Global Terrestrial Observing System

# Report of the

# Global Observing Systems

# Space Panel

## Third Session
## (Paris, France, May 27-30, 1997)

## August 1997

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# Report of the Global Observing Systems Space Panel

## I. Organization of the Joint Session

*i. Opening of the Joint Session*

The Global Observing Systems Space Panel (GOSSP) and the World Meteorological Organization (WMO) Commission for Basic Systems (CBS) Working Group on Satellites (WGSAT) held a joint meeting in Paris, France, 27 - 30 May 1997. The objectives of the joint session were to realise a mutual approach of problems and to obtain coordinated solutions. After the opening joint session, the two groups met separately to deal with their particular agenda. One major aim of the GOSSP meeting was to discover overlap or conflicting data requirements from climate related space-based observations to create a coherent set of data requirements. It was expected that the G3OS, i.e., Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS) and Global Terrestrial Observing System (GTOS) on behalf of the G3OS, will define and clarify their input to the database and discuss a suggested review methodology.

The Chairman of the GOSSP, Mr John Morgan and of WGSAT, Dr John Eyre, opened the third session of the GOSSP and the third session of WGSAT, on Tuesday, May 27th, 1997. The joint meeting was held at the United Nations Educational, Scientific and Cultural Organization (UNESCO) building, in Paris, France. The Chairmen thanked the local organiser, the Intergovernmental Oceanographic Commission (IOC) of UNESCO, for hospitality and secretarial support.

The meeting was introduced with welcoming remarks by Mrs Marton-Lefèvre, Executive Director of the International Council of Scientific Unions (ICSU). She expressed her highest regards for all the efforts being made on inter-organisational work level, noting that the GOSSP is a good demonstration of cross-cutting work in connecting three global observing systems G3OS.

Dr Kullenberg, Executive Secretary of the IOC of UNESCO, welcomed all GOSSP and WGSAT participants. He expressed his appreciation of the link between the international space community and IOC and stressed the importance of panels like GOSSP.

*ii. Adoption of the Agenda*

The Chairmen reviewed briefly the agenda items which were accepted by the participants (Annex I). The agenda adopted by GOSSP is in Annex II.

*iii. Working Arrangements of the Session*

It was agreed that the meeting would be in plenary session to inform both GOSSP and WGSAT participants on the relevant issues. Specific items would be done in separate sessions or in *ad hoc* groups as needed.

iv. Election of the Joint Session Chairman

The plenary elected Mr John Morgan as Chairman of the joint session. He invited all participants to introduce themselves.

## II. Chairmen's Report

*i. Chairman WGSAT*

The Chairman of WGSAT, Dr John Eyre, presented the goals of WGSAT, which were to improve the quality of the user requirements and the space system capability databases. The requirements should be sufficient to obtain credible results from subsequent stages of the "rolling review of requirements" process, as decided at the second session of WGSAT, in April 1997, in Geneva, Switzerland. The "rolling review" and up-date process will be used by the group of expert users and space agencies. WGSAT plans to set up a "critical review" process and to come to an agreement on the details of the application of the method. The last part of the review process should be the preparation of a statement of guidance on feasibility of meeting user requirements which will be provided to space agencies.

*ii. Chairman GOSSP*

The Chairman of GOSSP, Mr Morgan, gave a review of GOSSP activities since its last meeting in October 1996, in Geneva, Switzerland. A progress report and modified terms of reference (Annex III) were presented at the sixth Joint Scientific and Technical Committee (JSTC) meeting at the end of October 1996, the GTOS Steering Committee (SC) in December 1996 and the Joint Scientific and Technical Committee for GOOS (J-GOOS)[1] in April 1997, and received general support. It was suggested that the science panels of G3OS should evaluate the validity of a proposed method intended to compare user requirements with satellite capability before general acceptance of the technique. A first draft of sections of a revised Space Plan, prepared for the meeting, led the Chairman to stress the importance of the complete revision of the first version of the Space Plan and the assignment of follow-up actions. For this process, it will be crucial to address a variety organisational issues.

The Chairman pointed out that the joint session between WGSAT and GOSSP should help to provide coherency in data requirements, to remove overlap and avoid conflicting requirements. Satellite data requirements and satellite systems resources are now being analysed by three groups. The Committee on Earth Observation Satellites (CEOS) established a Strategy Implementation Team (SIT) and an Analysis Group (AG), to evaluate the concept of an Integrated Global Observing Strategy (IGOS). The AG will analyse requirements and capabilities for six prototype projects (ozone monitoring, ocean biology, ocean data assimilation, forest cover, upper-air measurements, disaster monitoring) (see Annex VI). AG meetings and a workshop are being held in 1997. The analyses methodology would be similar to that presented to the

[1] J-GOOS is now the GOOS Steering Committee (GSC).

second session of GOSSP. The Chairman urged all three groups to use the same database as input for their analyses. GOSSP and WGSAT are using the WMO stand-alone database, whereas CEOS uses the on-line database established at the European Space Research Institute (ESRIN). Action to reconciliate both databases have begun.

The Chairman noted that the specific GOSSP objectives for the meeting were to review the progress on GOSSP requirements, develop a set of recommendations and assign follow-up actions. G3OS requirements need to be updated to the extent possible and, bearing in mind the CEOS initiatives, the methods of analysis should be discussed. The panel should agree on the degree of support needed for the CEOS AG and to consider possible G3OS application areas or "themes" for which detailed analysis should be made.

## III. Update on Global Observing Systems and WGSAT Activities

*i. Global Climate Observing System (GCOS)*

The Director of the GCOS Joint Planning Office (JPO), Dr Spence, gave an overview of GCOS and its relation to the G3OS. To meet GCOS objectives, the GCOS plans to take a comprehensive view of the observational requirements for climate information, and address the required observations from the atmosphere, ocean, land surface, and cryosphere. GCOS includes surface-based and space-based observations, and a comprehensive data strategy.

The GCOS is planned as a phased programme, building upon the present observational activities of the operational and research programmes of the participating countries. For the atmosphere, a close coordination with ongoing WMO programmes has begun, including the World Weather Watch, the Global Atmosphere Watch, and operational hydrology programmes. Recommendations are being made for enhancements and new observations which should be done, in concert with existing programmes, to ensure the climate needs are met. In a similar fashion for the ocean, the GCOS programme is co-operating with the IOC in its efforts to establish a Global Ocean Observing System (GOOS). For Terrestrial Systems a joint work with the Global Terrestrial Observing System (GTOS) is underway.

The detailed scientific plans for GCOS have considered the full scope of issues, including the requirements of users, the contributions of existing research and operational programmes and data systems, and the participation of both international and national organisations. With the completion of its plans and documents in 1995, GCOS entered a new phase in 1996, that of implementation. The initial implementation of GCOS has stressed observations to improve seasonal to interannual predictions of climate. It is expected that as GCOS continues to be implemented, countries will see benefits not only from improved seasonal to interannual climate predictions but in planning for sustainable development and in assessing the impacts of climate change on both agricultural and natural ecosystems.

Development of overall strategies for observations of the Earth system have received considerable attention over the last two years. Most attention has been paid to space-based observations, but of comparable importance is the wide variety of *in situ* observations made at the surface of the Earth and in its atmosphere and oceans. The GCOS Upper-Air Network (GUAN), as an example of an existing Global Observing System, was successfully implemented in 1996.

*ii. Global Ocean Observing System (GOOS)*

The Director of the GOOS Support Office, Dr Summerhayes, reported on GOOS and gave an overview of its activities. GOOS is a system based on long-term monitoring for providing detailed nowcasts and forecasts of ocean conditions for the benefit of coastal states and marine users. It is based on the notion that improvements of just 1-2% in the efficiency of marine and coastal operations, which could be achieved through more detailed marine observations, at a cost of up to US$ 1 billion would lead to annual savings of US$ 8-10 billion, for a benefit to cost ration of 10:1 globally. This excludes the benefits to agriculture, and the energy and water supply industries from improved weather and climate forecasts based on imposed marine data.

GOOS is being implemented in 5 phases: (1) planning, (2) pilot projects, (3) integration with pre-existing systems, (4) full system implementation and (5) performance monitoring and improvement. Planning culminates this year. GOOS is preparing for a "Heads of Agencies" meeting in summer 1998 to gain commitments to GOOS by the nations which will implement it. GOOS centrally, through the GOOS Project Office and GOOS Steering Committee, will guide design, set standards, coordinate and oversee implementation, providing some essential services like a Data and Information Management Service for the benefit of developing states. Planning initially focused on four customer groups: coastal, climate, living marine resources, and health of the ocean. All have some requirement for space-based data.

A data and information management policy is being developed for GOOS with GCOS and GTOS through the Joint Data and Information Management Panel (JDIMP). The Director stated that GOOS is not just about the delivery of data, although that is all that some users may need. GOOS is based on the production line or end to end concept in which data flow and products are integrated. It involves the collection of data to provide services and products that nations really need. For that reason GOOS is looking at the provision of products and services, current and future, and asking the question: how does the service infrastructure have to be improved to achieve GOOS ?

The Director noted that GOOS needs a Space Plan, hence the involvement in GOSSP. GOOS is also interested in working with CEOS in the development of an Integrated Global Observing Strategy (IGOS). In this context GOOS is promoting, through the GCOS/GOOS/World Climate Research Programme (WCRP) Ocean Observation Panel for Climate (OOPC), a Global Ocean Data Assimilation Experiment (GODAE) to learn how to assimilate masses of satellite data and other *in situ* data into advanced numerical models. GODAE is also one of CEOS's pilot projects. GOOS will promote the development of advanced global ocean models through the GOOS Core System.

GOOS is already being implemented through national and regional efforts in pilot projects that are practical demonstrations of how GOOS could or should work. It is hoped that success breeds success and that, seeing working projects, other nations will want to join. In the North East Asian Region, NEAR-GOOS is involved in a project of data exchange between Russia, Japan, Korea, and China. In Europe, 22 operational agencies from 14 countries have banded together to form the EuroGOOS Association through which six pilot projects are being developed for launch in the near future: Baltic, Arctic, Mediterranean, Black Sea, North West Shelf and Atlantic. In the Tropical Pacific the Tropical Atmosphere-Ocean (TAO) array of moorings for El-NiZo-Southern Oscillation (ENSO) prediction, led by the USA, is a climate component of GOOS. So too is the Pilot Research Array in the Tropical Atlantic (PIRATA), led by Brazil. In the USA five coastal GOOS Pilot Projects are being developed. Thus by early 1998 there should be 15 or 16 active GOOS Pilot projects, including GODAE. These projects will be linked by the previously existing bits of a global observing system provided by the IOC's International Ocean Data Exchange (IODE) network of data centres, and the IOC-World Meteorological Organization (WMO) Integrated Global Ocean Services System programme (IGOSS) of collecting expendable bathythermograph (XBT) and other data, and the Voluntary Observing Ship (VOS) programme.

One of GOOS prime functions is to involve developing states in GOOS to gain a complete global network. The development of a GOOS Space Plan linked to a GOOS Data and Information Management Plan is crucial to help developing nations participate in and benefit from GOOS. One of the key tasks through the Data and Information Management Service is to help developing states see what data is available to them, and how to use it to develop products of value to decisions makers. GOOS hopes to persuade a consortium of developed world states and space agencies to fund this service. Training courses may well be a key part in this service.

Mr Withrow supplemented this overview of GOOS activities in the past and emphasised the value of updating requirements for space observations.

*iii. Global Terrestrial Observing System (GTOS)*

The member of the Steering Committee (SC) for GTOS, Mr Bassolé, reported on GTOS activities. Since its first meeting held in Rome (FAO) in December 1996, the Steering Committee has been working, together with the Secretariat, at setting up the framework for an efficient evolution of the GTOS towards its goal. The SC meeting established working groups to cover several issues of interest to the GTOS. The SC also decided to have SC members representing the GTOS on joint panels involving the other global observing systems, namely GOOS, the Joint Data and Information Management Panel (JDIMP), GOSSP and the Terrestrial Observation Panel for Climate (TOPC). On a voluntary basis, members of the SC joined the various working groups, whose leaders were given the responsibility to prepare draft terms of reference to be discussed in order to serve as guidelines for defining the objectives and activities assigned to each working group. This task has been carried out since the SC meeting.

Another topic of importance is the development of a GTOS implementation plan. A draft of such a plan, proposed by the working group on implementation, was presented and discussed recently during a coordination meeting that took place in Rome, in May 1997. A new version of the implementation plan that came out of this meeting is expected to be distributed soon to all the SC members for comments .

Variables for climate have been defined on global and regional scales and corresponding measurements have been identified. Work still has to be done to identify requirements for water resources, pollution and toxicity, loss of biodiversity and land degradation. Of great importance are *in-situ* measurements. The Global Hierarchical Observing Strategy (GHOST) concept will be discussed at a meeting on *in-situ* network representatives in June 1997.

Since the last meeting, SC members have been reporting to the Secretariat of the GTOS the existence of potential sites or networks in their respective geographical area, whose data might be relevant for the objectives of the GTOS. This will serve as the basis for the core data source of the GTOS.

The Director of the GCOS JPO informed the panel, that GTOS was represented on GOSSP by Mr Bassolé, Dr Cihlar, Chairman of the TOPC, and Dr Janetos, who was not able to attend this meeting.

*iv. Review of WGSAT Actions*

The Chairman of WGSAT, Dr Eyre, gave an overview of activities since WGSAT-II. At that meeting the relational database on user requirements and instrument performances developed by the WMO secretariat was endorsed. It was recommended to have a regular review and update ("rolling review") of the database. At the CEOS Task Force on long-term Planning and Analysis meeting in September 1996, the group established an Internet on-line database at ESRIN which recorded user and space agencies requirements. The CEOS Plenary, held in November 1996, decided on a database reconciliation meeting to resolve differences between the on-line and stand-alone databases. This reconciliation meeting was held in January 1997[2]. The CEOS Members and users reviewed the list of parameters, which led to an up-date of the database in February 1997. The database manual will serve as the reference for stating requirements and satellite system information until the beginning of 1998. Since March 1997 a mechanism for the on-line and stand-alone database to achieve a common data set has been available. An action still to be completed is to find an effective control mechanism to update and review the common databases.

## IV. Initiative for an Integrated Global Observing Strategy (IGOS)

*i. Rationale of an IGOS*

Dr Schiffer gave a presentation on the status of planning of an IGOS. The rationale for IGOS is to provide an overall framework for users to present their requirements and for providers to address their commitments. A more effective use of Earth observations assets requires closer coordination of observing and analysis programmes. Data providers need a strategy to avoid redundancy, to fill data gaps, to integrate data from various sources and to coordinate operational and research systems.

Dr Schiffer stressed that, despite the expressed broad interest by the international community, the current situation is that measurements still do not meet the requirements of major international research and operational programmes, e.g., WCRP

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[2] "CEOS Database Reconciliation Meeting Report", WMO Headquarters, Geneva, 23-24 January 1997, (available through the GCOS Joint Planning Office).

or the International Geosphere-Biosphere Programme (IGBP). IGOS will be dependent on international coordination among participating agencies, based on a mutually agreed framework for definition, planning and conduct of observations. There is a need for a commitment to full and open data exchange.

IGOS has to integrate three different global observing systems as part of its strategy: (1) the operational observing systems, e.g, the World Weather Watch (WWW), (2) systems for coordinated Earth observations, and (3) research observing systems. Dr Schiffer outlined the implementation steps of an IGOS and discussed the benefits from enhanced global observations. He stressed, that the function of IGOS is dependent on an integrated framework for space-based and *in-situ* observations and on voluntary participation of countries and agencies. One of the prime IGOS objectives is to acquire high level political support. Within this framework, above all, requirements from multiple user communities have to be integrated and prioritised. One of the major challenges for an IGOS will be the achievement of a balance between research and operations, as well as between space and *in-situ* measurements.

ii. IGOS as a New Strategy

Dr Schiffer outlined the six prototype projects (Annex VI) which have been agreed on at the IGOS SIT meeting in February 1997 mentioned earlier in the GOSSP chairman's report.

In the following discussion the panel participants concluded: (1) politicians need to be convinced that IGOS is of economic and social benefit, and (2) a vital part of IGOS are the data systems, which have to be build up and supported. For clarification Dr Schiffer stated that the integration of all observing systems is a part of the "strategy" and not a new "system".

## V. Consideration of the Space Plan Draft

*i. GOSSP Session*

In the separate GOSSP session, the participants agreed that Version 1.0 of the GCOS Space Plan needs a thorough revision. The ownership and validation of the plan needs to be clarified. There should be a clear commitment and a broader responsibility coming from the G3OS to support the panel.

The participants agreed on a new Space Plan structure in two parts. The first part would contain general items which do not need a continuous review (Annex IV). This permanent part would include the overall strategy, objectives, background and purposes of the Space Plan. The second part would contain all items which need a constant review and up-dating. It could be in a loose-leave format which can be regularly electronically up-dated. It will be crucial to track the heritage of any modifications.

*ii. Intersessional Task Groups*

The participants decided to set-up intersessional Task Groups for their work (Annex V). The leading role in preparing the new version of the Space Plan is with Task Group I. The chapter on user data and product requirements will be under the guidance of Task Group II. The chapter on the Initial Operational System will belong to Task Group III, and the chapter on developing countries will be provided by Task Group IV. In the discussion on individual chapters the clear need to keep a separate chapter on developing countries was agreed.

The participants agreed to try to complete a draft version for the JSTC meeting in September 1997, and should be an input for the CEOS plenary meeting in November 1997. The final draft of the plan should be circulated to G3OS chairs in February 1998.

## VI. Review and Update of Current Requirements and Instrument Performances

*i. Space Agencies - Status and Future Plans*

Representatives of space agencies reported to the full assembly on future plans and status of the space programmes.

In late 1996 NASA / Mission To Planet Earth (MTPE) undertook the first of a planned series of biennial reviews to assess its end-to-end observations/research/data management programme to provide confidence that its planning and programme implementation reflect the highest priority science needs of the US Global Change Research Programme, and are conducted in a cost-effective manner. The review, to be completed in summer 1997 in time to affect the financial year 1999 budget planning, covers all elements of the MTPE programme, including the Earth Observing System (EOS), EOS Data Information System (EOSDIS), mission operations and data analysis, research and analysis, the Pathfinder and small satellite (Earth Probes and Earth Systems Science Pathfinders) elements. Particular attention is being directed at:

- new paradigms for EOSDIS, possibly involving a form of federation of data centres and principal investigator responsibilities for value-added product generation;
- new approaches to mission/payload selection beyond the missions AM-1, PM-1 and CHEM-1;
- incorporation of an instrument “incubator” programme for developing new technology;
- re-examination of the CHEM-1 mission and its relationships within the entire MTPE atmospheric chemistry discipline;
- the overall programme balance among observations, data and scientific research.

The biennial review is expected to result in a more efficient programme that has the flexibility to respond to changing scientific issues as they emerge, to incorporate new technology as is becomes available, and to reduce the elapsed time from mission approval to launch. At present no decision affecting the EOS-24 measurements commitment has been made, although it is clear that successive instruments may evolve with new technology, as opposed to previous plans to successively launch three series of identical instruments, e.g., Moderate-Resolution Imaging Spectroradiometer (MODIS).

The European Research Satellite (ERS-1) was terminated at the end of June 1996, but ERS-2 will continue to operate towards the end of the century. The Environmental satellite (ENVISAT) will be launched in the second half of 1999. The Meteorological Operational Weather Satellite (METOP-1) will be launched by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) in 2002, as the first of a series of three satellites to be launched over 15 years. The Earth Explorer missions comprise magnetometry, gravity and ocean circulation, land surface processes and interaction, Earth radiation, atmospheric dynamics, atmospheric chemistry and profiling, precipitation and topography. The Earth Explorer missions for gravity and ocean circulation, land surface processes and interaction, Earth radiation and atmospheric dynamics, have been selected for “Phase A” in the context of GCOS missions. The first Earth Explorer Mission, with the emphasis on advancing the understanding of different Earth system processes, will be launched in 2004. The Earth Watch missions will cover coastal zone, polar ice, open ocean, land surface and atmospheric chemistry. The first Earth Watch Mission, addresses the requirements of specific Earth observation application areas, will be launched in 2005. The corresponding Earth Explorer programme proposal will be finalised in autumn 1997. Moreover, there will be a rolling user consultation meetings every 2-3 years. The next user consultation meeting will take place in 1998/1999.

NASDA is currently revising the existing draft plan of its long-term Earth observation scenario beyond 2003, in cooperation with the Japanese user community. NASDA intends to make the new draft plan more feasible to implement, and will revise it in early 1998. NASDA's on-going projects are; the second Advanced Earth Observing Satellite (ADEOS-II), planned in August 1999 to continue the global environment observations, the Advanced Land Observing Satellite (ALOS), planned in early 2003 to perform regional land observations, and the Tropical Rainfall Measuring Mission (TRMM), planned in November 1997 to carry out diurnal cycle observations of the tropical rainfall. The other small mission/technology demonstration projects include instrument/technical demonstrations on the Exposed Facility Flyer Unit (EFFU) of the Japanese Experiment Module (JEM) on the Space Station as well as the instrument/component demonstrations on the Mission Demonstration Satellites (MDS). Both are part of a series of small satellite projects newly introduced in the revised Japanese Fundamental Space Policy. The Super-conducting Millimeter-wave Limb Emission Spectrometer (SMILES) demonstration, planned in the year 2001 on JEM, and the LIDAR demonstration, planned in the year 2000 on MDS-2 were recently selected. Regarding future missions, based on the existing scenario, NASDA plans the follow-on mission of ADEOS-II expected in 2004, and the start of a new series of the Atmospheric Observing Satellite (ATMOS) for diurnal cycle observations of rainfall, cloud/radiation and atmospheric chemistry expected in 2004 or later. All of the new satellite missions will be decided on an annual basis, depending on the budget situation.

The implementation of new or improved programmes of the NOAA have been operational (especially regarding continuity) as well as political and policy priorities. Space-based climate data observations are less defensible quantitatively than those of operational meteorological missions. Therefore, NOAA is performing cost/benefit analyses of climate data. The development of new or improved capabilities for the Geostationary Operational Environmental Satellite (GOES) and polar missions will continue to be in danger due to funding changes, i.e., reductions in planning budgets. The traceability of G3OS requirements, like those of future operational meteorology missions, is crucial. The rationale for those requirements shown to be system drivers must be defensible in terms of benefits. In the NOAA National Polar Orbiting Environmental Satellite System (NPOESS) programme, "Phase I" of instrument development and risk reduction is now underway with proposal reviews for several national instrument concepts in progress. The planning date of the first launch is the year 2007. The Integrated Operational Requirements Document (IORD-1) is available to all[3], and has been reviewed internally by NOAA climate scientists in a workshop, in January 1996. This review has also recently been published. Comments on NPOESS IORD requirements, especially comments citing benefits of proposed climate-related observational requirements, are welcome prior to the completion of the early phase of instrument developments.

The Russian Federation has plans for the meteorological METEOR system spacecraft and the Russian satellite series for resource monitoring (RESURS). In the 1970s satellites for the exploration of the Earth's natural resources and for ecological monitoring began to be developed on the basis of METEOR. The objective of this series is the observation and monitoring of natural resources. In further discussions, it was remarked that the Total Ozone Mapping Spectrometer (TOMS) and the Scanner for Radiation Budget (SCARAB) will be launched in the year 2000.

Prof. Townshend strongly supported the view that the requirements from the G3OS and especially long-term scenarios should be considered by the space agencies. He noted the lack of long-term commitment after the year 2005. CEOS members should be challenged by GOSSP and use its input to define their strategy. The panel attendees agreed that space agencies should commit to the Integrated Global Observing Strategy (IGOS) projects. Panelists agreed that there is an urgent need to publicise requirements and concerns. In particular a statement from GOSSP, with regard to METOP, should be sent to EUMETSAT[4]. Additionally, the participants were informed that there will be a "Uni-Space" conference in 1999, which has adopted Earth Science themes.

Dr Karpov reminded attendees that, in the light of the upcoming second meeting on the Convention of Climate Change in Kyoto in December 1997, the message of the G3OS should come across clearly to the space agencies.

*ii. WGSAT Review of Observation Requirements*

The Working Group reported that their major concern is to complete the database and maintain its functionality. Therefore, a single and unique updating process by WMO and ESRIN will be guaranteed. At the Database Reconciliation Meeting in January

[3] The report can be made available by the GCOS Joint Planning Office.
[4] *Correspondence was sent out on behalf of GOSSP and other WMO programmes by the Secretary-General of WMO.*

1997, the database and the manual were reviewed and updated. The draft set of observational requirements were reviewed in February 1997. The WGSAT stressed the importance of completing the updating process for the requirements by the end of May 1997, addressing a list of deficiencies existing in the observational requirements.

The "critical review" analysis method was only applied to WMO requirements. Preliminary results showed unrealistically modest contributions by satellite systems. This result was attributed to the method rather than to the systems. A modification to the method, using "maximum" and "minimum" requirement ranges, resulted in the satellite observations being represented more realistically. This analysis method is still in the approval process of WGSAT.

*iii. WGSAT Review of Estimates of Instrument Performances*

The WGSAT participants gave the plenary an overview of the review activities related to a selected subset of instrument performances based on user estimates. The user estimates would be guided initially by information provided by space agencies but would represent a user perspective of satellite instrument performances. To develop a more complete set of instrument performances coming from the user perspective WGSAT prepared a review process in spring 1997. Responses were input to the database. Dr Hinsman called on the GOSSP panel to initiate a process to develop and review G3OS requirements, which should carry a time stamp to guarantee the updating process. Both chairmen also supported the point that benefits will only arise if the potential value of instrument performances is clearly defined.

Dr Richter noted that the GCOS JPO initiated the same review process as WGSAT, but only for GCOS requirements. The few responses were collected, but had not yet been entered into the database.

*iv. GOSSP Requirements*

The participants reviewed G3OS requirements which had been entered in the database. They noted that GCOS and GOOS, via the IOC, have formulated their requirements. GTOS contributed a subset of terrestrial requirements from the TOPC. The discussion on specific data and product requirements for GTOS led to the observation that there is an urgent need in preparing such requirements. The GTOS Secretariat should take actions to develop these requirements in order to contribute to a coherent evolution of the G3OS programmes. Panel members asked for a thorough scientific control of the review process and mechanism to fix or modify the review process if necessary. Priority for the space agencies in reviewing their requirements should focus on identifying gaps and overlaps. Mr Morgan emphasised the importance of reviewing product requirements to support user needs. In respect of requirements formulated by space agencies, panel participants stressed again that those should be well articulated for climate. It was suggested to set-up a strawman proposal of space agency requirements to be verified by experts.

Drs Croom and Richter reported on the status of requirements for atmospheric composition. To initiate discussion, an *ad hoc* working group on behalf of the Atmospheric Observation Panel for Climate (AOPC), held a meeting following the Global Measurement Systems for Atmospheric Composition (GOMAC) conference in

Toronto, May 1997. The GOMAC showed clearly that although there are many upcoming space observations, with few exceptions (e.g., Total Ozone Mapping Spectrometer (TOMS), Stratospheric Aerosol and Gas Experiment (SAGE)) most contribute little to long-term monitoring for atmospheric composition. Measurements in the upper troposphere/lower stratosphere region are of varying quality, and space-based observations of the lower troposphere are very difficult to obtain. There are several existing networks for atmospheric species for surface observations which complement the data collected by Global Atmospheric Watch (GAW) stations. The *ad hoc* working group re-formulated GCOS requirements for atmospheric composition, which will be presented and reviewed at the upcoming third session of the AOPC, in Reading, UK, in August 1997.

The panel adopted the concept of “application” areas to facilitate the identification of detailed and precise requirements. Possible GCOS application areas have been expressed already in the GCOS plan (i.e., detection of climate change, impact from climate change, determination of climate forcing and response, model validation, etc.). GOOS requirements are concentrated on requirements for applications and for specific regions. GTOS has addressed only application areas for climate through the TOPC. The panel participants broke up into three groups, representing atmosphere, land and ocean. The individual groups worked out applications and an associated list of requirements (Annex VII).

The panel attendees suggested a procedure for a systematic and consistent way of defining G3OS requirements as an input into the GOSSP/CEOS analysis. Variables can be classified into four different types. “*Measured*” variables describe the data as measured by satellite and are defined by satellite operators. “*Ancillary*” variables are needed by research scientists to correct the satellite measurements. “*Input*” variables are used by the environment scientists, resulting from a model and are input into an ‘earth system model’. “*Target*” variables are the variable as required by the user, resulting from a final model step (Annex VIII).

The participants noted that the CEOS projects “GODAE, Upper-Air, Ocean-Colour and Forest Cover” should be reflected in the GOSSP requirements. Each of these projects will be represented at the upcoming AG meeting in Tokyo, in July 1997. The terrestrial group prepared a requirement list to be applied to the project “Forest Cover” (Table II, Annex VIII). The ocean group decided to follow this example and to prepare a list for the project “GODAE” and “Ocean Biology”. GOOS has an existing list of requirements which can be taken as a strawman list and which could be verified by GODAE. Results would be reported through the OOPC. It was noticed that the outcome of group working on GODAE requirements, which combine *in-situ* measurements and space-based observations, will be a challenge to space agencies. WGSAT will prepare a strawman list of the “Upper-Air” and “Ozone” projects.

Prof. Townshend welcomed the initiative of GOSSP to demonstrate to the space agencies how to approach the needs of the G3OS by reflecting its requirements in IGOS projects. He pointed out that there is a discrepancy between the upcoming needs for user requirements and the long-term set-up of space agency requirements. The participants recommended that the G3OS views and concerns be presented in an annual report to CEOS, and other organisations.

## VII. “Critical Review”

*i. Methodology to Evaluate Satellite Data*

The Chairman presented to the plenary a methodology to evaluate satellite data, called a “critical review”. He noted that an evaluation is important for users to estimate the usefulness of the data for specific applications, and is vital for planning operational activities and research programmes. Space agencies need the evaluation of satellite performance against user requirements to help to define future systems and to fine-tune existing systems. GOSSP, WGSAT, the CEOS Task Force and the CEOS AG have put a lot of effort into establishing a relational database, listing requirements for science areas and initiated the development of its analysis by referring to prototypes. It is essential to link requirements to specific applications, which makes it easier to specify, to validate and to update them. Furthermore, it is important to agree on standard definitions and basic terminology.

Mr Morgan introduced the concept of a requirement “range”. The most demanding level is the “optimal” level, defined as the necessary level to meet requirements consistent with well documented specific applications. The least demanding level is the “threshold” level, defined as the minimal level of performance at which the system begins to add useful information to the application.

A consistent database, comprising requirement values on spatial and temporal resolutions, delivery times, random errors and bias is the essential first step. Next, it is necessary to verify satellite performances. Finally, the process compares requirements with performances for each specific application. It is intended to develop a software which will generate a colour coded summary chart. This chart will show the degree of compliance of the satellite capacities to meet the requirements and will include time-lines for relevant satellite instruments.

*ii. Space Plan*

The process of the “critical review” will be documented in the revised Space Plan. It is proposed that the Space Plan should include summary charts of requirements and satellite capability. Other detailed information is intended to be included as supplement or may be only presented as a World Wide Web page.

In the succeeding discussion, it was stressed that the use of application areas should guarantee coherency in data requirements. Furthermore, this methodology will reveal how instrument performances will improve. It is hoped it will demonstrate how complex information on instrument performances and user estimates can be described in a clear and concise manner. Mr Morgan summarised that for the “critical review” the database is fundamental and that the required value must be correct. The challenge in establishing this process is to retain the heritage of the application requirement.

## VIII. Consolidation of Action Items and Future Work Programme

*i. GOSSP Actions and Recommendations*

| | | |
|---|---|---|
| • In order to express the panel participant's concerns on research activities and operational matters, a letter is to be sent to EUMETSAT and ESA, to put stress on the importance of an early decision of the new European meteorological operational satellite system (METOP). | Action with:<br>J. Morgan, T.Spence | Due Date:<br>10 June 1997<br><br>[*Completed*] |
| • The panel participants agreed on the completion of the "critical review" to discover inconsistencies between space agencies and users. It is recommended to use existing requirements as input and to relate to CEOS SIT prototype projects, i.e., Ocean Biology, GODAE, Ozone and Upper-Air Measurements. The methodology to identify requirements has been introduced by Dr Cihlar. | Action with:<br>N. Hoepffner (Ocean Biology)<br>M. Lefèbvre (GODAE);<br>D. Croom (Ozone);<br>N.N. (Upper-Air) | Due Date:<br>12 June 1997<br><br>[*Completed*] |
| • In order to give a clear statement of broad requirements, number of instruments in orbit and key observations, the participants recommended to articulate all G3OS requirements. The established Task Groups should seek for input. The panel agreed on the set-up of an electronic mail process. | Action with:<br>GCOS Secretariat;<br>J. Cihlar;<br>J. Withrow | Due Date:<br>June 1997<br><br>[*Completed;* see Annex V] |
| • The participants decided to revise the requirements and the list of applications by Steering Committees.<br>The list should be used to start analytical process of the "critical review".<br>It was planned to deliver a description of the "critical review" process for G3OS requirements as input for the Space Plan. | Action with:<br>GOSSP Virtual Task Groups<br><br>J. Morgan<br><br>J. Morgan | Due Date:<br>1 August 1997<br><br>middle of August 1997<br><br>middle of September 1997 |
| • The panel participants agreed on proceeding with the Space Plan draft, Version 2.0. It was recommended to identify arguments for cost benefits. The document should contain a strong rationale. | Action with:<br>GCOS Secretariat and GOSSP Virtual Task Groups | Due Date:<br>middle of September 1997 |
| • The panel attendees decided to improve publicity. It was agreed to send out an annual report containing G3OS chairmen's messages, recent developments, and concerns to space agencies and the relevant science community. | Action with:<br>Task Groups III (R. Schiffer) | Due Date:<br>before CEOS meeting in November 1997 |

*ii. WGSAT Statement of Guidance on Feasibility of Meeting Requirements*

The chairman of WGSAT summarised the outcome of the separate parallel WGSAT session related to WMO requirement review and update. The review of WMO applications showed that the application "hydrological modelling" should be split into two areas. Since there was only one application which covered climate ("climate applications and diagnosis"), it was concluded that, at the moment, the existing database was not adequate for climate requirements. Therefore, it was decided to follow the GCOS requirements. GOSSP input will be a crucial basis for WMO.

The "critical review" was applied to database requirements with good results. The WGSAT recommended using the "minimum-maximum" requirement range with a logarithmic scale. A review of requirements related to application areas using the "critical review" methodology is desirable.

The working group agreed on an outline for a statement of guidance describing the "rolling requirements review" and the evaluation of the method. The draft should be available for the next WGSAT meeting in spring 1998.

## IX. Closure

*i. Closing Comments*

The Chairman closed the session at 1 p.m., on Friday, May 30, 1997. The date of the next meeting will be scheduled for spring 1998.

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## Annex 2: Agenda

This agenda describes the joint sessions of the Commission for Basic Systems (CBS) Working Group on Satellites (WGSAT) with the Global Observing Systems Space Panel (GOSSP). Item 5 was specific to GOSSP.

1. ORGANISATION OF THE JOINT SESSION
   - 1.1 Opening of the Joint Session
   - 1.2 Adoption of the Agenda
   - 1.3 Working Arrangements of the Session
   - 1.4 Election of the Joint Session Chairman

2. CHAIRMEN'S REPORT

3. UPDATE ON GLOBAL OBSERVING SYSTEMS AND WGSAT ACTIVITIES

4. INITIATIVE FOR AN INTEGRATED GLOBAL OBSERVING STRATEGY (IGOS)

5. CONSIDERATION OF THE SPACE PLAN DRAFT

6. REVIEW AND UPDATE OF CURRENT REQUIREMENTS AND INSTRUMENT PERFORMANCES

7. "CRITICAL REVIEW"

8. CONSOLIDATION OF ACTION ITEMS AND FUTURE WORK PROGRAMME

9. CLOSURE

## Annex 3: Terms of Reference

Recognizing the need for a comprehensive approach to the various space-based observational activities for the global observing systems, the JSTC of GCOS, the Joint Scientific and Technical Committee for GOOS (J-GOOS)[5], and the Steering Committee (SC) for GTOS have established a Global Observing Systems Space Panel (GOSSP).

Terms of Reference:

Based on guidance from the JSTC, J-GOOS, and the SC, the primary tasks of the Panel are:

- To maintain and further develop the plan for the space-based observation components of the global observing systems considering the requirements from the scientific panels;

- To develop, integrate, and promote the space-based observational requirements of the user communities carrying out global studies and providing related advice and services;

- To recommend to the space agencies how these requirements may be met (e.g., through such bodies as the Committee on Earth Observation Satellites or the Coordination Group on Meteorological Satellites);

- To facilitate the participation of the global observing communities, in particular in developing countries, through regional activities;

- To identify and evaluate problems, and advocate solutions;

- To report regularly to the JSTC, GOOS, and GTOS SC.

The GOSSP will be the focus for exploiting space systems in meeting the objectives of the global observing systems. The Panel must continually refine, update, and interpret the implications of the requirements of the user communities carrying out global studies, and provide related advice in terms of space instruments and satellite pay loads flown by the data providing agencies.

Chairman: Mr. John Morgan

[5] Now the GOOS Steering Committee (GSC).

## Annex 4: Space Plan, Version 2.0, Draft Outline

Tentative Chapter Headings and Actions were presented at the meeting. The GCOS Joint Planning Office suggested an approach to guide the Panel through the discussion of the revision, and to provide some simplifications to the structure of the document.

Basically, it is proposed that the plan should consist of two sections. Chapters 1, 2, 3, 6, 7 and 8 are relatively general, and with some modifications, could provide a focused discussion of the overall strategy. This first section would therefore be a relatively **permanent** one, stating the overall aims and purposes of the space plan, describing key aspects of the G3OS, providing the adequate background for the process used to obtain user requirements and to compare them with agency missions and plans, and indicating the mechanisms whereby the plan is maintained in a current state.

The second section would contain integrated recommendations from the user groups, the specific evaluation of the space agency missions which are relevant to them and the recommendations for actions. This section will be constantly under review and will be subject to frequent updates and modifications. It is proposed that it appear in a **"loose-leaf"** format.

Both printed and electronic versions will be available.

**Chapter I Introduction**

*Action:*
- *Prepare input from GOOS and GTOS for incorporation in the G3OS discussion.*
- *Prepare brief discussion of methodology for user requirements*

**Chapter II The G3OS Space Strategy**

*Content:* *Vision, overall concepts relating to space.*

*Action:*
- *Outline the concept of the G3OS strategy toward space observations.*
- *Consider the incorporation of Chapters 6, and 8 in this one.*

**Chapter III The G3OS Themes**

*Content:* *Requirements drivers, methods to obtain them from users, structure to present and analyse them in context of space-agency plans.*

*Action:*
- *Review the concept of this chapter to see if it can be part of Chapter 2, and if not, what it should contain.*

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-

The next two chapters require frequent update, therefore it is suggested that they be done in a "**loose-leaf"** and **electronic version**, where the information may be modified and updated conveniently.

**Chapter IV The G3OS Space Requirements**

*Action:* • *Propose an effective way to obtain and describe the G3OS requirements.*
• *Relate the process to the database activity of the affiliates.*

**Chapter V The Space Agency Missions**

*Action:* • *Propose an effective way to describe the space agency programmes.*

**Chapter VI The Analysis Method**

*Content:* *Discussion and illustration.*

*Action:* • *Propose an effective way to describe the analysis method.*
• *Select illustrative examples.*
• *Extract priority recommendations.*

Concerning **the former Chapter on Ground Segments**:

*Action:* • *Develop a consistent perspective on the 'ground segment' needed for the G3OS,*
• *Relate and link to the strategy of Chapter 2.*

**Chapter VII Enhancement for Developing Country Needs**

*Content:* *Special Focus.*

*Action:* • *Develop an appropriate posture for the G3OS space plan to take regarding developing countries.*
• *Prepare text for consideration.*
• *Prepare short reference and explanatory piece for Chapter 2.*

Concerning **the former Chapter on Cost-Effectiveness**

*Action:* • *Develop key points to be retained on this topic.*
• *Elaborate the space agency perspective on coordination/integration.*
•*...Consider link to Chapter 2.*

**Chapter VIII Conclusions**

*Actions:* • *Prepare a set of important, timely, well-focused recommendations.*
• *Where possible, designate specific 'actors' who should take initiative.*
• *Conclude on optimistic note.*

## Annex 5: Virtual Task Groups

The Panel decided to set-up **Virtual Task Groups** to work intersessionally. Panel attendees and representatives of other science groups will be invited to participate.

The messages will automatically be resent to the following lists:
(The GCOS office will get a copy of your correspondence.)

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N. Andersen (Chairman HOTO) - not in the list
N. Flemming (Chairman *ad hoc* Coastal Panel) - not in the list
G. Grise (OSLR ,re LMR) - not in the list
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## Annex 6: Proposed Initial IGOS Implementation Projects

The IGOS Strategic Implementation Team (SIT) agreed at its first meeting in Irvine, California, February 1997, on six key issues, as the basis for developing project statements for prototype activities. The Irvine reports includes a table listing the proposed initial IGOS implementation projects. The slightly expanded version for each of the proposed projects has been produced by the SIT:

### Global Ocean Data Assimilation Experiment

**Issue:** Need an integrated suite of remote (and direct) measurements of the ocean for real-time assimilation, interpretation and application. The project will provide a regular, global depiction of the ocean circulation, from climate down to ocean eddy scales, consistent with the measurements and appropriate and physical constraints.
**Tools Needed**: Real-time satellite data stream; global *in situ* observing system; assimilation to exploit integrated data stream; models and computer for production and output; high band-width communications.
**Partners:** GOOS/GCOS/WCRP OOPC, CNES, ESA, NASA, EUMETSAT, NOAA, NASDA.
**Products/Results:** Global analyses/forecasts based on limited models, data streams; global products at reduced resolution (time and space); global hindcasts based on past remote sensing and *in situ* data; global eddy-resolving analyses with reduced physics, dynamics, assimilation; some regional analyses/forecasts based on enhanced data models.

### Upper Air Measurements Including Upper Air Network and Tropospheric Winds from Space

**Issue:** Ground-based radiosonde observations and omega sondes are being reduced and could impact numerical weather prediction models.
**Tools Needed:** *In situ* and satellite data of tropospheric winds and profiles of temperature and specific humidity.
**Partners:** WMO, EC, NOAA, ESA. NASA, CNES, EUMETSAT.
**Products/Results:** New/improved satellite-derived products assimilated into operational models.

### Long-Term Continuity of Ozone Measurements

**Issue:** No long-term strategy for continuity of stratospheric ozone observations.
**Tools Needed:** Space and ground-based measurements of total ozone and vertical profiles. Ground-based measurements of both ozone and spectrally resolved surface UV. Space-based full daily global coverage total ozone; vertical profiles of ozone, other species, temperature.
**Partners:** WMO/IPCC, ESA, NASA, EUMETSAT, CNES, NOAA, NASDA, ASI, CSA/AES.
**Products/Results:** Commitment by identified agencies to long-term total ozone and ozone vertical profile measurements and data exchange.

### Global Observation for Forest Cover

**Issue:** Monitoring of forest cover and its changes is essential to a variety of issues including land cover change, biodiversity, renewable energy resources, and more. There is no systematic plan for routine acquisition and analysis of data on global forest cover from optical and microwave satellites.
**Tools Needed**: Optical and microwave imaging satellites (already in existence and planned); acquisition stations and processing facilities.
**Partners:** GCOS/GTOS TOPC, IGBP LULC, EC, FAO, CSA/CCRS, INPE, ESA, NASA, CNES, EUMETSAT, ASI NASDA, NOAA.
**Products/Results:** Database of georeferenced high resolution data with periodic systematic coverage of all forested areas globally; periodic analysis of change on regional and global scale.

### Long-Term Ocean Biology Measurements

**Issue:** Multiple ocean colour sensors in operation and planned; need coordinated strategy to support data needs for scientific studies of ocean biogeochemical and ecosystem processes.
**Tools Needed:** Satellite and *in situ* observations, coordinated calibration/validation campaign.
**Partners:** GOOS, IOC, EC, NASDA, NASA, CSA, ESA, NOAA, CNES, WGISS, WGCV.
**Products/Results:** Internationally coordinated calibration/validation programme to understand regional influences and variations in the ocean environment; integrated database with *in situ* and satellite data; multi-sensor data streams and products.

### Disaster Monitoring and Management Support

**Issue:** Earth observation satellite data is not being fully utilised to support disaster prediction, monitoring, and mitigation on a worldwide basis.
**Tools Needed**: Information systems to locate, acquire, re-format as necessary, and deliver Earth observation satellite data products rapidly to emergency response authorities; improved understanding of the requirements of emergency response authorities.
**Partners:** NOAA, EC, ESA, BNSC, ASI, STA/NASDA, NASA, CSA, CNES, WGISS.
**Products/Results**: Work with subset of agencies with broad geographic responsibility to develop an initial requirements and capabilities profile for the contribution of Earth observation satellite data and to implement a capabilities demonstration.

## Annex 7: List of Applications

A. ***GOSSP APPLICATIONS***

The panel agreed upon the following list of application to be used for GOSSP. The closed circle signifies that the application is a major focus in one or more of the three areas (atmosphere, land, ocean), whereas the open circle indicates only a contributing effect. This list of applications resulted from the three *ad hoc* groups at the meeting. The specific group applications have been mapped into the GOSSP applications

| Atmosphere | Land | Ocean | Application |
|---|---|---|---|
| ○ | ❸ | ❸ | Ecosystem Productivity |
| | ❸ | | Sustainable Land Use |
| ○ | ❸ | | Hydrological Resources |
| ❸ | ❸ | ❸ | Green House Gas Trend<br>*(Sources, sinks, dynamics, concentration)* |
| ○ | ❸ | ❸ | Biodiversity and Ecosystem Health |
| ❸ | ❸ | ❸ | Climate Trend Assessment / Impact |
| ❸ | ○ | ❸ | Hazard Mitigation |
| | | ❸ | Transport Services |
| | ○ | ❸ | Coastal Zone Management |
| ❸ | | ❸ | Climate Modelling<br>*(Boundary, Initialisation, Validation)* |
| ❸ | ○ | | Improved Operational Prediction<br>*(Seasonal, Interannual)* |
| | ❸ | ❸ | Biogeochemical Cycling |

❸ Major Focus ○ Contributing Effect

B. ***TERRESTRIAL APPLICATIONS***

The “Land” *ad hoc* group developed the following list of applications for terrestrial use. Participants of “Land” *ad hoc* group were: J. Cihlar, A. Bassolé, J. Townshend, D. Williams

- *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)*

Characterisation of the present land use and the potential for land development 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 trends, 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 their 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); 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 latter two), and to the status of the ecosystem in comparison with a similar fully-functioning, vigorous one.

- *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.

The six application areas found by the “Land” group map into the G3OS objectives as indicated with an “X”. Further, the group indicated the scope of the applications.

| Application | G3OS Objectives | | | | | Scope | | |
|---|---|---|---|---|---|---|---|---|
| | Climate Varia-bility. | Clim./Global Change Impact | Sustain. Develop. Planning | Climate Feedback | Fore-casts | Global Wall to Wall | Global sampl. | Regional |
| Ecosystem productivity & Sustainable Assessment | | X | X | X | | X | | X |
| Land Use & Sustainable Development Planning | | X | X | X | X | | X | X |
| Hydrological Resources Assessment | X | X | X | X | X | | | X |
| GHG Trend Assessment | X | | | X | X | X | | X |
| Biodiversity | | X | X | | | | X | X |
| Climate Trend Assessment | X | X | | X | X | X | | X |

## C. *OCEAN APPLICATIONS*

The *ad hoc* group "Ocean" presented a list of eight applications and examples. Participants were: N. Hoepffner, J. Johannessen, M. Lefebvre, K. Ohta, M. Ono, P. Ryder, T. Spence, S. Viktorov, J. Withrow.

- *Hazard Mitigation*
  Tsunamis, Iceberg, Storm Survey
- *Biodiversity and Ecosystem Health*
  Waste disposal, Habitat Destruction (N.B. there is need of a new entry for "coral growth")
- *Marine Productivity*
  Fisheries, Aquaculture
- *Transport Services*
  Ship Routing, Port Operational Prediction Service
- *Coastal Zone Management*
  Efficient Off-Shore Operational Prediction Service, Erosion, Land-Surface Fluxes can be included
- *Improvement and Use of Deterministic Ocean Models*
- *Climate Model Validation*
  El-NiZo-Southern Oscillation (ENSO), North Atlantic Oscillation (NAO)
- *Climate Assessment*
  Carbon Dioxide Uptake, Variation of Currents

## D. *ATMOSPHERE APPLICATIONS*

The *ad hoc* “Atmosphere” group worked out a list of five applications. Members of the group were: D. Croom, J. Hawkins, A. Karpov, D. Mitchell, J. Morgan, C. Richter, R. Schiffer.

- *Green House Gases Trend*
- *Climate Impacts*
- *Climate Modelling (Boundary, Initialisation, Validation)*
- *Seasonal / Inter-Annual Prediction*
- *Climate Trend Assessment*

## Annex 8: Methodology to Identify Requirements

Dr Cihlar suggested the following procedure for a systematic and consistent way of defining G3OS requirements as an input into the GOSSP/CEOS analysis.

**Step 1**: Finalise the list and definitions of the twelve "Applications" (Annex VII):

(1) Ecosystem productivity
(2) Sustainable land use
(3) Hydrological resources
(4) Green house gas trend
(5) Biodiversity and ecosystem health
(6) Climate trend assessment
(7) Hazard mitigation
(8) Transport services
(9) Coastal zone management
(10) Climate modelling
(11) Improved operational prediction
(12) Biogeochemical cycling

and for the CEOS prototype projects (Annex VI):

(a) Ozone
(b) Ocean Biology
(c) Global Ocean Data Assimilation Experiment (GODAE)
(d) Forest Cover
(e) Upper-Air
(f) Disaster Monitoring

**Step 2**: Finalise the list of variables required by each G3OS panel and provide definitions for all the variables in geophysical terms. The list and draft definitions for the terrestrial, atmospheric and oceanic "Applications" can be found in Annex VII.

**Step 3**: Categorise each variable into one of four types:

(1) Target:
Variable giving the final information for an application or an important stand-alone data set for an application, e.g., net primary productivity;

(2) Input:
Variable needed as an input into an 'earth system model', a generic term referring to models which produce the target variable, (e.g., leaf area index);

(3) Ancillary:
Variable used to specify/correct measured variable (e.g., atmospheric optical depth);

(4) Measured:

Variable actually measured ( e.g., spectral radiance).

If more than one category applies for an application, use the most relevant (i.e., the primary use for that variable) to identify the category.

**Step 4**: Identify the applications (Annex VII) for which each variable is required. A variable may be needed for one or more applications, and/or it may be needed as an input in conjunction with other variables. Typically (especially in the case of satellite data), target variables will be required for one or more applications; input variables will be required by target variables; ancillary and measured variables will be required by input variables. No distinction is made at this step. The intent is to clarify the reasons for wanting that variable so that its characteristics may be defined in a rational way (see next step).

**Step 5**: For each variable define five observational characteristics and two classes. The characteristics are:

(i) Horizontal Resolution (Hor):

The horizontal resolution is intended to mean sampling distance, which is perhaps the most familiar concept to the user (average distance between observing stations in remote sensing or the integration distance). Specification of significant/integration distance is not requested at this stage. In the case of images, horizontal resolution is agreed to mean the pixel size. In the case of parameters of fractal nature observed in images, horizontal resolution is agreed to mean the image resolution. In the case of products or images oversampled in respect of the integration distance, the integration (not sampling) distance has to be quoted.

(ii) Vertical Resolution (Ver):

The vertical resolution also is intended as vertical sampling distance, with the same understanding as above in respect of the vertical significant/integration distance.

(iii) Cycle (Cyc):

The observing cycle is intended to mean the required interval between two successive global coverages (including the equatorial regions), i.e., the time needed for the whole Earth surface to be provided with at least one observation each grid square of size equal to the horizontal resolution, and with the specific accuracy. Again, this is not the integration time for taking a single measurement. If a parameter is going to be used after time integration or other filtering processes over several measurements (e.g., daily radiation budget reconstructed by integrating hourly measurements), the observing cycle has to refer to the measurements.

(iv) Timeliness (Time):

Timeliness describes the delay between satellite observation of the area concerned, and the availability of the processed geophysical parameter for distribution to the user.

(v) Accuracy (Acc):

The accuracy is intended to be the root mean square difference between the observed and the true values, i.e., inclusive of both random and systematic errors. If there is a particular reason to require that the systematic error (bias) is specifically controlled, two separate figures could be specified: standard deviation and bias. Provision for two values is also foreseen in cases when the parameter has been specified with two facets (e.g., wave period and direction), or actually requires two figures (e.g., horizontal and vertical accuracy of topography). For images or features, accuracy is not applicable. For parameters of fractal nature, accuracy is accuracy of location. For parameters resulting from classification processes, accuracy is the number of recognisable classes. It is recommended to use proper physical units, not percentages as far as possible. Where accuracy is expressed in percentage error, this will be understood to mean that there is no requirement for absolute calibration. The figure quoted for accuracy must be consistent with those quoted for horizontal and vertical resolution, i.e., the figure must be valid for a product sampled at that horizontal/vertical distance.

The two classes are:

(a) Optimal Requirement:

The optimised (or “necessary”) requirement is the value which, if exceeded, would not yield significant improvements in performance for the application in question. Therefore the cost of improving the observations beyond this requirements would not be matched by a corresponding benefit. Optimal requirements are likely to evolve; as applications progress, they develop a capacity to make use of better observations.

(b) Threshold requirement:

The threshold (or “minimal”) requirement is the value below which the observation would not yield any significant benefit for the application in question (or below which the benefit derived would not compensate for the additional cost involved in using the observation). Assessment of minimal requirement for any given observing system is complicated by assumptions concerning which other observing systems are likely to be available. It may be unrealistic to try to state the minimal requirement in an absolute sense, because the very existence of a given application relies on the existence of a basic observing capability.

The following tables (Table I and Table II) give examples of how the variables of a specific heritage, (i.e., GCOS, GTOS, GOOS, GOSSP) can be assigned to the different application areas 1-12 or IGOS projects a-f.

Table I illustrates the assignment of required parameters to one of the four "Types", for a specific application area, e.g., (1) Ecosystem productivity.

***Table I***

***Application: (1) Ecosystem Productivity (not complete list)***

| *Variable* | *Type* | *Optimised Requirements* | | | | | *Threshold Requirements* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Hor km* | *Ver km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* | *Hor km* | *Ver km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* |
| Biomass | Target | 0.1 | | 5 y | 3 m | ± 5% | 1 | | 10 y | 6 m | 15% |
| Spectral vegetation greenness index | Input | 0.1 | | 1 d | 1 d | ± 1% | 2 | | 1 d | 10 d | ± 3% |
| Vegetation hydric stress index | Ancillary | 0.1 | | 0.04 d | 1 d | ± 10% | 4 | | 1 d | 2 d | ± 20% |
| Radiation - reflected short-wave satellite (multispect.) | Measured | 0.01 | | 1 d | 1 d | | 1 | | 2 d | 1 m | |

Table II, compiled by Dr Cihlar, demonstrates the assignment of the required parameters to the "Type", for a CEOS project, e.g, (d) Forest Cover. Shaded cells indicate numbers need to be specified.

***Table II***

***Application: (d) Forest Cover***

| ***Variable*** | ***Type*** | ***Optimised Requirements*** | | | | | ***Threshold Requirements*** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *Hor km* | *Ver km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* | *Hor km* | *Ver km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* |
| Land Cover 1 | Target | 0.01 | | 5 y | 3 m | 50 class. | 0.05 | | 10 y | 6 m | 10 class. |
| NPP | Target | 0.5 | | 1 d | 10 d | 0.1 | 4 | | 10 d | 1 m | 0.2 |
| NEP | Target | 0.5 | | 1 d | 10 d | 0.1 | 4 | | 10 d | 1 m | 0.2 |
| Fire scars and damage | Target | 0.25 | | 1 y | 1 m | 5 class. | 1 | | 3 y | 3 m | 2 class. |
| Harvest / loss | Target | 0.01 | | 5 y | 3 m | 0.1 | 1 | | 10 y | 6 m | 0.1 |
| Biomass-above ground | Target | 0.25 | | 5 y | 3 m | 0.1 | 1 | | 10 y | 6 m | 0.1 |
| Land cover 2 | Input | 0.25 | | 1 y | 1 m | 40 class. | 1 | | 3 y | 3 m | 20 class. |
| LAI | Input | 0.25 | | 10 d | 10 d | 0.2 | 2 | | 30 d | 10 d | 1 |
| FPAR | Input | 0.25 | | 10 d | 10 d | 0.05 | 2 | | 30 d | 10 d | 0.1 |
| PAR | Input | 1 | | 1 d | 1 d | 10 W/m2 | 4 | | 12 h | 2 d | 20 W/m2 |
| Active Fires | Input | 1 | | 1 d | 1 d | 1 K | 4 | | 2 d | 2 d | 1.5 K |
| Max stomatal conductance | Input | 0.25 | | 2 d | 2 d | 0.1 | 2 | | 30 d | 10 d | 20% |
| Precipitation | Input | 30 | | 1 d | 1 d | 0.6 mm/h | 100 | | 1 d | 10 d | |
| Aerosols | Ancillary | 1 | | 1 d | 10 d | | 4 | | 2 d | 1 m | |
| Water Vapour (total) | Ancillary | 1 | | 1 d | 10 d | | 4 | | 2 d | 1 m | |
| Ozone (total) | Ancillary | 1 | | 1 d | 10 d | | 4 | | 2 d | 1 m | |
| Multispec. Radiance 1 | Measured | 0.01 | | 2 y | 3 m | | 0.05 | | 10 y | 6 m | |
| Multispec. Radiance 2 | Measured | 0.25 | | 1 d | 10 d | | 1 | | 2 d | 1 m | |
| Microwave backscatter | Measured | 0.025 | | 1 y | 1 m | 0.5 dB | 0.5 | | 5 y | 3 m | 1 dB |
| Spectral VI | Measured | 0.25 | | 1 d | 10 d | 0.02 | 2 | | 30 d | 1 m | 0.06 |

### *Terrestrial Requirements List*

The next table (Table III), compiled by Dr Cihlar, contains all variables as required by the TOPC, where space observations can provide input. They have been assigned to relevant applications areas 1-12, as indicated by the numbers. Some “input” variables are directly related to “target” variables, which indicates that “target” variables still need a clear definition. Shaded cells indicate those items needing to be filled in, (e.g. accuracy formats to be clarified, or existing numbers requiring further discussion).

***Table III***

***Heritage: “Land” Group;***

***TOPC (GCOS/GTOS)***

| ***Variable*** | ***Type*** | ***Optimised Requirements*** | | | | ***Threshold Requirements*** | | | | ***Application*** |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *Hor km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* | *Hor km* | *Cyc d/m/y* | *Time d/m/y* | *Acc* | |
| Albedo satellite | Target | 1 | 10 d | 30 d | + 2% | 4 | 30 d | 60 d | + 7% | 6,10 |
| Biogeochem. transport from land to oceans | Target | | | | | | | | | 1,2,9,12, HOTO,.. |
| Biomass - above-ground | Target | 0.1 | 5 y | 3 m | +5% | 1 | 10 y | 6 m | 15% | 1,2,4,5,6,12 |
| Carbon dioxide flux | Target | Tier 1,2 (100 globally) | | cont | + 5% | | | | | 1,4,6, 10,12 |
| Dissolved C, N, and P in water (rivers and lakes) | Target | | | river depend. | + 5% | | | | | 1,2,5, 9,12 |
| Dry depo- sition of nitrate and sulphate | Target | Tier 1,2,3 | | weekly to monthly | +10% | | | | | 1,5,12 |
| Emissions of CO2, NOX and SOX from combustion of fossil fuels | Target | 50 | | 3 y | | | | | | 4,6,12 |
| Fire area and impact | Target | 0.25 | 1y | 1m | 5 classes | 1 | 3y | 3m | 2 classes | 1,2,4,5,6,12 |
| Firn temperature (ice sheets, ice caps, glaciers) | Target | 100 $km^2$ | | 10 y | + 0.1°C | | | | | 6,10 |
| Glacier inventory | Target | 0.01 | 30 y | 2 y | | 0.1 | 50 y | 5 y | | 3,6 |
| Glaciers mass balance | Target | 50 globally | 1y | 3m | .01 m | 30 globally | 5y | 6m | 0.1m | 2,3,6 |
| Ground water storage fluxes | Target | Tier 1,2 | | Annually | 1% of true depth | | | | | 2,3,6,9 |
| Ground water storage fluxes | Target | Tier 3,4 | | After all storms | 1% of true depth | | | | | 2,3,6,9 |
| Ice sheet mass balance | Target | 5 | 10 y | 1 y | $3 \times 10^3$ kg $y^{-1}$ | | 15 y | 2 y | $6 \times 10^3$ kg $y^{-1}$ | 6,10 |
| Lake and river freeze-up and break-up (timing) | Target | 300 lakes globally | Daily spring and fall | 1m | + 1 d | 200 | Daily spring and fall | 2m | + 2 days | 6,7 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Land cover | Target | 0.01 | 5 y | 3 m | 50 class. | 0.05 | 10 y | 6 m | 25 class. | 1,2,3,4,5, 7,8,9,10,12 |
| Land use | Target | 0.01 | 5 y | 6 m | TBD class. | 1 | 10 y | 1 y | TBD class. | 1,2,3,4,5,6,7,8, 9, 12 |
| Methane flux (CH4) | Target | Tier 1,2 (100 globally ) | | contin. | + 5% | | | | | 4,6,10,11,12 |
| Net eco- system productivity (NEP) | Target | Tier 1,2 | | annually | +10% for annual budget | | | | | 1,4,5,6, 12 |
| Net primary productivity (NPP) satellite | Target | 0.1 | 1 d | 10 d | +10% | 4 | 10 d | m | | 1,2,3,4,5,6,9,12 |
| Permafrost - active layer | Target | 150 sites | 10 d | 1 m | + 0.01 m | 60 sites | 30 d | 3 m | + 0.1 m | 1,2,4,5,6, 7,8,12 |
| Permafrost - thermal state | Target | 150 sites | 10 d | 1 m | + 0.05 C | 60 sites | 30 d | 3 m | + 0.1C | 6,10,12 |
| Permafrost extent | Target | 0.01 | 5 y | 3 m | | 1 | 10 y | 1 y | TBD | 1,2,3,4,5,6,8,9, 10,12 |
| Radiation - out long wave satellite | Target | 50 | 20 d | 1 m | + 2% | 100 | 60 d | 3 m | + 10% | 6,10 |
| Rainfall chemistry | Target | Tier 1,2,3 | | once per event | + 5% | | | | | 2,12 |
| Snow cover area | Target | 1 | 1 d | 2 d | +5% | 5 | 3 d | 3 d | + 10% | 3,6,8,10 |
| Snow water equivalent (SWE) satellite | Target | 10 | 1d | 2 d | +5% | 25 | 3 d | 3 d | +20% | 1,2,3,5,6, 7,8,10 |
| Soil moisture | Target | Tier 1,2,3 | 1 d | 3 d | + 2% | Tier 1,2,3 | 5 d | 5 d | + 10% | 1,2,3,4,5,6,7,8, 9, 10,11,12 |
| Stomatal conductance - maximum | Target | Tier 2, 3 | 10 y | 1 y | + 10% | Tier 2,3 | 20 y | 2 y | +15% | 1,4,6,10,12 |
| Surface water flow - discharge | Target | Tier 1,2,3 | 0.01 d | 1 d | + 5% | Tier 1,2,3 | 30 d | 30 d | +20% | 3,9 |
| Surface water storage fluxes | Target | 600 largest lakes | 10 d | 1 m | + 2% | 300 largest lakes | 40 d | 2 m | + 5% | 2,3,6 |
| | | | | | | | | | | |
| Albedo *in situ* | Input | Tier 1,2,3 | | | + 5% | | | | | Albedo satellite |
| Biomass - below-ground | Input | Tier 1,2,3 | 5y | 1y | +5% | Tier 1,2,3 | 10y | 1y | + 15% | 12,NPP,NEP |
| Evapotran-spiration | Input | Tier 1, 2 | contin | 1 d | + 5% | Tier 1,2 | 0.25 d | 2 d | + 20% | Surface and ground storage fluxes |
| Fertiliser use N and P | Input | Sub-national | 1 y | 1 y | +5% | National | 2 y | 1 y | +10% | 2,12 |
| Glacier length | Input | 0.001 | 5 y | 1 y | +1 m | 0.01 | 10 y | 1 y | +10 m | Glacier mass balance |
| Ice sheet geometry | Input | 0.01 | 5 | 1 y | + 10 m | 0.05 | 10 y | 2 y | +100 m | Ice sheet mass balance |
| Land cover | Input | 0.1 | 1 y | 1 m | 40 classes | 1 | 3 y | 3 m | 20 classes | |
| Leaf area index (LAI) | Input | 0.1 | 10 d | 10 d | + 0.2 | 2 | 30 d | 10 d | + 1 | NPP,NEP,10 |
| Light penetration | Input | #lakes | 10 d | 10 d | | | 30 d | 30 d | | 5 |
| Necromass | Input | Tier 1,2,3 | 1 y | 1 y | +5% | Tier 1,2,3 | 2 y | 1 y | + 20% | NEP,12 |
| Net primary productivity (NPP) *in situ* eddy flux | Input | 150 sites globally | contin. | 10 d | +5% | 80 sites | contin. | 30 d | +10% | NPP |
| Net primary productivity (NPP) *in situ* | Input | Tier 1,2,3 | 1 y | 3 m | +5% | Tier 1,2,3 | 1 y | 60 d | +10% | 1,5,12 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| biomass sampling | | | | | | | | | | |
| Peak leaf biomass of nitrogen-fixing plants | Input | Tier 1,2,3 | 1 y | 3 m | +5% | Tier 1,2,3 | 5 y | 1 y | +15% | 1,12 |
| Plant tissue nitrogen and phosphorus content | Input | Tier 1,2,3 | 1y | 3m | +5% | Tier 1,2,3 | 5y | 1y | +15% | NPP, Surface and ground storage fluxes |
| Precipitation - accumulated (solid and liquid) | Input | 1 | 0.04 d | 1 d | <+0.1 mm | 10 | 10 y | 1 d | +0.1 mm | NPP,3,6,7,8, 12 |
| Radiation - fraction of photosynthe-tically active radiation (FPAR) | Input | 0.1 | 10 d | 10 d | +0.05 | 2 | 30 d | 30 d | +0.1 | NPP,NEP |
| Radiation - incoming short-wave satellite | Input | 50 | 10d | 10 d | + 2% | 100 | 40 d | 30 d | +7% | NPP,3,5,6,12 |
| Radiation - outgoing long-wave *in situ* | Input | Tier 1,2,3 | 5 minute mean | 1 d | + 1% | Tier 1,2,3 | 10 minute mean | 5d | + 2% | NPP,10 |
| Relative humidity (atmospheric water content near the surface) | Input | Tier 1,2,3 & weath.st a'ns | 0.04 d | 1 d | + 1% | Tier 1,2,3 and weather stations | 0.04 d | 3 d | + 2% | NPP,NEP |
| Rooting depth - 95% | Input | Tier 1,2,3,4 | 5 y | 1 y | +5% | Tier 1,2,3,4 | 10 y | 2 y | +10% | 10,11 |
| Roughness - surface | Input | 1 | 5 y | 3 m | +5% | 10 | 10 y | 6 m | +15% | Surface and ground storage fluxes |
| Snow depth | Input | Tier 1,2,3 & weath.st a'ns | 1 d | 1 d | +2cm up to 20 cm, +10% > 20 cm | Tier 1,2,3 and weathe r station | 2 d | 4 d | +3cm up to 20 cm, +15% > 20 cm | 1,5,12 |
| Soil available phosphorus | Input | Tier 1,2,3 | 1 y | 6 m | + 5% | Tier 1,2,3 | 2 y | 1 y | + 10% | 1,5,10,12 |
| Soil bulk density | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | 1,2,4,5,12 |
| Soil cation exchange capacity | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | 1,2,3,5 ,7,8,9,12 |
| Soil particle size distribution | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | 1,2,4,5,12 |
| Soil pH | Input | Tier 1,2,3,4 | 1 y | 6 m | + 5% | Tier 1,2,3,4 | 10 y | 1 y | + 10% | 2,5,12, Surface water storage fluxes,Surface water flow-discharge |
| Soil surface state | Input | Tier 1,2,3,4 | 1 y | 6 m | + 5% | Tier 1,2,3,4 | 10 y | 1 y | + 10% | 1,5,12 |
| Soil temperature (subsurface) | Input | Tier 1,2,3, weather stations | | | | Tier 1,2,3, weathe r stations | | | | NPP,NEP,3,4,5 ,12 |
| Soil total carbon | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | 1,5,12 |
| Soil total nitrogen | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | 1,5,12 |
| Soil total phosphorus | Input | Tier 1,2,3,4 | 10 y | 2 y | + 5% | Tier 1,2,3,4 | 15 y | 3 y | + 10% | NPP,NEP, land cover,5 |
| Spectral vegetation | Input | 0.1 | 1 d | 1 d | + 1% | 2 | 1 d | 10d | + 3% | 1,3,6,7,9,12 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| greenness index | | | | | | | | | | |
| Temperature - air | Input | Tier 1,2,3 & weath.st a'ns | 0.02 d | 1 d | + 0.2 C | Tier 1,2,3 and weathe r stations | 0.5 d | 2 d | + 0.5C | 1,2,3,5 ,7,8,9,10,11,12 |
| Topography | Input | 0.01 | 10 y | 2 y | + 3% | 1 | 30 y | 5 y | + 10% | NPP,NEP,4,6 ,10,12 |
| Trace gas profile ($CO_2$) - Lower troposphere | Input | | | | | | | | | 4,6,10,12 |
| Trace gas profile ($HNO_3$) - Lower troposphere | Input | | | | | | | | | 4,6,10,12 |
| Trace gas profile ($N_2O$) - Lower troposphere | Input | | | | | | | | | 5,10,11 |
| Vegetation structure | Input | Tier 1,2,3 | 1 y | 6 m | + 5% | Tier 1,2,3 | 10 y | 1 y | + 10% | 4,6,7,10,12 |
| Volcanic sulphate aerosols | Input | At source | contin. during event | 1 d | +10% | At source | 5 d during event | 30 d | + 20% | ET,5,6,12 |
| Wind velocity | Input | Tier 1,2,3 | contin. | 1 d | + 10% | Tier 1,2,3 | hourly max and min | 10 d | + 15% | NPP |
| | | | | | | | | | | |
| Aerosols (total column)??or transmissivity measurements? | Ancillary | 1 | 1 d | 10 d | | 4 | 2d | 1m | | Satellite data corrections |
| Aerosols *In situ* | Ancillary | Tier 1,2,3 | continuo us | 1d | +5% | Tier 1,2,3 | Hourly | 5d | | Satellite data corrections |
| Cloud cover | Ancillary | Tier 1,2 | 0.01 d | 1d | +10% | Tier 1,2 | 0.04d | 5d | + 15% | Radiation - incoming short-wave satellite?? |
| Cloud cover satellite | Ancillary | 1 | 0.02 d | 1 d | +5% | 10 | 0.5 d | 10d | +10% | NEP,12?? |
| Decomposition rate | Ancillary | Tier 1,2,3 | 30 d | 30 d | +10% | Tier 1,2,3 | 60 d | 30 d | + 15% | NEP,12 |
| Fire type | Ancillary | 0.25 | 1 y | 1 m | 6 classes | 1 | 3 y | 3 m | 2 classes | Fire area and impact |
| Ozone (total column) | Ancillary | 1 | 1 d | 10 d | | 8 | 2 d | 1 m | | Satellite data corrections |
| Radiation - incoming short-wave *in situ* | Ancillary | Tier 1,2,3 | contin. | 1 d | + 1% | Tier 1,2,3 | 0.01 d | 30 d | + 1% | Radiation - incoming short-wave satellite |
| Radiation - reflected short-wave *in situ* | Ancillary | Tier 1,2,3 | contin. | 1 d | + 1% | Tier 1,2,3 | 0.01 d | 30 d | + 1% | Radiation - reflected short-wave satellite |
| Snow melting conditions | Ancillary | 10 | 1d | 2 d | 5 classes | 25 | 3 d | 3 d | 2 classes | Surface and ground storage fluxes;surface water flow-discharge |
| Snow water equivalent (SWE) *in situ* | Ancillary | Tier 1,2,3, surface network | 1 d | 2 d | + 5% | Tier 1,2,3, surface network | 3d | 3d | + 15% | Snow water equivalent satellite |
| Vegetation hydric stress index | Ancillary | 0.1 | 0.04 d | 1 d | +10% | 4 | 1 d | 2 d | + 20% | 1,2,5,6 ,10,12 |
| | | | | | | | | | | |
| Microwave backscatter | Measured | 0.01 | 1 d | 1 d | +0.2 dB | 1 | 2 d | 10 d | + 0.6 dB | 1,2,3,4,5 ,7,8,9,11,12 |
| Radiation - outgoing long-wave satellite (multispectral) | Measured | 0.01 | 1 d | 1 d | | 2 | 2 d | 1 m | | 1,2,3,4,5,6 ,7,8,9,10,11,12 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Radiation - reflected short-wave satellite (multispectral) | Measured | 0.01 | 1 d | 1 d | | 1 | 2 d | 1 m | | 1,2,3,4,5,6,7,8, 9,10,11,12 |

### *Ocean Requirements List*

The following list is the result coming from the *ad hoc* “ocean” group”, based on the list of requirements documented in the WMO stand-alone:

| ***Table IV*** | |
|---|---|
| ***Heritage: “Ocean” Group*** | |
| ***Variable*** | ***Application*** |
| | |
| Air pressure over sea surface | 7 |
| Wind vector over sea surface (horz.) | 1,5,6,7,8,9,10,11 |
| Wind speed over sea surface (horz.) | 1,5,6,7,8,9,10,11 |
| Significant wave height | 6,7,8,9,10,11 |
| Sea Surface Temperature | 1,5,6,8,9,10,11 |
| Wave period and direction | 6,7,8,9,10,11 |
| Sea level | 6,7,8,9,11,10 |
| Ocean Topography | 6,10,11 |
| Ocean Chlorophyll | 1,5,6,8,9,10, 11 |
| Ocean suspended sediment | 1,5,6,8,9,10, 11 |
| Ocean yellow substances | 1,5,6,9,10,11 |
| Ocean salinity | 1,5,6,8,9,10,11 |
| Ocean currents | 1,5,6,7,8,10, 11 |
| Sea Surface features | 1,5,6,8,9,10, 11 |
| Bathimetry | 6,7,8,9,10,11 |
| Habitat extent (land use) | 5 |
| Sea-ice cover | 6,8,9,10,11 |
| Sea-ice type | 6,8,9,10,11 |
| Sea-ice surface temperature | 6,8,9,10,11 |
| Ice-sheet elevation | 6,8,9,10,11 |
| Ice-sheet topography | 6,8,9,10,11 |
| Ice thickness | 6,8,9,10,11 |
| Icebergs | 6,7,8,9,10,11 |
| Crustal motion (horiz./vert.) | 6,7,10,11 |
| Photosynthetically active radiation (PAR) (or atmosph. transmission model) | 1,6 |
| Land surface features | 5 |
| Land use | 9 |
| Coastlines | 5,6,8,9,10 |
| PPS | 6,10,11 |
| Geoid | 6,10,11 |

| | |
|---|---|
| Earth Rotation | 6,10,11 |
| Crustal Plates Positioning | 6,10,11 |
| Crustal motion | 6,10,11 |

***Atmosphere Requirements List***

The following list is the result coming from the *ad hoc* “atmosphere” group. The variables for the application area “Climate Modelling”, indicated by the number 10, were divided into “validation” (v), “boundary (b)” and “initialisation (i)” conditions. The requirements are documented in the WMO stand-alone database.

***Table V***

***Heritage: “Atmosphere” Group***

| ***Variable*** | ***Application*** |
|---|---|
| | |
| Temperature Profile<br>-lower/higher troposphere | 4,6,10v<br>11 |
| Air temperature at surface over land | 10v |
| Wind profile (horiz. comp.)<br>-lower/higher troposphere | 4,10v<br>11 |
| Wind profile (vert. comp.)<br>-lower/higher troposphere | 4,10v<br>11 |
| Wind speed over land surface (horz.) | 10 |
| Wind speed over sea surface (horz.) | 10v&b |
| Wind vector over land surface (horz.) | 10v&b |
| Wind vector over sea surface (horz.) | 10,11 |
| Specific Humidity Profile<br>-lower/higher troposphere | 4,6,10v<br>11 |
| Air relative humidity (at surface) | 10 |
| Air pressure over land surface | 10,11 |
| Air pressure over sea surface | 10v,11 |
| Cloud water profile | 10v |
| Precipitation rate at ground (liquid) | 11 |
| Cloud cover | 6,10v |
| Cloud type | 10 |
| Cloud base height | 10v |
| Cloud top height | 10v |
| Cloud drop size | 6,10v |
| Cloud optical thickness | 6 |
| Cloud Imagery | 6 |
| Precipitation Index | 10v |
| Aerosol profile | 4,6,10v&b |
| Aerosol (total column) | 4,10 |
| Ozone profile/total | 4,10v&b |
| Trace Gases profile/total | 4,10v&b |
| Vegetation type | 4,10v&b |
| Fires | 4 |

| | |
|---|---|
| Solar irradiance at TOA | 4,6,10b |
| Photosynthetically active radiation (PAR) | 6 |
| Long-wave Earth surface emissivity | 10 |
| Short-wave outgoing radiation at TOA | 6,10v |
| Long-wave outgoing radiation at TOA | 6,10v |
| Short-wave cloud reflectance | 10v |
| Long-wave cloud emissivity | 10v |
| Short-wave Earth surface radiation | 10v |
| Short-wave Earth surface reflectance | 10v |
| Long-wave Earth surface reflectance | 10v |
| Long-wave earth surface emissivity | 10v |
| Albedo | 10v&b |
| Sea surface temperature | 10v&b,11 |
| Sea-Ice Surface temperature | 10 |
| Land surface temperature | 10v |
| Soil moisture | 10v |
| Sea-Ice cover | 6,10v |
| Sea-Ice Thickness | 10v |
| Sea-Ice type | 6 |
| Normalised differential vegetation index (NDVI) | 10v&b |
| Snow water equivalent | 10 |
| Snow cover | 10v |
| Snow depth | 10v |
| Ice-sheet elevation | 10v&b |
| Ice-sheet topography | 10v&b |
| Significant wave height | 10v |
| Ocean Currents | 11 |
| Sea surface topography | 6 |
| Ocean Chlorophyll | 6,10v |
| Ocean yellow substances | 10v |
| Ocean suspended sediments | 6,10v |
| Ocean Topography | 10v&i |