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The Global Earth Observation System of Systems: Science Serving Society

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Abstract

Over the next decade, a Global Earth Observation System of Systems (GEOSS) will revolutionize our understanding of the Earth and how it works, producing societal benefits through more coordinated observations, better data management, increased data sharing and timely applications. The political momentum behind the establishment of GEOSS is described and examples of its benefits—drought prediction, disease monitoring, accuracy of weather and energy needs forecasting, disaster mitigation—are provided. While challenges exist, particularly in the area of making data accessible, steps are being taken to meet them, e.g. through the new GEO-Netcast concept. Interagency collaboration within countries is as important as international cooperation; the efforts of the US Group on Earth Observations in this regard are discussed. Maintaining the strong political support here and in all participating countries will be key to the success of GEOSS.
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1. Introduction

Over the next decade, a Global Earth Observation System of Systems (GEOSS) will revolutionize our understanding of the Earth and how it works. With benefits as broad as the planet itself, this initiative promises to make peoples and economies around the globe healthier, safer and better equipped to manage basic daily needs. The aim is to make 21st century technology as interrelated as the planet it observes as well as to provide the tools and science on which sound policy and decision making must be built.

Over the past 2 years, the visibility of Earth observations and their importance to society have grown significantly among policy makers worldwide. The science and technology community has recognized for decades the critical nature of Earth observations as a tool for advancing our understanding of the Earth system and addressing the pressing issues facing society, but now our decision makers are beginning to understand how Earth observations may be applied to benefit society as well.

GEOSS is an excellent example of science serving society. The focus of GEOSS is to produce societal benefits through more coordinated observations, better data management, increased data sharing, and application to societal needs. Over time, GEOSS will provide an important scientific basis for sound policy and decision making in every sector of our society including energy, public health, agriculture, transportation and numerous other areas that shape the quality of everyday life. In addition, it will enhance our capability to address natural disasters throughout the world.

Because it has enormous potential benefits for the entire world, GEOSS is an environmental priority at my agency, the US National Oceanic and Atmospheric Administration (NOAA), a high-level priority within the US government, and a global priority within the entire international community.

2. Political momentum

At the third Earth Observation Summit in February 2005 in Brussels, ministers from nearly 60 countries and the European Commission endorsed the 10-Year GEOSS Implementation Plan and established the intergovernmental Group on Earth Observations (GEO) on a long-term basis to take those steps necessary to implement it.

These developments stem from the first Earth Observation Summit, hosted by the USA in July 2003, at which ministers adopted a Declaration that announced their commitment to develop a comprehensive, coordinated, and

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sustained Earth observation system of systems, built on existing systems. This Declaration affirmed the need for timely, quality, long-term global information as a basis for sound decision making; recognized the need to support the exchange of observations recorded from in situ, aircraft, and satellite networks in a full and open manner with minimum time delay and minimum cost; committed to improving Earth observation systems and scientific support in developing countries; and established an ad hoc GEO to prepare a 10-Year Implementation Plan.

Between the first and third summits, Japan hosted Earth Observation Summit-II in Tokyo in April 2004, at which a GEOSS Framework Document was adopted. The Framework offers a vision for GEOSS, highlights the benefits of a global system, identifies key societal benefit areas, and points to shortcomings in existing systems and coordination.

It has been my pleasure and privilege to co-chair both the ad hoc GEO and, now, the permanent GEO. Its origins can be traced to both the 2002 World Summit on Sustainable Development (WSSD) event in Johannesburg, South Africa, and the June 2003 G8 Summit in Evian, France.

At the WSSD the developing countries that participated strongly endorsed the value of Earth observation information as essential for planning and building a better social and economic infrastructure in key areas ranging from energy to water to agriculture. The final WSSD Plan of Implementation contains numerous statements regarding the need for Earth observation data and information and for scientific understanding that can only result from cooperation and coordination among observing systems and research programs for integrated global observations.

In 2005 the G8 Heads of State at Evian issued a Science and Technology Action Plan calling on the nations of the G8 to strengthen cooperation on global observations, and a status report was presented to the G8 meeting at Sea Island, Georgia, USA the following year. Moreover, the 2005 G8 meeting at Gleneagles, Scotland, reaffirmed their commitment to exercise leadership in this area and welcomed the adoption of the GEOSS 10-Year Implementation Plan. They also affirmed the role of GEOSS to ensure a coordinated monitoring capacity in the disaster risk reduction area and closer coordination of natural hazard assessments.

3. Benefit focus

The GEOSS initiative seeks to focus the attention of world leaders on existing and developing capabilities of GEO members and participating organizations, identifying and filling capability gaps and—very important—relating these observations to specific benefits for society. Existing programs as well as new initiatives are necessary. GEOSS as a ''system of systems'' is helping to refocus and make more effective the existing systems (e.g. Global Climate Observing System, Global Ocean Observing System) and existing Earth observation coordination mechanisms (e.g. Committee on Earth Observation Satellites, Integrated Global Observing Strategy Partnership), all of which need to be strengthened to provide effective underpinnings for GEOSS.

Further, GEO broadens this effort across disciplines because, just as the Earth's systems are interlinked, Earth observation data and products can benefit multiple application areas simultaneously.

GEOSS will be *comprehensive*—by including observations and products gathered from all components (satellite, aircraft, in situ) required. While space-based observations are not the sole source for this endeavor, they will provide a major contribution. GEOSS will be *coordinated*—in terms of leveraging resources of individual contributing members to accomplish this system, whose total capacity is greater than the sum of its parts. GEO will also be *sustained*—by the collective and individual will and capacity of participating members.

GEOSS will be a distributed system of systems, addressing data utilization challenges as well as facilitating capacity-building efforts. An initial set of nine societal benefit areas are identified for GEOSS:

- reducing loss of life and property from natural and human-induced disasters;
- understanding environmental factors affecting human health and well-being;
- improving management of energy resources;
- understanding, assessing, predicting, mitigating, and adapting to climate variability and change;
- improving water resource management through better understanding of the water cycle;
- improving weather information, forecasting, and warning;
- improving the management and protection of terrestrial, coastal, and marine ecosystems;
- supporting sustainable agriculture and combating desertification;
- understanding, monitoring, and conserving biodiversity.

The nations of the world have generated a great deal of political will in support of GEOSS, and it is imperative to this process that we maintain it. Highlighting the human dimension and the benefits to society from a comprehensive system has been and will continue to be the key.

3.1. Examples of benefits

Building an integrated, comprehensive, and sustained GEOSS opens a world of possibilities. Consider the following examples:

- A comprehensive system of Earth observations will supply critical information, allowing us to predict and plan for droughts and other phenomena affecting our agricultural outputs. Estimates of costs associated with drought in the USA alone range from $6 to $8 billion annually. However, if we knew years in advance that these patterns would be

occurring, we could take necessary precautions such as crop planting decisions, seed selection, and fertilizer application to mitigate the impacts.

- The health of our citizens will also benefit from an integrated system of observations that will be used for novel applications such as disease tracking and prediction. While still in their infancy, these projects are already underway.
- Malaria killed more than one million people in 2004, primarily in the developing world. Weather patterns—temperature, soil moisture and rainfall patterns—often set the stage for optimal conditions for the spread of diseases like malaria. By combining information on soil-type and recurring standing puddles with satellite-based information such as temperature and rainfall, a computer simulation may be used to estimate the risk of disease outbreak, helping us predict, and possibly control or prevent, its occurrence.
- Utility companies typically use weather forecasts to determine the mix of coal, hydroelectric, nuclear, wind, natural gas and oil plants that will be used to meet consumer needs. In June 2001 the *USA Today* newspaper reported that annual costs of electricity could decrease by an estimated $1 billion in the USA alone if we could improve the accuracy of weather forecasts by 1° Fahrenheit. This difference in just 1° of accuracy could affect the decision a utility company will make in determining whether to buy electricity from the wholesale market or fire-up a more expensive facility to meet increased demand.
- From an energy exploration perspective, Earth observations are also playing innovative roles. New techniques allow us to picture what is beneath the sea floor. By the introduction of three-dimensional seismic data, we can understand whether an area has potential for energy resources. Better evaluations result in cost-savings and the prevention of wasteful drilling and mining. Directed drilling and mining efforts would reduce strain on the oceanic environment and ecosystems.
- Disaster mitigation is another focus area for GEOSS. Better ocean observations—tide gauges, buoys, sensors—will allow us to forecast with more accuracy and issue more effective warnings to coastal communities.

Of course, the recent tsunami highlighted the importance not just of observations but of a warning system. The Intergovernmental Oceanographic Commission (IOC) has paved the way, through its efforts towards tsunami mitigation in general, and specifically, for a warning system in the Indian Ocean. It is imperative that we move forward on tsunami issues while they still hold the world's attention. UNESCO Director General Koichiro Matsuura has expressed his support for developing a global tsunami warning system within the GEOSS framework. As UN Environment Programme Executive Director Klaus Toepfer has highlighted, an early warning system must include all hazards, not just tsunami.

At the Brussels Earth Observation Summit, GEO participants adopted a "Communiqué Relating to Support for Tsunami and Multi-Hazard Warning Systems within the Context of GEOSS," which included a request that GEO "support the coordinating activities of the UNESCO-IOC and related national and regional initiatives to realize effective tsunami warning systems in the Indian Ocean and other regions of the world, as an integral part of a multi-hazard approach supported by GEOSS." The benefit of GEO is that it facilitates the kind of coordination among nations that will enable us to build, for example, a multi-hazard warning system.

4. The challenge: connecting the dots

Implementation is the key to GEO's success. An all-hazards warning system, based on the immense benefits it would offer the world, is one of GEO's first real challenges. Another near-term challenge is the development of plans for better management of Earth observation data. Our individual agencies' current data management systems are already challenged to process current data streams. New observation systems will lead to a 100-fold increase in Earth observation data. Only by viewing observations as part of an end-to-end process will we fully maximize their utility.

Another major challenge for GEO is data access. Some nations support the goals of GEO yet have restrictive policies when it comes to sharing their own data. The societal benefits of GEOSS will not stop at national borders, so the data should not either.

A key feature in increasing the use of environmental data is to make data accessible to all nations in a cost-effective and efficient manner. Given the volumes of data, particularly from satellites, and the diversity of data sets, this is not an easy challenge. The introduction of a well coordinated, global dissemination scheme that addresses these problems is to be welcomed, and a new concept, GEO-Netcast, has the potential to achieve these goals.

Through the GEO-Netcast environmental satellite and in situ systems data and products from all nine societal benefit areas would be transmitted to users through a global network of communications satellites, using a multicast capability or the internet. Data reception would be through satellite user reception stations that can be located anywhere within the dissemination satellite "footprint". Thus, users could receive data, data products, and services from providers regardless of their location. The multicast capability allows different data sets to be handled in parallel regardless of the source. GEO could add value to existing operational and prototype technological efforts underway by coordinating these efforts to address standard user reception terminals and common software, which would enhance the delivery of data and information to users, particularly those in developing countries, at reasonable cost to both providers and users.

5. US implementation

Successful implementation requires not just international collaboration among the many stakeholders, but also interagency collaboration within each nation. In the USA we have created a US Group on Earth Observations (USGEO) to coordinate Earth observation activities and policies across 15 government agencies and three White House offices.

One early outcome of the US interagency effort is the recently published *Strategic Plan for the US Integrated Earth Observation System*, which focused on integration of agency efforts, particularly of six Near-Term Opportunities:

1. data management;
2. improved observations for disaster warnings;
3. global land observation system;
4. sea-level observation system;
5. national integrated drought information system;
6. air quality assessment and forecast system.

By taking a cross-agency perspective, USGEO is able to identify gaps or necessary components that might be overlooked within individual agency planning efforts.

The need for integrated Earth observations has been prominently mentioned in the last three guidance memos on research priorities from the White House Offices of Management and Budget and of Science and Technology Policy. The guidance memo for fiscal year 2007 states:

> Global earth observations support research in a wide range of sciences important for society. The *US Strategic Plan for an Integrated Earth Observations System* (IEOS) provides guidance for agencies contributing to these efforts. Agencies should focus on near-term opportunities to pilot integrated observing systems, such as those that contribute to natural hazards assessment and disaster warnings. Agencies also should work through the…US Group on Earth Observations Subcommittee to ensure continued coordination and implementation of the US Strategic Plan and continued strong US leadership in the international community.

All our coordination efforts in the past have laid the foundation to create a truly Integrated Earth Observation System here in the USA, which can be a contribution to the international system of systems.

6. Building blocks for the future

GEO would not exist today without the high-level political commitment of all the participating nations. All nations and relevant organizations are encouraged to join GEO to help address the ongoing societal challenges to which Earth observation data and information can contribute. For years, our science and technical communities have discussed and understood that we must link our individual observation systems in order to understand Earth's complex processes. We can and already have begun to make our systems and computers talk to each other. GEO's challenges are not just technical, but include maintaining political support as well. The focus on societal benefits allows one measure of progress, which will be critical to sustaining that momentum.

Over the next decade, I believe we will look back at this period and recognize what an enormous turning point it represents in the scientific understanding of our planet. The goal of every country participating in GEOSS is to ensure that this understanding leads to improved operational capabilities that will be put to work for the benefit of people throughout the world and the economies on which they depend. That is what is unique about the GEOSS initiative—it will better empower science to serve society.