Ad hoc Group on Earth Observations (GEO)
Implementation Plan Task Team (IPTT)

Draft GEOSS 10-Year Implementation Plan

DRAFT TECHNICAL BLUEPRINT / REFERENCE DOCUMENT
201-1

NOTE TO REVIEWERS

The GEO Implementation Plan Task Team (IPTT) is pleased to circulate the "zero" draft of the GEOSS 10-Year Implementation Plan "technical blueprint" (IPTT 201-1). As agreed at GEO-4 in Tokyo, this document will serve as a detailed reference for the GEOSS 10-Year Implementation Plan document, to be negotiated at GEO-5.

With the issuance of this zero draft, the IPTT recommends that the GEO community refer to this longer document as the GEOSS 10-Year Implementation Plan Reference Document (to replace the term "technical blueprint"), and this new title has been provisionally used in the draft.

The draft is being circulated to the entire GEO community, but it is not intended for formal review by governments. Rather, it is an opportunity for specialists and experts, particularly those who have collaborated with the GEO subgroups and topic coordinators, to comment on the technical accuracy and appropriateness of the text. All comments received will be regarded as the individual comments of the reviewers and not representative of their governments or organizations.

The primary aim of soliciting comments at this stage is to confirm that the IPTT has correctly interpreted the material provided by contributors. Given the space limitation, it was not possible to accommodate all the available material, and the IPTT is seeking comments principally concerning any technical errors, particularly the omission of key material or any unintentional distortion of fact.

The IPTT acknowledges that there are many drafting imperfections in the text of this "zero" draft. Reviewers are asked to bear in mind the following points the IPTT intends to address before the next issuance:

- The wording and presentation of the recommendations will be strengthened and sharpened;
- The examples will be revised and strengthened;
- A graphic layout will be prepared;
- Spelling and grammar will be more thoroughly checked;
- Language concerning governance, particularly in sections 9, 10 and 11, will be added subsequent to the GEO Special Session on Governance on 27-28 September.

Given these caveats, reviewers are asked to focus comments on technical issues. While comments on all sections are welcome, individual reviewers are not expected to read the entire document but to concentrate on his or her field of specialty or competence.

Instructions for Comment Submission

The closing date for comments on this "zero" draft is 25 August 2004. The IPTT would be grateful to receive comments as early as possible, particularly if it appears that further work is required. Reviewers are asked to be specific as possible in the content as of their comments, and submit them with the following information:

- Specific reference to line number range for each comment;
- Name and organization of reviewer.

Comments should be submitted electronically (in the form of a separate Microsoft Word file) to Peter Colohan in the GEO Secretariat Office at the following email address:

geosec@noaa.gov

If necessary, comments may be faxed to +1-202-482-2869.

Comment Review

The month of September 2004 has been reserved for the IPTT's second writing period. At the start of this period, the IPTT will carefully review and determine the final disposition of all comments submitted before the deadline. The first formal draft of the Technical Blueprint/Reference Document will then be distributed to the GEO community in the week of 11 October 2004.

The IPTT extends special thanks to all those who have contributed to this process, often at short notice. In particular, we wish to thank the GEO subgroup participants and the topic coordinators, who contributed extensively to the preparation of this document.

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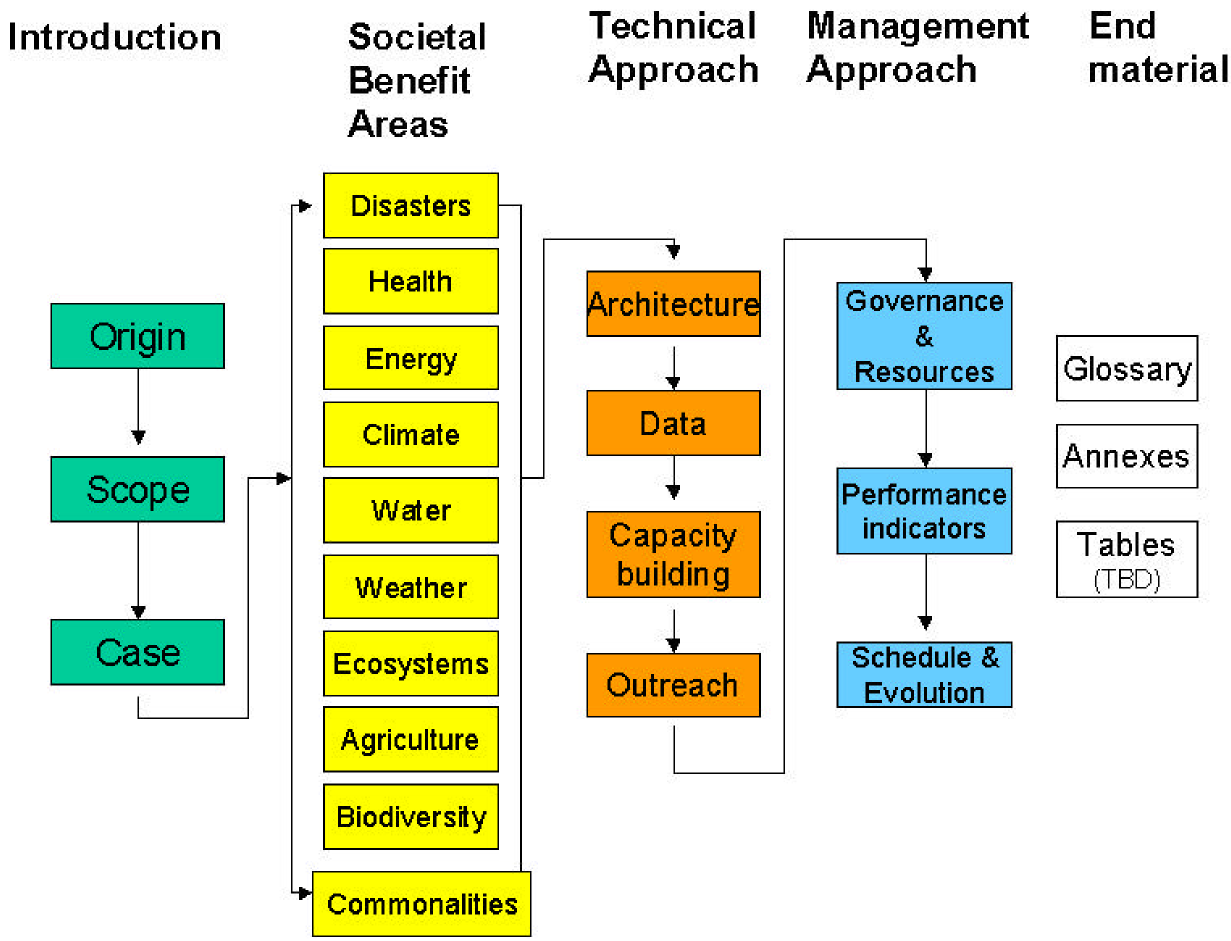
DOCUMENT PLAN



SECTION 1
ORIGIN AND PURPOSE

1 Origin and Purpose of this Plan

The World Summit on Sustainable Development, Johannesburg 2002, highlighted the urgent need for coordinated observations relating to the state of the Earth. The First Earth Observation Summit was convened in Washington, DC in July 2003, attended by high-level officials of 33 countries and the European Commission and 21 international organizations involved in Earth observations[1]. Governments adopted a Declaration signifying a political commitment to move toward development of a comprehensive, coordinated, and sustained Earth observation system. The Summit established the *ad hoc* intergovernmental Group on Earth observation (GEO), co-chaired by the European Commission, Japan, South Africa and the United States of America, and tasked it with the development of an initial 10-Year Implementation Plan by February 2005. GEO established five technical subgroups and a small secretariat. A series of subgroup meetings and a plenary meeting led to a Framework Document[2], negotiated at GEO-3 in Cape Town and adopted at the Second Earth Observation Summit in Tokyo in April 2004 by 47 nations and the European Commission, joined by 25 international organizations. The Framework defines the scope and intent of a Global Earth Observation System of Systems (GEOSS). A small task team was charged by the GEO with the drafting of an Implementation Plan, building on inputs from the subgroups and other sources.

The Implementation Plan establishes the operating principles, institutions and commitments relating to GEOSS. It is supported by a longer Reference Document (this document), which is consistent with the Implementation Plan, and provides the substantive detail necessary for implementation. The Implementation Plan was negotiated by the GEO in Ottawa in November 2004, and adopted at the Third Earth Observation Summit in Brussels, February 2005. The Reference Document was extensively reviewed by technical experts, nations and international organizations.

[1] Declaration of the First Earth observation Summit [Full citation]. See Annex 1
[2] Framework Document [full citation]. See Annex 2.

SECTION 2
SCOPE

2 Scope of the GEOSS Implementation Plan

The Washington Summit Declaration establishes the objective *"to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our international environmental treaty obligations"*, and thus the need for *"timely, quality, long-term, global information as a basis for sound decision making*". The Framework Document adds that to move from principles to action, a *"10-Year Implementation Plan for establishing the Global Earth Observation System of Systems (GEOSS)"*, which should be *"comprehensive"*, *"coordinated"*, and *"sustained"* is needed.

The first 10-Year Implementation Plan of GEOSS defines a sequence of actions and responsibilities, commencing from the Third Earth Observation Summit in February 2005. GEOSS has an indefinite lifetime, subject to periodic review of its continued effectiveness.

A global…

In the GEOSS context, the word 'global' has two meanings. In the first sense, GEOSS aspires to be as inclusive as possible, embracing all nations and parts of the world and the organizations with Earth observation mandates. In the second sense, its priority focus is Earth system processes that operate at scales greater than the individual nation, for instance the global climate system. Phenomena that operate at lesser scales are the primary responsibility of local and national observing systems, but *may* be included in GEOSS if any of the following three conditions are met:

- They have global consequences in aggregate (e.g. desertification),
- They have significant global-scale causes (e.g. biodiversity loss);
- Their observation is enhanced by global systems (e.g. natural hazards)

…system of systems…

The components of GEOSS consist of existing and future Earth observation systems across the processing cycle from data collection to information production. Contributors maintain their respective responsibilities, ownership and mandates, but commit to making all or a portion of their observations available and easily accessible for collective use. GEOSS thus makes it possible to combine information from currently unconnected sources, in order to obtain a view that is sufficiently comprehensive to meet user needs.

…for Earth Observation

GEOSS will facilitate access to direct *observations* as well as *products* based on the collation, interpolation and processing of observations, and the *services* necessary for such a coordinated system, such as the maintenance of data description and exchange standards. The observations provided by GEOSS will originate entirely from contributing national, intergovernmental and non-governmental systems. They will include observations made outside the territory of any nation, for example of open oceans, Antarctica and from space. GEOSS will give priority to the development of observation-based products that are not currently available.

The content of GEOSS will be defined, from time to time, by its governance structures. Initially it covers the nine topic areas agreed by the second Earth observation Summit to be beneficial to many nations, and included in the Framework Document. GEOSS shall be built step-by-step through cooperation among existing observing and processing systems, while encouraging and accommodating new components as needs and capabilities develop. The plan includes the actions needed to build capacity, particularly in developing countries, that will permit the system to be useful to all participants.

SECTION 3
THE CASE FOR GEOSS

3 The Case for a Global Earth Observation System of Systems

Rational management of the environment and its impact on human well-being requires information that is relevant and timely. Ensuring that such information is available to those who need it is a function of governments at all levels, and the current situation with respect to the availability of Earth observations fails, in many respects, to meet the needs of sustainable development. It is therefore common cause—as agreed at the World Summit on Sustainable Development, in the GEOSS Framework Document, and in many other fora—that targeted, collective action is needed to bring operational observing systems in line with the requirements for addressing a range of issues of concern to society.

The specific shortcomings of the existing systems, addressed in Section 4 of the Framework Document, can be described as follows:

- Much more data is collected than used by those who need it, because it is hard or costly to access, or is in a form that is difficult to interpret, or is of uncertain quality;
- There is insufficient exchange of data among agencies and nations;
- Long delays in data access prevent the timely use of information that could save lives or minimize loss of property;
- Spatial and temporal coverage is not optimized, leaving large parts of the globe under-sampled, diminishing the effectiveness of sampling systems in regions with adequate observations, and wasting resources in places with an overly dense sample network;
- Observations of the same variable in different places or by different agencies cannot be combined, either because the methods used to measure it are different, or because the data structures in which it is stored are mutually incompatible;
- There is substantial redundancy in observation effort resulting from lack of coordination and a failure to use one observation to serve in a number of different users;
- Many observations derive from research projects lacking stable funding and staff, and often the appropriate attitude and skills, to perform and manage observations in a consistent way over long periods of time;
- Entire topics of vital interest to society are missing crucial observations taken on a sustained, operational basis.

In short, society is not getting full value from the substantial investment—on the order of tens billions of dollars per year in total—already made in Earth observation. This results from the lack of systematic implementation, coordination, data exchange and attention to information systems that meet user needs. The incremental cost of bringing the systems up to specification is small relative to the existing expenditure, and very small relative to the potential benefits that can accrue. The global, comprehensive, integrated and sustained effort outlined in the GEOSS 10-Year Implementation Plan would address these shortcomings in the following ways:

3.1 Agreements to make systems interoperable and to share data.

The capacity to combine data from different sources substantially increases the number and type of observations available for analysis, as well as their spatial and temporal coverage, while only marginally increasing the cost of data provision. GEOSS provides a mechanism through which partial or full data sharing can be negotiated and a technical process by which it can be achieved. The Global Biodiversity Information Facility (GBIF) is an example. The vast collections in museums and herbaria around the world were mutually inaccessible before an agreement was reached to share information, and set of database protocols designed to make it possible.

3.2 Collective optimization of the observation strategy

For any topic of societal concern, there is a minimum sampling design required to meet the accuracy specifications appropriate to that application. In the absence of collaboration, each observing system needs to do this calculation individually, and deploy its own network to satisfy the requirement. By cooperating, such redundancies are avoided. Rapid technical progress is making hybrid observation systems the norm (combining, for instance the spatial coverage advantages of satellites with the precision of *in situ* measurements). The optimal configuration of the sampling system is therefore continuously changing. An integrated observation strategy is both more effective and more efficient than stand-alone strategies.

A second aspect of this point is the opportunity to gain synergies and cost savings by using one observational infrastructure for more than one purpose. For example, validation of land cover products requires a distributed network of ground locations. These can be co-located with existing stations currently set up for weather observations or ecosystem measurements, for example, saving additional overheads and providing a better dataset to both parties.

GEOSS creates a collaborative forum for technical analysis and observation strategy development.

An example is provided by the atmospheric carbon dioxide observation system designed by the many collaborating organizations in the Global Carbon Project. By combining space observations of the land and sea surface conditions, air movement data from the weather observation system data assimilation models, and a limited number of strategically placed, highly accurate, inter-calibrated surface stations, a specified accuracy can be obtained globally at minimum cost.

3.3 Cooperative gap filling

Because many Earth-system processes operate at large scales, deficiencies in observation in one area have an impact in other areas. It is recognized that the primary responsibility for observations within the territory of individual nations belongs with those nations, but reliance on independent efforts alone has two deficiencies. First, some types of observations are hard to justify, particularly in developing countries, in terms of immediate local benefit, and are therefore of low priority for national support. Second, large parts of the globe (specifically the open oceans, Antarctica and space) are outside of the territory of individual nations. It is to the benefit of all that these gaps be filled and that the burden of doing so be equitably shared. Similar arguments apply to new observation needs, for instance around emerging diseases. GEOSS provides a mechanism for identifying the gaps and mobilizing the resources needed to fill them. An example is the global system of ARGO floats proposed to provide information on sea temperature, salinity, and ocean currents—all of which are essential for accurate weather prediction, disaster management and climate studies. The logistics of deploying the system throughout the global oceans and the costs of doing so are daunting for a single nation, but much more feasible if undertaken as a cooperative action by many countries for the common good.

3.4 Commitments to observational adequacy and continuity

None of the above actions will be effective in the long term unless there is a fundamental commitment to continuation of observations at an acceptable level of accuracy and coverage. Commitment to GEOSS implies an acceptance of this need for adequacy and continuity.

An example is the network of hydrological gauging stations worldwide, which has been in decline since the 1960s. For many basins, the network is now below the minimum required for adequate engineering design of flood protection structures, bridges, dams, and water supply schemes. Ongoing investment is needed to keep the network functional and up to date with technical advances.

A further example is the need for continuity of moderate- to high-resolution, space-based observations of the land and sea surface in the visible and near-infrared wavebands. At any time, at least two systems are needed in polar orbit. This requires a planned migration of sensor platforms out of the research domain and into operational agencies, with a schedule for regular launches and a commitment to backward compatibility of observations and to a process of inter-calibration when new systems are implemented.

Failure to take the opportunity afforded by GEOSS to rectify the current observation system deficiencies will mean, at a minimum, continuation of the current unsatisfactory situation. In certain important aspects (e.g. in surface climate, upper atmosphere, and hydrological observations) the observational capacity is likely to continue the decline that has been evident for several decades unless a decisive intervention is made. With respect to new observation areas just emerging (e.g. around issues of health), future coordination will be hampered by the failure to agree on interoperability standards at this stage. In others, such as climate change and biodiversity loss, failure to establish a comprehensive observation baseline at this time will hamper the ability to detect and quantify changes and the achievement of treaty targets.

SECTION 4
SOCIETAL BENEFITS AND REQUIREMENTS

4 Societal Benefits, Requirements, and Earth Observation Systems

The Framework Document set out nine topics on which there was agreement that clear societal benefits could be derived from a coordinated global observation system. Some of these societal benefit topics are themselves complex clusters of issues, with many and varied stakeholders. In each topic area there are observational needs for many variables, with requirements for their accuracy, spatial and temporal resolution and speed of delivery to the user. It is also clear that there is considerable commonality of observation needs among societal topics. This is the powerful argument for implementing GEOSS.

The societal benefit areas are at widely varying levels of maturity with respect to establishing user needs, defining the observation requirements, and implementing coordinated systems. For example, the weather area is very mature while the health area is relatively immature in the context of Earth observation. In the former case, the activities to be undertaken under the auspices of GEOSS are largely in the areas of data sharing, advanced products and the coordination of future technologies. In the latter case, GEOSS activities commence with assisting the users to define their requirements, which in turn will lead to better use of existing data in the mid-term and new operational coordinated observation systems and synthesis products only towards the end of the initial 10-year GEOSS implementation period.

It is anticipated that each of the nine topic areas will evolve over time and it is also probable that entirely new topic areas may be added, in time. Mechanisms are established in later sections of this Plan to allow for orderly growth, review, and revision.

4.1 Reducing loss of life and property from natural and human induced disasters

4.1.1 Statement of Need

Disasters killed 500,000 people and caused $750 billion of damage over the decade 1990-1999, according to data presented in the "Living with Risk" report of the UN International Strategy for Disaster Reduction (ISDR) [*citation*]. Although damage cannot be completely avoided, better coordination of observation systems and data will reduce these losses and help protect biota and other resources. Improved monitoring of hazards and delivery of information about them are critical for preventing hazards from becoming disasters.

Natural hazards such as wildland fires, earthquakes, volcanic eruptions, landslides and subsidence, tsunamis, floods, droughts, and extreme weather events, coupled with a wide range of pollution and other events that are at least partially human induced, impose a large and growing burden on society. Hazard events can trigger a cascade of further disasters, for example disease outbreaks that commonly follow floods or earthquakes. These events are a major cause of loss of life and property, and often affect key natural resources (e.g. the ecological impact of a major oil spill). Natural hazards have a disproportionate impact on developing countries where they are major barriers to sustainable development. Recent wildland fires in the United States and Australia, the millennium flood in Europe, and the earthquake in Iran where over 30,000 lives were lost, underline the vulnerability of all societies to natural hazards.

As both human population and the complexity of our infrastructure increase, the risk posed by hazards to our collective well-being increases. The possibility of complex disasters, with spills or pollution events being triggered by a natural event, escalates. Improving our ability to monitor, predict, mitigate, and respond to natural, human-induced, and compound hazard events is crucial to reducing the occurrence and severity of disasters. Progress relies heavily on the use of information from well-designed and integrated Earth observations. This requires extensive integration of diverse data streams, improved predictive modeling, and the generation and dissemination of timely and accurate information needed by decision makers and the public. It also requires improved understanding of the underlying natural and human systems gained through basic research. Such basic research itself also requires enhancements to the exchange of Earth observations and related data, information, and knowledge.

DISASTERS Example: A wildland fire hazard system monitors for early detection of fire outbreaks.

In late autumn some years from now, enhanced remote and *in situ* observations of dry fuel load (biomass with low water content) in East Kalimantan, Indonesia, indicate a high potential for severe fires. Wind observations and weather data indicate that lightning strikes could ignite uncontrollable fires in the next few days. Increased satellite surveillance detects a possible wildland fire, which is quickly confirmed by airborne observers. Maps showing areas at risk are generated and local authorities issue specific alerts to the affected population, government officials, and media. Tactical maps and evacuation routes are generated as response crews deploy and people are removed from immediate danger. Equipment requests and optimal deployment plans are generated, based on specific local weather and smoke prediction models, including effects of the fire itself. Wind profiles at higher levels and weather at larger scales are factored into predictions of potential for spread and the relative effectiveness of fire management options. When the fires are brought under control within two days, the event is reviewed, with all players involved, to improve future preparedness and response for such events.

4.1.2 Vision and How GEOSS Will Help

The overarching 10-year vision in the area of disasters is to build toward coordinated operational observing systems with global coverage. These need to be capable of supporting effective disaster warnings, response, and recovery, and generating information products that enable planning and mitigation, in support of sustainable development. Disparate, multidisciplinary, basic, and applied research must be integrated into operational systems. Gaps in observations, in knowledge, in technology, in capacity, but above all, in organization must be filled. Providing this collaborative framework, together with support for continuity of operations for all essential systems, is precisely the purpose of GEOSS.

For fire detection and monitoring, GEOSS can facilitate rapid tasking of the available moderate- to high-resolution infrared imaging satellites to provide the most frequent revisits possible to areas of concern. Geostationary weather satellites can view a given area at 15-minute repeat cycles but lack the spatial resolution needed for detecting wildland fires while they are small. For the next 10 years, fire monitoring will depend on polar-orbiting satellites with appropriate bands and spatial resolution supporting the geostationary data. The best intermediate solution will be robust international coordination of satellite tasking, along the lines of the present International Charter on Space and Major Disasters, but allowing for pre-event tasking where appropriate (as is the case for wildland fires and volcanic eruptions).

Another area of benefit of GEOSS will be to facilitate cross-checking and evaluation of real-time and other data streams. This will aid in identifying possible precursor signals for earthquakes, enabling a clearer distinction between geothermal and magmatic volatility at volcanoes, and determining the circumstances under which a significant tsunami may be generated. Weather-related hazards are covered in section 4.6, but they concern the prediction of short and intermediate-term forecasts, especially critical for local, severe weather such as heavy rain (triggering flash floods or debris flows), hail and tornadoes, which still cause major loss of life because of insufficiently detailed forecasts and warnings.

4.1.3 Existing Situation and Gaps

A large number of agencies and organizations deal with disaster issues at national, regional and global levels. The key issue for GEOSS is to ensure that relevant data and products are produced and that the data and information are received in a timely fashion. WMO has a mechanism that enables the provision of weather data to areas suffering from disasters, and the International Charter on Space and Major Disasters focuses the efforts of participating satellite data providers against specific requests.

Improving the monitoring capability of hazards is required in order to provide early warnings, which prevent hazards from becoming disasters. An approach that includes data from many different sources from both the natural environment and human infrastructure is essential. To provide timely and accurate information, it is necessary to integrate *in situ* measurements, aerial and satellite remote sensing, and/or predictive models. It is also essential to have basic geographic information systems as a base for analysis, including many varieties of socio-economic and other relevant data.

GEOSS must address a number of issues to realize solutions, including filling technical and organizational gaps, as well as continuity issues. Major technical gaps are summarized in table 4.1.1 below, which shows that, apart from weather, few of the observational requirements of the 10 hazards listed are adequately met on a worldwide basis. For instance, there is a lack of worldwide, high-resolution terrain models. There are efforts to develop a global terrain model (e.g. the SRTM), but even when fully available the results have resolutions no better than 30 meters. Effective monitoring of crustal deformation using InSAR requires 10-meter resolution, and this is currently not available routinely. Floods, storm surge and tsunami in areas of low relief raise the requirement for DEMs (Digital Elevation Models) with vertical resolution of less than one meter. This resolution is achievable with LiDAR (Light Detection and Ranging), an airborne technology.

There are gaps relative to specific hazards. For instance, the study of geo-hazards requires integrated, multi-disciplinary research focused on particular groups of volcanoes or high-priority tectonic zones for earthquakes. Deployment of *in situ* instruments is incomplete. Remote sensing support, especially SAR imagery for deformation monitoring, has no guarantee of continuity, and the dissemination schemes are inadequate for real-time monitoring. These limitations are also true for ice hazards and oil spill monitoring. Wildland fire detection depends in most areas on direct human observation on the ground or incidental observation from aircraft.

Existing regional-scale maps of volcanic terrain, seismically active zones, landslide-prone areas, flood plains, and low-lying coastal areas, together with current land cover, land use, and population densities are inadequate to support disaster reduction strategies. This background information is required in order to generate meaningful hazard zonation maps, which are essential for planning and mitigation efforts.

Coordination between observation organizations and research communities remains weak. Earth observation information, whether from space, airborne or ground-based systems, is not used consistently or optimally for disaster management decision making. GEOSS has a role in building the bridge between the communities, and demonstrations showing the usefulness of such information in an operational, integrated manner would be helpful and achievable within a two-year horizon.

4.1.4 Targets

2 Year Targets

4.1 Disasters

GEOSS will facilitate global access to the 100-meter digital terrain information produced during NASA's Shuttle Radar Topography Mission (SRTM). GEOSS will also seek worldwide release of the 30-meter data taken as part of the same mission. (Rec# 1)

GEOSS will advocate for real-time flood forecasting information to developing countries. This will be in concert with efforts by UNESCO and WMO to broaden flood-related information systems. (Rec# 2)

GEOSS will help to assure efficient exploitation of data from Japan's upcoming ALOS satellite. Its L-band synthetic aperture radar (SAR) sensor serves geo-hazard and wild land fire needs and is the first such sensor since 1998. (Rec# 3)

GEOSS will aggressively pursue ongoing capacity building, with a focus on transferring technologies and best practices. Hazard mapping is essential at local and regional scales, as base maps, fuel maps, seismic hazard maps, and such are key tools for disaster preparedness and mitigation. Also essential are best practices for dissemination of real-time information and early warnings to end users and the public. Moreover, frequency analysis of extreme events on a global scale is important for budget planning. (Rec# 4)

GEOSS will work to strengthen the International Charter and similar support activities to enable better response and documentation of effects of disasters. Its scope may be expanded to allow for pre-event tasking where the hazard can be anticipated (wildland fires, some floods, volcanic eruptions). An expanded scope may also encompass Earth observation training and capacity building of local users in affected areas, particularly in developing countries.

GEOSS will help to realize effective monitoring from geostationary satellites for volcanic eruptions, forest fires, aerosols, and other hazards through technologies such as optical and SAR satellites that provide high frequency, high-resolution, and all-weather Earth observations. (Rec# 5)

GEOSS will support focused pilot studies in underserved hazardous areas, by providing new instrumental and mapping support, in addition to remote sensing support. An example here is the proposed strengthening of earthquake and volcano monitoring in the Philippines, Indonesia, and the Pacific Ocean as part of the DAPHNE project [citation]. (Rec# 6)

GEOSS will promote further development of the Global Spatial Data Infrastructure (GSDI). GEOSS will also draw on GSDI components as institutional and technical precedents. This will include geodetic reference, common geographic data, standard protocols, and interoperable system interfaces, among other components. (Rec# 7)

GEOSS will conduct an inventory of existing hazard zonation maps and identify areas and types of hazards where they are most critically lacking. (Rec# 8)

GEOSS will conduct a comprehensive gaps analysis to assess the status and regional distribution of existing disaster management capacity-building programs and initiatives. (Rec# 9)

6 Year Targets

4.1 Disasters

GEOSS will develop a means to support or share critical airborne sensor data and capabilities, including that from hyper-spectral sensors and high-resolution infrared sensors. For floods and coastal hazards, the most crucial need is for high-resolution (less than 1 meter) topographic data, plus good shallow-water bathymetry. GEOSS will support widespread use of LiDAR, the tool of choice for topography in areas of low relief. (Rec# 69)

GEOSS will advocate for continuity and interoperability of all Global Positioning System (GPS) satellite constellations. This includes support of the global geodetic networks that define the orbits of the GPS satellites and thereby enable the use of GPS for precise geo-location. Applications of GPS essential to disaster response include precision topography, mapping support, and deformation monitoring, as well as geo-location for search and rescue operations. (Rec# 70)

GEOSS will promote enhancements of the automatic processing and evaluation of satellite imagery and production of digital topography, in support of rapid detection of fire or oil spills. GEOSS will also promote more rapid SAR processing for interferometry to enable strain mapping over large seismically active zones and to monitor landslide and subsidence in populated areas and along transportation corridors. (Rec# 71)

GEOSS will aggressively pursue a systematic expansion of the inventory of hazards zonation maps and expansion of Geographic Information Systems (GIS) as a critical tool for managing spatial information for disaster management. (Rec# 72)

GEOSS will support real-time data exchange and archiving among regional and local data centers. (Rec# 73)

GEOSS will encourage basic research to enhance understanding of the solid-earth system, as a key aspect of mitigating natural disasters. (Rec# 74)

GEOSS will help to instigate a process for monitoring of capacity-building efforts in disaster management to enable building upon strong existing programs in the continuing efforts to integrate and share resources. (Rec# 75)

GEOSS will seek access to data from seismic and infrasound networks operated by the CTBTO that are useful and relevant for monitoring earthquakes and volcanic activity (Rec#187).

10 Year Targets

4.1 Disasters

GEOSS will support further elaboration of means for real-time monitoring of submarine seismic and volcanic activity and tsunami propagation, including re-use of submarine telephone cables. (Rec# 132)

GEOSS will advocate that the international satellite community, coordinated through the Committee on Earth Observation Satellites (CEOS), plan for assured continuity of critical sensing capabilities. For example, certain research systems should become operational systems and the projected lifetime of some systems should not result in service gaps of key satellite sensor data. Longer-term actions for monitoring of geo-hazards include realization of an integrated observation system of SAR interferometry and GPS. (Rec# 133)

GEOSS will continue to pursue further expansion and integration of regional projects like DAPHNE and Global Monitoring for Environment and Security (GMES) [citation], and the development of efficient interfaces between these and other such programs.

GEOSS will advocate meeting various unmet needs for classes of satellite sensors. Of particular importance for the area of hazards and disasters is the global need for a significant increase in SAR satellites, both C-band and L-band. The disaster management community needs an L-band system optimized for interferometry, and an expanded L-band capacity for better forest and fuel characterization. Monitoring the range of smoke and pollution plumes in the atmosphere around the globe requires expanded hyper-spectral capability, which is currently limited to airborne sensors. A passive-microwave capability would help in determining soil moisture repeatedly over broad areas. (Rec# 134)

GEOSS will advocate development of systematic methods for rapid determination of shallow bathymetry, especially in slightly (or very) turbid water. Such research is vital to characterizing near-shore bathymetry, whether for improved modeling of tsunami and storm surge or for documenting changes produced during such events. (Rec# 135)

Ten years after initiation, GEOSS will evaluate the effectiveness of its capacity-building activities for the disaster management sector, including an assessment in the effectiveness of building the needed inventory of hazards zonation maps. (Rec# 136)

4.1.5 Table of Observation Requirements

In the table given on the following page, several types of hazard or disaster are charted as examples. Certain hazard types are absent here as they are treated elsewhere within this report. For instance, droughts are addressed within the Agriculture area.

Legend for Table 4.1.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.1.5 beginning on the following page.

Disasters

Table 4.1.5

#	Observational Requirement	A: Wild land Fires	B: Earthquakes	C: Volcanoes, Volcanic Ash and Aerosols	D: Landslides, Subsidence	E: Floods	F: Extreme Weather	G: Tropical Cyclones	H: Sea and Lake Ice	I: Coastal Hazards, Tsunami	J: Pollution Events
		Societal Benefit Subtopic									
1	Digital topography –broad, regional	2	2	2	2	2		2	2	2	2
2	Digital topography, bathymetry – detailed or high-resolution	3	3	3	3	3	3	3	2	3	3
3	Paper maps with natural (terrain, water) and cultural features (includes geographic names, all infrastructure and transportation routes)	1	1	1	1	1	1	1	1	1	1
4	Detailed mapping, dating of bedrock, surficial deposits, fill, dumps		3	3	3	3			3	3	3
5	Documentation/ assessment of effects during & after event	2	2	2	2	2	2	2		2	2
6	Seismicity, seismic monitoring		1	2	3					1	
7	Strong ground shaking, ground failure, liquefaction effects		2							2	
8	Deformation monitoring, 3-D, over broad areas		3	3	3					3	
9	Strain and creep monitoring, specific features or structures		2	2	2						
10	Measurement of gravity/ magnetic/ electrical fields – all scales		3	3							
11	Physical properties of earth materials (surfac e and subsurface)		3	3	2					3	
12	Characterize regional thermal emissions, flux – all time scales	2	3	2							
13	Detect, characterize local thermal features, varying time scales	2		2							2
14	Characterize gas emissions by species and flux		3	2							3
15	Detect, monitor smoke or ash clouds, acid and other aerosols	2		1							3
16	Water chemistry, natural and contaminated		3	2		2				2	2

Disasters Table 4.1.5 **Observational Requirement**		Societal Benefit Subtopic									
		A	B	C	D	E	F	G	H	I	J
		Wild land Fires	Earthquakes	Volcanoes, Volcanic Ash and Aerosols	Landslides, Subsidence	Floods	Extreme Weather	Tropical Cyclones	Sea and Lake Ice	Coastal Hazards, Tsunami	Pollution Events
17	Detect/monitor sediment, other discharges (oil, etc.) into water	3		2		1				2	2
18	Water levels (groundwater) and pore pressure		2		3	2					3
19	Stream flow: stage, discharge and volume	2			2	2	2	2		2	2
20	Inundation area (floods, storm surge, tsunami)					2	2	2		2	2
21	Soil moisture	4	4		4	4	4	4		4	4
22	Precipitation	1		1	1	1	1	1		1	1
23	Snow/ ice cover: area, concentration, thickness, water content, rate of spring snow melt, ice breakup, ice jams				1	1	1		1	1	
24	Coastal erosion or deposition, new navigational hazards or obstructions, icebergs						3	3	3	3	
25	Waves, heights and patterns (ocean, large lakes), currents						1	1	2	2	2
26	Tides/ coastal water levels					1	1	1	1	1	1
27	Wind velocity and direction, wind profile	1		1			2	1	2	2	2
28	Atmospheric temperature, profile	1					1	1	1	1	
29	Surface and near-surface temperature (ground, ice and ocean)	1					1	1	2		2
30	Airmass differences and boundaries	1					1	1			
31	Moisture content of atmosphere	1					2	2			
32	Vegetation and fuel characteristics (structure, load, moisture content)	3									

Sources: IGOS Geohazards Report [citation] (earthquakes, volcanic activity, landslides and subsidence), CEOS Disaster Management Support Group Report [citation] (same, plus wildfires, floods, sea ice, oil spills).

4.2 Understanding environmental factors affecting human health and well being

4.2.1 Statement of Need

People born in the 21st century, on average, have a life expectancy of twice that of those born just over a century ago. Improvements in environmental management have been a significant factor in this increase, including improved sanitation, purified water, more effective control of disease vectors and reservoirs, cleaner air, and safer use of chemicals in our homes, gardens, factories, and offices.

However, there are significant differences in the health and well-being of peoples in different parts of the world. One person in five of the world's population still does not have access to good quality drinking water. To expand these benefits to people everywhere necessitates development, communication, and fulfillment of user requirements, which are part of the complex web of information needed to protect and improve human health and well-being. This can be accomplished to a great extent by first satisfying fundamental needs for clean air and water, food and shelter, and ultimately by enhancing our present quality of life and the sustainable development necessary for our future.

Earth observation data transformed into information concerning environmental indicators, such as quality and pollution exposures, is needed. This indicator information needs to be integrated with environment-related health and well-being statistics, to provide improved information as a basis for decisions that will improve the lives of all people. This could be at an individual level for family decisions on lifestyle, activities and healthcare, or as a basis for policy development, nationally and globally. The demands of the ever-increasing global population make this a major imperative.

One set of key health and environmental indicators includes basic forecasts of famine/food security, quality and quantity of water for human use, vector and water borne diseases and wildfire/weather factors. A second set includes air quality, recreational water quality, and UV-B indices. Third, a broader set of indicators for health and well-being policy development will include change indicators, such as land use, the urban environment, transportation infrastructure and patterns, energy use, agricultural-chemical use, and waste management.

HEALTH Example: A Future When the Ocean Warns of a Cholera Epidemic

Some years from now, remote sensing identifies strong ocean upwelling in the northern regions of the Bay of Bengal. Increasing sea surface temperatures suggest the development of conditions conducive to increased ocean productivity. In the following days, ocean color measurements indicate strongly increasing concentrations of chlorophyll-a and the proliferation of phytoplankton. (The significance of this sequence of events in cholera has been appreciated for many years, but this is the first time such a massive phytoplankton bloom could be predicted from such an early stage.) Epidemiological information reported from international researchers in Dhaka, Bangladesh, report novel serogroups of cholera pathogens that can evade vaccine-derived immunity. Time remains, however, to prepare in case the cholera-bearing copepods approach the Ganges Delta: home to over one hundred fifty million persons.

A major public health effort, coordinated by the Ministry of Health with significant international support, provides to hospitals, clinics, and healthcare providers in the threatened areas immense stocks of pre-packaged oral rehydration salts with instructions for use. Meanwhile, sea-surface height increases, and high-resolution imaging tracks large populations of plankton being carried into the delta. Geographic Information Systems with Global Positioning System coordinates from the long-standing vaccine field trial sites are used to identify the at-risk communities and health care centers in the track of the pathogen that need additional medical supplies.

Shortly thereafter, an explosive epidemic occurs, and cholera cases pour into the hospitals and clinics. Patient numbers rapidly increase, and cholera cots are set in the corridors and parking lots of clinics. Microbiologists identify a new antibiotic resistant cholera strain. In previous years this would have been a recipe for disaster; however, early warning and pre-placement of adequate medical supplies minimize cholera casualties to near zero.

4.2.2 Vision and How GEOSS Will Help

The vision is for Earth observation to make a significant contribution to the continued improvements in human health. It will be achieved through the development of a system of remote sensing and *in situ* systems integrated through assimilation and modeling tools with census data on health. The outputs will be to identify environmental conditions, health hazards, and at risk populations, and to establish epidemiological associations between measurable environmental parameters, chronic and infectious diseases, and health conditions. To accomplish this, the available data will be identified, processed into a useable form, and disseminated to all users, including the health community represented by appropriate international bodies such as the World Health Organization. Models relating environmental hazards to health condition/disease will be developed and tested in appropriate areas. Data delivery mechanisms to get the information to public health officials, connecting to well-developed decision support systems for health care planning and delivery, is an essential component.

GEOSS will be a vital means of bringing useful environmental data to the health community in a user-friendly form. Comprehensive datasets are powerful tools that support research, epidemiology, health care planning and delivery, and provide a variety of timely public alerts.

For example, by linking weather and air quality data, air quality forecasts can help protect asthmatics, the elderly and young from air pollution episodes. Also, by connecting the environmental requirements of pathogens with weather and other data, it can be possible to predict outbreaks of infectious diseases such as malaria, and reduce the impact and severity of the outbreak. By using remotely sensed land use data, it is possible to predict areas of probable water quality impairment, which allows local communities to better target *in situ* water quality monitoring and remedial efforts. Better UV-B measurements and warning systems will reduce the incidence of skin cancer and cataracts around the world.

GEOSS will bring a focus to predictive and preventative aspects of health, particularly with respect to environmental conditions such as pollutants and contaminants. Thus, at the global level, the availability of remotely sensed and *in situ* environmental data raises the opportunity of applying powerful new tools to discovering early indicators of adverse conditions, thereby alerting the community and providing time for hazard avoidance or disease mitigation. This contrasts with the focus of most of the health care today, which is primarily a treatment-based system with research on the processes underlying chronic and infectious diseases.

Currently, the work being conducted with remote sensing technologies and disease is through interdisciplinary research groups involving scientists with varied backgrounds such as remote sensing, epidemiologists, and atmospheric scientists. The science of epidemiology involves observing factors that might be associated with disease, and then calculating the degree of significance in the association. The true value of remotely sensed data will become more fully realized when simple, user-friendly data products are prepared that are easily overlaid onto disease/dysfunction maps. For example, if an epidemiologist wished to investigate factors associated with childhood asthma, it will be useful to model the physical location of patients with real-time and cumulative local airborne particulates over the study period. GEOSS can make a significant contribution to this class of activity by ensuring data are available and developing the model capability.

It is essential to be able to relate the results of disease studies conducted in different times and locations. GEOSS will be invaluable in allowing exposure and disease data to be related among populations. For example, the aerial particle pollution and health consequences among the world's major cities could be compared and contrasted, and degenerating environmental conditions that could lead to emergence of infectious diseases could be identified and reversed before a new epidemic occurred.

4.2.3 Existing Situation and Gaps

All countries have a capability to provide health support, and a number of intergovernmental and governmental agencies provide global support. What are not well developed are the linkages between these efforts and the agencies making environmental observations. Equally, there is little systematic work on the integration of environmental data with health statistics and information.

An important step is the need for better interaction between the GEOSS community and the health community. Relatively few individuals are able to bridge this gap, and the full value of

Earth observation data being used with health data will not be realized until there are more individuals trained in this area. For example, training for both the malaria teams and those charged with developing predictive models for climate and other factors, which influence mosquito vector populations, and therefore, the transmission of the parasite, will be a major goal. Universities and funding agencies will be encouraged to strengthen support of interdisciplinary research and scientific training to provide and use GEOSS data and data products.

Adequate observations exist for weather and meteorology (precipitation, temperature, etc.) and census data, and through established techniques can be transformed into useful data and products. There is also be some satellite information collected for parameters such as wind blown dust, cloud cover, and ground cover/land use. Data on emissions inventories and other environmental releases are extensive although the accuracy of the data is often unknown and more work is needed. Effort is also needed to improve the systems for reducing the data into information and distributing/archiving the data. Monitoring data for air, water, and food is patchy, being considered adequate only for some contaminants. Some countries collect extensive data on pesticide and chemical use; in others there is little or no data collection. For air and water quality, information on the chemical composition in real time is limited. There is a need for routine global scale chemistry measurements in the atmosphere. In general, there is lack of appropriate spatial and temporal resolution to directly relate releases of pollutants and chemicals to exposure or human health. There are no observation systems available for collecting human activity or human exposure data; data is generally only available for individual studies. Innovative approaches are needed for routinely observing individual activities across most of the globe.

In order to integrate ground, health and remotely sensed data for health use, improved capacity of modeling and analysis techniques is necessary. Information is needed at a level that enables the accurate assessment of health issues and correlation with the environment observations and products. Gaps also exist in the integration of relevant existing observation systems, for example, integrating the global urban land observations with data that characterizes the built environment, and with indicators of environmental quality, health and disease. There are also gaps and challenges ahead to produce a more comprehensive set of indicators, for example the tracking of pollutant and pathogen occurrences, as well as patterns of human activities. This will enable the establishment of indicators showing for example the possible adverse exposures to the health of specified populations. Assimilation and modeling techniques can enable epidemiologists to relate physio-chemical, microbiological, pollutant and chronic or infectious disease to Earth observations for prediction purposes. These models could also be used to predict or forecast some of these indicators for use by the public and environmental managers to modify behaviors both to avoid exposures and to produce less pollution.

There is an ongoing need in all nations to provide education and training for people who design, build, and operate observing systems, who analyze data, and who produce data products. This needs to be seen as a parallel activity to the building of institutional willingness and capacity in public health to move beyond surveillance and response by having a focus on prediction and prevention. This capacity building will help people everywhere–especially those for whom poverty has a direct impact on health--gain a better understanding of the effects of environmental exposures on health and well-being and how to prevent or reduce harmful effects. Capacity building in the tools for collection, processing and use of data and data products will help significantly to improve public health by providing integrated information for the health research, provider, and policy communities.

Demonstration projects will be of value where associations are implicated between Earth observation data and the epidemiology of disease; high-resolution imaging could be used to test the hypothetical association. For example AVIRIS imaging of phytoplankton blooms could be conducted in regions of the world such as Mozambique and Peru at the earliest stages of seasonal cholera outbreaks, IKONOS could be used to evaluate surface temperature, habitation patterns, soil moisture and surface water when unusual outbreaks of malaria are being experienced, or remotely sensed data could show when storm outflows from rivers are causing adverse water quality at beaches that would necessitate beach closures to protect public health.

4.2.4 Targets

2 Year Targets

4.2 Health

GEOSS will work to inventory all available Earth remote sensing and ground-based databases that can be associated with known health problems such as asthma, pollutant exposure, and certain infectious and vector-borne diseases. This includes remote sensing and ground-based databases, historic datasets encompassing well-characterized epidemics, and gaps in human health related environmental data (e.g., places where water quality and air quality are not measured.) (Rec# 10)

GEOSS will address interoperability among data sets acquired by different nations and agencies, as these are not likely to be in compatible formats or easily usable form. (Rec# 11)

GEOSS will promote development of data products and systems that integrate Earth science databases with health and epidemiological information. This includes social and infrastructure data needed in decision support systems for health care planning and delivery. For example, in places having no water quality data but large populations with a reduced life span, the best way to improve health may be to monitor water quality, implement water purification, and inform the public about the need to use purified water.

GEOSS will also promote development of models relating remotely sensed and *in situ* data to the epidemiology of environmentally related infectious and chronic diseases. (Rec# 12)

GEOSS will promote mechanisms that help to translate the needs of health data users into requirements that Earth observation data providers can address. (Rec# 13)

GEOSS will enhance the ability to overlay on epidemiology maps the variety of relevant inventoried and processed data, including meteorological, aerosol, ocean and land features, demographic, and infrastructure. (Rec# 14)

GEOSS will help to identify data gaps limiting the development of disease models. (Rec# 15)

GEOSS will lobby for the enhancements to international networks and systems needed to support Earth observation data sharing in areas of human health. (Rec# 16)

GEOSS will help to identify technical needs in instrumentation and data products that will yield useful epidemiological data at the community level. (Rec# 17)

GEOSS will help to identify "paradigm environments", such as vaccine field sites that have strong epidemiological and demographic data. Here, GEOSS will demonstrate the utility of overlaying high resolution remotely sensed data as a way to correlate environmental factors and specific infectious diseases (e.g., cholera and malaria). (Rec# 18)

GEOSS will conduct a comprehensive gaps analysis of existing capacity building programs and will aggressively promote initiatives for improved coordination. (Rec# 19)

GEOSS will advocate, within its field of competence, an increase in collaborative research programs between developed and developing country scientists, to their mutual benefit. (Rec# 20)

GEOSS will aid the establishment of exchanges between developed and developing country health care experts to ensure a global perspective of the challenges and some coordinated development of a network to address problems and to leverage Earth observation systems where appropriate. (Rec# 21)

GEOSS will start developing a series of educational and training workshops in the area of Earth observations as applied to human health, with a specific focus on the needs of developing countries. (Rec# 22)

6 Year Targets

4.2 Health

GEOSS will catalyze the development of monitoring methods and systems to detect early evidence of health-related changes and to further inform epidemiological modeling studies. (Rec# 76)

GEOSS will advocate for development of indicators of human health based on environmental measurements. (Rec# 77)

GEOSS will promote further development of remotely sensed maps describing the global system for sources, transport, and deposition of aerosols, and systems characterizing river and coastal pollution. (Rec# 78)

GEOSS will facilitate the availability of wide-area health parameters derived from geostationary satellite data. (Rec# 79)

GEOSS will help to develop mechanisms for alerting public health professionals about hazardous conditions identified by environmental monitoring. (Rec# 80)

GEOSS will facilitate coordinated approaches to the integration of environmental monitoring parameters with vectors, animal reservoirs of disease, and clinical admissions. (Rec# 81)

GEOSS will regularly ensure that the human health community has input to the technical specification of new major environmental observation capabilities. (Rec# 82)

GEOSS will help to develop sets of environment and infrastructural determinants of health, e.g., sanitation, transport, energy, communications, housing. (Rec# 83)

GEOSS will facilitate the establishment of a coordinating group focused on health organizations as users of Earth observations data and information. This outreach and information-sharing group must engage developed and developing country health communities to ensure a global perspective of the challenges and to catalyze a global network to address problems. (Rec# 84)

GEOSS will develop the tools and processes needed to address concerns in health and will develop a useful regional network of experts and information databases, working primarily through the GEOSS coordination group for health described above. (Rec# 85)

10 Year Targets

4.2 Health

GEOSS will enhance the early detection and control of environmental risks to human health through improvements to the sharing and integration of Earth observations, monitoring, and early warning systems, databases, models and communications systems. (Rec# 137)

GEOSS, after consultation with the user community, will help to fill data gaps by advocating for new, high-resolution Earth observations relevant to health needs. (Rec# 138)

GEOSS will encourage the formation of a global community of operational and academic researchers who use remote sensing data in a standard format to characterize epidemiological associations with disease. (Rec# 139)

GEOSS will improve access and usability of data needed to assess health vulnerabilities of human populations and support decisions at the local, regional and global scales. (Rec# 140)

GEOSS will advocate for better on-ground disease surveillance, linked with open national reporting practices, for better understanding and documentation of environmental influences on infectious, chronic and other diseases and disorders. (Rec# 141)

GEOSS will promote improved methods to fill in gaps from ground based to remote sensors. For example, improved methods may be appropriate to integrate data from *in situ* water quality monitoring at specific points with remotely sensed water quality characterizations of whole watersheds. (Rec# 142)

GEOSS will promote community-based research that involves the collaboration of people living or working in a community with scientists to design and execute research projects to solve community environmental health problems. (Rec# 143)

GEOSS will help to assure that developing countries share in environmental monitoring data and collection methods. This may stimulate greater environmental protection and improved health at all levels and in all settings. (Rec# 144)

4.2.5 Table of Observation Requirements

Legend for Table 4.2.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.2.5 on the following page.

Health

Table 4.2.5

	Observational Requirement	Societal Benefit Subtopic					
		A	B	C	D	E	F
		Infectious Diseases	Cancers	Respiratory Problems	Environmental Stress	Nutrition	Accidental Death & Injury
1	Air quality (O3, SO2, PM2.5, allergens)			3			
2	Drinking water quantity				2	2	
3	Access to food (carbohydrates, protein, nicronutrients)					2	
4	Drinking water chemical quality (salinity, metals, nitrate, flouride)		3		3		
5	Pathogens in domestic and recreational water	2					
6	Contaminants in food (POPs, metals, pathogens)	3	3				
7	UV levels		2				
8	Max and min temperature, wind, humidity	1			1		2
9	Wind direction and speed	2					
10	Coastal current direction and speed	1					
11	Drainage basin flows	1					
12	Human movements(air, land and sea transport, refugees)	2					
13	Trade flows	2					
14	Precipitation and soil moisture						2
15	Topography						1
16	Land cover	1					1
17	Disease occurrence and cause of death statistics	2	2	2	2	2	2
18	Population density, by age and socio-economic class	2	2	2	2	2	2

4.3 Improving management of energy resources

4.3.1 Statement of Need

Energy underpins all aspects of the economic and social development policy in developed as well as developing countries. The energy sector covers a wide range of activities such as oil and gas exploration, extraction and production, transportation, power (electricity) production, transport and distribution. The optimal management of this diverse, global trillion-dollar industry which includes non-renewable resources such as oil and gas as well as renewable resources such as solar, wind, biomass and hydropower generation is a critical concern to all nations[3].

Major issues for the energy industry include fuel supply, type, and sustainability, as well as power efficiency, reliability, security, safety and cost effectiveness. Nations need reliable and timely information in order to manage the risks associated with uncertainty in supply, demand, and market dynamics. This requires sound management practices and strategies, both of the industry as well as the government. As weather and climate directly influence the demand as well as the supply to the electricity grid, access to accurate, reliable, affordable real time data from observation systems, as well as predictive information derived from the modeled data, is critical for the continued stability and growth of the economies.

According to OECD and IEA analyses, primary energy demand is likely *to double over the next 30 years* with most of the increase occurring in the developing world, notably in China and India. To date, some 1.7 to 2 billion people have no access to electricity and a further 2 billion are severely undersupplied. The UN has targeted development goals to enhance the quality of life through cost-effective supply of energy to these societies. In developing countries, therefore, major issues are energy access and reliability with efficient energy management being a secondary issue. Observing system information that enables countries and regions to meet their development and sustainability goals will be of critical value. Flood- and drought- induced impacts on the electrical power generation infrastructure are the types of information critical to the siting and operation of this infrastructure.

[3] World Development indicators 2001, The World Bank group; World Development Report 2000/2001, Attacking Poverty, IBRD, The World Bank.

ENERGY Examples

Perhaps no other illustration of the critical dependence of nation's functioning upon energy is more striking that the "blackout" in eastern North America in August 2003. It occurred during summer peak seasonal energy use periods when air conditioning demand was in full force. Impacts extended to potable water loss, loss of sanitation, food spoilage due to heat, defense industrial base shut down, intermittent telecommunications failure, transportation shut down, banking and finance interruption, mail service disruption, and tourism industry closures. The four-day outage affected an area of 50M people and 61,000 megawatts of power, with an estimated total North American cost between $5.8 and 11.8 billion US dollars[4]. The Canadian GDP was down 0.7% in August, with a net loss of 18.9 million work hours. Manufacturing shipments in Ontario were down $2 billion Canadian Dollars (1.8 billion US).

In September 2003, the impacts from winds and floods of Hurricane Isabel on the energy infrastructure of the east coast of the U.S. resulted in widespread power outages to 5.5 million customers due to downed power lines and the loss of water supplies due to the loss of electricity to run the pumps. Lack of power had a financial impact as the sales at major retail stores fell 1.8%. The cost of repairing damage to the power grid in Virginia alone was over $40 million[5].

In another instance, unanticipated climate-related events such as droughts or floods can seriously affect the energy resources of a nation. For example in Ethiopia, where 97% of the hydroelectric power comes from Koka Dam, major strategies need to be developed to mitigate risks due to flash flood and periods of water scarcity. The Ethiopian Electric Power Corporation (EEPCo) reported drought induced hydroelectric power failure leading to revenue losses of $8M [6]. While this dollar loss is modest for a developed country, the loss in Ethiopia is enough to destabilize the economy. Thus the relative value of the vital observing system data to the developing nation is orders of magnitude higher.

In Kenya where hydropower makes up 75% of the generation (Kenya Power and Lighting Company and Ken Gen), drought-induced rationing decreased the overall production of electricity to 40%. Emergency power credits were issued to purchase fuel since there are no internal sources of fossil fuel. The World Bank contributed $47M to import and operate generators. The economic losses due to rationing and failure were estimated at $2M/day. KPLC lost $20M/6 months with expenditure of $141M for fuel. It was estimated that the loss to the economy approached $100M/month. Incorporation of weather and climate forecasts as well as soil and evaporation for calculation of water loss could help mitigate these types of disasters.[7]

[4] U.S.-Canada Power System Outage task Force report: August 14th Blackout: Causes and Recommendations, April 2004

[5] Infrastructure Interdependencies associated with Hurricane Isabel. Argonne National Laboratory, October 8, 2003

[6] IRI assessment studies

[7] IRI Assessment studies

The first beneficiaries of GEOSS will be the end-user populations (1) through the reliable and safe provision of electricity and the impact on prices and tariffs and (2) in contributing to sustainable development, food security, irrigated agriculture, health, education for youth (women in particular), gender equity. In addition the energy industry will benefit from improved safety for critical energy operations, and optimized energy resources management. Furthermore, industrial activities dependent upon continuous and reliable energy availability will also improve their performance and results. Finally, the impact of energy efficiency on national economies resulting from GEOSS will facilitate delivery of further social benefits in areas such as education, health and tourism.

4.3.2 Vision and How GEOSS Will Contribute

The vision is to balance the supply and the demand of energy of the planet in a sound, equitable, and environmentally responsible way, enabling nations to meet and further their economic, social and environmental agendas. This requires involvement of both the leaders of nations and of the energy industry, the implementation of GEOSS will offer unique capabilities for the global industry to meet these goals through delivering accurate "Situational Awareness" of both current and future states of the energy system and their environmental context.

At regional level, differences in energy management are influenced by availability, cost, and impacts on ecology, environment, and human health and well-being. GEOSS and its associated modeling capabilities will "make the unpredictable, predictable", allowing energy management actions to be taken to reduce risk due to weather, climate, oceanic, geological and human threats. Using the observing systems and modeled products, coupled with energy decision support models and tools, industry will create "Action Plans" to improve the management of energy resources in a safe, efficient, cost effective, reliable, secure and socially responsible manner.

The objective is to create an informed "proactive" strategic energy planning together with tactical management based on accurate situational awareness and prediction. This will supersede the "reactive" management practices currently in use in much of the world today. GEOSS will play a role in providing data and information relevant to control power and pipeline distribution systems, hydropower dam operations, wind power generation commitment, traffic congestion management, city lighting, and building heating/cooling, to name a few. In addition, GEOSS will facilitate the entry of renewable energy into the grid, and extend the life expectancy of non-renewable energy sources.

4.3.3 Existing situation and gaps

The energy industry is already an important user of Earth observation-derived information and products. Weather data in the hourly to monthly range, as well as for extreme events such as heat waves or droughts, is necessary for energy usage forecasts. Climate statistics and predictions are important in long term supply planning. Marine forecasts are essential in the offshore drilling business, providing information on sea-state conditions, wind, wave, surface temperature, and extreme events such as severe storms and hurricanes.

Assessment of greenhouse gases (GHGs) emissions and the monitoring of air pollution and air quality is a key requirement for energy producers. The need for systematic detection of marine oil pollution (not only for major disasters, such as Prestige, which in total represent less than 10% of world marine oil pollution) and oil drift monitoring for coastal zone protection is also critical. Managing pipelines through weather data and terrain movement is also important. Exploration also benefits from Earth observation in primary geological mapping.

Real opportunity exists for information from Earth observations to contribute to the optimization of renewable energy systems for power production, and to contribute to the provision of information for optimal integration of traditional and renewable energy supply systems into electric power grids. GEOSS data can also contribute to the modeling needed for improved prediction of electric power supply and demand, thus mitigating power shortages. In addition the energy industry must ensure the minimization of greenhouse emissions and other pollutants from energy production (e.g. for Kyoto Protocol verification). Effective management of the above energy issues requires a broad variety of data, information, models and decision support systems. Whilst some of these needs can be met, the tools and products are often proprietary or suffer from inadequate inter-operability.

The minimum observation requirements are essentially those set out under Weather and Climate. Gaps exist in the data and information products needed for efficient exploration, production, transportation and use of energy while minimizing associated environmental risks. There is a need for better and more informative indicators of the factors influencing energy demand (including socio-economic trends) which decision-makers and stakeholders can use to assess the current situation and to take both short-term and long-term corrective actions. These will result from improved forecast models to predict environmental conditions (weather, air quality, water quality etc) as well as a better integration of data, information, and models into spatial/temporal databases and decision tools (e.g. GIS).

The energy industry's operational requirements listed in the table of Appendix 1 identify, for the main energy sub-sectors and operations, the information requirements necessary to take action. This table is based on a one-year study examining the diversity of needs of the industry ranging from utility operations to policy development[8].

4.3.4 Targets

To provide improved strategic and tactical energy-management information, GEOSS will promote wider use of existing environment-aware energy-management tools, foster R&D on improved tools and facilitate wider access to significantly better and more reliable weather & ocean forecasts on a wide range of time-scales (hours to months, years and decades or even centuries) and of geographical scales (from local to regional and global), all of which will have substantial impacts on the energy industry.

Short-term (2 years)

[8] Requirements of the energy industry for weather, climate and ocean information by Altalo, et al, Technical report to NOAA OAR, 2000

The short-term goal for GEOSS in the energy industry must be to optimize the use of existing data and forecast information. Preparing the industry to "receive and use" the new GEOSS products when available is critical to the early success of GEOSS. To this end it is essential that GEOSS and nations foster investments at local, national and regional level in improved energy management through use of GEOSS data and information products. Actions are needed as follows:

2 Year Targets

4.3 Energy

GEOSS will promote the exchange and use of *existing* data/products and forecast information through specific initiatives and actions in coordination with the energy community (i) to raise awareness about the importance and potential of environmental information (ii) to facilitate access to the existing information and products and (iii) to develop training and encourage the development of decision-support tools for optimal energy use. (Rec# 23)

GEOSS, in coordination with the energy community, will define a strategic 5-10 year plan for exploitation of the benefits of the new generation of operational observing systems - both space and *in situ* - which comes on-stream in this decade. The plan should include efforts on (i) operationalizing existing research capabilities to meet the needs of the energy industry (ii) research and development of advanced end-to-end modeling and forecasting techniques (such as ensemble-based methods) covering both environmental and energy processes, and with an emphasis on issues of risk assessment (iii) the improvement of information networks by linking and making inter-operable existing systems (iv) continue efforts to raise awareness of, facilitate access to, and operationalize improved methodologies for exploitation of GEOSS data and information products for the industry. (Rec# 24)

Medium-term (6 years)

In the medium term, progress and improvement of energy resources management activities, ranging from exploration to exploitation, transport and distribution, will be largely related to the improvement of short-term to medium term (up to 8-10 days) weather predictions as well as progress in seasonal to inter-annual climate forecasts. The new generation of satellites coming on-line will enable the range of deterministic forecasts to be extended to 15 days. Predictions of high-impact weather will use ensemble forecasts to assess of the rarity of the forecast event; the useful forecast range will depend on the event—up to five days for flash floods, storms, blizzards and tsunamis, 10 days for plain floods, and 15 days or beyond for droughts, heat waves and severe cold spells. Seamless systems for probabilistic predictions from a few days to a month ahead will be developed. The range of seasonal to inter-annual forecasts will be extended with new application products in energy as well as health, agriculture, and water resources management. Operational weather systems will be extended to provide operational daily global analyses of greenhouse gases, monthly estimates of the sources and sinks of CO_2; plus daily global / regional analyses and forecasts of reactive gases and aerosols.

6 Year Targets 4.3 Energy

GEOSS to assess progress on the plan and revise strategy as needed. GEOSS to promote the use of improved weather and climate products for the development of new energy tailored products and services. (Rec# 86)

Long term (10 years)

Energy management needs and opportunities for improvement vary globally. However, in view of the increasing demand for energy and the simultaneous need to reduce environmental impacts, the energy sector in the long-term shall rely increasingly on improved, tailored products and services derived from operational Earth observation systems and modeling.

10 Year Targets 4.3 Energy

GEOSS to ensure the implementation of appropriate operational observing systems – space and *in situ* - for the continuous and sustainable provision of reliable and timely data in support to energy operations. (Rec# 145)

GEOSS to encourage and support the development of new generation weather and climate forecasting models. (Rec# 146)

GEOSS to organize and stimulate the exchange of data and products for efficient energy management. (Rec# 147)

GEOSS to develop capacity-building in order to bring energy management at local level to equivalent high (national and regional) levels of efficiency. (Rec# 148)

4.3.5 Table of Observation Requirements

Legend for Table 4.3.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.3.5 beginning on the following page.

		Social Benefit Application				
		A	B	C	D	E
Energy Table 4.3.5 **Observational Requirement**		Oil & Gas Exploration, Development & Production Operations (onshore & offshore)	Refining & Transport Operations (at sea and over land), Environment-al Impact of Emissions & Transport	Renewable Energy Operations, Environmental Impact of Plant Siting & Operations, Biomass Crops Optimisation	Electricity Generation, Transmission & Distribution Energy Load Demand, & Supply Forecasting	Global Energy Management, Emissions Trading, Impact of Climate Change, Treaties & Regulations
Land Requirements						
1	Digital terrain model / digital topography maps*	2	2	2	2	
2	Land use / Land cover maps*	2	2	2	2	2
3	Geological maps*	3	3	3		
4	Soil maps & parameters	3	3	3		3
5	Subsidence maps	3	3	3		
6	Urban extent	2	2	2	2	2
7	Hydrological parameters**			3 (see Water)		3 (see Water)
8	Crop parameters**			2 (see Agriculture)		

*Depends on geographical scale and accuracy required.
**Depends on types of parameters required.

Atmosphere Requirements						
9	Weather and short-term climate forecasts*	1 (for 1 to 3-day forecast), 2 (for 3 to 10-day forecast), 3 (for climate forecast)				
10	Extreme weather & climate event forecasts*	3 (for 1 to 5-day forecast)				
11	Measurements and forecasts of air pollutants	4	4	4	4	4
12	Climate statistics for atmosphere parameters**	3	3	3	3	3

*See Weather and Climate topic areas for detailed information.
**Depends on types of parameters required.

Ocean Requirements						
13	Sea surface temperature*	1	1			(see Climate)
14	Sea surface ice*	2	2			(see Climate)
15	Sea-level*	1	1	1		(see Climate)
16	Tides*	1	1	1		(see Climate)

		Social Benefit Application				
		A	B	C	D	E
Energy Table 4.3.5 **Observational Requirement**		Oil & Gas Exploration, Development & Production Operations (onshore & offshore)	Refining & Transport Operations (at sea and over land), Environmental Impact of Emissions & Transport	Renewable Energy Operations, Environmental Impact of Plant Siting & Operations, Biomass Crops Optimisation	Electricity Generation, Transmission & Distribution Energy Load Demand, & Supply Forecasting	Global Energy Management, Emissions Trading, Impact of Climate Change, Treaties & Regulations
Ocean Requirements (continued)						
17	Surface currents*	2	2	2		(see Climate)
18	Sub-surface currents*	3	3			(see Climate)
19	Eddies*	3	3			(see Climate)
20	Salinity*	3	3			(see Climate)
21	Ocean colour*	2	2			(see Climate)
22	Surface waves*	1	1	1		(see Climate)
23	Surface winds*	1	1	1		(see Climate)
24	Extreme event: Hurricanes*	2	2	2	2	
25	Extreme event: Tsunami*	4	4	4	4	
26	Extreme event: ENSO*	3	3	3	3	3
27	Bathymetry*	4				
28	Climate statistics for ocean parameters*	3	3	3		3
*Depends on the accuracy required for various forecasting timescales.						
Solid Earth Requirements						
29	Seismic surveys	4		4		
30	Gravity field anomaly data	2				
31	Magnetic field data	3				

4.4 Understanding, assessing, predicting, mitigating and adapting to climate variability and change

4.4.1 Statement of Need

All societies and ecological systems are affected by climate variability, climate change and extreme events. As the "climate system" can be described by statistical properties obtained from sufficient long observations of the state of the atmospheric, oceanic, and terrestrial domains, there is a need to have long and homogeneous time series of complete observations in each of these domains. Risks associated with the observed trend of global warming and with extreme events are often poorly known or not fully recognized when planning for socio-economic development. For adaptation to be effective, governments as well as the private sector need information about past and current climate conditions, their variability and extremes, as well as sound projections of future conditions, not only on a year-over-year basis but for many decades into the future.

The climate system responds to both external forcings[9] and to perturbations of internal processes, with evidence from IPCC assessments indicating that human activities are leading to changes to our climate. It therefore is important to track climate change and variability in a way that causes can be determined, trends and variability predicted, and appropriate adaptation and mitigation strategies defined for implementation. Governments, through the UNFCCC, have already agreed to achieve stabilization of atmospheric greenhouse gas concentrations at a level that would prevent dangerous anthropogenic interference with the climate system. This is within a time frame that will allow ecosystems to adapt naturally to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

Human and technological capacity is needed for the end-to-end collection, management, exchange and utilization of current and future observations from the atmosphere, ocean, and terrestrial domains. Procedures for the storage and exchange of metadata may also need to be implemented. This stewardship is a significant challenge since developed and developing countries are currently barely able to keep up with the influx of new data from satellites and *in situ* observations. Furthermore, observing standards and guidelines for required climate variables must be agreed to, adopted and supported by countries making observations. In many cases, this may require that outside assistance be available so key countries can contribute to a global climate network.

[9] Such as volcanoes, solar radiation etc.

EXAMPLE

Climate Extremes Warning System for Seasonal Forecasts

Five years from now, in June, seasonal climate forecasts predict an exceptionally strong El Niño event for the following December to February season in the Central and Eastern Pacific, with heavy impact on regional weather patterns in parts of Central and South America. A timely and tailored forecast is broadly disseminated and provides the opportunity to plan adequate mitigation measures in all affected regions and with respect to various societal areas for the coming months: in the agriculture sector, farmers in Northwestern Peru, Southern Ecuador and Uruguay are advised to expect heavy rainfalls and react accordingly, thereby improving national food security; Northeast Brazilian farmers are advised to plant drought-resistant or fast-ripening crops to adapt to forecast drought conditions; livestock farmers will time their slaughtering, transportation and marketing schedules on the predicted seasonal rainfall; countermeasures against impending floods, which can lead to prolonged food shortages by ruining stocks and fertile topsoils, will be taken, saving lives and property in flood-prone areas. For the regional health sector, surveillance by early warning systems enabled within the GEOSS helps to combat diseases, such as malaria, affected by exceptional climatic conditions. The seasonal El Niño forecast has been enabled by substantial enhancement, through GEOSS, of satellite and composite *in situ* observing networks (e.g., ships, drifting buoys) over previously data-sparse areas, such as the Tropical Indian and South Pacific Ocean. Improved data exchange, capacity building and computer technology will have improved the regional detail of models predictions and the information dissemination to potentially affected communities, and this greater detail allows for specific regional and local response measures to be implemented.

4.4.2 Vision And How GEOSS Will Help

The vision is to have an understanding of the Earth climate system that will enable economic growth to be undertaken in a sustainable way and without inducing any perturbations to the climate system.

GEOSS can be highly effective by facilitating access to data, developing and implementing new observing systems, and integrated climate products. It can support compliance of existing and new observing systems with the GCOS Climate Monitoring Principles (WMO, 2003; UNFCCC, 1999, 2003). The phased 5-10 years *"Implementation Plan for the Global Observing Systems for Climate in Support of the UNFCCC"*, GCOS-92 (GCOS, 2004), provides GEOSS with a blueprint of actions to implement the climate requirements for a "system of systems" involving at least 5 observing systems in the atmospheric, oceanic and terrestrial domains. At the same time GEOSS can make use of the scientific guidance provided by WCRP and the IGOS-P Theme Reports.

GEOSS can work to ensure sustained operation of essential networks and systems (including satellite systems) and develop its activities in close contact with the scientific community, in order to take advantage of new observation techniques. For the atmosphere emphasis must be on filling data gaps in Latin America, Africa and the Pacific islands. Supporting the completion of the ARGO floats deployment and the TAO/TRITON buoys deployment is an important goal, as is continuity of satellite data. Data assimilation and modeling to integrate the data and produce useful information should also be part of GEOSS objectives.

Adapting to climate change, and mitigation of climate change, including variability, will benefit from GEOSS through improvements in the provision of services to other socio-economic areas, as many of them are linked to climate variability and change. GEOSS will promote utilization of satellite data and their synthesis with assimilation techniques. GEOSS can also facilitate better telecommunications networks to exchange the data sets in an operational mode. It is important to include metadata to activate data exchange. Data centers should be developed that systematically meet the functions and purposes of user, and take into account the increasing volumes of data.

Because all countries contribute to factors affecting climate variability and change and are affected by them in different ways, an understanding of these phenomena should be tailored to the specific priorities of countries, as well as to broader regional and global considerations. For example, small island countries and coastal communities may be focused on the socio-economic impacts of sea-level rise, whereas inland countries and communities, such as in the African Sahel, may consider the impacts of desertification a higher priority. Once the priorities and impacts are understood, each country should establish the necessary capabilities to assess, predict, mitigate and adapt to these priority issues on both the local and national level. In turn, the contribution of their knowledge to the international community will provide a more comprehensive global understanding of the Earth's climate. A capacity building commitment will require that national institutions or organizations assume operational responsibility for making the observations and for their distribution, analysis, and archiving. To do this, sustained sources of funding are needed. Countries with little or no infrastructure or capacity could focus first on the collection of essential *in situ* observations, which provide valuable data for local applications and also contributes to the cross-calibration of satellite sensors. Higher priority observations, infrastructure, and even sustained operational activities, where national capacity is insufficient, could in some cases be supported by relevant funding mechanisms with appropriate international coordination (such as the GCOS Cooperation Mechanism).

4.4.3 Existing Situation and Gaps

The IPCC Third Assessment Report (IPCC, 2001) highlighted scientific uncertainties that need additional research as well as new observational data. The Essential Climate Variables (ECVs) to fulfill the requirement for climate monitoring are given in the Global Climate Observing System Second Adequacy Report (GCOS, 2003). Research activities aimed at improving our capability to predict climate variability and change are coordinated by the World Climate Research Programme (WCRP) and include modeling and observation programs.

The observational networks, especially the terrestrial networks, are incomplete and are still to be fully implemented. The ocean networks lack global coverage and commitment to sustained operation. There is a need to complete the ARGO float deployment to provide operational full-depth observations of physical and chemical parameters with long-term commitment and global coverage. The atmospheric networks are not operating with the required global coverage and quality, and the global upper air network (GUAN) stations still need to be fully implemented. Satellite observations are an essential part of the global observing systems for climate for all three domains. Their contributions, though already substantial, and in many cases impossible to replicate with in situ approaches, have not realized their full potential because the mission design parameters have not considered the needs of long-term climate monitoring requirements. Many of the Earth observation missions, relevant for the climate variables, are either for research and development purposes, most of which by their very nature have a limited time horizon, or are implemented in support of weather services where the primary requirements are not as demanding on the observational quality. It is important to note the need for ground-truth observations at reference sites or observatories for calibration and verification of satellite products. Adherence by nations and their agencies to the GCOS Climate Monitoring Principles for global climate observations is required.

Global climate products are commonly generated by blending data from different sources, such as *in situ* and satellite observations, through data assimilation and modeling. It is essential that additional analysis centers be identified and existing centers continue to regularly generate these products. Real-time data-assimilation and re-analysis systems need to be extended in order to generate comprehensive and internally consistent descriptions of the state of the climate system.

Many nations, especially those least-developed countries and small-island developing states, as well as some countries with economies in transition, are not in a position to participate fully in global observing systems for climate. Problems include a lack of trained personnel, expensive consumables, inadequate telecommunications, and an absence of equipment. There is also limited capacity for them to draw benefits from the observations currently being taken. In many nations some historical data are still only available in non-digital formats, and thus cannot be used. Action to recover these data in a digital format is required.

There are many observations of the climate system being made that remain unavailable to users beyond the groups making the observations. Better interoperability standards for data and mechanisms to disseminate the data sets need to improve. Nations need to ensure that their observations and associated metadata for climate variables, including historical observations, are available in a timely manner at international data centers[10] for application to climate analyses.

[10] The term “international data center” covers the ICSU World Data Centres as well as other centres identified by GCOS and its sponsors as the organisations responsible for the storage of data for specific networks and for making it available to the users. It is implicit that these centres will adhere to GCOS data policy, apply the GCOS Climate Monitoring Principles in their operations, and implement cataloguing, auditing and reporting procedures on the availability of data.

4.4.4 Targets

2 Year Targets

4.4 Climate

Support GSN and GUAN networks, Global Atmospheric Watch (GAW) observatories (GHG), Initial Global Ocean Observing System (GOOS), river discharge, lake levels, snow cover and glacier observing networks, which are recommended in GCOS-92 (GCOS, 2004). (Rec# 25)

Improve the reporting of observations to international data and analysis centers. (Rec# 26)

Establish an intense collaboration mechanism between observation organizations and research communities with users of climate information to further refine the analyses and products required. (Rec# 27)

Identify the needs and solutions necessary to implement the global observing systems for climate in all regions and countries based on the outcomes of the GCOS Regional Workshops. (Rec# 28)

Simulate the creation, in the terrestrial domain, of an intergovernmental mechanism to prepare and issue regulatory and guidance information. (Rec# 29)

Encourage satellite operators to ensure that all Earth observing satellite systems adhere to the GCOS Climate Monitoring Principles (WMO, 2003) and to commit to the suite of instrumentation called for in GCOS-92. (Rec# 30)

Focus on research programs for the development of new *in situ* and/or satellite observing capabilities and instrumentation for the observation of ECV such as cloud and aerosol properties and their vertical profiles, ocean salinity, ocean carbon and nutrients, soil moisture and ground water, CO2 and other greenhouse gasses. (Rec# 31)

Emphasize detection of climate changes and their impacts linked with other topics such as disaster, health, water, ecosystem and agriculture by combining the natural scientific data and socio-economic information and introducing paleoclimate research approaches. (Rec# 32)

6 Year Targets

4.4 Climate

Enhance the collaboration mechanism between observation organizations and research communities with users of climate information to make maximum use of the analyses and products. (Rec# 91)

Support implementation of actions called for in GCOS-92. (Rec# 92)

Encourage the establishment of data archive centers for all ECVs. (Rec# 93)

Promote institutional commitments to provide integrated global analyses of all ECVs. (Rec# 94)

10 Year Targets

4.4 Climate

Provide support to the development of a long-term strategy, which encompasses progress in observation, data assimilation and modeling. (Rec# 149)

Promote re-analysis programs for the oceanic, terrestrial and atmospheric domains. (Rec# 150)

Contribute to major advances in the predictability of climate at seasonal, interannual and decadal time scales, including the occurrence of extreme events. (Rec# 151)

4.4.5 Table of Observation Requirements

Legend for Table 4.4.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
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3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.4.5 beginning on the following page.

		Social Benefit Application				
		A	B	C	D	E
Climate Table 4.4.5 **Observational Requirement**		Understanding	Assessing	Predicting	Adapting to	Mitigating
Atmosphere domain, Surface measurement						
1	Air temperature	1	1	1	1	1
2	Precipitation	1	1	1	1	1
3	Air pressure	1	1	1	1	
4	Surface radiation budget	2	2	2		
5	Wind speed and direction	1	1	1	1	
6	Water vapor	1	1	1	1	
Atmosphere domain, Upper air measurement						
7	Earth radiation budget (including solar irradiance)					
8	Upper-air temperature (including MSU radiances)	1	1	1	1	
9	Wind speed and direction	1	1	1	1	
10	Water vapor	1	1	1	1	
11	Cloud properties	3	3	3	3	
Atmosphere domain, Composition						
12	Carbon Dioxide	2	2	2	2	2
13	Methane	2	2	2	2	2
14	Ozone	1	1	1	1	1
15	Other long-lived greehouse gases	3	3	3	3	3
16	Aerosol properties	2	2	2	2	2
Oceanic domain, Surface measurement						
17	Sea-surface temperature	1	1	1	1	
18	Sea-surface salinity	2	2	2	2	
19	Sea level	1	1	1	1	
20	Sea state	2	2	2	2	

		Social Benefit Application				
		A	B	C	D	E
Climate Table 4.4.5 **Observational Requirement**		Understanding	Assessing	Predicting	Adapting to	Mitigating
Oceanic domain, Surface measurement *(continued)*						
21	Sea ice	2	2	2	2	
22	Current	2	2	2	2	
23	Ocean color (for biological activity)	2	2	2	2	
24	Carbon dioxide partial pressure	2	2	2	2	2
Ocean domain, Sub-surface measurement						
25	Temperature	2	1	2	2	
26	Salinity	2	3	3	3	
27	Current	3	2	2	3	
28	Nutrients	2	2	2	2	
29	Carbon	2	2	2	2	
30	Ocean tracers	3	2	3	3	
31	Phytoplankton	3	3	3	3	
Terrestrial domain						
32	River discharge	1	1	1	1	1
33	Water use	2		2	2	
34	Ground water	2			2	
35	Lake levels	2	2	2	2	
36	Snow cover	1	1	2	1	
37	Glaciers and ice caps	1	1	1	1	
38	Permafrost and seasonally-frozen ground	2	2	2	2	
39	Albedo	1	1	1		1
40	Land cover (including vegetation type)	3	3	3	3	3
41	Fraction of absorbed photosynthetically active radiation (FAPAR)	1	3	3		1

	Social Benefit Application				
	A	B	C	D	E
Climate Table 4.4.5 **Observational Requirement**	Understanding	Assessing	Predicting	Adapting to	Mitigating
Terrestrial domain *(continued)*					
42 Leaf area index (LAI)	2		2		
43 Biomass	3		3		3
44 Fire disturbance	1		1		1

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4.5 Improving water resource management through better understanding of the water cycle

4.5.1 Statement of Need

Reliable supplies of fresh water are an essential ingredient for human prosperity and health, as well as ecosystem functioning. Water is an important, geo-socio-economic issue at local, national and global scales and its changes are a part of the history of civilization. Socially and economically, the impacts of water deficits and surpluses are large. In 1995, the World Bank reported that 80 countries, with 40% of the world's population, faced water scarcity, with this percentage projected to increase as the world population grows.

In developing nations, water limitations are a major contribution to poverty and human misery [citation]. Food security, well-being, and ultimately economic and political stability depend upon the capability to provide reliable supplies of clean water. Rapid population growth and development pressures impose additional stresses on scarce resources. Drought brings such a vulnerable situation in a crisis. Enhanced and timely information pertaining to water resources has the potential for increasing the development capability of many of these nations. As a result, there are increasing human, institutional, and infrastructural needs for access to and use of water cycle data in water resource management.

In addition to water scarcity concerns, floods are the number one disaster in terms of human life and property. On average, floods affect 140 million people each year according to the latest World Disasters Report (IFRC/RCS, 2003). Furthermore, more than 5 million people die each year from water-borne diseases such as malaria and cholera.

The global water cycle—the transport and distribution of large amounts of water associated with its constant phase changes among solid, liquid and gaseous states—is, therefore, one of the most important features of the Earth system. Local and regional water cycle variations are correlated among different areas and seasons, because of the effects of atmospheric and ocean circulations and the variations in water storage, such as in snow and soil moisture. Even when a more localized water-related event is addressed, we need to consider its connections with other areas or regions under the global water cycle variation.

Today, humans actively manage over 30% of the world's runoff in the inhabited regions of the globe (Postel et al. 1996). Management of the world's rivers has resulted in profound changes in the dynamics of the terrestrial water cycle. Water development has had major impacts on the quality of the world's surface and groundwaters and has degraded extensive areas of aquatic habitat. However, water cycle measurement capability is inadequate for monitoring long-term changes in the global water system and their feedback on the climate system. Furthermore, the quality aspects of surface and groundwater remain largely unknown in many parts of the world.

To enhance prediction of the global water cycle variation based on improved understanding of hydrological processes and its sustained monitoring capability is a key contribution to mitigation of water-related damages and sustainable human development. Improved monitoring and forecast information, whether of national or global origin, if used intelligently, can provide large benefits in terms of reduced human suffering, improved economic productivity, and the protection of life and property. In many cases, the combination of space-based data and high-resolution *in situ* data provides a powerful combination for effectively addressing water management issues. Information on water quantity and quality and their variation is urgently needed to inform national policies and management strategies as well as UN conventions on climate and sustainable development, and the achievement of the Millennium Goals.

WATER CYCLE EXAMPLE

In May 2010, the Central African famine relief agency received word from the African Centre for Seasonal Climate Predictions and climate observations that the monsoon would be very weak and rainfall amounts would be only 20% of the climatological average. International agencies had been monitoring conditions in Chad and other central African countries and recognized the poor states of crops from vegetation observations and the record-low river and reservoir levels throughout central Africa. They were quite prepared for the aid request that came from the Central Africa Relief Agency asking for phased drought relief over the next three weeks. Fortunately with their long-range predictions they had known that drought conditions were a possibility and had begun to stockpile food and other necessary staples. Relief workers had already volunteered and were ready to work out of a temporary base that had been set up in Chad. Information was distributed to the people about the building drought conditions. Through the local drought relief centers local conditions were monitored to ensure that no members of society were missed and that crisis hotspots were identified. The national health agencies were also alerted and they imposed regulations on industries that were polluting local waters and sought to bring in supplies of fresh water from Zambia and the Congo in anticipation of the demand. Although there was some hardship the drought did not result in the direct loss of any lives. Furthermore, people followed law and order as they obtained their supplies and ensured that their families and neighbors had sufficient food. This was in contrast to the drought of 2004 when a large number of people died as a result of a less intense drought that had caught the central African and the world by surprise and was acted upon only after the media began to report deaths from starvation and widespread anarchy and looting in society.

4.5.2 Vision And How GEOSS Will Help

GEOSS water cycle activities will bring together observational systems, data assimilation, prediction systems and decision support capabilities into a system of systems that supports integrated water management. It will also enable closure of the water budget on regional and global scales to the point where effective management is possible across the globe.

GEOSS will provide a process for the continuous evolution of the water cycle observing system. It will do this by inventorying and evaluating existing plans and new water cycle data needs, and the ability of observing systems to meet those needs. It will develop action plans to address the needs and ensuring that nations and programs take steps to meet those needs. There will be support for research and development activities related to the generation and evaluation of new data products. Finally GEOSS will act as a conduit between the capabilities of national observing programs, international science programs and global conventions and policies, and will develop action plans to build capacities in developing countries.

GEOSS will contribute by working with the user communities to define the needs to be met by agencies planning water cycle observations. It will offer a framework for joint planning of expert systems for decision support where water information is an input (e.g., hydrologic prediction services) or is dependent on inputs from other sectors (e.g. Energy sector demands for water). It will also coordinate the development of a capacity building plan for the use of satellite data in water management in developing countries.

On the operational side GEOSS will facilitate the development of new applications of remote sensing data in water quality and groundwater monitoring, oversee the development of plans to increase the accuracy and space and time resolution of satellite data relevant to water budgets, and support/ promote the maintenance and enhancement of *in situ* hydrometeorological observations and international coordination of planning and operating national *in situ* monitoring networks.

GEOSS will also be active in promoting the integration and use of *in situ* data with remotely sensed data to produce new products, in order to provide the data needed to develop indicators that will be useful in advising the international conventions, and managers concerned with integrated water management at a local level. This will involve facilitating access to water resources data bases needed to develop expert systems in support of integrated water management decisions. It will also provide strong leadership and advocacy to ensure that an open data policy is approved and enforced, and systems for open data exchange are developed and deployed.

4.5.3 Existing Situation And Gaps

Critical observations for closing water and energy budgets are missing, including soil moisture, evaporation, surface wind speed, and precipitable water over land, although missions that will be launched over the next decade will start to address these needs. However, the sensor capability for these missions is not adequate to fully meet the requirements of many user communities.

Space agencies should fully implement planned space missions and are encouraged to continue new sensor development based on user needs. To the degree possible, space agencies should give priority to the development of effective sensors and missions for surface and subsurface water stores - including snow water equivalence, water stored in natural and man-made reservoirs, and groundwater. For example, in the next decade considerable effort will be needed to develop space-based missions to measure the stage heights of medium to large rivers (i.e. 100 m wide) and the topographic heights of fresh water in the form of lakes and wetlands. Moreover, the systematic global monitoring of base-flow, deep soil moisture, and the density of snow and ice cover and their rates of change may remain unfulfilled, preventing closure of water budgets at any scale.

For *in situ* data, hydrologic networks have been allowed to decline in many countries. For example, only a few dedicated organizations have high-quality data extending back 50 years. Furthermore, many countries have long-term paper and tape data archives that are at risk of being destroyed and need to be rescued and stored on modern media. Therefore, GEOSS must maintain flexibility for its data and information system network and ensure that the various existing high quality global and regional datasets needed to augment the global datasets are effectively merged into the network. The requirements for socio-economic data to support the demand side of water management have not been fully defined nor have the options for acquiring these data been explored.

Long-term global data sets and products for water vapor, clouds and precipitation are essential for assessing trends. Given the tendency of networks to change over time and for satellites to drift or be moved, there is a need for routine reanalysis of such data products for use in determining trends in water cycle variables. Products to support many water quality applications are not available. This is particularly problematic for health where threats must be monitored on a global basis, and for water quality programs that need to target vulnerable areas where *in situ* monitoring would be most beneficial. Unfortunately, many of these vulnerable areas are located in poorer economies, where water monitoring systems are often fragmented or non-existent.

A comprehensive, coupled, land-atmosphere-ocean data assimilation capability is needed to optimize the use of advanced data systems. The process and budgeting for the transfer of systems from a research environment to operations needs to be strengthened. Currently, although data archives exist for special collections, there is insufficient integration capacity for global observing systems. This situation is aggravated by incompatible data management plans among the individual components. A special challenge is the development of assimilation methodologies to integrate satellite and *in situ* observations, and the development of high-performance distributed data management and archiving systems with harmonized access nodes to use data from largely different sources for studies of the global water cycle. An overall plan for *in situ* and satellite water cycle observational systems is needed so that data can be readily exchanged, and so that standards can be set and data quality can be monitored. Elements of such planning do occur at present within CEOS, but GEOSS should take on this role for the wider issues. Data services should be enhanced by a global Earth system observation centre that maintains a globally standardized archival scheme (metadata), globally standardized interfaces to the archives, and a globally agreed upon, harmonized, affordable data and information infrastructure.

National policies regarding copyright laws and the sale of data have led to problems in the free and open distribution of hydrologic data. Although WMO has a standing policy to correct this problem, many nations are not following the policy. GEOSS should work with nations and other international bodies to eliminate barriers to the free and open exchange of data and software so that water managers in developing countries have access to all necessary *in situ* and satellite data and software for analysis, display, and decision making.

Many developing countries lack the basic capabilities needed to access, interpret, and apply water cycle information available from satellite systems. While hardware and software capabilities are quickly improving for much of the developed world, countries with economies in transition are increasingly burdened with outdated hardware and expensive software that requires high levels of expertise to use effectively. Social and economic differences preclude the application of a single "on size fits all" solution to every situation. Trained technicians, programmers, and analysts are needed in the disadvantaged countries to tailor new techniques to specific regional water management applications, and for the longer term, to train a new cadre of software engineers who can generate and customize the needed software systems from the ground up. Supporting Integrated Water Resources Management (IWRM) in developing countries demands flexibility and the capacity to respond to their special situations, actions, policies and infrastructure needs. Moreover, there is an urgent need for continuing dialogue between the providers of advanced data systems and the associated data system specialists in the developing countries to have strategies tailored to each country's water needs.

A plan for building the technological capacity of developing nations based on both operational and experimental satellites, and advanced data assimilation capabilities should be a GEOSS priority to assist in the improvement of water management practices. These plans should include hardware and software for receiving and processing satellite and appropriate *in situ* data. Training modules should be provided and a commitment made to enable personnel from the developing countries to use and maintain this infrastructure.

The inability of many developing countries to maintain adequate hydrometeorological networks needed to generate the required data is also a problem. Consequently there are gaps in the global data base. In addition, where the needed capabilities exist, there are often no quality assurance and control standards applied to the instruments, and data reduction methods and procedures. Without an effective *in situ* ground system, meaningful data validation is jeopardized or in some cases, out of reach. Building the capacities of those countries for effective *in situ* measurements will greatly contribute to the success of the GEO process.

4.5.4 Targets

2 Year Targets

4.5 Water Cycle

Improve existing *in situ* observation systems, or at a minimum, maintain at current levels. (Rec# 33)

Develop a plan for a network of sophistically integrated *in situ* observation sites, to support process studies and algorithm and model development. (Rec# 34)

Promote an open data policy, as approved by WMO, and monitor compliance with the policy. (Rec# 35)

Develop a plan for a broad global water cycle data integration system that combines in situ and satellite and numerical model outputs and disseminates usable information for decision-making. (Rec# 36)

(Rec#37 deleted.)

Promote studies on evaluation of contribution of space observations to determination of surface water quality. (Rec# 38)

Evaluate the resolution and accuracy requirements for applying satellite altimetry to measurement of streamflow and surface water storage. (Rec# 39)

Initiate an international coordination function of *in situ* water cycle observation and data integration and dissemination. (Rec# 40)

Initiate a framework for developing ensemble hydrologic predictions and the capability of users to utilize the information. (Rec# 41)

Plan workshops and special studies for documenting the cultural barriers to technology transfer and procedures to identify and avoid these obstacles. (Rec# 42)

6 Year Targets

4.5 Water Cycle

Provide a number of new products of precipitation, soil moisture, evaporation, evapotranspiration and other water cycle variables, by the planned space missions. (Rec# 95)

Validate new water cycle data products. (Rec# 96)

Continue sensor development with improvement of accuracy and higher spatial-temporal resolutions and with special attention on snow water equivalence and streamflow. (Rec# 97)

Provide international and fully-networked operational data exchange capabilities. (Rec# 98)

Test a fully integrated prototype data system, with data assimilation, analysis and visualization capabilities for the water cycle. (Rec# 99)

Promote a study on the water resource variables required to support an expert system in water management. (Rec# 100)

Develop a system for the routine collection of water level data for use in validating satellite data and for monitoring surface water storage. (Rec# 101)

Develop a plan for institutionalizing surface flux measurements. (Rec# 102)

Implement coordinated surface observation networks with high (and low) elevation sites along mountain transects. (Rec# 103)

Implement an experiment of the global network of sophistically and temporally integrated *in situ* observation sites. (Rec# 104)

Develop integrated water cycle data sets, on a continental scale such as the Asian monsoon region. (Rec# 105)

Review the requirements of data and products for use in applications to water-related health issue with a view to developing a specialized observing system in support of health. (Rec# 106)

Promote a study on the basis of a global system for monitoring drinking water quality, along with efforts to extend water and sanitation services, especially in developing countries. (Rec# 107)

10 Year Targets

4.5 Water Cycle

Develop the ability to characterize the long-term water cycle budget on a hierarchy of spatial and temporal scales. (Rec# 152)

Promote the global network of sophistically and temporally integrated *in situ* observation sites operational. (Rec# 153)

Make the integrated data system fully operational. (Rec# 154)

Provide data and information, including quantity and quality for both surface and groundwater, to a prototype water cycle expert decision support system. (Rec# 155)

Establish realistic weather and climate simulations involving precipitation, water cycling and water cycle acceleration. (Rec# 156)

Enable changes in the water cycle, including clouds and precipitation by the integrated data system. (Rec# 157)

Document and understand the relationship between known climate indices, particularly ENSO, PDO and MJO and flood and drought frequency and precipitation type and intensity. (Rec# 158)

Produce appropriate indicators of “watershed health” routinely from satellite data, surface and subsurface data, and data assimilation capabilities. (Rec# 159)

Advocate that IGOS-P and its partner research programs should take the lead in development of an integrated precipitation and soil moisture products and new products including indicators. (Rec# 160)

Deleted for 200-5.

Endorse space agencies to give priority to the development of effective sensors and missions for surface and subsurface water stores -- including snow water equivalence, water stored in natural and man-made reservoirs, and groundwater. (Rec# 162)

Endorse numerical weather prediction agencies, space agencies, and international programs to place priority on carrying out reanalysis of products for use in determining trends in water cycle variables. (Rec# 163)

Endorse nations to develop plans for more effective transfer into operations of technologies that have been proven in the research environment. (Rec# 164)

Coordinate the development of a plan for building the technological capacity of developing nations based on both operational and experimental satellites, and advanced data assimilation capabilities. (Rec# 165)

Develop a plan for capacity building to support water management, including hardware and software for receiving and processing satellite and appropriate *in situ* data, and training modules in the developing countries. (Rec# 166)

Advocate eliminating barriers to the free and open exchange of data and software for the full access by water managers in developing countries. (Rec# 167)

4.5.5 Table of Observation Requirements

Legend for Table 4.5.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.5.5 beginning on the following page.

Water Cycle

Table 4.5.5

		Societal Benefit Subtopic														
		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
	Observational Requirement	Water Cycle Research	Resource Management: Short-term Water	Resource Management: Long-term Water	Impacts of Humans on Water Cycle	Global Biogeochemistry	Ecosystem and Water Quality Assessment	Land Use Planning	Production of Food	Weather Prediction	Heavy Rainfall and flood prediction	Drought Prediction	Climate Prediction	Human Health	Fisheries and Habitat Management	Telecommunication / Navigation
1	Surface Liquid Precipitation*	3	3		3	3			3	3	3	3	3	3		3
2	Surface Solid Precipitation*	3	4							3	3		3			
3	Atmospheric Precipitation*	3								3	3	3	3			1
4	Soil Moisture (surface)*	3	3	3	3	3			3	2		3	3			
5	Soil moisture (vadose zone)*	4		3					4			4	4			
6	Streamflow*	4	4	4	4	4			4		4	4			4	4
7	Lake Levels*	3	3	4	3				3		3	3				
8	Reservoirs*	3	3	4	3				3			3				
9	Snow Cover*	2	2	2						2	2	2	2			2
10	Snow Water Equivalent*	3	3	3			3				3	3	3			3
11	Ground Ice*	3		3						3						
12	Permafrost/Frozen Soil*	4		4						4			4			4
13	Glaciers*	2		2												
14	Clouds*	2								2	2		2			
15	Water Vapor (specific humidity)*	2							2	2	2		3			
16	Evapotranspiration*	3	3	4		4			3	3			3			

Water Cycle

Table 4.5.5

	Observational Requirement	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
		Water Cycle Research	Resource Management: Short-term Water	Resource Management: Long-term Water	Impacts of Humans on Water Cycle	Global Biogeochemistry	Ecosystem and Water Quality Assessment	Land Use Planning	Production of Food	Weather Prediction	Heavy Rainfall and flood prediction	Drought Prediction	Climate Prediction	Human Health	Fisheries and Habitat Management	Telecommunication / Navigation
17	Groundwater*	4	4	4	4			1				4	4			
18	Nutrient Cycling*					3	3								3	
19	Vegetation*	2		2	2	2	2	2	2			2				
20	Radiation and Energy Budget (short wave, long wave, heat flux)*	2		2					2	2		2	2			
21	Topography/Geography*	1	1	1	1	1		1			1				2	
22	Land Cover and its Change	1		1	1			1	1			2				
23	Sea Surface Salinity	3		3		3				3		3	3		3	
24	Sea Level			2									2			
25	Water Chemistry (quality, isotopic ratio, etc.)	3			3	4	4								4	
	Socioeconomic information															
26	Water Use Information by Infrastructure (includes artifact, tradition, culture, history, etc.)		4	4	4									4		
27	Population		1	1	1											
28	Water Pollutant Area					3	3							3		

Societal Benefit Subtopic: columns A–O.

*Asterisk denotes parameters documented in IGOS-P Global Water Cycle Observation Theme Report.

4.6 Improving Weather Information, Forecasting and Warning

4.6.1 Statement of Need

Severe weather events—hurricanes, tornadoes, flash floods, blizzards, droughts, and poor air quality episodes—impact every person and nation on the face of the Earth. This is why national weather services were established in the 1850's, leading to the current set of meteorological systems. Each year, tens of thousands of lives are needlessly lost and many billions of dollars in avoidable economic impact result because of society's inability to reliably forecast and warn appropriate decision makers and people about impending weather hazards.

Worldwide social and economic sectors, including agriculture, energy distribution, construction, financial, tourism and recreation, public health, ecosystems and biodiversity are directly affected by temperature, precipitation, and other general weather conditions. These industries need improved and extended lead-time weather forecasts to improve productivity and cut costs. Successful scientific research is rapidly providing the foundations to produce more accurate weather forecasts and warnings.

Achievable improvements in Earth observations (the crucial front-end of weather forecasting and warning) are needed to improve timeliness, data quality, and long-term continuity of observations in order to reduce analysis and model initialization error, increase forecast accuracy, extend warning lead times, and maintain the climate record. The depiction of critical phenomena and processes to enable more accurate and extended lead-time warnings and forecasts will be enhanced by increased coverage and resolution of observations. New observations will not just improve existing capabilities but will also enable new forecast products such as air quality. Finally, rapid dissemination of weather information will provide more timely data access to people and decision makers.

Improvements in the above will lead to better forecasts in 30-minute, high-impact events e.g. tornadoes, 1- to 12-hour short-term severe weather forecasts, 5-day hurricane forecasts, and medium range to seasonal forecasts relevant to monsoons and El Nino.

In summary, weather impacts every societal benefit area in this plan. In particular, forecasting weather not only improves weather information, but, in doing so, also produces derivative contributions to the other areas, creating an interdisciplinary approach to addressing societal needs—improving information quality for all and reducing development costs.

> Example:
>
> Ten years from now, a weak tropical storm forms in the Caribbean Sea. In situ AMDAR measurements from commercial aircraft and space-based hyper-spectral sounders and NPOESS instruments provide atmospheric and oceanic environmental data to advanced numerical prediction models. These models predict a high probability of a minimum-intensity hurricane with great rainfall potential making landfall along the coasts of Honduras and Guatemala days hence. Other space-based sensors detect abnormally high soil moisture along northern slopes of

the Honduran and Guatemalan highlands. Using these soil moisture data and numerical rainfall predictions, hydrologic models predict massive run-off, flooding and high probability of mudslides for a 300-km band of the highlands 18-24 hours following landfall. Global weather and hydrological predictions are transmitted from the U.S. National Weather Service to a new regional environmental prediction and warning centre, established to serve Central American nations. With expertise on local conditions, the regional centre issues warnings 4 days in advance, allowing decision makers, relief agencies and inhabitants to take action. As predicted the storm barely reaches hurricane strength, but following landfall rain totals exceed 25 cm in 6 hours over the higher elevations. Rampaging rivers subsequently uproot trees and destroy many hundreds of homes, but thousands of lives and much property are saved by the ample warnings.

4.6.2 10-Year Vision and How GEOSS Will Help

The vision is that every country will have the weather information needed to virtually eliminate loss of life and to reduce property damage from severe weather events. The aim is to have a society where weather forecasts are fully used in decision support systems to improve economic efficiency and productivity, as well as environmental protection, through improved longer-range predictions available in probabilistic terms.

In developing countries for which there are limited or no operational weather capabilities, the vision is to enable them to efficiently and effectively exploit existing weather observations and develop information services. This will include partnering with developed nations for access to high-cost weather data and prediction services, partnering with neighboring nations to develop and deliver regional warnings, and local education and training for use of warnings by decision makers and the public.

There should be an end-to-end weather information system that provides, to decision makers around the world, timely, reliable and actionable information prior, during and after the event for relief support. This system will have improved *in situ* and space-based observations of critical parameters, coordinated and exchanged globally. These will provide input to improved numerical prediction models, with advanced physics capabilities, providing accurate (in location and time) forecasts of severe weather events to new or strengthened regional and local warning centers, allowing rapid and tailored notification to local authorities responsible for protecting people and property.

GEOSS will contribute to improving weather information in three ways. First, GEOSS will contribute to providing a timely, comprehensive initial "Earth" picture, which is crucial to more specific short-range forecasts-more timely, and accurate weather information available to decision-makers for appropriate action. Second, GEOSS will provide comprehensive observations necessary to extend the range of useful products-reducing the impact of weather on a larger number of global inhabitants and regions. Third, GEOSS will provide an organization and infrastructure allowing GEO members to more efficiently address the end-to-end weather information services needs, resulting in greater service for less cost.

More specifically, models will exploit improved observations from GEOSS to produce weather forecasts of sufficient quality that many disciplines, which are currently structured to cope with weather as it occurs, will transition to operations that anticipate threats and take action days in advance. For example, energy generation decisions made 4-6 days in advance of heat waves and cold snaps based on accurate weather forecasts can save millions of dollars. Accurate forecasts of excessive temperature and humidity will allow health officials to anticipate and adequately staff for heat-stress-related emergencies. Similarly, accurate weather forecasts will allow: proactive measures for agriculture to protect crops; ecological monitoring teams to evolve beyond tracking to predicting biological invasions; and disaster teams to proactively respond, minimizing impact of potentially catastrophic environmental events threatening life and property.

4.6.3 Existing Situation and Gaps

The WMO Space Programme coordinates the provision of observations through national agencies. The Programme sets out the requirements for the weather observations. This covers the observing component (space and in situ), and data dissemination. It also harmonizes certain global products and model centers. The maintenance of the requirements is a key task for the WMO and is achieved through a rolling review process. Coordination with the space agencies for satellite data is through the Co-ordination Group for Meteorological Satellites (CGMS).

In situ observations are primarily undertaken at a national level, but there have been some significant developments in Europe on improved coordination through the European Meteorological Network (EUMETNET). EUCOS (the EUMETNET Composite Observing System) is an initiative of 19 European national meteorological services providing for integrated *in situ* observational elements. Through this cost sharing mechanism rapid expansion of the European data from aircraft (AMDAR) and upper air data from commercial shipping (ASAP) are envisaged to meet evolving user requirements. These integrated elements are managed at a European level so providing efficiency opportunities for the individual national meteorological services. GEOSS could provide a mechanism to expand this coordinated effort.

WMO, through its Expert Team on Observational Data Requirements and Redesign of the Global Observing System (GOS), has developed a vision for the GOS of 2015, which includes an observation component (with both space and *in situ* systems), and a data management component. This vision document provides a prioritized list of critical atmospheric parameters that are not adequately measured by current or planned observing systems.

The major categories of gaps affecting weather information, forecasting and warning are those concerning the exploitation of weather information that currently exists; and those relating to improving the existing information.

Exploiting existing weather information is a particular problem for developing countries, which often lack communication mechanisms to properly receive and act on that information. Additionally, there is a short fall in education and training processes, and the resources needed to sustain the development and use of existing weather information capabilities in those developing countries.

There are five sub-categories of gaps in weather information that can be addressed by GEOSS:

4.6.3.1 Observational Gaps

As previously stated, lack of complete global observational coverage of the atmosphere, land and oceans (e.g., inadequate resolution and quality) inhibits development and exploitation of extended range products. Table 4.6.1 illustrates the critical atmospheric parameters that are not adequately measured by current or planned observing systems.

Expansion of observing capacity is needed to detect precursor environmental conditions as the foundation for improving all weather and climate services, as called for in the WMO World Weather Watch Plan. Highest priority should be given to filling gaps in the *in situ* and space-based observation capacity that limits data assimilation and predictive capabilities. Additionally, emphasis is needed on open global sharing of data. Next, these data must be exploited through better research, advanced data assimilation and predictive models, building telecommunications infrastructure capacity, and transforming weather predictions into formats understandable to decision makers and the people.

The WMO GOS 2015 vision document sets out a set of prioritized recommendations for specific issues on parameters to be addressed and the satellite and *in situ* systems. The parameters to be addressed in order of priority are:

- Wind profiles at all vertical levels
- Temperature profiles of adequate vertical resolution in cloudy areas
- Precipitation
- Soil moisture
- Surface pressure
- Snow equivalent water content.

For satellites the priority covers the need for improved calibration of all data. In the geostationary orbit there is a need for improved Imagers and Sounders. There is a need to improve the timeliness and temporal coverage of data delivery from low Earth orbit. Improving the observations of Sea Surface winds, altimetry and the Earth radiation observations are the key observational needs from Low Earth orbit. More research is also needed in Doppler technology, precipitation observation capability and radio occultation techniques.

With respect to *in situ* observations, there is a need for improved Data Distribution and Coding, the development of AMDAR and ground-based GPS. Improving the network of observations in the oceans and Tropical Land Areas, as well as developing new observing technologies, are also seen as priorities. Improved effectiveness of in–situ data observations (including aircraft) could also be developed by GEOSS.

4.6.3.2 Gaps in Modeling

Despite the progress made, scientific modeling techniques (data assimilation, NWP, and statistical post processing) still limit the accuracy and reliability of weather forecasts and warnings. NWP models still have gaps in the following categories of data that increase uncertainty and reduce model accuracy: vertical profiles of moisture flux; coverage of tropical land areas and ocean areas; measurements of clouds, precipitation, and ozone; rigorous calibration of remotely sensed radiances. Enhanced data initialization and assimilation capabilities to facilitate full use of the expanded remotely sensed and *in situ* observations captured through GEOSS are needed.

4.6.3.3 Gaps in Decision Support Tools.

Decision analysis in disparate areas needs more than an accurate weather forecast. To achieve full value, they need techniques to tailor those forecasts to specific applications. Whilst this is outside its, GEOSS can offer an interface to these groups.

4.6.3.4 Gaps in Information Technologies

Telecommunication and computer processing gaps limit observations exchange, scientific collaboration, and dissemination of critical information to decision-makers and people. Also, full implementation of new observing systems technologies is challenging due in part to a lack of structure to facilitate transition of research technologies to operational use in all components of the end-to-end weather information services system.

4.6.3.5 Gaps in Research, Education and Training

With improvements in all facets of producing and delivering weather information, parallel improvements in education and training processes are necessary to ensure full user exploitation of that information worldwide. Research and Development activities are necessary, related to new archive, access and data processing (including numerical modeling) capabilities, to ensure sustained weather information for the long-term.

4.6.4 Targets

2 Year Targets 4.6 Weather

Invest in the critical data gaps (atmospheric wind and humidity profiles, soil moisture…) and improve predictive models to augment the quality of forecasts of severe events and general weather conditions. (Rec# 43)

Assist developing countries to utilize the forecasts in order to reduce impacts on life and property. (Rec# 44)

i. to work through WMO to educate and train developing country personnel on the effective use of currently available weather information. ii. Analysis the status and regional distribution of existing weather capacity building programs and initiatives. iii. Establish feasibility of expanding EUCOS to other regions. (Rec# 45)

6 Year Targets

4.6 Weather

i. Improve data observations and models to produce reliable forecasts of severe weather, i.e. forecasts that include reliability/probability estimates as well as range of possible outcomes, and interact with local authorities to improve usage and provide tailored services through newly established regional and local warning centers. (Rec# 108)

Working with weather services in developing countries to support the establishment of new regional centers, to allow reliable warnings of impending severe events. (Rec# 109)

Establish better coordinated regional *in situ* observation networks on the basis of EUCOS model. (Rec# 110)

10 Year Targets

4.6 Weather

Provide national weather services all the weather information and data they need to support services to local authorities to eliminate loss of life and greatly reduce property damage. (Rec# 168)

i. Continuous education, evaluation and improvements in developing countries will be maintained especially to allow sustained operations of the newly established regional centers.
ii. Establishment of new observing systems to cover specific observations set out in document. (Rec# 169)

4.6.5 Table of Observation Requirements

Legend for Table 4.6.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.6.5 beginning on the following page.

		Social Benefit Application			
		A	B	C	D
Weather Table 4.6.5 **Observational Requirement**		Warnings and Nowcasts **0-1 day**	Short-range Forecasts **1-3 days**	Medium-range Forecasts **3-5 days**	Long-range Forecasts **5-15 days**
1	Aerosol profile	4	4	4	4
2	Air pressure over land and sea surface	1	1	1	2
3	Air specific humidity (at surface)	1	2	3	3
4	Air temperature (at surface)	1	1	1	2
5	Atmospheric stability index	1	1	2	4
6	Atmospheric temperature profile	1	1	2	4
7	Cloud base height	2	3	3	4
8	Cloud cover	1	1	1	1
9	Cloud drop size (at cloud top)	4	4	4	4
10	Cloud ice profile	2	3	4	4
11	Cloud imagery	1			
12	Cloud top height	1	2	3	4
13	Cloud top temperature	1	2	3	4
14	Cloud type	1	3	4	4
15	Cloud water profile	2	3	4	4
16	Dominant wave period and direction	2	2	3	3
17	Fire area and temperature	2	3	4	4
18	Height of the top of the Planetary Boundary Layer	2	3	4	4
19	Height of tropopause	2	3	4	4
20	Land surface temperature	1	1	2	3
21	Leaf Area Index (LAI)	4	4	4	4
22	Long-wave Earth surface emissivity	1	2	3	4
23	Normalized Differential Vegetation Index (NDVI)	2	3	4	4
24	Ocean currents (vector)	3	3	4	4
25	Outgoing long-wave radiation at TOA	2	2	3	4
26	Outgoing short-wave radiation at TOA	2	2	3	4
27	Ozone profile	3	3	4	4

Weather Table 4.6.5 **Observational Requirement**		**Social Benefit Application** A Warnings and Nowcasts **0-1 day**	B Short-range Forecasts **1-3 days**	C Medium-range Forecasts **3-5 days**	D Long-range Forecasts **5-15 days**
28	Precipitation index (daily cumulative)	2	3	4	4
29	Precipitation rate (liquid and solid) at the surface	2	3	4	4
30	Sea surface bulk temperature	1	1	2	3
31	Sea-ice cover	1	1	2	3
32	Sea-ice surface temperature	4	4	4	4
33	Sea-ice thickness	3	4	4	4
34	Significant wave height	1	2	3	4
35	Snow cover	1	3	4	4
36	Snow water equivalent	3	3	4	4
37	Soil moisture	2	3	3	4
38	Specific humidity profile	2	3	4	4
39	Temperature of tropopause	2	3	4	4
40	Wind profile (horizontal and vertical components)	3	4	4	4
41	Wind speed over land and sea surface (horizontal)	2	2	3	4

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4.7 Improving the management and protection of terrestrial, coastal and marine ecosystems

4.7.1 Statement of Need

Ecosystems are the basis and necessary condition for all life on Earth. *Ecosystem services* are the benefits that people derive from ecosystems, such as food, water, fiber and timber, energy, climate, flood and pest regulation, nutrient cycling and soil fertility, detoxification of waste, coastal and marine protection. *Ecosystem condition,* also referred to as *health*, is the capacity of the ecosystems to sustainably supply services, even in the presence of mild disturbance and stress. *Ecosystem extent* is the actual (as opposed to potential) area and location of a particular ecosystem type.

The purpose of the Ecosystems Component of GEOSS is to describe accurately and to assess the present conditions and trends of ecosystem services, as well as the pressures and impacts upon them, for policy making to promote regional sustainability, as illustrated in Fig.1.

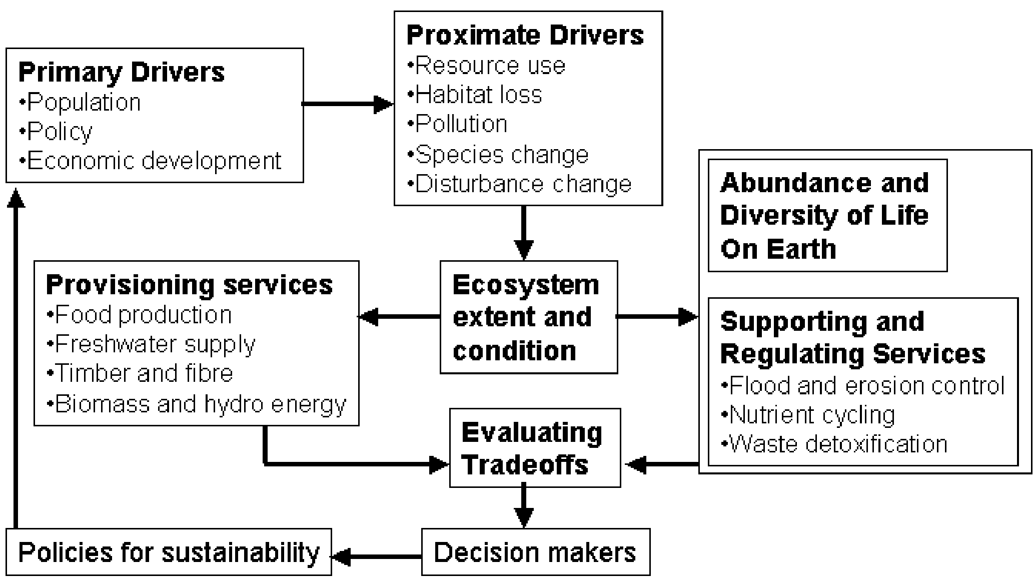

Figure 1. In order to support decisions relating to sustainability, decision makers need information on ecosystem services, as impacted by ecosystem extent and condition, which are in turn affected by direct and indirect drivers.

Many international agreements and conventions, as well as national laws, call for actions in ecosystem management and sustainable utilization of resources, including specifications for terrestrial, coastal and marine ecosystems monitoring, to detect rapidly and provide timely predictions of their changes (e.g., Johannesburg Declaration on Sustainable Development; the Convention on Combat Desertification; the Convention on Biological Diversity; the UN

Framework Convention on Climate Change; the UN Forum on Forests; and the Marine Conventions).

The capacity of ecosystems to support diverse and abundant life and to supply ecosystem services is under pressure world-wide. Levels of resource extraction are commonly unsustainable, i.e. they exceed the rate at which the resources are replenished. Examples include over-fishing, over-grazing and over-logging. Habitat degradation and loss, including deforestation, desertification, and destruction of wetland, riparian, coastal and marine habitats is widespread.

The byproducts of human activities have a negative impact on ecosystem condition, through the processes of eutrophication, nitrogen and sulphur deposition, aquatic and air pollution, and green-house gas induced climate change. Changes in the natural disturbance regime, through fires , pest outbreaks, major storms, earthquakes and climate variability alter ecosystem composition and function. Simplification of the ecosystem composition and connectivity through these processes leads to the over-abundance of particular species, including the invasion by alien species.

Given that ecosystem services are essential for human existence, their total economic value is incalculably large. Nevertheless, various partial analyses of the marginal net costs and benefits resulting from loss of particular ecosystem services at various scales indicate that the economic impacts run into millions, and in some cases billions, of dollars, and significantly affect the well-being of hundreds of millions of people.

The key users of improved observations of ecosystems will be decision makers in the field of natural resource management at the global, regional and national levels. At the global scale, particular beneficiaries will be those charged with implementing International Conventions (the UN FCCC, CCD, CBD). Environmental NGOs at the international and national scales, such as WWF and IUCN are also important users.

Example

In recent years, the economic losses caused by harmful algal blooms along Chinese coast are above 10 billion RMB (1.2 billion US $). To mitigate the damage to coastal and marine ecosystems and to reduce the economic losses, approaches to monitor and to predict the occurrence of the blooms are being developed. The observational products from GEOSS such as sea surface temperature (SST), sea surface chlorophyll, suspended sediment and ocean color could be used in monitoring the state of the coastal ocean and input into an ocean ecosystem model to predict the time of occurrence and spatial coverage and intensity of algal blooms. Complementary *in situ* data would provide additional detail on the nature of the blooms, and on their level of toxicity. A warning system would inform the fishing industry, transportation industry and recreation agencies of the risks.

4.7.2 Vision and how GEOSS will help

The vision is to develop, on a global basis, methodologies, observations and products that allow the detection mapping, quantification of ecosystems; the prediction of changes in ecosystem condition and extent; and the identification of ecosystem uses that are not sustainable.

Ecosystem properties are currently widely observed, but not consistently, systematically or in an integrated way, and the data are not widely shared. Many ecosystem processes are trans-national and require an integrated, global approach to avoid, contain and mitigate problems related to ecosystem management. GEOSS can be the mechanism to help the integration, harmonization, and coordination of the efforts and outcomes of current research and monitoring programs related to marine, coastal and terrestrial ecosystems at the international level.

GEOSS can also serve as an instrument that serves to scale up local and regional observations to the global scale, to address issues with global implications, or those that are ubiquitous in nature. To this purpose, regional networks or national institutions working on ecosystems monitoring must be actively integrated in the GEOSS process from the beginning.

Increasing world-wide concerns regarding ecosystems argue for improved monitoring. As yet, no system for sustained, long-term monitoring of ecosystem processes is in place at the global scale. The products derived from integration of remotely-sensed and *in situ* observations through GEOSS will contribute to addressing this issue. It will promote the capacity to monitor the status and variability of ecosystems and thus contribute to sustainable management of living resources. It will also contribute to monitoring the pressure on terrestrial, coastal, marine and freshwater ecosystems and the assessment of their ability to support sustainable development. Thirdly, it will be of value in acquiring and integrating information on the biological causes and feedback mechanisms implicated in climate change and climate variability.

4.7.3 Existing situation and gaps

There are elements of existing global observing systems that can contribute to the needs identified above. Specifically, the IGOS –P oceans, carbon, land and coastal themes describe most of the observational requirements relating to ecosystems. The IGOS-P specifications are themselves based on observations made by space agencies represented in the Committee on Earth Observation Satellites (CEOS) and *in situ* observations made by governmental agencies in individual nations (including environmental agencies, forestry, fisheries, and ocean departments; and research organizations), coordinated by the Global Ocean Observing System (GOOS), the Global Terrestrial Observing System (GTOS). Key organizations include: LOICZ, GLOBEC; SOLAS, IMBER, GEOHAB, IOCCP, UNEP Biodiversity Program and the FAO Forest Resource Assessment.

Global maps of land cover (from which ecosystem extent can be inferred) have been prepared by a number of organizations. The conceptual equivalent for oceans (large marine ecosystems, or alternately the biogeochemical provinces) has been mapped. High-resolution global products of leaf area, ocean color, and net primary production exist in the research domain. Observation-based maps of nitrogen deposition exist for limited regions. At the global scale, they are model-based and largely unvalidated.

Detailed observation plans exist in the following subtopics

- Coastal ecosystems (IGOS Coastal Theme, GTOS/GOOS coastal observation panel)
- Land cover, including global fire mapping products, cultivated area, and forest area (IGOS Land Cover)
- Carbon cycle observations (IGOS-P global carbon theme, GTOS Terrestrial Carbon Observations)

Nonetheless there are significant gaps. There is no universally-agreed upon classification scheme for ecosystems, and neither are there reliable maps of the soil and sediment properties that control many ecosystem processes, such as soil depth, carbon content, particle size distribution, at a resolution appropriate to ecosystem processes.

The observation and estimation of the lateral flow of material (carbon, nitrogen and other elements) in traded products, river discharge and water and air masses is poor. In addition there is no assured continuity of moderate to high-resolution satellite data for ecosystem mapping and key variable observations, specifically of land cover, ocean color and temperature.

There is not a sufficient and representative *in situ* observational network for validating and complementing satellite data. Nor do adequate observation systems exist for soil moisture; land-ocean-atmosphere exchanges of water, energy and carbon and nitrogen; biomass and standing stocks of carbon, nitrogen and other elements; canopy properties and their temporal dynamics; and *in situ* chlorophyll and primary production in lakes and oceans, and other routine chemical and biological measurements of the aquatic environment. There is a need to develop and improve data assimilation, models and algorithms in the ecosystems field, and to generate operational products relating to ecosystem disturbance regimes, such as fire, storms, drought, pest outbreaks, major storms, and large-scale climate anomalies (e.g. *El Nino-La Nina* events).

Targets

2 Year Targets

4.7 Ecosystems

Harmonize methods for observing the GEOSS set of ecosystem variables. (Rec# 46)

Implement a global carbon observing system, in accordance with the specifications detailed in the IGOS-P global carbon theme, which incorporates the Terrestrial Carbon Observation plan of GTOS, and carbon-related components of GOOS and GCOS. (Rec# 47)

Define a globally-agreed, robust and implementable (operational) classification scheme for ecosystems. (Rec# 48)

Establish a global, sufficient and representative network for validating and enhancing satellite observations of ecosystem properties, relying also on existing national and regional integrated environmental monitoring networks. (Rec# 49)

Ensure the operational continuity of moderate to high resolution Earth-observing satellites for land cover and ocean color. (Rec# 50)

Begin to eliminate regional disparity in observing capacity. For example, two thirds of the world oceans are in the Southern Hemisphere, whereas most of the advanced oceanographic centers are in the Northern Hemisphere. Stations for observing ecological variables on land are much more closely spaced in temperate countries than in the tropical belt. (Rec# 51)

Develop tools to scale up from a limited number of *in situ* ecosystem observations made at local scales, to arrive at large-scale, comprehensive picture of ecosystems. (Rec# 52)

6 Year Targets

4.7 Ecosystems

Execute a global (terrestrial, freshwater, coastal and oceanic) ecosystem mapping initiative at a resolution of 500 m, using a standardized classification. (Rec# 111)

Implement a global nitrogen observing system. (Rec# 112)

Implement a network of land, ocean and coastal reference stations for monitoring nitrogen, carbon, phosphorus and iron fluxes and other ecosystem properties. (Rec# 113)

Deliver baseline maps for the globe, with adequate resolution and known uncertainty, of selected ecosystem properties such as: leaf area phenology, phytoplankton bloom dynamics; primary production, and net carbon exchange; energy and water exchange; productivity at higher trophic levels (e.g. grazing, fisheries production). (Rec# 114)

10 Year Targets

4.7 Ecosystems

Spatially-resolved information on ecosystem change, in relation to their capacity to deliver sustainable ecosystem services in sufficient quantities to meet societal needs; i.e., data assimilated ecosystem models, maps of ecosystem health, risk and vulnerability. (Rec# 170)

Develop new sensors and platforms, and to facilitate their use for routine observations in the field on an operational basis. For example, molecular tools are now being developed to study the microbial ecology of marine systems. In situ, self-contained, flow cytometers for classification of phytoplankton and bacteria (the "cytobuoys") and underwater laser imaging and scanning techniques that can be used for recording marine life underwater and for detecting terrestrial ecosystem structures, are in advanced stages of development. New sensors are also on the horizon for measurement of chemical properties of the ocean and terrestrial ecosystems. (Rec# 171)

4.7.4 Observation Requirements Table

Legend for Table 4.7.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.7.5 beginning on the following page.

		Societal Benefit Subtopic		
		A	B	C
Ecosystems Table 4.7.5 **Observational Requirement**		Land, River, Coast & Ocean Management	Agriculture, Fisheries, Forestry	Carbon Cycle
Ecosystem extent and composition				
1	Extent and location of ecosystem and habitat types	1	1	1
2	Fragmentation of ecosystems	2	2	2
3	Community composition (including benthos)	2	2	2
Ecosystem structure and function				
4	Leaf Area Index or greeness	1	1	1
5	Ocean, freshwater water colour and chlorophyll content	1	1	1
6	Canopy architecture: height, cover	2	2	2
7	Biomass per unit area	2	2	2
8	Carbon fluxes: NPP,NEE and Respiration	3	3	3
9	Water fluxes: evaporation	2	2	2
Climatic drivers of ecosystem function				
10	Max and min temperature (at or near surface)	1	1	
11	Near-surface winds	2	2	
12	Humidity (near surface)	1	1	
13	Precipitation	1	1	
14	Ocean currents and waves	2	2	
15	Solar radiation (net, and PAR)	2	2	2
Soil, sediment and medium drivers of function				
16	Soil type (texture, depth)	3	3	3
17	Nutrient supply: nirogen, phosporus, micronutrients			
18	Water and soil salinity	2	2	2
19	Soil moisture	3	3	3
20	Optical properties of water	2	2	2
21	Soil, sediment and water column organic matter content	2	2	2
Human drivers of ecosystem function				

Ecosystems Table 4.7.5 **Observational Requirement**		**Societal Benefit Subtopic** A: Land, River, Coast & Ocean Management	B: Agriculture, Fisheries, Forestry	C: Carbon Cycle
22	Human population density and growth rate, urban and rural	1	1	
23	Harvest intensity (on land and oceans)		1	1
24	Nitrogen deposition	3		3
25	Extent of coastal and lake eutrophic zones	2		
Disturbance regime				
26	Burned area	1	1	1
27	Pest and disease outbreaks	3		
28	River discharge pattern	2		

Note: many ecosystem services are listed under other topics, and would be part of the ecosystem poic as well. These include water yeild, food and forest production, climate regulation, flood amelioration.

4.8 Supporting sustainable agriculture and combating desertification

4.8.1 Statement of Need

There are approximately 800 million people in the world who are chronically exposed to hunger or malnutrition. Moreover, most of these people are found in developing countries in Asia (62%), Africa (22%), Latin America and Caribbean (7%) and the Near East and northern Africa (4%). The 1996 World Food Summit (WFS) agreed that the number of hungry people should be reduced by half by the year 2015. This objective to reduce hunger is reflected in the Millennium Development Goals (MDG) of which the first one calls for eradicating poverty and hunger and establishes specific targets to be met consistent with the WFS.

The conditions for achieving food security in these vary by region. For example, in China and India, the conditions for achieving food security are relatively good in so far as both the countries and the region have been experiencing favorable economic growth over a number of years. This is despite the fact that they contribute the largest numbers in population to Asia's food insecure.

In the African sub-continent, where processes of desertification, highly variable climatic conditions and civil unrest have limited the achievement of sustainable increases in food production, there remain significant constraints to achieving the targets set for reducing the number of hungry and food insecure. This is despite the fact that considerable unused land of a good quality for agriculture is available.

The maintenance, enhancement and reliability of agriculture, rangeland, fisheries and forest production are essential if the world is to meet a global population that will require approximately 700 million additional tons of cereal production to meet projected population growth by the year 2020. Sustainable development is the key, with the introduction of new technologies and crops being broadly consistent with environmental protection, for example in biodiversity and ecosystems. In this context the issue of desertification in marginal lands is important and the assessment of drought is critical.

Although GEOSS is primarily global in scope, the specific issues identified in this section have direct benefit to agriculture planners, policy makers and technicians who can derive utility for applications at national level.

Primary among the potential beneficiaries are small farmers and land managers in lower income countries. These persons generally lack almost all of the essential information that many take for granted, including weather information, market and pricing data, crop forecasts. It is by no means unrealistic to envision a world in the not too distant future in which the use of Earth observation and communication technologies will bridge the divide, which separates these underprivileged persons from the economic and social benefits that can be obtained through access to appropriate information.

A second group of beneficiaries of a GEOSS will be agriculture development experts of countries and international organizations who run operational systems for production, distribution and consumption of food and other products. Improved data and information flow for early warning systems to detect crop yield shortfalls and pest outbreaks, for response farming, and ensuring the proper use of inputs and management of biophysical resources will provide immediate benefits.

A third community of beneficiaries are scientists and researchers who seek to understand better the potential impacts of global change on agriculture and food systems through data assimilation, modeling and food systems analysis. Important among these are forward-looking studies (e.g. Agriculture Towards 2015-2030) that are aimed at assessing future food needs in relation to the available biophysical resources and population projections to ensure that the necessary resources are invested in a timely manner to meet future food needs. Internationally coordinated research efforts, such as Global environmental change and food systems (GECAFS), which examine links between food production, climate change and biodiversity loss, will also be important users of the new and improved data and information generated under GEOSS.

A fourth community of beneficiaries is those national policymakers who are involved in efforts to ensure that coordinated actions are taken to respond to global environmental change. These include, in particular, a variety of multi-lateral environmental agreements such as the Convention to combat desertification, as well as the Millennium Development Goals.

Examples

Example one

A world in which there are reliable estimates of the numbers of people who live in the drylands of the world (i.e. sub-humid zones with less than 120 days of length of growing period) that are subject to desertification, climate variability and land degradation. First order estimates, obtained in 2003 through the allocation of global population density data into individual 1km map pixels, revealed that approximately 620 million persons inhabit these zones. However, a systematic effort to map all available socio economic data in agriculture at the pixel level would have an excellent cost/benefit and allow for strategic analysis and decision making based on human needs. It would be possible to identify highly vulnerable populations, to match income with production, to identify market and pricing opportunities, which can help, in strategic decision making to combat desertification and conserve biodiversity.

Example two

A world in which high resolution satellite imagery is validated in near real-time and combined with local information and provided to poor, low income farmers on a daily basis through wireless communication technologies such as rural radio. Market and price information, local weather forecasts, crop information would be provided directly to farmers in food insecure countries.

4.8.2 Vision and how GEOSS contributes

The vision is to have a truly global poverty and food monitoring, mapping and information service that will enable sustainable development within countries and allow international organizations to plan their activities. This involves developing effective national and regional capacity to use Earth observation data in local, national and regional agriculture, rangelands, forestry, and fishery sectors. It requires comprehensive socio-economic data that is disaggregated and geo-referenced at a pixel level.

One element of such a system will be operational and validated on-time drought early warning systems that reach to the level of the individual farmer in food insecure regions in Africa, Asia and Latin America. A second will be an on-time monitoring and information systems for events such as fire, forest conversion, forest concession management, crop yield, land degradation. A third is the need for periodic large-scale integrated assessments of land and water resources at a high-resolution that supports sustainable agriculture (e.g. irrigated land, land degradation, aquaculture expansion, land fragmentation). Underpinning this is a need for a set of comprehensive and validated global products for land cover and land use.

The aim will be to have a structured implementation with a first step being to work with international agencies and governments to agree a harmonized land cover classification system that can be widely adopted, and in parallel assist developing countries to access and manage geo-spatial data.

Completion of the ongoing global assessment of irrigated land is essential, and the early development of a world soil and terrain database at resolution of 1:1 million or better is needed. Other key aspects are: the assessment in drylands of Land degradation; a systematic farm systems mapping exercise at 1:500,000 resolution; fishing fleets monitoring as an input to ensuring sustainable use of resources, and high-resolution (5-40metre) monitoring of selected environmental hotspots in agriculture, rangelands, forestry, freshwater and fisheries.

GEOSS will contribute to the integration of all the parameters required to meet the vision. Three main categories of products or datasets are needed:

- Land resources, e.g. land cover and use, land degradation, crop production, soil characteristics, forestry assessment, fire.

- Freshwater resources e.g. total irrigated area, fluxes in small water bodies, and groundwater resources, aquaculture.

- Socio-economic conditions e.g. population distribution, production intensity, and food provision.

Foremost in importance among the products need for sustainable agriculture are those related to land cover, land use and the associated socio economic data. However, biological factors such as pollinators, wild relatives of domestic species, invasive species and pests are significant influences on agriculture, forestry and fisheries. All of this information must have known accuracies and be geo-spatially referenced.

GEOSS can work to ensure the continuity of existing satellite-based land observation systems and support the ongoing assimilation of these data with in *situ* data to the generation of products that are relevant for monitoring and assessing food security, crop production and land quality.

GEOSS also needs to work with the institutions that run programs to facilitate access to and use of Earth observation products in order to ensure an “end-to-end” system where the farmers and land managers receive sufficient information. This involves the provision of “change” products that demonstrate the response of agriculture, forestry and fishery systems to different management and environmental factors. GEOSS can also improve the ongoing dialogue between data and product providers and the local, national and regional bodies to ensure that relevant data and information gets into the hands of persons who make decisions about agriculture, forestry and fisheries policy.

4.8.3 Existing Situation and Gaps

The Food and Agricultural Organization (FAO) is a key player in establishing the link between the GEOS data and product suppliers and the communities of users at all levels. FAO has a well established and structured mechanism for interacting with farmers, national agencies and international agencies. It has also direct cross links to work on ecosystems and biodiversity.

During the past ten years the capacity to obtain access to data and information has consistently improved, but there remains a great weakness in the availability of trained personnel and dedicated financial resources to main technology and personnel needed to ensure archiving, access and use. As a consequence most developing countries use only a small fraction of the Earth observation data that is available and relevant to sustainable agriculture.

A key point for improving the capacity of developing countries to use Earth observation data is with regional and national bodies that are already involved in the use of these tools for drought or pest early warning systems or for monitoring significant natural resources such as forests. For example, the Southern Africa Development Committee (SADC) has developed significant Earth observation infrastructure capacity during the past 20 years and would be able to extend its capacity with relative ease, including the development of relevant policy products.

The drought monitoring centre for the Greater Horn of Africa can be a point for building upon existing capacity and familiarity with Earth observations. In all cases, it is essential that emphasis be given to improving the science / policy dialogue among the interest groups.

The existing class of observational systems can supply the majority of needs. The main efforts need to be directed toward improved product development -with validation- and ensuring continuity of data sources. One key gap is to ensure the continuity of funds for the high (5m) and medium (30-40m) resolution satellite systems such as LANDSAT and SPOT.

Integration of data collection, management and assimilation are also areas that can be improved considerably. There is a need to strengthen the links between *in situ* networks and satellite programs for the purposes of validating products such as those relating to land cover, land use, crop production, cultivated area, and forest area. There is scope to facilitate large-scale data assimilation exercises for agriculture related data and information and building capacity in the agriculture community to undertake such exercises on a regular basis. The Global ocean data assimilation experiment (GODAE) is an example that could be applied to the agriculture, forestry and fishery sectors.

There is a need for all relevant agencies to build an end-to-end process of data collection, analysis, product generation and decision making. This should include strengthening the capacity of developing regions to take up the existing flow of Earth observation data and to generate relevant products. To support this, there need for agreed international standards for registering and exchanging geo-spatial data and information. Once established these facilities can provide long-term support to the re-analysis of data archives relating to land cover, vegetative cover and other types to generate "change" products that facilitate understanding of the effects of global forces on sustainable agriculture;

Capacity building would be aided by the implementation of prototype projects at a multi-national level among developing countries. These could involve the use of precision agriculture technologies to assess water stress, plant disease and other factors using high-resolution satellite data on high-value crops.

4.8.4 Targets

2 Year Targets

4.8 Agriculture

With relevant users at regional, national and local level to define user needs for agriculture, rangelands, forestry and fisheries in terms of Earth observation data and information. (Rec# 53)

Regular update of land cover data at 1:1,000,000 scale. Using agreed ISO standard to initiate land cover mapping activities at 1:500,000. (Rec# 54)

Initiate regional training in land cover classification and the assimilation of existing data sets in Africa, Asia and Latin America. (Rec# 55)

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Initiate work to enable the agriculture, forestry, and fishery production statistics to be used at a pixel level. (Rec# 57)

i.Support the adoption and use of geostationary satellite data (e.g. Meteosat second generation) in food insecure regions.

ii. Establish basis for the continuity of high resolution satellite observing networks (5-30 metres). (Rec# 58)

Produce map of the World irrigated agriculture areas and establish with users a monitoring program. (Rec# 59)

Develop on-time monitoring and information systems for significant and extreme events such as fire, forest conversion, and forest concession management. (Rec# 60)

Develop courses to demonstrate the usage of Earth observation data and products in developing countries. (Rec# 61)

6 Year Targets

4.8 Agriculture

Develop and improve the analytical tools and methods for agriculture risk assessment, and establish common standards and formats. (Rec# 115)

Support the completion of the world soil and terrain database (Soter) at resolution of 1:1 million. (Rec# 116)

Completion of land degradation assessment in drylands (Lada). (Rec# 117)

Establishment of the provision of regular validated global land cover product at 1:500,000. (Rec# 118)

Establish the role of satellite data in monitoring and maintaining a global farming systems database. (Rec# 119)

Establish operational linkage of Earth observation data to geo-spatially referenced production and use statistics. This should cover crop agriculture, livestock, forestry and freshwater fisheries. (Rec# 120)

Continuity ensured to high-resolution imagery for monitoring logging concessions in areas with high biodiversity concentrations. (Rec# 122)

Operational on-time monitoring and information systems introduced for significant and extreme events such as crop yield, crop water stress. (Rec# 123)

10 Year Targets

4.8 Agriculture

Full integrated *in situ* and satellite-based observation service for on-time drought early warning systems in food insecure regions. (Rec# 172)

Comprehensive and validated global products suite production capability for land cover in higher resolution (e.g. 1:250,000) and land use in moderate resolution (e.g. 1:500,000). (Rec# 173)

Global databases and assessments of irrigated land, water availability for agriculture, land degradation, forest conversion, and aquaculture expansion are undertaken. Process for data supply for updates is defined. (Rec# 174)

All statistics and associated sub-national socio economic data and environmental information are converted to pixel format with known accuracies for cross linkage with satellite data. (Rec# 175)

On-time monitoring and information systems for significant and extreme events such as land degradation hotspots. (Rec# 176)

Assess effectiveness of delivery of GEOSS capacity building activities in the agriculture, forestry, and fishery sectors. (Rec# 177)

4.8.5 Table of Observation Requirements

Legend for Table 4.8.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.8.5 beginning on the following page.

		Societal Benefit Subtopic				
		A	B	C	D	E
Agriculture Table 4.8.5 **Observational Requirement**		Food Security	Fisheries	Timber, Fuel & Fiber	Agricultural Economy & Trade	Grazing Systems
Land						
1	Crop production (yield, by crop type)	1		1	1	
2	Livestock number, type and offtake	1			1	1
3	Land cover and change: cultivated area, forest area, rangeland area	1		1	1	
4	Within-season crop condition: greeness and water stress	1		1	1	1
5	Topography (Digital elevation model)	1		1		1
6	Fuelwood supply	2		1	2	
7	Drought risk	1		1	1	1
8	Active fire, burned area and fire risk	2		1		2
9	Soil type (depth, texture, stoniness, fertility, acidity)	3		3		3
10	Land quality and land quality change (degradation)	3		3		3
11	Nutrient status and balance	3		3	3	
12	Area affected by salinisation, water erosion, wind erosion	3		3		3
Marine & Coastal						
13	Fishery production, by resource type	1			1	
14	Fishing effort: ves sels and activity		2		2	
15	Fishery areas, marine protected areas		1			
16	Sea surface temperature		1			
17	Ocean colour and chlorophyll content		1			
Freshwater						
18	Aquaculture area and production	1	1		1	
19	Fishing effort: vessels, activity		3		3	
20	Water availability and quality for irrigation and pastoralism	2		2	2	
21	Irrigated area and quantity of water used for irrigation	1			2	
22	Wetland area	3	3			

		Societal Benefit Subtopic				
		A	B	C	D	E
Agriculture Table 4.8.5 **Observational Requirement**		Food Security	Fisheries	Timber, Fuel & Fiber	Agricultural Economy & Trade	Grazing Systems
Socioeconomic						
23	Farming systems	3			3	3
24	Land use and land use change	3		3	3	3
25	Distance to market and transport infrastructure			2	2	2
26	Agricultural income				1	
27	Food aid shipments	2			2	
28	Access to food (availability, infrastructure, income, physiology)	3		1	3	
29	Population density (rural and urban)	1		1	1	1
30	Production intensity (actual/potential)	2		2	2	2
31	Agricultural and forestry machinery			1	2	
32	Fertilizer and pesticide use				2	

4.9 Understanding, monitoring and conserving biodiversity

4.9.1 Statement of Need

Biodiversity is the *variety* of life on Earth. It can be thought of as having three major levels of organization (the genetic level, the population level, and the ecosystem level), within each of which there are three aspects of diversity: composition; structure and function (fig 1).

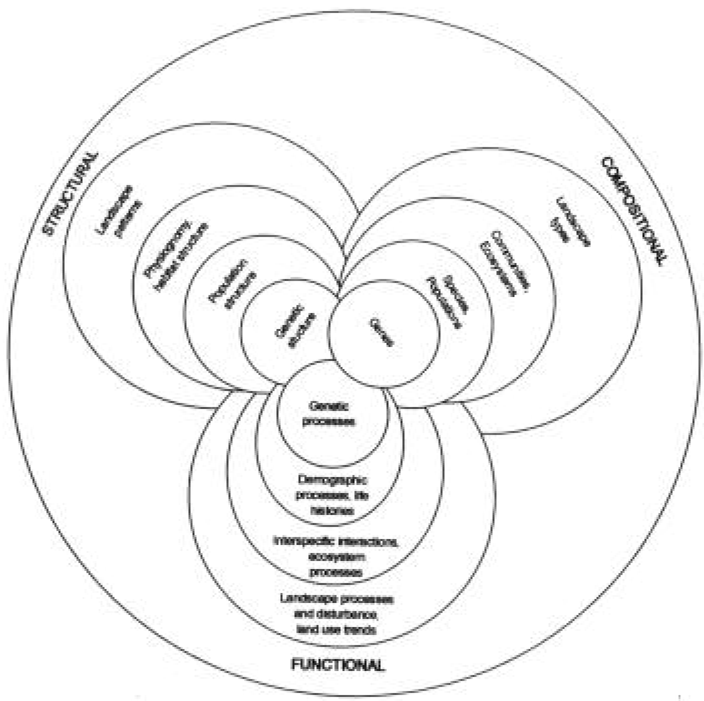

Figure 2. A conceptual diagram illustrating the multiple levels and aspects on biodiversity. After Noss (1990)

Biodiversity is necessary for the sustained delivery of the goods and services essential for human well-being, as well as for the maintenance of life on Earth in general. Examples of ecosystem services that fundamentally depend on the existence of adequate biodiversity include food, fiber, the control of pests and diseases and the discovery of novel natural products, such as pharmaceuticals. These are 'utilitarian' values for biodiversity. Biodiversity also has 'intrinsic' value; in other words a value independent of human use.

If we are to understand biodiversity and its loss, build global, regional and national baselines, make rational management decisions and assess the success of conservation measures, many sources of biodiversity observations must be pooled. Most biodiversity observations are, and will continue to be, made in situ. The sampling strategy must cover all major ecosystems and taxonomic groups and the ecosystem, population, and genetic levels of biological organization.

Although we have learned much about biodiversity, less than a fifth of all species are described. Thus we still do not know exactly what we are losing. The ecological importance and potential uses of most species is unknown, so we can not accurately predict the consequences of further loss. To answer key environmental, agricultural and health questions, biodiversity scientists are obliged to base their predictive models on incomplete data. A coherent global system of observations would greatly improve analysis and predictability.

Biodiversity is currently being lost across the globe at a rate unprecedented in human times. Recognizing the threat this poses to human societies, the nations of the world have agreed, in several international treaties and conventions, to protect aspects of biodiversity. These binding agreements include the Convention on Biological Diversity (CBD), the Convention on Migratory Species of Wild Animals (CMS) the Ramsar Convention, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa (CCD), among others. The World Summit on Sustainable Development endorsed the CBD target of significantly reducing the rate of loss of biodiversity by 2010. Currently no observation system exists in support of this objective.

Integrated biodiversity data is needed for local, national and international policy makers to develop science-based policy, establish priorities in biodiversity action plans and to implement legislation, especially in the context of international conventions. It also benefits scientists in their understanding of biodiversity drivers, pressures, processes, and interactions. Conservation management is aided by a better understanding of the biodiversity. Knowledge of biodiversity is also important for businesses as they work to develop sustainable growth plans.

This involves informing the populations about the benefits of biodiversity, and this flows through education, the activities of Non Governmental Organizations, indigenous and local communities, public interest and advocacy groups, as well as the news and media.

Example: On November 1, 2008, an oil tanker founders in seas off Acropora, a small island state. Satellite images collected by GEOSS show the oil slick as it approaches a marine protected area. Long-term monitoring data, collected for many years by Acroporan agencies participating in GEOSS and from GEOSS contributors are analyzed, using modeling tools. The data shows that this area contains endangered species of coral, mollusks and fish that are slowly recovering after having been at the edge of extinction. Officials in the Acroporan Ministry of the Environment, Tourism and Transport, who have been trained on the use of modeling and the available data and resources, immediately consult GEOSS and discover that most of the world's records of many other marine species were collected in or near the protected area. Further analysis of GEOSS data show that 5 of these species are now probably only found in the protected area and 2 just outside of it. Within three days of the accident the international effort to contain the oil slick focuses on limiting any damage to the protected area and the key areas outside it. Booms are placed enclose the protected area and skimmers remove much of the oil from the sea surface. Dispersants are prepared but prove not to be necessary thanks to the rapid reaction of the world community and the use of biodiversity data for decision making.

4.9.2 Vision and How GEOSS Will Help

The vision is to develop a high quality, timely, and comprehensive global biodiversity observation system that fulfils the data needs of the multilateral environmental agreements, governments, natural resource planners, scientists and civil society; and integrates with ecological, agriculture, health, disaster, and climate monitoring, policy.

A GEOSS biodiversity observation system would create a platform to integrate biodiversity data with other observations more effectively, leverage investments in local and national research and observation projects and networks for global analysis and modeling. It will need to build on existing efforts such as the Global Biodiversity Information Facility (GBIF), which provides essential data and models for monitoring and reporting in the framework of the biodiversity Conventions, and provides new information and tools for biodiversity research.

4.9.3 Existing Situation and Gaps

There are a number of existing observational organizations that are already providing support and information on biodiversity.

The Global Biodiversity Information Forum (GBIF) offers a coordinated list of known species and collections, which links to many taxon- or region-specific databases. The World-Wide Fund for Nature (WWF) has a global map of ecosystems (‘ecoregions’). Distribution maps for birds, mammals and reptiles are available from a variety of research and conservation agencies. The World Conservation Monitoring Centre maintains databases of protected areas. The WWF Living Planet Index (LPI) is an indicator of the state of the Earth's natural ecosystems, based on the area of the world's natural forest cover, and global populations of freshwater and marine species. The UNESCO Man And the Biosphere (MAB) program coordinates the International Network of Biodiversity Monitoring (IBMN), which monitors forest biodiversity. The UNESCO Biosphere Reserve Integrated Monitoring program monitors biodiversity in the World Network of Biosphere Reserves. Wetlands International operates the International Waterbird Census (IWC), a site-based scheme for monitoring waterbird numbers. GCRMN, the Global Coral Reef Monitoring Network, promotes coral reef monitoring. The Census of Marine Life (CoML) is a biodiversity research network that makes its global geo-referenced information on marine species available through the web-based Ocean Biogeographic Information System (OBIS). The state of global diversity has been assessed by Global Biodiversity Assessment, the Pilot Analysis of Global Ecosystems, PAGE, and the Millennium Ecosystem Assessment.

GBIF has developed protocols and mechanisms for data standards, sharing and interoperability. GOOS and GTOS (in coordination with Diversitas, a program on diversity of the International Council of Scientific Unions) integrate existing marine and terrestrial observing systems to observe, model, analyze and predict marine and ocean variables, including living resources.

The Global Marine Assessment (GMA) works with the International Oceanographic Commission (IOC) and GOOS to test ocean sampling methods, whilst the Smithsonian Tropical Research Institute Centre for Tropical Forest Science facilitates a network of long-term standardized Forest Dynamics Plots in tropical sites. The Global Invasive Species Programme (GISP) focuses on information exchange on invasive species. It does not collect field data.

FAO State of the World's Plant Genetic Resources for Food and Agriculture is based on 158 Country Reports. UNEP's Global Environment Outlook is based on information from a network of multidisciplinary Collaborating Centers and more specialized Associated Centers. Monitoring projects are under development or ongoing in several countries to provide statistically reliable estimates of species status and trends.

Together the above agencies and their activities provide a non-homogenous set of requirements and information on biodiversity and GEOSS would need to develop the appropriate links. Significant gaps exist and need to be addressed

Some taxa have not received the attention merited by their numerical contribution to biodiversity. There are few global assessments of less charismatic groups (such as lichens or marine worms). Many observations of components of biodiversity are uncoordinated, from easily accessible areas and hence not representative, recent, and without long time-series. Genetic data are largely absent. Most of the vitally important historical and baseline data is not yet digitized.

Comprehensive descriptions and listings of the fauna and flora exist for many countries, but are not updated effectively. Global distributions and conservation status of most organisms are not known. Gazetteers and geographic information systems for species distributions frequently lack necessary observational data. Terrestrial and marine research facilities that can collect comparable and long-term biodiversity data are not well-distributed across the ecosystems of the world, nor adequately coordinated, equipped or funded. Collections in museums, botanical gardens, seed banks, zoos, aquaria and culture collections universally need increased funding to prevent loss of specimens and human expertise and to leverage the investment in these invaluable, irreplaceable resources.

The Global Biodiversity Information Facility (GBIF) is a global effort to provide interoperability between biodiversity databases. Starting its work with specimen-level data, it will then integrate species, geospatial, genetic, and ecological data. GBIF and GEOSS must develop common interoperability protocols and tools, and extend them to other biodiversity-related observation systems.

Targets

2 Year Targets

4.9 Biodiversity

The distributed observation network is interoperable through GBIF and links to datasets of ecological and other related observation systems. (Rec# 62)

Develop an observation strategy that is spatially and topically prioritized, based on analysis of existing information, identifying unique or highly diverse ecosystems and those supporting migratory, endemic or globally threatened species, and those whose biodiversity is of socioeconomic importance. (Rec# 63)

Ten million new biodiversity observations are captured per year. Initiatives on 3 key issues are launched Networks of permanent sites agree to data collection protocols. (Rec# 64)

Data providers, particularly the research and collections institutions, receive additional support to permit data system integration and sharing. (Rec# 65)

The gaps and needs in capacity building initiatives are identified across sectors. (Rec# 66)

6 Year Targets

4.9 Biodiversity

The distributed observation network provides timely data and information for local, national, regional and international policy makers. (Rec# 125)

Monitoring systems established for policy-interest and endangered species, allowing frequently-repeated globally-coordinated assessment of trends and distributions of species of special conservation merit, including domesticated animals, cultivated plants, and fish species and their wild relatives and species of medicinal or economic value. (Rec# 126)

System in place to provide near-real-time data on detection, establishment and spread of problematic invasive organisms. (Rec# 127)

Biodiversity in all ecosystems selected and systematically monitored using statistically valid methods. (Rec# 128)

Twelve million new data points added yearly. (Rec# 129)

Capacity building programs on data use and interpretation offered. (Rec# 130)

10 Year Targets

4.9 Biodiversity

The distributed biodiversity observation network is integrated with sectoral, crisis, health and policy systems and is routinely used to solve problems, guide policy and management and generate opportunities for sustainable development. (Rec# 178)

Fifteen million new data points added yearly. Systems to model and analyze trends in abundance and distribution functional and widely accessible. (Rec# 179)

Observational network optimized, including where necessary the development of new sites, facilities, technologies and networks, based on an analysis of the observations collected in the first decade. (Rec# 180)

4.9.4 Table of Observation Requirements

Legend for Table 4.9.5	
0 -	Monitored with acceptable accuracy, spatial and temporal resolution; timeliness and in all countries worldwide.
1 -	Monitored with marginally acceptable accuracy, spatial and temporal resolution; timeliness or not in all countries world-wide.
2 -	Not yet available, but could be within two years.
3 -	Experimental; could be available in six years.
4 -	Still in research phase; could be available in ten years.

Please see Table 4.9.5 on the following page.

Biodiversity

Table 4.9.5

	Observational Requirement	Societal Benefit Subtopic A Conservation	B Invasive Species	C Migratory Species	D Natural Resources & Services
Ecosystem Level					
1	Location and area of ecosystem types (forest, coral reefs etc)	1	1	1	1
2	Condition of ecosystem types	3			3
3	Community composition (survey species lists)	3			3
4	Fisheries trophic index (marine and freshwater)				2
5	Species interactions	4			4
Population / Organism Level					
6	Geographic distribution of species	3	3	2	1
7	Population number or abundance of selected species	3	3	2	2
8	Threatened and exctinct species lists	1	1	1	1
9	Diversity of organisms used in medicine	4			3
10	Extent, intensity and cost of alien species invasion	3	3		2
Gene Level					
11	Number of land races/cultivars/breeds in production systems				2
12	Genetic heterogeneity within populations of selected species	4			3

4.10 Commonality Analysis

To realize the action plans of each of the nine societal benefit areas within the broader framework of GEOSS, common threads running among the benefit areas are identified below.

4.10.1 Observation commonalities

4.10.1.1 Satellite observation

Considerable effort has been expended on studying user requirements and reflecting them in the planning and coordination of satellite missions, but the current situation does not satisfy all requirements of each benefit area. All-weather observation data and climate-related observations as well as high temporal/spatial resolution data are basic observation data, and can be used across virtually all topics. SAR sensors, passive microwave observation, high-resolution optical observation systems and geostationary observation systems should also be considered key observing systems.

The following highlights requirements for satellite observation from specific societal benefit areas:

- Addressing disaster requirements includes the need for high spatial resolution and all-weather capability through technology such as optical and SAR satellites, as well as high temporal resolution observation from geostationary orbit for disaster monitoring of volcanic eruption, forest fires, aerosol and other hazards.

- Improving understanding of human health with satellites requires derivation of health parameters from geostationary satellites.

- For improved climate observations, all the satellite operators in GEOSS should adhere to the recommendations in GCOS-92, including global precipitation measurement that provides frequent coverage of global precipitation.

- Improving agriculture through observations requires high to medium resolution observation from space for land cover classification, and the widespread adoption and use of geostationary observations in food insecure areas.

4.10.1.2 *In situ* observation

Ground baseline observation networks are declining, and this trend needs to be reversed. The first step is to improve existing systems, or at a minimum, to maintain them at current levels. The second step is to optimize observation network, including where necessary the development of new site, facilities, technology, networks, based upon analysis of observation collected. Elimination of regional disparity in observing capacity, such as imbalance of advanced oceanographic observations sites in northern hemisphere and southern hemisphere needs to be tackled.

4.10.1.3 Convergence of observation

It is essential for GEOSS to encourage the establishment of global, efficient and representative networks of integrated *in situ* observation sites to support satellite data validation, process studies and algorithm and model development, relying also on existing national and regional integrated environmental monitoring networks. GEOSS will promote the convergence of observations.

4.10.2 Data Utilization Commonalities

4.10.2.1 User Involvement

To maintain the effectiveness of GEOSS, it is essential regularly to review and assess the needs and requirements of Earth observation data, products and services. GEOSS should focus not only on global users, but also on local and regional users.

4.10.2.2 Continuity of Observations

Continuity of SAR sensor data, including L-band and C-band, for interferometry and GPS capability is required to meet the needs of the Disaster societal benefits area. The Agriculture area needs continuity of a high resolution satellite network (5-30m) for monitoring selected hotspots in agriculture, rangelands, forestry, fresh water and fisheries. Societal benefits in the Water area could be served by development of a plan to institutionalize surface flux measurements.

4.10.2.3 Data products

There are several commonly required and used products among the nine societal benefit areas, (Disasters, Health, Energy, Climate, Water, Weather, Ecosystem, Agriculture and Biodiversity) and several of these address the need for data assimilation, modeling and re-analysis. The Water and Ecosystem topic areas demonstrate the need for a data assimilation tool to scale up from limited *in situ* observations made at local scales to arrive at a large-scale, comprehensive global picture of the water cycle and ecosystem. To respond to the needs of each topic area, integration of Earth observation data with socio-economic data will produce useful information for application in socio-economic areas. For example, improving understanding of human health through Earth observations requires the development of human health indicators based upon environmental measurements. Similarly, agriculture requirements include linking Earth observation data to geo-spatially referenced production and use-statistics for crop agriculture, livestock, forestry and freshwater fisheries.

4.10.2.4 Data transformation to information

It is essential to consider the impact or linkage among the different topic areas; for example, climate change impacts on other areas, such as disasters, health, water, ecosystems and agriculture. Thus, it is necessary to emphasize the detection of climate changes and their impacts on these other topics by combining scientific data and socio-economic information. In addition, different users have a variety of data exchange needs, including:

- Real-time data exchange for disaster management;
- Near real-time data on detection of problematic invasive organisms;
- Data exchange through international networks concerning health and water quality.

Appropriate data access needs to be provided for each user, and a proper end-to-end system needs to be designed to support specific user requirements for data, product and services.

SECTION 5
ARCHITECTURE OF A SYSTEM OF SYSTEMS

5 A System of Systems

GEOSS is defined as a system of systems. Societal benefits are derived from comprehensive, coordinated, and sustained Earth observations made possible by GEOSS and its components as illustrated in Figure 5.1 below:

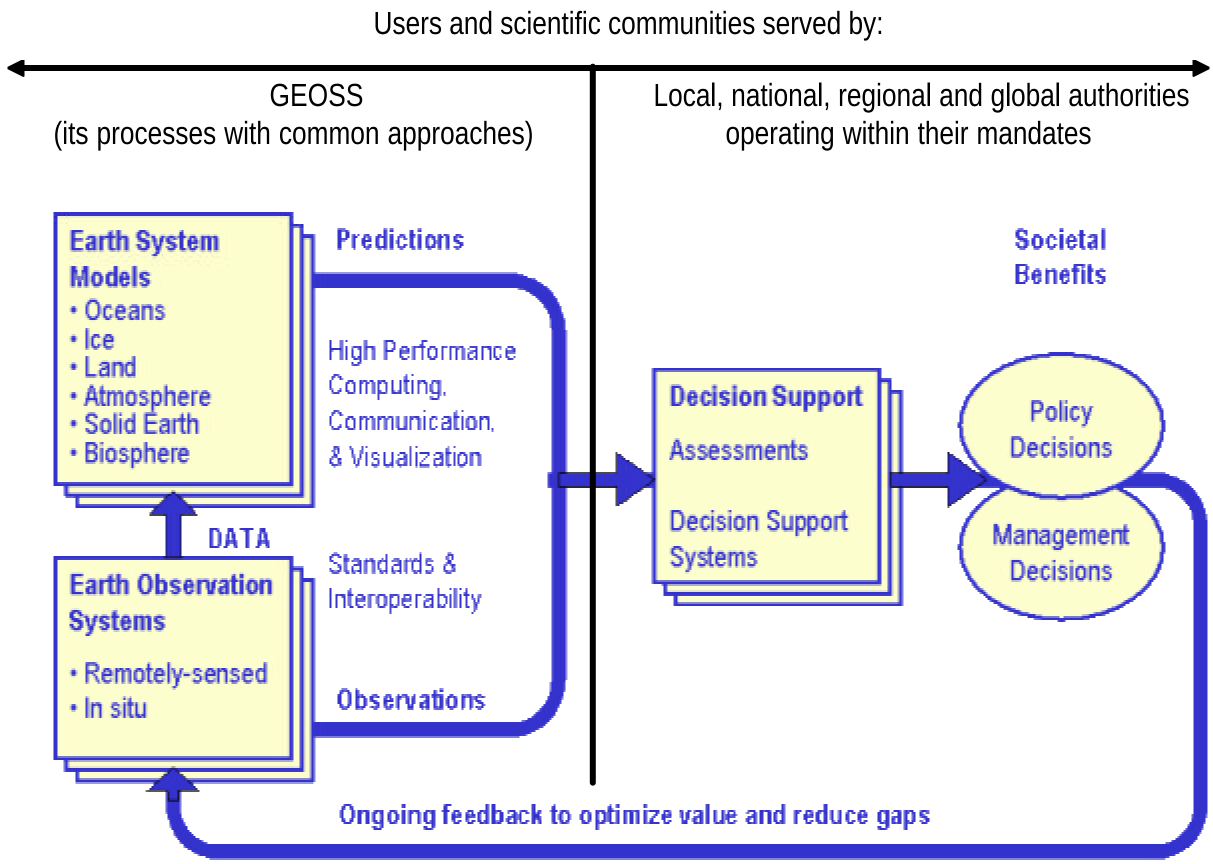

Figure 5.1: The diagram demonstrates the end-to-end nature of data provision, the feedback loop from user requirements, and the role of GEOSS in this process, demonstrated principally by the left side of the diagram.

5.1 Key Principles

GEOSS builds upon current cooperation efforts amongst existing observing and processing systems, while encouraging and accommodating new components. Across the processing cycle from data collection to information production, participating systems maintain their mandates, their national, regional and/or intergovernmental responsibilities, including technical operations and ownership.

For required new components, GEOSS participants will establish, encourage establishment, or find an organizational entity already existing, to be responsible. GEOSS participants may also possibly need coordination with commercial, academic, and other non-government organizations. Local, national, regional and global authorities, operating within their mandates, may access and utilize GEOSS data and products in the preparation and issuance for guidance resulting in societal benefits.

Section 6 describes how GEOSS component strategies and systems fit together to produce a comprehensive, coordinated, and sustained system of systems that better satisfies overall requirements in the identified societal benefit areas. The GEOSS Implementation Plan addresses not only cost effectiveness and technical feasibility, but also institutional feasibility.

The architectural approach for the GEOSS 10-year Implementation Plan builds on existing systems and historical data, as well as existing documentation describing observational needs in these areas. GEOSS is based on several key principles:

- GEOSS is to be driven by user needs, support a broad range of implementation options, and be able to incorporate new technology and methods;
- GEOSS is to address planned and operational observation systems required for participants to make products, forecasts and related decisions;
- GEOSS is to include observing, processing, and dissemination capabilities interfaced through interoperability specifications agreed and adhered to amongst all participants;
- GEOSS observations and products are to be observed, recorded and stored in clearly defined formats, with metadata and quality indications to enable search and retrieval, and archived as accessible data sets;
- GEOSS is to provide a framework for securing the future continuity of observations and the instigation of new observations; and,
- GEOSS participants and the components they support are to be documented in a catalogue that is publicly accessible, network distributed, and interoperable with major Earth observations catalogues;
- GEOSS will work closely with research initiatives that may use GEOSS data and products as well as improve the effectiveness of future observing systems.

5.2 Functional components

GEOSS is comprised of three types of functional components:

- Components to acquire observations based on existing local, national, regional and global systems to be augmented as required by new observing systems;

- Components to process data into useful information, i.e. geo-products that are part of GEOSS, recognizing the value of modeling, integration and assimilation techniques for example global sea-surface temperature fields - such geo-products will be prepared in those modeling centers participating in GEOSS and serve as input to the decision support systems required in response to societal needs; and

- Components required to exchange and disseminate observational data and information including those for archiving. Components are understood to include data management that encompasses issues such as QA/QC (Quality Assessment/Quality Control), access to data, and archiving of data and other resources.

In common with Spatial Data Infrastructures (SDI) and services-oriented information architectures, GEOSS system components are to be interfaced with each other through agreed interoperability specifications. Access to data and information resources of GEOSS will be accomplished through various service interfaces to be contained within the data exchange and dissemination component. The actual mechanisms will include many varieties of communications modes, with a primary emphasis on the Internet wherever appropriate but ranging from very low technology approaches to highly specialized technologies.

A key consideration is that GEOSS catalogues data and services with sufficient metadata information such that users can find what they need and gain access as appropriate. Internet is a primary medium for the mechanism to allow users to access the catalogue of available data and products, with hard copy media to also be available as appropriate. Users searching GEOSS catalogues will find descriptions of participants and the components they support, leading directly to whatever information is needed to access the specific data or service. In this sense, the interoperable GEOSS catalogues form the foundation of a more general clearinghouse. GEOSS data resources can be not only fully described in context, data access can be facilitated through descriptions of whatever analysis tools, user guides, and other services may be useful. Many examples of such clearinghouse facilities already exist in the realm of Earth observations and networked information systems generally, and many of these already employ interoperable interfaces.

GEOSS will develop a common set of guidelines for archiving. GEOSS will emphasize to participants that archive centers must have adequate funding to address data growth and be in a position to ensure the perpetuity of not only incoming data but also data safeguard on aging or obsolete media.

Historical data and data in developing countries are frequently kept on paper records in regional offices and their existence is not well known. The rescue of such data is important to strengthen and broaden the historical records for assessing trends.

GEOSS will promote the use of common mechanisms for the cataloguing of archives, including how to access them. All providers need to ensure that archived data and products provide a statement of the access conditions in terms of the mechanics and policies. There should also be a well-documented statement of the ancillary data needed to understand and use basic data sets and products.

5.3 Convergence of Observations

One of the goals of GEOSS is to establish a system of systems that can provide timely data and information for local, national, regional and international policy makers. Participating systems will provide real- or near real-time monitoring, early detection and globally integrated observations. Near real-time observations are required to address specific disaster needs (e.g., submarine seismic and volcanic activity and tsunami propagation) and significant extreme events in Agriculture (e.g., fire, forest conversion, forest concession management and land degradation hotspots).

Topic-specific integration of global observations is required by almost all of the identified societal benefit areas, but each area has a different balance between *in situ* and satellite observations.

5.4 Opportunities for Synergy

It is expected that there will be a large increase in the volume of Earth observation data. In addition to distributed data archives and integration systems, area-focused data management facilities will be used for diverse and large-volume Earth observation data from inhomogeneous information sources in cooperation with existing data centers that will keep their institutional identity and mandates. Thus, GEOSS will facilitate:

- Life-cycle data management for large volume data from leading-edge storage technology;
- Utilization of advanced database technology that enables multi-layered visualization of various types of data;
- Integration of natural science data and human societal data by standard co-registration techniques for data and geographic information;
- New value-added products resulting from information fusion of diverse and large volumetric Earth observation data;
- Implementation of international information sharing capabilities through an Internet-based service.

5.5 Interoperability Agreements

In order for interoperability to be broad and sustainable, fewer agreements accommodating many systems are preferred over many agreements accommodating few each. Interoperability should focus on interfaces, defining only how system components interface each other and thereby minimizing any impact on affected systems other than interfaces to the shared architecture.

Wherever possible, interoperability agreements must be based on non-proprietary standards, and profiles must be specified when standards are not sufficiently specific. Rather than defining new specifications, GEOSS should adopt standard specifications agreed upon voluntarily and by consensus, with preference to formal international standards such as ISO. All interface implementations should be specified in a platform-independent manner, and verified through interoperability testing and public demonstrations. In the instances cited below, the service standards are widely deployed in commercial products and are also available for free as open source software implementations.

GEOSS interoperability agreements are to be based on the view of complex systems as assemblies of components that interoperate primarily by passing structured messages over network communication services. By expressing interface interoperability specifications as standard service definitions, GEOSS system interfaces assure verifiable and scalable interoperability, whether among components within a complex system or among discrete systems.

GEOSS service definitions are to specify precisely the syntax and semantics of all data elements exchanged at the service interface, and fully describe how systems interact at the interface. At present, participants in GEOSS should agree to use any one of four open standard ways to describe service interfaces (CORBA, Common Object Request Broker Architecture; WSDL, Web Services Definition Language; ebXML, electronic business eXtensible Markup Language, or UML, Unified Modeling Language).

GEOSS participants agree to avoid non-standard data syntaxes in favor of well-known and precisely defined syntaxes for data traversing system interfaces. The international standard ASN.1 (Abstract Syntax Notation) and the industry standard XML (Extensible Markup Language) are examples of robust and generalized data syntaxes, and these are themselves inter-convertible.

It is also important to register the semantics of shared data elements so that any participant can determine in a precise way the exact meaning of data occurring at service interfaces between components. The standard ISO/IEC 11179, Information Technology--Metadata Registries, provides guidance on representing data semantics in a common registry.

A major concern in GEOSS is to agree on standards for archiving of data and other resources that are acceptable to both providers and users. Communities with particular expertise in archiving, such as those data managers associated with the World Data Center program managed by ICSU (International Council for Science) will advise GEOSS in its adoption of standards. Archived data should be well documented, be stored using known and published standards, and be readily transferable to a standard format for data exchange.

Many Earth observations catalogues that require interoperability at the search service have adopted the international standard used for catalogue search (ISO 23950 Protocol for Information Search and Retrieval). This search service is interoperable with the broadest range of information resources and services, including libraries and information services worldwide as well as the Clearinghouse catalogues supported across the Global Spatial Data Infrastructure now implemented in more than 50 nations. This standard search service also has demonstrated interoperability with services registries using either an ebXML metadata model or UDDI (Universal Description, Discovery, and Integration).

Data and information resources and services in GEOSS typically include references to specific places on the Earth. Interfaces to discover and use these geospatial data and services are agreed upon through the various Spatial Data Infrastructure initiatives. These include the ISO 23950 search service interface standard, as well as a range of ISO standards covering documentation and representation, and place codes. OGC (OpenGIS Consortium) specifications for Web Mapping Service, Web Coverage Service, and Web Feature Service are examples of publicly available standards on geospatial services.

Services providing access to Earth observations data and products often include significant requirements for assuring various aspects of security and authentication. These range from authentication of user identity for data with restricted access, to notification of copyright restrictions for data not in the public domain, and to mechanisms for assurance that data is uncorrupted. GEOSS will promote convergence on common standards for these various aspects.

5.6 Targets to Enable the Architecture for GEOSS

To enable implementation of the GEOSS architecture, certain actions should be undertaken as a first priority as follows:

- Formal commitments for GEOSS contributions must be made including agreement to adhere to GEOSS interoperability specifications;
- GEOSS will draw on existing Spatial Data Infrastructure (SDI) components as institutional and technical precedents in areas such as geodetic reference, common geographic data, and standard protocols;
- GEOSS participants and the components they support are to be catalogued in a publicly accessible, network-distributed clearinghouse maintained collectively under the auspices of GEOSS. The catalogue system will itself be subject to the agreed GEOSS interoperability specifications, including the standard search service and geospatial services;
- With regard to interoperability agreements, a GEOSS process for reaching agreements must be established, sustained, and informed by ongoing dialogue with major international programs and consortia. That process is to be sensitive to the technology and accessibility disparities among GEOSS participants.

5.7 Initial GEOSS Components

Table 5.7 shows governments and participating organizations that have provided an informal indication to contribute to the initial GEOSS with the noted individual component(s).

Table 5.7 - GEOSS Components as of 16 July 2004

Category	**Sponsor(s)**	**System**
Observing systems	Italy	COSMO-SkyMed (satellite system)
	Japan	DAPHNE
		Hi-NET
		K-NET/KIK/NET
		F-NET
		GEONET
	United States	EPA networks (various)
	WMO	World Weather Watch Global Observing System (GOS) EUMETNET Composite Observing System (EUCOS) (A regional component sponsored by 19 European national meteorological and hydrological services)
		Global Atmosphere Watch (GAW)
		World Hydrological Cycle Observing System (WHYCOS)
		Global Terrestrial Network for Hydrology (GTN-H)
	IOC, WMO	Global Ocean Observing System (GOOS)
	ICSU, UNEP, UNESCO, WMO	Global Climate Observing System (GCOS)
	FAO, ICSU, UNEP, WMO	Global Terrestrial Observing System (GTOS)
Modeling and data processing centers	ISCGM	Global Mapping Project
	WMO	World Weather Watch Global Data Processing and Forecast System (GDPFS)
		Global Runoff Data Centre (GRDC) (hosted by Germany)
		Global Precipitation Climatology Centre (GPCC) (hosted by Germany)
	18 European countries and WMO RSMC	European Centre for Medium range Weather Forecasting (ECMWF)
Data exchange and dissemination systems	WMO	Future WMO Information System (FWIS)

SECTION 6
DATA IN THE SERVICE OF USERS

6 Data In The Service Of Users

6.1 Key Principles

Data sharing is a critical component of GEOSS, without which the societal benefits of Earth observations cannot be achieved. To optimize data sharing, GEOSS participants will need to agree to the following principles:

- GEOSS promotes full and open access to observations, metadata and products, while respecting the different data policies of GEOSS data contributors.
- All such observations and related data should be made available for free or for the cost of reproduction to the research and education communities.
- Data needed for humanitarian purposes should be available free and without restriction.
- GEOSS will encourage access to free metadata, and promote the development and use of flexible, open, and easy to use community standards for metadata. These standards will be interoperable and independent of specific hardware and software platforms. Guidelines for their use will be widely circulated and incorporated into data management training courses. It must be possible to combine seamlessly spatial information from different sources and share it between many users and applications.
- GEOSS will encourage support to appropriate mechanisms for handling intellectual property rights issues.

The following subsections describe several other aspects of data sharing and the overall GEOSS approach in promoting the development of useful information from Earth observations data. These subsections are delineated as: Observations, Products, Disseminatio n, User Involvement, Research Issues, and Radio Frequency Protection.

6.2 Observations

6.2.1 Collaboration Mechanisms

GEOSS will provide coordination and cost-and-benefit-sharing mechanisms that address several challenges that plague typical international efforts requiring collaboration.

Sampling - Sampling problems emerge wherever Earth system processes operate at scales requiring observations beyond the boundaries of the operating agency, e.g., climate, weather, river basins, migratory species, etc. For instance, an atmospheric carbon dioxide observation system is required to satisfy the objectives and protocols of the UN Framework Convention on Climate Change. The observation system must be able to resolve, at the regional scale, net carbon dioxide fluxes into and out of the atmosphere, with sufficient accuracy to verify convention commitments. Given that the atmosphere mixes globally, the accuracy of the example observation system is limited, overall and for particular regions, by the accuracy of the most weakly-sampled region. Thus, adding more samples in the industrialized regions of the northern hemisphere would hardly improve the accuracy there or overall. However, improving the most weakly-sampled region would lead to greater improvements both there, *and in all other regions*. Clearly, coordination in such situations can minimize the duplication of effort, while also bolstering the credibility and transparency of the sampling program. GEOSS can enhance international coordination of investments in observation systems, observation procedures, and data exchange.

Multi-Use Systems - Another efficiency can be realized by designing Earth observation systems from a multi-use perspective as envisioned in GEOSS. For instance, weather data are necessary inputs to all the societal benefit areas specified in the Framework Document. An optimal observation system for, say, weather forecasting, would not likely be optimal or even sufficient for climate, ecosystems, agriculture or health. But, a mechanism promoting coordination of user requirements can expose opportunities for synergy among users with similar observation needs.

Shared Costs and Benefits - A mechanism for cost and benefit sharing such as GEOSS can often lead to a substantial improvement in an observation network. For instance, the accuracy of weather forecasting models is limited by upper air observations in the southern hemisphere, and particularly over Africa and South America. In the context of many of the developing countries located there, the national benefits of making such observations does not justify the cost, given all the other demands on national resources. Cost sharing can be crucial whenever the principal benefits of a given observation accrue at a scale or location that differs from the jurisdiction of those best placed to make it.

6.2.2 Shared Infrastructure

GEOSS will promote shared infrastructures for Earth observations, leading to cost reductions for participants and providing scientific benefits as well. For example, an oceanographic cruise to sample plankton diversity can simultaneously collect weather data, and a terrestrial network for weather observations can also measure pollution. Similarly, the incremental cost of adding another sensor to a satellite platform with spare capacity is much smaller than building, launching and operating another satellite. In general, sample co-location often yields savings. This is because the costs of single observations are often quite high (especially in remote places), but the incremental costs of taking other observations at the same place are relatively small.

6.2.3 Observation Continuity

GEOSS will address Earth observation continuity, emphasized as a fundamental requirement across the range of societal benefit areas. Continuity is needed for both basic observation networks and intensive observation focused on select areas. Only with assured continuity can users invest confidently. The continuity of high- to moderate-resolution optical and SAR observations over land and other critical observations over oceans needs to be assured. Accordingly, contingency plans of observation system operators should be sensitive to how their user communities are affected by interruptions of data and services.

6.3 Products

6.3.1 Common Products

GEOSS will place a high priority on data and information products commonly required across diverse societal benefit areas. Examples of such products include topography, land cover, soil moisture, vegetation, snow cover, wind profile, precipitation, cloud information, water quality, etc. For data with such wide application, it is very important to promote broad convergence on common methods of data classification, representation, calibration and validation.

To understand the interaction of societies with Earth systems, it is critically important to blend socio-economic data with other Earth observation data. Consequently, GEOSS will emphasize promotion of the development and accessibility of socio-economic products, including census data, economic activity, political boundaries, and land ownership records, among many others.

6.3.2 Modeling and Data Assimilation

GEOSS will advocate common methods in the modeling and analysis techniques needed to transform data into useful information. Best practices and up-to-date scientific understanding should be shared broadly. This should include techniques for the estimation and recording of quality indicators, and the representation of uncertainties in models as well as observation data.

In applications such as climate and weather modeling, methodologies known as data assimilation are commonly used. These procedures transform a wide variety of *in situ* and remotely sensed Earth observations data into parameters that feed into numerical models of physical and chemical processes calculated over time and space. There may be benefit in a targeted effort to enhance sharing across Earth observation areas of operational experience in data assimilation.

6.3.3 Data and Product Quality

GEOSS will advocate that quality assessments be associated with all Earth observations data. It is clear that observations data of known quality from calibrated sensors are essential. For instance, the ability to perform long-term ”traceability” is highly dependent on complete and accurate metadata about precision and accuracy. Calibration must be addressed during product creation and validation is required to ensure the quality of the resulting product. In addition to useful quality descriptions, greater standardization of quality control procedures may be needed.

6.4 Dissemination

GEOSS will promote data management approaches that encompass a broad perspective of the observations data life cycle, from input through processing, archiving, and dissemination. In some instances, Earth observation systems have met the needs of an immediate user community but lack the documentation or procedural rigor needed for the data to be broadly exchanged with other communities or useful for long-term applications. Data dissemination problems are encountered with restricted and charged data resources as well as with open and free data, and with data archives as well as real-time data sources. Raising the level of data dissemination practice is essential to meet the needs of the many disciplines and varying access requirements of the global Earth observations community.

Improvements in communications management are also important, whether handled as an integral data management function or treated as an outside utility. Earth observation systems utilize many types of communication technologies depending on the particular data, product and timeliness needs of the user. For instance, observation collection systems may involve data exchange among satellites in orbit or floppy disks sent by mail from remote rain forest locations; disaster-warning systems may involve broadcast TV alerts and messages displayed on highways. For many Earth observation applications the medium of choice will be the Internet, but system designers need to think globally when choosing appropriate communications technologies.

6.5 User Involvement

GEOSS will promote the regular involvement of users in reviewing and assessing requirements for Earth observation data, products and services. International organizations, such as FAO, WMO and WHO, are likely to have a key role in connecting users and Earth observation organizations. This may be more challenging in research as distinct from operational institutions. Although GEOSS focuses on global issues, involvement by regional or local regional users is also essential.

6.6 Research Issues

GEOSS will promote more effective transfer into operations of Earth observations technologies that have been proven in the research environment. Research strategic plans should not only address continued investment in the research, but how to turn a successful research system into an operational system.

Because the pace of technological change is rapid, continuous and evolutionary system development is necessary to keep Earth observations systems most effective and efficient. Clearly, the science and practice of Earth observations has a continuing need for improved sensors, sampling strategies, and networks, among many other components. Long-term consistency and sustainability are basic requirements for GEOSS, but new technologies often provide better coverage or precision at lower cost; occasional breakthroughs lead to societal benefits hardly considered possible before.

6.7 Radio Frequency Protection

In order to enable the various functions that must occur as part of the GEOSS, it is necessary that appropriate frequency allocations exist and are protected. The frequency allocations will be necessary both for telecommunications and for observing systems. In some cases for observations, the required radio frequency will be determined by the physics of atoms and molecules. The full set of GEOSS required radio frequency allocations must take into account national frequency plans as well as those of the International Telecommunication Union (ITU). GEOSS activities should include:

- Review allocations of radio-frequency bands and assignments of radio-frequencies to GEOSS related activities for requirements (telecommunications, instruments, sensors, etc.) and research purposes;
- Coordinate with GEOSS participants to ensure the proper notification and assignment of frequencies, and to determine their future use of the radio spectrum.
- Keep abreast of the activities of the Radio Communication Sector of the International Telecommunication Union (ITU-R), and in particular of the Radio Communication Study Groups;
- Prepare and coordinate proposals and advice to GEOSS participants on radio-regulation matters pertaining to GEOSS activities with a view to ITU Radio Communication Study Groups, Radio Communication Assembly, World Radio Communication Conferences and related regional/global preparatory meetings;
- Facilitate the coordination between GEOSS participants for the use of frequency bands allocated to GEOSS activities with respect to:
- Coordination of frequency use/assignments between countries;
- Coordination of frequency use/assignments between various radio communication services sharing the same band.
- Facilitate the coordination of GEOSS participant with other international organizations which address radio-spectrum planning, including specialized organizations (e.g. CGMS, SFCG) and regional telecommunication organizations (e.g. CEPT, CITEL, APT);
- Assist GEOSS participants, upon request, in the ITU coordination procedure of frequency assignment for radio communication systems sharing a frequency band.

SECTION 7
CAPACITY BUILDING

7 Capacity Building

7.1 Introduction

Capacity building is an integral part of the implementation strategy of GEOSS and is a cross-cutting component for the topical issues identified and discussed in Chapter 4. Specific capacity building activities, however, need to be tailored to suit regional or local requirements, existing capacity in the regions, and priorities within GEOSS.

The most efficient means to improve the geographic coverage of the Earth observing system is to encourage wider participation from all nations. The capacity building envisaged within this context must extend beyond training of qualified technical personnel to operate the instruments of observation, to include building of a broader community that will be trained on the development, interpretation and utilization of value-added products from the observations. This is essential, to ensure that all nations benefit from the integrated Earth observation system(s).

Many potential GEOSS components have made significant progress towards the development of capacity, but linkages and partnerships between these activities are critical to ensure the most effective use of resources and to ensure sustainability.

7.2 What is Capacity Building

The UNCED, (1992) definition for capacity building encompasses the country's human, scientific, technological, organizational, and institutional and resources capabilities. A fundamental goal of capacity building is to enhance the abilities of stakeholders to evaluate and address the crucial questions related to policy choices and modes of implementation among options for development, based on an understanding of environmental potential and limits and of needs perceived by the people of the country concerned.

GEOSS capacity building covers three elements:

- Human Resources
- Infrastructure
- Institutional capacity

7.3 Goals

The Goals of capacity building in GEOSS will be to strengthen the capability of all countries, and particularly of developing countries participating in GEOSS to:

1. Use Earth observation data and products (i.e. process, integrate, model, etc.) in a sustainable, repeatable manner (both space-based and *in situ* sensors), with results or outputs consistent with accepted Earth observing standards.

2. Contribute *in situ* observations to global networks, and access and retrieve relevant data from global data systems useful for *in situ* applications.
3. Analyze and interpret data to derive nationally, regionally and globally relevant information and provide decision-support systems and tools useful to decision makers.
4. Integrate Earth observation data and information with data and information from other non-Earth observation sources for a comprehensive and holistic view and understanding of problems, in order to identify sustainable solutions.

7.4 Strategy

The GEOSS capacity building strategy takes its lead from the emerging understanding of Best Practice devised for successful and failed approaches in the past. It follows the concept of capacity building that was promoted by the WSSD: an equal partnership between those whose capacity is least developed and those who are able to assist in the process. GEOSS capacity building activities will build on existing local, national, regional, and global initiatives to achieve the goals of the GEOSS. Capacity building across the entire continuum of GEOSS activities is crucial for sustained results. The capacity building recommendations contained in the implementation plan are based on the following considerations:

1. Capacity building efforts are funded and sustained to ensure the continuity and enhancement of initiatives.
2. Capacity building activities must respect the needs, recommendations, and lessons learned from previous and existing efforts.
3. Efforts must be based on the recognition that Earth observation and related capacity building activities have intertwined social, environmental and economic impacts.
4. Sustainable capacity building will only be successful if local and national stakeholders are partners in the process from the onset, and if there is an ongoing and long-term political and institutional commitment.
5. Capacity building envisaged here should lead to sustained improvements in Earth observations and related activities.
6. Capacity building efforts should aim to move individual nations from a position of awareness to a position where it takes all necessary actions to continuously improve its capacity
7. Capacity building should address not only issues related to data collection, but also those related to data archiving, data distribution, data analyses and interpretation.
8. A variety of outputs, ranging from raw data to processed outputs will be necessary to meet the needs of various applications. These outputs will have to be tailored to meet the

requirements of the applications envisaged, and adapted to the regional situations and technological capabilities.

9. Capacity building efforts should be directed not only at developing new infrastructure, but also at maintaining and strengthening existing structures.

10. Infrastructure development in regions of poor observational coverage is to be encouraged on a priority basis where maximum societal benefits can be realized.

7.5 Targets

The recommendations given below are in addition to specific capacity building recommendations given under each of the nine societal benefit areas in section 4 of the document. The recommendations given here relate to overarching capacity building issues that need to be addressed.

2 Year Targets

Capacity Building

A comprehensive review and gaps analysis of existing regional and international capacity building efforts will be conducted as a first step of implementation of GEOSS. (Rec#181)

Existing efforts on education and training, such as the work being developed under the WSSD, WMO, UNESCO, and CEOS as well as the various regional activities undertaken by groups of nations, are maintained and strengthened. (Rec# 67)

GEOSS mechanisms need to support developing countries to establish and maintain essential sites for global networks that cannot always be justified within the national priorities these countries. An example is the paucity of GCOS sites in developing countries and the need to establish a minimum set of oceanic, terrestrial and meteorological reference stations for long-term observations of key variables. (Rec# 68)

Based on an analysis of existing efforts, recommend coordination where appropriate, to organizations involved in relevant capacity building, with the objective of minimizing efforts and maximizing return. (Rec#182)

GEOSS will develop a communication network of experts involved in local, national and global Earth observation capacity building initiatives to facilitate the task of furthering capacity building, and inform the GEO members and participating organizations of existing efforts in capacity building. (Rec#183)

GEOSS will recommend the priorities for new or increased efforts in capacity building, to meet the objectives of the overall GEO Implementation Plan. (Rec#184)

6 Year Targets

Capacity Building

GEOSS to continue to encourage the funding of multinational projects to leverage the end to end value of observations including the establishment of necessary infrastructure. Examples of these, amongst others, are the TIGER, Africa Monitoring of the Environment for Sustainable Development, and Geographic Information for Sustainable Development projects. (Rec# 131)

GEOSS will recommend priorities for new or increased efforts in capacity building, to meet the objectives of the overall GEO Implementation Plan. (Rec#185)

10 Year Targets

Capacity Building

It is expected that the majority of GEOSS capacity building activities will be implemented during the 2-year and 6-year horizon

GEOSS will recommend priorities for new or increased efforts in capacity building, to meet the objectives of the overall GEO Implementation Plan. (Rec#186)

SECTION 8
OUTREACH

8 Outreach

8.1 Introduction

GEOSS outreach activities and the resulting dialogue will provide many benefits. It informs individuals or stakeholders to enable better decision making; it informs GEOSS principals, providing for continuous improvement of the "system of systems"; and it increases understanding among policy makers and the general public to ensure appropriate support for Earth observation systems

The overall objective of the GEOSS Outreach component is, therefore, to promote and increase the general awareness of the benefits of Earth observation, in the broadest sense possible. The key target audiences are the present and future users, beneficiaries and sponsors of relevant systems. The Outreach Plan should be considered as a flexible component. It can be adapted in response to major strategic and operational developments that might occur during the 10-Year implementation period. It should also include ways to measure its success.

Decision-makers and the general public are two target groups for Earth observation promotion activities. In the past, material generated for these groups has been insufficient and not always "tailored" to their needs (frequently focusing on engineering/technology/science). Several examples exist, where properly driven Earth observation promotion can successfully attract further governmental and general public attention.

8.2 Objectives of GEOSS outreach

The main objectives of outreach activities are:

- To convince key audiences that past, present, and future investments in Earth observation are delivering tangible socio-economic benefits, and thereby encourage more nations and organizations to participate actively in GEOSS.
- To show the practical applications of Earth observations and their relevance to government policy, socio-economic growth and interests of citizens.
- To increase public awareness on GEOSS scientific achievements, technology advances, applications and capabilities benefits and support to environmental management.

The outreach component has to address a wide range of audiences, including diverse language groups, differing national interests, all age groups, varying levels of technical sophistication, and high to low political influence.

While all materials will be web based, it is essential to recognize that hard copies (paper, CDs) will be necessary to reach all communities.

8.3 Outreach targets

The primary target audiences are GEOSS Member States and potential members, with particular attention to developing countries.

8.3.1 Decision and Policy Makers

These are primarily political level entities and representatives of GEOSS Member States, as well as those responsible or interested in the exploitation of Earth observation data and information. Typical entities/people included in this category are ministers, parliamentarians and specialized government committees, high-level civil servants, relevant national and international organizations, user groups. All need to be shown, beyond the specific technicalities, the usefulness of Earth observation information and data to solve their sector issues (e.g. ecosystem management, disaster management, agriculture, energy, health, etc.).

8.3.2 General public

The general public includes the "man-in-the-street" as well as opinion makers from the media (press, TV, radio), who need to be familiarized, through quality information, with Earth observation achievements. The goal is to increase confidence in public investment in this sector and raise awareness of the potential contribution that Earth observation tools and information can provide in everyday life. In today's "information society," the "image" of Earth observation can be channeled to the general public in an extremely effective way. The requirement is for effective and appealing sets of information.

8.3.3 Industry, Value Adding Companies (VAC) and Service Communities

Existing initiatives already link industrial, non-governmental, academic and government sectors to promote the understanding and use of Earth observations for societal and economic benefit, such as the Alliance for Earth observations. GEOSS could liaison with these types of initiatives to create a better dialogue with the industrial world. Service industries are also to be considered for possible outreach activities, since they are probably not fully aware of the potential economic benefits and markets that it can derive from Earth observation. Public/private partnership should also be encouraged in this sector. A first set of actions could be directed towards existing sector specific industrial associations.

8.3.4 Scientific & Technical Communities

It includes R&D institutions, universities and government laboratories. The interest of these communities must be drawn to the potential support Earth observations can provide to their research and investigations, also in order to complement and improve their scientific and technical achievements, exploiting the multidisciplinary nature of Earth observation data and facilitating the transfer of technology and know-how.

8.3.5 Education Entities

It includes Primary and Secondary schools as well as Universities. Outreach promotion of Earth observation to schools is meant to trigger and generate awareness of teachers and students on Earth observation techniques as part of basic education and of Earth observation products and services as useful and modern tools for teaching and learning. Today's students will, in the medium term, become decision-makers or potential data users and therefore need to be trained early to fully appreciate the usefulness of and benefit from Earth observation programs. This will involve the development of ad hoc educational curricula.

8.3.6 NGOs and Public Interest Advocacy Groups

NGOs include non governmental organizations devoted to specific or cross sectoral issues such as environment, sustainable development, health, agriculture, energy use, cooperation with developing countries, etc. Public Interest/Advocacy groups include citizen groups capable of influencing public opinion and of lobbying with decision-makers for their specific causes. Outreach promotion activities towards these categories could support and complement actions towards the general public in OECD and developing countries.

8.3.7 International Financial Institutions (IFIs) and Official Development Assistance Agencies (ODAs)

It includes international and national investment institutions and technical/development assistance organizations devoted to cooperation with developing countries. Outreach promotion activities directed at these institutions and organizations will increase their knowledge of Earth observation benefits, thus encouraging the inclusion of Earth observation programs in developing country investments and of appropriate partnerships to ensure the related capacity building activities.

8.4 Time frame

8.4.1 Short Term (Two-year)

Develop an overall outreach plan, identify level of resource, and identify GEOSS partners to implement the outreach plan. Highest priority for the first two years should be given to decision and policy makers and to the general public, aiming in particular to actively engage existing members and to enlist new ones.

8.4.2 Medium and Long-term (6 to 10 Year)

All target audiences should be reached, although with different priority level and resources. Decision-makers and the general public will remain of highest priority. In the longer term, priority will be given to private sector needs for triple bottom line reporting.

SECTION 9
GOVERNANCE AND RESOURCING

9 Governance and Resourcing

9.1 Guiding the Global Earth Observation System of Systems

[The following is placeholder text from the Framework Document, to be superseded by results from the GEO Special Session on Governance 27-28 September 2004.]

The adoption of the Framework Document represented a decision by GEO members and participating organizations to proceed with the elaboration of the GEOSS 10-Year Implementation Plan along the lines set forth in the Framework, and a willingness to cooperate on, and participate in, the implementation of the plan. The current ad hoc GEO is a "best efforts" activity with voluntary input from States and advice and support from international organizations.

For 2005 and beyond, the implementation of the "10-Year Implementation Plan" will require a ministerial-guided successor mechanism with maximum flexibility—a single intergovernmental group for Earth observations drawing on the experience of the ad hoc GEO, with membership open to all interested governments and the European Commission, and with representatives of relevant international organizations taking part. The successor mechanism will provide generally for:

(a) Coordination and planning of GEOSS implementation (*in situ* and remotely sensed);

(b) Opportunities for engagement of all members and relevant international and regional organizations;

(c) Involvement of user communities;

(d) Measuring, monitoring, and facilitating openness of GEOSS to improve cross-flow of observations and products;

(e) Coordination and facilitation of the development and exchange of observations and products between members and relevant international and regional organizations.

9.2 Resourcing GEOSS

It is anticipated that the cost of providing the systems will be borne directly by the participants. It is not recommended that GEOSS operate its own budget for major investments. Experience with IGOS-P and other similar "best efforts" activities, has shown, however that the process can be significantly slowed down or even halted for as want of relatively small amounts of funding. These modest sums are often extremely hard to produce on short notice through voluntary contributions, and delays are often incurred. To ensure that the implementation of the GEOSS plan will not similarly suffer, it is strongly recommended that the GEOSS Secretariat be allocated, from the start, a limited amount of funding over and above its running costs.

The primary source of resources for the implementation will be through governments, either within national programs or through international agencies. GEOSS has identified and prioritized user requirements in the nine societal benefit areas, and future investments need to be made in ways that produce the maximum benefit. This will involve continuing dialogue with observation system providers, persuading them to fill priority gaps and to ensure the continuity of the required observations. It must always be borne in mind that GEOSS is not attempting to take over from all who are already operating in this complex field. Existing programs and projects will of course, continue.

SECTION 10
PERFORMANCE INDICATORS

10 Performance Indicators

Participants in GEOSS and their funding sources will themselves require evidence that the implementation of GEOSS is measurably beneficial. The continuing support to GEOSS will also require this demonstration. The document has identified a number of specific actions for implementation in the short term (2 years), medium term (6 years), and long term (10 years). This section sets out the proposed mechanism for assessing the performance of the implementation plan against these goals. It is proposed to use a 4-part system for assessing performance, described below:

10.1 Inputs

This quantifies the effort and resources committed to the GEOSS implementation. It includes:

- Number of staff:
    - Professionals;
    - Support staff.
- Total budget:
    - Fraction spent on human resources;
    - Fraction spent on operations (meetings, travel etc);
    - Fraction spent on overheads (office etc).
- Number of participating countries and organizations.
- Percentage of due contributions received.

These will be provided annually and form part of an annual report.

10.2 Outputs

This quantifies the auditable products delivered in the reporting period. It includes:

- Reports issued;
- Meetings held;
- Standards/protocols published;
- Implementation plan targets achieved.

10.3 Outcomes

Outcomes are a measure of the effectiveness of the process of GEOSS in terms of the improvements made in observational networks. In effect they relate to the specific actions set out in each section and summarized in section 12. The timeline for this reporting will be consistent with the relevant time-scale of implementation across the ten-year period.

- New observational products traceable to GEOSS;

- Percentage interoperability achieved between collaborating systems;
- Number of users of GEOSS Internet-based resources;
- Use of GEOSS-sourced data in major assessments.

10.4 Impacts

This is the assessment of whether the activities of GEOSS have led to significant improvements of human well-being within the societal benefit areas. Almost by definition, these are measurable only on the decadal timescale, and are mostly qualitative. The mechanism of assessment is detailed, external review commissioned by the governing body on a regular basis, as appropriate.

SECTION 11
SCHEDULE AND EVOLUTION

11 Schedule for Implementation and Evolution

The GEOSS is a system of systems evolving and being driven by user requirements. This section sets out a schedule for the implementation and evolution of the GEOSS.

11.1 Schedule for GEOSS Implementation

The GEOSS will implement targets in the short- (2 years), medium- (6 years) and long- (10 years) term for the nine societal benefit areas identified in the section 4, in a step-by-step fashion. It is understood that the societal benefit areas will not be at the same level of maturity with respect to having a comprehensive understanding of their Earth observation requirements. The implementation schedule will necessarily be different from topic to topic.

The following chart provides an initial schedule for the GEOSS implementation in the short-, medium- and long-term for each societal benefit area.

GEOSS Ten-Year Implementation Plan Schedule

Table 11.1

Topics	Disaster			Health			Energy			Climate			Water			Weather			Eco-systems			Agri-culture			Bio-diversity		
Periods (years)	2	6	10	2	6	10	2	6	10	2	6	10	2	6	10	2	6	10	2	6	10	2	6	10	2	6	10
Observation:																											
1 In-situ	I	I	O	P	I	O	P	I	O	O	O	O	I	I	O	O	O	O	I	I	O	I	I	O	I	I	O
2 Satellite	I	I	O	P	I	O	P	I	O	I	O	O	I	I	O	O	O	O	I	I	O	I	I	O	P	I	O
3 Convergence of Obs.	P	I	O	P	I	O	P	I	O	I	O	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
4 Continuity	I	I	O	P	I	O	P	I	O	I	I	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
Product:																											
5 Specific Products	P	I	O	P	I	O	P	I	O	I	I	O	I	I	O	O	O	O	I	I	O	I	I	O	I	I	O
6 Data Assimilation	P	I	O	P	I	O	P	I	O	I	I	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
7 Synergy of Products	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O
8 Quality	I	O	O	P	I	O	P	I	O	I	O	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
Infrastructure:																											
9 Accessibility	I	I	O	P	I	O	P	I	O	I	I	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
10 Data Exchange	I	I	O	P	I	O	P	I	O	I	I	O	I	I	O	O	O	O	P	I	O	P	I	O	P	I	O
11 Interoperability	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O	P	I	O
12 User Involvement	I	O	O	P	I	O	P	I	O	I	O	O	I	O	O	I	O	O	P	I	O	P	I	O	P	I	O
13 R & D	I	I	I	P	I	I	P	I	I	I	I	I	I	I	I	I	I	I	P	I	I	P	I	I	P	I	I
Capacity Building:	P	I	O	P	I	O	P	I	O	I	I	O	I	I	O	I	I	O	P	I	O	P	I	O	P	I	O

Legend	P	**Planning Phase**	I	**Implementation Phase**	O	**Operational Phase**

11.2 GEOSS Evolution

It is important for the GEOSS to have a regular system for assessing the progress and providing feedback for the evolution of the systems. The assessment has to define *inter alia* the extent to which a comprehensive, coordinated and sustainable system of systems can be achieved and what actions and what actions are needed to ensure relevant feedback.

11.2.1 Involvement of users in defining new requirements

The needs for changes in data and information provision, access and quality are significant and concern different actors and institutions. Changes will not result from a single grand plan, but require progressive adjustments to be made as opportunities arise (e.g. regular reviews of monitoring programs, establishment or renewal of observational infrastructures, etc.).

For this approach, a distinct and common user requirements database for GEOSS should be established and maintained, building on and linking to existing user requirements databases, such as the CEOS/WMO database of user requirements and observation system capabilities.

For updating user requirements, the WMO experience in setting, reviewing and updating observational data following their process called the Rolling Review of Requirements (RRR) could be used as a model. All WMO-supported programs use the RRR process, which has become an effective tool to assess current capabilities of a global observing system and to define enhancements.

A GEOSS User Forum shall be held biennially, and involve observation providers and users, in order to review the requirements, and to assess and to assess the extent to which they are being met. The output of the forum will be an important input into the update of the implementation plan.

11.2.2 Involvement of the science and industrial communities

GEOSS needs to involve the science and industrial communities to ensure incorporation of technical developments that could enable existing (and new) requirements to be met, or exploitation techniques that will improve the utility of GEOSS. This activity should be part of the GEOSS forum.

Improvements in the observing system require support from research development in several areas. The most important of these are:

- Improved and new instrumentation for *in situ* and satellite observation;
- Data management, data integration and information fusion, data mining, network enhancement, and design optimization studies. This must include and evaluation of trade-offs in performance based on various hypothetical improvements in the observations; and

- Development of models and algorithms that are able to more effectively invert or assimilate raw observations to produce global products.

The involvement of standards organizations and certification bodies in the process will facilitate the development of user standards.

The GEOSS evolution is driven by user requirements and capability available. These user requirements and capabilities will grow as time goes by. There will be always prospects as to future requirements and capabilities. There needs to be a consistency check between the user requirements and capabilities available. This is a necessary step to access how much user requirements are being met by capabilities and how much future user requirements can be met by future capabilities, there by making it possible to make a feedback from user requirements to capabilities and vice versa.

The relationship among users, science and technologies is shown in Figure 11.1. It is important to ensure close links among these three communities in order to decide future user requirements and capabilities, and the societal benefits including scientific outcomes.

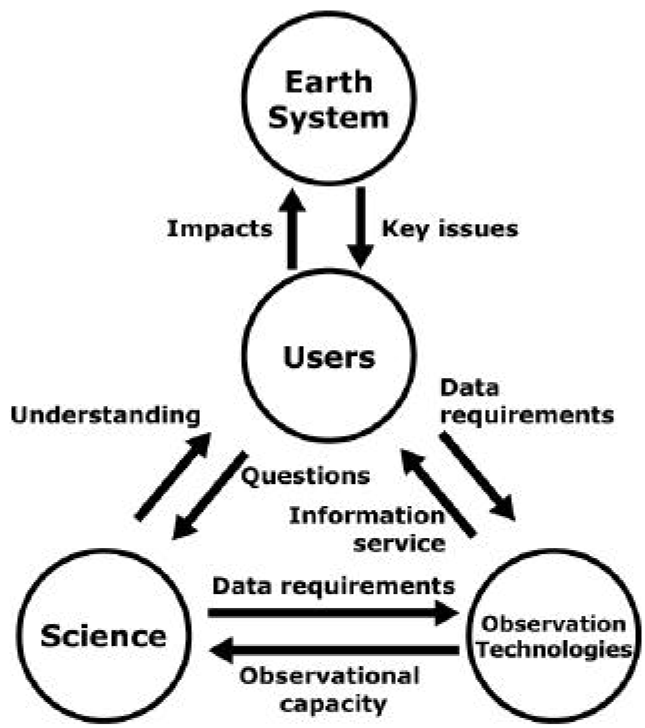

Fig 11.1: The GEOSS must have the capacity to evolve over time, as a result of changes in the Earth system itself, the perceived needs of data users, our developing insights into the key process, and our growing technological capacity to observe them.

SECTION 12
GLOSSARY AND ACRONYMS

12 Glossary and Acronyms

12.1 Glossary of Terms

C-band - a category of satellite transmission in the 6 GHz range

Global Earth Observation System of Systems (GEOSS) - A set of agreements, mechanisms and institutions with the purpose of continuously monitoring the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our environmental treaty obligations.

***in situ* observations** - Observations captured locally, i.e. within a few kilometers of the object or phenomenon being observed. Includes measurements taken at ground stations, by aircraft and sondes, ships and buoys.

integrated (dataset) - data sourced from multiple systems that are combined in a consistent and scientifically rigorous way.

L-band - The portion of the electromagnetic spectrum allotted for satellite transmission in the 1 to 2 Ghz frequency range.

observation(s) - quantitative or qualitative measurements of environmental and social variables obtained by instruments or human observers, either in situ or through remote sensing. Such observations frequently include numerical transformations to calibrate or interpolate them.

products (observational) - Information that is derived from observations, typically through the processes of collation, synthesis, integration, summarization and interpretation.

remote sensing - In general, observations made at a distance; in the GEOSS context it is specifically observations made from satellites in space, in the visible, infrared and microwave parts of the electromagnetic spectrum, at high, medium and low resolutions. Airborne, sonde and other forms of near-surface remote sensing are considered part of in situ observations for GEOSS purposes

services (observational) - Activities that are necessary in support of an observation system, but are not themselves observations – for example the development of standards and the provision of calibrations.

system of systems - a system composed of contributing systems, which each maintain their individual mandates [see GEOSS]

12.2 Acronyms

ALOS	Advanced Land Observation Satellite (Japan)
AMDAR	Aircraft meteorological data relay
APT	Asia-Pacific Telecommunity
ARGO	Array for Real-time Geostrophic Oceanography

AVIRIS	Airborne Visible InfraRed Imaging Spectrometer
CBD	Convention on Biodiversity
CCD	Convention to Combat Desertification in Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa
CEOS	Committee on Earth Observation Satellites
CEPT	European Conference of Postal and Telecommunications Administrations
CGMS	Co-ordination Group for Meteorological Satellites
CITEL	Inter-American Telecommunication Commission
CITES	Convention on International Trade in Endangered Species
CMS	Convention on Migratory Species
COBRA	Common Object Request Broker Architecture
CoML	Census of Marine Life
COSMO-SkyMed	Observing system (Italy)
CTBTO	Preparatory Commission for the Comprehensive Nuclear Test-Ban Treaty Organization
DAPHNE	Observing system (Japan)
DEMs	Digital elevation models
Diversitas	A biodiversity research program of ICSU
ebXML	Electronic business Extensible Markup Language
ECMWF	European Center for Medium-range Weather Forecasting
ECVs	Essential climate variables
EEPCo	Ethiopian Electric Power Corporation
EMETNET	The Network of European Meteorological Services
ENSO	El Niño/Southern Oscillation
EUCOS	EUMETNET Composite Observing System
FAO	Food and Agriculture Organization (of the United Nations)
F-NET	Observing system (Japan)
GAW	Global Atmospheric Watch (WMO)
GBA	Global Biodiversity Assessment
GBIF	Global Biodiversity Information Facility
GCOS	Global Climate Observing System (hosted by WMO)
GCRMN	Global Coral Reef Monitoring Network
GECAFS	Global Environmental Change and Food Systems
GEO	Group on Earth Observations
GEO (of UNEP)	Global Earth Outlook.
GEOHAB	Global Ecology and Oceanography of Harmful Algal Blooms
GeoHab	Marine Geological and Biological Habitat Mapping
GEONET	Observing system (Japan)
GEOSS	Global Earth Observation System of Systems
GHGs	greenhouse gases
GIS	Geographic Information Systems
GISP	Global Invasive Species Programme
GLOBEC	Global Ocean Ecosystem Dynamics Project (of the IGBP)
GMA	Global Marine Assessment
GMES	Global Monitoring for Environment and Security
GODAE	Global Ocean Data Assimilation Experiment
GOOS	Global Ocean Observing System. (hosted by IOC)
GOS	Global Observing System (WMO)
GPCC	Global Precipitation Climatology Centre (hosted by Germany)
GPS	Global Positioning System

GRDC	Global Runoff Data Centre (hosted by Germany)
GSDI	Global Spatial Data Infrastructure
GSN	GCOS Surface Network
GTN-H	Global Terrestrial Network for Hydrology
GTOS	Global Terrestrial Observing System. (co-sponsored by FAO, ICSU, UNESCO, UNEP and WMO, hosted by FAO)
GUAN	GCOS Upper Air Network
Hi-NET	Observing system (Japan)
IBMN	International Biodiversity Monitoring Network
ICSU	International Council for Science
IEA	International Energy Agency
IEC	International Electrotechnical Commission
IFI	International Financial Institutions
IFRC/RCS	International Federation of the Red Cross/Red Crescent Societies
IGBP	International Geosphere-Biosphere Programme (of the ICSU)
IGOS-P	Integrated Global Observation Strategy Partnership. (includes CEOS, FAO, GCOS, GOOS, GOS/GAW, GTOS, ICSU, IGBP, IGFA, IOC, UNESCO, UNEP, WCRP, WMO)
IHDP	International Human Dimension Programme
IKONOS	Observing system (commercial)
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
InSAR	Interferometric synthetic aperture radar
IOC	Intergovernmental Oceanographic Commission of UNESCO
IOCCP	International Ocean Carbon Coordination Project
IPCC	Intergovernmental Panel on Climate Change.
IRI	International Research Institute for Climate Prediction
ISCGM	International Steering Committee for Global Mapping
ISDR	International Strategy for Disaster Reduction
ISO	International Organization for Standardization
ITU	International Telecommunication Union
ITU-R	Radio Communication Sector of the International Telecommunication Union
IUCN	International Union for the Conservation of Nature
IWC	International Waterbird Census
IWRM	Integrated Water Resource Management
K-NET/KIK/NET	Observing system (Japan)
LANDSAT	Observing system (United States)
LiDAR	Light detection and ranging
LOICZ	Land-Ocean Interactions in the Coastal Zone Project (of the IGBP)
MAB	Man and Biosphere Programme of UNESCO
MDG	Millennium Development Goals
MJO	Madden-Julian Oscillation
NASA	National Aeronautic and Space Administration (United States)
NGOs	Non-governmental organizations
NOAA/OAR	National Oceanic and Atmospheric Administration/Office of Oceanic and Atmospheric Research (United States)
NPOESS	The National Polar-orbiting Operational Environmental Satellite System (United States)
NWP	Numerical weather prediction
OBIS	Ocean Biogeographic Information System
ODA	Official development assistance

OECD	Organization for Economic Co-operation and Development
OGC	OpenGIS Consortium
PAGE	Pilot Analysis of Global Ecosystems
PDO	Pacific Decadal Oscillation
QA/QC	Quality assessment/quality control
RRR	Rolling Review of Requirements
SADC	Southern Africa Development Committee
SAR	Synthetic aperture radar
SDI	Spatial Data Infrastructures
SFGC	Space Frequency Co-ordination Group
SOLAS	Surface Ocean - Lower Atmosphere Study
SPOT	Observing system (France)
SRTM	Shuttle Radar Topography Mission of NASA
SST	Sea-surface temperature
TIGER	Earth Observation for Water Resources Management in Africa
UDDI	Universal Description, Discovery, and Integration
UML	Unified Modeling Language
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Education, Science and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WCRP	World Climate Research Programme
WFS	1996 World Food Summit
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization
WSDL	Web Services Definition Language
WSSD	World Summit on Sustainable Development 2002
WWF	World-Wide Fund for Nature or World Wildlife Fund
XML	Extensible Markup Language

ANNEX 1
DECLARATION

DECLARATION OF THE EARTH OBSERVATION SUMMIT

We, the participants in this Earth Observation Summit held in Washington, DC, on July 31, 2003:

Recalling the World Summit on Sustainable Development held in Johannesburg that called for strengthened cooperation and coordination among global observing systems and research programmes for integrated global observations;

Recalling also the outcome of the G-8 Summit held in Evian that called for strengthened international cooperation on global observation of the environment;

Noting the vital importance of the mission of organizations engaged in Earth observation activities and their contribution to national, regional and global needs;

Affirm the need for timely, quality, long-term, global information as a basis for sound decision making. In order to monitor continuously the state of the Earth, to increase understanding of dynamic Earth processes, to enhance prediction of the Earth system, and to further implement our environmental treaty obligations, we recognize the need to support:

(1) Improved coordination of strategies and systems for observations of the Earth and identification of measures to minimize data gaps, with a view to moving toward a comprehensive, coordinated, and sustained Earth observation system or systems;

(2) A coordinated effort to involve and assist developing countries in improving and sustaining their contributions to observing systems, as well as their access to and effective utilization of observations, data and products, and the related technologies by addressing capacity-building needs related to Earth observations;

(3) The exchange of observations recorded from *in situ*, aircraft, and satellite networks, dedicated to the purposes of this Declaration, in a full and open manner with minimum time delay and minimum cost, recognizing relevant international instruments and national policies and legislation; and

(4) Preparation of a 10-year Implementation Plan, building on existing systems and initiatives, with the Framework being available by the Tokyo ministerial conference on Earth observations to be held during the second quarter of 2004, and the Plan being available by the ministerial conference to be hosted by the European Union during the fourth quarter of 2004.

To effect these objectives, we establish an *ad hoc* Group on Earth Observations and commission the group to proceed, taking into account the existing activities aimed at developing a global observing strategy in addressing the above. We invite other governments to join us in this initiative. We also invite the governing bodies of international and regional organizations sponsoring existing Earth observing systems to endorse and support our action, and to facilitate participation of their experts in implementing this Declaration.

(Adopted 31 July 2003)

ANNEX 2
FRAMEWORK DOCUMENT

From Observation to Action—

Achieving Comprehensive, Coordinated, and Sustained Earth Observations for the Benefit of Humankind

Framework for a 10-Year Implementation Plan

As adopted by Earth Observation Summit II
25 April 2004

1. Introduction

Understanding the Earth system—its weather, climate, oceans, land, geology, natural resources, ecosystems, and natural and human-induced hazards—is crucial to enhancing human health, safety and welfare, alleviating human suffering including poverty, protecting the global environment, and achieving sustainable development. Data collected and information created from Earth observations constitute critical input for advancing this understanding. In 2003, a consensus emerged among governments and international organizations that, while supporting and developing existing Earth observation systems, more can and must be done to strengthen global cooperation and Earth observations. This Framework Document, while not legally binding, marks a crucial step in developing the 10-Year Implementation Plan for the creation of a comprehensive, coordinated, and sustained Earth observation system or systems as envisioned by the Washington Declaration adopted at the Earth Observation Summit of 2003.

2. Benefits of Comprehensive, Coordinated and Sustained Earth Observations

Observing and understanding the Earth system more completely and comprehensively will expand worldwide capacity and means to achieve sustainable development and will yield advances in many specific areas of socio-economic benefit, including:

- 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.

2.2 Globally, these benefits will be realized by a broad range of user communities, including (1) national, regional, and local decision-makers, (2) relevant international organizations responsible for the implementation of international conventions, (3) business, industry, and service sectors, (4) scientists and educators, and (5) the general public. Realizing the benefits of coordinated, comprehensive, and sustained Earth observations (i.e. the improvement of decision-making and prediction abilities) represents a fundamental step toward addressing the challenges articulated in the declarations of the 2002 World Summit on Sustainable Development and fulfilling the Millennium Development Goals agreed at the Millennium Summit in 2000.

2.3 Full participation of developing country members will maximize their opportunities to derive real benefits in the above socio-economic areas. Such participation is supported as it enhances the capacity of the entire Earth observation community to address global sustainable development challenges.

3. Key Earth Observation Areas

3.1 Coordinated and sustained global cooperation on Earth observations is well established in the crucial area of weather. The World Meteorological Organization's World Weather Watch demonstrates the value of international collaboration in this arena. Improvements in observation networks are still needed and will yield further success through improved accuracy in weather information and long-term prediction.

3.2 Cooperation is less advanced in the areas of land, water, climate, ice, and ocean observation. Nevertheless, some important work and guidance for future action has been developed in a number of areas, for example:

(a) Natural hazard understanding through a range of international observing and early warning systems consistent with the International Strategy for Disaster Reduction (ISDR);

(b) Climate understanding and research through the World Climate Research Program (WCRP), and climate monitoring consistent with the Global Climate Observing System (GCOS) in support of the Conference of Parties (COP) of the United Nations Framework Convention on Climate Change (UNFCCC);

(c) Ocean monitoring, modeling and forecasting through the Global Ocean Observing System (GOOS);

(d) A range of observation themes addressed by the Integrated Global Observing Strategy Partnership (IGOS-P) including oceans; carbon; water cycle; solid earth processes, coastal zone (including coral reef); atmospheric chemistry; and land/biosphere.

3.3 In each of these areas, observation efforts to understand dynamic Earth processes have been identified and should be expanded to support action-oriented solutions in the areas of key socio-economic benefit.

4. Shortcomings of Current Observation Systems

4.1 Human knowledge of the Earth system, although advanced in certain areas, is far from complete. Current efforts to observe and understand the Earth system must progress from the separate observation systems and programs of today to coordinated, timely, quality, sustained, global information—developed in accordance with compatible standards—as a basis for future sound decisions and actions.

4.2 Many international organizations and programs are working to sustain and improve the coordination of Earth observations. However, current efforts to capture Earth observation data are limited by (1) a lack of access to data and associated benefits especially in the developing world, (2) eroding technical infrastructure, (3) large spatial and temporal gaps in specific data sets, (4) inadequate data integration and interoperability, (5) uncertainty over continuity of observations, (6) inadequate user involvement, (7) a lack of relevant processing systems to transform data into useful information, and (8) insufficient long term data archiving.

5. What is Needed - The 10-Year Implementation Plan for Earth Observations (2005-2014)

5.1 To achieve the many benefits of coordinated Earth observations and to move from principles to action, governments adopting this Framework Document set forth the primary components of a 10-Year Implementation Plan for establishing the Global Earth Observation System of Systems (GEOSS). GEOSS will be:

- *comprehensive,* by including observations and products gathered from all components required to serve the needs of participating members;
- *coordinated*, in terms of leveraging resources of individual contributing members to accomplish this system, whose total capacity is greater than the sum of its parts;
- *sustained,* by the collective and individual will and capacity of participating members.

5.2 GEOSS will be a distributed system of systems, building step-by-step on current cooperation efforts among existing observing and processing systems within their mandates, while encouraging and accommodating new components. Participating members will determine ways and means of their participation in GEOSS. The 10-Year Implementation Plan for GEOSS will be based on the following considerations:

(a) With the socio-economic benefits identified in Section 2 as the roadmap, the 10-Year Implementation Plan will identify, document, and prioritize actions to address user requirements for current and future Earth observations. This process will be based on appropriate dialogue and procedures, taking advantage of and building upon the experience of existing initiatives and infrastructures.

(b) The architecture model will build incrementally on existing systems to create a distributed system of systems, incorporating an observation component, a data processing and archiving component, and a data exchange and dissemination component.

(c) The 10-Year Implementation Plan will elucidate practical methods for filling critical gaps in, *inter alia*, observation parameters, geographical areas, observation specifications, and accessibility.

5.3 The GEOSS will address key challenges of data utilization, including the need for:

- Full and open exchange of observations with minimum time delay and minimum costs, recognizing relevant international instruments and national policies and legislation;
- Assured data utility and usability (including thresholds for validation, calibration, and spatial and temporal resolution);
- Assured continuity and availability of the many observations and products in place or planned;
- A robust regulatory framework for Earth observations (e.g. through protection of radio frequency bands that are uniquely essential for Earth observations).

5.4 The plan will facilitate both current and new capacity building efforts, particularly in developing countries, across the entire continuum of GEOSS activities, which will include education, training, institutional networks, communication, and outreach as fundamental to those efforts. Building on existing local, national, regional, and global capacity building initiatives, GEOSS will:

(a) Focus on training and education for the development and/or utilization of existing human, institutional, and technical capacities for data utilization;

(b) Develop the infrastructure resources necessary to meet research and operational requirements;

(c) Build on globally accepted sustainable development principles – most notably those outlined in the World Summit on Sustainable Development Plan of Implementation.

5.5 The development of GEOSS should take maximum advantage of developments in research and technologies. Conversely it will enable the global scientific community to address key scientific questions concerning the functioning of the Earth system.

6. Outcomes

6.1 The success of the 10-Year Implementation Plan will be measured by the operational achievement of GEOSS. Specific outcomes for GEOSS, both short and long-term, will be elaborated in the 10-Year Implementation Plan, including but not limited to the following:

(a) Enabling global, multi-system information capabilities for each of the following:

- disaster reduction, including response and recovery;
- integrated water resource management;
- ocean monitoring and marine resources management;
- air quality monitoring and forecasting;
- biodiversity conservation;
- sustainable land use and management.

(b) Global tracking of invasive species;

(c) Comprehensive monitoring of global and regional climate on annual, decadal, and longer time scales, and enabling information products related to climate variability and change;

(d) Improving the coverage, quality, and availability of essential information from the *in situ* networks and improving the integration of *in situ* and satellite data;

(e) Involvement of users from developed and developing countries, monitoring their needs and fulfillment over time;

(f) An outreach mechanism to actively demonstrate the usefulness of Earth observation to decision makers in key user communities.

7. The Way Forward

7.1 The adoption of this Framework Document indicates a decision to proceed with the elaboration of the GEOSS 10-Year Implementation Plan along the lines set forth in this Document and a willingness to cooperate on, and participate in, the implementation of the plan. At present, the *ad hoc* Group on Earth Observations (GEO) is a "best efforts" activity with voluntary input from States and advice and support from international organizations.

7.2 For 2005 and beyond, the implementation of the "10-Year Implementation Plan" will require a ministerial-guided successor mechanism with maximum flexibility—a single intergovernmental group for Earth observations drawing on the experience of the *ad hoc* GEO, with membership open to all interested governments and the European Commission, and with representatives of relevant international organizations taking part.

7.3 The GEOSS 10-Year Implementation Plan will elaborate details for this Group, which will provide generally for:

(a) Coordination and planning of GEOSS implementation (*in situ* and remotely sensed);

(b) Opportunities for engagement of all members and relevant international and regional organizations;

(c) Involvement of user communities;

(d) Measuring, monitoring, and facilitating openness of GEOSS to improve cross-flow of observations and products;

(e) Co-ordination and facilitation of the development and exchange of observations and products between members and relevant international and regional organizations.