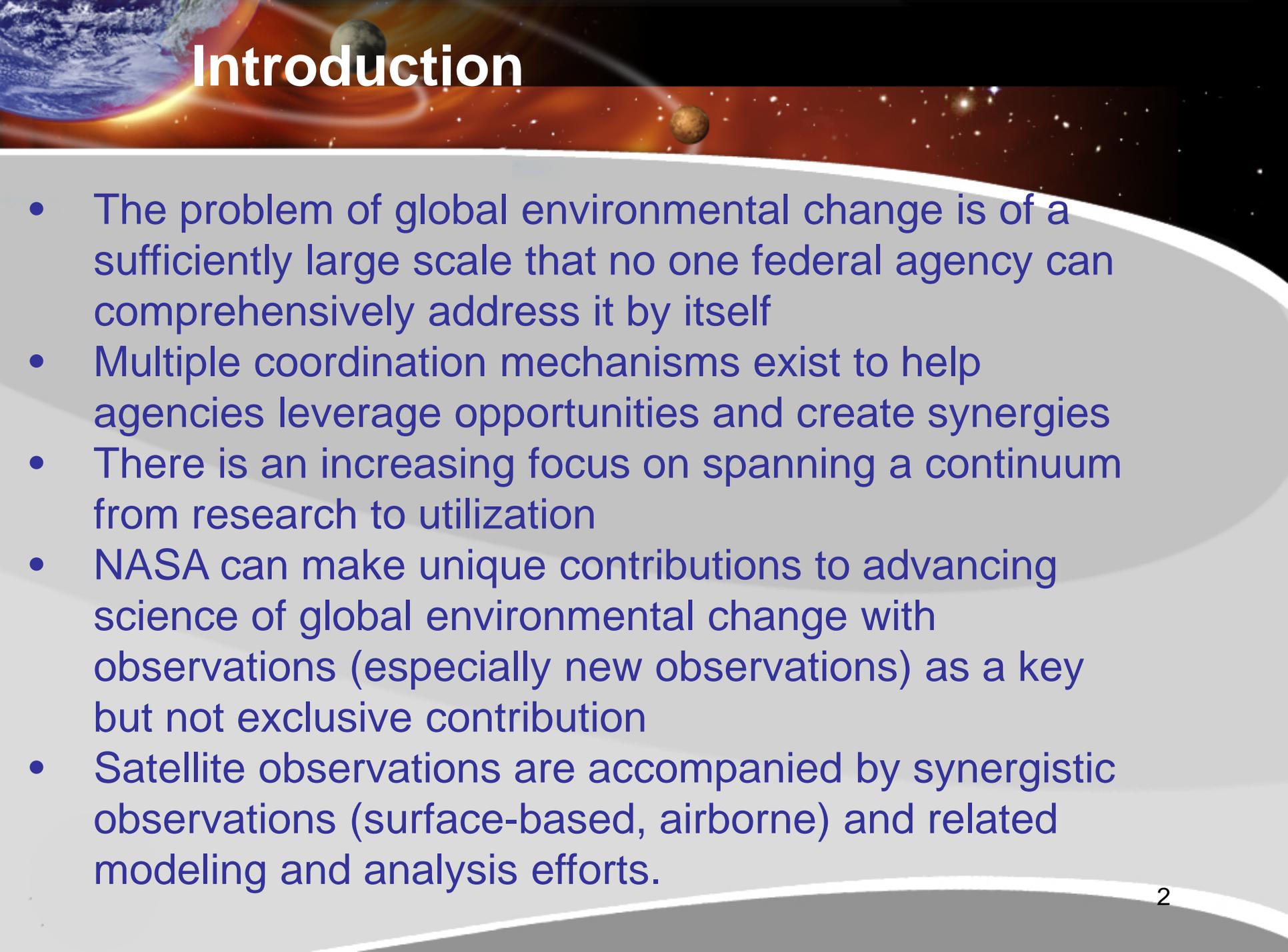




NASA Satellite Observations in Support of National Objectives

**Dr. Jack Kaye
Associate Director for Research
Earth Science Division
Science Mission Directorate
NASA Headquarters**

January 7, 2013



Introduction

- The problem of global environmental change is of a sufficiently large scale that no one federal agency can comprehensively address it by itself
- Multiple coordination mechanisms exist to help agencies leverage opportunities and create synergies
- There is an increasing focus on spanning a continuum from research to utilization
- NASA can make unique contributions to advancing science of global environmental change with observations (especially new observations) as a key but not exclusive contribution
- Satellite observations are accompanied by synergistic observations (surface-based, airborne) and related modeling and analysis efforts.

The background of the slide features a composite image of Earth from space, showing the blue oceans and white clouds of the planet against the blackness of space. A small, reddish planet is visible in the distance. The title text is overlaid on the top portion of this image.

NASA Earth Science Products for the Nation and the World

■ Scientific Knowledge

- Discovery
- Process Knowledge
- Trend Detection and Attribution
- Forecasting Capability

■ Applications to National and Global Needs

- Environmental Policy
- Resource Management
- Forecasting and Assessment
- Decision-Making by Public and Private Sectors

■ Technical Capability for Space and Airborne Science

■ Environmental Data for Public Use

■ Trained Workforce for Science and Technology

■ A Better-Informed and Inspired Public

NASA Earth Observing Satellite Fleet - 2012

- Launch-CY2011
- Launch-CY2012
- Launch-CY2013



Aquarius



OSTM/Jason 2 (NOAA)



Jason



QuikSCAT*

TRMM



EO-1

Landsat-7 (USGS)



Aqua

ACRIMSAT



Terra

SORCE



Aura

LDCM



GRACE (2)



CALIPSO

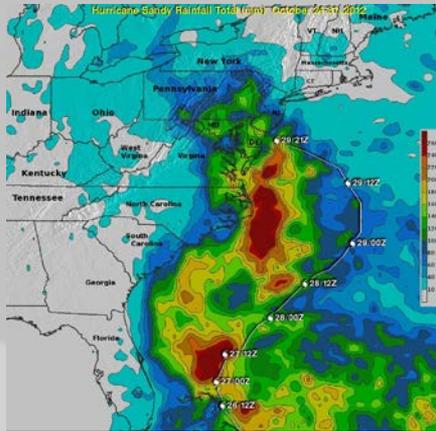
CloudSat



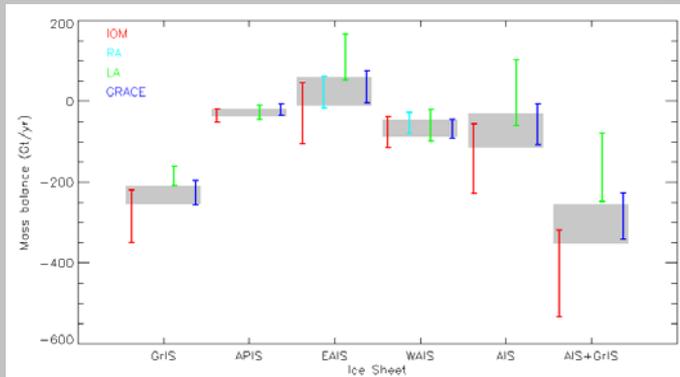
Suomi-NPP



NASA Observations of Earth System

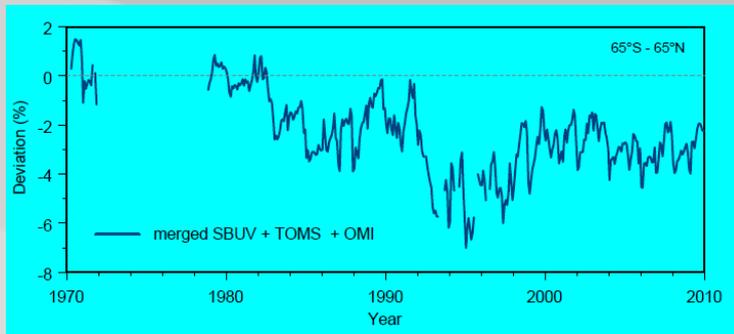


TRMM observations show greatest precipitation from Superstorm Sandy was off US East Coast

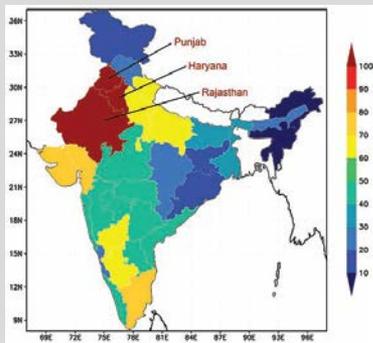
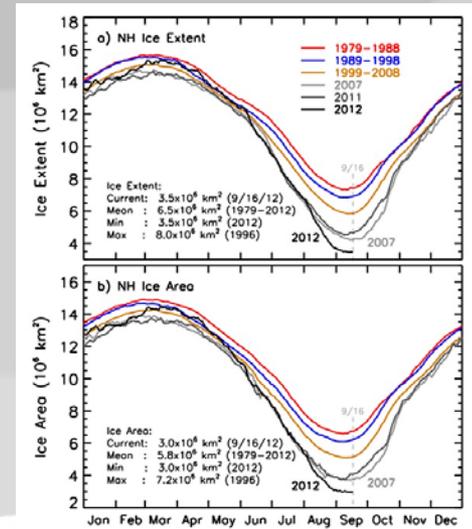


NASA-ESA led study shows consensus on ice sheet mass loss from Greenland and Antarctica using different approaches

Ozone measurements show minimum after Mt. Pinatubo eruption followed by recovery



Arctic sea ice extent observations show 2012 fall minimum was well below previous (2007) minimum



GRACE observations show groundwater withdrawal beneath NW India and Pakistan

ESD Orbital Flight Portfolio – 2012-2022

- **LDCM** (2/2013) – “Landsat-8” including thermal IR, w/USGS
- **GPM** (2/2014) – Global Precipitation mapping, w/JAXA
- **OCO-2** (7/2014) – Atmospheric CO₂ monitoring, recovery mission
- **SAGE-III/ISS** (8/2014) – Ozone, Temp, Humidity profiles, w/HEOMD, ESA
- **SMAP** (10/2014) – Soil Moisture and Freeze/Thaw cycling, w/CSA (minor)
- **ICESat-2** (late-2016) – Precision Ice Topography, Ecosystem monitoring
- **CYGNSS [EV-Mission/1]** (late 2016)
- **GRACE-FO** (8/2017) – Gravity/Ice Mass/Ground Water, w/GFZ & DLR
- **OCO-3/ISS** (Fall 2017) – CO₂ continuity, from ISS, OCO-2 spares
- **TEMPO [EV-Instrument/1]** (2017)
- **SWOT** (2020) – Wide-swath ocean altimetry, land water, w/CNES
- **PACE** (2020) – Ocean Color, possibly Aerosols
- **EV-Instrument/2 Venture-Class** (NLT 2020)
- **L-band SAR** (2021) – Solid Earth, Cryosphere, Ecosystems, w/ISRO
- **CLARREO** (2022?) – Precise global radiation balance, possibly w/UK
- **EV-Mission/2** (NLT 2022)
- **EV-Instrument/3** (NLT 2022)
- Significant studies ongoing for all other Tier-2 Decadal Survey missions

USGCRP in the Federal Context



CENRS Sub-Committees, WGs, & Task Forces

Air Quality Research (AQRS)

Critical and Strategic Mineral Supply Chains (CSMSC)

Interagency Arctic Research Policy Committee Interagency Working Group (IARPC)

Integration of Science and Technology for Sustainability Task Force

National Earth Observations Task Force (NEO)

Disaster Reduction (SDR)

Ecological Services (SES)

Global Change Research (SGCR)

Ocean Science & Technology (SOST)

Water Availability & Quality (SWAQ)

Toxics & Risks (T&R)

US Group on Earth Observations (USGEO)

NASA Role in National Initiatives

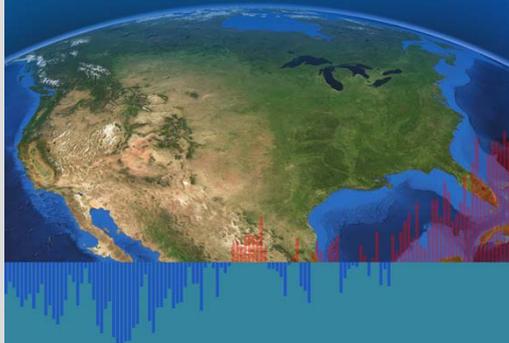
NASA is the largest contributor to the US Global Change Research Program (USGCRP), which coordinates climate-related research of 13 Federal Agencies and publishes documents, including

- Strategic Plan 2012-2021
- Annual *Our Changing Planet*
- Global Climate Change Impacts in the United States (2009)

NASA also contributes to National Initiatives in Earth Observation, Oceans, and Arctic

Global Climate Change Impacts in the United States

U.S. Global Change Research Program

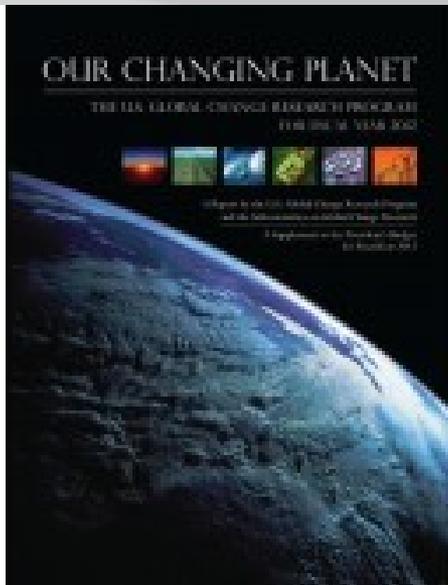


OUR CHANGING PLANET

THE U.S. GLOBAL CHANGE RESEARCH PROGRAM
FROM 1990 TO 2009



Published by the U.S. Global Change Research Program
with the participation of the National Science Foundation
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THE NATIONAL GLOBAL CHANGE RESEARCH PLAN 2012-2021

A STRATEGIC PLAN FOR THE U.S. GLOBAL CHANGE RESEARCH PROGRAM



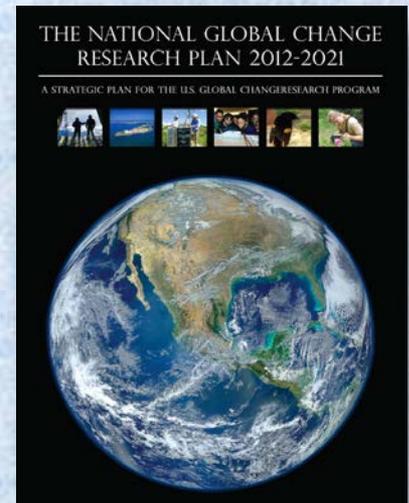
The USGCRP Vision and Mission

Vision - “A nation, globally engaged and guided by science, meeting the challenges of climate and global change.”

Mission - “To build a knowledge base that informs human responses to climate and global change through coordinated and integrated federal programs of research, education, communication, and decision support.”



USGCRP Decadal Strategic Plan



Goal 1 - Advance Science: Advance scientific knowledge of the integrated natural and human components of the Earth system.

- 1.1 Earth System Understanding
- 1.2 Science for Adaptation and Mitigation
- 1.3 Integrated Observations
- 1.4 Integrated Modeling
- 1.5 Information Management and Sharing

Goal 2 - Inform Decisions: Provide the scientific basis to inform and enable timely decisions on adaptation and mitigation.

- 2.1 Inform Adaptation Decisions
- 2.2 Inform Mitigation Decisions
- 2.3 Enhancing Global Change Information

Goal 3 - Conduct Sustained Assessments: Build sustained assessment capacity that improves the Nation's ability to understand, anticipate, and respond to global change impacts and vulnerabilities.

- 3.1 Scientific Integration
- 3.2 Ongoing Capacity
- 3.3 Inform Responses
- 3.4 Evaluate Progress

Goal 4 - Communicate & Educate: Advance communications and education to broaden public understanding of global change and develop the scientific workforce of the future.

- 4.1 Strengthen Communication and Education Research
- 4.2 Reach Diverse Audiences
- 4.3 Increase Engagement
- 4.4 Cultivate Scientific Workforce



The USGCRP Strategic Plan

Unifying Themes and Cross-Linking Activities

Unifying Themes

- **Providing Knowledge on Scales Appropriate for Decision Making**
- **Incorporating Social and Biological Sciences**
- **Enabling Responses to Global Change via Iterative Risk Management**

Cross-Linking Activities

- **Enhance Information Management and Sharing**
- **Enable new capabilities for Integrated Observations and Modeling**
- **Increase Proactive Engagement and Partnerships**
- **Leverage International Investments & Leadership**
- **Develop the Scientific Workforce for the Future**



A National Vision for the Oceans, Coasts & Great Lakes

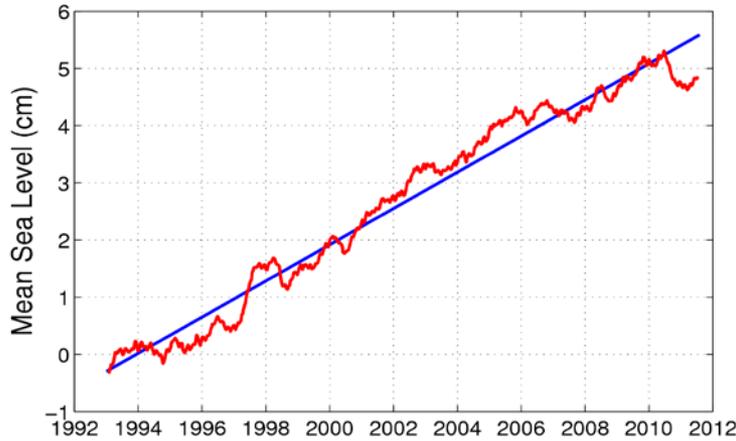
Vision : *“An America whose stewardship ensures that the ocean, our coasts, and the Great Lakes are healthy and resilient, safe and productive, and understood and treasured so as to promote the well-being, prosperity, and security of present and future generations.”*

Ocean Policy Goals

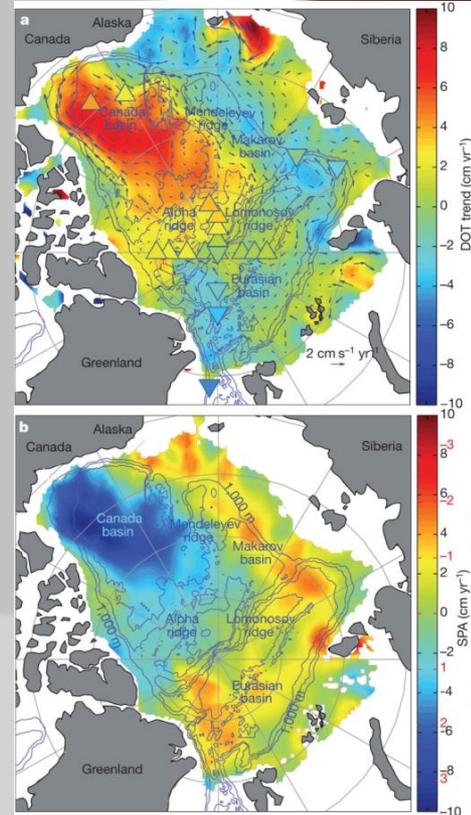
- Protect, maintain, and restore the health of ocean, coastal and Great Lakes ecosystems and resources;
- Enhance the sustainability of ocean and coastal economies
- Preserve our maritime heritage,
- Provide for adaptive management to enhance our understanding of and capacity to respond to climate change
- Coordinate with our national security and foreign policy interests

Office of Science & Technology Policy
Executive Office of the President

NASA Observations of Oceans

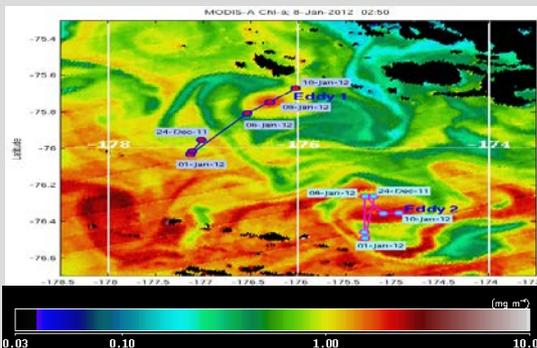
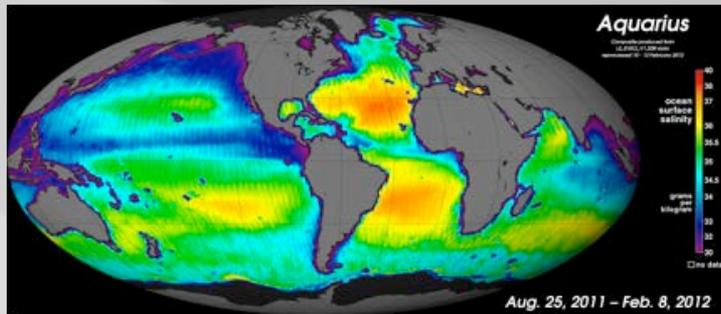


Sea surface altimetry measurements show global increase in sea level averaging $\sim 3.2\text{mm/yr}$



Right-Top: ICESat measured sea surface height trends (contours) which determine near surface ocean pressure gradients that drive surface currents (arrows).
Bottom: ocean bottom pressure trend minus ICESat sea surface height trend yields contours of steric pressure trends and freshwater content trend.

Aquarius measurements of Sea Surface salinity



Eastern Ross Sea Eddies as seen in MODIS chlorophyll a (1/8/12)

National Ocean Policy: Targeted Implementation Strategy

9 Priority Objectives

Ecosystem-Based
Management

Inform Decisions &
Improve Understanding

Ocean, Coastal, &
Great Lakes Observation,
Mapping & Infrastructure

Coordinate &
Support

Regional Ecosystem
Protection & Restoration

Resiliency & Adaptation
to Climate Change &
Ocean Acidification

Water Quality &
Sustainable Practices
on Land

Changing Conditions
in the Arctic

Coastal & Marine
Spatial Planning

NASA Actions in NOP Implementation Plan

Inform Decisions and Improve Understanding – Action 1 - Advance fundamental scientific knowledge through exploration and research. (2)

Inform Decisions and Improve Understanding – Action 5 - Develop human capacity and the skilled workforce necessary to conduct ocean research and manage ocean, coastal, and Great Lakes resources. (1)

Inform Decisions and Improve Understanding – Action 6 - Increase ocean and coastal literacy by expanding the accessibility and use of ocean content in formal and informal educational programming for students, educators, and the public. (1)

Observation, Mapping, and Infrastructure – Action 2 – Improve unmanned and satellite remote sensing systems. (2)

Observation, Mapping, and Infrastructure – Action 3 – Advance observation and sampling technologies for exploring and understanding the complexities of land, ocean, atmosphere, ice, biological, and social interactions on a global scale. (3)

Observation, Mapping, and Infrastructure – Action 4 – Provide local and regional observation systems to support a variety of ocean, coastal, and Great Lakes users. (2)

Observation, Mapping, and Infrastructure – Action 7 – Develop an integrated ocean and coastal data collection, processing, and management system to support real-time observations. (1)

Coordinate and Support – Action 6 – Address high-priority ocean policy issues through international engagement by promoting the exchange of information and expertise. (1)

Arctic – Action 2 - Observe and forecast Arctic sea ice (1)



Interagency Arctic Research Policy Committee (IARPC)

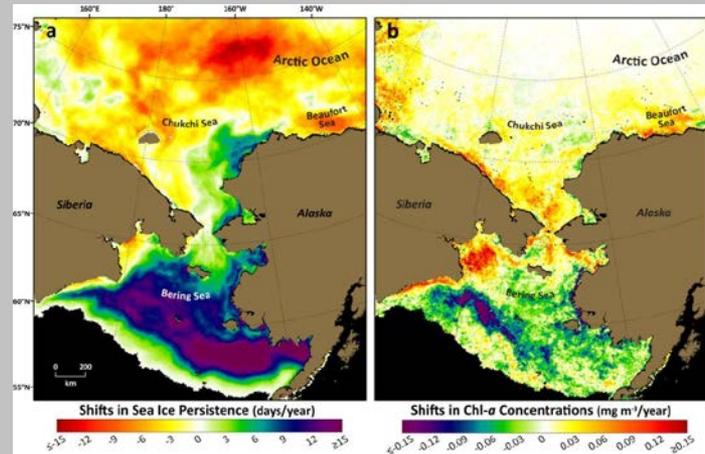
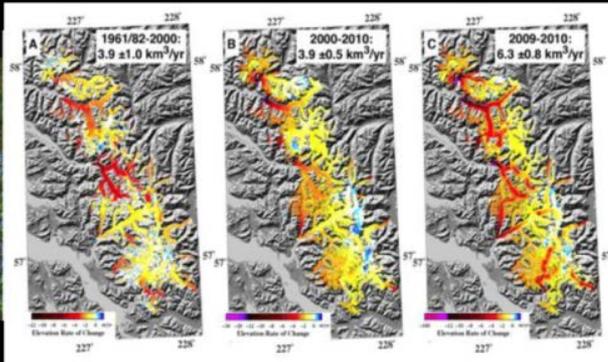
■ Established by Arctic Research Policy Act – 1984

- Department of Agriculture
 - Department of Commerce
 - Department of Defense
 - Department of Energy
 - Department of Health and Human Services
 - Department of Homeland Security (U.S. Coast Guard)
 - Department of Interior
 - Department of State
 - Department of Transportation
 - Environmental Protection Agency
 - Marine Mammal Commission
 - National Aeronautics and Space Administration
 - National Science Foundation (chair)
 - Smithsonian Institution
- 

NASA Observations of Arctic

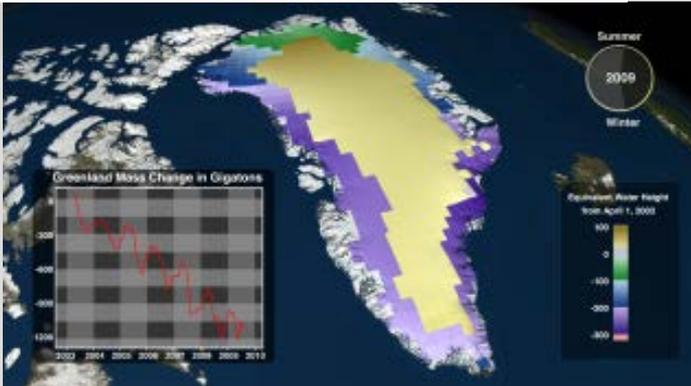
Stikine Icefield: 4 Southernmost Tidewater Glaciers in Alaska

OIB surveys show that ice loss has increased here by 60% over the last two years, compared to previous surveys

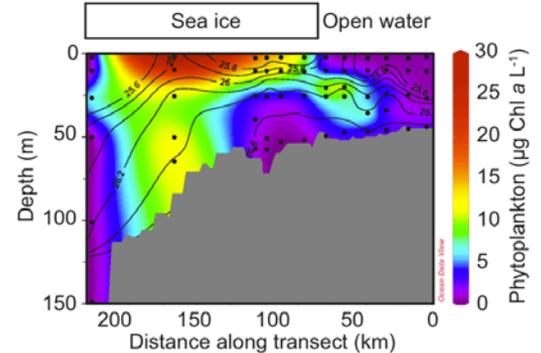


Shifts in sea ice persistence and Chl-a concentration from 2003-2009 (Frey and Grebmeier)

Greenland Glacier Mass Change (GRACE)



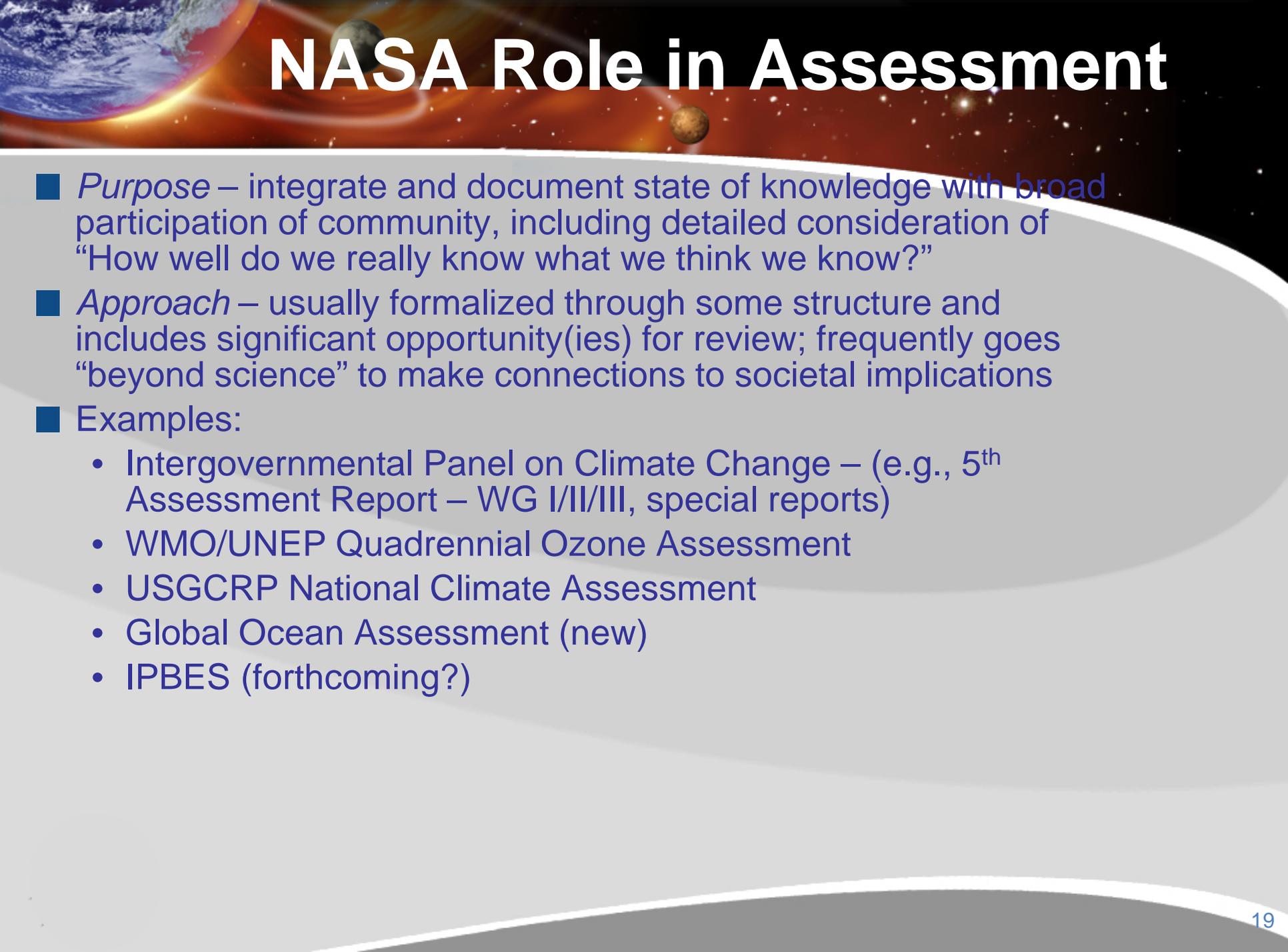
ICEScape cruise showed large phytoplankton concentrations under thick ice in Chukchi Sea





IARPC Research Plan Themes

- Understand sea-ice dynamics, ecosystem processes, ecosystem services, and climate feedbacks in the Beaufort and Chukchi Seas and the contiguous Arctic Ocean (DOD, DOE, DOI, NASA, NOAA, NSF)
- Understand terrestrial ice processes, ecosystem processes, ecosystem services, and climate feedbacks in the Arctic (DOI, NASA, NSF, SI)
- Improve and integrate atmospheric studies of surface heat, energy and mass balances (DOE, NASA, NOAA, NSF)
- Integrate and continue to deploy a national Arctic observing system and promote international cooperation to create a circumpolar observing system (NSF, NOAA, NASA, DOI, EPA, DOE, ONR, USCG)
- Integrate Arctic regional models (DOE, NOAA, DOI, NSF)
- Assess vulnerabilities of Arctic communities to impacts of climate change and develop adaptation strategies and tools to maximize sustainability, well-being, and cultural and linguistic heritage (DOI, DOS, EPA, NSF, NOAA, USDA, SI)



NASA Role in Assessment

- *Purpose* – integrate and document state of knowledge with broad participation of community, including detailed consideration of “How well do we really know what we think we know?”
- *Approach* – usually formalized through some structure and includes significant opportunity(ies) for review; frequently goes “beyond science” to make connections to societal implications
- Examples:
 - Intergovernmental Panel on Climate Change – (e.g., 5th Assessment Report – WG I/II/III, special reports)
 - WMO/UNEP Quadrennial Ozone Assessment
 - USGCRP National Climate Assessment
 - Global Ocean Assessment (new)
 - IPBES (forthcoming?)

Communications Tools Supported by ESD



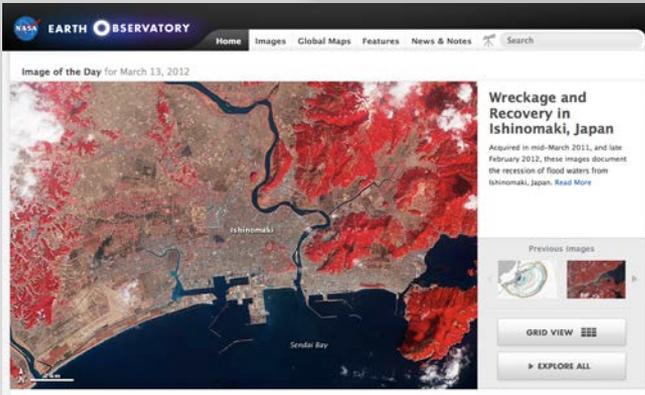
Eyes on the Earth-3D Website*



Dynamic Planet



NASA Earth Now I-Phone App



Earth Observatory Web Site



Climate.nasa.gov
web site



NASA Hyperwall

*Software demonstrated to audience at US Center at COP-18 meeting in Doha, Qatar



Concluding Message

- The issue of global environmental change is of sufficient scope and magnitude that it goes well beyond the ability of any single agency to address it
- There are numerous executive and/or legislative requirements on federal agencies to coordinate in their work towards national objectives, and NASA is very much engaged in them
- The satellite (and related ground and airborne data) data provided and made available by NASA constitute an ever-expanding national and global resource for documenting, understanding, and assessing the changing Earth environment as well as improving predictive capability for the future; they complement data from other sources for the needed comprehensive view of the Earth
- The relationships that NASA builds and nurtures are important to our collective future, especially in terms of enhancing the use of NASA data and models by an expanding set of partners