Global Terrestrial Observing System

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Global Climate Observing System

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1. Organization of the Meeting

1.1 Opening and Conduct of the Meeting

Dr. Josef Cihlar opened the meeting by welcoming the participants: the chairs of the GCOS Joint Scientific and Technical Committee and the GTOS Steering Committee, TOPC members, and representatives of other groups. He also thanked the Environmental Protection Agency for providing the facilities and the local organisers (Drs. Kibby and Solomon) for making the necessary arrangements.

Dr. Cihlar emphasised the working nature of the meeting and the need for dealing with a number of issues, in part as a result of a 2-year gap between the meetings. He identified the following broad objectives for the meeting:

Review the current situation in areas of importance to TOPC and developments since the last TOPC meeting in 1996
Complete or significantly advance tasks undertaken for 1998
Discuss priorities and important activities for the next 1-2 years

1.2 Approval of the Agenda

Dr. Cihlar reviewed the draft agenda distributed prior to the meeting. With some changes and refinements, the participants adopted the agenda. The final agenda is presented in Annex I.

2. Reports on Current Status and Updates

2.1 GCOS Activities

Dr. John Townshend, Chair of the Joint Scientific and Technical Committee of the GCOS, provided an update on GCOS status. He summarized the main objectives of GCOS and stressed its comprehensive responsibility with respect to climate, including not only the impact of land surface properties on climate but also the impacts of climate change on terrestrial characteristics. Its work is carried through various panels, all of which were joint panels either with other observing systems, or with the WCRP. No joint panels with IGBP (International Geosphere-Biosphere Programme) had yet been achieved which was to be regretted.

The first of the three main objectives of GCOS is to prepare a comprehensive set of plans. This work had gone through at least one phase and for some aspects two versions of plans have already been proposed. The second of GCOS's main objectives has been to implement the initial observing system and considerable progress has been made here in the form of several networks including the GCOS Upper Air Network and the GCOS Surface Network.

The third objective relates to the development of future plans and implementation beyond the Initial Observing System (IOS), which for space components is largely been carried through co-operation with the Committee for Earth Observing Satellites. The latter has led to a proposed strengthening of the role of the Global Observing Systems Space Panel (GOSSP) in assessing requirements for space observations.

The role of the Joint Data and Information Management Panel would likely be restricted to crosscutting issues leaving most specific data and management issues to the individual science panels.

A major activity for this year is the preparation of a report on the inadequacies of climate observations in support of the Framework Convention on Climate Change and the TOPC was encouraged to generate a submissions for inclusion in this document (refer to Section 8.0 below).

2.2 GTOS Activities

Dr. James Gosz, the Chair of the GTOS Steering Committee (GTSC) provided information on the current status and near-future plans for GTOS. Since the last TOPC meeting, several important developments have taken place, including:

- the establishment of the GTOS Steering Committee;
- preparation of several project proposals;
- preparation of an implementation plan, based on the GTOS Planning Group report and SC discussions;
- strengthening linkages with GCOS, GOOS and other global change initiatives;
- cosponsoring a meeting on terrestrial ecosystem networks;
- information dissemination.

The establishment of a network of terrestrial ecological observing sites is a key initial GTOS activity. The impetus for this initiative came from a meeting of representatives of ecosystem networks sponsored by GCOS, GTOS, and IGBP in Guernica, Spain, from 17 to 20 June 1997 (GCOS-38). At that meeting, the representatives of the participating networks endorsed the concept of, and expressed interest to participate in a global network of ecological sites. The proposed network, the GT-Net, would be consistent with the GHOST (Global Hierarchical Observing Strategy) sampling approach developed by the TOPC (GCOS 32).

At the Guernica meeting, critical need was identified for an activity that would (i) demonstrate the feasibility of a global terrestrial network and (ii) provide the means by which the practical aspects of establishing and operating the network could be developed and tested. The participants proposed a demonstration project on net primary productivity (NPP) of terrestrial ecosystems. NPP was chosen because of its ecological significance and the existing and future measurement capabilities, especially through space observations. Further information on the project and progress made at this meeting is presented in Sections 4.4 and 5.1.

The second meeting of the GTOS Steering Committee will take place in Santander, Spain, from 15 to 19 June 1998 and will be chaired by the new GTOS SC chairman, Dr. James Gosz of the University of New Mexico, Albuquerque, NM, USA. Dr. Gosz also chairs the U.S. LTER Network (a member of the GT-Net) and the International LTER Network. The main issues discussed at this meeting will be :

- GTOS Implementation plan
- Data and Information Management
- Space Observations

- Terrestrial Observations
- Networks
- Collaboration with other organizations and programmes
- GTOS programme development
- Functioning of GTOS
- The TOPC and results of this meeting will be presented by Dr. Cihlar.

2.3 Report of Recent JDIMP and AOPC Meeting

Dr. Ron Wilson, as a representative of the Global Observing Systems Information Centre (GOSIC), provided a brief report on the meeting of the Joint Data and Information Management (JDIMP) Panel in Manoa, Hawaii, 28 April - 1 May 1998. The JDIMP met in a joint session with the Atmospheric Observation Panel for Climate (AOPC).

The JDIMP discussed progress on the intersessional work plan, including: the drafting of new terms of reference and a plan reflecting the new responsibilities for ocean and terrestrial observations, the development of a metadata standard for G3OS data sets and, with the establishment of the GOSIC at the University of Delaware (refer to Section 10.1), an approach to co-ordinating data management aspects of the G3OS.

With respect to the JDIMP plan and terms of reference, the meeting noted that two previous JDIMP responsibilities (to identify data sets relevant to meeting G3OS objectives, and to identify and redress gaps in available G3OS data sets) were in fact being carried out by the scientific panels. The JDIMP meeting participants agreed that the expertise to carry out these tasks was generally available in the panels and not in the JDIMP. Thus it was recommended that these scientific activities should no longer be the responsibility of the JDIMP. The JDIMP will continue to be concerned with the definition of adequate metadata standards, with identifying cross-cutting data and information management issues, with the provision of advise and oversight on the performance of data and information systems, and with the development of the GOSIC.

The AOPC endorsed the new focus for the JDIMP, which in fact cleared up an area of duplication between the two panels in identifying data requirements and specifying some of the data management needs. The AOPC meeting also addressed the further development of the Global Upper Air Network (GUAN) and the Global Surface Network (GSN). Further, the AOPC concentrated on the development of the observation system for atmospheric constituents. No detailed information regarding the results of these discussions was available prior to the TOPC meeting.

2.4 Report of the Workshop on Climate Extremes

Dr. Jurate Landwehr presented information about the 1997 workshop entitled "Workshop on Indices and Indicators for Climate Extremes" which was held on 3-6 June 1997 in Asheville, North Carolina. It was hosted by NCDC, sponsored by GCOS, WMO and CLIVAR, and chaired by Mr. Thomas Karl. Attending were about 200 people from around the world. Additional sponsors included several insurance and re-insurance companies who are interested in climate change and its effect on the probabilities of more frequent and/or larger future claims. These companies have very specific concerns with respect to quantifying the probabilities of natural disaster extremes. Munich Reinsurance provided a list of data items of concern to them, which included air temperature, precipitation, wind speed and hail and lightning frequency and severity. Many of these variables were needed at a high temporal resolution (such as hourly maximum) that is not usually considered necessary for climatic data sets.

The first part of the workshop was devoted to presentations related to the assessment of regional climate trends. Three observations can be made: (1) there is a need to adopt a long-term perspective when discussing climate trends -- a 20 or 30 years window may not be sufficient; (2) the quality and commensurability of measurements in long records are critical for trend analysis; and (3) it is necessary that the same label be used for the same phenomena. For example, flooding cannot be defined by high precipitation averages in one case/country and extreme flow events in another, if meaningful comparisons are to be made.

The second part was devoted to three breakout sessions, which discussed statistics, analytical methods, and indices appropriate for the study of trends in time series of various phenomena. The three sessions addressed a) storms, hurricanes, lightning, etc.; b) precipitation; and c) temperature. Reports and recommendations of the three committees, along with the presentations will be published as a book. In all cases, the increasing importance of extreme events (and their associated probabilities) was evident.

Data needs to address the above issues were also discussed at the workshop. It is anticipated that specific data collection activities will be initiated to provide the basis for studying the identified questions. These data sets will be highly useful to TOPC because of their high temporal resolution (current global data sets are mostly aimed at monthly means).

TOPC agreed that Dr. Landwehr would continue to be the Panel's contact with these activities, and will ensure that the interests of the user community are represented as appropriate.

2.5 Integrated Global Observation Strategy

Dr. Townshend provided a description of the Integrated Global Observation Strategy (IGOS).

A single origin for the IGOS is impossible to identify. Indeed whatever origins of the recent discussions of the IGOS integrated systems of space and in situ observations had been successfully developed, especially in the field of weather forecasting through WMO's World Weather Watch. Conceptually, IGOS is based on the simple recognition that the range of global observations needed to adequately understand Earth processes, monitor the Earth and assess impacts exceeds the capability - scientifically, technically and financially - of any one country. Hence co-operation is necessary. Such co-operation must be based on a clear understanding between partners of the overall needs and the respective roles of partners to enable priorities to be addressed such that issues are neither duplicated nor omitted. As such, IGOS would not replace the bottom-up scientifically driven approach to individual concerns but would rather provide the overall framework against which progress can be measured.

In terms of the current evolution of ideas about an overall strategy, the beginning of explicit international discussions can be traced back to the 1994 meeting of the GCOS/JSTC in Hamburg. Earlier than that at the CEOS Plenary in London in 1991 the British National Space Centre developed the initial database of all existing and planned activities. Although this was paper-based it did have the first assessment of the extent to which requirements were being met, and a document was produced and distributed at the United Nations Conference on Environment and Development (UNCED) meeting in Brazil. In Berlin at the 1993 CEOS plenary it was agreed to carry out a comprehensive analysis of the relationship between space capabilities and the requirements of users resulting in a Task Force. Responsibility for the data base of user needs was led by WMO and the compilation of space observing system capabilities was led by the European Space Agency. Today, WMO is still managing the database, which is available on the Internet.

In 1995 the NASDA (National Space Development Agency, Japan) brought forward proposals to a number of agencies that a so-called Integrated Global Observation System should be considered. At the 1995 CEOS Plenary in Ottawa a side bar discussion contained a series of presentations from NASDA, NASA (National Aeronautics and Space Administration, USA) EUMETSAT (European Organization for Meteorological Satellites) and GCOS. As a result of the latter meeting a CEOS-sponsored ad hoc meeting was held in Seattle in March, 1996. This focused on the Space component of an Integrated Global Observation Strategy (rather than a System). A follow-on meeting was held later that year in September, sponsored by the three global observing systems, on the development of an IGOS for In Situ observations. One immediate outcome of these meetings was to call IGOS a strategy, not a system. This was in recognition of the fact that systems already exist and that IGOS would in reality be the collective of existing and new systems.

At the CEOS Plenary held in Canberra in November of 1996, a decision was made to set up two parallel activities. One was directed towards setting up prototypical projects to demonstrate the value of an integrated approach, called the Strategic Implementation Team (SIT) and the other to carry out an improved analysis of the relation between capabilities and requirements in an Analysis Group.

SIT first met in Irvine in February of 1997, where six projects were set up including the Global Observation of Forest Cover project to be discussed later in this meeting. Subsequently SIT met in Oxford in October 1997 and in Paris in March 1998, having had its mandate renewed by the CEOS Plenary in Toulouse in 1997. The Analysis Group first met in Darmstadt, Germany in March 1997, in Tokyo in July 1997, and in Silver Spring, Maryland in September 1997.

In parallel with this activity, the Sponsors of the three global observing systems (G3OS) endorsed the concept of an IGOS and prepared a discussion paper addressing a number of key issues. Recently, it was agreed that the joint space panel (GOSSP) be the controlling body for communicating the G3OS requirements to the CEOS affiliates. This task will require a broadening of the role of the panel and involve obtaining the approval of the sponsoring bodies.

3. Review of TOPC Goals and Strategy

3.1 Framework for TOPC

Dr. Cihlar introduced the subject by presenting a conceptual framework for the activities in the initial observing systems (IOS); reviewing the TOPC goals and strategy used to achieve these goals; and reviewing TOPC tasks presently underway.

The conceptual framework (Figure 1) is intended to facilitate the planning and execution of TOPC activities. The framework builds on the planning activities for terrestrial climate-related observations (presented in the second version of the TOPC planning document

(GCOS Report #32, 1997)), and relates to the initial implementation of the global terrestrial observing systems. In addition to helping TOPC identify critical tasks, it should assist in determining if various candidate activities are critical to the TOPC mission.

To ensure that the observing systems provide outputs relevant to the problems to be solved, it is necessary to identify key climate issues and questions in the terrestrial domain. Four such questions were previously identified and presented to the JSTC (Joint Scientific and Technical Committee, GCOS) and IGBP for comments. They concern four aspects of the climate - terrestrial environment relationship:

Changes in the magnitude, direction, and regional or seasonal distribution on climate change and variability;
Impact of climate change on terrestrial ecosystems;
Changes in terrestrial characteristics affecting processes and terrestrial-atmospheric interactions;
Critical terrestrial variables and data sets needed for general circulation models and for assessing the terrestrial impacts of climate change.

Specific sub-questions were identified as examples for each of these (see Annex IV).

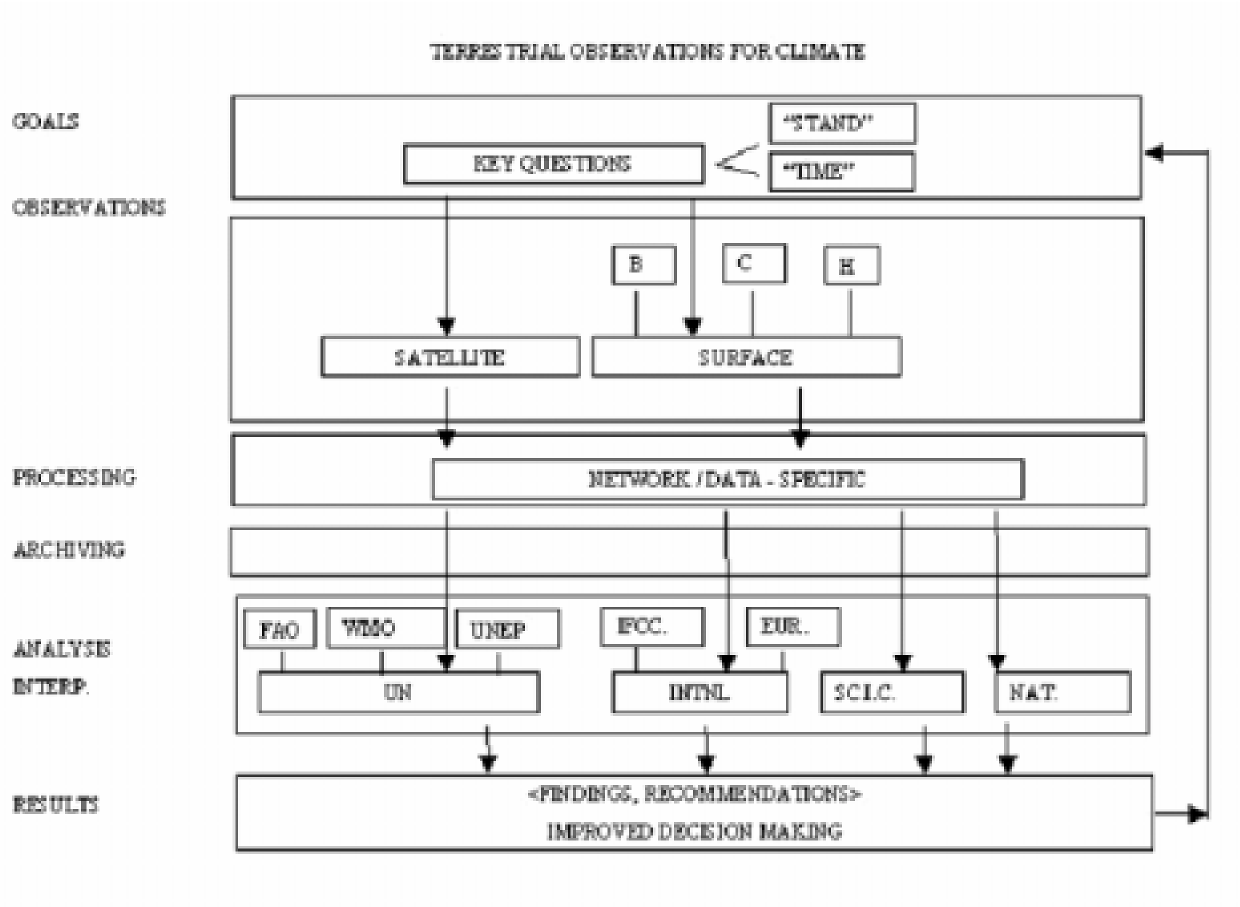

Figure 1: Terrestrial Observations for Climate

The conceptual framework in Figure 1 identifies the main activities and players in the domain of interest to TOPC, i.e. the climate-related terrestrial issues. It is evident that because of the important roles that climate plays in the terrestrial systems, the complexity of the latter and the number of agencies and interests at various geographic and policy levels, the initial implementation must be considered carefully and from a number of viewpoints. On the other hand, a functioning global observing system is relatively straightforward (refer to the left-hand side of Figure 1): the appropriate data must be collected, processed and analysed, and used for improved understanding of the changes and improved decision making.

3.2 Goals of TOPC

Based on the above schema, four goals were proposed for the next 5 years. They recognise that satellite observations and terrestrial networks are fundamental building blocks for global observing systems; that joint activities of terrestrial networks and sites are a key mechanism to establish a functioning system for land observations; and that the compiled global data sets is the key desired output. The proposed goals are:

By 2003:

- Establish networks, ensure their longer-term viability including the necessary ongoing support of GCOS/GTOS. Functional networks will be established for ecology, glaciers, permafrost, and hydrology;

- Stimulate completion or near-completion of two demonstration projects, Net Primary Productivity (NPP) and Global Observations of Forest Cover (GOFC);

- Stimulate compilation of critical data sets for IPCC or other important users;

- Demonstrate continuing responsiveness to (changing) requirements, including those flowing from IGBP, IPCC, and convention secretariats, WCRP.

The achievement of the above goals must be a collective effort, with TOPC contributing leadership and initiative in relation to specific issues and areas. Identifying appropriate new activities and the directions in which they should evolve, and providing leadership or stimuli to initial progress are among the most effective contributions of TOPC to establishing the Initial Operating System. Given in addition the very limited resources available to TOPC and the extra-curricular nature of TOPC members' contributions, the best strategies for achieving the goals appear to be:

- Assist in the establishment of networks through TOPC members' activities and professional contacts;
- Assist in the initial implementation by:
    - identifying data sets;
    - establishing linkages with scientific programs (IGBP, GEWEX.);
    - identifying opportunities for continuing long-term observations from sunset experimental programs;
    - collaborating with GOSSP and other panels;

Participating in the formulation of important demonstration projects;
Supporting JSTC and GTSC in developing full-scale implementation plans;

Monitoring related developments, changing requirements.

Dr. Cihlar noted that the various activities undertaken by TOPC over the last year are consistent with the above approach.

TOPC discussed the above plan. It was agreed that Figure 1 provides a suitable framework for TOPC activities. The goals as outlined above are appropriate given TOPC terms of reference, recognising that their achievement requires collective effort of a number of agencies and groups. The key questions were modified in a subsequent discussion group to better reflect their relationship to policy and decisions makers (refer to Annex IV).

4. Status of Networks

4.1 Glaciers

Dr. Roger Barry reported on behalf of Dr. Wilfried Haeberli regarding the status of the existing glacier monitoring network.

Two TOPC-relevant variables are observed: glacier length and mass balance. Changes in glacier length have been observed annually or every 5-10 years at about 800 sites worldwide, primarily by field surveys, in some cases for up to a century; the measurements are supplemented in remote areas by air photos and high resolution satellite imagery. These sites provide tier 4 information and their countries report those records to the World Glacier Monitoring Service (WGMS) in Zurich. Most climatic zones are represented but the sites are unevenly distributed, with considerable long term data in European countries and sparse data in the three primary regions (the coastal Alaska-northern British Columbia and the Yukon, the southern Andes, and the Karakorum-Himalayas) contributing melt water to the world ocean. To assess the range of variation in individual climatic zones will require the use of regionally differing statistical criteria for glacier selection. There is also considerable unassembled and unorganized air photo and satellite imagery which could provide a historical baseline for tier 5 data. Future plans by the US Geological Survey, Flagstaff, AZ are being developed for a Global Land Ice Monitoring from Space (GLIMS) program based on Earth Observing System Advanced Spaceborne Thermal Emission and reflection Radiometer (ASTER) sensor to be launched in early 1999. Glacier mass balance, which is a direct indicator of net water exchange is measured on about 60 small glaciers annually. The spatial coverage and representativeness is uneven: about 11 glaciological field stations, mostly in Europe and Asia, represent tier 2 while the remaining sites with annual mass balance measurements are tier 3. The data on Fluctuations of Glaciers (FoG) and Glacier Mass Balance, together with a partial World Glacier Inventory (WGI), are organized by the WGMS following recommendations prepared by UNESCO in 1969. WGMS belongs to the Federation of Astronomical and Geophysical data analysis Services (FAGS) of the International Council of Scientific Unions.

Recently, a data base system has been developed at the WGMS containing FoG data for 1970-1990 and part of WGI. It is accessible at: http://www.geo.unizh.ch/wgms

The meeting participants discussed the report and recommended that WGMD should:

- identify gaps in the existing data bases and reporting network (tiers 3-5) and suggest a strategy to improve the situation to achieve TOPC/GCOS goals;
- approach national contacts to obtain commitments to data reporting on a regular and

timely basis;
- finalize the draft strategy and guidelines documents to enable the preparation of invitation letters to WMO representatives of participating countries.

4.2 Permafrost

Dr. Barry reported on the draft proposal of the International Permafrost Association (IPA) for a Circumpolar Active Layer Monitoring (CALM) network. There are currently 69 CALM sites, mostly in the circum-Arctic. Observations are made annually of the maximum depth of the permafrost active layer; some sites also measure ground temperatures. Summary data for the last five years appear on the IPA web site: http://www.geodata.soton.ac.uk/ipa

Site metadata are published on the Circumpolar Active-Layer Permafrost System (CAPS) CD-ROM produced by the World Data Center-A for Glaciology, Boulder, CO. Annual transfer of the CALM data to WDC-A for Glaciology is planned, together with the establishment of a separate CALM web site. Version 2 of a measurement protocol is under development. Additional sites in the Southern Hemisphere, the subarctic and high mountain areas will be solicited. A working group of CALM regional partners and GCOS/GTOS will be organized and coordination with the EC program on Permafrost and Climate in Europe (PACE) is under development. The next steps will be to obtain the endorsement and approval of the IPA Council at its meeting in Yellowknife in June, 1998.

The meeting participants recommended that the IPA address the following issues:

- assign CALM sites to GCOS/GTOS tiers;
- assess the representation of various permafrost climatic regimes and identify any gaps in coverage;
- evaluate options for filling any gaps in the CALM network;
- formalise organisational arrangements within the IPA/CALM structure;
- finalise the strategy and guidelines documents to enable preparation of invitation letters to the WMO representatives of participating countries.

The follow-up activities are captured in the 1998/99 work plan (Annex VIII.).

4.3 Hydrology

Observations of the terrestrial hydrology are critical for G3OS. Potential stresses on water resource systems are of primary concern when considering the impacts of climate change because water availability is critical to human society, just as it is for terrestrial ecosystems. Hydrologic variables, such as river discharge or fluctuations in a closed basin lake, provide an integrated assessment of climatic conditions over a river basin, and so are stand-alone indicator variables of regional climate trends. Importantly, hydrologic information is also needed in conjunction with meteorological variables to validate climate models as well as to close regional and global water budgets. The quality and quantity of freshwater input into the ocean also needs to be assessed, both to understand the transport of terrestrial material (such as sediments and carbon) into coastal systems and to quantify salinity changes in climatically critical ocean regions.

Hydrologic observations are commonly made in all countries, but there are no established international hydrologic monitoring networks although several collections of historic international data do exist. This situation exists for many reasons: funding agencies that pay for these expensive in-situ observations have national or regional concerns rather than global; there are generally no compelling reasons for local agencies to share information; national sensitivities to various water resource issues encourage centrifugal tendencies; etc.

Dr. Kibby briefly reviewed the present situation in hydrological data networks and data collection, including previous contacts and discussions undertaken by TOPC. These followed a meeting of experts in Geneva (GCOS, 1996) at which a number of important conclusions regarding terrestrial hydrological observations for climate were reached.

The difficulties involved in advancing the state of co-ordinated global hydrological observations were analysed in a subsequent discussion group and reviewed in the plenary session. It was agreed that TOPC should aim to make progress in areas where incremental, near-term improvements are realistically achievable, while stimulating consideration and discussion of more complex, longer-term issues. The specific activities and recommendations are:

Recommendation 1: ***Assess the availability of historic international stream discharge records to the TOPC user community.***
Action: Consult with the Global Runoff Data Centre (GRDC) on the present practices and data availability, including discussions with present data users.

Recommendation 2***: In collaboration with GRDC investigate the feasibility of routinely providing, on behalf of GTOS, certain specific discharge observations at global or continental scales in the future.***
Action: Consult with GRDC about the feasibility of such a plan. The first draft of the proposal is given below:

What/Where:

- Provide data records for rivers discharging into the ocean, when any one of three conditions is met:
- The river is among the top 300 major inputs of freshwater into the ocean. This should account for about 60% of the estimated continental runoff (= precipitation minus evaporation) which flows into the oceans.
- The river is a major freshwater source for a climatically sensitive region of the oceans, e.g. the North Atlantic or the Arctic Ocean.
- The river basin contributing the outflow has a population of above 1,000,000 inhabitants.

When:
The data provided should include monthly and daily averages, as well as the maximum instantaneous annual peak event.

How:
These data could possibly be made available by GRDC via web access, perhaps following the example of the USGS water information web page, or any other means of easy data entry.

Recommendation 3: ***Asses the availability of the Flow Regimes from International Experiments Data (FRIENDS) data sets to the G3OS community***.
Action: TOPC should approach FRIEND to investigate the availability of research data sets developed by the program to the general hydrologic and meteorological community, in

particular, for access through the Global Observing Systems Information Centre (GOSIC).

The World Hydrological Cycle Observing System (WHYCOS) is implementing a number of regional networks to improve hydrological monitoring. Many of the collected data sets have strong potential to contribute to the monitoring of climate changes and impacts on the terrestrial hydrological cycle. Since the WHYCOS data are obtained for a variety of reasons, there is a need to examine the availability of the acquired data sets for climate-related applications, and to assist in making adjustments where this is feasible or desirable.

Recommendation 4: ***Assess linkages of GCOS and GTOS to the WHYCOS Network and the availability of WHYCOS data for climate purposes.***
Action: TOPC should inquire about WHYCOS willingness to share its observations with TOPC, and should maintain a continuing contact with WHYCOS.

Recommendation 5***: Develop or encourage the development of a hydrologic network of pristine discharge stations for climate purposes.***
Action: Publicize the need among international hydrologic programs/associations, such as the International Association for Hydrological Sciences (IAHS) and IGBP, for an international hydrologic network of pristine river observations, using the USGS Benchmark network as a paradigm. A straw-man plan for the such network would include:

What/Where:

The observation sites could possibly be located in national parks throughout the world. It may be possible to combine these with a BAHC (Biospheric Aspects of the Hydrological Cycle) proposal to develop a high mountain gauging network. The number of identified sites would probably not exceed 100 sites on a global basis.

Interest in developing this network could be promoted in the following ways:

- Describe a straw-man sampling scheme as part of a TOPC presentation on international hydrologic observations during the IAHS workshops at the forthcoming IUGG meetings in 1999 (see Section 12.2);
- Consult with various entities representing different aspects of international hydrologic activities, such as IAHS, GEWEX, IGBP, IHP, BAHC, perhaps also during the IUGG meeting in 1999;
- Prepare an article about TOPC activities, including discussion of hydrologic proposals for hydrology, to a journal such as EOS, SCIENCE or NATURE that will reach the international scientific community.

Because of the complexities of the various issues, the above TOPC activities focus on surface water quantity observations, and sets aside questions pertaining to ground water and water quality.

4.4 Ecology

Dr. Gosz reviewed the current situation in the establishment of the GT-Net (see also Section 2.2). Following the Guernica meeting, letters of invitation were sent to a number of the networks represented at the meeting. Numerous positive replies were received by the GTOS Secretariat. Under Dr. Gosz' direction, the LTER Secretariat proposed to act as the secretariat for the GT-Net. This proposal was endorsed, and funding support is expected from the U.S.

National Science Foundation and from the GTOS Secretariat. This will be used to set up data management support for the NPP demonstration project (refer to Section 5.1). The draft terms of reference for the GT-Net proposed by the LTER Office are reproduced in Annex VII.
The status of the GT-Net, the terms of reference, and related activities will be considered by GTSC at its next meeting in June, 1998. The participation of networks and sites not represented at the Guernica meeting will also be addressed by GTSC.

5. Demonstration Projects

5.1 Global Net Primary Productivity

The NPP demonstration project was initially proposed at the meeting of Experts of Ecological Networks in Guernica, Spain, 1997. The NPP project has two primary goals: first to distribute a global standard NPP product to regional networks for evaluation; and to translate this standard product into regionally specific crop, range and forest yield maps for land management applications. The project will demonstrate the potential of a limited network of surface sites to generate a reliable, useful product with global coverage and local relevance, rapidly and efficiently, by adopting the GHOST hierarchical sampling approach and by using models to combine in situ and remotely sensed data. The project is designed so that any network or site, regardless of its level of sophistication, can make a useful contribution to the project. The goal is to complete a demonstration project that would be of value to the participating GT-Net regional or national networks/sites, and to allow the development of the process for contributing site data to a central archive and utilising site capabilities to validate satellite imagery. The primary source of satellite data will be the AM-1 satellite of the Earth Observing System (EOS), to be launched in 1999 by the NASA.

It is envisaged that site data would be provided to the U.S. LTER Network Office for incorporation into the TEMS database and land cover and Leaf Area Index (LAI) validation data would be provided to the U.S. LTER Network Office for archival. Satellite imagery of land cover and LAI would be provided to sites by the U.S. LTER Network Office. In addition, the project will use the FLUXNET global network of eddy covariance flux towers to translate the EOS NPP product into net ecosystem productivity (NEP), or total net ecosystem CO2 flux, for use in global climate and carbon cycle models. In this context, the NPP project will inaugurate a globally distributed tracking of NPP and NEP which is critical to global change monitoring. As GT-Net achieves global coverage, it will quantify the significant trends in biospheric productivity, including NPP responses to desertification and land degradation trends, interannual climate variability, CO2 fertilisation, pollution effects, etc. This plan also incorporates the principles of GHOST, the global hierarchical observing strategy, in that the regional NPP drivers will be done as a tier 4 activity, regional NPP validation a tier 3 activity, and the FLUXNET towers function as tier 2 intensive continuous NEP study sites. Finally, the plan offers two end products, one of high practical utility at the local level, the other of high significance at the scientific level.

The project will extract the global 8-day NPP product from the U.S. NASA EOS Data Information System for dissemination to participating surface networks. The U.S. LTER Network Office will lead this effort, including archiving site data and extracting appropriate satellite coverage for individual sites. Specifically, EOS is computing a NPP product at 1 km for the entire global vegetated land surface every 8 days from the MODIS sensor and ancillary data. The initial EOS NPP algorithm is based on the relationship between time integrated absorbed PAR and NPP.

Each participating site should aim to collect the following input variables. Failure to collect the full set does not render the site useless, since the data, that are available, can be used for independent validation of the EOS-derived global data sets. The data must be collected to be representative of a minimum area of 3 km x 3 km. This is because the calculated NPP product will initially have a resolution of 1 km by 1 km, with a positional error of up to 1 km. Future products will have a resolution of 250 m x 250 m (see Annex X for the implementation steps of the NPP project).

Recommendation 6: *TOPC recommends that the NPP project should be executed in accordance with the above plans. TOPC should maintain contacts with the projects as it progresses, and should use the lessons learned to refine plans for other observing networks and for the compilation of global data sets.*

5.2 Global Observation of Forest Cover

Dr. Cihlar presented information on the Global Observations of Forest Cover (GOFC) project on behalf of the project co-ordinator, Dr. Frank Ahern from the Canada Centre for Remote Sensing (CCRS). The presentation was based on the current planning document and an update regarding recent activities and plans.

The GOFC project was proposed as part of several initiatives of IGOS in February, 1997. The objectives and an initial plan were defined at a July, 1997 workshop in Ottawa, Canada. As a contribution to the implementation of an ongoing global forest monitoring system, GOFC will:

- 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 variation on a three to ten year cycle;
- with associated regional applications and methodological investigations;
- for the benefit of multiple user communities;
- and ultimate transition to routine operational use.

GOFC plans to generate a series of products for diverse user communities, including: international environmental conventions and agreements, international policy and operational institutions, national and sub-national institutions, and the scientific community. The products are aimed to serve various applications: global and climate change, sustainable forest management and multiple land use, biodiversity, and others. The principal products to be generated are land cover and land cover change (at detailed spatial resolution), land cover at medium resolution for modelling purposes, net primary productivity, biomass, fire scars, harvest, leaf area index, fraction of photosynthetically active radiation, and the total amount of photosynthetically active radiation. GOFC is to take place over the next five years, and is expected to form the basis of an ongoing satellite-based monitoring system for the global forest. The project planning is led by the CCRS with the support of the Canadian Space Agency. Numerous space agencies have agreed to participate by contributing data or other resources.

In the subsequent discussion TOPC addressed the issues of product characteristics, product generation and distribution plans, and linkages to existing programs.

Dr. Townshend relayed results of the discussion at the last Strategic Implementation Team (SIT) meeting which considered it essential that GOFC be embedded in existing international programs. In particular, SIT requested that GOFC meet the needs of GCOS and GTOS as established by TOPC. To this end, GOFC should report to GCOS and GTOS through TOPC. The project should also meet the needs of IGBP as defined by IGBP DIS.

Recommendation 7: *The organisational structure of GOFC should be modified to include formal TOPC representation in GOFC planning and implementation. TOPC representative should represent the authoritative requirements of GCOS/GTOS climate-related applications, and should report to TOPC on GOFC developments.*

The difficulty of defining acceptable classification systems was discussed. A key requirement here is that the classification legends must be designed to meet the needs of specific user groups. Since this is difficult, and given that any fixed limits used render the products of limited usefulness, it is recommended that the GOFC should aim to define products quantifying continuous variables. These should include canopy cover, leaf area duration, and canopy height. It was pointed out that by avoiding the need for identifying arbitrary class limits, such variables permit various users to employ the same product for their specific purposes.

Recommendation 8: *GOFC should consider inclusion of continuous variable products, especially canopy cover, leaf area duration, and tree height. GOFC should also actively promote and facilitate further research to generate such products, where appropriate.*

To make the products widely useful in the tropical areas, it is important that the information extracted from satellite data allow determination of the extent of tree crops. Similarly, GOFC planning and product generation should include expertise with data analysis from sparse forest canopies, especially woody savannahs. It was suggested that GOFC should make direct contact with the Centre for International Forestry in Indonesia which is concerned with forestry issues at the international level and is particularly concerned with sustainable development. Further, it is essential to ensure that the product formats do not hamper the accessibility of the GOFC products in various countries of the world.

Recommendation 9: GOFC should ensure that the planned products meet the needs of the principal user groups. The principal user groups should be identified for the various planned products. Further, hardcopy as well as digital products should be planned.

6. Terrestrial Ecosystems Monitoring Sites

6.1 Presentation of Data Base

The Terrestrial Ecosystem Monitoring Sites (TEMS) database was originally developed in the mid to late 1980's by UNEP's Global Environment Monitoring System (GEMS) as a register of sites where integrated, multidisciplinary terrestrial ecosystem monitoring is carried out. The GTOS Planning Group extended this activity to develop a more comprehensive metadata base and to determine if the existing managed (largely long-term agronomic sites) and unmanaged monitoring sites could provide the starting point for a global observation system. Over the years TEMS expanded the original list of 150 sites to about 650 sites and networks with reasonably complete information and a further about 650 sites with limited information. The GTOS Planning Group concluded that many of the existing sites met the required criteria for integrated terrestrial ecosystem monitoring and were a good starting point for GTOS although there were important regional, biome and issue related gaps that remained to be filled.

A PC version of the data base has been developed for use by those with limited web access. In addition, two additional enhancements were added during 1997: a capability to search for networks with relevant information, and a capability to search variables by specific GCOS or GTOS issues.

6.2 Discussion

The meeting participants recognized that the existing TEMS was originally defined more than 10 years ago and for a different purpose. Numerous capabilities were added and modifications made since then. A sub-group of the TOPC discussed the issues and options relating to the further development of TEMS.

The subgroup found that the present TEMS contains many of the functionalities required for a metadata base of terrestrial sites and networks for G3OS purposes. It made the following recommendations which contain minor modifications agreed to by TOPC.

Recommendation 10: ***TEMS should remain as a metadata base of network and site descriptors, providing users with lists of major categories of variables and guiding them to the holders of the data.***

Recommendation 11: ***Version 2.0 of TEMS should be developed. Initially, the networks and sites involved in GT-Net and the NPP demonstration project should be used to test revised formats and procedures. The glacier and permafrost networks should be included in this process as soon as the required financial and other resources become available. Version 2.0 should include the following revisions:***

- modified questionnaires and web-based page formats to ease data assembly and updating;
- searching capabilities should continue to be based on the present main categories, that is, country, network, ecoregion, latitude and longitude, and variables but with the following changes;
- improved precision for site location with coordinates being given in degrees, minutes and seconds;
- better site size and shape information by specifying them in terms of a rectangle or polygon, thereby accommodating sites of large, narrow or irregular size;
- replace the ecoregion classification (based on that of Bailey) by a more flexible one that can accept a range of alternatives;
- restrict the list of variables to the main categories i.e. a reduction from 530 to some 150;
- provide agreed definitions of the main variables;
- add a searchable map;
- add principal scientists to the list of contact points and delete funding agency contacts;
- maintain both PC and web based versions and consider the need for Spanish and French versions.

Recommendation 12: ***TEMS should be managed by GTOS but GTSC should examine the case for TEMS evolving towards a G3OS system and make proposals to the Co-Sponsors.***

Recommendation 13: ***GTSC should decide on priorities for the GTOS issues so there is sound mechanism for prioritizing future expansion of TEMS.***

Recommendation 14: ***GTSC should consider a structured approach to determining geographical and thematic requirements for critical observations that are needed for the GTOS issues such as biodiversity and desertification. Once this is done TEMS can be used to determine where there are gaps in critical observations.***

7. Gaps Analysis

7.1 Comments on TEMS

The distribution of monitoring sites in the Terrestrial Ecosystems Monitoring Sites (TEMS) database was evaluated with respect to region, biome, land use, etc.. The analysis seemed to reveal less about the gaps in coverage, than about the shortcomings of the database itself. These shortcomings are probably a consequence of the way the database was assembled. Questionnaires were distributed from the GTOS Switzerland office with an approximately 30% return on the initial mailing. When data from the questionnaires and those from additional networks were entered in the TEMS database, little or no additional support was available to improve, check and/or complete the necessary site data. The TEMS database therefore retains many inconsistencies, errors and missing values, including several sites which are listed without their specific location (Table 1). The inconsistency of the database may be its largest drawback.

7.2 Geographical Coverage

The shortcomings are obvious when one analyses the distribution of the individual sites.. Europe is well represented, while substantially fewer sites (Table 2) are located on other continents. Latin America, Africa and the Indonesian Archipelago have the worst coverage with only 90, 82 and 12 sites, respectively. The few sites on these latter continents also are relatively small. The monitoring sites only cover less then 0.005% the total land area, although site size does not need to be a limitation. The sites available for analysis can also generate significant biases. Less than 40% (Table 1) of the sites had size data associated with them. The sites analysed all belong to GTOS site tiers 2-4. Large-scale experiments and remotely sensed data are absent from the current version of TEMS.

The continental distribution is skewed which also has consequences for assessing site representation of the different biomes. The observed biome distribution created by Olson *et al.* (1993) and the simulated biome distribution by Prentice *et al.* (1992; Table 3) have been used. The distribution of Olson *et al.* (1983) has the advantage that it characterises not only natural vegetation types but also some human-dominated land-cover types. The biome distribution of Prentice has the advantage of predicting the kind of ecosystems which should appear as remnants in areas otherwise too intensely used to be so classified by Olson, et al (1983). However, both databases have a relatively coarse resolution (0,5 x 0.5^{o} longitude and latitude) and were developed for different purposes than monitoring land-cover change As a result of these limitations, our current analysis defers examination of gaps in coverage by site numbers, instead illustrating some of the improvements of TEMS which needs to precede such analysis.

7.3 Biome Coverage

Both databases show that temperate deciduous and mixed forests are the best represented biomes in the TEMS database (Table 3). These land cover types coincide with the major European land cover types and are a consequence of the global distribution of sites in the most heavily developed countries. All other land cover types are less well represented. Both the databases (simulated by Biome and observed by Olson et al.) agree in this respect. The European domination of site numbers also results in the majority of human-dominated land cover types delimited by the Olson database being those found in Europe. The data clearly reveal the skewed distribution of the biome numbers in the database.

7.4 Other Coverages

This examination can also be readily extended to other overlays. Tables 4 and 5 show an example of the TEMS database with the wetland and related land-cover and the agricultural classes, respectively, of the Olson *et al.*(1983) database. While monitoring sites in individual agricultural land cover classes appear reasonably distributed, almost all wetland classes clearly are inadequately represented. Similar evaluations can be performed with other data sets. Groombridge (1992), for example, presents a map with biodiversity “hotspots.” The basic TEMS map can be used to evaluate whether the TEMS sites adequately cover these hotspots and therefore, are capable of assessing changes in regions important to biodiversity. The linkage between such capability and the TEMS database must be developed if GTOS and GCOS are to provide answers to the questions asked and issues raised by the Subsidiary Body on Scientific and Technical Advice (SBSTA) and the international conventions.

7.5 Discussion

The meeting participants discussed the analysis to date and the next steps. It was agreed that such an analysis is essential to: a) identify the greatest weaknesses of the present surface observation networks, and b) guide priority efforts for future improvements. It was agreed that future gap analyses should be undertaken with respect to only the networks/sites that have agreed to be part of the global terrestrial observing networks and that capabilities of the TEMS 2 should be used for this purpose. Once the required data and analysis capabilities are available, the priorities for gap analysis should be based on the importance and urgency of specific climate change terrestrial issues at the time.

Recommendation 15: Future gap analyses should be undertaken with respect to only the networks/sites that have agreed to be part of the global terrestrial observing networks.

Table 1: Overall availability of major characteristics of the TEMS database with 1398 sites.

Availability of data by	Number of sites	%
Location	1289	92
Site level	837	60
Altitude	548	39
Extent	532	38
Precipitation	218	16
Temperature	194	14
Site History	118	8

Table 2: Distribution of the sites in the TEMS database by continent.

Class name	Number of sites in class	%	Number of sites used	Extent total class in Mha	Area covered by sites in Mha	%	Tier undefined	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Undefined	119	8.9	59	136122	0.097	0	52	0	5	19	43	0
North America and Canada	137	10.3	83	19614.3	0.173	0.001	64	0	17	47	9	0
Mexico, Central America	23	1.7	17	2817.6	0.081	0.003	21	0	1	1	0	0
South America	57	4.3	28	17941.1	0.485	0.003	44	0	2	11	0	0
Europe (including western U.S.S.R)	719	54.0	175	10376.7	0.098	0.001	180	0	4	107	428	0
Africa	82	6.2	47	30028.8	0.34	0.001	59	0	0	16	7	0
Asia	129	9.7	76	41847.5	1.267	0.003	57	0	3	61	8	0
Indonesian and other Pacific I	12	0.9	2	3100.3	0.01	0	8	0	0	3	1	0
Australia and New Zealand	49	3.7	16	8101.4	0.047	0.001	12	0	1	35	1	0
Antarctica	1	0.1	0	0	0	n.a.	0	0	1	0	0	0
Greenland	4	0.3	2	2279.6	0.97	0.043	2	0	0	0	2	0
Total:	1332	100	505	136122	3.569	0.003	0	0	34	300	499	0

Table 3: Distribution of the sites in the TEMS database by Biome (Prentice *et al.*, 1992).

Class name	Number of sites in class	%	Number of sites used	Extent total class in Mha	Area covered by sites in Mha	%	Tier undefined	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Undefined	120	9	59	136197.4	0.097	0	52	0	6	19	43	0
Ice/Polar Desert	6	0.5	2	1839.1	0.004	0	5	0	0	1	0	0
Semidesert	33	2.5	27	5735.2	0.099	0.002	20	0	2	11	0	0
Tundra	34	2.6	11	8449	0.973	0.012	26	0	1	4	3	0
Taiga 97	97	7.3	19	13619.3	0.011	0	45	0	0	23	29	0
Cold Deciduous Forest	9	0.7	1	4199.2	0.003	0	4	0	0	2	3	0
Cool Grass/Shrub 26	26	2	13	4861.9	0.025	0.001	11	0	3	9	3	0
Cool Conifer Forest 43	43	3.2	10	3340	0.056	0.002	10	0	0	12	21	0
Cold Mixed Forest	9	0.7	5	666.1	0.004	0.001	3	0	1	4	1	0
Cool Mixed Forest	179	13.4	64	5910.6	0.113	0.002	58	0	6	41	74	0
Temperate Deciduous Forest	402	30.2	118	5983.9	1.085	0.018	74	0	8	62	258	0
Evergreen/Warm mixed Forest	74	5.6	29	5783.6	0.152	0.003	20	0	1	27	26	0
Warm Grass/Shrub	50	3.8	31	10807	0.095	0.001	30	0	0	10	10	0
Hot Desert	25	1.9	18	20893.6	0.218	0.001	18	0	2	4	1	0
Xerophytic Woods/Shrub	94	7.1	30	10770	0.035	0	35	0	2	35	22	0
Tropical Rain Forest	40	3	21	8133	0.124	0.002	27	0	2	10	1	0
Tropical Seasonal Forest	33	2.5	21	8272.9	0.099	0.001	28	0	0	5	0	0
Tropical Dry Forest/Savannah	58	4.4	26	16917.9	0.375	0.002	33	0	0	21	4	0
Total	1332	100	505	136197.4	3.569	0.003	0	0	34	300	499	0

Table 4: Distribution of the sites in the TEMS database by the Olson *et al.* (1983) wetland land-cover classes.

Class name	Number of sites in class	%	Number of sites used	Extent total class in Mha	Area covered by sites in Mha	%	Tier undefined	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Undefined	755	56.7	324	30624.4	2.464	0.008	361	0	19	150	225	0
Cool Crops	62	4.7	22	0	0.007	n.a.	18	0	0	14	30	0
Warm Farms	259	19.4	77	0	0.415	n.a.	51	0	9	59	140	0
Paddyland	19	1.4	12	0	0.618	n.a.	6	0	1	11	1	0
Warm Irrigated	13	1	4	0	0.009	n.a.	2	0	0	8	3	0
Cold Irrigated Drylands	3	0.2	2	0	0	n.a.	2	0	1	0	0	0
Cool Irrigated Drylands	0	0	0	0	0	n.a.	0	0	0	0	0	0
Med. Grazing	8	0.6	5	0	0.015	n.a.	6	0	0	2	0	0
Cool Field/Woods	12	0.9	3	0	0.003	n.a.	4	0	1	5	2	0
Warm Woods/Fields	63	4.7	17	0	0.029	n.a.	16	0	1	17	29	0
Cool Woods/Fields	78	5.9	28	0	0.007	n.a.	25	0	2	21	30	0
Warm Field/Woods	60	4.5	11	0	0.002	n.a.	8	0	0	13	39	0
Total	1332	100	505	30624.4	3.569	0.012	0	0	34	300	499	0

Table 5: Distribution of the sites in the TEMS database by the Olson *et al.* (1983) agricultural land-cover classes

Class name	Number of sites in class	%	Number of sites used	Extent total class in Mha	Area covered by sites in Mha	%	Tier undefined	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Undefined	1291	96.9	490	6006.9	3.545	0.059	481	0	33	294	483	0
Antarctica	1	0.1	0	0	0	n.a.	0	0	1	0	0	0
Bogs, Bog Woods	2	0.2	0	0	0	n.a.	2	0	0	0	0	0
Mangroves	10	0.8	6	0	0.006	n.a.	5	0	0	3	2	0
Heaths, Moors	7	0.5	1	0	0.002	n.a.	2	0	0	1	4	0
Marsh, Swamp	4	0.3	4	0	0.003	n.a.	3	0	0	0	1	0
Coastal Edges	13	1	2	0	0.003	n.a.	2	0	0	2	9	0
Ice	3	0.2	1	0	0.004	n.a.	3	0	0	0	0	0
Water	1	0.1	1	0	0.005	n.a.	1	0	0	0	0	0
Total	1332	100	505	6006.9	3.569	0.059	0	0	34	300	499	0

8. FCCC Subsidiary Body on Scientific and Technical Advice (SBSTA)

8.1 Report

8.1.1 At the Kyoto conference on greenhouse gases (GHG), it was agreed that long-term observations are critical to meeting the objectives of GHG reduction and of monitoring the impact of the increasing concentrations on the environment. GCOS was invited to provide information to SBSTA of the Framework Convention on Climate Change (FCCC) on the present state and deficiencies of the observing systems. At this meeting, a subgroup of participants addressed deficiencies and problems in terrestrial observations with the intent to provide a written input to the process. Following a discussion of present gaps and approaches to address these, a draft of an input to the report was prepared (Annex V). The issues and thrust of the report were agreed to by the plenary. The input to the SBSTA report is to be completed and revised by email following the meeting.

9. TOPC Data Sets

9.1 Presentations of Existing Data Sets

In its previous report (GCOS Report #32; GCOS, 1997) TOPC identified priority variables for the terrestrial climate-related issues. To assist the user community to whom G3OS is designed to serve, over the last 6 months TOPC set out to identify important existing global data sets for these priority variables. The search was based primarily on the personal knowledge of the TOPC members, supplemented to some extent by web search tools. A number of such data sets were identified, and were discussed by subgroups during the meeting. For uniformity, a common template was used by all members.

An important aspect of the search was to ensure that the data sets are of adequate quality. It was realized that the utility of a data set depends on the purpose and that in practice it may be impossible to decide ***a priori*** whether or not a given data set meets the needs of a user. Therefore, an important condition regarding the suitability of a data set is that the data sets be properly documented in terms of data characteristics, calibration and processing, errors, etc. The template thus included several questions regarding data set quality.

The data sets identified through this process are described in Annex III. The experience obtained with this approach is discussed in the next section.

9.2 Comments on the Selection Methodology and Problems Encountered

The discussion of data sets revealed several issues regarding the data sets review procedure.

It is clear that the approach is not systematic with respect to a) the data sets found and b) the evaluation of these data sets. Web search tools vary in their ability to find the relevant sites, as do individuals using the web. In addition, the individual conducting a search may not be expert in the subject scientific specialisation, resulting in web site data set collections which may not contain the best data sets. Thus, the web searches are likely to generate non-comprehensive data set lists, not necessarily the best data sets, nor data sets that are critically reviewed through this process (although they are likely to have been peer-reviewed as part of the data set production). One solution to the problem is to identify best experts regarding each variable and associated data sets, and either request them to conduct the search and evaluation, or request their review of the searches conducted by others. TOPC members can serve as experts for a number of, but not all, key variables.

Data sets accessible through the web appear, move, and disappear from the web at a high rate. Several very relevant and critical data sets (e.g., global biomass fire distribution, global soils characteristics) are expected to become available this summer, while many others are under development. Older data sets are being moved to new web sites, and others are being removed from the web as more appropriate data replace them. Hence, there is a fundamental need in a web-based environmental data system, such as that used here, for frequent and comprehensive updating.

For numerous TOPC variables, adequate global-scale data sets do not exist at the present. For others, the data sets have inadequate spatial or temporal resolution, or accuracy. Many of these deficiencies can only be improved through future activities of G3OS and similar programs.

There are inconsistencies in the information presented with the data sets. On the other hand, it was found that many data sets provide similar type of information. It is the degree of completeness which differs between the data sets. There is a need to define, and then widely publicise, a common set of needed types of information that should be provided with all data sets for G3OS-related applications.

It would be highly advantageous to potential users of a data set to have ready access to bibliographic citations in which the data sets have been used, especially where an evaluation of the strengths and weaknesses of the data are concerned. This is potentially a demanding task because it implies positive identification of a data set (even its specific version) within a particular citation. The only 'easy' way is for the data users to inform producers that the data have been used and to provide a reference, and then for producers to systematically update the metadata for their data sets;

Several variants of the same data set may exist. Some versions may be more processed or quality-controlled than others and thus may be more useful to researchers. Some researchers, however, may prefer the raw data.

Certain kinds of data for some countries have limited access.

The usefulness of a data set (at least for some applications) may be contingent on the availability of data sets for associated variables. This was not addressed in the search and is not easily handled by the procedure employed.

The process used in this data set search was intended to locate those which have sufficient quality information for the potential user to make informed decisions regarding the data set. For the reasons discussed above the data sets identified in this manner cannot be considered to be 'approved' by TOPC. When they are highlighted as part of the GOSIC (see Section 10.1), an appropriate disclaimer/user beware should therefore appear.

The data search undertaken by TOPC was an experiment. The ultimate test of the usefulness and effectiveness of this mechanism will be the degree to which it helps the G3OS community. In the G3OS implementation, a provision for feedback by the users should therefore be made.

The search carried out so far concentrated on global data sets. There are many continental or regional data sets of substantially higher quality. For users interested in specific regions, the data sets identified here are not the best starting point.

9.3 Future Actions by TOPC

TOPC discussed the available data sets for terrestrial climate requirements, and the members noted problems and limitations of this approach. The results of this effort (Annex XI) will be forwarded to GOSIC to be entered on the web site.

The meeting participants endorsed the decision of JDIMP with respect to the division of responsibilities for the G3OS data sets identification and for the criteria for accepting a data set for the purposes of the G3OS (Section 2.3 above). The identification of additional or improved data sets will continue to be important. Given the limited resources available to TOPC such effort should continue to focus on global data sets. The meeting participants also emphasised that JDIMP should continue to deal with cross-cutting issues related to data access, particularly those related to policies, pricing and intellectual property aspects; and should promote harmonisation of metadata and associated metadata formats.

The following specific recommendations are made.

Recommendation 16: GOSIC should establish direct links to the data sets identified in Annex XI, and should include, in an appropriate form, the information from Annex III associated with each data set.

Recommendation 17: TOPC members should help identify data sets and develop the associated information, based on their scientific expertise and familiarity with these data sets.

Recommendation 18: In searches such as undertaken here, an attempt should be made to involve the best experts regarding each variable and associated data sets.

Recommendation 19: If feasible, G3OSs should consider the development of web-based tools for: a) effective searches that would identify new, improved existing, and deleted data sets; b) mechanisms for locating citations/studies employing certain data sets; and c) searches for groups of thematically or geographically related data sets.

Recommendation 20*: JDIMP should define, and then widely publicize, a common set of metadata fields which should be provided with all data sets for G3OS-related applications. The metadata format should allow flexibility in the way the information is presented, i.e. it should be defined thematically rather than digitally.*

Recommendation 21: ***GOSIC should include an appropriate disclaimer with the information contained in Annex III.***

Recommendation 22: ***GOSIC should make a provision for feedback by the users of the information in Annex III.***

10. Coordination with JDIMP and GOSIC

10.1 Global Observing Systems Information Center (GOSIC)

Dr. Wilson presented an overview of the plans GOSIC, a center being established at the University of Delaware College of Marine Studies in Lewes, Delaware, USA. GOSIC is funded for three years and is staffed with a mix of scientific and data management expertise. The Center intends to hold up-to-date information on the initial operational systems that are established in the G3OS, on the data flows and data management plans for these operational systems, and on the data sets that are identified by the science panels as relevant to the requirements of the systems.

GOSIC is being designed to primarily serve the needs of the users. However, it will also serve the needs of DIMP and the G3OS science panels for managing the data flows. The Center will include metadata and contact information at all levels to facilitate user understanding and access. It will also help to support the evaluation and feedback functions that JDIMP is building into its data management model.

In building and maintaining its databases, GOSIC will require support from the centers that hold the actual data. A methodology is under development to automate this procedure, both at GOSIC and in the centers holding the data. The methodology involves the centers that hold the data preparing and maintaining simple files with a few specific fields identified by tags that hold the information required for the GOSIC database. The GOSIC computer will periodically access and process these files to update its database. It is recognised that these files must be simple and easily prepared by automated means. It is anticipated that some data centers holding TOPC data will participate in a test and development phase to evaluate the feasibility of this scheme.

The selection of existing data sets relevant to terrestrial aspects of climate by TOPC is of significant assistance to GOSIC. The database of existing data sets is an important element of GOSIC and will benefit from the involvement of the TOPC subject experts.

The TOPC meeting participants supported the GOSIC program as presented and agreed to continue to advise GOSIC on the development of the information center.

Regarding co-operation with JDIMP, the meeting participants agreed with the new focus for JDIMP as described by Dr. Wilson (Section 2.3). In addition, it was emphasised that JDIMP must provide strong leadership on a number of cross-cutting and data management issues that were outside the expertise of the science panels. In particular, JDIMP should take an active lead in providing the steering committees of the observation systems with the necessary information and advice on problems with free/inexpensive access to scientific data to enable them to put forth strong arguments to achieve this access.

11. Review and Revise TOPC Satellite Data Requirements

11.1 Background

Dr. Cihlar provided the background to the discussion of satellite data requirements. Although TOPC defined the requirements in its report (GCOS report#32; GCOS, 1997) the attempt by the Global Observing Systems Space Panel (GOSSP) to merge the requirements expressed individually by the GCOS, GTOS, and GOOS led to an extensive discussion and a proposed new framework for the input by scientific panels.

Dr. Cihlar described the preparatory work carried out to define TOPC requirements in a form suitable for this process. First, he proposed a new conceptual framework to facilitate unambiguous communication between earth scientists and satellite specialists. This framework (Figure 2) distinguishes between measurements and variables as understood by a satellite sensor designer, a remote sensing scientist, an earth system scientist, and the end user. These various specialists are concerned with one or more of, respectively, measured variables, ancillary variables, input variables, and target variables. Figure 2 shows the different categories, using net primary productivity as an example. So far, TOPC and other panels concentrated on defining the target variables, and appropriately so. The distinctions among the different types of variables and implicitly understood in the scientific community but they can create great confusion when communicating with non-specialists, engineers, or program managers. There is a strong need to define the terminology and then rigorously apply the definitions in all areas, otherwise confusion is unavoidable.

11.2 Framework

The meeting participants agreed that the proposed framework is appropriate and set out to provide specific details as required by the framework or GOSSP. These include:

(1) Finalisation of the lists of TOPC Target, Input, Ancillary, and Measured variables. For each of these variables, specification was established for Optimum and Threshold requirements for horizontal resolution, vertical resolution, cycle (revisit period), timeliness (time elapsed between satellite data acquisition and delivery of the derived product), and accuracy. (2) Finalisation of the definitions of Applications and of variables for the purpose of specifying TOPC satellite data requirements and allowing their traceability.

The work was conducted in two subgroups addressing the biosphere and cryosphere/hydrosphere, respectively. The results are provided in Annex VI.

Recommendation 23: The information in Annex VI should be used to specify satellite data requirements for climate-related terrestrial applications and to revise the data base maintained by WMO/CEOS.

When discussing the Applications the meeting participants pointed out the great potential impact of climate change on human health and other socio-economic aspects. These are outside the TOPC terms of reference. It was agreed to bring this issue to the attention of the GCOS/GTOS sponsors.

Recommendation 24*: G3OS sponsors should clarify the extent to which health, economic and other terrestrial impact of climate change should be considered, and by whom.*

Recommendation 25: While it is recognized that several Applications (presently not defined, Annex V.) are relevant mainly to other aspects of the G3OS program, all have some relevance to the terrestrial climate-related issues and TOPC should therefore be involved in their definition.

Although the differentiation of variables as target, input, ancillary and measured improves the clarity for easier communication with remote sensing specialists, it does not make clear the functional relations between the individual variables, nor does it reflect the complexity of these relationships for specific target variables. It was agreed that flowchart diagrams would be more appropriate for this purpose. However, the dependence of such diagrams on the algorithms and models assumed for the use of the measurements must be explicitly noted.

Recommendation 26: *As part of further documentation TOPC should prepare flowcharts for key target variables.*

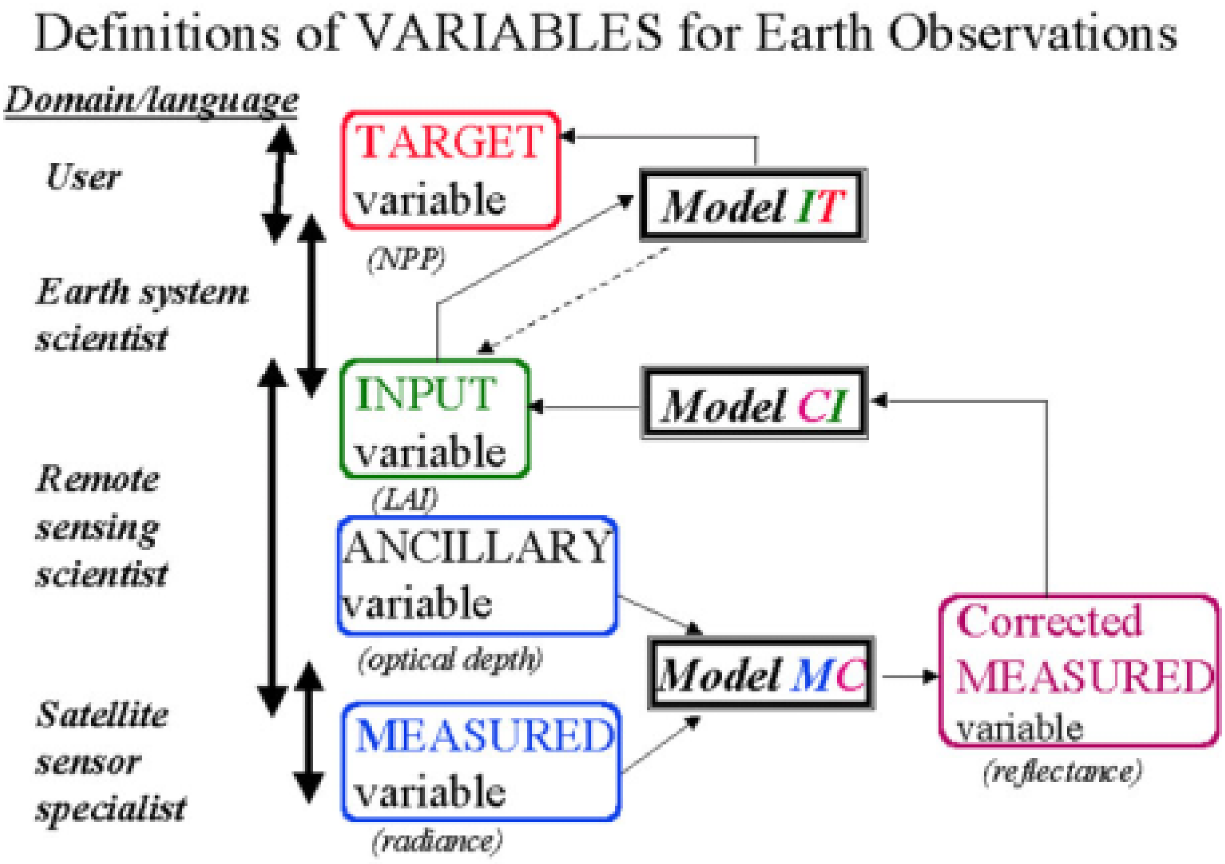

Figure 2: Definitions of Variables for Earth Observations

12. Implementation Plan and Future TOPC Activities

12.1 Work Plan for the Next Year

Since the last TOPC meeting (1996), considerable progress has been achieved. Some of the achievements were discussed at the meeting, and most confirmed the importance of the ground-laying activities in previous years. Based on the discussion, revised 5-year goals and a new work plan was prepared. For clarity, ease of communication and effective collaboration with other groups, the role of TOPC in each activity and the lead TOPC member were also identified for each task. The complete plan for the next year is provided in Annex VIII.

12.2 Collaboration with Other Programs

The primary activities of GEWEX (the Global Energy and Water Cycle Experiment) are global data set development, process studies, and model development support. Of particular relevance to TOPC is GEWEX's support of ISLSCP (International Satellite Land Surface Climatology Project), a project that focuses on large-scale field experiments and the development of global data sets associated with land surface processes. ISLSCP has already generated a widely-used collection of CD ROMs (the "Initiative 1 dataset") containing a wide assortment of earth-system fields covering 2 years at consistent spatial (1^o) and temporal resolution (some are included in Annex II.). The ISLSCP Initiative 2 dataset, which covers 10 years at higher (0.5^o) spatial resolution, is currently under construction.

Dialogue between TOPC and GEWEX/ISLSCP is appropriate given their common interests. One contribution of GEWEX/ISLSCP to the G3OS goals is through the support of large-scale field experiments. These experiments lead to improved algorithms for interpreting ongoing satellite measurements, and they provide the potential sites for continuing surface measurements (e.g., via flux towers).

It was agreed that GEWEX activities are important in view of the TOPC terms of reference. In addition to maintaining scientific contacts through cross-membership in both groups, a possibility of a joint meeting with ISLSCP should be considered. Furthermore, the transformation of research sites into long-term observation stations should be examined with GEWEX.

Recommendation 27: *TOPC should work with GEWEX to assist in the transition of research sites into long-term observing stations where feasible and appropriate.*

12.3 Soil Wetness Project

Dr. Ken'ichi Kuma presented information on the Global Soil Wetness Project (GSWP). The project is part of the ISLSCP/GEWEX/WCRP program. It is a pilot study of the feasibility of producing a global data set of soil wetness and related surface flux estimates using meteorological observations and analyses to drive global circulation models. The GSWP uses as basic input the ISLSCP Initiative 1 land-surface climatology data set. Soil moisture conditions as well as other products such as run-off, net evaporation, and snow water equivalent are being obtained by integration of land surface parameterizations with hourly atmospheric forcing. Eight centres are producing pilot data sets for 1987-1988, which are collected jointly and intercompared at the Inter-Comparison Centre, operated by the Japan Meteorological Agency and the Centre for Climate System Research of the University of Tokyo. The products are validated with the soil moisture data from in situ and satellite. Global runoff data provides the key assessment for the large scale hydrological cycle of GSWP. GSWP found that the temporal variation of the soil moisture agrees well among models and observation, although some biases are present.

The second phase of GSWP, GSWPII, is proposed to consist of 4 parts:

- Model intercomparison experiments as is in phase I.
- Rescue of the data sets related to GSWP.
- Four dimensional data assimilation (FDDA) for the land surface processes using both in situ and satellite data.
- Predictability studies with GCMs based upon global land surface data sets produced in this project.

ISLSCP Initiative 2 data will be used as an input to the land surface model. The period of the analysis will be from 1986 to 1995 with the horizontal resolution of 0.5ox0.5o. In addition to the model intercomparison, it is proposed to rescue observation data for soil moisture, runoff, soil temperature, fluxes, etc. which can be used for the validation of the GSWP II. It is also feasible to extend the GSWP II project to create the global dataset for CO2 flux over the land in a similar way as for moisture. FLUXNET observation can be used to validate water, heat, and CO2 fluxes, subject to overcoming the scale gap between the model and FLUXNET measurements.

FDDA and GCM predictability studies are required for the global land surface monitoring and for successful short-term climate prediction based upon the model. In order to meet operational requirements, observation data affecting the predictability must be exchanged on near-real time basis, 0-12 hours after the observation. With this requirement, NWP model will be able to assimilate the observations, which is important not only for operational weather forecast but also for climate applications.

The exchange of data in real time for NWP models is important in the climate application for several reasons. First, good climate models are often based upon NWP models. This is particularly true for land surface description, since the characteristic time scale of the land surface starts from diurnal variation. The development of land surface models for the NWP model is greatly facilitated by the real time availability of the land surface observation. Secondly, most sophisticated methods of the data assimilation are usually developed at NWP centers. The availability of the data in real time, including satellite radiance data, will immeasurably ehnance the global monitoring for the land surface with FDDA. Thirdly, the re-analysis (based on NWP) yields powerful data sets for the various time scale of the climate changes.

The GSWP and other GEWEX projects are both producers and users of global terrestrial data sets. TOPC should maintain contact with these activities and use the results to refine G3OS terrestrial observation requirements.

12.4 IGBP Sponsorship

The coordination and cooperation with various IGBP projects is important to the TOPC mission. These project provide the scientific understanding that is required to design optimum long-term observation programs, and also produce some valuable global data sets for the terrestrial environment. On the other hand, the global observing systems work towards long-term observations of critical climate-related processes and to produce data sets needed for scientific as well as policy and other purposes. The global observing systems also have an important role in pursuing continuity of observations for sites/transects initiated by various IGBP projects. At the present time, this mutually advantageous dependence is not reflected in the sponsorship of TOPC. This is unlike e.g. the Ocean Observation Panel for Climate (OOPC) which is co-sponsored by the World Climate Research Programme (WCRP).

Recommendation 28***: It is recommended that GCOS and GTOS approach IGBP to become a formal cosponsor of TOPC.***

12.5 Rates of Change

Dr. Kirk Dawson noted that he had observed significant progress in the development of the Terrestrial Observing Panel for Climate since the inception of work on GCOS some five or so years ago. This had to be a result of the commitment of the participants at this and earlier meetings. At the same time he suggested that the participants should not loose sight of the needs of the individual sponsors and governments around the world for information not only on the impact of climate change on the terrestrial ecosystem but also on the "rate" at which those changes might be occurring and also on any changes in the nature of "extreme events". He acknowledged that a basic observing system was needed in order to address the main question of whether or not there was an impact and that there was clearly a need to "walk before running". However, the need to answer questions such as rate of change imposed additional and important constraints on the observing system that needed to be addressed at an early stage. Specifically, he noted that it imposed a very strong need for a long term commitment to the operation of the observing system over periods of decades not just years and that this had a significant impact on the financial commitment of participating agencies such as the space agencies. One of the key measures of our success he noted would be the ability of future generations of scientists to provide informed answers to such questions. He also observed that there was considerable speculation at this time on changes of extreme events within the basic climate system, such as severe weather events, that was leading policy makers to ask whether or not there were associated changes occurring within the ecosystem. An early ability of the global observing systems to address aspects of this question was vital if the program was to be relevant to today’s issues. For example were there changes in the frequency of fires in specific regions of the world?

Dr. Dawson also encouraged TOPC to continue its current thrust towards the identification of pilot projects that could assist in the implementation phase. He strongly urged that such pilot projects involve specific clients at the early stages to ensure that the outputs of those pilot projects were indeed relevant to the user community. The involvement of clients in pilot projects could also lead to the identification of funding opportunities beyond the traditional sources of research and observing systems funding within governments. Specifically, the identification of developing country clients willing to participate in development projects revealed potential candidates for support from a variety of sources.

The above issue was briefly discussed. It was agreed that the rates of change are a very important consideration, and that with the initial planning completed by the TOPC, attention needs to be given to this question.

Recommendation 29: ***TOPC should examine the requirements and issues regarding the detection of rates of change in terrestrial ecosystems and should make appropriate recommendations to GCOS and GTOS.***

12.6 Information Dissemination

It was agreed that while the TOPC work has provided a sound basis for terrestrial climate-related observations, there is a need to increase the awareness of the scientific community and other groups regarding the importance of making long-term terrestrial observations, the conceptual approaches developed so far, and the progress in initial implementation. Several specific opportunities were identified, including:

Presentations at the General assembly of the International Union of Geodesy and Geophysics (IUGG) in Birmingham, UK (19-30 July, 1999). The relevant events include the general plenary sessions, Symposium 2 (Interactions between the Cryosphere, Climate and Greenhouse Gases), and WORKSHOP 1 (Global Data Bases).

An article for the EOS Newsletter (American Geophysical Union) or other scientific journals.

A poster (posters) which could be used in sessions at various meetings.

Recommendation 30: TOPC should actively communicate with the scientific community and the public regarding the issues in its area of responsibility and results of the work to date, using the above and other opportunities.

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Annex II: Meeting Agenda

1.	Organization of the Meeting	Josef Cihlar
1.1	Opening and Conduct of the meeting	
1.2	Approval of the Agenda	
2.	Reports on Current Status and Updates	
2.1	GCOS Activities	John Townshend
2.2	GTOS Activities	Jim Gosz
2.3	Report of Recent JDIMP and AOPC Meeting	Ron Wilson
2.4	Report of the Workshop on Climate Extremes	Jurate Landwehr
2.5	Integrated Global Observing Strategy	John Townshend
3.0	Review of TOPC Goals and Strategy	Josef Cihlar
3.1	Framework for TOPC	
3.2	Goals of TOPC	
4.0	Status of Networks	Josef Cihlar
4.1	Glaciers	Roger Barry
4.2	Permafrost	Roger Barry
4.3	Hydrology	Hal Kibby
4.4	Ecology	Jim Gosz
5.0	Demonstration Projects	
5.1	Global Net Primary Productivity	Steve Running
5.2	Global Observation of Forest Cover	Josef Cihlar
6.0	Terrestrial Ecosystems Monitoring Sites	Hal Kibby
6.1	Presentation of Data Base	
6.2	Discussion	
7.0	Gaps Analysis	Rik Leemans
8.0	Subsidiary Body on Scientific and Technical Advice (SBSTA)	Josef Cihlar et al.
9.0	TOPC Data Sets	Josef Cihlar
9.1	Presentations of existing data sets	
	Aerosols	Randall Koster
	Albedo	
	Plant biomass - above ground	Alan Solomon
	Fire area (biomass burning)	
	Carbon dioxide flux	Ken’ichi Kuma
	Evapotranspiration	
	Glacier length	Roger Barry
	Glacier mass balance	
	Ice sheet geometry	
	Ice sheet mass balance	

	Lake and river freeze-up and break-up Permafrost - active layer Permafrost - thermal state Snow cover area Snow depth Snow water equivalent	
	Rooting depth - 95%Soil bulk density Soil cation exchange capacity Soil moisture Soil particle size distribution Soil pH Soil surface state Soil temperature Soil total carbon Soil total nitrogen Soil total phosphorus	Robert Scholes
	Land cover Leaf area index Topography	Josef Cihlar
	Net ecosystem productivity Net primary productivity Spectral vegetation index	Hal Kibby
	Ground water storage fluxes Surface water flow - discharge Surface water storage fluxes	Jurate Landwehr
9.2	Criteria for accepting a Data set	Ron Wilson
9.3	Future Actions by TOPC	Josef Cihlar
10.0	Coordination with JDIMP and GOSIC	Ron Wilson
11.0	Review and Revise TOPC Satellite Data Requirements	Josef Cihlar
12.0	Implementation Plan and Future TOPC Activities	Josef Cihlar
12.1	Work Plan for the Next Year	
12.2	Collaboration with other programmes	
12.3	Soil Wetness Project	
12.4	IGBP Sponsorship	
12.5	Rates of Change	
12.6	Information dissemination	

Adjourn

Field trip to H.J. Andrews Forest Research Station (tier 2 research site)

Annex III: Review of Data Sets

TEMPLATE:	
VARIABLE:	**TOPC Variable Name**
DATA SET:	Data set name
DATA ADDRESS:	Where can the data be obtained?
AUTHOR:	Producer(s)
UNITS:	Units of measure
SOURCE:	Source of (raw) data from which it was derived (i.e., heritage)
RESOLUTION:	Spatial and temporal resolution
COVERAGE:	Spatial and temporal (i.e. period covered, if applicable) coverage (global, continental/which??)
METADATA:	Is metadata adequate (i.e., does it give enough information so that potential user can decide if it is useful for a specific purpose and has enough information to manipulate the data so that it fits other data sets, models, etc.)? This would be based on what is available on the web, unless you have your own, specialized knowledge
VALIDATION:	Has the data set been validated by producer?
REVIEW:	Has the data set been peer-reviewed or otherwise independently assessed?
USE:	Has the data set been used in published referred papers?
APPLICATION:	Has the data set been used in climate or earth system-related studies?
RECOMMENDATION:	

VARIABLE:	**Carbon Dioxide Flux**
DATASET:	FLUXNET
DATA ADDRESS:	http://cdiac.esd.ornl.gov/programs/NIGEC/fluxnet
AUTHOR:	Various
UNITS:	umol/sec/m2
SOURCE:	Eddy covariance method
RESOLUTION:	65 world wide, every 30 minutes
COVERAGE:	Global, Long-term
METADATA:	Available
VALIDATION:	Yes
REVIEW (peer):	Ongoing
USE in refereed papers:	Yes
APPLICATION:	One goal will be to provide data for validation of the EOS products. In particular, data will be used to test satellite-derived products of net primary productivity. Data will also be used to test and validate soil-vegetation-atmosphere-transfer models that are being used in global climate and ecosystem models
RECOMMENDATION:	Qualified acceptance. These are scattered point measurements and thus are not globally (or regionally) comprehensive. It should be noted that flux observation is strongly affected by the local heterogeneity of the land surface and the local circulation in the planetary boundary layer

VARIABLE:	**Carbon Dioxide Flux**
DATASET:	Monthly Exchange with Natural Ecosystems (e.g., vegetation and soils)
DATA ADDRESS:	http://www.giss.nasa.gov/data/co2fung
AUTHOR:	NASA Goddard Institute for Space Studies
UNITS:	1013 kg C/m2/s
SOURCE:	AVHRR
RESOLUTION:	4x5 degree monthly mean
COVERAGE:	Global, climatology
METADATA:	Fung, I., C.J. Tucker, and K.C. Prentice. 1987. Application of Advanced Very High Resolution Radiometer vegetation index to study atmosphere-biosphere exchange of CO2. J. Geophys. Res. 92: 2999-3015
VALIDATION:	Measurement of turbulent fluxes (FLUXNET), carbon transport model and atmospheric carbon concentration
REVIEW (peer):	
USE in refereed papers:	Yes
APPLICATION:	The monthly fluxes of CO2 thus obtained are employed as source/sink functions in a global three-dimensional atmospheric trace transport model to simulate the annual oscillations of CO2 in the atmosphere
RECOMMENDATION:	Qualified acceptance. It should be kept in mind that this data is based upon satellite remote sensing and needs extensive validation through ground-based observation and models

VARIABLE:	**Digital Atlas of the World Water Balance**
DATA SET:	Digital Atlas of the World Water Balance, Version 1.0, using ArcView Version 3.0 Geographic Information System. The Atlas contains five types of data: precipitation, temperature, radiation, runoff and political boundaries. Precipitation, temperature and net radiation have been used to generate evaporation and soil water surplus, which is partitioned into surface and groundwater flow. On each grid cell is presented the mean monthly and mean annual values of each variable in ArcView shapefiles. Mean monthly and mean annual runoff data at 160 stations from GRDC are also given
DATA ADDRESS:	http://www.ce.utexas.edu/prof/maidment/atlas/atlas.htm
AUTHOR:	Maidment, David R.,, S. M. Reed, S. Akmansoy, D. C. McKinney, F. Olivera and Z.Ye. Center for Research in Water Resources, University of Texas, Austin
UNITS:	Various
SOURCE:	Various
RESOLUTION:	Temporal - monthly; Spatial - 0.5 degree mesh
COVERAGE:	Global
METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	Yes
USE in refereed papers:	Yes
APPLICATION:	Yes

RECOMMENDATION:	Full acceptance. Data set is based on historic data rather than an ongoing measurement program
AVAILABILITY:	CD-ROM from the Center for Research in Water Resources of the University of Texas at Austin

VARIABLE:	**Evapotranspiration**
DATASET:	GEWEX Asian Monsoon Experiment/Asian Automated Weather Station Network (GAME/AAN)
DATA ADDRESS:	http://www.suiri.tsukuba.ac.jp/Project/aan/aan.html
AUTHOR:	Various
UNITS:	W/m2
SOURCE:	Various methods
RESOLUTION:	10 sites in Asia region
COVERAGE:	Asia region, planning the long-term observation
METADATA:	Will be available on the WEB
VALIDATION:	Unknown
REVIEW (peer):	
USE in refereed papers:	Yes
APPLICATION:	Used for SVAT model validation
RECOMMENDATION:	Qualified acceptance. It should be noted that flux observation is strongly affected by the local heterogeneity of the land surface and the local circulation in the planetary boundary layer. Soil moisture, radiation, sensible heat flux, and other meteorological fields are also observed

VARIABLE:	**Evapotranspiration**
DATASET:	FLUXNET
DATA ADDRESS:	http://cdiac.esd.ornl.gov/programs/NIGEC/fluxnet
AUTHOR:	Various
UNITS:	W/m2
SOURCE:	Eddy covariance method
RESOLUTION:	65 world wide, every 30 minutes
COVERAGE:	Global, Long-term (but these are point measurements)
METADATA:	Adequate - available on the WEB
VALIDATION:	Ongoing
REVIEW (peer):	
USE in refereed papers:	Will be used
APPLICATION:	Will be used
RECOMMENDATION:	Qualified acceptance. These are scattered point measurements and are thus not globally (or even regionally) comprehensive. It should be noted that flux observation is strongly affected by the local heterogeneity of the land surface and the local circulation in the planetary boundary layer

VARIABLE: **Evapotranspiration**
DATASET: Global Soil Wetness Project
DATA ADDRESS: http://climate3.ccsr.u-tokyo.ac.jp/~nishi/gswp-icc
AUTHOR: CCSR/University of Tokyo
UNITS: W/m2
SOURCE: Land surface model output intercomparison
RESOLUTION: 1x1 degree, 10-day mean
COVERAGE: Global, 1987 and 1988
METADATA: Adequate - available on the WEB
VALIDATION: Will be available on the WEB
REVIEW (peer):
USE in refereed papers: SWP special issue of Journal of Meteorological Society of Japan will be published in early 1999
APPLICATION: Used as the boundary condition for the GCM for seasonal prediction experiments
RECOMMENDATION Qualified acceptance. The coverage is globally comprehensive, but all products are derived from SVAT models. The models are forced with realistic precipitation and radiation. There are significant differences among the models, leading to a degree of uncertainty. Soil moisture of the surface and the rooting layer, skin temperature, sensible heat flux, snow depth, run-off rate, net surface radiation are also available

VARIABLE: **Glacier Length**
DATA SET: Fluctuations of Glaciers
DATA ADDRESS: http://www.geo.unizh.ch/wgms
AUTHOR(S): World Glacier Monitoring Service VAWV, ETH, Zurich, Switzerland
UNITS Length in km/metres
SOURCE: National representativesRESOLUTION: N/A
COVERAGE: Up to 1500 sites world-wide. Some records from late 19th centuryMETADATA: Unknown
VALIDATION: Unknown
REVIEW (peer):
USE in refereed papers: Yes
APPLICATION: Used in 1990 and 1995 assessments of the IPCC
RECOMMENDATION: Full acceptance

VARIABLE: **Global Hydrographic Data Set**
DATA SET: The Global Hydrographic Data Set is organised into eighteen files containing percentages of terrain type, stream frequency counts, major drainage basins, main features of the cryosphere surface, and ice/water runoff. A description can be found at several sites
DATA ADDRESS: http://edcwww.cr.usgs.gov/glis/hyper/guide/gghydro#mark14
http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/islscp_i1.html
AUTHOR: Cogley, J.G., Trent University, Great Britain
UNITS: Various
SOURCE: Various
RESOLUTION: Temporal - annual; Spatial - 1 degree longitude x 1 degree latitude
COVERAGE: Entire surface of the Earth

METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	Yes
USE in refereed papers:	Yes
APPLICATION:	Yes
RECOMMENDATION:	Qualified acceptance. This data is not being updated
AVAILABLITIY:	Fee - place orders either with USGS EROS Data Center Customer Services or with Dr. J. Graham Cogley, Trent University

VARIABLE:	**Ground Water Fluxes**
DATA SET:	No global or national currently available, although at least one national data set (for USA by USGS) is under development. Some regional data sets are available, e.g. for California, USA, http://well.water.ca.gov and British Columbia, Canada, http://www.env.gov.bc.ca/wat/gws/gwis.html

VARIABLE:	**Land Cover**
DATA SET:	Global forest cover data set
DATA ADDRESS:	http://www.wcmc.org.uk/forest/data/cdrom2/index.html
AUTHOR:	Iremonger, S., C. Ravilious and T. Quinton, The World Conservation Monitoring Centre (WCMC) Cambridge, UK
UNITS:	Cover type (15 types for tropical forest, 11 for temperate)
SOURCE:	Compiled from existing country maps
RESOLUTION:	Mapping scale varies from 1:10000000 (and less) to 1:250000 (and better) Mapping date variable
COVERAGE:	Global forests (includes some non-forest types)
METADATA:	Yes, data on CDROM, for use in GIS
VALIDATION:	Not applicable
REVIEW (peer):	Unknown
USE in referred papers:	Yes
APPLICATION:	Unknown
RECOMMENDATION:	Full acceptance

VARIABLE:	**Land Cover**
DATA SET:	Global Land Cover Characteristics Data Base
DATA ADDRESS:	http://edcwww.cr.usgs.gov/landdaac/glcc/globdoc1_2.html
AUTHOR:	Loveland, T. et al., US Geological Survey, Sioux Falls, SD
UNITS:	Cover type
SOURCE:	NOAA AVHRR
RESOLUTION:	Spatial resolution 1 km. Temporal resolution: daily data combined into 10-day composites
COVERAGE:	Global. April 1992 to March 1993 data were used
METADATA:	Yes
VALIDATION:	Not completed (underway)
REVIEW (peer):	Yes
USE in referred papers:	Yes

APPLICATION:	No
RECOMMENDATION:	Qualified acceptance (subject to successful completion of the validation)

VARIABLE:	**Land Cover**
DATA SET:	Global land cover classification from satellite data
DATA ADDRESS:	http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/DATASET_DOCUMENTS/VEG_CLSS.html
AUTHOR:	DeFries, R.,and John R.G. Townshend, University of Maryland, Greenbelt, MD
UNITS:	Cover type
SOURCE:	NOAA AVHRR data
RESOLUTION:	8 km resolution of original data, averaged to 1^ox1^o at monthly intervals
COVERAGE:	Global coverage Satellite data represent the year 1987
METADATA	Yes
VALIDATION:	Limited
REVIEW (peer):	Yes
USE in refereed papers:	Yes
APPLICATION:	Yes
RECOMMENDATION:	Qualified acceptance (limitations noted in the metadata).

VARIABLE:	**Land Cover**
DATA SET:	Hydrology cover fractions
DATA ADDRESS:	http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/DATASET_DOCUMENTS/HYDR_CVR.html
AUTHOR:	Cogley, J.G., Trent University
UNITS:	Cover type fraction (0-100%, for exposed land; freshwater lakes; swamp, marsh, other wetlands; saltwater; intermittent water bodies; glacier ice; sand dunes; salt marsh; salt flats; perennial rivers; intermittent rivers)
SOURCE:	Extracted from existing maps(100 points/1^ox1^o cell)
RESOLUTION:	Mapping scale for source maps 1:1,000,000 . Fractions given for 1^ox1^o cells
COVERAGE:	Global landmass
METADATA:	Yes
VALIDATION:	No/Not applicable
REVIEW (peer):	Yes
USE in referred papers:	Unknown
APPLICATION:	Unknown
RECOMMENDATION:	Full acceptance

VARIABLE:	**Leaf Area Index**
DATA SET:	Total Leaf Area Index (LAI)
DATAADDRESS:	

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/DATASET_DOCUMENTS/LAI.html

AUTHOR:	Los, S. O.,, P. J. Sellers, Biospheric Sciences Branch NASA Goddard Space Flight Center, Greenbelt, MD
UNITS:	Total (life and dead) one-sided Leaf Area Index (ratio between leaf area and ground surface)
SOURCE:	AVHRR data processed as Normalized Difference Vegetation Index (NDVI)
RESOLUTION:	$1^{o}x1^{o}$
COVERAGE:	Global landmass. Temporal coverage January to December, 1987
METADATA:	Yes
VALIDATION:	No
REVIEW (peer):	Yes
USE in referred papers:	Yes
APPLICATION:	Unknown
RECOMMENDATION:	Full acceptance

VARIABLE:	**Net Primary Productivity**
DATA SET:	NPP Database
DATA ADDRESS:	http://www-eosdid.ornl.gov/npp/npp_home.html
AUTHOR:	Jonathan Scurlock
UNITS:	Variable depending on data set
SOURCE:	Variable
RESOLUTION:	Variable
COVERAGE:	Global
METADATA:	Yes
VALIDATION:	Unknown
REVIEW (peer):	Unknown
USE in referred papers:	The data has been published
APPLICATION:	Unknown
RECOMMENDATION:	Full acceptance

VARIABLE:	**Permafrost Active Layer**
DATA SET:	Active layer depth
DATA ADDRESS:	http://www.geodata.soton.ac.uk/ipa
AUTHOR:	28 observers
UNITS:	Depth in cm
SOURCE:	Circumpolar Active Layer Monitoring System (CALM)
RESOLUTION:	Point measurement
COVERAGE:	69 sites mostly circum -Arctic
METADATA :	Adequate
VALIDATION:	Some
REVIEW (peer):	Unknown
USE in refereed papers:	Yes
APPLICATION:	Unknown
RECOMMENDATION:	Full acceptance

VARIABLE:	**Plant Biomass (Above Ground)**
DATA SET:	Woodlands Data
DATA ADDRESS:	DeAngelis, D.L., R.H. Gardner, and H.H. Shugart. 1981. Productivity of forest ecosystems studied during the IBP: the woodlands data set, pp. 567-672. In Reichle, D.E., ed., Dynamics of Forest Ecosystems. Cambridge University Press, Cambridge. 683p. Electronic version available at: http://www-eosdis.ornl.gov/npp/ibp/ibp_des.html
AUTHOR:	DeAngelis, D. L., R. H. Gardner and H. H. Shugart
UNITS:	See below
SOURCE:	DeAngelis et al. describe the data sources and their development, all from individual investigators
RESOLUTION:	See below
COVERAGE:	Site-specific (117 sites)
METADATA:	Excellent, as provided in DeAngelis et al (1981), and at the web site
VALIDATION:	Many sites have been validated, probably many more not, but validation history is unknown
REVIEW (peer):	Extensive peer-review
USE in refereed papers:	Published refereed papers in the Reichle book, and in numerous publications since then
APPLICATION:	Not known by TOPC reviewer
RECOMMENDATION:	Full acceptance. This is the type-specimen for how a biomass data base should be constructed

Woodlands Biomass Data Sets and their Units

General Site Data

AS	Age of stand	Years
LAI	Leaf area index	Square meters/square meter
BA	Basal area	Square meters/hectare
BAI	Basal area increment	Square meters/hectare
SH	Stand height	Meters
SD	Stocking density	Stems/hectare
SCA	Standing crop, above-ground	Grams/square meter
SCB	Standing crop, below-ground	Grams/square meter
PA	Productivity above-ground	Grams/square meter/year
PB	Productivity below-ground	Grams/square meter/year
LAT	Latitude	Degrees and minutes
LNG	Longitude	Degrees and minutes
ALT	Altitude	Meters
MAT	Mean annual temperature	Degrees Centigrade
MAP	Mean annual precipitation	Millimeters
MAR	Mean annual radiation(Global)	Calories/square centimeter/year
RBA	Radiation balance	Calories/square centimeter/year
LGS	Length of growing season	Days
TGS	Temperature during growing season	Degrees Centigrade
PGS	Mean precipitation in growing season	Millimeters

RGS	Mean radiation in growing season (Global)	Calories/square centimeter/year
RBG	Radiation balance in growing season	Calories/square/year
SPH	Soil pH	pH Units
DRZ	Depth of rooting zone	Centimeters

Compartment Biomass Data

OL	Overstory leaves	Grams/square meter
OFF	Overstory fruits, flowers	Grams/square meter
OBR	Overstory branches-sum	Grams/square meter
OBRB	Overstory branches-bark	Grams/square meter
OBRW	Overstory branches-wood	Grams/square meter
OBO	Overstory bole sum	Grams/square meter
OBOB	Overstory bole bark	Grams/square meter
OBOW	Overstory bole wood	Grams/square meter
OSTD	Overstory standing dead	Grams/square meter
OSUM	Sum overstory	Grams/square meter
UL	Understory leaves	Grams/square meter
UFF	Understory fruits, flowers	Grams/square meter
UBR	Understory branches-sum	Grams/square meter
UBRB	Understory branches-bark	Grams/square meter
UBRW	Understory branches-wood	Grams/square meter
UBO	Understory bole-sum	Grams/square meter
UBOB	Understory bole-bark	Grams/square meter
UBOW	Understory bole-wood	Grams/square meter
USTD	Understory standing dead	Grams/square meter
USUM	Sum understory	Grams/square meter
HERB	Herbaceous field	Grams/square meter
EPIP	Epiphytes total	Grams/square meter
PSUM	Total plants	Grams/square meter
RL	Living roots sum	Grams/square meter
RLL	Living roots > 5 mm	Grams/square meter
RLS	Living roots < 5 mm	Grams/square meter
RD	Dead roots	Grams/square meter
STO	Soil top organic	Grams/square meter
RZ	Rooting zone	Grams/square meter
IRZ	Intensive rooted	Grams/square meter
ERZ	Extensive rooted	Grams/square meter
SUBS	Subsoil	Grams/square meter
HETR	Heterotrophs sum	Grams/square meter
AGC	Above-ground consumers	Grams/square meter
DCFA	Decomposer fauna	Grams/square meter
DCFL	Decomposer flora	Grams/square meter

Compartment Flux Data

CS	Consumption total	Grams/square meter
CSF	Consumption foliage total	Grams/square meter
CSO	Consumption overstory	Grams/square meter
CSOW	Consumption wood-overstory	Grams/square meter/year

CSUW	Consumption wood-understory	Grams/square meter/year
CSR	Consumption roots-total	Grams/square meter/year
CSU	Consumption-understory	Grams/square meter/year
CSHB	Comsumption -herbaceous	Grams/square meter/year
CSW	Consumption wood total	Grams/square meter/year
LF	Litterfall total	Grams/square meter/year
LFL	Litterfall leaf	Grams/square meter/year
LFFF	Litterfall flower, fruit	Grams/square meter/year
LFBR	Litterfall branch	Grams/square meter/year
LFBO	Litterfall bole	Grams/square meter/year
LFFR	Litterfall frass	Grams/square meter/year
LFEP	Litterfall epiphytes	Grams/square meter/year
ATIN	Atmospheric input	Grams/square meter/year
PRE	Precipitation	Grams/square meter/year
DRP	Dry particulates (dust)	Grams/square meter/year
GAF	Gaseous fixation	Grams/square meter/year
LEAC	Leaching	Grams/square meter/year
LWAS	Leaf wash	Grams/square meter/year
STMF	Stem flow	Grams/square meter/year
LSOL	Leaching soil layers	Grams/square meter/year
OUTP	Output	Grams/square meter/year
OPWI	Output wind erosion	Grams/square meter/year
OPWA	Output water erosion	Grams/square meter/year
OPPR	Output percolation	Grams/square meter/year

VARIABLES: **Atmospheric variables: Precipitation, Air temperature, Relative humidity, Incoming Shortwave Radiation, Cloud cover, Wind speed**

DATA SET: An observed monthly surface climate data set over global land areas for 1901-1995

DATA ADDRESS: http://ippc-ddc.cru.uea.ac.uk

AUTHOR: Mark New (m.new@uea.ac.uk) and M. Hulme (m.hulme@uea.ac.uk)
Climatic Research Unit,
University of East Anglia
Norwich, East Anglia, UK

UNITS:

Variable	*Dimension*	*number of stations*
Precipitation	mm month^{-1}	19296
Wet-days	# days	9503
Mean temperature	^{o}C	12092
Diurnal temperature range	^{o}C	11319
Vapour Pressure	Pascal	4018
Relative humidity	%	4492
Sunshine	%	4040
Cloud cover	%	2611
Ground-frost days	# days	2708
Air frost days	# days	5220
Windspeed	m sec^{-1}	3584

SOURCE: The source of the database is a measured time series of standard WMO weather stations. First, the deviation for each variable and month for the period 1901-1996 with respect to the normal period 1961-1990 is determined. These deviations are then interpolated towards the terrestrial grid. The values are empirically corrected for orography, which is defined by the topography database of NGDC1 (1995)

RESOLUTION: 0.5^{o} longitude x 0.5^{o} latitude grid

COVERAGE: Global coverage of all land masses, ocean surface is not considered

METADATA: The database will be well documented. Several scientific papers are submitted and/or in press. (for example: New, M. & M . Hulme, 1997. Development of an observed monthly surface climate data set over global land areas for 1901-1995. Royal Meteorological Society. The physics of climate, Royal Society, London, 29-30 October 1997.). The underlying climatic normal database for the period 1961-1960 will be published in a forthcoming issue of the Journal of Climate

VALIDATION: The interpolation method also provides a goodness of fit field. These fields show that precipitation and wind speed were the hardest variables to interpolate successfully. In addition, Latin America proved to be the region with the lowest reliability of the interpolation

REVIEW (peer): The data has been submitted as one of the central IPCC databases for the third assessment report. Independent review of the database is currently performed

USE in referred papers: Published referred papers are in press (Journal of Climate, Bulletin of the Royal Meteorological Society)

APPLICATION: Yes, but the results are only sparsely published. The applications have been focusing on defining the climate variability through time (CRU-UEA, UK), evaluating future climate scenarios (CRU-UEA, UK), defining climate change indicators (RIVM, The Netherlands) and assessing the role of climate in food security (University of Kassel, Germany)

RECOMMENDATION: Full acceptance

LIMITATIONS: Limited coverage in some regions for some variables. The database is collected from ground stations, therefore the data is less valid for validating general circulation models, but the data set is tailor-made for many different applications in ecology, agronomy and biogeography

1 National Geophysical Data Center, 1988. . . 10-minute topography data base. . . Computer tape, NOAA, US Department of Commerce Boulder, USA.

VARIABLE: **Snow Cover Extent**
DATA SET: Weekly Northern Hemisphere Snow Cover
DATA ADDRESS: http://nic.fob4.noaa.gov/data/cddb
AUTHOR(S): NOAA/NESDIS Washington, DC
UNITS: Area (million sq.km)
SOURCE: NOAA/NESDIS Advanced Very High Resolution Radiometer data
RESOLUTION: 89 by 89 box grid. Weekly
COVERAGE: Northern Hemisphere land areas (1966)/1971 - present
METADATA: Adequate
VALIDATION: Yes
REVIEW (peer): Yes
USE in refereed papers: Yes
APPLICATION: Used in IPCC 1990 and 1995 assessments
RECOMMENDATION: Full acceptance

VARIABLE: **Spectral Vegetation Greenness Index**
DATA SET: Normalized difference vegetation index (NDVI)
DATA ADDRESS: http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/islscp_i1.html
AUTHOR: Sietse, Tucker and Justice
UNITS: Dimensionless
SOURCE: AVHHR data from NOAA 9 and NOAA 11
RESOLUTION: 1^o latitude x 1^o longitude
COVERAGE: Global (monthly 1987-1988)
METADATA: Yes
VALIDATION: Yes
REVIEW (peer): Yes
USE in referred papers: Yes
APPLICATION: Yes
RECOMMENDATION: Full acceptance

VARIABLE: **Surface Water - River Discharge**
DATA SET: An extended data set of river discharges for validation of general circulation models
DATA ADDRESS: ftp://kosmos.agu.org/apend/96jd00932
AUTHOR: Perry, G.D., P.B. Duffy, N.L. Miller
UNITS: Cubic meters/second
SOURCE: Various
RESOLUTION: average annual flow (single estimate; not a time series)
COVERAGE: Global (981 rivers)
METADATA: Yes
VALIDATION: Yes
REVIEW (peer): Yes
USE in refereed papers: Yes
APPLICATION: Yes
RECOMMENDATION: Qualified acceptance. This data set is strictly historical; it is not being updated
AVAILABILITY: On line from AGU ftp://kosmos.agu.org/apend/96jd00932

VARIABLE:	**Surface Water - Storage Flux**
DATA SET:	Global Lake and Catchment Conservation Database. Includes remote sensing data (derived lake-surface areas and the latest satellite imagery) and conservation information (protected forests, wetlands, endemic fish species) for a selection of lakes and inland seas.
DATA ADDRESS:	http://msslsp.mssl.ucl.ac.uk/orgs/un http://msslsp.mssl.ucl.ac.uk/orgs/un/glaccd/html/mgld.html http://msslsp.mssl.ucl.ac.uk/orgs/un/glaccd/html/rsgld.html
AUTHOR:	WCMC and the Mullard Space Science Laboratory at the University College London
UNITS:	Various
SOURCE:	Various
RESOLUTION:	Various
COVERAGE:	International (1400 large lakes). Lakes specified to be greater than 100 km^2 in area
METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	In process
USE in refereed papers:	Yes
APPLICATION:	Prototype
RECOMMENDATION:	Qualified acceptance. Still in developmental stages.
AVAILABILITY:	Available on-line

VARIABLE:	**Surface Water - River Discharge**
DATA SET:	Global Runoff Data Centre (GRDC), Federal Institute of Hydrology, Koblenz, Germany
DATA ADDRESS:	http://fserv.wiz.uni-kassel.de/kww/irrisoft/hydro/grdc.html
AUTHOR:	Various. The information has been compiled for use on the World Wide Web by Thomas-M.Stein (stein@wiz.uni-kassel.de)
UNITS:	Cubic meters per second
SOURCE:	Various, including UNESCO archives
RESOLUTION:	Point measurement (at gauging site)
COVERAGE:	Global Data for rivers with - mean annual discharge greater than 100 m^3/s, - catchment areas greater than 10^6 km^2, or - river basins with more than 10^6 inhabitants
METADATA:	Yes
VALIDATION:	Variable. Depends on the national hydrological services performing measurements. The GRDC performs plausibility tests on data it stores
REVIEW (peer):	Variable
USE in refereed papers:	Yes
APPLICATION:	Yes
RECOMMENDATION:	Full acceptance
AVAILABLITIY:	Access requires interaction with GRDC staff
NOTE:	A specific CD ROM product, derived from GRDC data set entitled: Streamflow Data of Major River Basins, by Soroosh Sorooshian, University of Arizona is described at :

http://daac.gsfc.nasa.gov/CAMPAIGN_DOCS/ISLSCP/DATASET_DOCUMENTS/RVR_FLOW.html
and is available for a fee from the GDRC

VARIABLE:	**Surface Water - River Discharge**
DATA SET:	Hydro-Climatic Data Network (HCDN). A U.S. Geological Survey Streamflow Data Set for the United States for the Study of Climate Variations, 1874-1988 (USGS OFR 92-129). Note: it includes USGS Benchmark data set.
DATA ADDRESS:	Defining Report and Metadata: http://wwwrvares.er.usgs.gov/hcdn_report/content.html Data: http://wwwrvares.er.usgs.gov/hcdn_cdrom/1st_page.html
AUTHOR:	Slack ,J.R., and J. M. Landwehr USGS, Reston, VA, 20192, USA
UNITS:	Cubic feet per second
SOURCE:	USGS archives
RESOLUTION:	Daily, monthly and annual average discharge, all based on measured discharge at site, accuracy ~5%
COVERAGE:	United States of America (1659 stations) Selection was limited to station records with minimal changes in watershed during period of record to maximize suitability for studies of climate forcing
METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	Yes
USE in refereed papers:	Yes
APPLICATION:	Yes
RECOMMENDATION:	Full acceptance. An update is currently being prepared. The data are limited to the US and territories.
AVAILABILITY:	No Cost - Online

VARIABLE:	**Surface Water - River Discharge**
DATA SET:	Hydroclimatology Data Set
DATA ADDRESS:	http://www-eosdis.ornl.gov/hydrology/wallis_hydroclimatology.html
AUTHOR	Wallis, J.R., D.Lettenmeier, and E.Woods
UNITS:	Cubic feet per second
SOURCE:	USGS archives
RESOLUTION:	Daily, monthly and annual discharge
COVERAGE:	United States of America (1009 stations), 1948-1988
METADATA adequate:	Yes
VALIDATION:	Yes
REVIEW (peer):	Yes
USE in refereed papers:	Yes
APPLICATION:	Yes
RECOMMENDATION:	Full acceptance. Historic data, covers US
AVAILABILITY:	Available from ORNL DAAC

VARIABLE: **Surface Water - River Discharge**
DATA SET: RivDis
DATA ADDRESS: http://pyramid.unh.edu/csrc/hydro/unescoTop.html
AUTHOR: UNESCO river archives digitized and checked by C.J. Vörösmarty, B.M. Fekete, B.A. Tucker and the staff of the Complex Systems Research Center (CSRC) at the University of New Hampshire
UNITS: Cubic meters per second
SOURCE: UNESCO archives
RESOLUTION: At gauging station site, monthly values
COVERAGE: Global (1018 stations)
METADATA: Yes
VALIDATION: Yes
REVIEW (peer): Yes
USE in refereed papers: Yes
APPLICATION: Yes
RECOMMENDATION: Full acceptance This data set is strictly historical; it is not being updated.
AVAILABILITY: Through the ORNL DAAC User Services Office: http://www-eosdis.ornl.gov/daacpages/rivdis.html

VARIABLE: **Surface Water - Storage Flux**
DATA SET: Selected Characteristics of Large Reservoirs
Map coverage and information on locations of and selected characteristics of approximately 2,700 reservoirs and controlled natural lakes that have normal capacities of at least 5,000 acre-feet or maximum capacities of at least 25,000 acre-feet and that were completed as of January 1, 1988; includes information on their control structures
DATA ADDRESS: http://water.usgs.gov/lookup/getspatial?reservoir
AUTHOR: Ruddy, B.C. and K.J. Hitt
UNITS: Various
SOURCE: Various, primarily U.S. Army Corps of Engineers
RESOLUTION: Various
COVERAGE: United States of America and Puerto Rico (2700 reservoirs and controlled lakes)
METADATA adequate: Yes
VALIDATION: Yes
REVIEW (peer): Yes
USE in refereed papers: Yes
APPLICATION: Yes
RECOMMENDATION: Full acceptance These are baseline data, not a time series
AVAILABILITY: Available on-line

VARIABLE**:** **Surface Water - River Discharge**
DATA SET: USGS National Data Set
DATA ADDRESS: Historical data available at: http://h2o-nwisw.er.usgs.gov/nwis-w/US . Real time data set available at: http://water.usgs.gov/public/realtime.html

AUTHOR:	USGS monitoring staff
UNITS:	Cubic feet per second
SOURCE:	USGS monitoring program
RESOLUTION:	At gauging site -- Historical data - daily average flow; real time data -- instantaneous flow
COVERAGE:	United States of America
METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	Internal agency standards
USE in refereed papers:	Yes
APPLICATION:	Extensive
RECOMMENDATION:	Full acceptance. These data are continually updated. They cover the US and territories.
AVAILABILITY:	No cost – Online

VARIABLE:	**Surface Water - River Discharge**
DATA SET:	WHYCOS data base
DATA ADDRESS:	http://www.wmo.ch/web/design2/homs/whycos.html
AUTHOR:	
UNITS:	
SOURCE:	
RESOLUTION:	Point measurements
COVERAGE:	
METADATA:	
VALIDATION:	
REVIEW (peer):	
USE in refereed papers:	
APPLICATION:	
RECOMMENDATION:	No. Very promising, but still in early stages of development.
AVAILABILITY:	Being implemented

VARIABLE:	**Topography**
DATA SET:	GLOBE Version 0.5
DATA ADDRESS:	*http://www.ngdc.noaa.gov/seg/fliers/se-1106.html*
AUTHOR:	David Hastings (contact), National Geophysical Data Center and World Data Center-A for Solid Earth Geophysics Boulder, Colorado, USA
UNITS:	Elevation in metres
SOURCE:	National Imagery and Mapping Agency's Digital Terrain Elevation Data (DTED)
RESOLUTION:	3 arc-seconds in latitude and longitude
COVERAGE:	About 60% of global landmass covered so far
METADATA:	Yes
VALIDATION:	Yes
REVIEW (peer):	Unknown to TOPC reviewer
USE in referred papers:	Unknown to TOPC reviewer
APPLICATION:	Unknown to TOPC reviewer
RECOMMENDATION:	Full acceptance

VARIABLE:	**Topography**
DATA SET:	National Geophysical Data Center TerrainBase Global DTM Version 1.0
DATA ADDRESS:	*http://www.ngdc.noaa.gov/seg/globsys/globe.html/*
AUTHOR:	Lee, W. R., III and David Hastings, National Geophysical Data Center and World Data Center-A for Solid Earth Geophysics, Boulder, Colorado, USA
UNITS:	Elevation in metres
SOURCE:	Extracted from existing maps and digital data sets
RESOLUTION:	Resampled to 5 minute x 5 minute cells
COVERAGE:	Global landmass and oceans
METADATA:	Yes
VALIDATION:	Yes (known errors highlighted)
REVIEW (peer):	Yes
USE in referred papers:	Unknown to TOPC reviewer
APPLICATION:	Unknown to TOPC reviewer
RECOMMENDATION:	Full acceptance

VARIABLE:	**Wildfire Distribution**
DATA SET:	IGBP-DIS Global Fire Product
DATA ADDRESS:	http://www.mtv.sai.jrc.it/projects/fire/gfp
AUTHOR:	Joint Research Centre, Space Applications Institute, Monitoring of Tropical Vegetation Unit, Ispra, Italy; International Geosphere-Biosphere Programme, Data and Information Systems (IGBP-DIS), The Fire Working Group; and, Earth Observation Sciences, Ltd., UK
UNITS:	(1) Daily global fire position tables and (2) Raster fire counts on 0.5° X 0.5° latitude-longitude grids over both 1 and 10-day periods. These rasters will also include cloud and no-data information
SOURCE:	IGBP-DIS 1 km AVHRR product, treated with two-stage hierarchical fire detection algorithm, after masking out clouds, water bodies, and other non-fire areas
RESOLUTION:	Fire position tables daily at 1 km, raster fire counts daily and 10-daily at on 0.5° X 0.5° latitude-longitude (this latter resolution not yet confirmed, 5/21/98)
COVERAGE:	Global vegetation derived from daily satellite observations over the period from April 1992 to December 1993
METADATA:	Web site metadata are adequate
VALIDATION:	Validation planned for specific (+ realistic?) sites where ancillary data will be taken upon detection of fire signature
REVIEW (peer):	Data has undergone beta testing by unidentified fire researchers
USE in refereed papers:	None to date, 5/21/98
APPLICATION:	None to date, 5/21/98
RECOMMENDATION:	When the data becomes available for examination (it was planned for July, 1997, then, for December, 1997 but is not available to date, although the Web site indicates that all 21 months of data have been extracted and derived), it should be accepted by GTOS subject to the products being validated. In the meantime, it should be listed and described, with a clear notification that the data have not yet been seen

Annex IV: TOPC Key Questions

(The primary intent of these questions is to help focus the development of priorities for TOPC activities.)

Policy makers have been informed that the global climate system is changing as a result of human activities. They now require information on the implications of such changes on terrestrial natural and managed ecosystems. Specifically, they need answers to four broad questions.

1. Are the changes to terrestrial ecosystems, which may be beneficial or detrimental, attributable to climate change? If so, what is the rate and magnitude of the change, and is there any change in the frequency of extreme events? To address these questions, several sub-questions must be addressed, including the following:

a. Are there changes in snow cover, glacier dimensions and the area or depth of permafrost?
b. Are there changes in the quantity, timing or location of runoff, especially in catchments not exposed directly to land use change?
c. Has there been a change in the frequency of floods or droughts?
d. Has there been a change in the frequency or extent of vegetation fires, insect outbreaks, windthrow or other major ecosystem disturbances?
e. Are there changes in the length of the growing season, either through changes in the frost-free period or the duration of soil moisture?
f. To what degree are changes in runoff and ice melt contributing to sea level rise?
g. To what degree has climate change contributed to changes in the volume of groundwater in aquifers?

2. Are the changes in terrestrial ecosystems affecting, or likely to affect, their ability to sustain food and fibre production to meet human needs, economic activities associated with terrestrial ecosystems, such as forestry and tourism, and suitable habitats for the full diversity of plants and animals? For example:

a. What is the impact of climate change and rising carbon dioxide on plant growth (net primary productivity) in terrestrial ecosystems?
b. Has the extent or location of land suitable for particular forms of agriculture or forestry altered?
c. What is the impact of climate change on the structure and composition of the land cover (including issues such as the location and extent of forests and wetlands), particularly in combination with direct human alteration of land cover?
d. What is the impact of climate change, the rate of climate change and the frequency of extremes on species near their climatic limits, particularly for isolated populations of rare organisms?

3. Are changes in terrestrial ecosystems acting to enhance or moderate climate change? For example:

a. How is the ability of terrestrial ecosystems to act as sinks or sources of radiatively-active gases, aerosols or the precursors, in particular carbon dioxide, methane, nitrous oxide and tropospheric ozone, modified?
b. Is the fraction of solar energy absorbed by the surface altered?
c. Is the partitioning of absorbed energy between latent and sensible energy changed?
d. Has the aerodynamic roughness of the land surface altered?
d. Are elevated carbon dioxide and nitrogen deposition altering altering the processes which control carbon pools in live and plants and the soil?

4. How can information from the study of terrestrial ecosystems be applied to improve the tools used to assess and predict climate change and its impacts? For example:

a. How can the data be assimilated in a form which improves the accuracy and resolution of the land surface-atmosphere interactions in general circulation models?
b. How accurate are the climate and terrestrial ecosystem models in mimicking existing conditions, and how sensitive are they to changes in their parameters within the range of natural variability plus measurement uncertainty?
c. Are there sensitive ‘early warning’ indicators of change in terrestrial ecosystems, or easily-measured and broadly distributed integrators of complex, slow or intermittent change processes?

Annex V: SBSTA Input (Preliminary Draft)

1. Introduction

It has been concluded by the IPCC that the global climate system is changing and that one of the components of that change is human intervention in the form of anthropogenic emissions of greenhouse gases and changes in land use.

In the development of response strategies to such changes in the climate system requires an understanding of the extent to which land surface changes are a contributing factor; the extent to which the terrestrial ecosystem is changing as a result of climate change and; the implication of these changes in the terrestrial ecosystem on food productivity, ecosystem-based economic development and the availability of clean fresh water.

While it is essential to be able to assess the magnitude of any ecosystem changes it is even more important to be able to assess the rate of such changes and any change in the frequency of extreme events. It is likely to be such rate and extreme event changes that dictate the speed at which governments may have to take action. The result of a focus on the rates of change has profound implications for the nature of the observing systems that are established to assess and monitor the Earth system. It means that systems must be operated over periods of decades rather than weeks, months or even years. Such observing systems, while they can be built upon research initiatives, must evolve into operational undertakings with solid commitments to manage a range of important issues which include instrument inter-comparison; site documentation; quality control and the long term archiving of data; and avoidance of the loss of essential data sets due to changes in personnel and programs.

The terrestrial observing system required to respond to these needs is in its infancy, much of it clearly lacking the maturity of the atmospheric system that has been in place for nearly a century or even the ocean system that has been in development for some time. At this time it is fair to say that there is almost no operational terrestrial observing system. There exist various components, mainly of research nature, that could evolve into the nucleus of an operational terrestrial observing system. Such evolution will require a sustained commitment by governments and both regional and international agencies to undertake new research initiatives and to ensure that critical observing sites and systems are maintained well into the foreseeable future.

Given the need to observe a large number of variables in a consistent manner at local, regional and global scales, it will be necessary to use satellite observation techniques to the maximum extent possible. At the same time there will be an on-going requirement for in situ observations for the validation and inter-comparison of satellite sensors in key locations around the globe. This commitment to the use of satellites in an operational observing system implies a significant investment on the part of the space agencies to provide a continuous program of specific sensor observations into the foreseeable future. At the same time the research community must identify as a matter of priority a limited set of indicators that can report on the health and viability of the terrestrial ecosystems.

At this time it is suggested that specific attention be paid to the following components of an initial terrestrial observing systems.

2. Land Use and Land Cover Change

Changes in land use and land cover strongly influence the climate system. Human activities now dominate many aspect and processes of ecosystems world-wide (Vitousek et al., 1997). This domination has lead to an increase in trace-gas emissions from land use to the atmosphere, to a globally decreased carbon content in terrestrial vegetation and soils, and to altered land-surface characteristics. These changes have already led to local, regional and global changes in climate. Both natural forests and wetlands have ver the last century been converted world-wide to agricultural land, managed plantations and pastures. The decrease in forest and wetland extent is, however, not the only change. Subtle modifications of the original land cover, such as the removal of selected timber species, habitat fragmentation, nutrients addition from air pollution, water drainage and land degradation, also have altered the original land cover characteristics considerably.

Adequate observation of land cover conversion and modification has been problematic up to now. Regional and national land-use statistics and satellite observations show different rates of change. These differences are partly due to the complexity of the different spatial and temporal scales involved and to the obvious reversibility of some of the changes. For example, converted land is often is abandoned after a few years of use it returns again to more natural conditions (Skole and Tucker, 1993). Monitoring of land-use and land-cover change therefore requires a continuous monitoring to be able to adequately quantify the relevant changes.

Budget for the land-cover observation:

Activity	*Estimated costs*
Repeating DISCOVER (cost depending on resolution):	US$ 5-15 million
Linkage to ground-based networks like fluxnet, LTER and statistical databases and processing towards an integrated land cover change product consistent between satellite observations and statistics	US$ 1-5 million.

3. Net Primary Productivity

This variable measures the growth rate of plants on which the functioning of both natural ecosystems and the human food and fiber producing systems depends. At a hemispheric scale it can be monitored through the seasonal variation in the atmospheric carbon dioxide concentration as provided by GAW observatories. It is central to the terrestrial ecosystem carbon sink which is known to account for about a fifth of the global net carbon flux. Regional location and quantification of this sink is technically possible and would require an intensification and long term commitment to the global flask sample network particularly in oceanic tropical and southern hemispheric locations. Precise, calibrated isotopic analysis requiring centralised facilities is essential. Finer scale monitoring and mapping of NPP relies on a combination of satellite-sensed absorption of photosynthetically active radiation by the vegetation cover (indices such as the Leaf Area Index or the Fraction of Photosynthetically Active Radiation) and simulation models which require soil, climate and land cover data for acceptable accuracy.

The emerging research network of land-based CO_2 flux towers is crucial for the validation of the satellite and model-based estimates. It needs to find support to continue in the longer term as a monitoring activity.

Budget for net primary productivity:

Activity	*Estimated costs*
GAW CO_2 stations (30)	TBD (?US$ 3 million)
Flask network (100)	TBD (?US$ 3 million)
Satellite NPP (1km LAI and NPP ~weekly) (this is just operation not satellite replacement)	TBD (?US$20 million)
Fluxnet (100) (amortizing equipment over 5 year period)	TBD (?US$10 million)

4. Fires

Biomass burning is both a globally important source of aerosols and greenhouse gases and a sensitive indicator of the disturbances associated with the adaptation of vegetation to a changing climate. There is currently no integrated global observing system for fires although there are several research projects which have demonstrated the technical feasibility of doing so, using a variety of satellite based sensors. This variable has strong links to the land cover variable since fire is an important agent of land cover change and the emissions from fires depend on the cover type burned.

Budget for fires:

Activity	*Estimated costs*
Annual burned area fraction (global 1 km resolution) (not including satellite costs; relies on EOS and SAR availability).	US$10 million

5. Water Resources

There is no existing mechanism for the assembly of water resource information at the required spatial and temporal scales. For some observations (e.g., run-off data, GRDC) institutional mechanisms are in place, although there is a need to change the frequency and the form in which the data are provided. However, many nations have never or are no longer able to supply GRDC with the required data because they lack the required financial resources and trained man-power. For other observations, e.g. changes (particularly declines) in water tables, there is no global mechanism and limited national capabilities. Part of the gap is being addressed through (WHYCOS), but this initiative is largely focused on the Mediterranean and Africa and it needs to be extended to other regions. Some x? sites are required at approximately US$50,000/site. In addition in those areas where human development is heavily dependent on ground water resources which are already under great pressure there is a need for monitoring wells that are measuring both quantitative and qualitative changes. Several hundred monitoring wells are required at the cost of some US$50,000/well and a new institutional mechanism for ensuring that the information meets local development and management needs and is shared with other communities at the regional scale.

6. Glaciers

Mountain glaciers account for only about one percent of global ice volume but they are much more sensitive indicators of decadal to century scale climate changes than the Greenland and Antarctic ice sheets. They are also of considerable economic importance (water resources, hydro-power, tourism) in many alpine countries.

Annual mass balance surveys are carried out for only about 50, mostly small, glaciers world-wide and the observations are not satisfactorily distributed to represent either the major climate zones or the estimated regional ice-melt contributions to global sea level rise. Glaciers account for about 15-20 percent of the ocean level rise in the 20th century. Currently, there is no inventory for over one-half of the world's glaciers and no global map of land ice areas. Many mass balance survey programs have been discontinued in Canada and the former Soviet Union territory, and in other regions (South America, the Himalayas) there have been few observations of any kind. In the case of Canada the extensive survey records, maps and air photographs assembled at NHRI, Saskatoon are essentially inaccessible and at risk of loss (Barry 1995; Ommaney, 1996).

Suggested Improvements

1. Rescue "at risk" data in Canada, the FSU (central Asia), and elsewhere and archive them in accessible formats/media. Estimated cost: US$75 thousand.

2. Resume discontinued mass balance surveys and initiate new programs at c. 20 well-chosen glaciers. Annual cost/glacier approx. US$10-20 thousand, according to location. The number of long-term continuing sites might be reduced when the representativeness of the sites is determined (e.g. after 5 years).

3. Link the field surveys (on-going and new sites) to the routine satellite monitoring program, Global Land Ice Monitoring from Space (GLIMS) proposed by Dr Hugh Kieffer, USGS, Flagstaff. The project will monitor areal extent, snow line at the end of the annual melt season, velocity field and terminus location using EOS-ASTER data. The field surveys will provide calibration and validation of the ASTER-based data. The GLIMS program is not funded at this time. It depends on partnerships with regional centres responsible for surveys of selected glaciers, retrieval of selected images from the EROS-DAAC and an indexing pointer system and product archived at the NSIDC-DAAC. An estimated annual cost for this 3 year pilot program is approximately US$250 thousand.

4. Accelerate the completion of the complete World Glacier Inventory using air photo and high resolution satellite imagery. The infrequency of Landsat coverage in cloudy regions has meant that images are not available for all areas. Estimated cost for imagery and related data purchases, processing and analysis and digital file preparation: c. US$600-700 thousand.

7. Permafrost

Perennially frozen ground underlies 25 percent of the Earth's land surface. It is widespread in northern North America, northern Eurasia, north-east China, the Tibetan Plateau and in high mountain regions. Thawing of frozen ground particularly where there is a high ice content, causes ground settlement or subsidence, creep on gentle slopes and landslides on steep slopes with severe damage to buildings, transportation routes, pipelines and other structures unless specialised engineering techniques are used (Melnikov et al 1993). Warming of the ground initially causes the summer "active layer" in the soil to become deeper. Thinning of ground ice (which can be 100s of meters deep in northern Canada, Alaska and Siberia) is a slow process but disappearance of thin patchy permafrost in mountainous regions such as the Alps and along the southern margins poses significant risks to structures and potentially in the sub-Arctic for release of methane. From the global climate change viewpoint, the potential accelerated release of greenhouse gases is the most important concern. Changes in the active layer thickness are also a sensitive indicator of the magnitude and rate of climate change, both globally and regionally.

Extensive amounts of data from thermal wells and other surveys are proprietary or in government geological of transportation agencies are the archives are inaccessible. Many oil and gas exploration company archives are also at risk due to economic circumstances.

Suggested Improvements

1) Seek partnerships with industry to ensure that data will be made available for GTOS/GCOS when its confidentiality is no longer essential.

2) Digitize extensive government agency records (US and Canadian Geological Survey) and archive them.
3) Estimated cost:

Estimated cost:	North America	US$250 thousand
	Russia	US$250 thousand

(The Russian data include surface to 3m temperatures and bore-hole data held at many institutions and the Council for Earth Cryology).

4) Augment the network of thermal wells inn areas where coverage (or data) are lacking.

8. References

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

Vitousek, P.M., Mooney, H.A., Lubchenko, J. and Melillo, J.M., 1997. Human domination of earth's ecosystems. Science, 277: 494-499.

Annex VI: Satellite Data Requirements Analysis

Part 1: Definitions of Applications

(Note: the assigned numbers are for use in the tables of specifications. They do not imply ranking or priorities)

1. Ecosystem productivity
2. Sustainable land use
3. Hydrological resources
4. GHG trend
5. Biodiversity and ecosystem health
6. Climate trend assessment
7. Hazard mitigation
8. Transport services
9. Coastal zone management
10. Climate modeling
11. Improved operational prediction
12. BGC cycling

Ecosystem Productivity and Sustainability (short title: Ecosystem Productivity)
Includes both terrestrial and marine ecosystems. For terrestrial ecosystems it covers: 1) the productivity of terrestrial ecosystems defined in terms of biomass increase over a time interval; and 2) sustainability, described as the ability of the ecosystems to maintain the functions and processes of growth, development, and renewal characteristic of that ecosystem type at the present time. Together, these measures reflect the ability of the ecosystem to remain viable over the long term.

Land use and sustainable development planning (short title: Sustainable land use).
Characterization of the present land use, its sustainabilty, and the potential for land development of the types of use that can be sustained over time.

Hydrological resources assessment (short title: Hydrological resources)
Use of G3OS data for the inventory and assessment of the terrestrial hydrological resources. Includes issues of water quantity and quality, seasonal and interannual variability or trend, natural (soil moisture, wetlands) and artificial (reservoirs) sources, and availability for various types of use. Both surface and ground water resources are included.

Greenhouse gas trend assessment (short title: GHG trend)
Evaluating and quantifying the role of terrestrial ecosystems in the cycle of GHGs and its change over time. The emphasis is on the natural sources and sinks of carbon dioxide, nitrogen oxides, and other gases which interact with (vegetation for carbon uptake or release, etc.); and on processes that are likely to change in response to human activities or to a changing climate.

Biodiversity and ecosystem health
Includes both terrestrial and marine ecosystems. For terrestrial ecosystems it refers to the diversity of the ecosystem at the gene, species and landscape levels (with emphasis on the last two), and to the status of the ecosystem in comparison with a similar fully-functioning, vigorous ecosystem.

Climate trend assessment
Evaluation of the change of climate through its effects on the terrestrial ecosystems. Uses the record of cryospheric, hydrologic, and biospheric processes or phenomena.

Part 2: Definitions of Variables

(Note: these definitions are intended for use with the database of satellite data requirements)

Albedo
Definition to be provided by AOPC

Biogeochemical transport from land to oceans
The transport of elements such as N, C, and P from land to oceans via the rivers or subsurface pathways along the shoreline.

Biomass-above ground
Organic material constituting the plant canopy above the soil.

Biomass-below ground
Organic material constituting plants below the soil surface, mostly in roots.

Peak leaf biomass of nitrogen-fixing plants
The highest leaf mass of nitrogen-fixing plants during the growing season.

Carbon dioxide flux (CO_2)
Definition to be provided by AOPC

Dissolved C, N, and P in water (rivers and lakes)
Concentration of carbon, nitrogen and phosphorus in the fresh water (lakes and rivers).

Dry deposition of nitrate and sulfate
The rate of deposition of nitrate and sulfate from the atmosphere into the terrestrial ecosystems.

Emissions of CO_2, NO_X and SO_X from combustion of fossil fuels
The emission of gases due to combustion of fossil fuels.

Evapotranspiration
The loss from the plants (transpiration) or soil/water surfaces to the atmosphere.

Fertilizer use
The amount of fertilizer used, mostly in agricultural production. Should be specified annually on a national or sub-national basis.

Fire area and impact
The area where the above ground biomass was fully or partly burned by an episodic fire event. Also indicates the intensity of the burn and the form of the carbon released.

Firn temperature
Temperature of the firn, usually measured in boreholes of ice sheets or glaciers etc.

Glaciers and ice caps
Change in the ice thickness, glacierized area, and length of glaciers or ice caps.

Glacier inventory
Identification and mapping the spatial extent of the present glaciers.

Glacier length
The length of a glacier from starting point to the terminus (melting line).

Glaciers mass balance
The difference in the mass of a glacier between the mass gained by snow accumulation and that lost by snow ablation.

Ground water storage fluxes.
The change in the volume of ground water over the observation period.

Ice sheet mass balance
The difference between the mass gained by snow accumulation and that lost by snow ablation and calving activity.

Ice sheet geometry.
The surface topography (3-D shape) of the ice sheet, both in the interior and at the margins.

Lake and river freeze-up/break-up
The timing (dates) of the annual freeze-up and break-up of ice in lakes and rivers.

Land cover
The composition of the land surface, described by assigning contiguous parcels of the terrestrial surface (including inland water) as belonging to various cover type categories (according to the classification scheme employed).

Land use
The economic or other human use of the land. It is often related to land cover but cannot be unambiguously derived from the knowledge of land cover alone.

Leaf area index
One half of the total projected green leaf area in the plant canopy per unit surface area (equivalent to one-sided leaf area for broad-leaf plants).

Light penetration
The extinction of light with depth within the water column of water bodies especially lakes.

Necromass
Dead plant biomass, mainly in plant litter at the soil surface or in standing plants (e.g., after forest fire).

Net ecosystem productivity
The total net annual uptake of carbon by the ecosystem, after all additions (photosynthetic assimilation) and losses (organic decay, plant respiration, grazing, and fires) have been accounted for.

Net primary productivity
The difference between the carbon uptake trough photosynthesis and release through plant respiration (both maintenance and growth respiration).

Peak leaf biomass of nitrogen fixing plants
The growing-season maximum leaf biomass of plants known to be associated with nitrogen-fixing organisms.

Permafrost active layer
The depth to the permafrost table.

Permafrost extent
The area of the permafrost detected within a defined depth increment.

Permafrost thermal state
The heat content of the permafrost and its structure with depth.

Plant tissue N and P content
The content of nitrogen and phosphorus in photosynthetic or structural tissues of plants.

Precipitation - accumulated (solid and liquid):
Definition to be provided by AOPC

Radiation - albedo
The ratio of the upwelling to the downwelling radiation at the surface.

Radiation-incoming short-wave
The amount of the incoming short-wave solar radiation at the surface.

Radiation - reflected short-wave
The amount of short-wave solar radiation reflected from the surface.

Radiation - fraction of photosynthetically active radiation (FPAR)
The proportion of the photosynthetically active solar radiation (400-700nm) which is absorbed by plant components containing chlorophyll.

Radiation - outgoing long-wave
The amount of long-wave radiation emitted by the earth's surface.

Relative humidity (atmospheric water content near the surface)
The concentration of water vapour in the air near surface.

Rooting depth (95%)
The depth of soil which encompasses most of the live roots.

Roughness - surface
The three-dimensional structure of the interface between the surface (top of plant canopy or bare soil) and the atmosphere.

Snow cover area
The area of the land surface covered by snow.

Snow water equivalent (SWE) satellite
The amount of water stored as snow on the land surface.

Soil available phosphorus
The fraction of soil phosphorus that is in a chemical form from which it can be extracted by plants.

Soil bulk density
The mass of soil per unit soil volume.

Soil action exchange capacity
A measure of the soil's chemical quality, specifically the ability to absorb and release ions.

Soil moisture
Water content in the soil within a specified depth, most often the plant root zone (1-2m).

Soil particle size distribution
The size distribution of the particles comprising the soil mineral matrix (often described in percent fractions of sand, silt and clay).

Soil pH
A measure of the concentration of hydrogen ions in the soil solution.

Soil surface state
A measure of the infiltration capacity of the soil for water at the surface. Can be expressed as infiltration rate or through surrogates such as the structure and roughness of the soil surface.

Soil temperature (subsurface)
Temperature at the specified depth(s) in the soil.

Stomatal conductance - maximum
The rate of exchange of the gases (H2O, CO2) between the interior of the leaf and the adjacent air outside the stomata leaf cells controlling the size of the opening).

Surface water flow - discharge
The amount of water flowing through a river channel cross-section per unit time.

Surface water storage fluxes
Change in the amount of water in surface reservoirs (lakes, artificial reservoirs, and wetlands). Requires simultaneous knowledge of area of the reservoir and the water level to determine the volume change.

Soil total carbon/nitrogen/phosphorus
The total amount of soil carbon/nitrogen/phosphorus.

Spectral vegetation greenness index
The ratio of reflectance from the plant canopy or its components in various spectral bands.

Temperature - air
Definition to be provided by AOPC

Topography
The characterization of the three-dimensional shape of the land surface.

Trace gas profile (CO2) - Lower troposphere
Definition to be provided by AOPC

Trace gas profile (HNO3) - Lower troposphere
Definition to be provided by AOPC

Trace gas profile (N2O) - Lower troposphere
Definition to be provided by AOPC

Volcanic sulphate aerosols
Definition to be provided by AOPC

Wind velocity
Definition to be provided by AOPC

Part 3. Specifications of Variables

TERRESTRIAL VARIABLES FOR CLIMATE-RELATED PURPOSES As modified at TOPC IV meeting, May 26-29, Corvallis, OR, USA See notes below table										
Type	**VARIABLE**	**OPTIMIZED**				**THRESHOLD**				**APPLICATION**
		Hor Res	**Cycle (d,m,y)**	**Timeliness (d,m,y)**	**Accuracy**	**Hor Res**	**Cycle (d,m,y)**	**Timeliness (d,m,y)**	**Accuracy**	
Target	Albedo satellite	1km	10d	30d	+ 2%	4km	30d	60d	+ 7%	6,10
Target	Carbon dioxide flux (CO2)	Tier 1,2 (100 sites globally)	Continuous	Continuous	+ 5%	TBD	TBD	TBD	TBD	1,4,6,10,12
Target	Radiation - outgoing long wave satellite	50km	20d	1m	+ 2%	100km	60d	3m	+ 10%	6,10
Target	Rainfall chemistry	Tier 1,2,3	Continuous	once per event	+ 5%	TBD	TBD	TBD	TBD	2,12
Target	Firn temperature (ice sheets, ice caps, glaciers)	10km	1m	5y	+ 0.1oC	100km	1y	10y	+ 0.5oC	6,10
Target	Glacier inventory	0.01km	30y	2y	TBD	0.1km	50y	5y	TBD	3,6,7,10
Target	Glaciers mass balance	50 sites globally	1y	3m	.01 m	30 sites	5y	6m	0.1m	2,3,6
Target	Ice sheet mass balance	5km	10 y	1y	3 x 103 kg y-1	10km	15y	2y	6 x 103 kg y-1	6,10
Target	Lake and river freeze-up and break-up (timing)	300 lakes globally	Daily, spring and fall	1m	+ 1 day	200 lakes globally	Daily, spring and fall	3m	+ 2 days	6,7
Target	Permafrost - active layer	150 sites	10d	1m	+ 0.01 m	60 sites	30d	6m	+ 0.1 m	1,2,4,5,6,7,8,12
Target	Permafrost -	150 sites	10d	1m	+ 0.05 C	60 sites	30d	6m	+ 0.1C	6,10,12

	thermal state									
Target	Permafrost extent	0.01km	10d	3m	TBD	1km	10y	1y	TBD	1,2,3,4,5,6,8,9,10,12
Target	Snow cover area	1km	1d	2d	+5%	5km	3d	3d	+ 10%	3,6,8,10,11
Target	Snow water equivalent (SWE) satellite	10km	1d	2d	+5%	25km	3d	3d	+20%	1,2,3,5,6,7,8,10
Target	Land cover	0.1km	1y	3m	50 classes	1 km	10y	1y	20	1,2,3,4,5,7,8,9,10,12
Target	Land use*	0.1km	1y	6m	>100 classes	1km	10y	1y	5 classes	1,2,3,4,5,6,7,8,9,12
Target	Net ecosystem productivity (NEP)*	1km	1d	annually	+10% for annual budget	1 km	1y	3y	+20%	1,4,5,6,12
Target	Net primary productivity (NPP) sattellite	0.1km	1d	10d	+10%	1km	10d	1y	+30%	1,2,3,4,5,6,9,12
Target	Canopy conductance - maximum	1km	10y	1y	+ 10%	1km	20y	2y	+20%	1,4,6,10,12
Target	Biogeochemical transport from land to oceans	10km	1d	10d	+ 10%	100km	1y	1y	+30%	1,2,4,5,9,12
Target	Biomass - total	0.1km	1y	3m	+5%	1km	10y	1y	+20%	1,2,4,5,6,12
Target	Dissolved C, N, and P in water (rivers and lakes)	10km	1d	river dependent	+ 5%	100km	1y	1y	+30%	1,2,5,9,12
Target	Dry deposition of NO3, SO4	1km	1m	7d	+10%	50km	1y	1y	+30%	1,2,5,12
Target	Emissions of CO2, NOx and SOx from combustion of fossil fuels	10km	1m	1y	+10%	country	4y	4y	+20%	4,6,12
Target	Fire area	0.1km	10d	1m	+10%	1km	1y	3m	+20%	1,2,4,5,6,12
Target	Fire intensity	0.1km	10d	1m	+20%	1km	1y	3m	+40%	1,2,4,5,6,7,12

Target	Methane flux (CH4), modelled	0.1km	1d	6m	+15%	10km	1y	1y	+30%	4,6,10,11,12
Target	Ground water storage fluxes	Tier 1,2,3,4	1y	Annually	1% of true depth	Tier 1,2,3,4	1y	Annually	+ 10%	2,3,6,9
Target	Soil moisture	Tier 1,2,3	1d	3d	+ 2%	Tier 1,2,3	5d	5d	+ 10%	1,2,3,4,5,6,7,8,9,10,11,12
Target	Surface water flow - discharge	Tier 1,2,3,4	0.01d	1d	+ 5%	Tier 1,2,3	30d	30d	+20%	1,2,3,5,6,7,8,9,10,11,12
Target	Surface water storage fluxes	50 largest lakes	10d	1m	+ 2%	30 largest lakes	90d	3m	+ 5%	2,3,6
Input	Albedo in situ	Tier 1,2,3	0.01d	7d	+ 3%	Tier 1,2,3	0.04d	1m	+5%	Albedo satellite
Input	Precipitation - accumulated (solid and liquid)	1km	0.04d	1d	<+0.1mm	10km	0.05d	1d	+0.1mm	NPP,3,6,7,8,10,12
Input	Radiation - fraction of photosynthetically active radiation (FPAR)	0.1km	10d	10d	+0.05	2km	30d	10d	+0.1	NPP,NEP,10
Input	Radiation - incoming short-wave satellite	50km	10d	10d	+ 2%	100km	40d	1m	+7%	NPP,3,5,6,10,12
Input	Radiation - outgoing long-wave in situ	Tier 1,2,3	0.01d	1d	+ 1%	Tier 1,2,3	10 miute mean	5d	+ 2%	NPP,10
Input	Relative humidity (atmospheric water content near the surface)	Tier 1,2,3 & weath.sta'ns	0.04d	1d	+ 1%	Tier 1,2,3 and weather stations	0.04d	3d	+ 2%	NPP,NEP,3,10,11
Input	Roughness - surface	1km	5y	3m	+5%	10km	10y	6m	+15%	Surface and ground storage fluxes
Input	Temperature - air	Tier 1,2,3 & weath.sta'ns	0.02d	1d	+ 0.2C	Tier 1,2,3 and weather	0.5d	2d	+ 0.5C	1,2,3,5,7,8,9,10,11,12

						stations				
Input	Volcanic sulphate aerosols	At source	continuous during event	1d	+10%	At source	5d during event	1m	+ 20%	ET,5,6,12
Input	Wind velocity	Tier 1,2,3	continuous	1d	+ 10%	Tier 1,2,3	hourly max and min	10d	+ 15%	NPP
Input	Glacier length	0.001km	5y	1y	+1m	0.01km	10y	1y	+10m	Glacier mass balance
Input	Ice sheet geometry	0.01km	5	1y	+ 10 m	0.05km	10y	2y	+100m	Ice sheet mass balance
Input	Snow depth	Tier 1,2,3 & weath.sta'ns	1d	1d	+2cm up to 20 cm, +10% > 20 cm	Tier 1,2,3 and weather stations	10d	5d	+3cm up to 20 cm, +15% > 20 cm	1,5,12
Input	Biomass - above ground	0.1km	1y	3m	+5%	1km	10y	1y	+ 20%	Biomass total,1,2,4,5,6,12
Input	Biomass - below ground	0.1km	1y	3m	+5%	1km	10y	1y	+ 20%	Biomass total,1,2,4,5,12
Input	Evapotranspiration	Tier 1, 2	0.5h	1m	+ 5%	Tier 1,2	1d	1y	+ 20%	Surface and ground storage fluxes,1,2,3,4,5,6
Input	Land cover	0.1km	1y	3m	50 classes	1km	10y	1y	20 classes	Land cover, 1,2,3,4,5,6,10,12
Input	Leaf area index (LAI)	0.1km	10d	10d	+ 0.2	1km	10d	1y	+ 1	1,2,3,4,5,6,10,12
Input	Methane flux (CH4), in situ	100 sites	1d	6m	+5%	30 sites	1y	1y	+15%	2,4,6,10,12
Input	Necromass	Tier 1,2,3	1y	1m	+5%	Tier 1,2,3	10y	1y	+ 20%	1,2,4,5,12
Input	Net ecosystem productivity (NEP) tower	150 sites	continuous	10d	+5%	80 sites	continuous	1m	+10%	1,2,4,5,6,10,12
Input	Net primary productivity (NPP) in situ biomass sampling	Tier 1,2,3	10d	3m	+10%	1km	1y	2m	+10%	1,2,4,5,6,10,12

Input	Peak leaf biomass of nitrogen-fixing plants	Tier 1,2,3	1y	3m	+5%	Tier 1,2,3	5y	1y	+15%	1,2,12
Input	Plant tissue nitrogen and phosphorus content	Tier 1,2,3	10d	3m	+5%	Tier 1,2,3	5y	1y	+15%	1,2,3,5,10,11,12
Input	Rooting depth - 95%	Tier 1,2,3,4	5y	1y	+5%	1km	10y	2y	+10%	1,2,3,5,10,11,12
Input	Soil available phosphorus	Tier 1,2,3,4	1y	6m	+ 5%	1km	10y	1y	+ 10%	1,2,5,12
Input	Soil bulk density	Tier 1,2,3,4	10y	2y	+ 5%	1km	20y	3y	+ 10%	1,2,3,4,5,12
Input	Soil cation exchange capacity	Tier 1,2,3,4	10y	2y	+ 5%	1km	20y	3y	+ 10%	2,5,12
Input	Soil particle size distribution	Tier 1,2,3,4	10y	2y	+ 5%	1km	20y	3y	+ 10%	1,2,4,5,12
Input	Soil pH	Tier 1,2,3,4	1y	6m	+ 5%	1km	10y	1y	+ 10%	2,5,12, Surface water fluxes & flow-discharge
Input	Soil temperature (subsurface)	Tier 1,2,3,weather stations	10d	1m	+ 5%	Tier 1,2,3,weather stations	1m	3m	+ 10%	1,2,3,4,5,12
Input	Soil total carbon	Tier 1,2,3,4	1y	2y	+ 5%	1km	10y	3y	+ 10%	1,2,4,5,6,12
Input	Soil total nitrogen	Tier 1,2,3,4	1y	2y	+ 5%	1km	10y	3y	+ 10%	1,2,4,5,12
Input	Soil total phosphorus	Tier 1,2,3,4	1y	2y	+ 5%	1km	10y	3y	+ 10%	1,2,5,12
Input	Spectral vegetation greenness index	0.1km	1d	1d	+ 1%	2km	1d	10d	+ 3%	1,3,6,7,9,12
Input	Vegetation structure	Tier 1,2,3	1y	6m	+ 5%	Tier 1,2,3	10y	1y	+ 10%	4,6,7,10,12
Input	Fertilizer use (N and P)	Sub-national	1y	1y	+5%	National	2y	1y	+10%	1,2,4,12
Input	Dry deposition of	200 sites	1d	1y	+10%	100 sites	1y	1y	+25%	1,2,3,4,5,6,10,12

	NO3, SO4 in situ*									
Input	Methane flux (CH4)	100 sites	1d	6m	+ 5%	30 sites	1y	1y	+15%	4,6,10,11,12
Input	Light penetration	Pristine lakes & estuaries	10d	1m	+ 5%	Pristine lakes & estuaries	1y	1y	+ 10%	5
Input	Soil surface state	Tier 1,2,3,4	1y	6m	+ 5%	Tier 1,2,3,4	10y	1y	+ 10%	1,5,12
Input	Topography	0.01km	10y	2y	+ 3%	1km	30y	5y	+ 10%	NPP,NEP,4,6,10,12
Ancillary	Aerosols (total column)??or transmissivity measurements?	1km	1d	10d	TBD	4km	2d	1m	TBD	Satellite data corrections
Ancillary	Aerosols In situ	Tier 1,2,3	continuous	1d	+5%	Tier 1,2,3	Hourly	5d	TBD	Satellite data corrections
Ancillary	Cloud cover	Tier 1,2	0.01d	1d	+10%	Tier 1,2	0.04d	5d	+ 15%	Radiation - incoming short-wave satellite
Ancillary	Cloud cover satellite	1km	0.02d	1d	+5%	10km	0.5d	10d	+10%	NEP,12
Ancillary	Radiation - incoming short-wave in situ	Tier 1,2,3	continuous	1d	+ 1%	Tier 1,2,3	0.01d	30d	+ 1%	Radiation - incoming short-wave satellite
Ancillary	Radiation - reflected short-wave in situ	Tier 1,2,3	continuous	1d	+ 1%	Tier 1,2,3	0.01d	30d	+ 1%	Radiation - reflected short-wave satellite
Ancillary	Snow surface state	10km	1d	2d	6classes	25km	3d	3d	2 classes	Surf.and ground storage fluxes & flow - discharge
Ancillary	Snow water equivalent (SWE) in situ	Tier 1,2,3,surface network	1d	2d	+ 5%	Tier 1,2,3,surface network	30d	3d	+ 15%	Snow water equivalent satellite
Ancillary	Vegetation hydric stress index	0.1km	0.04d	1d	+10%	4km	1d	2d	+ 20%	1,2,5,6,10,12
Ancillary	Decomposition rate	Tier 1,2,3	30d	30d	+10%	Tier 1,2,3	60d	30d	+ 15%	NEP,12
Ancillary	Fire type	0.25km	1y	1m	6classes	1km	3y	3m	2classes	Fire area and impact

Ancillary	Ozone (total column)	1km	1d	10d	TBD	8km	2d	1m	TBD	Satellite data corrections
Measured	Microwave backscatter	0.01km	1d	1d	+0.2dB	1km	2d	10d	+ 0.6dB	1,2,3,4,5,7,8,9,11,12
Measured	Radiation - outgoing long-wave satellite (multispectral)	0.01km	1d	1d	TBD	2km	2d	1m	TBD	1,2,3,4,5,6,7,8,9,10,11,12
Measured	Radiation - reflected short-wave satellite (multispectral)	0.01km	1d	1d	TBD	1km	2d	1m	TBD	1,2,3,4,5,6,7,8,9,10,11,12

Categories Target, Input, Ancillary, Measured: as defined by GOSSP at meeting in Paris, 1997
Categories (Optimized, Threshold) and Parameters (Horizontal Resolution, Cycle, Timeliness, Accuracy): as defined by GOSSP at meeting in Paris, 1997
Category Application: Driving aplication type, as defined at the GOSSP meeting in Paris, 1997 (refer to Appendix 5 of the report from TOPC IV meeting)

Annex VII: Scientific and Technological Support for the GT-Net by the U.S. LTER Network Office

Proposed Terms of Reference

Under the general direction of the GTOS Chairman, the U.S. Long-Term Ecological Research (LTER) Network Office (NET) will provide work toward the development and implementation of a global network of terrestrial monitoring sites (GT-Net). The focus of the work will be to implement a demonstration project for data exchange within GT-NET. The components described below will be integrated into ongoing International LTER research support activities at NET. These activities will be under the direction of the NET Associate Directors for Information Management, and Technological Development.

1. Develop an initial documentation and information centre for GT-NET at the ILTER Network Office in Albuquerque, New Mexico USA which will be made available via a web page developed with the Secretariat in Rome. This will serve as repository and dissemination point for data, policies on data management and dissemination, and documentation of methods from among the members of GT-Net.
2. Maintain a global database of metadata about the networks and sites participating in GT-NET based on the current MS Access version of the TEMS database. This work will be performed in consultation with groups in Corvallis Oregon (implementation of the current MS ACCESS version of TEMS) and Zurich, Switzerland (current Web/Oracle version of the database). Modifications made to the database will be made available on the Web via MS SQL Server interface and an ODBC data source. James Brunt, the NET Associate Director for Information Management will lead this effort to review the TEMS model, make necessary modifications to accommodate the demonstration project data, and implement the GT-NET database in MS SQL server and make the database accessible via a web interface.
3. Implement a demonstration project within GT-NET. This demonstration project will support the needs for global satellite data validation by the MODIS team of NASA, and provide global products from advanced satellite sensors useful to sites within GT-NET. Specifically, global products of land cover, snow cover, leaf area index (LAI), and net primary productivity (NPP) will be extracted from the NASA/MODIS product stream, and made available in a format useful for the participating sites. In exchange, similar validation data, or basic climatological information, as available from the participating sites, will be transferred to the NASA/MODIS team. This GT-NET demonstration project activity will be co-ordinated by John Vande Castle, NET Associate Director for Technology Development. He will be responsible to set up a system to reviewing existing data, collect data from GT-NET sites and transfer them to the NASA/MODIS team. A system will also be implemented to extract the data products from the NASA/MODIS team and provide it to participating sites within GT-NET
4. Provide computer support for the assembly and exchange of data to facilitate the work of the GT-Net, as agreed on by a case by case basis. NET Office computer servers and analytical software will be made available as needed to support these efforts. In the implementation of the GT-NET demonstration project, NET will evaluate the data requirements of the project and work with collaborating centres such as San Diego Super Computer Centre and NASA ORNL Distributed Active Archive Centre for future assembly, exchange and archive of data.
5. Develop a personnel database and managed email list server for GT-Net that can be maintained via web-based interface. Implementation of this system will be based on the models in use for the ILTER network and provide easy access for searching and updates.

6. Use accepted GTOS metadata policies, as set by GTOS for the release and exchange of data related to terrestrial measurements in consultation with network and site participants.
7. Develop a mechanism for documenting the various methods used for measuring or calculating terrestrial variables. Make the mechanism available for use by the members of GT-Net as well as other terrestrial monitoring networks and sites. Develop and maintain a library of methods that are used by sites and networks and provide a reference list of these methods on the web. For key variables, undertake efforts to harmonise measurement methodologies or other wise assure compatibility of data.

The preceding components represent the terms of reference for the U.S. LTER Network Office technical assistance to the developing Global Terrestrial Observing System Network. Development and Implementation will be done with existing NET staff under the direction of the Associate Director for Information Management, James W. Brunt, and the Associate Director for Technological Development, John Vande Castle. This effort will require additional time of these two individuals. These components will be integrated into ongoing NET activities spread throughout the year as part of the integration of GT-NET and ILTER activities and will be supported on NET computer equipment. Technological products such as the web site and database will be produced in standard format that can be easily transferred to other computer equipment in other GT-NET locations.

Annex VIII: Work Plan for 1998/99

A) WHERE SHOULD TOPC AGENDA BE IN 5 YEARS - GOALS:

1. Assist in the establishment of networks; ensure their longer-term viability including necessary ongoing support of GCOS/GTOS. Functional networks will be established for ecology, glaciers, permafrost, and hydrology.

2. Stimulate completion or near-completion of two demonstration projects, Net Primary Productivity NPP) and Global Observations of Forest Cover (GOFC).

3. Stimulate compilation of critical data sets for use in IPCC or for other important users.

4. Demonstrate continuing responsiveness to (changing) requirements, including those flowing from IGBP, IPCC, and convention secretariats, WCRP.

B) TOPC WORK PLAN FOR 1998/99

1. Networks establishment

1.1 Ecological network:
Task 1: Support GT-Net and GTOS Secretariat in establishing the network
Approach:
    Assist with climate-related issues
TOPC role: support
TOPC lead: Kibby

1.2 Glaciers network:
Task 2: Continue leading the implementation of the network, to be completed within a year
Approach:
    Complete documentation (strategy, guidelines, and letter of invitation)
    Formally invite countries/sites
    Receive response, initiate 'operation'
TOPC role: lead
TOPC lead: Haeberli (Barry)

Task 3: Identify gaps in existing coverage (tiers 3-5) and implement improvements where feasible
Approach:
        Prepare a strategy/plan for:
        tier 3 (Himalayas, Andes, and New Zealand)
        tier 4 (glacier length measurements)
        tier 5 (link with satellite-based measurements)
        Initiate implementation
TOPC role: lead
TOPC lead: Haeberli (Barry)

1.3 Permafrost network:

Task 4: Assist the IPA in setting up the network, using the same conceptual approach as for glaciers.

Approach:

- Prepare the strategy, guidelines and invitation
- Initiate implementation

TOPC role: co-lead with IPA

TOPC lead: Barry (Haeberli)

1.4 Hydrological network:

Task 5: Collaborate with other interested groups in setting up a hydrological network, ensuring that the needs of GTOS and GCOS are met

Approach:

- Investigate availability of existing GRDC runoff data sets, and make appropriate recommendations
- Approach FRIEND re general availability of the data sets for climate-related applications
- Working with GRDC, propose a global sampling scheme for runoff data, and make appropriate recommendations
- Work with WHYCOS to ensure the availability of WHYCOS data for climate-related applications
- Work with IAHS, IGBP and others to design and initiate pristine watershed sample for climate change detection
- Publicise TOPC/GCOS/GTOS observation requirements and activities

TOPC role: initiate

TOPC lead: Landwehr

2. Implementation activities

2.1 Demonstration projects

Task 6: Cooperate with GT-Net in implementing the NPP/NEP project

Approach:

- Provide technical and organizational leadership
- Develop detailed plan of action; organize participants meeting,....

TOPC role: technical lead

TOPC lead: Running

Task 7: Continue to promote GTOS and GCOS interests in the GOFC project

Approach:

- Ensure that TOPC provide effective direction to the GOFC
- Attend meetings; provide inputs, influence development

TOPC role: oversee development

TOPC lead: Cihlar

2.2 Databases

Task 8: Assist in the development of a metadata base for terrestrial climate-related networks and sites participating in the G3OSs

Approach:

- Develop concept
- Assist secretariats of initiated networks in implementation

TOPC role: support
TOPC lead: Norse

Task 9: Work with GOSIC to facilitate access to important existing and available data sets for priority variables:
Approach:
  Finalize description of selected data sets
  Assist GOSIC in implementation
TOPC role: support
TOPC lead: Leemans (biosphere), Barry (cryosphere), Koster (hydrosphere)

Task 10: Ensure TOPC satellite data requirements properly represented
Approach:
  Finalize documentation
  Present to WMO, GOSSP
TOPC role: lead
TOPC lead: Cihlar

Annex IX: Summary of Recommendations

Status of Networks

Recommendation 1: *Assess the availability of historic international stream discharge records to the TOPC user community.*

Recommendation 2*: In collaboration with GRDC investigate the feasibility of routinely providing, on behalf of GTOS, certain specific discharge observations at global or continental scales in the future.*

Recommendation 3: *Asses the availability of the Flow Regimes from International Experiments Data (FRIENDS) data sets to the G3OS community*.

Recommendation 4: *Assess linkages of GCOS and GTOS to the WHYCOS Network and the availability of WHYCOS data for climate purposes.*

Recommendation 5*: Develop or encourage the development of a hydrologic network of pristine discharge stations for climate purposes.*

Demonstration Projects

Recommendation 6: *TOPC recommends that the NPP project should be executed in accordance with the above plans. TOPC should maintain contacts with the projects as it progresses, and should use the lessons learned to refine plans for other observing networks and for the compilation of global data sets*

Recommendation 7: *The organisational structure of GOFC should be modified to include formal TOPC representation in GOFC planning and implementation. TOPC representative should represent the authoritative requirements of GCOS/GTOS climate-related applications, and should report to TOPC on GOFC developments.*

Recommendation 8: *GOFC should consider inclusion of continuous variable products, especially canopy cover, leaf area duration, and tree height. GOFC should also actively promote and facilitate further research to generate such products, where appropriate.*

Recommendation 9: *GOFC should ensure that the planned products meet the needs of the principal user groups. The principal user groups should be identified for the various planned products. Further, hardcopy as well as digital products should be planned.*

Terrestrial Ecosystems Monitoring Sites

Recommendation 10: *TEMS should remain as a metadata base of network and site descriptors, providing users with lists of major categories of variables and guiding them to the holders of the data.*

Recommendation 11: *Version 2.0 of TEMS should be developed. Initially, the networks and sites involved in GT-Net and the NPP demonstration project should be used to test revised formats and procedures. The glacier and permafrost networks should be included in this process as soon as the required financial and other resources become available. Version 2.0 should include the following revisions:*

- modified questionnaires and web-based page formats to ease data assembly and updating;
- searching capabilities should continue to be based on the present main categories, that is, country, network, ecoregion, latitude and longitude, and variables but with the following changes;
- improved precision for site location with coordinates being given in degrees, minutes and seconds;
- better site size and shape information by specifying them in terms of a rectangle or polygon, thereby accommodating sites of large, narrow or irregular size;
- replace the ecoregion classification (based on that of Bailey) by a more flexible one that can accept a range of alternatives;
- restrict the list of variables to the main categories i.e. a reduction from 530 to some 150;
- provide agreed definitions of the main variables;
- add a searchable map;
- add principal scientists to the list of contact points and delete funding agency contacts;
- maintain both PC and web based versions and consider the need for Spanish and French versions.

Recommendation 12: *TEMS should be managed by GTOS but GTSC should examine the case for TEMS evolving towards a G3OS system and make proposals to the Co-Sponsors.*

Recommendation 13: *GTSC should decide on priorities for the GTOS issues so there is sound mechanism for prioritizing future expansion of TEMS.*

Recommendation 14: *GTSC should consider a structured approach to determining geographical and thematic requirements for critical observations that are needed for the GTOS issues such as biodiversity and desertification. Once this is done TEMS can be used to determine where there are gaps in critical observations.*

Gaps Analysis

Recommendation 15*: Future gap analyses should be undertaken with respect to only the networks/sites that have agreed to be part of the global terrestrial observing networks.*

TOPC Data Sets

Recommendation 16: *GOSIC should establish direct links to the data sets identified in Annex VI, and should include, in an appropriate form, the information from Annex III associated with each data set.*

Recommendation 17: *TOPC members should help identify data sets and develop the associated information, based on their scientific expertise and familiarity with these data sets.*

Recommendation 18: *In searches such as undertaken here, an attempt should be made to involve the best experts regarding each variable and associated data sets.*

Recommendation 19: *If feasible, G3OSs should consider the development of web-based tools for: a) effective searches that would identify new, improved existing, and deleted data sets; b) mechanisms for locating citations/studies employing certain data sets; and c) searches for groups of thematically or geographically related data sets.*

Recommendation 20: *JDIMP should define, and then widely publicise, a common set of metadata fields which should be provided with all data sets for G3OS-related applications. The metadata format should allow flexibility in the way the information is presented, i.e. it should be defined thematically rather than digitally.*

Recommendation 21: *GOSIC should include an appropriate disclaimer with the information contained in Annex III.*

Recommendation 22: *GOSIC should make a provision for feedback by the users of the information in Annex III.*

Satellite Data Requirements

Recommendation 23: *The information in Annex VI should be used to specify satellite data requirements for climate-related terrestrial applications and to revise the data base maintained by WMO/CEOS.*

Recommendation 24: *G3OS sponsors should clarify the extent to which health, economic and other terrestrial impact of climate change should be considered, and by whom.*

Recommendation 25: *While it is recognized that several Applications (presently not defined, Annex V.) are relevant mainly to other aspects of the G3OS program, all have some relevance to the terrestrial climate-related issues and TOPC should therefore be involved in their definition.*

Recommendation 26: *As part of further documentation TOPC should prepare flowcharts for key target variables.*

Implementation Plan and Future TOPC Activities

Recommendation 27: *TOPC should work with GEWEX to assist in the transition of research sites into long-term observing stations where feasible and appropriate.*

Recommendation 28: *It is recommended that GCOS and GTOS approach IGBP to become a formal cosponsor of TOPC.*

Recommendation 29: *TOPC should examine the requirements and issues regarding the detection of rates of change in terrestrial ecosystems and should make appropriate recommendations to GCOS and GTOS.*

Recommendation 30: *TOPC should actively communicate with the scientific community and the public regarding the issues in its area of responsibility and results of the work to date, using the above and other opportunities.*

Annex X: Project on Net Primary Productivity (NPP)

The anticipated implementation steps are:

- The U.S. LTER Network Office would initiate a request to potential sites/networks for latitude and longitude data (to the nearest second) for a minimum area of 3 km x 3 km that best represents the research site and local vegetation type. A more ideal area would be 10 km x 10 km and sites would be encouraged to develop this larger area of research in subsequent phases of this demonstration project. The site location co-ordinates would be used by the U.S. LTER Network Office to develop extraction software for the MODIS satellite imagery. Requests for co-ordinate data will be initiated August 1, 1998. These data will also be added to the TEMS database. Dr. John Vande Castle from the U.S. LTER Network Office will lead this effort;
- The U.S. LTER Network Office will request additional information on site descriptions, associated research projects, and site facilities. This information will be added to the TEMS database and archived as companion information to the satellite and validation data sets . James Brunt will lead this effort;
- The U.S. LTER Network Office will develop an automated extraction routine to be used for each site. The extracted imagery will be archived by the LTER Network Office and distributed or made available to sites by the most appropriate method (e.g., ftp, diskettes, hard copy). Imagery will be extracted every 8 days from the EROS DAAC for MODIS Land products. Implementation will begin at the AM-1 launch date plus 4 months. Dr. Vande Castle will lead this effort;
- Participating sites will receive AVHRR derived global 1 km land cover data that is the at-launch EOS standard for their defined area. Landsat Thematic Mapper (TM) or SPOT imagery will be provided to complement AVHRR data for high resolution land cover validation for sites that do not have this imagery. The U.S. LTER Network Office will be responsible for providing this imagery by the most appropriate procedures after sites provide site co-ordinates and associated site information. Dr. Vande Castle will lead this effort;
- Participating sites will be requested to validate the land cover map for their study region during the summer of 1999. The methods and classification logic used for the land cover maps can be located on the web site at the EOS Distributed Active Archive Centre (DAAC) of the EROS Data Centre that accompanies these data sets. The U.S. LTER Network Office will provide this information for sites that cannot access this information. Validation data will be sent to the U.S. LTER Network Office by October 1, 1999 or made accessible on a site/network server for retrieval by the U.S. LTER Network Office. Dr. Vande Castle will lead this effort;
- Participating sites will be required to validate LAI imagery with a sampling design and methodology appropriate to their site (i.e., relative to vegetation type and site heterogeneity). These sampling protocols will be developed by a small group of experts in geostatistical sampling and LAI measurements at a workshop in the winter of 1998-99. The frequency of LAI sampling will be determined by seasonal dynamics of the vegetation type. Sampling protocols will be made available through web sites or mailings as appropriate. Training in methodology and sampling protocols will be ascertained on a case by case basis. LAI sampling and validation will commence after the AM-1 launch plus 4 months. Dr. Gosz and Dr. Running will lead the workshop effort on sampling and methodology protocols. John Vande Castle will lead the acquisition of the LAI validation data that will be archived in the U.S. LTER Network Office as companion data sets to the LAI imagery;
- The MODIS Land Team will access site validation data sets from the U.S. LTER Network Office archive to provide the direct validation of the imagery.

Annex XI: Abbreviations and Acronyms

AMAP	Arctic Monitoring and Assessment Programme
AOPC	Atmospheric Observation Panel for Climate
ASTER	Advanced Spaceborne Thermal Emission and reflection Radiometer
AVHRR	Advanced Very High Resolution Radiometer
BAHC	Biological Aspects of the Hydrological Cycle
CALM	Circumpolar Active Layer Monitoring network
CAPS	Circumpolar Active-Layer Permafrost System
CCRS	Canada Centre for Remote Sensing
CEOS	Committee on Earth Observation Satellites
CLIVAR	Climate Variability and Predictability (WCRP)
EOS	Earth Observing System
EUMETSAT	European Organization for Meteorological Satellites
FAO	Food and Agricultural Organization
FCCC	Framework Convention on Climate Change
FDDA	Four Dimensional Data Assimilation
FRIEND	Flow Regimes from International Experiments and Network Data
G3OS	Three Global Observing Systems
GCM	General Circulation Model
GCOS	Global Climate Observing System
GEMS	Global Environment Monitoring System
GEWEX	Global Energy and Water Cycle Experiment
GHG	Greenhouse Gases
GHOST	Global Hierarchical Observing Strategy
GLIMS	Global Land Ice Monitoring form Space
GOFC	Global Observation of Forest Cover
GOOS	Global Ocean Observing System
GOSIC	Global Observing Systems Information Center
GOSSP	GCOS/GOOS/GTOS Global Observing Systems Space Panel
GPCC	Global Precipitation Climatology Centre
GRDC	Global Runoff Data Centre
GSN	Global Surface Network
GSWP	Global Soil Wetness Project
GT-Net	GTOS System of Networks
GTOS	Global Terrestrial Observing System
GTSC	GTOS Steering Committee
GUAN	Global Upper Air Network
HDP	Human Dimensions of Global Environmental Change Programme
IAHS	International Association for Hydrological Sciences
IBFRA	International Boreal Forest Research Association
ICSU	International Council for Science
IGBP	International Geosphere-Biosphere Programme
IGOS	Integrated Global Observing Strategy
IHP	International Hydrology Programme
ILTER	International Long-Term Ecological Research
IOC	Intergovernmental Oceanographic Commission
IOS	Initial Observing System
IPA	International Permafrost Association

IPA	International Permafrost Association
IPCC	Intergovernmental Panel for Climate Change
ISLSCP	International Satellite Land Surface Climatology Project
IUGG	International Union of Geodesy and Geophysics
JDIMP	GCOS/GOOS/GTOS Joint Data and Information Management Panel
JSTC	Joint Scientifical and Technical Committee for GCOS
LAI	Leaf Area Index
LTER	Long Term Ecological Research
MODIS	Moderate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration, USA
NASDA	National Space Development Agency, Japan
NCDC	National Climatic Data Centre
NPP	Net Primary Productivity
NWP	Numerical Weather Prediction
OOPC	Ocean Observation Panel for Climate
PACE	Permafrost and Climate in Europe
SBSTA	Subsidiary Body on Scientific and Technical Advice
SIT	Strategic Implementation Team
TEMS	Terrestrial Ecosystem Monitoring Sites meta-database
TOPC	GCOS/GTOS Terrestrial Observation Panel for Climate
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational Scientific and Cultural Organization
WCMC	World Conservation Monitoring Centre
WCRP	World Climate Research Programme
WGMS	World Glacier Monitoring Service
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization

Annex XII: References

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