Statement Of
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Chairman Rockefeller, Ranking Member Hutchison, and Members of the Committee, I thank you for the opportunity to testify at this important hearing. Your Committee has a long history of leadership in addressing the need to improve our scientific understanding of climate change, which is so critical in shaping the kinds of policy decisions with which Congress is now grappling. I will focus my testimony here on the science of global climate change and what it is telling us about the challenges we face as a global community and as a nation, and on the role that the Office of Science and Technology Policy (OSTP) plays in coordinating climate change science and technology programs across the relevant federal agencies for the benefit of the nation.

Science and the climate challenge

Investments in climate science over the past several decades have contributed to greatly increasing understanding of global climate change, including its attribution mainly to human influences.

We now know that climate is changing all across the globe. The air and the oceans are warming, mountain glaciers are disappearing, sea ice is shrinking, permafrost is thawing, the great land ice sheets on Greenland and Antarctica are showing signs of instability, and sea level is rising. And the consequences for human well-being are already being felt: more heat waves, floods, droughts, and wildfires; tropical diseases reaching into the temperate zones; vast areas of forest destroyed by pest outbreaks linked to warming; alterations in patterns of rainfall on which agriculture depends; and coastal property increasingly at risk from the surging seas. All of these kinds of impacts are being experienced here in the United States as well as elsewhere, as extensively documented in a report of the U.S. Global Change Research program on *Global Climate Change Impacts in the United States* that was released with the endorsement of OSTP and NOAA last month.

We know the primary cause of these perils beyond any reasonable doubt. It is the emission of carbon dioxide (CO_2) and other heat-trapping pollutants from our factories, our vehicles, and our power plants, and from use of our land in ways that move carbon from soils and vegetation into the atmosphere in the form of CO_2. We also know that failure to curb these emissions will bring far bigger impacts from global climate change in the future than those experienced so far. Devastating increases in the power of the strongest hurricanes, sharp drops in the productivity of farms and ocean fisheries, a dramatic acceleration of species extinctions, and inundation of low-lying areas by rising sea level are among the possible outcomes.

And we know what we can and must do to avoid the worst of the possible outcomes of climate change. We can transform our technologies for supplying and using energy from polluting and wasteful to clean and efficient, using new incentives to accelerate the process and new agreements and forms of cooperation to bring the rest of the world along. We can halt and reverse deforestation, and we can modify farming practices in ways that increase rather than decrease the amounts of carbon stored in agricultural soils. Indeed, with care in choice of locations and methods, we can make our farms and our forests sustainable sources not only of food and fiber but of clean, renewable biofuels to help with the energy side of the solution.

Extensive use of technologies that increase energy end-use efficiency and that supply energy with greatly reduced carbon dioxide emissions will be needed, along with improved management of forests and agricultural soils, to achieve President Obama's stated goal of an 83% reduction in U.S. greenhouse gas emissions below 2005 levels by 2050 – a goal intended, when coupled with similarly ambitious performance by other major emitting countries, to avoid the worst effects of climate change. Improving the technologies of energy end-use and supply, as well as relevant practices in agriculture and forestry, will play a major role in getting this done. To this end, the Federal government is increasing funding for research and development across a broad portfolio of greenhouse gas mitigation options, including high-performance buildings; advanced manufacturing; advanced vehicles; clean biofuels; wind, solar, geothermal, and nuclear power; carbon capture and sequestration; advanced energy storage; a more intelligent electric grid; techniques for reducing emissions and/or increasing uptake of CO_2 in agriculture and forestry; and more.

The government will also need to implement incentives, as outlined in the Recovery Act and the FY 2010 Budget, to encourage firms and individuals to choose climate-friendly technologies, to contribute funding for early stage and high-risk research and development where the private sector on its own would do less than society needs, and to help execute ongoing and planned demonstration projects (such as for carbon capture and sequestration) where the scale and risk of the needed efforts would inhibit solely private approaches. The creation of the needed set of signals and supports is of course a primary aim of the comprehensive energy-climate legislation that has been passed by the House and is now under consideration in the Senate.

Unfortunately, it is simply not practical to reduce heat-trapping emissions rapidly enough to halt overnight the build-up of the offending substances in the atmosphere, both because of the inertia in our energy infrastructure and in agricultural and forestry practices and because of the long residence times in the atmosphere of many of the greenhouse gases. Even if the atmospheric concentrations of all of the relevant substances could be stabilized instantaneously, the average surface temperature of the Earth would continue to slowly climb for decades, with accompanying changes in associated climatic phenomena such as rainfall patterns and temperature extremes, because of long lag time needed for the oceans to reach equilibrium with these atmospheric conditions.

This circumstance underlines the need to invest, in parallel with efforts to reduce emissions and increase uptake of the main heat-trapping gases and particles, in adaptation to the changes in climate that can no longer be avoided – e.g., breeding heat- and drought-resistant crop strains, bolstering defenses against tropical diseases, improving the efficiency of water use, managing ecosystems to improve their resilience, and management of coastal zones with sea-level rise in mind. As noted by the USGCRP *Global Climate Change Impacts* report, informed choices about adaptation will need to be made at many scales of human activity, from an individual farmer switching to growing a different crop variety better suited to warmer or drier conditions, to a company relocating key business centers away from coastal areas vulnerable to sea-level rise and hurricanes, to a community altering its zoning and building codes to place fewer structures in harm's way and making buildings less vulnerable to damage from floods, fires, and other extreme events.

When we do all that we ought to do in the way of both mitigation and adaptation, we will benefit not only by avoiding the worst damages from climate change, but also by reducing our overdependence on petroleum, continuing to improve air quality in our cities, preserving our forests as havens for biodiversity and sources of sustainable livelihoods, reducing our vulnerability to the extreme weather events that occur from time to time even when climate is not changing overall, and generating new businesses, new jobs, and new growth in the course of getting it all done.

Accelerating progress through interagency coordination

The latest and best scientific information forms the bedrock on which effective policy to combat and cope with climate change must be built. To assist the government and society as a whole with understanding, mitigating, and adapting to climate change, the agencies of the federal government deploy a wide range of powerful science and technology resources. Each agency has different sets of key specialists and capabilities, different networks and relationships with the external research community, and separate program and budget authorities. The U.S. Global Change Research Program (USGCRP) brings together into a single interagency program the essential capacities for research and observations that are widely distributed across these government agencies. An essential component of success in delivering the information necessary for decision making is coordination of the programmatic and budgetary decisions of the 13 agencies that make up the USGCRP.

Growing out of interagency activities and planning beginning in about 1988, with relevant heritage going back even further, creation of the USGCRP energized cooperative interagency activities, with each agency bringing its strength to the collaborative effort. In 1990, the USGCRP received congressional support under the Global Change Research Act (GCRA). The act called for the development of a research program "…to understand, assess, predict, and respond to human-induced and natural processes of global change," and it guided federally supported global change research for the next decade. In 2001, President Bush established the Climate Change Research Initiative (CCRI) to investigate uncertainties and set research priorities in climate-change science, aiming to fill gaps in understanding within a few years. In the following year, it was announced that the USGCRP and CCRI together would become the Climate Change Science Program (CCSP). The USGCRP label remained attached to many of the program's activities, however, and consistent with the language of the GCRA statute the whole effort is going forward in the Obama administration as the USGCRP, with CCSP as a component.

The USGCRP is managed by a director from one of the participating agencies (currently from NASA) with the help of a program office (the USGCRP Integration and Coordination Office) and interagency working groups that plan future research and crosscutting activities, such as communications, decision support, and information and data concerns. OSTP and OMB work closely with the Interagency Integration and Coordination Office and the working groups to establish research priorities and funding plans to assure the program is aligned with the administration's priorities and reflects agency planning.

The 2010 Budget provides $2.0 billion for USGCRP/CCSP programs, an increase of $46 million or 2.3 percent over the 2009 level (excluding Recovery Act funds). USGCRP programs also received $461 million in Recovery Act funding based on preliminary agency allocations, including $237 million for NASA climate activities. Recovery Act funding also includes $170 million for NOAA climate modeling activities. The 2010 Budget supports research activities including the development of an integrated earth system analysis capability; a focus toward creating a high-quality record of the state of the atmosphere and ocean since 1979; development of an end-to-end hydrologic projection and application capability; enhanced carbon cycle research on high latitude systems; quantification of climate forcing and feedbacks by aerosols, non-carbon dioxide greenhouse gases, water vapor, and clouds; assessment of abrupt change in a warming climate; examination of the feasibility of development of an abrupt change early warning system; understanding climate change impacts on ecosystem functions; and refining ecological forecasting.

The Climate Change Technology Program (CCTP) is the technology counterpart to USGCRP. Its aim is to accelerate the development of new and advanced technologies to address climate change, focusing on energy-efficiency enhancements and technologies that can reduce, avoid, or capture and store greenhouse gas emissions. The CCTP was established administratively in 2002 and authorized by the Energy Policy Act of 2005, and it began supporting and coordinating programs in 2007. The Department of Energy serves as the lead agency for the effort. Twelve agencies participate in the interagency coordination efforts of CCTP, eight of which also fund activities included in the CCTP portfolio.

The 2010 Budget provides $5.3 billion for CCTP programs, an increase of $52 million over the 2009 level, excluding Recovery Act funds described below. The Budget funds a wide range of activities important to making progress toward climate-change goals. The Budget funds a wide range of activities that support progress toward climate change goals including programs that focus on energy efficiency improvements, low-carbon fuels and power, enabling technologies, such as energy storage and improving the electric power grid, power distribution and controls, and efforts to promote reductions emissions of non-CO2 greenhouse gases.

CCTP programs received over $25 billion in Recovery Act funding allocations, with most of it supporting DOE programs, including $16.8 billion for energy efficiency and renewable energy, $4.2 billion for electricity delivery and energy reliability, $3.4 billion for efficiency and sequestration programs in fossil energy R&D, and $400 million for the Advanced Research Projects Agency-E (ARPA-E), augmenting the support for advanced research in the DOE science programs. Other agencies also received Recovery Act funding for CCTP-related technology development and deployment, including DoD ($139M), DOT ($100M), NASA ($39M), and NSF ($2M).

Clearly, CCSP and CCTP need to coordinate their efforts in order to get the maximum benefit from each effort and from the combination. The necessary interaction has not always occurred, however. OSTP is now working with DOE and with OMB to help create the necessary coordination between the CCSP and the CCTP to help ensure maximum flow and synergy between science and technology programs.

Reforming the USGCRP to address emerging national needs

The USGCRP works most effectively to address national needs when the scientific capacities of individual agencies are leveraged with coordinated interagency planning and priority setting across the program. To encourage cooperation and budgetary discipline, the GCRA requires an integrated research plan in combination with an interagency budget cross-cut.

With strong OSTP and OMB involvement in their preparation, these collective interagency budgets have enabled significant advances in research efforts, including international field programs that combined the satellite and other capabilities of NASA, satellite, aircraft, ship and network capabilities of the Department of Commerce's NOAA, the university research and field experiment capabilities of NSF, and long-term atmospheric and terrestrial ecosystem observation capabilities of DOE.

These investments led to much more comprehensive and complete data sets for analysis by scientists in all nations, thus promoting, at lower cost to the United States, more complete and faster insight into such phenomena as the El Niño Southern Oscillation (ENSO), the photochemistry of global and polar ozone loss, oceanic uptake of carbon, and much more. Improvement of climate models and transfer of such models to the new generations of massively parallel computers was accelerated by combining the scientific and technical strengths of DOE, the Department of Commerce's NOAA, NSF, and NASA with the world leading high-performance computing capabilities developed by DOE. The sharing of data and model results allowed other agencies, such as the Department of Interior, the Department of Agriculture, and the Smithsonian Institution to draw on the results to study changes in terrestrial ecosystems, hydrology, agriculture, human settlements, and the polar-regions. The capacity and leadership of the program significantly advanced scientific understanding in ways that continue to benefit society.

Although the USGCRP supports a wide variety of research activities to gain more detailed predictive understanding of climate change, there remain significant gaps in going from an estimate of how much the climate may change to the effects these changes may have on ecosystem services, water resources, natural resource utilization, human health, and societal well-being. It is important for the USGCRP to make a strong commitment to providing the information that society is seeking in order to reduce vulnerabilities and improve resilience to variability and change. For example, a recent National Research Council report recommends restructuring the USGCRP around "…the end-to-end climate change problem, from understanding causes and processes to supporting actions needed to cope with the impending societal problems of climate change."[1] This will require the USGCRP to support a balanced portfolio of fundamental and application-oriented research activities from expanded modeling efforts to studies of coupled human-natural systems and institutional resilience.

In addition, it would mean boosting adaptation research; bolstering capacity to monitor change and its impacts (including not only enhancing our monitoring networks on land and for the oceans but also strengthening our system of Earth-observation satellites); producing the sorts of integrated assessment of the pace, patterns, and regional impacts of climate change that will

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[1] National Research Council, 2009. *Restructuring Federal Climate Research to Meet the Challenges of Climate Change*. National Academy Press, Washington DC.

be needed by decision makers as input into their deliberations on the metrics and goals to be embraced for both mitigation and adaptation; and making climate data and information accessible to those who need it.

Three areas of particular need for more comprehensive and coordinated treatment from USGCRP are adaptation research, integrated assessment, and climate services. I take up each briefly in turn.

Adaptation research

There currently exists limited knowledge about the ability of communities, regions, and sectors to adapt to a changing climate. To address this shortfall, research on climate change impacts and adaptation must include complex human dimensions, such as economics, management, governance, behavior, and equity. Interdisciplinary research on adaptation that takes into account the interconnectedness of the Earth system and the complex nature of the social, political, and economic environment in which adaptation decisions must be made would be central to this effort. Given the relationships between climate change and extreme events, the community of researchers, engineers and other experts who work on reducing risks from natural and human-caused disasters will have an important role to play in framing climate change adaptation strategies and in providing information to support decision-making during implementation. For example, assessments of emergency preparedness and response systems, insurance systems, and disaster-relief capabilities are an important component of a society's adaptive capacity.

Integrated assessment

Preparing for and adapting and responding to the impacts of climate change must start locally and regionally, as each region is distinct, and each type of impact is experienced in different ways in different places and for different sectors of the economy. Any national assessment activity must engage localities and sectors to aggregate information into a national picture of climate impacts, and should also use this engagement to gather information on the "demand-side" of the adaptation problem, where people live and work, to reorient research and observation investments. While there are certainly issues where national policy steps are warranted, there will be many challenges where individuals, public and private sector organizations, local communities, states, and regions will need to respond. USGCRP activities need to serve all of these scales and stakeholders, not dictating what policies to follow, but providing information and capabilities needed by those experiencing the impacts so that they can prepare for and adapt and respond to future conditions.

Climate services

Coordinated climate information and services are needed to assist decision-making across public and private sectors. Local planners will want information on likely changes in precipitation amount and flooding rains; farmers and farm cooperatives will want information on changes in season length and temperature, not just for their own farms, but for those of their local and distant competitors; coastal zone managers will want information on likely changes in sea level, storms, and estuarine temperatures; water resource managers will want information on likely changes in snowpack and runoff, and the chance of floods and drought; community health planners will want information on changes in location of freezing conditions and the frequency of extreme heat waves; industry will want information on changes in extremes that might affect their businesses and shipping; those preparing environmental impact statements will need information on how changes in a given location affect environmental outcomes; those doing economic analyses will want information across the region, and much more.

Just as the nation's climate research efforts require and benefit from interagency and academic partnerships, so too will the development and communication of climate change information to users. No single agency is capable of providing all of the information and services needed to inform decision-making. To be successful, the delivery of climate services will require sustained federal agency partnerships and collaboration with climate service providers and end users.

While much work has been done to evaluate the need for climate services and a National Climate Service, the Administration believes that additional assessment and analysis of existing climate- service capabilities and user needs for climate services is necessary. A National Climate Service and, more broadly, our nation's approach to delivering climate services will require that such analysis and assessment is ongoing, science-based, user-responsive, and relevant to all levels of interest, e.g., local, regional, national and international. Such a framework must also be able to adapt to new developments in the scientific understanding of climate change and resultant impacts to serve the needs of decision-makers and the public.

The Administration recognizes the Nation needs reliable and accurate climate information. To promptly address this issue, the OSTP is working to convene a task force with representation from a diverse group of key agencies whose charge will be to examine national assets, existing data and information gaps, and costs related to the development of a cohesive framework for delivering accurate climate-related information to the public. This process is intended to result in a more detailed functional and organizational approach for delivering climate services to the nation, in concert with the Administration's views presented here for a broad authorizing framework.

Earth observations and continuity of climate data records

Physical, chemical, and biological information about our planet is vital to our ability to plan, predict, respond, and to protect our citizens and infrastructure. Today, millions of individual observations are collected every day, allowing us to examine, monitor, and try to model atmospheric composition, seismic activity, ecosystem health, weather patterns, and hundreds of other characteristics of our planet. Developing the ability to assess and protect environmental services of all kinds--verifying ‘bottom-up” information used by decision makers with independent “top-down” observation systems--will require continuing efforts to improve our understanding of and ability to measure stocks and flows of water, carbon, and nitrogen at global, regional, and local scales.

Observations are taken from space, and within the Earth system (*in situ*), from the air and on and below the land and the oceans. Obtaining accurate climate data requires calibrated measurement systems that are traceable to national and international standards. Once the integrity of the data is validated, the data can then be interpreted, interpolated, and integrated. The myriad of observations taken today vary widely in purpose and scope and are appropriately distributed among hundreds of programs under the purview of Federal agencies and other institutions and individuals. To a large degree, these observations have been only loosely coupled, coordinated, traceable and integrated. The critical leap forward can only be achieved with a synergy between remotely sensed and *in situ* observations supported by robust data systems.

Increasingly this promise is being realized, and seemingly disparate observations are combined in new ways to produce benefits across multiple societal areas. This recognition has led to the concept of an integrated Earth observing system as articulated by the Group on Earth Observations (GEO). In order to achieve the synergies and benefits of an integrated system of observations, the United States Group on Earth Observations (USGEO) was formed in 2005 as a standing subcommittee of the National Science and Technology Council (NSTC). That same year, the Global Earth Observation System of Systems (GEOSS), was formed to coordinate observations at the international level. By 2009, 79 countries, the European Commission and over 50 international organizations were engaged in this effort. The U.S. contribution to GEOSS is the Integrated Earth Observation System (IEOS). GEOSS and IEOS will facilitate the sharing and applied usage of global, regional, and local data from satellites, ocean buoys, weather stations, and other surface and airborne Earth observing instruments. The end result will be access to an unprecedented amount of environmental information, integrated into new data products benefiting societies and economies worldwide.

The state of the U.S. space-based observational system in 2009 is largely unchanged from that of 2005, but the outlook has significantly worsened, according to the National Research

Council (NRC) Decadal Survey Report. Continuity of the weather system is threatened by reductions and delays in the National Polar-orbiting Operational Environmental Satellite System (NPOESS) and plans for climate measurements on NPOESS have been scaled back. The likelihood of a gap in land imagery impacting multiple societal needs (e.g., agriculture, biodiversity, climate, ecosystems, water, etc.) is now almost a certainty. In addition, no plans have been developed to continue some of the valuable observations demonstrated by the NASA Earth Observing System (EOS) program that benefit the disaster preparedness, human health, climate, and water areas.

OSTP will play an important role in coordinating interagency satellite observation policy. We must increase government oversight and improve the interagency partnerships central to the management of civilian satellite programs, which among other things are critical to the nation's climate and weather forecasting. We need to proactively manage our programs to avert future cost and schedule overruns. Agencies must work together to manage the contractors building these satellites and demand cost and schedule accountability. The management of the NPOESS program and ensuring continuity of weather and climate data is a high priority for the administration's leadership team. I have directed the formation of a Task Force within the Executive Office of the President (which will include representatives from the Office of Management and Budget as well as the National Security Council) that will meet regularly with NOAA, NASA, and the Department of Defense (DoD), the three agencies partnering on the program, to monitor progress and results in addressing key issues facing the success of this program.

In an overall sense, deployments of new and replacement satellites are not keeping pace with the termination of older systems, even though many existing satellites are operating well past their nominal lifetimes. A number of satellites built as research missions are now seen to have ongoing societal benefit, but there are currently no plans for continuity of many of these. Over the next eight years, 50% of the world's current and planned suite of Earth observing satellites will be past their useful life. Given the long development times associated with fielding new systems, particularly satellite systems, and absent a dramatically increased commitment to sensor system development, this declining census of instruments and missions could lead to a loss of observing capability in the next decade. This reality reinforces the need to address the recommendations in the NRC's Decadal Survey.

In addition to global observations made from space, *in situ* measurements provide critical data at fine spatial and temporal scales and of parameters and in places not achievable from space. Our observational infrastructure for in-situ measurements is aging and investment in monitoring programs has declined despite growing demand. And, there still remains the grand challenge and promise of using geospatial information to link the broad coverage and context of our top-down remote-sensing view with the comprehensive and detailed measurements made *in situ* in order to best characterize and understand environmental resources.

Development of an integrated climate observing system stands as a large and urgent challenge. One part of the challenge is that the required observing system must deliver multi-decade data records with the accuracy and precision needed to distinguish long-term climate changes from natural variability and other environmental influences. To help ensure compatibility and consistency between various international monitoring organizations and laboratories, the National Institute of Standards and Technology (NIST), the Nation's national measurement institute, can provide traceable measurement techniques and standards based on the International System of Units. In addition, NASA EOS demonstrated the ability to create long-term, high-precision climate data records. The experience of this program has revealed the difficulties in "transitioning" long-term, research-type measurements to an operational system. We have work to do in overcoming the limitations of the current "research to operations" paradigm with respect to climate observations, which require a long-term research effort. The institutional structures and capacity, and specific agency roles and responsibilities must be developed to deliver an integrated climate observing system.

The effort to evaluate and assess options for the NPOESS program is just the first step towards building a solid foundation of continued Earth observations for the future, which would take into account both the NRC's Decadal Survey as well as the ability to coordinate with GEOSS at an international level.

Conclusion

The climate is changing with increasing potential for disrupting human well-being. We know the causes, and we know what we have to do to avoid the worst of the possible effects. Science, technology, and innovation are all going to be crucial in mastering the climate-change challenge. As Director of OSTP, I regard one of the primary challenges and one of the primary functions of OSTP to be providing the leadership and needed coordination of global change research to ensure that our decision makers, our businesses, our farmers, our health care workers, and all our citizens have the information they need to take actions to improve human well-being and environmental management as the climate changes. Working in partnership with the Office of Management and Budget and the Congress, we aim to pull together the expertise across the government, drawing from each agency's distinctive capacity, to construct the relationships and interactions among the agencies that will result in a program for global change research that is both greater than the sum of its parts and adequate to the country's needs.

I look forward to working with the Committee in this effort. I will be pleased to try to answer any questions the Committee may have.