microwave Stratospheric ClO Instrument at Mauna Kea”, J. Geophys. Res., JGRD56492, doi:10.1029/2020JD033097

Nedoluha Gerald E., R. Michael Gomez, Ian Boyd, et al., 2024: “Measurements of Stratospheric ClO from Mauna Kea: 1992-2023”, Under Review, JGR 2024JD041848.

Instrument Description:

The instrument consists of a cooled heterodyne receiver operating at 278.6 GHz, originally feeding a filterbank spectrometer with a total bandwidth of 506 MHz (Mauna Kea 1992 to 2015 and Scott Base 1996 to 2023), and now feeding a 16384 channel FFT spectrometer with a total bandwidth of 1 GHz. We observe a thermally-excited rotational emission line of ClO; thus observations do not depend on the absorption or scattering of sunlight, and can be carried out day or night. To eliminate systematic instrumental artifacts such as differences in gain across the spectrometer's bandwidth, observations are made in a switched mode, the instrument looking alternately at the zenith (reference beam) and near the horizon (signal beam). The contributions to the spectrum from ClO at different altitudes are pressure broadened by different amounts, permitting the altitude distribution of ClO to be recovered from the shape of the observed spectrum. The instrument is indoors and looks at the sky through a Teflon window in the wall of the building. See Parrish et al. (1988) for details.

ChlOE1 (Scott Base to October 2023) and ChlOE3 (Mauna Kea to August 2015) used a filterbank spectrometer consisting of 306 channels over 506 MHz. The channels were 5 MHz wide in the line wings, and 1 MHz wide near the line center where greater resolution was needed. The ChlOE4 (Mauna Loa and Scott Base) and ChlOE5 (Mauna Kea from June 2018) backends consist of Fourier Transform spectrometers (FTS) with 16384 channels over 1 GHz, providing 61 kHz resolution.

Algorithm Description:

The goal of the v7 retrieval is to provide a stable dataset for multi-decadal trend studies. In order to reduce the effect of slowly changing instrumental baselines, the retrieval takes advantage of the large diurnal variation in ClO, and is determined from differences between the daytime and nighttime spectra and thus represent the difference between daytime and nighttime ClO mixing ratios. The retrieval is based on an optimal-estimation approach (Rodgers, Rev. Geophys. 14, 608, 1976). For Mauna Kea, all ChlOE profiles taken between 0900 and 1700 Hawaiian Standard Time (HST) are classified as daytime, while those taken between 2200 and 0500 HST are classified as nighttime. For Scott Base, daytime is defined as being 3 hours after the sun rises to 94 deg. SZA and 1 hour before it sets to 94 deg. SZA, while nighttime is 4 hours after the sun sets to 94 deg. SZA and 1 hour before it rises to 94 deg. SZA. While the additional channels available with the FTS can provide some additional information relative to the filterbank spectrometer, in the v7 retrieval these channels are mapped, as closely as possible, to the frequencies of the filterbank spectrometer. As a result ~82 FTS channels are mapped to each 5 MHz filterbank channel and ~16 to each 1 MHz filterbank channel.

Special processing of the Mauna Kea measurements, which examines the seasonal and diurnal variation of the 278 GHz opacity in a 2018-2019 study of ChlOE measurements, was performed for Nedoluha et al. (2020). Measurements submitted to NDACC are differentiated from the standard v7 retrievals by inclusion of the version name keywords “gn2020.diurnal” and “gn2020.monthly”.

L0/L1: L0 measurements, consisting of the raw data collected by the instrument logging program, are housed on the Bryan Scientific Consulting LLC server ‘Zenith’, at NRL and locally on each machine.

Expected Precision/Accuracy of Instrument:
An error estimate is listed in the files, and errors are discussed in Solomon et al. (2000) for Scott Base and Connor et al. (2005) for Mauna Kea.

Measurement History:
Scott Base (instrument designation ChlOE1) from January 1996 to October 2023: Instrument located in the Hatherton Lab on the main base. Instrument pointing to the SSE. Mostly continuous measurements but v7 retrievals are only made during the Antarctic Spring (August-October).
Due to issues with the instrument, there are no measurements for the 2018 Antarctic Spring. Measurements resumed after the instrument was repaired in November 2018.

Scott Base (instrument designation ChlOE4-Rx5) from February 2023 onwards: Instrument located in a purpose-built building, as part of the Scott Base redevelopment, ~100 m to the north of the Hatherton Lab, but with the same pointing direction. Mostly continuous measurements but v7 retrievals only made during the Antarctic Spring.

Mauna Kea (instrument designation ChlOE3-Rx3 from January 1992 to February 2012 and September 2012 to November 2014): Instrument located in a hut near the CSO telescope pointing toward the SW. Mostly continuous measurements in clear observing conditions.

Mauna Kea (instrument designation ChlOE3-Rx4 from February 2012 to September 2012 and November 2014 to August 2015): Instrument located in a hut near the CSO telescope.
New Receiver (Rx4) but same optics panel and spectrometer. Mostly continuous measurements in clear observing conditions.

Mauna Loa (instrument designation ChlOE4-Rx4 from March 2016 to June 2018):
Using Rx4, a modified version of the Mauna Kea optics panel, and AC240 FTS backend. Limited measurement capability at this site due to inconsistent periods of very clear conditions. At this stage, there are no plans to submit ClO measurements for this period to NDACC.

Mauna Kea (instrument designation ChlOE5-Rx4 from June 2018 onwards): Instrument located in a hut near the CSO telescope with pointing to the SW from June 2018 to March 2022. Moved ~400 m to a new location near the NASA IRTF telescope in March 2022 due to decommissioning of the CSO telescope. New pointing direction is toward the North.
Using Rx4 with a new optics panel and U5303a FTS backend. Mostly continuous measurements in clear observing conditions.