Revision Date: November 30, 2012

HIPPO MEDUSA Flask Sample Trace Gas and Isotope Data (R_20121129)

Summary:

This data set provides atmospheric trace gas concentrations of flask samples collected with the Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA) on Missions 1 - 5 of the HIAPER Pole-to-Pole Observations (HIPPO) of the Carbon Cycle and Greenhouse Gases Study. The Missions took place from January of 2009 to September 2011.

The MEDUSA flask sampler collects air into glass flasks that are continuously purged at a controlled flow and pressure with a mixing time of around 30 sec and a representative sampling time kernel that drops off exponentially with a several-minute tail. Up to 32 flask samples could be collected per flight. Number total number of flask samples collected was 1,690.

Flasks gas samples were analyzed for O_2, Ar/N_2, 13CO_2, and $C^{18}O^{16}O$ on a sector-magnet mass spectrometer and for CO_2 on a LiCor non-dispersive infrared CO_2 analyzer by the Atmospheric Oxygen Research Group at Scripps Institution of Oceanography.

MEDUSA flask sample results were joined with selected variables from concurrent Merged 1-second data (cite 1-second). This product accounts for flask fill dynamics by aggregating the 1-second data by weighted averages according to the sample kernel for each flask.

Values in this file are identical to those in the discrete file, but presented here for MEDUSA flasks alone, with additional MEDUSA diagnostic information, and without a correction for the Scripps-NOAA CO_2 scale offsets. The data file is in space delimited ASCII format.

MEDUSA served several roles in the HIPPO. It acted as a discretely-sampled comparison for onboard (“in-situ”) real-time O_2/N_2 ratio measurements from the AO_2 instrument; as a redundant measurement of CO_2; and as the only measurement of argon and 14C isotopes. The complementary measurements (CO_2, O_2/N_2) allow ground-truthing of onboard instrument measurements in a laboratory setting, where analysis conditions can often be more stringently proscribed, and carefully monitored. Isotope and argon measurements can provide additional information about land and ocean controls over the carbon cycle, about the age and source of the air sampled, and about the convective activity of the troposphere.

Summary of 10-Second Data Completeness by Mission

A supplementary file is provided with this product that summarizes the completeness of the reported data values. The completeness entries are the number of non-missing observations for each species in the main data file for each mission and in total. The number of observation given for species “jd” is the maximum number of possible non-missing observations per mission. The data are provided in one space-delimited format ASCII file.

Data Set Citation:

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Cite this data set as follows:

Wofsy, S. C., B. C. Daube, R. Jimenez, E. Kort, J. V. Pittman, S. Park, R. Commane, B. Xiang, G. Santoni, D. Jacob, J. Fisher, C. Pickett-Heaps, H. Wang, K. Wecht, Q.-Q. Wang, B. B. Stephens, S. Shertz, A.S. Watt, P. Romashkin, T. Campos, J. Haggerty, W. A. Cooper, D. Rogers, S. Beaton, R. Hendershot, J. W. Elkins, D. W. Fahey, R. S. Gao, F. Moore, S. A. Montzka, J. P. Schwarz, A. E. Perring, D. Hurst, B. R. Miller, C. Sweeney, S. Oltmans, D. Nance, E. Hintsa, G. Dutton, L. A. Watts, J. R. Spackman, K. H. Rosenlof, E. A. Ray, B. Hall, M. A. Zondlo, M. Diao, R. Keeling, J. Bent, E. L. Atlas, R. Lueb, M. J. Mahoney. 2012. **HIPPO MEDUSA Flask Sample Trace Gas and Isotope Data (R_20121129**). Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A. http://dx.doi.org/10.3334/CDIAC/hippo_014 (Release 20121129)   ***

***** Users are encouraged to include the Data File Name(s) with the citation to document the data file and version used for reproducibility. Please append: “[File name(s):** list file name(s) or reference another included table or source that lists the files**]”**

Data Set Contents:

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Data files with version control information:

Data Product	File Name w/Version	Date Published	Date Superseded	Change Description
MEDUSA Trace Gas	HIPPO_medusa_flasks_merge_insitu_20121129.tbl	20121129		First archived version
	MEDUSA_meta_summary.tbl	20121129		First archived version

User's Guide Contents:

HIPPO Project

The HIAPER Pole-to-Pole Observations (HIPPO) study is investigating the Carbon Cycle and greenhouse gases throughout various altitudes of the western hemisphere through the annual cycle. HIPPO is supported by the National Science Foundation (NSF) and its operations are managed by the Earth Observing Laboratory (EOL) of the National Center for Atmospheric Research (NCAR). Its base of operations is EOL's Research Aviation Facility (RAF) at the Rocky Mountain Metropolitan Airport (RMMA) in Jefferson County, Colorado. The main goal of this study is to determine the global distribution of carbon dioxide and other trace atmospheric gases by sampling at various altitudes and latitudes in the Pacific Basin.



Figure 1. NSF/NCAR G-V aircraft at various locations during Mission 1.

Data and Documentation Access:

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Get Data:

Integrated-product data access at CDIAC: (http://hippo.ornl.gov/dataaccess)

EOL HIPPO Data Archive and Web Site: Download imagery, publications, supporting documentation, and component data: (www.eol.ucar.edu/projects/hippo**)**

Links to Companion Files and Supplemental Information:

HIPPO Instrument Description Document:
(ftp://cdiac.ornl.gov/pub/HIPPO/HIPPO_all_docs/HIPPO_Instrument_Descriptions_20121116.doc)

Data Dictionary:
(ftp://cdiac.ornl.gov/pub/HIPPO/HIPPO_all_docs/HIPPO_data_dictionary.xls)

EOL HIPPO Data Quality Reports: (www.eol.ucar.edu/projects/hippo)

- Mission Data Quality Reports
- Investigator provided "Readme Files"

HIPPO Data Policy -- Sharing, Access, and Use Recommendations:
(ftp://cdiac.ornl.gov/pub/HIPPO/HIPPO_all_docs/HIPPO_Full_Data_Policy.pdf)

UCAR HIPPO Project Web Site: http://hippo.ucar.edu/

HIPPO Flight Tracks in Google Earth: Download *.kmz files for Google Earth

HIPPO Data Fair Use

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Before you use HIPPO data, please first familiarize yourself with the HIPPO Data Fair Use agreement below. Your cooperation is appreciated.

The HIPPO data provided on this public archive are freely available and were furnished by HIPPO researchers who encourage their use. Data users are encouraged to consider the following recommendations for fair, appropriate, and optimal use of data products.

HIPPO Scientist Interactions:

- Please kindly inform the HIPPO scientist(s) associated with each data product about the new data analysis activity near the beginning of the effort, and of any publication plans as the effort nears completion.
- Consult with the respective HIPPO scientist(s) concerning your data analysis plans to assure that the latest data product is being used and that it is being used appropriately.
- HIPPO science team members are listed at http://hippo.ucar.edu/team. Alternatively, initiate contact with Dr. Steven C. Wofsy (swofsy@seas.harvard.edu), Lead Principal Investigator.

Acknowledgments:

- Please acknowledge (1) the use of HIPPO data products with a citation as provided in the data archive documentation, and (2) website information downloads as a bibliographic web citation.
- Acknowledge the agency or organization (e.g., NSF and NOAA) that supported the collection of the original HIPPO data when publishing new analyses and results using HIPPO data products.
- Please submit a HIPPO publication reference or reprint at http://www.eol.ucar.edu/projects/hippo/publications/publication_refs.html of your independent work so that all publications resulting from HIPPO data products may be tracked, recorded, and referenced.

Read the complete HIPPO Data Policy: Sharing, Access, and Use Recommendations
(ftp://cdiac.ornl.gov/pub/HIPPO/HIPPO_all_docs/HIPPO_Full_Data_Policy.pdf)

Data Description:

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Temporal and Spatial (horizontal) Coverage of Research Flights

These tables describe at a general level the mission-by-mission research flights

Mission	Flight Path Notes	Flight Path
HIPPO-1 **Sampling Dates** January 8 to January 30, 2009 **Vertical Profiles Flown** 138	Northern polar flight #1 reached 80º N. Southbound Pacific flights followed the typical central flight path. Southern ocean flight reached 67º S, 175º W The northbound flights followed an Eastern Pacific Route over Central and Southern North America. HIPPO-1 was only mission to not return to the Arctic a second time.	

Mission	Flight Path Notes	Flight Path
HIPPO-2 **Sampling Dates** October 31 to November 22, 2009 **Vertical Profiles Flown** 148	Northern polar flight #1 reached 80º N. Both southbound and northbound Pacific flights followed a central flight path. Southern ocean flight reached 66º S, 174º W Northern polar flight #2 reached 83º N.	

Mission	Flight Path Notes	Flight Path

HIPPO-3 **Sampling Dates** March 24 to April 16, 2010 **Vertical Profiles Flown** 136	Northern polar flight #1 reached 84.75º N. Both southbound and northbound Pacific flights followed a central flight path. • Southbound RF04 reached 41,000 feet over the equator allowing insight into the atmospheric cross section near the Intertropical Convergence Zone (ITCZ). • Northbound RF09 was coordinated to track with the NASA Global Hawk (50,000 feet higher) and both intercepted the track of the NASA Aura satellite, which carries the Microwave Limb Sounder (MLS). Southern ocean flight reached 66.8º S, 170º E. Northern polar flight #2 reached 85º N. • Polar flight RF10 flew three 500 feet altitude by 5 minute legs crossing extensive networks of fractures in ice	

Mission	Flight Path Notes	Flight Path
HIPPO-4 **Sampling Dates** June 14 to July 11, 2011 **Vertical Profiles Flown** 175	Northern polar flight #1 reached 84º N. Southbound Pacific flights followed the typical central flight path. • In the Southern Pacific, a Chilean volcanic ash cloud caused a schedule change. Flights were delayed to allow ash-free air masses to move in to permit safe sampling. High latitude air masses were also pushed south, which limited GV access to Polar air. Southern ocean flight reached 58º S, 145º E. The northbound flights followed a Western Pacific route but the earthquake and tsunami in Japan necessitated a less westerly return than was planned. Northern polar flight #2 reached 82º N. • Polar flight RF11 flew over Point Hope, AK and traversed open ocean, scattered ice, flooded ice, and ice with melt ponds with a low altitude transect ranging from 500 to 5,000 feet. Solid ice was not reach by turnaround at 82N.	

<table>
<tr><th>Mission</th><th>Flight Path Notes</th><th>Flight Path</th></tr>
<tr><td>HIPPO-5</td><td rowspan="6">Northern polar flight #1 reached 82º N.

Both southbound and northbound Pacific flights followed a central flight path.

Southern ocean flight reached 67º S, 164º E.
• Flight RF09 reached the ice edge; one profile crossed the edge and another profile was over solid ice.

Northern polar flight #2 reached 87º N.</td><td rowspan="6">
</td></tr>
<tr><td>Sampling Dates</td></tr>
<tr><td>August 9 to September 8, 2011</td></tr>
<tr><td>Vertical Profiles Flown</td></tr>
<tr><td>190</td></tr>
</table>

<u>Bounding Box for All Research Flights:</u>

Flight paths for all five Missions

Longitude	Longitude	Northernmost Latitude	Southernmost Latitude
128.2 E	**-84.0 W**	**87.04313 N**	**-67.15801 S**

Spatial Coverage (vertical) of Research Flights

The 10-second merged data are highly time resolved due to the component 1-second in situ reporting frequency and vertically-resolved as well because of GV flight plans that performed 787 vertical ascents /descents from the ocean/ice surface/land surface to as high as the tropopause. It was planned to have two maximum altitude ascents per flight to the tropopause/lower stratosphere, one in the first half and one in the second half of a research flight. In between, several vertical profiles from below the planetary boundary layer (PBL) to the mid-troposphere (1,000-28,000 feet) were flown.

- Profiles were flown approximately every 2.2º of latitude with 4.4º between consecutive near-surface or high-altitude samples.
- Rate of climb and descent was 1,500 ft/ minute (457 m/minute).
- During these profiles, the GV averaged a ground speed of about 175 m/sec or 10 km/min.

Typical Flight Plan

Ideally a flight would take off and go to FL430 (43,000 ft or 13,100 m) over the first 15 minutes, then descend belowFL290 (29,000 ft or 8,850 m) and proceed in a sawtooth pattern between FL270 (27,000 ft or 8250 m) and FL10 (1,000 ft or 300 m) with a 1,500 ft (457 m)/minute climb/descent rate, then climb to FL450 (45,000 ft or 13,700 m) near the end of the flight for about 15 minutes, then descend, and proceed to the airport.

Most of a flight was conducted below the international Reduced Vertical Separation Minimum (RVSM) usually 29,000 ft or 8,850 m, in order to allow the G-V to descend and climb constantly to collect data at different altitudes throughout the troposphere. All flights plans were subject to modifications depending upon local atmospheric conditions and approval by air traffic control.

On average, consecutive profile samples in the midtroposphere are separated by 2.2º of latitude, with 4.4º between consecutive near-surface or high-altitude samples. Most profiles extended from approximately 300 to 8,500 m altitude, constrained by air traffic, but significant profiling extended above approximately 14 km.

Flight Patterns

These two images provide a good visualization of the typical HIPPO flight pattern, which is designed to sample the global distribution of carbon dioxide and other trace atmospheric gases at various altitudes and latitudes in the Pacific Basin.

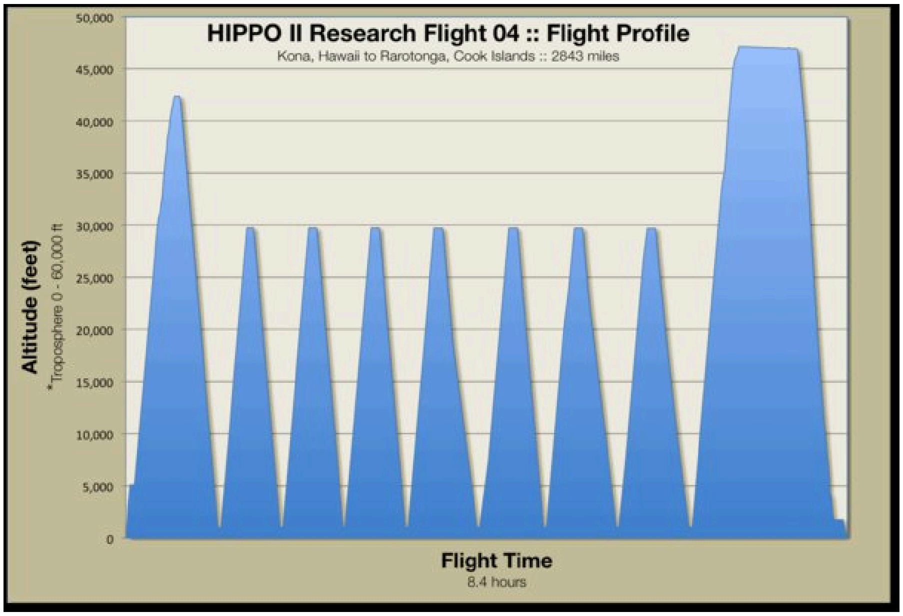

Figure 2. Example of NSF/NCAR G-V aircraft flight pattern. Eighteen profiles are shown in the image; the ascending and descending flight paths of each peak are a separate profile.

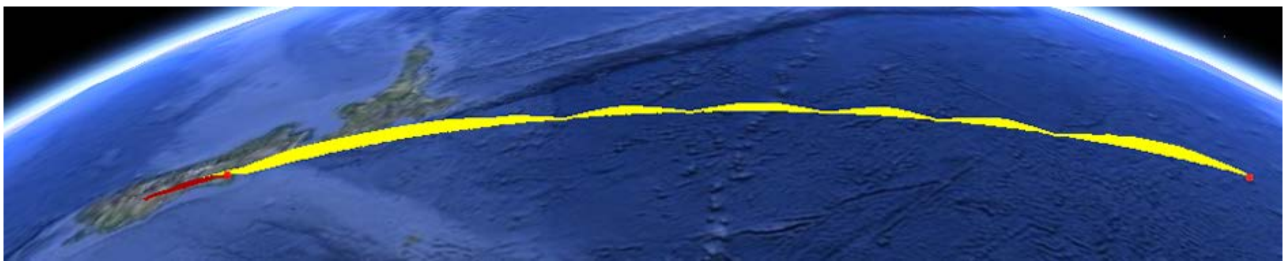

Figure 3. Example of NSF/NCAR G-V aircraft flight pattern. The x-axis in this figure is space and is a more realistic representation of the vertical aspect of a flight than in Figure 2.

Temporal Resolution of Merged Observations

Data Center Note: To provide a more complete description of the temporal resolution of measurements, we will be developing a table that lists for each instrument or sampling device, the native sampling duration, the reporting or integration interval, and the inter-sample interval.

Data File Description

A note about North American training and research flights:

For Mission 2-5, results of measurements collected during instrument check training flights and research flights conducted over North America are included in the data file. For Missions 2, 3, and 4, the training flights have “flt” values of -1 and 0. For Mission 5, research flights have “flt” values of 1 and 2. Users may want to exclude those from their HIPPO data analyses. The next flight in the series, the first HIPPO flight, originated at NCAR's Earth Observing Laboratory, Research Aviation Facility (RAF), located at the Rocky Mountain Metropolitan Airport (KBJC), Broomfield, CO and proceeded to Anchorage, AK.

Note that the first research flight for Mission 1 originated in Billings, MT, and has a“flt” value of 2.

Sources of data compiled for this MEDUSA flask data set.

Instrument code	Instrument detail	Institution	Investigators	Method
AO2-IR	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Vacuum-ultraviolet absorption and Infrared absorption
AO2-M	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Multiple
AO2-QCLS-OMS	Various	Multiple	Various	Various
AO2-VUV	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Vacuum-ultraviolet absorption
GV-1DOAP	One Dimensional Optical Array Probe	NCAR	Romashkin	Laser beam, diode array
GV-2D-C	2D-C Probe	NCAR	Romashkin	Laser beam, diode array
GV-2DOAP	Two Dimensional Optical Array Probe	NCAR	Romashkin	Laser beam, diode array
GV-AEROLASER	GV AeroLaser VUV CO sensor	NCAR	Campos	VUV fluorescence
GV-AV	GV Avionics	NCAR	Romashkin	Thermal sensor?
GV-CDP	Cloud droplet probe on GV	NCAR	Romashkin	Diode laser - forward scattered light
GV-CDPT	GV calibrated differential pressure transducer	NCAR	Romashkin	Pressure sensors
GV-CMS	GV cooled-mirror sensor	NCAR	Romashkin	Condensation?
GV-GP	GV gust probe	NCAR	Romashkin	Radome differential pressure
GV-GUST	GV 5-hole radome gust probe	NCAR	Romashkin	Differential pressure?
GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial Reference System 1	NCAR	Romashkin	IRS (Inertial Reference System) and GPS (Global Positioning System)
GV-LWCS	GV PMS liquid water content sensor (King probe)	NCAR	Romashkin	Heat loss from water vaporization
GV-MENSOR	GV Mensor 6100 sensor	NCAR	Romashkin	Pressure sensor
GV-MULTIPLE	Multiple GV instruments	NCAR	Romashkin	Various
GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)	NCAR	Romashkin	GPS (Global Positioning System)
GV-PS	GV Paroscientific Model 1000, using fuselage holes	NCAR	Romashkin	Pressure transducer
GV-RICE	GV Rosemount Model 871FA icing rate detector	NCAR	Romashkin	To be determined
GV-SENSOR	GV aircraft sensor	NCAR	Romashkin	To be determined
GV-TIME	GV time sychronized to GPS	NCAR	Romashkin	To be determined

Instrument code	Instrument detail	Institution	Investigators	Method
GV-UCATS	GV and UCATS instruments	NCAR	Romashkin	Various
GV-VCSEL	GV near-infrared vertical cavity surface emitting laser (VCSEL) hygrometer	Princeton	Zondlo	Laser hygrometer
MEDUSA-DA	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Data analysis
MEDUSA-IR	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Infrared absorption
MEDUSA-ME	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Manual entry
MEDUSA-MS	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Sector-magnet mass spectrometry
MEDUSA-PR	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Electronic pressure gauge
MEDUSA-SC	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	System clock
MEDUSA-SM				
MEDUSA-TM	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)	Scripps, NOAA	Stephens, Keeling, Bent	Thermal mass flow meter
NA	Not applicable	Harvard	Wofsy	Not applicable
NACA	National Advisory Committee for Aeronautics method	NCAR	Romashkin	National Advisory Committee for Aeronautics method
NA-V	Various	Various	Various	Not applicable
OMS	Harvard Licor 6251 NDIR CO2 sensor, heritage NASA "Observations of the Middle Stratosphere"	Harvard	Daube, Pittman, Kort, Jimenez	Non-dispersed infrared absorption
QCLS-IR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)	Harvard	Daube, Jimenez, Kort	Infrared absorption
QCLS-NDIR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)	Harvard	Daube, Jimenez, Kort	Nondispersive infrared analyzer
SP2	Single particle soot photometer	NOAA-CSD	Fahey, Gao, Spackman, Schwarz, Perring	LII (Laser-induced incandescence)
SP2-PRES	Single particle soot photometer	NOAA-CSD	Fahey, Gao, Spackman, Schwarz, Perring	Pressure sensor
UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)	NOAA-GMD	Hurst, Hintsa	Photometer
UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species	NOAA-GMD	Hurst, Hintsa	Tunable diode laser
UHSAS	Ultra-high sensitivity aerosol spectrometer	NCAR	Cooper	Aerosol spectrometer
UV-PHOT-N	UV ozone photometer (NOAA)	NOAA-CSD	Fahey, Gao, Spackman	Ultraviolet absorption

Data Dictionary:

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Each row contains the results from one MEDUSA flask sample. A row is uniquely defined by H.no, flt, and UT_MID, the average sample time for the sample kernel for each flask, in seconds since 0000 UTC on day the flight started. The variable "jd" also uniquely defines each roe.

In order to compare in situ and flask values, an averaging kernel is provided. The kernel takes into account flow rate and mixing time, tau, at time of sampling in order to express the sample as the result of ideal mixing. The leading tail of the integral has been removed, and a very slight correction has been applied to the remaining values in order to result in an integral of 1.

This product accounts for flask fill dynamics by aggregating the 1 Hz data by weighted averages according to the sample kernel for each flask.

These data are considered at **Quality Level 2**. Level 2 indicates a complete, externally consistent data product that has undergone interpretative and diagnostic analysis by HIPPO researchers. Sampling, data collection and instrument calibration issues are identified in the daily mission summary reports, daily technician's reports and the Project Managers' Data Quality Reports, and have been addressed to the extent possible as indicated in the metadata.

Note that the **data file is space delimited and uses "NA" as the missing value code**. NA is typically used in data products processed by "R".

Column	Column name	Expanded description	Unit	Unit long name	Instrument	Instrument code
meo	hippo_var	desc_lay	unit	unit_long	inst_code	inst_detail
1	jd	Decimal day number for HIPPO project, sequential, starting with January 1, 2009	d	day	NA	Not applicable
2	H.no	HIPPO mission number (1 through 5)	None	None	NA	Not applicable
3	Year	Year	y	year	NA	Not applicable
4	DOY	Day of the year	d	day	NA	Not applicable
5	flt	Flight sequence number within the mission	None	None	NA	Not applicable
6	MEDpos	MEDUSA flask position within rack (1-32)	dimensionless	dimensionless	MEDUSA-ME	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
7	MEDflID	MEDUSA sample flask identification number	dimensionless	dimensionless	MEDUSA-ME	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
8	UT_MID	Representative sample time, seconds, since 0000 UTC on day flight	s	second	NA-V	Various

Column	Column name	Expanded description	Unit	Unit long name	Instrument	Instrument code
		started				
9	GGLON	Longitude from GPS, datum WGS84	decimal degree	decimal degree	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
10	GGLAT	Latitude from GPS, datum WGS84	decimal degree	decimal degree	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
11	GGALT	Geometric altitude above mean sea level, datum WGS84	m asl	meter (above sea level)	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
12	CO2_MED	Carbon dioxide (CO2) adjusted to the WMO scale	ppm	part per million dry air mole fraction	MEDUSA-IR	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
13	O2N2_MED	Oxygen/nitrogen ratio (O2/N2) per meg	per meg	per meg (see reference)	MEDUSA-SM	
14	ArN2_MED	delta (Ar/N2). See Data Dictionary's More Information worksheet.	per meg	per meg	MEDUSA-MS	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
15	13CO2_MED	delta 13C in CO2. See Data Dictionary's More Information worksheet.	per mil	per mil	MEDUSA-MS	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
16	18CO2_MED	delta18O in CO2. See Data Dictionary's More Information worksheet.	per mil	per mil	MEDUSA-MS	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
17	MED14c	D14C in CO2	per mil	per mil	MEDUSA-MS	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
18	MEDUTCc	MEDUSA sample closure time, seconds, since 0000 UTC on day flight started	s	second	MEDUSA-SC	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
19	MEDpres	MEDUSA pressure of flask when analyzed	torr	torr	MEDUSA-PR	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
20	MEDFlow	MEDUSA mean flow rate during flask filling	sccm	Standard cubic centimeter per minute	MEDUSA-TM	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
21	APO_MED	Apparent potential oxygen (APO) based on best available data, weighted by MEDUSA averaging kernel. See Data Dictionary's More Information worksheet.	per meg	per meg	AO2-QCLS-OMS	Various
22	CO2_QCLS	Carbon dioxide (CO2)	ppmv	part per million dry air mole	QCLS-NDIR	Quantum Cascade Laser System (NCAR

Column	Column name	Expanded description	Unit	Unit long name	Instrument	Instrument code
				fraction		system built by Harvard/Aerodyne)
23	wt.qcls	Proportion of MEDUSA kernel with QCLS CO2 data	proportion	proportion	MEDUSA-DA	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
24	CO2_OMS	Carbon dioxide (CO2)	ppmv	part per million dry air mole fraction	OMS	Harvard Licor 6251 NDIR CO2 sensor, heritage NASA "Observations of the Middle Stratosphere"
25	wt.oms	Proportion of MEDUSA kernel with OMS CO2 data	proportion	proportion	MEDUSA-DA	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
26	CO2_AO2	Carbon dioxide (CO2) ppm	ppm	part per million dry air mole fraction	AO2-IR	NCAR Airborne Oxygen Instrument
27	wt.ao2	Proportion of MEDUSA kernel with AO2 CO2 data	proportion	proportion	MEDUSA-DA	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
28	UTC	Elapsed flight time, seconds, since 0000 UTC on day flight started	s	second	GV-TIME	GV time sychronized to GPS
29	O2_AO2	Oxygen (O2) per meg	per meg	per meg (see reference)	AO2-VUV	NCAR Airborne Oxygen Instrument
30	APO_AO2	Atmospheric potential oxygen (APO). See Data Dictionary's More Information worksheet.	per meg	per meg	AO2-M	NCAR Airborne Oxygen Instrument
31	ATX	Temperature of the ambient air outside the aircraft	deg C	degree Celsius	GV-AV	GV Avionics
32	GGALTm	Representative altitude above mean sea level of MEDUSA sample, datum WGS84	m asl	meter (above sea level)	MEDUSA-DA	Multiple Enclosure Device for Unfractionated Sampling of Air (MEDUSA)
33	PSXC	Reference static pressure: research static pressure corrected for airflow effects	hPa	hectopascal	GV-PS	GV Paroscientific Model 1000, using fuselage holes
34	THETA	Potential temperature	K	kelvin	GV-MULTIPLE	Multiple GV instruments
35	THETAE	Equivalent potential temperature	K	kelvin	GV-UCATS	GV and UCATS instruments
36	CO_QCLS	Carbon monoxide (CO)	ppbv	part per billion dry air mole fraction	QCLS-NDIR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)
37	CH4_QCLS	Methane (CH4)	ppbv	part per billion dry air mole fraction	QCLS-IR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)
38	N2O_QCLS	Nitrous oxide (N2O)	ppbv	part per billion dry air mole	QCLS-IR	Quantum Cascade Laser System (NCAR

Column	Column name	Expanded description	Unit	Unit long name	Instrument	Instrument code
				fraction		system built by Harvard/Aerodyne)
39	O3_ppb	Ozone (O3)	ppbv	part per billion dry air mole fraction	UV-PHOT-N	UV ozone photometer (NOAA)
40	H2Oppmv_vxl	Water (H2O) mole fraction	ppmv	part per million dry air mole fraction	GV-VCSEL	GV near-infrared vertical cavity surface emitting laser (VCSEL) hygrometer
41	AKRD	Aircraft attack angle	deg	degree	GV-GP	GV gust probe
42	MR	H2O mixing ratio	g/kg	gram per kilogram	GV-CMS	GV cooled-mirror sensor
43	QCXC	Dynamic pressure, corrected, reference	hPa	hectopascal	GV-CDPT	GV calibrated differential pressure transducer
44	TASX	Airspeed, true	m/s	meter per second	GV-MENSOR	GV Mensor 6100 sensor
45	SSRD	Aircraft sideslip angle	deg	degree	GV-GP	GV gust probe
46	DPXC	Dew point temperature of the ambient air outside the aircraft	deg C		GV-CMS	GV cooled-mirror sensor
47	PLWCC	Water (H2O), liquid content	g/m3	gram per cubic meter	GV-LWCS	GV PMS liquid water content sensor (King probe)
48	GGSPD	Ground speed	m/s	meter per second	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
49	GGTRK	Ground track (direction)	degree		GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
50	UIC	Wind vector, East component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
51	VIC	Wind vector, North component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
52	WIC	Vertical wind speed	m/s	meter per second	GV-MULTIPLE	Multiple GV instruments
53	PALT	Pressure altitude	m	meter	NACA	National Advisory Committee for Aeronautics method
54	PALTF	Pressure altitude	ft	foot	NACA	National Advisory Committee for Aeronautics method
55	PCAB_SP2	Cabin pressure	torr	torr	SP2-PRES	Single particle soot photometer
56	PITCH	Aircraft pitch attitude angle	degree	degree	GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial Reference System 1
57	RHUM	Relative humidity	%	percent	GV-SENSOR	GV aircraft sensor
58	RICE	Raw icing rate indicator	icing rate index	Icing rate index	GV-RICE	GV Rosemount Model 871FA icing rate detector
59	ROLL	Roll angle	degree	degree	GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial Reference System 1

Column	Column name	Expanded description	Unit	Unit long name	Instrument	Instrument code
60	TCAB	Cabin temperature at aerosol rack	deg C	degree Celsius	GV-SENSOR	GV aircraft sensor
61	THETAV	Virtual potential temperature	K	kelvin	GV-UCATS	GV and UCATS instruments
62	TTX	Total temperature (static and RAM), reference	m/s	meter per second	GV-SENSOR	GV aircraft sensor
63	UXC	Wind vector, longitudinal component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
64	XMACH2	Mach number squared	None	None	GV-SENSOR	GV aircraft sensor
65	CONC1DC_LWO	Cloud water droplet (40-600 um) concentration	number/L	number per liter	GV-1DOAP	One Dimensional Optical Array Probe
66	CONC2C_LWO	Cloud water droplet (25-800 um) concentration	number/L	number per liter	GV-2DOAP	Two Dimensional Optical Array Probe
67	DBAR1DC_LWO	Mean water droplet particle diameter?	um	micrometer	GV-2D-C	2D-C Probe
68	CONCD_LWI	Cloud water droplet (2-50 um) concentration	number/cm3	number per cubic centimeter	GV-CDP	Cloud droplet probe on GV
69	DBARD_LWI	Mean water droplet particle diameter?	um	micrometer	GV-CDP	Cloud droplet probe on GV
70	CONCU_RWI	Particle number density	number per cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
71	CONCU100_RWI	Concentration of particles 0.1 micrometer and larger	number/cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
72	CONCU500_RWI	Concentration of particles 0.5 micrometer and larger	number/cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
73	CO_RAF	Carbon monoxide (CO)	ppbv	part per billion dry air mole fraction	GV-AEROLASER	GV AeroLaser VUV CO sensor
74	BC_ng_kg	Black carbon (accumulation mode 100-600 nm assuming 1.8 g/cc density)	ng/kg	nanogram per kilogram of air	SP2	Single particle soot photometer
75	BC_ng_m3	Black carbon (accumulation mode 100-600 nm assuming 1.8 g/cc density)	ng/m3	nanogram per cubic meter of air	SP2	Single particle soot photometer
76	H2O_UWV	Water vapor (H2O)	ppmv	part per million dry air mole fraction	UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
77	H2Oe_UWV	Water vapor (H2O) 1 sigma error	ppmv	part per million dry air mole fraction	UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
78	O3_UO3	Ozone (O3)	ppbv	part per billion dry air mole fraction	UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)

Example Data Records

Note that the **data file is space delimited and uses “NA” as the missing value code**. NA is typically used in data products processed by “R”.

```
jd H.no Year DOY flt MEDpos MEDflID UT_MID GGLON GGLAT GGALT CO2_MED O2N2_MED ArN2_MED
13CO2_MED 18CO2_MED MED14c MEDUTCc MEDpres MEDFlow APO_MED CO2_QCLS wt.qcls CO2_OMS
wt.oms CO2_AO2 wt.ao2 UTC O2_AO2 APO_AO2 ATX GGALTm PSXC THETA THETAE CO_QCLS CH4_QCLS
N2O_QCLS O3_ppb H2Oppmv_vxl AKRD MR QCXC TASX SSRD DPXC PLWCC GGSPD GGTRK UIC VIC WIC
PALT PALTF PCAB_SP2 PITCH RHUM RICE ROLL TCAB THETAV TTX UXC XMACH2 CONC1DC_LWO
CONC2C_LWO DBAR1DC_LWO CONCD_LWI DBARD_LWI CONCU_RWI CONCU100_RWI CONCU500_RWI
CO_RAF BC_ng_kg BC_ng_m3 H2O_UWV H2Oe_UWV O3_UO3 CO2.ScrippsScale

9.93008101851852 1 2009 9 2 1 1017 80359 -111.9883 55.2881 7878 387.593587526272 -457.03 -10.08 NA NA
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0.740676497299973 387.014399581885 0.999999825180297 80358.5163198629 -447.115600105627 -
252.675993078796 -50.8372587624755 7878.31569552142 344.731511032639 301.378770189894
301.466192413556 97.8884261356783 1842.75474126326 322.781912465479 54.7196883541389
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11.1964817372774 0.389083763939329 27.2544719622098 5.87489218174976 1.95405209807423
6.2073320263873 1.30964206215405 296.976364842739 390.51

981.942569444444 5 2011 251 13 32 1303 81438 -145.9998 81.9933 13418 NA NA NA NA NA NA 81485 785.5
1902 NA 388.903065438717 0.0936895642171074 388.940693702545 0.999836246494519 388.987102708122
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6.99054083563807 0.284751067313867 19.3377704885065 6.66488727869925 1.48076531511174
2.51667313944778 1.12539566130525 525.732579205637 NA
```

Line breaks added to improve readability.

Supplementary Data File

Summary of 10-Second Data Completeness by Mission

A supplementary file is provided with this product that summarizes the completeness of the reported data values. The completeness entries are the number of non-missing observations for each species in the main data file for each mission and in total. . The number of observation given for species "jd" is the maximum number of possible non-missing observations per mission. The data are provided in one space-delimited format ASCII file.

Example Data Records

MEDUSA_meta_summary.tbl

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species total_nonmissing H1 H2 H3 H4 H5
jd 1689 271 350 333 384 351
H.no 1690 271 350 334 384 351
Year 1690 271 350 334 384 351
DOY 1690 271 350 334 384 351
flt 1690 271 350 334 384 351
MEDpos 1690 271 350 334 384 351
MEDflID 1690 271 350 334 384 351
…
BC_ng_m3 1477 260 330 281 286 320
H2O_UWV 1677 271 344 333 378 351
H2Oe_UWV 1677 271 344 333 378 351
O3_UO3 1316 271 316 0 378 351
CO2.ScrippsScale 1568 261 329 320 368 290
```

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Data Center Information:

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This data set is available through the Oak Ridge National Laboratory (ORNL) Carbon Dioxide Information Analysis Center (CDIAC).

Data Archive:

Web Site: http://hippo.ornl.gov/

Contact for Data Center Access Information:

E-mail: CDIAC
Telephone: +1 (865) 241-4846