



# **NASA Earth System Science in the National Perspective**

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# NASA ESD's 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
- Disaster Characterization and Response

## ■ Technical Capability for Space and Airborne Science

## ■ Environmental Data for National and Global Use

## ■ Positive Examples of International Cooperation

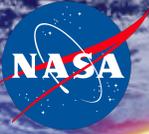
## ■ Trained Workforce for Science and Technology

## ■ A Better-Informed and Inspired Public

# NASA Operating Earth Science Satellites – with International Partners\*



\* Does not include GPS sensors on non-US spacecraft



# End-to-end Support in a Globally Integrated Program



Airborne Sensors



Research Balloons

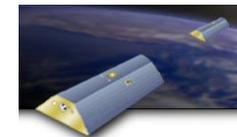
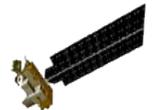
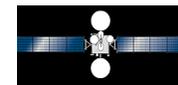
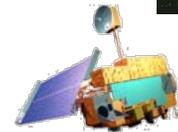


Uninhabited Aerial Vehicles



Field Campaigns

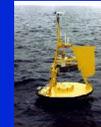
## Space-based: Sensors & Data Relay



Ground Networks



Research Vessels



Buoys



Ground Stations



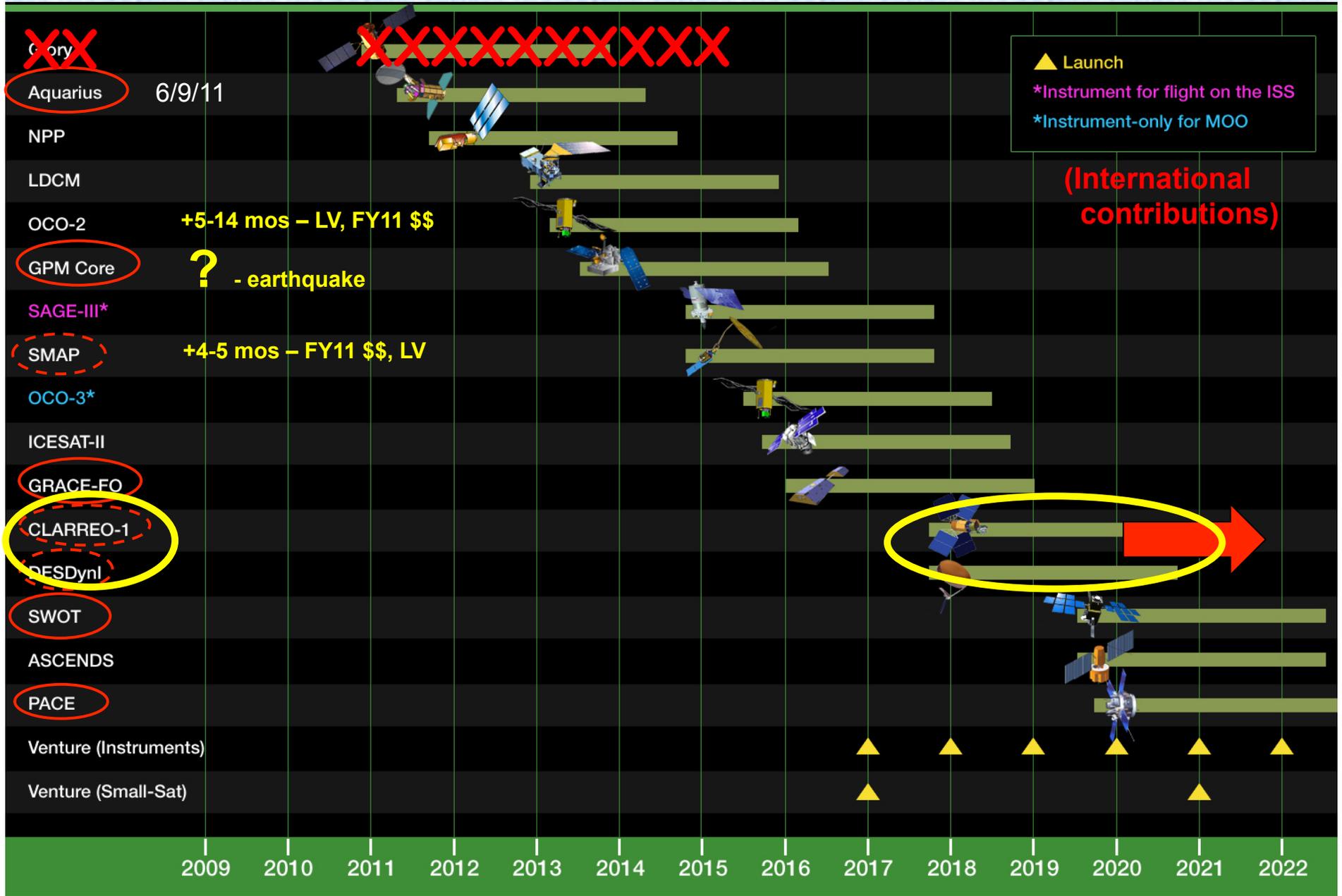
Ground Stations



Research Balloons

***NASA's & Partners' ground, sea, air and in-situ measurements augment space-based observations to validate science results and provide complimentary measurements***

# Future Orbital Flight Missions – 2011 – 2022

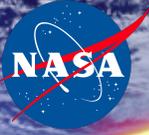




# The Bigger Perspective

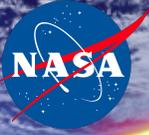
- Significant external attention is being placed on utilizing climate information to inform studies of impacts, adaptation, mitigation, and vulnerability
- NRC report (2009) on US Global Change Research Program suggested significant changes in interagency climate program (*Restructuring Federal Climate Research to Meet the Challenges of Climate Change*)\*
- US Global Change Research Program issued assessment report *Global Climate Change Impacts in the United States* (May, 2009)
- US National Research Council addressed all of these in its 2010 report series *America's Climate Choices* (final report released in 2011)
  - Advancing the Science of Climate Change
  - Adapting to the Impacts of Climate Change
  - Limiting the Magnitude of Climate Change
  - Informing an Effective Response to Climate Change
- US Global Change Research Program held Climate Adaptation Summit in May, 2010 (report issued 9/10)
- US Climate Change Adaptation Task Force issued report (10/5/10)
- International Council for Science (ICSU) released report *Regional Environmental Change: Human Action and Adaptation - What does it take to meet the Belmont Challenge?* (Sept., 2010)\*
- 9 Strategic Action Plans are being produced for the National Ocean Council
- Research Plan to be created by Interagency Arctic Research and Policy Council

\* Full Disclosure – JAK contributed to report development



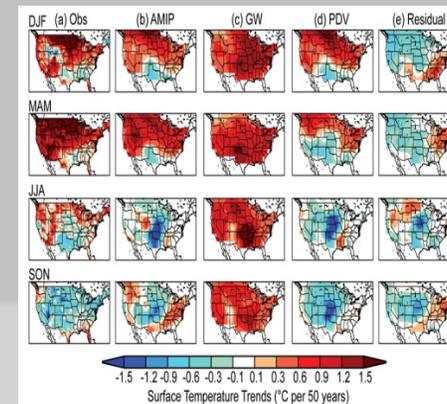
# NRC Review of USGCRP (2009): Top Priorities

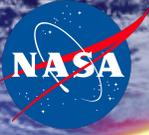
- Reorganize the program around integrated scientific-societal issues to facilitate crosscutting research focused on understanding the interactions among the climate, human, and environmental systems and on supporting societal responses to climate change.
- Establish a U.S. climate observing system, defined as including physical, biological, and social observations, to ensure that data needed to address climate change are collected or continued.
- Develop the science base and infrastructure to support a new generation of coupled Earth system models to improve attribution and prediction of high-impact regional weather and climate to initialize seasonal-to-decadal climate forecasting, and to provide predictions of impacts affecting adaptive capacities and vulnerabilities of environmental and human systems.
- Strengthen research on adaptation, mitigation, and vulnerability.
- Initiate a national assessment process with broad stakeholder participation to determine the risks and costs of climate change impacts on the United States and to evaluate options for responding.
- Coordinate federal efforts to provide climate services (scientific information, tools, and forecasts) routinely to decision makers.



# 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.”

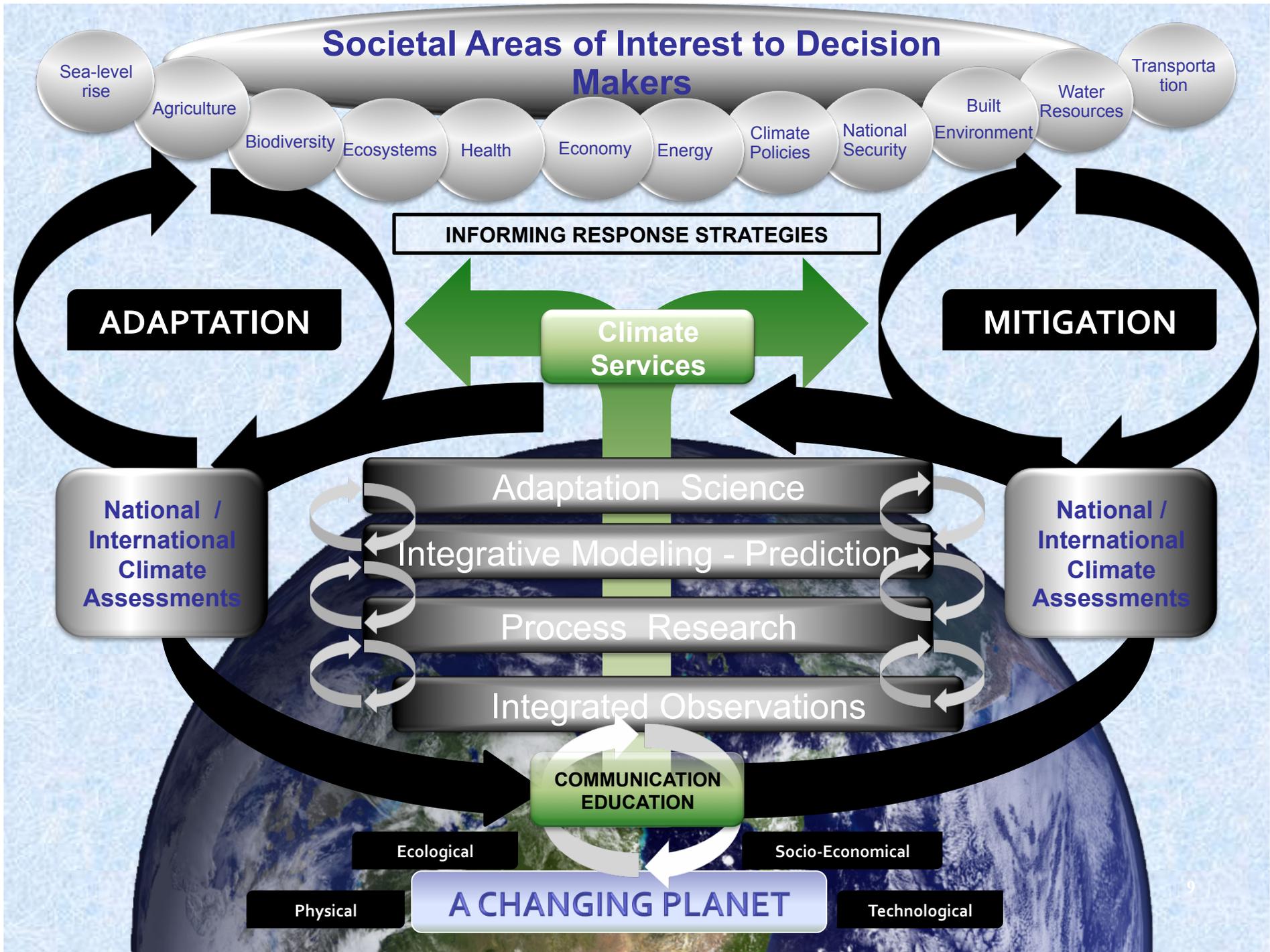




# USGCRP Interim Strategic Plan Goals

- ***Goal One: Advance Science*** – Advance scientific knowledge of the integrated natural and human components of the Earth system
- ***Goal Two: Inform Decisions*** – Provide the scientific basis to inform, support, and enable timely decisions on adaptation and mitigation
- ***Goal Three: Sustain Assessment*** – Foster sustained assessment that improves the nation's ability to understand, anticipate, and cope with global and climate change impacts and vulnerabilities
- ***Goal Four: Communicate and Educate*** – Advance communications and education to broaden public understanding of climate and global change and inspire the workforce of the future

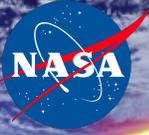
❖ ***NOTE: These goals are not finalized and are subject to change.***





## From *Global Climate Change Impacts in the United States* (USGCRP, 2009)

- Report included a section on “An Agenda for Climate Impacts Science:”  
“The focus below, however, is on advancing our knowledge specifically on climate change impacts and those aspects of climate change responsible for these impacts in order to continue to guide decision making”
  - Expand our understanding of climate change impacts.
    - Ecosystems
    - Economic systems, human health, and the built environment
  - Refine ability to project climate change, including extreme events, at local scales.
  - Expand capacity to provide decision makers and the public with relevant information on climate change and its impacts.
  - Improve understanding of thresholds likely to lead to abrupt changes in climate or ecosystems.
  - Improve understanding of the most effective ways to reduce the rate and magnitude of climate change, as well as unintended consequences of such activities.
  - Enhance understanding of how society can adapt to climate change.



# From America's Climate Choices: Advancing the Science of Climate Change

- **Conclusion 1:** Climate change is occurring, is caused largely by human activities, and poses significant risks for—and in many cases is already affecting—a broad range of human and natural systems.
- **Conclusion 2:** The nation needs a comprehensive and integrative climate change science enterprise, one that not only contributes to our fundamental understanding of climate change but also informs and expands America's climate choices.
  - This report identifies seven cross-cutting research themes, grouped into three general categories, that collectively span the most critical research needs for understanding climate change and for informing and supporting effective responses to it:

## **Research to Improve Understanding of Human-Environment Systems:**

- 1) *Climate Forcings, Responses, Feedbacks and Thresholds in the Earth System*
- 2) *Climate-Related Human Behaviors and Institutions*

## **Research to Support Effective Responses to Climate Change:**

- 3) *Vulnerability and Adaptation Analyses of Coupled Human-Environment Systems*
- 4) *Research to Support Strategies for Limiting Climate Change*
- 5) *Effective Information and Decision-Support Systems*

## **Tools and Approaches to Improve Both Understanding and Responses:**

- 6) *Integrated Climate Observing Systems*
- 7) *Improved Projections, Analyses, and Assessments*



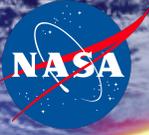
# From America's Climate Choices: Advancing the Science of Climate Change, cont.

- *Recommendation 1:* The nation's climate change research enterprise should **include and integrate disciplinary and interdisciplinary research across the physical, social, biological, health, and engineering sciences**; focus on fundamental, use-inspired research that contributes to both improved understanding and more effective decision making; and be flexible in identifying and pursuing emerging research challenges.
- *Recommendation 2:* Research priorities for the federal climate change research program should be set within each of the seven cross-cutting research themes outlined above...
- *Recommendation 3:* The federal climate change research program ... should **redouble efforts to develop, deploy, and maintain a comprehensive observing system** that can support all aspects of understanding and responding to climate change.
- *Recommendation 4:* The federal climate change research program should work with the international research community and other relevant partners to **support and develop advanced models and other analytical tools** to improve understanding and assist in decision making related to climate change.
- *Recommendation 5:* A single federal interagency program or other entity should be given the authority and resources to coordinate and implement an integrated research effort that supports improving both understanding of and responses to climate change...
- *Recommendation 6:* The federal climate change research program should be **formally linked with action-oriented response programs focused on limiting the magnitude of future climate change, adapting to the impacts of climate change, and informing climate-related actions and decisions...**
- *Recommendation 7:* Congress, federal agencies, and the federal climate change research program should work with other relevant partners ...to **expand and engage the human capital needed** to carry out climate change research and response programs.



# From Final NRC Report: *America's Climate Choices*

- **Recommendation 1:** In order to minimize the risks of climate change and its adverse impacts, the nation should reduce greenhouse gas emissions substantially over the coming decades. The exact magnitude and speed of emissions reduction depends on societal judgments about how much risk is acceptable. However, given the inertia of the energy system and long lifetime associated with most infrastructure for energy production and use, it is the committee's judgment that the most effective strategy is to begin ramping down emissions as soon as possible.
- **Recommendation 2:** Adaptation planning and implementation should be initiated at all levels of society. **The federal government**, in collaboration with other levels of government and with other stakeholders, **should immediately undertake the development of a national adaptation strategy** and build durable institutions to implement that strategy and improve it over time.
- **Recommendation 3:** **The federal government should maintain an integrated, coordinated, and expanded portfolio of research programs** with the dual aims of increasing our understanding of the causes and consequences of climate change and enhancing our ability to limit climate change and adapt to its impacts.
- **Recommendation 4:** **The federal government should lead in developing, supporting, and coordinating the information systems** needed to inform and evaluate America's climate choices, to ensure legitimacy and access to climate services, greenhouse gas accounting systems, and educational information.
- **Recommendation 5:** The nation's climate change response efforts should include broad-based deliberative processes for assuring public and private-sector engagement with scientific analyses, and with the development, implementation, and periodic review of public policies.
- **Recommendation 6:** **The United States should actively engage in international level climate change response efforts** to reduce greenhouse gas emissions through cooperative technology development and sharing of expertise, to enhance adaptive capabilities (particularly among developing nations that lack the needed resources), and to **advance the research and observations necessary to better understand the causes and effects of climate change**.
- **Recommendation 7:** The federal government should facilitate coordination of the many interrelated components of America's response to climate change with a process that identifies the most critical coordination issues and recommends concrete steps for how to address these issues.



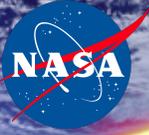
# Report from USGCRP Climate Adaptation Summit

## ■ Conclusions from Report:

- The United States' response to climate change must include adaptation as well as mitigation.
- The current suite of federal adaptation activities and plans lacks clear organization and is confusing to potential state, regional, and local partners and other stakeholders.

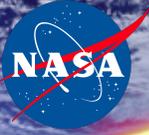
## ■ Seven priorities for near-term action were identified:

- Developing an overarching national strategy to guide federal climate change adaptation programs.
- Improving coordination of federal plans and programs.
- Creating a federal climate information portal.
- Creating a clearinghouse of best practices and toolkits for adaptation.
- Including support for assessment in USGCRP agency budgets.
- Increasing funding for research on vulnerability and impacts, including economic analyses, and pilot projects that join local, state, and regional governments and academic institutions to develop and test adaptation measures and tools.
- Initiating a regional series of ongoing climate adaptation forums.



# From Interagency Climate Change Adaptation Task Force

- Summary of Policy Goals and Recommended Actions for the Federal Government
  - Encourage and Mainstream Adaptation Planning across the Federal Government
  - Improve Integration of Science into Decision Making
  - Address Key Cross-Cutting Issues
    - Improve water resource management in a changing climate
    - Protect human health by addressing climate change in public health activities
    - Build resilience to climate change in communities
    - Facilitate the incorporation of climate change risks into insurance mechanisms
    - Address additional cross-cutting issues
  - Enhance Efforts to Lead and Support International Adaptation
  - Coordinate Capabilities of the Federal Government to Support Adaptation



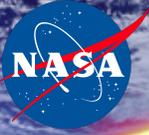
# From Report of Ocean Policy Task Force

## ■ National Priority Objectives

- Ecosystem-Based Management
- Coastal and Marine Spatial Planning
- Inform Decisions and Improve Understanding
- Coordinate and Support
- Resiliency and Adaptation to Climate Change and Ocean Acidification
- Regional Ecosystem Protection and Restoration
- Water Quality and Sustainable Practices on Land
- Changing Conditions in the Arctic
- Ocean, Coastal, and Great Lakes Observations, Mapping, and Infrastructure

## ■ The National Goals of Coastal and Marine Spatial Planning

- Support sustainable, safe, secure, efficient, and productive uses of the ocean, our coasts, and the Great Lakes, including those that contribute to the economy, commerce, recreation, conservation, homeland and national security, human health, safety, and welfare;
- Protect, maintain, and restore the Nation's ocean, coastal, and Great Lakes resources and ensure resilient ecosystems and their ability to provide sustained delivery of ecosystem services;
- Provide for and maintain public access to the ocean, coasts, and Great Lakes;
- Promote compatibility among uses and reduce user conflicts and environmental impacts;
- Improve the rigor, coherence, and consistency of decision-making and regulatory processes;
- Increase certainty and predictability in planning for and implementing new investments for ocean, coastal, and Great Lakes uses; and
- Enhance interagency, intergovernmental, and international communication and collaboration



# From ICSU “Belmont Challenge” Report

- The Belmont Challenge: “... a challenge for the international scientific community to *develop and deliver knowledge in support of national and international government action to mitigate and adapt to global and regional environmental change with an emphasis on regional hazards.*”
- *Urgent needs identified by the panel:*
  - Coordinate efforts and enhance the support required to address the needs of a sustainable environment and the needs of society. The challenge is to integrate environmental and developmental issues that have often been addressed independently in past decades.
  - Facilitate the dialogue between scientists, decision makers and the general public to support decisions and actions at the forefront of society’s needs.
  - Encourage natural and social scientists to work together to ensure that environmental observations, analyses, predictions and services most effectively meet the needs of society.
  - Maintain and expand access to, and use of, the current global observing and monitoring systems through coordinated databases and develop assimilation procedures to achieve the maximum benefit.
  - Respond to society’s increasing demand for detailed information at the regional and local scales. This requires sector-relevant information that includes observations, analyses, high-resolution projections/predictions at timescales from days to decades.



# NASA Earth Science Program Evolution

- Cooperative activity initiated in FY09 between ESD and Office of Strategic Infrastructure studying impacts of climate variability and change on NASA centers.
- Carbon Monitoring System (CMS) activity initiated in FY10 in response to Congressional direction to produce products on fluxes and stores of carbon in the Earth system will continue as part of Climate Initiative. Initial emphases
  - Production of “pilot products” on terrestrial biomass (US-focused) and global integrated emission/uptake (“flux”)
  - Scoping study to be initiated (building on output of July, 2010 workshop) to look at how to utilize future NASA observations most effectively for improving future products (in context of other observations)
  - CMS Science Definition Team (SDT) selected in March, 2011
- NASA is beginning to invest in USGCRP National Climate Assessment (NCA) in FY11 to support both development of 2013 statutory requirement for quadrennial assessment and longer-term sustained assessment capability for the nation
- Applied Sciences program is evolving with primary focus on four application areas (multiple solicitations out this year)