General Assembly

Distr.: Limited
21 November 2003

Original: English

Committee on the Peaceful Uses of Outer Space
Scientific and Technical Subcommittee
Forty-first session
Vienna, 16-27 February 2004
Item 6 of the provisional agenda*
Implementation of the recommendations of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III)

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Final report of the Action Team on Weather and Climate Forecasting

I. Introduction

1. The Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE III), held in Vienna from 19 to 30 July 1999, adopted "The Space Millennium: Vienna Declaration on Space and Human Development".[1] The nucleus of a strategy to address global challenges in the future included the protection of the Earth's environment and managing its resources. It further noted that several related actions should be taken, including the enhancement of weather and climate forecasting by expanding international cooperation in the field of meteorological satellite applications.

* A/AC.105/C.1/L.270.

II. Mandate and background

2. In accordance with General Assembly resolution 55/122 of 8 December 2000, the Committee on the Peaceful Uses of Outer Space at its forty-fourth session considered the implementation of the recommendations of UNISPACE III. The Committee noted that a survey had been conducted among Member States to identify the level of interest and priority for each action constituting the nucleus of a strategy contained in the Vienna Declaration to address global challenges in the future and that Portugal had offered to lead an action team to enhance weather and climate forecasting through expanded international cooperation in the field of meteorological satellite applications. Since its formation, the Action Team on Weather and Climate Forecasting has held several workshops and meetings at which Member States have provided information on the current status of international cooperation in the field of meteorological satellite applications that would enhance weather and climate forecasting. The workshops and meetings have been held in conjunction with the annual sessions of the Committee and its Scientific and Technical Subcommittee. The World Meteorological Organization (WMO), a specialized agency of the United Nations for meteorology and operational hydrology, has assisted the Action Team and recently agreed to serve as a co-leader with Portugal.

3. The Action Team agreed that, in order to fulfil its mandate, it should review existing satellite-based observing systems, including access and dissemination services; current weather and climate forecasting systems and the contributions they make to early warning and monitoring of high impact weather; and mechanisms for international cooperation. The Action Team noted that its activities would overlap with several other action teams, including the one established to implement the recommendation relating to an integrated global system to manage natural disaster mitigation, relief and prevention efforts. However, the Action Team felt that the overlap was unavoidable, but appropriate, in order to identify synergistic recommendations of benefit to Member States.

III. Present and future observational systems

4. The Action Team on Weather and Climate Forecasting assessed the present and future observational systems. In particular, it noted that the meteorological community and associated environmental disciplines such as climatology, including global change, hydrology and oceanography all over the world were now able to take advantage of a wealth of observational data, products and services provided by specially equipped and highly sophisticated environmental observation satellites. An environmental observation satellite is an artificial Earth observation satellite providing data on the Earth's system. A meteorological satellite is a type of environmental satellite that provides meteorological observations. Several factors make environmental satellite data unique compared with data from other sources. It is worth noting a few of the most important factors:

(a) Because of its high vantage point and broad field of view, an environmental satellite can provide on a regular basis data from the areas of the globe yielding very few conventional observations;

(b) The atmosphere is broadly scanned from the altitude of the satellite and large-scale environmental features can be seen in a single view;

(c) The ability of certain satellites to view a major part of the atmosphere continuously from space makes them particularly well suited for monitoring and warning about short-lived meteorological phenomena;

(d) The advanced communication systems developed as an integral part of the satellite technology permit the rapid transmission of data from the satellite or their relay to operational users from automatic stations on the ground and in the atmosphere.

5. These factors are incorporated into the design of meteorological satellites to provide data, products and services through three major functions:

(a) Remote sensing of spectral radiation, which can be converted into meteorological measurements such as cloud cover, cloud motion vectors, surface temperature, vertical profiles of atmospheric temperature, humidity and atmospheric constituents, such as ozone, snow and ice cover, and various radiation measurements;

(b) Collection of data from in situ sensors on remote fixed or mobile platforms located on the Earth's surface or in the atmosphere;

(c) Direct broadcast to provide cloud cover images and other meteorological information to users through a user-operated direct read-out station.

6. The first views of Earth from space were not obtained from satellites but from converted military rockets in the early 1950s. It was not until 1 April 1960 that the first experimental meteorological satellite, the television infrared observation satellite TIROS-I, was launched by the United States of America and began to transmit basic, but very useful, cloud imagery. That satellite was such an effective proof of the concept that by 1966 the United States had launched the first of a long line of operational polar satellites and its first geostationary meteorological satellite. In 1969, the former Union of Soviet Socialist Republics launched the first of a series of polar satellites. In 1977, geostationary meteorological satellites were also launched and operated by Japan and the European Space Agency (ESA). Thus, within 18 years of the first practical demonstration by TIROS-I, a fully operational meteorological satellite system was in place, giving routine data coverage of most of the planet. The rapid evolution of such a very expensive new system was unprecedented and indicates the enormous value of the satellites to meteorology and to society. Some four decades after the first Earth images, new systems are still being designed and implemented, illustrating the continued and dynamic interest in this unique source of environmental data.

7. The ability of geostationary satellites to provide a continuous view of weather systems makes them invaluable in following the motion, development and decay of such phenomena. Even such short-term events as severe thunderstorms with a lifetime of only a few hours can be successfully recognized in their early stages and appropriate warnings of the time and area of their maximum impact can be provided expeditiously to the general public. For that reason, their warning capability has been the primary justification for geostationary spacecraft. Since 71 per cent of the Earth's surface is water, and even the land areas have many regions that are sparsely inhabited, the polar-orbiting satellite system provides the data needed to

compensate for deficiencies in conventional observing networks. Flying in a near-polar orbit, the spacecraft is able to acquire data from all parts of the globe in the course of a series of successive revolutions. For these reasons the polar-orbiting satellites are principally used to obtain: (a) data on daily global cloud cover; and (b) accurate quantitative measurements of surface temperature and of the vertical variation of temperature and water vapour in the atmosphere. There is a distinct advantage to receiving global data acquired by a single set of observing sensors.

8. The thrust of the current generation of environmental satellites is aimed primarily at characterizing the kinematics and dynamics of the atmospheric circulation. The ability to achieve such objectives was demonstrated during the Global Weather Experiment in 1979. This capability is now part of the global operations of the World Weather Watch (WWW) of WMO. The existing network of environmental satellites, forming part of the Global Observing System (GOS) of WWW, produces real-time weather information on a regular basis. This is acquired several times a day through direct broadcast from meteorological satellites by more than 1,300 stations located in 125 countries.

9. During 2002, the most significant and important change since the early 1990s took place in WWW. The space-based component of GOS was expanded to include appropriate research and development satellite missions. In 2001, the Executive Council of WMO approved the expansion. In 2002, WMO was informed by several research and development space agencies of their commitment to participate in the space-based component of GOS. In particular, Aqua, Terra, the National Polar-Orbiting Operational Environmental Satellite System Preparatory Project, QuikSCAT and Global Precipitation Measurement missions of the National Aeronautics and Space Administration (NASA) of the United States, the ESA Envisat mission, Advanced Earth Observation Satellite II and the Global Change Observation Mission series of the National Space Development Agency of Japan and the research instruments of the Russian Aviation and Space Agency (Rosaviakosmos) on board the Russian Federal Service for Hydrometeorology and Environment Monitoring's operational METEOR 3M N1 satellite, as well as on its future Ocean series, are all now part of the research and development constellation. In response to this momentous expansion and in recognition of the increased responsibilities of WMO, at its 54th session, the Executive Council of WMO agreed to establish a WMO Space Programme as a matter of priority. The scope, goals and objectives of the new WMO Space Programme should respond to the tremendous growth in the utilization of environmental satellite data, products and services within the expanded space-based component of GOS that now included appropriate research and development environmental satellite missions. The research and development constellation joins the existing geostationary and polar-orbiting constellations.

10. The meteorological satellites comprising the present space-based component of GOS, both polar-orbiting and geostationary, have continued to prove invaluable to WMO national meteorological and hydrological services (NHMSs) through the provision of a multitude of services including imagery, soundings, data collection and data distribution. During 2002, the space-based constellation, in addition to the research and development satellites, was comprised of the following geostationary and polar-orbiting satellites: Geostationary Operational Environmental Satellite 8 (GOES-8), GOES-10, NOAA-15, NOAA-16 and NOAA-17, operated by the

United States; Geostationary Meteorological Satellite 5 (GMS-5), operated by Japan; Geostationary Operational Meteorological Satellite N-1 (GOMS N-1), Meteor 2-20, Meteor 2-21, Meteor 3-5 and Meteor 3M N1, operated by the Russian Federation; Meteosat-5, Meteosat-6 and Meteosat-7, operated by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT); and Feng Yun 2B (FY-2B), FY-1C and FY-1D, operated by China. NOAA-15, NOAA-16 and NOAA-17 are the first of the TIROS N series to fly the advanced TIROS operational vertical sounder (ATOVS), including the advance microwave sounding unit (AMSU). There were several satellite launches in 2002: China launched FY-1D in May; the National Environment Satellite, Data and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration (NOAA) of the United States launched NOAA-17 in June; and EUMETSAT launched the first of the Meteosat Second Generation (MSG) satellites, MSG-1, in August 2002.

11. The Action Team noted that the WMO Commission for Basic Systems had in December 2002 approved a vision for the future space-based component of GOS, as follows:

(a) *Six operational geostationary satellites*:

(i) All with multispectral imager (infrared/visible);

(ii) Some with hyperspectral sounder (infrared);

(b) *Four operational low-Earth orbit (LEO) satellites*:

(i) Optimally spaced in time;

(ii) All with multispectral imager (microwave/infrared/visible/ultraviolet);

(iii) All with sounder (microwave);

(iv) Three with hyperspectral sounder (infrared);

(v) All with radio occultation;

(vi) Two with altimeter;

(vii) Three with conical scanning microwave or scatterometer;

(c) *Several research and development satellites serving WMO members and comprised of*:

(i) A constellation of small satellites for radio occultation;

(ii) LEO satellites with wind light detection and ranging (lidar);

(iii) LEO satellites with active and passive microwave precipitation instruments;

(iv) LEO satellites and geostationary satellites with advanced hyperspectral capabilities;

(v) Geostationary satellites with lightning detection;

(vi) Possibly geostationary satellites with microwave sensors;

(d) *Improved inter-calibration and operational continuity*.

12. The Action Team was convinced that the present space-based observing system was adequate to provide the required data, products and services for the present weather and climate forecasting requirements and that the vision for the future system would respond to the increased requirements to enhance weather and climate forecasting. Those requirements are described in more detail in section IV.

IV. Present and future weather and climate prediction systems

13. The Action Team on Weather and Climate Forecasting reviewed the ongoing activities, both present and planned, for the next eight years as part of the WMO Sixth Long-term Plan. In particular, the Action Team noted that the primary operational component for observation and prediction lay within the WWW Programme and World Climate Programme (WCP) with research required to improve those operational services contained within them, as well as in the Atmospheric Research and Environment Programme (AREP), as described in more detail below.

A. World Weather Watch Programme

1. Purpose and scope

14. The WWW Programme facilitates the development, operation and enhancement of worldwide systems for collecting and exchanging meteorological and related observations and for the generation and dissemination of analyses and forecast products, as well as severe weather advisories and warnings and related operational information. The activities carried out under the Programme collectively ensure that the NMHS of each member has access to the information it needs to contribute effective services towards improving protection of life and property, increasing safety on land, at sea and in the air, enhancing quality of life, sustaining economic growth and protecting the environment. WWW is organized as an international cooperative programme, under which the infrastructure, systems and facilities needed for the provision of those services are owned, implemented and operated by the member countries. This is based on the fundamental understanding that weather patterns do not recognize national boundaries and are always interactive and that international cooperation is paramount, as no one country can be fully self-sufficient in the provision of all of its meteorological and related services.

15. The Programme’s main functions are planning, organization and coordination of the facilities, procedures and arrangements at the global and regional levels related to the design of observing and communication networks, the standardization of observing and measuring techniques, the use of data management principles and the presentation of the information in a form and format that is understood by all, regardless of language. WWW is the key programme of WMO to provide basic data, forecast products and services for other programmes of WMO. It directly supports international programmes, such as the Global Climate Observing System (GCOS), the Global Ocean Observing System (GOOS) and Global Atmosphere Watch (GAW).

16. Members will enhance efforts to make operational systems and practices more cost-effective. This will be achieved by establishing and sustaining new flexible,

composite, Earth- and space-based observing systems and adaptable networks for observing the conditions of the atmosphere/ocean system on a global scale. New strategies will be required to facilitate data availability and access so that the observing systems and programmes can be useful to operational meteorology and the research community in addressing global environmental problems.

17. The WWW Programme will continue to place priority on capacity-building activities to avail itself of technological advances in order to enhance the components of WWW, especially in developing countries, and on cost-effective, systematic monitoring and improvements to the operations of WWW that can be derived therefrom. It will thus endeavour, after assisting NMHSs, to participate fully in and obtain maximum benefits from the overall WWW system.

2. Overall objectives

18. The overall objectives of the WWW Programme are:

(a) To maintain and strengthen an efficient and economic worldwide integrated system for the generation, collection, processing and exchange of meteorological and related environmental observations, analyses, forecasts, advisories and warnings and other specialized products to meet the needs of all members, WMO programmes and relevant programmes of other international organizations;

(b) To promote and support, through capacity-building, measures for the introduction of standards, procedures and technology, which enable members to contribute to and benefit from the WWW system and ensure the high level of quality, reliability and compatibility of observations and forecasts needed for the delivery of services required in member countries;

(c) To provide the basic infrastructure for obtaining observational data and related services needed by relevant international programmes addressing global environmental issues.

3. Programme structure

19. WWW covers the design, implementation, operation and further development of the following three interconnected, and increasingly integrated, core components:

(a) GOS, consisting of facilities and arrangements for making observations at stations on land and at sea and from aircraft, meteorological satellites and other platforms;

(b) The Global Telecommunication System (GTS), consisting of integrated networks of telecommunication facilities and services for the rapid, reliable collection and distribution of observational data and processed information;

(c) The Global Data-Processing System (GDPS), consisting of world, regional/specialized and national meteorological centres to provide processed data, analyses and forecast products.

20. Coordination, integration and efficient operation of the three core components are achieved through support programmes, as follows:

(a) The WWW Data Management programme monitors and manages the information flow within the WWW system to assure quality and timely availability of data and products and the use of standard representation formats, to meet the requirements of members and other WMO programmes;

(b) The WWW System Support Activity programme provides specific technical guidance, training and implementation support and the WWW Operational Information Services and supports cooperative initiatives.

B. Global Observing System

1. Purpose and scope

21. GOS provides Earth and outer space observations of the state of the atmosphere and ocean surface for the preparation of weather analyses, forecasts, advisories and warnings for climate monitoring and environmental activities carried out under programmes of WMO and of other relevant international organizations. It is operated by national meteorological services and national or international satellite agencies and involves several consortia dealing with specific observing systems or specific geographical regions. One of the main goals within WWW will be the restructuring of GOS into a composite system, in particular for upper-air-based observations that will increase the use of ground-based remote sensing, aircraft meteorological data relay (AMDAR), satellites and Global Positioning System Meteorology (GPS/MET). Meeting the requirements of monitoring the climate and the environment, in collaboration with partner organizations, will also be a GOS priority. Areas of emphasis in the implementation of GOS may differ in individual countries, but cost-effectiveness, long-term sustainability and new collaborative arrangements among members will be key elements in the future design and operation of the observing networks.

2. Main long-term objectives

22. The main long-term objectives of GOS are:

(a) To improve and optimize global systems for observing the state of the atmosphere and the ocean surface to meet requirements, in the most effective and efficient manner, for the preparation of increasingly accurate weather analyses, forecasts and warnings and for climate and environmental monitoring activities carried out under programmes of WMO and other relevant international organizations;

(b) To provide for the necessary standardization of observing techniques and practices, including the planning of networks on a regional basis, to meet the requirements of users with respect to quality, spatial and temporal resolution and long-term stability.

C. Global Data-processing System

1. Purpose and scope

23. GDPS consists of a network of meteorological centres that generate weather and climate analyses, forecasts, advisories, warnings and specialized forecast products required by NMHSs and other members' agencies in order to provide effective services. These include services for the protection of life and property, increased safety on land, at sea and in the air, enhanced quality of life, sustainable development and the protection of the environment under WWW or within the framework of other WMO or international programmes. GDPS aims at the provision to all NMHSs of more specialized and increasingly reliable numerical weather prediction (NWP) products, spanning forecast ranges from instantaneous to long-term and from local to global scale, improved early warning services for the mitigation of meteorological disasters and effective advice for emergency response to environmental catastrophes.

2. Main long-term objectives

24. The main long-term objectives of GDPS are:

(a) To contribute to an improved understanding of the current and future state of the atmosphere, the weather and related environmental parameters through continuing efforts to improve the quality of numerical models and forecasting techniques;

(b) To review the operational requirements for and implement new functions, techniques and improvements to ensure provision of analyses, forecasts and warnings of weather in general and high-impact weather phenomena and natural disasters in particular;

(c) To support capacity-building of developing NMHSs by strengthening regional and/or national GDPS components, and providing technical guidance and training.

D. World Climate Programme

1. Purpose and scope

25. The purpose of WCP is to provide an authoritative international scientific voice on climate and climate change and to assist countries in the application of information and knowledge on climate to national sustainable development. This will be through the implementation of Agenda 21, adopted by the United Nations Conference on Environment and Development in 1992,[2] and associated instruments in order to achieve the maximum possible benefit for national economies and social welfare.

26. WCP is an integrating and catalytic agent for initiating and coordinating activities in the areas of data collection, research, applications and training. Promoting the establishment of relevant national committees is seen to be an effective means to mobilize support for those activities and to facilitate international

coordination. Within the Programme, special attention is given to developing and supporting national climate services through regional cooperation.

27. At the same time, WCP continues to support the provision of authoritative assessments on climate science, social and economic impacts and possible response options to climate change, especially through the work of the WMO/United Nations Environment Programme (UNEP) Intergovernmental Panel on Climate Change. Such assessments provide the scientific and technical basis for adopting national and international response measures within the United Nations multilateral environmental agreements aimed at the implementation of Agenda 21 and proposals emerging from the World Summit on Sustainable Development, held in 2002.[3] WCP can provide critical support to enable nations to meet their commitments under those environmental agreements. To that end, it is envisaged that the international climate-related programmes, including WCP as a core programme, will continue to be developed within the Climate Agenda framework, which has the following thrusts:

(a) New frontiers in climate science and prediction;

(b) Climate services for sustainable development;

(c) Studies of climate impact assessments and response strategies to reduce vulnerability;

(d) Dedicated observations of the climate system.

28. The overall objectives of WCP are formulated to ensure that these thrusts are pursued.

2. Overall objectives

29. The overall objectives of WCP are:

(a) To facilitate the effective collection and management of climate data and the monitoring of the global climate system, including the detection and assessment of climate variability and changes;

(b) To foster the effective application of knowledge and information on climate for the benefit of society and the provision of climate services, including the prediction of significant climate variations both natural and as a result of human activity;

(c) To assess the impact of climate variability and changes and economic or social activities that could markedly affect ecosystems and advise Governments thereon and to contribute to the development of a range of social and economic response strategies that could be used by Governments and the community;

(d) To improve the understanding of climate processes in determining the predictability of climate, including its variability and change, identifying the extent of human influence on climate and developing the capability for climate prediction.

3. Programme structure

30. The structure of WCP within WMO includes:

(a) Coordination activities within the Climate Agenda;

(b) Support to activities related to climate change;

(c) GCOS;

(d) The World Climate Data and Monitoring Programme;

(e) The World Climate Applications and Services Programme, including the Climate Information and Prediction Services project;

(f) The World Climate Impact Assessment and Response Strategies Programme;

(g) The World Climate Research Programme (WCRP).

E. Global Climate Observing System

1. Purpose and scope

31. GCOS is a joint undertaking of WMO, the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO), UNEP and the International Council for Science (ICSU). The purpose of GCOS is to ensure that the comprehensive observations needed to address general and specific climate-related issues are properly defined, obtained and made accessible.

32. GCOS focuses on improving the effectiveness and scope of existing operational networks and systems. However, it also provides a long-term, systematic framework for integrating (and enhancing as needed) the research-oriented observing systems of participating countries and organizations. Through this combination of operational and research-based inputs, GCOS aims to secure a comprehensive system that is focused on meeting the requirements set by users and on issues. GCOS is built primarily on the climate components of the following existing global observing systems: GOS of WMO’s WWW; GAW, GOOS and the Global Terrestrial Observing System (GTOS). WMO is a joint sponsor, with other agencies and organizations, of GOOS and GTOS. GCOS takes account of capabilities for both space-based and in situ observing techniques and aims to include all necessary physical, chemical and biological properties relating to atmospheric, oceanic, hydrological, cryospheric and terrestrial processes. GCOS is closely linked to the activities of other international programmes that address climate issues, such as the International Geosphere-Biosphere Programme (IGBP) and those relating to WCP.

2. Main long-term objective

33. The main long-term objective of GCOS is to ensure that climate observing systems provide adequate data for:

(a) Detection and attribution of climate change;

(b) Monitoring of the climate system;

(c) Prediction of operational climate, especially on seasonal to inter-annual time scales;

(d) Assessing the impact of and the vulnerability and adaptation to climate variability and change of, for example, terrestrial ecosystems and sea level;

(e) Research to improve understanding, modelling and prediction of the climate system;

(f) Application for sustainable economic development.

F. Atmospheric Research and Environment Programme

1. Purpose and scope

34. The purpose of AREP is to contribute to the advancement of atmospheric sciences and to assist members by fostering research in meteorology and related environmental fields. The Programme will thus make a major contribution in the area of understanding and improving the modelling of the processes that affect the current and future state of the atmosphere, the weather and related environmental states, such as air quality and pollution levels. The GAW component of the Programme has the major responsibility for assessments of the state of the atmosphere, in particular the ozone layer, and the provision of related warnings. Furthermore, the Programme makes significant improvements in observational networks, especially under GAW, and contributes to capacity-building. In addressing a wide range of scientific issues, the Programme provides WMO with the opportunity to work more effectively with international scientific institutions and other partners.

2. Overall objectives

35. The overall objectives of AREP are:

(a) To develop further the GAW system of monitoring stations, calibration and WMO world data centres in order to provide authoritative assessments of the state of the atmosphere and contribute to the prediction of its future composition;

(b) To contribute to improved cost-effective techniques for forecasting high-impact weather and promote their application among members to make possible reliable warnings of severe weather events;

(c) To improve understanding of the processes and phenomena common to low latitudes, making possible better weather and climate services provided by member States;

(d) To improve understanding of atmospheric processes, including the physics and chemistry of clouds, in recognition of their role in weather and climate predictions, transport and transformation of pollutants and for weather modification activities.

3. Programme structure

36. The Programme consists of the following components:

(a) Support to ozone and other environment-oriented conventions;

(b) GAW;

(c) The World Weather Research Programme (WWRP);

(d) The Tropical Meteorology Research Programme;

(e) The Programme on Physics and Chemistry of Clouds and Weather Modification Research.

G. World Weather Research Programme

1. Purpose and scope

37. WWRP will promote the development and application of improved weather forecasting techniques, with emphasis on high-impact events. The programme projects will emphasize a comprehensive approach involving all time scales associated with weather prediction and will ensure that the benefits of research advances are widely shared among nations. The Programme will thus make a substantial contribution concerning research and weather prediction activities and will help make possible the delivery of accurate, useful and reliable warnings of severe weather events.

2. Main long-term objectives

38. The main long-term objectives of WWRP are:

(a) To develop improved and cost-effective techniques for forecasting high-impact weather (which affects quality of life and is economically disruptive) and to promote their application among members;

(b) To improve public safety and economic productivity by accelerating research on the prediction of high-impact weather;

(c) To facilitate the integration of advances in research into weather prediction achieved via relevant national and international programmes;

(d) To demonstrate improvements in the prediction of weather, with emphasis on high-impact events, through the exploitation of advances in scientific understanding, observational network design, data assimilation and modelling techniques and information systems;

(e) To encourage the utilization of relevant advances in weather prediction systems for the benefit of all WMO programmes and members;

(f) To improve understanding of atmospheric processes of importance to weather forecasting through the organization of focused research programmes.

39. The Action Team was convinced that the present activities and long-term plans for WMO provided excellent worldwide services contributing directly to sustainable development and capacity-building in Member States. The WMO plans should be supported by Member States as a matter of priority.

V. International cooperation in the field of meteorological satellite applications

40. The Action Team on Weather and Climate Forecasting reviewed existing mechanisms for international cooperation in the field of meteorological satellite applications. In that regard, at the forty-fifth session of the Committee on the Peaceful Uses of Outer Space, in 2002, WMO informed the Action Team of several mechanisms, which are described below.

A. Internal coordination

41. The WMO programme with overall purview of matters related to satellites within WMO is the WMO Satellite Activities, which provides the necessary support to the Consultative Meetings on High-Level Policy on Satellite Matters, which advise the WMO Congress and Executive Council.

1. Background

42. In the opening decade of the twenty-first century, a major opportunity to support and enhance WMO programmes was available through existing and planned satellite programmes. At the same time, there was a need to demonstrate the value of those satellite programmes to all concerned parties and to ensure that future plans took into account the needs of WMO. In that context, the satellite operators and WMO agree that regular meetings to discuss high-level policy matters would be beneficial to all parties concerned. Such meetings would build on the good relationships that already existed between satellite operators and WMO bodies and would enhance the working relations already in place through existing mechanisms. Such meetings would promote the achievement of further efficiencies in the satellite observing system and would ensure a common understanding of objectives and lead to better harmonization of programmes, requirements, usage of satellite data products and services and high-level policy matters.

43. High-level policy matters could have a substantial impact on satellite operators and on most, if not all, WMO members, as well as on the allocation of resources. For WMO, the relevant decision-making authorities are the Congress and the Executive Council; for the satellite operators, the equivalent decision-making organ would be their relevant governing bodies.

2. Purpose

44. The purpose of the Consultative Meetings on High-Level Policy on Satellite Matters is to discuss matters of mutual interest between the satellite operators and the WMO user communities. One outcome of the meetings is to ensure a better understanding of issues. A second, and more important objective, is to agree on advice and guidance to be forwarded to the WMO Executive Council and/or satellite operators.

3. Membership, organization and resource implications

45. The Consultative Meetings are attended by the directors of satellite operating agencies either contributing, or with the potential to contribute, to the space-based

component of GOS, members of the WMO Bureau, the president of the WMO Commission for Basic Systems (representing all WMO technical commissions, but accompanied by representatives of the other commissions, as appropriate) and sufficient members of the Executive Council to adequately reflect the broad interests of WMO members (including consideration of regional balance, user representation and the role of the permanent representatives of those members with satellite operating agencies). The satellite operators attend meetings at their own expense and the timing is harmonized, as far as possible, with WMO Bureau sessions. The President of WMO serves as the Chairman of the Consultative Meetings. Preparation for the meetings is assured by the WMO Space Office staff as part of their normal duties and the meetings are convened by WMO. Additionally, the Chairmen of the Joint Scientific Committee for WCRP and the Joint Steering Committee for GCOS serve as members.

4. Meeting topics

46. Following are the topics of the meetings:

(a) Coordination and implementation of the WMO Space Programme, as described in the Sixth Long-term Plan, the WMO Space Programme Long-term Strategy and the programme and budget for the period 2004-2007;

(b) Discussion with satellite operators on WMO programmes and WMO-sponsored programmes, on meteorology (including climatology), oceanography and hydrology. That would provide WMO with a forum to present its requirements for meteorological and environmental satellites (operational, research and technology programmes) in a coordinated fashion;

(c) Consideration of the evolutionary design of the space-based component of GOS to take account of future technological developments and the evolution of the present-day in situ networks. WMO would become more proactive in providing a vision on future state-of-the-art systems;

(d) Preparation for the implementation of the transition between research and operational programmes through: (i) development of WMO recommendations identifying appropriate research and development instruments and missions based on the utility of their products and services in operational use; (ii) demonstration of the use of new capabilities by WMO members and work with satellite operators to evaluate the contributions towards meeting societal needs; and (iii) WMO assessment of new satellite systems from a user’s perspective to provide formal evaluation results to the satellite operators;

(e) Consideration of how to reduce costs, including standardization of equipment, taking into account the efficiency and effectiveness of the total observing system (including ground systems), as well as consideration of the need for compatibility among satellite systems, in particular ground stations, and product requirements;

(f) Maximizing the benefits to be derived from existing and planned satellite products and services in order to improve utilization of existing satellite data, products and services and to provide for better coordination of those benefits for all WMO members;

(g) Evaluating satellite missions to ensure, inter alia, the better use of existing and planned research and development missions in support of WMO programmes and provide an assessment of their operational utility.

5. Interests of developing countries

47. In all deliberations, the Consultative Meetings should take into account the needs of developing countries to ensure that they keep abreast of advances in satellite products and services. In particular, attention should be given to the access to satellite data, products and services and appropriate education and training programmes, especially those at the WMO regional meteorological training centres.

B. External coordination

48. In addition to internal coordination by the Consultative Meetings on High-Level Policy on Satellite Matters, emphasis is also placed on the close involvement of satellite operators in external coordination. Two specific relevant international groups are the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS). CGMS started as an informal group in 1972 to coordinate the first global geostationary system among satellite providers. The European Space Research Organization (ESRO), NOAA and the Japan Meteorological Agency were founding members. In 2002, research and development space agencies contributing to the space-based component of GOS became members of CGMS. The current members of CGMS include China, India, Japan, the Russian Federation, EUMETSAT, ESA, NOAA/NESDIS, NASA, UNESCO/IOC and WMO. EUMETSAT currently acts as the secretariat for CGMS. The recommendations of the Group are non-binding on members and are implemented on a voluntary basis.

49. The objectives of CGMS are: (a) to provide a forum for the exchange of technical information on geostationary and polar orbiting meteorological satellite systems, such as reporting on current meteorological satellite status and future plans, telecommunication matters, operations, inter-calibration of sensors, processing algorithms, products and their validation, data transmission formats and future data transmission standards; (b) to harmonize, to the extent possible, meteorological satellite mission parameters, such as orbits, sensors, data formats and down-link frequencies; and (c) to encourage complementarity, compatibility and possible mutual back-up in the event of system failure through cooperative mission planning, compatible meteorological data products and services and the coordination of space and data-related activities, thus complementing the work of other international satellite coordination mechanisms.

50. Some CGMS achievements are: (a) agreement on the nominal location of satellites to obtain optimum levels of data coverage with five satellites provided by four early members (recognition that additional satellites from other members provide additional system resilience, as well as serving national interests); (b) agreement on standards for the International Data Collection System (IDCS), as well as coordination of platform admissions to the system, data handling, IDCS channel allocations to platform systems and platform radio-set certification. Through such coordination, an aircraft, ship, balloon, buoy or other mobile platform

can report continuously over most parts of the world with the assurance that the data are handled correctly by the individual CGMS members; (c) agreement on standards for weather facsimile (WEFAX) image transmissions, with the result that the same equipment for reception of basic image data can be used in most parts of the world, making possible economies of scale in manufacture and facilitating the very large user base that exists worldwide today; (d) consensus regarding practical ways to address the problem of mutual back-up in the case of satellite problems and identification of the "help thy neighbour" philosophy, which is assisted by the mutually agreed standards for the user interfaces; and (e) establishment of practical documentation, including the CGMS meeting reports, the CGMS consolidated report (which defines standards) and the IDCS Guide.

51. Some CGMS tasks continue from meeting to meeting, including the routine exchange of validation statistics for cloud motion vectors, to encourage improvements in performance by all operators. CGMS also concerns itself with special actions and with planning of particular elements of future systems such as product improvements. CGMS has been the instigator of routine inter-comparisons of cloud motion vectors from the geostationary satellites and has also pressed for a higher degree of scientific research in this field, through a session during the meeting in 1990 of the Committee on Space Research. CGMS has a special relationship with WMO because the Organization is the only full member that is not a satellite operator. This means that WMO is in a unique position to represent the views of a specific (and major) user group.

52. CEOS was created in 1984 as a result of recommendations from the Economic Summit of Industrialized Nations and serves as the focal point for international coordination of space-related Earth observation activities among space agencies. CEOS addresses policy and technical issues of common interest related to the whole spectrum of Earth observation satellite missions and their data. CEOS encourages complementarity and compatibility among experimental and operational space-borne Earth observing systems through coordination in mission planning, promotion of full and non-discriminatory data access, setting of data product standards and development of compatible data products, services and applications.

53. Members of CEOS are those national and multinational government agencies with funding and programme responsibilities for a satellite Earth observation programme currently operating or in the later stages of development. Membership requirements also specify that members provide to the international community non-discriminatory and full access to their Earth observation data. CEOS members include ESA, EUMETSAT, NASA, NOAA and counterpart space and Earth observation agencies in Australia, Brazil, Canada, France, Germany, India, Italy, Japan and the United Kingdom of Great Britain and Northern Ireland. Current observers are agencies from Canada, New Zealand and Norway. At the plenary meeting of CEOS in November 1990, members recognized the need to extend membership to relevant agencies on a global basis and to strengthen interaction with both international scientific programmes (such as ICSU/IGBP and WCRP) and intergovernmental user organizations (such as WMO, UNESCO/IOC, UNEP and the Intergovernmental Panel on Climate Change) in order to enhance and further focus space agency Earth observation mission planning on global change requirements. An associate status was created for such organizations, as well as for other

international satellite coordination groups. WMO has become an associate organization of CEOS.

54. The Action Team was also briefed on the ongoing activities of IGOS. It noted that several global observing systems, which were either WMO programmes (WWW/GOS and GAW) or co-sponsored by WMO (e.g. GOOS, GTOS and the World Hydrological Cycle Observing System), in addition to the jointly sponsored, cross-cutting GCOS, were contributing to the implementation of an integrated global observing strategy through the arrangement of the IGOS Partnership. WMO contributed to the development of the current strategy through participation in the development of the themes and, ultimately, in the establishment of a coherent synthesis of those themes with existing programmes and activities. As the strategy matured, the emerging guidance would be taken into consideration by relevant WMO mechanisms. For example, the WMO Commission for Basic Systems would take into consideration IGOS strategic guidance as it related to the space-based component of GOS.

55. The Action Team was informed that the Commission for Basic Systems had for many years utilized an approved process called the “rolling review of requirements” in order to develop guidance for WMO members for both surface and space-based components of WWW/GOS. As had been the case in the past for WWW, it was anticipated that WMO members would voluntarily implement recommendations approved by the Commission for Basic Systems for the redesign of GOS. In the context of current IGOS terminology, the long-established WMO process could be considered an “atmospheric theme” already in its implementation phase and, therefore, not subject to any IGOS “approval” process. However, as the other observing systems did not yet have complete and rigorous development/review mechanisms in place such as that developed through the Commission for Basic Systems for the atmosphere (and in fact also for parts of the ocean and land surface domains), the IGOS process would serve as a valuable tool. WMO would help formulate the guidance being prepared within the strategy to ensure compatibility with its own activities. Conversely, the other IGOS partners would need to remain sensitive to WMO activities in view of their critical importance in underpinning the entire strategy.

56. The Action Team agreed that the plans contained in the WMO planning process directly addressed the activities needed to enhance weather and climate forecasting. The Action Team also agreed that the internal and external mechanisms jointly ensured an effective means for international cooperation to achieve the goals set forth in the WMO planning process.

VI. Necessary action plans to be implemented by Governments and intergovernmental organizations

57. The Action Team on Weather and Climate Forecasting concluded, therefore, that the most important actions Member States could take to enhance weather and climate forecasting by expanded international cooperation in the field of meteorological satellite applications would be twofold: firstly, to support the NMHSs of its Member States in the implementation of the WMO long-term plans, including the necessary financial resources; and, secondly, to support those national

and international organizations providing space systems which sought to meet the WMO requirements.

VII. Projected results of government action

58. The Action Team on Weather and Climate Forecasting agreed that the contribution to the societal needs of Member States would be greatly increased through enhanced weather and climate forecasting brought about by expanded international cooperation in the field of meteorological satellite applications. It agreed that both sustainable development and capacity-building in Member States would be substantially accelerated. The extension of reliable weather and climate forecasting and assessment of the causes and course of longer-term Earth system change were two major accomplishments of WMO and its partner organizations that have a demonstrable value to humanity. They also opened a door towards a greater range of possibilities in the future, however. Annual losses due to natural disasters, most of which were weather-related, exceeded on average 50,000 lives and tens of billions of dollars. Some research activities indicate that longer-term climate change would affect the distribution, frequency and intensity of severe weather events. Annual decisions on food and fibre production, multi-year investment in infrastructure development and management of freshwater resources, to name only a few contemporary socio-economic issues, could benefit tremendously from reliable, extended services and products, such as:

(a) *Thirty-minute warning of very destructive weather events*. For example, tornado prediction beyond 10 minutes is notoriously difficult but necessary in susceptible areas;

(b) *Five-day hurricane track prediction to ±30 kilometres*. To reduce the number of false warnings resulting from the present landfall location uncertainty of 400 kilometres at three days;

(c) *Ten- to fourteen-day weather forecasting*. New measurements, especially tropospheric winds, and substantial advances in modelling capability can extend short- and medium-term weather prediction to the limits;

(d) *Twelve-month regional rain rate*. Recent efforts in global water cycle modelling indicate the potential to "deconvolve" global-scale water cycle variation into regionally specific projections;

(e) *Fifteen- to twenty-month El Niño prediction*. "Hindcasting" of the two most recent El Niño events indicates that this is possible with an adequate system of space-based and in situ observing capability, paired with focused modelling efforts;

(f) *Ten-year climate predictions*. Decadal-scale climate prediction is theoretically possible with the extension of the research systems now being deployed to the operational systems of tomorrow.

59. Meteorological satellites provide essential data for weather and climate forecasting to Member States around the globe. This has been due in large part to direct broadcast and through global sharing of data and science. Satellites offer high-resolution digital renderings from a range of spectral bands, from which both qualitative and quantitative information about properties of the atmosphere, clouds, the land and the sea surface can be deduced.

Notes

[1] *Report of the Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, Vienna, 19-30 July 1999* (United Nations publication, Sales No. E.00.I.3), chap. I, resolution 1.

[2] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992* (United Nations publication, Sales No. E.93.I.8 and corrigenda), vol. I: *Resolutions adopted by the Conference*, resolution 1, annex II.

[3] *Report of the World Summit on Sustainable Development, Johannesburg, South Africa, 26 August-4 September 2002* (United Nations publication, Sales No. E.03.II.A.1 and corrigendum).