



REPORT ON PROGRESS
BEIJING MINISTERIAL SUMMIT
OBSERVE, SHARE, INFORM

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Preface

The second GEO Ministerial Summit marks the half-way point in the Global Earth Observation System of Systems (GEOSS) 10-year Implementation Plan. In Beijing, Ministers are receiving a Mid-Term Evaluation Report that rigorously assesses GEO's accomplishments and shortfalls. They are also reviewing a number of achievements and "showcases" of GEOSS implementation and finalizing the Beijing Declaration.

The following Report on Progress is being presented to the Beijing Ministerial and the GEO-VII Plenary as an information document. Part I provides a broad overview of the progress that the Group on Earth Observations (GEO) has made since 2005 in launching and developing the Global Earth Observation System of Systems.

Part II summarizes the contributions that hundreds of government agencies and national and international organizations and institutes have made through the GEO Work Plan. It features short updates from the teams responsible for the Work Plan's 44 overarching Tasks on the achievements and outputs of each Task (including their associated sub-Tasks). When compared to "The First 100 Steps" presented as part of the Report on Progress to the first GEO Ministerial Summit, held in Cape Town in 2007, this section clearly demonstrates the growing levels of coordination, investment and commitment behind GEOSS implementation.

To place the progress achieved in context, the refined GEOSS targets accepted at GEO-VI have been annexed to this report. These strategic targets provide direction for the Work Plan and reflect the GEO community's strong commitment to accelerating the construction of GEOSS.

Table of Contents

	3	Preface
7	PART I - BUILDING GEOSS: 2005 - 2010	
	8	Executive summary
	9	Introduction: responding to global challenges
	10	Mobilizing the Earth observation community
	12	Engaging and supporting users
	14	Attracting financial and in-kind resources
	15	Building the GEOSS backbone
	17	Providing services for decision makers
	21	Sustaining GEOSS
23	PART II - ADVANCING THE GEO WORK PLAN: REPORTS FROM THE TASK TEAMS	
25	GEOSS INFRASTRUCTURE AND DATA	
	26	How users access GEOSS data and information via the GEO Portal
	29	Making the System of Systems interoperable
	31	Advocating for sustained global observing systems
	33	Establishing the GEONETCast Global Data Dissemination System
	35	Protecting radio frequencies for Earth observations
	37	Implementing the GEOSS Data Sharing Principles
	39	From observations to information products and services
	41	Promoting “data democracy” around the world
	45	Developing cross-cutting Earth observation products and services
	47	Building global data sets for universal use
51	SOCIETAL BENEFIT AREAS	
	52	Accessing satellite data for monitoring and managing risk
	54	Improving vulnerability mapping and risk assessment for geohazards
	57	Crafting regional end-to-end solutions for disasters management
	59	Strengthening early warning systems for wildfires
	61	Using environmental data to address health risks
	63	Monitoring and predicting environmental impacts on health
	66	End-to-end services on health and environment
	69	Developing tools for managing renewable energy
	71	Monitoring the environmental impact of the energy sector
	72	How GEOSS supports energy planning
	74	Reanalyzing historical data for improved climate modelling

- 75 Collaborating on weather and climate information
- 76 Accelerating the implementation of the Global Climate Observing System (GCOS)
- 80 Towards a Global Carbon Observation and Analysis System
- 83 Improving flood, drought and water-resource management
- 85 Building capacity for managing water resources
- 87 Providing integrated products for water resource management and research
- 90 Improving global weather forecasts for early warning
- 92 Building capacity for high-impact weather prediction
- 94 GEO's EcoNet ecosystem observation and monitoring network
- 96 Ecosystem Vulnerability to Global Change
- 98 Applying Earth observations to fisheries and aquaculture
- 100 Towards a global agricultural monitoring system of systems
- 102 Developing a global Biodiversity Observation Network

105

USER ENGAGEMENT AND CAPACITY BUILDING

- 106 Training individuals to analyze and use Earth observations
- 108 Building institutional capacity to use Earth observations
- 111 Catalyzing research and development (R&D) funding for GEOSS
- 113 The social and human dimension of GEOSS

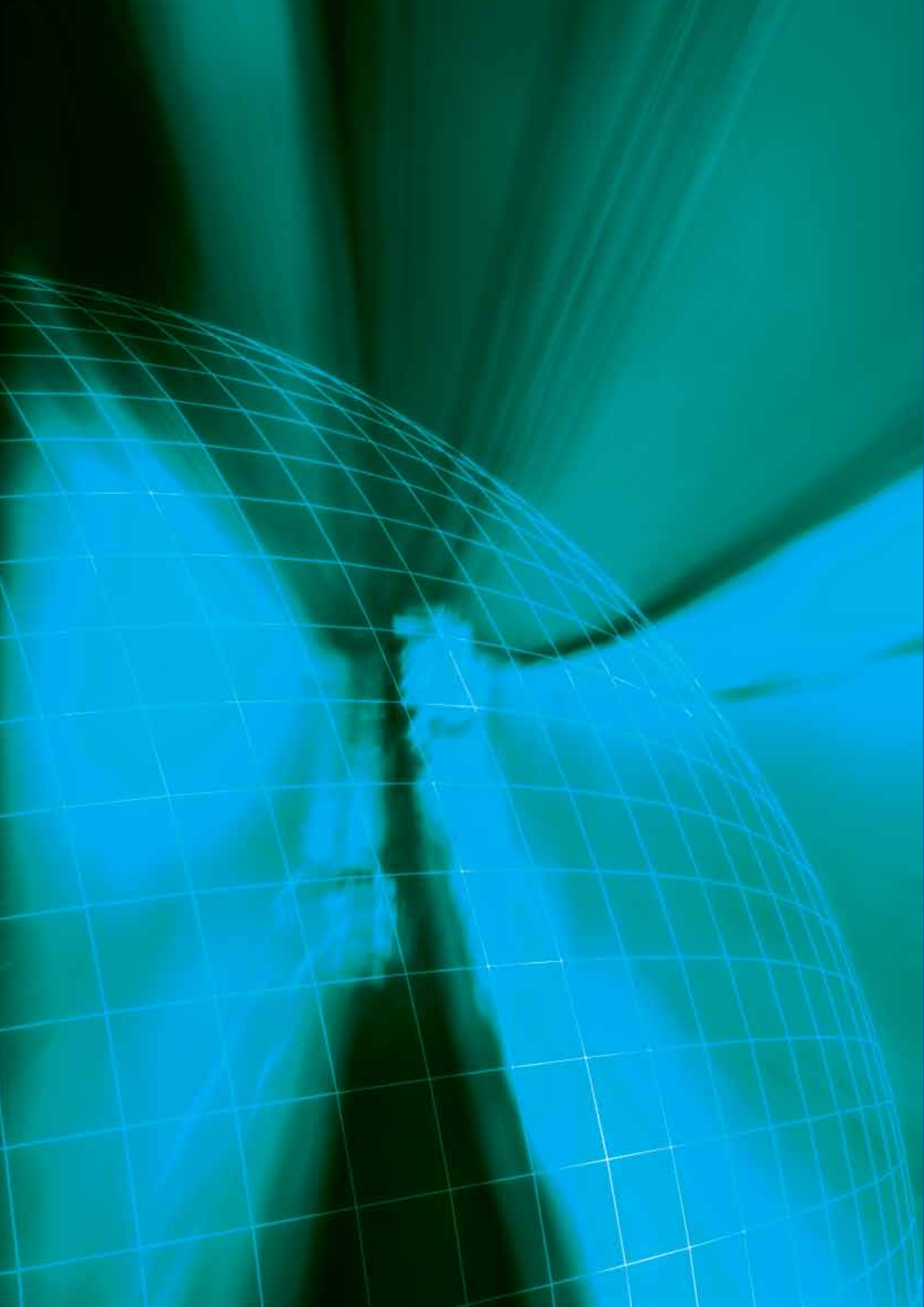
115

SCIENCE AND TECHNOLOGY

- 116 Engaging the science and technology community
- 118 Building Communities of Practice

125

ANNEX - STRATEGIC TARGETS FOR GEOSS THROUGH 2015 AS ACCEPTED BY GEO-VI



PART I

BUILDING GEOSS: 2005 - 2010

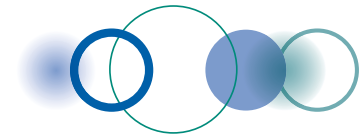
Executive summary

The Group on Earth Observations (GEO) has made significant progress during its first five years. The Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan for 2005 – 2015 is on track. The added value of GEO has been demonstrated by the increased coordination of Earth observation systems and investments, an accelerated trend towards the full and open sharing of data, and improved access to a broad range of data and information. An expanding portfolio of information products and services is supporting decision making on environment and development in nine Societal Benefit Areas. Many challenges, however, still lie ahead: there are projects to complete, gaps to fill and systems to sustain. These challenges are scientific, technical and – highlighting the vital role of Ministers in guiding GEOSS – institutional and political.

GEO's original membership of 61 grew by mid-2010 to include 81 national governments and the European Commission. The number of Participating Organizations grew from 43, including almost a dozen United Nations bodies, to 58. Particular progress has been made in developing Communities of Practice, which consist of experts and researchers from international organizations, national agencies and academia who share common concerns and interests, together with users and beneficiaries of Earth observations. GEO has actively reached out to user communities and built capacity for individuals and institutions to access and apply Earth observations, including the satellite-based GEONETCast system for disseminating data and information. Overall, much has been achieved in engaging the producers and users of Earth observation; at the same time, much remains to be done.

Resources continue to be channelled into GEOSS as governments increasingly align their national projects and investments with the GEOSS Implementation Plan. More and more GEO members coordinate their national strategies and investments through national GEO offices. Often, when governments announce new Earth observation projects, investments, and satellite launches, they explicitly present the news as a contribution to GEOSS. Investments in GEOSS are estimated to total some 10 billion US dollars per year. In addition, many governments as well as organizations provide funds for GEO operations and for international coordination.

The GEOSS Common Infrastructure and the GEO technical interoperability standards and formats have made it possible to integrate and disseminate data sets produced by diverse systems and instruments. The GEO Web Portal, complemented by a growing number of community portals, gives users comprehensive access to the wide range of data and services available through GEOSS. The GEOSS Data Sharing Principles, which advocate for the full and open access to data and were first agreed in the GEOSS 10-Year Implementation Plan, were reconfirmed by the 2007 Cape Town Ministerial Summit. This led directly to decisions by major satellite operators to provide unrestricted access – often cost-free – to remotely sensed data. These data, together with the information products and services made possible by in-situ data providers, modelers, and analysts, are already empowering decision makers and managers as they confront the complex and interlinked challenges of the 21st century.



Introduction: responding to global challenges

Events since the 2007 Cape Town Ministerial Summit have reconfirmed the need for a coordinated, sustained GEOSS. Earthquakes, volcanic eruptions, hurricanes and floods have continued to take lives, destroy infrastructure and disrupt economies. Concerns over climate change and the decline of biodiversity have filled headlines and conference halls. At the same time, emerging capabilities for monitoring and forecasting food, water and energy supplies have highlighted the potential benefits that operational Earth observation systems can provide.

Scientific understanding of the Earth system and its physical, chemical and biological components continues to improve every year. But more data is urgently needed for monitoring trends and predicting how physical and ecological systems will evolve. As humanity places ever greater demands on the Earth's resources over the coming years and decades, a greater ability to understand global change and predict how natural systems will respond to human activities and policies becomes ever more vital.

Recognizing the need for better environmental information, political leaders at the 2002 World Summit on Sustainable Development in Johannesburg called for urgent action on Earth observation. Earth observation summits in Washington, Tokyo and Brussels and declarations by three of the annual Group of Eight (G8) summits built on this momentum. Acting on a clear international consensus, Ministers established GEO in 2005 with a mandate to build a Global Earth Observation System of Systems, or GEOSS.

To establish this "system of systems," governments and organizations have been interconnecting their observing, decision-support and dissemination systems and services. They have formed partnerships to fill gaps in observing systems, promoted full and open access to data and information, developed interoperability and other technical standards, built the capacity of users to access GEOSS, and nurtured new cross-cutting and multi-disciplinary data sets. All systems, products and services contributed to GEOSS and generated by GEO are dedicated to the global public good; they remain under the authority and ownership of the countries and agencies that produce them.

The cross-cutting data, decision-support products and end-to-end information services that are increasingly available through GEOSS are improving the ability of governments to promote "green" economic growth, manage natural ecosystems and resources, ensure food security for a global population that may reach nine billion people by mid-century, respond more effectively to disasters, and address climate change, biodiversity loss and other global challenges.

Mobilizing the Earth observation community

From an original membership of 61 in 2005, GEO now includes 81 national governments and the European Commission as well as several observers. The number of Participating Organizations has increased from 43 to 58. Cooperation and dialogue within the GEO community has broadened and deepened over the past five years, and GEO is increasingly acknowledged in public statements and articles.

GEO's governance structure is in many ways unique. All contributions are voluntary and provided to GEO on a best-efforts basis. The partnerships and teams that together implement the GEO Work Plan are inclusive and open to all interested contributors. Because GEO has high-level political support and is the world's broadest and most inclusive forum for Earth observation and environmental monitoring, it has succeeded in facilitating many new partnerships that would not otherwise have existed. Cooperation on Earth observation is often complicated by political, institutional and technical barriers; overcoming these barriers requires trust and human and financial resources. The new levels of cooperation and partnership that GEO has inspired are already changing the way governments approach the development of new Earth observation programmes and infrastructure.

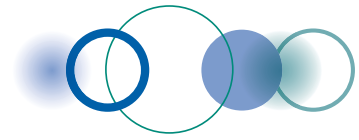
Contributions to GEOSS have steadily increased and broadened over the past several years. Many have been delivered through government-to-government cooperation. For example, the increasingly effective cooperation amongst the member space agencies of the Committee on Earth Observation Satellites (CEOS), which

Showcase: Space observations for water management in Asia/Oceania

Over the past several years, the countries of Asia-Oceania have dramatically increased their space-based capabilities for monitoring water resources and other critical sectors. For example, China continues to launch the Feng Yun series of meteorological satellites and new ocean-monitoring and Earth-resources satellites; it has also contributed the CMACast (FENGYUNCast) system to the GEONETCast data dissemination system.

India has launched the Indian Remote Sensing satellites, Earth resource satellites, the stereoscopic Earth observation satellite, and the Indian National Satellite Telecommunication System. Japan's major space resources include the Greenhouse gases Observing SATellite, the Tropical Rainfall Measuring Mission, the Advanced Land Observing Satellite, the Global Precipitation Measurement mission and the Multi-functional Transport Satellite. Thailand is using the Thai Earth Observation Satellite for supporting natural resource management in the region as well as disaster mitigation.

By collaborating through the Committee on Earth Observation Satellites (CEOS), the space arm of GEO, these national satellite programs are contributing to regional and global societal benefits, including improved management of water resources and disasters. For example, 20 countries in the Asia-Pacific region are cooperating through the Asian Water Cycle Initiative to strengthen decision making on water resources, while Sentinel Asia is promoting the sharing of information on floods and other disasters across the Asia-Pacific region.



serves as the space arm of GEO, has led to vital support for GEO activities, in particular those on earthquake assessment and forest monitoring. The coordination of national in-situ observation networks has advanced significantly at the continental scale in Asia and Africa.

GEO has also greatly benefited from the growing contributions of Participating Organizations and the many other organizations that, though not part of the GEO Plenary, contribute to GEOSS implementation. GEO aims to draw these organizations into the wider GEO framework where they can benefit from, and contribute to, GEOSS, while fulfilling their own well-established mandates. Ongoing efforts to engage the science and technology community in developing, implementing and using GEOSS are being strengthened to ensure that GEO benefits from the best possible scientific and technological advice.

Engaging and supporting users

Ensuring that the information generated by and supplied through GEOSS satisfies real needs and demands is essential for justifying, sustaining and guiding investments in Earth observation systems. GEO has therefore actively reached out to user communities and built capacity for individual users to access GEOSS and apply Earth observation data and information.

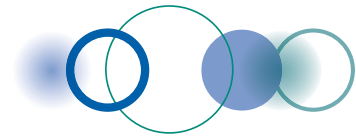
A growing number of Communities of Practice have coalesced around the GEO banner. By creating and nurturing these Communities of Practice, GEO has succeeded in engaging many people and institutions that are both contributors to and users of Earth observations. These Communities consist of experts, researchers and information users from international organizations, national agencies and academia who share common concerns and interests.

Encompassing diverse mandates and thematic specializations, dozens of leading monitoring bodies came together in 2007 to establish the GEO Biodiversity Observation Network (GEO BON). Other Communities of Practice established since 2005 focus on energy (2006), coastal zones (2006), health and environment (2009) and air quality (2009). Several Communities of Practice were initiated at least in part under the earlier Integrated Global Observing Strategy (IGOS) Themes and have transitioned into GEO. They address

Showcase: Capacity building for food security

GEO is building the capacity of governments and organizations to access and use Earth observation data and information in order to deliver local, national and regional support services. The satellite-based GEONETCast system has proven a particularly powerful tool for improving capacity for using Earth observations, while the trend towards “Data Democracy” has amplified opportunities for accessing and utilising data. For example:

- The National Food Supply Agency of Brazil’s Ministry of Agriculture contributes to the regularity of food supply and the income of agricultural producers. It supports local producers with bulletins providing information on the main Brazilian crops, including sugarcane, soybean, corn and coffee, using data obtained through GEONETCast. This information is used by local producers for making production, and thus their own incomes, more secure.
- Kenya’s Regional Center for Mapping of Resources for Development (RCMRD) obtains data needed for building capacity in agriculture. The data are used to derive a number of indicators for prediction and for improving governance within local communities, which foster the security of food production. The results that have been achieved are also recognized at the political level.
- Water supply and use is a problem for many farming communities in Rajasthan, India. Scientists originating from these local communities support regular training and provide information to farmers and others on the use of Earth observation with the aim of helping these communities better manage water resources and so boost food-production security.



forests (2006), geohazards (2006), global agricultural monitoring (2007), the carbon cycle (2009), and the integrated global water cycle (2009). Despite their unique histories and interests, each of these Communities has adopted GEO's core principles and highly values the link that GEO provides to the broader Earth observation community.

Improving access to data is a first vital step for engaging and empowering users. As described below, GEO has established the GEO Portal, numerous community web portals, the satellite-based GEONETCast dissemination system, and the GEOSS Data-Sharing Principles for the full and open access to data. Open access to particular data sets, including China-Brazil Earth Resources Satellite (CBERS) data, the Landsat archives, and China's rainfall data from 150 radar sites, has also greatly benefited users.

Specific activities for building capacity to interpret and apply Earth observations have included the development of a half dozen GEO "summer schools" for training individuals in various aspects of Earth observation as well as a series of outreach and training workshops. Outreach activities, such as electronic newsletters and popular atlases illustrating global environmental change, have helped to inform users about the benefits of Earth observation.

GEO, then, has made significant efforts to engage users and build their capacity to use GEOSS; nevertheless, much more work will be needed over the next few years to achieve a critical mass.

Attracting financial and in-kind resources

Mobilizing resources for GEOSS implementation and ensuring that they are effectively used is a major priority for GEO. The resources invested in GEOSS implementation over the past five years can be grouped into three categories:

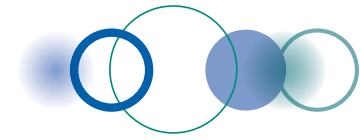
1. The major systems, networks and other components of the system of systems that have been contributed by Members and Participating Organizations, which constitute by far the largest investment in GEOSS and cost billions of US dollars a year;
2. The programmes dedicated to GEOSS implementation and facilitation, which cost tens or hundreds of millions of dollars a year; and
3. The GEO Trust Fund and support to workshops and other GEO activities, which costs several millions.

GEOSS leverages the combined investment made by GEO Members in Earth observation satellites, ocean vessels, in-situ networks, computing centers, research and operations. This total investment is estimated to be of the order of 10 billion US dollars per year. Often, when governments announce new Earth observation projects and investments, they explicitly present the news as a contribution to GEOSS.

Resources are channelled directly into GEOSS as governments increasingly align their national projects and investments with the GEOSS Implementation Plan. Last May, for example, the United States announced that it was repositioning its Geostationary Operational Environmental Satellite (GOES-12) over South America as a contribution to GEOSS. In 2007 South Africa launched its Earth observation strategy (SAEOS) as a contribution to GEOSS. The European Commission coordinates many European investments in GEOSS, including the Global Monitoring for the Environment and Security (GMES) program and projects funded by the 7th Research Framework Programme (FP7). Globally these various investments likely total hundreds of millions of US dollars annually.

Many governments and a few organizations are providing funds for GEO operations, seconding staff, and facilitating workshops and other mechanisms for international coordination. Up to 20 Members contribute to the GEO Trust Fund and second experts to the Secretariat. China, Germany, Romania, South Africa, the United States and the World Meteorological Organization (WMO) have funded and hosted annual plenary meetings. The European Commission and many countries have supported committee meetings, workshops and the travel of developing country participants. A growing number of GEO Members have established national GEO offices to coordinate their national strategies and investments, including Canada, Costa Rica, Germany, Greece, Japan, Pakistan and the United States. These activities are critical for leveraging the major investments described above, maximizing synergies and minimizing duplication.

The GEO community is taking additional measures to attract funding to the development and use of GEOSS. In February 2009, GEO issued a Call inviting organizations to propose or participate in projects that apply Earth observations to decision-support activities. Over 66 full proposals were received and reviewed, and GEO is working to broker connections between resource-providing organizations and these proposed projects. GEO also continues to reach out to research funding agencies, including through the Belmont Initiative, to encourage them to finance the Earth system science research required for GEOSS implementation.



Building the GEOSS backbone

In 2007, when Ministers met in Cape Town for the first GEO Ministerial Summit, they provided guidance to the GEO community on developing a common infrastructure for improving access to data through GEOSS, establishing technical standards for making data interoperable, and putting the GEOSS Data Sharing Principles into effect.

The GEOSS Common Infrastructure (GCI) will be presented to the GEO community as an operational system for the first time this year in Beijing. It will provide a sustained entry point to GEOSS data and resources via a dedicated web portal. As of mid-2010, over 300 data bases, information services and other resources have been registered in the GCI. Several large surveys of users have been conducted to assess and improve the portal's user interface. After a detailed selection process, a decision was taken in July 2010 on choosing the agencies that are to be responsible for assuring the development and maintenance of the GCI. With the European Space Agency as the dedicated provider of the GEO Portal and the US Geological Survey as the provider of the GEOSS Clearinghouse, work will accelerate on increasing the resources that can be searched through the GCI. The aim is to make the GCI a uniquely essential tool for finding multi-sectoral geospatial information at the national, regional, continental and global scales.

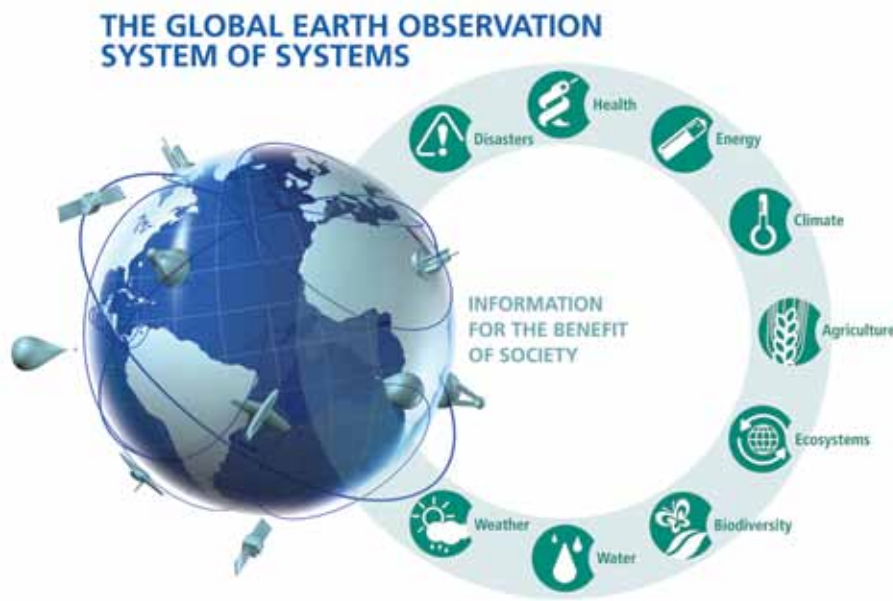
This comprehensive GCI is being developed at the same time as a growing number of focused “community portals”. These portals are emerging to meet the particular needs of individual communities and to develop solutions targeted to these specialized users. By aligning themselves with the consistent standards and registries developed for the GCI, community portals are able to draw on and benefit from all GEOSS information resources. At the same time, the GCI benefits from being able to direct users to the depth of information and the unique tools that these portals offer. At least a dozen emerging community portals, including those for Forest Carbon Tracking, OneGeology and ChloroGin, have developed a strong presence over the past several years.

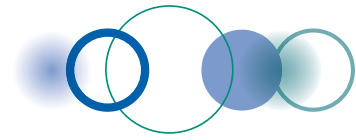
In addition to web portals, users can access the GEONETCast system, whereby data and information are broadcast via telecommunication satellites to inexpensive receiving stations. It is used to deliver all types of operational products and services, and it supports high volume, guaranteed timeliness and high availability. It is particularly applicable for receiving Earth observation data, products and services in those countries lacking easy access to large-bandwidth internet. GEONETCast is led by four regional infrastructure providers: Europe's EUMETSAT provides EUMETCast in Europe, Africa and part of the Americas; the China Meteorological Administration (CMA) provides CMACast (FENGYUNCast) in the Asia-Pacific region; Russia's Roshydromet provides MITRA in Asia; and the US National Oceanic and Atmospheric Administration (NOAA) provides GEONETCast Americas in the Western Hemisphere.

GEO has made progress on making it easier to integrate data from different instruments. It has promoted interoperability on the basis of open international standards and without requiring the use of proprietary products. Thanks to these standardized interoperability arrangements, many data holdings can now be searched by independent search facilities, and services from independent providers can be accessed and combined in sequence. GEO has also successfully worked with the International Telecommunication Union to protect the radio frequencies used for transmitting Earth observation data from satellites to ground stations.

The GEOSS Data Sharing Principles agreed by all Members and Participating Organizations in the GEOSS 10-Year Implementation Plan were reconfirmed by the 2007 Cape Town Ministerial Summit. The Cape

Town Declaration stated that “the success of GEOSS will depend on a commitment by all GEO partners to work together to ensure timely, global and open access to data and products.” Cape Town led directly to decisions by major satellite operators to provide full and open – and cost-free – access to satellite data. The next step on this critical issue is for the Beijing Ministerial Summit to reach a consensus on the practical steps for implementing the GEOSS Data Sharing Principles.





Providing services for decision makers

The majority of GEO activities are dedicated to developing information products and services that serve the nine Societal Benefit Areas listed below. They focus on the entire Earth observation value chain, from collecting data to assimilating and modelling them to disseminating information and using it for decision making. These services are described more fully in Part II of this Report, while a number of them are being showcased during the Beijing Summit.

By 2007, GEO had generated or attracted a diverse array of over 100 specific activities, which were presented to the Cape Town Ministerial as “The first 100 steps.” Many of these activities remain part of the GEO Work Plan which, in the three years since Cape Town, has been greatly strengthened and focused, with Tasks increasingly coordinated and aligned with one another. The Work Plan’s 44 “overarching” Tasks now represent a more strategic framework that contributes to synergies, cross-fertilization, momentum and sustainability.

Agriculture. Over the past three years, the Global Agriculture Monitoring Community of Practice has been joining together the major national and international systems for monitoring agricultural productivity and trends in order to establish a Global Agricultural Monitoring System of Systems. The GEO Joint Experiment on Crop Assessment and Monitoring (JECAM) has established seven pilot sites around the world to assess common data standards, cropland modeling methods, and future Earth observation requirements. The Societal Applications in Fisheries & Aquaculture using Remotely Sensed Imagery (SAFARI) project has identified and promoted urgent actions to strengthen the application of satellite information to fisheries and aquaculture research and management.

Biodiversity. Established in 2007, the GEO Biodiversity Observation Network (GEO BON) consists of dozens of government agencies and intergovernmental and international organizations. Based on a regularly updated implementation plan, GEO BON coordinates the gathering of data and the delivery of information. One of the first products contributed to GEO BON was the Continuous Plankton Recorder Survey. Other information

Showcase: The GEO Biodiversity Observation Network (GEO BON)

The national, regional and global organizations that are contributing to GEO BON are harmonizing their observation systems, identifying and addressing gaps and overlaps in existing coverage, and collaborating to ensure the continuity and sustainability of biodiversity information. Such increased coordination will enhance the value of existing observations as well as the effectiveness of current data gathering and analysis efforts, resulting in improved assessment and communication abilities at scales relevant to decision makers.

Examples of emerging information products and services include assessing global biodiversity change through new spatial models drawing on existing biological and environmental datasets to interpret satellite images of land and water conditions; mapping global ecosystems through a series of standardized, robust, and practical ecosystem classification maps at management-appropriate scales for terrestrial, freshwater and marine environments; and visualizing changes in ecosystem services using data from the network of International Long Term Ecological Research (ILTER) sites in 16 countries.

products are being developed through the GEO BON partnership, such as a visualization tool for African protected areas and a number of directories of global datasets on freshwater biodiversity and ecosystems. GEO BON's role and importance have been recognized by the Convention on Biological Diversity, which has also requested that it prepare an evaluation of existing observation capabilities relevant to the targets contained in the Convention's Strategic Plan for 2011-2020.

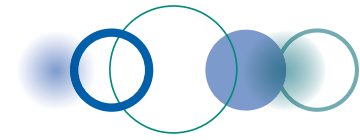
Climate. The GEO Global Carbon Observation and Analysis System is now bringing together systems and experts that monitor carbon flows on land, in the oceans and in the atmosphere. Particular progress has been made on establishing a Forest Carbon Tracking system, which has established at least 10 national or regional "demonstrators" with support from a coalition of governments and institutions. Other important progress includes continued outputs by major data-reanalysis projects based in Europe, Japan and the United States; reinvigoration of efforts to reprocess various data, especially from space, into climate data records; the 2010 update of the Global Climate Observation System (GCOS) Implementation Plan; the World Climate Research Programme's (WCRP) launch of two major modeling experiments (CMIP5 and CORDEX) to provide decade- and century-long climate predictions on global and regional scales; outputs from an intensive research programme to improve seasonal prediction worldwide; and the invigoration of the ClimDev Africa project with a \$30 million grant from the African Development Bank.

Showcase: A Global Carbon Observation and Analysis System

Understanding the global carbon cycle and predicting how it will affect future climate change is a major scientific challenge. In particular, the lack of data about how much carbon is absorbed by "sinks" such as forests and oceans is an important cause of uncertainty in climate change scenarios. Strengthening observation capabilities is therefore a major priority. This can best be achieved through international collaboration amongst the diverse communities now monitoring various components of the global carbon cycle.

The Global Carbon Observation and Analysis System is therefore bringing together systems and experts that monitor carbon flows on land, in the oceans and in the atmosphere. It will include satellite observations as well as in-situ observations from flux towers, tall towers, aircraft and ships of opportunity. This effort engages dozens of government agencies, intergovernmental and international organizations, and universities and research institutes. This is an ambitious – but essential – effort that will require further investments and commitments in the years ahead.

Disasters. A number of operational systems for supporting disaster response have made steady to strong progress. Collaborative "Supersites" have been established so that the scientific community can monitor and analyze volcanoes and earthquakes more rapidly and effectively; for example, Supersites have improved assessments of recent earthquakes in Haiti, China and Chile. SERVIR provides mapping and information services for disaster response and has assisted countries in Central America and the Caribbean to respond to hurricanes, earthquakes and other extreme events; SERVIR is now in the process of expanding its support to other regions, notably Africa and the Himalayas. Other advances include the development and contribution to GEOSS of global, regional and national early-warning and detection systems for forest fires; improved access for GEO Members to the International Charter on Space and Major Disasters and the satellite data it provides for countries of South East Asia and Latin America and, soon, Africa; and ongoing observations and reports on floods, landslides and other disasters by Sentinel Asia.



Showcase: Better knowledge about geohazards

The Geohazard Supersites initiative is a global scientific collaboration that aims to improve scientific understanding of the risks of earthquakes and volcanic events in selected regions. The Supersites currently being addressed are L'Aquila, Chile, Etna, Haiti, Istanbul, Los Angeles, Naples (Vesuvius), Seattle/Vancouver and Tokyo. The geohazard community is also working on establishing an earthquake Supersite for the disastrous 2008 earthquake in Wenchuan, China, to better understand China's worst disaster in the last 30 years.

The Supersites partnership consists of the providers of ground-based geophysical data, such as seismic and GPS data; space agencies, which provide satellite radar and other Earth observation data; along with scientists and decision makers who use and analyze these data. The initiative provides a cyber-infrastructure platform with a single web entry point that allows fast, easy and free-of-charge access to a complete satellite and ground-based geophysical data set derived from diverse sources and geophysical disciplines.

The Supersites complement the International Charter on Space and Major Disasters, which provides imagery for search and rescue operations.

Ecosystems. GEO has made important progress on developing a standardized, robust and practical classification and map of global ecosystems for terrestrial, marine, and freshwater environments. Ecosystem maps for South America, the US and Sub-Saharan Africa have been completed and are available as a framework for both researchers and managers. Global tree cover maps at 250m resolution are under development, and nearly 14,000 Landsat samples from 1990, 2000, and 2005 are being analyzed to detect changes in forested area for the benefit of forest resource managers. Other ecosystem mapping projects continue to advance, such as one on ecosystem vulnerability to climate change, which includes the vulnerability of sea basins (notably the EnviroGRIDS project on the Black Sea) and of mountain regions.

Energy. A number of data bases providing information on solar resources have been developed, including the European Solar Radiation Atlas, SoDa and Envisolar; efforts are ongoing to make these data bases fully comparable. A service for siting solar power plants has been established to provide data on time-averaged values of solar irradiance from which basic economic assessments can be made; in particular, the service supports the site selection process for large solar energy systems such as photovoltaic installations placed on open land. The EnerGEO project is using satellite data and environment and energy models to make a global assessment of the current and future impact of the exploitation of energy resources on the environment and on ecosystems. Other energy initiatives, such as those for wind power and carbon-capture-and-storage, have been launched.

Health. Working through local, regional, and international partners, the GEO community is developing a portfolio of services to help decision-makers use Earth observation data and information to prevent diseases and improve public health. Some of these services involve supporting a meningitis vaccination and control effort in Africa (MERIT) by linking forecasts of an extended dry season in the Sahel with disease outbreaks; monitoring global atmospheric mercury to establish a forecasting and alert system on health problems related to mercury; providing air-quality forecasts using on-the-ground monitoring stations, currently for 300 US cities, Shanghai (China), and soon for other cities; and using open-source software and space imagery to track potential outbreaks of epidemics.

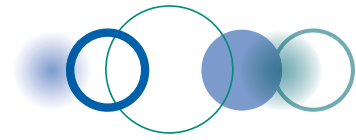
Showcase: Benefits for public health

Healthy communities are essential for social well-being, political stability and economic productivity. Scientists increasingly understand that many debilitating diseases, including malaria, meningitis, cholera, and dengue, are linked to changes in the environment. At the same time, chemicals, dust and other contaminants in our water and air cause a wide range of respiratory and other illnesses. These environmental risks to public health can increasingly be monitored, assessed and reduced through the data and information products available through GEOSS.

For example, a GEO project on biodiversity and human health is working to reduce the risk of Lyme disease and West Nile encephalitis by identifying best practices for land-use management. Global monitoring plans for atmospheric mercury and persistent organic pollutants are developing monitoring networks and baseline data to detect environmental health hazards and identify changes from climate change or other environmental stressors. The meningitis vaccination and control effort in Africa (MERIT) is linking forecasts of drought and dry spells in the Sahel with disease outbreaks in central Africa. AIRNow, an air quality-health monitoring tool, uses a network of on-the-ground monitoring stations to provide air quality forecasts for more than 300 cities in the United States; the tool is being replicated in Shanghai, China.

Water. GEO has advanced the integration of observations from satellites and in-situ instruments, strengthened collaboration within and between the water research and management communities, and promoted capacity building. The Asian Water Cycle Initiative has boosted regional cooperation on water monitoring, and the model is now being extended to Africa. The Latin American & Caribbean Community has launched a capacity building program to demonstrate the value of Earth observations in water resource management and to develop tools for applying remote sensing data. The North American Drought Monitor has generated improved regional drought assessments. The United States and Canada have inaugurated pilot drought monitoring test bed projects as a first step towards a Global Drought Early Warning System. The TIGER program is realizing improvements in the use of Earth observation data for water-resources management in Africa. The Coordinated Energy and water cycle Observations Project has improved access to integrated observational and model data through 50 reference sites around the world.

Weather. Weather monitoring and forecasting, which is traditionally the most mature sector for operational information based on Earth observations, continues to make important advances under the leadership of WMO. Collaboration through GEO has focused on improving the prediction of severe weather conditions. In particular, the THORPEX Interactive Grand Global Ensemble, or TIGGE, has advanced its goals of improving the accuracy of high-impact weather prediction. Based on ensembles containing more than 100 model outputs, TIGGE aims to make predictions available to decision makers in user-friendly formats with minimum time delay. The next step is to develop a common toolbox that can be used to develop probabilistic tropical-cyclone warning services, extreme-precipitation forecasts and other products.

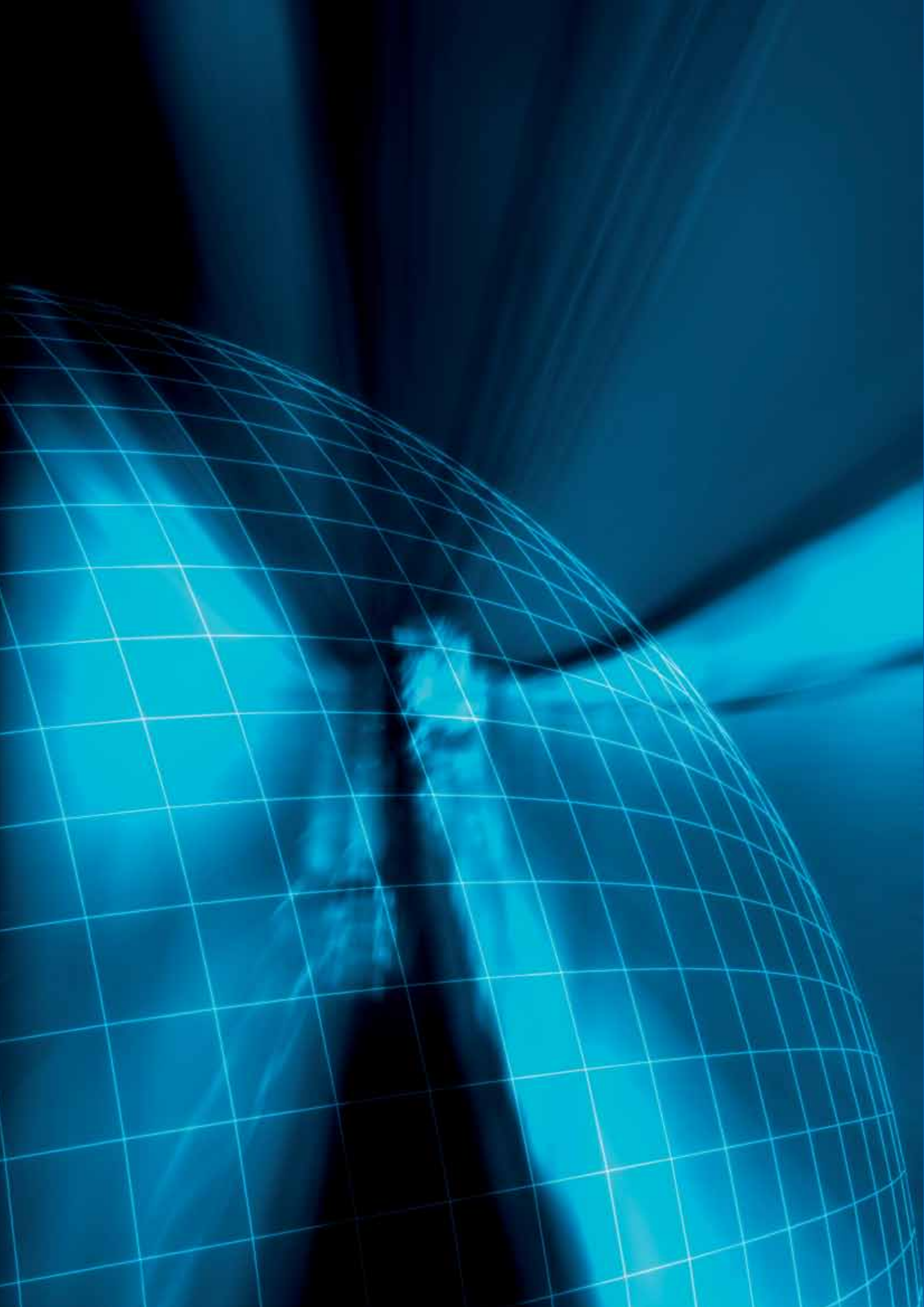


Sustaining GEOSS

The GEO vision is to “realize a future wherein decisions and action for the benefit of humankind are informed by coordinated, comprehensive, and sustained Earth observations and information.” The construction of GEOSS is designed to achieve this vision. The work is on track, but there are still many challenges to meet, many projects to complete, many gaps to fill, and many operations to be sustained. On the whole, these challenges tend to be political and institutional rather than technical or technological.

Critical next steps for seeing GEOSS through to the end of the GEOSS 10-Year Implementation Plan for 2005 – 2015 and beyond are:

- **Continue to engage policymakers and managers in using and guiding GEOSS.** The true value of GEOSS is its ability to support decision-making. As a key user group, senior policymakers can help to ensure that GEOSS addresses the UN’s Millennium Development Goals and other priority issues facing the global community.
- **Ensure that environmental experts come to consider GEOSS and its Common Infrastructure as a unique and essential tool for accessing Earth observations.** Strong, high-level support from governments and leading organizations is vital for maintaining the momentum generated by GEO and ensuring that GEOSS becomes recognized as a vital infrastructure that serves the global public good. Building the capacity of users to exploit GEOSS is also essential.
- **Develop a longer term strategy for sustaining GEOSS by attracting resources from public and private sources, supporting capacity-building,** strengthening national Earth observation programs, maintaining the GEOSS shared architectural and information infrastructure components, and nurturing the collective spirit.
- **Establish a governance structure for the post-2015 period.** Early guidance in Beijing will help to ensure a smooth transition to a longer-term approach to global cooperation on Earth observation.



PART II

ADVANCING THE GEO WORK PLAN: REPORTS FROM THE TASK TEAMS

GEOSS INFRASTRUCTURE AND DATA



How users access GEOSS data and information via the GEO Portal

The “GEOSS Common Infrastructure” consists of a dedicated web portal, a clearinghouse for searching data, information and services, and a registry containing information about GEOSS. It provides a “one-stop shopping” portal to help the users of Earth observations access and search for information more easily. After almost two years of development, in July of this year the GEO community formalized the arrangements by which leading institutions will operate and sustain the GEO Portal and its underlying clearinghouse and registry.

The Global Earth Observation System of Systems (GEOSS) seeks to connect the producers, users, and integrators of environmental data and to enhance the relevance of Earth observations to global issues. To achieve this aim, GEO has established the GEOSS Common Infrastructure (GCI) to ensure that the systems contributed voluntarily by governments and organizations to GEOSS become truly interoperable. The GCI provides a sustained internet entry point to GEOSS data and resources based on a consistent and agreed set of technical standards, registries, and metadata. This consistency is what makes it possible to combine data from diverse sources.

The front end of this system, and most important for the user, is the web-based GEO Portal, which is operated by the European Space Agency and the Food and Agriculture Organization of the United Nations. The GEO Portal provides convenient access to the full range of GEOSS data, information and services. The content available via the Portal continues to expand at a rapid rate and promises to reach a critical mass over the next year or two.

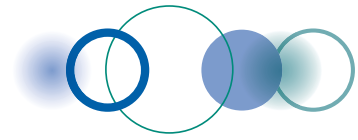
The registries

During the development and deployment of this architecture, it became clear that certain information resources need to be managed in a centralized manner – like a library – in order to assure the functioning and interoperability of GEOSS as a whole. For this reason, several GEOSS Registries were conceived as part of a GEOSS Common Infrastructure (GCI) to facilitate access and coordinate access to applications, models, data, metadata, products, and services.

The Components and Services Registry, which is operated by the US Geological Survey, allows governments and organizations to register the Earth-observing systems, programs, models, application software and other components that they wish to advertise and contribute to GEOSS. This capability provides a “yellow pages” or centralized directory of relevant resources that have a GEO affiliation, and describes them in basic detail to enable users to understand and access them. As of July 2010, over 250 approved components – including data sets, systems, portals and more – have been registered in GEOSS.

The Standards and Interoperability Registry stores a growing list of relevant standards and common practices, known as “special arrangements,” nominated by GEOSS users. Although GEO is not in the business of creating standards, there is a benefit to having a reference list of standards to associate with offered resources, requirements, and services.

The Best Practices Wiki is a GEOSS resource that hosts suggested practices associated with Earth observation, information management, or other relevant domains. A practice may reference multiple standards or may be pertinent to one or more societal benefit areas. The wiki is created to promote awareness and adoption of practices and to educate professionals across multiple application areas.



The User Requirements Registry, now under development, will be populated with user types and requirements for Earth observation data from existing and emerging sources. This Registry is intended to quantify the availability of Earth observation data in support of particular applications and user types, and to identify potential gaps in coverage based on unfulfilled user requirements.

The GEOSS Clearinghouse provides an all inclusive GEOSS search facility. Serving as a geographically-aware search engine, the Clearinghouse accesses all metadata from registered catalogs and the Components and Services Registry. A user can perform a search of the Clearinghouse through a user interface on the GEO Portal and get a quick list of resources that can be further explored or accessed.

Community portals

The GEOSS-wide GCI is being developed at the same time as a growing number of focused “community portals”. These portals are emerging to meet the particular needs of individual communities and to develop solutions specific to these specialized communities. GEO community web portals are as varied as the communities they serve in terms of the types and scope of the information they contain, as well as their complexity, maturity, interactivity, architecture, interoperability and degree of integration with the rest of GEOSS.

By aligning themselves with the consistent standards and registries developed for the GCI, these portals are able to draw on and benefit from all GEOSS information resources. Specifically, community web portals must also expose a standard metadata catalogue that can be searched through the Clearinghouse, allowing all GEO users access to the portal contents.



The diversity of communities that contribute to GEOSS is demonstrated by the diversity of their portals. Some portals, such as the Agriculture Community of Practice portal, consist of pages with resource links. Others, such as the Global Observing Systems Information Center (GOSIC), provide functions for searching multiple catalogues. All formal GEO web portals must, however, support and register a catalogue of their unique resources for access through the Clearinghouse and general GEO web portals.

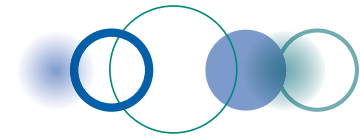
Other portals are structured by theme, such as the Energy Community of Practice portal, while still others are structured by region, such as the SERVIR portal, which serves communities involved with disaster management. Still another approach is illustrated by the Calibration/Validation portal, which addresses communities united by the shared use of a particular methodology. And while the Coastal Zone Community of Practice portal and the Architecture Implementation Pilot Portal aim to facilitate community processes, the Biodiversity Community of Practice portal focuses on outreach beyond the community itself.

Some of the most sophisticated community portals focus on a relatively narrow subject area. Examples include the GEO Forest Carbon Tracking, OneGeology and ChoroGIN portals.

The multiplicity of possible approaches to developing a portal is further demonstrated by the developers of the three candidate portals for the GCI. In addition to the ESA/FAO Portal chosen to operate the official GEO Portal, ESRI and Compusult provide solutions that may be adopted by nations or communities for deployment as community portals.

Continued progress on developing the GCI as well as the many community portals is critically important to the future success of GEOSS. Fortunately, the interaction between the GCI and the community portals is a win-win process that provides benefits all around. This ongoing co-evolution promises to strengthen the full and open access to Earth observations as GEOSS develops over the coming years.

AR-09-01 Task leads and contributors: EuroGEOSS, European Space Agency (ESA), IEEE, Open GeoSpatial Consortium (OGC), US Federal Geographic Data Committee (FGDC), US Geological Survey (USGS), US National Oceanic and Atmospheric Administration (NOAA), University of Tokyo, and many others.



Making the System of Systems interoperable

The observing, modelling and other systems that contribute to GEOSS must be interoperable so that the data and information they generate can be used effectively. The Committee on Earth Observation Satellites is promoting interoperability through the Virtual Constellations concept. Another initiative seeks to integrate via the Sensor Web approach, while yet another aims to facilitate model interoperability and access via the Model Web concept. The World Meteorological Organization Information System (WIS) uses interoperability standards that are also specified in the GEOSS 10-Year Implementation Plan; this enables GEOSS and WIS to leverage each other's components to their mutual benefit.

To support GEO objectives, harmonize the deployment of Earth observation missions and close emerging data gaps, the Committee on Earth Observation Satellites (CEOS) has established the concept of Virtual Constellations for GEO. The aim is to coordinate the operation of both existing and planned satellites and instruments so that their observation data can be merged or integrated. These data and the information derived from them can then better contribute to the analyses or measurements that are of interest. The Virtual Constellation concept offers opportunities to share experiences in the development of algorithms; standardize data products and formats; exchange information regarding the calibration and validation of measurements; facilitate timely exchange of and access to data products from existing and planned missions; and facilitate planning of new missions, ranging from coordinating orbits to optimizing observational coverage to sharing the implementation of mission components. The Virtual Constellations that are currently operational focus on the issues of atmospheric composition, land surface imaging, ocean colour radiometry, ocean surface topography, ocean surface vector wind, and precipitation.

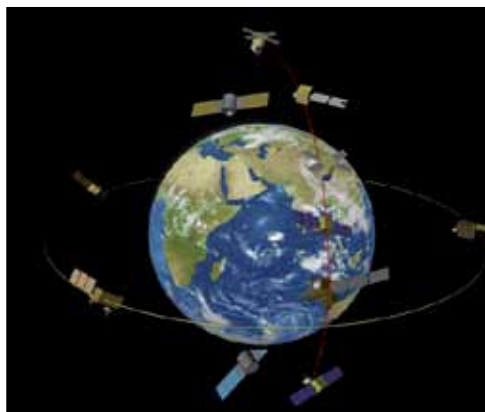
The Sensor Web concept, now in its initial phase, aims to improve interoperability between existing ground and satellite-based sensor systems that were originally designed to stand alone. In this way it will improve the relevance of the spatial and temporal data that they produce and increase the value of these earlier Earth observation investments. The Sensor Web will provide direct access to the sensors that gather the data rather than just to the resulting data sets. Users of the Sensor Web will be able to provide instructions to the sensors, thus influencing what they observe and ensuring that the relevant data with the correct spatial and temporal definition are gathered. The key to success for the Sensor Web will be the development of a set of standardized Internet-based web services. The Open Geospatial Consortium (OGC) is supporting the Sensor Web Enablement (SWE) initiative for open standards, including web service interface descriptions and data mark-up descriptions. The standards that make up the SWE are continuously evolving and being improved.

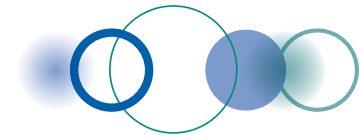
The Model Web is a concept for a system of interoperable computer models and databases communicating primarily via web services. It will consist of an open-ended, distributed, multidisciplinary network of independent, interoperating models plus related datasets. Models and data sets would be maintained and perhaps operated and served by a dynamic network of participants. In keeping with the system of systems approach, the Model Web initiative will explore the interoperability arrangements necessary to integrate multidisciplinary environmental model resources. The full Model Web concept is a long-term one, built upon the simpler concept of Model as a Service (MaaS), whereby models and their outputs are made available via web services. These services could then be used, for example, as input to other models, or as a feed to web sites. Both MaaS and the full Model Web concept will increase model access and sharing, facilitate interdisciplinary interaction, and reduce reinvention, thus making more efficient use of limited model development resources and speeding up progress on environmental modelling.

An initial, rather limited proof of concept system has been built, linking an existing Architecture Implementation Pilot (AIP) project with a NASA model. Several European Commission-supported FP7 projects are now utilizing or expanding on Model Web concepts. The Digital Observatory for Protected Areas (DOPA), a system for assessing protected areas developed by the European Commission Joint Research Institute, utilizes a Model Web approach in the framework of the EuroGEOSS project. Another project, called UncertWeb, will develop methods for estimating uncertainties when models are chained together.

Recognizing the importance of the collection and open sharing of information, the Members of the WMO (183 nations and 6 territories) are implementing the WMO Information System (WIS) as a key strategy for optimizing the efficiency and effectiveness of WMO services. WIS will also leverage the long-standing collaborative culture of WMO as well as new technologies. Each of the existing WMO centres, with some additional or modified capabilities, will become WIS Centres. So far, WMO Members have proposed about 125 WIS Centres, and over 300 can be expected eventually. The first global WIS Centres, operated by WMO Members in European countries, China, and Japan, are moving towards pre-operational status now. To be officially designated as a WIS Centre requires a demonstrated capability to implement the WIS Compliance Specifications. These specifications assure interoperability not only among WIS Centres but with the GEOSS clearinghouse and with libraries, spatial data infrastructures, and many other environmental data and information systems.

Task AR-09-02 leads and contributors: Australian Commonwealth Scientific and Research Organization (CSIRO), Committee on Earth Observation Satellites and its various members (CNES, EC, ESA, EUMETSAT, IOCCG, ISRO, JAXA, NASA, USGS), Council for Scientific and Industrial Research (South Africa), European Commission Joint Research Centre, Gund Institute for Environmental Economics, National Institute of Information and Communications Technology (Japan), IEEE, Open Geospatial Consortium (OGC) Interoperability Institute, University of California (UCLA), and the World Meteorological Organization.





Advocating for sustained global observing systems

To achieve its goal of providing integrated information on the entire Earth system, GEOSS depends on the health and vitality of major global observing systems. For this reason, GEO actively advocates for sustaining major observing systems for climate, oceans, land, weather and polar regions.

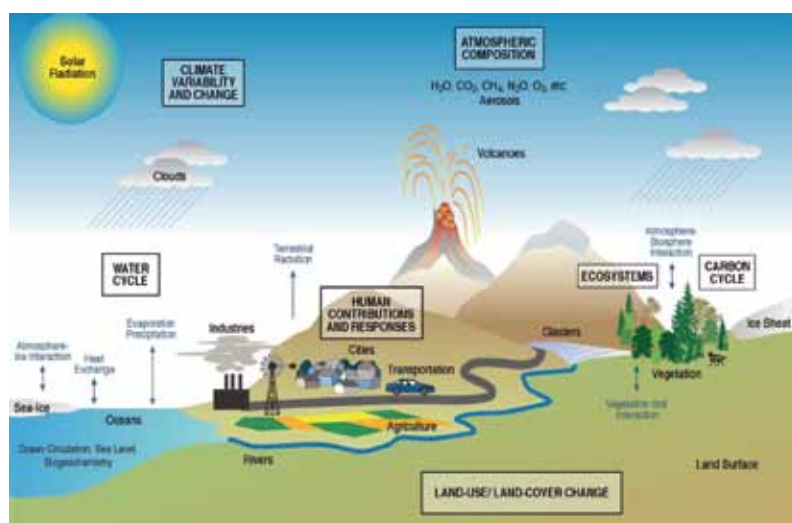
Four major UN-sponsored global observing systems provide a critical underpinning for GEOSS. They are the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS) and the WMO Global Observing System (GOS). Their work is complemented by the International Polar Year 2007-2008 (IPY) legacy project, with a focus on the cryosphere, and the Global Geodetic Observing System (GGOS). Strengthening the linkages amongst these systems and raising their overall visibility will support the efforts of researchers and decision makers in all nine of the GEOSS societal benefit areas.

- **The Global Ocean Observing System (GOOS)** is a scientifically designed, permanent international system for gathering, processing, and analysing oceanographic observations on a consistent basis and distributing data products. It gathers data from the open-ocean, coastal and shelf seas using remote sensing, sea-surface, and sub-surface instrumentation. Related activities include improving the global coverage and data accuracy of the coastal and open ocean observing systems as well as the management and archiving of the resulting data and information. Sustaining and extending the network of Argo buoys, a global array of profiling floats in the ocean, is particularly important. GOOS is sponsored by the Intergovernmental Oceanographic Commission (IOC of UNESCO), the International Council for Science (ICSU), the UN Environment Programme (UNEP) and the World Meteorological Organization (WMO).
- **The Global Terrestrial Observing System (GTOS)** is supporting its Sponsors (the Food and Agriculture Organization of the UN, ICSU, UNEP, UNESCO and WMO) and the broader stakeholder community in their efforts to address issues of climate change and climate variability, especially with regard to its effects on food security, the environment and sustainable development. The GTOS Secretariat, with the assistance of its Panels, is also supporting the observational requirements of the UN Framework Convention on Climate Change (UNFCCC), in particular the development of possible mechanisms for a terrestrial framework and the implementation of the 13 terrestrial Essential Climate Variables (ECVs), and including the assessment of the status of available standards, protocols and methodologies.
- **The Global Climate Observing System (GCOS)** aims to provide comprehensive information on the total climate system, including a multidisciplinary range of physical, chemical and biological properties, and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes. GCOS is sponsored by ICSU, IOC of UNESCO, UNEP and WMO and consists of the climate components of the WMO Global Observing System and Global Atmosphere Watch (GAW), GOOS, GTOS and research networks operating mainly under the World Climate Research Programme (WCRP). GCOS is designed to meet international and national needs for long-term and sustained climate-related observations, including those associated with the UNFCCC and the Intergovernmental Panel on Climate Change (IPCC). (See page 76)
- **The WMO Global Observing System (GOS)** provides ground, airborne and space-based observations of the atmospheric, oceanic, and terrestrial domains. It is operated by national Meteorological and Hydrological Services (NMHSs) and national and international satellite agencies, and it involves

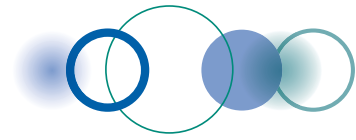
several consortia dealing with specific observing systems or specific geographical regions. The aim is to achieve a complete, stable and integrated GOS that meets the needs of WMO Members for weather, water and climate information.

- **The International Polar Year legacy Task** seeks to coordinate with the projects involved in the IPY to enhance the production and use of Earth observations involving the cryosphere. It advocates for an appropriate legacy for IPY projects and the continuation of relevant efforts. Cryospheric observations and related information products can directly contribute to all societal benefit areas identified by GEO. With scientific input from WCRP and Partners, WMO will make an effort to implement the WMO Global Cryosphere Watch (GCW), which will help meet most of the data and information requirements related to the cryosphere.
- **The Global Geodetic Observing System (GGOS)** provides observations of variations in the Earth's shape, gravity field and rotation and supports the International Terrestrial Reference Frame and International Celestial Reference Frame. GGOS thus provides the foundation for almost all types of environmental observations. GGOS observations directly contribute to at least seven of the GEOSS societal benefit areas. Geodetic monitoring crucially depends on the performance of the global geodetic ground networks. GEO promotes further development of the sustained infrastructure needed to satisfy the long-term (10-20 year) requirements for the reference frames and the monitoring of global change signals.

Task AR-09-03 leads and contributors: Food and Agriculture Organization of the United Nations (FAO), Geoscience Australia, GCOS, GGOS, GOOS, GTOS, Institute of Electrical and Electronics Engineers (IEEE), International Association of Geodesy (IAG), Intergovernmental Oceanographic Commission (IOC of UNESCO), Italian Space Agency, Korea Astronomy and Space Science Institute, National Geographic Institute (IGN) of France, US National Oceanic and Atmospheric Administration (NOAA), University of Maryland (UMBC), World Climate Research Programme (WCRP), World Meteorological Organization (WMO), and many other organizations and universities.



The Earth system



Establishing the GEONETCast Global Data Dissemination System

Reliable access to environmental data is critical for decision making. GEONETCast assures this access by broadcasting data from dozens of leading data providers to decision makers around the world. The data are transmitted via advanced communications satellites to thousands of low-cost, off-the-shelf receivers. GEONETCast also provides dedicated training and alert channels for capacity building and risk reduction, particularly in developing countries.

GEONETCast is a low-cost information-delivery system that transmits satellite and in-situ data, products and services from GEOSS to users through communications satellites. It is a key means of dissemination for GEOSS.

GEONETCast's near-global coverage is provided by GEONETCast Network Centers each offering data collection, management, and dissemination services for a given region. They are linked to one another through GEONETCast to provide global coverage and data-exchange capability.

The system's current coverage is provided by the China Meteorological Administration (CMA), which operates CMACast (FENGYUNCast) over Asia and parts of the Pacific; EUMETSAT, which operates EUMETCast over Europe, Africa, and parts of the Americas; and the US National Oceanographic and Atmospheric Administration (NOAA), which operates GEONETCast Americas over North, Central and South America as well as the Caribbean. Russia has also indicated its interest in providing additional regional coverage. The World Meteorological Organization (WMO) is also a GEONETCast partner and contributes its experience in global systems for disseminating weather-related data.

GEONETCast broadcasts all use a single digital video broadcasting standard protocol (DVB-S) and technology. No internet connection is required. A receiving station simply consists of a standard personal computer, an off-the-shelf satellite television dish and a couple computer cards. The materials needed to install a station can be obtained for less than \$2,000. There are already thousands of stations in use worldwide. This makes GEONETCast a compelling solution for getting high-quality Earth observation data and products quickly and cheaply to decision makers around the world, 24 hours a day.

GEONETCast Achievements

Since its inception in 2007, GEONETCast has moved quickly to put data exchange and interoperability agreements in place between data centers, allowing users in all regions access to products from any broadcast. Users and providers can search product offerings through the GEONETCast Product Navigator, a GEOSS-compliant search engine for discovering data and products using indicators such as societal benefit area, observation type and region, among others.

Since its inception, GEONETCast has worked continually to expand its scope, offering to include products and services in new societal benefit areas, in particular focusing on disaster risk reduction, environmental observation and management, food security, and climate. In 2009, Training and Alert Channels were added to broadcasts over Africa, the Americas and Europe, with this capability planned for Asia in 2010. GEONETCast is already being used to deliver training and capacity building products to workshops in Africa and Latin America in support of regional environmental prediction activities, including land cover monitoring, meteorology, water resources, environmental and climate monitoring. Pilot projects have been initiated for using GEONETCast

as a regional communications system for disaster risk reduction and as a means of dissemination when the International Charter on Space and Major Disasters is activated.

A Vision for 2015

By 2015, GEONETCast will be a robust global network linking many thousands of users to GEOSS and broadcasting thousands of products and datasets from dozens of active providers per day. Along with increasing the size and scope of its content, GEONETCast will grow its user population worldwide, with a particular emphasis on serving regions with a lower user base and a less robust information infrastructure, such as developing countries in Africa, the Americas, Asia, and the Pacific.

Through international partnerships brokered by GEONETCast and GEO, data providers will make available their information as well as their experience in utilizing it to new users across the globe. They will facilitate data exchange as well as the transfer of know-how to new groups. Current efforts to identify regional requirements and build capacity will lead to reliable, targeted services for new societal benefits, such as for local agriculture and health specialists or for coastal zone or fisheries managers. This will result in the greater adoption of the system as a low-cost extension of existing regional information systems in previously underserved areas.

Task AR-09-04 leads and contributors: China Meteorological Administration, Delivery of Advanced Network Technology to Europe (DANTE), European Space Agency (ESA), European Organisation for the Exploitation of Meteorological Satellites (EUMESAT), Flemish institute for technological research (VITO), German Meteorological Service (DWD), IEEE, Japan Aerospace Exploration Agency (JAXA), Russian Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet), Observing and Information Systems Department of WMO (WMO/OBS), United Nations Office for Outer Space Affairs (UNOOSA) and US National Oceanic and Atmospheric Administration (NOAA).

GEONETCast brings wildfire warnings to Sub Saharan Africa

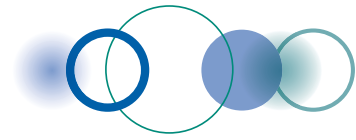
The South African Council for Scientific and Industrial Research (CSIR) has developed the Advanced Fire Information System (AFIS), which provides automated fire warnings and alerts to pre-defined areas, such as along electric power lines. AFIS uses advanced fire detection products developed from MSG and MODIS satellite images and disseminates them to Fire Control Centers in South Africa via GEONETCast. This system will be expanded to all the countries in Southern Africa through the European Commission-funded AMESD Programme.

GEONETCast Improves Flash Flood Communications in Central America

The National Meteorological Institute of Costa Rica (IMN) develops the Central America Flash Flood Guidance product, which uses satellite imagery to product flash flood risk maps for seven Central American countries. In 2009 IMN began a pilot effort to use GEONETCast as a way to improve dissemination of these alerts to flood-prone regions of Costa Rica. This pilot project will be joined by similar disaster risk reduction efforts across Central America using GEONETCast in 2010-11.

GEONETCast global coverage



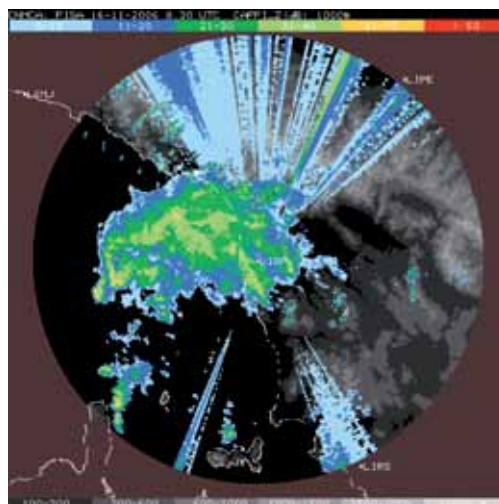


Protecting radio frequencies for Earth observations

Growing demand on radio spectrum by telecommunications, the automotive industry and other users of radio frequencies has raised the specter of competition over limited bandwidth. GEO members are therefore continuously working through national and international bodies in charge of frequency management to ensure the long-term availability of frequencies for terrestrial, oceanic, air-borne and space-based observations. This is absolutely vital to the success of GEOSS.

Since the start of GEO, and reiterated most recently by GEO's 2007 Cape Town Declaration, radio frequency protection has been recognized as a critically important issue for Earth observations. This is true in particular, but not only, for frequency bands where satellite passive sensing measurements are performed. Early in the development of the GEOSS 10-Year Implementation Plan, the ad hoc GEO subgroup on data utilization stressed that a specific goal of the GEOSS initiative should be to ensure that these radio frequencies are protected.

Acknowledging the increasing pressure on the frequency bands used by the Earth observation community from active services, mainly telecommunications and represented by a number of powerful lobbies, and recognizing that radio-frequency issues are managed either on a national or international basis by National Radio Administrations (NRA), the entire Earth observation community needs to be represented and to actively participate in frequency management processes in order to ensure the long-term availability of radio frequencies for terrestrial, oceanic, air-borne and space-based observations and data dissemination and avoid any harmful interference that could jeopardise related observations (see images below).



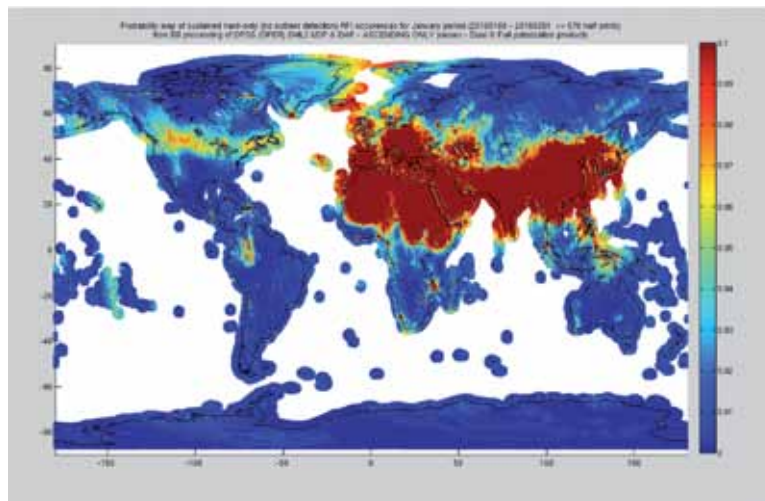
*Interference from an unlicensed RLAN
(Radio Local Area Network) 5 GHz affects
meteorological radar*

This effort is currently being handled through the participation of a number of GEO participants, in particular the World Meteorological Organisation (WMO), in the International Telecommunication Union (ITU-R) meetings, either during regular working parties or World Radiocommunication Conferences (WRC).

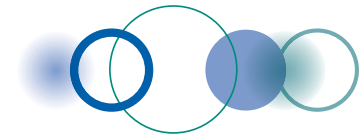
The adoption of the ITU-R Resolution 673 (WRC-07), among others, was a major achievement. This resolution emphasizes the importance and essential role of radio frequencies for Earth observation and clearly mentions GEO and GEOSS. Resolution 673 (WRC-07) is triggering a specific agenda item (8.1.1 issue c) for the next World Radiocommunication Conference (WRC-12) by calling for studying the “means to improve the recognition of the essential role and global importance of Earth observation radiocommunications applications and the knowledge and understanding of administrations regarding the utilization and benefits of these applications”. During the preparation for this agenda item, the International Telecommunication Union has already completed a number of recommendations and a dedicated report on “the essential role of Earth Observations” that was also coordinated within GEO and is providing relevant information on Earth observation benefits, largely advertising GEO activities.

Strong involvement from GEO and its members and participating organizations, WMO in particular, will be necessary to ensure that the WRC-12 outcomes will be as successful as those obtained during WRC-07. Overall, radio-frequency management is a never-ending process. Similar and consistent involvement from GEO and its members will clearly be necessary in the future.

Task AR-06-11 leads and contributors: Australia Bureau of Meteorology, Committee on Earth Observation Satellites (CEOS), European Space Agency (ESA), ECMWF, EUMETNET, EUMETSAT, European Commission, German Aerospace Center (DLR), IEEE, Japan Aerospace Exploration Agency (JAXA), Météo-France, Open Geospatial Consortium (OGC), Royal Netherlands Meteorological Institute (KNMI), UK Met Office, US National Oceanic and Atmospheric Administration (NOAA), and World Meteorological Organization.



European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission: areas affected more than 10 % of the time by strong interference for ascending orbits



Implementing the GEOSS Data Sharing Principles

Recognizing the importance that full and open access to data has for the success of GEOSS, the GEOSS 10-year Implementation Plan established a visionary set of Data Sharing Principles. These Principles aim to ensure that the data and information developed and disseminated through GEOSS yield significant benefits for a broad range of users around the world. Over the past five years, substantial progress has been made, not only in reaching a consensus on how best to implement the Data Sharing Principles, but also in demonstrating how full and open data sharing can help the GEO community to achieve its goals in the nine societal benefit areas.

The need for rapid, widespread access to Earth observation data is particularly clear in the case of dramatic disasters, such as the January 2010 earthquake in Haiti. There, remote sensing imagery helped to rapidly characterize the extent and severity of damage. Together with other spatial data, it supported relief, recovery, and reconstruction efforts. Due to the tragic loss of many national experts and capabilities in the earthquake, international assistance and the sharing of data remain vital to Haiti's continued recovery and reconstruction.

But the benefits of data sharing extend well beyond disasters to other societal benefit areas. Land-cover data from multiple sources such as the Landsat satellites and the China-Brazil Earth Resources Satellite (CBERS) program are widely used in agriculture, forestry, water resources applications and research, ecological and biodiversity assessments, and climate mitigation and adaptation efforts. Digital Elevation Model (DEM) data from the Japan/US ASTER mission have important applications for soil and water-resource management, studies of glaciers and ice sheets, coastal zone management, and urban planning.

The nearly 200 million biodiversity records now freely accessible through the Global Biodiversity Information Facility (GBIF) support research, conservation, and resource management in both developing and developed countries. They also contribute to international cooperation under the auspices of the Convention on Biological Diversity and other international agreements. GEO has played a critical role in increasing awareness of the benefits of these types of data. It has also focused attention on the need to address the technical and legal issues associated with promoting data interoperability and systems integration.

The Data Sharing Action Plan

The Cape Town Ministerial Summit in 2007 emphasized the importance of reaching a consensus on the implementation of the Data Sharing Principles. To support this effort, the GEO-V Plenary established the GEOSS Data Sharing Task Force to further develop implementation guidelines for the Principles that had been drafted by a GEO Task team and to prepare an Action Plan for implementing the Principles. The GEO-VI Plenary revised and accepted the proposed implementation guidelines in December 2009 and gave guidance to the Task Force on the Action Plan. The implementation guidelines address important issues such as the re-dissemination and reuse of GEOSS data, data pricing, time delays in data access, and research and education uses of GEOSS data.

Beginning in 2010, the Task Force focused on drafting the Data Sharing Action Plan along with a detailed set of supporting documents addressing key issues and concerns and highlighting a range of data sharing case studies. The draft Action Plan identifies a number of concrete actions that GEO Members, Participating Organizations, and GEO as a whole could take to implement the Data Sharing Principles. For example, the Plan proposes the establishment of the GEOSS Data Collection of Open Resources for Everyone (Data-CORE),

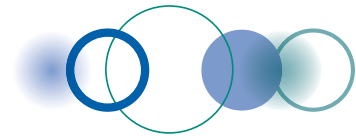
a distributed pool of documented datasets, contributed by the GEO community on the basis of full, open and unrestricted access and at no more than the cost of reproduction and distribution. The Plan's supporting documents also highlight the benefits of implementing the Data Sharing Principles and the implications of the Plan for the GEOSS Common Infrastructure. Selected case studies illustrate the value of increased access to data to both specific users and society in general.

In parallel with these efforts to identify the processes and procedures needed to implement the Data Sharing Guidelines, the Data Sharing Task Force and the GEO Task team have also engaged actively with the GEO community to raise awareness of the importance of data sharing and to address key implementation issues. Side events highlighting data sharing activities have been held at the GEO Plenaries in Cape Town, Bucharest, and Washington DC, and another is planned in Beijing. In 2009, a detailed white paper on GEOSS data sharing issues was published in two open access scientific journals. The Task Force has had extensive interactions with the GEO committees and with key Tasks, and Task Force members have given numerous presentations at GEO symposia and other conferences. As part of phase III of the Architecture Implementation Pilot, an initial set of requirements related to data sharing, attribution, and user registration is being developed, and planned prototyping activities will explore new approaches to dealing with key technical and legal interoperability issues.

Achieving the GEOSS vision

An underlying motivation in pursuing the full and effective implementation of the GEOSS Data Sharing Principles is the realization that, for all of the technical wizardry of the Internet and modern information technology, the vision of GEOSS as a fully integrated "system of systems" cannot be realized without a practical approach that respects the legal rights and requirements of data providers and at the same time facilitates the rapid and flexible use of data from multiple sources by a wide range of data users. Just as GEO must succeed in linking traditional "stovepipe" information systems and overcoming technical problems in accessing and integrating disparate datasets, so too must it succeed in enabling open data exchange across different legal traditions and jurisdictions and reducing institutional, legal, and cultural impediments to data sharing. This is the essence of the GEOSS Data Sharing Principles and the primary focus of the proposed Data Sharing Action Plan.

Task DA-06-01 leads and contributors: International Council for Science Committee on Data for Science and Technology (ICSU/CODATA), International Institute for Space Law (IISL), Japan Aerospace Exploration Agency (JAXA), UN Office for Outer Space Affairs (UNOOSA), World Meteorological Organization (WMO), and the members of the GEO Data-Sharing Task Force.



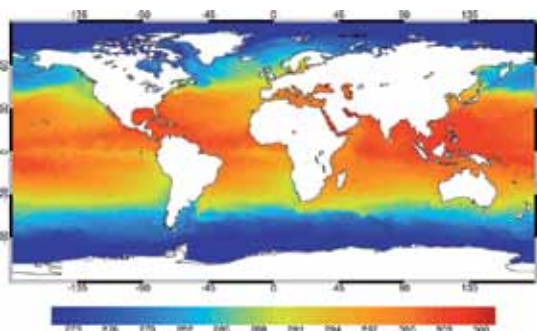
From observations to information products and services

Observation data provide great value, but combining data from different sources and then analyzing and modelling them can greatly enhance their usefulness for decision making. GEO has made significant progress in bringing together many diverse datasets and engaging scientific and technical experts to generate this added value. Continuing progress will require more and more agencies and organizations to work together to adopt common standards for integrating and analyzing all types of data.

Building alliances amongst different kinds of institutions is essential for achieving convergence to the common standards needed for combining data. Fortunately, many such partnerships have been established or are starting to emerge.

The Universities of Tokyo and Manitoba, together with the European Space Agency, have begun to coordinate their data-management approaches in order to improve observation data processing, archiving, and dissemination. This includes activities such as the reprocessing, analysis and visualization of large volumes and diverse types of data. This alliance between three facilities that manage and facilitate access to large datasets is gradually expanding with the addition of other institutions. The addition of new centres is currently underway, initially involving institutions active in water issues.

Elsewhere, the meteorological community has developed statistical methods to support the extraction of probability information from large datasets. These methodologies are gradually proving extremely useful in other domains as well. In particular, the UK Met Office is leading the world-wide Group for High Resolution Sea Surface Temperature, which generates, exploits and provides sea-temperature analyses. Many users benefit from its efforts, including numerical weather prediction centres, ocean-forecasting groups and climate monitoring and research groups.



Collaboration on statistical methods for analyzing sea-surface temperature data sets has resulted in a high-quality product widely used in climate and environmental research and applications.

The International Association of Geodesy is leading an effort to achieve highly consistent and interoperable geodetic reference frames. The International Terrestrial Reference Frame is the mandatory metrological basis for Earth science applications, and it also used for determining the orbit of satellite-navigation systems with great precision. This global collaboration, called the Global Geodetic Observing System, is also developing a common Unified Height System and supporting standardisation efforts through the International Organization for Standardization (ISO).

The goal of the Atmospheric Model Evaluation Network (AMEN) is to develop a web-based infrastructure for comparing global and regional atmospheric models to a variety of observations from distributed archives using standardized

approaches for evaluating and improving model performance. These computer models of atmospheric dynamics and chemistry are essential tools for managing air quality and addressing climate change. They must be evaluated using atmospheric-composition observations from instruments at the surface or carried by balloons, aircraft, or satellites. Global collaboration has already contributed significantly to the standardization of model evaluation procedures and benchmark observation sets, which has enabled comparisons between models.

The US Environmental Protection Agency is leading a broad global effort to interconnect facilities and large centres managing Air Quality data and models in a standardised manner, in order to facilitate discovery and exchange of observations and results from models. The aim is to allow users to interact with such facilities during their analyses and to enable automated exchanges between the facilities themselves.

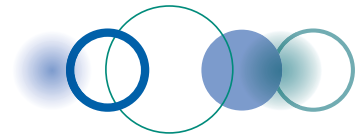
Tasks DA-09-01 and DA-09-02 leads and contributors: Canadian Space Agency (CSA), Committee on Earth Observation Satellites (CEOS), European Space Agency (ESA), French Space Agency (CNES), German Aerospace Center (DLR), IEEE, International Association of Geodesy (IAG), Italian Space Agency (ASI), UK Met Office, US Environmental Protection Agency (EPA), US Federal Geographic Data Committee (FGDC), University of Manitoba, and University of Tokyo.

Harmonising data for maximum usability

The Committee on Earth Observation Satellites leads the effort to establish a Quality Assurance Strategy for GEOSS. A framework of high-level guidelines has been developed in collaboration with experts specialised in ground-based observations. These guidelines are derived from best practices and are already suitable for use by the GEO community. Practical implementation will involve translating them into more detailed guidelines that are specific to each field. The number of providers and users applying the guidelines is steadily increasing.

The Committee on Earth Observation Satellites is facilitating the development, availability and harmonization of data, metadata and products required by the diverse set of projects and applications across all societal benefit areas. The harmonization effort focuses on achieving alignment within specific communities while simultaneously harmonizing with major independent regional and domain-specific initiatives. This has already resulted in the development of interoperable community catalogues, which leverage the standards of, and interaction with, the GEOSS Common Infrastructure (GCI).

For many applications and decisions it is essential that observations and information products be consistent over a variety of time scales. The need for consistency over long time scales, in particular, has increased in recent years, particularly in the field of environmental and climate monitoring. The European Space Agency is leading efforts to develop methods and guidelines for ensuring temporal consistency and preserving irreplaceable observations. This effort is timely as the diversity, amount, and value of observational data are drastically increasing for all time scales.



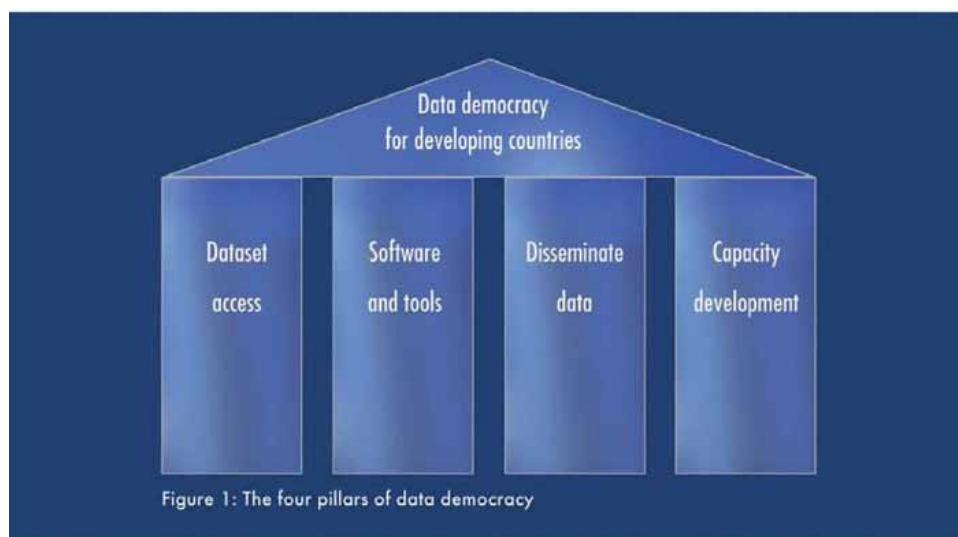
Promoting “data democracy” around the world

The term ‘data democracy’ was coined in 2008 by the South African Council for Scientific and Industrial Research (CSIR) as the title of a special project during its year as Chair of the Committee on Earth Observation Satellites (CEOS). It has since become a mantra among research and development communities in the Earth observation domain. In 2009, Data Democracy was approved as a new GEO Task in the framework of GEO’s work on capacity building, infrastructure development and technology transfer.

The aim of data democracy is to promote collaboration on projects for the common good, with the view that the sustainability of Earth observation will be determined by the end users. It relies on the active participation of CEOS agencies in broadening the capacity of end users to access data.

The data democracy theme calls for:

- Unhindered access to Earth observation information;
- Reliance on Open Source Software and open systems;
- Recognition of the realities of bandwidth limitations in many developing countries; and
- Promotion of locally initiated cross-border collaborative projects and intensive capacity building and training programs.



The Data Democracy concept goes beyond access to satellite data to include software availability, training and community building.

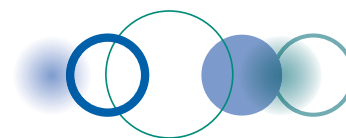
Raising awareness through news articles and workshops

Demonstrating the benefits of GEOSS through easy-to-understand success stories is an important part of capacity building. *Earthzine* is a web-based magazine that reaches out to the general public and to non-technical managers and decision-makers. Through *Earthzine*, IEEE has published dozens of articles covering the nine GEO societal benefit areas. It has focused on such themes as disaster mitigation and response, global energy dependency, new Millennium Development Goals, and agriculture and food availability. As an on-line publication, *Earthzine* is updated regularly with news from around the world about the Earth, Earth observation, environmental policy, and new and emerging environmentally-friendly and earth-observing technologies. In 2009, *Earthzine* attained an international audience of approximately 4,000 readers per month in more than 100 countries.

In addition, IEEE and its partners (including the Committee on Earth Observation Satellites, the US Environmental Protection Agency, the World Health Organization, the International Society for Photogrammetry and Remote Sensing and the Open Geospatial Consortium) have organized a series of workshops to demonstrate the GEOSS Common Infrastructure to users in all societal benefit areas. Some six workshops a year provide outreach to both contributors to, and users of, GEOSS. Proceedings are posted on the internet after each event. The workshops typically expose regional and local stakeholders to best practices in capacity building and to the benefits of using the GEONETCast data-dissemination system in combination with open-source, web-based applications and service deliveries.



Earthzine on the web



UNEP atlases communicate the value of Earth observations

The United Nations Environment Programme (UNEP) has found that presenting well-chosen satellite images in an atlas format can be a powerful means of communicating the meaning of complex Earth observations to a broader audience. For this reason, UNEP has contributed its “Atlas of Our Changing Environment” series to GEOSS.

Through a combination of ground photographs, current and historical satellite images, and narratives based on extensive scientific evidence, the UNEP Atlases illustrate how humans have altered their surroundings and continue to make observable and measurable changes to the global environment. The information provided is not only useful in the context of the selected locations, but also underscores the intrinsic value of harnessing, visualizing and communicating technologies to gain a deeper understanding of the dynamics and impacts of environmental change.

The UNEP Atlases focus on the global, regional and national levels. They draw the attention of governments to environmental issues and strengthen their capacity to monitor their resources through Earth observations. The 2010 releases in this series include the Uganda Atlas of our changing environment; the Atlas of water resources for Africa; and regional atlases for the Arab states, Europe, and Latin America & the Caribbean.

The example of Lake Faguibine in Mali, shown here, is powerful because the reader immediately understands the scale of the change that has taken place since the Sahelian drought of the 1970s and 80s.



03 January 1978 and 26 December 1978



03 January 1987 and 20 October 1987



18 January 2010



16 October 2001

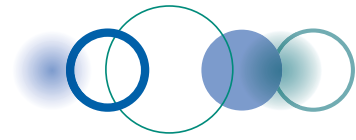


30 October 2006

Some of the achievements over the past three years include:

- CEOS agencies have provided users with free data received via their ground stations or acquired by their satellite missions:
 - The China-Brazil Earth Resources Satellite (CBERS) for Africa initiative established ground stations in Hartebeeshoek, South Africa; Aswan, Egypt; and Maspalomas, Canary Islands, Spain;
 - The US Geological Survey LANDSAT programme and the US National Aeronautics and Space Administration (NASA) now provide full and unrestricted access to data;
 - The European Space Agency (ESA) announced a free data policy for the Global Monitoring for Environment and Security (GMES) Sentinel satellites; and
 - The Sentinel Asia Program is supporting free data access for disaster management in Southeastern Asia.
- The CEOS Working Group on Education, Training, and Capacity Building, and other GEO Members and Participating Organizations have organized workshops and training programs involving the sharing of satellite data, relevant software, data processing, and training tools for information extraction to support local decision-making on land use and land cover.
- A Data Democracy Portal has been developed to enable users to access up-to-date data, software tools and training courses in a sustained way.

Task CB-09-05 leads and contributors: Brazil's National Institute for Space Exploration (INPE), China Center for Resources Satellite Data and Application (CRESDA), Committee on Earth Observation Satellites (CEOS), South Africa's Council for Scientific and Industrial Research (CSIR), and The Netherlands' Faculty of Geo-Information Science and Earth Observation (ITC).



Developing cross-cutting Earth observation products and services

GEO recognizes the value of fostering the use and development of Earth observation products and services that can contribute simultaneously to a number of societal benefit areas (SBAs). Two of the major ongoing efforts to develop such products and services are the Global Map and the International Phenology Network.

The concept for the Global Map is to develop global-scale geographic information through international cooperation. The Global Map data sets provide a full and consistent coverage of the Earth's land surface at a 1 km resolution. Each thematic data set or layer is equivalent to a conventional map scaled at 1:1,000,000 and is released to the public in a digital format for easy handling by computer. The layers include elevation, vegetation, land-cover, land-use, transportation drainage systems, boundaries and population centers. The data will be updated at approximately five-year intervals to facilitate the monitoring of changes occurring in the global environment.

The objective of this GEO initiative is to foster the use of the Global Map in the nine GEOSS Societal Benefit Areas (SBAs). Each SBA's needs for basic geographic data are assessed and reflected in the specifications used by the map providers.

National mapping organizations are cooperating with various other agencies to promote the use of the Global Map in each of the SBAs. As the needs for basic geographic data continue to be identified and reflected in the updated specifications, new versions of the Global Map are prepared and updated manuals are prepared accordingly.

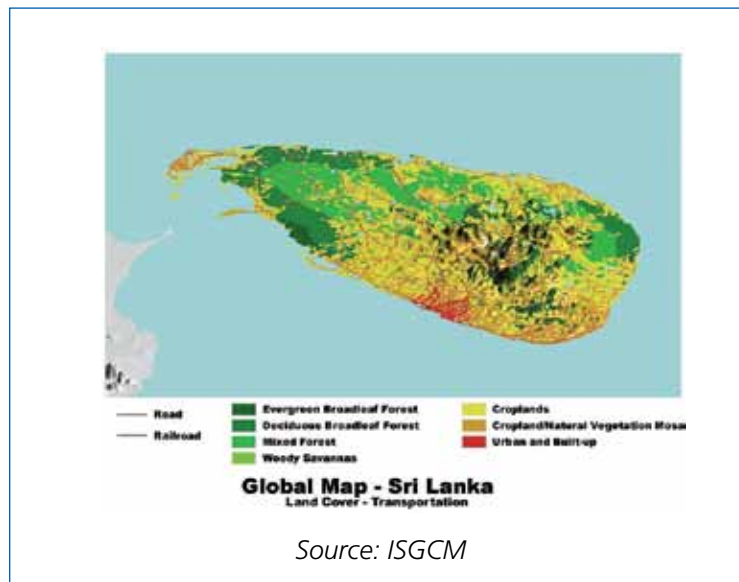
The effort to establish an International Phenology Network was inspired by the growing importance of phenology over the past decade as a cost-effective tool for climate change impact studies. Changes in vegetation phenology have an impact on biodiversity, net primary productivity, species distribution, albedo, biomass and, ultimately, the global climate. Forming an International Phenology Network Community of Practice will provide a global, scientifically robust framework for observations on the detection of spatial and temporal patterns of phenology.

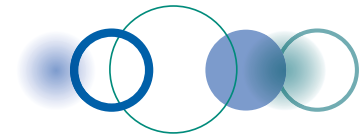
A number of existing phenology networks, principally in North America, Europe and Asia, focus on observations of in-situ or land-surface phenology. However, these networks are not well-coordinated. The International Phenology Network offers a mechanism for raising the level of standardization and coordination for this important ecosystem parameter and for expanding phenology networks around the world. It also aims to identify and generate satellite-derived phenological and temporal metrics and test models for describing the phenological characteristics of natural and modified ecosystems.

Phenological forecasts using numerical weather prediction for Europe have recently started being published, and access for research and education has been opened. A plant phenological database has been developed by European networks, and plant monitoring protocols finalized for some 225 species; a new animal phenology program was introduced in early 2010. Observational phenological guidelines were unified throughout Europe, and many scientific publications have been issued, including a set of "Guidelines for plant phenological observations".

The Network leverages the existing efforts of the Phenology Commission of the International Society for Biometeorology in order to establish a global phenology monitoring project, which will include data collection by citizen scientists throughout the globe, thus serving an important outreach function.

US-09-03 leads and contributors: Austria's Central Institute for Meteorology and Geodynamics (ZAMG), Center for Environmental Remote Sensing (CeRES) at Chiba University of Japan, Geospatial Information Authority of Japan (GSI), Germany's Federal Agency for Cartography and Geodesy (BKG), International Steering Committee for Global Mapping (ISGCM), UK EDINA National Data Centre, UN Office for Outer Space Affairs (UNOOSA), US Geological Survey, USA National Phenology Network, US Department of Agriculture/Forest Service, University of Wisconsin-Milwaukee (US), and contributors to the International Phenology Network.





Building global data sets for universal use

Data sets on critical global parameters are fundamental inputs for many information services and decision-support products. Changes and trends in land cover, soils, climate, the weather and the cryosphere can impact decisions on health, energy, biodiversity, ecosystems and much more. GEO actively promotes efforts to develop and sustain these core data sets.

Global land cover can be assessed by integrating a suite of global land cover datasets based initially on improved and validated moderate-resolution land-cover maps and eventually including land-cover change at high resolution. Land cover is one of the most important parameters for observing, describing and studying the environment. Despite the fundamental importance of land cover information and other land surface characteristics, systems for taking land observations are not yet operational and sustained, as compared to other Earth observation domains such as oceans and the atmosphere. Although numerous satellites acquire data suitable for land monitoring, large-scale regional and global mapping and monitoring programs have not reached operational status for delivering internationally accepted land cover and, in particular, land-cover change data to serve the many uses and applications. A global collaborative effort, led by the US Geological Survey and GOFC-GOLD/University of Wageningen and the European Space Agency, has made significant progress towards such goals by the release of new global land cover datasets, standards for land cover validation and documents supporting implementation of national forest monitoring in developing countries.

The **global soil survey** community is collaborating to produce accurate, geo-referenced soil information. The last decade has witnessed remarkable progress in Earth observation techniques and prediction of soil properties from data generated by remote and on-the-ground sensors. At the same time, geo-statistical techniques have been developed that allow for predicting soil properties in areas with little or no information as well as for indicating the uncertainty of such predictions. Soil spectral analysis is becoming a robust and inexpensive tool for identifying soil functional attributes and developing high-resolution soil databases. The development of high-resolution soil information for the whole world will take several years and is being undertaken in projects such GlobalSoilMap.net. At the same time, existing global soil geographical data at a lower resolution could already make a major contribution to improving analyses of global change processes. The overall resolution can be improved over time by incorporating national and regional datasets. Various techniques are currently being developed and tested at various institutions, and a global coordination could generate much synergy in this process. Projects such as e-SOTER and GlobalSoilMap.net can serve as vehicles to achieve this aim, as could other initiatives.

The **ASTER Global Digital Elevation Model (GDEM)** is the first comprehensive, fully consistent, and freely available Global Digital Elevation Model. Developed by Japan and the US, this new digital topographical map was formally launched in June 2009. Digital Elevation Models use remote sensing to map the elevation and contours of the Earth's surface, highlighting features such as mountains and rivers. They are used for a wide range of purposes, such as creating relief maps, modeling water flow to anticipate flooding impacts, predicting land slides, planning new infrastructure, and projecting the likely impacts of global environmental change. Until now, however, GDEMs have been patched together using data gathered by different instruments surveying limited areas of the Earth's surface at different resolutions at different times. As a result, topographical grids have been marred by internal inconsistencies and large gaps in coverage, particularly of Africa and other developing regions. GDEMs also tend to be expensive and unavailable to all but the largest institutions.

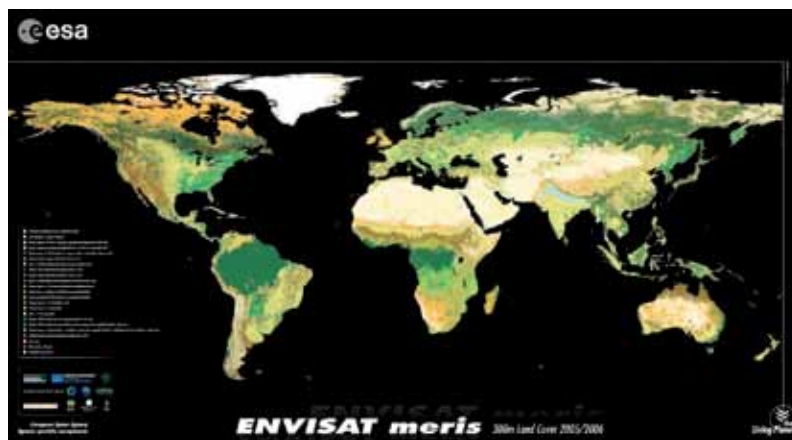
In addition to making Digital Elevation Models more affordable and accessible, the ASTER GDEM offers comprehensive coverage of the planet, including 99% of the area between 83°N and 83°S latitude, with data points 30m apart. As a result, many developing countries will for the first time have full access to the detailed topographical information they need for managing floods, landslides and other disasters.

The ASTER GDEM is named after the Japanese Advanced Space-borne Thermal Emission and Reflection Radiometer (ASTER) remote-sensing instrument that is carried by the NASA satellite Terra. ASTER has made nearly 1.3 million individual stereo-pair images of the planet by combining two images from different angles for each location.

Global geological map data are being contributed to GEOSS through the OneGeology project, which is committed to making the best available geological map data from around the world web-accessible. The OneGeology initiative, originally launched in 2007 as a contribution to the UN International Year of Planet Earth, is progressing rapidly towards its target of making geological map data at a scale of about 1:1 million accessible via internet. As of July 2010, the number of national geological surveys that are participating has reached 116. Of these, 41 are already providing their digital geological map data through web map services to the OneGeology portal.

Achieving the required interoperability and data exchange has been a major achievement of the OneGeology initiative. A set of detailed 'One Geology Cookbooks' on interoperability aspects has been written, and a Technical Working Group has been engaging with standardization efforts, with strong links to and dependence on GepSciML. The current year has been one of significant progress also in terms of strengthening OneGeology's organization, including through the establishment of a dedicated Steering Group. OneGeology is also fully interoperable with the GEOSS Common Infrastructure and its web service is accessible through the GEO Portal.

Further significant advances at the regional level have been made possible by funding obtained through the OneGeology-Europe (EC) and Geoscience Information Network (NSF) projects. OneGeology's bilingual portal has been highlighted in the mainstream media and already welcomes about 10,000 visitors per month. Among the many user-friendly services it provides is a function to interact with Google Earth.

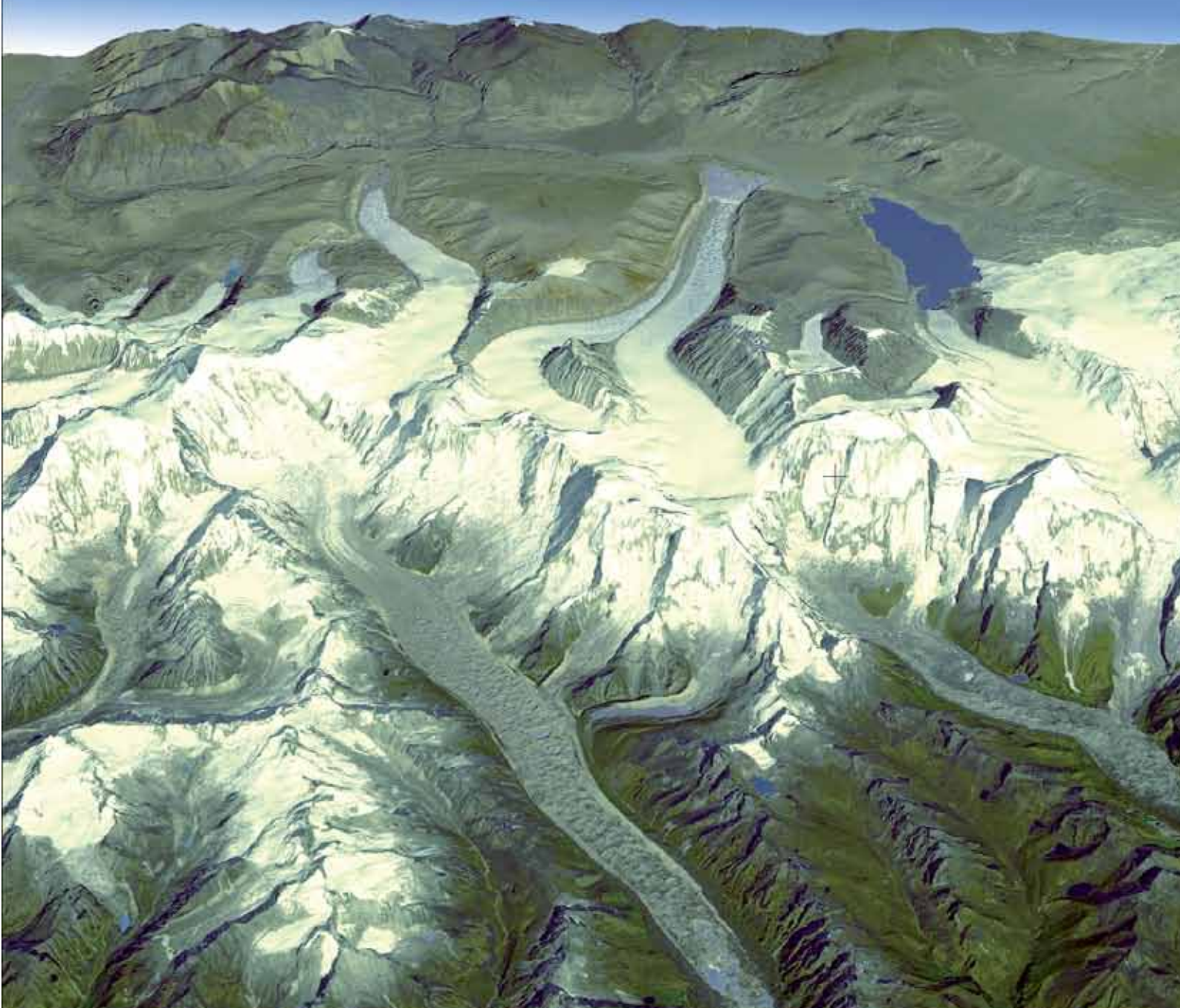


GLOBCOVER land cover map based on Envisat MERIS data (source: ESA)

Applying the Global Digital Elevation Model (GEDM)

In the Bhutan Himalayas, Advanced Spaceborne Thermal Emission and Reflection Radiometer data have revealed significant spatial variability in glacier flow, such that the glacier velocities in the end zones on the south side exhibit significantly lower velocities (9 to 18 meters, or 30 to 60 feet per year), versus much higher flow velocities on the north side (18 to 183 meters, or 60 to 600 feet per year). The higher velocity for the northern glaciers suggests that the southern glaciers have substantially stagnated ice. This view looking towards the northwest was created by draping an ASTER simulated natural color image over digital topography from the ASTER Global Digital Elevation Model (GDEM) data set. The ASTER scene was acquired November 20, 2001, and is centered near 28.3 degrees north latitude, 90.1 degrees east longitude.

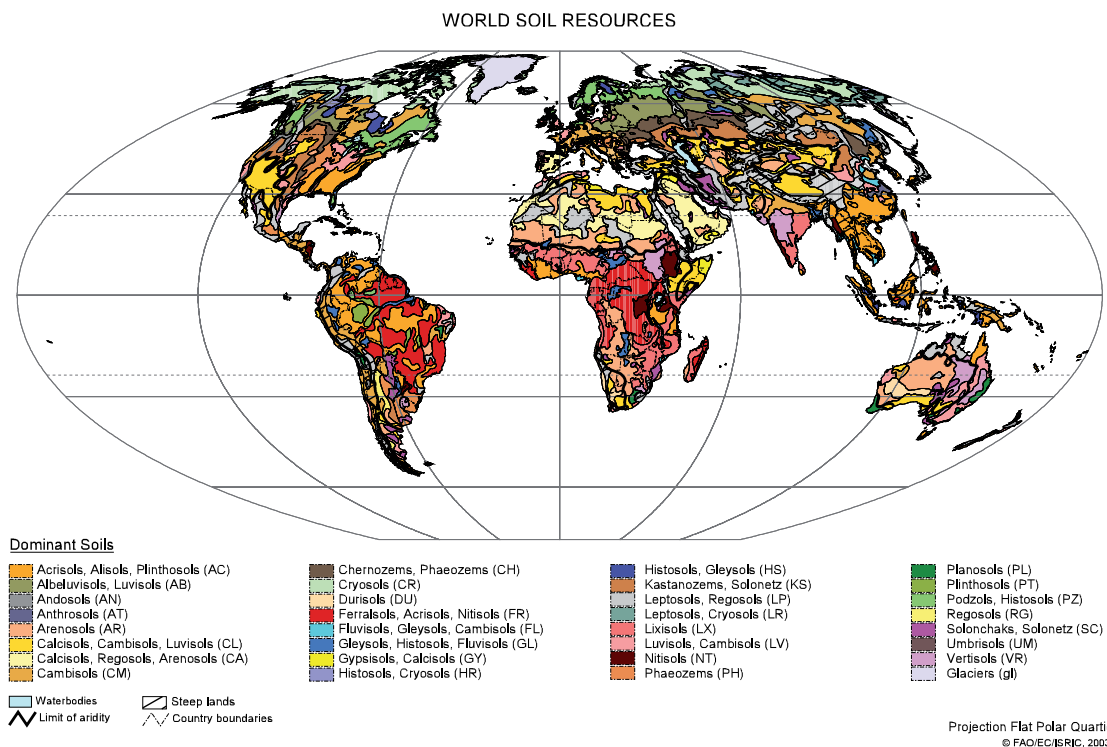
Source: <http://www.nasa.gov/topics/earth/features/20090629.html>



Global meteorological and environmental data are being provided by the world's national hydrometeorological agencies. For example, the Chinese Meteorological Satellite Program for global weather and environmental monitoring aims to provide users worldwide with low-resolution multiple-source observation data, develop integrated multi-source satellite retrieval products shared with users and enhance capabilities for acquiring and applying Chinese meteorological satellite data and products.

China is also investing in upgrading its satellite capabilities. On the FY-3A, China's second-generation polar-orbiting meteorological satellite, all 11 payload instruments were fully evaluated using real data during the on-orbiting commission test in 2008. Direct broadcasting users, in particular those from the Coordination Group for Meteorological Satellites, have been provided with the pre-processing software package which can process FY-3A raw data to L1 radiance data with appropriate geo-location information independently using personal computers.

Task DA-09-03 leads and contributors: British Geological Survey, China Meteorological Administration, Committee on Earth Observation Satellites, European Commission, European Space Agency, Global Terrestrial Observing System (GTOS)/Global Observation of Forest and Land Cover Dynamics (GOFC/GOLD), Japan Aerospace Exploration Agency, One Geology Europe, United States Geological Survey, US National Oceanic and Atmospheric Administration, Wageningen University, and many others.



SOCIETAL BENEFIT AREAS



Accessing satellite data for monitoring and managing risk

Space agencies and other partners are working together to expand the use of satellite images and maps for managing the risks posed by fires, floods, earthquakes and other hazards. They are evaluating user needs and matching them with existing or planned technologies and data sets, and they are expanding international access to satellite images via the International Charter on Space and Major Disasters.

Satellites have a uniquely valuable vantage point for monitoring many kinds of large-scale disasters, from forest fires to overflowing rivers to earthquake-prone zones. Remotely sensed data can be provided in near-real time or with very little delay and can include maps, optical images or radar images that accurately measure the burnt area, heat, flood extent, land displacement, and other key variables.

These data proved invaluable in January 2010 for providing rapid information services in response to the magnitude 7 earthquake that struck the south-east of Haiti and the capital city Port-au-Prince. They also supported the rapid and continuous monitoring of the oil slick following the collapse of the Deepwater Horizon drilling rig on 20 April in the Gulf of Mexico.

The International Charter

A key system that provides rapid access to satellite data and that is operational today is the International Charter on Space and Major Disasters. The Charter provides a unified system whereby 10 space agencies deliver space-based data to address natural and man-made disaster response. Today the Charter has already provided data to more than 90 countries worldwide in more than 260 activations over the past ten years.

Within its mandate, the Charter is available globally for a predefined list of appointed users, the 'authorized users' who are granted a direct access for triggering the system. Today, there are ten national and international space agency members of the Charter, representing over 40 countries; each of these countries designates authorized users who primarily are national disaster management authorities. There are several mechanisms to activate the International Charter so that other countries that do not have an authorized user can also access the system. However, this is not sufficient, and the intention is to increase Charter access with a primary focus on those regions exposed to major disasters without direct access to the system. Therefore, the Charter Board adopted the principle of 'universal access' in 2008 with the aim of improving Charter access worldwide.

To achieve this, and focusing on a formal request made by the GEO Secretariat in October 2007, the Charter is collaborating with GEO on the issue of triggering mechanisms. Priority has been put on the Asia-Pacific and African regions. In the Asia-Pacific region, thanks to the collaboration between the Charter and Sentinel Asia, a solution for a regional Earth observation capacity for emergency response has been defined involving 28 countries that did not have direct access to the Charter before.

Concerning the many countries in Africa exposed to major hazards and where the Charter is not directly accessible, a formal user consultation has been launched by the Charter in close collaboration with the GEO Secretariat in September 2009. The aim is to present the contribution that Earth observation can make to disaster response and gather the viewpoints from national authorities concerning how Charter access could be improved. A detailed investigation has been initiated to evaluate current access mechanisms, methods to

improve it and the potential role that national, regional or international organizations involved with disaster response could play to access or utilize the data that the Charter provides.

The CEOS study on requirements

The Committee on Earth Observation Satellites (CEOS) Disasters SBA Team has conducted a comprehensive study of the requirements of disaster managers for satellite data. They looked at requirements for seven different types of disaster, on a global basis, and across the full cycle of disaster management. Using an analysis from the World Bank, the study authors were able to determine which areas of the world were more likely to be severely impacted by disasters and to establish user requirements associated with those areas on a priority basis.

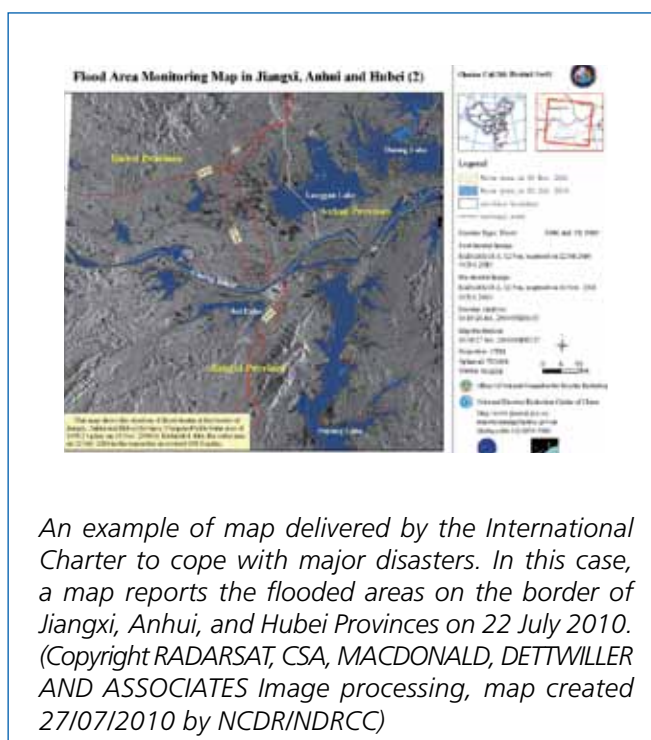
The report was eventually validated by representative users from disaster management organisations and space agencies from around the world. It was presented at a meeting in Bonn organised by the UN Office for Outer Space Affairs (UNOOSA) where 100 participants from various meteorological, disaster relief, and emergency management agencies provided feedback on both the methodology and specific user requirements. Completed in 2009, this user requirements report is now the starting point for a comprehensive gap analysis focussed on specific satellite data sets.

The CEOS Disaster SBA Team is working in conjunction with NASA's Strategic Engineering Office (SEO) to review the specific disaster-related user requirements highlighted in the report and identify observation and measurement parameters, which in turn will be tracked against the CEOS database of existing and planned missions for the 2010-2030 timeframe.

The current SEO database shows 339 (of 415) missions, 391 (of 984) instruments and 88 (of 146) measurements as being relevant to disasters in general. These measurements are a mixture of atmosphere, land and ocean parameters. Measurement requirements are based on the GEOSS 10-Year Implementation Plan. More detailed gap analyses require a better definition of measurements and their detailed requirements to match relevant missions.

This work is currently underway on flooding and is expected to be completed by late 2010. In 2011, the methodology will be extended to other hazards. In parallel to this gap analysis, work is underway within the CEOS Working Group on Information Systems and Services (WGISS) to develop a Data Dissemination model to integrate and make use of existing technologies within WGISS/CEOS, i.e. sensor web, web service, grid, and clearing house for disaster response. WGISS will then implement a prototype to demonstrate the use of these integrated technologies for disaster response.

Task DI-06-09 leads and contributors: Canadian Space Agency, China National Satellite Meteorological Center, Committee on Earth Observations, European Space Agency, and United Nations Office for Outer Space Affairs.



Improving vulnerability mapping and risk assessment for geohazards

Over the past few months and years, a number of powerful and devastating earthquakes have highlighted the need for improved seismic vulnerability mapping. A key priority has been to improve access to remotely sensed and other data to enable researchers to make more thorough and rapid assessments. The GEO Supersites initiative was established in 2009 to advance this goal, starting with seven initial sites that are prone to earthquakes, volcanic eruptions and other geohazards.

The Supersites initiative originated with the “Frascati declaration” at the conclusion of GEO’s 3rd International Geohazards workshop, held in November 2007 in Frascati, Italy. The workshop stressed the need “to stimulate an international and intergovernmental effort to monitor and study selected reference sites by establishing open access to relevant datasets according to GEO principles to foster the collaboration between all various partners and end-users”.

This recommendation was acted upon at the 2nd workshop on the Use of Remote Sensing Techniques for Monitoring Volcanoes and Seismogenic Areas – USEReST, held in Naples, Italy a year later. A scientific session on potential Supersites was convened, followed by an open discussion about the Supersite concept. More than 25 workshop participants agreed to contribute ground-based and space-based data to the initiative. A key contribution is that from the European Space Agency, which provides the information-technology infrastructure for an online synthetic aperture radar (SAR) data archive now known as ESA’s “Virtual Archive”.

There are currently three volcano Supersites – Mt. Etna, Vesuvius/Campi Phlegreii and Hawaii – and four earthquake Supersites – Istanbul, Tokyo, Vancouver/Seattle and Los Angeles. “Event Supersites” have been established for the 2009 L’Aquila earthquake and, most recently, for Haiti.

The Supersite web portals provide easy access to Earth science data and information on natural hazards in geologically active regions. The Haiti Supersite portal, for example, features seismic maps, damage maps, topography data, visible and infrared images, interferograms, and useful links. This portal was established as an impressively rapid response to the devastating 12 January 2010 earthquake. It marked the first time that satellite agencies provided data – and provided them quickly – to a central data repository accessible by researchers. As a result, researchers were able to generate early analyses of aftershock hazards and information products of benefit to both scientists and operational users.

The Supersite portals feature raw synthetic-aperture radar (SAR) data as well as Global Positioning System (GPS) and seismic data. The aim is to ensure easy access to Earth science data in order to promote their use and to advance scientific research, ultimately helping to reduce the loss of life from natural hazards.

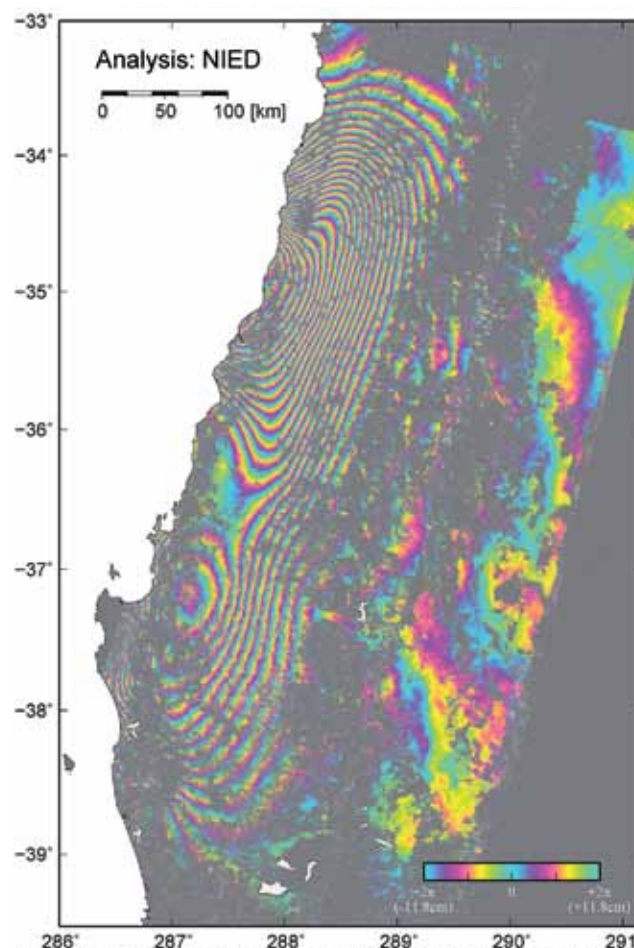
A new paradigm

Until recently, geohazards researchers have had to order each satellite image and data set individually, leading to lengthy delays. Thanks to a web server established by the European Space Agency, space agencies and other data providers can now post their geological and seismographic images and data one time only for widespread use. This allows researchers to assess the cause of the earthquake and the risk of aftershocks in a timely manner.

In the case of Haiti, the Supersites initiative proved itself on 26 January when the Japan Aerospace Space Agency (JAXA) as well as other space agencies posted essential images taken on the previous day. By comparing these images with pre-quake images, researchers were able to develop interferograms revealing the details of ground deformation. When combined with other data and products, this allowed researchers to make the best and most rapid estimate yet of the risk of another earthquake. The top priority for the scientific community is to understand the previous earthquake and to feed this information into seismic risk estimates.

Task DI-09-01 leads and contributors: Chinese Academy of Sciences, Institute of Earthquake Science, China Earthquake Network Center, EUCENTRE (Italy), European Space Agency, Italy's Institute for Environmental Protection and Research (ISPRA), University of Miami, University of Thessaloniki (Greece), UNITAR Operational Satellites Applications Programme (UNOSAT), and World Meteorological Organization.

PALSAR ScanSAR-ScanSAR interferometry
Path:422, Master: 2008/4/10, Slave:2010/3/1



PALSAR level 1.0 data are shared among PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface), and provided from JAXA under a cooperative research contract with ERI, Univ, Tokyo. The ownership of PALSAR data belongs to METI (Ministry of Economy, Trade and Industry) and JAXA.

*An interferogram of the Chilean earthquake of 27 February 2010
made available on the Supersites web portal.*

The benefits of satellite monitoring

Casualties and property losses resulting from earthquakes as well as other natural disasters have increased dramatically in recent decades. Civil protection authorities and insurers therefore seek more reliable methods for building loss models and disaster scenarios. Because seismic risk depends on the probability of a seismic event together with the level of vulnerability and preparedness of local populations, both types of information are needed for preventing and mitigating the loss in lives and property.

The standard method for evaluating the vulnerability of existing building stock requires a considerable amount of information to be collected on the physical features and characteristics of the buildings being assessed. This can severely limit the geographic scope of vulnerability estimates, either because historical data are unavailable at the desired precision or format, or because the in-situ collection of data is too expensive and time-consuming to be practical.

Researchers are therefore exploring how to provide vulnerability estimates using remote sensing, which can operate on far larger scales than in-situ data collection. Not all of the information required, however, can be acquired remotely. The solution is either to integrate satellite data with in situ and other data, or to derive the unavailable data statistically. While some precision may be lost, the benefits of a much larger geographic scope make the trade-off worthwhile.

Given the gap between the information required by the data-hungry vulnerability models commonly in use and the information that can be derived from remote sensing, the greatest possible amount of data needs to be collected. In particular, combining optical and radar data makes it possible to generate a large amount of useful information. Fortunately, Very High Resolution (VHR) optical satellites are commonplace today, while very high spatial resolution (VHR) multispectral and synthetic aperture radar (SAR) satellite systems such as COSMO/SkyMed and TerraSAR-X have recently become operational.



Sample output of a vulnerability assessment based on satellite observations. A "vulnerability" tag, represented by a colour in a "vulnerability palette" ranging from green (least vulnerable) to red (extremely vulnerable), is attached to the examined buildings shown on a GoogleEarth image

Crafting regional end-to-end solutions for disasters management

Since 2009, member agencies of the Committee on Earth Observation Satellites (CEOS) have been conducting regional demonstrations of a multi-hazard, end-to-end approach to disasters management. This approach is fully aligned with the UN's Hyogo Framework for Action. The two current demonstrations in the Caribbean and in Africa are based on clear user needs and seek to identify sustainable disaster-management practices.

The US National Aeronautics and Space Administration's (NASA) Goddard Spaceflight Centre is leading two disaster-management demonstrations that include a range of activities spanning the entire disaster cycle from mitigation through warning, response and recovery.

Six Caribbean projects

NASA, the Canadian Space Agency and the European Space Agency have been working closely with regional partners to define and implement the Caribbean Satellite Disaster Pilot. The lead user agency is the Caribbean Disaster and Emergency Management Agency (CDEMA), which was instrumental in setting up the pilot.

CDEMA and NASA wrote to some 24 Caribbean nations to invite them to submit their candidacy to become "National Partners" for the first phase of the pilot. Five national partners were selected in July 2010 based on their willingness to commit resources and data sets to the project and their commitment to have meteorological and disaster agencies working in close cooperation. They are Barbados, British Virgin Islands, Grenada, Jamaica and Saint-Lucia. Five more countries have been identified as Phase 2 partners. The project team is also cooperating closely with the Caribbean Institute for Meteorology and Hydrology (CIMH) and the University of the West Indies on capacity-building components.

The pilot includes six different projects: Sensor Web Flood Prediction and Near-Real Time Response (see diagram), Coastal Decision Support Tool, Urban Risk Mitigation, Flood Vulnerability Assessment and Mapping, Sensitive Ecosystem Monitoring (including landslides), and Integration of Satellite Data in existing Operational Flood Warning and Response Systems. Ultimately, the most successful projects will be selected for long-term implementation.

The Namibian Flood and Health Pilot

A similar effort is underway in Namibia, where CEOS agencies are working with local users and international donors to better monitor the full cycle of flooding across several large water basins. The Namibian Department of Hydrology approached CEOS and NASA to establish a monitoring program based on satellite data that would allow it to monitor flood risk in the main water basins and predict areas likely to flood, based on a combination of satellite imagery and hydrological modelling.

The satellite data is collected and predictions are issued in near-real time and later validated against ground truth data. Eventually, the system is to be broadened to include all major river basins in the surrounding countries of southern Africa. The project has been presented at the United Nations, and Namibia has put it out to donors to ensure longer term sustainability.

Future regional pilots

The early successes of the African and Caribbean pilots confirm that the approach being taken allows for strong user involvement and a flexible implementation of technology solutions. Pilots in South America and the Asia-Pacific are envisaged for the future to showcase the end-to-end management of natural hazards integrating all Earth observations.

Task DI-09-02 leads and contributors: Canada Centre for Remote Sensing (CCRS), Canadian Space Agency (on behalf of the Committee on Earth Observation Satellites), European Space Agency, German Aerospace Center (DLR), Italian Space Agency (ASI), US National Aeronautics and Space Administration (NASA), and United Nations Office for Outer Space Affairs (UNOOSA).



How the Sensor Web for Near-real Time Flood Prediction and Warning works



Lake Liambezi in Namibia, EO-1 ALI Image April 9, 2009. Overlaid on Formosat Image April 5, 2009 on Google Earth

Strengthening early warning systems for wildfires

A globally-coordinated warning system for wildland fires will improve prediction and response at the local, national and regional levels. Using sophisticated risk models and other analytical tools, emergency teams can coordinate and share their fire-fighting resources and rapidly move equipment to where it is needed. Working through the UN International Strategy for Disaster Reduction (UNISDR) and the Global Observation for Forest and Land Cover Dynamics (GOFC-GOLD) consortium, governments are making steady progress towards establishing and coordinating their national early warning systems.

Wildland fires, which already burn several hundred million hectares of vegetation every year, are on the increase. Extremely large and severe “megafires” have been reported in many parts of the world. Over half of all fires occur in Africa, primarily due to the use of prescribed fire for land and resource management.

Because most uncontrolled and destructive wildfires are human-caused, accurate fire-danger information can make an enormous difference. Space-based and in-situ data on weather and fire activity together with sophisticated modeling of fire risk can be used to generate early warnings of potential wildfire disaster conditions. Rapid access to this information can give forest and land-management agencies, as well as land owners and communities, enough time to implement fire prevention measures and to prepare fire-fighting plans before the situation gets out of control.

An international partnership of agencies has launched a three-year initiative to develop a globally-coordinated early warning system for operational decision-making as a contribution to GEOSS. The system is based on establishing linkages between Earth observation datasets and scientific models of fire weather, fire danger, and fire behavior.

The Centre for Australian Weather and Climate Research will provide data via the World Meteorological Organization (WMO) in order to produce daily actual fire danger products, including smoke trajectories and associated air-pollution warnings. It will also provide weather-based fire-danger forecasts for up to two weeks out.

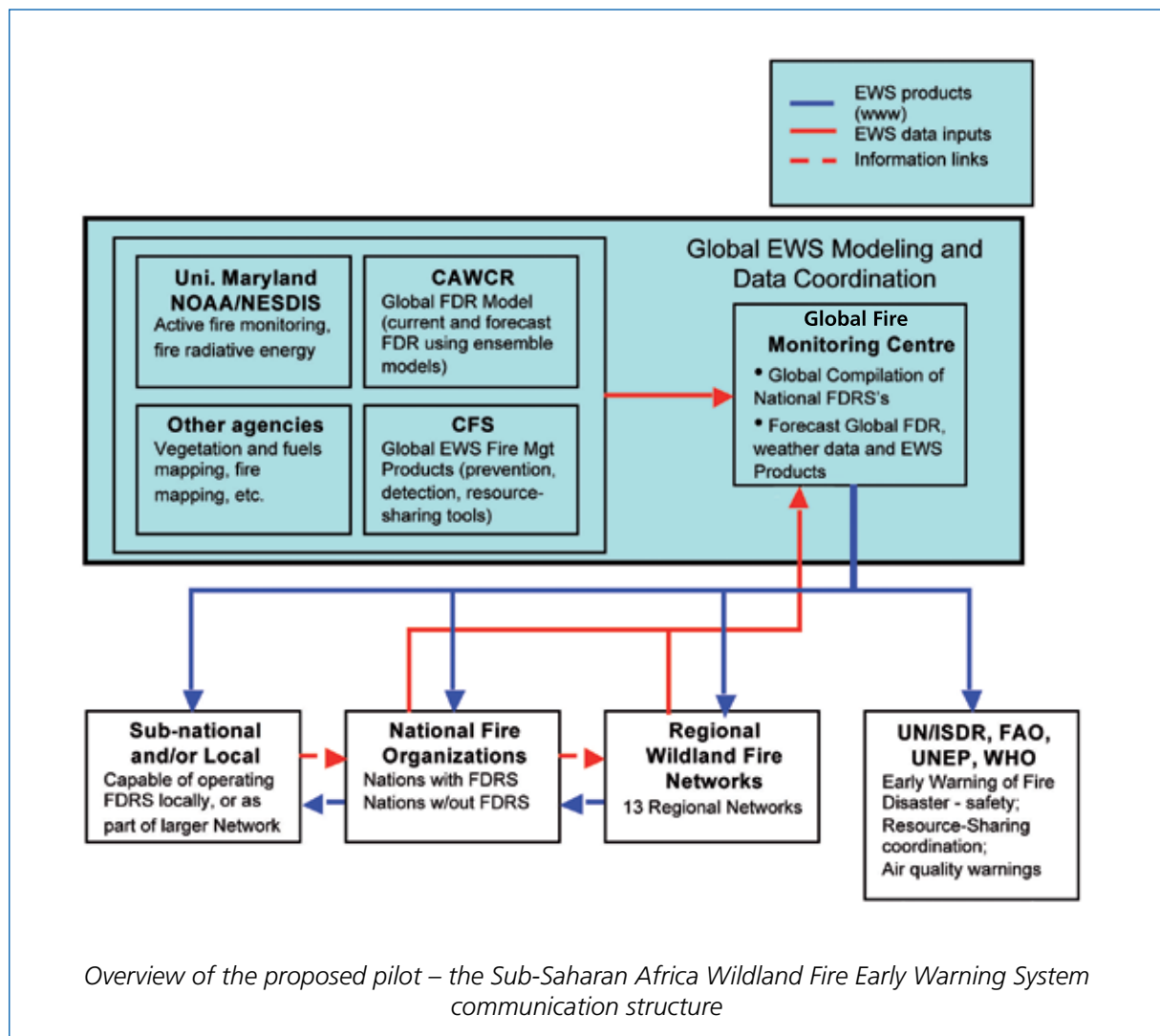
The GOFC-GOLD Fire Implementation Team will contribute satellite data through the University of Maryland and the US National Oceanographic and Atmospheric Administration’s National Environmental Satellite, Data, and Information Service. These data will include real- to near-real time detection of active fires for early alert, land-cover classification by fuel type, and possibly precipitation and other spatial weather information for areas where ground-based weather data is sparse.

The Global Terrestrial Observing System (GTOS) programme supports the Global Fire Information Management System (GFIMS), a joint initiative of the Food and Agriculture Organization of the UN, the US National Aeronautics and Space Administration and the University of Maryland, for disseminating active fire and burned area information products.

The Canadian Forest Service will develop the system to integrate all of these data sources. It will process early-warning indicators of fire danger and air quality, and it will provide models for estimating carbon emissions for carbon accounting and particulate-matter emissions for air-quality warnings. Together with other fire research agencies in the Global Wildland Fire Network (GWFN), it will also provide the scientific

expertise to calibrate fire-danger indices. The UNISDR's Global Fire Monitoring Center will provide the system's web-based networking and distribution centre. It will also lead the effort to promote technology transfer through the United Nations University with participation by the members of the Network.

Task DI-09-03 leads and contributors: Canadian Fire Service, Centre for Australian Weather and Climate Research, European Commission Joint Research Centre, UNISDR's Global Fire Monitoring Center, and the US National Oceanic and Atmospheric Administration (NOAA).



Using environmental data to address health risks

The risk of disease outbreaks can be greatly reduced by incorporating Earth observation data into decisions about global, regional, local, and personal health. Environment and health experts are collaborating through GEO to link together relevant data bases and to improve access to information.

The challenge today is to make environmental information more easily available to health professionals and to integrate this environmental data with health data to support decision making. Health professionals need this information in a timely manner and in user-friendly formats. The GEO community is therefore working to develop a global public-health information network database. The priority is to connect the Global Health Observatory of the World Health Organization (WHO) and other health and environmental information systems together through the GEO Web Portal and Common Infrastructure. This in turn will support the development and validation of decision-support tools for the health community.

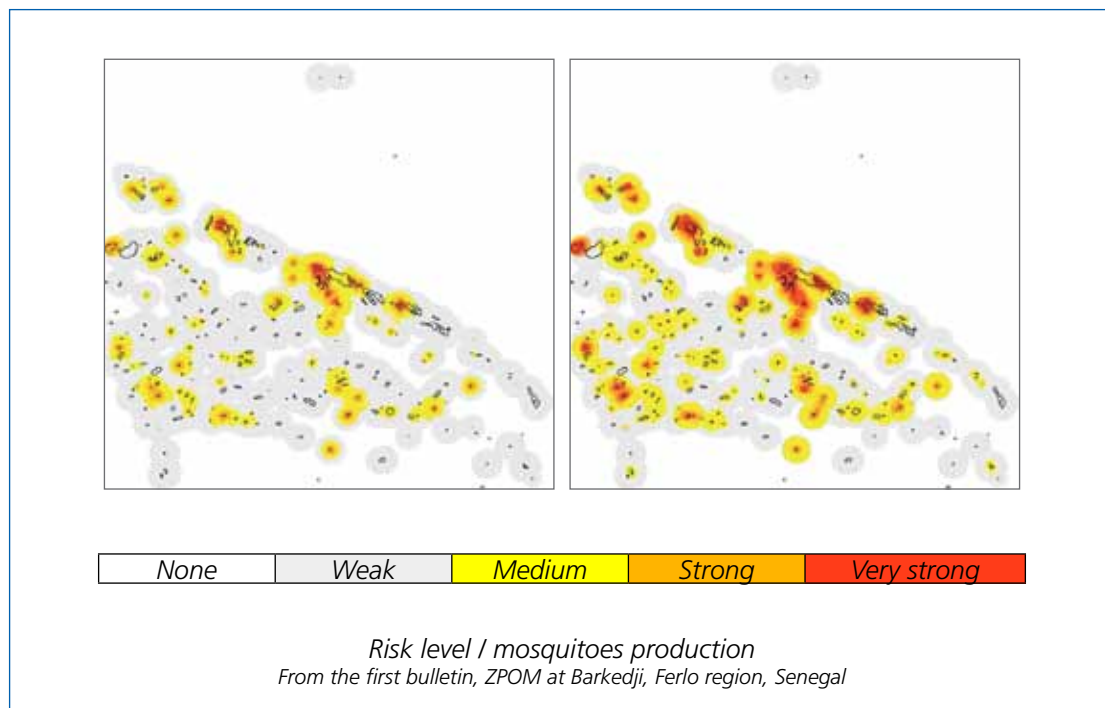
The GEO Health and Environment Community of Practice is leading the effort to strengthen access to data on diseases with environmental risk factors that are gathered by WHO and other organizations. This Community was launched in 2009 and currently boasts more than 70 active participants. It is actively discussing new pilot projects, how to integrate remote sensing and in-situ observations to serve public health, and how different projects could be interlinked to support each other.

As part of this broader effort, the French Space Agency (CNES) and its partners have made progress in two directions:

- **Building an efficient epidemiological data collecting system.** EPIDEFENDER is a software system developed by the Institute for Space Physiology and Medicine (MEDES) in France. The software can be run by a personal digital assistant (PDA) or a smart phone to facilitate epidemiological data collection in remote areas. Then, back at the user's office, the synchronisation procedure will upload all data collected into the main database of the user's computer. At the local level, a synthesis of epidemic cases can be produced. The data and the synthesis can then be sent to the regional level to be further aggregated and synthesized. EPIDEFENDER was deployed and validated operationally this year in Georgia for the national epidemiological surveillance network for tuberculosis.
- **Providing users with products integrating Earth observation remote-sensing on an operational basis.** When surveillance networks are operational and sustainable, health authorities will welcome information about epidemic outbreaks. The Ministry of Livestock in Senegal is interested in reducing the economic losses faced by breeders every year because of Rift Valley Fever. CNES together with three Senegalese partners – the Center for Ecological Follow-up (CSE), the Pasteur Institute of Dakar and the Directorate for Veterinary Services (DSV) – plus Météo France and Association Reflects have received financial support from the French Ministry of the Environment within the framework of the Global Change Impacts Group programme for providing DSV with prediction bulletins of the area at risk for disease-carrying mosquitoes. The areas at risk, also called ZPOM for Zones potentially occupied by mosquitoes, are determined by integrating Earth observations from remote sensing. Producing a regular operational bulletin is a challenge, and is one of the objectives of this AdaptRVF project. The first bulletin was published last July and future ones will normally be produced on a monthly basis. Feedback from AdaptRVF will be assessed both scientifically and at the information-system level. Setting up an

operational chain for the delivery of bulletins integrating remote sensing and added-value products integrating this information must be organised. The outcomes will be provided to GEO, the Committee on Earth Observation Satellites (CEOS) and the health community as a contribution to GEOSS.

Task HE-09-01 leads and contributors: French Space Agency (CNES), Committee on Earth Observation Satellites (CEOS), Germany Aerospace Center (DLR), German Meteorological Service (DWD), IEEE, Norwegian Institute for Air Research, Portugal's Hospital Santa Luzia, and US National Aeronautics and Space Administration (NASA).



Monitoring and predicting environmental impacts on health

Chemicals, dust and other contaminants in the water we drink and the air we breathe cause a range of respiratory and other illnesses. These widespread environmental risks to public health can best be monitored through international collaboration. Important advances are being made on providing sand and dust storm warnings and assessments and on monitoring persistent organic pollutants (POPs) and atmospheric mercury.

Sand and Dust

Airborne sand and dust present serious risks to human health in countries in, or downwind of, arid regions. Sand and dust aerosols can travel hundreds and even thousands of miles, carrying fine particles, spores, bacteria, viruses and persistent organic pollutants. Health impacts can include respiratory and cardiovascular illnesses, eye infections and, in some regions, diseases such as meningitis and valley fever.

The objectives of the Sand and Dust Storm Warning, Advisory and Assessment System (SDS-WAS) is to provide user communities access to forecasts, observations and information on sand and dust through regional centres connected to the WMO Information System (WIS) and the World Wide Web; identify and improve SDS products through consultation with the operational and user communities; enhance operational SDS forecasts through technology transfer from research; improve forecasting and observation technology through coordinated international research and assessment; build capacity of relevant countries to utilize SDS observations, forecasts and analysis products for meeting societal needs; and build bridges between SDS-WAS and other communities conducting aerosol related studies (air quality, biomass burning, etc.).

The World Meteorological Organization (WMO) is leading the development of SDS-WAS in collaboration with partners in GEO. It is establishing an international partnership of research and operational experts and users. SDS-WAS is now active, with a portal that includes regional nodes for Asia and for Northern Africa, the Middle East and Europe. Real-time data is available, primarily in the form of web-based graphics.

A community of practice for SDS-WAS initiated through GEO has focused on African meningitis health management through the Meningitis Environmental Risk Information Technologies (MERIT) project. SDS-WAS has provided dust occurrence over a five-decade period and an investigation of the potential link between dust levels and the seasonal nature of meningitis outbreaks. The first multi-sponsored (WMO, the European Space Agency, and Spain) training workshops are being conducted in November 2010 for the Northern African Meteorological Services; they will focus on the general use of satellite observations and on utilizing SDS-WAS products. The distribution of dust worldwide indicates a maximum in Northern Africa, which is the region of highest meningitis occurrence. Northern Africa also has sustained periods of very hot dry air often accompanied by dust.

Air Quality

Informing the public about air quality in near-real time, and forecasting air quality for the near future, can help people take action to avoid exposure and increase awareness of the health effects associated with air pollution. The AIRNow programme, run by the US Environmental Protection Agency in cooperation with

its partners, is a portable software system for managing, analyzing, translating, and publishing real-time air quality observations and forecasts for delivery to air quality managers, scientists, and the public. More than 300 cities are providing air quality forecasts, and more than 4,000 monitors are providing real-time data.

Today, the AIRNow system has been redesigned to provide multiple language support and a worldwide mapping capability. The new system, AIRNow-International, is improving access to air quality information throughout the world. As the first demonstration of this system outside the United States, the AIRNow-International system was launched in Shanghai on 10 May at the 2010 World Expo, providing real-time data and forecasts to attendees. The successful launch of AIRNow-I in Shanghai will encourage other pilots in China. Other provinces in the Yangtze River Delta in China have shown interest in the AIRNow-International software. Relationships are also being developed with Mexico and other international partners are being explored with projects funded by Europe.

The GEO Air Quality and Health Community of Practice was launched to support these activities. For instance, at the 2010 National Air Quality Conference (NAQC), the AIRNow team met with representatives of the National Institute of Ecology of Mexico (INE) to discuss an AIRNow-I pilot for Mexico. All parties agreed to proceed with a pilot, beginning with a workshop to bring air quality forecasters and monitoring experts together with the AIRNow team.

The worldwide sharing of air quality observations and forecasts can help researchers better understand the transmission pathways of respiratory diseases, and can help decision-makers intervene to reduce air pollution-related disease. AIRNow International envisions using GEOSS models and observations, such as satellite air quality data, and in turn providing GEOSS with observations from ambient air monitors worldwide.

Persistent Organic Pollutants (POPs)

The Stockholm Convention on Persistent Organic Pollutants (POPs), which came into effect in 2004, is a global treaty to protect human health and the environment from highly dangerous, long-lasting chemicals by restricting and ultimately eliminating their production, use, trade, release and storage. In May 2009, the baseline levels of POPs in ambient air and human milk or blood were adopted by the Stockholm Convention.

Led by the UN Environment Programme, this initiative seeks to develop and implement a global monitoring plan for tracking changing levels of POPs in the natural environment and in human beings. It is to interlink existing and emerging systems for monitoring air, water, ice caps and human health, and to identify, fill in gaps and address a number of technical and financial barriers. A baseline for the level of POPs in the environment was established in 2009 through a first global monitoring report. This report, along with five regional reports, is available on the POPs website.

Moreover, researchers investigated sampling and analytical methods for a group of chemicals newly listed by the Stockholm Convention: perfluorooctane sulfonic acid (PFOS) and its salts. This research includes an analytical methodology for PFOS in human breast milk, as well as a sampling and analysis method for air.

Atmospheric Mercury

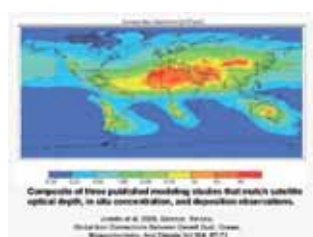
To establish a forecasting and alert system for health problems related to mercury exposure, a coordinated monitoring network is needed to provide high-quality observations for monitoring mercury and its compounds in air, atmospheric deposition, water, soil, sediments, vegetation and biota. The Italian National Research

Council's Institute of Atmospheric Pollution Research (CNR-IIA) is coordinating efforts for establishing a global observation system for mercury within the GEO framework.

A major step forward this year was the European Commission's approval of funding for the proposal to build a coordinated Global Mercury Observation System (GMOS). An overall budget of about €9 million for 2010 to 2015 will assist 24 of the world's leading research and university institutions to build upon regional programs such as the European Monitoring and Evaluation Programme (EMEP), the Atmospheric Mercury Network (AMNet), the National Atmospheric Deposition Program in the US, and MercNet. Additional partners from Canada, Japan, Korea and the US are also involved.

For the first time, then, a coordinated Global Mercury Observation System will soon be established. It will include observations from ground-based stations, ad-hoc over-water observation programs and aircraft-based tropospheric programs, and it will provide vertical profiles of tropospheric mercury concentrations at different latitudes and times of the year.

Task HE-09-02 leads and contributors: European Center for Medium-range Weather Forecasts (ECMWF), European Commission, German Meteorological Service (DWD), Greece's Atmospheric Modelling and Weather Forecasting Group, Greece's Institute for Environmental Research and Sustainability, Greece's National Observatory of Athens (NOA), Greece's University of Athens, International Centre for Integrated Mountain Development (ICIMOD), International Society for Photogrammetry and Remote Sensing (ISPRS) WGVI-2, Italy's Institute of Atmospheric Pollution Research (CNR-IIA), Italy's Institute for Environmental Protection and Research (ISPRA), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Japan's National Institute for Environmental Studies (NEIS), Norwegian Institute for Air Research, Portugal's Institute of Mediterranean Agricultural Sciences, Portugal's University of Algarve, Portugal's Vertical Grouping of Schools, South Africa's Department of Environment and Development Planning (DEADP), Secretariat of the Stockholm Convention on Persistent Organic Pollutants, US Environmental Protection Agency (EPA), US National Oceanographic and Atmospheric Administration (NOAA) World Meteorological Organization (WMO), and contributors to the Global Mercury Observation System (GMOS).



AIRNow Air Quality Index Forecast



GMOS Aircraft-based Programme

End-to-end services on health and environment

Scientists increasingly understand that many debilitating diseases, including malaria, meningitis, cholera, and dengue, are linked to changes in the environment. A number of innovative projects are working to support health professionals and emergency responders by providing them with the environmental information and analyses that they need.

Meningitis

The Health and Climate Foundation and the US-based International Research Institute for Climate and Society (IRI) have supported efforts to develop the Meningitis Environmental Risk Information Technologies (MERIT) project. MERIT aims to extend current capabilities to more effectively combine environmental information with knowledge of epidemic meningococcal meningitis to improve disease prevention and control. The implementation of MERIT promises to have an immediate impact on public health decision-making in Africa by increasing the effectiveness of prevention, response and control strategies and the surveillance of meningitis epidemics.

By adding environmental monitoring and forecast information to an epidemic surveillance system via a geographical information system, health researchers are starting to improve the response to meningitis epidemics. Occurring in the semi-arid Sahel region of Sub-Saharan Africa, such outbreaks are associated with the dusty dry season when sand storms are common. Researchers have identified a correlation between the environment and where and when epidemics occur. Ongoing work is exploring the basic mechanisms underlying this relationship. Physical damage to the throat and nasal passages from low humidity and dust is one explanation, but others exist, including the possibility that iron contained in dust may facilitate the passage of the bacteria from the throat into the blood stream. Increased crowding during cold nights during the Sahel's dry season may also facilitate outbreaks.

Two country-specific projects have been initiated in Niger and Ethiopia. The Niger project, activated in 2009, is developing a new decision-support tool that includes key environmental factors. Contributing to these developments, an exercise was recently undertaken by the health and climate communities to monitor in near-real time the changes in environmental conditions alongside the evolution of epidemics at the district level across the Meningitis Belt throughout the 2010 epidemic season. An evaluation of this exercise will be made available in late 2010. The Ethiopia project was a key outcome of the 2nd MERIT meeting in December 2008. Subject to securing funding for the activities, the MERIT Ethiopia project will support the collaboration between local and international partners with a focus on four main areas: (i) socio-economic impacts of meningitis; (ii) determinants and risk factors of epidemic outbreaks (bringing together environmental, socio-economic, epidemiological and biological factors); (iii) education and training; and (iv) disease surveillance.

Malaria

The development of a globally coordinated malaria warning system will foster the use of satellite and in-situ data for monitoring environmental conditions conducive to the spread of the disease. It will also support the development of user training for this technology.

Malaria, transmitted by mosquitoes, is a worldwide health challenge. In recent years, remote sensing specialists have been successful in mapping malaria's potential spread by tracking the climate and weather conditions

that influence the growth of the malaria-carrying *Anopheles* mosquito. Providing up to several months' lead time, these predictions can be extremely valuable to local health providers as they determine where to focus limited prevention and treatment resources.

Priorities include: (i) developing country-specific techniques for using satellite data for early malaria detection and monitoring; (ii) providing training to developing countries on satellite-based techniques used to identify mosquito habitat that stimulates the spread of malaria; and (iii) improving techniques by obtaining in-situ malaria data and feedback about the accuracy and effectiveness of the satellite data, analyses and services.

Related activities will include: (i) building support for the development of a "Globally Coordinated Malaria Warning System"; (ii) demonstrating new satellite-based methods for early warning of environmental conditions conducive to the development and spread of malaria; and (iii) advocating for bringing in other parties to share their experience in malaria monitoring.

Space agencies have given high priority to the development of a malaria early warning system and have confirmed their support to the required activities.

Ecosystems, biodiversity and health

Infectious diseases appear to have been emerging and re-emerging at a faster rate over the last 50 years. For example, Lyme disease is now the most common vector-borne disease in the US and in Europe. The West Nile virus (WNV), which emerged first in Africa, has re-emerged in recent years in temperate regions of Europe and North America, presenting a threat to human and animal health. Meanwhile, malaria continues to be a major problem in the tropics. New research is demonstrating that there are important links between the transmission of these diseases and land use and biodiversity (and its associated ecosystem services).

Improved understanding of the environmental, social and behavioral factors that contribute to human infectious disease is revealing the root causes of disease emergence and spread. This knowledge is being applied to tools that can be used to reduce and prevent disease. Using Earth observations of climate and land use along with in situ field data, scientists and public health officials are gaining a better understanding of the causal relationships. Over the next few years, science-based tools and environmental strategies will be delivered that will be useful to policy makers, public health officials, and the public. They include:

- Spatial models of disease risk based on field-based ecological data and earth observations;
- Easy to understand ecological indicators of human disease risk;
- Best management practices on land use to protect public health; and
- Guidance on the social and behavioral factors that need to be looked at locally for their contribution to human disease transmission

These tools will be readily available to apply, if appropriate, to the local context. Guidance also will be provided on how a country or region can enhance the flow of environmental data to the health community and the public through Community of Practice-based approaches. This involves bringing together the health community, the environmental community, land use planners, and the observation data providers to identify user needs and opportunities to coordinate and integrate information sharing and decision-making.

Task HE-09-03 leads and contributors: Climate and Health Working Group, Committee on Earth Observation Satellites (CEOS), European Center for Medium-range Weather Forecasts (ECMWF), French Space Agency (CNES), Greece's University of Crete, Italy's Institute for Environmental Protection and Research (ISPRA), International Research Institute for Climate and Society (IRI), Norwegian Space Centre, Portugal's Research Centre on Geographical Information and Land Planning (CIGPT) of University of the Azores, Spanish Meteorological Agency (AEMET), Thailand's Geo-Informatics and Space Technology Development Agency (GISTDA), US Centers for Disease Control and Prevention, US Environmental Protection Agency, US Fogarty International Center of the National Institutes of Health, US Health and Climate Foundation, US Meningitis Vaccine Project, US National Oceanographic and Atmospheric Administration, World Meteorological Organization and World Health Organization.



A bull's-eye rash is one of the tell-tale signs of Lyme disease, but some people can get sick without getting a rash.



Ixodes scapularis is a tick that spreads Lyme disease from animals to people.

Developing tools for managing renewable energy

The trillion-dollar energy sector increasingly relies on sustainable sources of energy supply. Exploiting the full potential of this renewable energy is critically important for all countries. New Earth observation products and services that support the managers of renewable energy sources, such as solar, wind, biomass and hydropower, are being made available within GEOSS. The development of these products and services is supported by national ministries and by organizations and universities.

The European Commission is supporting an effort to make existing data bases on solar radiation consistent and comparable. Because better knowledge about solar radiation is essential for planning and operating solar energy systems, a growing number of data bases on solar resources have been developed over the past several years. They include the European Solar Radiation Atlas, SoDa, SOLEMI, Satel-Light, PVGIS, PVSAT, PVSAT-2, Heliosat-3 and the European Space Agency's Envisolar.

The EC-funded "Management and Exploitation of Solar Resource Knowledge" (MESOR) project has surveyed user needs and is promoting the standardization of the approaches, coverage and resolution applied by these various data bases. A prototype web portal has been developed by Mines ParisTech, the German Aerospace Center (DLR), the US National Aeronautics and Space Administration (NASA) and the EC's Joint Research Centre. Within the Global Monitoring for Environment and Security's (GMES) preparatory project for an atmosphere service (MACC, or Monitoring of Atmospheric Composition and Climate), the SoDa and SOLEMI databases are currently being transferred into a European infrastructure.

Within its Integrated Application Programme, the European Space Agency (ESA) is supporting the German Space Agency's (DLR) development of a production forecast system prototype for concentrating solar power plants (CSP-FoS), based on the GEOSS monitoring and forecast capabilities.

The International Energy Agency's (IEA) Solar Heating and Cooling Programme has established a five-year task entitled "Solar Resource Knowledge Management". Coordinated by the National Renewable Energy Laboratory in the US, this international collaboration of 11 countries and over 15 organizations also seeks to further standardize space-based and surface-based data. Collaborators include the NASA SSE (Surface meteorology and Solar Energy) program, the German Aerospace Centre-led (DLR) Management and Exploitation of Solar Resource Knowledge (MESoR) project, and the École des Mines' SoDA project. In 2008, the task focused on benchmarking solar data products and developing solar forecasting methods. In 2010, a best practices guide designed to meet the needs of stakeholders, utilities, financial planners, and other end-users is being published to capture the key findings over the five years.

NASA has developed a number of services and data bases on renewable energy. The Surface Meteorology and Solar Energy (SSE) data set features over 200 parameters relating to global solar-energy resource assessment, cloud cover, and meteorological conditions on a 1°x1° latitude/longitude grid for a period from 1983-2006. Non-specialists can easily view and manipulate the data, while long data time series include the effects of inter-annual variability and long-term trends, which are possibly related to climate change impacts. SSE is freely available at the NASA Langley Atmospheric Science Data Center.

As part of its partnership with the US National Renewable Energy Laboratory, NASA provided data products for the freely available HOMER distributed power optimization model. HOMER is a computer model to evaluate

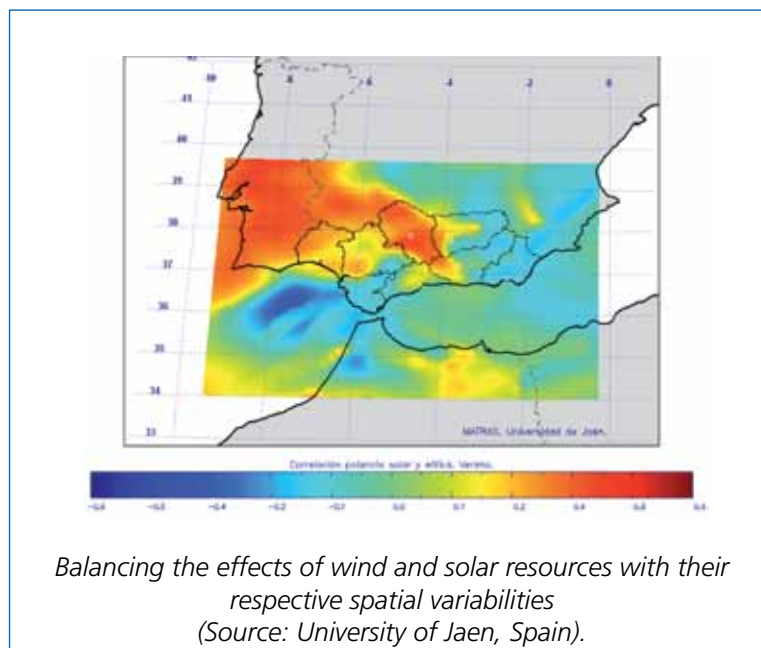
design options for off-grid and grid-connected power systems for remote, stand-alone, and distributed-generation applications. HOMER has been downloaded by over 30,000 users worldwide.

DLR has developed a methodology for analyzing the spatial distribution of biomass potential using Geographic Information Systems. Various remote sensing data are incorporated into this GIS tool. Data sets such as PELCOM (Pan-European Land Use and Land Cover Monitoring) deliver information on land use in Europe at a high resolution. Specific biomass fractions are assigned to various land cover classes. The land cover classes used, including arable land, grassland and forests, define the quality of biomass in a given area.

Researchers from the NASA Goddard Space Flight Center, in collaboration with the Electric Power Research Institute (EPRI), are collaborating on improving advance warning of the impacts of solar flares on the power grid using observations of the sun and the near-Earth space environment from platforms, such as the Solar and Heliospheric Observatory and the Advanced Composition Explorer. Solar flares can produce geomagnetic storms at high latitudes. Under some circumstances, these storms can cause geomagnetically-induced currents (GICs) to flow through power-transmission lines. These currents can perturb the power grid and, if strong enough, can cause serious impacts. A large solar flare in March 1989 led to currents which caused the collapse of the Hydro Quebec power grid for much of a day. EPRI's SUNBURST network monitors geomagnetically-induced currents and provide forecasts of impending events to the power industry.

An example of the products available due to the efforts above is shown in the figure below. The figure illustrates a study performed by the University of Jaen, Spain, on the balancing effects of wind and solar resources with their respective spatial variabilities, as described by GEOSS data sets.

Task EN-07-01 leads and contributors: European Centre for Medium-Range Weather Forecasts (ECMWF), German Aerospace Center (DLR), Mines Paris Tech, Norwegian Water Resource and Energy Directorate, Portugal's Higher Technical Institute (ICIST) and University of Algarve and Vertical Group on Schools, Republic of Congo's National Center for Statistics and Economic Studies (CNSEE), US Geological Survey, US National Aeronautics and Space Administration (NASA), US National Renewable Energy Laboratory, and others.



Monitoring the environmental impact of the energy sector

The International Energy Agency has estimated that global primary energy demand will increase by 40-50% from 2003 to 2030. Because the production, transportation and consumption of energy already put a great deal of pressure on the environment, managing and minimizing this pressure is critical. GEO aims to support decision making in this area by monitoring and predicting the environmental impacts of energy.

To date, GEO's major contribution to monitoring the impact of energy on the environment is the EC-supported EnerGEO project. EnerGEO is developing a strategy for assessing the current and future global impact of energy exploitation based on existing environment and energy models and satellite data. Four pilots will demonstrate the impacts of fossil fuels, biomass, wind energy and solar energy.

EnerGEO is building a versatile modelling platform to enable planners, environmentalists and governments to calculate, forecast and monitor the environmental impact of changes in the energy mix on local, regional and global scales. It will deliver a prototype of a distributed system that is compliant with GEO standards and architecture. This will enable users to access and collect data on how energy use impacts the environment and ecosystems.

They will be able to evaluate the impacts of different scenarios for transitioning to new energy sources and to quantify the environmental costs of energy exploitation.



Environmental indicators will be derived from existing global datasets and used to quantify changes to freshwater systems, the biosphere, eco-systems, the atmosphere and the oceans. The available models for the different types of energy (TASES, ReMix and MESSAGE) allow users to predict environmental impacts and calculate the real costs of energy exploitation. The different predictive scenarios will be stored as templates to facilitate continuous monitoring and to make it possible to constantly adapt the predictive models to actual circumstances. The testing and demonstration of the observation system and the developed scenarios will take place through the four dedicated pilots.

These pilots target the most important issues relating to atmospheric composition, sustainable bioenergy production, sustainable integration of solar energy into current grids, and the impact of wind energy on marine ecosystems. Special attention will be given to pollutants that are continuously cycling between the atmosphere and aquatic ecosystems.

The EnerGEO project launched its activities in November 2009 and will continue for four years. It is being executed under the European Commission's 7th Framework Program for Research and Technology Development. EnerGEO engages 12 partners from six countries and has a total budget of almost 8 million.

Task EN-07-02 leads and contributors: The Netherlands (EnerGEO), Pakistan (SUPARCO), and Portugal (CIGPT, University of the Azores - Research Centre).

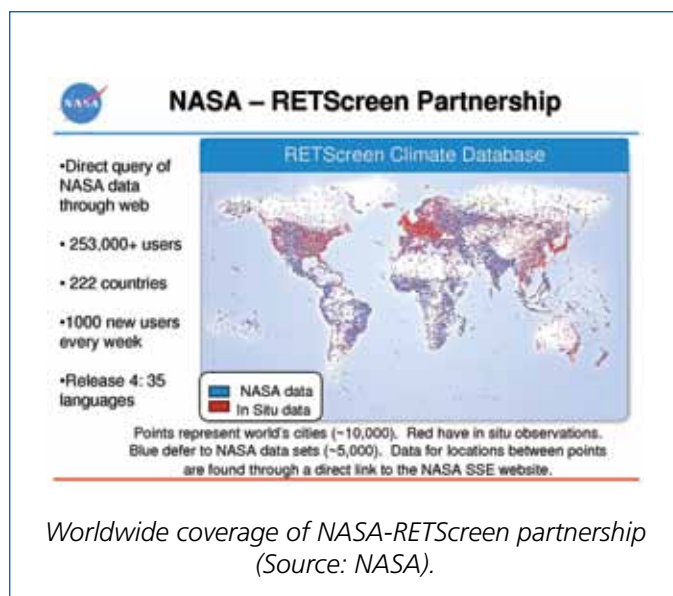
How GEOSS supports energy planning

A key concern for both governments and the private sector is matching energy supply and demand, which requires reliable access to accurate data. GEOSS facilitates the use of Earth observations by energy-policy planners through a diverse collection of initiatives.

The analysis software developed by Natural Resource Canada's RETScreen clean-energy project provides an end-to-end service for evaluating a wide range of renewable-energy and energy-efficiency technologies. It allows users to assess resources, emission reductions, and financial viability for both small-scale projects (such as renewable energy at the village level) and large-scale power-generation projects. RETScreen uses the US National Aeronautics and Space Administration's Surface Meteorology and Solar Energy data base for regions where ground-based climate data are sparse or non-existent. It is designed to ensure that the end-user need not be concerned with the intricacies of importing unfamiliar data sets into the decision-support software. RETScreen is freely available on the Web, has a registered user data base of nearly 225,000 users in 222 countries (see figure below) and is available in 26 languages. Natural Resources Canada provides manuals, video tutorials, and on-site training throughout the world.

Solar power

In France, the MINES ParisTech research institute and its lab dedicated to energy and processes have developed a service for siting solar power plants. The service provides data on time-averaged values of solar irradiance from which basic economic assessments can be made. In particular, it supports the site selection process for large solar-energy systems such as photovoltaic installations placed on open land. A comprehensive GEOSS Renewable Energy Scenario Script was developed to illustrate how a data provider and a consulting company looking for the best place to site a solar-power plant can benefit from the use of a centralized point of access, such as the GEO Web Portal and Clearinghouse. The scenario is available on the Energy Community Portal.



MINES ParisTech, in close collaboration with NASA, has also developed a combined service for delivering global information on daily solar irradiation. The service exploits the NASA-SSE and HelioClim-1 databases on daily solar irradiation, which each deliver time-series of daily values of irradiance for a site, but differ in their spatial and temporal coverage and in the resolution used to describe the spatial changes in irradiance. More than 43,000 users from 177 countries accessed this service in 2009. The databases can be accessed through a Web application launched via the Internet. In this way, applications such as RETScreen and the SoDa Service build can be built upon these databases to provide added-value information in renewable energies.

Environmental impacts

The production and use of energy are major contributors to greenhouse gas emissions. Decision makers and policy planners need better knowledge of how various energy production technologies impact the environment so that they can select the most appropriate ones. MINES ParisTech, in close collaboration with its partners, has developed a scenario focusing on the assessment of such impacts using data available within GEOSS. This new scenario benefits from existing energy-related services. Databases relating to technologies and emissions will be made available as GEOSS-compatible services in the near future.

The United Nations Environment Programme (UNEP) Solar and Wind Energy Resource Assessment (SWERA) programme is developing data products designed to support the deployment of renewable-energy technologies. It is focusing on 13 pilot countries in Asia, Africa, and Central and South America. As a contribution to GEOSS, the Committee on Earth Observation Satellites, the US Geological Survey, the US National Aeronautics and Space Administration and the US National Renewable Energy Research Laboratory, and the German Aerospace Center (DLR) are extending the use of these renewable-energy data products to other countries. An extensive array of geographical information system tools, together with NASA's Surface Meteorological and Solar Energy data set and its Shuttle Radar Topography Mission measurements, are provided to enable the end-user to map and manipulate the data. A prototype of a complementary small hydropower assessment has been developed which, together with the newly updated data products, is available freely on the internet.

NASA data sets are also being used to produce improved climate-zone maps for improving the design of buildings. This project is exploring the potential for providing NASA-derived meteorological values in areas that lack ground-site observations, thereby allowing a more realistic assessment of localized climate zones and a more realistic application of building design standards established by the American Society of Heating, Refrigerating and Air-Conditioning Engineers. These standards, currently based on ground-based data, are used extensively in the US and other countries.

In Africa, GEOSS is responding to the need for better information on local energy resources by developing the Bioenergy Atlas for Africa (BAfA). Bioenergy is renewable energy produced from biological sources, made available as electricity, heat, fuel or chemicals. If properly exploited, bioenergy in Africa can make a significant contribution to the continent's development. However, exploiting this potential faces special challenges. A major technical barrier is the unavailability of accurate and well organized renewable energy resource data. Biomass data as it relates to land availability, competing uses, water availability and processing is one such example. The Atlas is being developed as a tool for planning and managing bioenergy resources in Africa. It will allow policy-makers and other stakeholders to visualize which initiatives hold the greatest potential over time, and which ones have what kind of effects on the continent's sustainability.

Task AR-09-04 leads and contributors: German Space Agency (DLR), MINES ParisTech, South Africa's Council for Scientific and Industrial Research (CSIR), and US National Aeronautics and Space Administration (NASA).

Reanalyzing historical data for improved climate modelling

The world's major reanalysis projects, based in Europe, Japan and the US, are taking historical observations of the atmosphere, oceans and land, with all of their inconsistencies and irregularities, and reanalyzing them using today's state-of-the-art weather and climate models. Because these reanalyses of Earth observation data can make an essential contribution to virtually all societal benefit areas, GEO actively promotes their funding, coordination and use.

The reanalysis of historical data is necessary because of changes in monitoring techniques over time, upgrades in data quality control, the need to integrate modern high-resolution data with older lower-resolution data, expanded monitoring of the entire globe and of additional environmental variables, and constant advances in modelling and our scientific understanding of the Earth system. Continued improvements in reanalysis, including its expansion to the ocean, land and sea-ice domains, promise to expand its use in climate change studies, research and applications.

Unfortunately, the detailed, painstaking, but critical work tends to have low visibility. The GEO community therefore actively works to raise its profile. It promotes the use of reanalyzed data sets by researchers in other fields besides weather and climate. Furthermore, GEO's growing implementation of the GEOSS Data Sharing Principles is facilitating access to hard-to-find data archives and making them more easily available for reanalysis.

The GEO community also promotes international collaboration on reanalysis. This is being achieved through the World Climate Research Programme's (WCRP) Observation and Assimilation Panel (WOAP).

Finally, GEO advocates for the sustained funding of reanalysis projects. For example, building on the investments made to date by Europe, Japan and the US, the European Commission earmarked increased funding for reanalysis projects in its 2010 call for the 7th Framework Programme for research and technological development. Entitled "Building observational datasets for the predictability of global atmospheric, oceanic and terrestrial processes using reanalysis techniques", the call led to the selection of a proposal by the European Centre for Medium-Range Weather Forecasts (ECMWF). In addition, two reanalysis projects earlier received support from the FP7 space cooperation theme in the context of the Global Monitoring for Environment and Security (GMES) activities. FP7 is therefore expected to contribute a total of some €10 million to reanalysis projects this year.

Task CL-06-01 leads and contributors: Committee on Earth Observation Satellites (CEOS), European Centre for Medium-Range Weather Forecasts (ECMWF), European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), European Space Agency (ESA), German Weather Service (DWD), Global Climate Observing System (GCOS), Greek Centre of Technological Research, Italy's Institute for Environmental Protection and Research (ISPRA), International Geosphere-Biosphere Programme (IGBP), Norway's Bjerknes Centre for Climate Research, Norway's Nansen Environmental and Remote Sensing Centre, US National Aeronautics and Space Administration (NASA), US National Oceanographic and Atmospheric Administration (NOAA), University of Porto, World Climate Research Programme (WCRP), and World Meteorological Organisation (WMO).

Collaborating on weather and climate information

The World Meteorological Organisation, the World Climate Research Programme and the World Weather Research Programme are leading efforts to enhance predictions of weather and climate by fostering close collaboration between the weather and climate communities. .

Significant progress has been achieved in priority areas for joint research into weather and climate, in particular through the implementation of the Year of coordinated observing, modelling and forecasting of organised tropical convection and its influences on predictability. This effort is exploiting vast amounts of observations and computational resources through innovative modelling frameworks in order to advance modelling and prediction capabilities.

Further collaboration between the climate and weather communities is being pursued in the fields of polar weather and climate prediction and sub-seasonal to seasonal variability research and prediction. The latter effort, in particular, requires the development of a seamless approach to weather and seasonal prediction.

The Climate for Development in Africa Programme (ClimDev Africa) is an integrated, multi-partner programme designed to mainstream climate information into development practices throughout Africa. It has four components, which are climate observations, climate services, climate risk management and climate policy. The Programme is owned by African institutions and will be implemented by them. The principal partners are the African Union Commission (AUC), the UN Economic Commission for Africa (UNECA), and the African Development Bank (AfDB). The Global Climate Observing System (GCOS) Secretariat initiated the development of ClimDev Africa through its Regional Workshop Programme and has a continuing interest in promoting and facilitating the further development of the Programme. Donors that have pledged or have already provided initial funding for ClimDev Africa include the AfDB and the UK Department of International Development. In particular, the AfDB has provided \$37 million to four African regional climate institutions, including the African Centre for Meteorological Applications for Development (ACMAD), for institutional support activities related to ClimDev Africa implementation. Additional funding for ClimDev Africa is expected to be sought by the AfDB through a donors pledging conference.

A separate project, but one that fits well within the mandate of the much larger ClimDev Africa Programme, is the World Bank-supported project "Climate Observations and Regional Modeling in Support of Climate Risk Management and Sustainable Development." This project was initiated by GCOS, the World Climate Research Programme (WCRP), the World Meteorological Organization (WMO), and the IGAD Climate Prediction and Applications Centre (ICPAC, based in Nairobi, Kenya). The goals of this capacity-building project for the ten countries of the Greater Horn of Africa are (i) to ensure that attention is given by these countries to observation and data needs, (ii) to demonstrate the use and value of regional models, (iii) to provide advice on model limitations, and (iv) to improve capabilities across the region for using data records and model projections for adaptation planning. The project will demonstrate the application of climate information, in particular for the agriculture/food security and water-resources sectors.

Task CL-09-01 leads and contributors: Australia, ECMWF, European Commission, Global Climate Observing System, German Weather Service (DWD), Greece (Centre for Technological Research), Japan's National Institute for Information and Communications, Norway (Bjerknes Centre for Climate Research, Nansen Environmental and Remote Sensing Centre and Norwegian Meteorological Institute), United Nations Office for Outer Space Affairs (UNOOSA), US National Oceanic and Atmospheric Administration (NOAA), World Meteorological Organization, World Climate Research Programme and World Weather Research Programme).

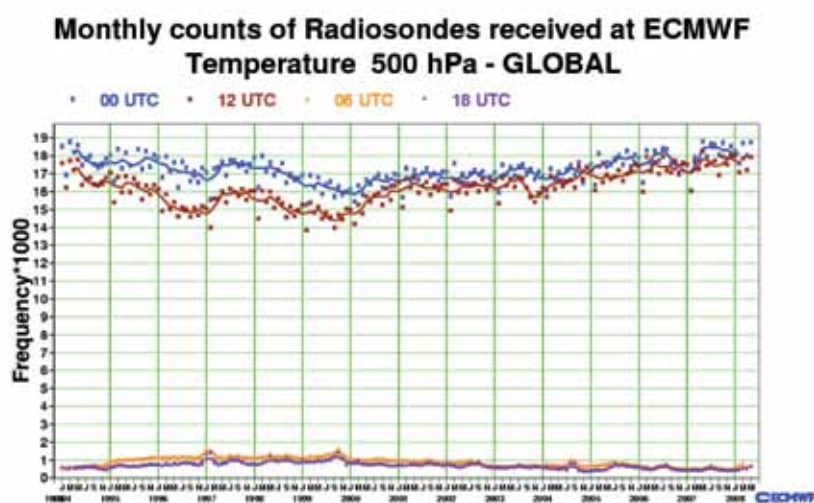
Accelerating the implementation of the Global Climate Observing System (GCOS)

As the climate observing component of GEOSS, GCOS aims to provide comprehensive information on the total climate system. It addresses a multidisciplinary range of physical, chemical and biological properties and atmospheric, oceanic, hydrologic, cryospheric and terrestrial processes. Significant progress has been made over the past five years, but many gaps remain. An accelerated effort by GEO members in 2010-2015 is needed to address the unprecedented demand for long-term, sustained, climate-related observations to support climate monitoring, research and decision-making.

Climate observations for policymakers and researchers

The GEOSS strategic target for climate calls for the full implementation of the Global Climate Observing System (GCOS) through support to the climate-relevant functions and activities of all the observing systems contributing to GCOS. These systems include the Global Ocean Observing System (GOOS), which provides the climate component for ocean observations, the Global Terrestrial Observing System (GTOS), which provides the climate component for terrestrial observations, and the WMO Integrated Global Observing System (WIGOS), which will contribute the climate component for atmospheric observations.

Together, these systems provide observational data sets on various temporal and spatial scales for the Essential Climate Variables, a priority set of meteorological and geophysical variables. Key users of these data include the Climate Change Convention (UNFCCC), the Intergovernmental Panel on Climate Change, the World Climate Research Programme (WCRP), the "Acting on Climate Change: The UN System Delivering as One" initiative, and national governments and research centres.



Frequency of 500 hPa radiosonde temperature data receipt 1994-2008 (Source: ECMWF)

The 2004 Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (GCOS-92) is the international consensus roadmap for global climate observations. It identified 131 measurable actions to guide the implementation of GCOS on a 5-10 year timescale. The 2010 update of the GCOS Implementation Plan includes an updated set of recommended actions and associated additional annual cost estimates to implement them over the coming years. It was published in August 2010 for consideration by Parties to the Climate Change Convention when they meet in Mexico in December.

Progress 2004-2008

The Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008 (GCOS-129) concluded that:

Developed countries have improved many of their climate observation capabilities, but national reports suggest little progress in ensuring long-term continuity for several important observing systems.

- Developing countries have made only limited progress in filling gaps in their in situ observing networks, with some evidence of decline in some regions, and capacity building support remains small in relation to needs.
- Both operational and research networks and systems, established principally for other purposes, are increasingly responsive to climate needs including the need for timely data exchange.
- Space agencies have improved both mission continuity and observational capability, and are increasingly meeting the identified needs for data reprocessing, product generation, and access.
- GCOS has progressed significantly over the last five years, but still falls short of meeting all the climate information needs of the UNFCCC and broader user communities.

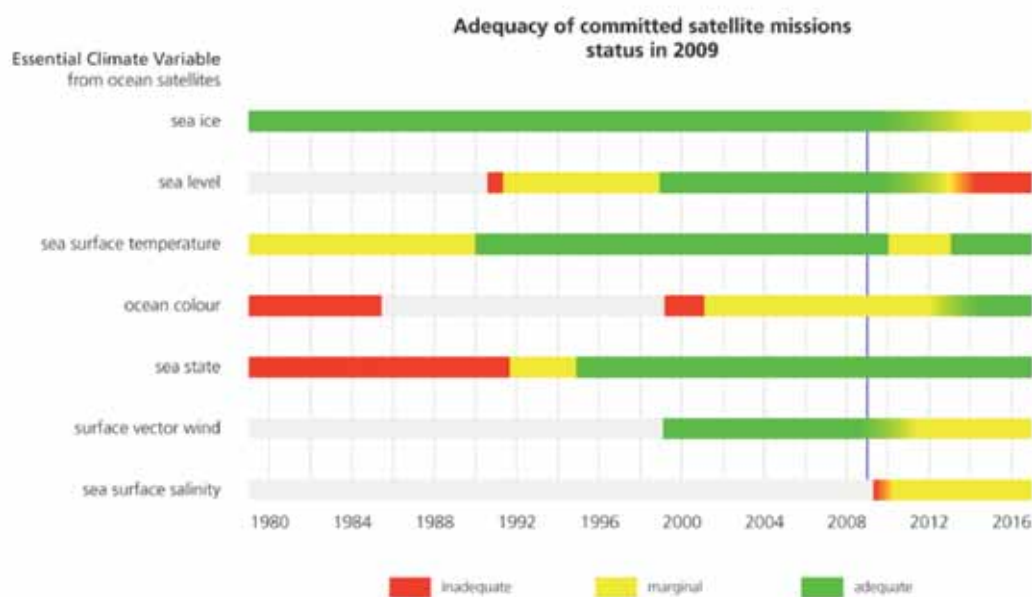
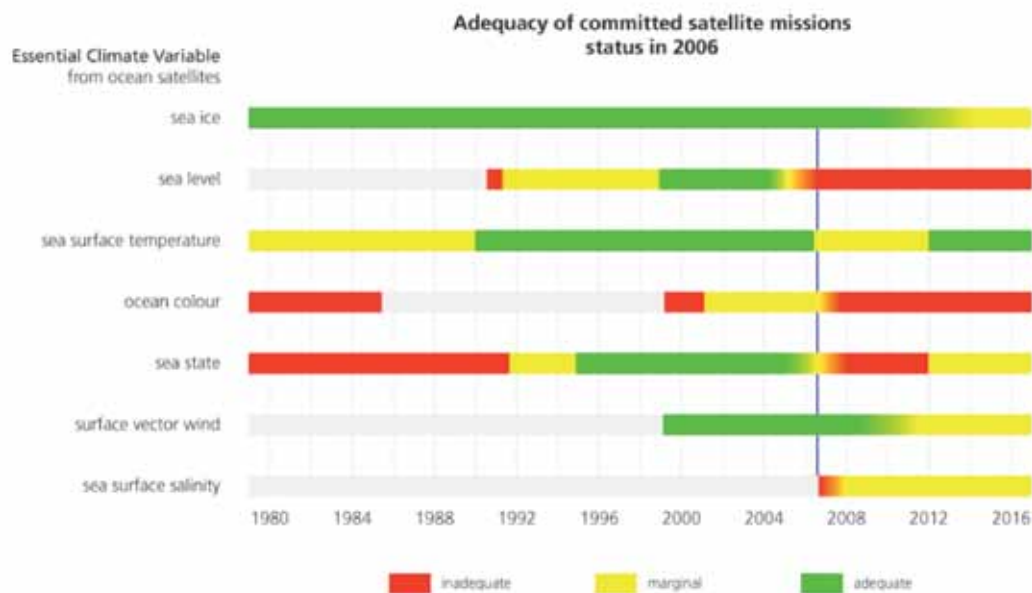
The contribution of space agencies

The space agencies active in Earth observation have been very responsive to the GCOS Implementation Plan. For example, specific steps have been taken to provide access by all countries to all satellite products. While there have also been some setbacks since 2004 in ensuring mission continuity, agencies have promptly taken remedial action to fill expected gaps between satellite missions. Space agencies are planning to respond anew to the 2010 Update of the GCOS Implementation Plan.

Agencies have also placed increased emphasis on the calibration of instruments and the intercomparison of sensors between satellites. The development of the Global Space-based Inter-Calibration System Programme (GSICS) by the WMO Space Programme and the Coordination Group for Meteorological Satellites (CGMS) is expected to meet many of these needs. Maintaining the archives of basic data records and metadata from past and current missions and reprocessing of datasets is also being given increasing attention by many agencies.

The GCOS Reference Upper-Air Network

The GCOS Reference Upper-Air Network seeks to provide the highest quality, long-term upper-air data for climate trend analysis. It seeks to constrain and calibrate data from more spatially-comprehensive global observing systems, such as those for satellites and radiosondes. The network builds on a wide range of in-situ as well as ground-based remote-sensing techniques at an initial set of 15 sites worldwide, most



Improvement in the commitments by satellite agencies to continuous climate-quality measurements of sea-surface ECVs by satellite has been substantial since 2006 (top, 2009 in bottom figure). The colour bars indicate the adequacy of committed satellite missions by the research and operational space agencies for the requirements set in the 2004 GCOS Implementation Plan and its Satellite Supplement. Marginal adequacy meets the requirements but relies on missions that are past their planned lifetime or with no redundancy.

of which are part of existing global networks. An Implementation Plan has been developed for the initial phase (2009-2013), after which the network should be expanded to its full envisaged size of 30-40 sites globally.

Transparency and traceability of climate data records

Decision-makers expect the information they use for climate change adaptation, mitigation and risk management, including the related uncertainties, to be based on sound science and trustworthy data. Ensuring transparency, traceability and good scientific judgment in the generation of the data that underpin climate research and climate change monitoring is imperative.

In May 2010, the secretariats of GCOS and WCRP issued a call for a coordinated international approach to ensure transparency, traceability and sound scientific judgment in the generation of climate data records across all fields of climate science and related Earth observations. This is to be achieved mainly by empowering existing international scientific working groups to carry out, on a regular basis, expert reviews of climate data records and derived products, through appropriate mandates and with adequate resources. Such groups should be initiated where necessary, and proper documentation of climate data records should be promoted at all institutions involved.

Task CL-09-02 leads and contributors: European Space Agency (ESA), Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS), Global Terrestrial Observing System (GTOS), US National Aeronautics and Space Administration (NASA), US National Oceanic and Atmospheric Administration (NOAA), World Climate Research Programme (WCRP), World Meteorological Organization (WMO)..

Towards a Global Carbon Observation and Analysis System

The GEO Global Carbon Observation and Analysis System aims to obtain precise, complete and sustained measurements of carbon stocks and fluxes in order to provide information to assist decision-makers with addressing climate change impacts, adaptation and mitigation. As this system develops over the next few years, it will provide invaluable data for both scientists and policymakers.

Understanding the global carbon cycle and predicting how it will affect future climate change is a major scientific challenge. In particular, the lack of data about how much carbon is absorbed by “sinks”, such as intact forests and oceans, and emitted by “sources”, such as cleared forests and fossil-fuel burning, and the geospatial distribution of these fluxes, is a major cause of uncertainty in climate change scenarios. Strengthening our observation capabilities is therefore a high priority. This can best be achieved through international collaboration amongst the diverse communities now monitoring various components of the global carbon cycle.

An efficient Integrated Global Carbon Observation and Analysis System is needed for bringing together systems and experts that monitor carbon flows on land, in the oceans and in the atmosphere. It will include satellite observations as well as in-situ observations from flux towers, tall towers, aircraft and “ships of opportunity”. This effort is being coordinated through the GEO Carbon Community of Practice (CCoP) and engages dozens of government agencies, intergovernmental and international organizations, and universities and research institutes. Members of the CCoP have produced a GEO Carbon Strategy Report containing a description of the current capabilities, gaps, needs, and recommendations and proposing the establishment and coordination of such an Integrated Global Carbon Observation and Analysis System.

The system will quantify large natural source and sink processes and determine their variability as well as the impacts of human emissions and activities. It could also, if governments so decided, be made available to monitor how national and global mitigation measures impact the carbon cycle. Developing and operating this comprehensive monitoring system will require a sustained and coordinated effort involving many partner agencies and organizations. These partners will contribute instrument and network development, sustained observations, quality assessment and control, data assimilation, database management, standardization, carbon-cycle modeling (including validation with data), fossil-fuel inventories, large-scale computing resources, decision-support analyses, synthesis, and systems engineering.

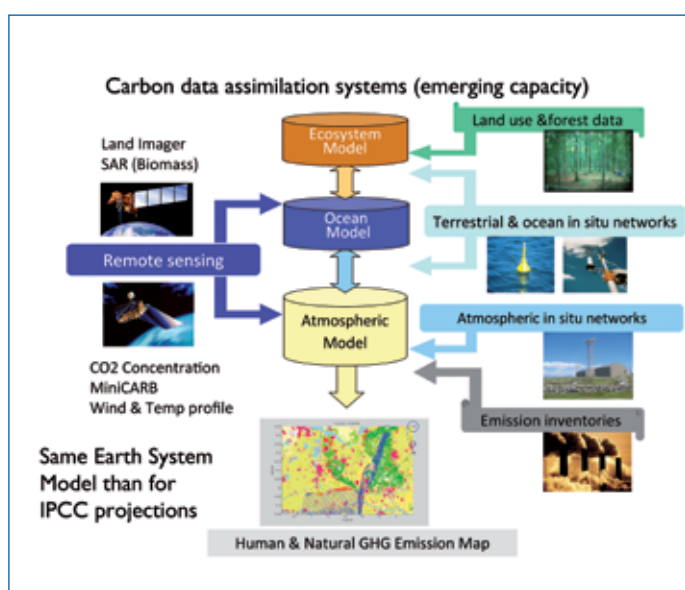
The key components of this emerging carbon monitoring system are:

- **In-situ observations.** These are needed to measure the composition of the atmosphere and the stocks and fluxes of carbon at intensive observation sites and to validate satellite observations. Several in situ networks are collaborating to improve the interoperability and harmonisation of data. FLUXNET is a global network of over 500 micrometeorological tower sites that measure the exchanges of carbon dioxide, water vapor, and energy between terrestrial ecosystems and the atmosphere. The World Meteorological Organization’s Global Atmosphere Watch program coordinates a global network of atmospheric-concentration monitoring stations and provides guidance for intercalibration. Large-scale in-situ programs, such as Europe’s Integrated Carbon Observation System (ICOS) are also being developed to be able to deliver components of the global observations that are needed for IGCO.

- **Satellite observations.** Satellite data are essential for improving the spatial coverage of the sparse in-situ networks, particularly where there are large gaps in coverage. The European Space Agency's SCIAMACHY (SCanning Imaging Absorption SpectroMeter for Atmospheric CHartographY) data are already being used for initial inverse modeling of CH₄ fluxes. GOSAT (Greenhouse gases Observing SATellite) was launched by JAXA in early 2009. Its goal is to measure CO₂ and CH₄ column integrals at better than 1% accuracy. This accuracy should be sufficient to improve the surface flux estimates compared with those obtained by using the surface in situ network alone. Following last year's failure of the Orbiting Carbon Observatory (OCO) launch, the US National Aeronautics and Space Administration (NASA) is planning to launch OCO-2 in early 2013. Other new missions dedicated to greenhouse gas-monitoring with active (LIDAR) sensors are planned by member agencies of the Committee on Earth Observation Satellites (CEOS).
- **Data assimilation and data integration.** Data assimilation and integration systems incorporate diverse data into a single consistent framework for use by sophisticated carbon cycle models. The goal is to produce routine carbon flux distribution and carbon flux diagnostics. Example of models are the US National Oceanic and Atmospheric Administration's (NOAA) CarbonTracker system and the EU's Global Monitoring for Environment and Security (GMES) MACC, CARBONES and GEOLAND projects, which provide access to a number of carbon-cycle products based on these assimilation schemes.
- **Forest Carbon Tracking (FCT).** A highly accurate global forest carbon tracking system is now possible due to a combination of high-tech instruments, advanced science and international collaboration. The GEO FCT partnership engages the world's space agencies, which have pledged to collaborate through the Committee on Earth Observation Satellites to provide the necessary space data. In situ and ground-based observations are being gathered at test sites around the world to calibrate and verify the forest-carbon models. Participants in the system are sharing images, photographs, in-situ data, models and results via an on-line platform.

Based on these and other emerging components, an Integrated Global Carbon Observation and Analysis System is being built. This system is already generating important and comprehensive global carbon data sets that can be integrated in different ways to generate various products and services for decision makers. However, there are still many gaps in this system. Key priorities over the next few years, as outlined in the GEO Carbon Strategy Report, are:

- Further harmonisation and standardisation of data and different methodologies;
- Improve interoperability among different systems and GEO Tasks;
- Improve uncertainties assessment;
- Expand the in situ network to improve global coverage;
- Develop improved satellite observations for column average CO₂ observations; and
- Promote continuity and sustainability of the whole monitoring system



Task CL-09-03 leads and contributors: Australia's Department of Climate Change, Australian Commonwealth Scientific and Research Organization (CSIRO), Committee on Earth Observation Satellites (CEOS), European Space Agency (ESA), Food and Agriculture Organization Forest Resources Assessment, France's Laboratory for Climate and Environmental sciences (LSCE), Global Terrestrial Observing System (GTOS), Japan Aerospace Exploration Agency (JAXA), Japan's Research Institute for Humanity and Nature (RIHN), National Research Council Canada, University of Amsterdam, Norwegian Space Centre, US Department of Agriculture Forest Service, US National Aeronautics and Space Administration (NASA), US National Oceanic and Atmospheric Administration (NOAA) and World Meteorological Organization Global Atmosphere Watch.

The Global Forest Observations Initiative

The GEO Global Forest Observations Initiative (GFOI) seeks to support countries in implementing their national forest information systems based on their national choice of data and tools. Its objectives are to foster the sustained availability of satellite and ground observations and to provide the evidence and guidance for their use that each individual country needs.

The GFOI recognizes the need for the various measurement, reporting and verification methods that are adopted to be consistent, comparable and transparent from country to country. The GFOI has been conceived to support a variety of national and international applications for forest data, including the long-term observation and information needs of the United Nations Framework Convention on Climate Change (UNFCCC).

The Initiative builds on national activities currently undertaken within the framework of the GEO Forest Carbon Tracking task. It will support their transition in the 2013-2014 timeframe to a global capability by systematically expanding observational capabilities, improving data availability, progressively increasing the number of national systems being implemented, and developing methods and guidance for utilising and integrating satellite, ground measurements and models and deriving emissions estimates.

The respective roles of GEO and of other major players, such as the Food and Agriculture Organization and the Intergovernmental Panel on Climate Change, as well as institutional arrangements for agencies engaged in data provision, processing, analysis and capacity building, will be further explored and defined during the development of the GFOI Plan in 2011.

Improving flood, drought and water-resource management

GEO is advancing the production of operational information for managing extreme events by bringing together the water research and user communities. The resulting portfolio of services and products continues to expand, and lessons learned and best practices are being shared through the GEO Integrated Global Water Cycle Observation (IGWCO) Community of Practice.

Floods

- The International Flood Network (IFNet) provides information on global rainfall and indicates heavy rainfall areas using data from satellites. The information is expected to become an increasingly valuable source for flood forecasting and warning, including a trial version of a Global Flood Alert System (GFAS) based on global satellite precipitation estimates.
- The International Centre for Water Hazard and Risk Management (ICHARM) has developed a flood-runoff analysis system for more effective and efficient flood forecasting in developing countries. This Integrated Flood Analysis System uses ground- and satellite-based rainfall data together with GIS functions to create river channel networks and estimates of runoff.
- The European Flood Alert System (EFAS) provides near real-time flood information as well as 10-day flood forecasts for the major rivers of Europe. Plans call for a similar system to be developed for providing flood information on the African continent.
- Working with National Meteorological/Hydrological Services, the World Meteorological Organization (WMO) Flood Forecasting Initiative (FFI) makes use of improved weather and medium-range forecasts from weather and climate models to deliver accurate flood forecasting information.
- The Hydrologic Ensemble Prediction Experiment (HEPEX) is an international effort bringing together hydrological and meteorological communities from around the globe to build research projects focused on advancing probabilistic hydrologic forecast techniques.
- The “Assessing Climate Impacts on the Quantity and quality of Water (ACQWA)” project, funded by the European Commission’s 7th Framework Programme, is analyzing the impacts of climate change on the hydrological cycle in vulnerable high-altitude regions. The project aims to go beyond the current state of hydrological modelling by identifying and incorporating diverse feedback mechanisms (hydropower, forest, land use, agriculture) coupled with advanced modelling techniques to quantify the influence of climate change on river discharge and the associated impacts on society. The project is coordinated by the University of Geneva and contributes its data sets and standards to GEOSS.

Droughts

- The North American Drought Monitor (NADM) is a cooperative effort within the GEO framework amongst Canada, Mexico and the United States. On an operational basis the NADM produces comprehensive analyses of end-of-month drought conditions across North America, based on a combination of objective drought indices and indicators, in addition to assessments by experts at regional, provincial and local levels.

- The National Integrated Drought Information System (NIDIS) brings together federal, state, and local agencies in the US to address the need for drought services and early warning. The NIDIS Drought Portal consists of an interactive drought information clearinghouse and delivery system for products and services.
- The WMO supports the drought Early Warning Systems (EWS) in developing countries through national and regional projects. It seeks to modernize the National Meteorological/Hydrological Services (NMHS) and observing networks, implement national operational multi-hazard early warning systems, strengthen hazard-analysis and hydro-meteorological risk-assessment tools, strengthen cooperation with civil protection and disaster risk management agencies, and coordinate training and public outreach programs.
- Focusing on the severe drought of 1999 - 2004/05, the Canadian Drought Research Institute (DRI) aims to improve understanding of the physical characteristics and processes leading to Canadian Prairie droughts and thereby contribute to better drought prediction. A DRI data legacy data system brings together data sets which produce an analysis system allowing users to identify the characteristics of the drought over the region during the 1999-2005 time periods. Additionally, online simulation exercises known as DPP (Drought Preparedness Projects) and DEWS (Drought Early Warning Systems) are used to better ascertain user needs.

Task WA-06-02 leads and contributors: European Centre for Medium-Range Weather Forecasts (ECMWF), European Commission (EC) Joint Research Centre (JRC), German Federal Institute of Hydrology (BfG), Greek Centre of Technological Research, International Centre for Integrated Mountain Development (ICIMOD), Norwegian Water Resources and Energy Directorate (NVE), Portuguese Territory, Culture and Development Research Centre (TERCUD), Princeton University, Slovenian Environmental Agency, United Nations Office for Outer Space Affairs (UNOOSA), United States Geological Survey (USGS), US National Oceanic and Atmospheric Administration (NOAA), University of Geneva, University of Michigan, University of Manitoba, University of Saskatchewan, World Climate Research Programme (WCRP), and World Meteorological Organization (WMO).

Building capacity for managing water resources

GEO is building capacity for individuals, infrastructure, and institutions to use Earth observation data to manage water resources, including surface waters, groundwater and water quality. This involves identifying data and general support from space agencies and seeking further funding sources, for example through the recent GEO call for participation. Efforts are currently concentrated on Latin America and the Caribbean, Asia and Africa.

Latin America and the Caribbean

GEO launched the Community for spatial and hydrological information in Latin America and the Caribbean (CIEHLYC) at a workshop in Lima, Peru in December 2009. The Community focuses on developing tools and encouraging data exchange to support the use of Earth observations for water management and on demonstrating the value of Earth system information generally in water-resource management. As a first step, it has established a dynamic web page featuring a listing of data services and projects for the region. Hosted by the Peru Space Agency (CONIDA), the site will form an initial contribution to GEOSS and be available via the GEO Portal. In addition, CIEHLYC is supporting the GEO Tasks in the Water societal benefit area and activities of the Integrated Global Water Cycle Observations (IGWCO) Community of Practice. It is addressing other recommendations from the Lima workshop dealing with the coordination of existing and new water cycle initiatives in the region. The US committee for the UN Educational, Scientific and Cultural Organization (UNESCO) has received a briefing from the group and agreed to look for ways to collaborate.

Asia

The Asian Water Cycle Initiative (AWCI) continues to address common water-related problems in Asia. It promotes integrated water resources management by making information usable through GEOSS. Twenty member countries are collaborating on demonstration projects in 18 river basins. They are working on issues related to coordinating observations, interoperability and data integration through the web-based Data Integration and Analysis System. Capacity building and training modules are being developed in cooperation with the Integrated Flood Alert System/International Centre for Water Hazard and Risk Management, the Japan Aerospace Exploration Agency, the Asian Institute of Technology, the United Nations University, the Institute for Sustainability and Peace and the University of Tokyo. The Initiative also works to promote the GEOSS Data Sharing Principles. All data, products, services and standards stemming from this initiative are contributed to GEOSS and registered with the GEOSS Common Infrastructure.

Africa

To improve Integrated Water Resource management, the European Space Agency's TIGER project (Phase I) assists water authorities at the national and basin scale in Africa with setting up prototype information systems and services. Activities have involved more than 30 African water authorities. They follow a Develop-Demonstrate-Transfer approach aimed at empowering African users to take the lead in managing the transition to an operational phase and ensuring sustainability in the long-term. Under Phase 2, launched in March 2009, 20 projects in 14 countries involving African scientists and technical centres in collaboration with water authorities have been selected for implementation. They will be supported via the Faculty of Geo-information Science and Earth Observation (ITC) of The Netherlands.

Modelled on the Asian Water Cycle Initiative, the African Water Cycle Coordination Initiative is being established to enhance coordination among disparate water projects and initiatives in Africa. The focus will be on harmonizing observational activities, techniques, interoperability arrangements, and data management. A capacity-building white paper analyzing the scope and nature of African needs and requirements for the enhanced use of Earth observations for water resource management was drafted in mid-2010. First-hand knowledge from river and river-basin authorities, hydrologists, and other water-resource managers and initiatives (such as the African Monitoring for the Environment and Sustainable Development programme, SERVIR, and TIGER) is being recruited in the project, as is expertise in capacity building from the Faculty of Geo-Information Science and Earth Observation (ITC) in The Netherlands.

Task WA-06-07 leads and contributors: Argentina's National Space Activities Commission (CONAE), Brazil's National Institute for Space Research (INPE), Canadian GEO, European Commission (EC), European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), European Space Agency (ESA), Faculty of Geo-information Science and Earth Observation (ITC), German Aerospace Center (DLR), International Centre for Water Hazard and Risk Management (ICHARM), Japan Aerospace Exploration Agency (JAXA), Peru's National Commission for Aerospace Research and Development (CONIDA), US National Aeronautics and Space Administration (NASA), US National Oceanic and Atmospheric Administration (NOAA), University of Manitoba (Canada), University of Maryland (USA), University of Tokyo (Japan), Working Group on Information Systems and Services (WGISS).

Providing integrated products for water resource management and research

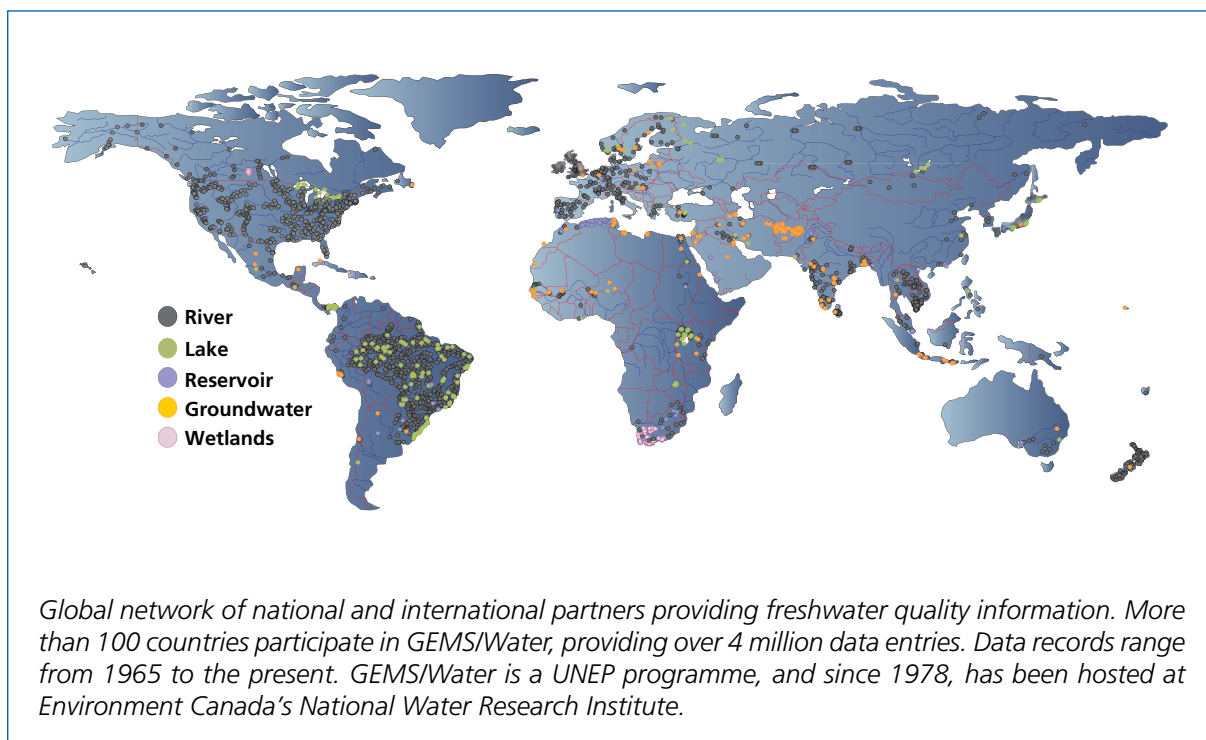
GEO is generating a wide variety of data sets and information products for water-resource managers by integrating observations from satellite and in-situ instruments. It is also strengthening collaboration within and between the water research and management communities and engaging the hydrology experts of the GEO Integrated Global Water Cycle Observation (IGWCO) Community of Practice.

Soil Moisture

The International Soil Moisture Working Group announced the opening of the Global Soil Moisture Network, hosted by the Institute of Photogrammetry and Remote Sensing of the Technical University of Vienna and co-sponsored by the European Space Agency. The Institute is already producing maps of soil moisture, surface hydrology, and freeze-thaw cycles routinely.

River Runoff / Surface Storage

The European Terrestrial Network for River Discharge (ETN-R) is an information infrastructure for the automated collection, quality control and redistribution of near real-time river discharge and water-level data from 30 European national and trans-boundary river basins, involving in total 35 countries. Forty-three providers have given their agreement to support the Network by providing their real-time data, covering the vast majority of stations relevant for the European Flood Alert System (EFAS).



Groundwater

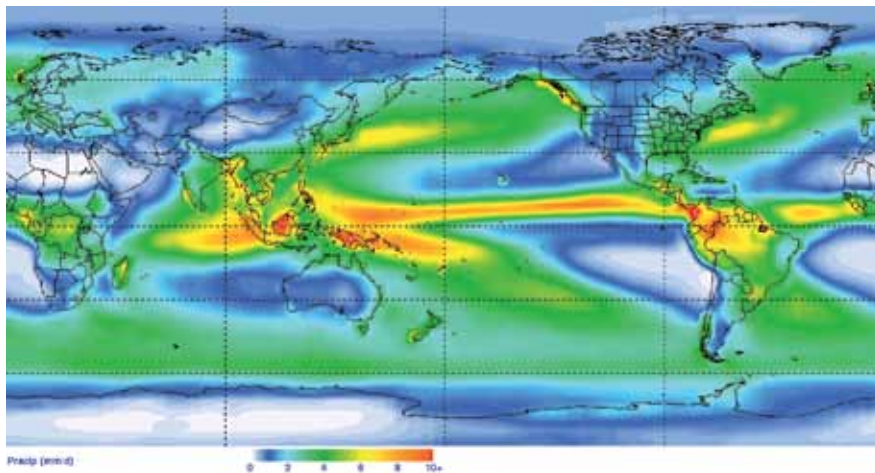
The International Groundwater Resources Assessment Centre (IGRAC), is setting up a global groundwater monitoring network by building a “people network” of skilled country representatives providing reliable groundwater monitoring data and information. The global monitoring system is using aggregated data and information from existing networks in order to assess regional changes in groundwater resources at the scale relevant for the global assessment.

Precipitation

Monthly gridded precipitation data sets from thousands of rain gauges world wide are being produced by the Global Precipitation Climatology Centre for climate monitoring purposes. The Global Precipitation Climatology Project provides data and products from integrated satellite and surface observations and from numerical model information to provide long-term records of global precipitation.

Data Analysis and Integration

The Coordinated Energy and Water Cycle Observations Project continues its activities as a prototype for the convergence and integration of water-cycle observations (including model outputs and both in-situ and remotely-sensed data) from over 50 sites globally. Meanwhile, interoperability arrangements between several research and data archiving institutions around the world allow for a well-organized approach to collecting, processing, storing, and disseminating shared data, metadata and products in support of Regional Hydroclimate Projects.



New global daily mean precipitation estimates (mm/day) for period 1979-2008 from the Global Precipitation Climatology Project (GPCP), Version 2.1. Precipitation estimates are produced on a 2.5-degree grid over the entire globe by merging estimates computed from microwave, infrared, and sounder data observed by the international constellation of precipitation-related satellites, and precipitation gauge analyses.

Water Quality

Working with a network of national and international partners, the UN Global Environmental Monitoring System for Water (GEMS-Water) Programme provides global freshwater quality monitoring and assessment. Hosted by Environment Canada's National Water Research Institute, GEMS-Water produces data and information in support of sustainable management and decision-making with respect to the world's fresh-water resources, based on reliable scientific data.

Pilot Projects

Pilot projects in cooperation with local, regional, and national groups, and other organizations are being conducted to provide water quantity and quality assistance where it is needed, but not now available. These projects focus on developing countries and are realizable in the field within one year. They will be sustainable, reusable, repeatable, and scalable. Currently, a rainwater-harvesting project has been successfully implemented in India.

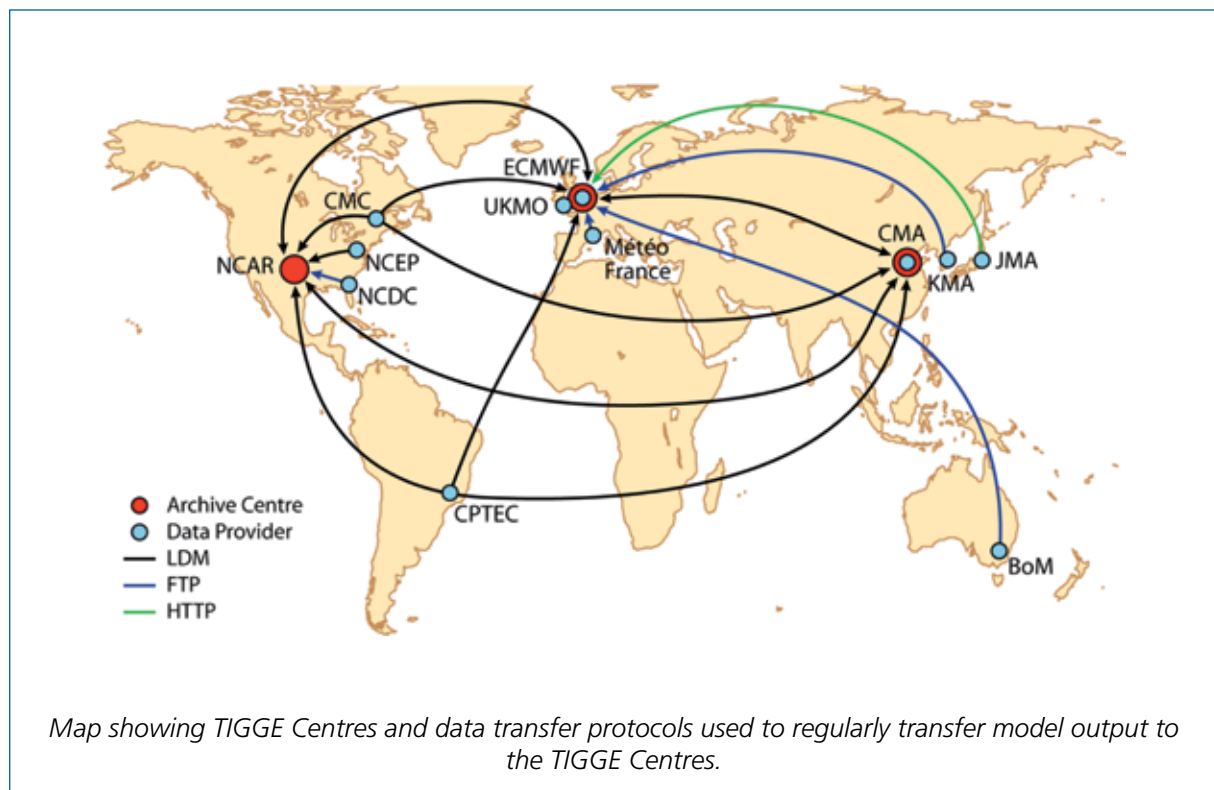
Task WA-08-01 leads and contributors: Agriculture and Agrifood Canada, Chinese Academy of Sciences (CAS), Committee on Earth Observation Satellites (CEOS), Commonwealth Scientific and Industrial Research Organisation (CSIRO), Environmental Protection Agency (EPA), Environment Canada, European Commission (EC), European Space Agency (ESA), German Weather Service (DWD), Germany's Society for the promotion of the nuclear energy in shipbuilding (GKSS), Global Energy and Water Cycle Experiment (GEWEX), Greek Laboratory of Hydrogeology & Engineering, Indian Space Research Organization (ISRO), Institute of Electrical and Electronics Engineers (IEEE), International Groundwater Resources Assessment Centre (IGRAC), Japan Aerospace Exploration Agency (JAXA), Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Max Planck Institute, US National Aeronautics and Space Administration (NASA), Japan's National Institute of Information and Communications Technology (NICT), US National Oceanic and Atmospheric Administration (NOAA), School of Engineering of the Technical University of Lisbon (IST), Princeton University, State of Wisconsin Department of Natural Resources, University of California, University Center for Atmospheric Research (UCAR), University of Colorado, University of Maryland College Park, University of Manitoba, University of Tokyo, United States Geological Survey (USGS), United States Department of Agriculture (USDA), and World Meteorological Organization (WMO).

Improving global weather forecasts for early warning

By drawing on 10 different weather-prediction models from around the world, TIGGE aims to improve the forecasting of extreme events. Better forecasts will support risk management, early warning systems, and disaster response. This Task is led by the World Meteorological Organization (WMO) and leading national weather services.

The development of numerical weather prediction represents one of the most significant scientific achievements of the 20th century. Forecasters use current weather conditions as inputs for mathematical models of the atmosphere and then use powerful supercomputers to simulate how the weather could evolve over the coming days. The THORPEX Interactive Grand Global Ensemble, or TIGGE, aims to improve the accuracy and utility of high-impact weather prediction even further and to ensure that this information is available to decision makers in user-friendly formats. It focuses on enhancing international collaboration on ensemble prediction, supporting research on weather forecasting, and developing new kinds of user-driven information products.

Weather events that are low probability/high risk – meaning that they are unlikely to occur but if they do could cause catastrophic loss of life or property – pose a particular challenge for forecasters. To predict such events, forecasters typically rely on ensemble forecasting, which combines several forecasts using the same numerical weather prediction model but with slightly varying initial conditions. The results are then combined to create a probabilistic forecast to express the likelihood that the event will occur and at what level of severity. The use of ensemble forecasts from multiple numerical weather prediction centers



can further enhance the quality of forecast products. Improved weather prediction is already benefiting farmers, water managers, health planners, and other decision makers.

TIGGE's next step is to assemble a common toolbox that can be used to develop probabilistic early warnings, first for tropical-cyclone and extreme-precipitation forecasting. The aim is to deliver these early products to users via the proposed Global Interactive Forecasting System (GIFS). These new prototype GIFS products will be tested and evaluated mainly through the Severe Weather Forecast Demonstration Project (SWFDP) and other regional projects which have been set up by the WMO and are already very successful. In addition to the tropical cyclone and precipitation products, GIFS probabilistic products will include wind-speed and near-surface-temperature forecasts.

TIGGE's data base of ensemble predictions are provided by many of the world's leading national weather-prediction centers. These national and regional centers are from Australia, Brazil, Canada, China, Europe, France, Japan, Korea, the UK and the US. Their ensemble predictions are collected at three data archive and distribution centers located at the China Meteorological Administration, the European Centre for Medium-range Weather Forecasts and the US National Center for Atmospheric Research. Anyone is welcome to download TIGGE data from these three centers for research purposes.

TIGGE is part of THE Observing system Research and Predictability EXperiment, or THORPEX, which was established in 2003 by the World Meteorological Congress as an international research programme to accelerate improvements in the accuracy of forecasts of high-impact weather. THORPEX itself is part of the wider World Weather Research Programme led by WMO.

Task WE-06-03 leads and contributors: European Centre for Medium-range Weather Forecasts (ECMWF), German Weather Service (DWD), UK Met Office, US National Oceanic and Atmospheric Administration (NOAA), World Meteorological Organization (WMO) and others.

Building capacity for high-impact weather prediction

The meteorological community is working to ensure that by 2015 developing countries have better access to operational numerical weather predictions. A growing number will also start producing weather data, information and products by using their own regional models and drawing on data from the world's major global forecasting centers.

A major priority for the global meteorological community is to develop capabilities for numerical weather prediction (NWP) in developing countries, in particular for extreme and other high-impact weather, by enhancing national infrastructure, training and research and development.

This requires identifying gaps and needs and facilitating technical cooperation on the exchange of hardware, software, technologies, and expertise, in particular for building infrastructure for operational numerical weather prediction. A series of regional capacity building workshops with major numerical weather prediction centers are being co-organized to assist developing countries in using currently available forecasts. Special attention is being given to countries South-east Asia and Africa, which are highly vulnerable to high-impact weather and climate variability and change.

The Korea Meteorological Administration (KMA) has established regional NWP models in Sri Lanka and Mongolia. It is providing the two countries with techniques to improve the quality of input data for the better performance of their models. KMA has also been working to enhance flood-monitoring and forecasting systems around the major basins in the Philippines under the auspices of the Korea International Cooperation Agency (KOICA). KMA also plans to assist Vietnam with improving its qualitative precipitation forecasting for better flood forecasts.

Two KOICA projects are also being implemented through the World Meteorological Organization (WMO) in Africa: they are (i) the Regional Climate Framework in Eastern Africa to Support Adaptation to Climate Change and (ii) Weather and Climate Impact on Community Health and Public Health Services. They aim to advance the economic and social development of the countries concerned by supporting the establishment of robust climate information services, national and regional weather and climate monitoring systems, weather forecasting and assistance to the agriculture, health and other economic sectors. Recently KMA has signed a Memorandum of Understanding with the Intergovernmental Authority on Development Climate Prediction and Applications Centre (ICPAC) to support east African countries in enhancing abilities to adapt to climate variability and change.

Meanwhile, THORPEX-Africa aims to accelerate improvements in the prediction of high-impact weather across the continent. An important aspect of this work is achieving a better scientific understanding of the nature and impacts of high-impact weather in Africa. It also considers the optimal design of observational networks and the use of new and novel observations to support improvements in NWP. In this way THORPEX will help to "close critical gaps in meteorological and related ocean observations, and enhance observational and information capabilities for the protection of life and property, especially with regard to high-impact events, and in the developing world."

This activity seeks to improve the prediction of high impact weather and help reduce the vulnerability to climate variability and change in Africa through the WWRP-THORPEX Africa initiative. This initiative is designed both to accelerate predictive skills and to help realize the related benefits for African society and the economy

through a set of priority demonstration projects. Planned specific activities include the development of a high impact weather information system, improved forecast verification systems, the design of optimal observing networks, enhanced use of non-conventional observing technologies as well as establishing the predictive skill of high impact-weather events and capacity building.

Science and Implementation Plans have been prepared which provide more detailed information on the activities that will help address the above issues including cross cutting tasks, communications, resources, monitoring/evaluation and expected benefits to society.

A priority initial activity is the development of a High Impact Weather Information System for Africa. This is expected to facilitate scientific studies of important high-impact weather systems in Africa along with collating information concerning the associated socio-economic impacts. As urbanization increases in Africa so susceptibility to the effects of high impact weather increases. Various case studies are currently being compiled including the collection of forecast and observational data to develop this activity further.

Other areas of interest include improved Limited Area Modeling; advances in Data Assimilation and forecast applications in Africa, especially for severe weather events; recommendations for improved observing networks; forecasting and the communication of high-impact weather forecasts; and mobilizing further resources for THORPEX-Africa.

Task WE-09-01 leads and contributors: European Centre for Medium-Range Weather Forecasts (ECMWF), Korean Meteorological Agency, Senegal Meteorological Agency and World Meteorological Organization.



Flooding on the Danube

GEO's EcoNet ecosystem observation and monitoring network

GEO EcoNet provides a framework for monitoring ecosystems, assessing and mapping protected areas, and mapping and monitoring forests. It is also expanding the Chlorophyll Global Integrated Network (ChloroGIN). By coordinating and improving the observation, characterization and monitoring of terrestrial, freshwater, ice and oceans ecosystems, EcoNet aims to ensure that more informed decisions can be made about ecosystem management.

EcoNet is producing a standardized, robust, and practical classification and map of global ecosystems at management-appropriate scales for terrestrial, freshwater, and marine environments. It provides a framework under which ecosystem management can be practiced. This effort involves a biophysical stratification approach to mapping landforms, bioclimates, biogeography, surface moisture, surface lithology, and land cover and then integrating these inputs to produce standardized ecosystems. Ecosystems classification and mapping has been completed for the conterminous US, South America, and Africa, while efforts over most of the rest of the globe have been initiated. The ecosystems maps are being used by the GEO Biodiversity Observation Network.

The Earth contains a wide variety of terrestrial, freshwater, and marine ecosystems, which provide biological resources and services that are essential to our survival. The rapid pace of change in the landscape threatens the existence of these ecosystems and the critical ecological services they provide. This makes it important to characterize, monitor and forecast changes in ecosystems on a systematic basis using standard data, analyses, modelling and reporting, and to conduct and promote integrated science and land use policy.

Further developing the Chlorophyll Global Integrated Network (ChloroGIN) and expanding its nodes in Canada, Africa, Indian Ocean, Antares, Europe, and Asia will contribute to this goal. ChloroGIN is developing algorithms for estimating phytoplankton biomass and primary production using satellite data. It has established a web portal that links to near-real time and archived measurements of ocean color and sea-surface temperature for South America, Africa, and the Indian Ocean. It is also delivering maps of ocean chlorophyll and sea-surface temperature as the basis for developing the ecosystem indicators needed for stewardship of the oceans.

EcoNet is also applying Earth observation technology to the characterization, mapping and monitoring of global protected areas consisting of the UNESCO World Heritage sites & Biosphere Reserves; RAMSAR Wetlands; natural areas; and sites of cultural, geological and archaeological significance. In this way it has helped to upgrade the World Database of Protected Areas, which is used as an indicator for Millennium Development Goal 7 on ensuring environmental sustainability. Establishing a protected area is a critical step toward ensuring biodiversity and ecosystem objectives, and so is measuring and monitoring the protected resources. EcoNet has developed standards for site level assessment for management effectiveness and developed an online methodology and guidance. It has also developed a set of time-series satellite images with tools to view, compare, annotate and measure changes from the imagery.

The mapping and monitoring of the world's forests is being advanced by developing more consistent maps of forest distribution and estimates of changes in forest area over time by using the same data and techniques globally. The extraction, evaluation and pre-processing of over 56,000 samples of 10 km squares of Landsat data for 1990, 2000 and 2005 for 13,500 sites has been completed, and all samples have been loaded into the project portal website (see figure). The data portal enables authorized access to the imagery and auxiliary information on-line and includes an enhanced interface, public access to Landsat data plus information on

the project, password protection for secure access for authorized users to enable downloading of draft labels and uploading of samples validated by national experts. Access to free remote sensing data and software will particularly benefit developing countries with limited forest monitoring data or capacity.

Task EC-09-01 leads and contributors: Global Observation for Forest and Land Cover Dynamics (GOF-C-GOLD), Guyra Paraguay, Partnership for the Observation of Global Oceans (POGO), UNEP World Conservation Monitoring Center, United Nations Food and Agriculture Organization, US Geological Survey, and US Department of Agriculture Forest Service.



The new portal to data for the Global Forest Remote Sensing Survey allows access to samples of Landsat data for all 13,689 sites used in the Global Forest Resources Assessment Remote Sensing Survey.

Ecosystem Vulnerability to Global Change

Terrestrial, coastal and marine ecosystems provide essential socio-economic and environmental benefits. Ecosystems the world over, however, are under tremendous stress from global change, including climate change, land-use change, pollution and the overexploitation of resources. GEO Members and Participating Organizations seek to understand the vulnerability of ecosystems to global change by improving spatial information on ecosystem conditions and trends, monitoring the effects of global change on different sectors, and creating high-quality maps and data sets for decision makers.

The tourism-intensive Eastern Mediterranean region features an extensive shoreline, thousands of islands, highly sensitive agricultural lands and fragile economies. As a result, small environmental changes can negatively affect the region's social and economic conditions. Potential impacts of global change on key sectors of the Eastern Mediterranean's economies and societies include: (i) changes in agricultural production, fisheries and water supplies; (ii) sea-level rise and its impact on tourism, manufacturing, land use, and urban areas; (iii) impacts on employment and other economic variables; and (iv) intra-regional and extra-regional migration. GEO seeks to map these impacts and identify measures for mitigating them.

A particular effort involves developing a decision support and management tool for the analysis, planning, and monitoring of transport infrastructure and related development activities by the countries and regional economic communities in Africa. The tool is envisioned as a source of information for investors and as a resource for analysis, querying, planning and decision-making for countries and user communities. An online visualisation tool for analysis, planning, decision making and monitoring of transport infrastructure and development using a GIS transport data model has been developed; it can be used to address route optimization and prediction of network loads for Africa. The development of transport infrastructure in Africa can strengthen the continent's efforts to achieve regional integration, economic development and poverty alleviation.

The Black Sea catchment suffers from ecologically unsustainable development and inadequate resource management, which has led to severe environmental, social and economic problems. A collaborative management system is being developed to store, analyze, visualize and disseminate crucial data and information on past, present and future states of European seas in order to assess their sustainability and vulnerability. It builds upon the EnviroGRIDS (gridded management system for environmental sustainability and vulnerability) project to develop a Black Sea basin observation and assessment system. EnviroGRIDS relies on modern technology using the largest gridded computing infrastructure in the world and several emerging information technologies that are revolutionizing Earth observation. EnviroGRIDS guidelines have been developed for interoperability, data storage, sensor data use and integration, remote sensing data use and integration, together with project fact sheets in 10 languages. These guidelines provide a firm baseline status and a set of recommendations for key technical aspects of the project.

High mountain spatial information on ecosystem conditions will be provided by the existing Stations at High Altitude for Research on the Environment (SHARE) network. The aim is to increase the knowledge related to ecosystem vulnerability in high mountain areas and to better assess climate change impacts, especially in terms of water, energy, air quality, food, forest products, and tourism. High-quality, long-term climatic and environmental data (e.g., atmospheric composition and meteorology, glaciology, hydrology, natural resources and biodiversity) is vital for the international scientific community and decision makers. The scientific information

being collected will permit a better understanding of the local, regional and global consequences of climate change in mountain regions and represent a key support to governments and international agencies engaging in capacity building and adaptation. Currently, the SHARE network is operational in Europe, Asia, and Africa (South America will be introduced in the next phase). It contributes data to several international programs. In the coming months, SHARE will concentrate its efforts on strengthening capacity building activities in the countries where it is operated in order to transfer more geophysical and environmental knowledge to local researchers and to awaken public opinion to environmental problems, particularly in mountain regions.

Task EC-0-02 leads and contributors: European Commission, Ev-K2-CNR Committee, Greek GEO, Italian National Research Council, United Nations Economic Commission for Africa (UNECA), United Nations Environment Programme, University of Geneva (Switzerland), World Conservation Reserve Programme and World Meteorological Organization.



Coral

Applying Earth observations to fisheries and aquaculture

For much of the world's population, fish are a vital source of protein, and fisheries are a major source of revenue. The enhanced use of Earth observation data can improve the management of these resources and reduce the stresses caused by overexploitation, pollution and climate change. Key efforts to promote Earth observations for fisheries include the SAFARI initiative (Societal Applications in Fisheries and Aquaculture using Remote Sensing) and the new FARO project (Fisheries Applications of Remotely-sensed Ocean colour data).

The SAFARI project has been coordinating Earth observation initiatives related to fisheries at the international level since October 2007. To achieve this, the project organized and coordinated an International Symposium on Remote Sensing and Fisheries in India in February 2010. Other events and outputs have included various workshops, conference sessions, training courses, monographs, white papers, outreach materials and information sessions for the fishing industry and for government representatives.

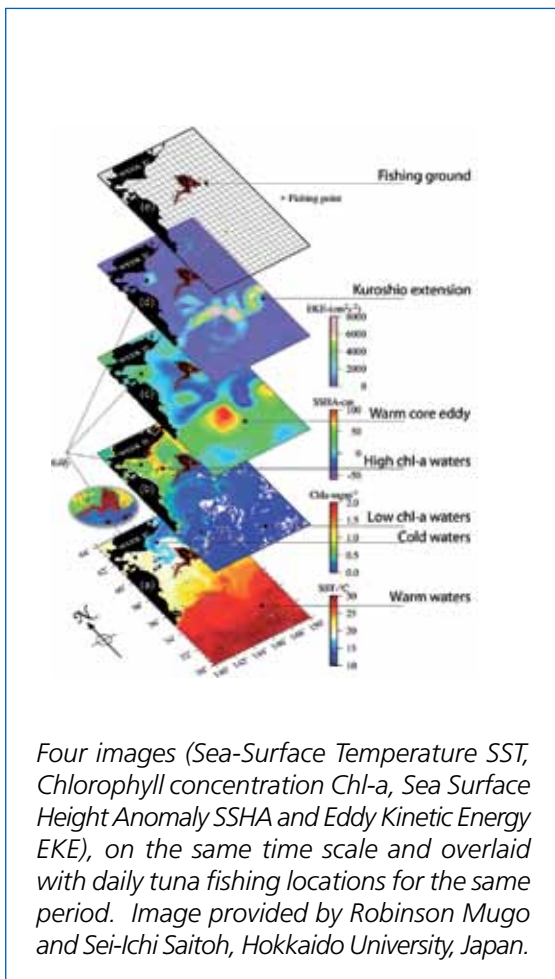
Both SAFARI and the Chlorophyll Global Integrated Network project (ChloroGIN – see page 94) recognize the fundamental requirement for an uninterrupted, long-term, well calibrated, satellite ocean colour data set for the coastal regions of the world's oceans. This need is being addressed by the Ocean Colour Radiometry constellation (see page 29). A joint international secretariat is being established to support SAFARI and ChloroGIN and to enhance synergies between their respective activities.

A second international symposium is being planned for 2013 to highlight the achievements of the SAFARI and ChloroGIN initiatives. Themes will include ocean colour applications, marine resources and societal impacts.

Meanwhile, the newly established Fisheries Applications of Remotely-sensed Ocean colour data (FARO) project, funded by the Canadian Space Agency, is developing information products for near-surface global ocean and coastal waters. These products will be provided to end users such as the fishing community and fisheries managers through a web interface. A new FARO website is under development to integrate the SAFARI and ChloroGIN websites, without losing their separate identities.

Maintaining momentum

SAFARI, FARO and others continue to organize workshops and information sessions on fisheries and Earth observations. Two outreach sessions will be held in Canada to engage and inform local fishing communities of the latest research using satellite ocean-colour data to monitor and manage marine fisheries. A national meeting will be



held to bring together Canadian scientific experts and government policy-makers with the goal of preparing a report on how remote sensing can contribute to ecosystem-based management of marine resources.

Some of the materials currently under development to promote the use of Earth observations for fisheries and aquaculture include:

- An educational handbook for the interpretation of satellite remote sensing image interpretation is being prepared by the EU Prespo project and the International Ocean-Colour Coordinating Group (IOCCG). The FARO Project will print and distribute selected case studies related to fisheries applications of remotely-sensed, ocean colour data.
- A special issue highlighting selected papers from the SAFARI international symposium will be published by the International Council on the Exploration of the Sea in the ICES Journal on Marine Science.
- A textbook on remote-sensing applications in biological oceanography will be produced by the FARO Project using contributions from SAFARI and ChloroGIN members and other experts. The book will serve as an instructional tool for students and researchers as part of FARO's continued outreach and capacity-building initiative.

Task AG-06-02 leads and contributors: Argentina's National Institute for Research and Development of Fisheries (INIDEP), Brazil's National Institute Space Research (INPE), Canadian Space Agency, Canada's Department of Fisheries and Oceans, European Commission Joint Research Centre (JRC), Global Biodiversity Information Facility (GBIF), Germany's Federal Agency for Agriculture and Food (BLE), Indian Centre for Ocean Information Services (INCOIS), Indian Space Research Organisation (ISRO), International Ocean Colour Coordinating Group (IOCCG), Japan's Natural Resources Institute for Far Sea Fisheries, Norway's Institute of Marine Research, Partnership for the Observation of the Global Oceans (POGO), Portugal's National Institute for Biological Resources (INRB), Plymouth Marine Laboratory (UK), South Africa's Council of Scientific and Industrial Research (CSIR), US National Oceanic and Atmospheric Administration (NOAA) and University of Cape Town (South Africa).



Tuna purse seiner in operation in the Indian Ocean. Credit: Jean-Pierre Hallier, Copyright IRD.

Towards a global agricultural monitoring system of systems

Governments and international organizations are collaborating through GEO to coordinate and improve agricultural monitoring in order to address the challenges facing global agriculture and promote food security. An unprecedented commitment to enhancing and sustaining observations and their use and analysis is critically needed. The GEO Global Agricultural Monitoring Community of Practice is leading the effort to develop a global agricultural monitoring system of systems.

Recent years have seen a dramatic increase in the demand for timely, comprehensive information on global agriculture and food security. Agriculture monitoring systems based on Earth observations can provide this vital information on croplands distribution, crop growth condition and crop production.

The Global Agricultural Monitoring System of Systems being promoted by GEO will consist of a large number of national and international agricultural monitoring systems. It will include the FAO's Global Information and Early Warning System (GIEWS), the USAID Famine Early Warning System, the EC's Monitoring Agriculture with Remote Sensing Project, China's Crop Watch Program and its China Agriculture Remote Sensing Monitoring System, the US Global Agricultural Monitoring System, Canada's Crop Condition Assessment Program, India's Forecasting Agricultural output using Space, Agro-meteorology and Land based observations (FASAL), the South African and Russia crop monitoring systems, and many others.

These systems often have similar data requirements and objectives, but until recently there has been little communication between them. Although many systems use a combination of ground-based and satellite derived observations, they are often not able to take full advantage of existing Earth observations for providing timely results. Other barriers include data access and data use policies with complex terms and conditions as well as commercial considerations, which can place limitations on data redistribution.

The GEO Global Agricultural Monitoring Community of Practice recognizes that developing and implementing the Global Agricultural Monitoring System of Systems will require meeting a number of enabling conditions. An increased level of cooperation will be needed amongst national governments, space agencies, commercial data providers and weather services. Non-prohibitive data pricing policies allowing for free and open sharing of data is essential, as is the timely availability of observations and data. Coordinated data acquisition would be needed during the agricultural growing season. Improved coverage and availability of meteorological data will be needed, particularly for Africa. Best practices, standardized and validated data products, the integration of satellite data into national operational agricultural monitoring systems, capacity building, and strategic investments in both satellite and in-situ instruments and systems, are all vital.

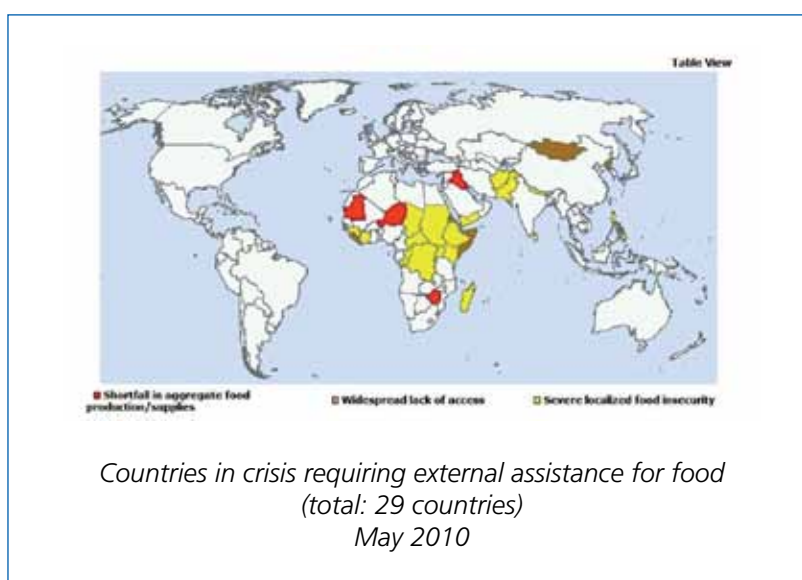
A number of early initiatives have been launched to promote the development of the agricultural monitoring system of systems:

- A Production, Acreage and Yield (PAY) data base using a common platform to integrate data from various reporting agencies is under development.
- The Joint Experiment on Crop Assessment and Monitoring (JECAM) is being planned for gathering and analyzing satellite and in situ data from multiple sources for sites around the world.

- The Coordinated Data Initiative for Global Agricultural Monitoring (CDIGAM) seeks to ensure the on-going acquisition and accessibility of satellite data during the growing season and the continuity of observations necessary for agricultural monitoring.
- Since 2008 the Thematic Workshop Series (GTWS) has been organized on thematic and methodological issues and topics (such as the impact of climate variability on agriculture). The series aims to develop best practices and standards and encourage cooperation, coordination and data sharing.
- The WMO Commission for Agricultural Meteorology (CAGM) Expert Team on Drought and Extreme Temperature is reviewing and developing standards for estimating missing weather and climate data to ensure complete input datasets for crop simulation models, and improving the integration of weather climate information into the existing Famine Early Warning systems.
- Uganda is spearheading the development of an agriculture capacity building programme for Africa. India has offered support for conducting trainings for African researchers and scientists in the field of agricultural monitoring.

The Community of Practice acknowledges that the objective of developing a Global Agricultural System of Systems is ambitious but believes that with political will it is entirely feasible.

Task AG-07-03 leads and contributors: China Meteorological Administration (CMA), Chinese Academy of Sciences (CAS), European Commission Joint Research Centre (JRC), Food and Agriculture Organization of the UN, Indian Space Research Organization (ISRO), South Africa's Agricultural Research Council (ARC), Uganda's Office of the Prime Minister, University of Maryland (UMD), US Department of Agriculture (USDA), US National Aeronautics and Space Administration (NASA), US National Oceanic and Atmospheric Administration (NOAA), World Meteorological Organization (WMO), and Zhejiang University.



Developing a global Biodiversity Observation Network

The GEO Biodiversity Observation Network is a coordinated, global network that gathers and shares information on biodiversity, provides tools for data integration and analysis, and contributes to improving environmental management and human well-being. GEO BON consists of government agencies and intergovernmental and international organizations. These partners work together to coordinate and connect their observation systems and develop information services and decision-support products.

Timely and relevant information on the status of biodiversity is critical to the effective conservation and management of the natural world and to human well-being. However, existing biodiversity information systems have developed independently of one another, making it difficult to integrate data or to conduct global-level assessments. The goal of the GEO Biodiversity Observation Network, therefore, is to provide a global, scientifically-robust framework for coordinating the gathering of data and delivery of information on biodiversity and ecosystem-services change.

Following the GEO philosophy, GEO BON is building upon the activities of existing organizations and programs, such as the Global Biodiversity Information Facility (GBIF), the UNEP World Conservation Monitoring Center (WCMC), the International Union for the Conservation of Nature (IUCN), as well as national and NGO-based monitoring programs. Based on the analysis of existing information, it highlights areas of importance for harmonization and for further targeted data collection and monitoring. Specific objectives include: (i) developing a strategy for assessing biodiversity at the genetic, species and ecosystems level; (ii) facilitating the establish-

ment of monitoring systems that enable frequent, repeated assessments of trends and distributions of species and ecosystems; and (iii) facilitating consensus on data collection protocols and the coordination of the development of interoperability among monitoring programs.

The GEO BON vision is for a coordinated, global network that gathers and shares information on biodiversity and ecosystem services, provides tools for data integration and analysis, and contributes to improving environmental management and human well-being. GEO BON is taking steps to achieve its vision by identifying the providers of observation systems, data and data bases, information services and other resources, and inviting them to contribute to GEO BON. It is building a network of people and organizations willing to collaborate and share ideas and information. It is identifying gaps in data coverage and barriers for data sharing, assembling partnerships to address these gaps and barriers, and advocating for strengthening, harmonizing and sustaining existing monitoring systems. GEO BON is also promoting better access to biodiversity data, as recommended by the GEOSS Data Sharing Principles.



A researcher making in situ observations of biodiversity

Based on these steps, GEO BON has already started to coordinate the gathering of data and the delivery of information. The Detailed Implementation Plan, which outlines the development activities through which the concepts described in the GEO BON Concept Document will be implemented, was released in May 2010 on International Biodiversity Day; eight working groups are now focused on implementing the activities in the Plan.

GEO BON is continuing to engage with the scientific, resource management and policy communities to ensure a significant increase in the availability of high-quality biodiversity information among others through pilot projects, such as EBONE in Europe. The Fourteenth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice of the Convention on Biological Diversity recommended: "Strengthening the capacity to mobilize and use biodiversity data, information and forecasts so that they are readily accessible to policymakers, managers, experts and other users, inter alia, through participation in, and support to, the Group on Earth Observations Biodiversity Observation Network (GEO BON)." GEO BON represents the observation component of the science-policy interface for biodiversity and ecosystem services. It will work closely with the new assessment component, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), to be established this year.

Task BI-09-01 leads and contributors: DIVERSITAS, European Commission, Global Biodiversity Information Facility (GBIF), US Aeronautics and Space Administration (NASA), US Geological Survey, US Department of Agriculture Forest Service, and many others organizations.

The Global Invasive Species Information Network

Invasive species (IAS) threaten biodiversity and exert a tremendous cost on society for prevention and eradication. They endanger natural ecosystem functioning and seriously impact biodiversity and agricultural production. Therefore, it is necessary to characterize, monitor and predict changes in the distribution of invasive species. The Global Invasive Species Information Network (GISIN) is characterizing current requirements and capacities for invasive species monitoring, identifying gaps, and developing strategies for implementing cross-search functionality among existing online invasive species information systems. GISIN has developed a prototype system for searching and integrating data across diverse invasive species information systems that are already present on the Internet as well as a prototype system for installation on the GISIN system.

USER ENGAGEMENT AND CAPACITY BUILDING



Training individuals to analyze and use Earth observations

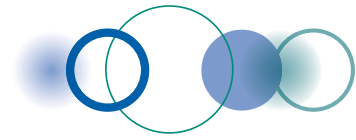
Training programs are essential for building capacity in Earth observation and geo-information sciences, particularly in developing countries. A number of GEO contributors have organized “summer schools” and other training courses to build knowledge and skills and expand the pool of people with expertise in Earth observation.

Disasters – The UN Office for Outer Space Affairs (UNOOSA) supports regional training and capacity building programs for disaster management and emergency response. The main focus is on developing individual capacity for drought, desertification, landslides and earthquake management as well as on establishing a regional network of practitioners in Latin America. The first Spring School on Drought and Desertification was held in Argentina in October 2009. A Spring School on landslides is scheduled for 2010 in Ecuador or Peru, and one on earthquakes will take place in Mexico in 2011. By addressing different types of disasters, the Summer Schools seek to enable disaster managers to take the necessary institutional and technical measures for the entire disaster management cycle.

Climate and Health – Three US-based institutes – the International Research Institute for Climate and Society (IRI), the Center for International Earth Science Information Network (CIESIN) and the Mailman School of Public Health – have developed a Summer Institute on Climate Information for Public Health. The Institute offers public health decision-makers and their partners the opportunity to learn practical methods for integrating climate knowledge and information into health decision-making processes through expert lectures, special seminars, focused discussions and practical exercises. The 2010 course, held in May 2010 in New York, exposed participants to data, methods and tools for integrating climate change and climate variability into public health decision-making. It included hands-on experience with decision tools and targeted professionals who play a role in public health-care planning, evaluation, surveillance or control of climate-sensitive diseases.

Receiving data via GEONETCast – EUMETSAT and the US National Oceanographic and Atmospheric Administration (NOAA) are developing GEONETCast training channels on their respective regional broadcasts of EUMETCast and GEONETCast Americas. The GEONETCast Training Channel is already operational over Europe, Africa and Americas, and a capability for Asia is coming online this year. The Faculty of Geo-Information Science and Earth Observation (ITC) in The Netherlands is partnering with GEONETCast and the DevCoCast project to provide training and capacity building to potential users in Africa. Brazil’s National Institute for Space Research (INPE) is leading distance learning on using GEONETCast stations and data across Latin America. Training materials will be available on the upgraded GEONETCast Product Navigator, which is compliant with GEO Architecture and Data specifications. Training materials developed through the DevCoCast project will also be shared via the EUMETCAST training channel.

Monitoring tropical forests – INPE inaugurated its new regional center in Belém, in the Amazon region, which aims to become a world reference in the monitoring of tropical forests. The center will offer training programs tailored for students from developing countries, especially in Africa and South America. Cooperation agreements signed with several organizations, including the UN Food and Agriculture Organization (FAO), France’s Research Institute for Development (IRD), and the Japan International Cooperation Agency (JICA), support this initiative. The first four-week course on tropical forest monitoring was held in October 2010.



Task CB-09-02 leads and contributors: Brazil's National Institute for Space Research (INPE), China Meteorological Administration (CMA-NSMC), China Center for Resources Satellite Data and Application (CRESDA), Department of Science and Technology of South Africa (DST), EUMETSAT, Faculty of Geo-Information Science and Earth Observation (ITC), GLOBE, International Research Institute for Climate and Society (IRI), UN Office for Outer Space Affairs (UNOOSA), US National Oceanographic and Atmospheric Administration, and World Meteorological Organization.

The GEO Call for Proposals

GEO issued a Call for Proposals (CFP) in February 2009 inviting organizations to propose or participate in projects that apply Earth observations to decision-support activities. The Capacity Building Committee and the User Interface Committee are co-managing this Call together with GEO Secretariat experts. The Call seeks to promote practical applications of Earth observations for improved decision making and to highlight specific examples of how Earth observations can benefit society. It focuses on projects in four societal benefit areas – Agriculture, Energy, Health and Water – and aims to increase the capabilities of end users, particularly in developing countries.

GEO received 133 concept proposals, from different 44 countries, mostly in the developing world. In response to a first round of review, 66 of the proponents developed and submitted full proposals, with two in the societal benefit area of Energy, 16 in Agriculture, 12 in Health and 36 in Water. The Committee members and the Secretariat organized panels of experts to review each of these full proposals and provide feedback to project teams. The final selections were announced in September. The GEO Committees are now working to broker connections between project teams and resource-providing organizations.

Building institutional capacity to use Earth observations

Coordinating, strengthening and sustaining capacity-building networks, developing stronger institutions, enabling enhanced data and information sharing, and increased training and e-learning opportunities are vital for the success of GEOSS. The GEO community's capacity-building activities include efforts to build national and regional capacity, expand the use of the GEONETCast data dissemination system, and stimulate global cooperation on operational oceanography, especially in developing countries.

Building national and regional capacity

Managing natural resources at the national level and producing national reports to submit to international bodies and treaties requires the capacity to coordinate, access, share and use environmental and socio-economic data, information and services. Many countries are committed to building this capacity by mobilizing their human, technical and institutional expertise for Earth observation. They often rely on a participatory model for networking and sharing data and information at the national level that involves engaging data providers, information disseminators and other key institutions and integrating them with regional and global platforms and mechanisms for environmental data and observation.

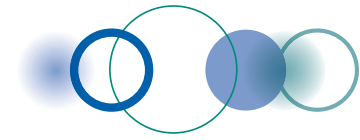
By strengthening coordination among national statistical organisations, remote-sensing agencies, and ministries for the environment, forests, wildlife and water, governments can improve general access to national environmental, socio-economic and demographic data. These national spatial data infrastructures facilitate data sharing with regional and global platforms for environmental monitoring and improve the integration of in-situ and space based observations systems. The overall objective is to enhance the use of spatial information products and services for improved policy design and decision making at the national and regional levels.

With the support of the UN Environment Programme and others, the main challenges being addressed are to:

- strengthen the national support for geoinformation institutions;
- facilitate networking based on thematic and sectoral expertise;
- link together national agencies involved in reporting for international conventions;
- support, develop and strengthen national Spatial Data Infrastructures;
- address interdisciplinary issues such as environment & security, impacts of regional conflicts, climate change adaptation, disaster risk reduction, bio-energy and biodiversity; and
- enhance the participation of developing countries in GEO and GEOSS.

The ITC GEONETCast Toolbox for capacity building networks

GEONETCast provides reliable, worldwide and continuous access to real-time data and information (see page 33). It is an easy-to-use and low-cost way for countries to receive satellite and environmental data. Its rapid



expansion requires the availability of continuous training and education for the various user communities, which can be achieved through the GEO capacity-building process.

Developed by ITC in The Netherlands, the GEONETCast Toolbox is a comprehensive, flexible and modular system that allows real-time data access via the user's desk top for producing and analyzing geo-information. Its open-source structure allows users to set up the system and design applications to address their own specific needs.

Universities and regional centres throughout the world are acquiring their own ground receiving station facilities for training and research in the use of GEONETCast data streams. New GEONETCast user communities are rapidly acquiring know-how on how to use the system and build applications through the capacity-building activities currently being carried out by ITC across Europe, Africa, Latin America and Asia. A global GEONETCast Toolbox user community and education and training support network is under development.

Building capacity for operational oceanography

GEO is facilitating operational oceanography by stimulating the sharing and use of marine-related observations. Well-developed marine monitoring and forecasting technologies, for example in Europe and US, bring additional value by being shared with developing countries in Asia, Africa and Latin America. Government agencies and international organizations are therefore working together to enhance global cooperation on operational oceanography, especially between developed and developing countries.

Key activities are: 1) establishing a global operational oceanographic network that connects advanced operational forecasting centres in developed countries and quasi-operational centres in, for example, Asia, Africa and Latin America; 2) demonstrating operational oceanography and its usefulness in developing countries within the GEOSS framework through networking; and 3) leveraging funding for, and raising awareness of, operational oceanography and related capacity-building activities.

A global operational oceanography network has been established with partners from Denmark, the Intergovernmental Oceanographic Commission/Global Ocean Observing System (IOC/GOOS), China, France, Germany, South Korea, Chile, Norway, South Africa and the US. Several regional operational oceanography demonstration projects are also ongoing. The European Commission's 6th Framework Programme funded project YEOS, a Yellow Sea Observation, Forecasting and Information System, has demonstrated a state-of-the-art regional weather-ocean-ice-wave forecasting system for East Asia through cooperation amongst EU countries, China and South Korea. Forecasting products, satellite products and in-situ observations have been shared by these partners for research. User meetings organized in China and South Korea have greatly enhanced the awareness there of operational oceanography, which is now becoming one of the major supporting areas in marine science for both countries.

The capacity building of operational oceanography is also supported by the FP7-funded project EAMNet. Training courses on operational oceanography will be provided to Africa partners. Other ongoing regional cooperation among partners includes cooperation amongst Chile, Denmark, France and the US on a Latin American coastal forecasting system and South Africa-US cooperation on an African coastal forecasting system.

Task CB-09-03 leads and contributors: Danish Meteorological Institute (DMI); European Commission; Centre for GeoInformatics (Z_GIS), Salzburg University, Austria; Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente, The Netherlands; and the United Nations Environment Programme (UNEP).

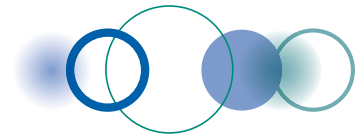
How GEONetCab supports capacity building

The GEO Network for Capacity Building (GEONetCab) project is a support action under the Environment theme in the European Union's Seventh Framework Programme (FP7). Over the next three years it will work in close cooperation with the GEO Capacity Building Committee (CBC) and relevant Task teams to enhance GEO's overall capacity-building efforts. The project is being coordinated by the Faculty of GEO-Information Science and Earth Observation (ITC) in The Netherlands.

GEONetCab is analyzing what Earth observation applications are currently available and identifying the bottlenecks that limit the possibilities for their further expansion. Special attention will be paid to success stories, experiences that can be considered as successful and as "quick wins", and initiatives that with additional effort would allow for rapid appraisal and comparatively easy fundraising. GEONetCab is focusing on practical examples coming from four regions/countries: Southern Africa, the French-speaking countries of Africa, Poland, and the Czech Republic.

The GEONetCab team has presented a first list of success stories and quick wins to the CBC members. Selected success stories are being compiled to support outreach and dissemination activities. The quick wins are being activated through networking and brokerage events organized by the project.

The capacity-building web portal that could eventually be integrated into the GEOSS Common Infrastructure will include improved access to and use of existing online courseware, the sharing of capacity-building expertise and material, search facilities for accessing existing capacity-building digital resources, and a catalogue web service to provide access to GEONetCab capacity-building resources.



Catalyzing research and development (R&D) funding for GEOSS

GEO encourages its Members and Participating Organizations to address the science and technology needs of GEOSS through their own research and development (R&D) programs. They can contribute by planning and conducting R&D activities that support GEOSS implementation, contributing current or planned R&D activities to GEOSS, earmarking resources, encouraging collaboration between relevant R&D programs, and advocating for GEOSS with decision-makers and funding agencies. GEO's Science & Technology Committee (STC) is taking the lead in this effort.

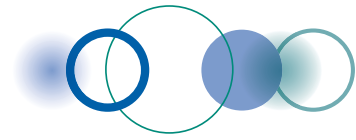
To strengthen the role of R&D in GEOSS, a Task team is identifying the key science and technology programs and funding and resource mechanisms that GEO can engage. It is also identifying commercial and industrial companies with substantial science, technology and applications interests or data sets of broad scientific value. The team will produce a report on science and technology gaps, priorities and needs, and it plans to establish an effective forum or network of funding agencies and GEO Members and Participating Organizations that can support science and technology programs.

The team is currently evaluating the resource gaps confronting the GEO Societal Benefit Areas (SBAs) and how to fill them. It has distributed a needs-assessment questionnaire to all Work Plan Task Leads and Points of Contact designed to identify the science and technology-related gaps that may prevent the full implementation of Work Plan task activities in the 2009-2011 timeframe. A gap-analysis review team has been assembled composed of members from the Science & Technology Committee and the GEO Secretariat to process the questionnaires.

In addition to this broader survey, the Committee is conducting an SBA-by-SBA review. The health, disasters, and water SBAs have been reviewed thus far. For the health review, the Committee explored efforts to connect the World Health Organization's Global Health Observatory with GEO and how the health Tasks benefit developing nations. Issues examined for disasters included integrating different observing techniques, integrating observations and model outputs, extracting relevant information from observations, identifying the potential for real-time, low-latency networks, and making products and information relevant for end users. For water the review found that some activities are very focused and are achieving results while others are very broad and clear deliverables and successes are more difficult to define; it also determined that how to make the best possible use of remotely sensed water cycle data and information needs further refinement and that more concerted efforts are needed to identify and act upon linkages between health and the other SBAs.

The Committee also recently developed a concept paper on the continuity requirements of GEOSS. Many of the tools currently under development in the GEO Work Plan will require the continuity of the observation systems, components, services and standards that are offered, in many cases, by third parties in the GEO community. The development of continuity indicators for the GEOSS components and services could assist member governments, organizational decision-makers and end users of such tools to assess the likelihood that the relevant product or service will be available over the long term. Such voluntary indicators could form a basis for evaluating how critical is the continuation of particular systems or services, thus adding value to both providers and users.

Task ST-09-01 leads and contributors: Cameroon, China, Denmark, European Environment Agency, European Commission, European Space Agency (ESA), Germany, International Council for Science (ICSU), Institute of Electrical & Electronics Engineers (IEEE), International Institute for Applied Systems Analysis (IIASA), Open Geospatial Consortium (OGC), Spain, Turkey, United Kingdom, United States, World Meteorological Organization (WMO).

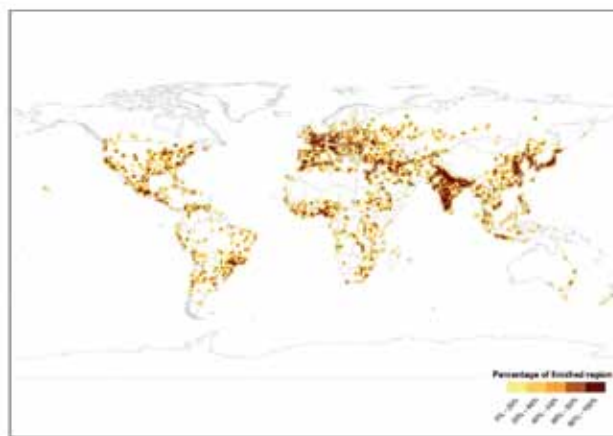


The social and human dimension of GEOSS

GEOSS is about the Earth system – but is also about people. GEO Members and Participating Organizations are carrying out projects to assess GEOSS' value to the people who use it, engage people in observing the Earth, build databases on socio-economic variables, track progress on the UN Millennium Development Goals, and monitor human settlements and infrastructure.

The portfolio of projects that contribute to GEO by addressing the social and human dimensions of GEOSS include:

- The European Commission-sponsored GEOBENE project (Global Earth Observation-Benefit Estimation: Now, Next and Emerging) assessed the benefits and added-value – including the contribution to cooperation and data sharing – of the Global Earth Observation System of Systems. Published in 2010, the GEOBENE final report concluded that the benefits of investing in GEOSS far outweigh the costs.
- Using the models developed for GEOBENE, the EuroGEOSS project will assess the value that GEOSS adds to multi-disciplinary interoperability and modelling, in particular in the fields of drought, biodiversity and forests. This integrated benefit assessment is also studying the value of improved global land cover information. The project is working towards 'best practice' guidelines that could be used by analysts to assess the value of interoperable geo-information.
- The Geo-Wiki project has built a global land-cover validation tool based on community remote sensing. A global network of volunteers who wish to help improve the quality of global land-cover maps are asked to review hotspot maps of areas where there are conflicting reports or descriptions of the kind of land cover. They then try to determine, based on what they actually see in Google Earth and on their local knowledge, whether the land cover maps are correct or incorrect. Their input is recorded in a database,

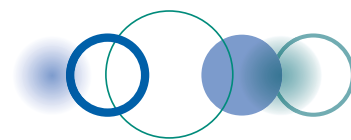


Percentage of area finished for developing global human settlement map

along with uploaded photos, to be used in the future for creating a new and improved global land cover map. The Geo-Wiki's functionality continues to increase, with 1,000 images from Malawi, for example, recently added, geo-referenced and orientation-referenced. A user-defined validation tool is available for people interested in validation. There are currently 150 registered users.

- The GEO Grid initiative is developing a global road and human settlements map. A new dataset for validating human settlement maps has been built by extracting human settlement information from high-resolution satellite images. Software to extract road vectors from satellite images has been evaluated as a web-based GIS tool. The end result will be an integrated Global Road and Human Settlements Map available on the GEO Grid system. For global road mapping, "crowdsourcing" is used to obtain initial inputs from people who interpret global satellite data. The next step will be to implement this method on the GEO Grid. Related activities include: (i) systems development to enable the GEO Grid to share, develop and distribute data; (ii) research and development for producing relevant data using satellite images; and (iii) collection, maintenance, and evaluation of relevant remote-sensing and GIS data.

Task US-09-02 leads and contributors: International Institute for Applied Systems Analysis (IIASA), European Commission, International Council for Science (ICSU) Committee on Data for Science and Technology (CODATA), Japan's National Institute of Advanced Industrial Science and Technology (AIST), Organization for Economic Co-operation and Development (OECD) Space Forum, Russia's Roshydromet, University of Tokyo, UN Office for Outer Space Affairs (OOSA), and US National Aeronautics and Space Administration (NASA).



SCIENCE AND TECHNOLOGY

115



Engaging the science and technology community

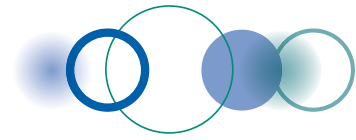
The science and technology community has an essential role to play in ensuring that GEOSS contributes to a greater understanding of global environmental change and the Earth system. To communicate more effectively with scientists and experts about the benefits of GEOSS, GEO is reaching out to the world's diverse scientific and technological communities, forming links with major scientific research enterprises in each societal benefit area, actively encouraging scientists and technical experts to participate in GEOSS, contacting universities and laboratories and organizing a GEO presence at major symposia and meetings.

To increase GEO's visibility, a number of sessions, workshops and Town Hall meetings have been organized to introduce various science and technology communities to GEO and attract their support for GEOSS implementation. The Integrated Global Observing Strategy (IGOS) Achievements Symposium, for example, was organized in Washington DC in November 2009 immediately following the GEO-VI Plenary. The Symposium featured the accomplishments of the former Integrated Global Observation Strategy (IGOS) Themes, which have now transitioned into the GEO framework. Several former IGOS Themes have been transformed into GEO Communities of Practice (CoP), including the Integrated Global Water Cycle Observation (IGWCO) CoP, the Coastal Zone CoP, and the Geohazards CoP. Reports on the successes of the Asian Water Cycle Initiative (AWCI), the GEO Biodiversity Observation Network (the Biodiversity CoP), ocean monitoring (Ocean CoP), and the Supersites Initiative (Geohazards CoP) were delivered to the Symposium.

A workshop entitled "Towards a Roadmap for Future Satellite Gravity Missions" was jointly organized by GEO, the US National Aeronautics and Space Administration (NASA), the European Space Agency (ESA), the Global Geodetic Observing System (GGOS), and the IGCP 565 Project in September/October 2009 in Graz, Austria. The workshop brought together researchers involved in analyzing satellite gravity data. It acquainted them with GEO and the societal issues that benefit from their research on climate monitoring, sea-level change, and the monitoring of natural and anthropogenic changes in the water cycle. The roadmap resulting from the workshop emphasizes the relevance of satellite gravity missions for GEO and affirms the researchers' support for GEOSS.

The Union Session on GEOSS was organized at the Fall American Geophysical Union (AGU) meeting held in December 2009 in San Francisco, USA. Convened by NASA, the University of Nevada at Reno, and the European Commission Joint Research Centre, the session served as an introduction to GEO for scientists unfamiliar with the framework that it provides. It featured presentations illustrating the importance of GEOSS services for science and research. Several of the presentations have since become key candidates for "compelling examples," a compilation of cases that demonstrate the benefits of GEOSS for the science and technology communities. These examples are also being used to illustrate the value of GEOSS at the Beijing Ministerial Summit.

The IEEE regularly organizes outreach workshops on GEOSS. For example, its GEOSS Workshop XXXIII focussed on the theme of "Using Earth Observations for Water Management." Also held in San Francisco in December 2009, the workshop targeted the users of Earth observations for research into the water cycle, with a special emphasis on water users with regional and local programs in California. Water resource managers at the state and municipal levels gave presentations, while the concept of GEO and Earth observation activities under the water societal benefit area were introduced.



Most recently, at the 2nd Pan-GEWEX (Global Water and Energy Cycle Experiment) Science Meeting held 23-26 August in Seattle, researchers involved in monitoring and modelling the water cycle were encouraged to continue and expand their contributions to GEOSS through, for example, activities such as the Coordinated Energy and Water Cycle Observations Project (CEOP). CEOP, already an integral component of tasks within the Water SBA, is perfecting its web-based Data Analysis and Integration System (DIAS) as it creates an infrastructure for bringing together water cycle and other Earth observation data from remotely-sensed and in-situ observation systems, as well as modelling studies, to ultimately provide integrated datasets for calibration/validation and management of resources.

The GEO voluntary label

The goal of developing a voluntary GEO label is to encourage scientists, researchers and others to contribute their data and systems to GEOSS by offering an accepted voluntary label that recognizes that their contributions are valued by the GEO community. The label will differentiate the components, data and products delivered through GEOSS and provide a “trusted brand” to GEOSS users. This will allow member governments greater confidence in basing their decisions on the data and products of such contributions. Another benefit will be to highlight the importance of GEOSS to scientists and experts previously unaware they are relying on the GEOSS initiative for their data or products.

The Science and Technology Committee believes that a voluntary GEO label could assist the users of GEOSS in assessing the scientific relevance, quality, acceptance and societal needs of the GEOSS components, services and data sets. These parameters clearly contain a mix of objective and subjective assessments. Conceptually, a GEO label could be broken into two categories: objective labelling (quality, reliability) and subjective labelling (relevance, usability). Both ratings would be voluntary in application and communicate the value of GEOSS products and services to both users and providers.

Task ST-09-02 leads and contributors: China, Committee on Earth Observation Satellites (CEOS), Committee On Space Research (COSPAR), Denmark, European Commission, European Space Agency (ESA), France, Germany, International Council for Science (ICSU), Institute of Electrical & Electronics Engineers (IEEE), International Association of Geodesy (IAG), International Institute for Applied Systems Analysis (IIASA), Open Geospatial Consortium (OGC), South Africa, Spain, Turkey, United Kingdom, United States, World Meteorological Organization (WMO).

Building Communities of Practice

One way GEO promotes partnership and collaboration on Earth observation is by developing and nurturing Communities of Practice. A GEO Community of Practice (CoP) is a self-organizing group of people committed to working together to foster the application of Earth observations in a particular field of interest in order to promote societal benefits. Ten have been established so far, and others are emerging. Communities of Practice are actively supported by the GEO User Interface Committee (UIC).

Air Quality – The Air Quality Community of Practice connects the providers of Earth observations to the users who apply these observations to achieve societal benefits. Key activities over the past three years include networking with members and other communities via workshops, wiki, and teleconferences; contributing to the GEOSS Common Infrastructure, including an air quality community catalogue and standard-based metadata for finding and understanding data; and coordinating a GEO Call for Proposals (see page 107).

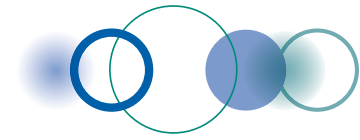
The Community of Practice also seeks to enable the development of a functioning Air Quality System of Systems by 2015. Anticipated activities in support of GEOSS include gathering user requirements for air quality management, science, and education; enabling data access and re-use through web services; supporting the use of standards for sharing data and metadata; and fostering and sharing tools and methods as best practices.

Biodiversity – The GEO Biodiversity Observation Network – GEO BON – is the biodiversity arm of the GEOSS. Some 100 governmental and non-governmental organizations are collaborating through GEO BON to make their biodiversity data, information and forecasts more readily accessible to policymakers, managers, experts and other users.

By bringing together the diverse, stand-alone observation instruments and systems now tracking trends in the world's genetic resources, species, and ecosystems, GEO BON is working to create a global platform for integrating biodiversity data with data on climate and other key variables. Work includes ascertaining the data requirements of user groups; reviewing and prioritizing research; facilitating interoperability among observation systems and databases; generating regularly updated assessments of global biodiversity trends; designing decision-support systems that integrate monitoring with ecological modelling and forecasting; and making data and reports available to users via GEOSS. GEO BON has been recognized by the Parties to the Convention on Biological Diversity as well as by GEO's member governments.

Carbon – The Carbon CoP works to improve scientific understanding of the global carbon cycle, monitor and assess the effectiveness of carbon sequestration and emission-reduction activities on global atmospheric carbon dioxide levels; and build and improve the infrastructure and interoperability of carbon monitoring systems. The CoP envisions a three-phased seamless deployment of an operational GEO Global Carbon Observation and Analysis System over the next 15 years or so (See page 45).

The Carbon CoP focuses on integrating carbon observations from all platforms, reservoirs, and time and space scales; establishing and integrating data from forest carbon tracking sites worldwide; and supporting the validation and use of space-based greenhouse gas observations. Its 2010 Carbon Strategy Report sets out a series of actions for disseminating information on the status and availability of carbon observations. The CoP has been reaching out to colleagues and potentially interested parties via presentations, workshops, and distribution of outreach materials at professional meetings in the carbon field. It would like to establish a



Identifying critical Earth observation priorities for the societal benefit areas

The GEO User Interface Committee (UIC), working closely with the Communities of Practice, has led an effort to identify the critical Earth observations priorities within each of the societal benefit areas (SBAs) and across the SBAs. The UIC assessed needs across a spectrum of user types and communities in each area, including the needs of users in developing countries and diverse geographic regions. Working with expert-based Advisory Groups, it analyzed user needs as described in publicly-available documents, including reports and workshop summaries published or released by GEO Members and Participating Organizations.

In 2010, the UIC delivered its report of the critical Earth observation priorities common to many of the nine GEO SBAs. The top three Earth observation priorities are precipitation, soil moisture, and air temperature. The final individual SBA and cross-SBA reports provide the complete lists of priority observations. The UIC has already begun using the results to evaluate the extent to which there are corresponding products already registered in the GEOSS Common Infrastructure. GEO will use the results of this effort to determine and communicate gaps in current and future Earth observations and to support discussions on potential investment opportunities.

carbon office housed at an international organization to provide support (e.g., for coordination and outreach) to the hundreds of scientists and dozens of projects connected with the Carbon CoP.

Coastal Zone – The GEO Coastal Zone Community of Practice (CZCP) brings together scientists and other experts to support integrated coastal zone management (ICZM) decisions through the use of Earth observations and derived products. The CZCP focuses on both research and practical applications related to ICZM.

Its work includes engaging coastal users and data providers in specifying priority needs and requirements for observations and products to support ICZM; identifying opportunities for linkage, collaboration, and support; holding workshops, including proof-of-concept pilot workshops, to address needs and enable data integration; and developing and strengthening networks that contribute to or benefit from GEOSS.

A main CZCP activity in recent years has been organizing a series of regional workshops worldwide to bring end users and experts together in an effort to initiate regional Communities of Practice. The series started in 2008 with a workshop in Athens, Greece, focusing on ICZM in the Mediterranean, and continued in 2010 with a workshop in Cotonou, Benin, focusing on climate change impacts on coastal zones in West Africa. For 2011, the CZCP is planning a workshop in Puerto Rico which will address Earth observations in support of sustainable tourism in small island states.

The CoP maintains a website, including the webpage “You & the CZCP,” which invites users to join and suggest activities for the CZCP. In June 2010, the CZCP met to develop a work plan for the next three years. As part of the work plan, the CZCP will encourage new membership and will start a quarterly web-based newsletter. The CZCP also will be organizing a global assessment of the state of coastal zones in coordination with other organizations.

Energy – The Energy Community of Practice works to promote the application of Earth observations for improving the management of energy resources. Active in GEO for many years, the Energy CoP has engaged

stakeholders via professional societies, conferences, publications and other communications, and it has educated end users about the utility of global products from satellite observations.

The CoP's involvement in various energy management applications has yielded significant results in national and international energy programs through the transfer of science results to improve decision-making, for example in support of renewable energy and energy-efficient technology optimization. An early key achievement was delivery of an Energy Strategic Plan to the GEO Ministerial in 2007.

The Energy CoP currently has two active components funded by the European Commission as a dedicated GEOSS contribution. Monitoring Atmospheric Composition and Climate includes a radiation activity to prepare existing solar irradiance services Solemi and SoDa as a Global Monitoring for Environment and Security (GMES) service component. EnerGEO seeks to develop a strategy for a global assessment of the current and future impact of the exploitation of energy resources on the environment and ecosystems and to demonstrate this strategy for a variety of energy resources worldwide.

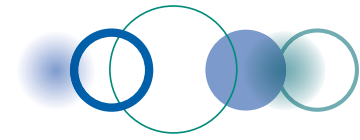
The Energy CoP is also contributing to the third phase of the GEOSS Architecture Implementation Pilot project (AIP-3) by developing a scenario and an associated web-based tool to provide information on the environmental impact of the production, transportation and use of energy, with a present focus on the carbon footprint of photovoltaic systems.

Forest – The Forest Community of Practice actively fosters communication and coordination among the teams involved in GEO's eight forest-related Tasks, which are all enhancing observations and systems for forest mapping and monitoring of features such as cover, cover change, biomass and carbon, biodiversity, and fire disturbances. It is also encouraging the registration of forest data, earth observations, systems, and users in GEOSS; advising GEO on matters relating to forest observations and related societal benefits; and supporting the forest observation community with information about activities and plans in the GEO process.

The Community of Practice's members have been connecting with the forest user community around the globe by actively participating in many workshops and meetings. Members have expressed interest in proceeding with the design of a global forest observations initiative, an ambitious activity to which all eight GEO forest Tasks would contribute. They also aim to foster better connection between remote sensing and ground-based observations and to collaborate with the Global Agriculture Monitoring CoP to fully address the Agriculture societal benefit area.

Geohazards – Over the past few years, initial steps have been taken by members of the former Integrated Global Observing Strategy (IGOS) Geohazards Theme Team to make progress towards a Geohazards Community of Practice (GHCP) for GEO. This has been seen in successful initiatives such as the Supersites and through the GEO community's work on disasters and other issues. In order to support and build on this progress, a comprehensive review of the current situation and the development of strategies for the next five years will be timely.

In January 2010, the Geohazards CoP drafted a roadmap that affirms its commitment to working towards putting in place by 2020 the building blocks for comprehensive geohazards monitoring. This will support all phases of the risk management cycle (mitigation and preparedness, early warning, response, and recovery) and provide a basis for increased resilience and disaster reduction. The GHCP will work to achieve this target by developing a few, carefully selected core sites on different continents to demonstrate how all the building blocks of a value chain, from observations to end users, can be linked and applied to the phases of the risk management cycle relevant to the region. These core sites will be developed as regional centers of excellence and will support scientific studies, technological developments, and policy and decision-making



in the region. They will also provide the basis for developing more general tools and training that will be useful to other regions.

Global Agricultural Monitoring – The GEO Integrated Global Observing Strategy (IGOL) Agricultural Monitoring Community of Practice was established in 2007 at the second workshop jointly convened by GEO and the Integrated Global Observations for Land (IGOL). This CoP has close to 300 members representing a wide range of national and international agencies and organizations that are concerned with agricultural monitoring. Its members work to promote the use of earth observations for global monitoring of agricultural production, reduced risk and increased productivity, timely and accurate national (and where possible sub-national) agricultural statistical reporting, accurate forecasting of shortfalls in crop production and food supply, effective early warning of famine to aid timely international response, and global mapping, monitoring, and modelling of changes in agricultural land use, type, and distribution.

Recognizing the importance of improving the ability to monitor agricultural systems and of expanding international cooperation, the CoP organized a set of well-attended international GEO agricultural monitoring workshops. At these workshops, participants reviewed the current state of the art, developed a common vision for a comprehensive global agricultural monitoring system and its functionality, identified the observational requirements for the system, and initiated near-term tasks to lay the foundation for the system's development. The CoP's work over the next five years will focus on the following initiatives:

- Joint Experiments on Crop Assessment and Monitoring (JECAM) to facilitate the inter-comparison of monitoring and modelling methods, product accuracy assessments, data fusion, and product integration for agricultural monitoring;
- a centralized Multi-source Production, Acreage and Yield (PAY) database providing crop statistics from different reporting agencies on a common platform;
- Coordinated Data Initiatives for Global Agricultural Monitoring (CDIGAM) to establish coordinated, timely acquisition and improved accessibility of satellite data, and to evolve a free and open data policy to support agricultural monitoring;
- the GLAMSS Thematic Workshop Series to improve communication among the CoP on priority topics, develop best practices and standards, and encourage international cooperation and coordination; and
- a project on Agricultural Land Use and Climate Change.

Health and Environment – The Health and Environment CoP, whose members include national and international organizations, seeks to address the user perspective on issues involving environment and health with an emphasis on using environmental observations to improve health decision-making at the international, regional, country and district levels. The CoP has been exploring possibilities for partnering with user communities and other support mechanisms. Areas of interest include information architecture for the environment, ecosystems, climate, and health; oceans, water quality, and health; vector-borne disease; and disasters and health.

The CoP supports several ongoing projects in GEO's Work Plan. One involves Health information systems integrating Earth observation remote-sensing imagery as a contributor to the World Health Organization's OpenHealth information system. Another focuses on health monitoring and prediction systems for aerosol impacts on health and the environment, air quality observations and forecasting, global monitoring of persistent organic pollutants, and monitoring of atmospheric mercury. Several end-to-end projects for

health aim to implement a meningitis decision-support tool and a globally coordinated malaria warning system, and to describe the linkage between ecosystems, biodiversity, and health; these components are to be integrated into decision-support tools. Members have also expressed interest in a new CoP effort on the *Vibrio* disease-causing bacteria that inhabit coastal waters and the link between biodiversity/landscape change and infectious diseases.

Water Cycle – The Water Cycle CoP has actively contributed to each of the 14 Water Tasks in GEO's Work Plan. Work includes activities on developing integrated data products for soil moisture, runoff, ground water, precipitation, water cycle data integration, water quality assessment, and monitoring; pilot projects for water discovery; and capacity-building activities and initiatives related to the monitoring and prediction of extreme events such as droughts. Specific projects include:

- The Asian water cycle initiative, which uses data integration and analysis systems to support users throughout Asia; a key target is to ensure interoperability within the timeframe of GEOSS.
- An African water cycle initiative following the model of the Asian Water Cycle, but adapted for the state of infrastructure development and different modes of watershed management.
- A US-Canada partnership, which is testing GEO tools in shared areas along the border.
- Significant work on drought in North America directed at improving drought monitoring and developing approaches that could be applied globally.
- Testing the concept of web-based product evaluation, including some experimental products to support drought management decisions.
- Projects to support capacity building throughout the Americas, including a 2009 workshop in South America.

The CoP held seven meetings and workshops in 2009 and 2010, including three regional workshops to identify priority issues for Africa, Asia, and Latin and Caribbean America. Future CoP activities include encouraging more regional and specialized workshops, including a workshop on evapotranspiration; revising the website to engage more interested people in the COP; and producing more experimental integrated data products.

Emerging Communities of Practice

Additional Communities of Practice are expected become a part of GEO over the next several years. Emerging Communities of Practice currently include Atmospheric Chemistry; Cryosphere; International Phenology Network; and Ecosystems, Biodiversity and Health.

Task US-09-01 leads and contributors: The User Interface Committee and Community of Practice members.



ANNEX

STRATEGIC TARGETS FOR GEOSS THROUGH 2015 AS ACCEPTED BY GEO-VI

GEOSS STRATEGIC DEFINITION AND GOALS

Definition of GEOSS

The Global Earth Observation System of Systems (GEOSS) is a coordinating and integrating network of Earth observing and information systems, contributed on a voluntary basis by Members and Participating Organizations of the intergovernmental Group on Earth Observations (GEO).

GEOSS Vision and Purpose

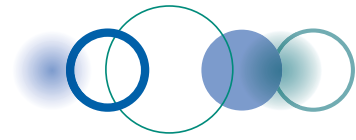
(GEOSS 10-Year Implementation Plan, February 2005)

“The **vision** for GEOSS is to realize a future wherein decisions and actions for the benefit of humankind are informed by coordinated, comprehensive and sustained Earth observations and information.

The **purpose** of GEOSS is to achieve comprehensive, coordinated and sustained observations of the Earth system, in order to improve monitoring of the state of the Earth, increase understanding of Earth processes, and enhance prediction of the behaviour of the Earth system. GEOSS will meet the need for timely, quality long-term global information as a basis for sound decision making, and will enhance delivery of benefits to society in the following initial areas:

- 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.

GEOSS is a step towards addressing the challenges articulated by the United Nations Millennium Declaration and the 2002 World Summit on Sustainable Development, including the achievement of the Millennium Development Goals. GEOSS will also further the implementation of international environmental treaty obligations.”



Strategic Goals of GEO in Support of GEOSS

- Sustain operation of comprehensive and coordinated Earth observation networks that meet user requirements in support of informed decision making;
- Sustain operations of the shared architectural GEOSS components and related information infrastructure;
- Address the need for timely, global and open data sharing across borders and disciplines, within the framework of national policies and international obligations, to maximize the value and benefit of Earth observation investments;
- Implement interoperability amongst observational, modelling, data assimilation and prediction systems;
- Foster research and development activities and coherent planning for future observation and information systems;
- Catalyze national, regional and global investments in scientific and technological advances and innovative approaches for upgrading and expanding Earth observations;
- Build the capacity of individuals, institutions and infrastructures to benefit from and contribute to GEOSS, particularly in developing countries.

GEOSS Implementation Strategy

As well as facilitating interoperability between, access to and use of existing observations and information systems, comprehensive gap analysis and gap filling, integrated across all Societal Benefit Areas, is a cornerstone of the GEOSS implementation strategy. To this end, GEO will:

- Elucidate practical methods for filling critical gaps in, *inter alia*, observation specifications and parameters, geographical areas, and observation and information accessibility;
- Identify opportunities and measures to minimize gaps in data, metadata, and products;
- Set and address priorities for filling gaps.

BUILDING AN INTEGRATED SYSTEM OF SYSTEMS: THE GEOSS BUILDING BLOCKS

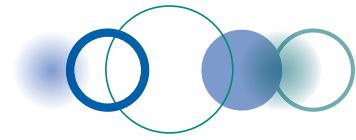
1.1. Architecture

Before 2015, GEO aims to:

-
1. Achieve sustained operation, continuity and interoperability of existing and new systems that provide essential environmental observations and information, including the GEOSS Common Infrastructure (GCI) that facilitates access to, and use of, these observations and information.
-

This will be achieved through:

- provision of long-term, continuous data and its periodic reanalyses with improved understanding which are:
 - fundamental for better comprehension of the Earth system;
 - dependent on operational support for component systems by GEO Members and Participating Organizations, including:
 - improved systems;
 - new instrumentation and measurement techniques;
 - the establishment and maintenance of baseline sites for global in-situ networks and data validation;
 - of a quality appropriate to meet user needs;
- identification of effective national coordination mechanisms across both observation-provider and observation-user communities;
- coordination at national, regional and global levels for linking and enhancing Earth observing and information systems;
- development of a framework to ensure data continuity, including the smooth transition from research to operational systems;
- adoption and advocacy of a comprehensive approach to global Earth observation systems, recognizing in particular the value of complementarity and integration of the surface- and subsurface-based, airborne and space-based components of GEOSS;
- securing the long-term use and protection of all parts of the radio frequency spectrum needed for its space-based and surface-based components;
- promotion of consistent standards and practices for observations across all earth systems by means of the GEOSS Common Infrastructure (GCI) which will:
 - consist of web-based portals, clearinghouses for searching data, information and services, registries and other capabilities supporting access to GEOSS components, standards, and best practices;



- provide the framework and operational interfaces for comprehensive, coordinated, and sustained observations of the Earth system, including space, airborne and in-situ systems;
- be constituted and populated by resources contributed from GEO Members and Participating Organizations, who will make best efforts to ensure sustained operation
- of the core components and related information infrastructure;
- maintain a process for interoperability that supports effective access to, exchange of and use of data, metadata and products across all GEOSS components, as identified in the appropriate GCI registries.

This will be demonstrated by:

- Deployment, population, and enablement of sustained operations and maintenance of a user-friendly and user-accessible GEOSS Common Infrastructure (GCI), including the core components and functions that link the various resources of GEOSS.
- Coordinated planning and sustained operation of national, regional and global observing and information systems within an interoperability framework.
- Continual improvement in observations and information available to users through the transition of research outcomes and systems into operational use, and through an optimal mix of space-based, airborne and in-situ observing platforms.
- Increased efficiency in the operation of observational systems through convergence among global, regional and national facilities.
- Comprehensive gap analysis and gap filling, integrated across all Societal Benefit Areas, including issues pertaining to operational redundancy and succession planning (especially with respect to space missions) for systems and products.

1.2. Data Management

Before 2015, GEO aims to:

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2. Provide a shared, easily accessible, timely, sustained stream of comprehensive data of documented quality, as well as metadata and information products, for informed decision-making.
-

This will be achieved through:

- preparation of and access to, among Member and Participating Organization communities, global and regional information encompassing:
 - geographic information such as basic global geodetic reference frames;
 - cross-cutting data sets such as land cover and land use information;
 - essential socio-economic information;
- data made available in accordance with GEOSS Data Sharing Principles, which includes:
 - full and open exchange of data, metadata and products shared within GEOSS, recognizing relevant international instruments and national policies and legislation;

- all shared data, metadata and products being made available with minimum time delay and at minimum cost;
- all shared data, metadata and products being provided free of charge or no more than the cost of reproduction will be encouraged for research and education;
- promotion of a coordinated, life-cycle data management process to support improved simulation, modelling, and prediction capabilities for each Societal Benefit Area and across multiple Societal Benefit Areas;
- development of best practices, identified in the appropriate GCI registry, for observation, collection and access to data and information, including best practices for data quality assurance for both observing system data and information products;
- evaluation of emerging information sources, including communities that may be global and not formally associated with any particular GEO Member or Participating Organization, and encouraging access to the information through, or integration into, GEOSS, as appropriate.

This will be demonstrated by:

- Increased use of observations through advances in all aspects of life-cycle data management, integration, and data recovery and conversion.
- Open, reliable, timely, consistent, and free access to a core set of essential environmental observations and information products, supported by adequate metadata, by users across all GEOSS Societal Benefit Areas in accordance with GEOSS Data Sharing Principles.
- Removal of important data management deficiencies.
- Enhanced information extraction from historical, current and future source data.

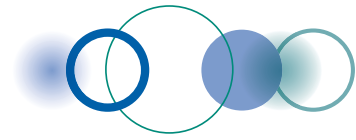
1.3. Capacity Building

Before 2015, GEO aims to:

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3. Enhance the coordination of efforts to strengthen individual, institutional and infrastructure capacities, particularly in developing countries, to produce and use Earth observations and derived information products.
-

This will be achieved through:

- working with and building on the capacity building efforts of GEO Members and Participating Organizations to further increase the synergies and effectiveness of national and international capacity building programmes;
- ensuring the engagement and committed involvement of resource providers in the GEO capacity building process;



- enhancing capacity building efforts to ensure the integration of mature Earth observation-based information systems into day by day end-user practices including decision making, management processes and planning for all Societal Benefit Areas.

This will be demonstrated by:

- Networking activities that specifically build individual, institutional and infrastructure capacity.
- Leveraging resources for Earth observation capacity building efforts.
- Increased use of Earth observation in policy and decision making.
- Enhanced participation of developing countries in GEO and GEOSS.

1.4. Science and Technology

Before 2015, GEO aims to:

-
4. Ensure full interaction and engagement of relevant science and technology communities such that GEOSS advances through integration of innovations in Earth observation science and technology, enabling the research community to fully benefit from GEOSS accomplishments.
-

This will be achieved through:

- promotion of research and development in key areas of Earth sciences to facilitate, on an ongoing basis, improvements to Earth observation systems;
- research and development for models, data assimilation modules and new or improved algorithms for global and regional services and products;
- encouraging and facilitating the transition of systems and techniques from research to operations by fostering collaboration and partnership between the operational and research communities;
- provision for sensor validation and verification so resource managers and industry can ensure sensors being developed are ready for operational use over a wide variety of environmental conditions;
- incorporation of science and technology outcomes that improve observing systems and observational capacity;
- improving interoperability between global observing systems and modelling systems;
- inclusion of societal needs in new research observing system planning and inclusion of research considerations in operational observing system planning;
- life-cycle data management and optimisation, data integration and information fusion, data mining, network enhancement, and design optimization studies, up-scaling and downscaling, and visualisation of large and diverse data sets.

This will be demonstrated by:

- Improved and new instrumentation and observation system design for *in-situ*, airborne, and space-based observation, benefiting from advances in science and technology.
- Increased accessibility of global sets of scientific data necessary for improved Earth System modelling in the different GEO Societal Benefit Areas.
- Increased accessibility of data and improved coordination and maintenance of observational systems through GEOSS are realized by the research community.

1.5. User Engagement

Before 2015, GEO aims to:

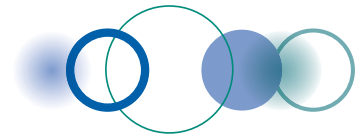
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5. Ensure critical user information needs for decision making are recognized and met through Earth observations.
-

This will be achieved through:

- developing a framework to identify and implement linkages across Societal Benefit Areas, thereby providing wider opportunities for synergistic collaboration;
- active partnerships among and within Societal Benefit Areas, promoting synergy among GEO projects and activities through the concept of user communities of practice;
- increased development of data and information, with special emphasis on socio-economic applications and the development of methods, for models and tools required to make best use of these data in science and technology development and decision-making;
- use, enhanced by a user-oriented GEOSS Common Infrastructure, of Earth observation products and services across all Societal Benefit Areas of GEOSS, especially in and for developing countries.

This will be demonstrated by:

- Establishment of an agreed core set of essential environmental, geophysical, geological, and socio-economic variables needed to provide data, metadata and products in support of all GEOSS Societal Benefit Areas.
- Involvement of users in: reviewing and assessing requirements for Earth observation data, products and services; creating appropriate mechanisms for coordinating user requirements; utilizing data/information delivery systems; and capturing user feedback on an ongoing basis across Societal Benefit Areas.
- Increased use of geo-spatial data in all Societal Benefit Areas and in particular in developing countries.



THE 9 GEOSS SOCIETAL BENEFIT AREAS

2.1. Agriculture

Before 2015, GEO aims to:

-
6. Improve the utilization of Earth observations and expanded application capabilities to advance sustainable agriculture, aquaculture, fisheries and forestry in areas including early warning, risk assessment, food security, market efficiency, and, as appropriate, combating desertification.
-

This will be achieved through:

- a set of distributed joint experiments to compare and evaluate data and methods;
- a series of thematic workshops for the Global Agricultural Monitoring Community of Practice;
- capacity building, particularly for improved national agricultural monitoring;
- sharing of operational applications and decision making support systems and tools;
- establishing regional components of a global agricultural monitoring system of systems;
- developing and adopting standards and common reporting formats;
- advancing free and open data policies and data exchange;
- advocating for data continuity, expanded data coverage and coordinated data acquisition;
- closing critical spatial and temporal gaps in key observations;
- collaborating and coordinating with the fisheries, aquaculture, forestry and land cover mapping communities, including the Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD).

This will be demonstrated by:

- Increased use of Earth observing capabilities and supporting applications systems to produce timely, objective, reliable, and transparent agricultural and forest statistics and information at the national and regional level.

- Improved agricultural risk assessment and operational weather/climate forecast systems for early warning and food security.
- Effective early warning of famine leading to more timely mobilization of an international response in food aid.
- Expanded monitoring of agricultural land use change, through periodic regional and global assessments.
- Development of quantitative measurements of global and regional desertification.
- Increased capacity building through targeted workshops and joint multi-institution research teams.
- Improved collaboration and coordination on the use and applications of Earth observations for fisheries, aquaculture, forestry and land cover mapping.

2.2. Biodiversity

Before 2015, GEO aims to:

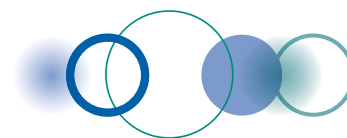
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7. Establish, in conjunction with a comprehensive ecosystem monitoring capability, a worldwide biodiversity observation network to collect, manage, share and analyze observations of the status and trends of the world's biodiversity, and enable decision-making in support of the conservation and improved management of natural resources.
-

This will be achieved through:

- working with all parties interested in biodiversity observations, and notably the United Nations Convention on Bio-Diversity (UNCBD), as well as:
- utilizing the resources and experience of GEO Members and Participating Organizations, non-governmental organizations, data providers and aggregators, tool developers and operators, and other types of practitioners, in order to establish the biodiversity observation network (GEOBON), which will:
 - promote standards for data collection and data management;
 - continue the development of a network of worldwide biodiversity observations;
 - institute an ongoing process to identify gaps in implementation that need to be filled;
 - implement reporting on biodiversity (ecosystems, species, genes) status, trends, services, risks, and conservation to all stakeholders;
 - develop and implement a service to respond to requests for new products or services.

This will be demonstrated by:

- Increased routine collection of long term *in-situ* and remotely sensed biodiversity observations.
- Access through GEOSS to a large panel of biodiversity observations, including satellite, aerial and *in-situ*



- Increased information sharing on biodiversity conservation and sustainable use of biodiversity resources.
- Implementation of a mechanism that enables users to interact with the development of biodiversity observations systems and request services.
- Increased availability of biodiversity information necessary to respond to and support related topics (ecosystems, health, climate, etc.).
- Increased information to reduce the cost and support the management of biodiversity issues.

2.3. Climate

Before 2015, GEO aims to:

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8. Achieve effective and sustained operation of the global climate observing system and reliable delivery of climate information of a quality needed for predicting, mitigating and adapting to climate variability and change, including for better understanding of the global carbon cycle.
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This will be achieved through¹:

- the full implementation of the WMO-IOC-UNEP-ICSU Global Climate Observing System (GCOS) as the climate observing component of GEOSS, *and especially through strong support for the climate-relevant functions and activities of:*
 - the IOC-WMO-UNEP-ICSU Global Ocean Observing System (GOOS);
 - the FAO-WMO-UNESCO-UNEP-ICSU Global Terrestrial Observing System (GTOS);
 - the WMO Global Observing System (GOS) and Global Atmosphere Watch (GAW);
 - the research observing systems and observing systems research of the WMO-IOC-ICSU World Climate Research Programme (WCRP) and other climate-relevant international programs;
 - CEOS, as coordinator of the satellite components of GCOS;
 - and their enhancement and supplementation as necessary, including closure of critical gaps, to ensure the availability of all the climate and climate-related observations needed to support GEOSS;
- promotion of data sharing as well as coordination of data management and exchange systems;
- contributions to major advances in the monitoring and prediction of climate on seasonal, interannual and decadal time scales, including the occurrence of extreme events;
- strengthened GCOS support for the assessment role of the IPCC and the policy development role of the UNFCCC;

¹ Acronyms: CEOS-Committee of Earth Observation Satellites; FAO-Food and Agriculture Organization; GCOS-Global Climate Observing System; ICSU-International Council for Science; IOC-Intergovernmental Oceanographic Commission; IPCC-Intergovernmental Panel on Climate Change; WCRP-World Climate Research Programme; UNEP-United Nations Environment Programme; UNESCO-United Nations Educational, Scientific and Cultural Organization; UNFCCC-United Nations Framework Convention on Climate Change; WMO-World Meteorological Organization.

- enhanced efforts for data rescue and digitization.

This will be demonstrated by:

- Improved scientific understanding, modelling and prediction of climate.
- Accessibility of all the observational data needed for climate monitoring and services in support of adaptation to climate variability and change.
- Development and facilitation of a comprehensive (atmosphere, ocean, land) global carbon observation and analysis system in support of monitoring based decision-making and related environmental treaty obligations.
- Availability of all Essential Climate Variables needed by the WCRP, the IPCC and the UNFCCC.

2.4. Disasters

Before 2015, GEO aims to:

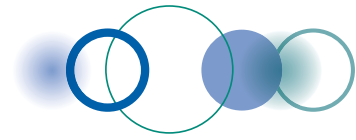
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9. Enable the global coordination of observing and information systems to support all phases of the risk management cycle associated with hazards (mitigation and preparedness, early warning, response, and recovery).
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This will be achieved through:

- more timely dissemination of information from globally-coordinated systems for monitoring, predicting, risk assessment, early warning, mitigating, and responding to hazards at local, national, regional, and global levels;
- development of multi-hazard and/or end-to-end approaches, as appropriate to meet the needs for disaster risk reduction, preparedness and response in relevant hazard environments;
- supporting the implementation of the priorities for action identified in the *Hyogo Framework for Action 2005-2015: Building the resilience of nations and communities to disasters (HFA)*.

This will be demonstrated by:

- Improved use of observations and related information to inform policies, decisions and actions associated with disaster preparedness and mitigation.
- More effective access to observations and related information to facilitate warning, response and recovery to disasters.
- Increased communication and coordination between national, regional and global communities in support of disaster risk reduction, including clarification of roles and responsibilities and improved resources management.



- Improved national response to natural and man-made disasters through delivery of space-based data, resulting from strengthened International Charter on “Space and Major Disasters.”
- Support to the successful implementation of the *Hyogo Framework for Action 2005-2015*.

2.5. Ecosystems

Before 2015, GEO aims to:

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10. Establish, in conjunction with a comprehensive biodiversity observation network, a wide-ranging monitoring capability for all ecosystems and the human impacts on them, to improve the assessment, protection and sustainable management of terrestrial, coastal and marine resources and the delivery of associated ecosystem services.
-

This will be achieved through:

- developing and promulgating wider availability of methodologies to understand interactions between human settlements and ecosystems;
- refinement of techniques for the delivery of ecosystem services;
- development of tools for decision making in support of the assessment, protection and sustainable management of ecosystems;
- working with established international monitoring communities and networks.

This will be demonstrated by:

- Implementation of a global standardised ecosystem classification system and map as a basis for worldwide inventory, assessment and monitoring.
- Implementation of a global, standardized inventory of major ecosystems and the protected areas within them.
- Increased operational monitoring of major ecosystems on land on an annual basis, including properties such as land cover type; species composition; vegetation structure, height and age; net ecosystem productivity; and biomass and carbon estimates of vegetation and soils based on remote sensing and sampled *in-situ* observations using internationally agreed standards.
- Increased operational monitoring of major marine and coastal ecosystems on an annual basis including properties such as extent, water temperature, salinity, pH and pCO₂, phytoplankton species composition and productivity and marine resource stocks, based on remote sensing and sampled *in-situ* observations using internationally agreed standards.
- Increased knowledge of environmental flow requirements of river baseflow and peak flow, as well as human requirements for irrigation and power plant cooling water and domestic usage.

2.6. Energy

Before 2015, GEO aims to:

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11. Close critical gaps in energy-related Earth observations and increase their use in all energy sectors in support of energy operations, as well as energy policy planning and implementation, to enable affordable energy with minimized environmental impact while moving towards a low-carbon footprint.
-

This will be achieved through:

- engaging and working with governments, national and international energy agencies, the energy industry, research communities and other stakeholders in order to:
 - map user needs and requirements for specific energy data sets (e.g. geophysical, geological, biological, weather, climatological, pollutant and greenhouse gases as well as socio-economic data);
 - develop best practices for the integration of information as well as support capacity building;
- initiating environmental impact studies to identify what data are needed to collect and share by developers to ensure impacts on the environment be as low as reasonably possible for all energy sources (biomass, fossils, geothermal, hydropower, nuclear, ocean, , solar and wind);
- initiating application and demonstration projects where earth observations are used for all sources of energy, thus enabling:
 - improved energy management, including balance between energy demand and supply as well as development of alternative energy scenarios;
 - safe, efficient and affordable development and operation of existing and new energy resources, with emphasis on minimizing environmental and societal impact while moving towards a low-carbon footprint;
 - advancement of the application of data, systems and tools.

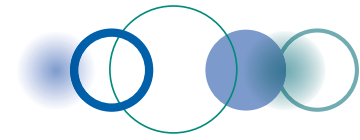
This will be demonstrated by:

- Significant increase in use of Earth observations by all sectors for improved:
 - Environmental, economic and societal impact assessments of energy exploration, extraction, conversion, transportation and consumption.
 - Prediction of potential hazards to the energy infrastructure.
 - Prediction of the production of intermittent sources of energy.
 - Mapping of renewable energy potential.

2.7. Health

Before 2015, GEO aims to:

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12. Substantially expand the availability, use, and application of environmental information for public health decision-making in areas of health that include allergens, toxins, infectious diseases, food-borne diseases, and chronic diseases, particularly with regard to the impact of climate and ecosystem changes.
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This will be achieved through:

- working with the World Health Organization (WHO) and the global community of human health and environment experts in order to develop and implement health-and-environment projects which will:
 - advance the application of observation, monitoring and forecasting systems to health decision-making processes;
 - foster the use of established and emerging observation systems in operational health-related applications for air and water quality, infectious diseases, and vector-borne diseases, and develop associated products such as forecasts and alerts compliant with the Common Alerting Protocol (CAP);
 - include efforts to examine terrestrial, freshwater, and marine (ocean) ecosystems and their services, to establish causality between changes in flora, fauna and other factors affecting the emergence and transmission of disease;
 - document links between water and communicable diseases, as part of the life cycle of vectors or as a medium infecting populations;
 - facilitate the integration of Earth science databases and emerging information products with public health data, socioeconomic data, and epidemiological information needed in decision support systems for health care planning and delivery.
- development of a global network of scientists, researchers, practitioners and other operational end users which will:
 - provide free access to an expanded inventory of available Earth observation data, metadata and products applicable to public health;
 - provide input relating to the technical specification of new major environmental observation capabilities, including in-situ and remotely sensed observations that will allow historical data analysis and early detection of changes that influence health;
 - facilitate Earth observation training and capacity building for future scientists, researchers, public health policy makers and practitioners, and end users, including contributions of best practices in this domain to the GCI best practices registry.

This will be demonstrated by:

- Access to improved environmental information and tools to support the global community of human health and environment experts.
- Increased use of environmental information and tools to support decision making in epidemics and/or disease management and planning for well-being. The effectiveness of these tools is demonstrated in at least 3 specific areas on different continents.
- Applying outcomes from other Societal Benefit Areas to improve health and well-being.

2.8. Water

Before 2015, GEO aims to:

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13. Produce comprehensive sets of data and information products to support decision-making for efficient management of the world's water resources, based on coordinated, sustained observations of the water cycle on multiple scales.
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This will be achieved through:

- development of a sustained, operational monitoring system for the global water cycle, combining space-based, airborne, and *in-situ* observation networks which will:
 - address water resources in terms of quantitative availability and water quality;
 - include integrated *in-situ* reference sites for monitoring essential variables for water cycle measurement;
 - promote the upgrading of *in-situ* networks in regions where current networks do not meet emerging standards for observations, network enhancements, data systems, planning frameworks and implementation programs;
 - allow for different types of measurements to be planned in a structured way across variables, sensors, platforms and nations and in some cases development of sensor technology;
 - deliver a broad range of integrated data products that cover many different spatial and temporal scales, combining detailed point *in-situ* measurements with coarser comprehensive coverage provided by satellites.
- development of widely available, sustained water cycle data sets and related information products, at both global and basin scales, tailored to the near- and long-term needs of stakeholders and end-users, which will:
 - exploit past and current *in-situ* and satellite-based observations as well as fostering their integration into advanced models for integrated water resource management;
 - focus attention on developing local, regional and global hydrological risk (e.g., floods, droughts) assessment, prediction and management systems and expanded applications of integrated water resource management for sustained development;
 - promote the next generation of improved/enhanced products and innovative observations (with special emphasis on observational gaps: e.g., precipitation and run-off at high latitudes and water quality measurements from space), for water resources management.

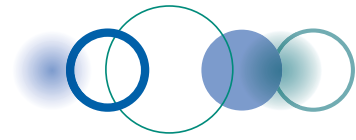
This will be demonstrated by:

- An operationalized and sustained global network of *in-situ* observation sites.
- Increased availability of information products and services for monitoring changes in the water cycle, including clouds and precipitation, appropriate for both research and integrated water resource management.
- Increased availability of data and information, including quantity and quality of both surface and groundwater, to support a water cycle decision making system.
- Routine, reliable production of “watershed” and human health indicators from satellite data, surface and subsurface data, and data assimilation capabilities.

2.9. Weather

Before 2015, GEO aims to:

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14. Close critical gaps in meteorological and related ocean observations, and enhance observational and information capabilities for the protection of life and property, especially with regard to high-impact events, and in the developing world.
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This will be achieved through:

- the programmes and activities of the World Meteorological Organization (WMO), and building on enhanced observational capabilities, which will:
 - monitor the performance and impact of global meteorological and related ocean observing systems, and facilitate the closure of critical gaps in observations and capabilities, utilizing a mix of space-based and *in-situ* observing systems as appropriate;
 - make progress towards implementing the Vision for the Global Observing System 2025;
 - encourage the design and implementation of optimal observational networks to better meet the needs of users for observational data;
 - promote the improvement of data assimilation, modeling systems, and verification and assessment techniques;
 - advance the use of observations in forecasting and warning services globally, advocate for research and development in key areas and encourage the rapid transfer of related research outcomes into operational use, especially in developing countries;
 - encourage more direct, two-way interactions between users, managers of observing systems and providers of forecasts, building on enhanced observational capabilities, to improve the forecast process;
 - provide integrated data collection and automated dissemination of observational data and products, as well as data discovery, access and retrieval services.

This will be demonstrated by:

- Identification and addressing of critical gaps in observational networks that reflect, in particular, the needs of developing countries, the need for continuity in space-based and *in-situ* observations, and the potential benefits of an interactive observing system to support user needs.
- Improvements in the range and quality of services for high impact weather forecasting due to the design, future development, and operation of global observing, data assimilation, numerical modelling, and user application techniques.
- More accurate, reliable and relevant weather analyses, forecasts, advisories and warnings of severe and other high impact hydrometeorological events enabled by enhanced observational capabilities.



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