National Aeronautics and Space Administration

Airborne Science Newsletter

Spring 2015

What's Inside...

NASA Global Hawk shown with the CAST AIITS and ATTREX Hawkeye instruments on the wing pylons. These state-of-the-art instruments provide previously-unavailable information about cirrus cloud ice crystal sizes, numbers, and shapes.

During early March 2015, NASA Global Hawk flights were conducted from Armstrong Flight Research Center (AFRC) with the primary purpose of testing and evaluating two new instruments supported by the United Kingdom National Environment Research Council's Coordinated Airborne Studies in the Tropics (CAST) program. In addition, six instruments from the NASA Airborne Tropical TRopopause Experiment (ATTREX) were included in the Global Hawk payload, providing measurements of cloud properties, water vapor, meteorological conditions, and trace gases.

The CAST Aerosol Ice Interface Transition Spectrometer (AIITS) instrument provides unique information about cirrus ice crystal shapes, and the CAST GreenHouse gas Observations in the Stratosphere and Troposphere (GHOST) instrument provides column-integrated concentrations of greenhouse gases such as carbon dioxide and methane. The AIITS payload was flown on a wing pylon, seen in Figure 1.

A long (21 hours) flight to the tropics on 4 March included sampling of thin cirrus near the cold tropical tropopause. The combination of AIITS and ATTREX measurements on this flight provide unprecedented information about the sizes and shapes of these climatically important clouds. A spectacular example of a scattering pattern from an ice crystal is seen in Figure 2. The flight on 10 March provided ideal conditions for GHOST measurements: clear skies and proper solar illumination over open ocean.

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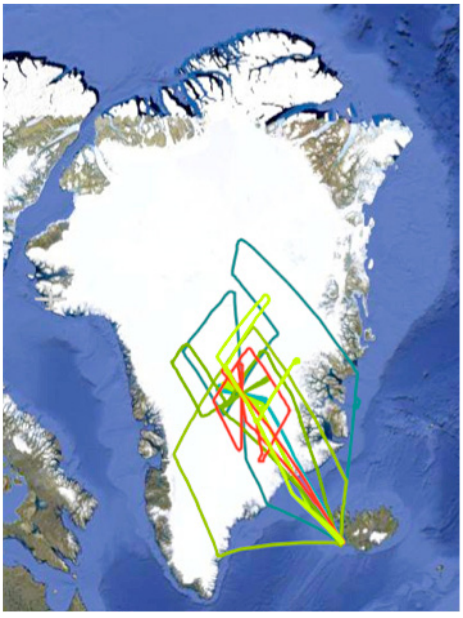
ER-2 provides Suomi-NPP Arctic Validation Experiment

The SNPP Arctic airborne field campaign, jointly supported by NASA and NOAA, was conducted out of Keflavik, Iceland during March 7-31, 2015. The ER-2 payload consisted of NAST-I (LaRC), MASTER (ARC), S-HIS (UW), and NAST-M (MIT-LL) and was successfully implemented in seven mission sorties underneath advanced sounder satellites (Suomi-NPP, Aqua, Metop-A, and Metop-B) for the purpose of cold scene radiance spectra assessment and retrieval evaluation. The primary objective of the campaign was SNPP validation and JPSS risk reduction for cold scene observations (~235K). The flight profiles not only enable validation of the accuracy of SNPP data, but also cross-validation of Arctic data among the other satellites.

The Suomi-NPP mission is a bridge between NASA's Earth-observing missions and NOAA's next-generation Joint Polar Satellite System (JPSS) missions. SNPP carries groundbreaking new Earth-observing instruments that the JPSS system will use. The first satellite in the JPSS series, JPSS-1, is targeted for launch in early 2017. "Experimental field campaigns like this are an essential part of validating satellite data systems and aimed at improving observations of the Earth's atmosphere, clouds, and surface for enabling enhancements in weather prediction, climate monitoring capability, and environmental change detection" said NASA Langley's lead mission scientist, Dr. Allen Larar.



ER-2 flight tracks during SNPP Arctic Validation Mission

The ER-2 was based in Iceland but flew missions to Greenland, as shown in the flight tracks image. Aircraft profiles also included over-flight of the Summit Station Greenland instrumented ground site and some joint sorties with the UK Met Office heavily instrumented BAe-146 aircraft.

The ER-2 flight altitude near 70,000 ft provides a unique vantage point for satellite validation, making it an ideal research platform. . The photo in Figure 2 illustrates the Arctic nature of this campaign and the high-altitude view from the ER-2.

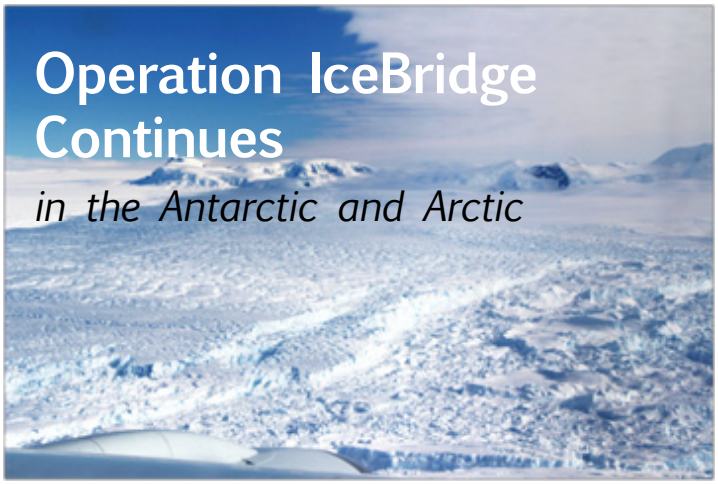
Contributed by Allen Larar

Directors' Corner

As you can see from the missions covered in this newsletter, the Airborne Science Program is off to another strong year of earth science data collections with over 1600 hours flown and counting. We have the WFF aircrew and Operation IceBridge teams currently in Greenland flying on the C-130, the ER-2 flying HyspIRI, the C-20 with UAVSAR flying Sacramento Deltas, and the C-23 up in Alaska waiting for the crew to return next week for the second CARVE deployment of the year. The reason I know all this is thanks to the hard work and dedication of the folks at ARC (Aaron Duley, Erin Justice, Katja Drdla, Marilyn Vasques, Sue Tolley, Sommer Beddingfield, Susan Schoenung, Gailynne Bouret, and Steven Todorov) who keep the online ASP website up, running, and with accurate schedules and numbers. If you haven't seen it in a while, check it out at https://airbornescience.nasa.gov/. In addition to the flight activity, campaign planning is in high gear for all EVS-2 missions as well as preparations for this year's SARP. As always, feedback is encouraged and welcome. FYI - We keep bugging the ASP team for a cost estimator and they keep deflecting, so if that's something the community is interested in, please make your voices heard and shoot us an email! We look forward hearing about your ASP experiences, and we hope everyone stays safe and gets a chance to enjoy some time off with family this summer.

Bruce Tagg and Randy Albertson
Airborne Science Program

The ER-2 crew makes final adjustments on the ground in Keflavik, Iceland as the pilot and aircraft prepare for take off. Image Credit: NASA / Stu Broce



The calving front of Fleming Glacier and the remnant Wordie Ice Shelf, on the west side of the Antarctic Peninsula. The left wing and #2 engine of the DC-8 is in the foreground.

NASA's Operation IceBridge (OIB) continued its polar flight operations with its sixth Antarctic deployment in October-November 2014, and its seventh Arctic deployment, in March-May 2015. Flying aboard Armstrong Flight Research Center's DC-8 and basing from Punta Arenas in Chilean Patagonia, IceBridge completed 22 science missions over Antarctica, in the process flying a distance of 106,775 nautical miles, a distance equivalent to traversing almost 5 times around the Earth at the equator.

Science targets in Antarctica included the fast-thinning Pine Island and Thwaites Glaciers, the rugged Antarctic Peninsula, sea ice in the Amundsen, Bellingshausen and Weddell Seas, and two Pole Hole flights around the South Pole at 88 degrees south latitude. Together these collections connect every single orbit of the IceSat-2 and CryoSat-2 earth observation spacecraft. With jet-speed transits of up to four hours across the storm-swept Drake Passage at the beginning and end of every research flight, the OIB team may have a claim to the title of the World's Longest Commute to Work.

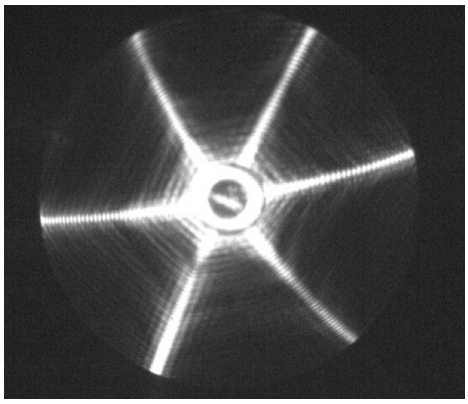
For the spring 2015 campaign and barely three months after completing the fall Antarctic campaign, hard-working team OIB utilized NASA-439 a C-130H aircraft operated by

Continued on page 5

C-130H (N439) shortly after takeoff from Fairbanks, Alaska, during OIB operations in March 2015. Note the optical instrument apertures in the belly, aft of the nose.

ATTREX/CAST

(continued from page 1)



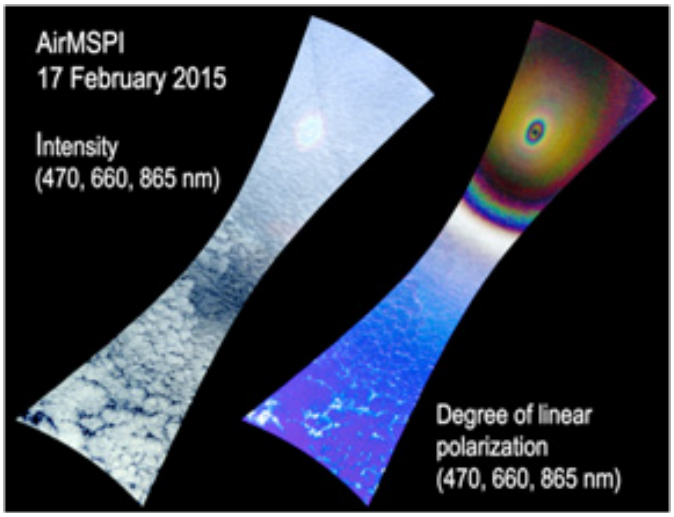
Scattering pattern from ice crystal sampled near the tropical tropopause. The sixfold symmetry indicates a pristine hexagonal plate. Photos by James Dorsey, University of Manchester, Manchester, UK.

The CAST instruments performed very well on these flights. The measurements will be used to evaluate and improve the CAST instruments, with the expectation of flying the instruments on high-altitude aircraft in the future. The measurements from this campaign will also be combined with the ATTREX dataset collected over the past few years to improve our understanding of transport and cloud processes near the tropical tropopause, and to improve the accuracy of climate change forecasts. These flights were the final flights of the 5-year ATTREX Earth Venture program.

Contributed by Eric Jensen

CalWater-2 Field Campaign Coordinates Moisture Measurements

Earlier this year, NASA's ER-2 aircraft participated in the CalWater-2 field campaign within and off the coast of California. The objective of the campaign, during which NASA partnered with NOAA, DOE, Scripps Institution of Oceanography, and other participants, was to measure the influx of moisture from landfalling atmospheric rivers and to study the influence of transported or local aerosols on precipitation over the Sierra Nevada mountains.



Droplet imagery from the Airborne Multi-angle SpectroPolarimeter Imager (AirMSPI).

Ten flights and 42 flight hours were logged by the ER-2 (N806) from 20 January - 24 February 2015. The ER-2 payload consisted of AirMSPI, AVIRIS-C, and HAMSR from JPL and the CPL lidar from GSFC. The flights were closely coordinated with other DOE, NOAA, and NASA assets, including the DOE G-1 aircraft for in-situ aerosol/cloud particle properties; the NOAA P-3 and G-IV aircraft for microphysics and meteorological information; the DOE ARM Mobile Facility-2 on the NOAA RV Ron Brown ship for atmospheric profiling data; NASA's Terra, CALIPSO, and International Space Station spacecraft; and various surface stations. The ER-2 and NASA satellites provided aerosol/cloud/water vapor remote sensing to complement the in-situ observations. Phenomena observed included mixed-phase orographic clouds over the Sierra Nevada and California Central Valley, as well as coastal aerosols and low/mid/high-level clouds, a major oceanic and landfalling atmospheric river, and stratocumulus clouds off the California coast.

During four flights, the ER-2 lined up with the International Space Station for calibration and validation of the recently launched Cloud Aerosol Transport System (CATS) lidar. In-situ wind observations from the NOAA RV Ron Brown also provided the first overwater opportunity to validate the RapidScat instrument, which also flies on the ISS.

AirMSPI intensity and degree of linear polarization imagery of a stratocumulus cloud deck are shown in the accompanying figure. A backscatter glory is visible in the upper portion of the intensity image. The glory is very prominent in polarized light, as are the bright white cloudbow and colored interference fringes known as supernumerary bows. All of these features are indicative of spherical droplets, and can be quantitatively processed to retrieve the cloud droplet size distribution.

Contributed by David Diner

OIB *(continued from page 3)*

the Wallops Flight Facility. This is the first expedition for this aircraft. After successfully completing the challenging first-time integration of its complex instrument suite aboard the platform at Wallops, OIB deployed to Thule, Greenland on March 17th to kick off the spring season.

The far-ranging Arctic campaign has staged flights stretching from Svalbard in the east to the Chukchi Sea in the west, and from the southernmost Cape Farvel (Farewell) in Greenland to the North Pole. OIB conducted science missions from bases in Fairbanks, Alaska and Kangerlussuaq, Greenland in addition to Thule, and at the time of this writing had completed 20 science flights, with 4½ weeks remaining in the campaign. Science targets included the shrinking sea ice of the Arctic Basin, the dramatically thinning Jakobshavn Glacier, dozens of internationally-operated science sites around the Greenland ice cap. Observations have also included an icebound Norwegian research vessel in the Fram Strait called the R/V Lance.

Contributed by Christy Hansen

Norwegian research vessel Lance, in the Fram Strait, 19 March 2015. OIB overflew both the ship itself and the research site on the adjacent ice floe to the right, outlined with black plastic bags filled with snow.

CARVE Earth Venture Mission Completing Final Year

The Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) has returned to Alaska for the final year of data collection. CARVE is one of the original Earth Venture (Suborbital) missions. CARVE quantifies correlations between atmospheric and surface state variables for the Alaskan terrestrial ecosystems through intensive seasonal aircraft campaigns, ground-based observations, analysis and modeling sustained over its 5-year mission. The data will be used in a multidisciplinary investigation to determine spatial and temporal patterns, sensitivity to change, and potential responses of Arctic carbon budgets to observed and projected climate change.

The 2014 mission year ended last November from a deployment of the C-23 Sherpa to Fairbanks, Alaska, that began in May. During that entire period, once a month, for a two week period, the CARVE flight crew observed enhanced CH4, CO2 over various locations, including the North Slope, Barrow, Prudhoe bay, Nome, Unalakleet, Innoko, Minto Flats, Fort Yukon, Bethel, Bettles, Kotzebue, and Kuskokwin Valley, as seen on the map in the image at right.

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CARVE 2014 flights tracks, radiating from Fairbanks, Alaska – CARVE's deployment base.

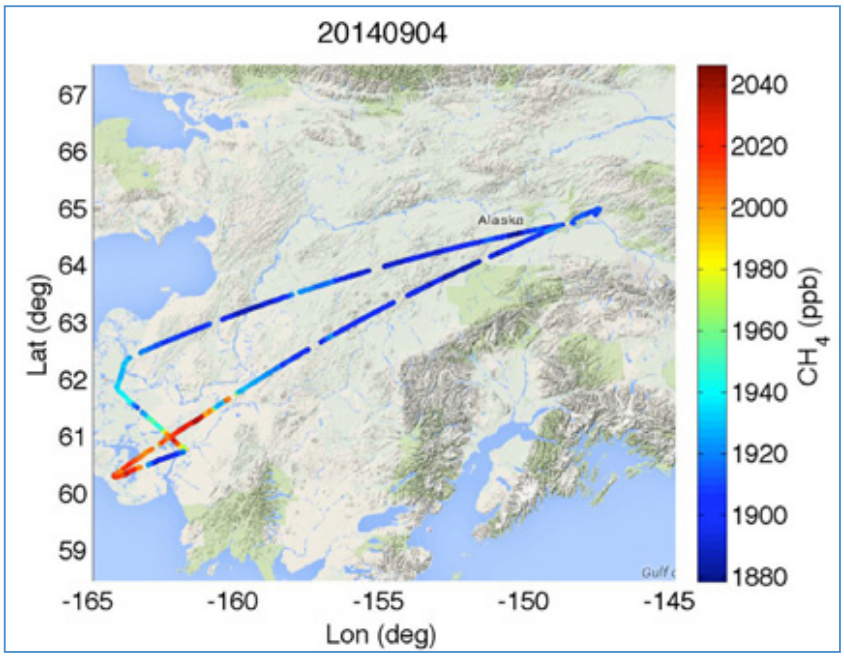
CARVE *(continued from page 5)*

The 2014 CARVE instrument system includes CARVE's custom navigation and logging system, which time tags and geo-locates data from the following probes and instruments: outside air temperature, relative humidity probes and ozone sensor, two Picarro real time gas analyzers which measures: Methane (CH4) Carbon dioxide (CO2), Carbon monoxide (CO) and water vapor (H2O), a Fourier Transformation Spectrometer (FTS), two Programmable Flask Packages (PFP) and a nadir looking, (1024 x 1024) Thermal Infrared camera. Methane measurements taken during a flight in September 2014 are shown in Figure 2.

In 2014, CARVE achieved the following major milestones: all 2013 level -2 data was released to the public, CARVE flew over 266 Alaskan science flight hours – in 47 flight days, and on May 29, 2014, CARVE exceeded it NASA's Program-Level Requirements and investigation success criteria, "Goal" requirement of flying 500 Alaskan Science flight hours in three years. (Dinardo and Miller celebrate in Figure 3.)

In this final year (2015) of the CARVE mission, flights will again continue through the end of November. The science plan for 2015 includes flight lines similar to 2014. More than 800 total hours of science flight time are anticipated by the end of the mission. Analysis of the data collected over the 5 years will look for any trends in ecosystem response to environmental changes, especially increases in permafrost out-gassing with time.

Contributed by Charles Miller and Steve Dinardo



Methane concentration measurements made during a flight in September 2014. (Data gaps are internal calibration periods.)

Steve Dinardo and Chip Miller celebrate 500 science flight hours for CARVE

AirSWOT 2015 Missions in full swing

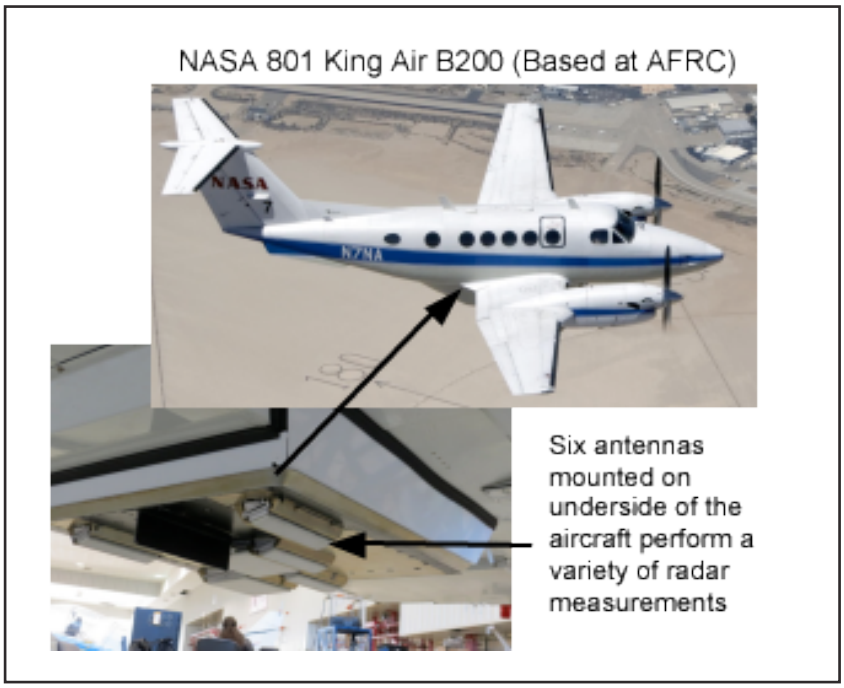
Airborne Surface Water Ocean Topography (AirSWOT) mission completed the first phase of its 2015 campaign by flying 51 hours on the AFRC B-200 over the Sacramento and Willamette (Oregon) Rivers. The mission has completed its second phase flying off the coast of Monterey Bay.

AirSWOT payload consists of JPL's Ka-band SWOT Phenomenology Airborne Radar (KaSPAR) interferometric radar and ARC's digital color infrared camera (DCS). These will be used for calibration and validation for NASA's Surface Water and Ocean Topology (SWOT) satellite mission. AirSWOT will be able to:

1) measure sea surface height (SSH) to unprecedented precision, providing unique measurements of the ocean mesoscale and submesoscale circulation;
2) Measure river stage, slope, and width, key variables in understanding and predicting river discharge;
3) Simultaneously measure water surface radial velocity;
4) Ka-band near nadir cross section; and
5) Provide near-infrared imagery.

Following these first two phases, AirSWOT will deploy to New Orleans to observe the Mississippi River Delta in May, and finally complete the 2015 campaign with a deployment to Fairbanks in June to observe arctic water characteristics.

Contributed by Randy Albertson and Greg Sadowy



AirSWOT radar operator Mauricio Sanchez-Barbetty jumps into the Edwards pool in survival suit as part of water survival training for the AirSWOT 2015 Ocean Validation phase.

EVS-2 Awards

Eight different ASP platforms will participate in the recently-announced Earth Venture Suborbital-2 missions. Proposals were under review in 2014 and announcements were made late last year for these 5-year missions. The Airborne Science Program has been working with the aircraft managers and PI teams to firm up schedules and support requirements for the five projects, which will take to the skies in locations all over the globe, as seen in the accompanying figure. The five projects are described in the table below. The NASA news release can be found at: http://www.nasa.gov/press/2014/november/nasa-airborne-campaigns-tackle-climate-questions-from-africa-to-arctic.

Contributed by Susan Schoenung

Acronym	Full title	Principle Investigator	Aircraft	Location
ATOM	Atmospheric Tomography	Steve Wofsy, Harvard University	DC-8	Multiple, global
NAAMES	North Atlantic Aerosols and Marine Ecosystems Study	Michael Behrenfeld, Oregon State University	C-130	North Atlantic Ocean
ACT-America	Atmospheric Carbon Transport - America	Kenneth Davis, Pennsylvania State University	C-130, UC-12	Eastern USA
ORACLES	Observations of Aerosols Above Clouds and their Interactions	Jens Redemann, NASA Ames Research Center	P-3, ER-2	West coast of equatorial Africa (Namibia)
OMG	Oceans Melting Greenland	Josh Willis, JPL	S-3, G-III	Greenland

TRANSITIONS

Chris Naftel retires

Chris Naftel, manager of the Global Hawk environmental science research unmanned aircraft systems project at NASA's Armstrong Flight Research Center, Edwards, California retired from government service in December 2014. His NASA career spanned over 36 years and he served as the Global Hawk Program Manager since program initiation in 2005.

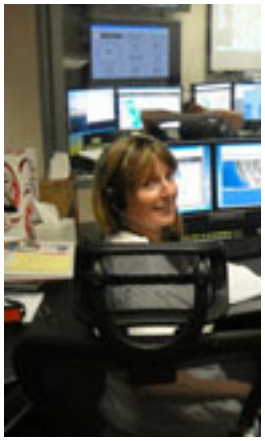
Chris orchestrated the transfer of five Global Hawk Aircraft – three early Advanced Concept Technology Demonstration versions and two "Block 10" models – from the U.S. Air Force to NASA and oversaw the development of the Global Hawk partnership between NASA and the Northrop Grumman Corporation. He has managed all aspects of the Global Hawk Project from initial planning, advocacy, business development, infrastructure development, and several successful environmental science missions.

His early NASA career was spent at NASA's Langley Research Center in Virginia, where he was a member of a launch vehicle systems analysis team. He transferred to NASA's Marshall Space Flight Center in Huntsville, Alabama in 1998, where he worked in the NASA X-33 Program Office.

Chris has been succeeded by Frank Cutler, an Airborne Science veteran who was previously assigned as the DC-8 Program Manager at Armstrong Flight Research Center.

Mike Craig retiring, Marilyn Vasques to assume ESPO Directorship

After 33 years with NASA, 30 of them in Earth Science, Michael Craig will be retiring this time next year. As the director for the Earth Science Project Office (ESPO), he led the group through 50+ successful campaigns and to an excellen reputation for success. Over the last couple over years, he has been transitioning his role to very capable hands of Marilyn Vasques. Marilyn came to ESPO 10 years ago with experience in Life Science / Shuttle Payloads and a MS in project management. With her as director, and Bernie Luna as Deputy, the ESPO office will be under excellent leadership. Michael will stay involved in Airborne Science and Division responsibilities until his retirement.



ASP Upcoming Events

* AUVSI Unmanned Systems North America 2015
  May 4-7, 2015; Atlanta, GA
  http://www.auvsishow.org/auvsi2015/public/enter.aspx

* ASPRS Annual Meeting and JACIE Workshop
  May 4-7, 2015; Tampa, FL
  http://conferences.asprs.org/Tampa-2015/blog

* 36th International Symposium on Remote Sensing of Environment (ISRSE)
  11-15 May 2015; Berlin, Germany
  http://www.isrse36.org/

* USGS UAS Workshop
  National Workshop on Unmanned Aircraft Systems (UAS)
  May 19-21, 2015; USGS Headquarters, Reston,Virginia
  http://geography.wr.usgs.gov/ICES/UAS-workshop.html

* 2015 Unmanned Systems Canada Annual Conference
  3-5 November 2015; Halifax, Nova Scotia, Canada
  Call for papers closes May 25, 2015
  https://www.unmannedsystems.ca/content.php?doc=182

* Spring 2015 TFRSAC Meeting
  Tactical Fire Remote Sensing Advisory Committee
  May 27-28, 2015 NASA Ames Research Center
  Contact: Everett Hinkley, ehinkley@fs.fed.us

* 2015 HyspIRI Mission and Products Symposium
  3-5 June, 2015; NASA GSFC
  http://hyspiri.jpl.nasa.gov/events/2015-hyspiri-science-symposium

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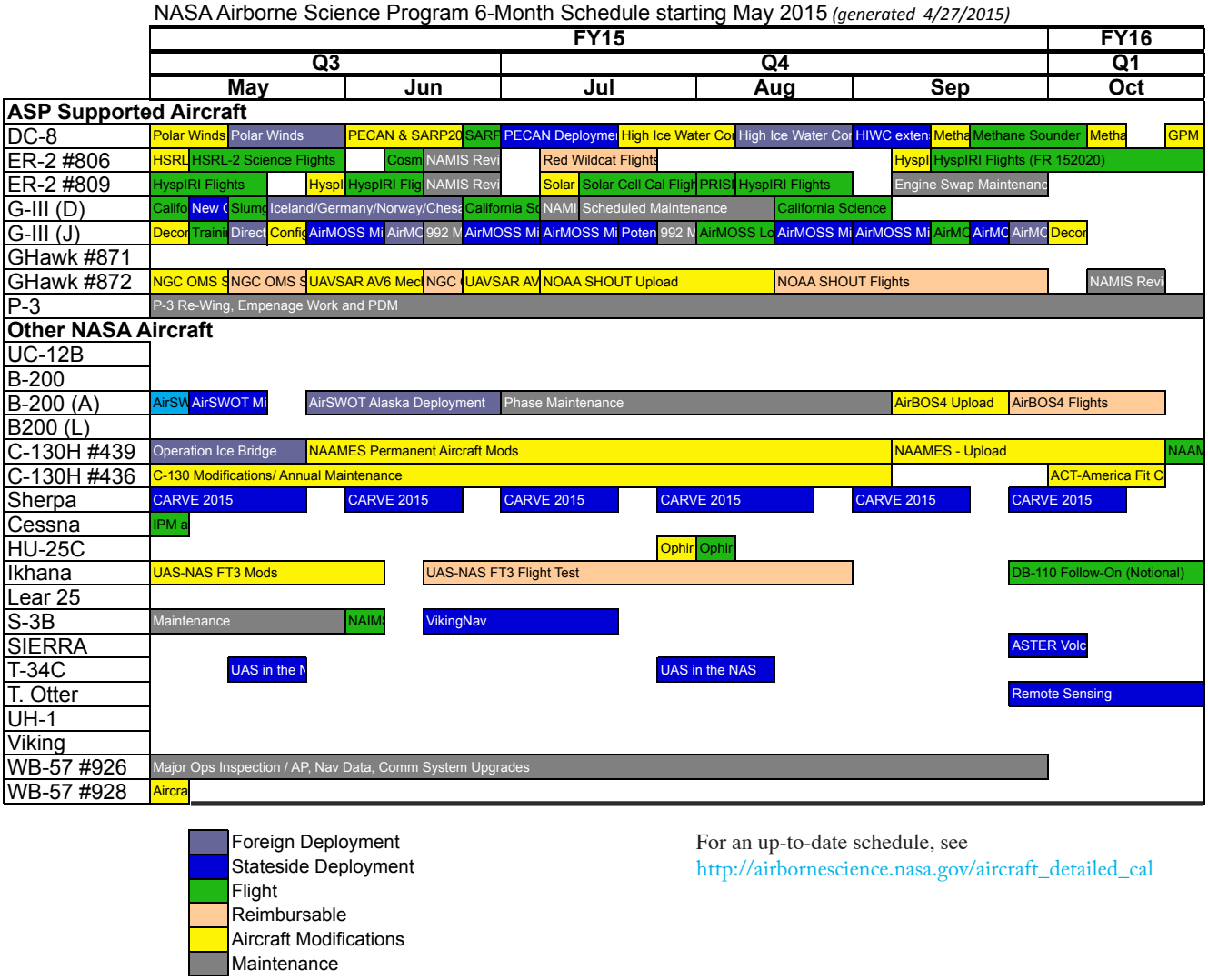
NASA SMD ESD Airborne Science Program 6-Month Schedule

NASA Airborne Science Program 6-Month Schedule starting May 2015 *(generated 4/27/2015)*



For an up-to-date schedule, see
http://airbornescience.nasa.gov/aircraft_detailed_cal

ASP Events *(continued from page 11)*

* NASA Ocean Color Research Team Meeting (OCRT)
  June 15-18, 2015; San Francisco, CA
  Contact: Paul Bontempi, paula.bontempi@nasa.gov

* 11th International Workshop on Greenhouse Gas Measurements from Space (IWGGMS-11)
  16-18 June, 2015; Pasadena, CA
  https://sites.google.com/site/iwggms11/

* ASCENDS Community Workshop
  19 June, 2015; Pasadena, CA
  https://sites.google.com/site/iwggms11/

* 2015 Alaska UAS Interest Group Annual Meeting
  1-3 September 2015; Fairbanks, Alaska
  CALL FOR PAPERS closes July 1, 2015
  http://uasalaska.org/meeting2015

* 6th SMAP Cal/Val Workshop
  29-30 August, 2015; Washington, DC
  http://smap.jpl.nasa.gov/events/39/

Call for Content

Working on something interesting, or have an idea for a story? Please let us know, we'd love to put it into print.

Contact Susan Schoenung (650/329-0845, susan.m.schoenung@nasa.gov) or Matt Fladeland (650/604-3325, matthew.m.fladeland@nasa.gov).

Airborne Science Program

Platform Capabilities

Available aircraft and specs

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	DC-8	NASA-DFRC	12	30,000	340,000	41,000	450	5,400	http://airbornescience.nasa.gov/aircraft/DC-8
	ER-2	NASA-DFRC	12	2,900	40,000	>70,000	410	>5,000	http://airbornescience.nasa.gov/aircraft/ER-2
	Gulfstream III (G-III) (C-20A)	NASA-DFRC	7	2,610	69,700	45,000	460	3,400	http://airbornescience.nasa.gov/aircraft/G-III_C-20A_-_Dryden
	Gulfstream III (G-III)	NASA-JSC	7	2,610	69,700	45,000	460	3,400	http://airbornescience.nasa.gov/aircraft/G-III_-_JSC
	Global Hawk	NASA-DFRC	30	1900	25,600	65,000	345	11,000	http://airbornescience.nasa.gov/aircraft/Global_Hawk
	P-3B	NASA-WFF	14	14,700	135,000	32,000	400	3,800	http://airbornescience.nasa.gov/aircraft/P-3_Orion
Other NASA Aircraft	B-200 (UC-12B)	NASA-LARC	6.2	4,100	13,500	31,000	260	1,250	http://airbornescience.nasa.gov/aircraft/B-200_UC-12B_-_LARC
	B-200	NASA-DFRC	6	1,850	12,500	30,000	272	1,490	http://airbornescience.nasa.gov/aircraft/B-200_-_DFRC
	B-200	NASA-ARC/ DOE	6.75	2,000	14,000	32,000	250	1,883	http://airbornescience.nasa.gov/aircraft/B-200_-_DOE
	B-200	NASA-LARC	6.2	4,100	13,500	35,000	260	1,250	http://airbornescience.nasa.gov/aircraft/B-200_-_LARC
	C-23 Sherpa	NASA-WFF	6	7,000	27,100	20,000	190	1,000	http://airbornescience.nasa.gov/aircraft/C-23_Sherpa
	Cessna 206H	NASA-LARC	5.7	1,175	3,600	15,700	150	700	http://airbornescience.nasa.gov/aircraft/Cessna_206H
	Dragon Eye	NASA-ARC	1	1	6	500+	34	3	http://airbornescience.nasa.gov/aircraft/B-200_-_LARC
	HU-25C Falcon	NASA-LARC	5	3,000	32,000	42,000	430	1,900	http://airbornescience.nasa.gov/aircraft/HU-25C_Falcon
	Ikhana	NASA-DFRC	24	2,000	10,000	40,000	171	3,500	http://airbornescience.nasa.gov/aircraft/Ikhana
	Learjet 25	NASA-GRC	3	3,200	1,500	45,000	350	1,200	http://airbornescience.nasa.gov/aircraft/Learjet_25
	S-3B Viking	NASA/GRC	6	12,000	52,500	40,000	450	2,300	http://airbornescience.nasa.gov/aircraft/S-3B
	SIERRA	NASA-ARC	10	100	400	12,000	60	600	http://airbornescience.nasa.gov/platforms/aircraft/sierra.html
	T-34C	NASA-GRC	3	500	4,400	25,000	75	700	http://airbornescience.nasa.gov/aircraft/T-34C
	Twin Otter	NASA-GRC	3	3,600	11,000	25,000	140	450	http://airbornescience.nasa.gov/aircraft/Twin_Otter_-_GRC
	WB-57	NASA-JSC	6	6,000	63,000	60,000+	410	2,500	http://airbornescience.nasa.gov/aircraft/WB-57