Revision Date: November 30, 2012

HIPPO NOAA Flask Sample GHG, Halocarbon, and Hydrocarbon Data (R_20121129)

Summary:

This data set provides a NOAA flask sample oriented data product of meteorological, atmospheric chemistry, and aerosol measurements from all Missions, 1 through 5, of the HIAPER Pole-to-Pole Observations (HIPPO) study of carbon cycle and greenhouse gases. The Missions took place from January of 2009 to September 2011.

This data set provides atmospheric concentrations of CO_2, CH_4, CO, H_2, N_2O, halocarbon, hydrocarbon, and sulfur-containing trace gases from flask samples collected with the NOAA/ESRL Programmable Flask Package. Flask samples were analyzed on the NOAA/GMD Measurement of Atmospheric Gases that Influence Climate Change (MAGICC) instrument system and the NOAA/GMD GC/mass spectrometric instrument. Results from 1,374 flask samples are reported. The included data file is in ASCII space delimited format.

The main file was constructed so that its data would be directly comparable with data from the NOAA global cooperative air sampling network, NOAA/ESRL/GMD ESRL Carbon Cycle Greenhouse Gases (http://www.esrl.noaa.gov/gmd/ccgg/flask.html

For this data set, the flask sample results were joined with selected variables from concurrent 1-second data. The merging was accomplished by first subsetting and then averaging the 1-second observations corresponding to the fill time range for individual flask samples (e.g., UTSTART_M2 to UTSTOP_M2). This data file is better for instrument comparisons than files constructed by inserting flask values at a single “mean fill time observation” in a corresponding 1-second or 10-second 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.

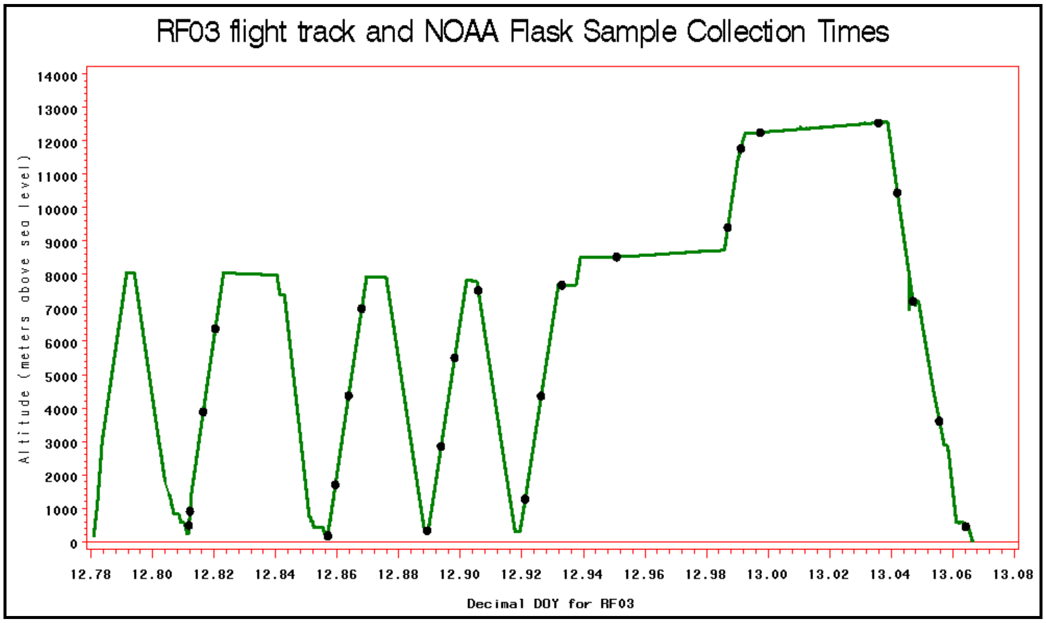

Figure 1. Example of flask sample collection times for Mission 1, research flight 3.

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 NOAA Flask Sample GHG, Halocarbon, and Hydrocarbon 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_013 (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/Release date	Date Published	Date Superseded	Change Description
NOAA Flask Data	HIPPO_noaa_flask_allparams_merge_insitu_20121129.tbl	20121129		First archived version.
NOAA Flask Data	PFP_meta_summary.tbl	20121129		First archived version.

User's Guide Contents:

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

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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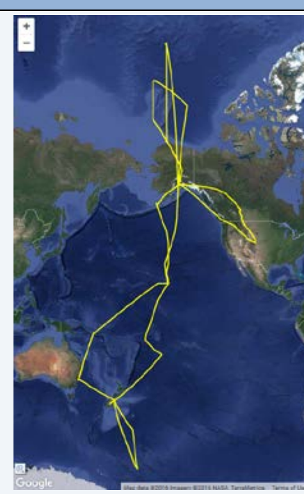
Temporal and Spatial (horizontal) Coverage of Research Flights

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.	

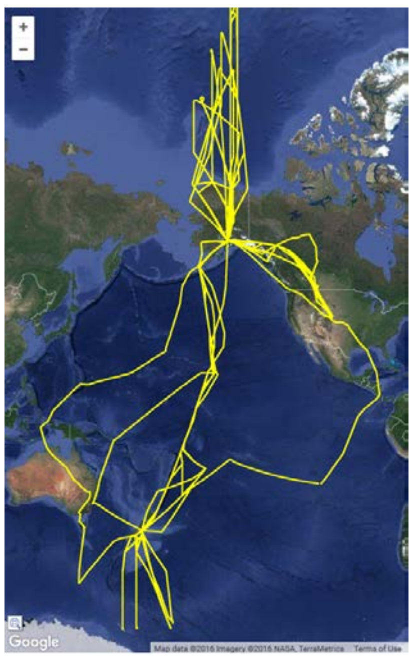
Mission	Flight Path Notes	Flight Path
HIPPO-2 **Sampling Dates** October 31 to November 22, 2009 **Vertical Profiles Flown** 148	Northern polar flight #1 reached 80º N. Both southbound and northbound Pacific flights followed a central flight path. Southern ocean flight reached 66º S, 174º W Northern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

Mission	Flight Path Notes	Flight Path
HIPPO-5	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.	
Sampling Dates		
August 9 to September 8, 2011		
Vertical Profiles Flown		
190		

<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.

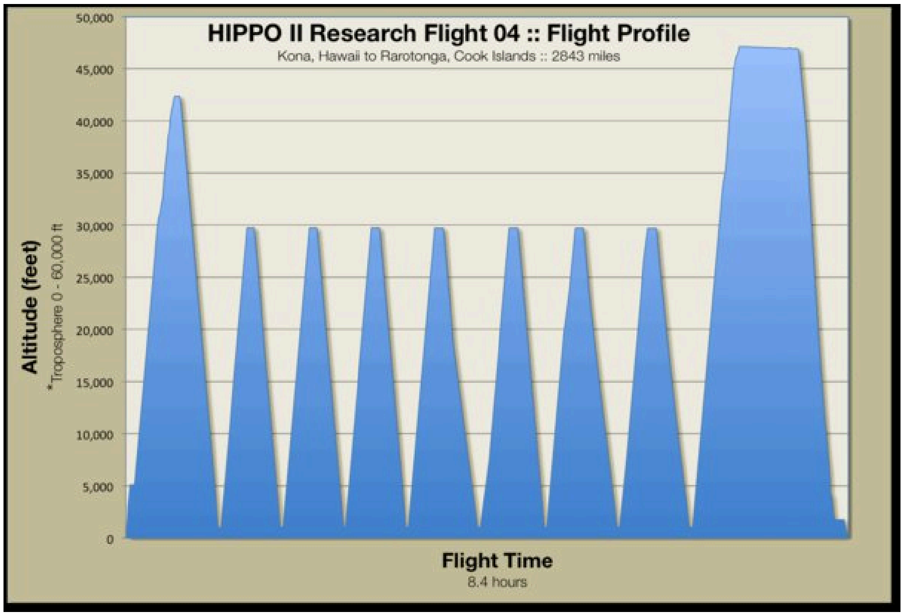


Figure 2. Example of NSF/NCAR G-V aircraft flight pattern. Eighteen profiles are shown in the image; the ascending and descending flight paths of each peak are a separate profile.

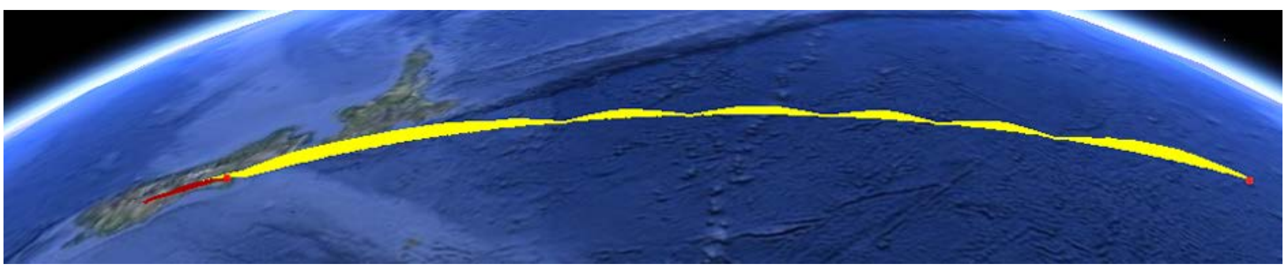


Figure 3. Example of NSF/NCAR G-V aircraft flight pattern. The x-axis in this figure is space and is a more realistic representation of the vertical aspect of a flight than in Figure 2.

Temporal and Spatial Resolution of Individual Measurements

The temporal resolution (fill time) of most individual flask measurements ranges from ~15 seconds at higher altitudes and to ~5 seconds lower altitudes. The pressurization of a flask is monitored by an internal absolute pressure sensor. The complete flush and fill cycle takes about 40 seconds.

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.

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.

This table provides an overview of sources of data in the NOAA flask data product.

Instrument code	Instrument / source 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-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
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

Instrument code	Instrument / source detail	Institution	Investigators	Method
NA	Not applicable	Harvard	Wofsy	Not applicable
NACA	National Advisory Committee for Aeronautics method	NCAR	Romashkin	National Advisory Committee for Aeronautics method
NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2	NOAA-GMD	Montzka, Miller	GC/MS (Gas chromatograph/mass spectrometer)
NWAS-M2-SC	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2	NOAA-GMD	Montzka, Miller	System clock
NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change	NOAA-GMD	Tans, Miller	GC/NDIR/Resonance Fluorescence/UV Absorption Spectroscopy
NWAS-MAGICC-SC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change	NOAA-GMD	Tans, Miller	System clock
NWAS-SIL	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry	NOAA-GMD	Vaughn, White	Mass spectrometry
NWAS-SIL-SC	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry	NOAA-GMD	Vaughn, White	System clock
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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A unique observation in the data file is defined by the Flight sequence number and the UTSTART_M2 time on the date the flight started. Data for all Flights are contained in one file.

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.

Missing fill start and fill stop times indicates that there are no results from that laboratory for that flask: UTSTART_CCG and UTSTOP_CCG, UTSTART_M2 and UTSTOP_M2, and UTSTART_SIL and UTSTOP_SIL.

The merge time, UTC, is the center time of merging interval. The time between flask sample filling intervals is not constant and varies per the sampling strategy for each research flight.

Note that the **data files are space delimited and use "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 code	Instrument / source detail
noo	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	flt	Flight sequence number within the mission	None	None	NA	Not applicable
5	DOY	Day of the year	d	day	NA	Not applicable
6	UTC	Elapsed flight time, seconds, since 0000 UTC on day flight started	s	second	GV-TIME	GV time sychronized to GPS
7	AKRD	Aircraft attack angle	deg	degree	GV-GP	GV gust probe
8	SSRD	Aircraft sideslip angle	deg	degree	GV-GP	GV gust probe
9	ATX	Temperature of the ambient air outside the aircraft	deg C	degree Celsius	GV-AV	GV Avionics
10	DPXC	Dew point temperature of the ambient air outside the aircraft	deg C		GV-CMS	GV cooled-mirror sensor
11	PLWCC	Water (H2O), liquid content	g/m3	gram per cubic meter	GV-LWCS	GV PMS liquid water content sensor (King probe)
12	GGALT	Geometric altitude above mean sea level, datum WGS84	m asl	meter (above sea level)	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
13	GGLAT	Latitude from GPS, datum WGS84	decimal degree	decimal degree	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
14	GGLON	Longitude from GPS, datum WGS84	decimal degree	decimal degree	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
15	GGSPD	Ground speed	m/s	meter per second	GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
16	GGTRK	Ground track (direction)	degree		GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)
17	UIC	Wind vector, East component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
18	VIC	Wind vector, North component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
19	WIC	Vertical wind speed	m/s	meter per second	GV-MULTIPLE	Multiple GV instruments
20	MR	H2O mixing ratio	g/kg	gram per kilogram	GV-CMS	GV cooled-mirror sensor
21	PALT	Pressure altitude	m	meter	NACA	National Advisory Committee for Aeronautics

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
						method
22	PALTF	Pressure altitude	ft	foot	NACA	National Advisory Committee for Aeronautics method
23	PCAB_SP2	Cabin pressure	torr	torr	SP2-PRES	Single particle soot photometer
24	PITCH	Aircraft pitch attitude angle	degree	degree	GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial Reference System 1
25	PSXC	Reference static pressure: research static pressure corrected for airflow effects	hPa	hectopascal	GV-PS	GV Paroscientific Model 1000, using fuselage holes
26	QCXC	Dynamic pressure, corrected, reference	hPa	hectopascal	GV-CDPT	GV calibrated differential pressure transducer
27	RHUM	Relative humidity	%	percent	GV-SENSOR	GV aircraft sensor
28	RICE	Raw icing rate indicator	icing rate index	Icing rate index	GV-RICE	GV Rosemount Model 871FA icing rate detector
29	ROLL	Roll angle	degree	degree	GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial Reference System 1
30	TASX	Airspeed, true	m/s	meter per second	GV-MENSOR	GV Mensor 6100 sensor
31	TCAB	Cabin temperature at aerosol rack	deg C	degree Celsius	GV-SENSOR	GV aircraft sensor
32	THETA	Potential temperature	K	kelvin	GV-MULTIPLE	Multiple GV instruments
33	THETAE	Equivalent potential temperature	K	kelvin	GV-UCATS	GV and UCATS instruments
34	THETAV	Virtual potential temperature	K	kelvin	GV-UCATS	GV and UCATS instruments
35	TTX	Total temperature (static and RAM), reference	m/s	meter per second	GV-SENSOR	GV aircraft sensor
36	UXC	Wind vector, longitudinal component, GPS-corrected	m/s	meter per second	GV-GUST	GV 5-hole radome gust probe
37	XMACH2	Mach number squared	None	None	GV-SENSOR	GV aircraft sensor
38	CONC1DC_LWO	Cloud water droplet (40-600 um) concentration	number/L	number per liter	GV-1DOAP	One Dimensional Optical Array Probe
39	CONC2C_LWO	Cloud water droplet (25-800 um) concentration	number/L	number per liter	GV-2DOAP	Two Dimensional Optical Array Probe
40	DBAR1DC_LWO	Mean water droplet particle diameter?	um	micrometer	GV-2D-C	2D-C Probe
41	CONCD_LWI	Cloud water droplet (2-50 um) concentration	number/cm3	number per cubic centimeter	GV-CDP	Cloud droplet probe on GV
42	DBARD_LWI	Mean water droplet particle diameter?	um	micrometer	GV-CDP	Cloud droplet probe on GV
43	CONCU_RWI	Particle number density	number per cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
44	CONCU100_RWI	Concentration of particles 0.1 micrometer and larger	number/cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
45	CONCU500_RWI	Concentration of particles 0.5 micrometer and larger	number/cm3	number per cubic centimeter	UHSAS	Ultra-high sensitivity aerosol spectrometer
46	CO2_AO2	Carbon dioxide (CO2) ppm	ppm	part per million dry air mole fraction	AO2-IR	NCAR Airborne Oxygen Instrument
47	O2_AO2	Oxygen (O2) per meg	per meg	per meg (see	AO2-VUV	NCAR Airborne Oxygen Instrument

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
				reference)		
48	APO_AO2	Atmospheric potential oxygen (APO). See Data Dictionary's More Information worksheet.	per meg	per meg	AO2-M	NCAR Airborne Oxygen Instrument
49	CH4_QCLS	Methane (CH4)	ppbv	part per billion dry air mole fraction	QCLS-IR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)
50	N2O_QCLS	Nitrous oxide (N2O)	ppbv	part per billion dry air mole fraction	QCLS-IR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)
51	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)
52	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"
53	CO2_QCLS	Carbon dioxide (CO2)	ppmv	part per million dry air mole fraction	QCLS-NDIR	Quantum Cascade Laser System (NCAR system built by Harvard/Aerodyne)
54	CO_RAF	Carbon monoxide (CO)	ppbv	part per billion dry air mole fraction	GV-AEROLASER	GV AeroLaser VUV CO sensor
55	O3_ppb	Ozone (O3)	ppbv	part per billion dry air mole fraction	UV-PHOT-N	UV ozone photometer (NOAA)
56	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
57	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
58	H2O_UWV	Water vapor (H2O)	ppmv	part per million dry air mole fraction	UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
59	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
60	O3_UO3	Ozone (O3)	ppbv	part per billion dry air mole fraction	UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)
61	O3e_UO3	Ozone (O3) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)
62	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
63	n.prof	Profile number, u. sequential within mission	None	None	NA	Not applicable

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
64	Dist	Cumulative distance from takeoff	km	kilometer	NA	Not applicable
65	UTMID_CCG	CCG (MAGICC) sample midpoint time, seconds, since 0000 UTC on day flight started	s	second	NWAS-MAGICC-SC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
66	UTSTART_CCG	CCG (MAGICC) sample start time, seconds, since 0000 UTC on day flight started	s	second	NWAS-MAGICC-SC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
67	UTSTOP_CCG	CCG (MAGICC) sample closure time, seconds, since 0000 UTC on day flight started	s	second	NWAS-MAGICC-SC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
68	CO2_CCG	Carbon dioxide (CO2)	ppm	part per million dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
69	CH4_CCG	Methane (CH4)	ppb	part per billion dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
70	CO_CCG	Carbon monoxide (CO)	ppb	part per billion dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
71	H2_CCG	Hydrogen (H2)	ppb	part per billion dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
72	N2O_CCG	Nitrous oxide (N2O)	ppb	part per billion dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
73	SF6_CCG	Sulfur hexafluoride (SF6)	ppt	part per trillion dry air mole fraction	NWAS-MAGICC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change
74	UTMID_SIL	SIL sample midpoint time, seconds, since 0000 UTC on day flight started	s	second	NWAS-SIL-SC	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
75	UTSTART_SIL	SIL sample start time, seconds, since 0000 UTC on day flight started	s	second	NWAS-SIL-SC	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
76	UTSTOP_SIL	SIL sample closure time, seconds, since 0000 UTC on day flight started	s	second	NWAS-SIL-SC	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
77	CO2isoC13_SIL	delta 13C in CO2. See Data Dictionary's More Information worksheet.	per mil	per mil	NWAS-SIL	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
78	CO2isoO18_SIL	delta 18O in CO2. See Data Dictionary's More Information worksheet.	per mil	per mil	NWAS-SIL	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
79	CH4isoC13_SIL	delta 13C in methane (CH4). See Data Dictionary's More Information worksheet.	per mil	per mil	NWAS-SIL	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry
80	UTMID_M2	M2 approximate true flow-weighted average time of the sample, seconds, since 0000 UTC on day flight started	s	second	NWAS-M2-SC	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
81	UTSTART_M2	M2 sample start time, seconds, since 0000 UTC on day flight started	s	second	NWAS-M2-SC	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
82	UTSTOP_M2	M2 sample closure time, seconds, since 0000 UTC on day flight started	s	second	NWAS-M2-SC	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
83	C2Cl4_M2	Tetrachloroethylene (C2Cl4)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
84	Ethyne_M2	Ethyne (C2H2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
85	Propane_M2	Propane (C3H8)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
86	Benzene_M2	Benzene (C6H6)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
87	CCl4_M2	Carbon tetrachloride (CCl4)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
88	CFC_113_M2	CFC-113 (CCl2FCClF2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
89	CFC_115_M2	CFC-115 (CF2ClCF3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
90	CFC_11_M2	CFC-11 (CCl3F)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
91	CFC_12_M2	CFC-12 (CCl2F2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
92	CFC_13_M2	CFC-13 (CClF3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
93	CH2Br2_M2	Methylene bromide(CH2Br2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
94	CH2Cl2_M2	Methylene chloride (CH2Cl2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
95	CH3Br_M2	Methyl bromide(CH3Br)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
96	CH3Cl_M2	Methyl chloride (CH3Cl)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
97	CH3I_M2	Methyl iodide (CH3I)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
98	CHBr3_M2	Bromoform (CHBr3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
99	CHCl3_M2	Chloroform (CHCl3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
100	CS2_M2	Carbon disulphide (CS2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
101	Halon_1211_M2	CFC-12b1 (Halon 1211,CF2ClBr)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
102	Halon_1301_M2	CFC-13b1 (Halon 1301, CF3Br)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
103	Halon_2402_M2	CFC-114b2 (Halon 2402, C2F4Br2)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
104	HCFC_142b_M2	HCFC-142b (CH3CF2Cl)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
105	HCFC_22_M2	HCFC-22 (CHF2Cl)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
106	HFC_125_M2	HFC-125 (C2HF5)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
107	HFC_134a_M2	HFC-134a (C2H2F4)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
108	HFC_143a_M2	HFC-143a (C2H3F3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
109	HFC_152a_M2	HFC-152a (C2H4F2) (1,1-difluoroethane)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
110	HFC_23_M2	HFC-23 (CHF3)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
111	Isopentane_M2	Isopentane (C5H12)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
112	n_butane_M2	n-Butane (C4H10)	ppt	part per trillion dry air mole fraction	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2
113	n_pentane_M2	n-Pentane (C5H12)	ppt	part per trillion dry air mole	NWAS-M2	NOAA Whole Air Sampler - Montzka Mass Spectrometer #2

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
				fraction		

Example Data Records

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

```
jd H.no Year flt DOY UTC AKRD SSRD ATX DPXC PLWCC GGALT GGLAT GGLON GGSPD GGTRK UIC VIC WIC MR PALT
PALTF PCAB_SP2 PITCH PSXC QCXC RHUM RICE ROLL TASX TCAB THETA THETAE THETAV TTX UXC XMACH2
CONC1DC_LWO CONC2C_LWO DBAR1DC_LWO CONCD_LWI DBARD_LWI CONCU_RWI CONCU100_RWI
CONCU500_RWI CO2_AO2 O2_AO2 APO_AO2 CH4_QCLS N2O_QCLS CO_QCLS CO2_OMS CO2_QCLS CO_RAF O3_ppb
BC_ng_kg BC_ng_m3 H2O_UWV H2Oe_UWV O3_UO3 O3e_UO3 H2Oppmv_vxl n.prof Dist UTMID_CCG UTSTART_CCG
UTSTOP_CCG CO2_CCG CH4_CCG CO_CCG H2_CCG N2O_CCG SF6_CCG UTMID_SIL UTSTART_SIL UTSTOP_SIL
CO2isoC13_SIL CO2isoO18_SIL CH4isoC13_SIL UTMID_M2 UTSTART_M2 UTSTOP_M2 C2Cl4_M2 Ethyne_M2 Propane_M2
Benzene_M2 CCl4_M2 CFC_113_M2 CFC_115_M2 CFC_11_M2 CFC_12_M2 CFC_13_M2 CH2Br2_M2 CH2Cl2_M2
CH3Br_M2 CH3Cl_M2 CH3I_M2 CHBr3_M2 CHCl3_M2 CS2_M2 Halon_1211_M2 Halon_1301_M2 Halon_2402_M2
HCFC_142b_M2 HCFC_22_M2 HFC_125_M2 HFC_134a_M2 HFC_143a_M2 HFC_152a_M2 HFC_23_M2 Isopentane_M2
n_butane_M2 n_pentane_M2 OCS_M2

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37.204 7.311 495.683 0.09 0.241 9.357 NA 4.02 3.299 0.41 22.368 225.941 11.427 69.255 12.136 9.162 25.533 2.855 15.775
3.512 441.121
Line breaks inserted 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

PFP_meta_summary.tbl

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species total_nonmissing H1 H2 H3 H4 H5
jd 1374 228 209 326 272 339
H.no 1374 228 209 326 272 339
Year 1374 228 209 326 272 339
flt 1374 228 209 326 272 339
DOY 1374 228 209 326 272 339
UTC 1374 228 209 326 272 339
AKRD 1361 225 209 322 272 333
…
HFC_23_M2 1099 0 205 314 243 337
Isopentane_M2 1354 228 205 314 270 337
n_butane_M2 1354 228 205 314 270 337
n_pentane_M2 1354 228 205 314 270 337
OCS_M2 1291 228 205 314 243 301
```

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Tollefson, J. 2010. Jet reveals atmosphere's secrets. Published online 17 August 2010, Nature 466, 912. doi:10.1038/466912a

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 Merged 1-second Meteorology, Atmospheric Chemistry, Aerosol Data Collection (R_20121129). EOL Xxxxxx. DOIxxxxx.**

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