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WORLD METEOROLOGICAL
ORGANIZATION

INTERGOVERNMENTAL
OCEANOGRAPHIC COMMISSION

REPORT OF THE GCOS SPACE-BASED OBSERVATION TASK GROUP

(Darmstadt, Germany, May 3-6, 1994)

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TABLE OF CONTENTS

1.	ORGANIZATION OF THE MEETING	1
1.1	Opening of the Meeting	1
1.2	Approval of the Agenda	1
1.3	Working Arrangements for the Meeting	1
2.	INTRODUCTION AND GCOS BACKGROUND	1
3.	OPENING STATEMENT OF THE TASK GROUP CHAIRMAN	2
4.	INVITED REPORTS	3
4.1	Overview of Space-based Climate Observations	3
4.2	Other Reports	4
5.	CONSIDERATION OF THE GCOS SPACE PLAN	5
5.1	GCOS Space-based Observation Concept	5
5.2	Review and Discussion of the GCOS Space Plan	6
5.3	GCOS Space-based Data Requirements	7
5.4	Space Agency Programmes in Support of GCOS	7
5.5	CEOS Relationship	7
6.	DEVELOPMENT OF THE GCOS SPACE PLAN DOCUMENTATION	8
6.1	Working Groups	8
6.2	Documentation of the GCOS Space Plan	9
7.	SPECIFIC PROPOSALS FOR FUTURE WORK	9
8.	CLOSURE OF THE MEETING	10

ANNEXES

- I. List of Participants
- II. Agenda
- III. Terms of Reference for the Space-Based Observation Task Group
- V. **GCOS** Missions
- Iv. Summary of the GCOS Space Plan

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SPACE-BASED OBSERVATION TASK GROUP

1. ORGANIZATION OF THE MEETING

1.1 Opening of the Meeting

1.1.1 Dr. Peter Ryder, Chairman of the Space-Based Observation Task Group, opened the meeting at the Headquarters of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT) in Darmstadt, Germany on 3 May 1994 and welcomed the participants (See Annex I).

1.1.2 As the local host of the meeting, Mr. John Morgan, EUMETSAT Director, welcomed the participants to the his Headquarters. He reminded the participants that EUMETSAT has a keen interest in GCOS, and expressed the willingness of his organization to assist the GCOS programme, particularly with regard to its space-based observational activities. He discussed the logistical arrangements for the meeting.

1.1.3 The Chairman, noting that the participants represented diverse communities, invited them to make brief introductions.

1.2 Approval of the Agenda

1.2.1 The Chairman reviewed the provisional agenda and outlined the aim of the meeting. The agenda was discussed and approved with slight modification (See Annex II).

1.3 Working Arrangements for the Meeting

1.3.1 The Chairman suggested a schedule of the meeting. He noted that he would be able to chair only the first two days and invited Mr. Morgan to assume the chair for the following two days. He reviewed the documentation that was prepared for the meeting.

2. INTRODUCTION AND GCOS BACKGROUND

2.1 Dr. **Spence**, Director of the Joint Planning Office (JPO) for GCOS, provided an overview of the GCOS activities to date. He reviewed the highlights from the inception of the program at the Second World Climate Conference to the present meeting and noted the responsibilities of the Joint Scientific and Technical Committee (JSTC) in planning, implementing and overseeing the development of the GCOS programme. He specifically noted that the Third Session of JSTC had established several discipline-oriented panels and cross-cutting task groups.

2.2 The Director described the other panels and task groups, pointing out their responsibilities. He reported on the recent meetings of the Data System Task Group and the Ocean Observation System Development Panel (OOSDP). He particularly noted the meeting of the Atmospheric Observation Panel (AOP) which was held in Hamburg, Germany the preceding week.

2.3 He pointed out that the Space-based Observation Task Group is expected to begin the development of the GCOS Space Plan and to address particularly the GCOS Initial Operational System (**IOS**) and its implementation. The Task Group will make its recommendations to the JSTC. Further, the Task Group should suggest ways for the GCOS programme to make its plans known to organizations such as the Committee on Earth Observation Satellites (CEOS).

3. OPENING STATEMENT OF THE TASK GROUP CHAIRMAN

3.1 The Chairman, referring to the terms of reference of the Task Group (See Annex III) reviewed the objectives, work plan, and actions to be taken. He noted that the principal activity for this meeting would be the consideration of the Draft Space Plan document, developed by Dr. Croom, Dr. Brownscombe, and Mr. Matsuura, that was provided to the members. He stated that the plan for space-based observations must be rooted in science, must recognize the user community needs, and must be presented to the appropriate agencies that are engaged in the provision of space-based observations. He considered the user requirements to be the 'driving force' for the process.

3.2 The Chairman reviewed the activities of the GCOS panels, and noted that they had not yet provided adequate guidance concerning scientific requirements to fully specify the detailed needs for space-based observations. He indicated that their input, combined with inputs from a number of other sources, would be essential in this regard, but that this Task Group would have to begin the process and in the future, assimilate and synthesize inputs into a consistent set of scientific requirements for GCOS which could be convincingly presented to space agencies.

3.3 With regard to the development of user requirements, the Chairman pointed out the need to for the GCOS programme to cooperate with other research and operational programmes. He noted that the GCOS space requirements may differ from those of other programmes, especially insofar as GCOS has a clear need for long-term continuity to address climate data objectives. Thus, while satellite instruments and missions may undergo changes as they evolve, GCOS will require intercomparability among instruments or missions to provide the needed continuity and consistency of the observational base. He recommended that certain non-space observations should be included in the remit of the Task Group. For example, calibration and validation activities are critical to ensure that data and products of high quality are made available.

3.4 The Chairman felt that the Task Group and its successor could provide an effective bridge between user communities and agencies providing space observations. He stated that the GCOS programme would need to develop well documented requirements in order to persuade space agencies to develop and continue missions which would yield the

consistent data products required for climate purposes. He expected that detailed requirements from GCOS would provide useful guidelines that space agencies would find valuable.

3.5 The Chairman then summarized his view of the responsibility of the Task Group. It is to: (1) develop current and future requirements for data and products, considering the objectives of GCOS; (2) examine the role for space-based observations in meeting these requirements; and (3) develop appropriate documentation to persuade the agencies responsible for space-based observations and data to undertake activity to provide the essential observations, and products based upon them as required.

3.6 The remarks of the Chairman prompted considerable discussion among the members of the Task Group. Members were concerned about the relationship of the various GCOS panels to the work of the Task Group since they recognized that many of the **space-based** observational issues are truly interdisciplinary. The Chairman noted that the Task Group has the responsibility to communicate its concerns to the JSTC to ensure that integrated planning occurs, and he agreed to communicate their views of this point. Several members reinforced the Chairman's view that both research and operational viewpoints be included in the development of requirements. Some noted further that the user community is quite diverse, and that consistent priorities would be difficult to establish.

4. INVITED REPORTS

4.1 Overview of **Space-based Climate Observations**

4.1.1 Professor Harries was invited to present an overview of climate applications of current satellite data. In his presentation, he stressed that the approach is to utilize available space-based observations in the context of specific climate theories. Seldom are the available observations taken as a result of a consistent and overall design. He noted the crucial role of GCOS in taking an integrated approach to design criteria in which the assessment of the value and priority of observations is solidly based on an evaluation of the purposes for which they will be used.

4.1.2 Prof. Harries selected several types of **satellite** data to illustrate the role of space-based observations in climate problems. He first considered radiation, and described available observations of humidity and cloudiness. He noted the close relationship in the research community between the observations and computer simulations -- many of the observations must be assimilated via models to produce the essential products.

4.1.3 He used observations of the chemical constituents in the stratosphere to further illustrate a role for GCOS. He noted that some observations, such as **total** ozone, will surely be continued, while other observations now being taken (e.g., from the UARS mission) may not be continued. He felt that GCOS could serve an important function by developing a rationale and methodology for selecting those observations which should be continued or which require repeat missions at an appropriate interval.

4.1.4 He also illustrated the variety of uses for Sea Surface Temperature (SST), showing how space-based data are needed both in seasonal-to-interannual prediction and for detection of climate change.

4.1.5 Prof. Harries concluded by noting several particular areas where space-based observations will be critical. His examples include: (1) time-resolved earth radiation budget; (2) spectrally-resolved outgoing long wave radiation; (3) chemical constituents in the stratosphere and troposphere; (4) 3-D cloud imagery; (5) tropospheric winds; and (6) aerosols. He urged the Task Group to recognize what may potentially be measured from earth observation satellites, but to be attentive to the purposes and applications for which such observations would be used.

4.1.6 Members appreciated Prof. Harries' review. They agreed that the scientific questions should provide the basis of the requirements. Some also stressed that for some issues, model diagnostics play a role comparable to observations, particularly for applications.

4.2 Other Reports

4.2.1 Dr. Hinsman was invited to review, from a historical perspective, the development of satellite data requirements by the World Meteorological Organization (**WMO**). The evolution of these requirements has taken many years, but has recently resulted in a comprehensive matrix indicating the parameters, the purposes for which they are required, the resulting accuracy and sampling constraints, and the recommendations for platforms and instruments.

4.2.2 Dr. Hinsman noted that the WMO, as an Affiliate Member of CEOS, has recently documented its requirements to the Committee. Subsequently, the other affiliates have cooperated to provide a comprehensive suite of requirements to CEOS. This information was presented in a consolidated document at the latest plenary in Japan.

4.2.3 The Task Group members recognized that the development of satellite data requirements by WMO provided an example which would be useful to follow in its development of its space plan. However, it was noted that the requirements of the various affiliates would represent individual programme objectives and therefore have a set of unique requirements, although subsets of the requirements could be common to many **affiliates**. While an ensemble approach toward requirements may be taken for CEOS, GCOS should develop its specific requirements and priorities to satisfy its objectives. This has already been done by some other affiliate members of CEOS.

4.2.4 Dr. Ratier presented some recent sea surface topography results from the **TOPEX/Poseidon** (T/P) mission. He described the process whereby the science community provided extensive input in the design of the mission, and will be consulted to provide guidance about future such missions. After the demonstration T/P mission, a follow-on is proposed to contribute observations necessary to quantify the ocean's role in heat transport and the global carbon cycle, as well as the long-term ocean circulation and mean sea level changes.

4.2.5 Dr. Rao contrasted the needs for weather prediction and climate, and illustrated the spatial and temporal relationships between the two. For climate change detection, for example, observations should be done continuously or at regular intervals for extended periods and on global or very large scales, albeit with high accuracy and consistency. Weather prediction, on the other hand, requires more frequent observations and higher spatial resolution. Thus, while both may specify requirements for the same parameters, the constraints on the observational systems to meet the requirements may be quite different.

4.2.6 The Chairman invited Dr. Mitchell to review the status of the study of user requirements being conducted on behalf of GCOS by Smith System Engineering Ltd., with support from the Japanese Space Agency (NASDA) and in collaboration with a similar study by the Hadley Centre in the UK. Dr. Mitchell reviewed the methodology of the study which was to: (1) develop a comprehensive questionnaire for the user community; (2) distribute it to a few dozen research centres, institutions, or key individuals for their input; (3) compile and analyze the results; (4) distribute the preliminary results to the correspondents for their review and further input; and (5) prepare a final report for the JSTC. Dr. Mitchell noted that the questions addressed both the space and ground segments, and spanned a number of variables, but that it did not specifically address climate impact requirements.

4.2.7 In his interim report, Dr. Mitchell noted that 40% of the questionnaires had been returned and the preliminary results compiled into documents made available to the Task Group. Regarding the space segment, respondents were concerned to have consistent, long-term, high-quality data. They urged that advanced instruments be flown on repeat or operational missions. Regarding the ground segment, they were concerned with the timeliness and flexibility of the data, processes of assimilation and gridding, and archiving with quality assurance standards. Many respondents stressed the need for products rather than data, and urged that they be developed consistently with documented validation and where possible, include effective mechanisms to accept user feedback.

4.2.8 Dr. Mitchell suggested that the way forward will include regular updates of the user requirements, identification of gaps, and the recommendations for action.

4.2.9 Task Group members noted that some key users had not been consulted, and stressed that a more comprehensive approach would be required as the planning proceeds. The Chairman agreed that GCOS user requirements would involve not only the Smith study, but the work of the other GCOS panels which is still underway. However, he urged the Task Group to proceed with its work in developing a space plan.

5. CONSIDERATION OF THE GCOS SPACE PLAN

5.1 GCOS Space-based Observation Concept

5.1.1 Dr. Croom introduced the draft GCOS Space Plan, and provided an overview of the document. He invited the Task Group members to provide input for subsequent drafts, noting in particular that much needs to be supplied regarding requirements and technical details. He suggested that some of this material will be specified as a result of the study of

data requirements being conducted by Smith System Engineering Ltd., the related work of national agencies, international organizations, other CEOS affiliates, and other JSTC subsidiary bodies.

5.1.2 The members of the Task Group expressed appreciation to Dr. Croom for his efforts in providing a comprehensive document to guide the work of the group. Members provided many specific comments on the GCOS Space Plan which will be helpful in the revision of the document. Some particular points to be addressed in the revision include:

detailed discussion of primary satellite data applications;

indicating the relationship to other research activities (e.g., WCRP, IGBP);

showing the links to operational programmes (e.g., **WMO/CBS** Working Group on Satellites);

including the more active involvement of developing countries.

5.1.3 The members agreed that the subsequent process of developing the plan will be evolutionary. They proposed this process be the responsibility of an ongoing Space-based Observation Panel which should be established by the JSTC to continue the development and refinement of the plan (See section 7).

5.2 Review and Discussion of the GCOS Space Plan

5.2.1 The Chairman next focused attention on the detailed development of the plan and suggested a sequence of steps for the Task Group: (1) select the necessary observations that will meet GCOS requirements, especially those for the Initial Operational System (**IOS**); (2) develop a mission based approach to relate specific plans to GCOS requirements; (3) identify gaps and shortfalls of the plans of the agencies providing space-based data in meeting these requirements; and (4) develop proposals to rectify the gaps and shortfalls.

5.2.2 Following this strategy, the Task Group considered the observing system requirements for the **IOS** which consists of currently operational system components, those necessary enhancements which **are** proven and could be implemented using current technology, and a comprehensive data system.

5.2.3 To proceed, the Task Group reconsidered the purposes for which the observations should be taken, and identified five specific ones:

- (i) the detection of climate change, including anthropogenic influence;
- (ii) the prediction of seasonal-to-interannual variability;
- (iii) the determination of climate forcing and response functions;
- (iv) the validation of models (and their initialization if appropriate);

- (v) the monitoring of climate, including regional climate anomalies.

It was noted that some observations will likely satisfy several of these purposes, while for others, dedicated observations may be required. However, it was agreed that these specific purposes be used to assess and prioritize the observations needed. The Chairman **proposed** that a **small** working group on requirements be identified to consider this task.

5.2.4 The Task Group next considered the concept of a “GCOS Mission”. The group agreed that a relatively small number of such GCOS Missions could be defined to address the purposes above, and could also be used to assess the specific missions underway or being considered by the agencies. The Chairman proposed this issue be addressed by a small working group on mission definition.

5.3 GCOS Space-based Data Requirements

5.3.1 The Task Group recognized the work already done in developing requirements for space-based data, especially for atmospheric observations. At its meeting the preceding week, the AOP agreed that for many climate purposes, the measurements being made for Numerical Weather Prediction (**NWP**) provided a fundamental data base, and that current accuracies and sampling, while not optimal, are adequate for the present. However, the AOP did identify additional parameters, particularly for boundary conditions, radiation, and atmospheric constituents which are not adequately being observed to meet GCOS objectives. Thus, the Task Group recommended that the working group on requirements consider the degree to which additional and more specific constraints may be placed on the meteorological parameters.

5.3.2 Apart from the efforts of research programmes (e.g., WCRP, IGBP, etc.) space-based data requirements for ocean and terrestrial/ecosystem parameters are not well established yet. In this area, both the OOSDP and the GCOS/GTOS Terrestrial Observation Panel are providing helpful guidance. But, despite the limited input on specific requirements available at this stage, the working group on requirements was nevertheless urged to make an initial attempt to identify requirements and to suggest future steps to add additional detail.

5.4 Space Agency Programmes in Support of GCOS

5.4.1 The Task Group recognized that there were many missions, satellites, and instruments of relevance to GCOS already underway or in advanced planning stages. Mr. Matsuura presented a background document which compiled and described the various missions/instruments being developed or considered for development by the space agencies. Such information is essential for the development of the plan. It was agreed that agency plans should be reviewed and included on the agenda of the working group on mission definition.

5.5 CEOS Relationship

5.5.1 The Task Group appreciated that GCOS is an affiliate member of CEOS. It further recognized that CEOS could be a primary avenue for GCOS to provide advice to the space agencies to develop programs which respond to the needs of GCOS and related climate

requirements. The Task Group also recognized that the other affiliates should work closely with GCOS to assist in developing a comprehensive earth observing system to meet societal needs such as climate change.

6. DEVELOPMENT OF THE GCOS SPACE PLAN DOCUMENTATION

6.1 Working Groups

6.1.1 The Chairman proposed that the Task Group divide into the two working groups identified above to consider: (1) developing and updating the GCOS user requirements; and (2) defining the space missions/instruments relevant to GCOS, including a review of current space agency plans.

6.1.2 The first working group was tasked to consider the parameters required for the various purposes noted in section 5.2.3, to establish priorities, and to address necessary coverage, temporal sampling, and accuracy. The working group first consulted the available documentation concerning user requirements. While the group could agree on the fundamental parameters to be included, it faced immediate difficulties in specifying necessary details concerning the observations. The working group noted that respondents to the user requirement study often specified their needs in terms of products (which are often based on analyses of a number of satellite fields or involve model interpretations) rather than data. Thus, specification of actual data accuracy or sampling details depends on the product requirements which, in turn, depend on the applications for which the product is to be used.

6.1.3 The working group nevertheless developed a series of matrices which displayed, for each parameter, the purposes for which the parameter might be used, and the coverage, temporal sampling and accuracy likely to be required. For nearly all the parameters, the working group recognized the need for continuity and consistency of measurements (same instrument suite or compatibility between generations of instruments) as well as careful calibration and validation. Members of this working group agreed to continue working on this assignment after the conclusion of the Task Group meeting to provide further input to the GCOS Space Plan.

6.1.4 The second working group considered the definition of space instruments relevant to GCOS in the context of GCOS missions. The group recommended that seven such missions be considered. The missions would address: (1) global radiative properties; (2) ocean characteristics; (3) ocean-air boundaries; (4) atmospheric dynamics; (5) atmospheric composition; (6) land-air boundaries; and (7) biosphere climate response. The mission concept permitted the working group to assign all the ongoing operational and proposed mission/instruments to a particular component. A schematic diagram was developed by the working group (See Annex IV).

6.1.5 The working group also reviewed current and planned space programmes, and identified mission/instruments which met or approached GCOS user requirements. In addition, it identified several instruments which are not currently planned. Their recommendations include: (1) a conical scan radar for wave height and wave spectra; (2) a radar altimeter for ocean wind speed; (3) a low frequency radar for ice topography; and

(4) the continuation of the radar mission for precipitation. Regarding atmospheric chemistry, the group recommended further consideration be given to the selection of constituents to be observed.

6.1.6 The group noted that candidate space instruments for GCOS missions must be evaluated in light of issues such as data continuity and data consistency, since these are priority concerns for GCOS.

6.2 Documentation of the GCOS **Space** Plan

6.2.1 Based on the plenary discussions and the results of the two working group sessions, a strategy for refining the GCOS Space Plan was developed. Comments and inputs would be reflected in a subsequent draft document to be circulated to the attendees. After their review, the **final** version would be provided to the JSTC in September for their approval and then would be prepared for the CEOS plenary meeting later that month.

6.2.2 While this process of preparation is underway, a synopsis of the GCOS Space Plan has been included in Annex V.

7. **SPECIFIC PROPOSALS FOR FUTURE WORK**

7.1 The Task Group agreed that a standing Space-based Observation Panel should be established by the JSTC to continue **the** work begun by the Task Group. The group reviewed the terms of reference, and made a few suggestions which will be included in the Chairman's report to the JSTC. In particular, they urged that developing countries become more involved in future activities and that additional experts and consultants be invited to attend future meetings and actively participate in developing the plan.

7.2 The Task Group urged that meetings be scheduled more frequently until the initial plan has been completed. After that stage, less frequent meetings to maintain the currency of the plan would be appropriate.

7.3 The group urged that dedicated people be identified to work on the plan. While background documents may be prepared from panel and task group meetings, it was clear that additional resources must be found and used to expeditiously develop the **space-**based component of GCOS.

7.4 Noting the emphasis from the user community on products, the Task Group recommended that a suite of essential products should be drawn up based on input from both developed and developing countries. Similarly, the Task Group recognized that **additional** inputs are needed to complete the set of user requirement matrices. Several members volunteered to continue this as an intersessional activity.

7.5 The Chairman proposed that the concept of GCOS Missions be developed further by relating them to the purposes for which the observations are required and the missions/instruments of the agencies. Using such a construct, the gaps that are uncovered

should be identified to appropriate agencies for action. Several members agreed to continue this activity.

7.6 The report of the Task Group and the Chairman will be tabled at **JSTC-IV**.

8. CLOSURE OF ~~THE~~ MEETING

8.1 The Chairman thanked the participants for their contributions to the Task Group and closed the meeting at noon on Friday, 6 May 1994.

Annex I

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Annex I, page 2

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Annex II

Agenda

1. ORGANIZATION OF THE MEETING
 - 1.1 Opening of the meeting
 - 1.2 Approval of the agenda
 - 1.3 Working arrangements for the meeting

2. INTRODUCTION AND GCOS BACKGROUND

3. OPENING STATEMENT OF THE TASK GROUP CHAIRMAN

4. INVITED REPORTS
 - 4.1 Overview of space-based climate observations
 - 4.2 Other reports

5. CONSIDERATION OF THE GCOS SPACE PLAN
 - 5.1 GCOS space-based observation concept
 - 5.2 Review and discussion of the GCOS Space Plan
 - 5.3 GCOS space-based data requirements
 - 5.4 Space agency programmes in support of GCOS
 - 5.5 CEOS relationship

6. DEVELOPMENT OF THE GCOS SPACE PLAN DOCUMENTATION
 - 6.1 Working groups
 - 6.2 Documentation of the GCOS Space Plan

7. SPECIFIC PROPOSALS FOR FUTURE WORK

8. CLOSURE OF THE MEETING

Annex III

Terms of Reference for the Space-based Observation Task Group

Recognizing the need for a comprehensive approach to the various space-based observational activities for the Global Climate Observing System, the JSTC hereby establishes an ad hoc Space-based Observation Task Group. The Task Group has the following terms of reference.

Terms of Reference:

Based on guidance in the *Draft Plan* for GCOS, the ad *hoc* Space-based Task Group will be established for a period of nine months with the objectives to:

- o Develop a plan for the space-based observation components of GCOS, considering the GCOS requirements, inputs from the science panels, and the needs of the GCOS user community;
- o Develop, define, integrate, interpret, and promote the space-based observational requirements of the user communities carrying out climate studies and providing related advice and services;
- o Recommend how these requirements may be met, including, when possible, proposed responsibility for implementation and funding;
- o Define and propose to the JSTC the ongoing responsibilities of a Space-based Observation Panel to exploit space systems in meeting the objectives of GCOS.

In order to accomplish this the Task Group will:

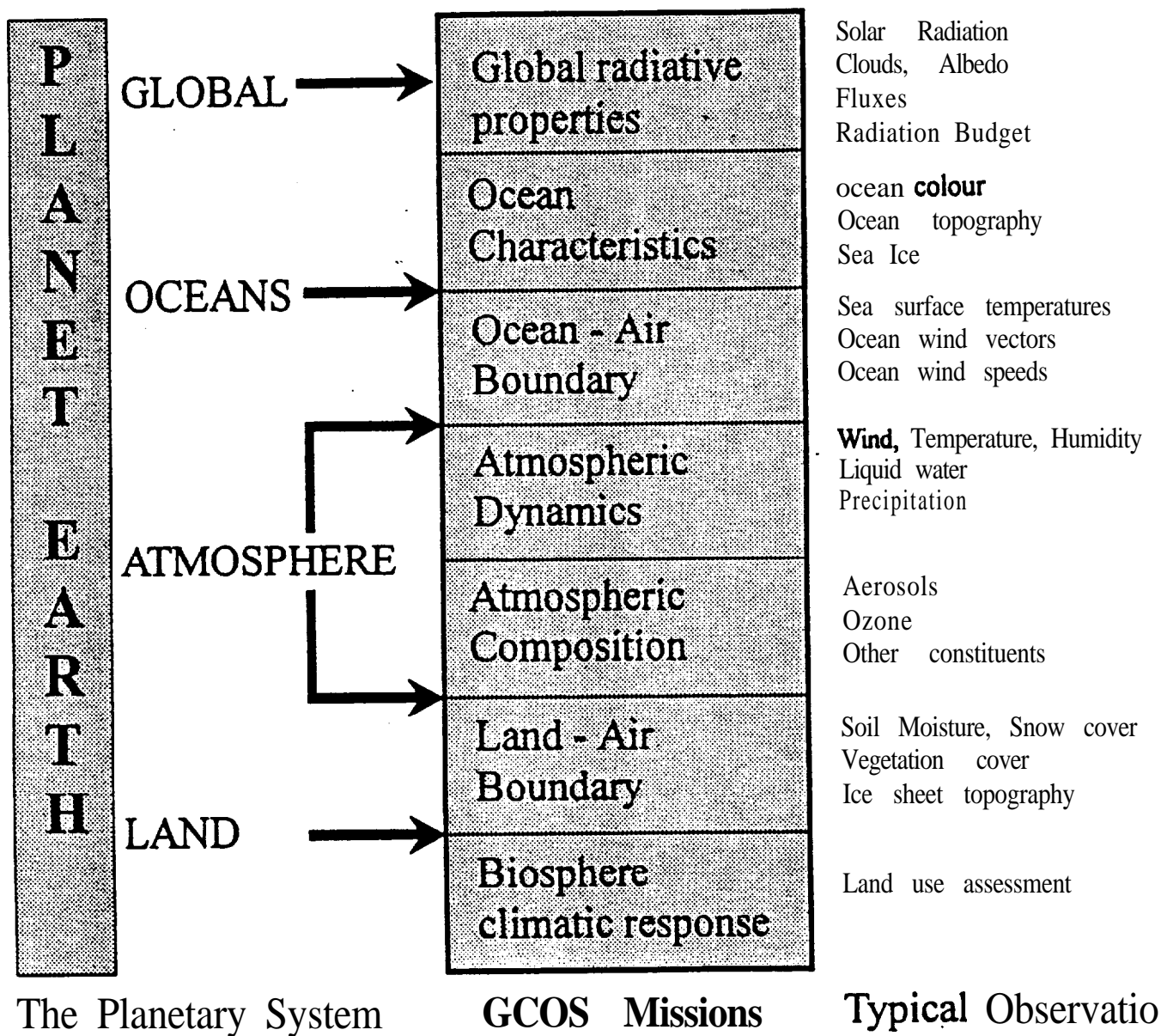
- i) maintain close contact with the user community, collaborators, and potential suppliers, to encourage innovation and achieve the closest **possible** match between user requirements and technical solutions;
- ii) prepare and maintain documents that:
 - (a) describe the prioritized capabilities required of the space agencies and their sustaining industries and research activities,
 - (b) reassure the user community that their needs are being properly recognized,
 - (c) advise and assist developing countries in exploiting the data and services which will result from space-based observations;

- iii) generate a GCOS Space Plan which will define the activities necessary to:
- (a) establish an Initial **Operational** System for climate, comprising the space and associated ground segments, and including validation activities and integration with *in situ data* sources;
 - (b) identify the enhancements to present components of the operational system that are required to satisfy the needs of the user community;
 - (c) secure an operational observing system, designed to meet those needs, which will overlap with and follow-on from the end of the currently planned space missions, extending to about 2030.

Chairman: Dr. Peter Ryder, UK

Annex IV

Schematic Diagram of the GCOS Missions



Annex V

Summary of the GCOS Space Plan

Introduction

1. The GCOS Space Plan is intended to identify and prioritize the requirements for spaced based observations to meet the principal applications driving GCOS, namely:

- o **Detection** of climate change, especially anthropogenic effects and regional climate anomalies
- o **Determination** of climate forcing and response functions (i.e., due to solar radiation variations, aerosol loading etc.)
- o **Prediction** of seasonal, annual and **interannual** variability
- o **Validation** of models (including **initialisation** as appropriate)
- o **Monitoring** of climate, including maintenance of records.

2. The Space Plan will be developed to meet the requirements posed by these applications by considering the implications of these requirements on satellite observing systems. The Space Plan should provide a link between the GCOS requirements and the capabilities of the current and future missions of space based data providers. These providers include national and international space agencies and the operators of operational meteorological and earth resources satellites. The result should be an assessment of the extent to which those plans meet GCOS needs, and specific recommendations to the providers when the plans are insufficient.

3. For the Initial Operational System (**IOS**) up to about the year 2005, the plan aims to identify where requirements are being completely or partially met and where small adjustments to programmes, payloads, individual instruments or data processing might fill identified gaps. The consideration of those gaps not capable of being filled by minor adjustments to the **IOS** leads to suggestions for new observing systems for the later post-**IOS** system.

4. The GCOS Space Plan will be an evolving document, updated as necessary to include the requirements for global climate observations to address both the needs; for the current applications and possible future applications as they emerge. The Plan will also be updated as necessary to incorporate new information from the providers of space based data identified above on their current and future planned space programmes which may be potential contributions to GCOS.

5. This first draft of the GCOS Space Plan brings together information available to the members of the first Task Group on the data/products requirements of users involved in the principal applications driving GCOS, and the current knowledge of existing and **firmly** planned space missions. The results of ongoing studies of requirements for ocean and terrestrial applications and the final results of the NASDA • GCOS studies will be incorporated as they become available.

6. It is anticipated that the JSTC will wish to solicit input widely from involved national and international agencies and scientific experts in the essential process of validating and continually updating the GCOS Space Plan. Only in this way will the programmes help the agencies providing data to meet the needs for climate applications for long term climate observations from space more effectively.

Work Accomplished

7. To assist in determining which existing and planned space programmes will contribute to meeting GCOS requirements, the Space-based Observation Task Group **categorised** the observational requirements into seven "GCOS Missions" chosen to reflect scientific needs. They are:

1. Global Radiative Properties
2. Ocean Characteristics
3. Ocean-Atmosphere Boundary
4. Atmospheric Thermodynamics
5. Atmospheric Composition & Chemistry
6. Land-Atmosphere Boundary
7. Land Biospheric Climatic Response

Not all the scientific requirements for these missions have been adequately stated to date. Further, most can be expected to change as further knowledge and insight is obtained.

8. For each of these missions, the known available and planned space observing instruments were analyzed to identify the extent to which they were able to satisfy general requirements. These included: (1) identifying those parameters for which useful measurements could be made, (2) identifying the availability of operational platforms, and (3) assessing **the** potential for continuity. This process needs to be extended to assess the **enhanced** usefulness of particular combinations of instruments which may be synergistic.. In addition, the quantitative relations between data/products requirements and instrumental performances need much more detailed investigation.

9. However, even at this preliminary stage some important actions may be recommended to adjust existing and planned space observing systems in ways which would greatly enhance the utility of the data and products for the principal GCOS applications. These recommendations should be considered by both the data providers and data users to determine what may be accomplished during the period of the Initial Operational System up

to about 2005. An excerpt of the Task Group recommendations, and a suggested work plan to implement them, is provided in the next section.

Recommendations for the Initial Operational System (IOS)

10. It is clear that the GCOS Initial Operational System (**IOS**) must rely almost entirely on the existing planned programmes of the major providers of space-based data. The review of these programmes undertaken in the production of this initial draft GCOS Space Plan shows that major contributions to all areas of GCOS data requirements are already being made. The operational meteorology satellites, in particular, underpin and provide critical atmospheric, ocean and land observations. Other environmental and applications satellite programmes will also provide valuable contributions if they can be maintained to provide long term continuity and observational consistency.

11. The principal recommendations for activities for the **IOS** are:

- (a) Very high priority must be given to the maintenance of coverage by polar and geostationary operational meteorological satellites to continue and enhance the existing record of the atmosphere and surface;
- (b) Those aspects of the environmental satellite programmes of CEOS members, which potentially provide additional contributions to the **IOS**, need to be continued to provide consistent 10 to 15 year data sets at a minimum;
- (c) In nearly all areas, data processing efforts need to be increased to produce high level products for the principal GCOS applications. This will encourage the wider use of satellite data products and enhance their potential in climate studies;
- (d) Comprehensive archiving of GCOS related satellite data is required at the highest fully reversible level to allow reprocessing when improved calibration information becomes available;
- (e) To provide the best possible absolute calibration for long term consistency, instruments should be well calibrated in **specialised** calibration facilities before launch, intercompared in space - both with other similar instruments on the same satellite or other satellites, and by overlapping series of observations carefully validated against in-situ measurements either in special campaigns or routinely;
- (f) Since the future programmes of many agencies are subject to change, sometimes at short notice, it is essential that the implications of such changes for the GCOS **IOS** are expeditiously investigated as unexpected gaps or inconsistencies may otherwise occur in important parameter records;

- (g) The technical and cost implications of providing the additional features required to complete the **IOS** should be given urgent consideration by the space-data providing agencies and the various national and international bodies who fund climate research and monitoring.

12. It is important that scientists and applications specialists from developing countries are able to play a full part in GCOS both by providing essential observations for GCOS from their climatologically important areas and in developing their capability to provide regional advisory services dealing with both seasonal and interannual forecasting and long term climate change.

13. More detailed recommendations with respect to individual space programmes, missions, spacecraft payloads and instruments will need to be refined in cooperation with the agencies involved when the implications of the users requirements for the detailed performance specification of instruments individually or in combination have been studied in more depth.