

National Aeronautics and Space Administration



NASA's Earth Science Division Earth Science Technology Forum

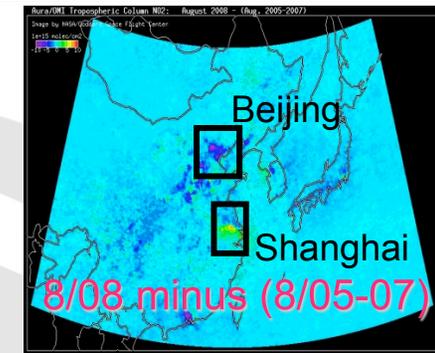
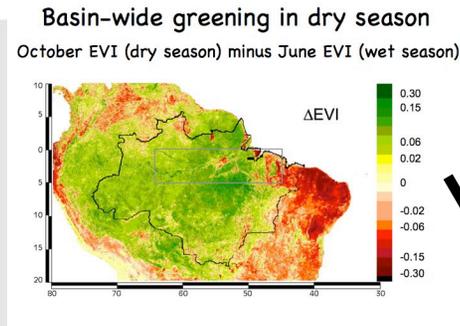
Michael H. Freilich
22 June 2010

Earth Science Division Overview



- Overarching goal: to advance Earth System science, including climate studies, through spaceborne data acquisition, research and analysis, and predictive modeling
- Six major activities:
 - **Building and operating Earth observing satellite missions**, many with international and interagency partners
 - Making high-quality data products available to the broad science community
 - Conducting and sponsoring cutting-edge research
 - **Field campaigns to complement satellite measurements**
 - Analyses of non-NASA mission data
 - Modeling
 - **Applied Science**
 - **Developing technologies to improve Earth observation capabilities**
 - Education and Public Outreach

Earth SCIENCE Division Focus Areas



Atmospheric Composition

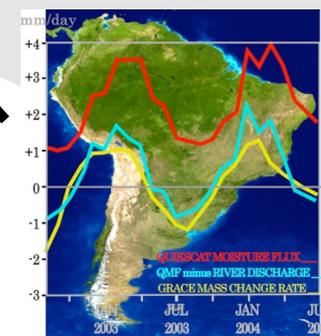
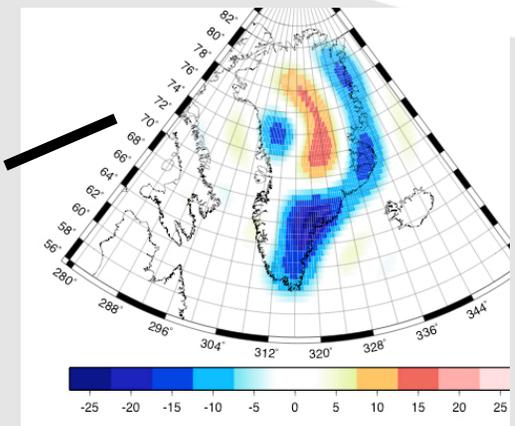
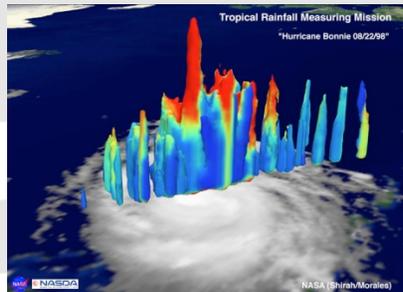
Carbon Cycle and Ecosystems

Climate Variability and Change

Weather

Water and Energy Cycle

Earth Surface and Interior

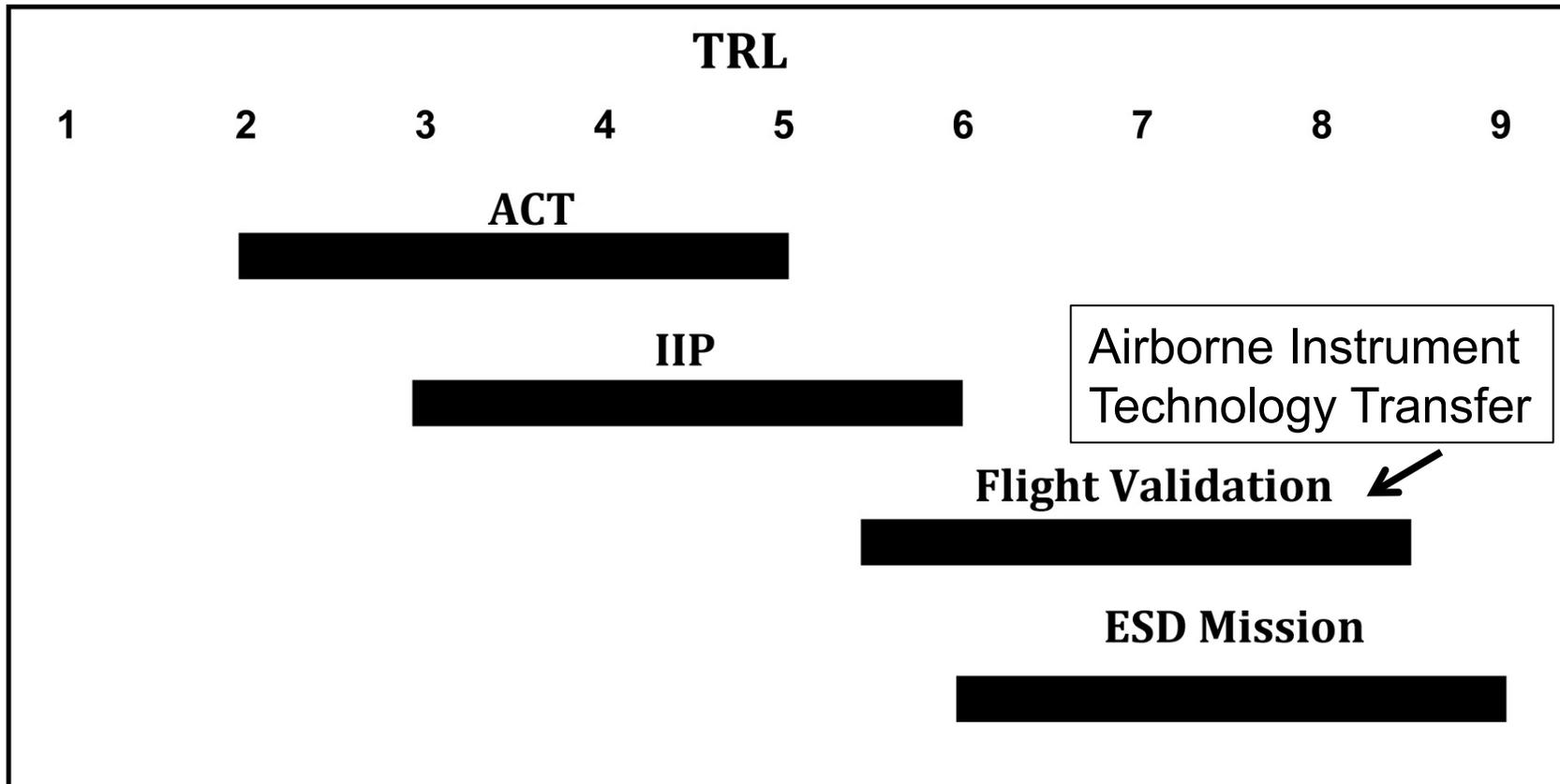


Earth Science Division Overview



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Earth Science Technology Program





Airborne Science Program

Observing Platforms for Earth System Science Investigations



WB-57



Global Hawk



ER-2



G III



Learjet



DC-8



Ikhana



P-3



S-3B



B-200



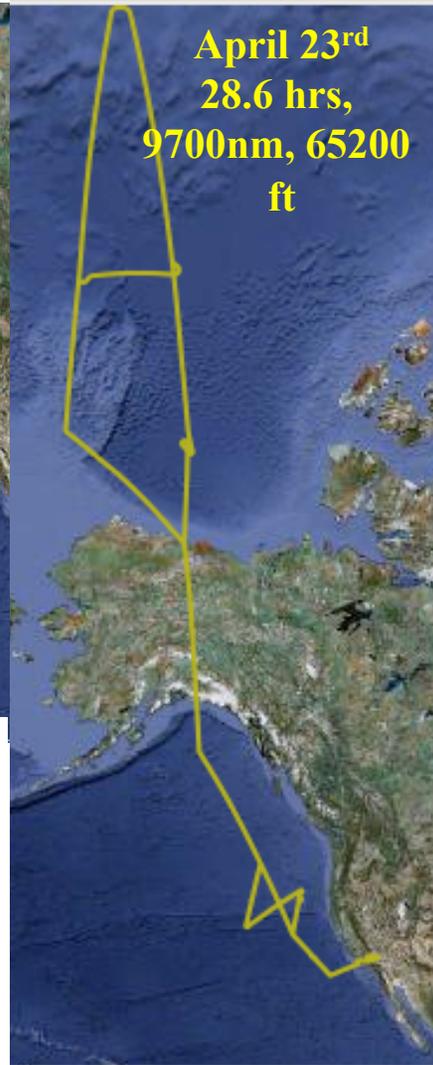
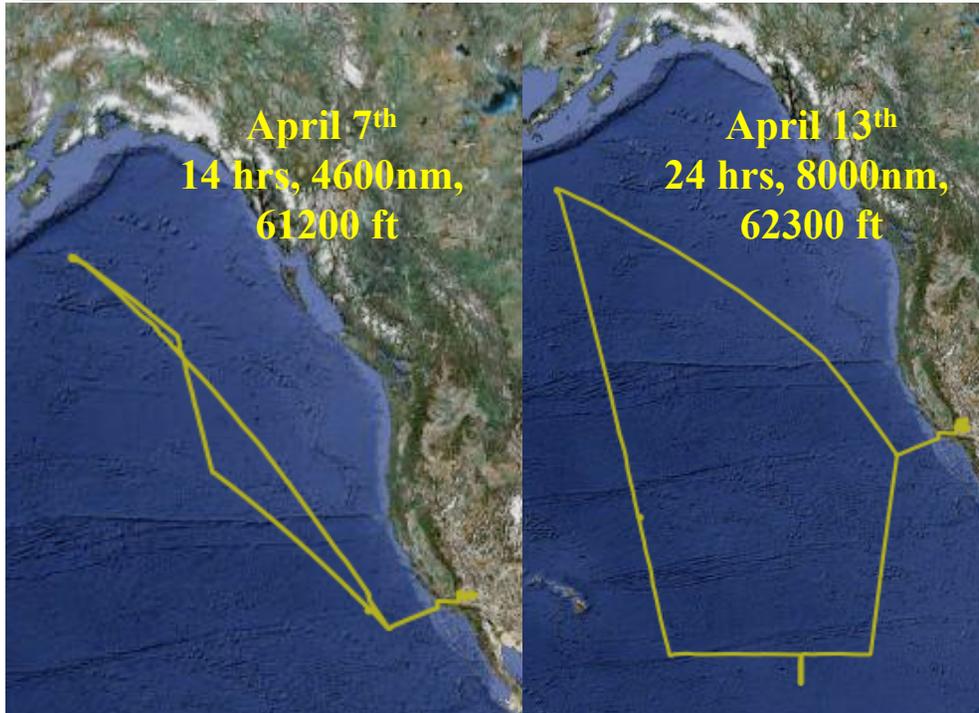
Twin Otter



SIERRA

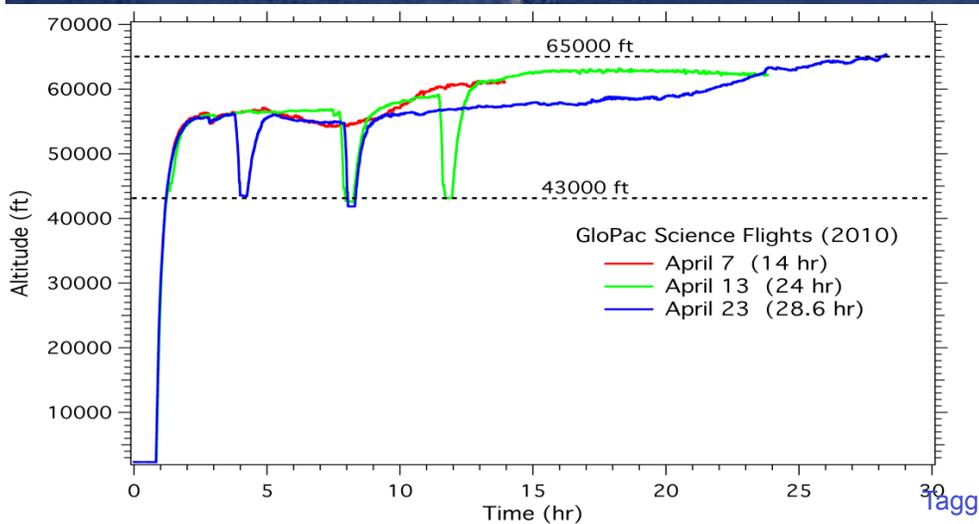


GloPac Flight Tracks



April 30th - 9.3 hrs
Curtailed due to
generator malfunction

total: 75.9 hrs
(2 Apr. test flight: 6 hrs)

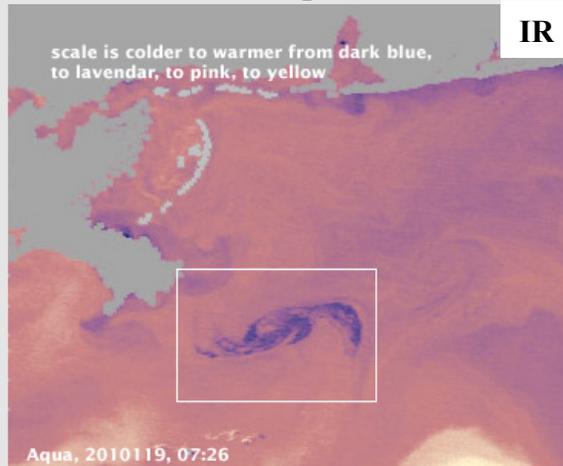


Response to Gulf Oil Spill (GOSpill)

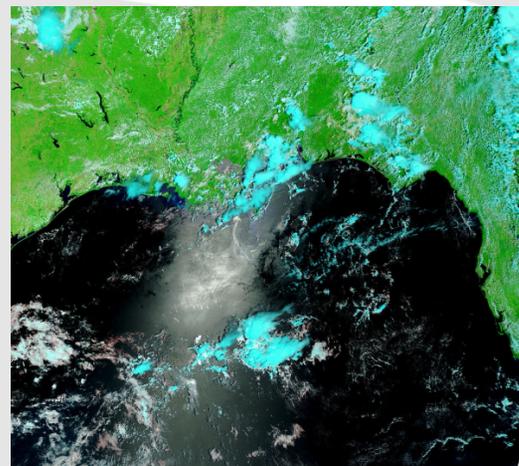


Visible

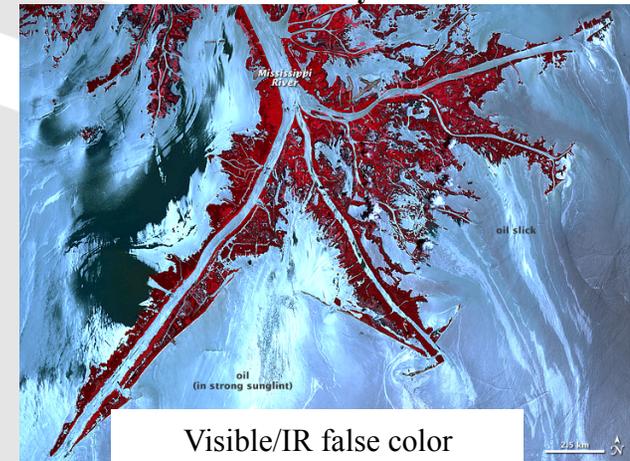
MODIS 29 April 2010



MODIS 31 May 2010



ASTER 24 May 2010

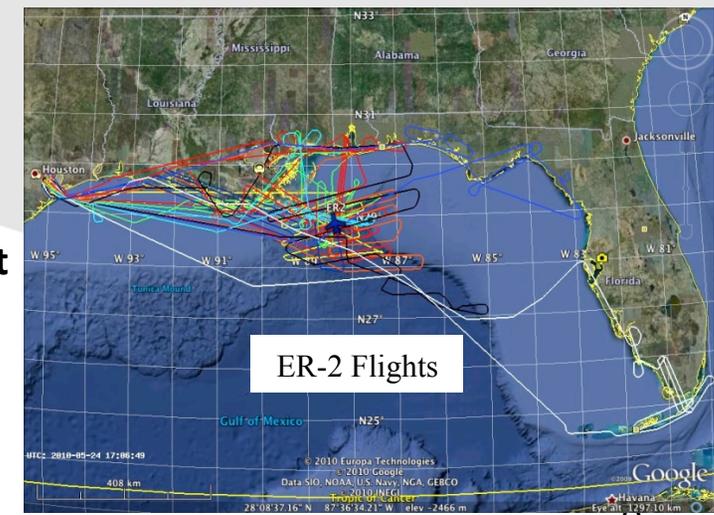


Satellite instruments: continually monitoring the extent of the spill

- Terra & Aqua / MODIS – visible and infrared daily synoptic
- Terra / ASTER – visible, near IR and thermal IR high res
- EO-1 / Advanced Land Imager and Hyperion – highest res
- Terra / MISR
- CALIPSO / CALIOP

Airborne instruments: measuring *surface* extent , volume, impact

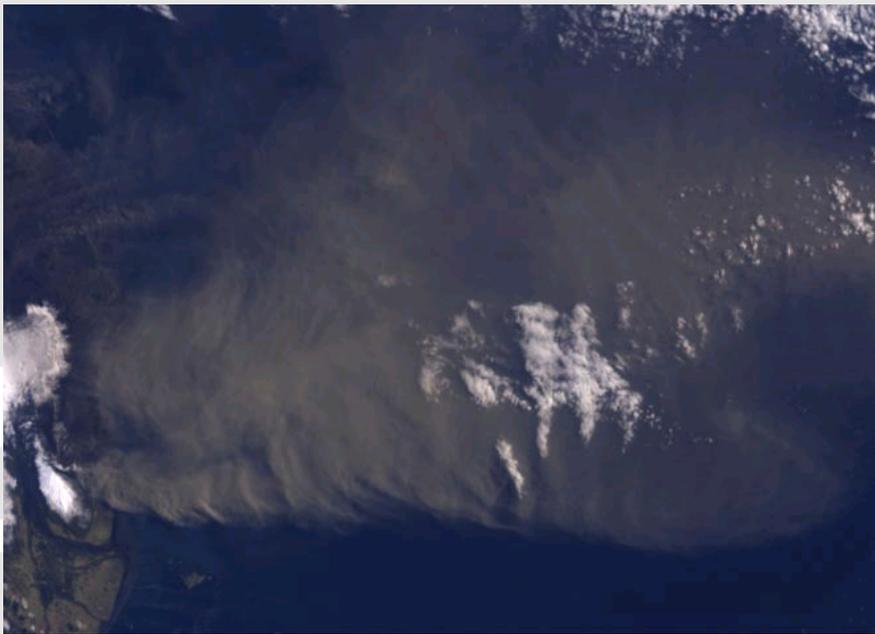
- ER2 / AVIRIS and DCS– 6, 10, 11, 13, 17-20, 23-25 May
- B200 / HSRL– 10-11 May; two FOO; CALIOP studies
- UAVSAR– First flights 22-24 June
- Data and products being provided to USGS distribution center for use by first responders to position equipment and for analysis of slick volumes. NOAA using radiances to initialize trajectory model



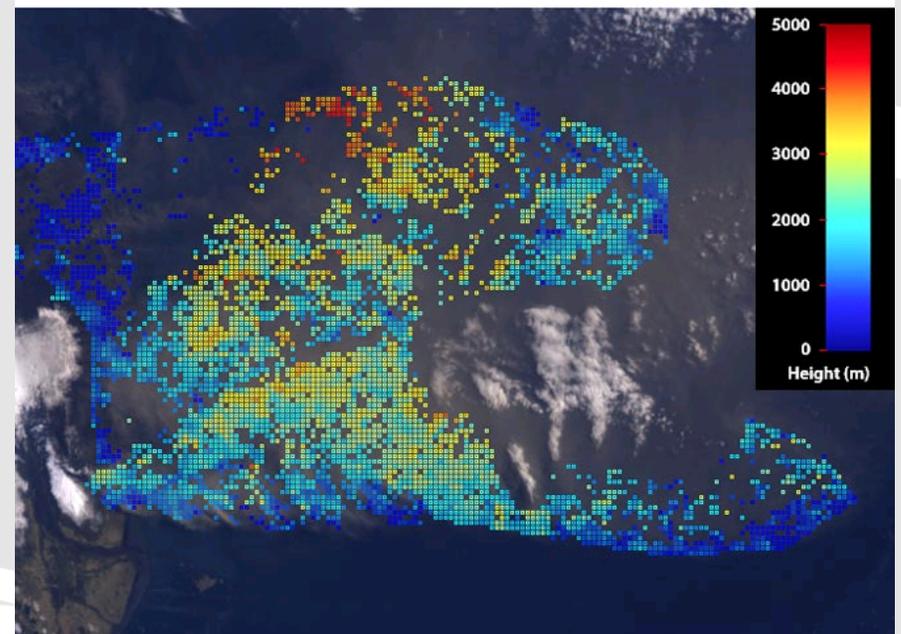
MISR Measures the Iceland Volcano Ash Cloud Heights



20 April 2010

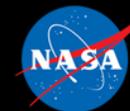


Visible from nadir camera

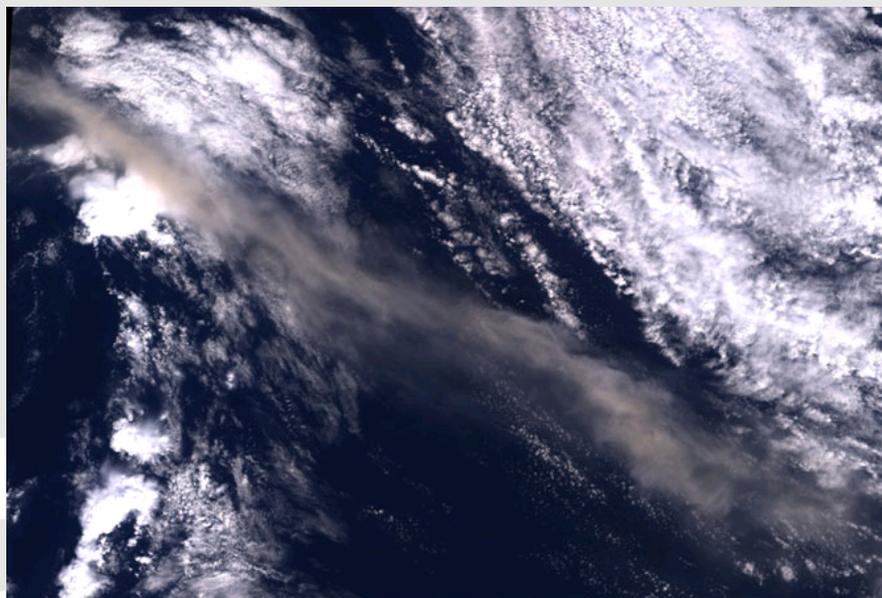


Corrected height estimate
from stereo views

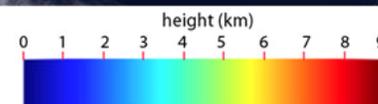
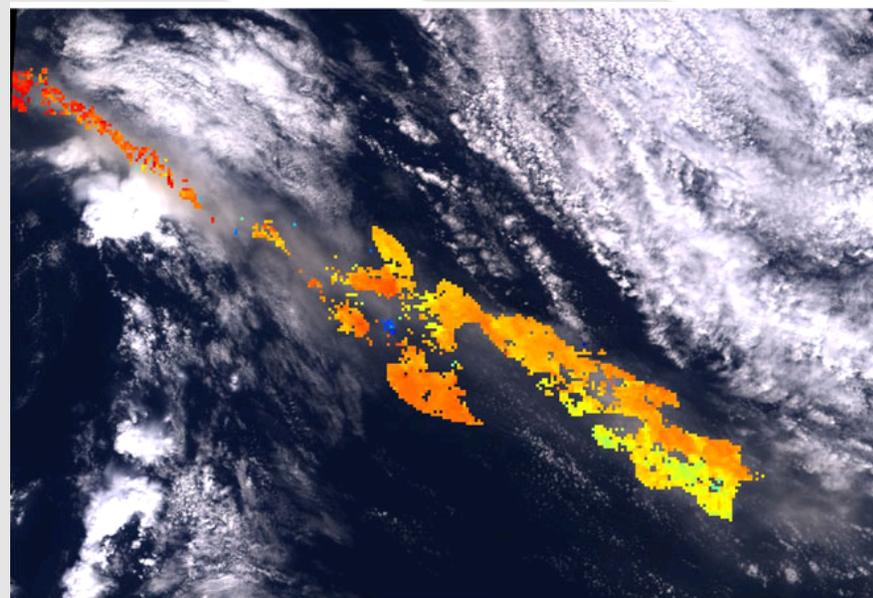
MISR Measures the Iceland Volcano Ash Cloud Heights



16 May 2010



Visible from nadir camera



Corrected height estimate
from stereo views

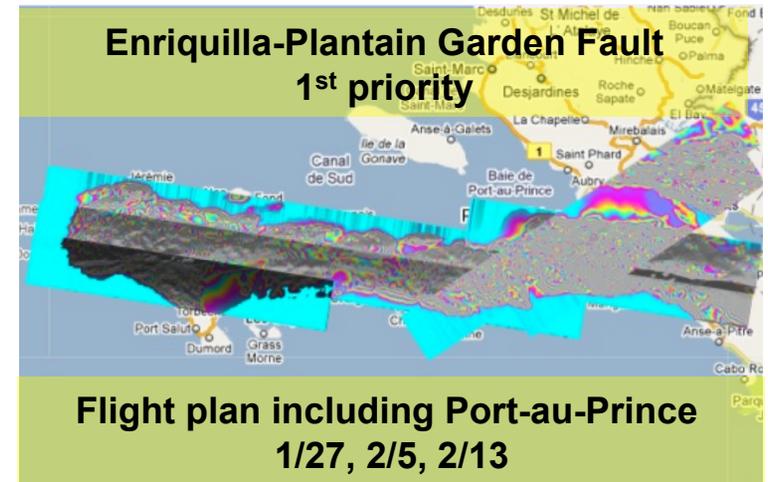


Opportunity to Observe Hispaniola Fault Zones During Planned UAVSAR Deployment to Central America

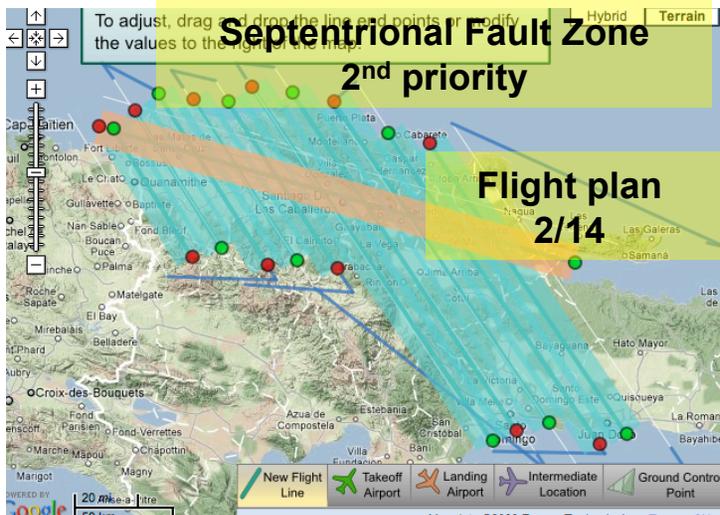
Main Mission: Central America Deployment

- Planned for Jan. 25 – Feb. 14, 2010
- Studies of: Volcanoes, Tropical forest structure and biomass, Mayan archaeology sites
- DESDynI-relevant science studies

Flight of Opportunity: Haiti & Dominican Republic



- Identify fault rupture
- Assess earthquake and aftershock triggering
 - From loading of adjacent fault segments
 - Measure post-seismic deformation
- Landslide hazard identification



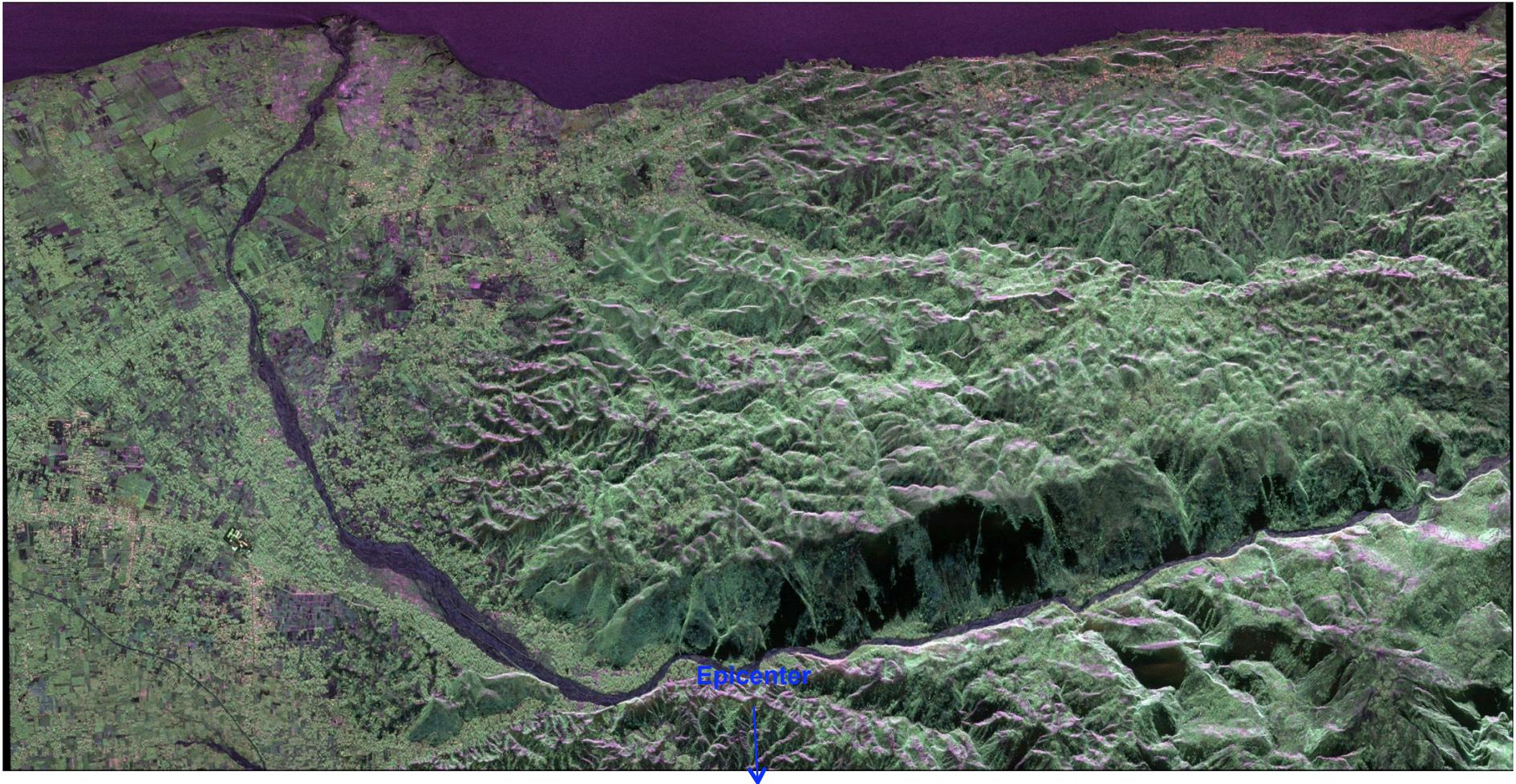
Baseline observations for possible future event

- Historically very active
- Propagating to the west
- Major concern to USGS

UAVSAR: repeat-pass L-band InSAR

Rapid access, short revisit interval, high resolution and variable viewing geometry

Optimize observation of surface deformation associated with earthquake and landslide hazards Airborne test-bed for the DESDynI climate and hazards observatory



Red: HH polarization **Green: HV polarization** **Blue: VV polarization**

Acquired on January 27, 2010

Quicklook Image along the Enriquillo-Plantain Garden Fault near the epicenter of the M7.0 earthquake. The epicenter is just beyond this quicklook image, which shows only half the acquired range swath.

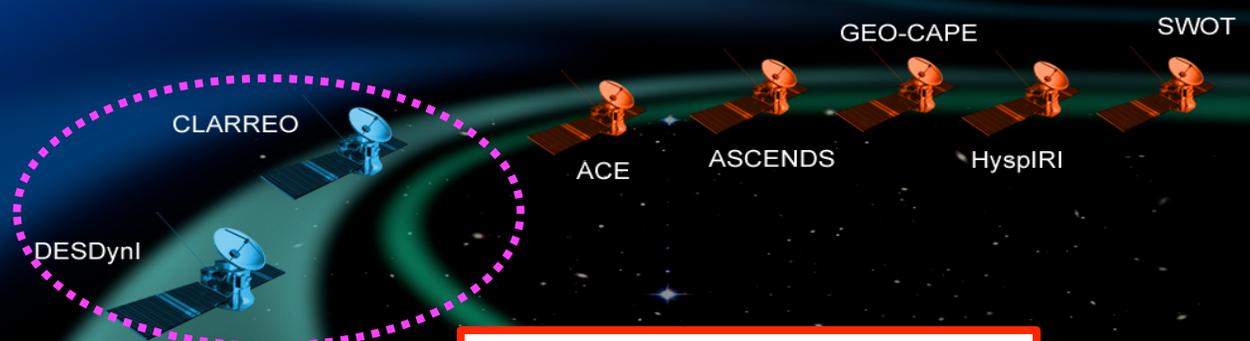
Decadal Survey Missions Next Generation



Near-Term Missions:

Mid-Term Missions:

Late-Term Missions:



VENTURE-CLASS

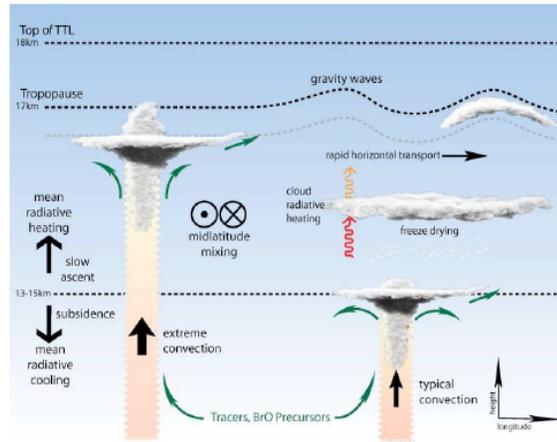
Global Hawk

DC-8

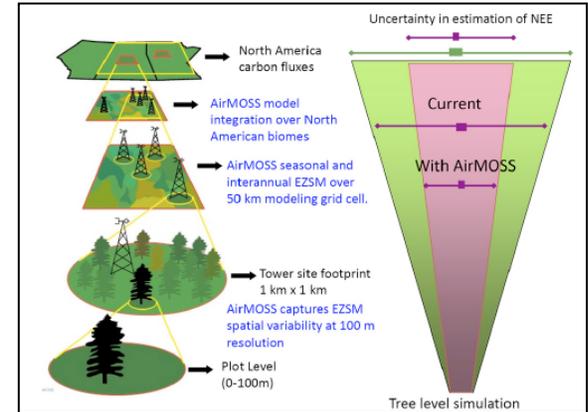


NASA ANNOUNCES FIRST SELECTION OF FIVE 'EARTH VENTURE' RESEARCH MISSIONS

Maximum \$150 million total funding ceiling



NASA's Earth Venture missions, part of the Earth System Science Pathfinder program, are small, targeted science investigations. They complement larger research missions and were recommended by the National Research Council Decadal Survey as quick-turnaround projects. This year's selections are all airborne investigations. Future Venture proposals may include small, dedicated spacecraft and instruments flown on other spacecraft.



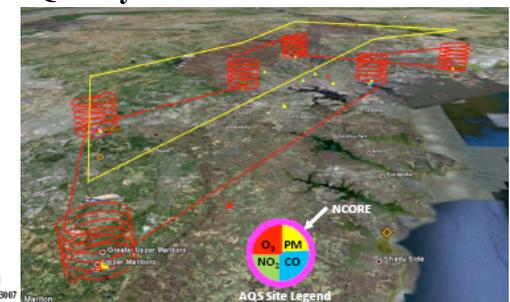
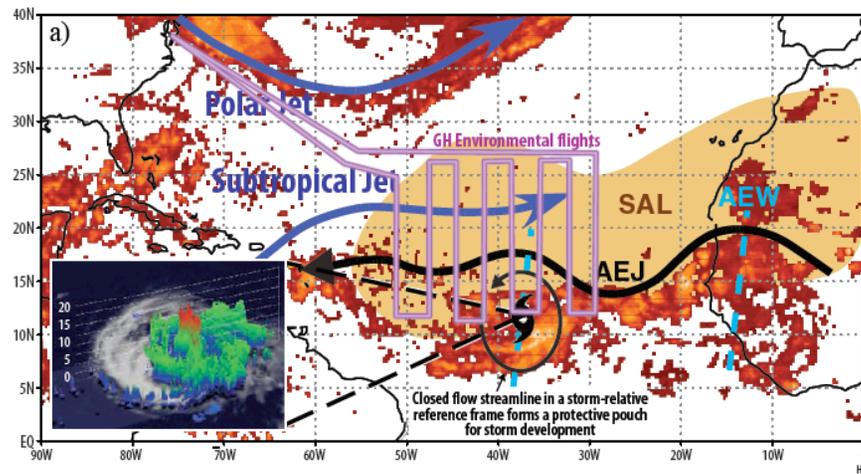
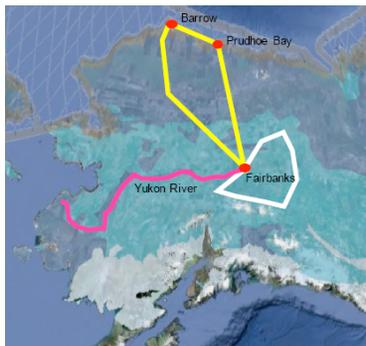
Above: Airborne Tropical Tropopause Experiment: will improve understanding of the processes that control the flow of atmospheric gases into this region by studying chemical and physical processes at different times of year.

Above: Airborne Microwave Observatory of Subcanopy and Subsurface: will address the uncertainties in gas exchange estimates by measuring soil moisture in the root zone of representative regions of major North American ecosystems.

Below: Carbon in Arctic Reservoirs Vulnerability Experiment: investigations into Arctic carbon cycling.

Below: Hurricane and Severe Storm Sentinel: will investigate hurricanes intensity change processes in the Atlantic Ocean basin.

Below: Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality





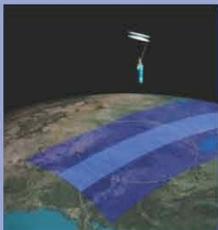
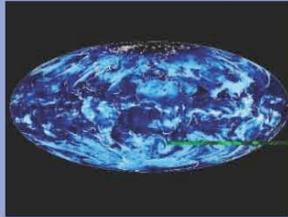
EARTH VENTURE-1

Co-Investigator Institutions

- **Airborne Microwave Observatory of Subcanopy and Subsurface (AirMOSS) Moghaddam – U Mich**
University of Michigan – Ann Arbor, Oregon State University, Massachusetts Institute of Technology, Harvard University, Purdue University, USDA Agricultural Research Service, USDA – Forest Service, NASA Goddard Space Flight Center , NASA Jet Propulsion Laboratory
- **Airborne Tropical Tropopause Experiment (ATTREX) Jensen – NASA Ames Research Center**
University of Colorado – Boulder, National Center for Atmospheric Research, University of Maryland - Baltimore, Harvard University, University of Miami – Key Biscayne, NOAA Oceanic & Atmospheric Research, Northwest Research Associates Inc., Park Stratton Engineering Co. Inc., University of California - Los Angeles, University of Heidelberg, NASA Ames Research Center, NASA Goddard Space Flight Center, NASA Jet Propulsion Laboratory, NASA Langley Research Center,
- **Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE) Miller – Jet Propulsion Laboratory**
NOAA Oceanic & Atmospheric Research, University of Colorado – Boulder, San Diego State University, University Of California – Irvine, California Institute of Technology, Harvard University, University of California – Berkeley, University Of California - Santa Barbara, Commissariat A L'Energie Atomique , NASA Jet Propulsion Laboratory
- **Deriving Information on Surface Conditions from COLUMN and VERTically Resolved Observations Relevant to Air Quality (DISCOVER-AQ) Crawford – Langley Research Center**
University Of Maryland – Baltimore, University of California - Berkeley, National Center for Atmospheric Research, Pennsylvania State University, Leopold Franzens Universitaet Innsbruck, Howard University , NASA Ames Research Center, NASA Goddard Space Flight Center, NASA Langley Research Center
- **Hurricane and Severe Storm Sentinel (HS3) Braun – Goddard Space Flight Center**
NOAA National Environmental Satellite Data And Information Service, University Of Maryland - Baltimore, Naval Postgraduate School, University Of Wisconsin – Madison, State University Of New York - Albany, University Of Utah - Salt Lake City, Northrop Grumman Inc., Naval Research Laboratory, NOAA National Center for Environmental Prediction, NASA Dryden Flight Research Center, NASA Goddard Space Flight Center, NASA Jet Propulsion Laboratory , NASA Marshall Space Flight Center

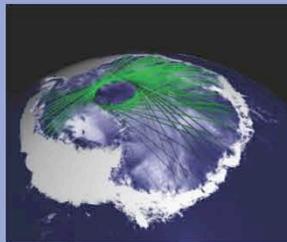
NASA Earth Science Decadal Survey Missions

Climate Absolute Radiance and Refractivity Observatory (**CLARREO**)



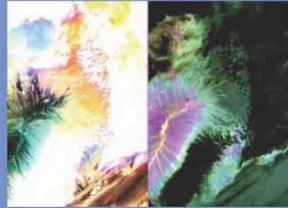
Soil Moisture Active Passive (**SMAP**)

Ice, Cloud, and land Elevation Satellite II (**ICESat-II**)



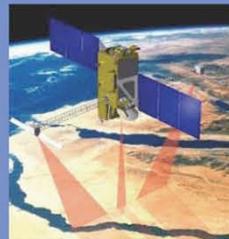
Deformation, Ecosystem Structure and Dynamics of Ice (**DESDynI**)

Tier I



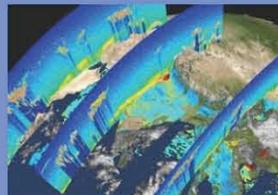
Hyperspectral Infrared Imager (**HYSPIRI**)

Active Sensing of CO2 Emissions (**ASCENDS**)



Surface Water and Ocean Topography (**SWOT**)

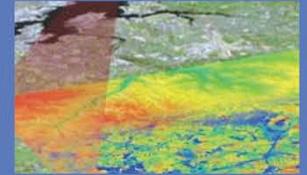
Geostationary Coastal and Air Pollution Events (**GEO-CAPE**)



Aerosol - Cloud - Ecosystems (**ACE**)

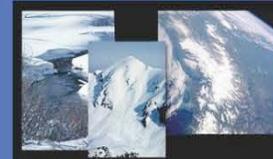
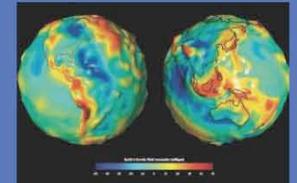
Tier II

LIDAR Surface Topography (**LIST**)



Precipitation and All-Weather Temperature and Humidity (**PATH**)

Gravity Recovery and Climate Experiment - II (**GRACE - II**)



Snow and Cold Land Processes (**SCLP**)

Three-Dimensional Winds from Space Lidar (**3D-Winds**)



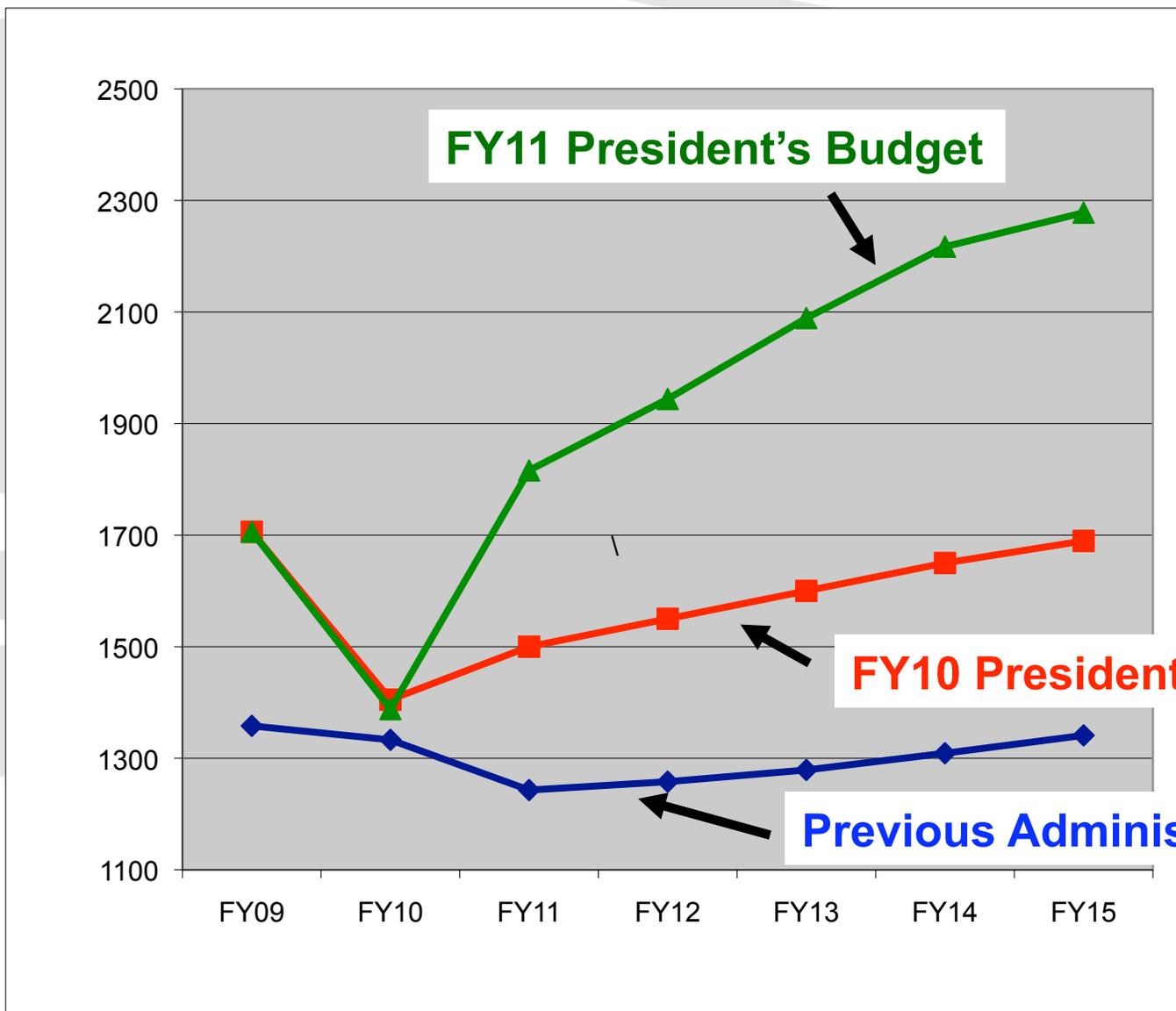
Global Atmospheric Composition Mission (**GACM**)

Tier III

NASA Earth Science Division BUDGET MARKS: FY11 Submit



BUDGET (\$M)





Welcome to
ESTF2010

EARTH SCIENCE TECHNOLOGY FORUM 2010

June 22 - 24, 2010
Sheraton Crystal City, Arlington, VA



esto.nasa.gov

ESD SELECTION/PRIORITY APPROACH



- Decadal Survey for missions and programs
- Competition/Peer Review through ROSES and AOs
- National Needs – Administration/Congressional guidance

President's FY11 NASA Budget Request: Earth Science Plan



- Present infusion enables significant mission accelerations and program expansions
 - FY09 Stimulus + FY10 President's budget increase for Earth Science provided a realistic basis for the Foundational Missions
 - **All Foundational missions launched by mid-CY2013** (Glory, Aquarius, NPP, LDCM, GPM)
 - **Build on existing balanced program (non-flight as well as flight)**
- **Enables OCO-2 development and launch by 2/2013**
 - OCO-3 instrument build for MoO in late CY2015
- **Accelerates selected Decadal Survey systematic missions**
 - **Launches all 4 Tier-1 missions between 2014 and 2017**
 - SMAP: 11/2014; ICESAT-2: 10/2015 DESDynI*: 2017; CLARREO-1*: 2017
- **Expands and accelerates Venture-class competitive, PI-led program**
 - **ANNUAL solicitations for major flight instruments PLUS biannual alternating airborne and small-mission solicitations**
 - **First small-sat selections in 2012** (solicitation in 2011)
 - Develops Common Instrument Interface, encouraging flight on ISS, international partner missions, private/commercial missions

**Constrained, focused refined mission*

(continued)

President's FY11 NASA Budget Request: Earth Science Plan (cont.)



- **Develops selected Climate Continuity Missions**
 - **SAGE-III** refurbishment/hexapod development, ready for **flight to ISS** in CY2014
 - **GRACE-FO** (GRACE Follow-on), launch late CY2015 (joint with DLR)
 - **Additional measurements have been identified in concert with USGCRP (2019-2020)**
- **Enables Key Non-Flight activities**
 - Multi-year **carbon monitoring pilot** program
 - Expanded Earth Science-specific **technology** program
 - **SERVIR expansion**
 - **Expanded modeling, synthesis, computing capability**
 - **NASA substantial support/participation in National Assessment activities**
 - **Geodetic ground network expansion/modernization**
 - **Expanded NASA support for GLOBE**
- **With US Global Change Research Program, identifies and enables two additional Tier-2 Decadal Survey missions to be developed for flight in 2019-2020 time frame**

MISSION LAUNCH CADENCE

NASA EARTH SCIENCE FY11 BUDGET



- GLORY (11/2010)
 - Aquarius (12/2010) (with CONAE)
 - NPP (NET 9/2011) (with Interagency partners)
 - LDCM (12/2012) (agency external commitment 6/2013) (with USGS, TIRS capability)
 - OCO-2 (2/2013)
 - GPM Core (7/2013) (with JAXA)
 - SAGE-III on ISS (late 2014) (launch required and not in budget, includes hexapod)
 - SMAP (11/2014) (date set by LV selection issues, SRB's recommendation for Phase C-D)
 - ICESAT-2 (10/2015) (date constrained by technical development)
 - GRACE-C (12/2015) (possibly with DLR)
 - OCO-3 (12/2015) (instrument-only, MoO)
 - CLARREO-1 (10/2017) (cost-constrained mission)
 - DESDynI RADAR+LIDAR (10/2017) (possibly with DLR, partnership not essential)
 - 2 additional missions for launch prior to 2020, identified in concert with USGCRP
-
- Annual Venture major instrument solicitations starting in FY12
 - First small-sat Venture mission call in FY12

Challenges Moving Forward



- What we do in Earth Science is recognized by the public and national leaders as **IMPORTANT**, not simply interesting and challenging.
- There is relentless pressure on NASA ESD to expand the scope of our contributions
- Preserving a balanced program, completing and launching the missions in development and planned, executing a future flight program based on the Decadal Survey and national needs are the key **programmatic** objectives
- There will be no new research mission launches until the very end of CY 2010 (Glory, Aquarius in 2011) – **BUT**
- ***A steady stream of field campaigns, scientific discoveries, applications expansions, and **technology developments** will carry the program and advance understanding of our planet***

Mission Addition/Acceleration Criteria



- Science/Applications contributions
 - Decadal Survey
 - Thematic focus area programs (integration, science progress)
- Technological maturity
- Complementarity to the planned international constellation
 - Explicit examination of partner missions
 - Realistic mission lifetime projections
- **BUDGET AND SCHEDULE REALISM** within the constraints