

File Revision Date: Sep 6, 2020

File: m4_avg_1985_2019.vav.ames

Data Set Description:

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Instrument: JPL MkIV Interferometer

Sites: See table below

Site	Abbr	N_obs	N_day	Lat(deg)	Long(deg)	Alt(km)
Esrange, Sweden	ESN	154	32	+67.889	+21.085	0.271
Fairbanks, Alaska	FAI	124	46	+64.830	-147.614	0.182
Lynn Lake, Manitoba, Canada	LYL	20	11	+56.858	-101.066	0.354
Mt. Barcroft, California	MTB	1369	255	+37.584	-118.235	3.801
Mountain View, California	ARC	7	4	+37.430	-122.080	0.010
Daggett, California	DAG	33	21	+34.856	-116.790	0.626
Ft Sumner, New Mexico	FTS	521	106	+34.480	-104.220	1.260
TMF, Wrightwood, California	TMF	475	45	+34.382	-117.678	2.257
B183, JPL, Pasadena, Calif	JPL	2273	698	+34.199	-118.174	0.340
Mesa, JPL, Pasadena, Calif	JPL	20	5	+34.205	-118.171	0.460
NSBF, Palestine, Texas	PAL	4	3	+31.780	-95.700	0.100
McMurdo, Antarctica	MCM	37	20	-77.847	+166.728	0.100

-----+ve

Latitude = N ; +ve Longitude = E ; Altitude in km

N_{OBS} = Total number of observations from that site

N_{DAY} = Total number of observation days from that site

The large number of locations is the result of MkIV performing ground-based observations while waiting for balloon launches from various sites. I thought that it would be better for the end-user to include all 12 sites into one file, rather than split up the data into 12 files. All analyses have been performed in the same way, using the same software and linelist. To obtain data from one location only, filter on latitude/longitude which are included in every data record.

Measurement Quantities:

Column abundances (molec.cm⁻²): H₂O, CO₂, O₃, N₂O, CO, CH₄, NO, NO₂, NH₃, HNO₃, HF, HCl, ClO, OCS, H₂CO, ClNO₃, HCN, CFC-12, COF₂, C₂H₆, C₂H₄, C₂H₂, N₂, HCFC-22, HCOOH, HDO, SF₆, C₃H₈

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Selected Reference Articles (for full list see: <https://mark4sun.jpl.nasa.gov/paper.html>):

- Toon, G. C., Blavier, J.-F. L., and Sung, K.: Atmospheric carbonyl sulfide (OCS) measured remotely by FTIR solar absorption spectrometry, *Atmos. Chem. Phys.*, 18, 1923-1944, <https://doi.org/10.5194/acp-18-1923-2018>, 2018
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- Notholt J, Toon GC, Fueglistaler S, et al., Trend in ice moistening the stratosphere - constraints from isotope data of water and methane, *ACP*, 10, 201-207, 2010
- Notholt J, Toon G, Jones N, et al. Spectral line finding program for atmospheric remote sensing using full radiation transfer JQSTR, 97: 112-125, 2006
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- Toon, G.C., J.-F. Blavier, B. Sen, R.J. Salawitch, G.B. Osterman, J. Notholt, M. Rex, C.T. McElroy, and J.M. Russell III, Ground-based observations of Arctic ozone loss during spring and summer 1997, *J. Geophys. Res.*, 104, 26,497-26,510, 1999.
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Instrument Description

The MkIV interferometer is a high resolution FTIR spectrometer designed and built at JPL in the early 1980's for solar absorption measurements. The MkIV employs a double-passed optical configuration for compactness and to provide passive shear compensation. Two parallel detectors, an HgCdTe photoconductor covering 650-1950 cm⁻¹ and an InSb photodiode covering 1850-5650 cm⁻¹, allow the entire mid-infrared spectrum to be measured simultaneously in every spectrum. For ground-based observations an optical path difference of 117 cm is usually employed, which takes about 3 minutes per scan sampling at 10kHz with a step of 633 nm (one wavelength of the He:Ne reference laser).

Interferogram Processing

Interferogram data are converted to spectra using the following procedures:

- 1) The HgCdTe interferograms are corrected for the effects of detector non-linearity using the method of Abrams, Toon and Schindler (1994).
- 2) Interferogram glitches (birds, insects flying through the solar beam) are repaired using the "birdfix" program, which replaces the damaged section of the igram with the average of the previous & next igrams of the same scan direction.
- 3) The resulting interferograms are phase corrected and FFT'd into spectra.

The HgCdTe and InSb spectra are kept in separate files (not merged).

Spectrum Averaging

Typically, FWD and REV spectra are averaged, prior to analysis. Around noon, if the conditions are unchanging, up to 8 scans (~25 min) are averaged. At other times of day when the conditions (airmass, cloudiness, H₂O) are changing more rapidly, the number of averaged scans is reduced. But we still try to use equal numbers of FWD and REV scans in each average, so that the average observation time, and hence SZA is independent of the spectral resolution.

Spectral Fitting Algorithm

Column abundances were derived from the spectra by least squares fitting using the version 4.82 GFIT algorithm, developed at JPL for the analysis of solar absorption spectra. The entire dataset was re-analyzed with this version, not just the latest year. Temperature and H₂O profiles come from NCEP analyses. An initial set of vmr profiles derived from MkIV balloon and ACE measurements, which are then stretched/compressed above 10 km altitude to account for day-to-day variations in tropopause altitude and hence the amount of stratospheric subsidence. These vmr profiles were then scaled in order to derive the vertical column abundances.

This is the same procedure (GFIT, T/P and VMR priors) as is used for the GGG2014 TCCON analyses. The only difference is that TCCON expresses the results as a column-average mole fraction (X_{gas}), whereas we use the total vertical columns. The columns can be converted into X_{gas} values by computing the total column of dry air (luft – h₂o) and dividing the gas column by this. Luft is the total column of all molecules (including H₂O) and is based on the measured surface pressure. A fuller description of the TCCON retrieval process, can be found at: <https://tcon-wiki.caltech.edu/>

The 2020 version of the ATM.101 linelist was used for the analyses, complemented by pseudo-linelist for the gases C₂H₆, CCl₄, CFC-11, CFC-12, CF₄, SF₆, ClNO₃ and HCFC-22.

Expected Precision/Accuracy of Instrument:

The errors tabulated in the main part of the data file, determined by GFIT from the quality of the spectral fits and the Jacobians. In the ideal case of random residuals, these uncertainties represent the 1-sigma measurement precisions. In the case of systematic residuals that change little or slowly from spectrum to spectrum, these uncertainties over-estimate the true precision. These error estimates are appropriate for comparing columns measured on different days.

Absolute accuracies are more difficult to determine. For most gases, the main systematic errors arise from uncertainties in the assumed vmr profiles shapes, and from uncertainties in the spectroscopic parameters (of both the target gas and interfering gases).

Instrument History:

The MkIV instrument was built in 1984, acquired first ground-based solar spectra from JPL in 1985, took ground-based solar spectra from McMurdo, Antarctica in 1986. MkIV flew on the NASA DC-8 aircraft mission to Antarctica in 1987, and on missions to the Arctic in 1989 and 1992. The first balloon flight was in 1989, and the 25'th was in 2019. A more detailed breakdown of this history can be found in: https://mark4sun.jpl.nasa.gov/field_campaigns.html