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Global Observation of Forest Cover: one component of CEOS' Integrated Global Observing Strategy

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Abstract - CEOS, the Committee on Earth Observation Satellites, has recognized the need for a coordinated approach to providing global data sets. One important need is for coordinated global observation of forest cover to address global concerns, particularly about biodiversity, land cover degradation, and greenhouse gas buildup in the earth's atmosphere.

As a result, Global Observation of Forest Cover (GOFC) has become one of six prototype projects within the CEOS Integrated Global Observing Strategy (IGOS). GOFC has established a network of participating organizations which, at present, are making voluntary contributions to the effort of planning a response to the need.

GOFC will propose means to produce specific products to address specific user requirements, assemble the networks of facilities to produce these products, and begin to produce them on a pilot-project basis, with plans for ultimate transition to operational production. This paper discusses the requirements, the strategy to satisfy the requirements, technical and non-technical obstacles which must be overcome, and suggest ways in which other organizations may become involved.

I. INTRODUCTION

The management of the forests of the earth has become an issue of global concern. In addition to traditional anxiety over adequate supplies of wood for fuel, construction, and papermaking, more recent indirect but related concerns centre on issues of soil erosion, watershed protection, biodiversity, recreation and tourism, equitable treatment of indigenous populations, and the buildup of greenhouse gases in the Earth's atmosphere. Stimulated especially by the Rio

Earth Summit in 1992, the nations of the earth, through the United Nations and other bodies, are laying the groundwork to deal with these problems.

Several Agenda 21 initiatives, including the Convention on Biological Diversity, the Kyoto Protocol to the United Nations Framework Convention on Climate Change, the Montreal, Helsinki, and Tarapoto Processes leading to

Criteria and Indicators of Sustainable Forest Management, and the Intergovernmental Panel of Forests all represent concrete steps forward by sovereign nations dealing with global problems. All of

these initiatives require information about forests to assess progress, although some have progressed further in identifying specific information requirements.

With a mandate to report on the state of the Earth's forests every 10 years, the Food and Agriculture Organization (FAO) of the United Nations has pioneered in the use of earth observation data as part of its Forest Resource Assessment for the year 1990 (FAO, 1995, 1996).

Since 1972, the earth has been under observation from space with satellites designed to provide information about earth resources, including forests. The data from these satellites has been widely used to map and monitor forest resources. However, these mapping and monitoring projects have generally been made within individual jurisdictions, such as states, provinces, or forest management units. Until recently, there has been little effort to use earth observation data, particularly data from the higher resolution natural resource satellites, to create a consistent global picture of the earth's forests, or to monitor changes in the forests worldwide.

In response to concerns about the global impact of human activities on the earth's forests, researchers have begun to assemble national, continental, and global data sets from earth-observation satellites in an attempt to provide badly-needed information about the state of the earth's forests, and how they are changing. Examples of programs which have provided essential experience and positive results include the World Forest Watch (INPE, Brazil), Landsat Pathfinder (NASA, U.S.), TREES (Joint Research Centre, Europe), IGBP 1 km Land cover (NASA, NOAA, USGS), Forest Resource Assessment (FAO, UN), North American Landscape Characterization (U.S. Environmental Protection Agency), and Global Rainforest Mapping (NASDA, Japan, and JPL, U.S.).

II. CEOS RESPONSE

The Committee on Earth Observation Satellites (CEOS) is an organization composed of space agencies, affiliates, and observers linked by a common interest in the provision and use of earth observation data from space. Recognizing the accomplishments to date, but also the shortcomings, CEOS members have developed an Integrated Global Observing Strategy (IGOS) to coordinate earth observation programs in six critical areas, including Global Observations of Forest Cover (Shaffer, 1996 and 1997, Ahern, 1998). The objectives are to increase international cooperation in the integration and use of data from several earth observation satellites for mapping and monitoring the earth's forests, to identify technical and non-technical barriers, to improve the integration of earth-observation and *in-situ* data, and to provide feedback to the space agencies to enable them to better coordinate future space missions. A team of experts met in Ottawa, Canada, in July, 1997 to draft a plan for a co-ordinated program for Global Observation of Forest Cover (Janetos and Ahern, 1997).

Rather than creating a new institution, GOFC seeks to produce a networked international consortium of existing programs. The objectives of the GOFC consortium are:

- to produce high quality, multi-resolution, multi-temporal global data sets and derived products of forest cover and attributes;

- with particular attention to areas of rapid change and fragmentation;
- to be repeated for quantitative analysis of subdecadal variation;
- with associated regional applications and methodological investigations;
- for the benefit of multiple user communities;
- with ultimate transition to routine operational use.

Four classes of user groups, each with distinct information requirements, were identified:

- International organizations;
- National and regional forest agencies;
- Science community (as represented by IGBP, for example);
- International treaties and conventions (e.g. Convention on Biological Diversity, Intergovernmental Panel on Climate Change, Criteria and Indicators of Sustainable Forest Management).

A suite of potential products has been defined which is expected to meet many of the information needs of users from the above categories. including:

- coarse and fine resolution optical and SAR (L and C band) data;
- coarse and fine scale land cover maps, to repeated on a 3 to 10 year cycle (depending on budgets and capabilities);
- forest disturbance maps (fire on a one year cycle and harvest on a 3 to 10 year cycle);
- forest functioning variables (LAI, FPAR, PAR) at coarse spatial resolution but fine time resolution;
- land cover change, concentrating on areas of rapid change on a 1 to 5 year cycle.

It is proposed for GOFC to make maximum use of existing capabilities within CEOS partners and affiliates, recognizing that considerable effort will be required to coordinate activities and to expand technical and institutional capabilities.

Three phases of GOFC are proposed: (1) a Design Phase, in which technical details of product definition, acquisition, processing, access, distribution, analysis and institutional cooperation are worked out, and in which further consultation with user and operational communities are pursued; (2) a Prototype Phase, in which implementation begins, regional experiments are conducted, and the first set of experimental products are produced; and (3) an Execution Phase, in which the production and distribution of final products is achieved with new acquisitions from Earth observation sensors.

This plan has been endorsed by CEOS members. As a result we are working in 1998 to produce a detailed design of a network of agencies, to work together to develop the requisite systems and know-how to produce the proposed products.

To achieve its objectives, GOFC must make progress in both technical and institutional spheres.

Technical progress will be needed in coordinated acquition of data from multiple missions to ensure the necessary data sets are acquired under the conditions necessary to provide the requisite information. Because of the need to cover large areas, highly automated preprocessing methods will have to be developed, particularly in the

areas of geometric and radiometric correction of data from optical and microwave satellites. The acquisition of a suitable geometric reference ("base map") and congruent digital elevation information will be an early challenge. Techniques to mosaic many scenes from optical sensors such as the Thematic Mapper have been developed under previous projects. These will have to be implemented on a large scale for GOFC. Innovation will be required to catalog individual scenes and derived, wide area products, and to provide ready information and access for a variety of users for differing products. Cost and delivery will be important data access issues. Recent experience has shown that image classification requires a tremendous amount of manual work by skilled professionals, and therefore carries a very high price. GOFC will be looking for advances in this area. The IGBP has defined a highly automated fire detection algorithm using AVHRR data, which may be used to produce global fire products. No such approach appears to be on the horizon for land cover classification and land cover change detection/classification. GOFC will attempt to stimulate research in this critical area.

In parallel with the growth of the Internet (perhaps stimulated by that growth) recent years have shown a marked improvement in the willingness of organizations to share data and cooperate in joint projects. The success of GOFC will depend critically on such sharing and cooperation. GOFC will have to supply the tools to foster the necessary cooperation. Innovations will be required in distributed project management, making liberal use of the Internet and wider-band communications technology.

The provision of information alone is an empty exercise if the information does not make an impact on policy. The opportunity presented by GOFC will stimulate progress in this area. Likewise, the provision of forest information from space must be continue indefinitely if this endeavour is to be truely successful. This necessitates the identification of stable, secure sources of funding for data procurement, processing, and distribution. Finally, GOFC will clearly identify gaps and overlaps in the current and planned supply of earth-observation data. This will challenge CEOS members to improve the coordination of their earth observation programs to provide better data at lower cost, not only for monitoring the earth's forests, but for numerous land surface applications.

III. HOW TO GET INVOLVED

GOFC is a project which is global in scope, with an interest in all forested areas. The United Nations FAO, the IGBP, and many space agencies are participating in or intend to participate in GOFC. There is an ongoing need for additional participation by both suppliers and users of data. There is also a need for supporting research in areas identified in section II. Currently there is no external funding; participation requires the committment of individuals' institutions for their time and travel costs. Recognizing the importance of forests in many developing countries, the GOFC team is searching for sources of funds to increase participation by developing countries. Organizations or individuals who are interested in volunteering their participation in GOFC are invited to contact the first author.

IV. CONCLUSIONS

Recognizing the essential contribution which can be made by data from spaceborne earth observation data, a program for Global

Observations of Forest Cover has been initiated through the stimulus of the Committee on Earth Observation Satellites in response to numerous environmental concerns related to forest management. A project proposal was prepared in 1997, endorsed by the CEOS Strategic Implementation Team, and subsequently accepted at the CEOS plenary meeting in Toulouse, France. GOFC has now entered its design phase. We expect GOFC to become a broadly-based participatory endeavour linking data providers, processors, and users worldwide. It will make optimum use of Internet technology to provide current information about the project, facilitate a distributed form of project management, and make data and products widely available.

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