Revision Date: November 30, 2012

HIPPO Merged 10-second Meteorology, Atmospheric Chemistry, and Aerosol Data (R_20121129)

Summary:

This data set provides the merged 10-second 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. All of the data are provide in one space-delimited format ASCII file.

HIPPO measured atmospheric constituents along transects from approximately pole-to-pole over the Pacific Ocean and flew hundreds of vertical profiles from the ocean/ice surface to as high as the tropopause, at five times during different seasons over the three year period. HIPPO provides the first high-resolution vertically-resolved global survey of a comprehensive suite of atmospheric trace gases and aerosols pertinent to understanding the carbon cycle and challenging global climate models.

This 10 second merge product contains all data that can reasonably be compared at 10 second resolution. This product should support most visualization efforts and exploratory investigation. Included are results from 90+ (check??) species merged with navigation and atmospheric structure data. Some species were measured using many different instruments (e.g., CO_2: 3 in situ and two flask measurements). Measurements fall into these general classes:

1) greenhouse gases and carbon cycle gases,
2) ozone and water vapor,
3) black carbon and aerosols,
4) CFCs, HCFCs, and HFCs,
5) light hydrocarbons and PAN, and
6) sulfur gases and ocean-derived gases

The 10-second merged data product was derived by combining the NSF/NCAR GV aircraft navigation and atmospheric structure parameters for position, time, temperature, pressure, wind speed, etc., reported at 1-second frequency, with meteorological, atmospheric chemistry and aerosol measurements made by several teams of investigators on a common time and position basis.

Investigators reported most continuously measured parameters at a 1-second interval. The 1 second measurements were aggregated with a median filter to 10 seconds. The fast-sample GC and whole air sample measurements reported at the greater than 10 second intervals (15-120 seconds including processing time) were aggregated to the most representative 10 second sample interval.

The 10-second merged data are highly time resolved due to the underlying 1-second in situ measurement frequency and vertically-resolved as well because of GV flight plans that performed 787 vertical ascents/descents from the ocean/ice 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, as permitted by air controllers. In between, several vertical profiles from below the PBL to the mid-troposphere (1,000 -28,0000 feet) were flown. Profiles were flown approximately every 2.2º of latitude with 4.4º between consecutive near-surface or high-altitude samples.

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 Merged 10-second Meteorology, Atmospheric Chemistry, Aerosol 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_010 (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**]”**

Version Control:

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Data files with version control information:

Data Product	File Name w/_release date	Date Published	Date Superseded	Change Description
10-second merged data	HIPPO_all_missions_merge_10s_20121129.tbl	20121129		First archived version
	HIPPO_10s_meta_summary.tbl	20121129		First archived version

User's Guide Contents:

HIPPO Project

The HIAPER Pole-to-Pole Observations (HIPPO) study investigated 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 was to determine the global distribution of carbon dioxide and other trace atmospheric gases by sampling at various altitudes and latitudes in the Pacific Basin. These data are pertinent to understanding the carbon cycle and are useful for challenging global climate models.

Figure 1. NSF/NCAR G-V aircraft at various locations during Missions 1 through 5.

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

<table>
<tr><th>Mission</th><th>Flight Path Notes</th><th>Flight Path</th></tr>
<tr><td>HIPPO-1</td><td rowspan="6">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.</td><td rowspan="6">
</td></tr>
<tr><td>Sampling Dates</td></tr>
<tr><td>January 8 to January 30, 2009</td></tr>
<tr><td>Vertical Profiles Flown</td></tr>
<tr><td>138</td></tr>
</table>

<table>
<tr><th>Mission</th><th>Flight Path Notes</th><th>Flight Path</th></tr>
<tr><td>HIPPO-2</td><td rowspan="5">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.</td><td rowspan="5">
</td></tr>
<tr><td>Sampling Dates</td></tr>
<tr><td>October 31 to November 22, 2009</td></tr>
<tr><td>Vertical Profiles Flown</td></tr>
<tr><td>148</td></tr>
</table>

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>

Bounding Box for All Research Flights:

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.

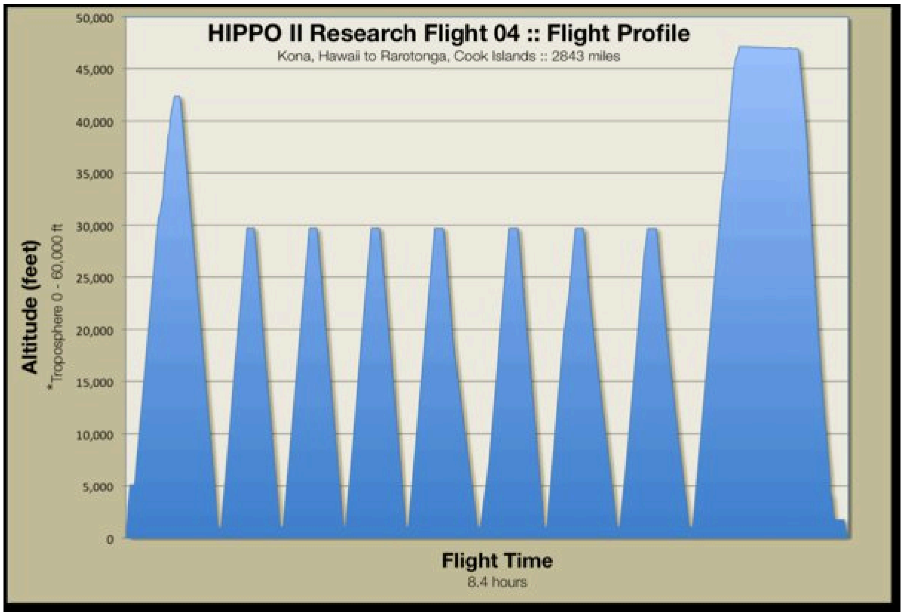

Figure 2. Example of NSF/NCAR G-V aircraft flight pattern. Eighteen profiles are shown in the image; the ascending and descending flight paths of each peak are a separate profile.

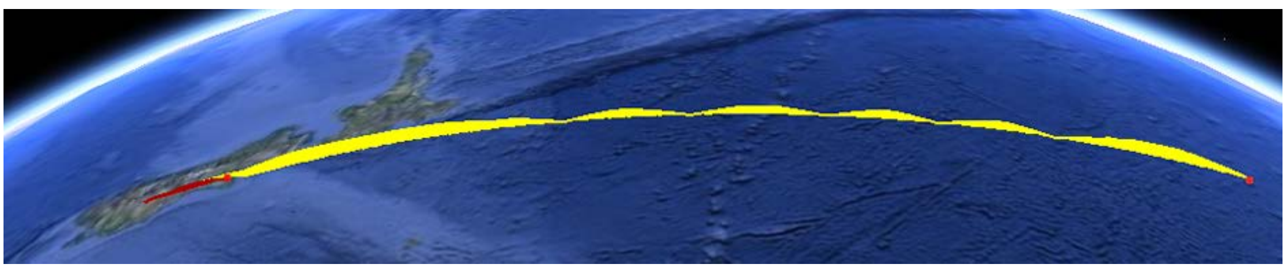

Figure 3. Example of NSF/NCAR G-V aircraft flight pattern. The x-axis in this figure is space and is a more realistic representation of the vertical aspect of a flight than in Figure 2.

Temporal Resolution of Merged Observations

The temporal resolution of merged observations is 10 seconds.

The 10-second merged data product was derived by combining the NSF/NCAR GV aircraft navigation and atmospheric structure parameters for position, time, temperature, pressure, wind speed, etc., reported at 1-second frequency, with meteorological, atmospheric chemistry and aerosol measurements made by several teams of investigators on a common time basis.

Investigators reported most continuously measured parameters at a 1-second interval. The 1 second measurements were aggregated with a median filter to 10 seconds. The fast-sample GC and whole air sample measurements, collected consistent with a ~10 second sampling time but reported at the greater than 10 second intervals (15-120 seconds including processing time), were aggregated to the most representative 10 second sample interval.

Included with each 10 second observation are several NSF/NCAR G-V aircraft altitude, latitude, and longitude measures and additional scalar and vector measures of horizontal and vertical velocity. Select the most appropriate position and velocity measures for your data use.

Some chemical measurements collected over a short time and therefore included here are reported at longer intervals; values for these columns are missing (NA) in most data rows.

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

This table shows the number of 10-second observations for each Mission and the percentage distribution of the total HIPPO observation among the five missions.

	HIPPO Mission					
	H1	H2	H3	H4	H5	Total
Number of Observations	25,974	31,585	29,429	33,887	35,676	156,551
% of Observations	17	20	19	22	23	100

The number of observations for a Mission is the total count by HIPPO mission number (H.no) and by the Flight sequence number (flt) within the mission, of the Elapsed flight time (UTC) entries on the date the specific flight started. This total count characterizes the GV navigation data and to many GV atmospheric temperature, pressure and meteorological measurements. Note that “jd” is the decimal day for an observation and is continuous across all missions and flights, and also reflects the total number of possible observations.

The number of non-missing observations for each species in the main data file, for each mission and in total, is provided in the supplemental file described below.

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.

This table provides an overview of sources of data in the 10-second Merged product (Release 20121129).

Instrument code	Instrument / source detail	Institution	Investigators	Method
NA	Not applicable	Harvard	Wofsy	Not applicable
GV-TIME	GV time sychronized to GPS	NCAR	Romashkin	To be determined
GV-GP	GV gust probe	NCAR	Romashkin	Radome differential pressure
GV-AV	GV Avionics	NCAR	Romashkin	Thermal sensor?
GV-CMS	GV cooled-mirror sensor	NCAR	Romashkin	Condensation?
GV-LWCS	GV PMS liquid water content sensor (King probe)	NCAR	Romashkin	Heat loss from water vaporization
GV-NOGPS	GV Novatel Omnistar-enabled GPS (Reference)	NCAR	Romashkin	GPS (Global Positioning System)
GV-GUST	GV 5-hole radome gust probe	NCAR	Romashkin	Differential pressure?
GV-MULTIPLE	Multiple GV instruments	NCAR	Romashkin	Various
NACA	National Advisory Committee for Aeronautics method	NCAR	Romashkin	National Advisory Committee for Aeronautics method
SP2-PRES	Single particle soot photometer	NOAA-CSD	Fahey, Gao, Spackman, Schwarz, Perring	Pressure sensor
GV-HIRS	GV Honeywell YG1854 Laseref SM Inertial	NCAR	Romashkin	IRS (Inertial Reference System) and GPS (Global Positioning System)

Instrument code	Instrument / source detail	Institution	Investigators	Method
	Reference System 1			
GV-PS	GV Paroscientific Model 1000, using fuselage holes	NCAR	Romashkin	Pressure transducer
GV-CDPT	GV calibrated differential pressure transducer	NCAR	Romashkin	Pressure sensors
GV-SENSOR	GV aircraft sensor	NCAR	Romashkin	To be determined
GV-RICE	GV Rosemount Model 871FA icing rate detector	NCAR	Romashkin	To be determined
GV-MENSOR	GV Mensor 6100 sensor	NCAR	Romashkin	Pressure sensor
GV-UCATS	GV and UCATS instruments	NCAR	Romashkin	Various
GV-1DOAP	One Dimensional Optical Array Probe	NCAR	Romashkin	Laser beam, diode array
GV-2DOAP	Two Dimensional Optical Array Probe	NCAR	Romashkin	Laser beam, diode array
GV-2D-C	2D-C Probe	NCAR	Romashkin	Laser beam, diode array
GV-CDP	Cloud droplet probe on GV	NCAR	Romashkin	Diode laser - forward scattered light
UHSAS	Ultra-high sensitivity aerosol spectrometer	NCAR	Cooper	Aerosol spectrometer
AO2-IR	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Vacuum-ultraviolet absorption and Infrared absorption
AO2-VUV	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Vacuum-ultraviolet absorption
AO2-M	NCAR Airborne Oxygen Instrument	NCAR	Stephens, Bent	Multiple
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
OMS	Harvard Licor 6251 NDIR CO2 sensor, heritage NASA "Observations of the Middle Stratosphere"	Harvard	Daube, Pittman, Kort, Jimenez	Non-dispersed infrared absorption
GV-AEROLASER	GV AeroLaser VUV CO sensor	NCAR	Campos	VUV fluorescence
UV-PHOT-N	UV ozone photometer (NOAA)	NOAA-CSD	Fahey, Gao, Spackman	Ultraviolet absorption
SP2	Single particle soot photometer	NOAA-CSD	Fahey, Gao, Spackman, Schwarz, Perring	LII (Laser-induced incandescence)
UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species	NOAA-GMD	Hurst, Hintsa	GC/ECD (Gas chromatograph/ electron capture detector)
UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for	NOAA-GMD	Hurst, Hintsa	Tunable diode laser

Instrument code	Instrument / source detail	Institution	Investigators	Method
	Atmospheric Trace Species			
UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)	NOAA-GMD	Hurst, Hintsa	Photometer
GV-VCSEL	GV near-infrared vertical cavity surface emitting laser (VCSEL) hygrometer	Princeton	Zondlo	Laser hygrometer
PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment	NOAA-GMD	Moore, Elkins	GC/ECD (Gas chromatograph/ electron capture detector)
NWAS-MAGICC-SC	NOAA Whole Air Sampler - Measurement of Atmospheric Gases that Influence Climate Change	NOAA-GMD	Tans, 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-SIL	NOAA Whole Air Sampler - INSTAAR Stable Isotope Lab Mass spectrometry	NOAA-GMD	Vaughn, White	Mass spectrometry
Various-Integ	Data integration	Harvard	Wofsy	Data integration
AO2-QCLS-OMS	Various	Multiple	Various	Various

Data Dictionary:

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A unique observation in the 10-second merged data file is defined by the HIPPO mission number (H.no), the Flight sequence number (flt) within the mission, and the Elapsed flight time (UTC) on the date the specific flight started. Note that “jd” is the decimal day for observation and is continuous across all missions and flights.

Data for all Flights are contained in one merged 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.

Note that the 10-second merged **data file is space delimited and uses “NA” as the missing value code**. NA is typically used in data products processed by “R”.

More information about some calculated variable is provided in the full Data Dictionary and in the "More Information" worksheet.

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source 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 method

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

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
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 reference)	AO2-VUV	NCAR Airborne Oxygen Instrument
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

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
58	N2O_UGC	Nitrous oxide (N2O)	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
59	N2Oe_UGC	Nitrous oxide (N2O) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
60	SF6_UGC	Sulfur hexafluoride (SF6)	pptv	part per trillion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
61	SF6e_UGC	Sulfur hexafluoride (SF6) 1 sigma error	pptv	part per trillion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
62	CH4_UGC	Methane (CH4)	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
63	CH4e_UGC	Methane (CH4) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
64	H2_UGC	Hydrogen (H2)	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
65	H2e_UGC	Hydrogen (H2) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
66	CO_UGC	Carbon monoxide (CO)	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
67	COe_UGC	Carbon monoxide (CO) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-UGC	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
68	H2O_UWV	Water vapor (H2O)	ppmv	part per million dry air mole fraction	UCATS-UWV	Unmanned Aircraft Systems (UAS) Chromatograph for Atmospheric Trace Species
69	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
70	O3_UO3	Ozone (O3)	ppbv	part per billion dry air mole fraction	UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)
71	O3e_UO3	Ozone (O3) 1 sigma error	ppbv	part per billion dry air mole fraction	UCATS-PHOT	2B (modified) UV ozone photometer (UCATS)

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
72	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
73	N2O_P	Nitrous oxide (N2O)	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
74	N2Oe_P	Nitrous oxide (N2O) 1 sigma error	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
75	SF6_P	Sulfur hexafluoride (SF6)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
76	SF6e_P	Sulfur hexafluoride (SF6) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
77	CFC_11_P	CFC-11 (CCl3F)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
78	CFC_11e_P	CFC-11 (CCl3F) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
79	CFC_12_P	CFC-12 (CCl2F2)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
80	CFC_12e_P	CFC-12 (CCl2F2) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
81	CFC_113_P	CFC-113 (CCl2FCClF2)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
82	CFC_113e_P	CFC-113 (CCl2FCClF2) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
83	Halon_1211_P	CFC-12b1 (Halon 1211, CF2ClBr)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
84	Halon_1211e_P	CFC-12b1 (Halon 1211, CF2ClBr) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
85	H2_P	Hydrogen (H2)	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
86	H2e_P	Hydrogen (H2) 1 sigma error	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
87	CH4_P	Methane (CH4)	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
88	CH4e_P	Methane (CH4) 1 sigma error	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
89	CO_P	Carbon monoxide (CO)	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
90	COe_P	Carbon monoxide (CO) 1 sigma error	ppbv	part per billion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
91	PAN_P	Peroxyactyl nitrate (C2H3NO5)	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
92	PANe_P	Peroxyactyl nitrate (C2H3NO5) 1 sigma error	pptv	part per trillion dry air mole fraction	PANTHER-ECD	PAN and other Trace Hydrohalocarbon ExpeRiment
93	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
94	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
95	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
96	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
97	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
98	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

Column	Column name	Expanded description	Unit	Unit long name	Instrument code	Instrument / source detail
99	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
100	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
101	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
102	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
103	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
104	n.prof	Profile number, u. sequential within mission	None	None	NA	Not applicable
105	Dist	Cumulative distance from takeoff	km	kilometer	NA	Not applicable
106	P.H2O.DP	Water (H2O) vapor pressure	?hPa	?hectopascal	NA	Not applicable
107	CO2.X	Carbon dioxide (CO2) based on best available data	ppmv	part per million dry air mole fraction	Various-Integ	Data integration
108	APO.X	Apparent potential oxygen (APO) based on best available data. See Data Dictionary's More Information worksheet.	per meg	per meg	AO2-QCLS-OMS	Various
109	CO.X	Carbon monoxide (CO) based on best available data	ppbv	part per billion dry air mole fraction	Various-Integ	Data integration

Example Data Records

Note that the 10-second merged **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 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 N2O_UGC N2Oe_UGC SF6_UGC SF6e_UGC CH4_UGC CH4e_UGC H2_UGC H2e_UGC CO_UGC
COe_UGC H2O_UWV H2Oe_UWV O3_UO3 O3e_UO3 H2Oppmv_vxl N2O_P N2Oe_P SF6_P SF6e_P CFC_11_P CFC_11e_P
CFC_12_P CFC_12e_P CFC_113_P CFC_113e_P Halon_1211_P Halon_1211e_P H2_P H2e_P CH4_P CH4e_P CO_P COe_P
PAN_P PANe_P UTSTART_CCG UTSTOP_CCG CO2_CCG CH4_CCG CO_CCG H2_CCG N2O_CCG SF6_CCG
CO2isoC13_SIL CO2isoO18_SIL CH4isoC13_SIL n.prof Dist P.H2O.DP CO2.X APO.X CO.X

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0 0 0 6.313325 1587.694336 5208.970703 NA -1.297072 836.500366 0.258033 29.611698 0.340824 -0.199405 7.24507
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NA NA NA NA NA NA NA NA NA NA NA NA NA NA NA 0 64437.3465080447 8.39280823485323 NA NA NA
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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

```
species total_nonmissing H1 H2 H3 H4 H5
jd 156551 25974 31585 29429 33887 35676
H.no 156551 25974 31585 29429 33887 35676
Year 156551 25974 31585 29429 33887 35676
flt 156551 25974 31585 29429 33887 35676
DOY 156551 25974 31585 29429 33887 35676
UTC 156551 25974 31585 29429 33887 35676
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…
Dist 156551 25974 31585 29429 33887 35676
P.H2O.DP 135081 18082 23285 24711 33637 35366
CO2.X 130016 15339 25404 24543 32334 32396
APO.X 102514 12693 21016 19249 26243 23313
CO.X 132178 24603 25741 23813 27261 30760
```

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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