GEO Information Sheets

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Foreword

The Global Earth Observation System of Systems, or GEOSS, is an idea whose time has come. The need to monitor and understand the Earth system – including its physical, chemical and biological dimensions – has never been greater. As human society becomes ever more global, we need global vision – literally – to address the environmental challenges of climate change, biodiversity loss, resource depletion and pollution. We also need a truly global perspective for improving human health and well-being on our socially and economically integrated planet.

Fortunately, sophisticated new technologies for gathering vast quantities of timely and high-resolution Earth observation data have now made global vision a reality. With investments in Earth observations now reaching a critical mass, it has become possible to link diverse observing systems together to paint a full picture of the Earth's condition. At the same time, improved forecasting models and decision-support tools increasingly allow decision makers and other users of Earth observations to fully exploit this widening stream of information. GEOSS promises to connect the producers of environmental data and decision tools with the end users of these products, thus further enhancing the relevance of Earth observations to real-life issues and problems.

This collection of information sheets has been produced by the Secretariat of the Group on Earth Observations (GEO) as a public information document. The first two introductory sheets describe the work coordinator – GEO – and the "system of systems" that it is constructing – GEOSS. As the reader will discover, GEO provides a flexible and inclusive framework within which governments and organizations can collaborate on Earth observations, while GEOSS is a wide-ranging and ambitious enterprise involving hundreds of activities and many thousands of experts and decision makers.

The next nine sheets explain the "Societal Benefit Areas", or SBAs, which provide a convenient reference-frame for understanding GEO and GEOSS. They introduce the strategies and outputs being pursued in various fields. They also describe the many benefits GEOSS will bring to the producers and users of Earth observations and to the public at large. None of these areas, of course, exists in isolation: much of the value of GEOSS lies in its ability to integrate information across disciplines. This collection therefore concludes with several sheets on issues that cut across, and are relevant to, all of the Societal Benefit Areas.

I hope you find these information sheets useful. For further information, please visit our web site, which features technical and official documents as well as additional public information materials.

José Achache
Director, Secretariat
Group on Earth Observations

The Group on Earth Observations (GEO)

The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS). It was established in February 2005 by the Third Earth Observation Summit in Brussels at the end of a process that started in 2003 with the First Earth Observation Summit in Washington DC. GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and the Group of Eight (G8) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.

GEO is a voluntary partnership of governments and international organizations. It provides a framework within which these partners can develop new projects and coordinate their strategies and investments. As of February 2008, GEO's Members include 72 Governments and the European Commission. In addition, 52 intergovernmental, international, and regional organizations with a mandate in Earth observation or related issues have been recognized as Participating Organizations. Each Member and Participating Organization is represented by a Principal and a Principal Alternate. Members make financial contributions to GEO on a voluntary basis.

GEO is constructing GEOSS on the basis of a 10-Year Implementation Plan. Adopted by the Third Earth Observation Summit, the Plan runs from 2005 to 2015. It defines a vision statement for GEOSS, its purpose and scope, expected benefits, nine "Societal Benefit Areas" (disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity), technical and capacity-building priorities, and the GEO governance structure. To measure progress and maintain momentum, the Plan also sets out 107 two-year targets, 83 six-year targets and 56 ten-year targets.

GEO is governed by a Plenary consisting of all Members and Participating Organizations. It meets in Plenary at least once a year at the level of senior officials and periodically at the ministerial level. The Plenary held its first meeting in May 2005 in Geneva, followed by GEO-II in December 2005 in Geneva, GEO-III in Bonn in November 2006, and GEO-IV (plus a Ministerial Summit) in Cape Town in November 2007. Members take decisions at the Plenary by consensus.

An Executive Committee oversees GEO activities when the Plenary is not in session. The Committee consists of 12 representatives elected from the five GEO regions, including three each from the Americas, Asia and Europe, two from Africa, and one from the Commonwealth of Independent States. The Committee is also responsible for guiding the Secretariat. The GEO Members elect four Co-Chairs who preside over both the Plenary and the Executive Committee.

GEO-I established four Committees and one Working Group to guide the implementation of the 10-Year Plan. The Committees are organized around the four Transverse Areas of user engagement, architecture, data management and capacity building, which cut across, and are relevant to, each of the issue-specific Social Benefit Areas. The four permanent bodies are the Architecture and Data, Science and Technology, User Interface, and Capacity Building Committees. The Plenary also established a Working Group on Tsunami Activities.

GEO-III generated further momentum by adopting a three-year Work Plan for 2007 – 2009. This "living" document grew out of the 2006 Work Plan and sets out more than 70 practical Tasks.

Each Task supports one of the nine societal-benefit or four transverse areas and is carried out by interested Members and Participating Organizations. Governments and organizations have also advanced the work of GEO by contributing a variety of “Early Achievements”; these “First 100 Steps to GEOSS” were presented to the 2007 Cape Town Ministerial Summit.

The GEO Members and Participating Organizations are supported by a Secretariat. Based in Geneva, Switzerland, the Secretariat consists of a Director appointed by the Executive Committee, several international civil servants, and approximately 10 national technical and scientific experts who are seconded to the Secretariat for two or three years. The Secretariat is responsible for coordinating the Tasks and other activities that are driving the 10-Year Implementation Plan for GEOSS. It also services the Plenary and the Committees and implements outreach and other support activities.

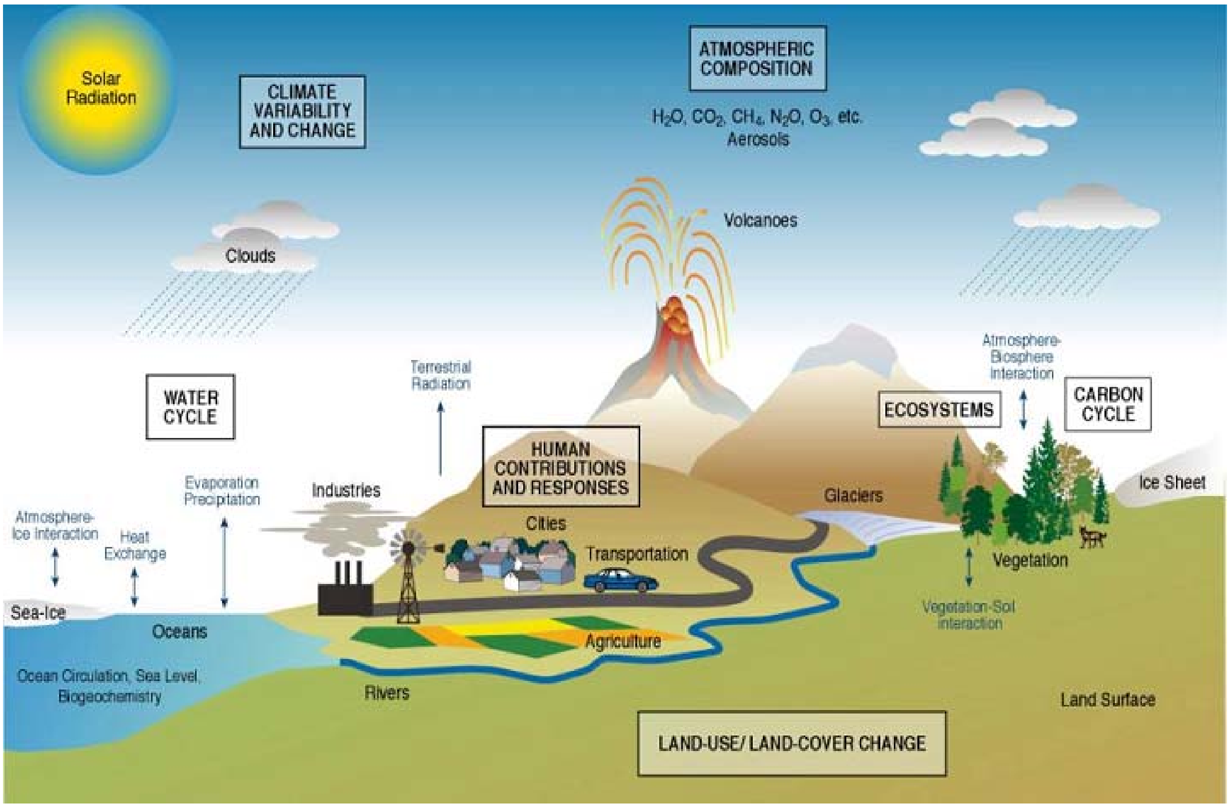

Diagram of the Earth System

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Information Sheet 2

The Global Earth Observation System of Systems

The Global Earth Observation System of Systems (GEOSS) promises to revolutionize our ability to understand and manage the planet. This emerging global public infrastructure is starting to generate comprehensive, near-real-time environmental data, information and analyses. It serves a wide range of users and empowers decision makers to respond more effectively to the many environmental challenges facing modern civilization. GEOSS is being constructed by the Group on Earth Observations (GEO) based on a 10-Year Implementation Plan for the period 2005 - 2015.

GEOSS is interconnecting existing and future Earth observation systems. Investments in environmental monitoring and forecasting have now reached a critical mass, resulting in a vast and expanding array of observation systems and decision-support tools. Buoys floating in the oceans monitor temperature and salinity; meteorological stations and balloons record air quality and rainwater trends; sonar and radar systems estimate fish and bird populations; seismic and Global Positioning System (GPS) stations record movements in the Earth's crust and interior; more than 60 high-tech environmental satellites scan the planet from space; powerful computerized models generate simulations and forecasts; and early warning systems issue alerts to vulnerable populations. GEOSS promises to make these and other technologies fully "interoperable".

GEOSS reduces costs, promotes international cooperation and serves the public good. Because the sheer costs and logistics of expanding Earth observations would be daunting for any single nation, GEOSS will make the production of comprehensive Earth observations more sustainable by leveraging investments from a wide range of partners. It will also ensure that Earth observations remain a global public good accessible to all.

Technological advances have made GEOSS possible, while the expanding requirements of users have made it necessary. We are entering a new era of global risks and opportunities where policy and management decisions must be based on the near-real-time environmental monitoring of the entire Earth system. This need for decision-support tools by a wide range of user groups is the driving force behind the development of GEOSS. The GEOSS Implementation Plan identifies nine distinct groups of users and uses, which it calls "Societal Benefit Areas". The nine areas are disasters, health, energy, climate, water, weather, ecosystems, agriculture and biodiversity. Although the user groups each have their own distinctive features and needs, the Societal Benefit Areas are mutually interdependent and cannot be addressed in isolation.

One user may require many data sets, while one data set may serve many users. The complexity of the Earth system cannot be captured by any single observation system. Combining observations from multiple systems, however, can generate the integrated data set that a user may need. Similarly, a data set collected for one purpose will often be of value for another. For example, land-cover data gathered for the forestry and agriculture sectors could be equally useful for forecasting and abating the risks that severe weather events pose to people, infrastructure and the environment. Similarly, solar radiation data targeted to the energy sector could be useful for predicting future movements of threatened and endangered species.

Interlinking observation systems will require common standards for architecture and data sharing. The architecture of an Earth observation system refers to the way in which its components are designed so that they function as a whole. Each GEOSS component must be configured so that it can communicate with the other participating systems. In addition, each contributor to GEOSS must subscribe to the GEO data-sharing principles, which aim to ensure the full and open exchange of data, metadata and products. These issues are fundamental to the successful operation of GEOSS. The end result will be an interlinked and interactive network of independent content providers, similar in many ways to the internet.

GEOSS disseminates information and analyses directly to users. GEO is developing the GEOPortal as a single Internet gateway to the comprehensive and near-real-time data produced by GEOSS. GEOPortal will make it easier to integrate diverse data sets, identify relevant data and portals of contributing systems, and access models and other decision-support tools. For users without good access to high-speed internet, GEO has established GEONETCast, a system of four communications satellites that transmit data to low-cost receiving stations maintained by the users.

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GEO GROUP ON EARTH OBSERVATIONS

Information Sheet 3

Responding to natural and man-made disasters

Earth observations can play an essential role in reducing the loss of life and property from natural and human-induced disasters. When disaster looms, rapid access to weather forecasts, data on land and ocean conditions, maps of transport links and hospitals, and information on socio-economic variables can save uncounted lives. When integrated with other information, observations can help planners reduce vulnerability, strengthen preparedness and early-warning measures and, after disaster strikes, rebuild housing and infrastructure in ways that limit future risks.

Reducing risk over the long term requires a better understanding of the relationship between disasters and climate change. Climate change scenarios suggest that new types of hazards will emerge in the decades ahead and that existing hazards may be magnified. Climate forecasts must therefore become an integral part of sustainable development planning and of strategies for adaptation and risk management. By making it possible to integrate different types of data and information from diverse sources, the Global Earth Observation System of Systems (GEOSS) will strengthen analytical capabilities and decision making for disaster response and risk reduction.

Strengthening and coordinating global seismographic networks will reduce earthquake damage. Greater interoperability amongst the world's seismographic networks will improve earthquake prediction by giving researchers and experts greater access to real-time and archived seismological data and products. By promoting the sharing of costs, it will also make investments in seismographic networks more sustainable. Similar cost savings could be realized by co-locating GEOSS in-situ measuring instruments for biodiversity and other fields at seismographic stations. A Group on Earth Observations (GEO) task team that includes officials from global seismological networks is actively pursuing these benefits as well as the extension of seismological coverage to more ocean regions.

GEO is supporting the establishment of a global Tsunami Early Warning System. Concerned about the weaknesses in current systems as revealed by the December 2004 Indian Ocean tsunami, GEO is pursuing the interoperability of all relevant observation and emergency systems. UNESCO's Intergovernmental Oceanographic Commission and other national and international initiatives are working to improve the network of ocean-bottom systems for tsunami detection. Data on seismic activity and sea-level change, in particular, which are currently gathered by separate networks of ocean- and land-based sensors and by satellite-based optical and radar instruments, need to be integrated.

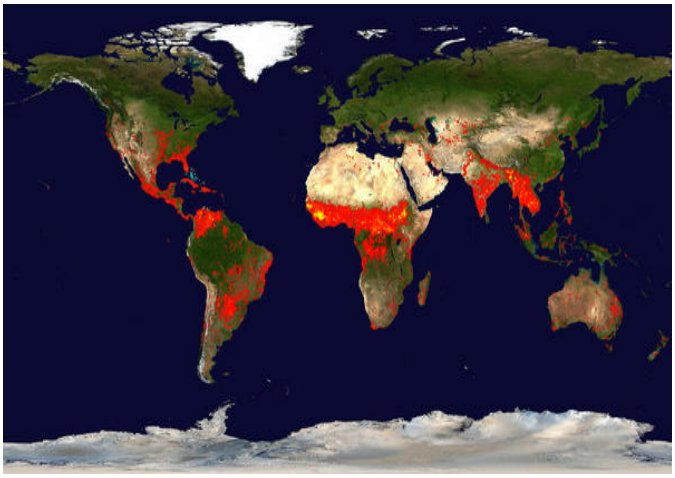
A Global Early Warning System for Wildland Fire will greatly improve prediction and response measures. Key environmental variables used for predicting wildfire risk include soil and tree moisture, long-term drought episodes, wind and rain forecasts, and settlement patterns. The GEO wildfire team is working to fortify existing warning systems, information products and risk-assessment models and to promote better coordination amongst these systems and products. It is also addressing gaps and promoting training and capacity building. A prototype African component of the System was recently established.

GEO's disaster-related activities are fully coordinated with related processes. GEO is collaborating with the United Nations International Strategy for Disaster Reduction (ISDR) on implementing the Hyogo Framework for Disaster Risk Reduction, particularly on defining and implementing the multi-hazard risk-management approach (whereby each observation and early-warning system addresses many types of hazard). Other key partners include the World Meteorological Organization, which is initiating a Disaster Risk Reduction Program; the Committee on Earth Observation Satellites, which supports the use of satellites for risk management; the Intergovernmental Oceanographic Commission, which promotes tsunami early warning systems; and the United Nations Office for Outer Space Affairs, which is implementing the UN Platform for Space-based Information for Disaster Management and Emergency Response. GEO is also working with the humanitarian aid community led by the United Nations Office for the Coordination of Humanitarian Affairs.

Disasters case example: Sentinel Asia

Sentinel Asia seeks to improve the speed and accuracy of disaster preparedness and early warning and thus minimize victims and socio-economic losses from disasters. It draws on imagery and information products from all available geostationary and low-Earth orbiting observations satellites, including those dedicated to meteorology. It then enables this disaster information to be shared throughout the Asia-Pacific region.

Sentinel Asia is also used to trigger the acquisition of data when a disaster unfolds in the region. Its initial focus has been on monitoring wildfires and floods and ensuring the availability of targeted observations in cases of emergency. It also supports capacity building aimed at assisting disaster managers to exploit satellite imagery. Led by the Asia-Pacific Regional Space Agency Forum, the system is being implemented by a joint project team comprising 44 national agencies from 18 countries and seven international organizations.



Regions (in red) affected by wildfires

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Protecting human health and well-being

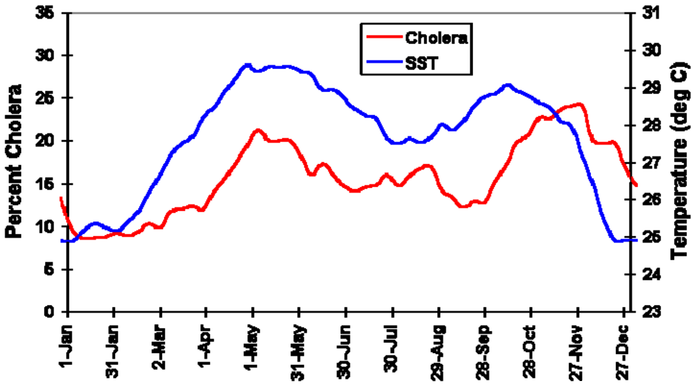
Changes in the natural environment can compromise human health. Droughts may lead to malnutrition and life-threatening forest fires. Dust storms and smog cause respiratory illnesses. Algal blooms contaminate seafood. Climate change and extreme weather events are associated with a wide range of health risks. The spread of infectious diseases such as malaria and Lyme appears to be linked to environmental changes that have opened up new pathways for disease transmission.

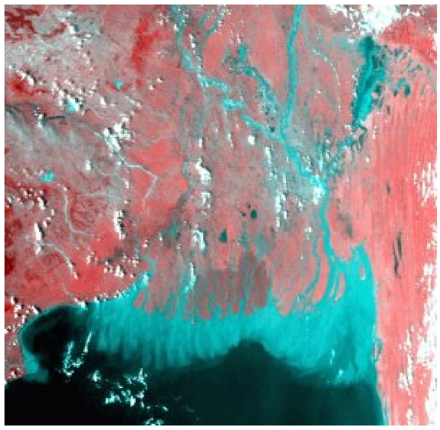
Understanding how the environment affects human health can dramatically boost human well-being. Addressing the environmental impacts on health first requires gathering and analyzing large quantities of timely Earth observation data. Key environmental variables include airborne, marine, and water pollutants; stratospheric ozone depletion; land-use change; food security and nutrition; noise levels; population trends; and weather-related stresses and disease vectors. According to the World Health Organization's 2007 World Health Report, better environmental management could reduce deaths from malaria, lower respiratory infections and diarrhea – three of the world's biggest childhood killers – by 40%, 41%, and 94% respectively.

The Global Earth Observation System of Systems (GEOSS) will improve the flow of user-friendly environmental data to the health community. Comprehensive data sets are essential for research, prevention, early warning, risk mapping, health-care planning and delivery, timely public alerts and rapid response to crises. For example, by integrating data on weather, air quality and the urban heat-island effect, air-quality forecasts can protect asthmatics, the elderly and the young from the respiratory risks of upcoming air-pollution emergencies. These data may also be used to anticipate longer-term air-quality impacts such as cancers and birth defects. Remotely sensed data on land-use change are useful for predicting and responding to trends in water quality, which are linked to disease outbreaks and to general well-being. Better measurements and warning systems for ultraviolet radiation will reduce the incidence of skin cancer and cataracts. By strengthening prediction and prevention in these various ways, GEOSS will reduce the need for expensive and risky treatments; coordinated Earth observations could radically change the global approach to public health, allowing health workers to become increasingly proactive rather than merely reactive.

Earth observations can predict likely epidemics of meningitis and other infectious diseases. Experts concerned with public health in Africa's "meningitis belt", which runs from Senegal to Ethiopia, have noted that meningitis outbreaks are sparked by periods of unusual drought and dryness (minute abrasions in the throat and mucous membrane caused by dry and dusty conditions may allow the bacteria to enter the bloodstream more easily). The Group on Earth Observations' collaborative Meningitis Environmental Risk Information Technologies (MERIT) project aims to make it possible for health agencies to integrate their epidemiological maps with Earth observation maps of climate, weather, water supplies, soil conditions and ecosystems, as well as with maps on topography, population and transport infrastructure. Thus empowered, health experts will be able to anticipate outbreaks of meningitis and to prioritize the supply of vaccines to the areas at highest risk. The spread of other infectious diseases such as malaria, cholera, dengue fever and river blindness can also be predicted with the help of remote-sensing observations of weather, land, ocean and other environmental parameters.

GEOSS will provide improved early warnings of sand and dust storms. Vast quantities of aerosols are frequently transported through the atmosphere to distant places where they can harm human health and disrupt social and economic activity. Sand and dust from the Sahara, for example, often sweeps across the Mediterranean to southern Europe, and sometimes even crosses the Atlantic to reach the Caribbean; similarly, dust from the arid areas of East Asia can blow as far away as the western coast of North America. Linking together now-separate prediction and observing systems for sand and dust storms will greatly reduce the risks associated with such events. Effective cooperation between data producers and user communities will strengthen the implementation of early warnings and countermeasures. For example, by coupling long-term dust models with health-risk mapping, it will be possible to improve health planning in the Sahel. Sand and dust storm information will also benefit critical economic sectors, such as the airline industry, which can use storm warning charts to ensure flight safety.





Left: Studies using remote-sensing data show correlation between cholera cases and sea-surface temperatures in the Bay of Bengal (Lobitz et al., 2000). Right: Advanced Very High Resolution Radiometer image over the Bay of Bengal, 26 October 1992.

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Information Sheet 5

Securing clean energy

Exploiting the full potential of energy resources is critically important to all countries. This trillion-dollar economic sector includes coal, oil and gas as well as renewable energy sources such as solar, wind and hydropower. Key concerns for both governments and the private sector include reliable access to energy, the efficient management of energy resources, improved technologies for stabilizing or reducing greenhouse gas emissions, and the need to report energy emissions levels to the UN Climate Change Convention and other bodies.

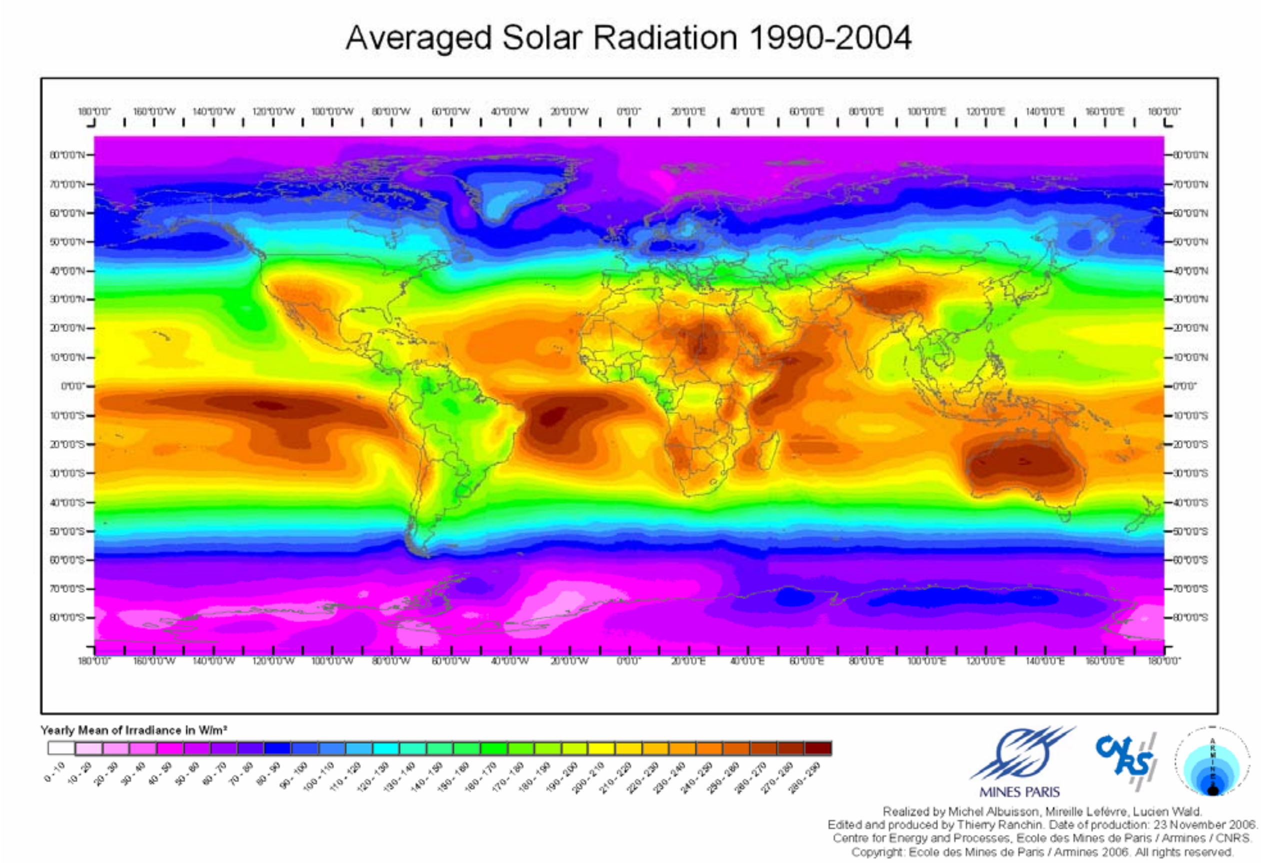
The Global Earth Observation System of Systems (GEOSS) will help governments and companies manage energy resources more effectively. GEOSS will integrate energy-related data and analyses with information from other fields. It will provide data and information relevant to monitoring and forecasting fluctuations in hydropower, solar, ocean and wind energy sources; assessing and predicting the environmental impacts of energy exploration, extraction, transportation and consumption; reducing weather-related and other risks to energy infrastructure; matching energy supply and demand; and informing other aspects of energy-policy planning in both developing and developed countries. The content and design of these outputs will be based on surveys of priority data needs in specific energy sectors such as solar and wind.

The Group on Earth Observation (GEO) promotes international collaboration on energy issues through its Energy Community of Practice. The Community supports GEO's energy goals by providing online information and other resources, promoting training and education, enhancing the value of Earth observation data for policymaking, and engaging a wide array of stakeholders and professional societies in related fields such as sustainable buildings and carbon capture and storage. The Community maintains a web portal at www.geoss-ecp.org.

GEOSS will help decision makers evaluate the potential for producing renewable energy. The GEO-led Solar Energy Data for Developing Countries project has linked together databases on solar radiation from around the world. This easy access to solar-radiation information facilitates the work of energy-policy planners, particularly in developing countries. The first version of the "SoDa" service combines surface-meteorology and solar-energy data from the National Aeronautics and Space Administration in the US and the Helioclim database at the Ecole des Mines de Paris in France. It automatically selects the database offering the best quality data for any particular location and use. The project may be extended to include additional databases. (See www.soda-is.com/eng/services/ meteo_eng.html#ssehc.)

GEOSS can support assessments of the risks and potential of carbon capture and storage (CCS) systems. CCS involves capturing carbon dioxide from a power plant or industrial facility before it can be emitted into the atmosphere, transporting it to a secure location, and isolating it from the atmosphere, for example by storing it underground in a geological formation. GEOSS can help provide a coherent approach to monitoring and verifying the safety and effectiveness of CO_2 geological storage by enhancing international cooperation among industrial, research and service organizations. As an example, the European initiative CO2ReMoVe brings national geological surveys and research institutes together with private companies. The resulting consortium for monitoring and verifying the potential risks of CO_2 injection and other underground activities (such as nuclear-waste disposal and aquifer protection) will facilitate the sharing of knowledge between the commercial and regulatory sectors.

Many of the Earth observations applied to energy management can also support decision-making in other fields, and vice versa. The potential synergies for solar-radiation information extend to human health (air quality in cities and exposure to ultra-violet radiation), water supplies (reservoir evaporation, primary production and water quality), and agro-meteorology, agriculture, oceanography, climate, solar chemistry, sustainable building design and tourism. Similarly, data and products needed for managing hydropower resources can also be used for managing water resources and adapting to climate change impacts (which in turn can impact the water resources needed for hydropower). GEOSS will greatly facilitate the exploitation of such synergies.



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Addressing climate variability and change

Many aspects of the global climate system are still not fully understood. The emergence of large, organized tropical clouds, in particular, is a major source of uncertainty. Scientists still find it much more difficult to model and predict climate change and variability at the regional and other small-scale levels than at the global level. Other key uncertainties involve sea-level rise, the climate-carbon cycle and related feedbacks, and the impact of sulfates and other human-caused aerosols on temperatures and precipitation. Together these uncertainties constrain the ability of governments to adopt effective policies for mitigating and adapting to climate change.

The Group on Earth Observations (GEO) is a leading advocate for sustained and coordinated climate observing systems. In particular, GEO is supporting the Global Climate Observing Systems (GCOS) Implementation Plan, under which the Committee on Earth Observation Satellites (CEOS), the Global Terrestrial Observing Systems (GTOS), the Global Oceans Observing System (GOOS) and other partners are setting priorities for future Earth-observation space missions and land, sea, and air observation systems.

An ambitious and multidisciplinary Weather, Climate and Earth-System Prediction Project for the 21st century has been initiated within the GEO framework. The project aims to strengthen the ability of governments to minimize and adapt to the societal and environmental impacts of extreme weather events and climate variability and change. It seeks to stimulate a quantum leap in the speed, resolution, accuracy and sophistication of weather and climate modelling and forecasting. No single country or group of countries has the resources to achieve these advances on its own: international collaboration is the key to ensuring that national investments are synergistic and mutually supportive and that gaps and overlaps in capacities are identified and addressed. Bringing reseachers in the fields of weather and climate together with researchers studying other Earth systems, natural hazards and socio-economic questions is equally important. This effort is being led by the World Climate Research Programme, the World Meteorological Organization's World Weather Research Programme, the International Biosphere-Geosphere Programme and the natural-hazards and socio-economic research communities.

Key GEO targets for meeting the "climate challenge"

- Develop a long-term strategy to improve observation capability, data assimilation and modelling;
- Advance the monitoring and predictability of weather and climate on weekly, seasonal, inter-annual and decadal time scales;
- Facilitate access to, and utilization of, weather and climate data and models for developing countries;
- Implement actions called for in the Global Climate Observing System (GCOS) Implementation Plan (including atmospheric, oceanic and terrestrial domains);
- Emphasize to satellite agencies the importance of satellites for long-term climate monitoring;
- Promote the improvement of emission databases for aerosols, greenhouse gases and their precursors; and
- Enhance collaboration between observation, research and user communities.

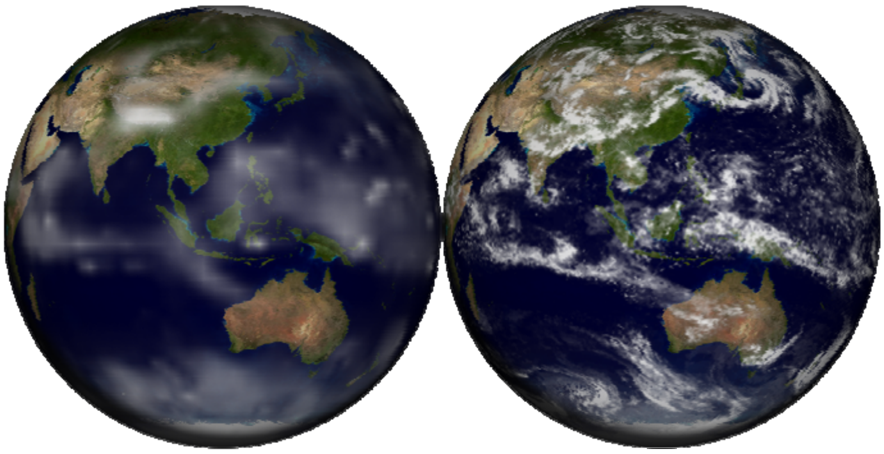
Investments in climate observation and prediction systems must be driven by user needs. Users range from water-resource and fisheries managers to disaster-response teams and energy companies to senior national policymakers. To strengthen the link between the providers and users of climate data and predictions, GEO seeks to disseminate user-friendly information and decision-support tools. It also plans to build capacity for using climate and Earth observation data and products more effectively and to integrate climate-risk management into national policy frameworks for sustainable development.

Climate case example: Argo

Climate forecasts for the next season or two would benefit virtually every person on the planet. Much of the information needed to generate such forecasts must come from monitoring conditions in the oceans. Until recently, however, information on ocean heat transport was only available at great cost and effort.

Enter the global system of Argo ocean floats. A fleet of almost 3,000 of these robotic buoys, with support from satellite altimetry instruments, are now measuring ocean temperature and salinity. The resulting data are essential for weather and climate forecasting, oceanographic studies, fishing management and disaster mitigation.

The logistics and costs of deploying this system throughout the world's oceans and in space would have been daunting for any single nation. The project has become feasible because it is being jointly undertaken by many countries for the common good. Ensuring the long-term sustainable operation of such systems will require continued international cooperation.



The benefits of boosting the resolution of long-term climate projection models. *Left panel*, global cloud distribution in a 320-km resolution climate simulation experiment. *Right panel*, same as left panel, but for a 20-km resolution simulation with the same model, comparable in resolution to the most advanced operational weather forecast models of today. (Courtesy of Takeshi Enomoto, Earth Simulator Center/JAMTEC.)

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GROUP ON EARTH OBSERVATIONS

Information Sheet 7

Managing global water resources

Despite its central importance to human well-being, the natural water cycle is still poorly monitored. Freshwater is vital for households, agriculture, and industry, and ever larger quantities will be needed by burgeoning human populations over the coming decades. More than 40 percent of the world's population, however, already faces water scarcity. Unfortunately, current observation systems cannot adequately monitor long-term changes in the global water system and their far-reaching implications for people, the climate, and biodiversity.

Earth observations can improve water-resource management. The amount of freshwater available for human consumption and ecosystem services is affected by many variables. Tracking these variables more effectively will require filling in existing information gaps about water resources, integrating data sets from various monitoring systems, developing better forecasting models, and disseminating the results to a wider range of decision makers.

The Global Earth Observation System of Systems (GEOSS) is combining water-cycle measurements from in-situ and remote-sensing instruments. Integrating data on lake and reservoir water levels from satellite-based radar altimeters with data from ground-level, in-situ monitors will improve the ability of water managers to map the water cycles of major rivers. Other key data variables needed for a complete hydrological picture include precipitation, soil moisture, stream flow, snow cover, glacier and ice extent, evaporation and transpiration, groundwater, water quality and use, and gravity-field fluctuations.

Water-research and water-management communities around the globe are collaborating closely to improve Earth observations. National meteorological and hydrological services, along with several United Nations agencies and programmes, are working to improve water-cycle data and information through a Group on Earth Observations (GEO) project entitled "Integration of In-Situ and Satellite Data for Water Cycle Monitoring". The project aims to fill in the gaps in global measurements, standardize metadata, and improve the accuracy of data and predictions. Other ongoing initiatives relate to integrated products on precipitation, soil moisture, and groundwater.

Hydrological services will benefit from better forecasting models. Water experts are collaborating through GEO to define the data and information infrastructure they will need for improving water-cycle forecasting. This emerging system will start by establishing global prediction models, which will incorporate moisture flux from the air-sea interface in addition to data from the world's hydrological and meteorological services. It will then develop national and regional models and finally river-basin or catchment–level models. These models will eventually become interoperable, creating a "system of systems" that will facilitate the global exchange of observation data and forecasting information. The resulting ability of water-resource managers to access new and more powerful decision-support tools will completely change the way they do their jobs.

More capacity-building programmes are needed to support the production and use of water-cycle data in developing countries. GEO is assisting a number of developing countries to obtain the technical, institutional, and financial resources they need to conduct proper assessments of water quantity and quality. These investments aim to meet the particular needs of the participating countries while contributing to the Global Earth Observation System of Systems. Current capacity-building initiatives include setting up an advanced training facility in South America, testing a flash flood warning system in Central America, and improving water-quality monitoring in Southeast Asia, Africa and Latin America.

Water case example: the Hydrological Applications and Run-Off Network (HARON)

HARON is a GEO initiative that seeks to build on and add value to existing water-related observation systems. It will achieve this by coordinating monitoring efforts, addressing critical gaps, supporting interoperability, sharing information, reaching a common understanding of user requirements, and improving the delivery of information to users.

The project will start by integrating dedicated river-gauge networks maintained by national hydrological stations into a global runoff-observation network. It will then gradually link in-situ and remote-sensing global observation networks on climate and other variables relevant to freshwater into this integrated observing system. It will also identify key national, regional, and global organisations to implement, support, and maintain the network. In this way, HARON will improve the ability of water-resource managers to access high-quality observations, predictions, and decision-support tools through the Global Earth Observation System of Systems.

The HARON project is being carried out in collaboration with the Integrated Global Water Cycle Observation Theme and the Global Terrestrial Network Hydrology.

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Information Sheet 8

Leveraging the value of weather forecasts

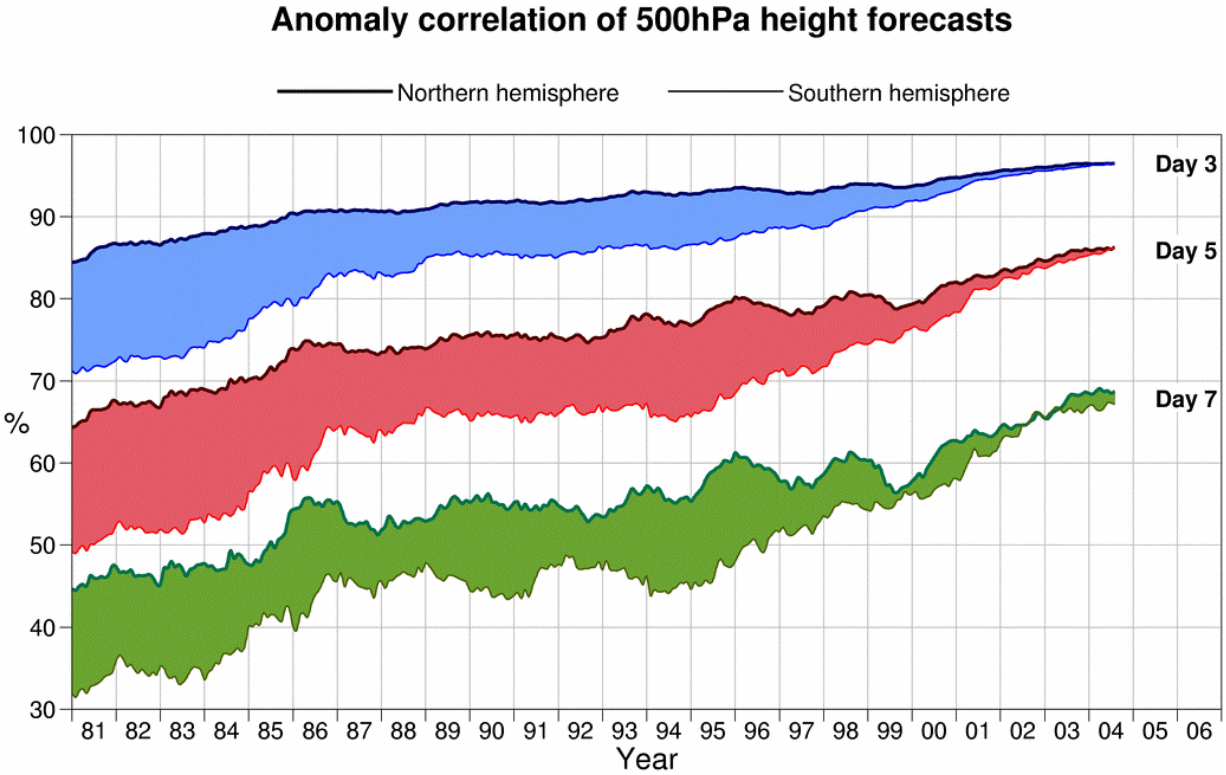
Weather monitoring and prediction is the most operationally advanced discipline in the field of Earth observation. Global cooperation on gathering weather data was formalized over 130 years ago with the founding in 1883 of the direct predecessor to the World Meteorological Organization (WMO). Since then, national meteorological and hydrological services have continuously shared data and information. They have developed extensive national and global databases on wind, rain, temperature and other key weather variables. The resulting global network of weather monitoring instruments, databases and forecasting models is already making a critical contribution to the emerging Global Earth Observation System of Systems (GEOSS).

Connecting international weather forecasting systems to other Earth observation systems will produce enormous social and economic benefits. Every year, millions of people are affected by tornadoes, droughts, lightning strikes, blizzards and many other kinds of extreme weather events. At the same time, social and economic sectors such as agriculture, energy, water management, construction, transport, finance, tourism, recreation, and public health are directly affected by temperature, precipitation and other weather conditions. GEOSS will address these diverse needs by integrating weather data with the growing number of Earth observation data sets available in such fields as biodiversity, health, energy, and water management. This will greatly expand the range of uses to which weather information and forecasts can be put. Achieving this goal will require developing common interfaces and data formats and increasing collaboration amongst experts in wide range of scientific and socio-economic disciplines.

The Group on Earth Observations (GEO) is working with the weather community to boost the quality and value of weather data. GEO is supporting efforts to fill in critical data gaps; advocating support to decisions makers in developing countries eager to make better use of weather forecasts; promoting training, education and other capacity-building initiatives; supporting WMO's plans for establishing new regional weather centers and networks; and encouraging the coordination of regional in-situ weather observation networks.

GEO is also contributing to improvements in weather and climate forecasting. The THORPEX Interactive Global Grand Ensemble project, or TIGGE, aims to accelerate improvements in the accuracy of one-day to two-week weather forecasts. Better forecasts will support early warning systems for risks and natural hazards and the management of health, energy and other issues. (See graphic overleaf.)

A project on the 2008 Beijing Olympics illustrates some of the benefits GEO can bring. Implemented by the Government of China and WMO together with several meteorological offices from affected countries, the project seeks to reduce the risks of high-impact weather events. Researchers, operational teams and end-users are collaborating to interlink major advanced numerical weather-prediction systems from around the world. This demonstration project will be extended to future Olympic Games to ensure that storms, pollution and other extreme events do not unnecessarily disrupt these high-profile global events.



Evolution of forecast skill for the northern and southern hemispheres: 1980-2004. Anomaly correlation coefficients of 3, 5, and 7-day ECMWF 500-mb height forecasts for the extratropical northern and southern hemispheres, plotted in the form of running means for the period of January 1980-August 2004. Shading shows differences in scores between hemispheres at the forecast ranges indicated (from Hollingsworth, *et al*. 2002 as featured in Thorpex International Science Plan, November 2004).

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Information Sheet 9

Managing ecosystems for conservation and sustainable use

Terrestrial, coastal and marine ecosystems provide essential socio-economic and environmental benefits. Ecosystems the world over, however, are under tremendous stress from rapid land-use change, pollution and the overexploitation of natural resources. Unfortunately, current systems for monitoring forests, coastal areas, wetlands, deserts and other ecosystems suffer from numerous gaps and weaknesses. As a result, these monitoring systems cannot adequately support efforts to revive, protect or manage ecosystems.

The Group on Earth Observations (GEO) aims to strengthen ecosystem monitoring through the Global Earth Observation System of Systems (GEOSS). The development of GEOSS will improve spatial information on ecosystem conditions and trends. It will generate a wide variety of ecosystem data, for example on leaf area, primary-production levels, and energy and water exchange, and combine them with supporting data on topography, land use, geology, soils and climate. These integrated data sets will feed into decision-support tools in the form of high-resolution maps, allowing decision makers to monitor the sustainability of ecosystem services such as flood control and sustainable timber harvests.

An expanded and coordinated network of land, ocean and coastal monitoring systems will produce information of the required breadth and depth. More and better sensors and platforms for observing ecosystems are urgently needed. Many ecosystem parameters can only be monitored through highly specialized techniques such as synthetic aperture radar and hyperspectral imagers, molecular tools for studying microbial ecology, and underwater laser imaging and scanning instruments. Many other sophisticated technologies are now available or under development.

Governments are collaborating through GEO to classify and map ecosystems. An ad hoc Ecosystems Classification Task Force has been established to create a globally agreed, robust, and viable global classification scheme for ecosystems. It aims to establish links to existing classification databases and to spatially delineate and map ecosystems once they have been classified. Many of the activities are being carried out at the regional level. The work on US ecosystem footprints, for example, is close to completion, with landforms and bioclimates now mapped for the entire country. China has launched the China GEOSS Ecosystems Mapping Project, and Australia will soon launch its own national activity. Meanwhile, the US Geological Survey and a number of African institutions are engaged in the most rigorous effort to date to classify and map African ecosystems.

A project on Earth Observations for Protected Areas Monitoring will assist managers by delineating and updating the boundaries of protected areas. Although there are well over 100,000 protected areas in the world – and the total area of parks and reserves continues to grow – their conservation value, the degree of protection they truly provide, and their role in protecting ecosystems and species are not well understood. Part of the challenge is that these areas are managed by a broad range of organizations with differing objectives, resources, capacities, and thematic and geographic priorities. This project will reinforce GEOSS by improving the characterization, mapping, and monitoring of protected areas. It will also support efforts to predict the impact of environmental and other change, disseminate Earth observation data and information

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to protected-area planners and managers, and increase the amount of data and information that is interlinked and shared. Much of this work will also be relevant to areas lacking official protection.

The Integrated Global Carbon Observation project is developing a global carbon-observing system. The aim is to link together existing regional networks and to improve in-situ observations of atmospheric carbon dioxide, its absorption by the oceans, and the resulting acidification of ocean waters. The project has already established global standards for data-basing flux data, the post-processing of flux data (including correction, gap-filling and error removal), and flux-site ancillary data.

Further activities for improving ecosystem observations are planned or under way. Next steps include setting up an Ecosystem Observation Network, developing land-surface parameters, establishing a global sampling frame for ecosystems, improving the monitoring and assessment of desertification, and coordinating global, regional and national forest monitoring programs.

Key ecosystem Services

Provisioning Services	Regulating Services	Cultural Services
Products obtained from ecosystems • Food • Freshwater • Fuelwood • Fibre • Biochemicals • Genetic resources	*Benefits from regulation of ecosystem processes* • Climate regulations • Disease regulation • Water regulation • Water purification • Pollination	*Nonmaterial benefits obtained from ecosystems* • Spiritual and religious • Recreation and ecotourism • Aesthetic • Inspirational • Educational • Sense of place • Cultural heritage
Supporting Services		
Services necessary for the production of all other ecosystem services		
• Soil formation	• Nutrient cycling	• Primary production

Source: Millennium Assessment, 2005

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Information Sheet 10

Promoting sustainable agriculture

Greater food security is essential in a world where some 830 million people are chronically undernourished. The causes of this widespread malnutrition are often complex but are primarily linked to poverty. Increasingly variable climate conditions also play a role, particularly in the African subcontinent, where desertification and irregular rainfall can combine with economically challenging conditions to exacerbate the spectre of hunger.

The Global Earth Observation System of Systems (GEOSS) will help to alleviate this humanitarian crisis. It will support decision makers by collecting and disseminating data on poverty, food supplies, and the management of productive lands and ocean areas. Benefits will include early warning of droughts and floods, more adaptive and precise farming practices, and the improved management of fisheries and grazing lands. Enhanced and comprehensive Earth observations will also enable international relief organizations to plan their activities more effectively.

Like all cross-cutting issues addressed by GEOSS, agriculture will benefit from integrated data sets. Farmers will greatly benefit from information culled from a variety of sources, such as short-term and seasonal weather forecasts, early warnings of storms and other extreme events, trends in water supplies, forecasts of climate variability and climate change and their potential impacts, and the outlook for market demand. GEOSS is being designed to integrate these and other data while facilitating their use in forecasting models for agricultural management and crop simulation.

Accurate measurements of biomass are needed for a variety of purposes. Biomass – the total amount of living material in a given habitat or population – is a critical variable for understanding and managing agriculture, forestry, fisheries, and aquaculture. Estimates of global primary productivity are key to understanding climate change and the role of terrestrial and marine biomass in the all-important carbon cycle. Accurate measurements are also an essential input for predicting and managing fire hazards. The ability to characterize and more accurately measure various types of biomass is particularly vital in many developing countries.

The Group on Earth Observations (GEO) is bringing together researchers, managers, and decision makers via an Agricultural Monitoring Community of Practice. This informal group seeks to enhance the global mapping and operational monitoring of the changing distribution of cropland and associated cropping systems, the timely reporting of national agricultural statistics, the accurate forecasting of shortfalls in crop production and food supplies, and the early warning of pending famines.

GEO is also promoting international collaboration through a Forest Community of Practice. This Community is concerned with integrating international efforts to assess and monitor the status of and changes in forests based on a combination of ground and satellite observations. Its participants include UN bodies such as the Food and Agriculture Organization and the UN Environment Programme, the European Commission's Joint Research Centre, the International Geosphere-Biosphere Programme, the European Space Agency, and Global Observation of Forest and Land Cover Dynamics.

Greater investments are needed for improving the quality of Earth observations for agriculture. Emerging gaps in satellite coverage of agricultural areas and activities urgently need to be addressed. There is also a strong demand for more trained personnel and dedicated funding to support the integration of in-situ and remote-sensing data. The recovery and archiving of data in developing countries is another critical issue. GEO aims to design training modules for developing countries on how to integrate remote-sensing and in-situ observation networks and establish frameworks for characterizing, assessing, and monitoring key variables. GEO is also actively promoting investments in observations for four main areas: land resources (land use and degradation, crop production, soil characteristics, and forestry); freshwater resources (irrigation, groundwater resources, aquaculture); ocean and coastal resources (aquaculture, shellfish, fish); and socio-economic conditions (population distribution, production intensity, food provision, and cultural heritage).

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Information Sheet 11

Establishing a Biodiversity Observation Network

Monitoring biodiversity trends is critical to the conservation and sustainable use of the world's biological resources. The international community has adopted a series of conventions for protecting threatened and endangered species, combating invasive alien species and animal-borne diseases, maintaining the diversity of species and ensuring that biodiversity is used sustainably. Decision makers can implement the Convention on Biological Diversity, the Convention on the Conservation of Migratory Species, the Ramsar Convention on Wetlands, the Convention on International Trade in Endangered Species (CITES), the UN Framework Convention on Climate Change and the UN Convention to Combat Desertification more effectively if they have ready access to comprehensive, high-resolution and near-real-time data and analyses on all aspects of the world's biological diversity.

The Global Earth Observation System of Systems (GEOSS) will greatly improve the quality and quantity of information about biodiversity. GEOSS will link together the world's many stand-alone biodiversity monitoring systems. It will connect them to other Earth observation networks that generate data of relevance to biodiversity, such as climate and pollution indicators. At the same time, the Group on Earth Observations (GEO), which is coordinating the construction of GEOSS, serves as an advocate for investments in biodiversity observation systems. Greater investment is essential to ensuring the adoption of new and emerging technologies for monitoring species populations, modelling changes in biodiversity and filling in the many gaps in biodiversity observations.

The Biodiversity Observation Network will serve as the biodiversity arm of GEOSS. Constituting an essential component of the emerging "system of systems", "GEO BON" will bring together the many observing instruments and systems now tracking trends in the world's genetic resources, species and ecosystems. It will create a global platform for integrating biodiversity data with data on climate and other key variables. It will fill gaps in taxonomic and biological information and speed up the pace at which information is collected and disseminated. It will ascertain the data requirements of user groups, review and prioritize research, facilitate interoperability among observation systems and databases, generate regularly updated assessments of global biodiversity trends, design decision-support systems that integrate monitoring with ecological modelling and forecasting, and make data and reports available to users via GEOSS. The GEO Biodiversity Community of Practice is preparing to launch the Biodiversity Observation Network in 2008.

The Biodiversity Observation Network will monitor the spread and retreat of invasive alien species. One of the most advanced biodiversity components of GEOSS is the Global Invasive Species Information Network. Biodiversity information managers have recently developed a prototype system that searches and integrates data across diverse invasive-species information systems. This allows users to search across existing on-line databases. The team continues to work through GEO to standardize the system's user interface.

The Global Biodiversity Information Facility, or GBIF, forms another significant contribution to the Network. The mission of GBIF is to monitor and model the ways in which species and ecosystems respond to climate change. GBIF is capturing historical biodiversity data and digitizing them. It is also making biodiversity and climate data and models interoperable so that biodiversity data can be combined with climate and weather data from the World Meteorological Organization Information System. For example, an analytical technique known as Ecological Niche Modelling is being developed to map out how the distribution of Canadian and Alaskan butterfly species is likely to evolve in response to various climate change scenarios.

Additional components of the Biodiversity Observation Network will be developed over the next few years. A key priority is establishing an enhanced ability to identify ecosystems that are unique or highly diverse; that support migratory, endemic or globally threatened species; that are of socio-economic importance; and that can support the 2010 target for reducing the rate of biodiversity loss as agreed under the Convention on Biological Diversity. Work is also ongoing to develop a Census of Marine Life, assess the potential for protected areas in Africa, and establish an Ecological Model Web for improving model interoperability and thus ecological forecasting.

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Information Sheet 12

Architecture, data-sharing principles and interoperability

The Global Earth Observation System of Systems (GEOSS) will revolutionize decision-making by integrating data from a wide variety of sources. All too often, the observation data needed by decision makers is difficult or costly to access. These data may be incomplete, out of date or presented in an inconvenient format. GEOSS will improve the quantity and quality of environmental information by making the world's observation systems "interoperable". This will make it possible, for example, to combine the broad spatial coverage that is one of the great advantages of satellites with the precision of in-situ instruments located in the ocean or on land.

The emerging "architecture" of GEOSS will ensure the compatibility of different types of data. Architecture refers to the fundamental design and operational structure of a system and its components. The components of GEOSS include numerous in-situ, airborne and space-based Earth observation systems; data-assimilation centres for collecting and processing the raw data needed by modellers and researchers; computerized models of the oceans, atmosphere and other Earth systems; systems and services for distributing data; and decision-support tools and other products for end-users. These various instruments and systems need to be configured so that they can exchange information with one another and provide the integrated data and information products that decision makers need.

The Group on Earth Observations (GEO) is drafting "interoperability" standards for GEOSS. Based on non-proprietary, formal international standards, the agreed technical specifications will facilitate the collection, processing, storage and dissemination of shared data, metadata and products. Because the individual systems comprising GEOSS maintain their own mandates and operational independence, GEO seeks to standardize only the interfaces through which GEOSS components connect with one another. This will also minimize any potential impact on non-GEOSS systems that do not choose to reconfigure their own architecture. Guidance documents will assist managers to transition GEOSS components towards interoperability. A formal registry will describe the components, services and standards that constitute GEOSS.

Some parts of GEOSS are taking additional measures to become interoperable. For example, to facilitate the creation of in-situ observing networks, GEO has defined an infrastructure for sensor webs, defined as networks of spatially distributed sensor platforms that communicate with one another wirelessly. Similarly, the Committee on Earth Observation Satellites is developing a "Virtual Constellations" concept aimed at addressing gaps in observations by coordinating and linking outputs from the different satellite networks.

The participating systems in GEOSS will be guided by three key Data Sharing Principles. These principles all aim to improve the quality and availability of Earth observations. The first principle calls for the full and open exchange of data, metadata and products within GEOSS, accompanied by the simultaneous recognition of relevant international instruments and national policies and legislation. The second states that all shared data, metadata and products should be made available with a minimum time delay and at minimum cost. The third seeks to encourage producers to supply all shared data, metadata and products to research and education institutions free of charge or at the cost of reproduction. GEO has published draft Implementation Guidelines for these GEOSS Data Sharing Principles.

Data formats need to be standardized so that data can be combined and presented in a meaningful way. The underlying formats of such diverse data sets as base maps, land-use trends and socio-economic variables need to be harmonized. In particular, an accurate, homogeneous and stable global geodetic reference frame is needed to ensure that the observations produced by different systems are comparable. Establishing a common Digital Elevation Model (DEM) is similarly vital for the consistency of data. GEO will develop a guidance document on standardizing the format, precision, accuracy and other parameters of basic geographic data, taking into account relevant national, regional and global initiatives. It is also developing a GEOSS Data Quality Assurance Strategy and GEOSS Calibration and Validation Guidelines.

The harmonized outputs of GEOSS will be disseminated via a 'GEOPortal'. Currently under development, the GEOPortal will rely on standardized interfaces for presenting data to decision makers and other users of Earth observations. A single entry point will permit these users to access a wide range of harmonized data sources. The GEOSS Clearinghouse that underlies the GEOPortal will also require a minimum set of standard interfaces and metadata content.

Dedicating particular radio frequencies to Earth observations will further enhance data quality. In late 2007, the International Telecommunication Union (ITU) organized the World Radiocommunication Conference, which adopted a resolution recognizing the need to provide "for the international protection and long term availability of frequencies for terrestrial, oceanic, air-borne and space-based observations." GEO will continue to work with the ITU to ensure that other users of radio frequencies do not unintentionally interfere with Earth observation applications.

Architecture and data-sharing case example: CBERS in Africa

The Chinese-Brazilian Earth Resources Satellite Programme (CBERS) has launched a new Earth observation service that provides state-of-the-art images of the planet to end-users throughout Africa – free of charge. This service will empower governments and organizations in Africa to use satellite imagery to monitor and respond to natural disasters, deforestation, desertification and drought, threats to agricultural production, and health risks.

CBERS-2B, the third and most recent satellite in the CBERS series, scans the entire planet over a 26-day period with three different imaging cameras. It then transmits multi-spectral, 20-metre-resolution images and other data to three ground receiving stations in China and one in Brazil. The satellite also carries a transponder for collecting data from automatic weather stations, river gauges and other observation platforms, particularly in remote areas.

Brazil and China have signed MOUs enabling four African ground stations to download and process CBERS imagery. The data is being distributed cost-free throughout Africa via GEONETCast, a data-dissemination system that has been established by GEO, and a number of web-based distribution schemes.

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Information Sheet 13

Building capacity for Earth observations

Building a sustainable Global Earth Observation System of Systems (GEOSS) will require strengthening human skills, institutional capacities and infrastructure. Individuals need training on how to access and use Earth observation data and decision-support tools. Governments and institutions need long-term programmes that build their capacity to make decisions based on Earth observations, manage and protect natural resources and engage the private sector in these activities. Infrastructure investments are essential for upgrading and inter-linking hardware and software for acquiring, processing, interpreting and distributing observation data.

Efforts to build capacity must overcome several key barriers. Although a growing number of policymakers appreciate the importance of Earth observations, others lack awareness of how such data can improve their government's capacity for informed decision making. Other barriers that must be addressed include limited knowledge of and access to available capacity-building resources, a lack of e-learning systems for creating flexible and low-cost training and education programmes, and the difficulty of sustaining systems and expertise after they have been established.

The Group on Earth Observations (GEO) seeks to improve the efficiency of capacity-building resources by coordinating existing efforts. Its role is to serve as an honest broker that assists the providers and users of Earth observations as well as potential resource providers. GEO also collects information on current capacity-building efforts and needs around the world in order to identify gaps and possible duplication. More generally, both the donor and Earth observation communities will benefit from the implementation of GEOSS, which by coordinating Earth observations more effectively will help to leverage limited capacity-building resources.

The 2007 GEO symposium on capacity building produced the "Seville Roadmap for mobilizing resources for implementing GEOSS". The roadmap focuses on developing a global partnership and dialogue between donors and the managers and users of observation systems. The GEO Capacity Building Committee will pursue the Roadmap's goals through a practical work plan. To succeed, GEO will need to create mutual benefits by matching the strategies and priorities of potential donors with those of Earth observation users. The donor community includes governments, multilateral banks and agencies, and the private sector.

Capacity-building case example I: Cross-border training opportunities

Effective capacity building often requires taking advantage of training and education courses in other countries. Unfortunately, national accreditation systems do not always recognize foreign qualifications. This can discourage individuals from pursuing cross-border training opportunities.

Based in The Netherlands, the International Institute for Geo-Information Science and Earth Observation is actively advocating solutions to this widely recognized barrier to capacity building. It is holding a series of workshops bringing together providers of capacity building, professionals in Earth observation and experts in accreditation and quality assurance in education. Workshop participants explore the experiences of other science-education sectors, assess gaps in capacity building and identify best practices. The next step is to bring these gaps and requirements to the attention of national and regional accreditation bodies. The Institute is also exploring how to expand cross-border opportunities for capacity building through improved e-learning systems, with the eventual goal of establishing a virtual university for Earth observations.

Capacity-building case example II: Strengthening institutional networks

The Chorophyll Ocean Globally Integrated Network (ChlorOGIN) project aims to establish indicators for ecosystems and fisheries management. At some sites, it will also measure light penetration into the ocean to assist with calculating plankton primary production. The end result will include the production of decision-support tools in the form of ocean maps of chlorophyll content and sea-surface temperature.

This GEO project is contributing to institutional capacity building by facilitating the transition from the separate regional networks operating today to a globally integrated network. ChlorOGIN's effort to integrate regional networks includes a specific focus on building the capacity of institutions in developing countries.

Capacity-building case example III: The GEONETCast data dissemination system

GEONETCast is a near real-time, global delivery system for environmental information. It obtains Earth observations from the various land, sea, air and space-based systems that contribute to GEOSS. It then transmits this information to users via a network of four communications satellites.

Targeted users include developing country institutions with limited or no access to high-speed Internet. The GEONETCast team continues to engage existing and potential users to identify their priority needs and expects to provide services to almost every country in the world in the very near future. A key next step will be to link GEONETCast to other dissemination systems and to incorporate a broader range of data.

The GEO capacity-building strategy specifically identifies GEONETCast as a significant technology for advancing the capacity of Governments and institutions to exploit Earth observation infrastructure more effectively. It also sees the system as an efficient means for exchanging and distributing training resources to a larger number of individuals.

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Information Sheet 14

The role of science and technology in GEOSS

The Global Earth Observation System of Systems (GEOSS) both depends on, and contributes to, scientific and technological progress. The international goal of constructing GEOSS has been made possible by recent progress in the Earth sciences. It also rests on dramatic technological advances in observation instruments, data management and modelling. GEOSS will return the favour to science by generating the comprehensive, near-real-time and integrated Earth observation data and information so vital to future scientific progress. The science and technology community, then, is both a key sponsor and a key beneficiary of GEOSS. This community includes research and development institutions, universities, government laboratories, non-governmental organizations and industry.

Scientists continue to invent new Earth observation and measurement techniques. For example, synthetic aperture radar (SAR) interferometry, which can produce high-resolution images of the Earth's surface even at night or on cloudy days, can support Earth-observation applications previously considered impossible. In many cases, monitoring systems that have been developed to support scientific research projects come to be seen as essential for the sustained operational monitoring of the Earth system. New funding approaches must be found to transition these systems from a research to an operational mode. This requires coordinating the scientific agenda, technology development and national policy setting.

Advances in modelling are also critical to the development of GEOSS. Models simulate real-world processes. Generally run on high-powered computers, they produce homogenous data sets, test scientific theories and develop new forecasting capabilities. The scientific community has been developing more and more sophisticated, high-resolution models and data-assimilation techniques. In addition, models increasingly require large sets of data from different sources and with highly varying time and spatial scales. GEOSS will help to generate these data and provide a framework in which to coordinate modelling activities across the nine societal benefit areas of GEOSS.

Science and technology are also driving advances in data handling, processing and visualization. The raw data obtained from observation instruments needs to be manipulated in various ways to assist the work of modellers, forecasters, analysts and policy makers. Progress continues to be made on sophisticated manipulation procedures such as algorithm techniques, semantic interoperability and data visualization.

Gaps and overlaps in observations, research and systems development will be identified through GEOSS. By collaborating through the Group on Earth Observations (GEO) to establish goals for GEOSS, decision makers and scientists can link societal needs and research priorities. Such interaction can also accelerate the introduction of policy-relevant scientific techniques and technologies into observation systems. GEO can help set funding priorities by connecting public and private investors to the science and technology community.

GEOSS can provide the framework and stability needed for ensuring long-term time series of observations. The provision of long time-series of Earth observations from in-situ, airborne and satellite monitors is fundamental to progress in the Earth sciences. Such observations are crucially important for detecting decadal and centuries-long trends in climate, biodiversity and land use. For example, scientists have defined continuity and quality criteria for observational data under the

"Global Climate Observing System climate monitoring principles". Ensuring the reliable detection of slow-evolving trends also requires that data be well calibrated and cross-calibrated with data from other sources. GEO can further support the sustainability of long-term measurements by advocating for this critical issue with relevant funding agencies.

The Earth sciences will also benefit from improved access to and harmonization of data. GEOSS will facilitate easy access to data from a wide range of sources. By making these sources "interoperable" and harmonizing data formats and parameters, it will greatly improve the ability of researchers to integrate the various data they need for a more comprehensive view of the Earth system.

The science community is becoming more and more engaged in implementing GEOSS. A growing number of GEO Work Plan Tasks and activities are being incorporated into the programmes and strategies of research institutions. Many of the international organizations involved in shaping and implementing science and technology research programmes have already joined GEO as Participating Organizations or are contributing to the work of the GEO Science & Technology Committee. Increasingly, a connection to GEO is seen to strengthen the credibility of a scientific programme or activity and becomes an asset for fund raising. The continued engagement of the scientific community in the construction of GEOSS is critical to achieving further breakthroughs in our understanding of the Earth system and its impact on human well-being.

This information sheet is based on "The Role of Science & Technology in GEOSS", a paper prepared by the GEO Science & Technology Committee.

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