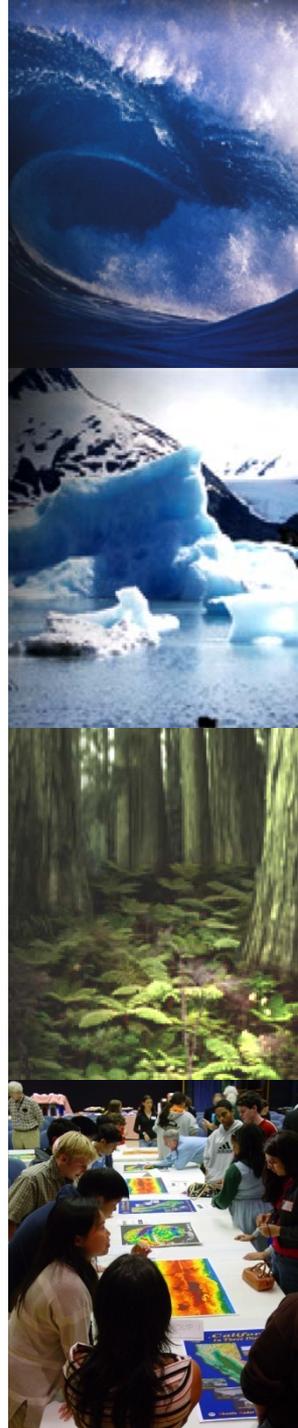
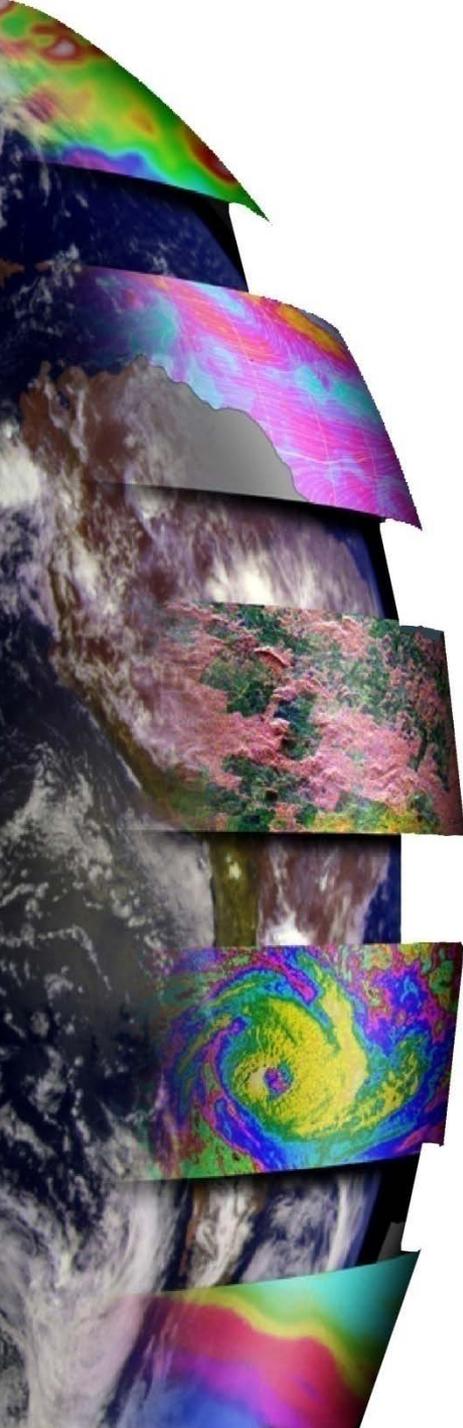


JPL's Role in Advancing Earth System Science to Meet the Challenges of Climate and Environmental Change

Diane Evans, Director
June 22, 2012



Jet Propulsion Laboratory
California Institute of Technology





Strategic Goals



Strategic Goal 2:

Expand scientific understanding of the Earth and the universe in which we live.

2.1: **Advance Earth system science** to meet the challenges of climate and environmental change.

Objective 2.1.1: **Improve understanding of and improve the predictive capability** for changes in the ozone layer, climate forcing, and air quality associated with changes in atmospheric composition.

Objective 2.1.2: **Enable improved predictive capability** for weather and extreme weather events.

Objective 2.1.3: **Quantify, understand, and predict changes** in Earth's ecosystems and biogeochemical cycles, including the global carbon cycle, land cover, and biodiversity.

Objective 2.1.4: **Quantify the key reservoirs and fluxes** in the global water cycle and assess water cycle change and water quality.

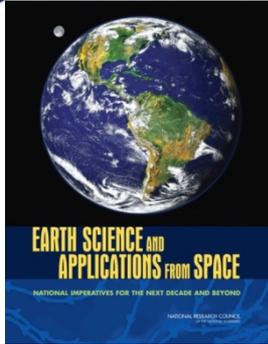
Objective 2.1.5: **Improve understanding** of the roles of the ocean, atmosphere, land and ice in the climate system and improve predictive capability for its future evolution.

Objective 2.1.6: **Characterize the dynamics of Earth's surface and interior** and form the scientific basis for the assessment and mitigation of natural hazards and response to rare and extreme events.

Objective 2.1.7: **Enable the broad use of Earth system science observations and results** in decision-making activities for societal benefits.



JPL Earth Science Overview



Measurement Needs



Component Technologies

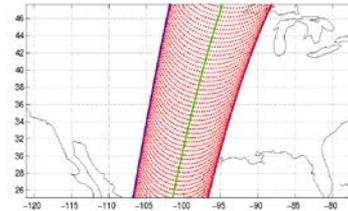


Testbeds



Airborne/Balloon Prototypes

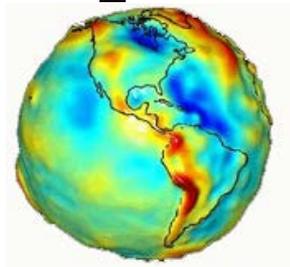
Scientific Research Outreach Decision Support



Campaign/Mission Design



Formulation Team X



Science Operations and Data Processing



Cal/Val



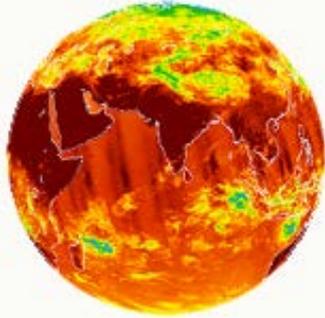
Integration and Test



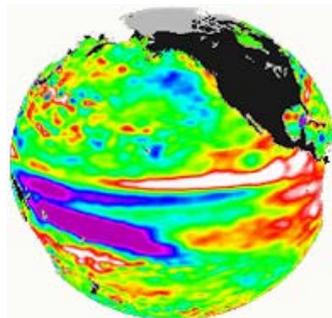
Flight Experiment Development



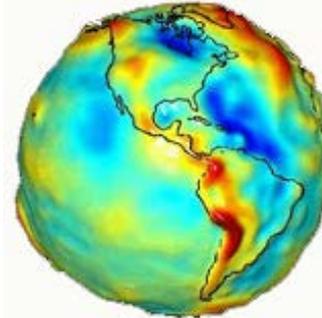
JPL's Earth Science Observations



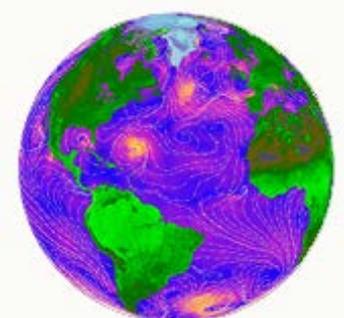
**Atmospheric Infrared
Sounder (AIRS)**
provides monthly
global
temperature maps



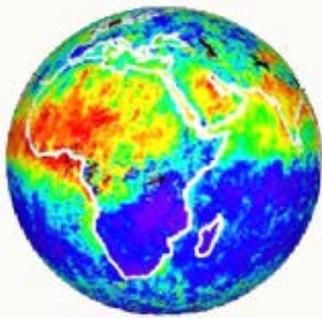
Jason provides
global sea surface
height maps every
10 days



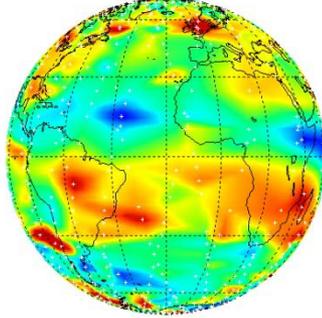
**Gravity Recovery
and Climate
Experiment (GRACE)**
provides monthly
maps of Earth's
gravity



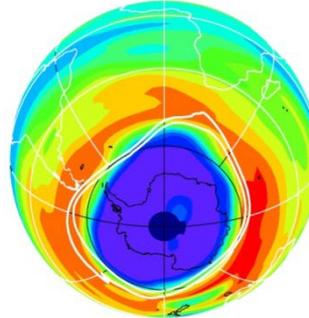
Quikscat collects
data over the polar
regions, and
supports Cal/Val of
India's Oceansat-2



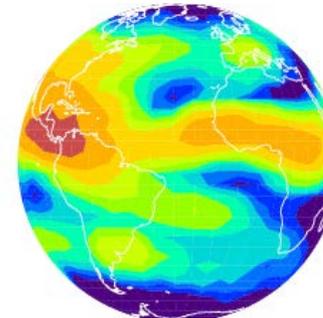
**Multi-angle Imaging
Spectro Radiometer
(MISR)** provides
monthly global
aerosol maps



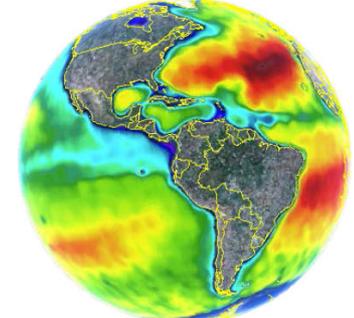
**Tropospheric
Emission
Spectrometer (TES)**
provides monthly
global maps of
Ozone



**Microwave Limb
Sounder (MLS)**
provides daily maps
of stratospheric
chemistry



CloudSat provides
monthly maps
of cloud ice
water content

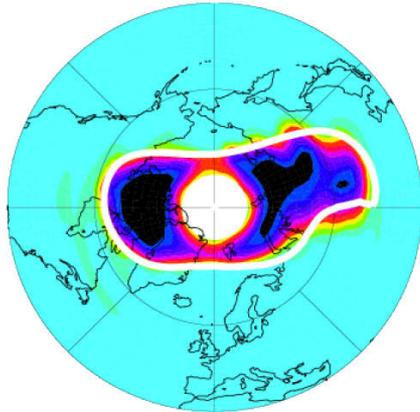


Aquarius provides
monthly maps of
sea surface salinity

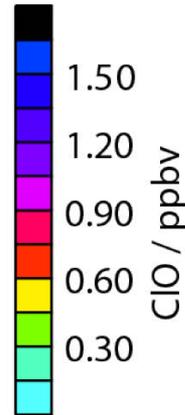
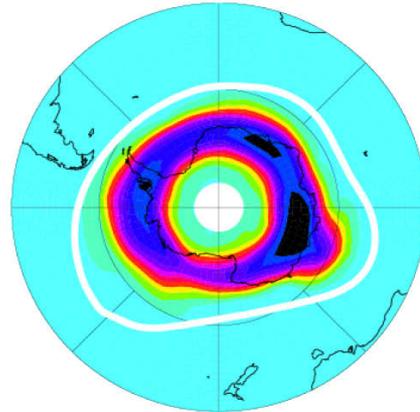


Improve Understanding of and Improve the Predictive Capability for Changes in the Ozone Layer, Climate Forcing, and Air Quality Associated with Changes in Atmospheric Composition (2.1.1)

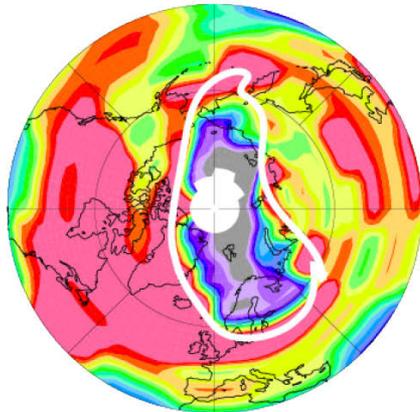
28 Feb 2011



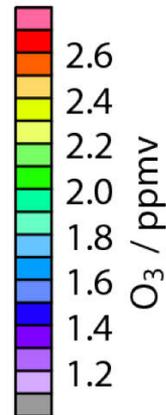
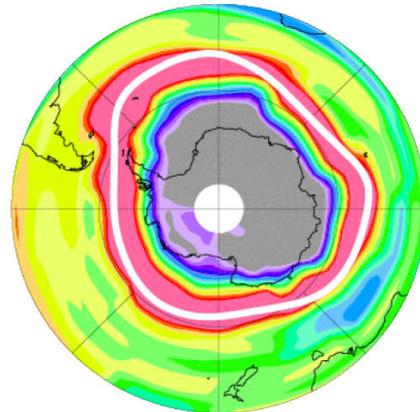
29 Aug 2010



26 Mar 2011



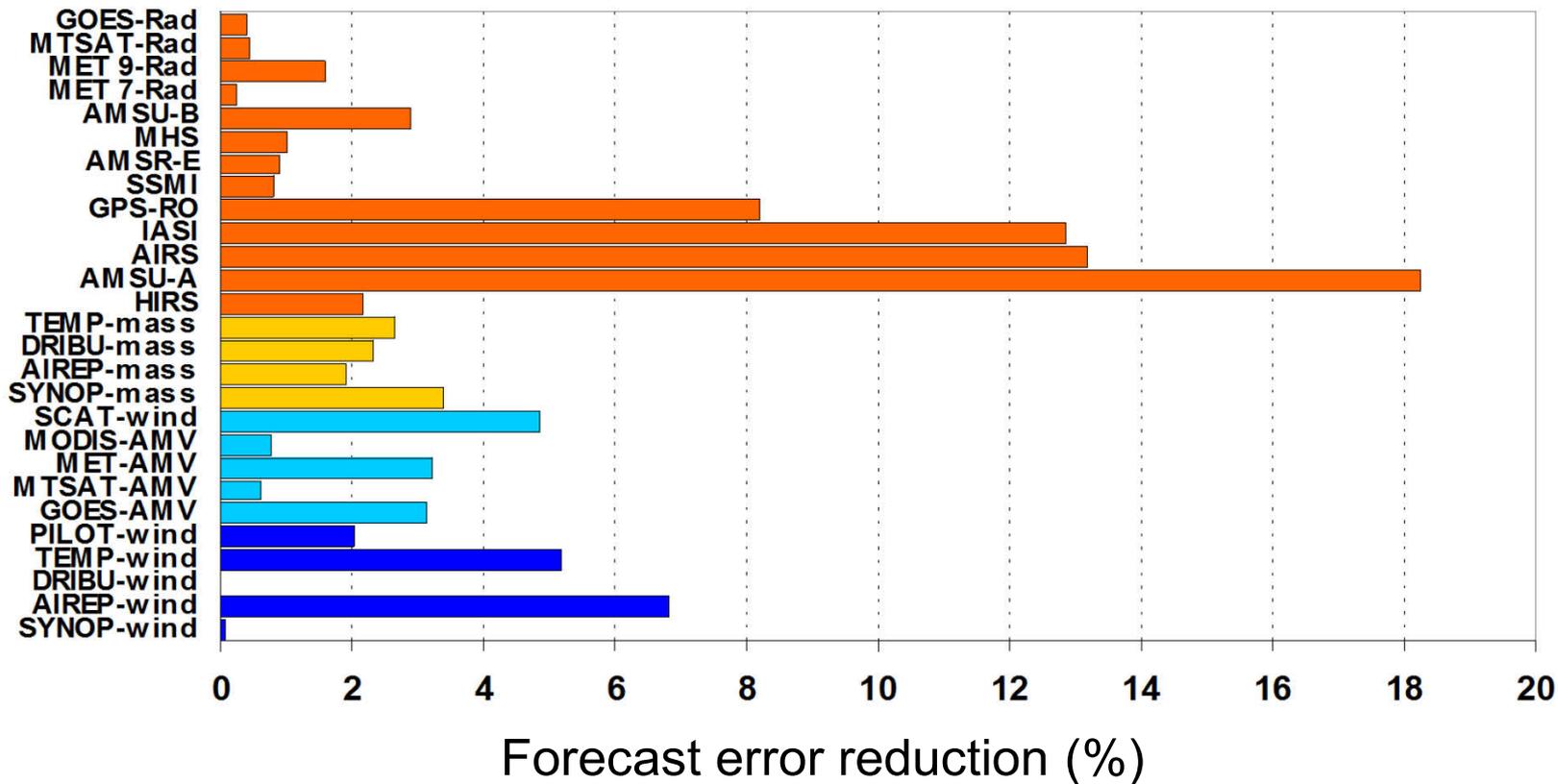
26 Sep 2010



Unusually prolonged cold conditions in the spring 2011 Arctic stratosphere promoted conversion of atmospheric chlorine to ozone-destroying forms to a degree never before seen in the Arctic. This resulted in chemical ozone loss comparable to that seen in the Antarctic in some winters

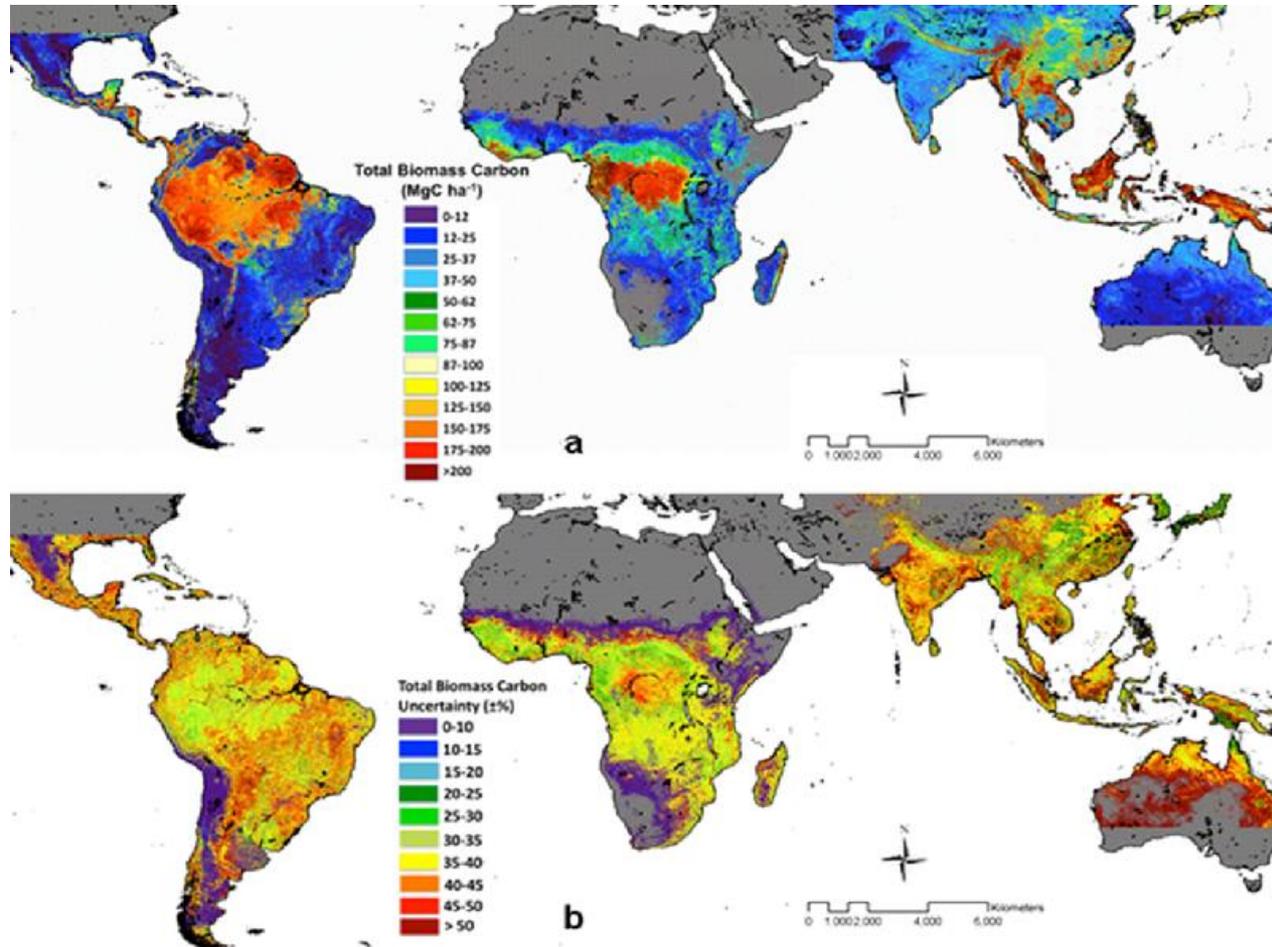


Enable Improved Predictive Capability for Weather and Extreme Weather Events (2.1.2)





Quantify, Understand, and Predict Changes in Earth's Ecosystems and Biogeochemical Cycles, Including the Global Carbon Cycle, Land Cover, and Biodiversity (2.1.3)



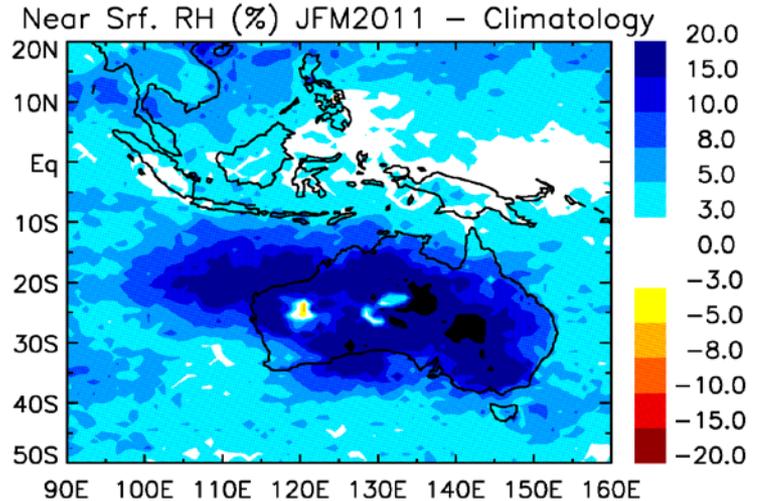
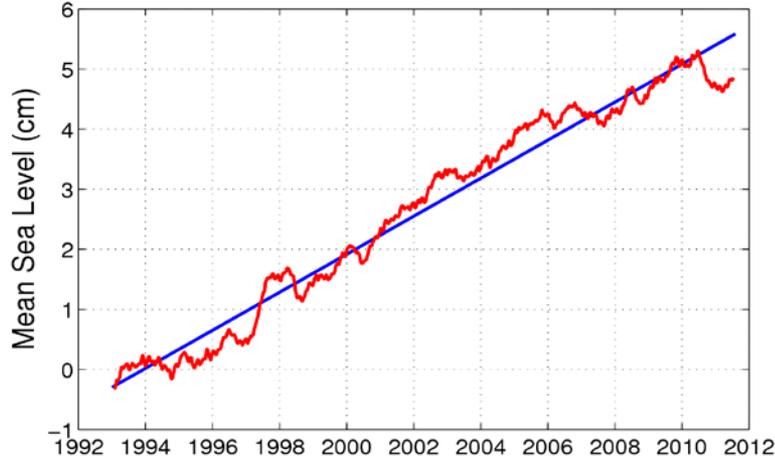
Benchmark map of carbon stored in Earth's tropical forests, covering about 2.5 million hectares of forests over more than 75 countries. Image credit: NASA/JPL-Caltech/UCLA/Winrock International/Colorado State University/University of Edinburgh/Applied GeoSolutions/University of Leeds/Agence Nationale des Parcs Nationaux/Wake Forest University/University of Oxford Saatchi et al (2011)



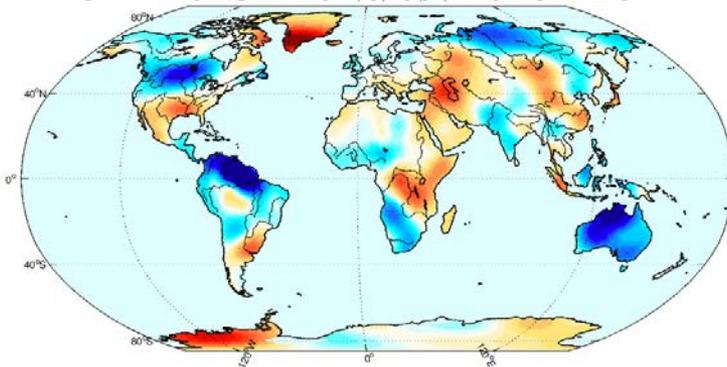
Jet Propulsion Laboratory
California Institute of Technology

Quantify the Key Reservoirs and Fluxes in the Global Water Cycle and Assess Water Cycle Change (2.1.4)

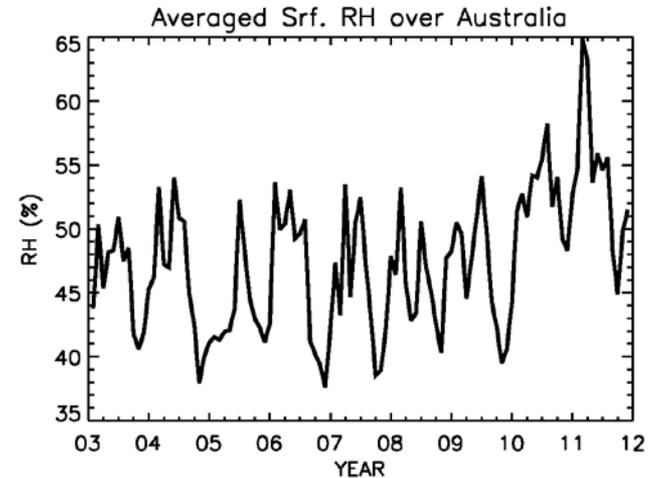
Global Sea Level Drops 5 mm in 2010



GRACE Shows Change in Water
from March 2010 to March 2011



Mass in centimeters of water thickness
From Boeing et al., submitted

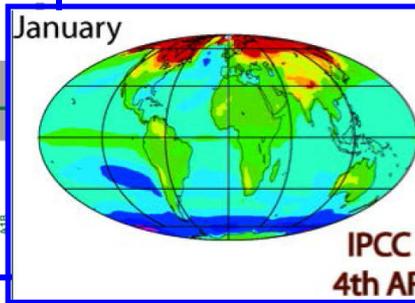
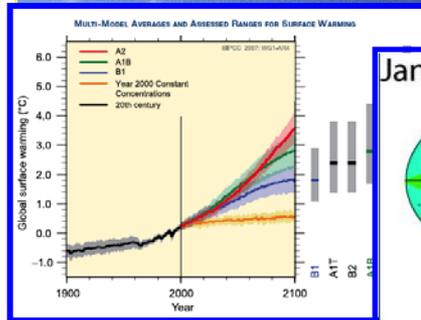


Courtesy Joao Teixeira



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Improve Understanding of Climate System and Improve Predictive Capability (2.1.5)



Sea Level Observations versus Predictions

Tide Gauge Observations
Satellite Observations
Climate Model Predictions (IPCC 3rd Assessment, 2001)

CERES-Derived ENSO Shortwave Anomalies

WATTS/METER²

ARCTIC SEA ICE BOUNDARY IN 1979

Since 1979, more than 20% of the Polar Ice Cap has melted away.

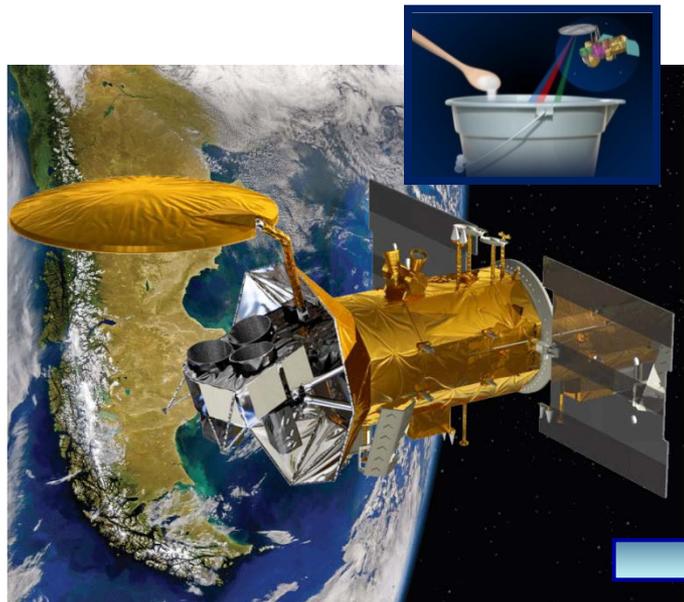
How to bring as much observational scrutiny as possible to the IPCC process?

How to best utilize the wealth of NASA Earth observations for the IPCC process?



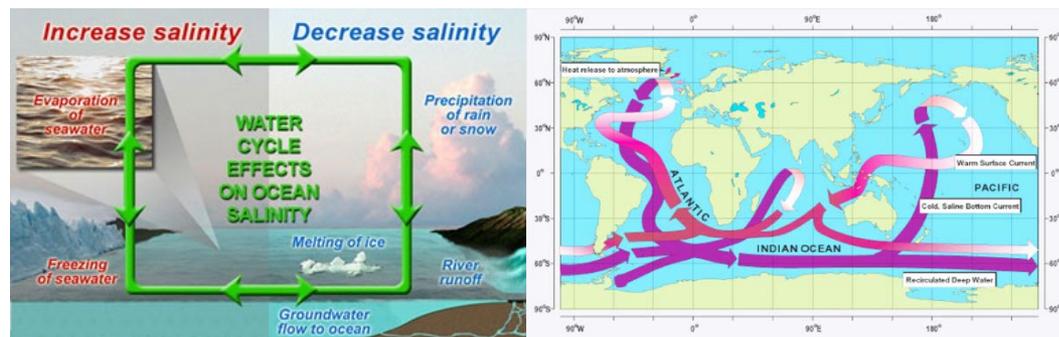
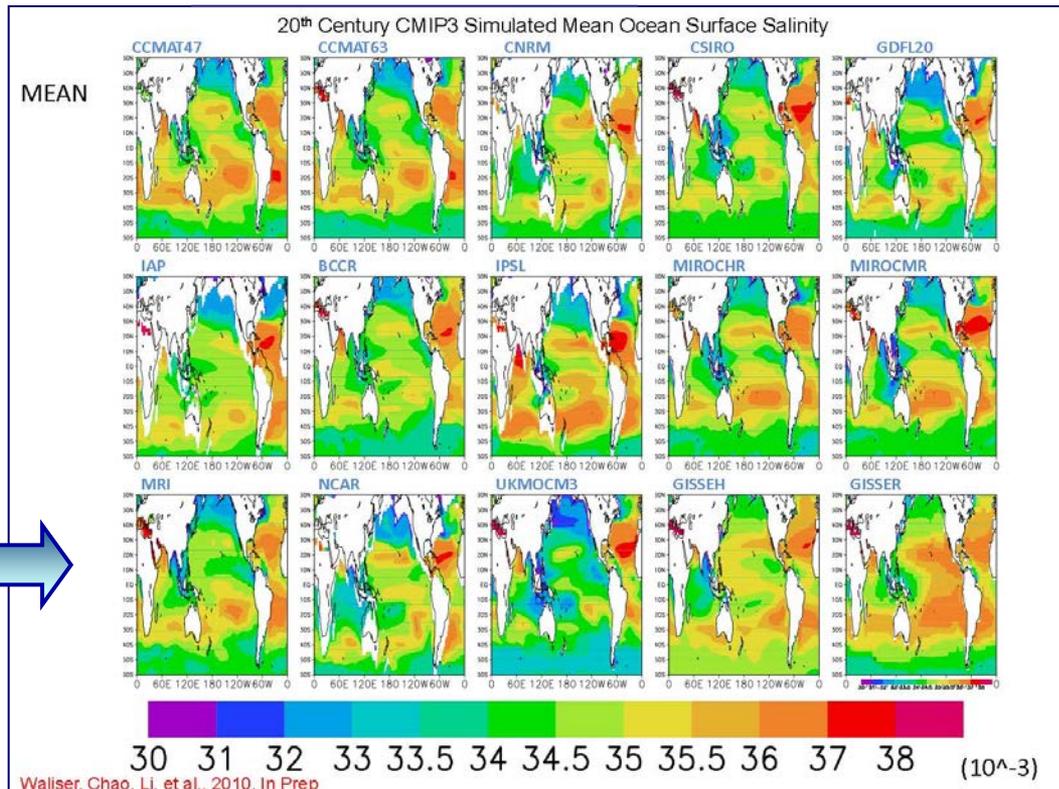
Jet Propulsion Laboratory
California Institute of Technology

Aquarius



Aquarius uses an L-band radar (JPL) and radiometer (GSFC) to make monthly maps of sea surface salinity with precision of 0.2 PSU ($.2 \text{ gkg}^{-1}$) and resolution of $150 \times 150 \text{ km}$

Partners:
CONAE
(INPE, ASI, CNES, CSA)





Satellite Observations for CMIP5 Simulations ESG-JPL Gateway: Side by Side Archive

Earth System Grid
Home Data Account About Contact Us Log In

ESG Gateway hosted by the Program for Climate Model Diagnosis and Intercomparison

Search: for: Search

To conduct a search, select a category from the pull down menu and/or enter free text into the text box.

Search Categories

- Project
 - > CMIP5
 - > TAMIP2
 - > gfdl_test
 - > obs4MIPs
- + Institute
- + Model
- + Experiment
- + Frequency
- + Product
- + Realm
- + Variable
- + Ensemble

Welcome to PCMDI

The Program for Climate Model Diagnosis and Intercomparison was established in 1989 at the Lawrence Livermore National Laboratory. Our staff includes research computer scientists, and data management personnel.

The PCMDI mission is to develop improved methods and tools for the diagnosis and intercomparison of general circulation models (GCMs) to simulate the global climate. The need for innovative analysis of climate simulations is apparent, as increasingly more complex models are developed, while the disagreements among these simulations to climate nature and poorly understood processes must be accounted for in GCMs for simulation.

obs4MIPs Project

Status of the CMIP5 Archive

6/3/2011: CNRM-CERFACS decadal hindcast/forecast datasets available for all realms but sea-ice (10 members already available for all realms ocean, only 3 so far for realms land/atmos/landIce).

6/25/2011: PCMDI CMIP5 data server is back online. The INM datasets are available.

7/7/2011: NCC datasets are now available to all users.

7/19/2011: PCMDI data server will be down for maintenance on 7/19/2011 PST. It is expected back online 7/20 17:00 PST.

7/20/2011: PCMDI data server is back online.

7/20/2011: Because of a processing fault affecting the MOHC rcp85 data from 2080 onwards, this data has been withdrawn. They expect to provide us with corrected data in a month at which time a new version of these datasets will be published.

9/7/2011 - 9/9/2011: The BADC ESGF system will be unavailable on September 7th and 8th. As a precaution you should consider "At Risk" on Friday September 9th.

Earth System Grid
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ESG Gateway hosted at the NASA Jet Propulsion Laboratory

Search: for: Search Start Over

To conduct a search, select a category from the pull down menu and/or enter free text into the text box.

Please note that the NASA datasets accessible through this gateway are provided as part of an experimental activity to increase the usability of NASA satellite observational data for the model and model analysis communities. These are not standard NASA satellite instrument products. They may have been reprocessed, reformatted, or created solely for comparisons with the CMIP5 models. Community feedback to improve and validate the dataset for modeling usage is appreciated.

Search Categories

- Project
 - > CMIP5
 - > obs4MIPs
- + Institute
- + Model
- + Experiment
- + Frequency
- + Product
- + Realm
- + Variable

AIRS (Atmospheric Infrared Sounder)

AIRS Data Catalog at ESG
Documentation: Air Temperature
Documentation: Specific Humidity
AIRS Home at NASA/JPL

AMSR-E (Advanced Microwave Scanning Radiometer - EOS)

AMSR-E Data Catalog at ESG
Documentation
AMSR-E Home at NSIDC

AVISO

AVISO Data Catalog at ESG
Documentation: Sea Surface Height (SSH)
AVISO Home

MLS (Microwave Limb Sounder)

MLS Data Catalog at ESG
Documentation: Specific Humidity
Documentation: Air Temperature
MLS Home at NASA/JPL

MODIS (Moderate Resolution Imaging Spectroradiometer)

MODIS Data Catalog at ESG
Documentation
MODIS Home

TES (Tropospheric Emission Spectrometer)

TES Data Catalog at ESG
Documentation: Ozone
TES Home at NASA/JPL

Quick Links

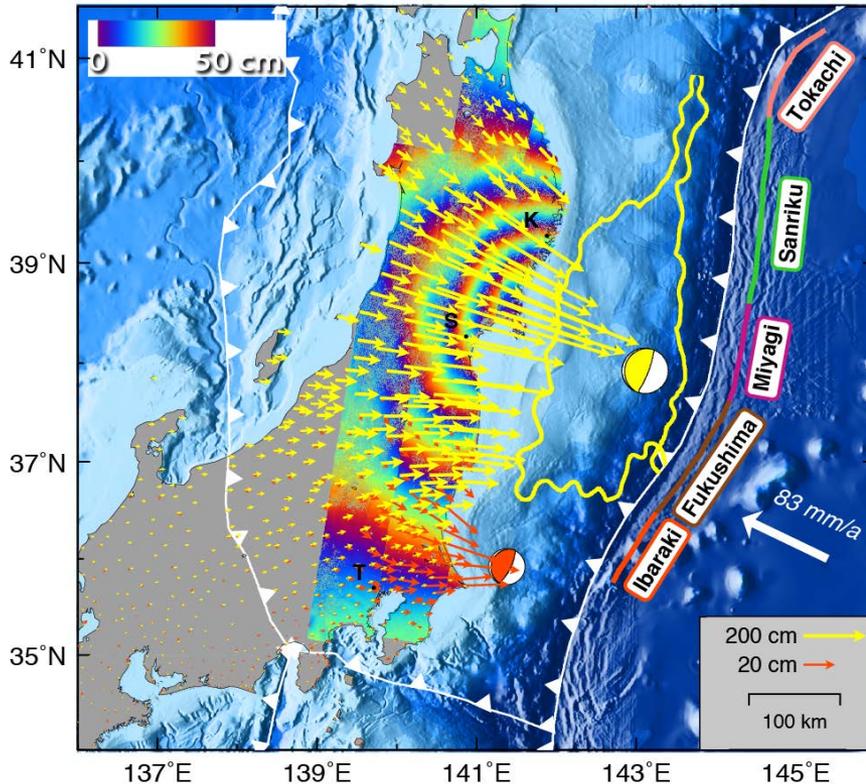
- Getting Started Guide
- Create Account
- Browse Catalogs
- Search for Data

ESG Federation

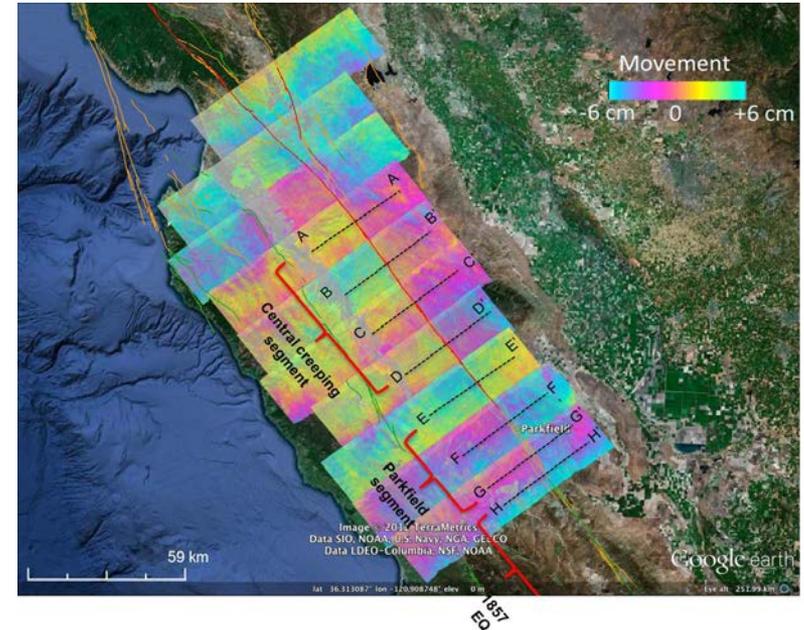
- PCMDI Gateway
- BADC Gateway
- DKRZ Gateway
- NASA JPL Gateway
- NCAR Gateway
- ORNL Gateway
- NERSC Gateway



Characterize the Dynamics of Earth's Surface and Interior and Form the Scientific Basis for the Assessment and Mitigation of Natural Hazards (2.1.6)



Coseismic interferogram (Envisat), coseismic GPS offsets (mainshock in yellow, aftershock in orange), and 8 m contour of mainshock fault slip model (Simons et al, Science, 2011)

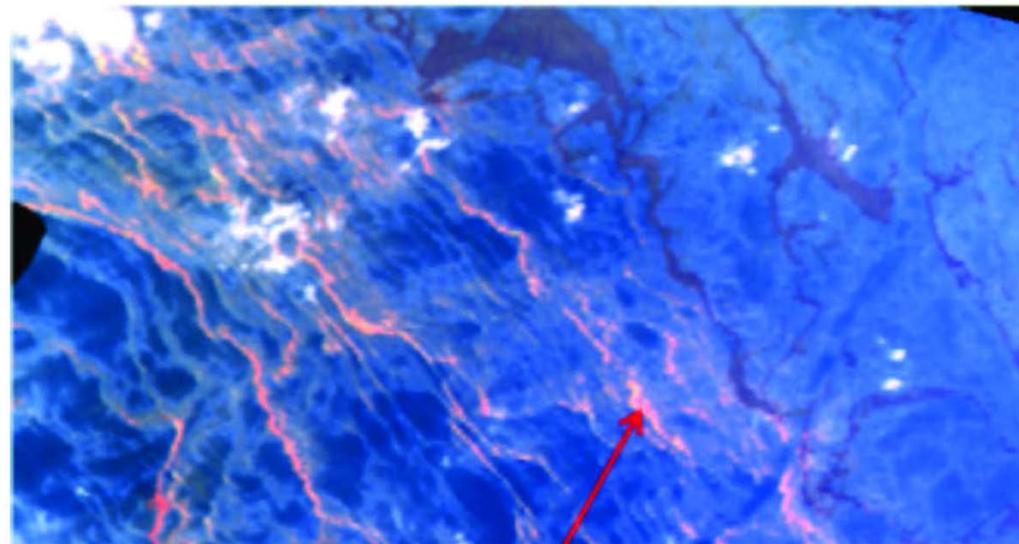


Fault slip along the central San Andreas fault from airborne interferometric SAR (InSAR) (Liu, et al, 2011)



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Use of AVIRIS Observations in Decision-making Activities (2.1.7)



 United States Department of the Interior
OFFICE OF THE SECRETARY
Washington, D.C. 20240
JUN 24 2010

Dr. Michael H. Freilich, Ph.D.
Director, Earth Science Division
Science Mission Directorate
NASA HQ, Mail Suite 3F71
300 E Street, SW
Washington, DC 20546

Dr. Diane E. Wickland, Ph.D.
Manager, Terrestrial Ecology Program and
Lead, Carbon Cycle & Ecosystems Focus Area
Earth Science Division, Mail Suite 3B74 (Room 3G86)
National Aeronautics and Space Administration
300 E Street, SW
Washington, DC 20546

Dear Dr. Freilich and Dr. Wickland:

On behalf of the Department of the Interior and the United States Geological Survey (USGS), we are writing to thank you for NASA's support of the Department of the Interior's work through the Flow Rate Technical Group (FRTG) to estimate the oil flow rate from BP's damaged well into the Gulf of Mexico. We are also requesting your continued assistance in these efforts. In particular, the effort of one of the FRTG teams, the Mass Balance Team, is dependent on the remote sensing data from deployment of the Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and satellite imagery to calculate the amount of oil on the ocean surface on a certain day. NASA's outstanding work provided the data necessary to aid the National Incident Command in assessing the extent of the spilled oil in the ongoing response effort.

As the response continues, the FRTG will shift its focus to development of the science needed to understand ecosystem impact, which will assist in cleanup operations. NASA's continued support, through deployment of AVIRIS, will be invaluable to these efforts. Our understanding is that NASA plans a near-shore mapping effort in the near term, via deployment of AVIRIS on a Twin Otter aircraft, which could be followed by deployment of ER-2 flights to provide additional data that would assist in spill-wide mapping.

We are confident that the use of AVIRIS on the low-altitude Twin Otter aircraft, followed as quickly as possible by AVIRIS data collection on the high-altitude ER-2 platform, will provide invaluable information that will allow us to better define spill response efforts. We request NASA's assistance in providing the crucial support that will allow us to carry out this mission.

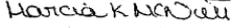
2
...s on coastal
up, and evolution of
lid in the on-the-ground
exceptionally suited as a

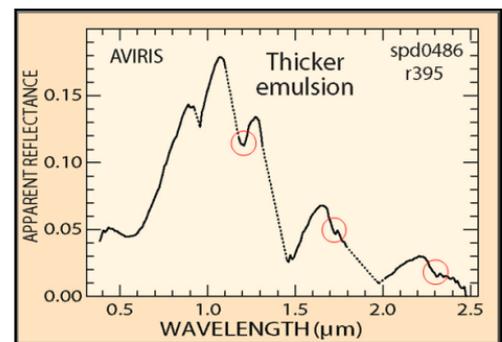
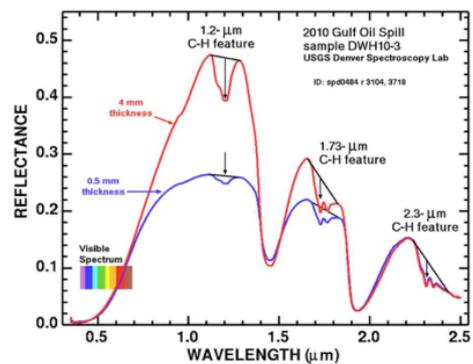
To our knowledge, this use of AVIRIS is the first application of this sensor to quantify the impacts of a large, protracted oil spill. The team involved in the data collection, reduction, and analysis is arranging for oceanographic field programs that will provide additional ground truth to validate the results from these studies. Methods for acquiring a scientifically rigorous inventory of oil slicks given the varying thicknesses of oil in the sea have been sorely lacking. This research therefore continues in the NASA tradition of expanding the use of remote sensing tools to new applications for the benefit of all mankind.

NASA has been an indispensable partner in the effort to respond to this disaster, and your continued support is critical. We look forward to continuing that partnership as we engage in an "all hands" effort to assist in the response.

Sincerely,

Anne J. Castle
Assistant Secretary for Water and Science


Dr. Marcia K. McNutt
Director, United States Geological Survey

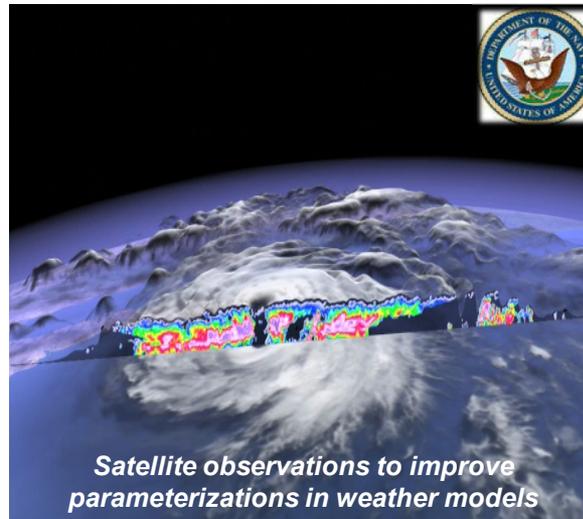
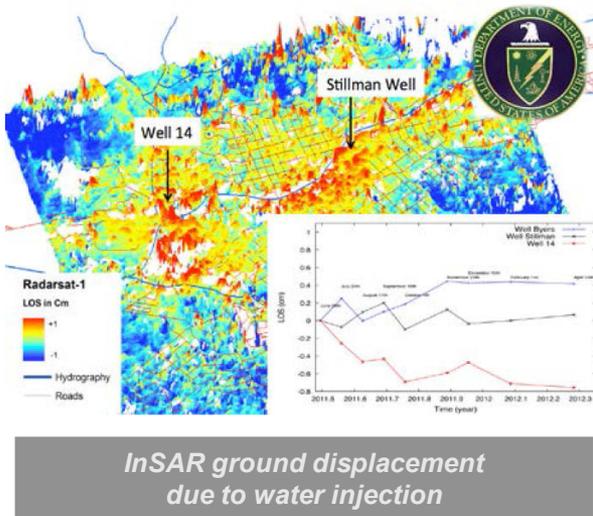
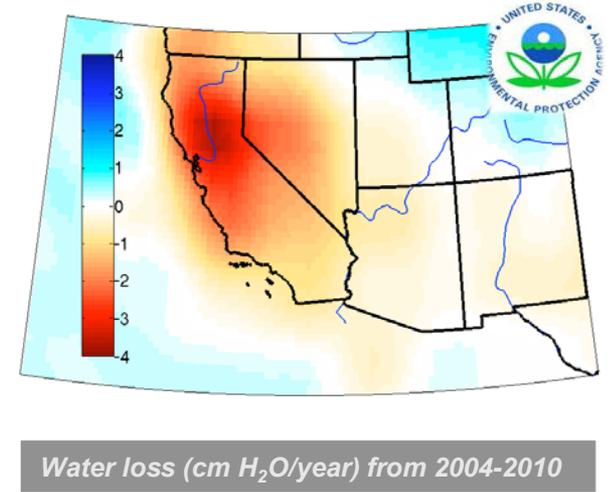
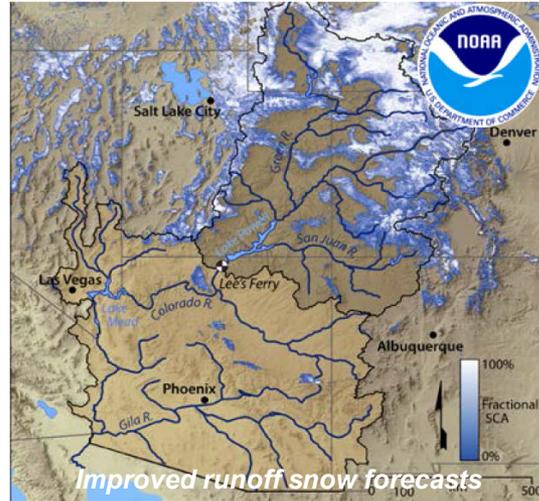


*A Method for Quantitative Mapping of Thick Oil Spills Using HypsIRI; Roger N. Clark¹, Gregg A. Swayze¹, Ira Leifer², K. Eric Livo¹, Raymond Kokaly¹, Todd Hoefen¹, Sarah Lundeen³, Michael Eastwood³, Robert O. Green³, Neil Pearson¹, Charles Sarture³, Ian McCubbin⁴ Dar Roberts³, Eliza Bradley³, Denis Steele³, Thomas Ryan³, Roseanne Dominguez², and AVIRIS Team³; ¹USGS, ²UCSB, ³NASA, ⁴ DRI



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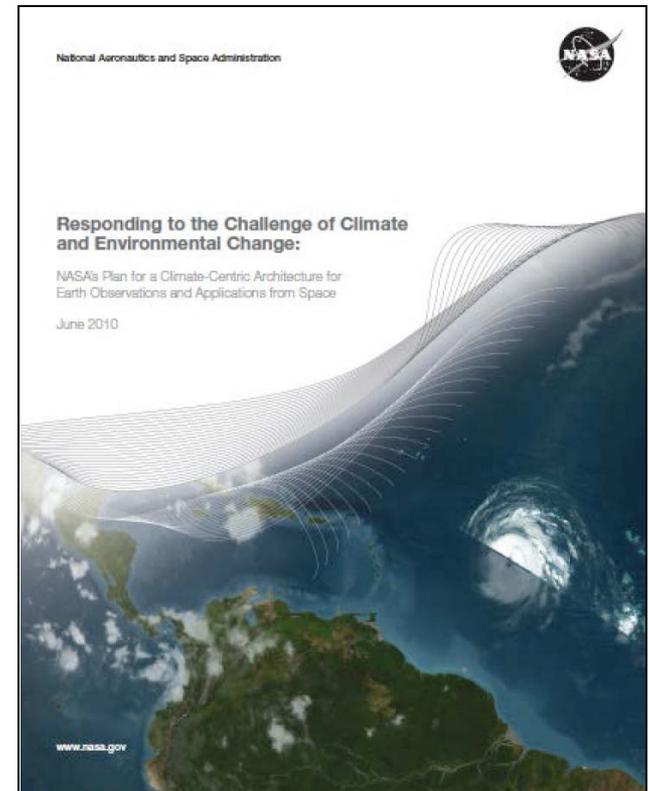
Agency Collaborations in Earth Science for Societal Benefits





Additional Guidance

- Space-based Observing Systems
 - Orbiting Carbon Observatory-2
 - Accelerated Decadal Survey Tier 1 Missions
 - Expanded Venture-class Program
 - Climate Continuity Missions
 - Accelerated Decadal Survey Tier 2 missions
- Mission-enabling / data-exploiting research and applications



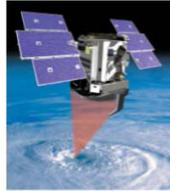


JPL Earth Science Flight Projects

Operational



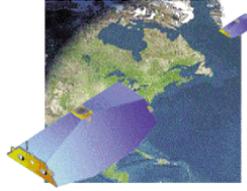
QuikSCAT
(1999)



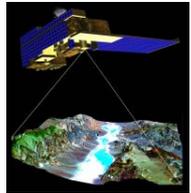
CloudSat
(2006)



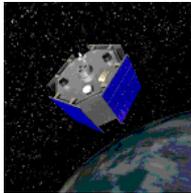
TES
(2004)



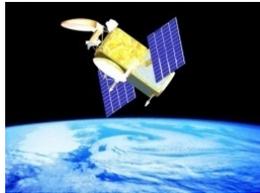
GRACE
(2002)



ASTER
(1999)



ACRIMSAT
(1999)



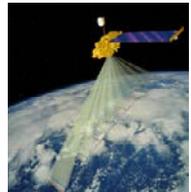
**Ocean Surface
Topography
Mission**
(2008)



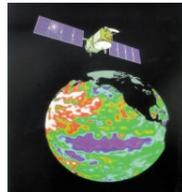
MLS
(2004)



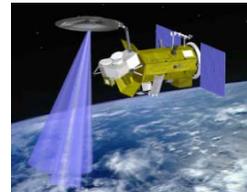
AIRS
(2002)



MISR
(1999)



Jason-1
(2001)

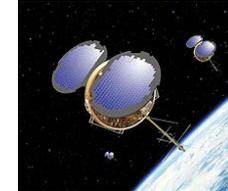


**Sea Surface
Salinity:
Aquarius**
(2011)

Formulation/Development



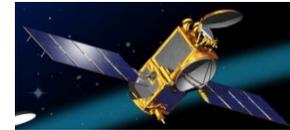
Carbon Cycle: OCO-2
(2014)



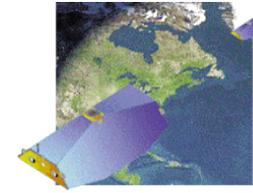
COSMIC-2*
(2014)



**DESDynI
(L-band Radar)**
(~2019)



Jason 3*
(04/2014)



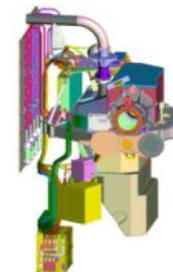
GRACE-FO
(2017)



SWOT
(2019)



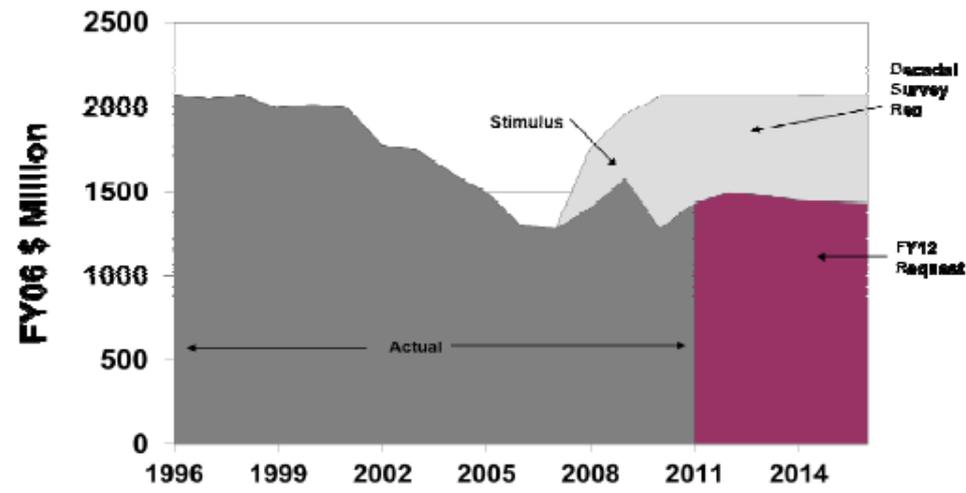
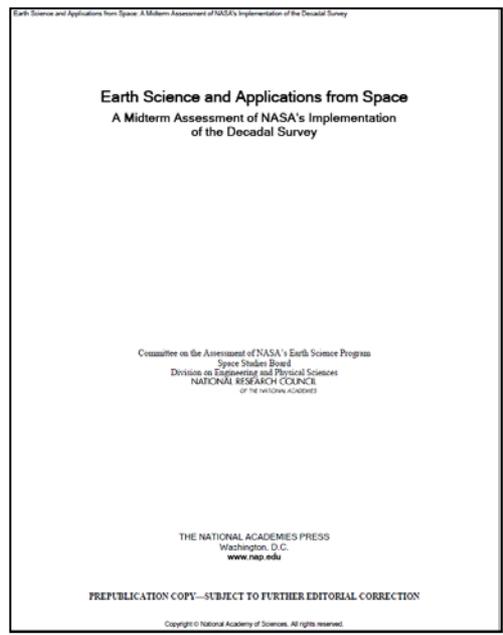
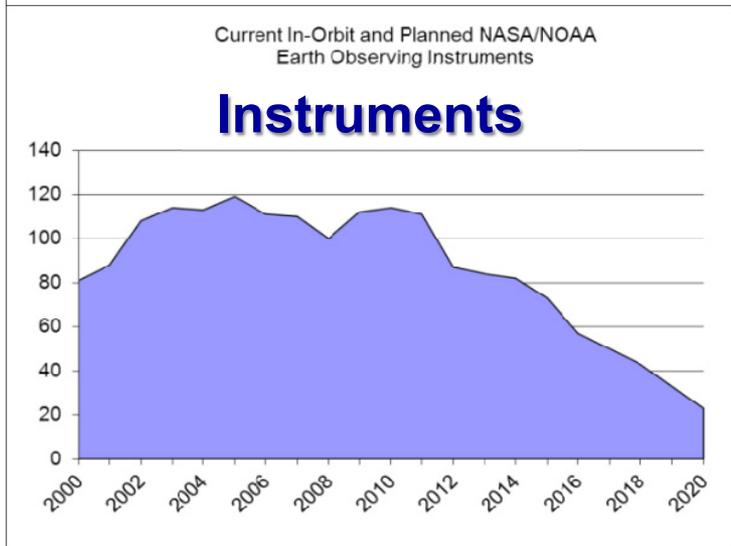
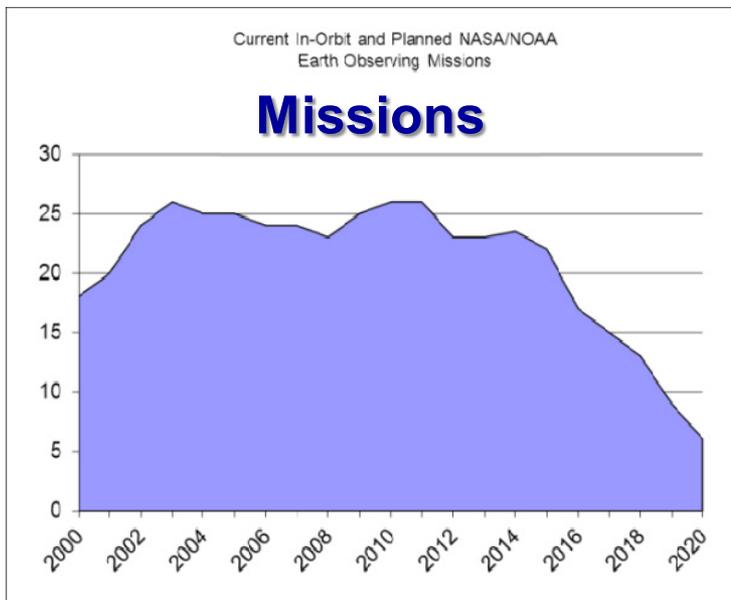
Soil Moisture: SMAP
(2014)



OCO-3
(2017)



Independent Assessment





Excerpts from Mid-term Assessment

- NASA responded favorably and aggressively to the decadal survey, embracing its overall recommendations for Earth observations, missions, technology investments, and priorities for the underlying science. As a consequence, the science and applications communities have made significant progress over the past 5 years.
- The integrated and balanced program described in NASA's *Responding to the Challenge of Climate and Environmental Change* is aligned with the Administration's overarching emphasis on climate research and monitoring. It is further consistent with, and has been informed by, the comprehensive vision for NASA's Earth Science endeavor set forth by the NRC in its Decadal Survey.
- Funding for NASA's Earth science program has not been restored to the \$2 billion per year (in fiscal year [FY] 2006 dollars) level needed to execute the 2007 decadal survey's recommended program. Congress' failure to restore the Earth science budget to a \$2 billion level is a principal reason for NASA's inability to realize the mission launch cadence recommended by the survey.