A Revised Strategy for GOFC-GOLD

Prepared by

John R. Townshend and Michael A. Brady

With contributions from

Ivan A. Csiszar

Johann G. Goldammer

Martin Herold

Christopher O. Justice

Murugi K. Larsen

Christiane Schmullius

David L. Skole

January 2006

GOFC-GOLD Report No. 24

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and other land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management.

GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality.

GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GOFC-GOLD Secretariat is hosted by Canada and supported by the Canadian Space Agency and Natural Resources Canada. Other contributing agencies include NASA, ESA, START and JRC. Further information can be obtained at http://www.fao.org/gtos/gofc-gold

Executive Summary

GOFC-GOLD is an organization with an ambitious, multifaceted international strategy to bring the Earth's land cover including forests under continuous observation. It has a vision to share data, information and knowledge, leading to informed action and decision making. It consists of a coordinated program of activities to ensure that earth observation and other data are used effectively for global monitoring of terrestrial resources and the study of global change.

This document presents a revised strategy document for GOFC-GOLD. It contains many of the components of the first strategic document prepared in 1999. It differs, however, from the earlier document in identifying more specifically the roles that GOFC-GOLD, as an international coordination organization, should play.

As an international coordination body for observations it is essential to distinguish the roles of GOFC-GOLD from those of the predominantly national bodies that actually collect the observations. The strategy outlines the primary roles essential to ensure the global systematic collection of observations for the two main themes of land cover characteristics and change, and fire mapping and monitoring. It attempts to provide, as part of the revised strategy, a comprehensive list of the types of functions that GOFC-GOLD has carried out or could potentially carry out.

The principal goals for GOFC-GOLD were set out approximately 5 to 6 years ago. The revised strategy summarizes the extent to which these goals have been met. Substantial advances have been made in recent years. In some cases there is already a commitment to long term operational measurement and product generation as a result of GOFC-GOLD activities.

GOFC-GOLD initially focused on defining the requirements for observational products and their specifications, mainly for the needs for global change science and the natural resources communities. More recently, GOFC-GOLD has also directed its efforts towards addressing the needs for terrestrial observations for the following initiatives:

- International environmental conventions such as United Nations Framework Convention on Climate Change, United Nations Convention to Combat Desertification, Convention on Biological Diversity, Ramsar Convention on Wetlands
- Implementation Plan for the Global Climate Observing System
- Land theme of the Integrated Global Observing Strategy
- Societal benefit areas of the Global Earth Observation System of Systems
- Proposed international Land Earth Observation Satellite network composed of multiple satellites with 30-m (or better) capabilities

The goals of GOFC-GOLD, revisited and reported in the strategy document, are to be progressed further largely through Regional Networks, i.e. voluntary groups of scientists within a specific geographic region, whose work is directly relevant for GOFC-GOLD's mission. In addition, GOFC-GOLD has two so-called Implementation Teams, dedicated to globally implement relevant activities on Land Cover and Fire, respectively.

Acknowledgements

The revised strategy document was discussed at length during the GOFC-GOLD Third Scientific and Technical Board meeting held from 19-22 April 2005 at Beijing, China. We are grateful to the following participants who reviewed the document: Alfred De Gier, Ashbindu Singh, Garik Gutman, John Latham, Paul Briand, Laura Frulla, Sergey Bartalev, Gowda S.K. Ramalinge, Alan Belward, Didier Devers, Pauline Dube, Paul Desanker, Mastura Sharifah, Tsolmon Renchin, Olga Krankina, Toshio Koike, Congbin Fu, Jiyuan Liu, Liu Rui, Cao Chunxiang, Zhu Zhongli, Zhang Guocheng, Li Zengyuan, Pei Jun Shi, Shao Liqin, Jing Guifei, Joon Kim, Kim Song Chol, Vladimir Gershenzon, Jiaguo Qi, Shuming Bao, and Li Mengxue. Appreciation goes to the National Remote Sensing Centre of China for hosting the meeting.

We wish to express our gratitude to the following principal sponsors of GOFC-GOLD for their financial support and guidance: Canadian Space Agency; Natural Resources Canada, Canadian Forest Service; Center for Global Change and Earth Observations, Michigan State University; Committee on Earth Observation Satellites, Land Product Validation Subgroup of the Working Group on Calibration and Validation; European Commission Joint Research Centre; European Space Agency; Global Terrestrial Observing System; Food and Agriculture Organization of the United Nations; Friedrich-Schiller University, Jena; Global Fire Monitoring Center; International Strategy for Disaster Reduction; National Aeronautics and Space Administration; United States; SysTem for Analysis, Research and Training; and the University of Maryland.

Citation of the report:

Townshend, J.R. and M.A. Brady 2006. A Revised Strategy for GOFC-GOLD. Report no. 24. Edmonton: Natural Resources Canada-Canadian Forest Service. 47 pp.

The GOFC-GOLD document series and other information can be found at the Web site: http://www.fao.org/gtos/gofc-gold

A Revised Strategy for GOFC-GOLD

Contents

List of Figures

List of Tables

1. INTRODUCTION

At the beginning of the 21st century, there is a growing global consensus that the cumulative effects of past and present human activities are having a global impact on the Earth's ecosystems, atmosphere, and climate, and on the ability of environmental systems to support sustainable development. We need to improve our knowledge of biophysical and social systems and change policies and management practices throughout a broad range of human activities. A key, underpinning requirement to support these activities is to have systematic long-term observations of the environment.

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) as an organization, has as its mission the international coordination needed to ensure systematic long-term observations of land cover and forest change, including the role of fire. Originally it was set up to coordinate the monitoring of forests and hence the original name of Global Observation of Forest Cover (GOFC) but has been extended to all land cover types (see section 4.3). Its remit was broadened at the 2nd meeting of its Scientific and Technical Board to include all types of land cover. One significant practical reason for this is that some definitions of forests, such as that of the FAO, include canopy cover as low as 10%, so that to include all land cover types represents a relatively modest extension in areal terms of the organization's scope. The organization's name reflects both its original focus on forests and its remit to consider all land cover types.

GOFC-GOLD works largely through Regional Networks, i.e. voluntary groups of scientists within a specific geographic region, whose work is directly relevant for GOFC-GOLD's mission. In addition, GOFC-GOLD has two so-called Implementation Teams, dedicated to globally implement relevant activities on Land Cover and Fire, respectively.

GOFC-GOLD is now one of the Panels of the Global Terrestrial Observing System (GTOS), an organization sponsored by four UN bodies, namely the Food and Agricultural Organization (FAO), the United Nations Educational Scientific and Cultural Organization (UNESCO), the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) and also the International Council for Science (ICSU), which is non-governmental.

This document presents a revised strategy document for GOFC-GOLD. It contains many of the components of the earlier strategic document written some 6 years ago (Ahern et al 1999)[1]. However it differs from the earlier document in identifying more specifically the roles that GOFC-GOLD, as an international coordination organization, should play.

In reading this document those less familiar with GOFC-GOLD should also consult the GOFC-GOLD planning documents listed in Appendix 1 and found at http://www.fao.org/gtos/gofc-gold/series.html. Report 2 provides the initial strategy document (Ahern et al 1999) accompanied by separate documents on coarse and fine resolution product design strategies (Skole et al 1998, Loveland et al 1998). This site also contains reports of the development of regional networks and of the Land/Forest Cover and Fire Implementation Teams.

[1] When the original strategy document was written there were extensive references to CEOS since at that time the organization was subsidiary to CEOS. Now it is a Panel of the Global Terrestrial Observing System and hence these references have been largely replaced.

2. THE NEED FOR GOFC-GOLD

2.1. The Role of GOFC-GOLD

GOFC-GOLD is an organization with an ambitious, multifaceted international strategy to bring the Earth's land cover including forests under continuous observation. It has a vision to share data, information and knowledge, leading to informed action and decision making. It consists of a coordinated program of activities to ensure that earth observation and other data are used effectively for global monitoring of terrestrial resources and the study of global change. It represents an international organization bringing together space agencies, international coordinating organizations, researchers and end users. It operates through a network of scientific groups and participants implementing coordinated demonstration and operational projects. Its goals will be achieved through a long-term process of building an improved match between data products and services compatible with user needs.

2.2. Fundamental Drivers of the Work of GOFC-GOLD

Observations are not collected for their own sake. The expense and effort to make globally representative observations can only be justified because they contribute to high-level goals relating to societal benefits. Table 1 summarizes some of the beneficial outcomes associated with a subset of the societal benefits identified under the recently agreed Global Earth Observing System of Systems (GEOSS). It is little exaggeration to state that there are few uses of the terrestrial environment where reliable information on land cover and land cover change is not needed. We would add to the high level societal benefits identified through GEOSS the importance of forests for the material well-being of societies and the significance of ecosystem services relating to areas as diverse as climate change, water quality and aesthetic values that they provide as well as their importance in understanding the operation of the Earth system.

Table 1. Societal Benefits, Requirements, and Earth Observation Systems.

GEOSS Topic	Examples of specific GOFC-GOLD products
Reducing Loss of Life and Property from Natural and Human Induced Disasters	Early warning systems for fires
Understanding, Assessing, Predicting, Mitigating and Adapting to Climate Variability and Change	Role of forest change on carbon sequestration; monitoring compliance with Kyoto Protocol
Improving the Management and Protection of Terrestrial, Coastal and Marine Ecosystems	Monitoring of terrestrial ecosystems using satellite observations
Supporting Sustainable Agriculture and Combating Desertification	Identifying changes in agricultural land cover
Understanding, Monitoring and Conserving Biodiversity	Monitoring protected areas and the landscapes within which they are found

2.3. The Role of Terrestrial Observational Products

Realizing the benefits outlined in section 2.2 relies on an integrated use of observations, their transformation into products, their assimilation into models, effective model design and their use in assessments, decision-support systems for managers of the environment, and the presentation of the information into clear and user-friendly products, suitable to support policy making. Success depends on a balance between all these components. Sometimes improved observations may be needed; sometimes it may be an issue of improved models. In general although there are enormous numbers of observations collected both from remote sensing and in situ observations there are relatively few observations collected that are consistent at global or regional scales and are suitable for reliable detection of change. GOFC-GOLD needs to focus on the improvements in terrestrial observations crucial to achieving societal benefits such as those outlined in table 1.

Scientists investigating of global change require global, regional, and local observations of forests and other land cover types to develop a better understanding of the complex, inter-related processes involved. At the same time, policy makers need to realize that we cannot afford to wait until all of the scientific questions are solved.

2.4. Principal Roles of GOFC-GOLD

Ultimately the goal is to ensure the long-term spatially and temporally consistent land cover information. The principal roles of GOFC-GOLD in this goal are to increase international cooperation in the standardization, integration and use of data from multiple earth observation satellites, in conjunction with in-situ data, for mapping and monitoring the earth's forests, and to provide feedback to agencies responsible for space and in situ observations to enable them to improve the quality of observations. GOFC-GOLD is working to develop the means to undertake sustained, operational inventories of land cover, fire and selected biophysical characteristics.

As part of this process, GOFC-GOLD assembles teams to execute prototype projects, develop consensus algorithms and standard methodologies for product generation and product validation in conjunction with in-situ measurements, and develop and demonstrate procedures for improved data access for the user community.

As a consequence, GOFC-GOLD identifies gaps and overlaps in earth observation data, ground systems, methods, and scientific knowledge from the experience gained in developing and executing GOFC-GOLD prototype projects. Additionally, GOFC-GOLD seeks to achieve the following:

- creating and strengthening partnerships between space agencies and user agencies;
- identify gaps and overlaps in space agency programs and make recommendations how these might be resolved;
- increase operational use of earth-observation data for policy decision making at national, regional, and global levels;
- ensure the provision of validated products which can be used to derive credible information concerning the forest/land cover component of the carbon budget for research and policy use;

- promote common data processing standards and interpretation methods, which are necessary for inter-comparison of regional studies;
- stimulate advances in the state of the art in the management and dissemination of large volume datasets and information from multiple sensors;
- use data from multiple sensors, in combination with in-situ data, to produce validated prototype information products, which satisfy clearly identified requirements of user agencies;
- enhance the use of earth-observation information products for forest land use and that other and cover types and enhance scientific research concerning forest biophysical processes; and
- strengthen capacity building, at both science and at user level in the application and use (policy and management level) of remote sensing, in-situ and GIS products.

3. ORIGINS OF GOFC-GOLD

The design of GOFC-GOLD arose from substantial earlier efforts to monitor the earth's land cover and especially its forests. The following are some of the important precursor activities identified in the original strategy document for GOFC prepared for CEOS (Janetos and Ahern, 1997). The remainder of this section is based closely on this document.

The World Forest Watch Conference held in São José dos Campos, Brazil (June 1992) provided an initial high-level international forum for the assessment of current approaches to satellite-based monitoring. This meeting also served as a basis for forwarding recommendations from the technical and scientific communities to the policy makers and government leaders at UNCED, and the international global change research community through IGBP. The conference concluded that significant technical and methodological advances have been made in recent years, and they were sufficient to proceed with an observation system, which could satisfy both scientific and national-level forest management requirements.

NASA, in conjunction with the US-EPA and USGS, undertook a prototype procedure for using large amounts of high resolution satellite imagery to map the rate of tropical deforestation, one of the most important land cover changes. This activity, called the Landsat Pathfinder Project built on experience gained during a proof-of-concept exercise as part of NASA's contribution to the International Space Year/World Forest Watch Project (Skole and Tucker, 1993) (Townshend et al., 1995). It focused initially on the Brazilian Amazon, and was expanded as part of NASA's Earth Observing System activities to cover other regions of the humid tropical forests. In principle, it provided an initial large-scale prototype of an operation program.

The TRopical Ecosystem Environment Observations by Satellites (TREES) project was implemented as a demonstration of the feasibility of applying space observation techniques to monitoring of land cover and biomass burning (Malingreau et al., 1993). This project utilized global coverage with a wide range of sensors including AVHRR, ERS-SAR, JERS-1 SAR, ATSR, Resurs, Landsat, and SPOT. It also focused on the use of thermal sensors for the detection of fires, and incorporated other indicators of deforestation.

In conjunction with NOAA and the USGS, NASA supported an IGBP project to acquire global, daily coverage with the AVHRR sensor at 1 km resolution (Eidenshink and Faundeen, 1994; Townshend et al., 1994). This project was the first of its kind to acquire global, daily coverage at this resolution. The resultant dataset was processed at the EROS Data Center and provided the basis

for globally mapping land cover, vegetation phenology and fires. As part of a land-cover mapping exercise, this project eventually led to the DISCover global land cover data set (Belward et al., 1999; Loveland et al., 2000).

The FAO Forest Resource Assessment for the 1990 period (FRA-90) used a combination of earth observation data and national statistics to derive statistics about forest cover for the 1990 datum, and forest cover change for the period 1980 to 1990 (FAO 1995). For tropical forests, FAO developed a technique called the Interdependent Interpretation Procedure, which relied primarily on a two-date interpretation of large-scale photographic prints of full Landsat scenes. Using training centers in Latin America, Africa, and Asia, FAO was able to train local interpreters and obtain consistent results. The resulting change classes also allowed FAO to estimate transitions between several woody biomass categories for Africa, Latin America and Asia (FAO 1996). Subsequently the FRA 2000 assessment has been reported (FAO 2001), though with concern expressed about its accuracy (Matthews 2001).

An early major example of a regional /continental scale land cover mapping study was the USFS /USGS US Forest Cover Map. This map was produced using the 1km AVHRR data set generated by (Loveland et al., 1991). A similar effort was undertaken in Mexico with the help of in-country collaborators. An Interagency Multi-Resolution Land Characterization (MRLC) project, implemented by the USGS on behalf of a number of federal agencies, subsequently generated land cover data sets for the conterminous US. This data set included products from coarse and high spatial resolution satellite sensors. This project also provided complete coverage of the United States with Landsat Thematic Mapper data.

Within the framework of NASDA's Global Forest Mapping Program, the Global Rain Forest Mapping project was a collaboration between NASDA, JPL and the Joint Research Centre with the aim of generating JERS-1 L-band SAR data sets of the global tropical forests. A complete SAR coverage over the tropical belt - in total some 13,000 scenes - was acquired in 1995-96, including multi-temporal coverages over the Amazon and Congo river basins to capture season effects and to map inundation in flooded forests. SAR mosaics at 100 m resolution were generated to cover the tropical region in all three continents. The mosaics were radiometrically and geometrically corrected, though not for topographical effects.

Starting in 1997, the Global Boreal Forest Mapping Project (GBFM) formed a follow-on project to the GRFM. The GBFM project aimed at covering the boreal forests in Siberia, Northern Europe and North America with JERS-1 SAR Also the GBFM project is a joint effort by NASDA, NASA/JPL/ASF and the JRC, with collaboration from DLR, the National Swedish Space Board, CCRS, and CSA.

The Canadian Radarsat program acquired complete global coverage in the ScanSAR mode during its initial phase of operations (Mahmood et al., 1998). An associated research program was initiated to demonstrate applications, including applications to forest are research. Research showed that Radarsat held promise for mapping logging and deforestation in tropical and boreal forests (Ahern et al., 1997; Kux et al., 1997; Shimabukuro et al., 1997) and for monitoring macrophyte growth in tropical reservoirs and floodplains (Costa et al., 1997).

Many regional land cover mapping activities were initiated in the 1990s. Within the IGBP System for Analysis, Research and Training (START) a number of regional activities focusing on the land cover change question were begun. Most notable were the Southeast Asian and Southern Africa regional activities (IGBP 1997).

These various initiatives led to the formulation of an overall observational strategy for the monitoring of land cover change (Skole et al., 1997), which contains many of the elements of the subsequent GOFC-GOLD programs.

4. USER NEEDS

The user needs for consistent and reliable information on land cover are summarized in Table 2, taken from the early strategy documents of GOFC-GOLD. Note that different user groups may have different needs even for the same variable. (e.g. annual monitoring for natural resource managers is often needed whereas semi-decadal monitoring is likely sufficient for some global change scientific problems.)

Table 2. Main user communities for forest and other land cover information (adapted from Janetos and Ahern, 1997).

(1) Timber, fuel, and fiber. For centuries, human society has depended critically on the continued supply of wood and fiber from forest land. Many societies have declined after depleting their forest resources (Perlin 1991). The twentieth century produced substantial improvements in the efficiency of production of wood and fiber from forests. Increasing populations and increasing literacy and affluence in the twenty-first century will continue to put increasing demands on the forests of the world. Continued improvements in forest management will be necessary to meet these demands without depleting the forest resource (Nyland 1996)
(2) Watershed Protection. Forested areas and other wooded lands play a crucial role for terrestrial hydrological systems (Hammond 1991; Nyland 1996). These areas constitute the most important buffer zones for both runoff and infiltration to ground water reserves. The actual location and size of forests in relation to the watershed often determines the run-off fraction of the precipitation and becomes the dominant factor in flood and erosion prevention. Close monitoring of forests in relation to the hydrographic network thus becomes a critical issue in physical planning, landscape planning, and environmental protection in all regions of the world.
(3) Biodiversity. Concern over the rapid, human-driven loss of biodiversity worldwide is rapidly mounting, culminating in the International Convention on Biological Diversity. The extent and condition of forested lands are central issues to the preservation and sustainable use of biodiversity. The scientific community has implicated both forest loss and forest fragmentation in losses of biodiversity. On the other hand, many national programs for sustainable forest management are now incorporating biodiversity as one of the attributes to be enhanced and maintained.
(4) FCCC and other environmental treaties. As a result of the FCCC and its Kyoto Protocol, particular emphasis is placed on reforestation, afforestation, and deforestation. Several other international environmental agreements apart from the CBD require reliable land cover and fire information the Convention to Combat Desertification and Ramsar among others.

Table 2 continued

(5) Recreation and Tourism. Forests provide habitat for wildlife, and opportunities for recreation and tourism. In many countries, the direct economic return from these activities approaches the return from extraction of wood and fiber. Many other countries want to increase the benefits they derive from recreation and tourism. Information obtained from Earth observation data can aid in the strategic planning for recreation and tourism in forested areas.
(6) Sustainable Forest Management. Sustainable forest management has become an extremely important philosophy, along with ecosystem management, to guide the plans of land-managers (both public and private) for the use of forested lands over the next several decades. Sustainable forest management recognizes the multiple benefits provided by forests, and strives to respond to the needs and wants of the multiple stakeholders who benefit from the forest, while conserving its resources so future generations can also benefit from the forest. Earth observation data, in conjunction with geographic information systems, provides exciting new opportunities to engage a broad spectrum of stakeholders in long-term forest management planning.
(7) Fire response systems. Increasing use of near real time information from satellites is being made primarily reliant on data from MODIS at present but with the potential to be used by many other systems. Primarily information is used for strategic allocation of human and material assets in fire fighting but they are also used tactically as well for example in South Africa.
(8) Global Change. There are three pathways of relevance for global change and forest lands with implications. (Turner II et al. 1995). The first is the interaction of forests and the atmosphere: regulation of the hydrologic cycle and energy budget, with implications for weather and climate prediction. Understanding these interactions is a crucial part of the global change science agenda. The second is both a scientific and policy issue: the implications of changes in forest land for the atmospheric carbon dioxide budget. Are forested lands net sources of carbon or net sinks of carbon? What are the rates of deforestation and reforestation? What are the implications of changes in fire frequency? The third pathway is the potential impacts of climate change: what effect will changes in temperature, precipitation, and concentrations of carbon dioxide and other radiatively active gases have on forest composition, productivity, health, and distribution, and therefore on the economic activities that are generated by forested lands? What feedbacks might these changes have to the climate system itself?

Capacity building is a necessary component of the above user needs in order to facilitate the acquisition and processing, as well as the uptake and effective use of the information.

5. THE INTERNATIONAL CONTEXT OF GOFC-GOLD

The current international organization of panels, committees and commissions relating to earth observations is quite complex and in a state of flux. It is beyond the scope of this document to articulate the eventual arrangements and it has to be recognized that some of the roles of the organizations described below may change and that GOFC-GOLD may also have changing responsibilities.

GOFC-GOLD (initially named GOFC) was originally set up by CEOS as a prototype IGOS activity. With the setting up of the IGOS Partnership after the prototype phase, the latter sought broader

themes and GOFC-GOLD found its home as a panel of the GTOS, whose main sponsor is FAO and which is also sponsored by UNEP, WMO and ICSU. GTOS has other panels including the Terrestrial Observing Panel for Climate and the Terrestrial Carbon Observing (TCO) panel.

GOFC-GOLD has at various times, as appropriate, worked closely with Working Groups of CEOS, notably the Working Group on Calibration and Validation's Land Product Validation sub-group and the Working Group on Information Systems and Services.

At a high level, observations are coordinated through the Integrated Global Observing Strategy Partnership (IGOS-P) and the recently founded Global Earth Observing System of Systems (GEOSS).

IGOS-P's work is organized through a series of Themes, including Oceans, Carbon, Water Cycle Coasts and Natural Hazards. In 2004 it was decided that IGOS-P should have an additional theme so that international agreement could be reached concerning all land requirements outside of those covered by other established themes. This new theme is known as Integrated Global Observations for the Land (IGOL): its work has involved considerable participation by members of GOFC-GOLD

At the present time while GEOSS is being set up, there is clearly considerable overlap between IGOS-P and GEOSS, and that given the national backing for GEOSS, the latter is likely to dominate. GEOSS is structured in terms of a number of major societal benefit areas and if the themes of IGOS-P are to continue to play a role, then some reorientation with the GEOSS benefit areas will likely become necessary. Whatever the outcome of these changes it is clear that GOFC-GOLD as an organization and its component Implementation Teams and Regional Networks have important roles to play.

A further role of GOFC-GOLD relates to the GCOS Implementation Plan now accepted by the FCCC's COP. Within this plan there are several actions assigned to GOFC-GOLD. GOFC-GOLD should also play a role in relation international environmental conventions especially the assessments (IPCC and MA) as well as broader implementation and compliance with Kyoto. In the new international coordination commission for land proposed in the GCOS Implementation Plan, GOFC-GOLD will also expect to play a role.

GOFC-GOLD should also expect to work directly with UN agencies notably with UNEP, FAO (GLCN, FRA Africover), and WMO.

6. NATIONAL CONTEXT OF GOFC-GOLD

It is ultimately nations that are responsible for the collection of observations. Considerable diversity exists in the way that observations are collected and in terms of the definition of terms such as forest cover. Such differences arise in part because of the different priorities of nations in relation to their resources.

GOFC-GOLD currently has no direct interactions with nations but achieves interactions through other inter-governmental organizations such as the FAO. In addition, the scientific members of the Regional Networks also have direct contacts with their respective governments, which will also contribute to data and information harmonization in a regional context. GTOS has no formal structure for directly interacting with nations unlike GOOS, which has a formal structure (I-GOOS) where national representatives have the opportunity to influence the strategy of GOOS and to respond to its goals.

The proposed inter-governmental terrestrial commission proposed in the GCOS Implementation Plan may provide a more direct route for GOFC-GOLD and GTOS as a whole to interact with national representatives.

In the case of remote sensing where most assets for operational observations are controlled by a relatively small number of nations, GOFC-GOLD has had success in encouraging improved collection of observations by the involvement of representatives from national space agencies in implementation teams, for example in relation to the work of the Fire Implementation Team's efforts to coordinate the processing of geostationary satellite data.

7. FUNCTIONS OF GOFC-GOLD

As an international coordination body for observations it is essential to distinguish the roles of GOFC-GOLD from those of the predominantly national bodies that actually collect the observations. This section outlines the primary roles essential to ensure the global systematic collection of observations of land cover and fire. It attempts to provide, as part of the revised strategy, a comprehensive list of the types of functions that GOFC-GOLD has carried out or could potentially carry out.

7.1. Specifying Requirements

The requirements for products need to be clearly stated in quantitative terms. They should arise from wide consultation with user communities and they should be grounded in the refereed scientific literature so far as possible. It is also desirable that the consequences of not achieving a particular specification also be clearly articulated where possible. Does the failure to reach a given accuracy level or a stated required precision mean that the observations otherwise have no value? Ideally what is needed is a statement of the reduction in value of an observation as its quality declines, but in practice this may be difficult to provide.

Many of the requirements of GOFC-GOLD arise from statements of needs derived before the organization was set up. Several derive from the work of the Data and Information System of the International Geosphere Biosphere Program (e.g., Townshend 1992). Given that most of the requirements were articulated over 5 years ago it is advisable they are all systematically revisited in the near future. An additional complication is that different users may require similar sounding products, but with different specifications. This has already been recognized to a degree by the Land Cover Implementation Team which has identified a suite of products which are similar in most respects but with very different spatial resolutions.

It is important to avoid very lengthy lists of products tuned to the needs of every conceivable stakeholder, since the result is unlikely to be persuasive to agencies responsible for generating products. It is also clear that different end-users will require products with different specifications. Those concerned primarily with observations for biophysical models may require very different inputs than those concerned with natural resources managers or governmental decision-support systems.

It is desirable to define a relatively small number of basic products, which can then be transformed to specific products tuned to particular user needs. For example, an annual land cover product at 250m resolution, which might be used to assist national forest inventories, can also be transformed into products at coarser resolutions, to suit the needs of regional and global modelers who need products at much coarser resolutions. It will be important to ensure that well-defined rules of

aggregation are defined to ensure that such users obtain the products they need. A further example from land cover is the possibility of creating products defining physiognomic characteristics as continuous fields (DeFries et al. 1999). These can then be broken out into arbitrary classes by applying user-defined thresholds.

In assessing requirements there will always be need for a practical concern with what is feasible both in technological terms and in terms of resources. A key role of GOFC-GOLD is therefore to identify the capabilities of current observational assets in meeting requirements and in assessing what improvements may be needed to match the requirements more closely. This will allow technical challenges to be clearly identified. A further important task will be to assess whether sufficient continuity of observations is guaranteed: this will allow continuity challenges to be identified. Finally in relation to requirements there needs to be an assessment of whether there are access or availability challenges, which need to be overcome for users to gain ready access to products (see section 7.3).

To ensure that the requirements of GOFC-GOLD are clearly stated and communicated a standard template should be completed and maintained for each product containing, but not limited to, the following categories:

- Name of product and units of measurement
- Spatial resolution/minimum size of mapping unit
- Temporal resolution/frequency of collection
- Accuracy and precision
- Methods of measurement/estimation, including integrated use of remote sensing and in situ observations

Defining Improved Acquisition Strategies

One of the key issues for many types of observations is in ensuring that acquisitions strategies are optimized in time and space. As an example of the importance of this issue, we point to the Long Term Acquisition Plan (LTAP) of Landsat 7, which ensured for the first time in the 25-year history of this program that global, seasonal coverage of fine-resolution data were collected. Another key issue in terms of in situ observations is what should be the spatial distribution of operational CO_2 flux towers as opposed to the current distribution of research towers.

Monitoring Progress in Meeting Requirements

GOFC-GOLD needs to monitor its own progress as described in the next section. But there is also a need for regular monitoring to determine whether key observations are being regularly collected especially where nations have agreed to do this. For example the European Medium Range Weather Forecasting Center monitors national collection of key GCOS observations such as those of the GCOS Upper Air Network (GUAN). What is less clear strategically is what is to be done when countries having agreed to collect and deliver certain sets of observations fail to do so. Neither the GCOS Surface Network (GSN) for measuring surface temperature, nor the GCOS Upper Air Network (GUAN) has as yet achieved satisfactory performance despite formal long-term commitments made by national governments (GCOS 2003).

7.2. Evaluation and Assessment of Algorithms and Data Assimilation Procedures

Raw data sets are often of limited value to most users who require higher-level products. This requires the use of algorithms to convert the data into geophysical variables. For an algorithm to be regarded as acceptable it should have been subject to independent scientific scrutiny usually through publication in the scientific literature.

For many products there has been relatively little scrutiny of the algorithms themselves, and relatively limited subsequent validation is usually carried out. For some products there has been active consideration of the algorithms used in generating products, notably in algorithms for active fire detection, especially contextual ones and also in estimating proportional cover estimation (Giglio et al., 1999). But other products and algorithms have received little consideration, as in the case of land cover change. Although the current emphasis on the quality of the end product is appropriate, there are will be benefits from a more organized consideration of the relative merits of different algorithms in particular in relation to their physical soundness.

One other issue deserving comment is that of data assimilation in part to serve the needs of modelers but also to lead to improved synthetic fields of observations. Currently assimilation for terrestrial processes is in its infancy but comparisons with atmospheric and oceanographic domains show that it is likely to become much more important in the future and that there is a need to establish improved procedures for assimilation from the numerous ones available (Liang 2003). This is undoubtedly a major future issue in the creation of improved products and GOFC-GOLD's Implementation Teams should develop plans to evaluate products derived by data assimilation and should use the results of such assimilations to guide the refining of requirements in a similar way carried out for physical oceanographic observations by the Global Ocean Data Assimilation Experiment (GODAE) (http://www.bom.gov.au/bmrc/ocean/GODAE/frames.html).

Given the proposed revised role of TCO to increase its role in data assimilation for carbon observations, GOFC-GOLD should pay close attention to its activities.

7.3. Ensuring the Availability of Observations

Assessing whether observations once collected are available can be a relatively complex issue. First there is the question of whether the observational assets are in place to provide the needed data stream. One of the continuing goals of GOFC-GOLD is to try and ensure the latter happens. However it is not until an operational agency takes responsibility that this can be considered certain. Even then unless redundancy is built into the system there may still be gaps in the record as occurred in the mid 1990s for the afternoon AVHRR.

There is a wide range of factors, which inhibit free unfettered access to useful data products. Data policy especially as it relates to costs and copyright is one major issue. The liberalization of copyright and lower costs of Landsat Enhanced Thematic Mapper data compared with products from earlier Thematic Mappers have greatly increased their use throughout the world (Goward et al., 2001). While the pricing is drastically reduced to reflect marginal cost recovery, access to large number of individual scenes adds up to a very large, possibly prohibitive, allotment of resources by the end user. Similarly, many in situ data also have to be paid for and although not necessarily individually expensive may be costly for a comprehensive data set. The current US government policy of making most satellite data available for the incremental costs of reproduction or even free if electronic means are used for acquisition is a worthy goal for all those responsible for distributing environmental data, but attention also needs to be paid to creative mechanisms to provide large

quantities in bulk, or to provide resources to directly support those laboratories or institutions which can provide large quantities to many users cost-free.

The formats of data can also hinder availability. Apart from ensuring that appropriate data standards are adhered to, including the provision of high quality meta-data, different user communities may have very different technological abilities in handling data. One recent example was the supply of MODIS products in HDF format using an integerized sinusoidal (ISIN) projection. Many users found both the format and projection sufficiently problematic to make them reluctant to move from the lower quality AVHRR products to the MODIS ones. Many data are now being made available in alternative formats and projections and software has been provided to facilitate conversion to different projections.

To ensure that appropriate products are available for all of GOFC-GOLD's user communities, the organization should work with agencies to ensure that appropriate products are being made available. It should also attempt to capitalize on existing assets such as the Global Land Cover Facility and the Tropical Rain Forest Information System in ensuring that improved optimized data products are made available. Attention should also be paid to the burgeoning GRID technologies which with their increasingly powerful middleware tools bring the prospect of providing for the user integrated data systems based on distributed, heterogeneous data systems (Foster and Kesselman, 1998).

GOFC-GOLD should also work to ensure that users have information on where products, conforming to the requirements and standards of GOFC-GOLD can be obtained. Table 3 illustrates the way in which such information can be provided for Fire products.

Table 3. Locations of GOFC-GOLD specified Fire products.

Active fire detection daily (polar):
NASA (MODIS) http://modis-fire.umd.edu/
ESA (ATSR) http://odisseo.esrin.esa.it/ionia/FIRE/AF/ATSR/
Canadian Forest Service http://cwfis.cfs.nrcan.gc.ca/en/index_e.php
Avialesookhrarna (Russia) http://www.nffc.aviales.ru/engl/main.sht
INPE (Brazil) http://www.cptec.inpe.br/products/queimadas/queimap_i.html
Sukachev Forest Institute (Russia) http://gofc-fire.umd.edu/projects/sukachev.asp
CONABIO (Mexico) http://www.conabio.gob.mx/conocimiento/hotspots/doctos/puntos_calor.html
Sentinel (Australia)
http://www.sentinel.csiro.au/sentinel.html
National Environment Agency (Singapore) http://app.nea.gov.sg/cms/htdocs/article.asp?pid=1674

Table 3 continued

Active fire detection – diurnal cycle (geostationary and polar): UW/NOAA (GOES) http://cimss.ssec.wisc.edu/goes/burn/wfabba.html NASA (TRMM/VIRS) http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/hydrology/TRMM_VIRS_Fire.shtml NOAA http://www.ssd.noaa.gov/PS/FIRE/hms.html
Burnt area: ESA http://shark1.esrin.esa.it/ionia/FIRE/BS/ATSR/ JRC http://www.grid.unep.ch/activities/earlywarning/preview/ims/gba/
Emission product suite: Naval Research Laboratory http://www.nrlmry.navy.mil/flambe/ INPE/CPTEC (Brazil) http://tucupi.cptec.inpe.br/meio_ambiente/ NOAA http://www.arl.noaa.gov/smoke/forecast.html National Environment Agency (Singapore) http://app.nea.gov.sg/cms/htdocs/article.asp?pid=1195
Fire danger rating: Canadian Forest Service http://cwfis.cfs.nrcan.gc.ca/en/index_e.php Canadian Forest Service (SE Asia) http://nofc.cfs.nrcan.gc.ca/seasia/en/index_e.html US Forest Service http://www.fs.fed.us/land/wfas/wfas23.html

Whereas there remain significant challenges in the availability of remotely sensed data, the difficulties associated with obtaining many in situ data are much greater because of their distributed nature, restrictive data policies including privacy issues as well as costs. Some initial steps have been taken. For example, GTOS is increasing awareness of the availability of in situ data through its TEMS data base (GTOS 2003) and through the US Global Change Master Directory (NASA 2003). As yet most of these efforts are at the directory or catalog level, rather than at the data base level, i.e. one can find out about data, but obtaining them normally requires interactions with multiple providers. For observational data sets to be regarded as being "available", GOFC-GOLD needs to set a minimum standard that they are openly available to any user without prejudice.

7.4. Harmonization and the Development of Protocols and Standardization

Harmonization is a process to union similarities in existing definitions to allow intercomparability between heterogeneous data sets (Herold and Schmullius 2004). The process follows a "bottom up" perspective. Beginning from a state of divergence in data sets it seeks compatibility and comparability. Harmonization does not necessarily eliminate all inconsistencies.

Standardization, in contrast, is a "top down" process. It requires common definitions and standards

to derive land cover and fire information and should eliminate all inconsistencies between the data sets. In general, data set heterogeneity in products results from different standards being used to derive them and is multifaceted. They include syntactic issues (e.g. logical data models: vector/raster), schematic heterogeneity (e.g. database models, spatial reference systems, cartographic standards) and semantic aspects.

GOFC-GOLD should ensure, by the adoption of existing procedures or in the absence of satisfactory procedures by their creation, that there is harmonization between observations, products, classification schemes, validation and QA to ensure the creation of internally consistent global and regional products.

As necessary it should also develop internationally agreed standards and protocols especially for validation. For example as part of the land cover activities a manual of procedures for validating land cover classification products is being developed. Efforts are also underway to develop agreed procedures for the validation of continuous fields products of land cover.

7.5. Ensuring that Products Meet Requirements

Accuracy assessment of products, often called validation, is widely recognized as an important component in the development of operational observations, especially those from satellites, but related procedures to establish the quality of in situ observations are also routinely carried out. Comparison of satellite products is being continued by the CEOS Cal/Val Working Group on Land Product Validation (Morisette et al., 2002). Validation has always been regarded as a key activity for GOFC-GOLD and has formed the subject of a number of workshops, notably for active fires and burn-scars (http://gofc-fire.umd.edu/products/pdfs/events/Lisbon_7_01_ExecSum.pdf) and for LAI (http://modis.gsfc.nasa.gov/MODIS/LAND/VAL/CEOS_WGCV/lai_intercomp.html). Whereas there has been agreement on the approaches that should be adopted, a routine set of procedures and implementation of a continuing validation programs have yet to be established. Nor has there been a structured comparison of the relative merits of different products of the same variable. In part this relates to the substantial costs of such work, but these costs are relatively small compared with the costs of space missions themselves.

Deciding on the relative merits of different products created that nominally meet requirements but which are derived either from different instruments or using different algorithms has the potential to be contentious. Differences between products may arise from differences in the time of sensing or due to diurnal variability. Other differences may arise due to instrument sensitivity or to differences in the performance of the algorithms. Users of these products need guidance concerning their different capabilities and merits.

Validation itself has its own challenges. Formal inter-comparisons between different products have been carried out in a number of areas including land cover and NPP. IGBP carried out extensive inter-comparisons of different NPP products (Cramer et al., 1999). Where complex models are used with different observational inputs and no universally accepted validation set then deciding on the relative merits of products and what leads to the observed differences can be very difficult.

In many respects the term “validation” is an unfortunate one since it implies that data sets are capable of being categorized as true or untrue, whereas almost all data sets hover somewhere between these two extremes. Additionally there are the practical difficulties of carrying out a comprehensive validation so we understand the reliability of a product for all geographic locations and for all time periods. In this respect it would be advisable if GOFC-GOLD adopted the scheme

proposed by the MODIS Land Team (Table 4), which represents different levels of effort (Justice 2002).

Assessing the accuracy of global products is an expensive and time consuming task and there are distinct advantages in international cooperation in terms of cost sharing and increasing the pool of available expertise for data collection (Justice 2002). Responsibility for validation lies primarily with the data producer and there is a need for accuracy assessment to be included in the overall costs of the satellite mission.

Table 4. Levels of Validation (Justice 2002).

Stage 1 Validation: product accuracy has been estimated using a small number of independent measurements obtained from selected locations and time periods. Validation assessed locally under a limited range of geographic conditions for a limited period of time.
Stage 2 Validation: product accuracy has been assessed over a widely distributed set of locations and time periods Validation assessed over a significant range of geographic conditions and for multiple time periods and seasons.
Stage 3 Validation: product accuracy has been assessed and the uncertainties in the product well established via independent measurements in a systematic and statistically robust way representing global conditions. Validation assessed over the full range of global conditions for all time periods.

GOFC-GOLD must work to ensure that all of the products it identifies as being central to its goals are validated using internationally agreed standards and that validation is carried out on a continuing basis, so that the reliability and usefulness of products are understood.

Validation, although essential, is not the ultimate way of assessing the usefulness of a given set of observations. What one really wishes to know is how much difference a product makes to the end-user. In this context “field-testing”, by incorporating new observational products into actual models or decision-making systems, may reveal the most relevant guidance of their quality.

GOFC-GOLD must work to ensure that quality assurance flags are assigned to all key products based on internationally agreed standards.

Quality assurance and continuing validation need to be a continuing effort if the long-term internal consistency of products and their relation to defined standards is to be maintained. Ideally this also should be carried out by an operational agency. In addition periodic scientific assessment of the results is also necessary. Examples of the required approach can be found in a critical review of measurements for long-term climate monitoring (Karl 1996).

7.6. Capacity Building

The Role of the Regional Networks

The Regional Networks form an important venue through which capacity-building can be achieved. Inter- and intra-regional capacity building activities should be continued and strengthened. User

driven training workshops can be organized, where current techniques are learnt. In addition to workshops, a mechanism for information exchange can be set up. Regional networks affiliated to universities or colleges in the region should provide the training that will ensure development of capacity in the long term. It is important to build capacity in all the projects related to GOFC-GOLD. Continued training where capacity exists should be maintained including study visits (Justice 1999). To ensure that capacity building is maintained the regional networks should form or strengthen their linkages and partnerships to international development agencies and organizations.

There is renewed interest in coordinating activities across regions, as well as cultivating the end-to-end stream of capacity building from product generation to application in decision support. Regional Networks have played a unique role in GOFC-GOLD. It is suggested that key products and outputs be collated and listed visibly on the GOFC-GOLD website to ensure access by all users.

The status needs of the GOFC-GOLD Regional Networks are described further in section 13.

7.7. GOFC-GOLD Products and Services

Usually it is anticipated that GOFC-GOLD will not be directly responsible for creating products. But there may be situations where this is appropriate. "GOFC-GOLD" products or services should have value-added in some way, i.e. it does not make sense for us to claim products as those of GOFC-GOLD, simply because we identified them as a requirement. Possible types of GOFC-GOLD products include the following:

- Creation of products in which there is improved detection of trends: International Satellite Cloud Climatology Product of WCRP is one such product even though it is largely funded through one agency (NASA) at one institution (GISS).
- Creation of collections of integrated data sets e.g. ISLSCP data set of GEWEX.
- Creation of specific subsets and delivery them in a timely fashion, e.g. the fire products of the GOFC-GOLD Fire IT.
- Assembly of fine resolution data sets from multiple sensors to create global coverage in anticipation of the demise of Landsat.

The Implementation Teams should consider whether the creation of GOFC-GOLD products and services is necessary for them to achieve their goals and what funding mechanisms are available to support such ventures.

7.8. Supporting International Assessments

GOFC-GOLD should provide information to assist international environmental assessments. Working with IGBP it carried out this role in relation to the Millennium Ecosystem Assessment.

It likely should play a similar role with respect to the next IPCC. To carry out such work competently this almost certainly means the raising of funds to conduct the work.

The Implementation Teams should consider the inputs they can provide to the IPCC and should work with the TOPC in relation to its interactions through GCOS to the FCCC.

7.9. Advocacy Role

GOFC-GOLD should seek to influence international and national agencies and other stakeholders to help it achieve its goals, especially in relation to the continuity of observations and validation. This

will be achieved through participation in national and international meetings and through the publication of documents describing its work. The latter will include:

- reports of its meetings (Current series of GOFC-GOLD reports – see Appendix 1);
- publications in the scientific refereed literature;
- brochures and similar materials highlighting the needs for systematic long-term land cover and fire observations; and
- creation and maintenance of web resources.

These efforts should be conducted through the work of the Implementation Teams and the Regional Networks.

8. PROGRESS IN ACHIEVING THE GOALS OF GOFC-GOLD

To move from a set of plans to the operational collection of a set of systematic long-term observations is always very challenging however important the observations (Karl 1996). In Figure 1 we provide a template showing the main stages, which have to be gone through. It should be noted that the process is almost always an iterative one. Once observational products are created and used on a regular basis they are rarely optimal for all users, nor will requirements normally remain static. It also needs to be recognized that in achieving such goals, implementation usually remains largely with specific programs in national agencies rather than with resources channeled through international organizations. Thus international observing programs need both formal and informal mechanisms to influence national agencies in terms of implementation. For example, currently the operation of all environmental satellites remains with individual space agencies. One notable exception to this is EUMETSAT, which acts on behalf of Europe's meteorological agencies and has a governing council of the member nations. The difficulties in trying to influence several different space agencies is in many respects quite minor compared with getting national agencies to become responsible for in-situ observations.

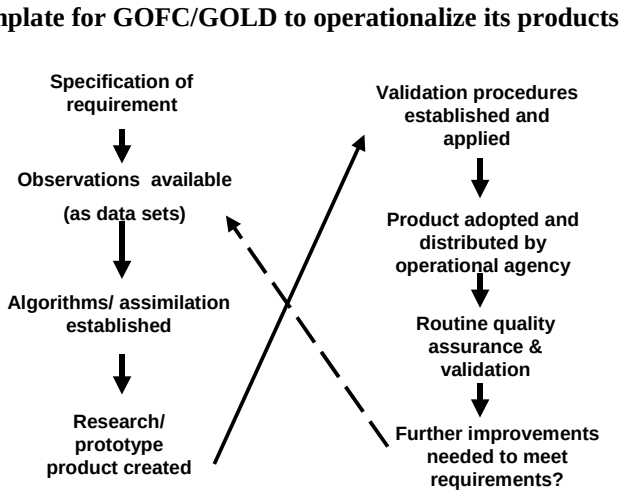


Figure 1. Template of the main stages in the development of capabilities within the framework of GOFC-GOLD.

As previously stated the principal goals for GOFC-GOLD were set out approximately 5 to 6 years ago. Figure 2 summarizes the extent to which these goals have been met using a simple coding scheme to indicate whether substantive progress has been made for each of the stages outlined in figure 1.

It is clear that substantial advances have been made in recent years. Few if any of the boxes would have been colored when the planning documents were first created. In some cases there is already a commitment to long term operational measurement and product generation as a result of some properties being accepted as environmental data records for NPOESS (Townshend and Justice, 2002). However it needs to be recognized that although they will be generated regularly they may not have the long-term internal consistency needed for detecting long-term change (NRC 2000).

The GOFC-GOLD effort has stimulated advances in both science and applications, hence the recognition of the important role of observations to support LCLUC research on two important fronts: research and natural resource management/policy. In its report on Grand Challenges in Environmental Science, the NRC (NRC 2001) has identified land use dynamics as one of the emerging key research domains as a result of significant advances in the community readiness through increased observational capacity. Similarly, the NRC report, Down to Earth (NRC 2002), has pointed to new and increased opportunities for the use of geographic information to support sustainable development. Moreover, international agencies, in particular the UN Food and Agriculture Organization are beginning to develop cooperative observation-intensive approaches to their operational mission for collecting data on the state of the world's forests through the Forest Resource Assessment.

Figure 2a,b,c. Progress in meeting the goals of GOFC-GOLD (Dark gray indicates substantive progress; light gray partial progress and white no progress yet.

a) Fine Resolution Cover Products

	Stages to operationalize products								
GOFC-GOLD Products	**GOFC-GOLD Specifications**	**Requirements**	**Observations**	**Algorithms**	**Prototype**	**Assessment**	**Operational**	**QA & Val**	**Iterate**
Land Cover Classification	http://www.fao.org/gtos/gofc-gold/docs/GOLD_4.pdf (Table 1)	Y	Y Landsat HRV	Y	N (available regionally)	N	N	N	N
Land Cover Change (RAD)	http://www.fao.org/gtos/gofc-gold/docs/GOLD_4.pdf (Table 1)	Y	Y Landsat HRV	Y	N (available regionally)	P	N	N	N
Land Cover Change (harvesting, insect and disease, regeneration)	http://www.fao.org/gtos/gofc-gold/docs/GOLD_4.pdf (Table 1)	Y	P Landsat HRV	P	N (available regionally)	P	N	N	N
Forest Cover fragmentation	http://www.fao.org/gtos/gofc-gold/docs/GOLD_4.pdf (Table 5)	Y	Y	N	N	N	N	N	N

(Y = yes, completed; N = no progress; P = partial progress)

b) Coarse Resolution Land Cover Products

	Stages to operationalize products								
GOFC-GOLD Products	**GOFC-GOLD Specifications**	**Requirement**	**Observations**	**Algorithms**	**Prototype**	**Assessment**	**Operational**	**QA & Val**	**Iterate**
Land Cover Classification	http://www.fao.org/gtos/gofc-gold/docs/GOLD_3.pdf	Y	MODIS/ Vegetation/ AVHRR	Y	MODIS standard product, GLC 2000	P	Y (VIIRS EDR)	N	N
Forest Density (continuous fields)	http://www.fao.org/gtos/gofc-gold/docs/GOLD_3.pdf	Y	MODIS/ Vegetation/ AVHRR	Y	MODIS product	P	N	N	N
Land Cover Change (indicator)	http://www.fao.org/gtos/gofc-gold/docs/GOLD_3.pdf	Y	P (MODIS 250m)	Y	N (available regionally)	N	N	N	N

(Y = yes, completed; N = no progress; P = partial progress)

c) Fire Products

	Stages to operationalize products								
GOFC-GOLD Products	**GOFC-GOLD Specifications**	**Requirements**	**Observations**	**Algorithms**	**Prototype**	**Assessment**	**Operational**	**QA & Val**	**Iterate**
Active fire detection – daily (polar)	http://www.fao.org/gtos/gofc-gold/docs/GOLD_3.pdf	Y	Y	Y	MODIS, AVHRR, DMSP, AATSR, VIRS	P	Y	P	N
Active fire detection – diurnal cycle (geostationary +Polar)	http://gofc-fire.umd.edu/	Y	Y	Y	GOES, VIRS	P	Y	N	N
Burnt area	http://www.fao.org/gtos/gofc-gold/docs/GOLD_3.pdf	Y	Y	Y	Globscar, GBA 2000 MODIS Regional	P	N	N	N
Emission product suite	http://gofc-fire.umd.edu/	Y	P	?	N (available regionally)	N	N	N	N
Fire danger rating	http://gofc-fire.umd.edu/	Y	?	?	N (available regionally)	N	N	N	N

(Y = yes, completed; N = no progress; P = partial progress)

Another key issue is the steps needed to ensure that the various products are made available to users in product delivery systems suited to their requirements and their technological level. Simply because archives exist holding data does not ensure that users will be able to utilize the products. Among the continuing challenges are: the provision of sufficient bandwidth for users; that products are available in easily readable formats; that the projections are compatible with commonly available software; and that the data sets have been subsetted so as not overwhelm the modest computing facilities of many users. There may be additional obstructions to use caused by charging policies and copyright.

The goals of GOFC-GOLD, revisited and reported in this strategy document, are to be progressed further through the ongoing and future activities within the two main themes of land cover characteristics and change, and fire mapping and monitoring. In the next two sections, the ongoing and future advancement of the themes is reviewed with respect to their fundamental goals,

implementation requirements, international and national context, and the key objectives and activities of the GOFC-GOLD implementation teams and regional networks. It should be noted that the work to advance the two themes, which is described below falls within the overall functions of GOFC-GOLD described previously.

9. IMPLEMENTATION OF LAND COVER CHARACTERISTICS AND CHANGE

9.1. The Fundamental Goals of GOFC-GOLD Land Cover Implementation Team

The GOFC-GOLD Land Cover theme is aimed at providing an international forum for identifying and developing consistent land cover data and information to support and global change science and applications. The aim is to simultaneously support the needs of the science community and the agencies and programs, which need information for decision support and policy.

GOFC-GOLD Land Cover is working on ensuring the provision of long-term, systematic satellite observations necessary for the production of a range of data and information products which are needed to understand the rates and magnitudes of land cover change and how these trends influence the carbon cycle, ecosystem services, water resources, and a host of other environmental factors of interest to improved scientific understanding for the earth system. In its activities, the land cover team follows guidelines of international conventions and treaties that emphasize the need for consistent, sustained, harmonized, and validated land cover observations.

GOFC-GOLD Land Cover is working on ensuring the provision of long-term, systematic satellite observations necessary for the production of the full suite of Land Cover products. The critical issue is to have series of directly comparable and consistent observations. The Implementation Team aims to establish observatories that are capable of assuring continuous data acquisition and processing that is of sufficient quantity and quality for global and regional evaluations of land cover characteristics. They are conceptual guidelines that provide specification of overall data acquisition strategies, necessary data sources, classification schemes, quality, and validation components necessary for the global effort.

The primary observing systems for Land Cover include:

- polar orbiters that will provide status data on the current extent of various land covers, with known and reported validation estimates;
- polar orbiters which will provide annual rates of change in the current extent of these land covers;
- both optical and microwave assessments of land cover density and its change, with advanced research leading to mapping of biomass estimates;
- a regular assessment of the rate of tropical deforestation and changes in boreal forests to be used for global carbon assessments;
- a focal point for international inquires for both raw data and derived products through on-line data and information systems;
- coordination of various international satellite assets for land cover monitoring at both fine and moderate resolution; and
- forwarding planning for new systems and space assets which will provide for routine global land-based observations.

9.2. Requirements

Both the science and applications user groups require land cover information. This has been articulated in numerous international documents and various national strategic plans. These requirements aim at long term goals but have to start and evolve from an international cooperation and consensus building efforts, both in on the strategic level and in implementation activities. Of particular importance are the requirements posed by UNCED's Agenda 21, UNFCCC and the Kyoto protocol, the World Summit on Sustainable Development (WSSD) in Johannesburg 2002 and the related Group of Earth Observations (GEO) formed in 2003 that has evolved to a Global Earth Observation System of Systems (GEOSS), the Millennium Ecosystem Assessment, the European GMES initiative, as well as the GCOS implementation plan calling on land cover. It is compelling that there is a convergence of requirements between the global science requirements and national needs/applications requirements. For instance, forest cover change and forest density and biomass are important to both communities.

There is a need to move from research to operational monitoring capabilities for land cover with operational data and product suites that are better defined, flexible, and openly available. Related implementation requirements are:

- coordinated and consistent land cover data acquisition, both from satellite and in situ observations;
- standardized mapping and derivation land mapping products;
- harmonization and synergy of existing land cover/forest maps;
- rigorous validation of map products;
- improve match between data, data products and user needs, i.e. ensure adequacy and advocacy to serve international conventions; and
- analysis, understanding and modeling of land change and spatial-temporal change processes.

GOFC-GOLD Land Cover emphasizes the needs to develop long term records of changes in global land cover, beginning with a baseline for 2000. To do this we strive to support the on going international efforts to derive a standard global land cover baseline using existing assets, and to advocate and support needs for on-going and future operational or routine missions.

9.3. International Context of GOFC-GOLD Land Cover

GOFC-GOLD Land Cover is aimed at increasing user awareness on the value of land cover information, the access to quality data, and expected observation improvements. Without coordinated and continuous observations, harmonization, interoperability, and validation some applications are not appropriately served (e.g. land change assessment). It is sometimes difficult to provide information for individual users to show which products are best suited to their needs. The Implementation Team cooperates with data producers (e.g. space agencies and land cover facilities), data users (e.g. UN organizations like FAO and UNEP), and the science community to overcome these limitations.

Recently, the adoption of the GEOSS 10 year implementation plan and the GCOS implementation plan has, again, tasked GOFC-GOLD to take efforts in coordinating improvement of land cover observations. The Land Cover Team engages in the development, review and implementation of international documents, i.e. the GTOS-Coastal implementation plan, the GLOBCARBON product

validation plan, the CEOS Cal-Val 'best practice' document on validation of global land cover datasets, and the Integrated Global Observations of Land (IGOL) documents. In addition Land Cover will work closely with other land cover initiatives such as GLOBCOVER and follow-on activities related to GLC2000, as well as validation efforts in partnership with the CEOS group on Calibration and Validation.

Near term priorities are to support the efforts of the UN Global Land Cover Network (GLCN), which is a collaborative effort of various UN agencies. The role of GOFC-GOLD Land Cover has been identified in several GLCN meetings and is expected to grow with increasing GLCN implementation activities.

Lastly, GOFC-GOLD Land Cover will work within the framework of the international global change programs such as the IGBP Land Science Theme, and the upcoming Global Land Project sponsored by IGBP and IHDP.

9.4. National Context of GOFC-GOLD Land Cover

Several countries have established land cover change observation systems (satellite and in situ), operational national mapping and monitoring programs, and comprehensive research programs. Examples are the USGS land cover facility, the Canadian EOSD land cover program, the European SIBERIA projects, to name a few. The main purpose of the GOFC-GOLD land cover team is to act as focal point in assistance to standardize mapping. There is a growing need and interest from national and regional actors involved in land cover assessment for guidance to ensure standardized development and validation of land cover data. The goal is to establish a communication platform, capacity building, and increased visibility of international strategies and requirements, and help to link land assessment efforts beyond the boundaries of individual countries and regions. In addition, national needs for land cover-derived products remain high and are an important source for economic development. Land Cover IT has long recognized in previous efforts the importance of integrating land cover change data with resource assessment and analysis.

The national and regional activities of the Implementation Team primarily evolve from a close cooperation with the GOFC-GOLD regional networks and the UN GLCN. They are targeted at improving land observations, data access, interoperability (profits from existing international mapping programs), and utilization of land cover information among different scales. Countries are encouraged to harmonize their efforts with international activities and make their regional information available and usable for the international community.

The Implementation Team supports an integrated system of coarse resolution (250-1000 m) and fine resolution (20-50 m) satellite, and in situ land observations. Most of these systems are developed and maintained by national agencies. A long term commitment of funding from individual countries and agencies is essential to provide continuity and consistency on all these observation scales. US systems like MODIS, AVHRR, and upcoming NPP/NPOESS along with European systems from SPOT VEGETATION and ENVISAT MERIS provide and will provide quality data for coarse scale land observations. Fine resolution land mapping has widely relied upon sensors like Landsat TM/ETM (US), SPOT (France), ERS 1+2 and ENVISAT-ASAR (ESA), and IRS satellites (India). Future systems will include ALOS-PALSAR (Japan), TERRASAR and RapidEye (Germany) and other national satellite programs (e.g. India, Russia, China, and Korea). However, there are strong concerns about the continuity of long term land observations from the LANDSAT and SPOT programs. Another key challenge remains for the standardized observation of in situ land cover

information for calibration and validation of coarser scale satellite mapping. There seems to be the least amount of coordinated international cooperation to make such data accessible and usable in an international context.

9.5. Objectives and Activities of GOFC-GOLD Land Cover

The primary goals of GOFC-GOLD Land Cover theme are to establish an operational observation system and protocols for land cover change monitoring, and to provide accuracy assessment for operational products and a test bed for new or enhanced products, which leads to standardized and flexible land cover information of known accuracy. The goals are achieved through the following objectives and activities.

Ensure Continuity and Consistency of Observations

Among the priorities is to work towards continuity and consistency in land observations. Moderate resolution sensors are essential for land cover phenology and other changes over seasons, fractional cover estimates and deriving other biophysical attributes. Coarse scale observations seem to be better respected in current and planned satellite systems regarding availability and accessibility of EO data. Urgent action is required to ensure continuity for fine resolution polar orbiting land observations similar to Landsat for rates of change and fractional cover, and the development of a system for baseline land cover mapping, plus change detection and quantification over time. Along the same vain, fine resolution EO data are acquired from several nations with limited access to the international community. A related key task is to resolve similar limitations on the in situ scale. A GOFC-GOLD in situ land cover network is anticipated in cooperation with GTOS and the TEMS framework.

Harmonization, Interoperability, and Synergy

The previous consensus building efforts and experiences of GOFC-GOLD have resulted in general agreement that the FAO Land Cover Classification System (LCCS) provides a valuable universal land cover language for building land cover legends and comparing existing legends. The Land Cover Team will support efforts to provide harmonization resources, compare and assess synergy between existing products (IGBP DISCOVER, MODIS-LAND, GLC2000, UMD-LAND, Vegetation Continuous Fields products), and assist in the standardized development of future mapping products (e.g. GLOBCOVER), hence establish an operational land cover validation framework. These efforts will help to overcome current limitations in dataset compatibility and comparability and result in more flexible and accurate land cover products that better fit user requirements.

Develop Validation Standards and Support Their Implementation

Understanding and explicit statements of the land cover product accuracy fosters an informed user community, forms the base for good science, interoperability, and resource management. In cooperation with the CEOS Cal-Val group, the land cover helps develop and implement validation standards, as well as, support acquisition of appropriate local reference information. Currently, a joint harmonization and validation initiative is in planning phase involving important actors in land cover assessment, and including on all existing and future global land cover datasets.

Improve Adequacy and Advocacy of Land Information Products

An emphasis is given to ensure and improve the adequacy and advocacy of land cover products based on user requirements. Interaction with users on the one hand, and assistance for ongoing mapping projects and interoperability studies on the other fosters a better match improved match between observations, data products and user needs.

Engage Regional Networks and Capacity Building

The Land Cover team maintains and is planning to extend the suite of regional networks. They act as coordinators for local land cover data acquisition, user interaction, and regional incubators for implementation of mapping standards and data access. Substantial experiences exist for the networks in Southeast Asia, Southern and Central Africa, Northern Eurasia, and Latin America. New regional networks are planned (West Africa, East Asia). Ensuring basic funding for them is a primary objective. An important implementation tools are regional capacity building efforts that are fostered in cooperation with the UN Global Land Cover Network.

Share Data, Information and Knowledge

GOFC-GOLD Land Cover encourages open access to land cover data on all scales and level of details. While standardization and data availability are ensured through interaction with mapping facilities and agencies, related information are distributed to the user community through quarterly newsletter, the GOFC-GOLD Land Cover webpage and contributions to conferences and workshops.

Assess Land Cover Change

Despite previous progress, there are still many unmeasured land-cover changes at global and regional scales. They relate to sub/tropical dry forests, de/reforestation, forest cover changes caused by selective logging, alteration of wetlands, degradations in croplands, dry land degradation or desertification, and urbanization. Causes, drivers, factors, actors, and feedbacks together with the initial conditions make up pathways of land change. The understanding of these pathways, identification of hot spots and the human dimension of land dynamics are essential in land change assessment modeling for assessing possible impacts and elaborate on future development scenarios.

9.6. Summary of Top Priorities for GOFC-GOLD Land Cover

The recent land cover requirements by GEOSS and the GCOS implementation plan encourage the Land Cover team to work on the following priorities:

- Encourage consistency, continuity, adequacy, and accessibility of coarse and fine resolution satellite and in situ land cover observations.
- Establish international standards and specifications for the production of land-cover characterization maps and their accuracy assessment. The implementation is ensured through the joint international harmonization and validation framework.
- Cooperation with ongoing international mapping initiatives (e.g. GLOBCOVER).
- Further engagement in capacity building (link to GLCN) and regional partnerships and networks.
- Implementation of land cover harmonization and interoperability case-studies to make best use of existing resources.

10. IMPLEMENTATION OF FIRE MAPPING AND MONITORING

10.1. The Fundamental Goals of the GOFC-GOLD Fire Implementation Team

The GOFC-GOLD Fire Mapping and Monitoring Theme is aimed at refining and articulating the international requirements for fire related observations and making the best possible use of fire products from the existing and future satellite observing systems, for fire management, policy decision-making and global change research.

GOFC-GOLD Fire is working on ensuring the provision of long-term, systematic satellite observations necessary for the production of the full suite of fire products.

The primary observing system for fire includes:

- polar orbiters with fire monitoring capability to provide operational moderate resolution long-term global fire products (e.g. active fire, burned area, fire radiative power, fire danger) and distributed ground stations providing enhanced regional products;
- an operational global geostationary fire network providing observations of active fires in near real-time; and
- operational high resolution data for targeted observations of fire events of major importance, post-fire assessments and systematic validation of products from moderate resolution sensors.

10.2. Requirements

The various user groups of fire products have different requirements regarding timeliness, resolution, quality and data format. One of the goals of GOFC-GOLD-Fire is to enhance fire product use and access by developing operational multi-source fire and related GIS data and making these available over the Internet. It is recognized that for some regions internet connectivity is limited and alternative mechanisms for fire information delivery are needed e.g. text messaging, data on CD's.

GOFC-GOLD-Fire also recognizes the science goal of developing long-term science quality fire data records for the study of global change. Development of long term records necessitates using data from a time-series of satellites, resulting in dynamic product continuity. There is therefore a requirement for an explicit activity associated with long term product characterization, validation and multi-satellite data integration.

10.3. The International Context of GOFC-GOLD Fire

GOFC-GOLD Fire is aimed at increasing user awareness by providing an improved understanding of the utility of satellite fire products for resource management and policy internationally, for example within the United Nations and at regional, national and local levels.

Near–term priorities are to develop improved access to and use of fire data within UNEP and UN FAO, and to work more closely with UN OOSA on increased GOFC-GOLD Fire participation in programs such as the Space Technology and Disaster Management program. There is also potential for WMO and WHO to make use of fire information for improved monitoring of smoke and haze in the context of air safety and human health.

In the framework of a broader program of land observations, GOFC-GOLD Fire will be an active

component of the new Integrated Global Observation of Land (IGOL) initiative. GEOSS offers an important opportunity for securing the necessary fire observations and providing improved products directed at societal benefit. GOFC-GOLD Fire can provide an international coordination mechanism for GEOSS fire observation activities.

10.4. National Context of GOFC-GOLD Fire

A number of satellite systems used for fire monitoring and fire product validation are operated by national agencies. GOFC-GOLD Fire continues interaction with these agencies to ensure that the fire mapping capabilities are among the priorities for mission design. From the US, the current priorities are to secure a fire product NPP/NPOESS from VIIRS building on the heritage of the MODIS capabilities and providing a continuing long term data record., to secure the fire band on GOES-R and address the pressing issue of Landsat continuity and the fire requirements from the Operational Land Imager (OLI) planned for NPOESS C1 and C4. Interaction with national agencies operating existing or new moderate resolution polar orbiting (e.g. China, Russia), geostationary (e.g. China, Japan, Russia, Korea, India) or high resolution polar orbiting satellites (e.g. India, China/Brazil, Russia, Germany) is needed. In Europe new fire monitoring activities are being developed by ESA in the framework of GMES. Continuing commitment by EUMETSAT is needed for participation in the global geostationary fire monitoring network. GOFC-GOLD Fire also promotes the inclusion of BIRD-like instruments on the ESA/GMES Sentinel satellites.

National agencies are also responsible for running operational fire monitoring systems. GOFC-GOLD Fire has been collaborating with a number of agencies such as NOAA (US), Avialesookhrana (Russia), IBAMA (Brazil), CSIR (South Africa), LATUV (Spain) and CONABIO (Mexico), NRC (Canada), CSIRO (Australia). New collaborations are being established in India and China. Although some of the monitoring systems obtain data from the global distribution systems (e.g. MODIS Web Fire Mapper), most obtain their data from national networks of direct broadcast (DB) stations. Major issues are the development and sharing of DB software to generate standardized fire products, sharing data, keeping the ground stations up to date on satellite instrument developments, the transition of research and development into operations (including funding commitment), management of duplicate systems generating different products, that can result in confusion within the user community and international cooperation on product validation.

10.5. Objectives and Activities of GOFC-GOLD Fire

Establish a Geostationary Global Fire Network

The diurnal cycle of fire activity means that polar orbiting satellite systems provide only a sample of the daily fire activity. In some regions fire are short-lived lasting no more than a couple of hours. In other systems fires will burn throughout the day. Geostationary systems providing frequent acquisitions give perhaps the best opportunity to detect active fires from space. However in the past, these systems have been limited by their spatial resolution. New generation geostationary systems with 1km spatial resolution or higher and with temporal resolutions of 15-30 minutes, provide an enhanced capability for operational monitoring. Developing an international network of geostationary satellites with standard products would provide an important advance for monitoring active fires. A current activity is to increase involvement of the geostationary satellite community beyond US and Europe - especially with the recent/near-term launch of FY-2C, MTSAT-1R, INSAT-3D, GOMS Electro N2.

Secure Operational Polar Orbiters with Adequate Fire Monitoring Capability

Moderate resolution polar orbiters have been used to develop the current suite of global products and will remain an important source of data provision. Ensuring that current and future operational sensors include the capability to detect fires is an important goal. The lead time between project concept, instrument design and operation is long and there is a need for a well articulated set of requirements. Polar orbiters (e.g. AVHRR, MODIS, ATSR, VEGETATION, Landsat, ASTER) are currently being used for detecting active fires, mapping burned area, assessing fire susceptibility and estimating fire emissions. Improvements in these systems for fire monitoring can be envisioned and need to be shared with instrument design engineers and data providers. High resolution data are needed to provide information at a finer spatial scale, for example to assess fire damage and monitor post fire recovery. High resolution polar orbiters need to be moved into the operational domain for land monitoring and the data need to be made available at prices affordable to the user community. A current activity is to secure operational fire monitoring capabilities from NPOESS VIIRS and METOP.

Develop Long Term Fire Data Records

The continuity of Landsat and similar high resolution sensor data is essential for burned area validation. Also, the study of global change requires long-term science-quality fire data records. Development of long term records necessitates using data from a time-series of satellites, resulting in dynamic product continuity. A related requirement is to establish the commitments for long-term data record generation. The data issues may be partly addressed by establishing GOFC-GOLD Fire as a coordination mechanism for securing the necessary fire observations through the GEOSS.

Establish Enhanced User Products and Data Access

One of the obstacles to using satellite data is the availability of data products. Information on where to go to get data and how to read and interpret the products needs to be made more readily available. At present the data from different systems are provided by different means and in different formats. GOFC-GOLD is promoting ease of access to multiple archives and standard data formats. Similarly when the data are obtained they need to be readily combined with other geospatial data. The availability of WEB-GIS data will lead to an advance in current capability. Promoting affordable data for the common good is an important message from GOFC-GOLD to the operational agencies and data providers. A current activity is to develop workarounds to Internet limitations (e.g. text messaging).

Determine Fire Product Accuracies

One of the primary goals of GOFC-GOLD Fire is to establish an operational network of fire validation sites and protocols, providing accuracy assessment for operational products and a test bed for new or enhanced products, leading to standard products of known accuracy. Current priorities include:

- continuity of Landsat and similar high resolution sensor data for burned area validation;
- continuity of high resolution sensors with proper specifications for active fire validation;
- development of a burned area product inter-comparison program and creation of a shared burned area validation database with the participation of regional network scientists; and

- development of a generic multi-platform active fire validation protocol.

Develop a Global Fire Danger/Susceptibility Product

GOFC-GOLD Fire encourages the development and implementation of standard methods for Fire Danger Rating to meet the needs of fire managers for performing ecosystem management, protecting values at risk and monitoring global shifts in fire danger. The most promising methods combine satellite and meteorological information. The current priority is to develop a conceptual framework for a standardized global fire danger system and regional implementation.

Develop Fire Emissions Product Suites

An important goal of GOFC-GOLD Fire is the creation of emissions product suites, developed and implemented providing annual and near real-time emissions estimates with available input data. The research community is starting to explore the use of satellite data in generating regional fire emissions. The combination of satellite time series data on the timing and areal extent of burning, dynamically modeled fuel load, indicators of vegetation state and ground based emission factors provide the basis for emission products. As part of the emission product suite, it will be important to provide the data inputs and an estimation of the output product accuracy.

Promote Experimental Fire Observation Systems and Related Research

Emerging approaches need to be tested to achieve consensus procedures and protocols for satellite data product usage. Current priority is for the development of a consistent validated multi-year burned area product and the associated dynamic multiyear global fuel load product.

Meet Fire User Needs

GOFC-GOLD Fire has given emphasis to the development of regional networks with a fire focus, as a mechanism to bring together fire data providers and fire data users to exchange information on capabilities and needs. These fire focus networks are a subset of the larger GOFC-GOLD regional network program. The networks allow for lateral exchange of information and provide a means for strengthening regional and in particular national related fire activities. It should be recognized that strengthening national capabilities is a high priority for most regional network participants. Fire networks have been developed in Southern Africa (SAFNET), Russia and the Far East (NERIN-Fire), Southeast Asia (SERIN Fire) and Latin America (REDLATIF). New fire network activities are emerging in Australia around the validation of fire products and DB software. An increasingly important priority for the regional networks is the development of on-going training capabilities and obtaining provision of funding for regional fire networks. GOFC-GOLD Fire is working closely with the emerging UN Global Wildland Fire Network being developed by the Global Fire Monitoring Centre in the Framework of the UN ISDR Wildland Fire Advisory Group. This is an important partnership for GOFC-GOLD Fire which will continue to promote within the UN support for the regional fire networks and required capacity building.

10.6. Summary of Top Priorities for GOFC-GOLD Fire

Future priorities for GOFC-GOLD Fire are to:

- advocate international space agency coordination of global high resolution data acquisition and availability;

- obtain meteorological agency support for the global geostationary fire network;
- ensure operational fire monitoring capabilities on NPOESS and METOP providing data continuity (MODIS and Landsat (NPOESS), AVHRR (METOP));
- develop an international collaborative program on global burned area product validation;
- obtain support to run the regional network fire programs and develop capacity building programs on the use of satellite fire data;
- identify research priorities and gaps, e.g., fire affected area, rather than just burned area; and
- establish GOFC-GOLD Fire as a coordination mechanism for securing the necessary fire observations for GEOSS and products in support of the international conventions.

11. BIOPHYSICAL IMPLEMENTATION

In the 1999 strategic plan of GOFC-GOLD a Biophysical Implementation Team was planned. The outcomes of this effort were anticipated to be a suite of biophysical products related in particular to the carbon cycle and primary productivity. The main products were Leaf Area Index (LAI), Fraction of Photosynthetically Active Radiation (FPAR), Photosynthetically Active Radiation (PAR), and Net Primary Productivity (NPP). These are needed also collectively to provide estimates of annual forest ecosystem dynamics. An additional product, biomass, was seen as needed to provide an indication of overall forest carbon stocks and sequestration potential, as well as provide land use implications.

Much of the planning for this suite of products was conducted by Terrestrial Carbon Observations, an organization operating now within the framework of GTOS[2]. The Terrestrial Panel for Observations of Climate (TOPC), a joint panel of GTOS and GCOS, in part based on the recommendations of TCO has specified requirements for these observations in its various reports and these now form part of the GCOS Implementation Plan (GCOS 2003).

Taking account of the above considerations and the limited resources available to GOFC-GOLD in terms of its activities, this aspect of implementation should no longer be considered part of the remit of GOFC-GOLD.

12. GOFC-GOLD MANAGEMENT STRUCTURE

The management structure of GOFC-GOLD has been developed to take maximum advantage of existing organizations and capabilities and create a minimum of bureaucracy to meet its objectives. The management structure and organizational procedures, as they have evolved since 1999, are described in Appendix 2. A key goal for GOFC-GOLD in the upcoming period is to ensure the smooth succession of existing and new Executive Committee members.

[2] TCO/GCP Terrestrial Carbon Observations and Model-Data Fusion Workshop, Sheffield, UK 3-6 June 2003;
TCO Frascati report, on in situ carbon data and information June 2001;
TCO Rio de Janeiro report, recommendations for terrestrial and atmospheric measurements February 2001;
IGOS-P Carbon Cycle Observation Theme: Terrestrial and Atmospheric Components June 2000;
TCO Ottawa report, assessment of requirements, status and next steps February 2000

13. THE ROLE AND FUNCTION OF THE GOFC-GOLD NETWORKS

GOFC-GOLD is being implemented through a series of regional networks, providing a forum for regional scientists, data providers and operational users to articulate their information requirements and improve access to and use of the observations (Justice et al., 1999). The regional networks also provide a mechanism for calibrating, validating and improving methods and algorithms and a place to test integration of in-situ and remote sensing observations.

Since 1999, GOFC-GOLD has established associations with five regional networks in Africa, Southeast Asia and Northern Eurasia (Table 5). Additional associations are under development with networks in East Asia, Latin America and West Africa. The regional networks provide a forum for users and researchers operating in (or with an interest in) a common geographic area, and represent a link between national agencies and user groups and the global user/producer community. They provide a mechanism for sharing of resources and expertise, and perform an essential cross-cutting role in the implementation and integration of GOFC-GOLD's thematic components. The Regional networks also form an important venue through which capacity building can be achieved.

Not all parts of the world may be represented by regional networks, nor is it necessary for agencies or groups to join a regional network in order to contribute to, or participate in GOFC-GOLD. However, they do provide important visibility and credibility to the organizations, which participate in them.

The outcomes of regional networks should be based on the overall goals of GOFC-GOLD, but the priorities should arise from the needs of regions as identified by members of the networks. For some regions there may be more need for enhanced delivery of land cover products, whereas in others the priorities might be fire products. Some regions may choose to have separate land cover and fire organizations or may wish to combine both in a single network structure.

The five regional networks have each adopted and implemented to varying degrees the goals and standards of GOFC-GOLD. The summary in Table 6 of the needs and constraints of each network indicates that while the networks have some unique needs, there are several areas of common interest among all of the networks. These include training, sustained funding, standardized monitoring, and improved access to earth observations.

The GOFC-GOLD regional networks collaborate with several other key international organizations and programs related to earth observations (Table 5). Where possible GOFC-GOLD should also form strategic partnerships with other networks and organizations, which share at least some of the goals of the organization, including START and the IGBP Regional Network.

Table 5. Current status of GOFC-GOLD Regional Networks.

Regional Network	Countries included	Status	International linkages	Website
Miombo Network	Angola, DR Congo, Malawi, Mozambique, Tanzania, Zambia, Zimbabwe	The Miombo Network was founded in 1995 under the auspices of the IGBP, LUCC and START. National level activities in: Malawi, Mozambique, S. Africa, Tanzania, Zambia and Zimbabwe involving over 40 scientists and natural resources managers.	IGBP, WWF-SAPRO, IUCN, ROSA, SADC RRSU, UNFCC, NASA LCLUC, MEA, regional NGOs, START	http://www.miombo.org/.
NERIN	Russia, Ukraine, others under development	Initiated at the GOFC-GOLD Boreal Forest workshop in Novosibirsk, Russia, 2000. Over 50 scientists and natural resources managers involved. Developing points of contact in the region.	Russian Federal Forest Agency, NASA, START	http://www.fao.org/gtos/gofc-gold/net-NERIN.html.
OSFAC	DR Congo, Congo (Brazzaville), Cameroon, Gabon, Central African Republic and Equatorial Guinea	Initiated at the GOFC-GOLD regional workshop in 2000. Network linked to GIS/RS lab at the University of Kinshasa.	CBFP, WSSD, COMIFAC, US, EU, regional NGOs, START	http://www.osfac.org/.
SAFNet	Angola, Botswana, DR Congo, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe	Initiated in 2000 during a GOFC-GOLD regional network. SAFNET has over 60 members from 12 southern African countries.	IGBP, UNEP – DEWA /GEF, BGCC, regional NGOs, WWF, AWF, APINA, UNFCCC, IPCC, GFMC, AEO-II, START	http://safnet.umd.edu/index.asp.
SEARRIN	Thailand, Indonesia, Malaysia, Philippines, Vietnam, Laos, Cambodia	Initiated during the Manila workshop in 2000. Activities have involved over 60 scientists and natural resources managers. Conducts research on LUCC and Forest Fire.	IGBP, IHDP, CGIAR, UNDP-GEF, Asia Pacific Network, START	http://www.eoc.ukm.my/searrin/.
East Asia	China, N. Korea, S. Korea, Mongolia, Japan	Initiated during the GOFC-GOLD third STB meeting in 2005. Network under development.	START	
Latin America		Under discussion, with initial focus on fire monitoring.		
W. Africa		Under discussion, with initial focus on land cover.		

The five regional networks have each adopted and implemented to varying degrees the goals and standards of GOFC-GOLD. The summary in Table 6 of the needs and constraints of each network indicates that while the networks have some unique needs, there are several areas of common interest among all of the networks. These include training, sustained funding, standardized monitoring, and improved access to earth observations.

The GOFC-GOLD regional networks collaborate with several other key international organizations and programs related to earth observations (Table 5). Where possible GOFC-GOLD should also form strategic partnerships with other networks and organizations, which share at least some of the goals of the organization, including START and the IGBP Regional Network.

Table 6. Comparison of needs* of GOFC-GOLD Regional Networks.

	GOFC-GOLD Regional Network				
Need	Miombo	NERIN	OSFAC	SAFNet	SEARRIN
Training and capacity building	✓	✓	✓	✓	✓
Adequate funding for administration and programs	✓	✓	✓	✓	✓
Standardization of monitoring mechanisms and systems used in the region	✓	✓	✓	✓	✓
Improved access to EO data	✓	✓	✓	✓	✓
Improved dissemination to national and sub national levels			✓	✓	✓
Improved product validation based on standardized protocols		✓		✓	
Stronger program and scientific coordination with implementation teams	✓	✓			
Improved Internet access and capacity	✓		✓		
Better understanding of other EO projects in the region			✓		✓

*As indicated by networks at 3rd Science and Technical Board meeting, 19-22 April 2005, Beijing, China.

14. REFERENCES

Ahern, F. J., R. Landry, I. McKirdy, V. Janusauskas, A. Banner, J. Russell, and T. Balce, 1997. Factors affecting clearcut mapping accuracy from single-date RADARSAT images, Proceedings of Geomatics in the Era of RADARSAT, Canadian Aeronautics and Space Institute, Ottawa, Canada, May 26 - 30.

Ahern, A., A. Belward, P. Churchill, R. Davis, A. Janetos, C. O. Justice, T. Loveland, J.-P. Malingreau, M. Maiden, D. Skole, V. Taylor, Y. Yasuoka and Z. Zhu (1999). A Strategy for Global Observations of Forest Cover, Ottawa, CCRS, GOFC-GOLD Report No. 2.

Belward, A. S., J. E. Estes and K. D. Kline (1999). "The IGBP-DIS Global 1-Km land-cover data set DISCover: a project overview." Photogrammetric Engineering and Remote Sensing 65(9): 1013-1020.

Costa, M. P. de F., E. M. L. de M. Novo, F. Mitsuo II, J. E. Mantovani, M. V. Ballester, and F. J. Ahern, 1997. Classification of floodplain habitats (Lago Grande, Brazilian Amazon) with RADARSAT and JERS-1 data. Proceedings of Geomatics in the Era of RADARSAT, Canadian Aeronautics and Space Institute, Ottawa, Canada, May 26 - 30.

Cramer, W., D. W. Kicklighter, A. Bondeau, B. Moore III, G. Churkina, B. Nemry, A. Ruimy and A. L. Schloss (1999). "Comparing global models of terrestrial net primary productivity (NPP): overview and key results." Global Change Biology 5, (Suppl. 1): 1-15.

DeFries, R. S., J. R. G. Townshend and M. C. Hansen (1999). "Continuous fields of vegetation characteristics at the global scale at 1km resolution." Journal of Geophysical Research 104: 16911-16925.

Eidenshink, J. C. and J. L. Faundeen (1994). "The 1 km AVHRR global data set: first stages in implementation." International Journal of Remote Sensing 15(17): 3443-3462.

FAO (1995). Forest Resources Assessment 1990: Global Synthesis, Rome, Food and Agriculture Organization of the United Nations, FAO Forestry Paper, 124, 44pp.

FAO (1996). Forest Resources Assessment 1990: Survey of tropical forest cover and study of change processes, Rome, Food and Agriculture Organization of the United Nations, Forestry Paper, 130, 152pp.

FAO (2001). Global Forest Resources Assessment 2000, Rome, FAO, 140, 479pp.

Foster, I. and C. Kesselman (1998). The Grid: Blueprint for a New Computing Infrastructure. San Francisco, Morgan Kaufmann.701 pp

GCOS (2003). The Second Report on the Adequacy of the Global Observing Systems for Climate in support of the UNFCC, Geneva, Switzerland, Global Climate Observing System, GCOS-82, 85pp.

Giglio, L., J. D. Kendall and C. O. Justice (1999). "Evaluation of global fire detection algorithms using simulated AVHRR infrared data." International Journal of Remote Sensing 20(10): 1947-1985.

Goward, S. N., J. Masek, D. L. Williams, J. R. Irons and R. J. Thompson (2001). "The Landsat 7 mission: terrestial research for the 21st century." Special Issue on Landsat 7, Remote Sensing of Environment 78(1-2): 3-12.

GTOS (2003). TEMS: Terrestrial Ecosystem Monitoring Sites, http://www.fao.org/gtos/tems/index.jsp, 2/9/03.

Hammond, H. (1991). Seeing the forest among the trees: The case for holistic forest use. Polestar Book Publishers, Polestar Book Publishers.309 pp.

Herold, M. and Schmullius, C 2004..Report on the Harmonization of Global and Regional Land Cover Products Meeting Rome, Italy 14th – 16th July 2004, GOFC-GOLD Report No. 20

IGBP (1997). The Miombo Network: framework for a terrestrial study of land use and land cover change in the Miombo ecosystems of Central Africa. Stockholm IGBP Report, 41, 109pp.pp.

Janetos, A. C. and A. Ahern (1997). CEOS Pilot Project: Global Observations of Forest Cover (GOFC), Version 3.3, Global Observations of Forest Cover: Ottawa Workshop Report, Ottawa, Ontario, Canada, CCRS, 38pp.

Justice, C.O., F. Ahern and A. Freise (1999). Regional Networks for Implementation of the GOFC Project in the Tropics, GOLD-5/START-4, Washington, D.C., 15-17 March 1999,

Justice, C. O. (2002). "MODIS Science Team Meeting Land Discipline Summary. " Earth Observer 5(14): 12-13.

Karl, T. R. (1996). Long term climate monitoring by the Global Climate Observing System. Dordrecht, Kluvier Academic publishers.(reprinted from Climate Change Vol 31, nos. 2-4, 1995) pp

Kux, H. J. H., J. R. Dos Santos, M. S. P. Lacruz, F. J. Ahern, and R. W. Pietsch, 1997. Capabilities of RADARSAT data for land use/land cover analysis in S.W. Amazonia, Proceedings of Geomatics in the Era of RADARSAT, Canadian Aeronautics and Space Institute, Ottawa, Canada, May 26 - 30.

Liang, S. (2003). Quantitative Remote sensing of Land Surfaces. New York, John Wiley.550 pp

Loveland, T., Y. Yasuoka, B. Burgan, J. Chen, R. Defries, H. G. Lund, T. Lynham, P. Mayaux and J.-M. Gregoire (1998). Global Observations of Forest Cover: Coarse Resolution Products Design Strategy, Sioux Falls, South Dakota, US EROS Data Center, GOFC-GOLD Report No.3, 23pp.

Loveland, T. R., J. W. Merchant, D. O. Ohlen and J. F. Brown (1991). "Development of a land-cover characteristics database for the conterminous U.S." Photogrammetric Engineering & Remote Sensing 57(11): 1453-1463.

Loveland, T. R., B. C. Reed, J. F. Brown, D. O. Ohlen, Z. Zhu, L. Yang and J. W. Merchant (2000). "Development of a global land cover characteristics data base and IGBP DISCover from 1 km AVHRR data." International Journal of Remote Sensing 21: 1303-1330.

Mahmood, A., et al, 1998, Mapping the World with Remote Sensing, EOS: Transactions of the American Geophysical Union, (American Geophysical Union, Washington) 79: pp. 1 and 23.

Malingreau, J. P., F. A. Albini, M. O. Andreae, S. Brown, J. S. Levine, J. M. Lobert, T. A. Kuhlbusch, L. Radke, A. Setzer, P. M. Vitousek, D. E. Ward and J. Warnatz (1993). Quantification of fire characteristics from local to global scales. Fire in the environment: the ecological, atmospheric and climatic importance of vegetation fires. P. J. Crutzen and J. G. Goldammer. New York, Wiley & Sons: pp. 329-343

Matthews, E. (2001). Understanding the FRA 2000, Washington DC., World Resources Institute.

Morisette, J. T., J. L. Privette and C. O. Justice (2002). "A framework for the validation of MODIS

Land products." Remote Sensing of Environment 83(1-2): 77-96.

NASA (2003). Global Change Master Directory, http://gcmd.gsfc.nasa.gov/, 2/9.

NRC (2000). Issues in the Integration of Research and Operational Satellite Systems for Climate Research. II Implementation, Washington DC, Committee on Earth Studies, National Academy Press.

NRC (2001). Grand Challenges in Environmental Sciences. Committee on Grand Challenges in Environmental Sciences. Washington D.C., National Academies Press, 106 pp.

NRC (2002). Down to Earth: Geographical Information for Sustainable Development in Africa. Washington D.C., National Academies Press.

NRC (2003). Satellite observations of the Earths environment: accelerating the transition of research to operations, Washington D.C., National Academies Press, 158 pp.

Nyland, R. D. (1996). Silviculture: Concepts and Applications. New York, McGraw-Hill.633 pp

Perlin, J. (1991). A forest journey. The role of wood in the development of civilization. Cambridge, MA, Harvard University Press,.445 pp

Shimabukuro, Y. E., S. Amaral, F. J. Ahern, and R. W. Pietsch, 1997. Classification and monitoring the Tapajós National Forest region using SAR (RADARSAT Standard Mode and SAREX Wide Swath Mode) and Landsat Thematic Mapper data, Proceedings of Geomatics in the Era of RADARSAT, Canadian Aeronautics and Space Institute, Ottawa, Canada, May 26 - 30.

Skole, D. and C. J. Tucker (1993). "Tropical deforestation and habitat fragmentation in the Amazon: Satellite data from 1978 to 1988." Science 260: 1905-1910.

Skole, D. L., C. O. Justice, J. R. G. Townshend and A. C. Janetos (1997). "A land cover change monitoring program: Strategy for an International effort." Mitigation and Adaptation Strategies for Global Change 2(2-3): 157-175.

Skole, D. L., W. A. Salas and V. Taylor (1998). Global Observation of Forest Cover: Fine Resolution Data and Product Design Strategy Report of a Workshop, Paris, France, CNES, GOFC-GOLD Report No. 4, 29pp.

Townshend, J. R. G., Ed. (1992). Improved Global Data for Land Applications: A Proposal for a new High Resolution Data Set. IGBP Report, No. 20, International Geosphere Biosphere Programme, Stockholm, Sweden.

Townshend, J. R. G., V. Bell, A. C. Desch, C. Havlicek, C. O. Justice, W. E. Lawrence, D. Skole, W. W. Chomentowski, B. Moore III, W. Salas and C. J. Tucker (1995). The NASA Landsat Pathfinder Humid Tropical Deforestation Project. Land satellite information in the next decade, Tysons Corner, Virginia, American Society of Photogrammetry and Remote Sensing.

Townshend, J. R. G. and C. O. Justice (2002). "Towards operational monitoring of terrestrial systems by moderate resolution imaging." Remote Sensing of Environment 83: 351-359.

Townshend, J.R.G., Justice, C.O., Skole, D.L., Belward, A., A. Janetos, Gunawan, I., Goldammer, J., Lee, B. (2004) Meeting The Goals Of GOFC: an evaluation of progress and steps for the future. In Gutman, G. et al (Eds.) Land Change Science, Kluwer Academic Publishers, Dordrecht, Netherlands, pp 31-52.

Townshend, J. R. G., C. O. Justice, D. Skole, J.-P. Malingreau, J. Cihlar, P. Teillet, F. Sadowski and

S. Ruttenberg (1994). “The 1 km AVHRR global data set: needs of the International Geosphere Biosphere Programme.” International Journal of Remote Sensing 15(17): 3417-3441.

Turner II, B. L., D. Skole, S. Sanderson, G. Fischer, L. Fresco and R. Leemans (1995). Land-use and land-cover change: science/research plan, International Geosphere-Biosphere Programme and the Human Dimensions of Global Environmental Change Programme, Stockholm and Geneva, IGBP, 35.

15. APPENDICES

Appendix 1. List of GOFC-GOLD Reports

GOLD-21: Report of the 3rd Meeting of the GOFC-GOLD Scientific and Technical Board, M.A. Brady and M. Larsen, Beijing, China, 19-22 April 2005. See presentations

GOLD-20: Report on the Harmonization of Global and Regional Land Cover Products meeting, Martin Herold, FAO, Rome, Italy, 14-16 July 2004.

GOLD-19: Report on the Joint GOFC-GOLD Fire and CEOS LPV Working Group Workshop on Global Geostationary Fire Monitoring Applications, E. Prins, Y. Govaerts, and C.O. Justice, EUMETSAT, Darmstadt, Germany, 23–25 March 2004.

GOLD-18: Land Cover Implementation Team meeting report, M. Herold, K. Neumann and C. Schmullius, Jena, Germany, 2–4 March 2004. See presentations

GOLD-17: Executive Committee meeting report, J.R. Townshend, Joint Research Center, Ispra, Italy, 17-18 March 2003. See attached appendices

GOLD-16: Joint GOFC-GOLD Fire and IGBP-IGAC/BIBEX, Workshop on Improving Global Estimates of Atmospheric Emissions from Biomass Burning, Executive Summary, E. Kasischke, J. Penner and C.O. Justice, College Park, USA, 2002.

GOLD-15: The Toulouse Plan: Implementation of the Land Cover Characteristics and Changes Implementation Team, D. Skole, Toulouse, France, 11-13 February 2002.

GOLD-14: Land Cover Characteristics and Changes Implementation Team report, D. Skole, Toulouse, France, 11-13 February 2002.

GOLD-13: Report of the Forest Cover Implementation Team. GOFC Science and Technical Board Meeting, D. Skole and I. Gunawan, Frascati, Italy, 12-13 June 2001.

GOLD-12: Global Observations of Forest Cover, Report of the 2nd Science and Technical Board Meeting, J. Townshend, Frascati, Italy, 12-13 June 2001.

GOLD-11: Summary of Products: Forest Cover Characteristics and Changes Implementation Team. Background document for the GOFC Science and Technical Board, D. Skole, Frascati, Italy, 1 June 2001.

GOLD-10: Remote Sensing of Forest Cover in Western Russia and Fennoscandia, O. Krankina, St. Petersburg, Russia, 25-27June 2001.

GOLD-9: Report of the Miombo GOFC Coordination Meeting, Editors: P. Yanda, P.V. Desanker, and C.Justice, Maputo, Mozambique, 20-22 July 2000.

GOLD-8: 1st GOFC Science and Technical Board meeting report, F. Ahern, Ottawa, Canada, 21-23 June 2000.

GOLD-7: Atelier de création du réseau GOFC - OSFAC en Afrique Centrale, P. Mayaux, C. Justice and R.S. Lumbuenamo, Libreville, Gabon, 22-24 February 2000.

GOLD-6: Southeast Asia Regional GOFC Planning meeting report, I. Gunawan, D. Skole, H. Sanjaya, A. Rahmadi, M. Muchlis, G.A. Adi, L. Gandharum and S.B. Agus, Bogor, Indonesia, 31

January - 2 February 2000.

GOLD-5/START-4: Regional Networks for Implementation of the GOFC Project in the Tropics, C. Justice, F. Ahern and A. Freise, Washington, D.C., 15-17 March 1999.

GOLD-4: Global Observation of Forest Cover: Fine Resolution Data and Product Design Strategy workshop report, D. L. Skole, W. A. Salas and V. Taylor, Paris, France, 23-25 September 1998.

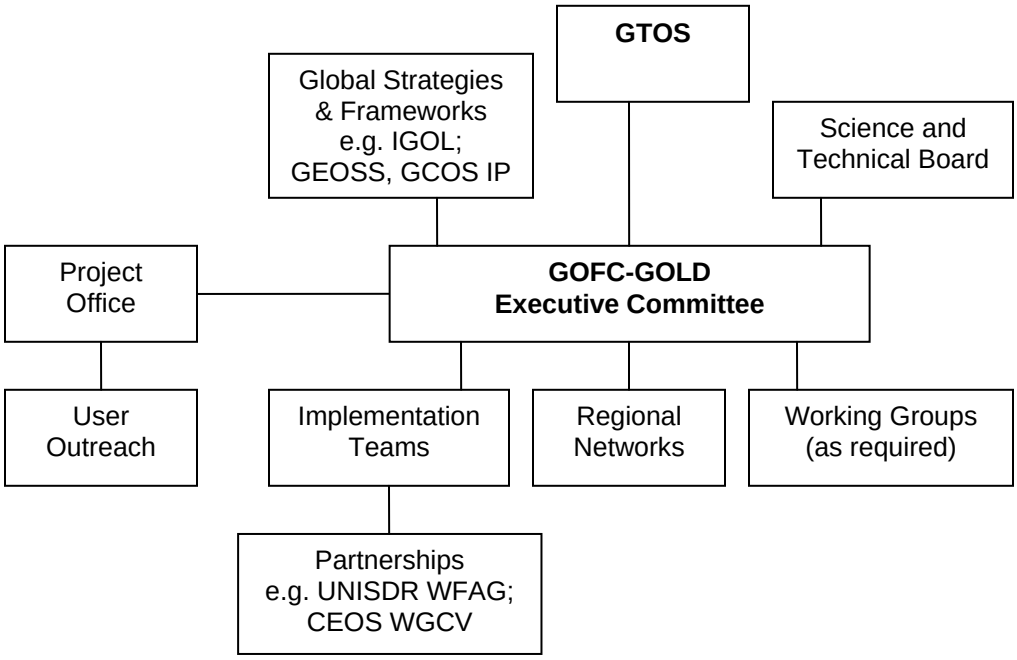
GOLD-3: Global Observations of Forest Cover: Coarse resolution Product Design Strategy workshop report, T. Loveland, Y. Yasuoka, B. Burgan, J. Chen, R. Defries, H.G. Lund, T. Lynham, P. Mayaux, and J.-M. Gregoire, Sioux Falls, USA, July 1998.

GOLD-2: A Strategy for Global Observation of Forest Cover, F. Ahern, A. Belward, P. Churchill, R. Davis, A. Janetos, C. O. Justice, T. Loveland, J.-P. Malingreau, M. Maiden, D. Skole, V. Taylor, Y. Yasuoka and Z. Zhu, Ottawa, Canada, 4 January 1999.

GOLD-1: CEOS Pilot Project: Global Observation of Forest Cover, Editors: A.C. Janetos, and F. Ahern, Ottawa, Canada, July 7-10, 1997.

Appendix 2. GOFC-GOLD Management Structure

The guiding principal in the organization of GOFC-GOLD is to take maximum advantage of existing organizations and capabilities and create a minimum of bureaucracy to meet GOFC-GOLD objectives. The structure described below consists of several organizational units and a number of positions within the units assumed by individuals. The current management structure is as follows:



Global Terrestrial Observing System

GOFC-GOLD is one of several Panels of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GTOS Panels are a key tool of GTOS in achieving objectives and facilitating implementation. The GOFC-GOLD Chair is appointed by and is a member of the GTOS steering committee, which meets annually.

Scientific and Technical Board

The Scientific and Technical Board (STB) is the senior oversight committee of GOFC-GOLD. It sets the overall strategy for GOFC-GOLD and advises on implementation. It meets periodically but no more frequently than once per year. It is convened only when significant new alignments of GOFC-GOLD's activities are needed. Membership is drawn from the scientific, natural resources, NGO and observational space and in situ communities including space agencies.

Through close dialog with GTOS, the STB ensures continuing progress toward the long-term objective of providing sustained space-based and in-situ observations of forests and other vegetation cover. To accomplish this objective, the STB:

- reviews and recommends revisions to the GOFC-GOLD Strategic Design and other planning

documents;

- reviews and assesses the development and implementation of the components of GOFC-GOLD;
- recommends revisions and pursues solutions when necessary in relation to the development and implementation of GOFC-GOLD
- seeks to provide the international coordination necessary for the implementation of GOFC-GOLD in coordination with other international organizations, including members of IGOS-P and GEOSS, and work to build partnerships to achieve common objectives;
- ensures effective use of existing international mechanisms, including the working groups of CEOS and other components of GTOS;
- reports annually to GTOS;
- by means of reports from the Implementation Teams and Regional Networks, and other sources, articulates and advocates observational requirements for space agencies and in-situ agencies, with particular emphasis on long lead-time requirements, and identify gaps and overlaps in current plans; and
- ensures the reporting of GOFC-GOLD activities beyond the solely technical, especially in relation to the needs for capacity building.

The STB also communicates with the GTOS/GCOS Terrestrial Observation Panel for Climate to ensure that GOFC-GOLD is responsive to the observational requirements for products necessary to understand the terrestrial carbon cycle. The STB communicates with the IGOS Partnership to ensure that GOFC is responsive to the needs of CEOS members and other IGOS Partners. This communications channel provides input from GOFC-GOLD to CEOS members to enable them to modify their programs to become more efficient in responding to the observational needs identified by GOFC-GOLD.

The **Chair of the STB** of GOFC-GOLD has the following responsibilities:

- provide overall strategic leadership of GOFC-GOLD as well as chairing the Board itself when it meets;
- as necessary, represent GOFC-GOLD in international fora and in particular will represent it as a one of the Panels of GTOS, when its steering committee meets;
- seek, in collaboration with others, those funds necessary for the operation of GOFC-GOLD;
- serve as a member of the Executive Committee of GOFC-GOLD; and
- with the guidance of the Executive Committee and Board, approve the appointments of members of the Implementation Teams.

The Executive Director and leaders of the implementation teams serve as non-voting members of the STB.

Executive Committee

The Executive Committee is a small, active group which takes the important actions necessary to ensure that GOFC-GOLD continues to make progress toward its objectives. The committee meets once per year in person and monthly through teleconferences. Between meetings, members

maintain frequent contact by list server, email, and phone. The Executive Committee:

- works to form partnerships which lead to the initiation of project activity;
- helps to arrange sponsorship of projects;
- monitors program and project implementation and progress;
- ensures availability of project outputs and results;
- reviews proposals for inclusion in GOFC-GOLD against clearly stated criteria; and
- creates short term teams to address specific issues.

Initial membership was drawn from the design teams. Current membership includes the Chair, Vice Chair, Executive Director, and Implementation Team Co Leaders. Other invited members include individuals from CEOS participating agencies and GOFC-GOLD partners (IGBP, FAO, GTOS/GCOS/TOPC, NGOs, national forest ministries), which are contributing to the implementation of GOFC-GOLD.

The invited membership on the Executive Committee is reviewed by the STB at its periodic meetings where new members are nominated and selected. Letters of invitation are prepared by the Executive Director.

The **Vice Chair** assumes all of the duties of the Chair when the latter is unavailable. As well, The Chair is invited to remain active in GOFC-GOLD for three years after the change of position and to participate as needed in Executive Committee functions.

Project Office

The Project Office provides the main administrative infrastructure of GOFC-GOLD and hence requires that a proactive stance is taken to ensure that meetings are properly prepared, reports written and the web site is maintained.

Record-keeping and Communication

The primary function of the GOFC-GOLD Project Office is to ensure effective record-keeping, and communication between all GOFC-GOLD elements, including the STB, the Implementation Teams and the Regional Networks.

The project office also ensures effective communication and documentation of communications between GOFC-GOLD and its external audience. Communications are carried out using electronic means such as: electronic mail; the GOFC-GOLD Website; a GOFC-GOLD/GOLD Data Site; as well as by traditional printed media when appropriate.

The Project Office provides planning support for meetings and is responsible for public outreach.

The Office assists in funding the GOFC-GOLD program by collecting resource requirements from the various elements of GOFC-GOLD, assessing the extent to which available resources can meet the program and then helping the various elements of GOFC-GOLD to acquire the additional resources needed.

Representatives of the office and normally the Executive Director is expected to attend a substantial number of GOFC-GOLD meetings. This responsibility of representing GOFC-GOLD as a whole would normally be shared with the chair of the STB.

Reporting and Communication

The Project Office reports to the STB through a draft Annual Report to STB, and incorporates modifications and revisions required by STB.

The Project Office communicates regularly with the Chair of STB and with the Leaders of the Implementation Teams [and RNs] to ensure orderly execution of GOFC-GOLD activities.

The Project Office provides an **Executive Director** for GOFC-GOLD, plus professional and technical support staff to support the office functions. The Executive Director plays a substantive role in the development of the GOFC-GOLD program at both strategic and implementation levels. Responsibilities include:

- raising resources for GOFC-GOLD;
- maintaining overall time-table of events - to avoid conflicts between GOFC-GOLD activities and with other meetings of other organizations;
- organize meetings of the STB;
- financial planning;
- publicity and outreach materials: Support of web site, brochures, posters etc.;
- GOFC-GOLD Reports (ensuring these are available through the web site, have a common front page, have a number etc.);
- representing GOFC-GOLD at meetings of other organizations;
- maintaining lists of memberships of STB, ITs, sub-groups etc.;
- development and support of GOFC-GOLD-DIS;
- liaison with key agencies (e.g. UN organizations. space agencies, etc.); and
- support of IT meetings.

Implementation Teams

GOFC-GOLD depends on the voluntary contributions of organizations to carry out project work. Therefore, implementation teams are formed by participating organizations to accomplish specific tasks. Under the desired scenario, GOFC-GOLD recommends products which should be produced, and encourage suitable organizations to take the lead to form projects to produce them.

Following the GOFC-GOLD strategy document, implementation teams have been formed to address each of the two primary themes: Land Cover Characteristics and Changes, and Forest Fire Monitoring and Mapping.

The implementation teams normally have one annual face-to-face meeting in addition to workshops and seminars that they may organize.

Each team is led by two **Co-Leaders** who are the points of contact between the implementation team and GOFC-GOLD, and communicate through the Executive Committee. The role of the co-leaders is to:

- provide strategic leadership of the GOFC-GOLD implementation teams, as well as chairing the teams when they meet;
- as necessary represent the implementation teams in international fora;

- seek in collaboration with others those funds necessary for the operation of the implementation teams;
- serve as member of the Executive Committee of GOFC-GOLD; and
- nominate team members for the approval of the Executive Committee.

Implementation Team Members conduct activities, which advance GOFC-GOLD's overall objectives. Team members are invited to include their land cover and fire-related scientific and technical activities as projects contributory to the GOFC-GOLD implementation themes.

Implementation teams may establish separate Project Offices to support their activities.

Regional Networks

The regional networks provide a forum for data providers, users and researchers operating in (or with an interest in) a common geographic area, and represent a link between national agencies and user groups and the global user/producer community. The regional networks also provide a mechanism for calibrating, validating and improving methods and algorithms and a place to test integration of in-situ and remote sensing observations.

Networks are self governed and self supporting. At the strategic level, GOFC-GOLD provides the networks with a minimum set of requirements to guide the collaborative association, which are based on the nine panel functions. At the technical level, the networks receive guidance from the Implementation Teams. Network representatives attend and contribute to STB and IT meetings.

Regional Network Members are selected to represent the countries within each Network's area of focus. The members conduct activities, which advance their Network's objectives.

Working Groups

From time to time the GOFC-GOLD Executive Committee will identify specific topics where recommendations are urgently needed to enable GOFC-GOLD to meet its objectives. The Executive Committee will have a mandate to form Working Groups which will be given a specific task, and requested to report back to the Executive Committee within a relatively short time period. In many cases existing WGISS or WGCV working groups, or subsets of these, might be able to address topical tasks identified by the GOFC-GOLD Executive Committee.

Appendix 3. List of Acronyms

ALOS – PALSAR	Advanced Land Observing Satellite - Phased Array type L-band Synthetic Aperture Radar
ASAR	Advanced Synthetic Aperture Radar
ASF	Alaska Satellite Facility
ATSR	Along Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
Avialesookhrana	Remote Wildfire Monitoring Information System (Russia)
CBD	Convention on Biological Diversity
CCRS	Canada Centre for Remote Sensing
CEOS	Committee on Earth Observation Satellites
CEOS WGCV	CEOS Working group on Calibration and Validation
CEOS WGCV LPV	CEOS WGCV - Land Product Validation Subgroup
CEOS WGISS	CEOS Working Group on Information Systems and Services
CNES	Centre National d'Etudes Spatiales
CONABIO	Comisión nacional para el conocimiento y uso de la biodiversidad
CSA	Canadian Space Agency
CSIR	Council for Scientific and Industrial Research (S. Africa)
CSIRO	Commonwealth Scientific and Industrial Organisation
CSIRO	Commonwealth Scientific and Industrial Organisation
DLR	Deutsches Zentrum für Luft- und Raumfahrt
EDC	EROS Data Center (USGS)
ENVISAT	Environmental Satellite
ENVISAT	Environmental Satellite
EOSD	Earth Observation for Sustainable Development of Forests
EROS	Earth Resources Observation Systems (under USGS)
ERS	Earth Resource Satellite
ESA	European Space Agency
EUMETSAT	European Meteorological Satellite Agency
FAO	Food and Agriculture Organization of the United Nations
FCCC	Framework Convention on Climate Change

FPAR	Fraction of Photosynthetically Active Radiation
FRA	Forest Resources Assessment
GBFM	Global Boreal Forest Mapping Project
GCOS	Global Climate Observing System
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GEWEX	Global Energy and Water Cycle Experiment
GFMP	Global Forest Mapping Program
GFRA	Global Forest Resources Assessment
GIS	Geographic Information Systems
GLCF	Global Land Cover Facility
GLCN	Global Land Cover Network
GMES	Global Monitoring for Environment and Security
GOES-R	Geostationary Operational Environmental Satellite System -R
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GOOS	Global Ocean Observing System
GRFM	Global Rainforest Mapping Project
GSN	GCOS Surface Network
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper-Air Network
IBAMA	Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (Brazil)
ICSU	International Council for Science
IGBP	International Geosphere-Biosphere Programme
IGOL	Integrated Global Observations of the Land
I-GOOS	Intergovernmental - Global Ocean Observing System
IGOS	The Integrated Global Observing Strategy
IGOS-P	Integrated Global Observing Strategy Partnership
IHDP	International Human Dimensions Programme on Global Environmental Change
IPCC	Intergovernmental Panel on Climate Change
IRS	Indian Remote Sensing Satellites
ISLSCP	International Satellite Land Surface Climatology Project

JERS-1	Japanese Earth Resources Satellite-1
JPL	Jet Propulsion Laboratory
JRC	Joint Research Centre
LAI	Leaf Area Index
Landsat TM/ETM	Landsat Thematic Mapper/Enhanced Thematic Mapper
LATUV	Laboratorio de Teledetección de la Universidad de Valladolid (Spain)
LCCS	FAO Land Cover Classification System
LCLUC	Land Cover and Land Use Change
LTAP	The Long Term Acquisition Plan
MA	The Millennium Ecosystem Assessment
MERIS	Medium Resolution Imaging Spectrometer
MODIS	Moderate Resolution Imaging Spectroradiometer
MRLC	Multi-Resolution Land Characterization
NASA	United States National Aeronautics and Space Administration
NASA GISS	NASA Goddard Institute for Space Studies
NASDA	National Space Development Agency
NERIN	Northern Eurasia Regional Information Network
NOAA	United States National Oceanographic and Atmospheric Adimintration
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NPP	Net Primary Productivity
NPP (NPOESS)	NPOESS Preparatory Project
NRC	National Research Council
OLI	Operational Land Imager
OSFAC	Observatoire Satellital des Forêts d'Afrique Centrale (GOFC-GOLD Central Africa Regional Network)
PAR	Photosynthetically Active Radiation
Ramsar	Ramsar Convention on Wetlands
REDLATIF	Red Latinoamericana de Teledetección e Incendios Forestales
SAFNET	Southern African Fire Network
SAR	Synthetic Aperture Radar
SAR	Synthetic Aperture Radar
SAR	Synthetic Aperture Radar
SEARRIN	South East Asia Regional Research and Information Network

SPOT	Spot Earth Observation Satellites
START	System for Analysis, Research and Training
STB	Scientific and Technical Board
TCO	Terrestrial Carbon Observation
TEMS	Terrestrial Ecosystem Monitoring Sites
TOPC	Terrestrial Observing Panel for Climate
TREES	The TRopical Ecosystem Environment Observations by Satellite
UMD	University of Maryland
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNFCCC - COP	UNFCCC - Conference of Parties
UNISDR	United Nations International Strategy for Disaster Reduction
UNOOSA	United Nations Office for Outer Space Affairs
USDA	United States Department of Agriculture
US-EPA	US Environmental Protection Agency
USFS	USDA Forest Service
USGS	United States Geological Survey
VIIRS	The Visible Infrared Imager Radiometer Suite
WCRP	World Climate Research Programme
WGCV	Working Group on Calibration and Validation
WGISS	The Working Group on Information Systems and Services
WHO	World Health Organization
WMO	World Meteorological Organization
WSSD	World Summit on Sustainable Development