National Aeronautics and Space Administration

2014

CLIMATE

RISK MANAGEMENT PLAN

IDENTIFY RISKS

PROPOSE STRATEGIES

INTEGRATE SOLUTIONS

NASA 2014 Climate Risk Management Plan:

Managing Climate Risks & Adapting to a Changing Climate

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I. Introduction

NASA has an important responsibility to the nation and to the world with regard to climate change. NASA builds the satellites that collect weather and climate data, contributing to a robust research program dedicated to understanding how the Earth and its systems behave. From this understanding, we build models to project likely consequences of the interaction among such systems, and develop tools that help others apply scientific understanding in their work and other aspects of their lives. NASA therefore is critical in providing the understanding to the nation and the world that serves as the foundation for adaptation planning. To provide that information, NASA must maintain a workplace (administrative, technical, and supporting workspaces), that enables its employees, contractors, and partners to conduct its research and development, and to help translate Earth data into useful information for decision makers the world over. This workplace must also reliably enable the rest of NASA's work, including launch capabilities, space hardware, space communications networks, and other science and aeronautics research. Finally, NASA's workforce and workplaces are part of (and integrated into) larger communities. In being prudent managers of climate risks in its own work, NASA partners with local and regional industry, government, academia, and other stakeholders to understand and address climate risks we face collectively.

Background. NASA recognized as early as 2005 that 'regional climate variability' could pose a risk to its operations and missions and identified it as a risk within NASA's risk management framework. Many Agency assets - 66% of its assets when measured by replacement value - are within 16 feet of mean sea level and located along America's coasts, where sea level rise and increased frequency and intensity of high water levels associated with storms are expected, and in other parts of the country where long-term changes in temperature and precipitation intensity and duration are expected to impact potable water supplies.

Subsequent initiatives at NASA, such as encroachment risk assessment workshops held in 2007, confirmed that 'natural hazards' could impact NASA Centers and their ability to execute mission activities. Fortunately, engagement of NASA's own preeminent climate science expertise enabled NASA to refine a vulnerability assessment and adaptation strategy process at both cross-Agency and Center-specific workshops starting in 2009, which has led to local Center-level capacity building, increased awareness of NASA's climate-related vulnerabilities and risks, and changes in policy. While climate change is a global phenomenon, impacts are being and will be felt at all scales, and NASA recognizes that integrating climate change adaptation into Center planning is a local activity, guided by Headquarters support. Thus, NASA Centers *own and manage risks*, including those associated with a changing climate and NASA Headquarters provides policy and planning directives and guidance, such as issuing a new Land Management Policy in 2013.

Format. NASA presents its Climate Risk Management Plan () in a structure recommended by the Climate Disclosure Standards Board's (CDSB) "Climate Change Reporting Framework," a voluntary risk disclosure format.[1] The blue text boxes contain section descriptions from CDSB's Framework. The Climate Risk Management Plan addresses both section 8(i) of Executive Order (EO) 13514 – "*[E]ach agency Plan shall: … evaluate agency climate-change risks and vulnerabilities to manage the effects of climate change on the agency's operations and mission in both the short and long term*" and section 5 of EO 13653, *"Preparing the United States for the Impacts of Climate Change,"* (issued November 1, 2013) which builds on the requirements of EO 13514 and requires that agencies update their plans to integrate consideration of climate change into agency operations and overall mission objectives.

Please note: NASA voluntarily discloses its climate risks and climate vulnerabilities, subject to national security and International Traffic in Arms Regulations (ITAR) restrictions.

II. Strategic Analysis

In keeping with CDSB's Climate Change Reporting Framework, NASA provides a brief statement regarding its examination of long-term and short-term climate change impacts on NASA's strategic objectives, roles, and responsibilities.

*CDSB Section 4.6 Disclosure about **strategic analysis** shall include a statement about the long-term and short-term impact climate change actually and potentially has on the organization's strategic objectives.*

NASA's analysis concludes that there is potential for a changing climate to impact some of the required facilities and systems necessary to execute NASA's Strategic Goals.

***Facilities and Systems at Risk from Climate Change Impacts**:*

- *Launch facilities to provide access to space for humans, cargo, and research;*
- *Space assets and their operational support capabilities, such as space hardware, and the International Space Station;*
- *Ground systems, including IT, communication and data systems and Space Communication and Navigation systems;*
- *Test facilities, including research, development and demonstration facilities;*
- *Training facilities; and*
- *Supply chain for necessary materials and services.*

These assets represent combinations of capabilities and systems – built infrastructure, land and natural resources, and the workforce that operates, uses and manages them – that can be impacted by various events, such as extreme heat events, drought or inland and coastal flooding. These types of events could compromise or interrupt particular capabilities or assets for short or long time periods.

NASA's risk management process – described further in Section IV - is designed to help identify risks to mission and assets to ensure the Agency has plans and strategies in place to address disruptions.

The following strategic documents were reviewed during this analysis.

- **National Aeronautics and Space Administration Authorization Act of 2010** - authorizes NASA's programs for fiscal years 2011 through 2013 and contains statutory objectives.[2] The Act lists several Congressional findings including: "It is essential to the economic well-being of the United States that the aerospace industrial capacity, highly skilled workforce, and embedded expertise remain engaged in demanding, challenging, and exciting efforts that ensure United States leadership in space exploration and related activities."
- **National Space Policy of the United States of America** (2010) - expresses the President's direction for the Nation's space activities and articulates the President's commitment to reinvigorating U.S. leadership in space for the purposes of maintaining space as a stable and productive environment for the peaceful use of all nations.[3]
- **U.S. Space Transportation Policy** (National Security Presidential Directive (NSPD) #40, 2005) - establishes national policy, guidelines and implementation actions for U.S. space transportation programs and activities to *ensure the Nation's ability to maintain access to and use space for U.S. national and homeland security, and civil, scientific, and commercial purposes*.[4]
- **2014 NASA Strategic Plan** - outlines the long-term goals of the Agency and how the goals will be accomplished over the next decade or more.[5]
- **2012 National Strategy for Global Supply Chain Security** - establishes the U.S. Government's policy to strengthen the global supply chain to protect the interests of the American people and enhance our Nation's economic prosperity.[6]
- **Presidential Directive "Critical Infrastructure Security and Resilience"** (February 12, 2013) - directs federal agencies to take proactive steps to manage risk and strengthen the security and resilience of the Nation's critical infrastructure, including physical space and cyberspace for information systems.[7]

- **National Security Space Strategy** (January 2011) - is an approach to maintain the advantages derived from space while confronting the challenges of an evolving space strategic environment. It is the first such strategy jointly signed by the Secretary of Defense and Director of National Intelligence.[8]

III. Risks

Six sets of facilities and systems are identified in Section II – Strategic Analysis, in which long-term and short-term climate impacts could hamper NASA's strategic objectives, roles, and responsibilities. The risks associated with these impacts fall into four primary categories, listed below with examples of current and anticipated risks associated with climate change.

CDSB Section 4.9 Disclosure about risks shall include an explanation and qualitative assessment of the organization's exposure to current and anticipated (long-term and short-term) significant risks associated with climate change.

Technical Capabilities – The Nation's access to space is currently being threatened by beach erosion. This risk is predicted to accelerate due to both sea level rise and the intensity and frequency of storms. In addition, the Nation's world leadership in space and aeronautics depends on NASA research and development, testing, and training facilities, several of which are especially vulnerable to coastal flooding due to sea level rise and storm surges. Inland testing and training facilities may also be vulnerable to rising average temperatures and extreme events, such as heat waves and intense precipitation. NASA serves many other federal agencies by providing data and knowledge to inform decision making. This capability may be threatened by impacts to physical facilities and to NASA personnel supporting the development and delivery of data and knowledge. Impacts to supply chains may present risks to our launch capabilities, particularly if access to specific materials or chemicals is affected.

Built Systems – Energy, communications, and information technology systems are vulnerable to storms that are increasing in intensity and frequency. Electrical black-outs and brown-outs associated with heat waves and with changes in the availability of electric power threaten commercial energy utilities that provide the power NASA uses to receive, process, and archive data sets from space, and the information and knowledge needed and used by a multitude of federal agencies, researchers, and decision-makers across all levels of government to understand, plan for, and adapt to climate in their areas. Increased runoff associated with heavy precipitation, especially when accompanied by storm surges in coastal locations, may overwhelm stormwater conveyance systems, leading to flooding of buildings and transportation systems, limiting the ability of the workforce to perform its job.

Workforce and Communities – Health and safety impacts to NASA employees, their families, and the communities around NASA Centers may pose operational risks. Employees addressing health concerns relating to worsening air quality, heat waves, or problems caused by disease-borne vectors will miss days of work or be distracted by caring for others in their family affected by these climate change impacts. Assured operation of space assets is at risk due to impacts to the personnel providing the necessary support.

Natural systems – Impacts to threatened and endangered species at NASA Centers may require additional or different management. The increasing possibility of wildfires puts natural and built systems at risk. Wetland losses due to increased storm surge impacts may affect the buffering effect that protects some of our coastal facilities. Increasing downpours and fluctuating groundwater tables may mobilize contaminants at remediation sites.

Figure 1 depicts the key climate hazards anticipated to impact NASA assets and capabilities and current and expected impacts.[9]

Figure 1. Key Climate Hazards and Potential Impacts to NASA Assets and Capabilities

Key Climate Hazards	Potential Impacts
More frequent and extreme high temperatures and humidity	Increased risk of heat-related ailments among outdoor workers; higher cooling costs; decreased utility reliability; damage to buildings
More frequent and intense droughts, seasonal shifts in water cycle	Reduced water availability; higher water costs; salt water intrusion; ground water changes
More intense precipitation events	More frequent flooding of low-lying indoor and outdoor areas
Sea level rise	Loss of usable land; inundation of coastal ecosystems
More frequent and intense coastal flood events	Coastal erosion; safety implications for surrounding communities

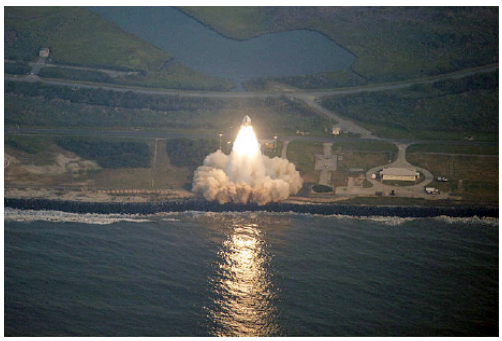
In general, NASA anticipates short-term risks to result from extreme weather such as heat waves, precipitation, wind, flooding, and drought, each of which will become more difficult to manage because of changes in event intensity, duration, and frequency. Over a longer time horizon, NASA anticipates a continuation of extreme weather challenges experienced in the short-term, possibility exacerbated because of longer term gradual trends such as sea level rise and increased average temperatures.

From a long-term, strategic perspective, NASA sees the following risks as affecting the ability to carry out its mission:

1. Loss of land to support **launch capabilities** on the coast.
2. **Downtime for facilities** subject to extreme events, especially those subject to recurring nor'easters or hurricanes. Inland facilities could also be subject to downtime from impacts of extreme storms (flooding and/or electrical outages). As NASA has consolidated various functions at single Centers, downtime at a single facility may have a ripple effect across the Agency, such as when servers go offline. Additionally, as extreme events increase in the future, repeated recovery actions strain financial resources and the morale of emergency responders and employees whose work is disrupted.
3. **Competing cost priorities**. Over the next 20-30 years, NASA may incur significant costs in implementing adaptation strategies. Given the already degraded condition of much of NASA's infrastructure portfolio, how will NASA find the money to conduct necessary adaptations, repair failing infrastructure, and maintain mission tempo?

Wildfires burn near the Jet Propulsion Lab in California.

Storm damage to the Vehicle Assembly Building at Kennedy Space Center.



A launch from Wallops Flight Facility on Virginia's Eastern Shore illustrates the close proximity of the Atlantic Ocean.

IV. Opportunities

NASA sees two opportunities to conserve resources in its approach to address climate impacts and risks: using an integrated strategy and pooling resources.

*CDSB Section 4.10 Disclosure about **opportunities** shall include an explanation and qualitative assessment of current and anticipated (long-term and short-term) significant opportunities associated with climate change.*

Integrated Strategy. Integrating climate-related considerations – climate science data and associated impacts, risks, and strategies – into existing programs and processes is the best path forward because it leverages scarce resources to advance multiple objectives rather than dividing them across "silos." NASA's climate policy, now within NASA Procedural Directive 8500, *NASA Environmental Management*, signed by the NASA Administrator in December 2013, emphasizes that point:

> *…it is NASA policy to:*
> *….Apply NASA's scientific expertise and products so that we can incorporate climate information into our decision making and planning; create innovative, sustainable, and flexible solutions; and share best practices; in order to create climate-resilient NASA Centers.*

Numerous Agency vulnerability and risk assessment, planning, budgeting, and management processes have their respective planning horizons, decision methodologies, and stakeholders. Respecting these methods and refining policies and/or processes where necessary, yields an approach that should not require additional resources, allows the Agency to make the most of limited resources (skills, time, and money,) and also helps avoid the unforeseen (usually negative) consequences of un-coordinated independent initiatives. NASA has already included climate considerations into its *Handbook: Master Planning Procedural Requirements* and via a NASA Interim Directive, set policy to consider flooding risks when making plans and agreements regarding land use and investment decisions on facilities projects by utilizing an elevation-based zoning system. NASA will continue to identify policies and processes where climate-related considerations can be incorporated.

Pooling Resources. Because resource constraints are on the rise, acting alone is rarely an option for a small Federal agency. NASA actively seeks out best practices and expertise from within and without. NASA seeks to build relationships with others because they help us all leverage strengths and fill gaps.

Building external relationships with others in the form of partnerships, alliances and coalitions is standard practice for NASA, with particular value in managing climate risks. It is standard practice for NASA's climate science community and for NASA's community of institutional managers to establish relationships with academia, other government agencies, private sector firms and public sector entities.

One of NASA's strengths in managing climate risks is collaboration between NASA's climate science community and NASA's managers. As a result of this relationship, NASA supports the application of climate science, providing advice to the NASA Center institutional stewards. NASA's Climate Adaptation Science Investigator (CASI) Workgroup engages NASA climate modelers, scientists, engineers, and institutional stewards to explore climate impacts and adaptation strategies for institutional stewards, with a special focus on NASA installations. The group includes NASA and external members committed to expanding the information and toolsets of use to these institutional stewards. While focused upon NASA Centers and the surrounding communities, such work may often be of value far beyond NASA's workplaces. Examples of relevant CASI research efforts:

- CASI scientists at Kennedy Space Center (KSC), working with our regional partners at the St. Johns River Water Management District and the EPA funded Indian River Lagoon National Estuaries Program, developed sea level rise scenarios and conducted sea level affecting marshes modeling (SLAMM) for KSC and the surrounding Indian River Lagoon estuary. Results suggest that sea level rise on the order of 0.4 m will inundate approximately 25% of the current KSC land

area, converting extensive wetlands into open water. Warming weather and less frequent and intense cold spells will also allow for the expansion of mangrove forest into the region displacing current high marsh habitats that are home to numerous species of special concern.

- Rocket engine testing at Stennis Space Center depends on surrounding forests to buffer the necessary testing noise and vibration. CASI scientists at Stennis used a model to assess forest health based on growth and decline observations compared to climate and weather observations and predictive models. This approach, baselined with observed and verified measurements, helps Stennis resource managers better understand the buffer area's resilience to climate change, approximating the future climate impacts, planning accordingly, and implementing adaptation strategies proactively.

Additional examples of how NASA science has supported NASA Centers are included in Section V.2.

V. Management Approach

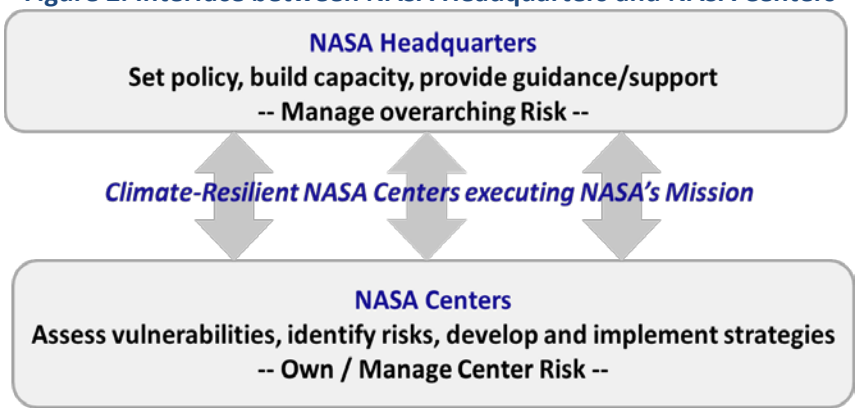
The following explains NASA's management approach for managing climate risks and provides some of its long-term and short-term strategies to address climate change. Sub-sections describe NASA's overall goal and strategy, the primary steps utilized, and method for measuring progress. This section also contains information regarding NASA's targets to reduce GHG emissions and performance against those targets.

*CDSB Section 4.12 Disclosure shall include a description of the organization's long-term and short-term **strategy or plan** to address climate change-related risks, opportunities and impacts, including targets to reduce GHG emissions and an analysis of performance against those targets.*

V.1. Overall Goal & Strategy

The overall goal is to create climate-resilient NASA Centers able to execute NASA's mission. This concept is depicted in **Figure 2**; Section VII, Governance, describes these and additional organizations and their roles and responsibilities.

Figure 2. Interface between NASA Headquarters and NASA Centers



"***Adaptation is fundamentally a risk-management strategy***."[10] From an organizational and cultural perspective, a risk management approach resonates within NASA as it has a sophisticated and mature enterprise risk management framework based both in policy and procedures. Central to NASA's climate change management strategy is the premise that *every Center is required to manage risk,*[11] including those associated with climate change. Centers are responsible for assessing their threats, identifying risks, and developing and implementing adaptation strategies endorsed by Center or Headquarters leadership. *NASA Headquarters manages the overarching risks*[12], sets policy, builds capacity at the Centers, and provides guidance and support.

NASA organizes its risk management systems into two complementary processes: Risk-Informed Decision Making (RIDM) and Continuous Risk Management (CRM). NASA uses CRM for the management of risks associated with implementation of designs, plans, and processes (**Figure 3**).[13] In accordance with this process, NASA's Office of Strategic Infrastructure has managed the overarching 'natural hazards' risk within the Agency's enterprise risk management framework since 2005, aware that a changing climate could impair its ability to provide important services to the Nation.[14]

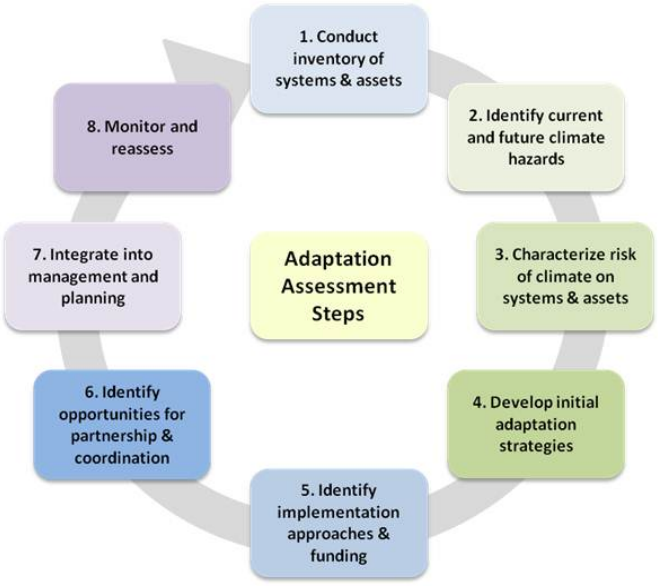
Figure 3. NASA's Continuous Risk Management Diagram

CRM plays an important role once a risk is identified and elevated to a Center or Headquarters level. Identification and characterization of potential impacts and vulnerabilities are necessary stages prior to formal risk categorization and entry into a Center or Headquarters risk management system.

NASA recognized the need to build local adaptation capacity in order to identify, characterize, and manage local and regional vulnerabilities and risks associated with climate change. NASA's Office of Strategic Infrastructure (OSI) partnered with NASA's Earth Science Division to develop and offer to its Centers a systematic approach. Whether facilitated via a 2-3 day workshop or executed by other means, the approach follows a framework for action with 8 steps originally developed for New York City by NASA's Goddard Institute for Space Studies (GISS), which was modified to meet NASA's own internal organizational-management needs and demands (**Figure 4**).[15]

NASA's approach addresses conventional assets, such as built infrastructure and natural ecosystems, and also less tangible resources including workforce, emergency response, and information systems – all of which support mission - for a full sense of the potential vulnerabilities and adaptations.

Figure 4. NASA's Adaptation Assessment Steps



Eight site-specific workshops have initiated this systematic approach to local climate adaptation across the Agency since May 2010, and several Centers adapted the approach, following the risk identification and adaptation strategy process as best fit local circumstances. While initiating adaptation thinking at its sites is a crucial early step, the Agency recognizes that sustaining leadership attention and strategy development involves building on these workshops as the Agency moves forward with its mission. For instance, Centers located along coasts gathered for a workshop in 2013 to together explore adaptation strategies for their common vulnerabilities. Building capacity within Center staff yields a continual risk characterization process which elevates the risks and potential adaptation strategies to the appropriate management level at the Center or Headquarters, aligning with NASA's continuous risk management process.

V.2 Current and Planned Actions

NASA's overall goal is to create climate-resilient NASA Centers able to execute NASA's mission. Remaining proactive, applying NASA's scientific expertise and products, and focusing on integration enables NASA to incorporate climate risks into decision-making and planning, and create innovative, sustainable and flexible solutions for NASA Centers, as expressed in NASA's Procedural Directive 8500 (Section II). Obviously, successful execution of the policy relies on NASA Center support – the place where NASA's operations and mission are accomplished, as well as knowledge sharing and partnering with others. Thus, while tactical, shorter efforts are still necessary, current integration, research and planning activities will provide benefit in the long-term.

An example of CASI research that helps NASA manage its long-term climate risks strategies is at Stennis Space Center, which tests large rockets by securing them to several-stories-tall rocket test stands. The CASI team there is developing a new test stand thermal model to support the Space Launch System program. This model is being developed to address concerns about test stand structural changes on extremely hot days and under full sun illumination. Solar flux, local surface albedo, and temperature record data for the hottest 1% of the days for months of June-September from 1973-2012 and climate projections for 2020 and 2050 have been used as input for the model. This knowledge will help those responsible for maintaining the test stands' capabilities assess whether adjustments need to be made prior to testing on extremely hot days or whether testing will need to be postponed to cooler days.

Examples of shorter-term strategies to preserve mission capabilities include:

Dune repair at Kennedy Space Center

- NASA Kennedy Space Center's (KSC) Dune Vulnerability Team continues to address beach and sand dune erosion as the sand dunes are the physical protection barrier for NASA's Launch Pads 39A and 39B from the sea. Further, beach dunes are habitats for a number of threatened and endangered species. Impacts from Hurricane Sandy exacerbated the conditions along Launch Complex 39. The Dune Vulnerability Team (CASI scientists, the U.S. Geological Survey, the University of Florida, and the U.S. Fish and Wildlife Service) developed a plan for restoring the coastal dune in an area of high beach erosion. KSC used Hurricane Sandy Emergency Funding to repair part of the most critically eroded shoreline. The project included the removal of a portion of the beach rail line and the construction of an inland dune. The dune is approximately 1.2 miles in length, 15 feet in height, and approximately 50 feet wide at the base. In some of our most critically eroded areas this dune is actually our primary dune feature along the beach. Construction of the dune is complete; the vegetation planting was completed in May 2014. More than 180,000 specimens were planted by hand over a period of two months. Monitoring of project success will be conducted over the next few years to assess the potential for utilizing the approach in support of "a controlled retreat" concept of adaptation to changing climate. Although the 1.2 mile dune is not a permanent fix, it will allow additional time for seeking funding to implement the overall shoreline protection project. Options include construction of the three mile long secondary/inland dune, and/or secondary dune and beach nourishment. The draft Environmental Assessment for the overall shoreline projection project is being updated in 2014 to incorporate the Hurricane Sandy funding dune project. This project is also an illustration of how natural and built systems can work in harmony. The sea turtles (who use the beach for nesting) win, and so does launch reliability.

- Likewise, a major beach replenishment project was completed in September 2012 to protect launch capabilities at Wallops Flight Facility (WFF). This project was conducted by NASA in coordination with several other federal, local, and non-profit organizations. Hurricane Sandy degraded the beach expansion and while currently being replenished, does serve as a reminder that this type of solution requires continual maintenance to preserve its protective ability. WFF is part of a new Mid-Atlantic Climate Resiliency Institute being organized to coordinate research of climate impacts in the area. MACRI will be a multi-state, multi-disciplinary partnership with the goal of helping local and regional leaders make coastal communities and habitats more resilient through scaled science and research informing public policy.

Wallops Island, View to the North

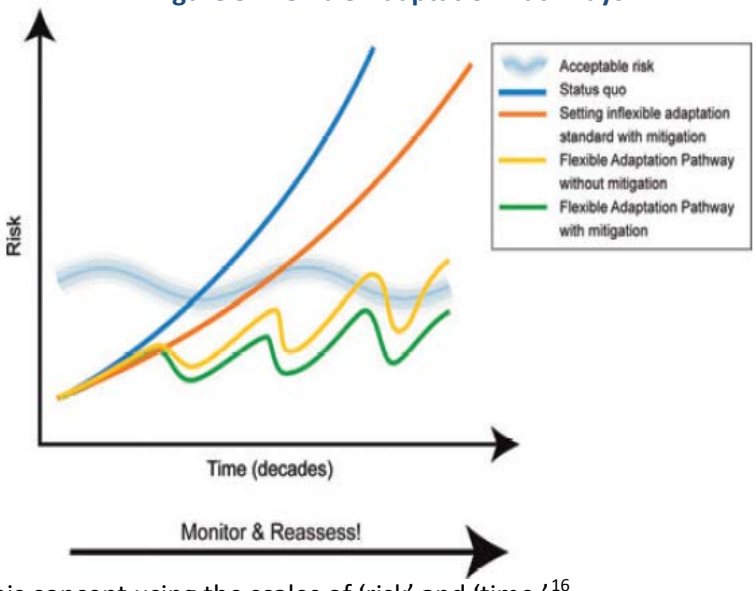
Pre-Fill Post-Fill

- Climate scientists at Ames Research Center are collaborating with partners to analyze the impacts of sea level rise and extreme high tides. The analysis will help to size the levees required to provide flood protection; the analysis will also determine the area of wetlands that may be lost by the levee footprint.
- NASA climate scientists conducted modeling to assess the potential for sea level rise to damage a specific communications building at Johnson Space Center, concluding that while sea level rise alone was not a threat (at least through 2100), the addition of storm surge through hurricanes could pose a threat.

Not all adaptation involves construction, but when proposed construction has the potential for impact on the environment, NASA provides information to interested parties through the NEPA process before making decisions to act. The NEPA process includes characterization of any potential environmental justice issues. As NASA works in coordination with communities near NASA Centers, the aim is to make the entire community more resilient.

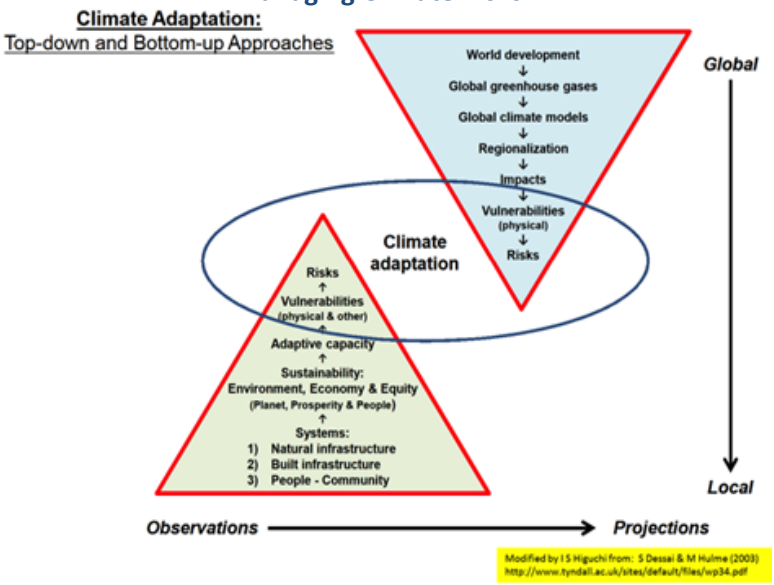
Flexible Adaptation Pathways. The best available science changes over time and with better understanding of likely changes and advancements in adaptation strategies, site-specific adaptation must also evolve. Rather than static risk assessment, the Agency's policies, actions and risk tolerances must be reconsidered and revised on a dynamic basis as science and understanding evolve. While efforts at KSC and WFF (described above) represent one type of example, NASA is still seeking examples from other organizations of flexible adaptation pathways that illustrate how to incorporate this concept into its adaptation strategies. **Figure 5** illustrates this concept using the scales of 'risk' and 'time.'[16]

Figure 5. Flexible Adaptation Pathways



Process Evolution. As NASA's process to manage climate risks matures, the Agency has recognized the importance of a balance between leadership-directed (top-down) and grass-roots (bottom-up) approaches. Consistent with external research (**Figure 6**), NASA leadership brings focus to emerging concerns such as a changing climate, while local participation can more fully identify vulnerabilities, vet the viability of potential adaptation approaches and incorporate sustainability principles into its adaptation strategies. In 2009, NASA's first Climate Risks Adaptation workshop was a top-down, Agency-wide starting-point. While leadership continues its policy coordination and resourcing roles, subsequent climate risks adaptation efforts have been site-specific, locally-led initiatives.

Figure 6. Top-down and Bottom-up Elements of Managing Climate Risks



V.3 Interagency Contributions and Partnerships

NASA contributes to and partners with many to advance to scientific understanding, share knowledge, and work collaboratively; some examples follow.

Through NASA partnerships with other agencies that maintain forecast and decision support systems, such as the National Oceanic and Atmospheric Administration (NOAA), United States Geological Survey (USGS), and Environmental Protection Agency (EPA), NASA improves the national capabilities to predict climate, weather, and natural hazards, manage resources and develop environmental policy. NASA's Earth science activities are an essential part of national and international efforts to understand global change and use Earth observations and scientific understanding in service to society.[17]

In addition to global efforts, NASA's scientists will continue making important contributions to earth science research and assessments, including the National Climate Assessment and Intergovernmental Panel on Climate Change efforts, as well as several of the working groups developed under EO 13653.

NASA will also continue to support the *Interagency Forum on Climate Change Impacts & Adaptation*, a knowledge network, which it founded and leads together with co-chairs from the U.S. Global Change Research Program and the U.S. Department of Interior. Sharing knowledge about the best available climate science and management practices, the Forum has included over 100 presentations over seven years, linking people from numerous federal agencies with common interests and spurring common efforts and activities.[18]

Outreach Material for Community-Wide Adaptation process

Illustrative of NASA's desire to share and refine its adaptation process, it partnered with key partners in

the Washington, DC area to sponsor a community-wide adaptation process. More than 30 agencies participated in a series of workshops and webinars in fall 2013 and spring 2014 focusing on built, natural, and workforce and community systems in light of a changing climate. The main webpage for this effort is: http://www.mwcog.org/environment/climate/resilience.asp.

V.4 Measuring Progress

The Council on Environmental Quality has encouraged organizations to consider a phased approach and use metrics performance to measure their accomplishments.[19] NASA is currently applying - at the Headquarters level - an existing voluntary standard – National Indicator (NI) 188, which focuses on processes rather than outcomes (**Figure 7**).[20] NASA modified the color-coded progress icons to reflect the iterative nature of climate risk characterization and adaptation: white is "Not Started," yellow is "Initiated," green is "In Progress," and a new icon – blue – is "Mature or Completed."

Figure 7. Measuring Progress to Adaptation from NASA Headquarters Perspective (A Phased Approach)

		2012	2013	2014
LEVEL 1: Getting Started				
	1.1 Initial Planning			
	1.2 Engage Stakeholders, Community & Key Partners			
	1.3 Scoping Resources			
	1.4 Baseline Identification			
	1.5 Develop Strategic Vision			
LEVEL 2: Public Commitment & Impacts Assessment				
	2.1 Leadership & Commitment to Public			
	2.2 Understand Current Vulnerability			
	2.3 Identify Significant Potential Impacts from Future Weather & Climate			
	2.4 Ongoing Project Planning			
	2.5 Monitoring Future Impacts			
LEVEL 3: Comprehensive Risk Assessment				
	3.1 Comprehensive Potential Impacts Assessment			
	3.2 Risk-Based Priorities			
	3.3 Identify Priority Adaptation Actions			
	3.4 Implement Priority Actions			
	3.5 Integrate Local Stakeholders & Partners			
	3.6 Monitor New Mission Aspects			
	3.7 Monitor Adaptation Measures			
LEVEL 4: Comprehensive Action Plan				
	4.1 Develop Adaptation Action Plan			
	4.2 Embed Climate Risks into Decision Making			
	4.3 Implement Adaptation Responses			
	4.4 Support Stakeholders & Partners			
LEVEL 5: Implementation, Monitoring & Continuous Review				
	5.1 Monitor Implementation Plan			
	5.2 Monitor Performance of Actions			
	5.3 Review & Update Plan			

KEY	
	= Not started
	= Initiated
	= In Progress
	= Mature or Completed

V.5 NASA Greenhouse Gas (GHG) Emission Reduction Targets and Performance

As required by NASA's chosen voluntary risk disclosure format, NASA includes its targets to reduce GHG emissions and an analysis of performance against those targets. NASA recognizes that participating in national and international efforts to reduce GHG emissions and adapting to projected local circumstances are both important.

Goal 1 of NASA's Strategic Sustainability Performance Plan (SSPP) is devoted to its GHG emission reduction targets and performance against those targets.[21] NASA is on target to meet its GHG emission reduction targets in FY 2020. In FY 2013, from baselines established for FY 2008, NASA reductions are as follows:

- Scope 1 and 2 GHG emissions. Tracking with required energy reductions, NASA **achieved 16.3% reductions versus an FY 2020 target of 18.3%.**
- Scope 3 GHG emissions. Including Scope 3 renewable energy project hosting credits, NASA **achieved 17.9% reductions versus an FY 2020 target of 12.6%.**

NASA GHG emission reduction targets reflect: identified reductions in energy use and intensity; reduced use of fossil fuels and increased use of alternative fuels in fleet vehicles; increased application of green building technologies and sustainable design; and innovative energy technologies and funding strategies which promote conservation and renewable energy use. NASA hosts a third-party operated renewable energy project at a Center for which NASA earned "Scope 3 percentage points" so that its overall Scope 3 reduction is actually 24.4%. (NASA retains neither the renewable energy produced nor the associated renewable energy credits (RECs)).

VI. Future Outlook

This portion of the Climate Risk Management Plan provides an opportunity for an organization to include information about "trends and factors related to climate change that are likely to affect management's view of the organization's strategy or the timescales over which achievement of the strategy is typically planned."[22]

CDSB 4.14 Disclosures shall include information about the future outlook, long-term and short-term, including trends and factors related to climate change that are likely to affect management's view of the organization's strategy or the timescales over which achievement of the strategy is typically planned.

NASA has identified several trends or factors that may affect its climate risk identification and adaptation strategies:

- Supply chain
- Strategic assets and capabilities risk assessment
- Greater intra-Agency collaboration

Supply chain. It's been long recognized, from a business management perspective, that an organization's supply chain can pose a business risk.[23] This was further emphasized in Executive Order 13653. Supply chain risk is of particular concern because much of NASA's annual budget is spent via acquisitions of material and labor conducted away from NASA worksites. Part of the supply chain, key minerals necessary for the production of essential materials for aerospace structures, mechanisms, and electronics may become unavailable if climate change exacerbates social disruption in source countries. NASA will continue analysis in this area in concert with existing processes.

Strategic assets and capabilities risk assessment. NASA will commence a risk assessment in FY 2014 focused on NASA's strategic assets and capabilities in the Civil Space Sector. Leveraging previous and ongoing efforts, the vulnerability analysis is expected to identify how existing encroachment risks may be exacerbated by future climatic conditions and may include networked or correlated impacts. The assessment results are intended to help prioritize future Agency decisions and actions required to mitigate or adapt to those identified risks that may impact NASA's ability to accomplish its mission, operations, and programs. The assessment will also aid in identifying existing policies and guidance that hinder preparedness, adaptation and resilience planning within the Agency. The assessment will also

help identify gaps in existing policies and programs which might hinder the Agency as it moves forward with executing its mission and the intent of EO 13653.

Greater intra-Agency collaboration. NASA recognizes that, as with many Agencies or organizations, its efforts have resided primarily within the infrastructure, operations and maintenance, and environmental departments and that integration should go beyond those policies and procedures. Cross-Center collaboration is good and we wish to make it better. More inclusion of the NASA Mission Directorates will strengthen NASA's ability to carefully assess priorities for funding to balance climate adaptation and mission so that it can realistically request the needed funds to address adaptation critical to mission success.

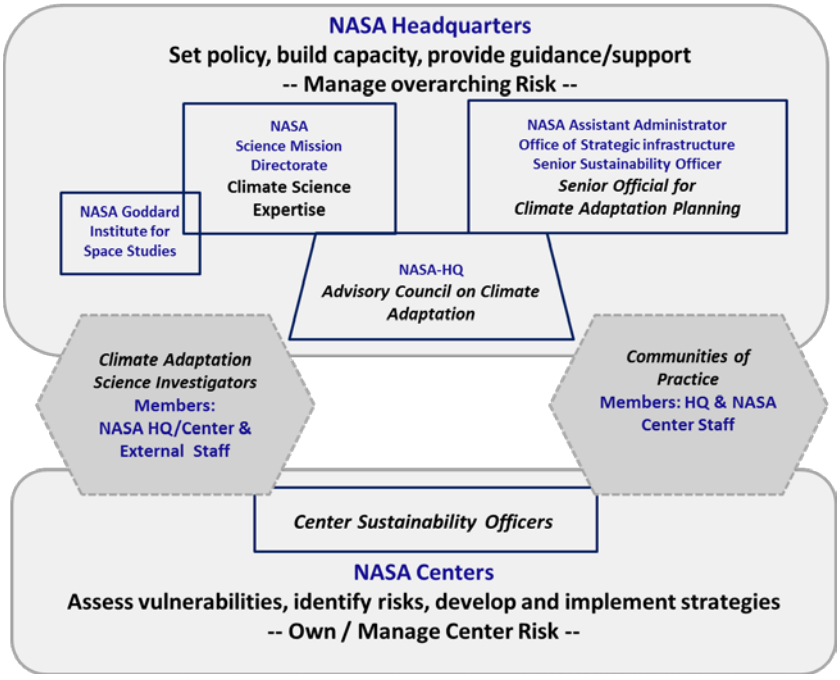
NASA's decentralized organization means that adaptation is the responsibility of Center and worksite management. While this strengthens the Agency's ability to draw on local and operational expertise and capitalize on local opportunities, it also means that good ideas at one location can be overlooked elsewhere. In response, NASA Headquarters recognizes a special need to foster routine, collaborative communication across the communities of practice Agency-wide. Virtual and face-to-face interactions among sustainability officers and other institutional stewardship networks is a continuing avenue to address this need, and NASA intends to maintain a considerable focus on adaptation across these networks in years to come.

VII. Governance

CDSB 4.16 Disclosures shall describe the governance processes and organizational resources that have been assigned to the identification, management and governing body oversight of climate change-related issues.

As described in Section V.1, central to NASA's climate change management strategy is the premise that *every Center is required to manage risk,*[24] including those associated with climate change. Centers are responsible for assessing their vulnerabilities, identifying risks, and developing and implementing adaptation strategies endorsed by Center or HQ leadership. *NASA Headquarters manages the overarching risks*[25], sets policy, builds capacity at the Centers, and provides guidance and support. NASA organizes its climate risk management as illustrated in **Figure 8**; each organization or individual is described in the accompanying narrative.

Figure 8. NASA Governance: Climate Risk Management & Adaptation



VII.1 Senior NASA Official for Climate Change Adaptation Planning

The Senior NASA Official for Climate Change Adaptation Planning is the Assistant Administrator, Office of Strategic Infrastructure. This official is responsible for developing, reviewing and updating NASA's Climate Risk Management Plan and implementing the required climate change adaptation planning actions. Additionally, the official has the authority to manage, oversee and report on NASA's implementation of climate change adaptation planning to NASA's Administrator and the Council on Environmental Quality and coordinate with and distribute NASA's Climate Risk Management Plan to the Center Sustainability Officers and others within the Agency. This official is also the Agency's Senior Sustainability Officer.

Based on workshop feedback and key lessons learned from other Agencies and organizations, the Office of Strategic Infrastructure has already made policy changes to ensure appropriate consideration for climate change adaptation in future master planning efforts, construction of facilities projects, energy projects, environmental management systems, and permitting.

VII.2 NASA Science Mission Directorate

The NASA Science Mission Directorate, and especially its Earth Science Division, supports basic and applied research on the Earth system and its processes. Primary efforts are to characterize, understand, and improve predictions of the Earth system, including climate change. The Earth Science Division pursues the application of its climate data, new scientific knowledge, and predictive capabilities to aid in planning and management actions. NASA participates actively in the Interagency Climate Change Adaptation Task Force, with NASA scientists and applications specialists on the Task Force, as well as on three of the Workgroups. NASA's Earth Science Division personnel were also actively involved and led efforts to produce the Third National Climate Assessment report through the Interagency National Climate Assessment Task Force, a group chartered under the U.S. Global Change Research Program, and the Intergovernmental Panel on Climate Change.

VII.3 NASA Headquarters Advisory Council on Climate Adaptation

The Advisory Council on Climate Adaptation supports the Senior NASA Official in implementing efforts and activities. The Advisory Council comprises members from NASA's Office of Strategic Infrastructure and NASA's Science Mission Directorate. The Advisory Council's work teams are responsible for drafting proposed Agency policy and direction, and implementing the day-to-day NASA Headquarters efforts and activities related to climate adaptation.

VII.4 NASA Center Sustainability Officers

In addition to most serving as their Center's Director of Operations, NASA's Center Sustainability Officers provide leadership and direction for implementation and coordination of sustainability and climate adaptation activities, establish Center level targets, and monitor their performance and progress. They are part of the Center team responsible for assessing their vulnerabilities, identifying risks, and developing and implementing adaptation strategies endorsed by Center or HQ leadership. Quarterly video-teleconferences enable the Center Sustainability Officers to share successes and lessons learned with each other and NASA's Senior Sustainability Officer.

VII.5 Goddard Institute for Space Studies Climate Scientists

NASA's Goddard Institute for Space Studies climate scientists provide NASA-wide advice to the Senior NASA Climate Official and are responsible for coordinating the efforts and activities of NASA's Climate Adaptation Science Investigators Working Group. GISS climate scientists are instrumental in providing computational climate modeling and downscaling information usable at the Center level.

VII.6 Climate Adaptation Science Investigators Workgroup

Established in 2010, NASA's Climate Adaptation Science Investigator (CASI) Workgroup consists of NASA scientists and applications developers (along with additional experts from academia, the private sector,

and non-governmental organizations) who research climate vulnerability at NASA Centers and develop the scientific and technical basis for adaptation. CASI has thus far initiated: 1) local workshops to introduce and improve planning for climate risks, 2) analysis of climate data and projections tailored to each Center, 3) climate impact and adaptation toolsets, and 4) Center-specific research and engagement. Team members utilize NASA products to understand the Earth's climate system, variability and change, and impacts. Through CASI, NASA scientists not only put these products to use, but also learn how their products impact decision-making, which feeds back on their research. From the workgroup, NASA's managers have immediate access to climate and impacts science relevant to their Centers and regions, facilitating the adaptation process across the institution.

VII.7 Communities of Practice

Well-established communities of practice exist and include energy, water, transportation, recycling and sustainable acquisition, design and construction, maintenance and operations, master planning, climate change adaptation, and electronic stewardship. These groups represent a wealth of cross-Agency knowledge and experience as they comprise Headquarter and Center staff, meet at appropriate time intervals, and tackle new issues. Many of these staff collaborate with CASI members and provide valuable input on the practical aspects of adaptation implementation.

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[1] Climate Disclosure Standards Board's (CDSB) "Climate Change Reporting Framework – Edition 1.0," September 2010, http://www.cdsb.net/climate-change-reporting-framework/. This is a voluntary standard. The use of this voluntary standard is consistent with OMB Circular A-119 "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities." NASA's use of this standard is proactive and is consistent with the action by the U.S. Securities and Exchange Commission (see the "Commission Guidance Regarding Disclosure Related to Climate Change;" 17 CFR Parts 211, 231 and 241; (8 February 2010)). Other indications of this climate risk disclosure trend are the American Institute of Certified Public Accountants' (AICPA) (9 December 2009) press release "AICPA and World Accounting Bodies Call for Single Standard for Climate Change Reporting," and the Industrial Economics, Inc. (28 April 2008) report for the U.S. Environmental Protection Agency titled "Preliminary Summary of Financial Accounting Standards for Environmental liabilities, Intangible Assets and Climate Change Risk." Annex 3 summarizes the Standard.

[2] National Aeronautics and Space Act of 2010, 51 USC Sec. 20101 et seq (http://www.nasa.gov/offices/ogc/about/space_act1.html)

[3] National Space Policy of the United States of America (http://www.whitehouse.gov/sites/default/files/national_space_policy_6-28-10.pdf)

[4] National Security Presidential Directive (NSPD) #40: U.S. Space Transportation Policy (http://www.fas.org/irp/offdocs/nspd/nspd-40.pdf)

[5] 2014 NASA Strategic Plan http://www.nasa.gov/sites/default/files/files/FY2014_NASA_SP_508c.pdf

[6] The National Strategy for Global Supply Chain Security, released in January 2012, established the U.S. Government's policy to strengthen the global supply chain to protect the interests of the American people and enhance our Nation's economic prosperity (http://www.whitehouse.gov/sites/default/files/national_strategy_for_global_supply_chain_security.pdf). One-Year Update on the Implementation of the National Strategy for Global Supply Chain Security (http://www.whitehouse.gov/sites/default/files/docs/national_strategy_for_global_supply_chain_security_implementation_update_public_version_final2-26-131.pdf)

[7] Presidential Directive – PPD 21 – on Critical Infrastructure Security and Resilience, http://www.fas.org/irp/offdocs/ppd/ppd-21.pdf

[8] National Security Space Strategy - http://www.defense.gov/home/features/2011/0111_nsss/docs/NationalSecuritySpaceStrategyUnclassifiedSummary_Jan2011.pdf

[9] Results from NASA-wide Climate Change Impacts & Adaptation Workshop at Kennedy Space Center, July 2009.

[10] National Research Council (2010) Adapting to the Impacts of Climate Change, at page 124.

[11] NPR 8000.4A. page 4 –"Center Directors are responsible for management of institutional risks at their respective Centers. Headquarters Mission Support Offices are responsible for management of Agency-wide institutional risks."

[12] Ibid.

[13] NASA Procedural Requirement (NPR) 8000.4A "Agency Risk Management Procedural Requirements". Figure 5 within the NPR is illustrative of the coordination of RIDM and CRM within the NASA Hierarchy.

[14] NASA's Enterprise Risk Management Framework is part of NASA's "Internal Control" (NASA Policy Directive (NPD) 1200.1E "NASA Internal Control") required by the Government Accountability Office (GAO) (See GAO (1999) "Standards of Internal Control in the Federal Government" ("Green Book"); and GAO (August 2001) Internal Control Management and Evaluation Tool (GAO-01-1008G)) and the Office of Management and Budget (OMB) (OMB Cir A-123 "Management's Responsibility for Internal Control.") The Agency uses its Enterprise Risk Management Framework (referred to as the "Active Risk Manager" or ARM) to manage risks.

[15] Process based on methodologies successfully implemented by New York City planners. The New York City Panel on Climate Change (NPCC), co-chaired by Cynthia Rosenzweig, Ph.D., leader of the Climate Impacts Research Group at NASA's Goddard Institute for Space Studies (GISS), developed and tested adaptation planning tools and methodologies to help varied stakeholders identify climate vulnerabilities and generate strategies for building resilience. The NPCC was convened by Mayor Bloomberg to help "develop a framework and tools to assist the City create a risk-based response to climate change that is grounded in state-of-the-art science information (Remarks by Mayor Bloomberg in Forward to *Climate Change Adaptation in New York City; Building a Risk Management Response*, page 1.")

[16] Flexible adaptation pathways. Image from: New York Panel on Climate Change. 2010. Climate Change Adaptation in New York City: Building a Risk Management Response. C. Rosenzweig & W. Solecki, Eds. Prepared for use by New York City Climate Change Adaptation Task Force. Annals of the New York Academy of Sciences. 2010. New York, NY 354 pp. (See page 30; adapted from City of London, "The Thames Estuary 2010 Plan." April 2009.)

[17] The full breadth of NASA's science efforts can be found in the NASA 2014 Science Plan (http://science.nasa.gov/media/medialibrary/2014/05/02/2014_Science_Plan-0501_tagged.pdf) and at http://science.nasa.gov.

[18] More information about the *Interagency Forum on Climate Change Impacts & Adaptation* can be found at https://www.fedcenter.gov/programs/greenhouse/ccforum/

[19] As expressed in Section D. of the "Federal Framework for Climate Change Adaptation Planning," in CEQ's "Support Document," Implementing Instructions for Federal Agency Adaptation Planning, Support Document - http://www.whitehouse.gov/sites/default/files/microsites/ceq/adaptation_support_document_3_3.pdf

[20] National Indicator (NI) 188 is about 'planning to adapt to climate change.' The indicator is a key driver for local action on adaptation. It measures progress on assessing and managing climate risks and opportunities, and incorporating appropriate action into local authority and partners' strategic planning. The indicator is 'process-based' rather than outcome focused to recognize that adaptation is an emerging field. Progress on this target is measured via a self assessment with each local authority reporting a level of preparedness they have reached from level 0 to level 4." http://www.yourclimate.org/pages/ni-188-guidance

[21] http://www.nasa.gov/agency/sustainability

[22] "Climate Change Reporting Framework – Edition 1.0," pg 21, September 2010. http://www.cdsb.net/climate-change-reporting-framework/

[23] R A Kerr (25 November 2011) "Humans are Driving Extreme Weather, Time to Prepare," in Science

[24] NPR 8000.4A. page 4 – "Center Directors are responsible for management of institutional risks at their respective Centers. Headquarters Mission Support Offices are responsible for management of Agency-wide institutional risks."

[25] Ibid.