U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE AND TECHNOLOGY
SUBCOMMITTEE ON SPACE AND AERONAUTICS

HEARING CHARTER

NASA's Earth Science and Applications Programs:
Fiscal Year 2008 Budget Request and Issues

Thursday, June 28, 2007
10:00a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose:

On Thursday, June 28, 2007 at 10:00 am, the House Committee on Science and Technology's Subcommittee on Space and Aeronautics will hold a hearing to examine the National Aeronautics and Space Administration's (NASA) Fiscal Year 2008 budget request and plans for the Earth science and applications programs, and issues related to the programs.

Witnesses:
Witnesses scheduled to testify at the hearing include the following:

Dr. Michael H. Freilich
Director, Earth Science Division,
Science Mission Directorate, NASA

Dr. Richard A. Anthes
President, Universities Corporation for Atmospheric Research

Dr. Eric J. Barron
Dean, Jackson School of Geosciences, The University of Texas, Austin

Dr. Timothy W. Foresman
President, International Center for Remote Sensing Education

Potential Issues

The following are some of the potential issues that might be raised at the hearing:

What is the future direction of NASA's Earth Science program?

- *The authors of the recently released National Academies' report, Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond (the "decadal survey") found that "The NASA/NOAA Earth Observation Satellite system, launched at the turn of the millennium, is aging and the existing plan for the future is entirely inadequate to meet the coming challenges." (Attachment 1) Over the last two years, for example, several missions or instruments that were planned to study the climate, weather, precipitation, and land cover changes have been descoped, delayed, on the brink of cancellation, or canceled. Examples of these decisions are listed below and in Attachment 2.*
    - *Deep Space Climate Observatory (decision not to launch)*
    - *Hydros mission to measure soil moisture (canceled)*
    - *Global Precipitation Mission (delayed)*
    - *National Polar-orbiting Operational Enviromental Satellite System (NPOESS) (descoped and delayed)*
    - *Glory (delayed)*
    - *Landsat Data Continuity Mission (changing acquisition approaches, possible data gaps)*

  The authoring committee recommended a set of observing systems and supporting research and technology elements needed to meet the high priority Earth science and socioeconomic challenges that face our planet over the next decade. The committee estimated that returning to the FY 2000 budget level for NASA's Earth science and applications program—approximately $2 billion per year—would be sufficient for building the recommended program. (Attachment 3) The President's FY 2008 budget request for NASA's Earth science and applications program and the projections through FY 2012, however, do not include resources for initiating the future missions or research activities recommended in the decadal survey. What is NASA's plan for implementing the Earth sciences decadal survey and what is the timeline? What future direction will NASA's Earth science and applications program take given the available resources? Which of the decadal survey priorities will be addressed and what observations will be made?

How Important Are Observations from NASA's Earth Science Missions to the Nation's and the World's Overall Climate Research Efforts?

- *The recent release of the Fourth Assessment Report of the International Panel on Climate Change (IPCC) Working Group I found that the climate is warming and the catalysts for that warming are due, in part, to human contributions of greenhouse gases to the Earth's atmosphere. To what extent did data from NASA Earth observing satellites contribute to the IPCC assessment and which missions recommended in the Earth science decadal survey can help reduce uncertainties mentioned in the report? At the national level, an "Overview of U.S. Research in Climate and Global Change," noted that "The USGCRP* [U.S. Global Change Research Program] *and* <u>*Climate Change Research Initiative*</u> *(CCRI) will place major emphasis on requirements-driven specification of comprehensive observing systems…." The attributes of those systems would include:*
    - *"Development of new observing capabilities to illuminate Earth system processes and increase spatial, temporal, or spectral resolution where needed to reduce key uncertainties in climate change and address emerging Earth science questions….*
    - *Special emphasis on the complex observations and monitoring systems needed to analyze terrestrial and aquatic ecosystem variability."*

  Are NASA's plans for Earth Science and Applications consistent with the goals set out in the U.S. Global Change Research Program and Climate Change Research Initiative? How important are NASA's Earth observation satellites to the nation's and the world's climate research efforts? What percentage of the world's space-based climate monitoring is performed by NASA's Earth observing sensors? What percentage of the nation's and the world expenditures on climate research does NASA's contribution represent? What is the potential impact on plans and policies for adapting to climate change if new observing systems are not developed?

- ***Leadership in Future Earth Sciences and Applications Activities***
  According to the decadal survey, "Sustained multi-decadal, global measurements and data management of quantities that are key to understanding the state of the climate and the changes taking place are crucial." Sustaining multi-decadal measurements requires commitment and leadership, as noted by the survey's call for the U.S. government to

restore leadership in Earth sciences and applications. In a recent interview on National Public Radio's (NPR) Morning Edition program, the NASA Administrator said, "I have no doubt that…a trend of global warming exists. I am not sure that it is fair to say that it is a problem we must wrestle with." NASA's own scientists use NASA Earth observation data to research Earth's climate. Dr. Griffin has since apologized for his remarks on NPR to employees at the Jet Propulsion Laboratory, yet his statements are leading some people to question NASA's commitment to leadership in climate monitoring and Earth science. How committed are the agency and the nation to ensuring U.S. leadership in Earth sciences and applications? To what degree will leaders commit to multi-decadal, global measurements of the Earth system?

How Well Balanced is the NASA Earth Sciences Program?

- *The National Academies' decadal survey emphasized that NASA's Earth science and applications program must be balanced across scientific disciplines within Earth system science; across mission sizes (small, medium, and large); technology maturity; and between observations and analysis, modeling, and applications. Does NASA agree with this definition of balance? How well is NASA's current Earth science and applications program balanced according to these elements? What performance measures might be used to assess balance within and among NASA's Earth science program elements?*
    - *<u>Importance of the Grants Program (Research and Analysis)</u> The decadal survey raises concern about reductions in the research and analysis accounts (grants for interpreting data, developing new concepts for algorithms, models, technology, and missions, and for training graduate students) and emphasizes the need for a strong R&A program to support the ongoing and planned missions. According to a 2006 National Academies report, <u>An Assessment of Balance in NASA's Science Programs</u>, "The most serious impacts on the long-term strategy and capacity-building efforts in Earth science will result from the severe cuts in the R&A program. Although the proposed R&A cuts across NASA are approximately 15 percent, the cuts for FY 2007 appear to be closer to 20 percent in key elements of the Earth sciences." In a constrained resource environment, are there elements of a balanced program, such as R&A, that should be protected beyond others? If so, what are they? What is the appropriate mechanism for assessing balance and making adjustments as needed? What*

threshold of R&A resources is required to ensure a healthy program? Are there measures to assess the effectiveness of investments in R&A?

What is NASA Doing to Better Utilize Earth Science Research Data to Address Societal Needs?

- *The National Academies Earth science decadal survey stresses the importance of "advances in fundamental understanding of the Earth system and increased application of this understanding to serve the nation and the people of the world." NASA's Earth science applications program supports competitively selected proposals to apply NASA Earth science research results, technologies, and data to high priority societal needs. Those priorities include agricultural efficiency, coastal management, energy management, air quality, and public health among other application areas. The applications program focuses on developing federal decision support tools. Is NASA's application program structured to address the decadal survey's recommendations on applications for societal benefit? What, if any, changes to NASA's applications program are needed to make NASA's Earth science information more responsive to societal needs?*
    - *<u>NASA Authorization Act and Earth Science Applications.</u> Section 313 of The NASA Authorization Act of 2005 directs NASA to "establish a program of grants for competitively awarded pilot projects to explore the integrated use of sources of remote sensing and other geospatial information to address State, local, regional, and tribal agency needs." NASA's response to Section 313, so far, has been to note in its grant solicitations that the applications program supports organizations with connections to State, local, regional, and tribal constituencies. Does this step represent any change to grant solicitations prior to the Authorization Act? Is NASA's response sufficient to address the Section 313 directive? How many grants does NASA issue that directly address State, local, regional and tribal needs? To what extent do national decision support systems serve as pilot projects to address State, local, regional, and tribal agency needs?"*
    - *<u>Commercial Initiatives in Using Earth Observation Data.</u> Google Earth and Microsoft Virtual Earth are making Earth observation data available over the Internet at no cost to users. What impacts are these initiatives having on the use of NASA-provided Earth*

observations data for applications? What is NASA's relationship to these commercial enterprises?

What is the Fate of the Climate Instruments That Were Removed From NPOESS?

- *When the NPOESS program was certified under Nunn McCurdy, a number of climate sensors were removed from the system and the coverage and/or capability of some sensors was reduced. Following the Nunn McCurdy certification, OSTP requested that NASA and NOAA assess the impacts of the demanifested climate sensors on NASA's and NOAA's climate objectives. OSTP also asked the agencies to propose options for mitigating the impacts. At a recent meeting at the National Academies Panel on Options to Ensure the Climate Record from the NPOESS and GOES-R Spacecraft, NASA and NOAA described several possible mitigation strategies including returning some of the lost climate sensors to NPOESS satellites; placing climate sensors on other (non-NPOESS) planned Earth science platforms; developing free-flyer platforms to fly the sensors; or partnering with other U.S. agencies to fly sensors or obtain the data. NASA and NOAA have asked the National Academies to provide further input on options to mitigate the impact of the lost sensors. NASA and NOAA are developing a set of near-term actions and cost estimates to inform OMB and OSTP for the FY 2009 budget process. What are the implications of potential data gaps on U.S. climate research and monitoring? What contribution can the missions recommended in the Earth science decadal survey make to minimizing potential data gaps? To what extent will the reduced capability/ coverage of the sensors being retained in the NPOESS program compromise the measurements needed for climate research and monitoring? How well do the possible mitigation strategies address the required accuracy for climate research measurements? When will funding decisions be needed to accommodate development of satellites and sensors on a schedule that avoids potential data gaps?*

What Is NASA's Plan for Transitioning Research Data and Instruments into Operational Services?

- *NASA research satellites often provide vital data for ongoing, operational services such as weather prediction and disaster warnings. For example, data from the NASA QuikSCAT satellite, which measures ocean wind speed and direction, is being used at NOAA's National Hurricane Center to help determine a hurricane's path. In a May 8,*

2007 letter to NASA Administrator Michael Griffin and NOAA Undersecretary Vice Admiral Conrad Lautenbacher, Jr., Representative Nick Lampson voiced concerns about the lack of planning for a successor to QuikSCAT, which has started its ninth year of operation and is six years beyond its designed lifetime. Without QuikSCAT data, hurricane predictions and evacuation plans would be less accurate. The QuikSCAT example points to the larger challenge, as noted by Rep. Lampson, for NASA and NOAA to "systematically evaluate the technology and capabilities from NASA's Earth-observing missions for application to NOAA's operational responsibilities." What are NASA's and NOAA's plans for a follow-on to QuikSCAT and what is the status of those plans?

- *Congressional Legislation Section 306 of The NASA Authorization Act of 2005 directed NASA and NOAA to establish a joint working group and report on coordination between the agencies on Earth science missions and their potential for transition into operational service. In addition, the Earth science decadal survey states that "The committee is particularly concerned with the lack of clear agency responsibility for sustained research programs and the transitioning of proof-of-concept measurements into sustained measurement systems." To date, NASA and NOAA have not established a plan for transitioning research into operations, and Congress continues to await NASA and NOAA's response to the Authorization Act's directive. What is NASA's and NOAA's plan for transitioning from research to operations? As NASA considers moving forward with missions recommended in the decadal survey, how and when will decisions on research to operations be made?*

What role should international partners play in NASA's future Earth science system?

- *NASA has a long history of using international and bilateral cooperation on Earth science missions. NASA's Upper Atmosphere Research Satellite launched in 1991 included instruments from the United Kingdom and from a French-Canadian team. U.S.-French collaboration on the Topex/Poseidon and follow-on Jason satellites to measure sea surface height and the U.S.-Japanese collaboration on the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Mission (GPM) that is currently in development are examples of bilateral cooperation. The decadal survey discusses international cooperation as a means for realizing the missions recommended in the report. In a hearing of the House Subcommittee on Space and Aeronautics held on*

May 2, Dr. Alan Stern, Associate Administrator for NASA's Science Mission Directorate, testified that he plans to "make strong progress advancing all four decadal surveys…by increasing our international collaboration efforts." Dr. Stern also testified that NASA is considering international arrangements in which the agency "would collaborate at higher, more strategic level." What, in specific terms, do Dr. Stern's proposals mean for future NASA Earth science missions? What steps has NASA taken to explore potential international arrangements on future Earth science missions? What are the opportunities and risks for working with international partners to advance the missions recommended in the decadal survey? Are there mission areas, technology areas, or measurements and observations that the U.S. should carry out on a unilateral basis to maintain leadership?

What are NASA's Near and Long-term Plans for Sustaining Land Cover Observations?

- *NASA's Landsat system has collected land cover data for over thirty years. These data are used by U.S. government, scientific, State and local governments, non-profit organizations, and international entities to study land use and change. The currently operating Landsat 7 satellite has lost 25 percent of its imaging capability, according to NASA officials. Landsat 7 is expected to cease useful operation by 2010 at which point NASA anticipates a 6-12 month gap in the collection of Landsat data until the follow-on satellite, the Landsat Data Continuity Mission (LDCM), enters service in 2011. NASA is involved in a Data Gap Study Team to assess "alternatives to at least partially offset the data gap." NASA is investigating whether data from international satellites, including an Indian satellite and a Chinese/Brazilian land observing system could help address the data gap.*
    - *<u>Instability in the Landsat Program</u> Since 1999, NASA has shifted its procurement approach for LCDM three times. Approaches have included a public-private partnership, placement on the NPOESS platform, and finally the current plan for a free-flying mission to be developed and launched by NASA and operated by USGS. These procurement struggles echo a longer history of difficulties in maintaining the program. What is the current status of LDCM? Will LDCM provide data that is comparable to or better than Landsat 7? How likely is a data gap prior to the LDCM availability? What lessons from the Landsat experience can*

be applied to plans for future long-term observation systems, such as those being considered for climate monitoring?

- *<u>LDCM and Thermal Imaging Capability</u> LDCM includes one instrument, the Operational Land Imager (OLI). According to NASA officials, this instrument will not image in thermal bands, a capability that has been provided on the last 3 Landsat spacecraft. The data collected in the thermal bands provide information to assist in the management of water resources, in particular agricultural water uses. Adding thermal imaging capability to LDCM will increase the mission cost and delay the schedule. Is NASA considering alternatives to LDCM for providing thermal image data?*
- *<u>LDCM as a Possible Platform for a Climate Sensor</u> NASA officials have also indicated that LDCM is being considered as a potential platform on which to fly a Total Solar Irradiance Sensor (TSIS)---one of the climate sensors demanifested from the NPOESS system. When will a decision on adding a sensor to LDCM be made? How would adding the TSIS sensor affect the cost and schedule of the LDCM mission, including the length of the gap in land cover data?*
- *<u>Policy for Maintaining the Long-Term Land Cover Record</u> The Office of Science and Technology Policy (OSTP) is preparing a long-term plan for acquiring moderate resolution, space-based land observation data following the launch of LDCM in 2011. The Landsat Policy Act of 1992 seeks to ensure the continuity of Landsat data. What is the status of OSTP's development of a long-term plan for moderate resolution land imagery? What would an operational program mean, in specific terms, for the U.S.? What role would NASA have in an operational land observing program? What responses do the science and user communities have to the goal of an operational Landsat system?*

Is a National Strategy for Earth Monitoring Across Relevant Agencies Needed?

- *NASA has the largest program in the U.S. government for observing the Earth and supporting research to understand the Earth system. Other agencies such as NOAA and the Department of the Interior's U.S. Geological Survey (USGS) also monitor the Earth system and fund Earth science research. How does NASA coordinate with NOAA, USGS, and other federal agencies on Earth observations? Has coordination among*

NASA, NOAA, and USGS been successful, and if not, why not? Should the U.S. consider a "National Earth-Information Initiative," as proposed by former Presidential Science Advisor, Neal Lane, and others "to reevaluate the national process of collecting and using civil Earth information, including the effectiveness of governmental organizations, the relationship between government functions and private sector activities, and the ability to effectively connect scientific developments to societal uses"? The authors recommend that a blue ribbon panel be created to consider improvements to the nation's process of collecting and using Earth information. What are the pros and cons of such as proposal? What approach have other nations and regions, such as Europe, Japan, and China taken to exploit Earth information? How important is a potential Earth information strategy to U.S. national competitiveness?

BACKGROUND

Fiscal Year 2008 Budget Request

The President's Fiscal Year 2008 budget request includes $1.497 billion for NASA's Earth science and applications programs, an increase of 2 percent over the Fiscal Year 2007 budget request. In the FY 2008 request, increases over the President's FY 2007 budget estimate for FY 2008 were required on several missions as a result of schedule delays and cost overruns. Those missions include the Global Precipitation Measurement (GPM), Glory, Landsat Data Continuity Mission (LDCM), NPOESS Preparatory Mission (NPP), and Aquarius mission. In addition, NASA canceled the Hydros mission, which was designed to measure soil moisture, due to the agency's lack of funding to support it. Attachment 4 provides details on the FY 2008 budget request for NASA's Earth sciences and applications programs.

NASA Earth Science Program Elements

- The Earth Science Research Program provides grant support for research and analysis activities (e.g., basic research, modeling, and technology development); research on interdisciplinary science from the Earth observing system; suborbital projects (aircraft and uncrewed aircraft); the use of supercomputers for the development of Earth

science models; and access to supercomputers for users from other agencies.

- The Earth sciences applications program supports competitively selected grants to apply results from NASA Earth science research to societal benefit areas. Specific areas of applications include agricultural efficiency, air quality, aviation, carbon management, coastal management, disaster management, ecological forecasting, energy management, homeland security, invasive species, public health, and water management. The applications program involves two components:

    - **National Applications** matches decision support systems in Federal agencies with information from NASA Earth science research that can benefit from the additional NASA information.
    - **Crosscutting Solutions** supports the National Applications decision support projects by providing systems integration, engineering, and the development of prototypes.

- Earth Science Multi-Mission Operations is dedicated to archiving, preserving, and disseminating Earth science data. The primary data management system for Earth science data is the Earth Observing System Data and Information System (EOSDIS). EOSDIS handles 4 terabytes of incoming data from the Earth observing system (the Aqua, Terra, and Aura satellites) per day and consists of eight Distributed Active Archive Centers (DAACs). The DAACs are located at universities and research facilities across the country and distribute the data to users.

- Earth Systematic Missions include over a dozen Earth science satellites that are collecting data about the Earth and its atmosphere and other missions that are in development. Many of the Earth Systematic Missions enable researchers to study Earth's changes in and effort to improve predictions of climate, weather, and natural hazards. Key missions include:

    - The Global Precipitation Measurement (GPM). GPM is a joint U.S.-Japanese mission to measure precipitation at a frequent rate across the globe and enable correlation of precipitation

measurements. GPM, which consists of two spacecraft, is expected to help improve the prediction of flood hazards and measurements of fresh water resources. GPM spacecraft are planned for launch in 2013 and 2014.

- The Glory mission will study the properties and chemical composition of aerosols and clouds. Data collected from the Glory spacecraft will provide insights into the natural and anthropogenic contributions to climate change. Glory is planned for launch in 2013.

- The Landsat Data Continuity Mission (LDCM) is the follow-on mission to the Landsat 7 satellite. The objective of LDCM is to continue the thirty-year data record of moderate resolution, multispectral land observations, which are used by U.S. government, scientific, State and local governments, and other communities to study land use and change. LDCM is slated for launch in 2011.

- The NPOESS Preparatory Project (NPP) will continue measurements of atmospheric and sea surface temperatures; humidity sounding; land and ocean biological productivity; cloud and aerosol properties that are being collected on NASA Earth observing missions (Terra, Aqua, Aura). NPP is also intended to reduce the risk of sensors being planned for the operational NPOESS system. NPP, which is a joint program with NOAA and the DOD, is slated to launch in 2009. Technical issues related to NPP are:

    - The Visible/Infrared Radiometer Suite (VIIRS) instrument has encountered technical problems that will affect ocean color and aerosol studies. According to a recent *Space News* article on VIIRS, the contractor and NPOESS program officials are evaluating possible solutions to the problem. A science team is analyzing what level of capability is needed from VIIRs to obtain science-quality measurements and whether such a capability can be met.

        - A flight model of the Cross-track Infrared Sounder (CrIS) experienced a failure during a vibration test. The instrument will undergo additional tests.
        - The Ozone Mapping and Profiling Suite (OMPS) Limb sensor was removed from the NPOESS program during Nunn McCurdy. NASA and NOAA have decided to add the OMPS Limb sensor to NPP and to split the costs.

    - The Quick Scatterometer (QuikSCAT) is a satellite launched in 1999 to measure wind speed and direction, factors that hurricane forecasters have come to rely on to "measure the size of a developing storm's wind field, and in some cases to locate its center of circulation," according to a *Space News* article on "Scientists Exploring Options for QuikScat Successor." QuikSCAT measurements contribute to climate change research, for instance, through the study the movements and changes of sea ice and Arctic and Antarctic ice packs. The data are also used to investigate changes in rain forest vegetation. Issues with QuikSCAT are:
        - The lack of a back-up satellite or planned back-up, should QuikSCAT fail.
        - The implications of losing QuikSCAT on the accuracy of hurricane monitoring.

- The Earth System Science Pathfinder (ESSP) Program solicits proposals for scientists to propose small to medium-sized missions that can involve studies of the atmosphere, oceans, land surface, polar ice regions, and solid Earth. Upon selection, scientists are granted the funds to serve as principal investigator of the mission and are responsible for the scientific and technical success of the mission. ESSP missions complement larger missions, but are conducted on shorter timescales.
    - The next solicitation for ESSP proposals is expected in late FY 2008. This represents a gap of approximately 7 years since the last ESSP solicitation in 2001.

- The Education and Outreach program provides support for fellowships and new investigators, as well as K-16 education. The FY 2008 program will focus on the activities of the International Polar Year.

- The Earth Science Technology program includes development of new instruments and measurement techniques, information technologies, and technologies for the Earth science program. NASA's Langley Research Center and Goddard Space Flight Center are focusing on laser development technologies that can be applied to future Earth science missions.

Global Earth Observation System of Systems

NASA is a member of the group overseeing the U.S. contribution to a Global Earth Observation System of Systems (GEOSS). GEOSS is an international effort to share the Earth observation data collected from space, ground, and air observatories by individual nations. By creating a common format for the data and providing a means for integrating and sharing the data, GEOSS will allow for a richer set of data by which to address national and international societal needs and to support scientific research of the Earth system. The U.S. and international members that are working toward GEOSS are focusing on key societal issues that can benefit from the shared and integrated data enabled by GEOSS. Focus areas include improved observations for disaster reduction, a National Integrated Drought Information System; and Air Quality Assessment and Forecast. NASA's Earth science applications program is involved in providing the U.S contribution to the GEOSS societal benefit areas.

Summary of February 13, 2007 Hearing of the Committee on Science and Technology on National Imperatives for Earth and Climate Science Research and Applications Investments Over the Next Decade

The Committee on Science and Technology of the House of Representatives held a hearing on February 13, 2007 to review the results of the National Academies report, *Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond*.

- Dr. Richard Anthes, President, University Corporation for Atmospheric Research and Co-Chair, Committee on Earth Science and Applications From Space, National Research Council, National Academies testified that "at a time when the need has never been greater, we are faced with

an Earth observation program that will dramatically diminish in capability over the next five to ten years." The resulting impacts are likely to include less accurate weather forecasts, uncertainty about the rate of rising sea levels and uncertainty about the intensity of hurricanes, for example. It is critical to measure the imbalance between the radiation the Sun is putting out and what is going out from the Earth and back into space, a factor that is contributing to global warming. Dr. Anthes noted that implementing the missions recommended in the Earth science decadal survey is not just important for reducing the risks of natural hazards, it is important for managing our natural resources, including water, energy, fisheries, and ecosystems more efficiently.

- Dr. Berrien Moore, III, University Distinguished Professor, Director, Institute for the Study of Earth, Oceans, and Space, University of New Hampshire; Co-Chair, Committee on Earth Science and Applications from Space, National Research Council, The National Academies testified that NASA's Earth science budget has decreased by 33 percent in real terms since 2000. Any budget increases that NOAA enjoyed during the same period were diverted to NPOESS, which suffered from technical and managerial problems. The decadal survey "set forth a strategy for a strong, balanced national program in Earth science to reverse this trend." He noted that by using small missions rather than large missions with multiple instruments, the decadal strategy could be implemented for a reasonable investment, in particular, the budget levels provided for Earth science in the year 2000. Dr. Moore testified that the Fiscal Year 2008 budget is not sufficient to enable the implementation of the decadal survey. While it does provide resources to move forward with high priority missions already underway, the FY 2008 budget, "will leave NASA's Earth science with nearly 50 percent less buying power in comparison to the year 2000 and…by 2012 will put us at a 20-year low in real terms for Earth science."
- NOAA's budget is insufficient to address the growth in cost of the NPOESS and GOES-R missions or to restore the losses of climate measurements that were removed from the NPOESS program. He noted that a small investment, $70M, in early technology development for the recommended missions would be a good first step in implementation. Dr. Moore testified that finding the additional funds to move forward should focus on the benefits of Earth observations including increased reliability in infectious disease forecasts, monitoring of crustal

movements and identifying active faults, and improved precipitation and drought forecasts, among other benefits.

- Honorable James Geringer, Director of Policy and Public Sector Strategy, Environmental Systems Research Institute (ESRI) testified that drought can be longer term and more widespread than tornadoes, floods, hurricanes, and earthquakes. He noted that 19 western governors convened to support the use of satellite data to reduce the impact of droughts on the region, and requested funds for the National Integrated Drought Information System. He noted that the decadal survey explored issues including the benefits of Earth science data. Mr. Geringer also discussed the frustration that users experience by the lack of access to and the relevance of remote sensing data to their needs. Mr. Geringer recommended, based on the decadal survey, that the people should have the best possible information to respond to their changing environments, and to protect their lives, livelihood, and property. He also recommended that an Integrated Earth Observation System be provided to ensure U.S. competitiveness. He referred to the activities of the private sector, including Google Earth, Microsoft Virtual Earth, and other tools that use remote sensing imagery and the data provided by commercial space remote sensing companies. He noted that users "want objective, timely, and accurate information." He discussed the need for a system that integrates space, ground, airborne, and ocean-based sensors as well as a web-based network that integrates the information.

ATTACHMENT 1

Earth Observing Instruments (2000-2020)

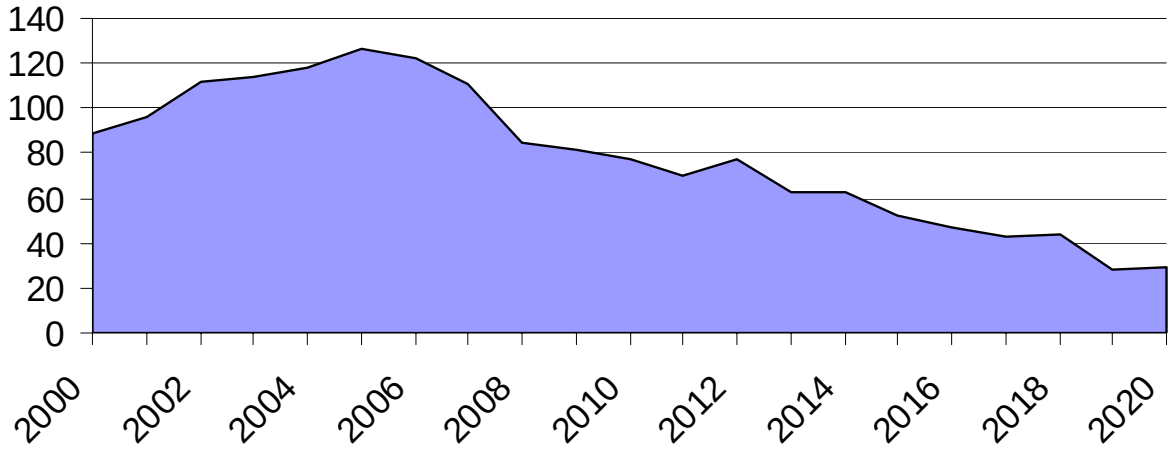

Figure 1. Number of current and planned U.S. space-based Earth Observations instruments, not counting the recommended missions in the Committee's report. For the period from 2007 to 2010, missions were generally assumed to operate for four years past their nominal lifetimes. SOURCE: Information from NASA and NOAA websites for mission durations.

Source: Testimony of Dr. Richard Anthes, at a Hearing of the Committee on Science and Technology, held on February 13, 2007 on National Imperatives for Earth and Climate Science Research and Applications Over the Next Decade.

ATTACHMENT 2

Canceled, Descoped, or Delayed Earth Observation Missions
(from the April 2005 Pre-Publication of the Interim Report of the Decadal Survey on Earth Science and Applications from Space)

Mission	Measurement	Societal Benefit	Status
Global Precipitation Measurement (GPM)	Precipitation	Reduced vulnerability to floods and droughts; improved capability to manage water resources in arid regions; improved forecasts of hurricanes	Delayed
Atmospheric Soundings from Geostationary Orbit (GIFTS—Geostationary Imaging Fourier Transform Spectrometer)	Temperature and water vapor	Protection of life and property through improved weather forecasts and severe storm warnings	Canceled
Ocean Vector Winds (active scatterometer follow-on to QuikSCAT)	Wind speed and direction near the ocean surface	Improved severe weather warnings to ships at sea; improved crop planning and yields through better predictions of El Niño	Canceled
Landsat Data Continuity—bridge mission (to fill gap between Landsat-7 and NPOESS)	Land cover	Monitoring of deforestation; identification of mineral resources; tracking of the conversion of agricultural land to other uses	Canceled

Source: Testimony of Dr. Berrien Moore, III, at a Hearing of the Committee on Science and Technology, held on February 13, 2007 on National Imperatives for Earth and Climate Science Research and Applications Over the Next Decade.

ATTACHMENT 3

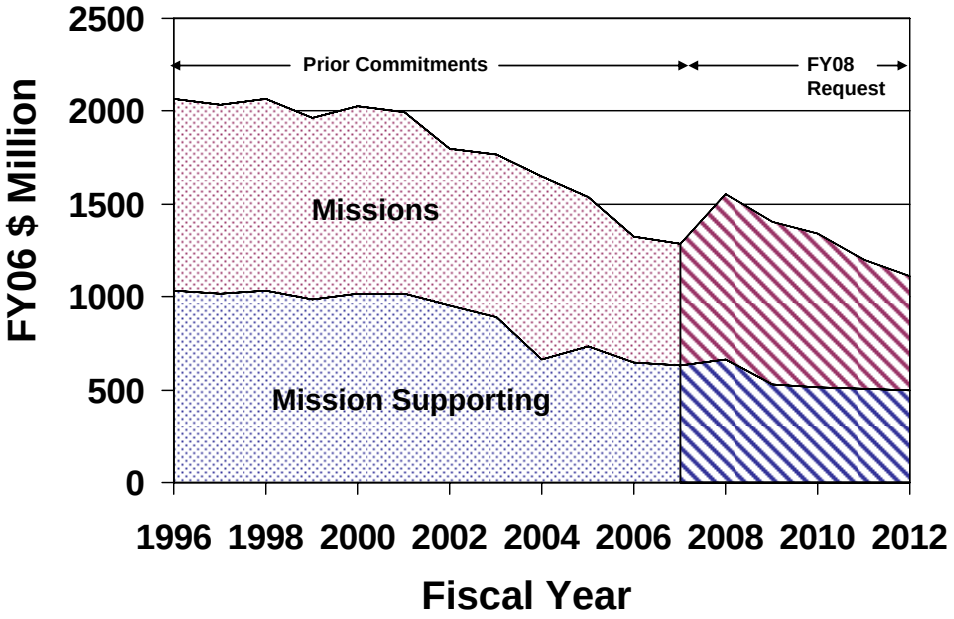

Figure 1: The NASA Earth Science Budget in constant FY 06 dollars (normalized for full-cost accounting across entire timescale; assumes 3%/year inflation from 2006 to 2012). Mission supporting activities include Earth Science Research, Applied Sciences, Education and Outreach, and Earth Science Technology.

Source: Testimony of Dr. Berrien Moore, III, at a Hearing of the Committee on Science and Technology, held on February 13, 2007 on National Imperatives for Earth and Climate Science Research and Applications Over the Next Decade.

ATTACHMENT 4

FY 08 NASA Budget Request - Earth Science

(Budget authority, $ in millions)	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	FY 2012
EARTH SCIENCE	**1,464.5**	**1,497.3**	**1,545.8**	**1,520.1**	**1,411.2**	**1,353.2**
Earth Systematic Missions	523.8	606.1	693.0	576.0	387.9	387.9
Earth System Science Pathfinder	165.2	135.7	94.9	171.6	242.3	161.2
Earth Science Multi-Mission Operations	192.9	204.4	181.3	191.3	185.8	194.2
Earth Science Research	453.4	428.5	453.0	453.8	469.1	481.4
Applied Sciences	46.8	40.3	41.3	41.1	38.0	38.9
Education and Outreach	25.9	23.5	23.6	23.7	23.9	24.1
Earth Science Technology	56.6	58.9	58.7	62.6	64.2	65.5
Year to Year Increase		**2.2%**	**3.2%**	**-1.7%**	**-7.2%**	**-4.1%**