AIRBORNE SCIENCE PROGRAM

2011

ANNUAL REPORT

Pictured on the front cover are the support teams for ASP Core Aircraft. Names of personnel are listed on the following pages:
P–3 (p. 33), Global Hawk (p. 37), DC–8 (p. 30), ER–2 (p. 31), DFRC G–III (p. 35).

AIRBORNE SCIENCE PROGRAM

2011

ANNUAL REPORT

National Aeronautics and Space Administration

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Leadership Comments

Welcome to the 2011 Airborne Science Annual Report. This year, like 2010, was another busy year for us with over 2600 flight hours flown, including deployments all over the world. We supported numerous satellite instrument calibration and science data product validation flights, multiple Earth Science missions including two Operation Ice Bridge deployments (Arctic and the Antarctic), Earth Venture 1 missions, UAVSAR studies, AVIRIS and MASTER work, to name a few. In addition, we trained another 29 undergraduate and graduate students through our Student Airborne Research Program for a total of over 80 students over the last three years. While 2011 was another great year it also was one of profound sadness for the Airborne Science Program. We lost a great member of the team this year, Michael Fitzgerald. We'd like to dedicate this annual report to Michael and his family. He will be missed.

In 2011, we continued to look closely at our short, mid-, and long term needs to meet Earth Science requirements, and we are improving and updating our web presence, infrastructure, and platforms accordingly. As part of our look, it became apparent that we really had a capability gap in the manned platform area. When you look at the platforms available to us for more than 4 researchers and their instruments we really only had the GRC Twin Otter (very tight fit for 4), the P-3 and the DC-8. We have used private assets as well as other government agency assets but those aren't always available, cost effective, or meet the science requirements. The result is the addition of an HU-25 Falcon jet that we acquired from the Coast Guard and a C-23 Sherpa which we acquired from the US Army. These will be available beginning in 2012. We are also taking a close look at what assets we no longer require as we work within our budgets to provide what the scientists need to do their jobs.

Thank you for taking the time to read this year's annual report and hopefully we have provided useful information and given you an understanding of our capabilities and accomplishments in 2011. We made a push in 2010 and in 2011 to get feedback on the program, and while we've received some, which we truly appreciate, we're asking for more. We exist to provide the scientific community the infrastructure you require to support science, so please let us know what you need and how we are doing. ■

Bruce Tagg
Director

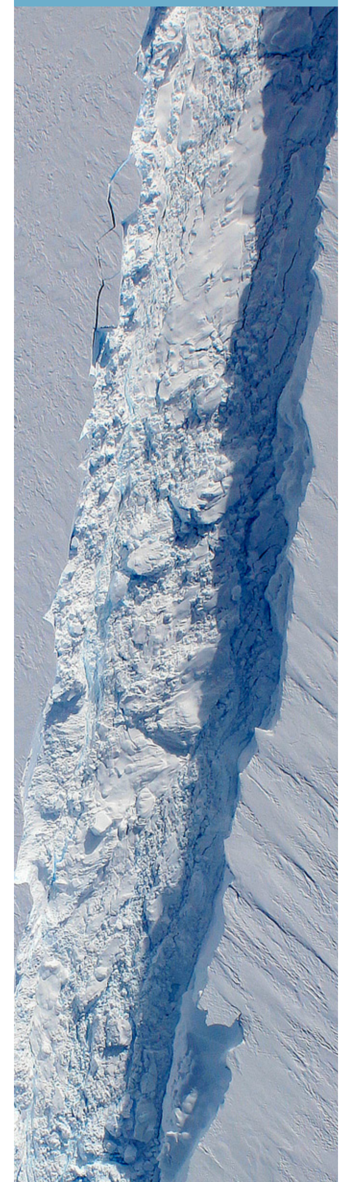
Randy Albertson
Deputy Director

In Memoriam

Michael T. Fitzgerald

It is with great sadness that the MAS instrument team announces the passing of Michael Fitzgerald, one of the original data analysts and a driving force behind the successful development and operation of a number of major NASA airborne instruments, including the MAS, MASTER, and TIMS. For nearly 20 years, from its first deployment to the Azores in 1992, Mike spearheaded MAS data processing, software development, and field operations. His boundless energy, imperturbable optimism, and good spirits will be remembered fondly by all who knew him. He died peacefully at his home in Boulder Creek with family on the 12th of February, 2012. He was only 52 years old and a 4th generation native of San Mateo, California. He died of ALS (Lou Gehrig's disease) seven years after being diagnosed.

Prior to coming to NASA, Mike worked for seven years as a union electrician (IBEW 617) until he suffered several disabling injuries. He then received his BS in Geography from San Francisco State University under a career rehabilitation program, and came to Ames Research Center as a student intern. He quickly became fascinated with Earth science and remote sensing, and over the next 20 years went on to become a leading member of the technical staff at the Airborne Sensor Facility. He led the MAS and MASTER deployment teams on major field experiments from Alaska, to Brazil, Costa Rica, and South Africa, to name but a few; and his contagious good nature and technical skills together were a big part of their collective success. His motto after being struck down by ALS became "Faith, Not Fear," exemplifying the indomitable spirit which will remain forever an inspiration to friends and colleagues alike. ■



Program Overview

The Airborne Science Program (ASP) serves to enable scientists to achieve NASA Earth science objectives and goals that require the use of airborne platforms and infrastructure.

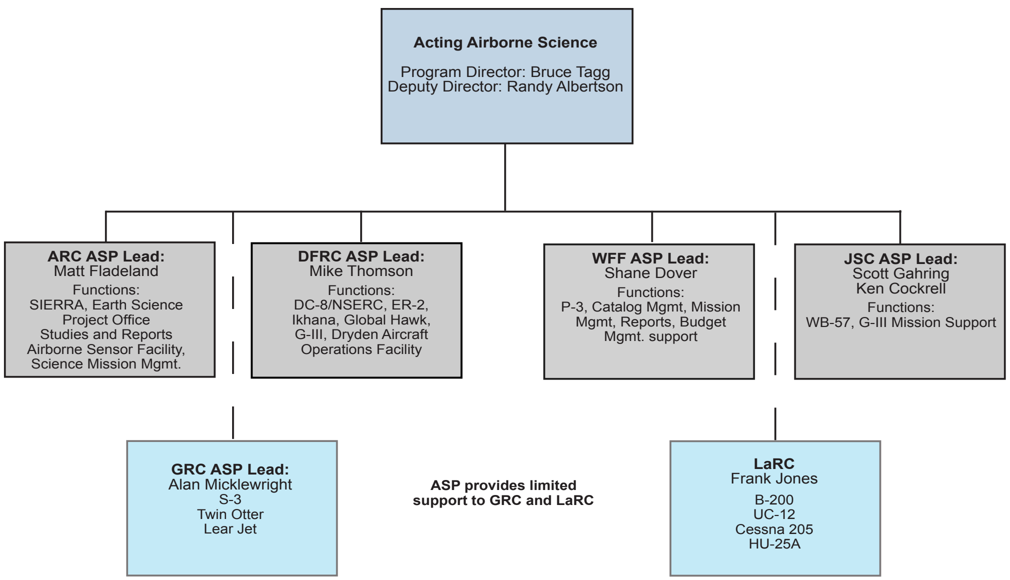


Figure 1: Airborne Science Program Organization.

The ASP Program objectives are to provide the capability to:

- Accomplish the essential calibration measurements for the NASA Earth observing satellites and the validation of data retrieval algorithms
- Obtain variable high-resolution temporal and spatial measurements of complex local processes to facilitate a physics based understanding of the Earth system.
- Test and refine instrument technologies/algorithms, as well as innovative observing techniques, and reduce risk prior to committing sensors for launch into space.
- Foster the development of our future workforce with the hands-on involvement of graduate students and young scientists/engineers in all aspects of ongoing Earth Science investigations.

Structure of the Program

The Center Airborne Science Leads or their designated representatives report to the ASP Director in all matters pertaining to the Airborne Science Program. An organizational chart is shown in Figure 1.

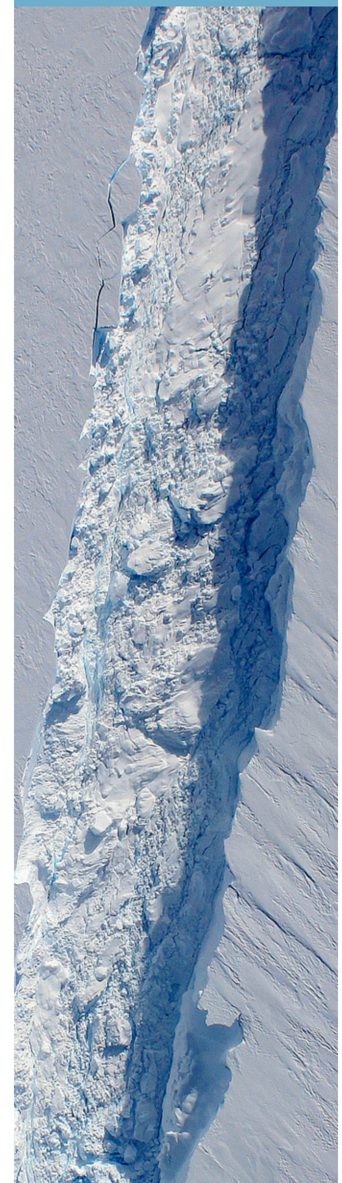
FY2011 Major Improvements

The ASP made a number of investments and improvements to enhance capabilities for the Earth science community. On the Dryden C-20/G-III, engine hush kits were procured and installed; these will enable UAVSAR missions at more airports worldwide. Antiquated seats on the P-3B were replaced, the electrical convertors in the load center were replaced and a new galley and lavatory were procured for installation in the next maintenance cycle. The Johnson Space Center G-III, N992NA, started its modification to become a UAVSAR platform, principally for the EV-1 AirMOSS mission. Numerous investments were made to the program's web presence, such as the platform tracker feature. A substantial investment was also made to increase sensor portability between platforms by procuring the material to build more NASA Airborne Science Data and Telemetry (NASDAT) modules and Experimenter Interface Panels (EIPs).

Flight Request System

The flight request system manages and tracks the allocation of the ASP aircraft and facility sensors. The Science Operations Flight Request System (SOFRS) is a web-based database to facilitate the review and approval process for every airborne science mission using NASA SMD funds, personnel, instruments or aircraft. Requests for these assets and the scheduling of their use are accomplished through SOFRS. This system was designed to allow researchers that are funded by NASA or other agencies to have access to unique NASA aircraft, as well as commercial aircraft with which NASA has made contracting arrangements. The only way to schedule the use of NASA SMD platforms and instrument assets is to submit a Flight Request for approval through SOFRS ((http://airbornescience.nasa.gov).)

The SOFRS team strives for continuous improvement by improving the interface with users and the data products. In 2011, the focus was on making reports available to NASA headquarters from the data collected in the Flight Requests and to make modification in the flight request template to collect additional requested data. ■



Science: Mission Accomplished

Science Flight Statistics

The annual Airborne Science Call Letter was distributed in June of 2011. There were 185 flight requests submitted in 2011. Seventy-seven requests were completed, some were deferred and the rest were withdrawn or canceled depending upon the availability of resources at the time of the request. The details are listed in Table 1. The history of flight hours is illustrated in Figure 2.

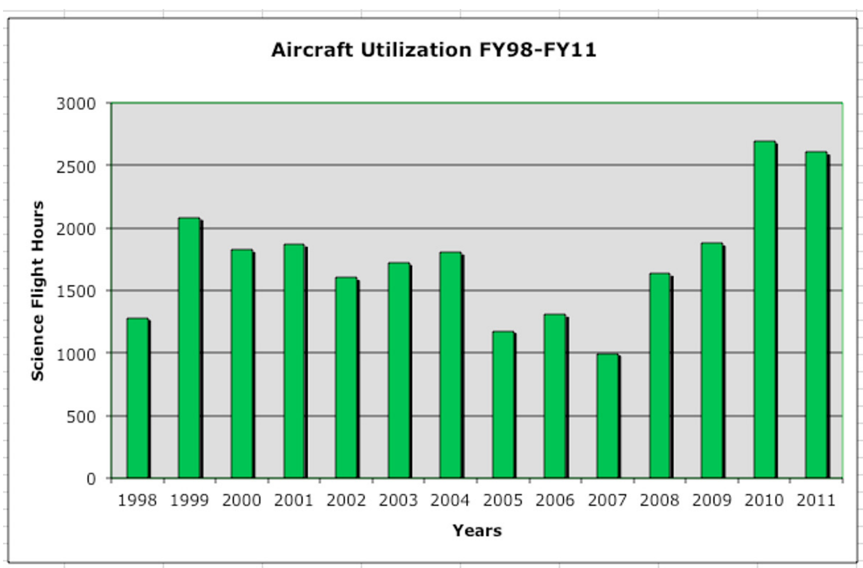


Figure 2: ASP science flight hours over the past 14 years.

Table 1: FY2011 Flight Requests and Flight Hours by Aircraft.

Aircraft	Total FRs	Total Approved	Total Completed	Total Hours Flown
DC-8	16	10	8	228.3
ER-2	31	20	11	143.7
P-3	17	7	5	533.3
WB-57	7	5	3	79.7
Twin Otter	20	10	8	281.6
B-200	20	14	9	304.5
Cessna 206	4	3	2	87.2
Gulfstream G-3	34	27	17	448.4
Ikhana	4	1	0	0.0
Learjet 25	1	0	0	0.0
SIERRA	9	2	2	17.0
Other	19	14	10	363.7
TOTALS:	**185**	**115**	**77**	**2605.4**

Table notes:

These totals are based on the flight request's log number, and therefore include all flight requests whose log number starts with "11".

The "Total FRs" column includes all flight requests that were submitted and whose log number starts with "11".

The "Total Approved column includes flight requests that were set to a status of *Approved* or *Internally Approved* at some point.

The "Total Completed" column includes only flight requests whose final status is *Completed*.

The "Total Hours Flown" column includes all "Flight Hours Flown" for flight requests with a status of *Completed* or *Partial* for 2011. For multi-year missions, this may include hours flown in years prior to 2011.

Other Aircraft includes: Alpha Jet, BT-67, Cessna 172, F-18, FS King Air, H211 Alpha Jet, NRL 0-3, Otter DHC-3, Piper Cherokee PA-32, PNNL G-1, Purdue University's Beechcraft Duchess Airborne laboratory for Atmospheric Research, SDSU Sky-Arrow, Twin Otter - Twin Otter International, UTSI Piper Navajo PA-31, Viking 300, Zeppelin NT.

Flight requests were submitted for 15 aircraft platforms and flew more than 2600 flight hours in all. Several large campaigns were successfully conducted this year (MACPEX, Operation ICE Bridge, HS3, ATTREX and more). The locations of flights in FY2011 are indicated in Figure 3.

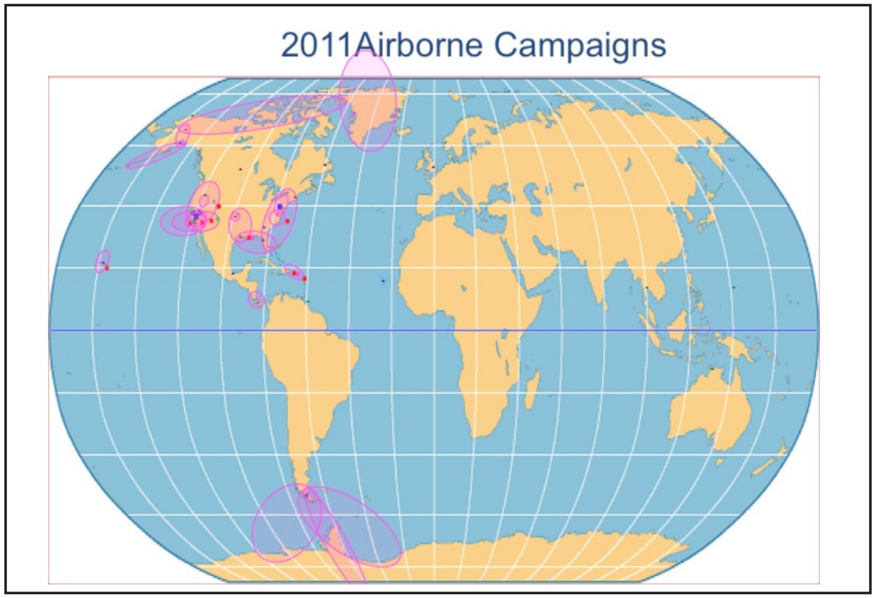
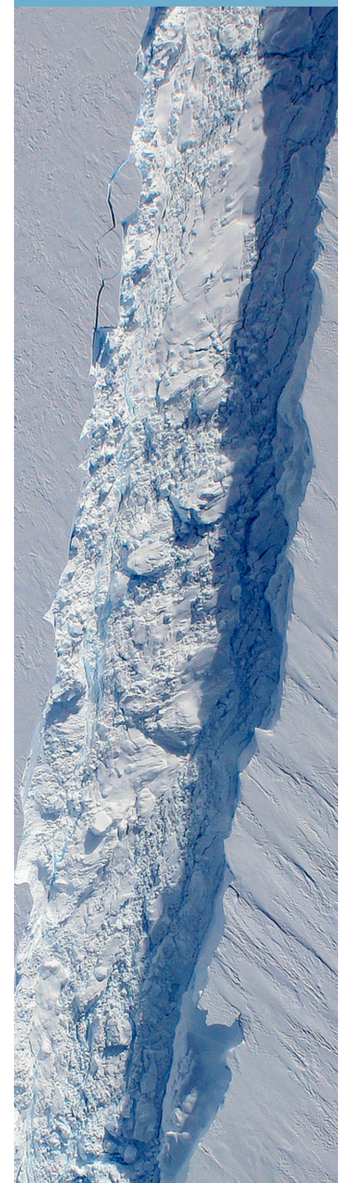


Figure 3: Locations of airborne campaigns during FY11.



Major Mission highlights

MACPEX

The Mid-latitude Airborne Cirrus Properties Experiment (MACPEX) focused on investigating the properties of mid-latitude cirrus clouds, the processes affecting these properties and their impact on the earth's radiation. The campaign took place during spring 2011 (March and April) over central North America with special emphasis in the vicinity of the Department of Energy ARM SGP site in Oklahoma.

Based from Ellington Field, TX, the MACPEX mission integrated 24 science instruments on board the WB-57 to make critical measurements needed for the mission objectives. The main focus of the measurements were the aerosol and cloud microphysical properties, including particle size distribution, composition, extinction,

Figure 4: MACPEX Team. Front Row (L to R): John Bain, Bill Rieke

Row 2 (L to R): Ru-shan Gao, Karen Rosenlof, Chris Yost, Eric Jensen, Paul Bui, Martina Kraemer, Tim Klostermann, Tom Slate, Jim Alexander, Marilyn Vasques, Dom Del Rosso, Glenn Diskin, Gao Chen, Yi-wen Huang, Lance Christensen, Dave Natzic, Robert Troy, Robert Herman, Marco Rivero

Row 3 (L to R): Allen Jordan, Mike Carrithers, Carl Schmitt, Anne Perring, Drew Rollins, Hermann Gerber, Rabi Palikonda, Brad Baker, Daniel Cziczo, Karl Froyd, Mike Reeves, Hal Maring, Dale Hurst, Rick Stimpfle, Jay Mace

By Aircraft (L to R): Luther Levan, Don Hanselman, John Hazelhurst, Dave Hendrickson, David Wyckoff, Don Greenway

ice water content, and ice crystal habitat. In addition other instruments provided measurements of water vapor, water isotopes, chemical tracers (CO, CH_4, O_3), and the dynamics including pressure, temperature, vertical and horizontal winds.

Flights were planned with an emphasize on ground based and satellite observations including the EOS/ A-Train satellites Aqua, Aura, CALIPSO, CloudSat, PARASOL, and Terra for the purposes of scientific utilization, as well as, satellite validation. In addition, the field measurements should provide the cirrus microphysical information needed for improvement and evaluation of remote-sensing retrievals and climate model cloud parameterizations. The MACPEX science team is shown with the WB-57 in Figure 4.

Operation Ice Bridge

Operation IceBridge continued in FY2011 with major campaigns in the Arctic and Antarctic.

The fall Antarctic campaign involved the DC-8 aircraft carrying seven instruments. Mission managers reported that the science instruments functioned well during the campaign, which included 10 dedicated science flights totaling almost 115 hours of flight time, not including checkout and transit flights. Flight lines covered Antarctica and its environs, including Thwaites Glacier and Pine Island Bay, as shown in Figure 5. The mission measured the ice thickness and surface elevations of the numerous tributaries feeding into the main Pine Island Glacier. New flight destinations beyond those flown in FY2010 included West Antarctica's Getz Ice Shelf and an arc-shaped flight path around the South Pole. In addition to the DC-8, we were joined by the NSF GV aircraft.

The IceBridge mission also visited the Arctic between March and May of 2011. Based out of Thule and Kangerlussuaq, Greenland, this field campaign focused on re-surveying areas that are undergoing rapid change and embarking on new lines of investigation, such as surveys of Canadian ice caps. NASA's P-3B and King Air B200 (IceBridge newcomer) aircraft were used on this campaign. The extensive flight coverage is shown in Figure 6.

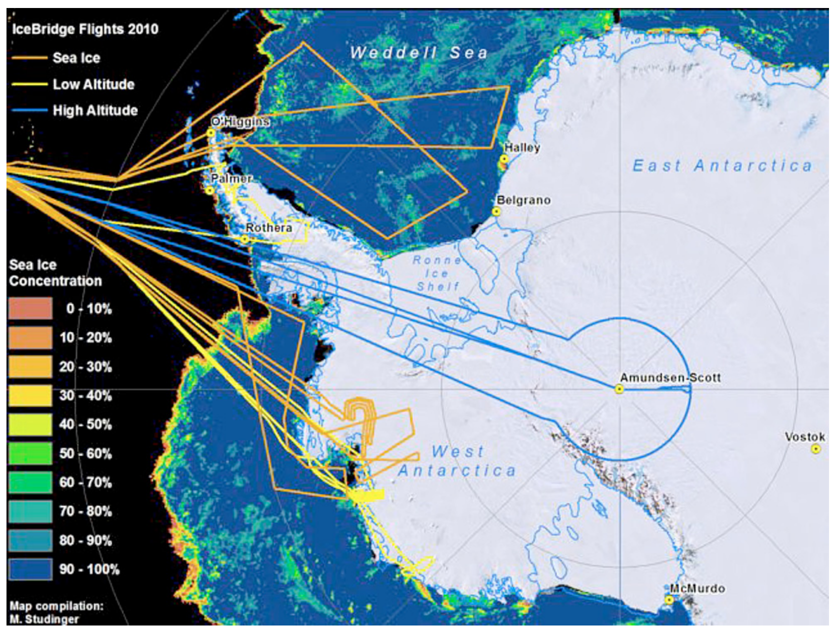
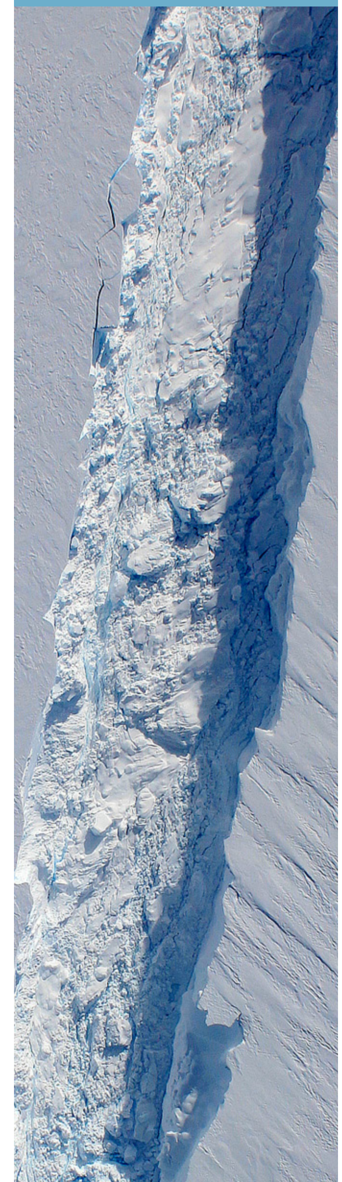


Figure 5: Flight lines for Fall 2010 Antarctic OIB mission.



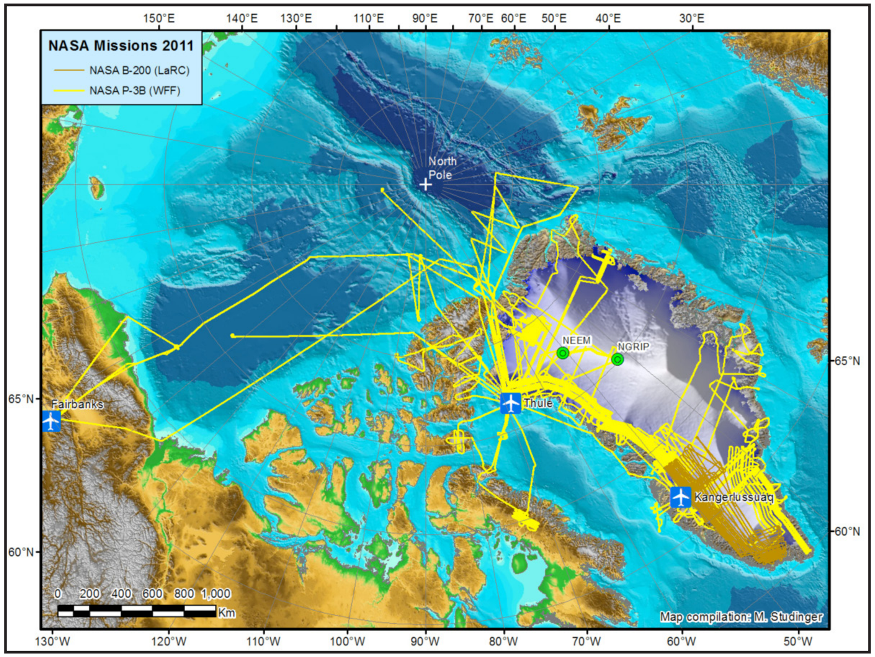


Figure 6: Flight tracks of Spring 2011 OIB Arctic mission.

The following quote from the OIB blog indicates the extensive coordination with other agencies during this mission.

> "Over the past 67 days, the P-3 has been in the air 325 hours. It is difficult to comprehend the magnitude of airborne activities that have taken place over Greenland, the Canadian Arctic, and the Arctic Ocean [during] the past couple of weeks. IceBridge deployed two aircraft that have collected a tremendous amount of data, but we were not alone. Our colleagues from the European Space Agency had an extremely successful CryoVEx campaign with two survey aircraft involved and many ground activities. A UK-US project surveyed the Greenland Ice Sheet as well, and so did a team from CReSIS. In the Beaufort Sea, the US Navy and its partners conducted ICEX 2011, with survey aircraft and measurements on the sea ice. The scope and level of coordination between all these airborne and ground campaigns makes the International Polar Year look small. Thank you all for the excellent coordination!"

ASCENDS II

The objective of the 2011 ASCENDS DC-8 Airborne Campaign, also known as ASCENDS II, was to measure CO2 columns over a variety of topographic targets and under varying atmospheric conditions with developmental LIDAR and in situ sensors under consideration for the ASCENDS satellite mission. The simultaneous flight of four LIDAR candidates allows for comparison of technologies. Measurements were made over extensive and varied surface and meteorological conditions. The wide-ranging flight tracks are shown in Figure 7.

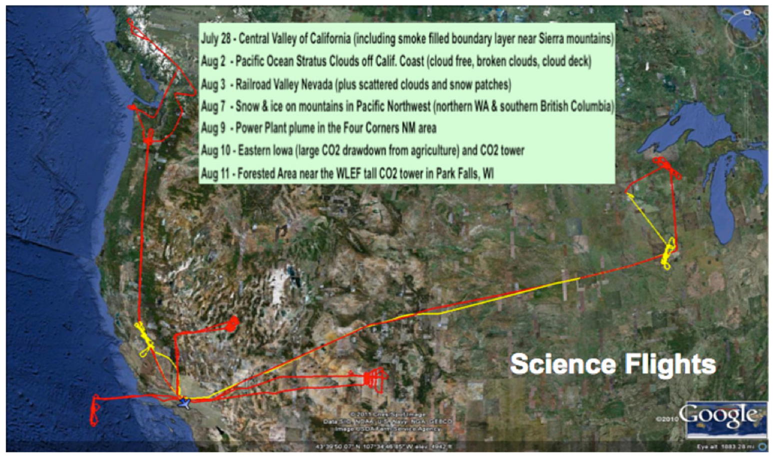


Figure 7: ASCENDS II science flight tracks.

Supporting NASA Science – the Airborne Science role

NASA ESD objective is to detect and understand environmental change from regional to global scale. This necessarily requires regional to global scale monitoring of critical parameters and process studies.

Since it is not possible to measure everything, everywhere, all the time and because NASA has unique ability to execute space borne measurements, NASA emphasizes space based observations of the earth system. From an observational perspective, NASA makes long-term observations (e.g., satellite observations, surface/subsurface-based network

Table 2: ESD Satellite Mission support in FY2011.

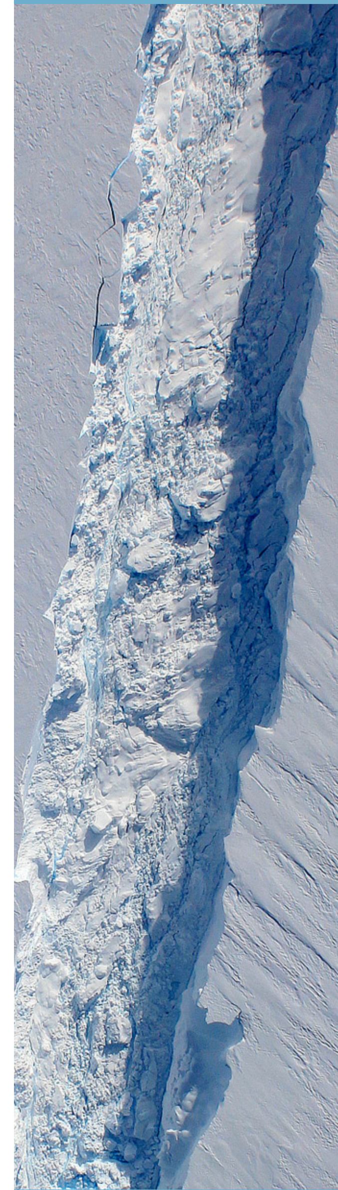
Airborne Mission Name	Satellite Mission Name	Aircraft flown	Locations
ASCENDS II	ASCENDS	DC-8	CONUS
AID for ASCENDS 4	ASCENDS	Cessna 206	LaRC
Operation IceBridge	ICESat 2	P-3, Otter, B-200	Arctic, Greenland
Operation IceBridge	ICESat 2	DC-8, BT-67	Chile, Antarctica
Calipso Night Cal/Val	CALIPSO	UC-12B	LaRC
MC3E	GPM	ER-2	CONUS
GOSAT / OCO2	GOSAT, OCO2	SIERRA, Alpha Jet	NV
Soil Moisture	SMAP	G-III	CONUS
Forest Conditions and Structure	DESDynI	G-III	CONUS
AVIRIS / MASTER	HypsIRI	ER-2, Twin Otter	CONUS
MABEL	ICESat 2	ER-2	CONUS
ALIST	LIST	Learjet 25	CONUS
SweepSAR	DESDynI	DC-8	CONUS

measurements, and, to a lesser degree, repeated aircraft observations) and short-term observations (e.g., field campaigns, both airborne and surface/subsurface-based).

From an observational platform basis, ESD develops and performs satellite observations as well as developing and performing airborne and surface/subsurface measurements. To develop satellite observational capabilities, we design and build remote sensing instruments as well as algorithms. These activities typically (but not always) involve airborne and surface/subsurface-based measurements.

After a satellite is launched, the calibration and validation of the measurements made by the satellite typically involve airborne and surface/subsurface-based network observations.

Since the understanding of some critical earth system processes cannot be completely accomplished by satellite observations, NASA augments satellite observations with more detailed, higher frequency, greater spatial resolution measurements from aircraft and/or surface/subsurface platforms.



Support to ESD Satellite Missions, including Decadal Survey Mission

One of the primary activities of the Airborne Science Program is to support the development and implementation of NASA's space satellite missions. This includes not only flights to collect calibration and validation data once a satellite has been launched, but also to collect data for algorithm development prior to launch. Thus, many ASP missions make field measurements to build relevant databases. Others carry instruments that are prototypes of satellite payload instruments. Still others carry instruments that are simulators, but not necessarily prototypes.

While there are a large number of Earth satellites currently in orbit, there are even more Earth satellites planned for launch in the near term. Many of these were initially defined in the 2008 "Decadal Survey." Since the release of the Decadal Survey and initial science mission developments, the Airborne Science Program has been assisting in the development of support plans for all aspects of these missions. Table 2 (page 13) lists the FY2011 ASP activities, which supported ESD satellite missions. Most of these are related to algorithm development or validation. An example of MASTER data acquired in support of HyspIRI algorithm development is shown in Figure 8. The mission concept for MC3E on the ER-2 supporting GPM is shown in Figure 9.

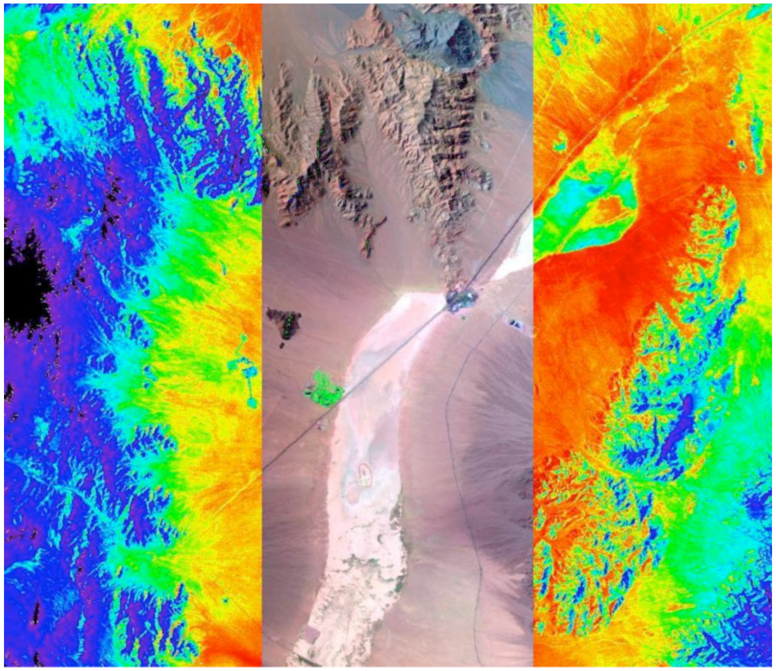
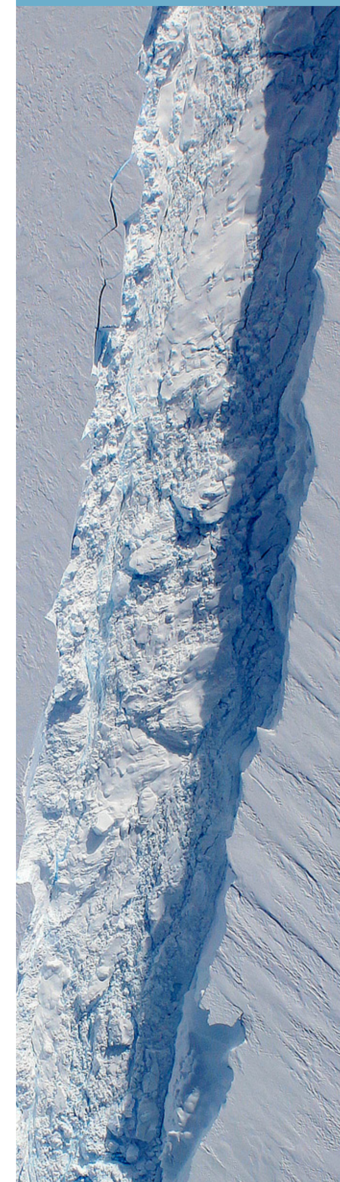


Figure 8: MASTER imagery acquired on the ER2 8 June 2011 over Ivanpah playa. Center swath depicts vis/swir spectral data, while background shows pseudo-colored thermal response.



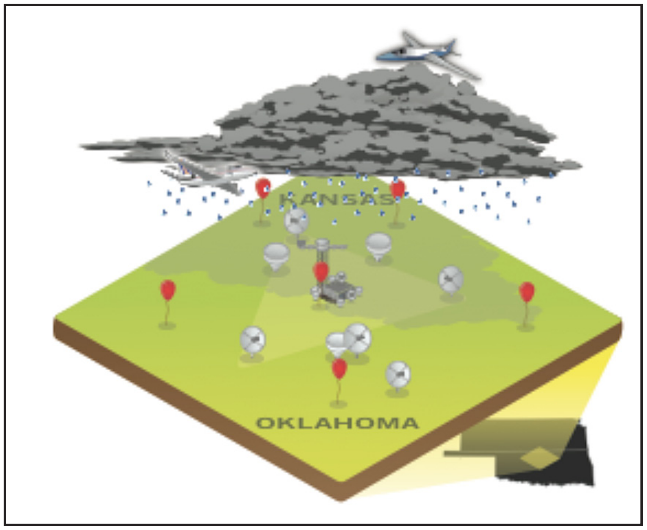


Figure 9 (left): Data gathered during MC3E on the ER-2 support GPM algorithm development and cal/val planning.

Support to Instrument Development

ASP flights also support the testing of many different instruments. NASA's Earth Science Technology Office (ESTO) develops many of the new payloads for upcoming satellite missions through the Instrument Incubator Program and has focused in recent years on instruments for the Decadal Survey missions. Table 3 (page 16) lists FY2011 instrument flight test activities performed by ASP. An example of instrument test is the G-LiHT instrument, which was flown on the Cessna 206. Pictures from that activity are shown in Figure 10.

Figure 10: G-LiHT on the Cessna 206.

Table 3: Instrument development flights: satellite simulator and prototype instruments.

Airborne Mission Name	Instruments	Aircraft flown	Locations
G-LiHT	G-LiHT	Cessna 206	LaRC
ECO-3D	LIDAR / RADAR	P-3	New England
ASCENDS II	3 CO2 systems	DC-8	CONUS
AMIGA-Carb	G-LiHT	Cessna 206	CONUS
CH4 Sounder	Methane LIDAR	DC-8	CONUS
SweepSAR simulation	JPL SAR	DC-8	CONUS
AirMSPI	Polarimeter	ER-2	CONUS
TWiLiTE	Doppler LIDAR	ER-2	CONUS
MABEL	ICESat 2 LIDAR simulator	ER-2	CONUS
OAWL	Wind LIDAR	WB-57	CONUS
Broadband LIDAR	CO2 LIDAR	DC-8	So. Cal.
WISPARS	Dropsondes and dispenser	Global Hawk	Pacific, Arctic
AMS checkout	Multi-spectral scanner	B-200	So. Cal
DEVOTE	Aerosol instruments (Nephelometer, DLH, CAPS)	B-200	LaRC
DEVOTE	HSRL and RSP	UC-12	LaRC

Support to R&A process studies

In addition to supporting satellite missions, ASP carries out major field campaigns for science process studies in all the science areas of the Earth Science Research and Analysis (R&A) program. These contribute greatly to our understanding of climate and climate change, atmospheric composition, weather and precipitation, the carbon cycle and Earth ecosystems, the oceans and vegetation, the water and energy cycle, the dynamics of the Earth surface and its interior. All of the ASP core platforms were involved in major field campaigns in 2011. Interferograms from volcano studies using the UAVSAR on the G-III are shown in Figure 11.

Table 4: Science process studies.

Airborne Mission Name	Science program area	Aircraft flown	Locations
Operation IceBridge	Cryosphere	P-3, Otter, B-200	Arctic, Greenland
Operation IceBridge	Cryosphere	DC-8	Chile, Antarctica
MACPEX	Atmospheric Composition	WB-57	CONUS
Forest conditions and structure	Carbon cycle and ecosystems	G-III	CONUS
Fault lines	Earth surface and Interior	G-III	Hispaniola, California
Volcano studies	Earth surface and interior	G-III	Hawaii, Central America, Alaska
Sea Eddies	Climate variability	G-III	Pacific
WISPARS	Weather	Global Hawk	Pacific, Arctic
SARP	Atmospheric Composition	DC-8	Southern California

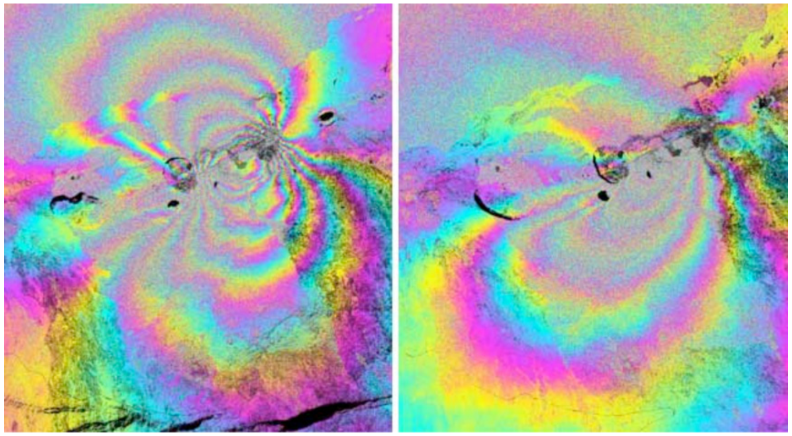


Figure 11: Interferograms of Kilauea volcano generated from the UAVSAR show lava flows.

Earth Venture-1 (EV-1) activities and accomplishments

The five EV-1 projects selected in 2010 were all underway in 2011. The list of projects, aircraft being used, and flight locations are included in Table 5. (As a reminder, the solicitation for Earth Venture-3 suborbital and airborne missions will be released in 2013 for awards in 2014.)

Table 5: Earth Venture 1 Flight Activities.

EV-1 Mission	Aircraft flown	Locations
Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality (DISCOVER-AQ)	P-3, UC-12B	Baltimore / Washington area
Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)	Twin Otter	Alaska
Hurricane and Severe Storm Sentinel (HS3)	Global Hawk	Pacific
Airborne Tropical Tropopause Experiment (ATTREX)	Global Hawk	Pacific
Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS)	New G-III with SAR pod in preparation	JSC

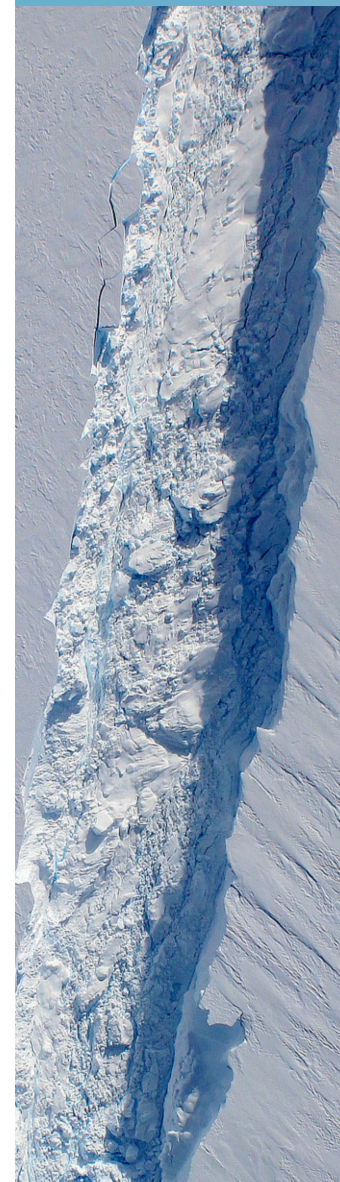
DISCOVER-AQ

In July, NASA researchers and partners provided an unprecedented view of air pollution over the Baltimore-DC metropolitan area. This was the first of four field campaigns for the DISCOVER-AQ mission. Satellite observations of atmospheric pollutants generally provide “column” amounts, meaning that they can diagnose the total abundance of a constituent from the surface to the top of the atmosphere, but regulators concerned about high levels of ozone and particulate matter are interested in what resides at the surface where populations and ecosystems are exposed to poor air quality. Differentiating between pollution near the surface and aloft is a particularly difficult problem for current satellites.

With two NASA aircraft and an extensive ground network, DISCOVER-AQ operated as a complex observing system, providing multiple perspectives on the factors that control air quality and influence our ability to monitor pollution events from space. NASA’s UC-12 King Air flying at an altitude of 27,000 feet was used to collect remote sensing observations of particulate matter and gaseous pollutants. Profiling underneath, NASA’s P-3B used in situ sampling to provide detailed information on the distribution of pollutants from

1000 to 10,000 feet where most pollution resides. (See Figure 12.) These flights were anchored to a network of ground sites where particulate and trace gas pollutants were measured at the surface with in situ instruments, from the surface to 1000 feet with tethered balloons, and for the atmospheric column with lidars, passive remote sensors, and ozonesondes.

During the month of July, aircraft took to the skies on 14 flight days, sampling repeatedly over the ground sites to observe the distribution and diurnal evolution of pollutants. Low altitude flight by the P-3B provided the biggest challenge as profiling over ground sites was conducted in some of the nation's busiest airspace and transects at 1000 feet over the I-95 traffic corridor were highly visible to commuters. FAA support through air traffic control and public announcement of flights was critical to the mission's success.



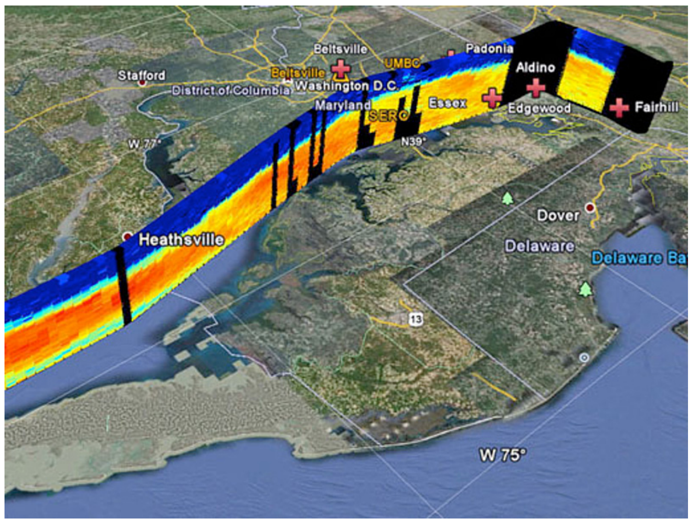


Figure 12: This July 2 image shows smoke over the Chesapeake Bay drifting north from wildfires in North Carolina and Georgia as viewed by High Spectral Resolution Lidar (HSRL) aboard NASA Langley's UC-12 research aircraft.

CARVE

The CARVE mission is investigating Arctic carbon cycling and the release of greenhouse gases from permafrost. Deployments will occur during the spring, summer and early fall when Arctic carbon fluxes are large and change rapidly. Further, at these times, the sensitivities of ecosystems to external forces such as fire and anomalous variability of temperature and precipitation are maximized. Continuous ground-based measurements provide temporal and regional context as well as calibration for CARVE airborne measurements. The payload for the Twin Otter includes PALS, Picarro (CO_2 and CH_4), and sample flasks.

CARVE successfully completed its Integration and Test, Flight Readiness Review, and four engineering flights in the Alaskan Arctic experimental domain. The locations are shown in Figure 13. Phase 1 of the Engineering Test Flights was completed in June 2011 with flights over the Oklahoma ARM site (in conjunction with the SMAP Cal-Val team).

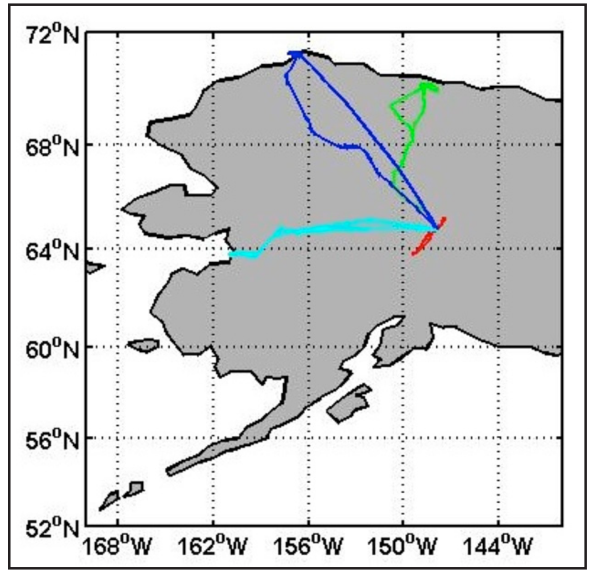
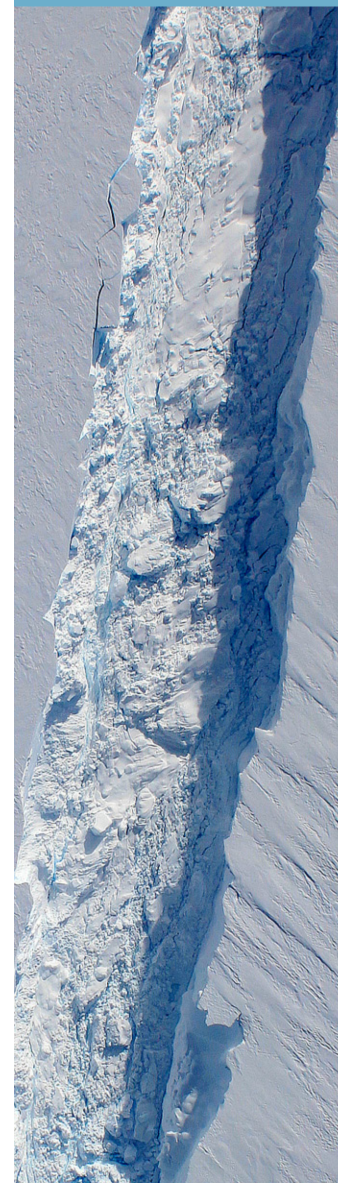


Figure 13: CARVE spring 2011 flight tracks.

Hurricane and Severe Storm Sentinel (HS3)

The NASA Global Hawk UASs are ideal platforms for investigations of hurricanes, capable of flight altitudes greater than 55,000 ft and flight durations of up to 30 h. HS3 will utilize two Global Hawks, one with an instrument suite geared toward measurement of the environment and the other with instruments suited to inner-core structure and processes. The environmental payload includes the scanning High-resolution Interferometer Sounder (HIS), dropsondes, the TWiLiTE Doppler wind lidar, and the Cloud Physics Lidar (CPL) while the over-storm payload includes the HIWRAP conically scanning Doppler radar, the HIRAD multi-frequency interferometric radiometer, and the HAMSR microwave sounder. Field measurements will take place for one month each during the hurricane seasons of 2012-2014.

The HS3 project performed a series of range and instrument comparison test flights during summer 2011 on the Global Hawk from



DFRC, first over the Pacific and then to the Gulf of Mexico. These test flights were in preparation for the hurricane research flights that will take place over the next three years (2012-2014) over the Atlantic hurricane region from Wallops Flight Facility. The ESPO team is shown in the Global Hawk Operation Center (GHOC) in Figure 14.

Figure 14: ESPO Team in the GHOC during HS3.

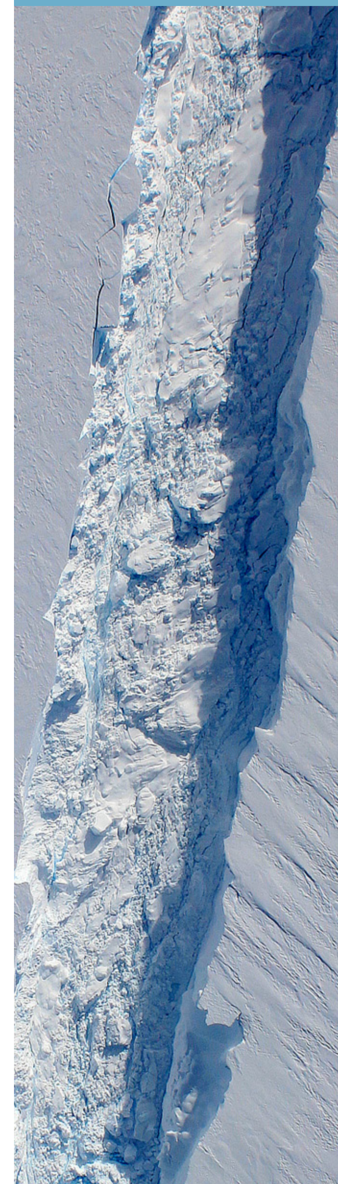
ATTREX

Airborne Tropical Tropopause Experiment (ATTREX) will perform a series of measurement campaigns using the long-range NASA Global Hawk (GH) unmanned aircraft system (UAS) to directly gaps in our understanding of physical processes occurring in the Tropical Tropopause Layer (TTL, ~13-18 km), the region of the atmosphere that controls the composition of the stratosphere. Specifically, the experiment is designed to measure stratospheric humidity and other chemical components of the TTL.

During FY2011 the ATTREX team prepared for its upcoming missions by taking major steps to:

- Identify payload instruments, their locations and operation on the Global Hawk. The eleven - instrument configuration is the largest and heaviest payload suite ever flown on a NASA Global Hawk.
- Identify deployment sites at Guam and Darwin and address remote basing issues. ATTREX represents the first deployment of the NASA GH.
- Address flight clearances in the Asian Pacific region.
- Form cooperation with NOAA to fly their GV jointly at lower altitude.

Continued on page 22



Test flights were flown in late 2011.

Because of the extensive activity generated for the NASA Global Hawks by HS3 and ATTREX, a large science / instrument laboratory area has been built within the DFRC GH hangar. Complete with internet, telephone, and instrument test stations, it is shown in Figure 15.

Figure 15: Global Hawk payload scientists' instrument and data laboratory.

Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS)

The AirMOSS mission is designed with the goal of improving the estimates of the North American net ecosystem exchange (NEE) through high-resolution observations of root zone soil moisture (RZSM). To obtain estimates of RZSM and assess its heterogeneities, AirMOSS will fly a P-band (430 MHz) synthetic aperture radar (SAR) over 2500 km2 areas within nine major biomes of North America. The flights will cover areas containing flux tower sites in regions from the boreal forests in central Canada to the tropical forests in Costa Rica.

The AirMOSS radar is currently under construction at the Jet Propulsion Laboratory (JPL), with first science flights expected in June 2012. The SAR will be housed in a pod more or less identical to the UAVSAR pod that flies on the DFRC G-III and will be installed on a JSC G-III being modified at Johnson Space Center. (See Section 5 – New Platforms). In-situ soil sensing profiles are currently being deployed at the AirMOSS sites, and test flights for atmospheric carbon measurements are also planned.

Support to Applied Science

In addition to supporting the Earth Science R&A program, ASP activities also directly or indirectly support the Earth Science Applied Sciences program and partner agencies. Table 6 lists 2011 ASP activities that supported objectives of the Applied Science program.

Table 6: ESD Applied Science support.

Airborne Mission Name	Applied Science area/ partner agency	Aircraft flown	Locations
EPA EMVIS	Air quality/EPA	Cessna 206	LaRC
EPA standards mission	Air quality/EPA	UC-12B	VA
Oil spill impact	Disasters	G-III	Gulf Coast
Mississippi River levees and Gulf Coast subsidence	Disasters	G-III	Mississippi Delta
Sacramento Delta levees	Disasters	G-III	Sacramento Delta
Los Conchas BAER	Disasters/USFS	B-200	So. Cal.
Wildfire disaster support	Disasters/CalFire	B-200	So. Cal.

Upcoming Missions

UAS Enabled Earth Science

In 2011, the ROSES A.40 solicitation "Airborne Science: UAS Enabled Earth Science" collected over 30 responses to utilize unmanned aircraft systems (UAS) for earth science studies. The proposers to A.40 were required to propose the use of two different UAS in their studies, one of which was to be a NASA platform. Most proposed either the NASA Ikhana long-endurance UAS or the SIERRA mid-size UAS. Figure 16 shows the range of science topics proposed.

Three projects were awarded in late FY2011, with flight activities to take place primarily in 2012. The three projects are listed in Table 7.

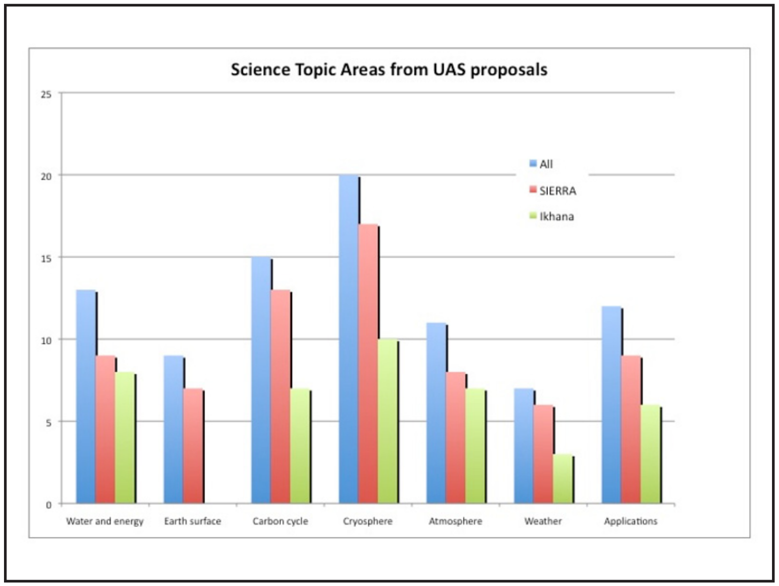
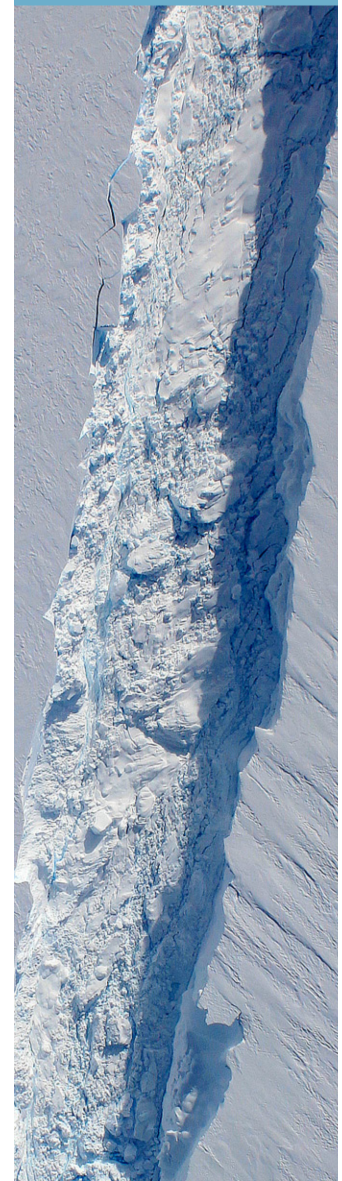


Figure 16: Histogram of proposed UAS mission types.

Table 7: A.40 missions.

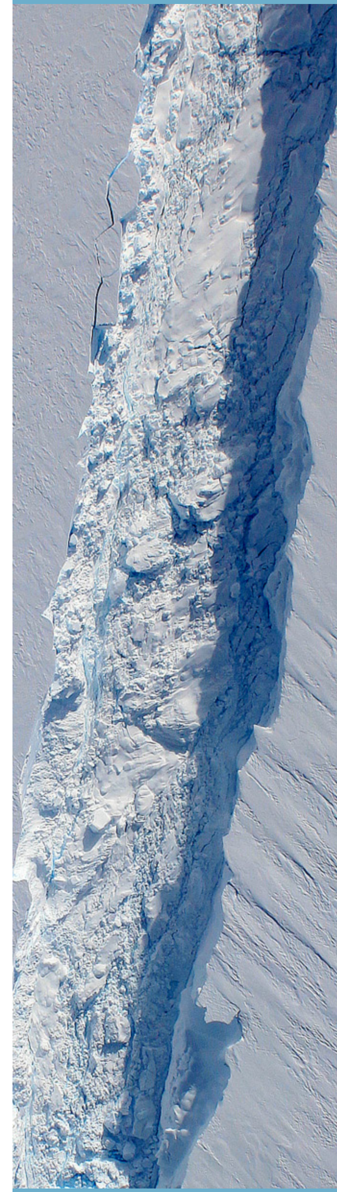
Airborne Mission Name	Science supported	UAS Aircraft to be flown	Locations
Earthquake fault study	Earth surface and interior	SIERRA and Swift	Surprise Valley, CA
Sea Grass and Coral study	Ecosystem science	SIERRA and MLB Bat	Florida Keys and Tobago
MIZOPEX	Cryosphere	Ikhana and Scan Eagle	Oliktok, Alaska



SEAC4RS South East Asia Composition, Cloud and Climate Coupling Regional Studies

Southeast Asia Composition, Cloud, Climate Coupling Regional Study (SEAC4RS) will take place in August and September of 2012. This deployment will address key questions regarding the influence of Asian emissions on clouds, climate, and air quality as well as fundamental satellite observability of the system. Science observations will focus specifically on the role of the Asian monsoon circulation and convective redistribution in governing upper atmospheric composition and chemistry. Satellite observations suggest a strong impact of the Asian Summer Monsoon on Tropopause Transition Layer (TTL) composition and a direct relationship to surface sources including pollution, biogenic emissions, and biomass burning. Attention will also be given to the influence of biomass burning and pollution, their temporal evolution, and ultimately impacts on meteorological processes which in turn feed back into regional air quality. With respect to meteorological feedbacks, the opportunity to examine the impact of polluting aerosols on cloud properties and ultimately dynamics will be of particular interest.

To accomplish the goals of SEAC4RS, multiple aircraft are required. The NASA DC-8 will provide observations from near the surface to 12 km, and the NASA ER-2 will provide high altitude observations reaching into the lower stratosphere as well as important remote sensing observations connecting satellites with observations from lower flying aircraft and surface sites. A critical third aircraft needed to sample convective outflow and slow ascent of air above the main convective outflow level (~12 km) has been identified as the NSF/NCAR GV (HIAPER). Basing the aircraft in Thailand is optimal for achieving science objectives with a preferred base in U-Tapao, Thailand. ■



Aircraft

The Airborne Science Program operates the NASA aircraft, consisting of unique highly modified "science-ready" platforms, as well as an aircraft catalog program, which consists of other government, university and commercial NASA aircraft that have completed NASA safety reviews. The supported aircraft are those subsidized by the Airborne Science Program.

The costs per flight hour to the scientist are established yearly and published in the annual "call letter." Other aircraft in the NASA fleet are operated by individual NASA centers at hourly rates established at those centers. The NASA aircraft are listed in Table 8 below. Note that NASA includes unmanned aircraft systems (UAS) among both the supported and catalog aircraft.

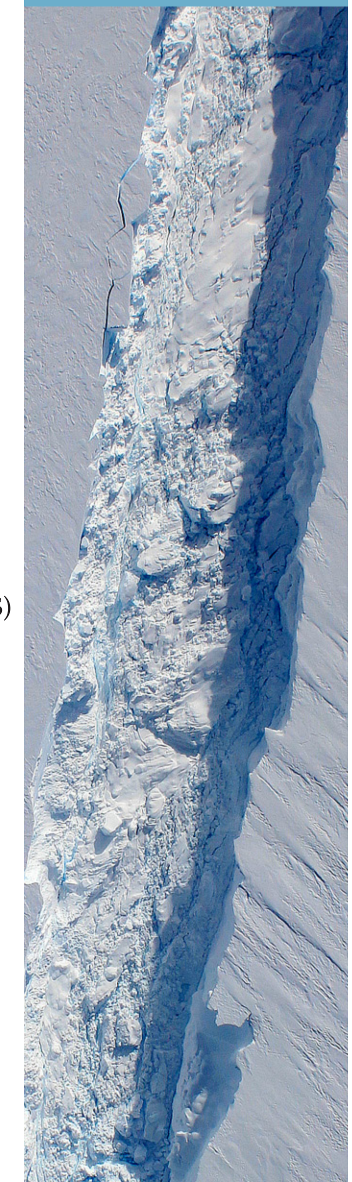


Table 8: NASA ASP Aircraft.

ASP Supported Aircraft	Other NASA Aircraft
DC-8	B-200 - DFRC
ER-2	B-200 - DOE
G-III	B-200 - LARC
Global Hawk (UAS)	Cessna 206H
P-3 Orion	Ikhana
WB-57	Ikhana (UAS)
	SIERRA (UAS)
	Learjet 25
	S-3B
	T-34C
	Twin Otter - GRC
	UC-12B - LaRC

Capabilities

The capabilities of each aircraft are described in detail on the Airborne Science webpage at http://airbornescience.nasa.gov. They range in altitude and endurance performance as indicated in Figures 17 through 19 and Table 9.

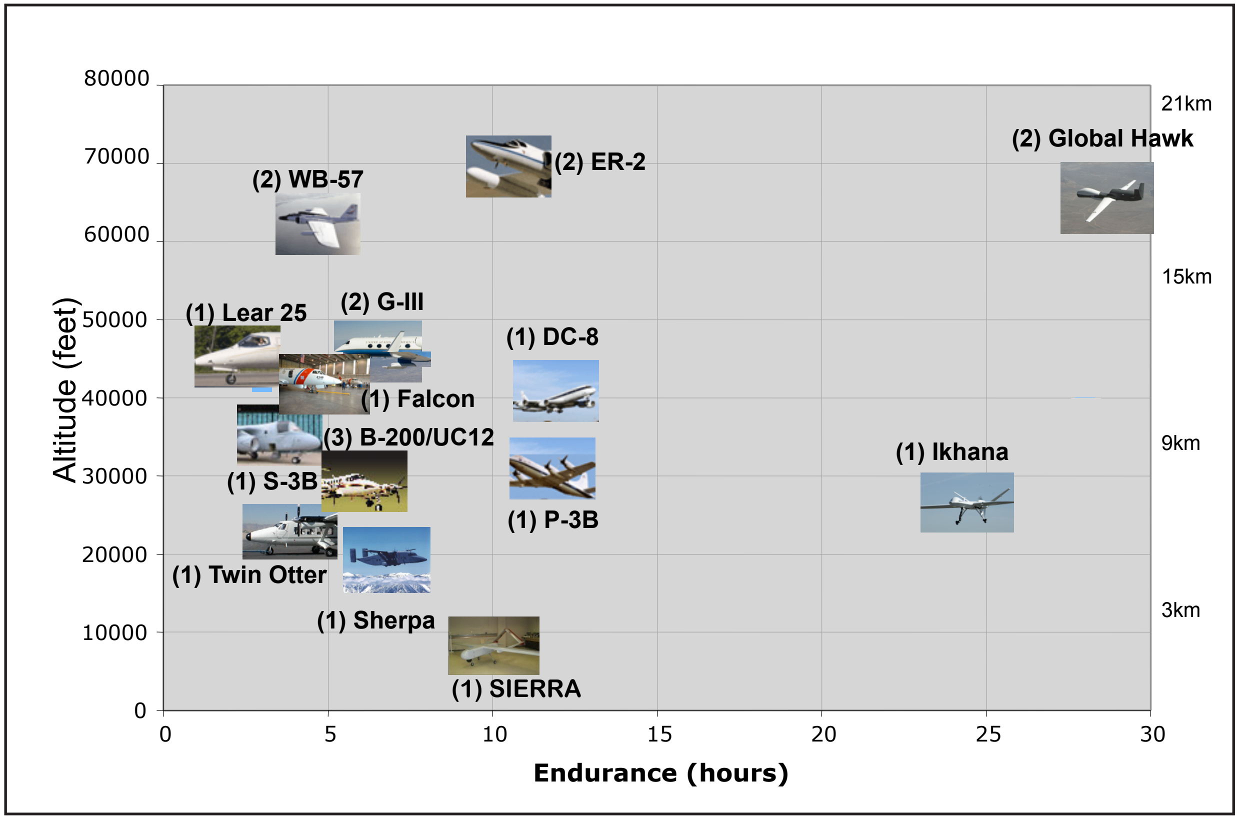
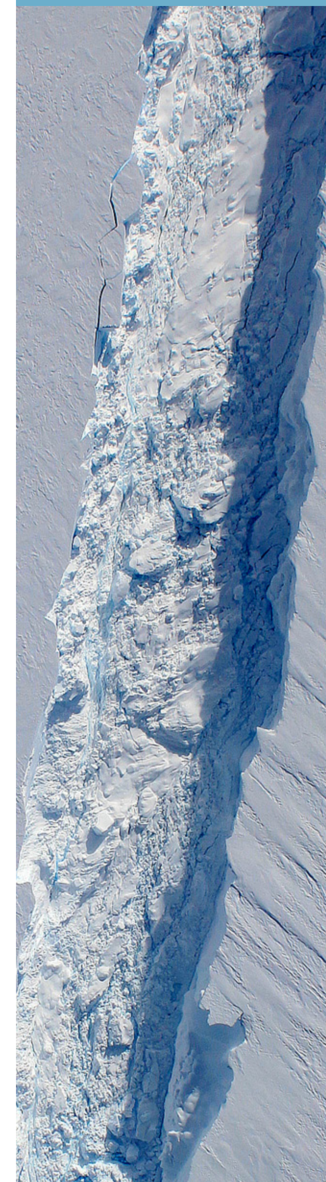


Figure 17: Altitude v. duration.



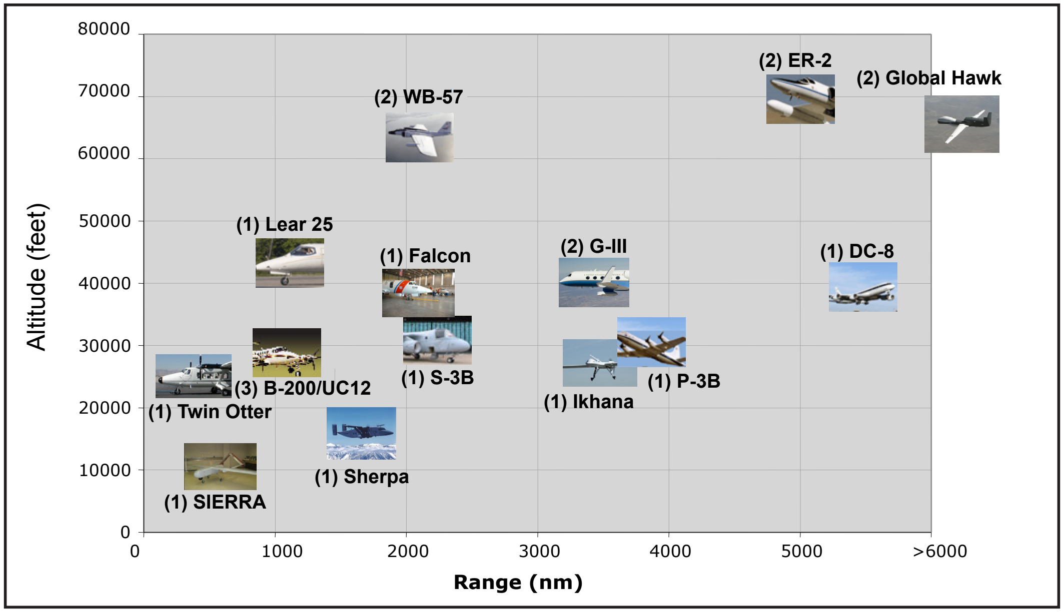


Figure 18: Altitude v. range.

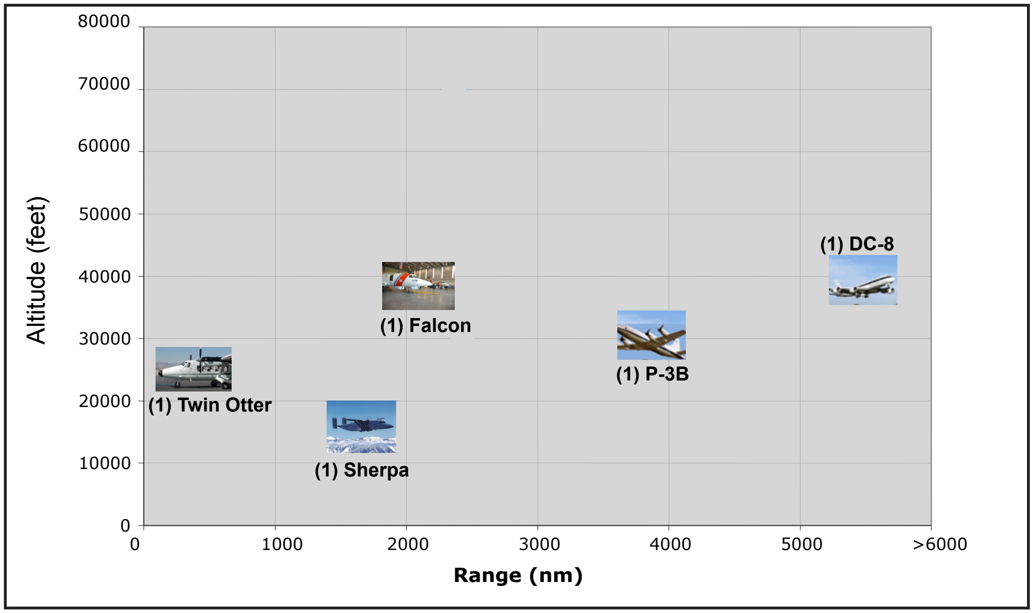
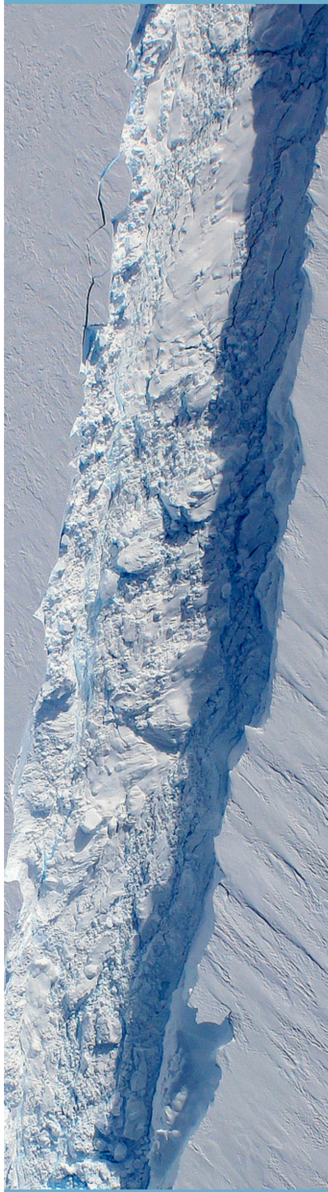


Figure 19: Altitude v. range for manned science aircraft with nadir ports and room to work for 4+ people.

Table 9: ASP Platform capabilities.

Airborne Science Program Resources	Platform Name	Center	Duration (Hours)	Useful Payload (lbs.)	GTOW (lbs.)	Max Altitude (ft.)	Airspeed (knots)	Range (Nmi)	Internet and Document References
ASP Supported Aircraft	ER-2	NASA-DFRC	12	2,900	40,000	>70,000	410	>5,000	http://www.nasa.gov/centers/dryden/research/AirSci/ER-2/
	WB-57	NASA-JSC	6	6,000	63,000	65,000	410	2,172	http://jsc-aircraft-ops.jsc.nasa.gov/wb57/
	DC-8	NASA-DFRC	12	30,000	340,000	41,000	450	5,400	http:///.nasa.gov/centers/dryden/research/AirSci/DC-8/
	P-3B	NASA-WFF	12	16,000	135,000	30,000	330	3,800	http://wacop/wff.nasa.gov
	Gulfstream III (G-III) (mil: C-20A)	NASA-DFRC	7	2,610	45,000	45,000	459	3,400	http://airbornescience.nasa.gov/platforms/aircraft/g3.html
	Global Hawk	NASA-DFRC	31	1500	25,600	65,000	335	11,000	http://airbornescience.nasa.gov/platforms/aircraft/globalhawk.html
NASA Catalog Aircraft	King Air B-200 AND UC-12B	NASA-LARC	6.2	4,100	12,500	35,000	260	1250	http://airbornescience.nasa.gov/platforms/aircraft/b-200.html
	DHC-6 Twin Otter	NASA-GRC	3.5	3,600	11,000	25,000	140	450	http://www.grc.nasa.gov/WWW/AircraftOps/
	Learjet 25	NASA-GRC	3	3,200	15,000	45,000	350/.81 Mach	1,200	http://www.grc.nasa.gov/WWW/AircraftOps/
	S-3B Viking	NASA/GRC	>6	12,000	52,500	40,000	450	2,300	http://www.grc.nasa.gov/WWW/AircraftOps/
	Ikhana (Predator-B)	NASA-DFRC	30	3,000	10,000	52,000	171	3,500	http://airbornescience.nasa.gov/platforms/aircraft/predator-b.html
	SIERRA	NASA-ARC	11	100	445	12,000	60	550	http://airbornescience.nasa.gov/platforms/aircraft/sierra.html
	Cessna 206H	NASA-LARC	5.7	1,175	3600	15,700	150	700	http://www.nasa.gov/centers/langley/pdf/70892main_FS-2004-07-92-LaRC.pdf



Aircraft Activities and Modifications in 2011

DC-8 Flying Laboratory

Aircraft manager: DFRC

Website: http://airbornescience.nasa.gov/aircraft/DC-8

Science Flight hours in FY11: 227.1 hours

Figure 20: DC-8 Team in Bangor, Maine. From left to right: Ron Wilcox, Tom Ryan (NASA G2 Pilot), Pat Lloyd, Denis Steele, Greg Schaeffer, Tim Sandon, Trevor Haupt, Paul Aristo, Marty Trout, Scott Zinn (NASA G2 Pilot), Donny Bailes, Joe Niquette, Larry Phillips, Brad Grantham.

Names and locations of missions flown:

- ASCENDSII (CO2 lidar instrument development) flown western and midwest US and Canada.
- Broadband Lidar (CO2 lidar instrument development) flown in California.
- Methane Sounder (Methane lidar instrument development) flown in California.

Figure 21: NASA DC-8.

- Glory Launch Support (launch telemetry retrieval) flown Pacific equator region.
- Operation IceBridge Antarctic (Antarctic ice studies) flown from Punta Arenas, Chile.
- SARP 2011 (Student Missions) flown in California.
- DESDynl SweepSAR (JPL radar system development) flown in California.

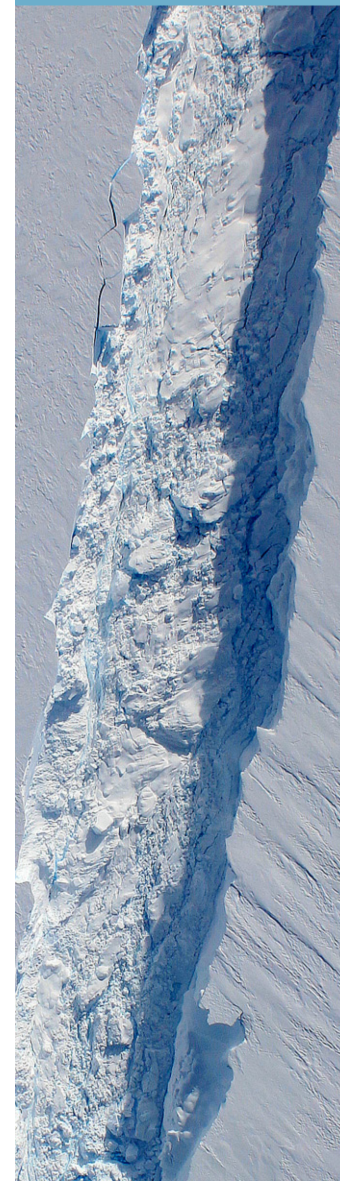
Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status – airworthy

Modifications:

Data system and communication modifications to enhance system performance.

1) Installed Bose Noise Canceling Headsets throughout cockpit and cabin



2) Replaced the existing forward and nadir video cameras with higher resolution high definition cameras
3) Installed Thecus N8800PRO data storage server in the house keeping rack
4) Installed a server in the house keeping rack for software development
5) Installed a Ballard AB2342 data recorder and WxWorx REWX9ID XM weather data receiver
6) Installed a BSI EMS-6830 embedded computer in the House Keeping rack (dedicated computer to run Falconview moving map)
7) Replaced the two existing house keeping touch screen displays with upgraded units
8) Installed touch screen at Mission Director panel
9) Installed enhanced house keeping rack cooling

Planned or expected short and long maintenance periods in upcoming 5 years:

- B-Check inspection due March 2012 (3 weeks required)
- B-Check inspection due March 2013 (3 weeks required and can be moved to left)
- C/D-Check/Landing Gear Swap due January 2014 (4 months to 1 year depending on how performed)
- B-Check inspection due in 2015, 12 months after completion of C/D-check (3 weeks required)
- B-Check inspection due in 2016 (3 weeks required)

ER-2

NASA currently operates two ER-2 aircraft – N806 and N809.

Aircraft manager: DFRC

Website: http://airbornescience.nasa.gov/aircraft/ER-2

Figure 22: ER-2 team. Front Row (L-R): Robert Navarro, Keith Rossman, Monty Cook, Anne Odenthal, Jennifer Penrod, Nick Felix. Back Row (L-R): Tim Moes, Tim Williams, Paul Everhart, Mike Kapitzke, Jerry Roth, Mike Bereda, Dan Heckle, Kevin Kraft.

Science Flight hours in FY11: A/C 806 = 298.6; A/C 809 = 39.6   Total hours = 338.2 hours

Names and locations of missions flown:

- JSC AVIRIS/MASTER flown over Southwest Kentucky, Wisconsin, Colorado, Louisiana Coast and Islands, Timmins Ontario.
- Mid-Latitude Continental Convective Clouds Experiment (MC3E), deployed to Nebraska, flown over Santa Catalina Island, Santa Barbara Channel, Lake Isabella, Oklahoma.
- Airborne Multiangle Spectro-Polarimetric Imager (AirMSPI) sensor development flown in California.
- AVIRIS/MASTER flown in California.
- Tropospheric Wind Lidar Technology Experiment (TWiLiTE) sensor development flown in California.
- Multiple Altimeter Beam Experimental Lidar (MABEL) sensor Development flown in California and Nevada.

Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft Status:

- 809 in maintenance phase. Completion date April 9, 2012.
- 806 – airworthy

Modifications: none

Planned or expected short and long maintenance periods in upcoming 5 years:

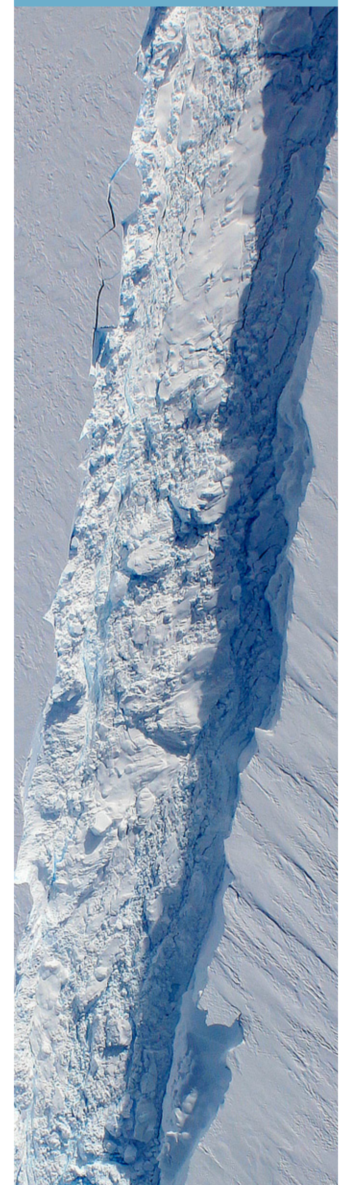
Figure 23: ER-2 carrying CPL, TWiLiTE and CoSSIR for an instrument test mission.

A/C 806:

- Maintenance phase to integrate NASDAT – 4 months (timeframe TBD).
- Seat inspections every 6 months for one week.
- Maintenance phase every 200 flight hours (timeframe varies).

A/C 809:

- Currently in maintenance phase with a complete by date of April 6, 2012.
- Seat inspections every 6 months for one week.
- Maintenance phase every 200 flight hours (timeframe varies).



P-3 Orion

Aircraft manager: WFF

Website: http://airbornescience.nasa.gov/aircraft/P-3_Orion

Figure 24: The P-3 in Thule.

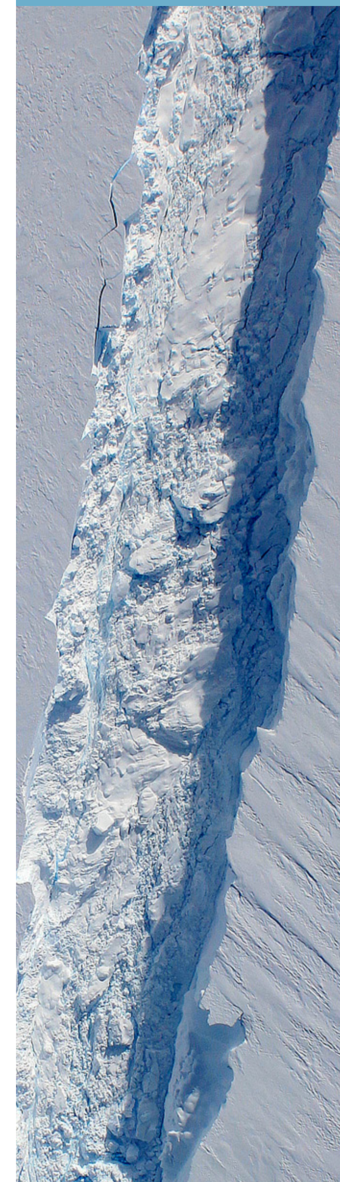
- ECO-3D – WFF local; Bangor, ME; Homestead, FL

Aircraft status, modifications made in FY11, impact of those improvements:

No modifications to the aircraft were performed in FY11 however new experimenter seats, power converters, galley and lavatory equipment were purchased to be installed in FY12.

Planned or expected short and long maintenance periods in upcoming 5 years:

- FY12 – annual phase maintenance (typically scheduled in November and December each year for 4-6 weeks, can be moved to support missions)
- FY16 – aircraft unavailable mid FY16 for 12-18 months for re-wing effort



Names and locations of missions flown:

- Data System Test Flight – WFF local
- Operation Ice Bridge – Kangerlussauq and Thule, Greenland and Fairbanks, Alaska
- DISCOVER-AQ – WFF local, and flown over Washington D.C./Baltimore metro areas

Figure 25: P-3 Team. Front Row (L to R): Barbara LaBarge, Sylvia Bell, Mark Russell, Martin Nowicki, Cate Easmunt, Freddie Bynum. Back Row (L to R): David McNaught, John Doyle, Mike Cropper, Brian Yates, Pete Peyton, Mellissa Cold, Mike Terrell, Alan Sturgis, Alan Barringer, Jeff Sigrist. Absent: Shane Dover, Rich Rogers, Todd Brophy, Wayne Jester, Mike Singer, Karalyn Springle.

WB-57

NASA currently operates two WB-57 aircraft – N926 and N928.

Aircraft manager: JSC

Website: http://airbornescience.nasa.gov/aircraft/WB-57

Science Flight hours in FY11: 102.7 hours

Names and locations of missions flown: All of the following were flown on N926.

- Mid-Latitude Airborne Cirrus Properties Experiment (MACPEX), Ellington Field TX.
- Optical Autocovariance Wind Lidar (OAWL) payload, Ellington Field TX.
- NPOESS Airborne Sounder Testbed – Interferometer (NAST-I) and Cosmic Dust Collector (CDC) payloads each flown as piggybacks from Ellington Field TX.

Aircraft status, modifications made in FY11, impact of those improvements:

- N926 currently deployed on a reimbursable mission through Dec 2011.
- N928 currently in Long MX inspection, expected completion Jan 2012.
- N927 is the new third WB-57 aircraft currently being regenerated to flying status, expected completion Oct 2012.
- Modifications to the fleet in FY11 include a new Keyboard Video Mouse (KVM) system for increased capacity and reliability (N926);

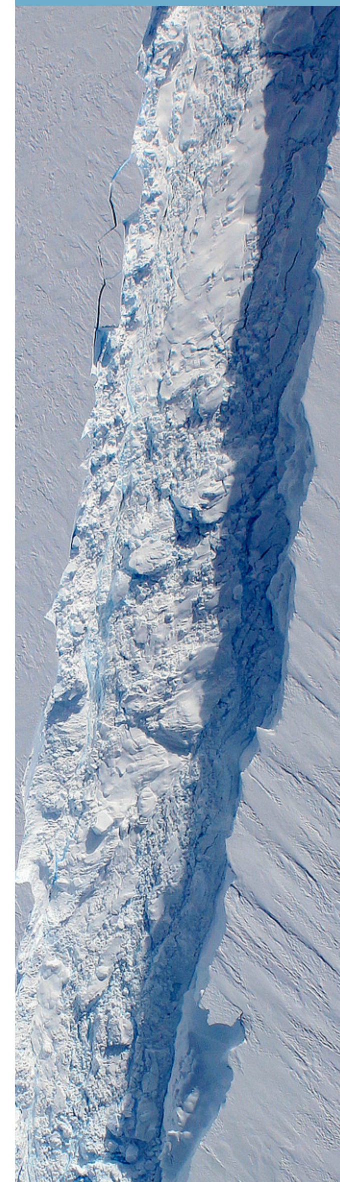
Figure 26: NASA WB-57.

- Installation of new communications systems to support payload operations (N926)
- Installation of a Garmin 696 GPS in both cockpits for enhanced navigation and weather capability;
- Development of a standard external stores rack similar to the BRU-15 to easily accommodate various payloads without additional engineering effort;
- Development of an adapter ring and related hardware to allow mounting a spearpod forebody on a superpod pylon, providing more flexibility in payload mounting options.
- In addition, we obtained one additional 6 ft pressurized pallet,

two additional 6 ft unpressurized pallets, and four additional 3 ft unpressurized pallets to accommodate additional customers.

Planned or expected short and long maintenance periods in upcoming 5 years:

- N926: Short MX inspection (3 weeks) in 2012, 2014, 2016; Long MX inspection (4 months) in 2013, 2015.
- N928: Short MX inspection (3 weeks) in 2012, 2014, 2016; Long MX inspection (4 months) in 2013, 2015.
- N927: Short MX inspection (3 weeks) in 2013, 2015; Long MX inspection (4 months) in 2014, 2016.



DFRC G-III with UAVSAR

Aircraft manager: DFRC operates the aircraft; JPL operates the UAVSAR system.

Figure 27: DFRC G-III team. Front row, left to right: Glenda Almeida, Michelle Haupt, Anne Odenthal, Brittany Wells, Richard Hang, Vince Moreno, Carlos Meza. Back row: Trevor Haupt, John McGrath, Kirk Caldwell, Dick Ewers, Tim Moes, Tim Williams, Tim Miller, Chris Miller, Mike Thomson.

Figure 28: NASA G-III.

Website: http://airbornescience.nasa.gov/aircraft/G-III

Flight hours in FY11: 395.8 hours

Names and locations of missions flown:

G-III UAVSAR Deployments

- Volcano Study - Hawaii
- Volcano Study - Central America
- Oil Spill Impact - Gulf Coast
- Mississippi River Levees and Gulf Coast Subsidence
- Fault Lines - Hispaniola
- Volcano Study - Alaska

G-III Local Missions – based at Palmdale

- San Andreas and Hayward Faults
- Sea Eddies
- Soil Moisture
- Sacramento Delta Levees
- Forest Conditions & Structure

Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status: operational

Modifications in FY11:

- Stage III noise compliant hush kit installed – opens many domestic and international airports to UAVSAR missions
- Improved robustness platform precision autopilot (PPA) installed – improved system reliability and reduced long-term supportability costs
- Added DGPS antenna to the upper fuselage – improved RADAR data processing accuracy

Planned or expected short and long maintenance periods in upcoming 5 years:

- Feb 2012 - Ops 1 & 3 inspection/maintenance (4 weeks)
- Feb 2013 - Ops 1 & 2 inspection/maintenance (3 weeks)
- Feb 2014 - Ops 1 & 3 inspection/maintenance (4 weeks)
- Feb 2015 - Ops 1 & 2 inspection/maintenance (3 weeks)
- Feb 2016 - Ops 1 & 3 inspection/maintenance (4 weeks)

Global Hawk

NASA currently operates two Global Hawks – TN871 and TN872.

Aircraft manager: DFRC

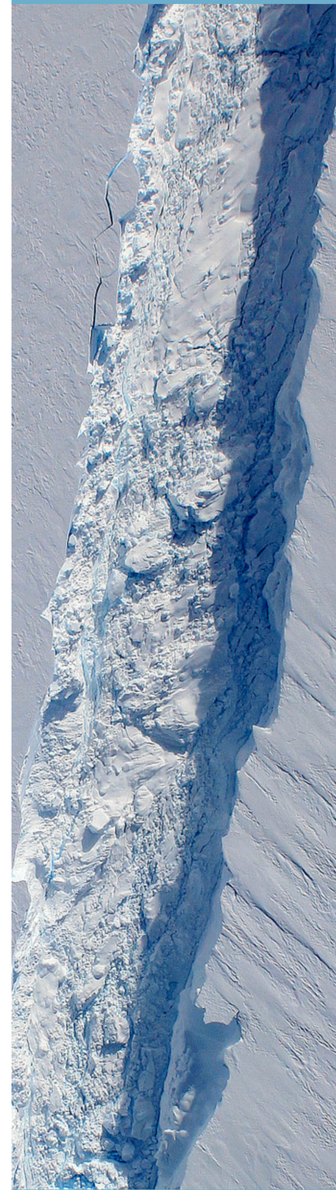
Website: http://airbornescience.nasa.gov/aircraft/Global_Hawk

Science Flight hours in FY11: 130.5 hours

Names and locations of missions flown: All missions were conducted from EAFB.

- Winter Storms and Pacific Atmospheric Rivers (WISPAR): Missions covered the Pacific and Arctic regions; 6 missions, including dropsonde system checkout flights.
- Hurricane and Severe Storm Sentinel (HS3): Missions covered the Pacific and Gulf of Mexico regions; 3

Figure 29: The Global Hawk team. From left to right: Steve Madison, Mark Shanks, Phil Kerschner, Ralph Doull, Mark Griffiths, Ken Wilson, Gina Patrick, Steve Sipprell, Ryan Dibley, Dorothy Patterson, Wesley Li, Bill Stanfield, Mike Yandell, Dan Long, Kent Fuller, Mark Bushbacher, Beth Hagenauer, Abby Ruvalcaba, Robert Medina, Mark Browder, Linda Soden, Loc Bui, Chris Naftel, William Fredriksen, Dave Fratello, Robert Rivera, Caitlin Barnes, Loc Pham, Chris Lavin, Michael Young, David Stafford, Clint Nelson, Sammy McKeehan, Tim Williams, Tom Cronauer, Dennis Pitts, James Reynolds, Rich Weaver, Jerry Cousins, Don Sessions, Randy Button, Tom Ripley.



missions, including the instrument checkout flight.

Aircraft status, modifications made in FY11, impact of those improvements:

- Aircraft status: TN871 is currently supporting KQ-X through July 2012.

Modifications in FY11:

- The payload support system wiring and attachment hardware was installed.
- Rear ballast capability was added to aircraft.

Aircraft status: TN872 is currently supporting KQ-X through July 2012.

Modifications in FY11:

- Aircraft ATC system was separated from the aircraft C2 system. This improves ATC voice capability.
- Ku payload data modem was procured and added to the aircraft.

Planned or expected short and long maintenance periods in upcoming 5 years:

TN871:

- 500 flight hour inspections/maintenance, October 2013, 1 week
- 1000 flight hour inspections/maintenance, September 2015, 1 week
- 75 cycles inspections/maintenance, 2016, 3 weeks

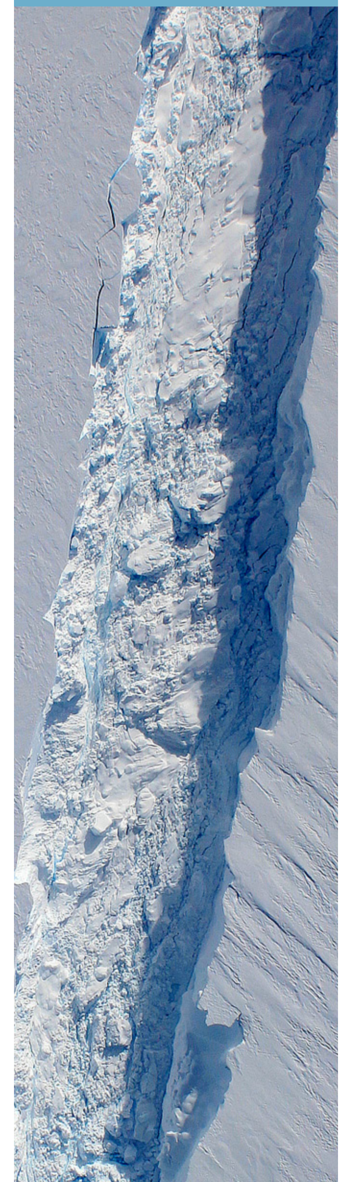
TN872:

- 500 flight hour inspections/maintenance, April 2012, 1 week

Figure 30: The NASA Global Hawk (top) with dropsonde dispenser (middle) for WISPAR mission.

- 75 cycles inspections/maintenance, March 2013, 3 weeks
- 1000 flight hour inspections/maintenance, June 2013, 1 week
- 2000 flight hour inspections/maintenance, January 2015, 1 week

The dates included above are based on known missions and will need to be adjusted as new missions are added for Airborne Science and/or Northrop Grumman.



Ikhana UAS

Aircraft manager: DFRC

Website: http://airbornescience.nasa.gov/aircraft/Ikhana

Figure 31: The Ikhana.

Figure 32: The Ikhana team. (L–R) Mauricio Rivas, James Smith, Joe Kinn, Don Johnson, Terry Bishop, Kathleen Howell, Kelly Snapp, Systems Safety, Greg Buoni, Trevor Haupt, Andy Gutierrez.

Science Flight hours in FY11: 0

Names and locations of missions flown:

All Ikhana missions in FY11 were flown from DFRC, all for non-NASA customers.

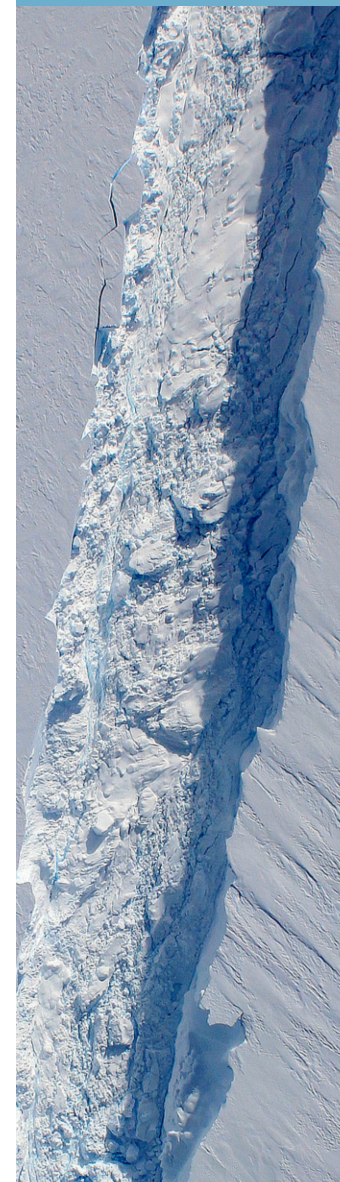
Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft is undergoing integration of ADS-B system in support of NASA's UAS Integration in the NAS Project.

In 2012 the Ikhana will be prepared for the MIZOPEX mission.

Planned or expected short and long maintenance periods in upcoming 5 years:

The Ikhana UAS will be down for between six to nine months beginning in April of 2012 for a major upgrade to USAF Block 1 configuration.



SIERRA UAS

Aircraft manager: ARC

Website: http://airbornescience.nasa.gov/aircraft/SIERRA

Science Flight hours in FY11: 17

Figure 33: The SIERRA team. From left to right: Randy Berthold, Don Herlth, Mark Sumich, Steve Patterson, Tom Lynn, Phil Schuyler, Rick Kolyer, Rich Hirata.

Names and locations of missions flown:

- An Airborne UHF/L-Band broadband SAR for SMAP/DESDynI cal/val: Crow's Landing
- JAXA/JPL GOSAT and OCO-2 science team support: Railroad Valley, NV

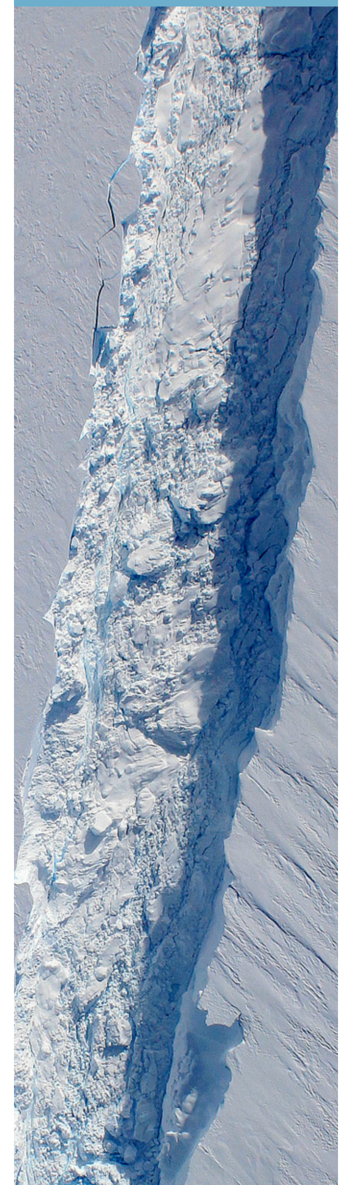
Aircraft status, modifications made in FY11, impact of those improvements:

Figure 34: The SIERRA.

Aircraft status: operational, in mission prep.

Modifications made in FY11:

- Installed new electrical bus for nose payloads; new plugs enable additional upgrades.
- Installed new electrical feedthrough for the wings and hardpoints for wing mounted sensors; this enables integration of payloads on the wingtips and wingtip anti-collision lights.
- Re-wired control panel; this provides better external control of payload power.
- Consolidated internal components; this makes more room for payload components such as data systems in the fuselage.
- Installed Mode C Transponder to satisfy FAA requirements for integration into NAS for upcoming FL mission.
- Began work on a mini-NASDAT to enable telemetry of navigation data as well as providing some payload data storage.



- We also fabricated an engine test stand to enable engine tuning and optimization to improve efficiency for longer-range flight.

Future missions include hyperspectral and carbon flux surveys over sea grass and coral reefs, magnetometer surveys in northern California, and volcanic plume sampling in Costa Rica. Planned or expected short and long maintenance periods in upcoming 5 years:

- Completed first 100 hour inspection and found no major structural discrepancies.
- Cylinder inspection is conducted after every flight.
- Ongoing inspections every 50 hrs including engine.

Cessna 206H

Aircraft manager: LaRC

Website: http://airbornescience.nasa.gov/aircraft/Cessna_206H

Science Flight hours in FY11: 101.5

Figure 35: The Cessna 206H.

Names and locations of missions flown:

- AMerican Icesat Glas Assessment of Carbon (AMIGA-Carb): LaRC, N. Myrtle Beach, SC, Bradford, PA, Huntington, WV, Windsor Locks, CT, Bangor, ME, Augusta, GA, DeKalb, GA, W. Lafayette, IN, Marquette, MI, Cuyahoga, OH
- EPA EMVIS: NE North Carolina from LaRC
- Goddard's LiDAR, Hyperspectral, and Thermal airborne imager (G-LiHT) Mid-Atlantic Campaign: LaRC

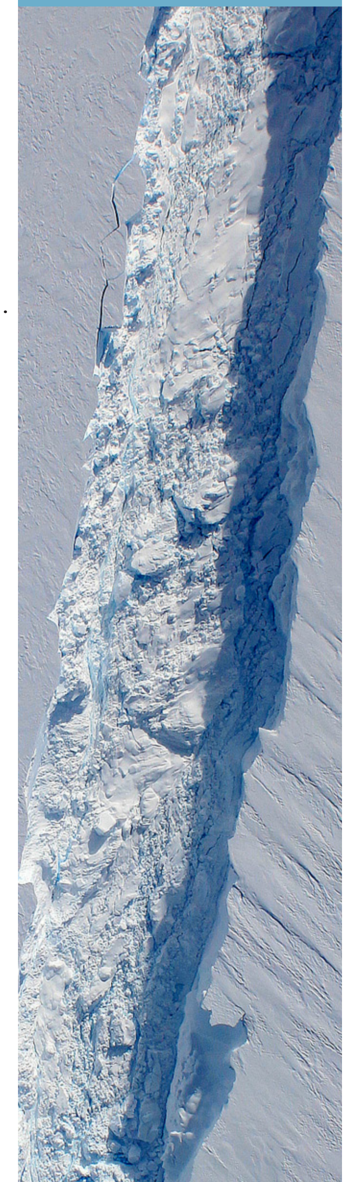
Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status: operational

Modifications in FY11: Designed, fabricated and installed removable pod under right wing and removable leading-edge cuff to right wing. This enables aircraft to conduct low-speed/low-altitude remote sensing missions. It also provides additional research volume to that provided by the existing removable belly pod.

Planned or expected short and long maintenance periods in upcoming 5 years:

Aircraft requires annual inspections and periodic inspections based on accumulated flight hours. The annual inspections typically require four weeks. The periodic inspections are typically completed in a few days. All inspections are performed in house at NASA LaRC. There are no firm schedules for these inspections.



UC-12B

Aircraft manager: LaRC

Website: http://airbornescience.nasa.gov/aircraft/UC-12B_-_LARC

Flight hours in FY11: 163.8

Continued, page 42

Figure 37: The UC-12B .

Figure 36: The NASA Langley support team for the ASP aircraft (all catalog) is shown in front of the Hawker Beech UC-12B Huron. These personnel also support the B200, Cessna 206H and the new HU-25C.

Left to right: Noel J. West, Dale A. Clark, Michael S. Wusk, Dale R. Bowser, Ted Wilz, Robert T. White, Annie P. Wright, Ashton D. Brown, Cecil D. Mellanson, Carey D. Smith, J. Dean Riddick, Michael A. Basnett, and Mark R. Hinton.

UC-12B: Continued from page 41

Names and locations of missions flown:

- AID for ASCENDS 4: LaRC
- CALIPSO Night Cal/Val: LaRC
- Development and Evaluation of satellite Validation Tools by Experimenters (DEVOTE) on UC-12B: LaRC
- DISCOVER-AQ: Washington/Baltimore from LaRC
- EPA on UC-12B: LaRC

Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status: operational

Modifications in FY11: Transferred High Spectral Resolution Lidar (HSRL) from B200. This allows HSRL to be used on either B200 or UC-12B. Therefore, UC-12B can perform remote sensing as well as in situ sampling.

Planned or expected short and long maintenance periods in upcoming 5 years:

Aircraft requires annual inspections and periodic inspections based on accumulated flight hours. The annual inspections typically require four weeks. The periodic inspections are typically completed in a few days. All inspections are performed in house at NASA LaRC. There are no firm schedules for these inspections.

B-200 - LaRC

Aircraft manager: LaRC

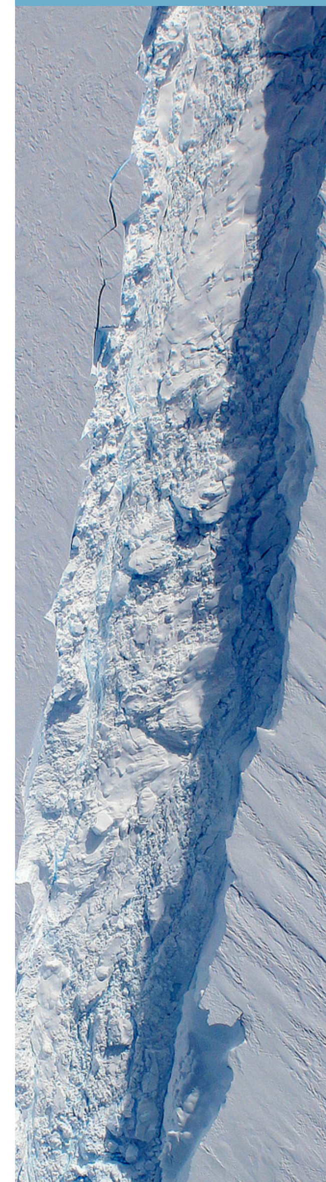
Website: http://airbornescience.nasa.gov/aircraft/B-200_-_LARC

Flight hours in FY11: 98.7

Names and locations of missions flown:

- Development and Evaluation of satellite Validation Tools by Experimenters (DEVOTE) on B200: LaRC
- Operation IceBridge (OIB): Kangerlussuag, Greenland

Figure 38: LaRC B-200.



Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status: operational

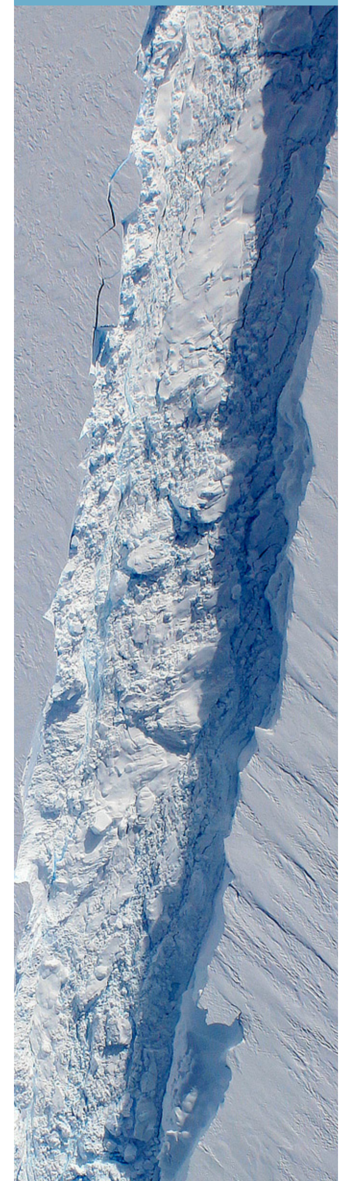
Modifications made in FY11:

- Installed removable isokinetic air inlet to top of fuselage.
- Transferred Aux. Meas. System from UC-12B.
- Installed optical window blanks in two aft windows.
- Installed removable venturis under the fuselage.
- Installed removable pylon under each wing.

These allow B200 to be used as complete in situ sampling platform or as a remote sensing platform.

Planned or expected short and long maintenance periods in upcoming 5 years:

Aircraft requires annual inspections and periodic inspections based on accumulated flight hours. The annual inspections typically require four weeks. The periodic inspections are typically completed in a few days. All inspections are performed in house at NASA LaRC. There are no firm schedules for these inspections.



B-200 - DFRC

Aircraft manager: DFRC

Website: http://airbornescience.nasa.gov/aircraft/B-200_-_DFRC

Flight hours in FY11: 25 hours.

Names and locations of missions flown:

All flights flown from DFRC.

- Autonomous Modular Sensor (AMS) integration and checkout
- Thermal imaging of Caves, Mojave
- Los Conchas Burned Area Emergency Rehabilitation (BAER) flights
- Western States Fire Mission (WSFM), Wildfires Disaster Support

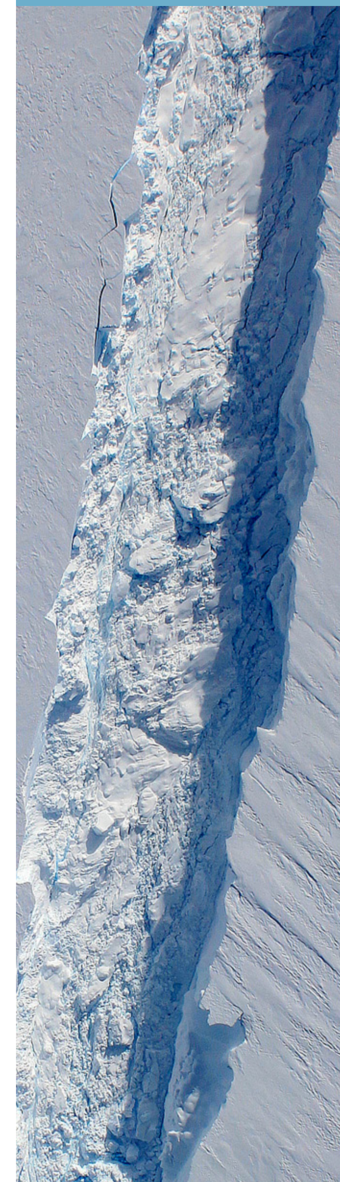
Figure 39: DFRC B-200.

Aircraft status, modifications made in FY11, impact of those improvements:

No SMD modifications were made in FY11.

Planned or expected short and long maintenance periods in upcoming 5 years:

Fall FY12 Phase 3-4 Months



Learjet 25

Aircraft manager: GRC

Website: http://airbornescience.nasa.gov/aircraft/Learjet_25

Science Flight hours in FY11: 11.7

Names and locations of missions flown:

> Airborne Lidar Surface Topography Simulator (ALISTs) – Cleveland, OH

Aircraft status, modifications made in FY11, impact of those improvements:

> Aircraft status: operational, currently flying NASA Aeronautics project

Planned or expected short and long maintenance periods in upcoming 5 years:

> Annual phase maintenance, 4-6 weeks, typically in Jan-Feb, can be moved.

Figure 40: Learjet 25.

Twin Otter - GRC

Aircraft manager: GRC

Website: http://airbornescience.nasa.gov/aircraft/Twin_Otter_-_GRC

Science Flight hours in FY11: 43.1

Names and locations of missions flown:

> PRISM modifications check flights; flown from GRC.

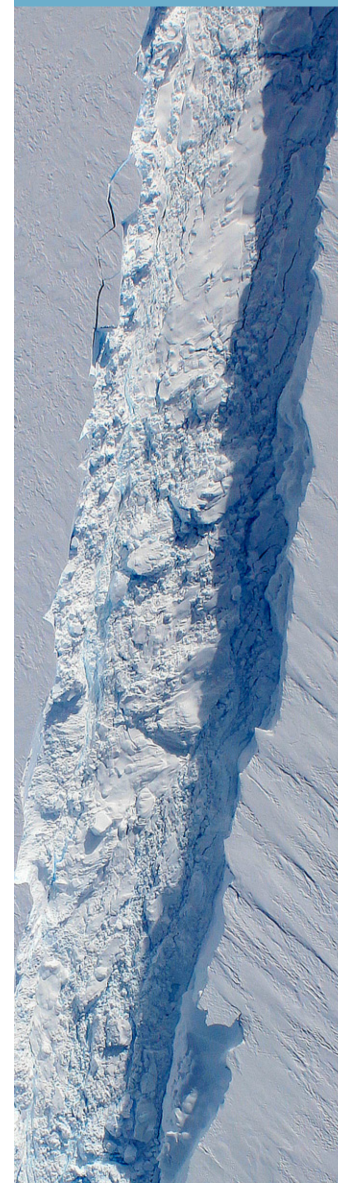
Aircraft status, modifications made in FY11, impact of those improvements:

> Aircraft status: Maintenance completed in December 2011.
>
> Modifications made in FY11:
> Nadir port mod, avionics upgrade; modifications allow for greater instrument/sensor carriage capability.

Planned or expected short and long maintenance periods in upcoming 5 years:

> 100 hour phase inspection, 3-4 weeks, varies with flight hours flown, can be moved.

Figure 41: GRC Twin Otter.



S3-B Viking

Aircraft manager: GRC

Website: http://airbornescience.nasa.gov/aircraft/S-3B

Science Flight hours in FY11: 0

Names and locations of missions flown:

No science missions flown in FY11.

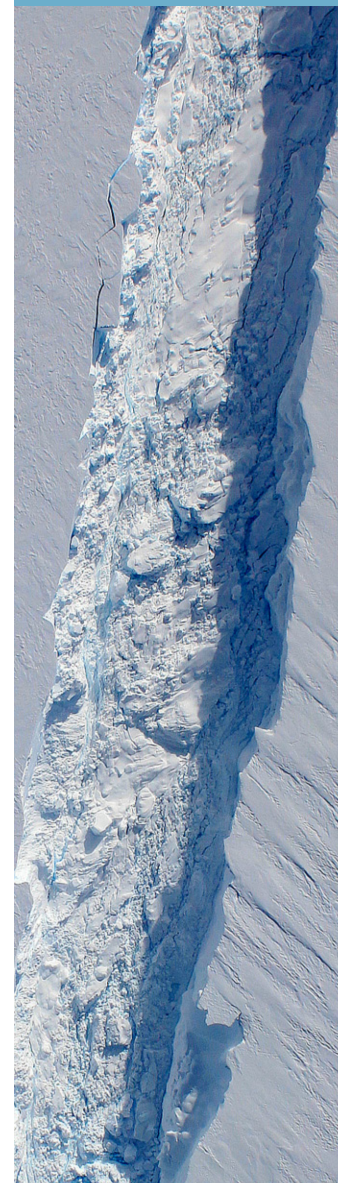
Aircraft status, modifications made in FY11, impact of those improvements:

Aircraft status: operational, currently flying NASA Aeronautics project.

Planned or expected short and long maintenance periods in upcoming 5 years:

Annual phase maintenance, 4-6 weeks, typically in Feb-Mar, can be moved.

Figure 42: GRC S3-B.



T-34C

Aircraft manager: GRC

Website: http://airbornescience.nasa.gov/aircraft/T-34C

Science Flight hours in FY11: 0

Names and locations of missions flown:

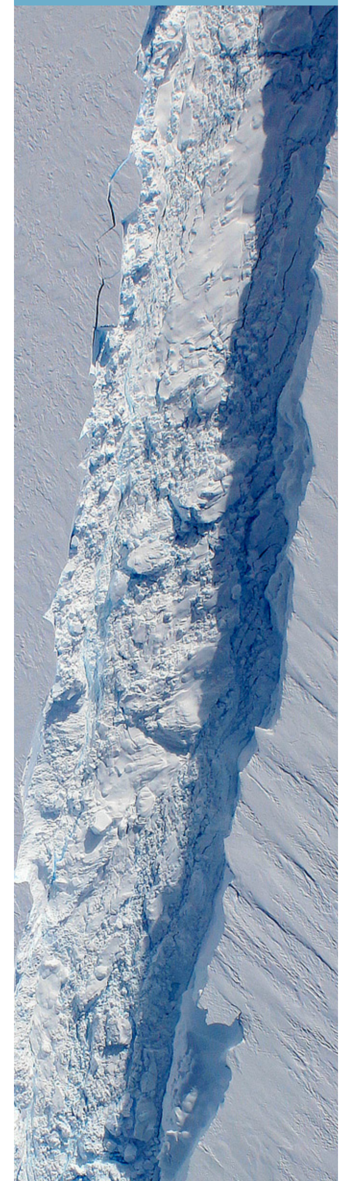
Aircraft status, modifications made in FY11, impact of those improvements:

> Aircraft status: currently down for maintenance.
>
> Modifications in FY11:
> Auto-pilot modification was performed to improve repeat path track capability.

Figure 43: GRC T-34C.

Planned or expected short and long maintenance periods in upcoming 5 years:

> 100 hour phase inspection, 3-4 weeks, varies with flight hours flown, can be moved.



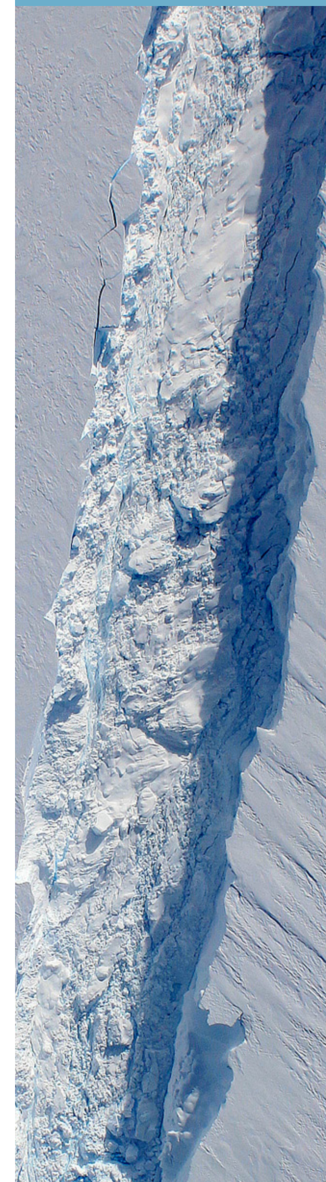
New Platforms

G-III (JSC) with P-band radar

Following the Earth Venture Initiative 1 selection of the AirMOSS mission, NASA ESD determined that access to another G-III aircraft was needed because it was not possible to reduce the number and duration of missions using and planning for the L-band UAVSAR on the DFRC C-20/G-III. The AirMOSS mission will carry a P-band radar and is projecting a 350 hour per year flight schedule; thus another platform was required. After looking into a few options, the Program accepted the JSC proposal to co-utilize the JSC G-III N992NA. This N992NA primarily supports the Astronaut Direct Return mission, but could be modified to support AirMOSS in between the direct return missions. (The direct return missions return US astronauts for medical processing after they return from the International Space Station on Soyuz spacecraft.) The G-III will be configured the same as the DFRC C-20 except where needed to enable easier reconfiguration back to the direct return mission. In 2011, the G-III team worked with the JPL UAVSAR and DFRC C-20 project teams to develop plans and designs for the AirMOSS mission on N992NA, seen in Figure 45. In late 2011 actual modifications were started with a plan to start flying the AirMOSS P-band UAVSAR in early 2012.

Figure 45: JSC G-III during installation of P-band SAR.

Figure 44: JSC's G-III UAVSAR aircraft TN992 with JSC, Dryden, and JPL team. Front Row (L-R): Richard Hang, Mike Robinson, Johnny Scott, Scott Leonard, Brittany Martin, Mike Brown, Carlos Meza, Roger Chao, Back Row (L-R): Matt Redifer, Bob Warren, Sean Clarke, Brian Strovers, John McGrath, Derek Rutovik, Mike Vandewalle, Tim Moes, Kean Tham.



Other new aircraft

In FY2011, ASP added two new reimbursable aircraft for Earth Science. NASA LaRC took possession of a Falcon derivative from the US Coast Guard, while NASA WFF obtained four Sherpa aircraft, one has been approved by SMD for activation for science missions.

“Falcon Aircraft” is a Dassault HU-25C Guardian

The HU-25C arrived at NASA Langley on October 20, 2011 following transfer from the U.S. Coast Guard. The aircraft is now undergoing a NASA acceptance inspection in preparation for participating in Operation IceBridge with the NASA Goddard Land, Vegetation and Ice Sensor (LVIS) as the research payload. This aircraft will have more capability than the B-200, which flew Operation IceBridge in 2011.

Figure 46 shows a Guardian in USCG livery with all of the external stores (none of which were provided by the USCG), as well as the plans for painting the aircraft in NASA colors. The closest civilian equivalent is the Dassault Falcon 20G.

The data for the Dassault HU-25C Guardian are as follows:

Service Ceiling = 41,000 ft
Max gross weight = 32,000 lbs
Best range speed = 415 KTAS
Distance traveled at cruise altitude = 2075 n.mi.
Best endurance speed = 360 KTAS
Duration = 5 hr
Research payload = ~4000 lbs
Researchers = 2-4

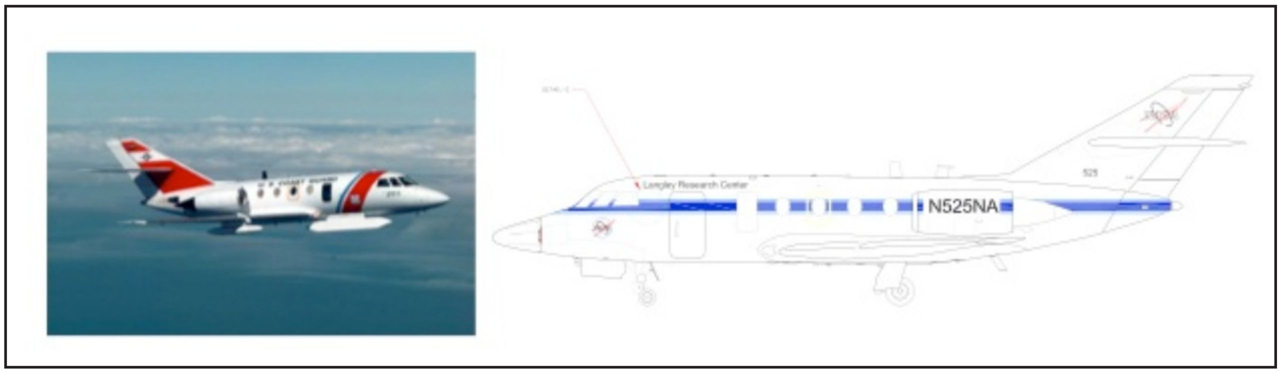
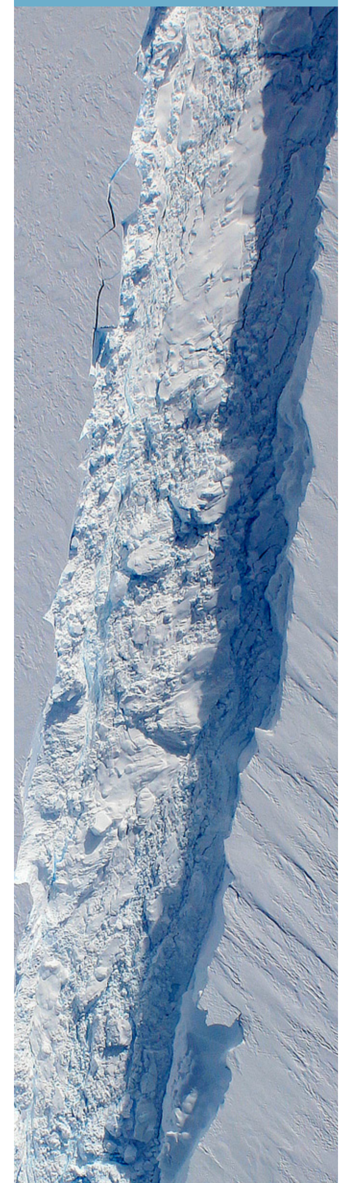


Figure 46: Falcon aircraft and planned paint scheme.



"C-23 Sherpa"

The NASA Goddard Space Flight Center's Wallops Flight Facility received four C-23 Sherpa aircraft, which are available to support airborne science research and other flight activities. At this time only one aircraft will be activated for use by the Airborne Science Program. The C-23 can be used to perform scientific research, provide logistics support on an as-needed basis to other airborne science or NASA missions, and can be used as a technology test bed for new airborne and satellite instrumentation. The C-23 is also able to support range surveillance and recovery operations as needed. The C-23 is a self-sufficient aircraft that can operate from short field civilian and military airports to remote areas of the world in support of scientific studies and other operations.

The C-23 is a two-engine turboprop aircraft designed to operate efficiently, under the most arduous conditions, in a wide range of mission configurations. The large square-section cargo hold, with excellent access at both ends (4 side fuselage doors and aft cargo ramp), and a 7000-pound payload, offers ready flexibility to perform a variety of missions. The aircraft also has 22 cabin windows as well as a nose cargo area available for installations. The Sherpa aircraft is shown in Figure 47.

C-23 Sherpa Specifications:

- Duration: 7 hours (payload and weather dependent)
- Useful Payload: 7,000 lbs
- Gross Take-off Weight: 27,100 lbs
- Onboard Operators: 10
- Max Altitude: 20,000 MSL
- Air Speed: 190 KIAS
- Range: 1,800 nm

During FY12 the Jet Propulsion Laboratory will be using a C-23 to support the Earth Venture -1 CARVE (Carbon in Arctic Reservoirs Vulnerability Experiment) mission. ■

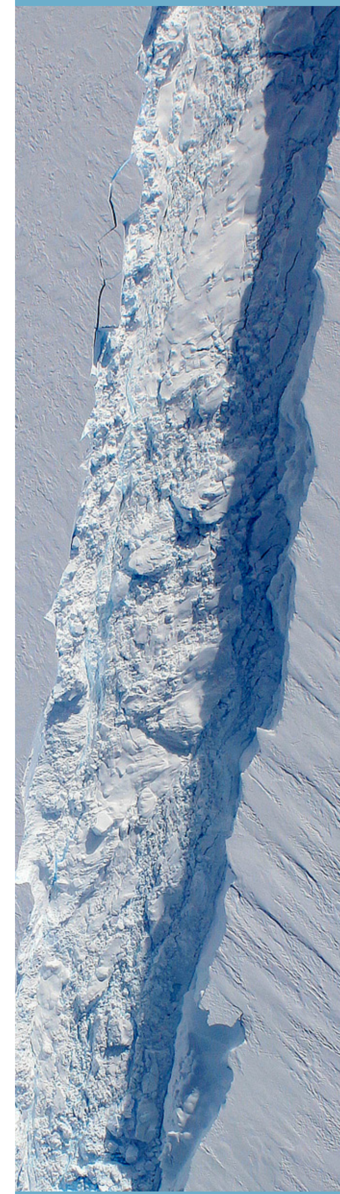


Figure 47: Sherpa aircraft.

Aircraft Cross-Cutting Support and IT Infrastructure

Aircraft support entails aircraft facility instrument operations and management, engineering support for payload integration, flight planning and mission management tools, flight navigation data hardware and software support, and flight data archiving and distribution In FY2011 the Program centralized cross-cutting aircraft support at the Ames Research Center with personnel at Ames and DFRC partners at the University of California (Santa Cruz), and the University of North Dakota (Grand Forks).

The Airborne Science Program provides facility instrumentation and science support systems for use by NASA investigators. Facility instruments include stand-alone precision navigation systems, digital tracking cameras, video systems, and suite of aircraft state parameter instruments including temperature, pressure, winds and more than 100 other variables. The Program also supports multi-spectral infrared sensors (jointly supported by the EOS Project Science Office) and other imaging devices that support multidisciplinary research applications.

Onboard Data Network Infrastructure

A state-of-the-art real-time data communications network is being implemented across the Airborne Science Program core platforms. Ethernet network upgrades and improved interfaces to satellite communications systems will maximize the science return from both single-platform

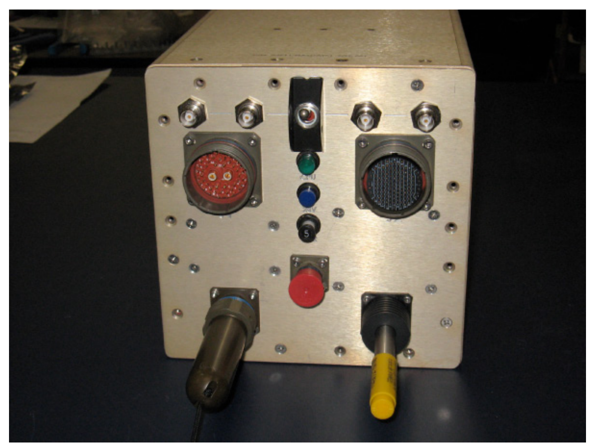
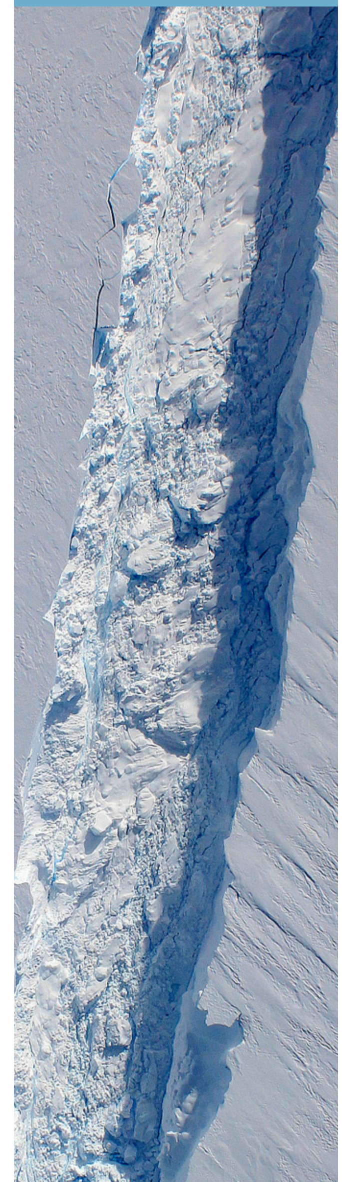


Figure 48: NASDAT, the new navigation data re-corder, network server, and Iridium gateway for all ASP platforms.



missions and complex multi-aircraft science campaigns. The sensor network architecture includes standardized instrument interface protocols, a new common Experimenter Interface Panel, and an airborne network server and satellite communication gateway known as the NASDAT (NASA Airborne Science Data and Telemetry system - the follow-on to the prototype REVEAL system, shown in Figure 48.) These capabilities became operational this year on the Global Hawk UAS, and are being incrementally implemented on the DC-8, P-3B, ER-2, and the WB-57 aircraft in 2012.

Early this year, a new data recording system was integrated with the P-3 aircraft systems, including avionics, satcom and facility instrumentation. Significant upgrades were also made to the facility instrumentation, including new cameras capable of higher resolution recording, a three-stage hygrometer capable of operating at extremely low temperatures and a new pyrometer for IR measurements of cloud tops and surface temperature.

Tests were successful, allowing inter-comparison of data from the new system with data from the legacy PDS (P-3 Data System), and the first airborne checkout of the aircraft satcom systems.

Satellite Communications Systems

Several types of airborne satellite communications (satcom) systems are currently operational on the core science platforms. High bandwidth Ku-Band systems, which use a large steerable dish antenna, are installed on the Global Hawk and Ikhana UAS. New Inmarsat BGAN (Broadband Global Area Network) multi-channel systems, using electronically-steered flat panel antennas, are now installed on many of the core aircraft. Data-enabled Iridium satellite phone modems are also in use on most of the science platforms as well. Although these have a relatively low data rate, unlike the larger systems, they operate at high polar latitudes and are lightweight and inexpensive to operate. Satcom systems are listed in Table 10.

Table 10: ASP Satcom types.

Satcom System Type	Data Rate (nominal)	Equipped Platforms
Ku-Band (single channel)	> 1 Mb/sec	Global Hawk & Ikhana UAS
Inmarsat BGAN (two channel systems)	432 Kb/sec per channel	DC-8, WB-57, P-3B, S-3B, DFRC, B200 (ER-2 in 2013)
Iridium (1 -4 channel systems)	2.8 Kb/sec per channel	Global Hawk, DC-8, P-3B, ER-2, WB-57, G-3, SIERRA, others

Significant benefits were realized from satcom upgrades made the DC-8 and P-3 over the last two years, in particular the INMARSAT BGAN systems. With the first check flight of the BGAN system on the P-3B conducted in January, the system was used extensively throughout the DISCOVER-AQ campaign. Although transmitting relatively low data rates, the significant increase in reliability from the high-power directional INMARSAT system over past Iridium based systems allowed for a much greater reliance on in-flight tracking and text-based chat systems than has been possible on previous campaigns. This reliability was particular impressive in light of the large percentage of the DISCOVER-AQ campaign spent in vertical profiles.

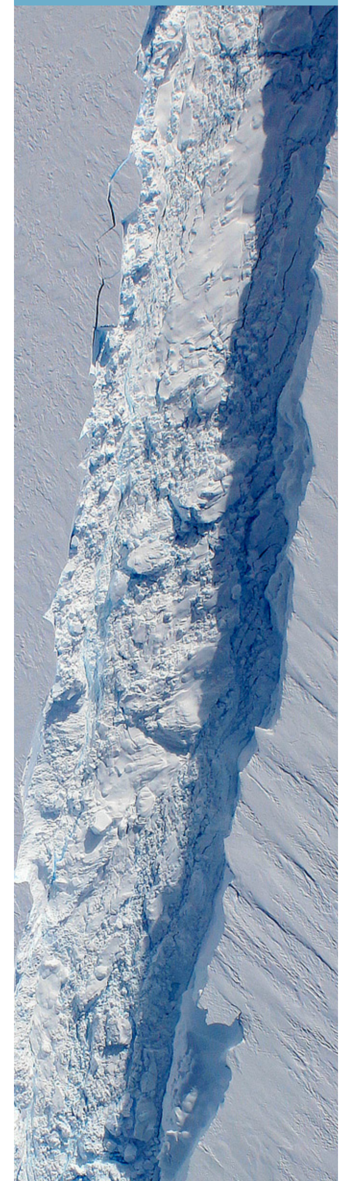
The INMARSAT was also used effectively aboard the NASA DC-8, and played a significant role in relaying rocket telemetry during the Glory launch. The availability of the system allowed for an easy transition for the K-Tech engineering team when their primary aircraft was unavailable due to launch delays. The BGAN system was also used for the first time this year to transmit the DC-8 track and telemetry data that has traditionally gone via Iridium. A dual-system approach has allowed network staff to route around infrastructure problems and provide a higher level of communication reliability in the air.

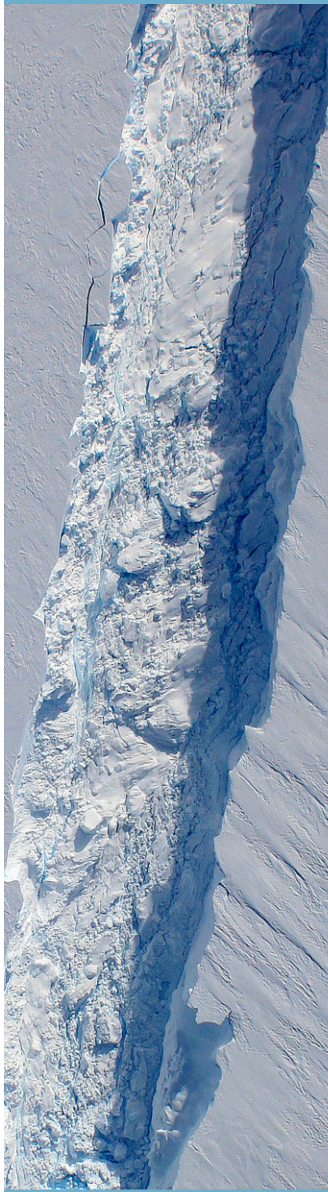
Iridium SATCOM

A new Iridium modem bank was installed at NASA Ames to support existing multi-channel Iridium systems and the new NASDATs. This modem bank was used for the first time during the fall Operation IceBridge deployment for tracking of both the NASA DC-8 and NCAR G-V during Antarctic operations. The installation includes a data storage and access system similar to what was designed for the NASA Global Hawks, allowing for easy integration of data into ASP Mission Tools and third party software. Existing multi-channel Iridium systems were also upgraded with newer modems to improve system reliability and failure detecting.

XM Radio

The NASA DC-8 and P-3B have both been equipped with XM Radio Antennas and receivers allowing for reception of aviation related weather products including satellite images, NexRAD radar data, winds aloft and METAR data when located over the continental United States. Although not a fundamentally new capability, the use of XM Radio provides a wide array of products at a considerably lower cost than would be involved with retrieving them through other two-way satcom systems.





Facility Instruments

Additional facility instruments as well as High Definition cameras have been added to airborne science platforms this year. High accuracy AIMMS-20 3-dimensional winds and air data systems have been purchased for the P-3B as well as two of the Global Hawks. 3-stage hygrometers have been rigorously tested and implemented into the data systems on both the DC-8 and P-3B platforms. Data from the DC-8 pyrometer became of large interest to the sea ice community during Ice Bridge this year. The ability of the pyrometer to be sampled at higher frequencies will aid researchers in detecting leads or stretches of open water in the sea ice.

In addition, high definition cameras were purchased for both the DC-8 and P-3B; over 250 hours of full frame rate, high definition video was recorded on the DC-8 during the IceBridge 2011 campaign in Antarctica. This system is currently scheduled to be implemented on the P-3 for the Spring 2012 OIB Campaign. The complete complement of ASP facility instruments is listed in Table 11. Table 12 lists EOS instruments that are jointly managed by ASP.

Table 11: Airborne Science Support Instruments.

Instrument / Description	Supported Platforms
DCS (Digital Camera System) 16 MP natural color or color infrared cameras	B200, DC-8, ER-2,Twin Otter, WB-57
DMS (Digital Mapping System) 21 MP natural color cameras	DC-8, P-3B
POS AV 510 (3) Position and Orientation Systems DGPS w/ precision IMU	B200, DC-8, ER-2, Ikhana UAS, P-3B
POS AV 610 (2) Position and Orientation Systems DGPS w/ precision IMU	DC-8, P-3B
HDVIS High Definition Time-lapse Video System	Global Hawk UAS
LowLight VIS Low Light Time-lapse Video System	Global Hawk UAS

Table 12: EOS Airborne Science Instruments

Instrument / Description	Supported Platforms
MASTER (MODIS/ASTER Airborne Simulator) 50 ch multispectral line scanner V/SWIR-MW/LWIR	B200, DC-8, ER-2, WB-57
Enhanced MAS (MODIS Airborne Simulator) 38 ch multispectral line scanner V/SWIR-MW/LWIR	ER-2 (4Q FY2012)

The MASTER and AVIRIS sensors were used extensively in 2011 to map recovery in the Gulf of Mexico, as shown in Figure 49.

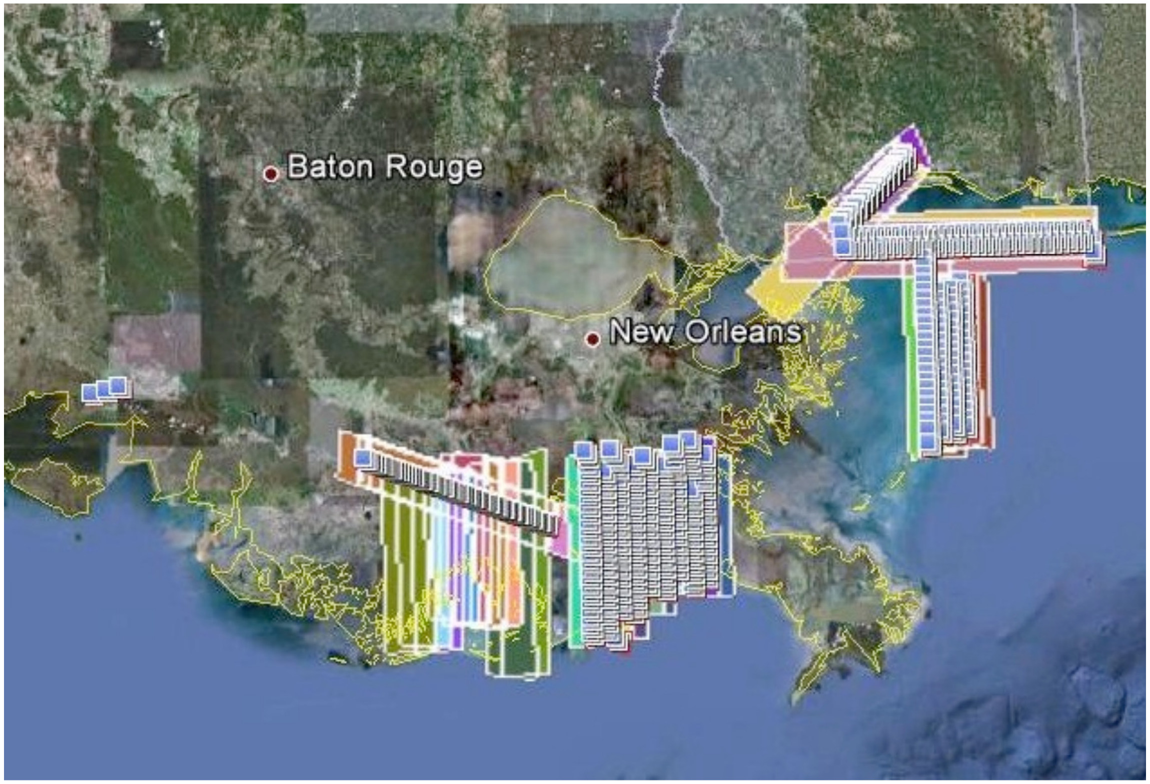


Figure 49: Compilation of all ER-2 MASTER, AVIRIS, and DMS flight tracks for the Gulf Coast Oil Spill recovery study flown in August 2011.

New Sensor - PRISM

The Portable Remote Imaging Spectrometer (PRISM) completed its second year of development in October 2011. PRISM is an airborne instrument specially designed for the challenges of coastal ocean research, intended to become a NASA facility instrument. PRISM comprises an imaging spectrometer covering the

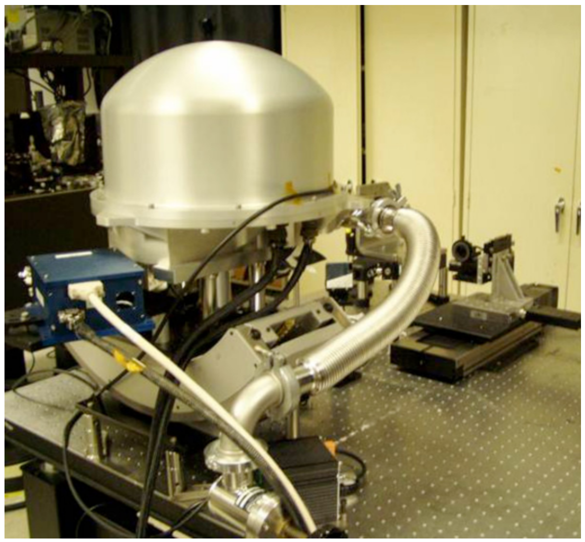


Figure 50: PRISM.

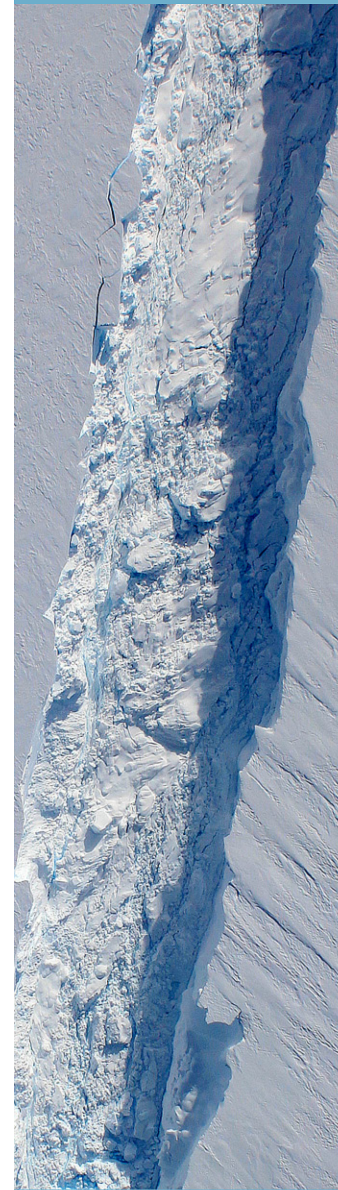
350-1050 nm range and a separate two-channel short-wavelength infrared (SWIR) radiometer at 1240 nm and 1610 nm to aid with atmospheric correction. PRISM will be the first high-throughput and high-uniformity Dyson imaging spectrometer to operate in the visible near IR spectral range. It incorporates unique JPL technologies including a broadband, concave, low-polarization grating, and a lithographically formed slit on low-scatter substrate. At the end of the second year, the instrument entered the final integration and testing phase. Optomechanical subassemblies were completed and integrated with electronics and thermal control. Laboratory characterization takes place in January 2012, followed by first calibration flight in March, and a science investigation over the Monterey Bay area in July 2012. The laboratory instrument is shown in Figure 50.

On-board Data Displays

New touch screen display systems have been acquired for the DC-8 and P-3B, replacing older, lower resolution systems with single piece, lightweight, low cost units. A two-pronged approach was taken, purchasing both large 15-inch units and smaller android based tablets with rack mount hardware. The tablets have the ability to be mounted in experimenter racks, taking up considerably less space then the 15-inch units, allowing for mounting in space and weight constrained installations.

ASP Mission Software Toolset

The Airborne Science Program has built a suite of web-based enterprise management capabilities and improved situational awareness tools to freely support Airborne Science Missions of any size. The ASP mission toolset presents the companion ground segment to the upgraded network and computing hardware, which together enables enable high-speed satcom of aircraft parameter and instrument data during flight missions.



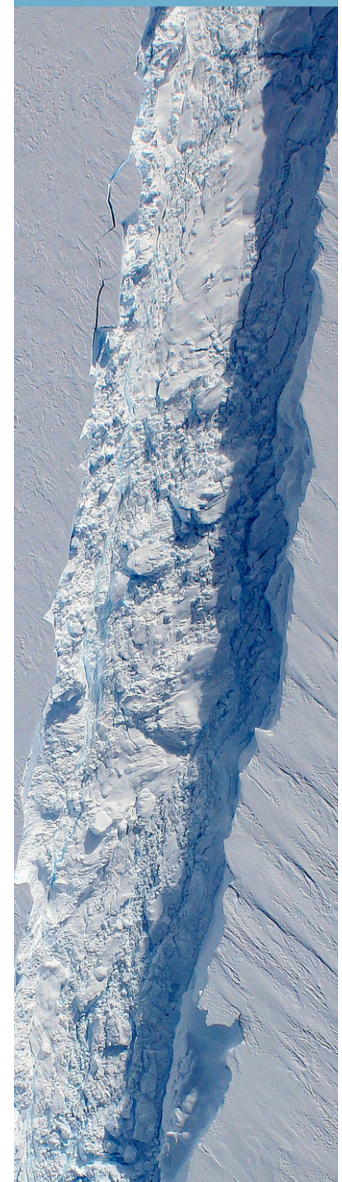
The ASP mission tools target a number of key objectives based upon user requirements.

- First, deliver a common operating picture for improved shared situational awareness to all participants in NASA's Airborne Science missions. These participants might include scientists, engineers, managers, and the general public.
- Second, encourage more responsive and collaborative measurements between instruments on multiple aircraft, satellites, and on the surface in order to increase the scientific value of these measurements.
- Third, provide flexible entry points for data providers to supply data products and model runs to mission team members before and during a mission while providing a mechanism to ingest, search and display related data products.
- Lastly, embrace an open and transparent platform where common data products, services, and end user components can be shared with the broader scientific community.

Core components now include an enterprise portal, a tool for tracking aircraft and for accessing and displaying data products, communication and collaboration tools, and tools for file sharing.

The early introduction of mission tools supported a strategic objective to involve the user community early in the product's development lifecycle. Early feedback from several members of the Earth Science Project Office (ESPO) and Goddard Earth Sciences and Technology (GEST) Center advanced the release of an early beta, which was successfully introduced into operations supporting both the Hurricane and Severe Storm Sentinel (HS3) and the Airborne Tropical Tropopause Experiment (ATTREX) for their 2011 campaigns.

Figure 51 shows real-time aircraft tracking with NOTAM information overlay, along with the live Global Hawk high definition camera feed. As illustrated in Figure 52, the toolset provides three-dimensional views (Google Earth) and two-dimensional tools to support a wide range of browsers and operating platforms. ■



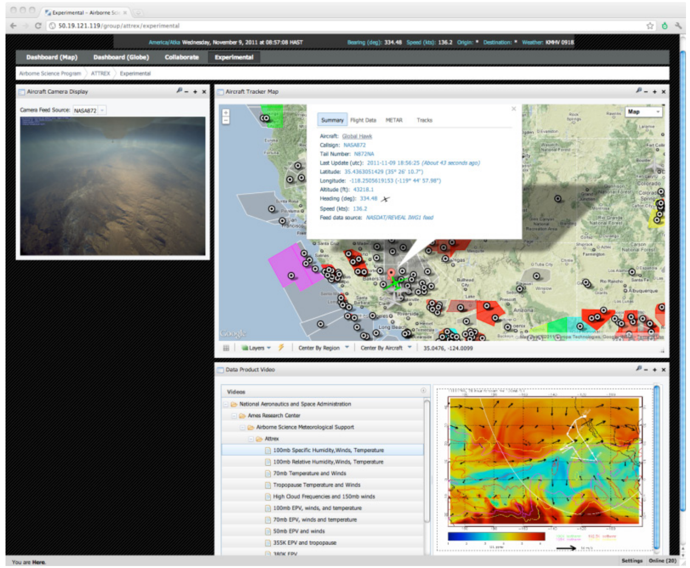
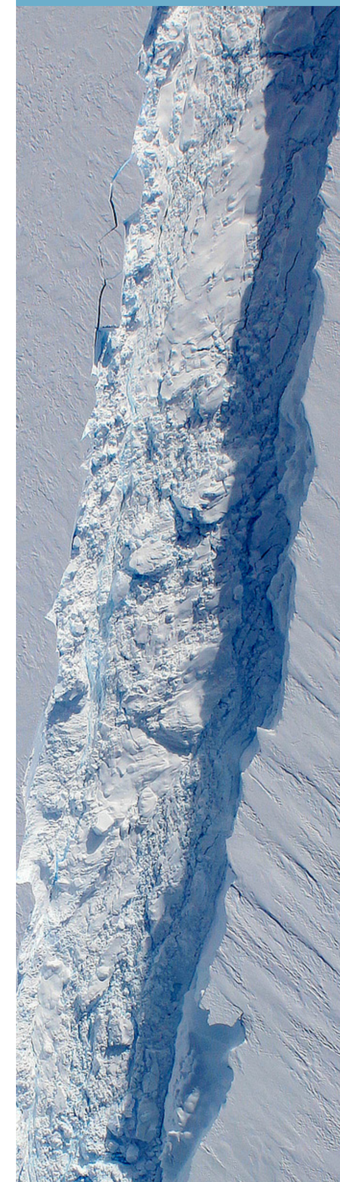


Figure 51: Real-time aircraft tracking with NOTAM information overlay, along with the live Global Hawk high definition camera feed.



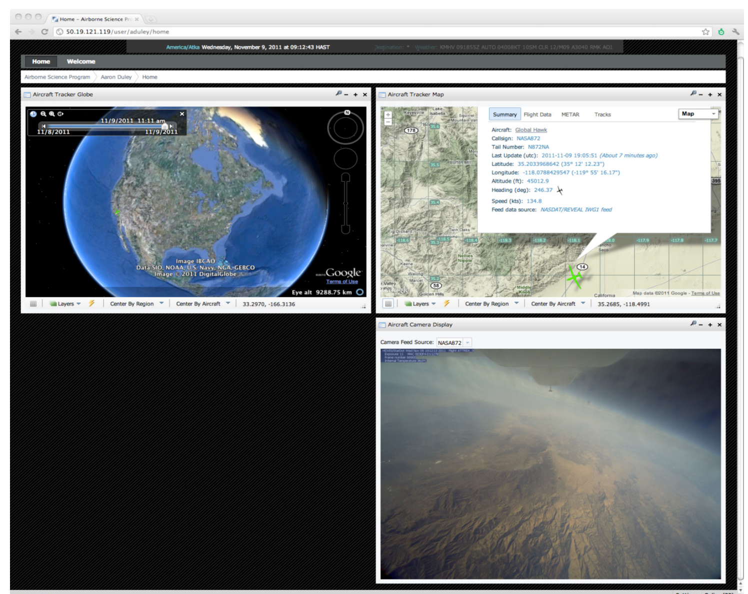


Figure 52: Screen shot showing Google Earth, tracking map, and camera view.

Strategic Planning

The Airborne Science Program maintains and operates a diverse fleet of aircraft, people and infrastructure that support a varied and evolving stakeholder community. ASP leadership conducts a yearly strategic planning meeting in order to ensure the program maintains currently required capabilities, renews these assets and as new technologies become available, and extend the observational envelope to enable new earth science measurements. The program also plans strategically by looking at past experiences through formal meetings to discuss lessons learned following all major campaigns.

Requirements for Program assets are collected and communicated through the program flight request system (http://airbornescience.nasa.gov/sofrs) the annual 5-yr schedule update, and through ongoing discussions with Mission and Program managers and scientists.

ASP Vision:

> Building on our Airborne Science Program foundation, to continually increase our relevance and responsiveness to provide airborne access to the Earth Science community.

Program Mission Statement:

> ASP enables Earth Science researchers and scientists to improve society's understanding of Earth system science by providing a pre-eminent suite of airborne capabilities that meet NASA Earth science requirements.

Strategic planning in the program is focused on the following areas:

- Core Aircraft – maintenance, upgrades, determining future composition;

- Observatory management - improved tools for managing assets and requirements while improving the service to science investigators; and

- New Technology – bringing new technologies to observational challenges including application of advanced telemetry systems, on-board processing, IT mission tools, and new platforms.

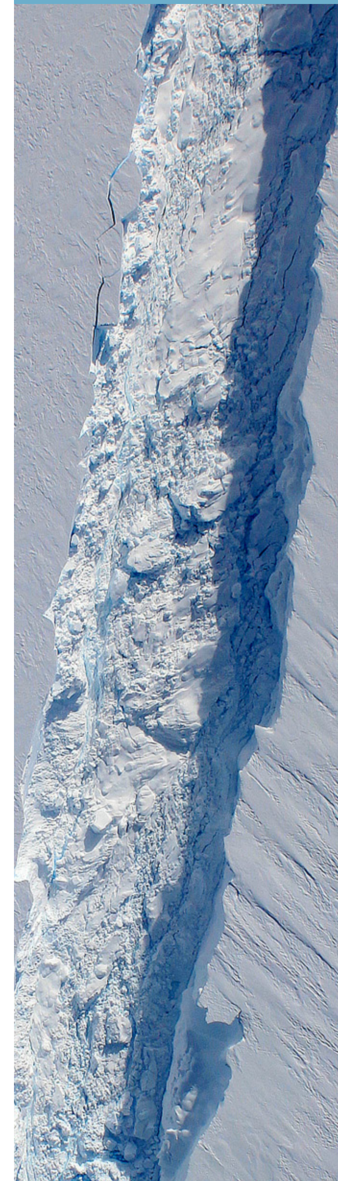
ASP accomplishes its mission by:

- Fostering a team of energetic, safety conscious, and customer-focused experts;
- Ensuring the capabilities it offers are safe, affordable, robust, modern, and meet the needs of the Earth science community;
- Continuously improving the relevance and responsiveness of airborne capabilities for the Earth Science community.

In FY2011 the program focused on several important strategic goals to achieve balance during uncertain environment. The first was to continue to provide the capability to collect data at varying suborbital conditions. Refine baseline estimates of personnel required for different levels of operation, especially given longer endurance missions on unmanned systems. The Program launched a new initiative to increase cross-Center sharing of aircraft and ground support equipment. Personnel from other agencies are also being sought to fill critical roles in the program as they evolve on a mission-by-mission basis. The other important goal is to improve our direct service to science through integration engineering support and improved instrument accommodations on the aircraft including data and telemetry systems.

Satellite support requirements

The ASP requirements analysis team maintains a database of known and projected airborne support requirements for Earth Science satellite missions. ASP flies calibration and validation (cal/val) flights for ongoing satellite missions, especially the A-Train and Calipso, and recently launched satellites such as Aquarius and Suomi NPP. Foundational missions and decadal survey missions scheduled for launch between now and 2020 have ongoing algorithm development and cal/val requirements, which will drive ASP airborne activities and strategic planning. In addition, satellite instrument development requirements (prototypes and/or simulators), as well as new instruments for process studies will drive ASP strategic planning and requirements to fly on ASP assets. An overview of the known requirements is shown in Figure 53 (page 62).



Five-Year Plan

A five-year plan is also maintained by the Program. A graphical copy is shown in Appendix B (page 71), depicting plans by science area and aircraft platform. Significant maintenance periods for the various aircraft are also indicated. ■

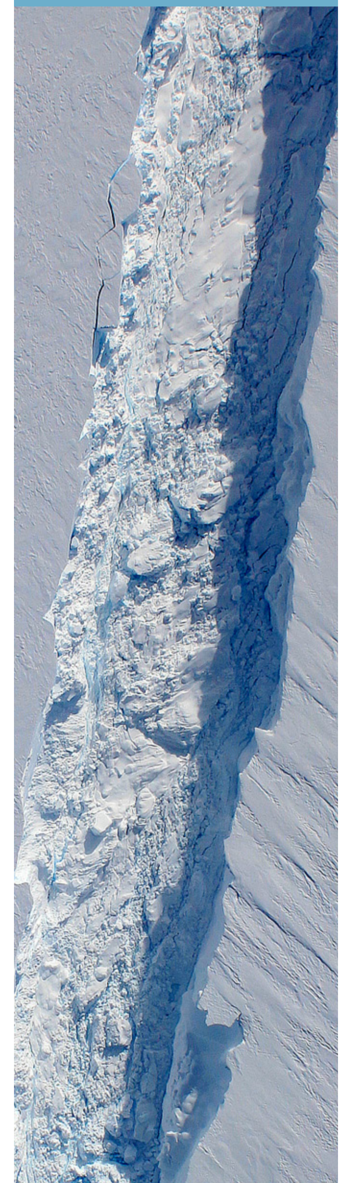
NASA Airborne Science Program supporting upcoming foundational and Decadal Survey Missions	Aquarius	NPP	LDCM	OCO-2	GPM	SAGE-III	GOES-R	CLARREO	SMAP	ICESat-II	Earth Radar Mission	Hyspiri	ASCENDS	SWOT	GEO-CAPE	PACE	ACE	LIST	PATH	GRACE-II	SCLP	GACM	3D-Winds
DC-8				■	■	■				■			■ ● red ● red ● red		■ ● blue	■	■ ● yellow						■ ● red ● red
ER-2		■			■	■	■	■ ● yellow		■		■				■	■ ● blue ● yellow ● red						■ ● yellow
WB-57															■ ● red							■ ● red	■ ● red
P-3	■								■	■	■ ● blue		■ ● red ● red ● red		■ ● yellow	■	■ ● yellow				■ ● blue		
G-III / UAVSAR											■ ● yellow	■			■ ● yellow								
Lear 25								■ ● red					■ ● blue ● red					■ ● red					
B-200			■										■	■ ● blue ● yellow	■								
Global Hawk					■					■	■ ● blue		■ ● blue	■									■
Ikhana										■													
SIERRA					■				■		■		■		■								
Twin Otter									■		■	■			■								

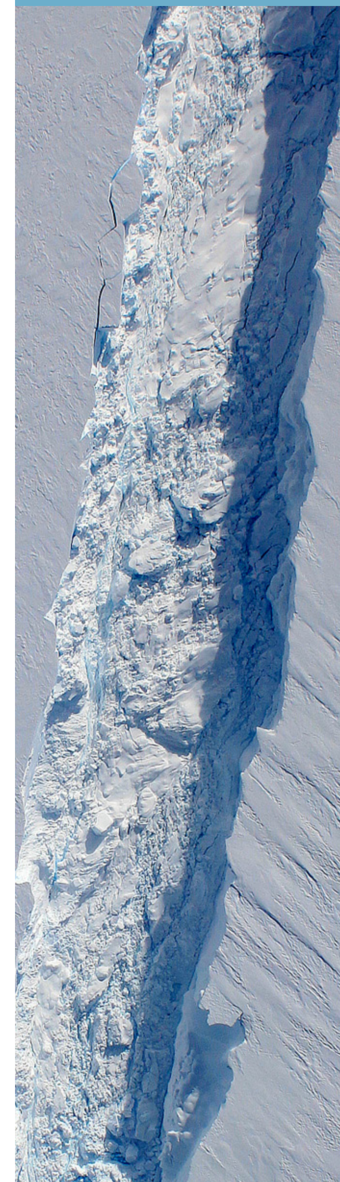
● (red) - Instrumnet Incubator Program 07-funded instruments

● (yellow) - Airborne Instrument Technology Transition-funded instruments

● (blue) - Instrumnet Incubator Program 10-funded instruments

Figure 53: This matrix shows how ASP aircraft support various future satellite missions as well as the testing of new instruments that are aligned with these missions.





Education, Outreach, and Partnerships

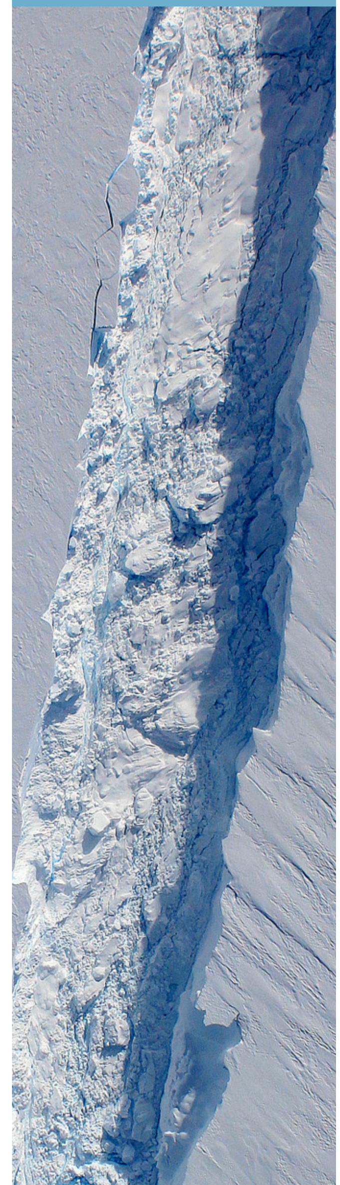
SARP

The third NASA/NSERC Student Airborne Research Program (SARP) was held during June and July 2011. The 6-week program was designed to expose and engage advanced undergraduate and early graduate students to NASA research and airborne science and engineering. The program was based at both the University of California Irvine, for the lectures and data analysis, and at the NASA Dryden Aircraft Operations Facility in Palmdale, CA for the preparation and execution of four 3-hour research data flights.

The program contained the following elements:

- An introductory student poster session. The 29 participants (shown in Figure 54) from 28 different universities in 20 states (shown in Figure 55, page 64) presented their varied research interests to other participants, lecturers, and SARP faculty and staff.
- Lectures on NASA research programs, the Airborne Science Program, instrumentation, meteorology, atmospheric chemistry research, remote sensing techniques, oceanography, agricultural practices, instrument integration, airborne data systems, and sustainability and the environment.

Figure 54: 2011 SARP Students with the DC-8.



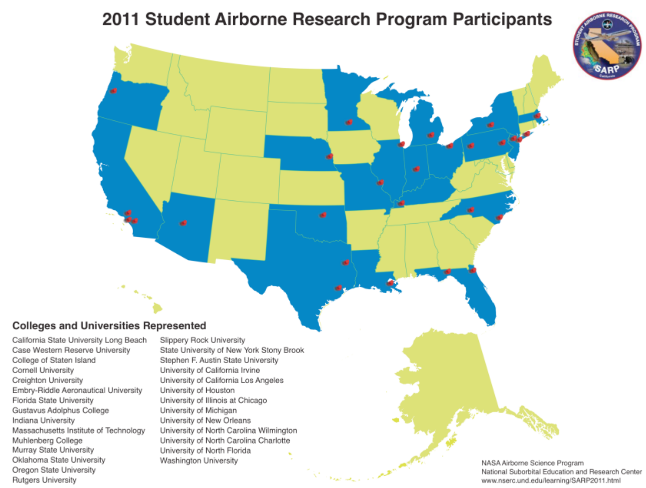


Figure 55: Locations of Colleges Represented in the 2011 SARP Program.

- Experiences with instrument integration, flight planning, and data collection on four three-hour science flights on the NASA DC-8.
- Research projects included atmospheric science, oceanography, and land use topics.
- Atmospheric effects of emissions from waste-water treatment plants in the Los Angeles basin and from large commercial dairies in the California Central Valley
- Distribution and abundance of giant kelp and algal blooms in Santa Barbara Channel
- Evapotranspiration from almond orchards and row crops in the California Central Valley.
- Multispectral remote sensing and in situ sampling techniques were employed.
- Field trips for ground truth validation of the airborne measurements.

Outreach: International Symposium on Remote Sensing of the Environment (ISRSE)

As in previous years, NASA provided support to the premier international conference on remote sensing that combines airborne activities with space-based science. The 34th ISRSE was held in Sydney, Australia in April 2011. NASA SMD set up an exhibit that included a hyperwall, scheduled talks, and display and hand-out information from all programs within Earth Science.

The Airborne Science program supported the symposium with numerous presenters and session chairs, as well as participants in side meetings of the ISPRS and other groups.

In addition to hearing what others are doing the symposium provided a venue for telling others about airborne science.

There could be no better illustration that people are listening to airborne than the fact that a paper on Airborne Science ("Airborne Remote Sensing in Australia Using Small Modern, Highly Efficient Platforms-Capabilities and Examples." By Jorg Hacker, Flinders University, Australia.) was judged the best Oral Paper at the symposium (selected by a committee of predominately space remote sensing researchers).

Partnerships

ISPRS WGl-1 Standardization of Airborne Platform Interface

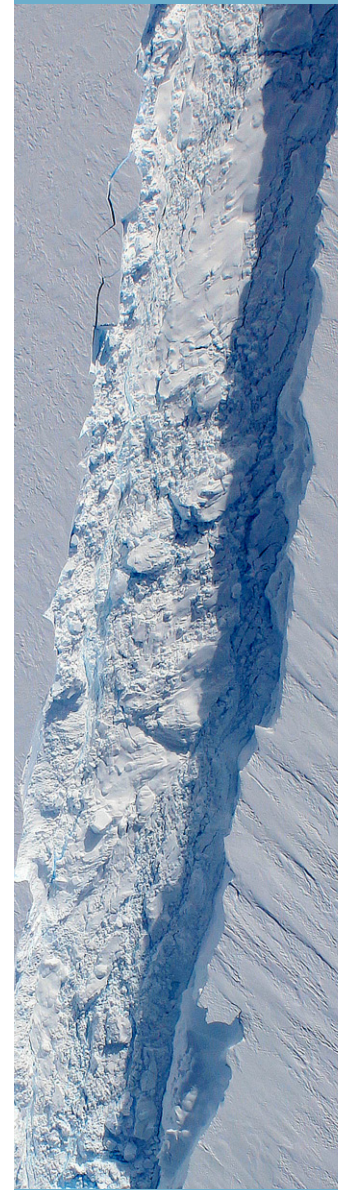
NASA Airborne Science is a long-time member of the International Society for Photogrammetry and Remote Sensing (ISPRS). The primary mission of Working Group I/1 seeks to promote the standardization of instrument interfaces, data formats, and aircraft accommodations, to facilitate more efficient, flexible, and cost-effective international science flight operations.

The Working Group has now completed over 2 1/2 years of activity with good progress overall in building international relationships for the airborne science communities. We have expanded or combined some of the standards or guidance that is used in the different agencies that operate airborne science programs. The subgroups, working under 11 "Terms of Reference" (TORs), have participated in over 15 international meetings and conferences during this period. Our most recent combined meeting was in April 2011 at ISRSE34, Sydney Australia.

ICCAGRA, TFUS, AMAP

The Airborne Science Program (ASP) continued its involvement in many interagency committees and forums in 2011. Of particular note are the Interagency Coordinating Committee for Airborne Geoscience Research Applications (ICCAGRA), the Task Force for Unmanned Systems (TFUS), and the Arctic Monitoring and Assessment Program's (AMAP) UAS Expert Group, in each of which ASP has taken a leadership role.

Co-led by the United States (NASA ASP) and Norway (NORUT), the AMAP UAS Expert Group continues to make progress towards improved access to Arctic airspace for UAS science research and environmental



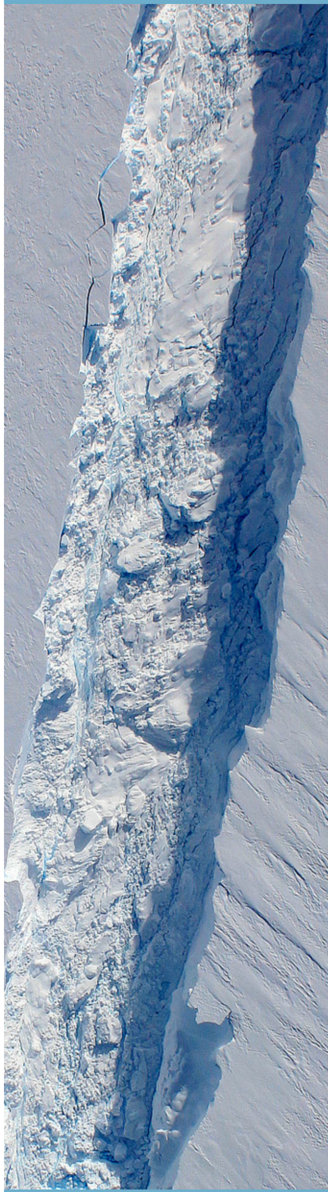
Appendix A: ASP Historical Perspective

By Earl Peterson

In a continuing effort to capture and share the evolution of the NASA's Airborne Science Program, we are compiling the historical highlights and perspectives that molded our history.

Pursuant to that goal, Jim Weber, with Matt Fladeland and Randy Albertson caught up with, and interviewed long time airborne science operations stalwart Earl Peterson at AGU in December 2009.

This summary, contributed by Steve Wegener, attempts to highlight some of the important activities and contributions that occurred during Earl's tenure at Ames. The Interview is 35 pages long, and it is tricky to distill such a rich history into these few pages. Fortunately many of the readers of this ASP Annual Report have an understanding of the scope of the Airborne Science Program, and can appreciate many of Earl's challenges in context. Besides the content of the interview, I was fortunate to work with Earl starting shortly after he returned from the first ozone mission to the Antarctic. Earl was a friend, and a smart and resourceful colleague, with a really dry sense of humor, who was a tireless advocate for safe and productive airborne science missions. I've supplemented the material in the interview with my personal perspective to provide some additional context. I encourage you visit the ASP history page to download Jim's interview and enjoy a more intimate insight into the program than I'm able to capture here.



Earl's tenure

Earl Peterson came to Ames in 1967 to help develop sensor systems for the Convair 990 (later named Galileo), and retired as the last Ames aircraft was consolidated at Dryden in 1998. During his tenure Earl was a key player in the development and operation of the Ames airborne science activities over thirty years. He did almost everything, including; sensor development, integration, test and operation; mission planning, mission management; growing into flight operations management coordinating aircraft, pilots, maintenance and flight operations. Earl wasn't load or pushy, but he did represent the institution that provided safe, efficient and productive airborne science missions for NASA (both Earth and space science) and fostered a healthy reimbursable activity). Earl's organizational skills, rich operational heritage, and personal tenacity shaped the evolution the Ames aircraft activities, and many aspects of the larger Airborne Science Program.

As NASA focused on new and evolving science priorities in the 1960s, the value of airborne missions became apparent. From an astronomy perspective, high flying platforms provide observations largely unencumbered by Earth's atmospheric effects. It became apparent that airborne platforms provided great observational opportunities, and were versatile and cost effective platforms for new satellite sensor development. The emerging Earth Science community, striving to understand the our planet as a system, from the unique vantage point of space, embraced observations from aircraft as a means to better understand the physical processes driving our ecosystem. Earth scientists also found flying senor prototypes on aircraft lower the cost and risk of developing new satellite payloads.

Ames has always been a leader in airborne science. Ames led early airborne investigations in space science, in particular, high altitude astronomy missions studying solar eclipses as early as 1963. The mission was so successful, space scientists pressed Ames management and headquarters for the purchase of a science laboratory aircraft resulting in the acquisition of the two Convair 990 aircraft. This foundation evolved into an institutional expertise in organizing and conducting safe, successful and productive airborne science investigations for space and Earth science communities. Earl Peterson played a key part in the creation of that capability at Ames.

Earl came to Ames in 1967, working with Ames astronomer Dr Mike Bader and Meteorologist Dr Bill Nordberg at Goddard. This work with the Convair 990 laboratory laid the foundation for an airborne science capability that grew into a sizeable fleet that included the early Convair 990s, the DC-8, 6 U-2s, a C130B, a T-38 for pilot proficiency flights, and the astronomy aircraft including Lear jets, the C141 Kuiper Airborne Observatory (KAO) and 747 SOFIA - Stratospheric Observatory for Infrared Astronomy.

The Convair 990 flew many solar investigations, in addition to imaging comets, meteor showers, and planets. The CV-990 was active from 1965 to 1973, when tragically the aircraft and everyone onboard were lost in a mid-air collision with a P-3 while attempting to land at Moffett Field, CA. NASA replaced the Galileo with another CV-990, called Galileo

II, which was used very little for airborne astronomy, as by then, the Learjet and the Kuiper Airborne Observatory were in operation.

NASA's DC-8 came on in a white heat in 1978, outfitted in a hurry to support the Airborne Antarctic Ozone Experiment (AAOE) to help characterize ozone loss over the South Pole. This included converting the newly acquired DC-8-62 to the -72 for extended range and higher altitude. The payload integration was a challenge with all new instruments, many systems needing access to free stream air. The extended range of the DC8 brought challenges with ten to twelve hour flight time. The duty day needed to be extended to fourteen hours, allowing two crews to do back-to-back eleven-hour missions from Punta Arenas, Chile.

Ames hosted testing on a considerable amount of shuttle hardware, much of it through the Airborne Science Program. Prototypes of many of NASA's Earth observing instruments were test flown on ASP aircraft

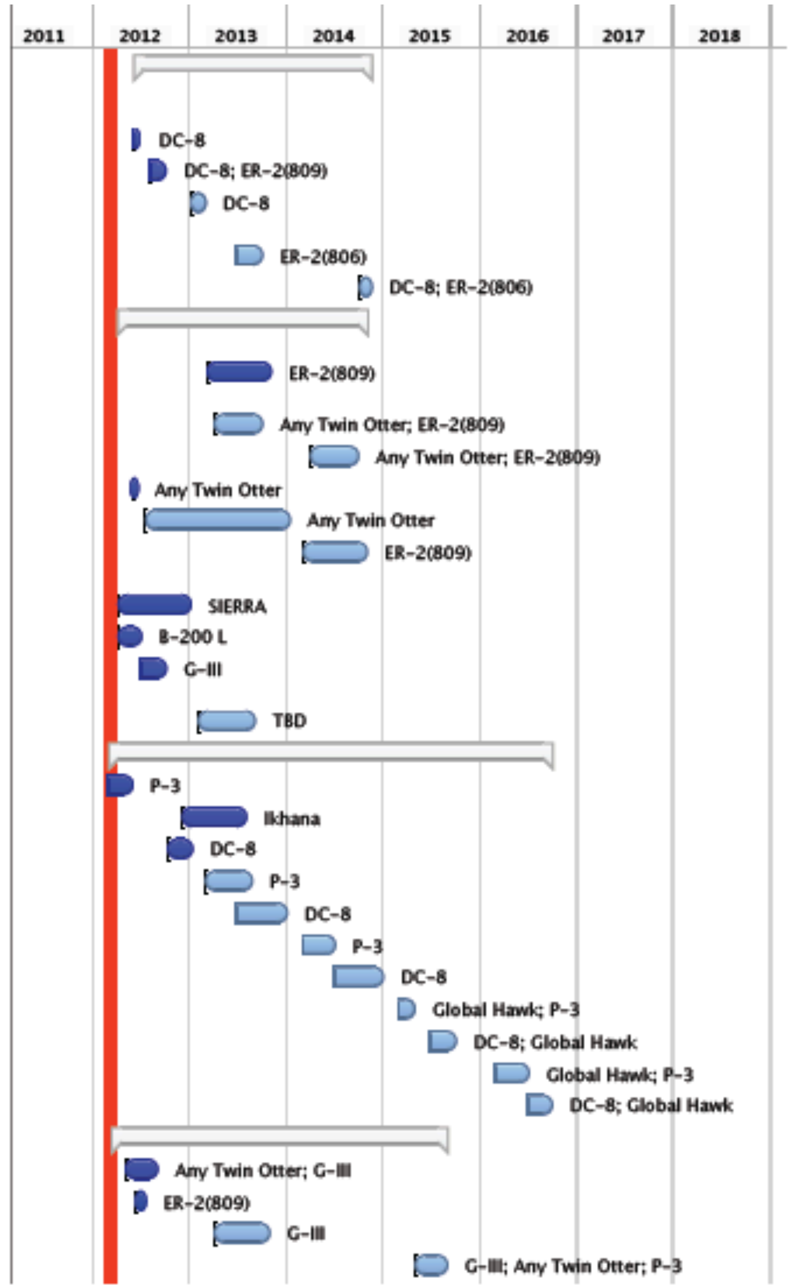
As the NASA Earth Science program began developing research activities focusing on Earth systems, the demand for airborne observations increased to the point where the scheduling of missions required a more systematic approach. Earl's solution was instituting a flight request system, the precursor of our present day system.

Under firm direction from the NASA administrator, the Ames aircraft were consolidated down to Dryden. As Earl points out, there was an earlier consolidation when the JSC aircraft went to Ames and Wallops. Earl was a good soldier and facilitated the move to Dryden as everybody struggled through the logistics, personnel issues and politics.

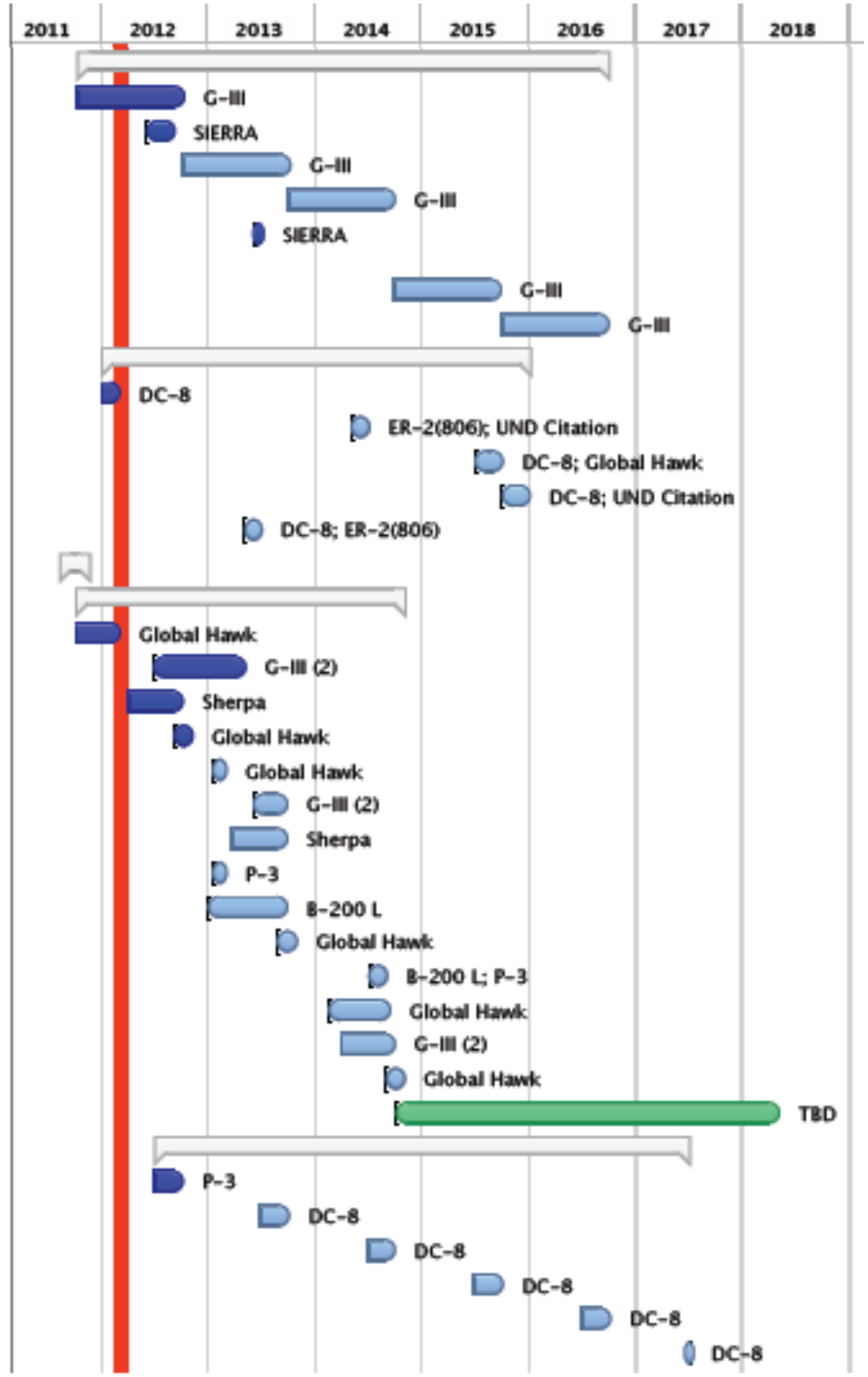
Earl retired upon the last aircraft (DC-8) transferring to Dryden. Earl is doing well and continues to follow the ASP activities with interest. Earl's contributions have provided both the Earth and Space science airborne research programs with an enduring legacy of safety, professionalism and productivity that continue to underpin our success today.

Appendix B: Five-Year Plan

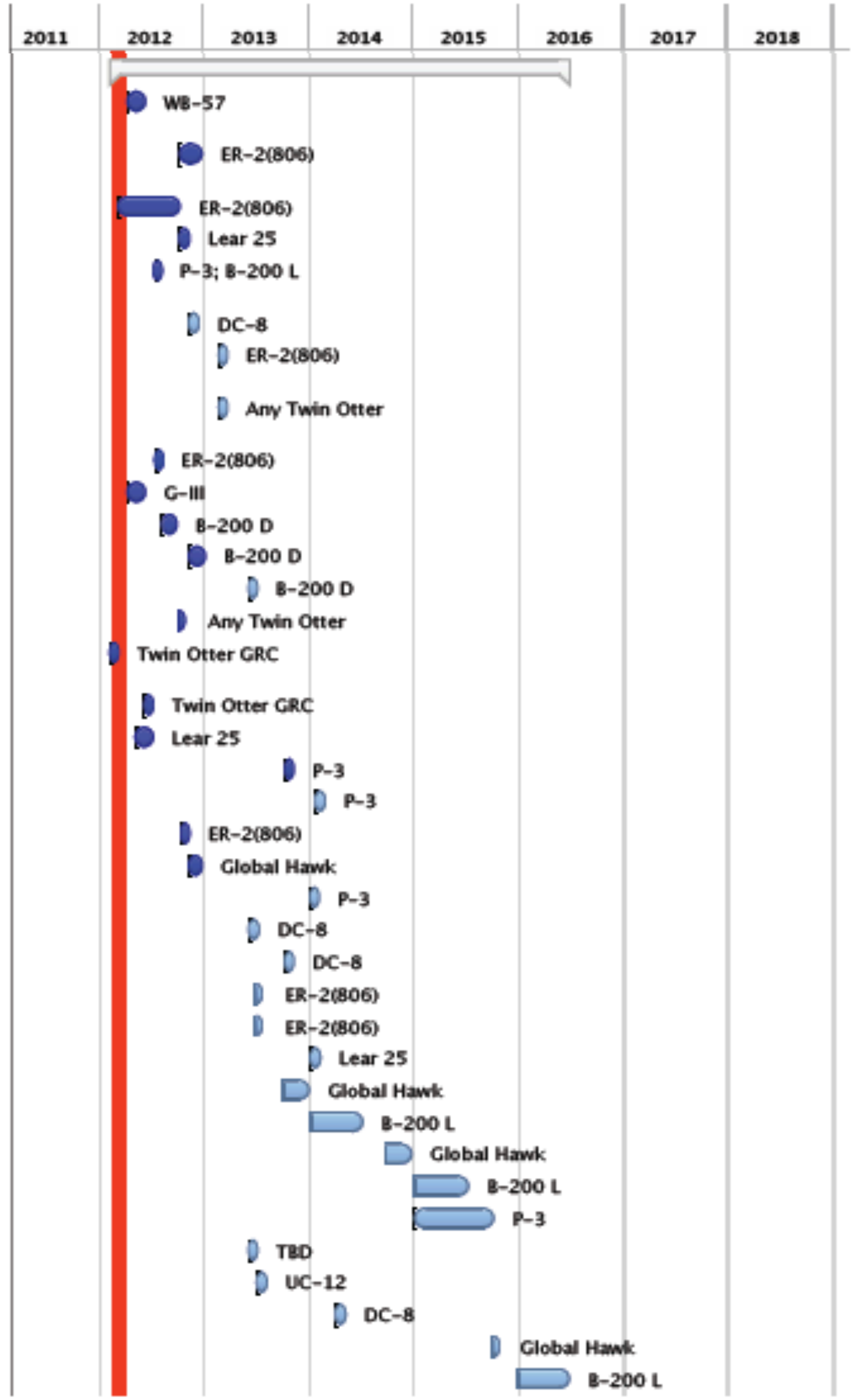
Task	Flt Hours	PS/PE/PM	Related Satellite/Sensor
▼ 1) Atmospheric Composition and Chemistry			
• 1.1) DC-3	100	Jucks; Maring; Tagg	
• 1.2) SEAC4RS	150/ac	Jucks; Maring; Tagg	NPP, A-Train, Terra
• 1.3) ASCENDS instrument development	30	Jucks	ASCENDS/OCO2
• 1.4) PODEX	50	Maring	ACE
• 1.5) Atmo.Chem.Mission		Jucks	OCO2
▼ 2) Carbon Cycle & Ecosystems			
• 2.1) AVIRIS & MASTER California transects	100	Turner/Neeck	HyspIRI
• 2.2) AVIRIS Classic	30	Wickland; Tagg	HyspIRI
• 2.3) AVIRIS Classic	30	Wickland; Tagg	HyspIRI
• 2.4) AVIRISng/test	10	Wickland, Tagg	HyspIRI
• 2.5) AVIRISng/science	95	Wickland	
• 2.6) AVIRIS & MASTER California transects	100	Turner/Neeck	HyspIRI
• 2.7) Sea Grass/Coral	200	Wagner; Tagg	HyspIRI
• 2.8) LVIS CONUS		Wickland	
• 2.9) UAVSAR – Ecosystem Structure		Wickland	DESDynI
• 2.10) CCE Field Campaign	100	Wickland	
▼ 3) Cryospheric Science			
• 3.1) OIB Greenland	300	Wagner; Tagg	ICESat 2
• 3.2) MIZOPEX	100	Wagner; Tagg	ICESAT 2
• 3.3) OIB Antarctica	250	Wagner; Tagg	ICESat 2
• 3.4) OIB Greenland	300	Wagner; Tagg	ICESat 2
• 3.5) OIB Antarctica	250	Wagner; Tagg	ICESAT 2
• 3.6) OIB Greenland	300	Wagner; Tagg	ICESat 2
• 3.7) OIB Antarctica	250	Wagner; Tagg	ICESat 2
• 3.8) OIB Greenland	300	Wagner; Tagg	ICESAT 2
• 3.9) OIB Antarctica	250	Wagner; Tagg	ICESat 2
• 3.10) OIB Greenland	300	Wagner; Tagg	ICESAT 2
• 3.11) OIB Antarctica	250	Wagner; Tagg	ICESat 2
▼ 4) Water and Energy Cycle			
• 4.1) SMAPVEX- 12	50	Entin	SMAP
• 4.2) SMAPVEX-12	24	Wickland	SMAP
• 4.3) CANEX -13	30	Entin, Dobson	SMAP
• 4.4) SMAPVEX-15 Cal/val	50	Entin	SMAP



Task	Flt Hours	PS/PE/PM	Related Satellite/Sensor
5) Earth Surface & Interior			
5.1) UAVSAR - 12	500	Dobson; Tagg	DESDynl
5.2) Fault Detection-Glen	50	Wagner; Tagg	n/a
5.3) UAVSAR - 13	500	Dobson; Tagg	DESDynl
5.4) UAVSAR - 14	500	Dobson; Tagg	DESDynl
5.5) Costa Rica - volcanic plumes	30	LaBrecque	HyspIRI
5.6) UAVSAR - 15	500	Dobson; Tagg	DESDynl
5.7) UAVSAR - 16	500	Dobson; Tagg	DESDynl
6) Weather			
6.1) GPCex	80	Kakar; Neek	GPM
6.2) HMT-SE (COPrHEX)	100	Kakar; Neek	GPM
6.3) GPM Cal/Val	100	Kakar; Neek	GPM
6.4) OLYMPEX	100	Kakar, Neek	GPM
6.5) Iowa Campaign	0	Kakar, Neek	GPM
7) Applications			
8) Earth Venture 1			
8.1) ATTREX - 11	200	Jucks; Tagg	
8.2) AirMOSS - 12	326	Entin; Tagg	
8.3) CARVE - 12	240	Wickland; Tagg	
8.4) HS3 - 12	327	Kakar; Tagg	
8.5) ATTREX - 13	200	Jucks; Tagg	
8.6) AirMOSS - 13	326	Entin; Tagg	
8.7) CARVE - 13	336	Wickland; Tagg	
8.8) DISCOVR-AQ	40	Maring; Tagg	
8.9) DISCOVR-AQ - 13	100	Maring; Tagg	
8.10) HS3 - 13	327	Kakar; Tagg	
8.11) DISCOVR-AQ - 14	100	Maring, Tagg	
8.12) ATTREX-14	200	Jucks, Tagg	
8.13) AirMOSS - 14	326	Entin; Tagg	
8.14) HS3-14	327	Kakar; Tagg	
9) Earth Venture 3		Tagg	
10) Education			
10.1) SARP 2012	14	Kaye; Tagg	
10.2) SARP 2013	14	Kaye; Tagg	
10.3) SARP 2014	14	Kaye; Tagg	
10.4) SARP 2015	14	Kaye; Tagg	
10.5) SARP 2016	14	Kaye; Tagg	
10.6) SARP 2017	14	Kaye; Tagg	



Task	Flt Hours	PS/PE/PM	Related Satellite/Sensor
11) New Techology			
11.1) Stek - MW Limb Sounder	12	Komar	
11.2) HSRL2 - 12	15	Maring; Bontempi; Tagg	ACE
11.3) Myers - EMAS/IR	28	Tagg	
11.4) Yu - SMLA	25	Komar; Tagg	DESDynI, LIST
11.5) HSRL/RSP	15	Maring; Bontempi; Tagg	ACE
11.6) Hair / DIAL		AITT	ACE
11.7) Schmidt / Radiometer		AITT	
11.8) Weimer / Lidar forest carbon	35	AITT	DESDynI
11.9) McGill / CATS		AITT	ICESAt 2
11.10) Moller - GlistenA	22	AITT	SWOT
11.11) Moller - AIRSWOT	224	SBIR	SWOT
11.12) Moller - AIRSWOT		SBIR	SWOT
11.13) Moller - AIRSWOT		SBIR	SWOT
11.14) Hook - HyTES		Wickland, Komar	HyspIRI
11.15) Zakos - PRISM test flight	12	Bontempi; Tagg	ACE
11.16) PRISM first science	15	Bontempi, Tagg	ACE
11.17) SIMPL	20	Wickland	HyspIRI
11.18) Fatoyinbo		Komar	DESDynI
11.19) Fatoyinbo		Komar	DESDynI
11.20) Li - EXRAD	16	Smith	
11.21) UAVSAR/LVIS-GH	50	Dobson; Tagg	DESDynI; ICESAT 2
11.22) Durham - WISM	16	Komar	SLCP
11.23) Geo-TASO/Leitch		Komar	GEO-CAPE
11.24) Geo-TASO/Leitch		Komar	GEO-CAPE
11.25) Racette - ACERAD		Komar	ACE
11.26) Diner		Komar	ACE
11.27) Abshire IIP		Komar	
11.28) UAVSAR-GH	50	Dobson; Tagg	DESDynI
11.29) HSRL/PRISM - 14		Bontempi; Tagg	ACE
11.30) UAVSAR-GH	50	Dobson; Tagg	DESDynI
11.31) HSRL/PRISM - 15		Bontempi; Tagg	ACE
11.32) Rotating PALS	70	Entin	SMAP
11.33) Reising IIP		Komar	SWOT
11.34) Prasad		Komar	ASCENDS
11.35) Prasad		Komar	ASCENDS
11.36) Prasad		Komar	ASCENDS
11.37) HSRL/PRISM - 16		Bontempi; Tagg	ACE



Appendix C: SARP Students and their Colleges

The third annual NASA/NSERC Student Airborne Research Program (SARP) was held during June and July 2011. This 6-week program is designed to expose and engage advanced undergraduate and early graduate students to NASA research and airborne science and engineering.

The number of students in each of the three past years is shown in Table 12 and the wide breadth of participation is indicated in the maps in Figures C.1, C.2 and C.3. The program is planned to continue in 2012.

Table 13: SARP student numbers and schools.

Year / Number of Students	Schools
2009 / 29	26
2010 / 28	24
2011 / 29	28

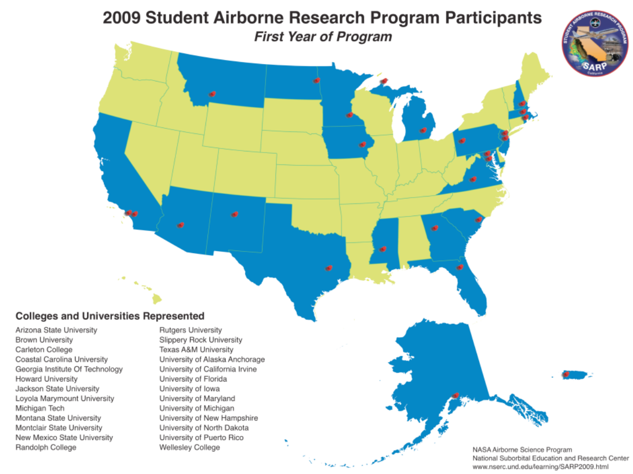


Figure C.1: SARP student numbers and schools for 2009.

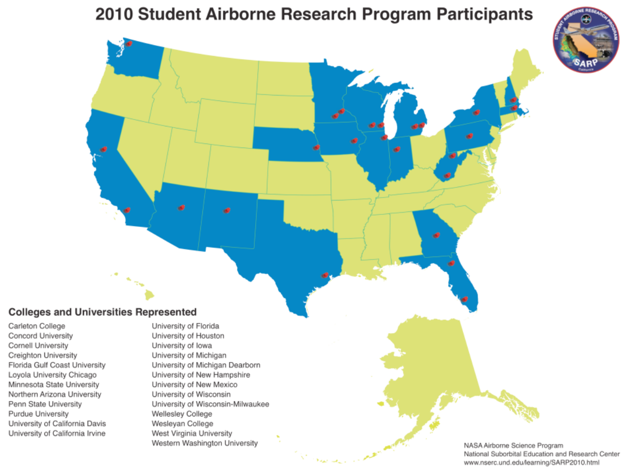


Figure C.2: SARP student numbers and schools for 2010.

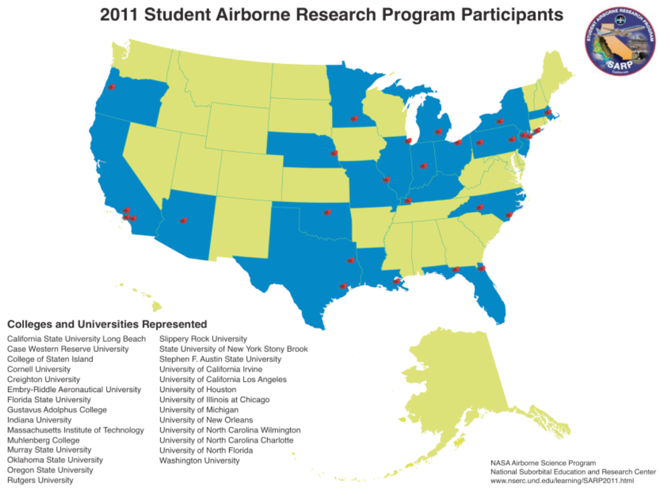


Figure C.3: SARP student numbers and schools for 2011.

Appendix D:
Aircraft Flight Profiles

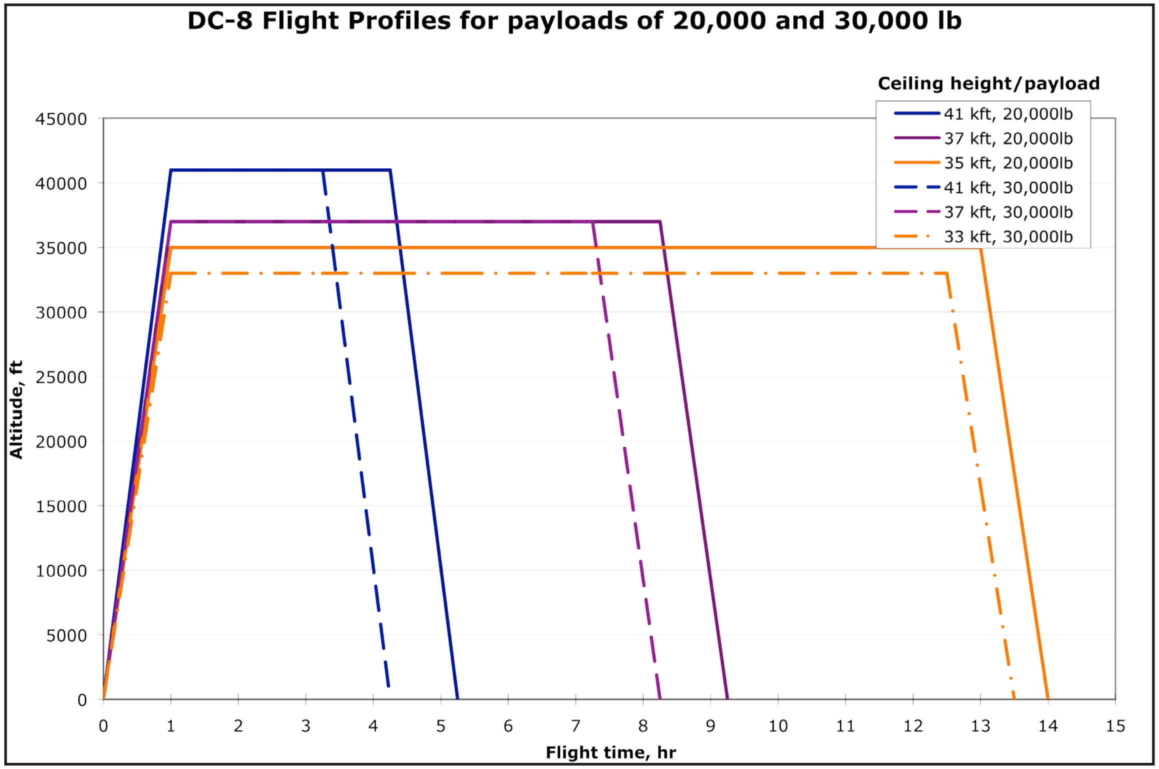
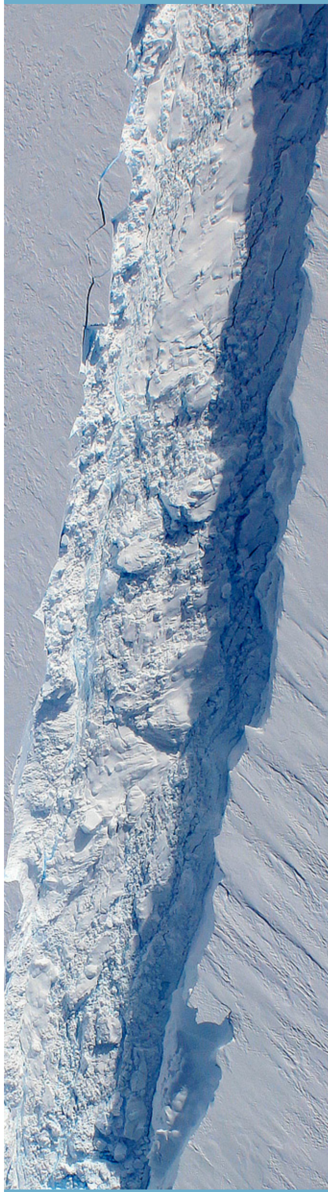


Figure D.1: DC-8 Flight Profiles for payloads of 20,000 and 30,000 lbs. Aircraft details on pages 30-31.



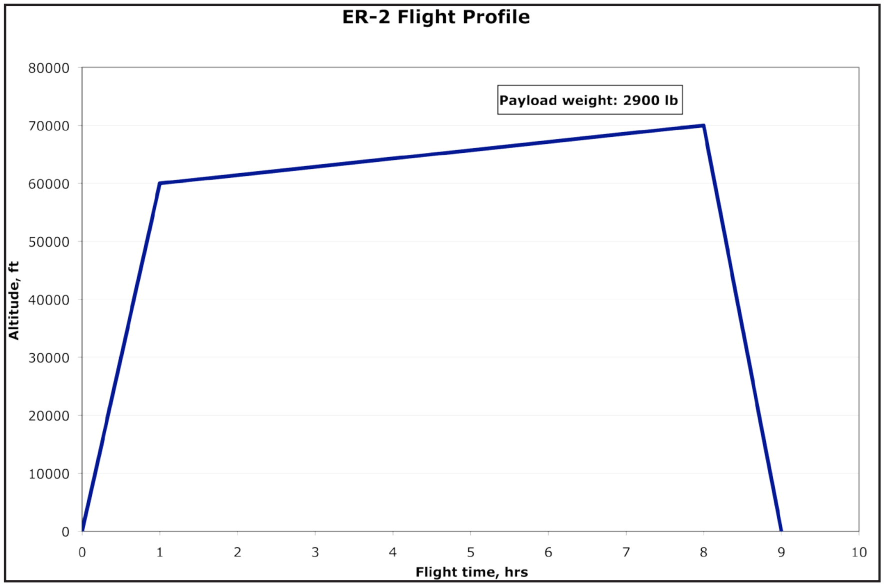


Figure D.2: ER-2 Flight Profile. Aircraft details are on pages 31–32.

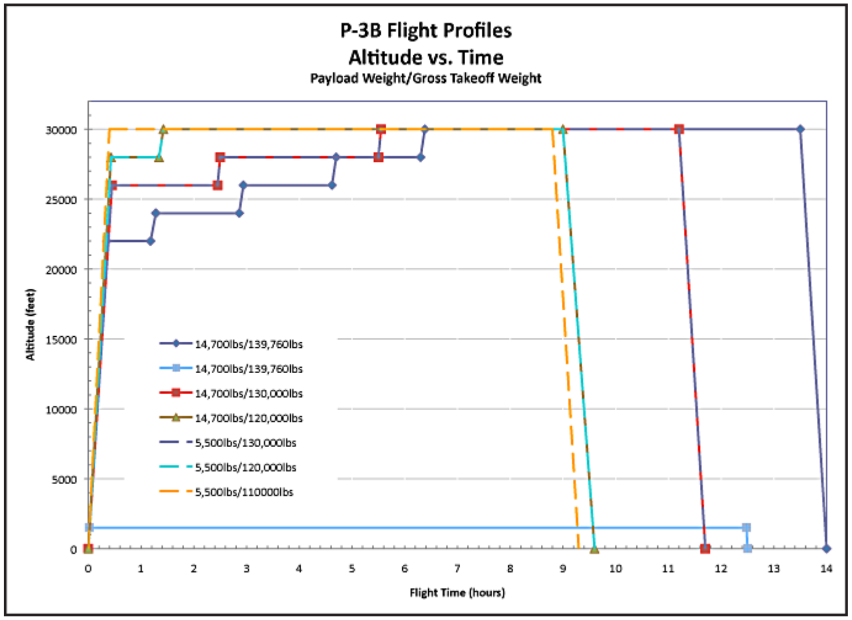
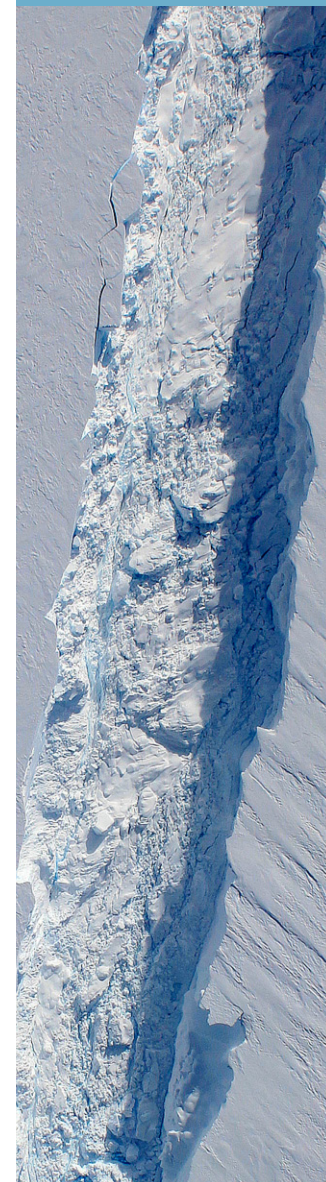


Figure D.3: P-3B Flight profiles. Aircraft details are on page 33.



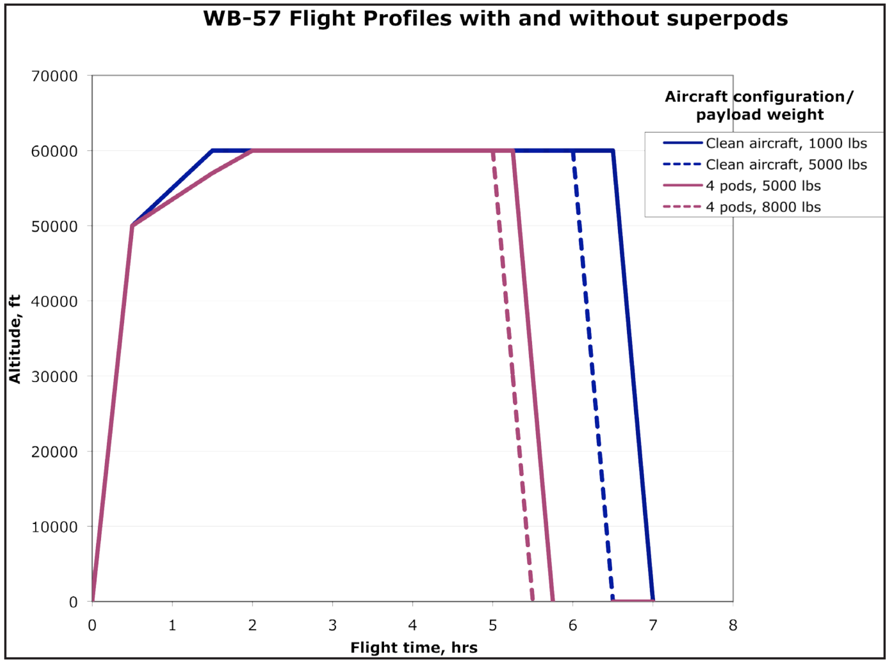


Figure D.4: WB-57 Flight Profiles. Aircraft details are on pages 34.

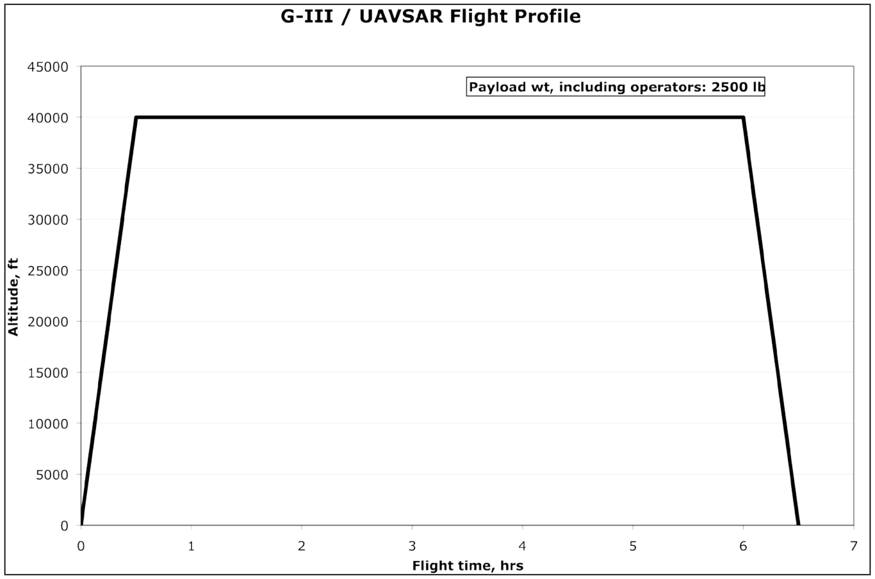


Figure D.5: NASA G-III flight profile. Aircraft details are on pages 35-36.

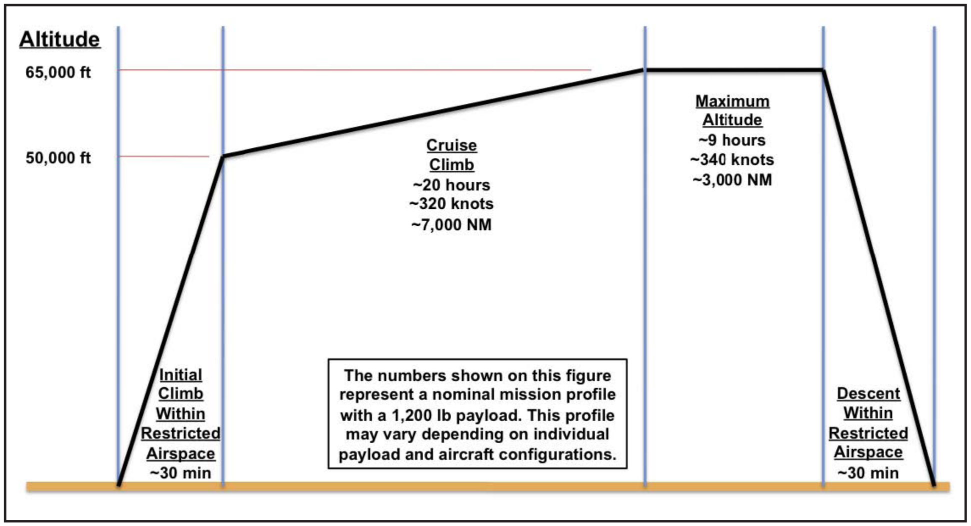


Figure D.6: Global Hawk nominal flight profile. Aircraft details are on pages 37-38.

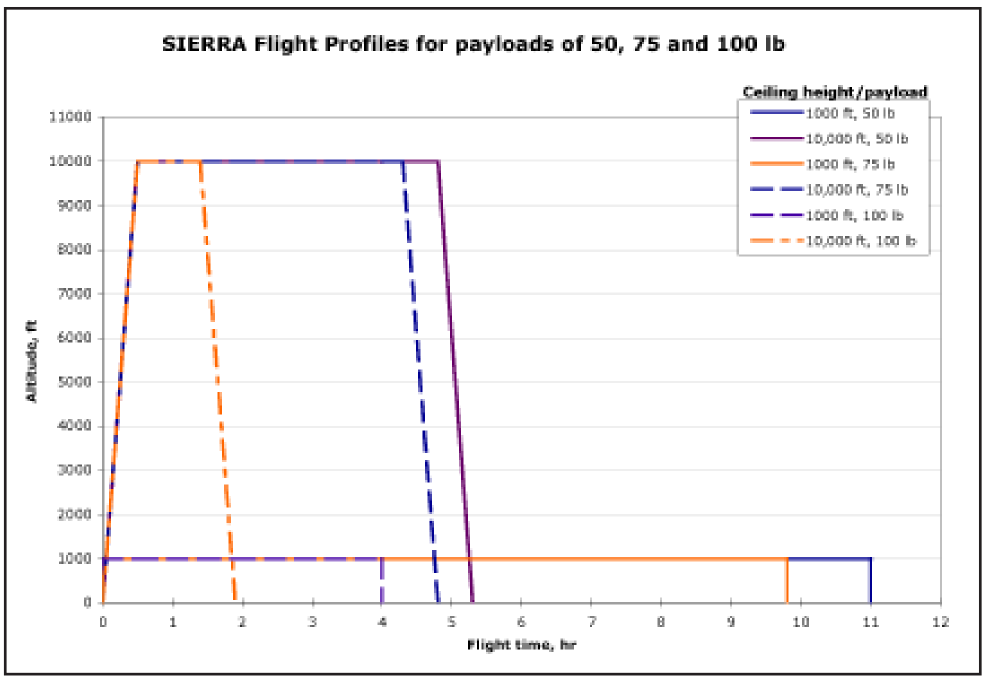
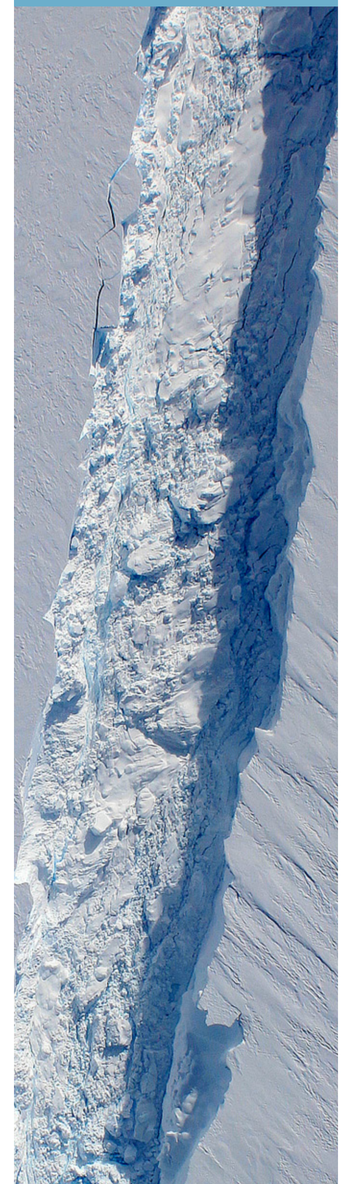


Figure D.7: SIERRA flight profiles. Aircraft details are on pages 40.



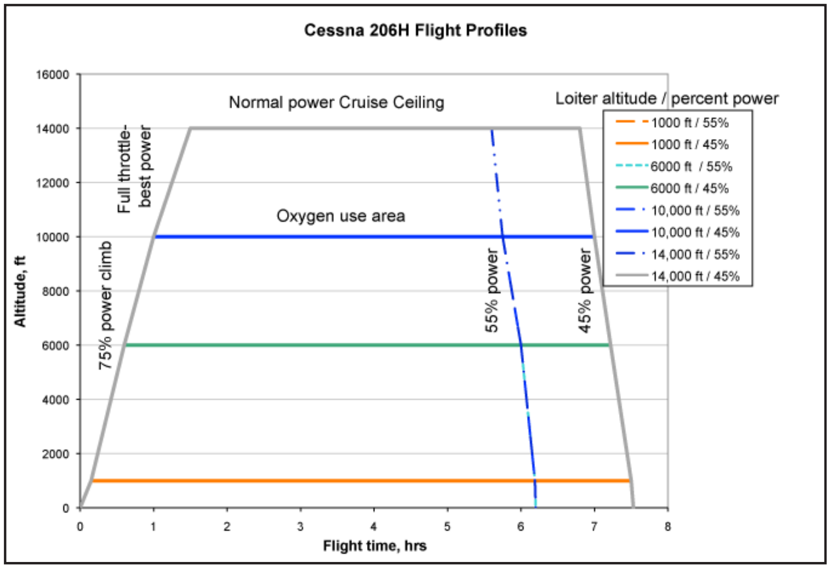


Figure D.8: Flight profile for the Langley Cessna 206-H and the UC-12 aircraft. Aircraft details for the Cessna are on pages 41-42, and for the UC-12 are on pages 42-43.

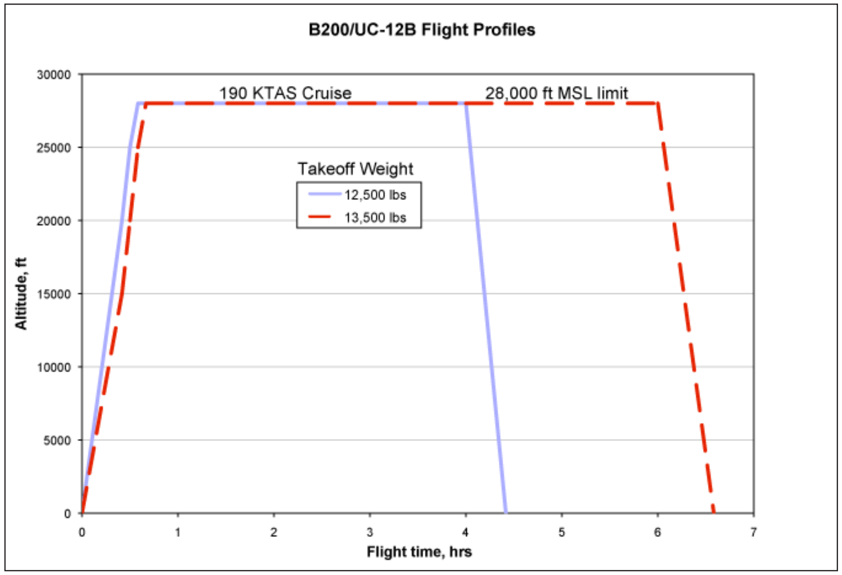


Figure D.9: Flight profile for the Langley and Dryden B-200 aircraft. Aircraft details are on pages 43-44.

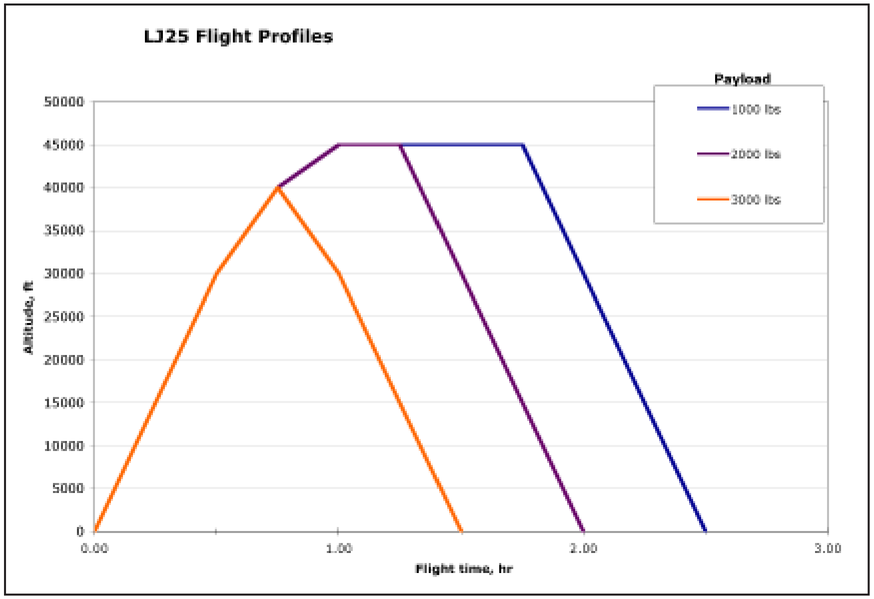


Figure D.10: Learjet 25 flight profile. Details are on page 45.

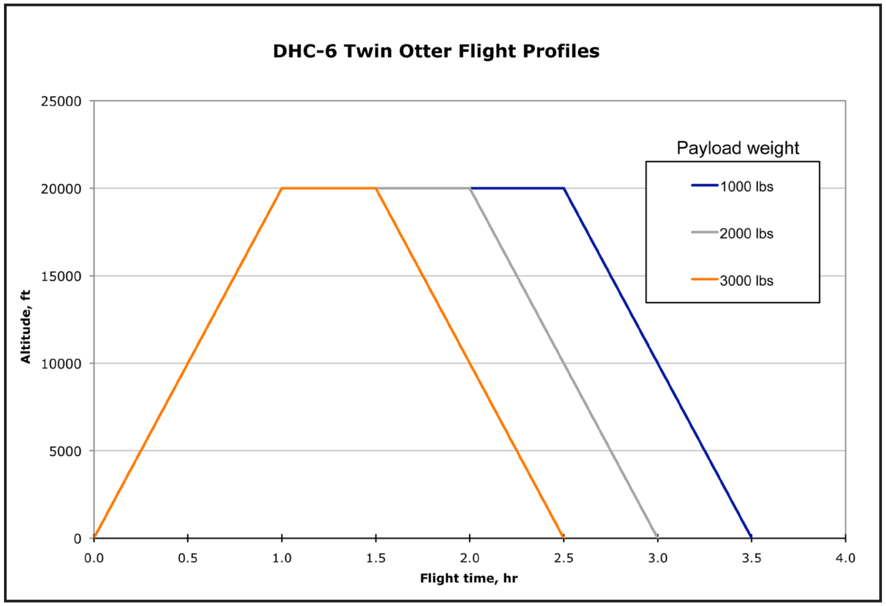


Figure D.11: Twin Otter profiles. Details are on page 46.

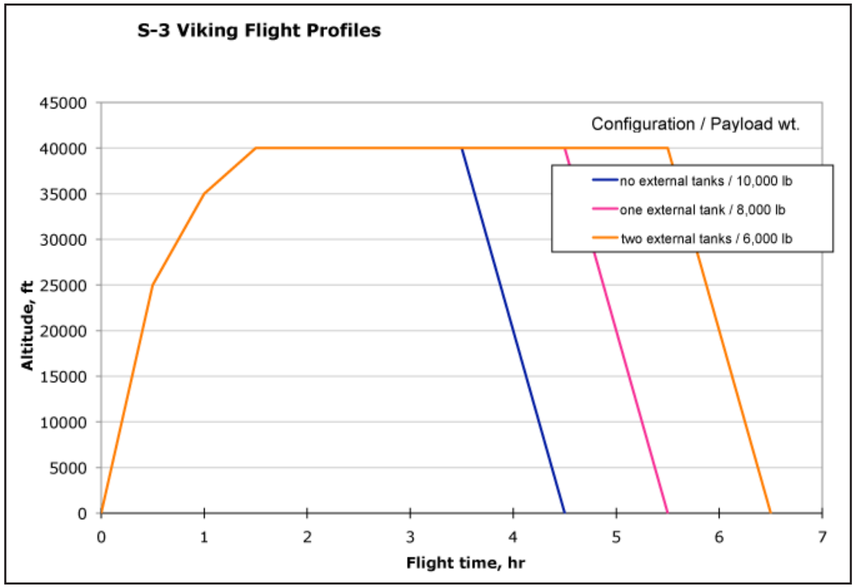


Figure D.12: S-3 Viking flight profile. Aircraft details are on page 47.

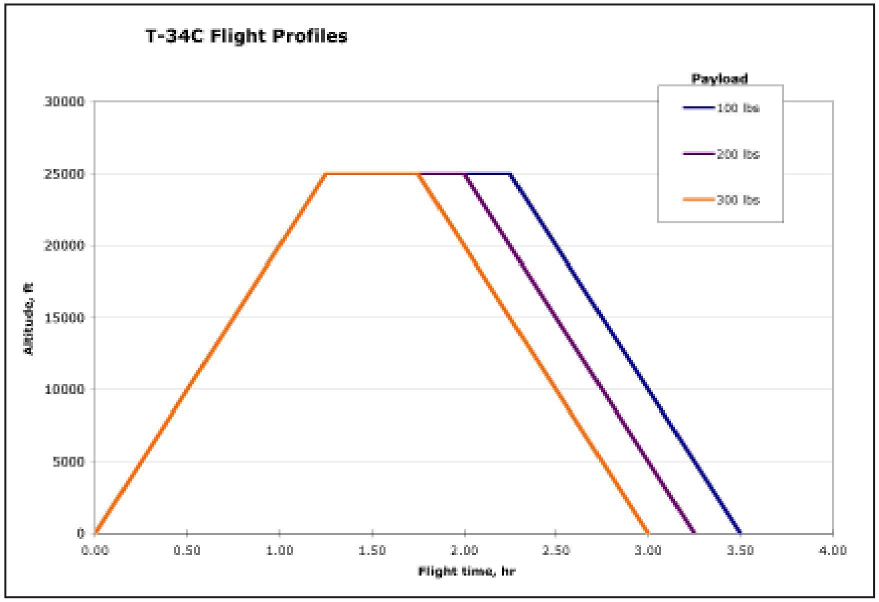
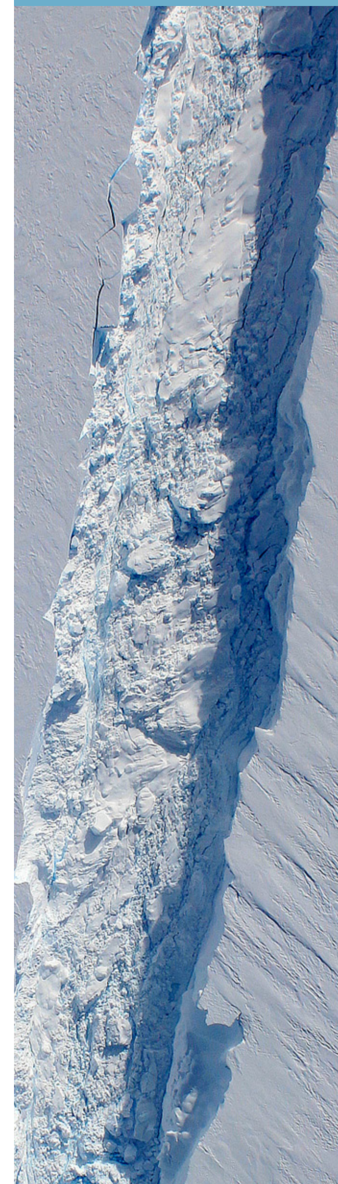


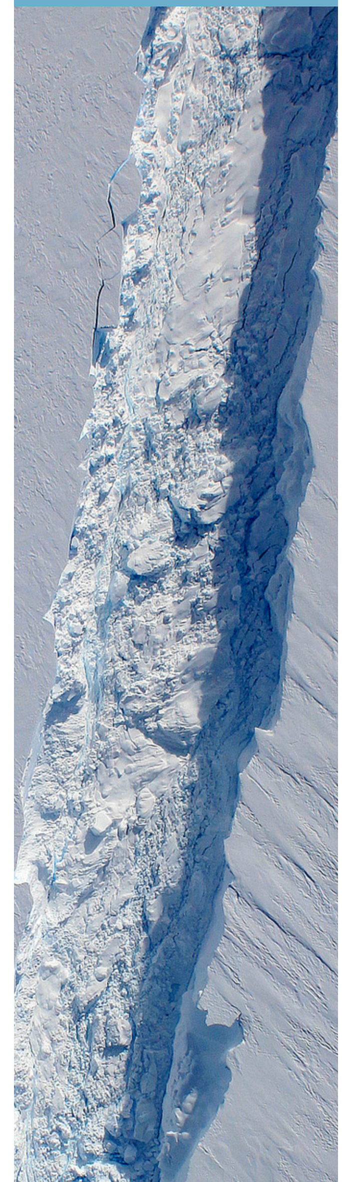
Figure D.13: T-34C flight profiles. Details are on page 48.

Appendix E: Acronyms

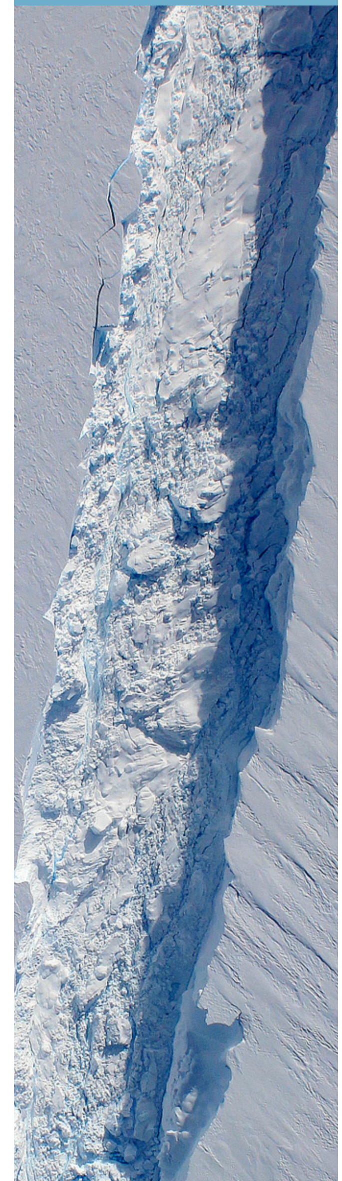


ADS-B	Automatic dependent surveillance-broadcast
AGU	American Geophysical Union
AID	Airborne Instrument Demonstrator
AirMOSS	Airborne Microwave Observatory of Subcanopy and Subsurface
AirMOSS	Airborne Microwave Observatory of Subcanopy and Subsurface
AirMSPI	Airborne Multiangle SpectroPolarimetric Imager
AirMSPI	Airborne Multiangle Spectro-Polarimetric Imager
ALIST	Airborne Lidar Surface Topography Simulator
AMAP	Arctic Monitoring and Assessment Program
AMIGA-Carb	AMerican Icesat Glas Assessment of Carbon
AMS	Alpha Magnetic Spectrometer
AMS	Autonomous Modular Sensor
ARC	Ames Research Center
ARM SGP	Atmospheric Radiation Measurement, Southern Great Plains (site)
ASCENDS	Active Sensing of CO2 Emissions over Nights, Days and Seasons
ASF	Airborne Sensor Facility
ASP	Airborne Science Program
ATTREX	Airborne Tropical Tropopause Experiment
BAER	Burned Area Emergency Rehabilitations
BGAN	Broadband Global Area Network

CALIPSO	CloudSat and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation
CAR	Cloud Aerosol Radiometer
CARVE	Carbon in Arctic Reservoirs Vulnerability Experiment
CAVES	[Can't find server]
CDC	Cosmic Dust Collector
CERES	Clouds and the Earth's Radiant Energy System
CH4	Methane
CICCI	Coordinated Investigations of Climate-Cryosphere Interactions
CMS	Carbon Monitoring System
CO	Carbon
CO2	Carbon dioxide
COMPASS	Common Operations and Management Portal for Airborne Science Systems
CONUS	Continental United States
CoSSIR	Compact Scanning Submillimeter-wave Imaging Radiometer
CPL	Cloud Physics Lidar
CReSIS	Center for Remote Sensing of Ice Sheets
CryoVEx	CryoSat Validation Experiment
DAOF	Dryden Aircraft Operations Facility
DESDynI	Deformation, Ecosystem Structure and Dynamics of Ice
DEVOTE	Development and Evaluation of satellite ValidatiOn Tools by Experimenters
DFRC	Dryden Flight Research Center
DGPS	Digital GPS
DISCOVER-AQ	Deriving Information on Surface Conditions from COlumn and VERtically Resolved Observations Relevant to Air Quality
DoE	Department of Energy
ECO-3D	[Mission to develop instruments for determining biomass structure]
EIPs	Experimenter Interface Panels

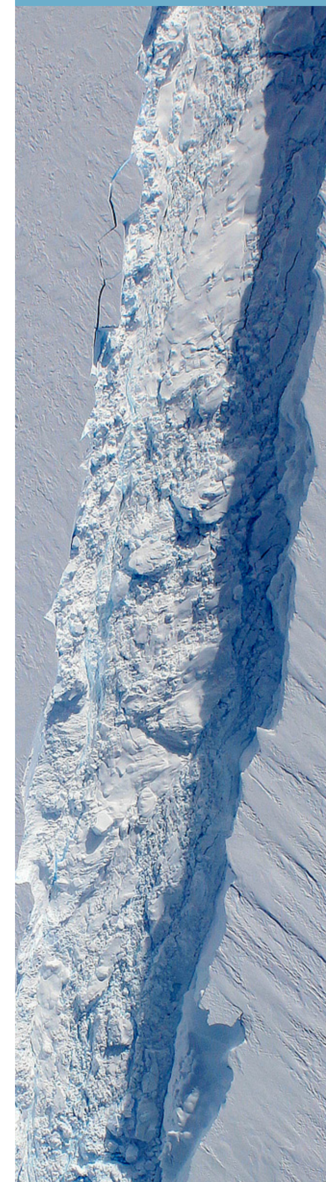


EPA	Environmental Protection Agency
ESA	European Space Agency
ESPO	Earth Science Projects Office
ESTO	Earth Science Technology Office
FAA	Federal Aviation Administration
G-LiHT	Goddard's LiDAR, Hyperspectral, and Thermal airborne imager
GEST	Goddard Science and Technology
GFRC	Goddard Flight Research Center
GOSAT	Greenhouse Gas Observing Satellite
GRC	Glenn Research Center
HAMSR	High Altitude MMIC Sounding Radiometer
HIAPER	High-performance Instrumented Airborne Platform for Environmental Research
HSRL	High Spectral Resolution Lidar
HIRAD	Hurricane Imaging Radiometer
HIS	High-resolution Interferometer Sounder
HS3	Hurricane and Severe Storm Sentinel
HyspIRI	Hyperspectral InfraRed Imager
ICCAGRA	Interagency Coordinating Committee for Airborne Geoscience Research Applications
ICESat2	Ice, Cloud and Land Elevation Satellite
ICEX 2011	Ice Exercise 2011
ISPRS	International Society for Photogrammetry and Remote Sensing
ISRSE	International Symposium on Remote Sensing of the Environment
IWG-FI	Interagency Working Group for Facilities and Infrastructure
JAXA	Japan Aerospace Exploration Agency
JSC	Johnson Space Center
KTAS	Knots True Air Speed
KVM	Keyboard Video Mouse
LaRC	Langley Research Center



LIDAR	Light Detection And Ranging
LIST	Lidar Surface Technology
MABEL	Multiple Altimeter Beam Experimental Lidar
MACPEX	Mid-latitude Airborne Cirrus Properties Experiment
MASTER	Modis / Aster Airborne Simulator
MC3E	Midlatitude Continental Convective Clouds Experiment
MC3E	Mid-latitude Continental Convective Clouds Experiment
MIZOPEX	The Marginal Ice Zone Observations and Processes Experiment
NASA	National Aeronautics and Space Administration
NASDAT	NASA Airborne Science Data and Telemetry system
NASDAT	NASA Airborne Science Data Acquisition and Transmission
NAST-I	NPOESS Airborne Sounder Testbed – Interferometer
NEE	Net ecosystem exchange
NexRAD	Next generation radar
NOAA	National Oceanic and Atmospheric Administration
NOOP	National Oceanographic Partnership Program
NORUT	Northern Research Institute (Norway)
NOTAM	Notice to Airmen
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NSERC	National Suborbital Education and Research Center
NSERC	National Suborbital Education and Research Center
O3	Ozone
OAWL	Optical Autocovariance Wind Lidar
OCO-2	Orbiting Carbon Observatory 2
OIB	Operation Ice Bridge
PALS	Passive-Active L-Band Sensor
PARASOL	Polarization & Anisotropy of Reflectances for Atmospheric Sciences coupled with Observations from a Lidar
PPA	Platform precision autopilot

PRISM	Portable Remote Imaging SpectroMeter
REVEAL	Research Environment for Vehicle-Embedded Analysis on Linux
RZSM	Root zone soil moisture
S-HIS	Scanning High-resolution Interferometer Sounder
SARP	Student Airborne Research Program
SATCOM	Satellite communications
SEAC4RS	Southeast Asia Composition, Cloud, Climate Coupling Regional Study
SIERRA	Sensor Integrated Environmental Remote Research Aircraft
SIMPL	Slope Imaging Multi-polarization Photon-counting Lidar
SMD	Science Mission Directorate
SOFRS	Science Operations Flight Request System
SWIR	Short-wavelength infrared
TFUS	Task Force for Unmanned Systems
TOR	Terms of Reference
TTL	Tropical Tropopause Layer
TWiLiTE	Tropospheric Wind Lidar Technology Experiment
UAV	Unmanned Aerial Vehicle
UAVSAR	UAV Synthetic Aperture Radar
UND	University of North Dakota
WFF	Wallops Flight Facility
WISPAR	Winter Storms and Pacific Atmospheric Rivers
WISPARS	Winter Storms and Pacific Atmospheric Rivers
WSFM	Western States Fire Mission



Pictured on the back cover are the support teams for ASP Catalog Aircraft. Names of personnel are listed on the following pages: (clockwise from top) JSC G-III (p. 49), LaRC Aircraft (p. 42), Earth Science Projects Office*, SIERRA (p. 40), Ikhana (p. 39).

*Back row: Quincy Allison, Bernadette Luna, Erin Justice, Mike Craig, Dave Jordan. Middle row: Katja Drdla, Marilyn Vasques, Sue Tolley, Dan Chirica. Front row: Stacy Stuart, Kent Shiffer. Not in picture: Jhony Zavaleta, Erin Czech and Marshal Chaidez.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