

Overview of All 5 HIPPO Missions November 19, 2012

More Detailed Research Flight Descriptions follow these Mission overview tables.

Mission	Flight Path Notes	Features of Interest
HIPPO-1	Northern polar flight #1 reached 80° N.	<p>CO₂: High CO₂ at low altitude and high latitude, reaching 2 km at 75° N, reflecting respiration and industrial emissions from late autumn / early winter. Small decreases in CO₂ at low altitude over the Southern Ocean.</p> <p>O₂ and APO: Hemispheric-scale plume of high O₂ and APO emanating from the Southern Ocean during austral summer, starting near the surface at 20° S and growing to 10 km at 67° S. In the Northern Hemisphere, low O₂ and APO concentrated between 40° and 60° N.</p> <p>Black Carbon: Southbound results characterize background BC mass concentrations over the central Pacific. Northbound results showed enhanced BC loadings in the lower troposphere over Central and Southern North America.</p>
Sampling Dates	Southbound Pacific flights followed the typical central flight path.	
January 8 to January 30, 2009	Southern ocean flight reached 67° S, 175° W	
Vertical Profiles Flown	The northbound flights followed an Eastern Pacific Route over Central and Southern North America.	
138	HIPPO-1 was only mission to not return to the Arctic a second time.	

Mission	Flight Path Notes	Features of Interest
<i>HIPPO-2</i>	Northern polar flight #1 reached 80° N.	<p>CO₂: Several plumes of high CO₂ (and aerosols) at high altitude over the arctic, 2 – 6 km at 80° N reflecting Asian emission sources. Low CO₂ on approach / departure from New Zealand but otherwise fairly homogenous CO₂ from 60° N to 67° S at this time of seasonal transition.</p> <p>O₂ and APO: Mainly homogeneous O₂ throughout N-S slice but with plumes of low O₂ at high altitude over Arctic matching CO₂ and aerosols. Several plumes of low APO over the Southern Ocean.</p> <p>Black Carbon: During RF02, at 80° N there were stratified aerosol plumes in the middle and upper troposphere likely pollution from Asia--the atmosphere was full of dark material, with high concentrations of CO. Diluted long-range biomass burning plumes were encountered in the southern hemisphere.</p> <p>Results for two pre-mission training/research flights are also included.</p>
Sampling Dates	Both southbound and northbound Pacific flights followed a central flight path.	
October 31 to November 22, 2009	Southern ocean flight reached 66° S, 174° W	
Vertical Profiles Flown	Northern polar flight #2 reached 83° N.	
148		

Mission	Flight Path Notes	Features of Interest
<i>HIPPO-3</i>	Northern polar flight #1 reached 84.75° N.	<p>CO₂: High CO₂ permeated the entire Northern Hemisphere troposphere from the surface to 8 km near the end of the winter build-up. Between 50° N and 10° N much stronger horizontal than vertical gradients. Low CO₂ throughout the Southern Hemisphere extratropics for the greatest N-S CO₂ difference observed.</p> <p>O₂ and APO: The remains of the high O₂ and APO over the Southern Hemisphere during late austral summer. Low O₂ throughout Northern Hemisphere matching CO₂ buildup from terrestrial and industrial processes, but also showing low in APO indicating additional ocean contribution to O₂ signals.</p> <p>Black Carbon: BC from Asian sources was extremely high and well stratified in the Arctic. During RF03, from Alaska to Hawaii, the highest BC mass loadings in the free troposphere during HIPPO were observed in biomass burning plumes from SE Asia between the ITCZ and ~40° N. BC mass varied by as much as 4 orders of magnitude between northern and southern hemispheres.</p> <p>Results for 2 pre-mission training/research flights are also included.</p>
Sampling Dates	Both southbound and northbound Pacific flights followed a central flight path.	
March 24 to April 16, 2010	<ul style="list-style-type: none"> Southbound RF04 reached 41,000 feet over the equator allowing insight into the atmospheric cross section near the Intertropical Convergence Zone (ITCZ). 	
Vertical Profiles Flown	<ul style="list-style-type: none"> 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). 	
136	<p>Southern ocean flight reached 66.8° S, 170° E.</p> <p>Northern polar flight #2 reached 85° N.</p> <ul style="list-style-type: none"> Polar flight RF10 flew three 500 feet altitude by 5 minute legs crossing extensive networks of fractures in ice 	

Mission	Flight Path Notes	Features of Interest
<i>HIPPO-4</i>	Northern polar flight #1 reached 84° N.	
Sampling Dates	Southbound Pacific flights followed the typical central flight path.	
June 14 to July 11, 2011	<ul style="list-style-type: none"> 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. 	
Vertical Profiles Flown	Southern ocean flight reached 58° S, 145° E.	
175	<p>The northbound flights followed a Western Pacific route but the earthquake and tsunami in Japan necessitated a less westerly return than was planned.</p> <p>Northern polar flight #2 reached 82° N.</p> <ul style="list-style-type: none"> 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. 	<p>CO₂: Rapid seasonal changes observed between southbound and northbound legs. Southbound still had remains of high CO₂ in Northern Hemisphere but Northbound showed regions of strongly lower CO₂ north of 50° N, especially at high altitude over the Arctic. Low CO₂ at low altitude over the Southern Ocean.</p> <p>O₂ and APO: Increasing O₂ in Northern Hemisphere between southern and northern legs in N matching CO₂. Mostly homogeneous APO, but with low APO near surface over Southern Ocean and signs of strong O₂ production from algae blooms over the North Pacific and Arctic Oceans.</p> <p>Black Carbon: Moderate loadings in both the northern and southern hemispheres. This was the closest flight to Asia although no significant enhancements in BC were observed.</p> <p>Results for two pre-mission training/research flights are also included.</p>

Mission	Flight Path Notes	Features of Interest	
<i>HIPPO-5</i>	Northern polar flight #1 reached 82° N.	<p>CO₂: Deepest CO₂ drawdown and strongest vertical gradients seen on southbound leg starting at 2 km depth at 30° N and growing to 10 km at 60° N. On northbound leg, CO₂ drawdown permeates more broadly, to 8 km at 40° N, but with weaker gradients. Very homogeneous CO₂ over the Southern Hemisphere.</p> <p>O₂ and APO: High O₂ in the Northern Hemisphere with greater stratification on southbound leg, matching CO₂. Moderately low O₂, and very low APO permeating the Southern Hemisphere south of 5° S to 8 km reflecting ventilation of O₂ depleted waters.</p> <p>Black Carbon: Observed lowest northern hemisphere BC mass loadings. Well defined biomass burning plumes were encountered in the middle troposphere between 50° and 25° S.</p> <p>Results for two pre-mission North American research flights are also included.</p>	
Sampling Dates	Both southbound and northbound Pacific flights followed a central flight path.		
August 9 to September 8, 2011	Southern ocean flight reached 67° S, 164° E. <ul style="list-style-type: none"> Flight RF09 reached the ice edge; one profile crossed the edge and another profile was over solid ice. 		
Vertical Profiles Flown	Northern polar flight #2 reached 87° N.		
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Detailed Mission Research Flight Descriptions November 19, 2012

All missions began and ended at NCAR's Earth Observing Laboratory, Research Aviation Facility (RAF), located at the Rocky Mountain Metropolitan Airport (KBJC), Broomfield, CO.

[Profiles (1 Count 138 2 Count 148 3 Count 136 4 Count 175 5 Count 190 Grand Count 787)]

HIPPO-1 Mission Segments	Flight Descriptions	Research Flight Number(s)	Vertical Profile Numbers
HIPPO Initiation	Billings, MO to Anchorage, AK >> RF01, Broomfield, CO to Billings, MT turned into an overnight stop due to GV maintenance issue. No data reported for RF01.	RF02	1-16
Northern Polar Region #1	Anchorage to 80° N and return	RF03	17-26
Pacific Southbound	From Anchorage, to Honolulu, HI, to Pago Pago, American Samoa, and to Christchurch, NZ. >> This was the only mission that stopped in Honolulu, with subsequent missions using Kona.	RF04 - RF06	27-72
Southern Ocean	Christchurch to 67° S, 175° W and return	RF07	73-88
Pacific Northbound	Eastern Pacific Route: From Christchurch to Papeete, Tahiti, to Easter Island, Chile, and to San Jose, Costa Rica >> Air traffic control limited profile flight frequency approaching Central America.	RF08 - RF10	89-132
Northern Polar Region #2	HIPPO-1 was also the only mission to not return to the Arctic a second time.		
Return	San Jose, Costa Rica to Broomfield, CO	RF11	133-138

HIPPO-2 Mission Segments	Flight Descriptions	Research Flight Number(s)	Vertical Profile Numbers
Test Flight	Test flight for instrument checks from Broomfield, CO to Ponca City, OK and return. >> Missed approach at Ponca City, OK	RF-1	1-4
Test Flight	Test flight for instrument checks from Broomfield, CO to Northern Wisconsin and return. >> Low approach near WLEF tall tower*	RF00	5-8
HIPPO Initiation	Broomfield, CO to Anchorage, AK	RF01	9-14
Northern Polar Region #1	Anchorage to 80° N and return >> Profiles down to 500 ft were conducted over the sea ice and open leads to sample the shallow Arctic boundary layer for the first time.	RF02	15-26
Pacific Southbound	From Anchorage, to Kona, HI to Rarotonga, Cook Islands, and to Christchurch, NZ. >> Only a fly-by of American Samoa en route to Rarotonga due to recent tsunami.	RF03 - RF05	27-74
Southern Ocean	Christchurch to 66° S, 174° W and to Honiara, Solomon Islands >> GV flew a profile over the TCCON site in Wollongong, Australia en route to Honiara, Solomon Islands	RF06	75-88
Pacific Northbound	Central Pacific Route: From Honiara, Solomon Islands to Kona, HI, and to Anchorage, AK.	RF07 - RF09	89-132
Northern Polar Region #2	Anchorage to 83° N and return	RF10	133-144
Return	Anchorage, AK to Broomfield, CO	RF11	145-148

*Park Falls, WI, and WLEF tall tower is an AmeriFlux site (<http://ameriflux.ornl.gov/fullsiteinfo.php?sid=100>) and a Total Carbon Column Observing Network (TCCON) site (https://tcccon-wiki.caltech.edu/Sites/Park_Falls).

HIPPO-3 Mission Segments	Flight Descriptions	Research Flight Number(s)	Vertical Profile Numbers
Test Flight	Test flights for instrument checks from Broomfield, CO around CO and return.	RF-1	1-2
Test Flight	Test flights for instrument checks from Broomfield, CO to OK and return	RF00	3-6
HIPPO Initiation	Broomfield, CO to Anchorage, AK	RF01	7-12
Northern Polar Region #1	Anchorage to 84.75° N and return	RF02	13-24
Pacific Southbound	From Anchorage, to Kona, HI, to Pago Pago, American Samoa, and to Christchurch, NZ.	RF03 - RF05	25-64
Southern Ocean	Christchurch to 66.8° S, 170° E and return	RF06	65-78
Pacific Northbound	Central Pacific Route: From Christchurch, NZ , to Pago Pago, American Samoa, to Kona, HI, and to Anchorage, AK.	RF07 - RF09	79-120
Northern Polar Region #2	Anchorage to 85° N and return	RF10	121-132
Return	Anchorage, AK to Broomfield, CO	RF11	133-136

HIPPO-4 Mission Segments	Flight Descriptions	Research Flight Number(s)	Vertical Profile Numbers
Test Flight	Test flight for instrument checks from Broomfield, CO to southwest Colorado and Farmington, NM and return. >> With low approach and overfly of Los Alamos TCCON site.	RF-1	1-4
Test Flight	Test flight for instrument checks from Broomfield, CO to TX, LA, OK and return. >> Flight in series to investigate the emissions of CH ₄ , CO ₂ and other gases from the intensive natural gas extraction operations in Texas (conventional and shale) and Northwestern Louisiana (shale gas only).	RF00	5-16
HIPPO Initiation	Broomfield, CO to Anchorage, AK	RF01	17-22 (23-24 gap)
Northern Polar Region #1	Anchorage to 84° N and return	RF02	25-42
Pacific Southbound	From Anchorage, to Kona, HI, to Rarotonga, Cook Islands, and to Christchurch, NZ. >> 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. >> After delaying in Rarotonga, the GV flew to Christchurch with restricted profiling.	RF03 - RF05	43-90
Southern Ocean	Christchurch to 58° S, 145° E and to Hobart (Tasmania), Australia. >> Polar air masses were at the margin of the GV flight track that landed in Hobart, Tasmania	RF06	91-101
Pacific Northbound	Western Pacific Route: Hobart to Darwin, Australia, to Saipan, Northern Mariana Islands, to Midway Island, and to Anchorage, AK.	RF07 - RF10	102-147
Northern Polar Region #2	Anchorage to 82° N and return	RF11	148-169
Return	Anchorage, AK to Broomfield, CO	RF12	170-177 (175 total)

HIPPO-5 Mission Segments	Flight Descriptions	Research Flight Number(s)	Vertical Profile Number(s)
North American Research Flight #1	Broomfield, CO to Northern Wisconsin WLEF tall tower*, and conducted three low approaches in the US corn belt, and return.	RF01	1-10 (11-18 gap)
North American Research Flight #2	Broomfield, CO to TX, LA, AR, OK and return >> Test flight in series to investigate the emissions of CH ₄ , CO ₂ and other gases from the intensive natural gas extraction operations in Texas (conventional and shale) and Northwestern Louisiana (shale gas only).	RF02	19-32
HIPPO Initiation	Broomfield, CO to Anchorage, AK	RF03	33-38
Northern Polar Region	RF04 was cut short because of research instrumentation issues. Anchorage return	RF04	39-42
Northern Polar Region #1	Anchorage to 82° N and return	RF05	43-62
Pacific Southbound	From Anchorage, to Kona, HI to Rarotonga, Cook Islands, and to Christchurch, NZ.	RF06 - RF08	63-114
Southern Ocean	Christchurch to 67° S, 164° E and return	RF09	115-128
Pacific Northbound	Central Pacific Route: From Christchurch, NZ , to Rarotonga, Cook Islands, to Kona, HI, and to Anchorage, AK.	RF10 - RF12	129-180
Northern Polar Region #2	Anchorage to 87° N and return	RF13	181-194
Return	Anchorage, AK to Broomfield, CO >> Limited measurements.	RF14	195-198 (190 total)

*Park Falls, WI, and WLEF tall tower is an AmeriFlux site (<http://ameriflux.ornl.gov/fullsiteinfo.php?sid=100>) and a Total Carbon Column Observing Network (TCCON) site (https://tcccon-wiki.caltech.edu/Sites/Park_Falls).