17 September 2010

English only

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

Subsidiary Body for Scientific and Technological Advice
Thirty-third session
Cancun, 30 November to 4 December 2010

Item 5 of the provisional agenda
Research and systematic observation

Update of the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC

Submission from the secretariat of the Global Climate Observing System

1. The Conference of the Parties, by its decision 9/CP.15, invited the Global Climate Observing System (GCOS) secretariat, under the guidance of the GCOS Steering Committee, to update, by the thirty-third session of the Subsidiary Body for Scientific and Technological Advice (SBSTA), the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (hereinafter referred to as the GCOS implementation plan), taking into account emerging needs in climate observation, in particular those relating to adaptation activities.[1]

2. At its thirtieth session, the SBSTA noted that an updated GCOS implementation plan that takes into account emerging priorities, such as the need for data for adaptation, may assist in continuing progress with GCOS implementation. At the same sesssion, it invited the GCOS secretariat to include, in the updated GCOS implementation plan, a breakdown of costs involved, broken down by region, observing system and between developed and developing countries.[2]

3. A provisional updated implementation plan including a provisional estimation of costs was made available as document FCCC/SBSTA/2009/MISC.12, following an invitation extended to the GCOS by the SBSTA at its thirtieth session.[3]

4. In response to the invitations referred to in paragraphs 1 and 2 above, the secretariat of the GCOS has submitted an update of the GCOS implementation plan. The executive

[1] FCCC/CP/2009/11/Add.1, pages 23–24.
[2] FCCC/SBSTA/2009/3, paragraphs 57–58.
[3] FCCC/SBSTA/2009/3, paragraph 58.

GE.10-62731

summary of this plan is reproduced in this document. The complete version of the plan is available at <http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf>.

5. In accordance with the procedure for miscellaneous documents, this submission is attached and reproduced* in the language in which it was received and without formal editing.

* This submission has been electronically imported in order to make it available on electronic systems, including the World Wide Web. The secretariat has made every effort to ensure the correct reproduction of the text as submitted.

WORLD METEOROLOGICAL ORGANIZATION

INTERGOVERNMENTAL OCEANOGRAPHIC COMMISSION

IMPLEMENTATION PLAN FOR THE GLOBAL OBSERVING SYSTEM FOR CLIMATE IN SUPPORT OF THE UNFCCC

(2010 UPDATE)

EXECUTIVE SUMMARY

August 2010

GCOS-138 (ES)

UNITED NATIONS ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL FOR SCIENCE

Chairperson, Publications Board
World Meteorological Organization (WMO)
7 *bis*, avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland

Tel.: +41 (0)22 730 84 03
Fax: +41 (0)22 730 80 40
E-mail: Publications@wmo.int

NOTE

The designations employed in WMO publications and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of WMO concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

Opinions expressed in WMO publications are those of the authors and do not necessarily reflect those of WMO. The mention of specific companies or products does not imply that they are endorsed or recommended by WMO in preference to others of a similar nature which are not mentioned or advertised.

This document (or report) is not an official publication of WMO and has not been subjected to its standard editorial procedures. The views expressed herein do not necessarily have the endorsement of the Organization.

FOREWORD

This 2010 Update of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*[4] was prepared in response to a request by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) expressed at the 30th session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) in June 2009 and confirmed in UNFCCC Decision 9/CP.15 (December 2009). It was prepared under the overall guidance of the Global Climate Observing System (GCOS) Steering Committee and its Chairs (initially John Zillman, followed in January 2010 by Adrian Simmons), supported by a task team led by Paul Mason (the former Chair of the GCOS Steering Committee) and including the GCOS Panel Chairs and staff of the GCOS, Global Ocean Observing System (GOOS) and Global Terrestrial Observing System (GTOS) Secretariats.

Full implementation of the 138 Actions recommended in this Plan over the coming five years will ensure that countries have the observational information needed to understand, predict, and manage their response to climate and climate change over the 21st century and beyond. It will address the commitments of the Parties under Articles 4 and 5 of the UNFCCC and support their needs for climate observations in fulfilment of the objectives of the Convention. The Actions in this Plan, if fully implemented by the Parties, will provide a major contribution to the WMO/IOC-UNESCO/UNEP/ICSU-sponsored GCOS and the evolving climate information services it supports.

The Plan calls for sustained observations of the Essential Climate Variables (ECVs) that are needed to make significant progress in the generation of global climate products and derived information; the document also recommends enhanced support to the research, modelling, analysis, and capacity-building activities required by all Parties to the UNFCCC. Furthermore, the need for observational records to improve seasonal-to-interannual climate predictions is also addressed.

This Plan updates an original version published in 2004. It takes account of the latest status of observing systems, recent progress in science and technology, the increased focus on adaptation, enhanced efforts to optimize mitigation measures, and the need for improved predictions of climate change.

A draft version of this document was subject to a two-month web-based open review by the community from November 2009 until January 2010. The GCOS Steering Committee expresses its thanks to all institutions and individuals who provided around 450 individual comments which helped improve the content considerably.

The GCOS Steering Committee approved the release of this Plan for general publication, and for submission to the UNFCCC and general publication in August 2010. It has been submitted to the UNFCCC Secretariat as a final document for consideration by Parties at SBSTA 33, to be held in conjunction with the UNFCCC Conference of the Parties (COP) 16 in Cancún, Mexico.

Adrian Simmons, Chair of the GCOS Steering Committee (August 2010)

[4] The full Plan is available at http://www.wmo.int/pages/prog/gcos/Publications/gcos-138.pdf ; the 2004 version of this Plan is available at http://www.wmo.int/pages/prog/gcos/Publications/gcos-92_GIP.pdf

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1. Introduction

1.1. Context

The demand for information on climate has never been greater than today. Long-term, high-quality and uninterrupted observations of the atmosphere, land and ocean are vital for all countries, as their economies and societies become increasingly affected by climate variability and change.

As highlighted by the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, observations have shown that warming of the climate system is unequivocal. Observations must be sustained into the future to evaluate how the climate is changing so that informed decisions can be made on prevention, mitigation, and adaptation strategies. They are crucial to support the further research needed to refine understanding of the climate system and its changes, to initialise predictions on time scales out to decades ahead, and to develop the models used to make these predictions and longer-term scenario-based projections. Observations are also needed to assess social and economic vulnerabilities and to develop the actions needed across a broad range of societal sectors.

Observations need to be recognised as essential public goods, where the benefits of global availability of data exceed any economic or strategic value to individual countries from withholding national data. In short, observations underpin all efforts by Parties to the United Nations Framework Convention on Climate Change (UNFCCC) to mitigate, and adapt to, climate change.

This 2010 edition of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* (IP-10) replaces a similarly titled Plan (IP-04) which was published in 2004.[5] Its purpose is to provide an updated set of Actions required to implement and maintain a comprehensive global observing system for climate that will address the commitments of the Parties under Articles 4 and 5 of the UNFCCC and support their needs for climate observations in fulfilment of the objectives of the Convention. This revised Plan updates the Actions in the IP-04, taking account of recent progress in science and technology, the increased focus on adaptation, enhanced efforts to optimize mitigation measures, and the need for improved prediction and projection of climate change. It focuses on the timeframe 2010-2015.

Full implementation of the WMO/IOC-UNESCO/UNEP/ICSU[6]-sponsored Global Climate Observing System (GCOS) – and the evolving climate information services it supports – is required to ensure that countries are able to understand, predict, and manage their response to climate and climate change over the 21st century and beyond. This Plan, if fully implemented by the Parties, will provide observations of the Essential Climate Variables (ECVs) needed to make significant progress in the generation of global climate products and derived information; it will also provide support for the research, modelling, analysis, and capacity-building activities required by all Parties to the UNFCCC, as well as underpin most of the data and information needs of the "Acting on Climate Change: The UN System Delivering as One" initiative. The Plan also addresses the need for observational records to improve seasonal-to-interannual climate predictions.

[5] GCOS (2004): *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*, GCOS-92 (WMO/TD-No. 1219), October 2004, http://www.wmo.int/pages/prog/gcos/Publications/gcos-92_GIP.pdf ('IP-04')

[6] WMO: World Meteorological Organization; IOC/UNESCO: Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization; UNEP: United Nations Environment Programme; ICSU: International Council for Science

The IP-10 makes an attempt to address the needs and associated costs of Parties to build national observational capacity in support of assessments of local impacts and adaptation. In addition, a substantial additional effort in building the scientific and technical capacity in many countries is needed for all Parties to benefit fully from the observations and information that the Plan addresses. The Plan recognises progress made over the past five years (since publication of the IP-04) and takes into consideration the main findings from the GCOS Progress Report 2004-2008,[7] namely that:

- The increasing visibility of climate variability and change has reinforced world-wide awareness of the importance of an effective Global Climate Observing System;
- Developed countries have improved many of their climate observation capabilities, but national reports suggest little progress in ensuring long-term continuity for several important observing systems;
- Developing countries have made only limited progress in filling gaps in their *in situ* observing networks, with some evidence of decline in some regions, and capacity-building support remains small in relation to needs;
- Both operational and research networks and systems, established principally for other purposes, are increasingly responsive to climate needs including the need for timely data exchange;
- Space agencies[8] have improved both mission continuity and observational capability, and are increasingly meeting the identified needs for data reprocessing, product generation, and access;
- The Global Climate Observing System has progressed significantly over the last five years, but still falls short of meeting all the climate information needs of the UNFCCC and broader user communities.

International awareness of the importance of global observing systems for all Societal Benefit Areas has improved through the establishment of the Group on Earth Observations[9] (GEO) and the adoption of the Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan. The GCOS is the climate observing component of the GEOSS.

The August-September 2009 World Climate Conference-3 (WCC-3) decided to establish a new Global Framework for Climate Services (GFCS) to provide a full range of climate information and prediction services for all climate-sensitive sectors in all countries. The detailed design of the GFCS by the subsequently-established task force of high-level independent advisors is expected to address the need, identified in the WCC-3 Conference Statement, for "major strengthening of the essential elements of a global framework for climate services [including] the Global Climate Observing System and all its components and associated activities." Meeting the full observational needs of the GFCS would involve the substantial investment in establishment and strengthening of national climate observing networks in most countries – an objective which is included in the Plan.

1.2. Background to this Plan

The GCOS Steering Committee and Secretariat, in consultation with the GCOS sponsors WMO, IOC/UNESCO, UNEP and ICSU, the sponsors of other contributing observing systems, and a wide cross-section of climate and observing system experts have prepared this Plan (IP-10) to respond to a request by Parties to the UNFCCC at the 30th session of the UNFCCC Subsidiary Body on Scientific and Technological Advice (SBSTA) in June 2009 (cf. Appendix 1 of the full Plan), and in accord with the general guidance provided by the UNFCCC Conference of the Parties (COP) 9 in its request for the IP-04 (Decision 11/CP.9).

[7] GCOS (2009): *Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008*, GCOS-129 (WMO/TD-No. 1489; GOOS-173; GTOS-70), August 2009, http://www.wmo.int/pages/prog/gcos/Publications/gcos-129.pdf

[8] The Satellite Supplement (GCOS (2006): *Systematic Observation Requirements for Satellite-Based Products for Climate,* GCOS-107 (WMO/TD-No. 1338), September 2006), designed to help satellite operators respond to satellite-specific elements of the IP-04, will be updated as a consequence of this Plan.

[9] http://www.earthobservations.org

The SBSTA request was affirmed by COP 15 in its Decision 9/CP.15 (cf. Appendix 2 of the full Plan). Completion of a provisional version of the IP-10 prior to COP 15 in December 2009 was part of the response. The updated Plan recognises the progress made since 2004 as outlined in the GCOS Progress Report 2004-2008. It also considers perspectives arising from the IPCC Fourth Assessment Report and a related joint GCOS-World Climate Research Programme (WCRP)-International Geosphere-Biosphere Programme (IGBP) workshop held in 2007,[10] as well as from the UNFCCC Nairobi Work Programme on Impacts, Vulnerability and Adaptation to Climate Change. Whereas most parts of this Plan have simply been updated relative to the IP-04, a few sections have undergone more substantial revision, including the identification of new objectives and requirements.

This IP-10:

- Takes into consideration existing global, regional and national plans, programmes and initiatives;
- Is based on extensive consultations with a broad and representative range of scientists and data users, including an open review of the Plan;
- Is based on close collaboration with GEO in developing their broader Work Plans for the implementation of GEOSS;
- Identifies implementation priorities, resource requirements and funding options; and
- Includes indicators for measuring its implementation.

More information on the background and purpose of GCOS is given in Appendix 3 of the full Plan.

2. Meeting the Needs of the UNFCCC for Climate Information

This Plan, if fully implemented by the Parties both individually and collectively, will provide those global observations of ECVs and their associated products to assist the Parties in meeting their responsibilities under Articles 4 and 5 of the UNFCCC. In addition, although the Plan does *not* include changing needs for limited duration observations in research studies, it will provide most of the essential observations required by the WCRP and the IPCC. Specifically the proposed system would provide information to:

- Characterise the state of the global climate system and its variability;
- Monitor the forcing of the climate system, including both natural and anthropogenic contributions;
- Support the attribution of the causes of climate change;
- Support the prediction of global climate change;
- Enable projection of global climate change information down to regional and local scales; and
- Enable characterisation of extreme events important in impact assessment and adaptation and for the assessment of risk and vulnerability.

Key Need 1: Urgent action and clear commitment by Parties to sustain, and build upon, the achievements in systematic observation of climate since 2004 are required to ensure that the Parties have the information they need to plan for, and manage effectively, their response to climate change.

As noted above, this Plan primarily addresses the needs of the UNFCCC for systematic observation of the climate system. Implementation of its recommendations, however, would also underpin a broad range of other climate applications for the benefit of Parties. It would support other UN Conventions, such as the United Nations Convention on Biological Diversity (UNCBD) and the United Nations Convention to Combat Desertification (UNCCD), the initiative “Acting on Climate Change: The UN System Delivering as One,” and also the evolving development of climate services at both the national and international levels.

[10] GCOS, WCRP, IGBP (2008): *Future Climate Change Research and Observations: GCOS, WCRP and IGBP Learning from the IPCC Fourth Assessment Report*, GCOS-117 (WMO/TD-No. 1418; WCRP-127; IGBP-58), January 2008, http://www.wmo.int/pages/prog/gcos/Publications/gcos-117.pdf

2.1. Essential Climate Variables

This Plan specifies the Actions required to implement a comprehensive observing system for the Essential Climate Variables (ECVs). The list of ECVs (see Table 1) is evolving slowly as requirements change and as technological developments permit. Compared to the IP-04, the updated list of ECVs now includes soil moisture, soil carbon, and ocean oxygen content, and recognises the role of precursors in contributing to the formation of the ozone and aerosol ECVs. Additionally, for clarity, some variables have been given a different name: 'ice sheets' were previously included in 'glaciers and ice caps' in the IP-04, and 'ocean acidity' and 'carbon dioxide partial pressure,' whose measurement allows characterisation of ocean carbon content, replace 'ocean carbon' in the IP-04. Actions in this Plan related to emerging ECVs, such as soil carbon, are more limited in what is expected to be achieved over five years. The Plan notes that biodiversity and habitat properties are important to climate impact studies but that they are currently impossible to define as an ECV as only aspects of these complex properties can be measured, and only at a relatively small number of sites. Therefore, the Plan seeks the establishment of "Essential Ecosystem Records" at sites where such observations will be conducted in adherence to high standards (with collocated measurement of meteorological variables) and will be sustained over the long term to allow future impact assessments.

2.2. Implementation Actions and Associated Cost Implications

The Plan includes some 138 specific Actions to be undertaken, mostly over the next five years, across the atmospheric, oceanic, and terrestrial domains. Many of the proposed Actions are already underway, at least as part of research activities, and most of the required coordination mechanisms have been identified. The Plan is both technically feasible and cost-effective in light of the societal and economic importance of climate observations to the work of the UNFCCC. It involves global extension and improved operating practices for observing systems that are currently supported and functioning for other purposes. While its implementation is dependent on national efforts, success will be achieved only with international cooperation, coordination and in some cases, sustained technical and financial support for least-developed countries.

For many ECVs, although the Plan focuses on meeting global requirements, global data and products are also relevant to regional and local needs. Additionally, for the ECVs critical to impacts assessments and adaptation, the need for data at the regional and national scale is recognised. This includes data needed to characterise extreme events, which are usually of a small scale and short-lived, and for which the Plan recommends Actions to support both national and regional as well as global estimates. Finally, the Plan will be updated about every five years as networks and systems become operational and as new knowledge and techniques become available.

Priority in implementing the Plan should be given specifically to improving the quality of, and access to, high-quality global climate data; generating global analysis products; improving key satellite and *in situ* networks; and strengthening national and international infrastructure, including achieving the full participation of least-developed countries and small island developing states.

Table 1: Essential Climate Variables that are both currently feasible for global implementation and have a high impact on UNFCCC requirements

Domain	Essential Climate Variables	
Atmospheric (over land, sea and ice)	**Surface:**[11]	Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget.
	Upper-air:[12]	Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance).
	Composition:	Carbon dioxide, Methane, and other long-lived greenhouse gases[13], Ozone and Aerosol, supported by their precursors[14]
Oceanic	**Surface:**[15]	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton.
	Sub-surface:	Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers.
Terrestrial	River discharge, Water use, Groundwater, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture.	

The estimated costs of implementing Actions in this Plan are given as additional annual costs on top of the costs of maintaining and operating existing[16] networks, systems and activities that are required to address climate needs but that are in many cases not specifically designed for climate purposes. These additional costs include costs for augmenting existing systems in support of climate needs, for continuing some existing networks, systems and activities undertaken for research purposes with no plans for continuity, for the transition of systems from research to operations, and for new systems needed to satisfy climate needs.

Figure 1 schematically illustrates the cost estimates in this Plan within four cost categories (satellite-related, open-ocean related, related to enhancements in developing countries, and related to enhancements in developed countries). The estimates were calculated by adding up, by category, the estimated costs for all Actions proposed in the Plan (see Appendix 6 of the full Plan for details). For relevant Actions, estimates have been made of the share of additional annual expenditure needed within the national territories of non-Annex-I[17] (mostly developing) countries and Annex-I (developed) countries respectively. Other Actions require funding for satellite-related and open ocean-related systems and activities, which is mostly, but not exclusively, provided by developed countries. The breakdown of costs was made in response to the SBSTA 30 request (cf. Appendix 1 of the full Plan) which asked the GCOS Steering Committee to provide estimates "by region and observing system and between developed and developing countries."

[11] Including measurements at standardized, but globally varying heights in close proximity to the surface.
[12] Up to the stratopause.
[13] Including N_20, CFCs, HCFCs, HFCs, SF_6 and PFCs.
[14] In particular NO_2, SO_2, HCHO and CO.
[15] Including measurements within the surface mixed layer, usually within the upper 15 m.
[16] Funding for these existing networks, systems, and activities is not necessarily secured in the future.
[17] Appendix 7 of the full Plan lists all Annex-I and non-Annex-I Parties to the UNFCCC.

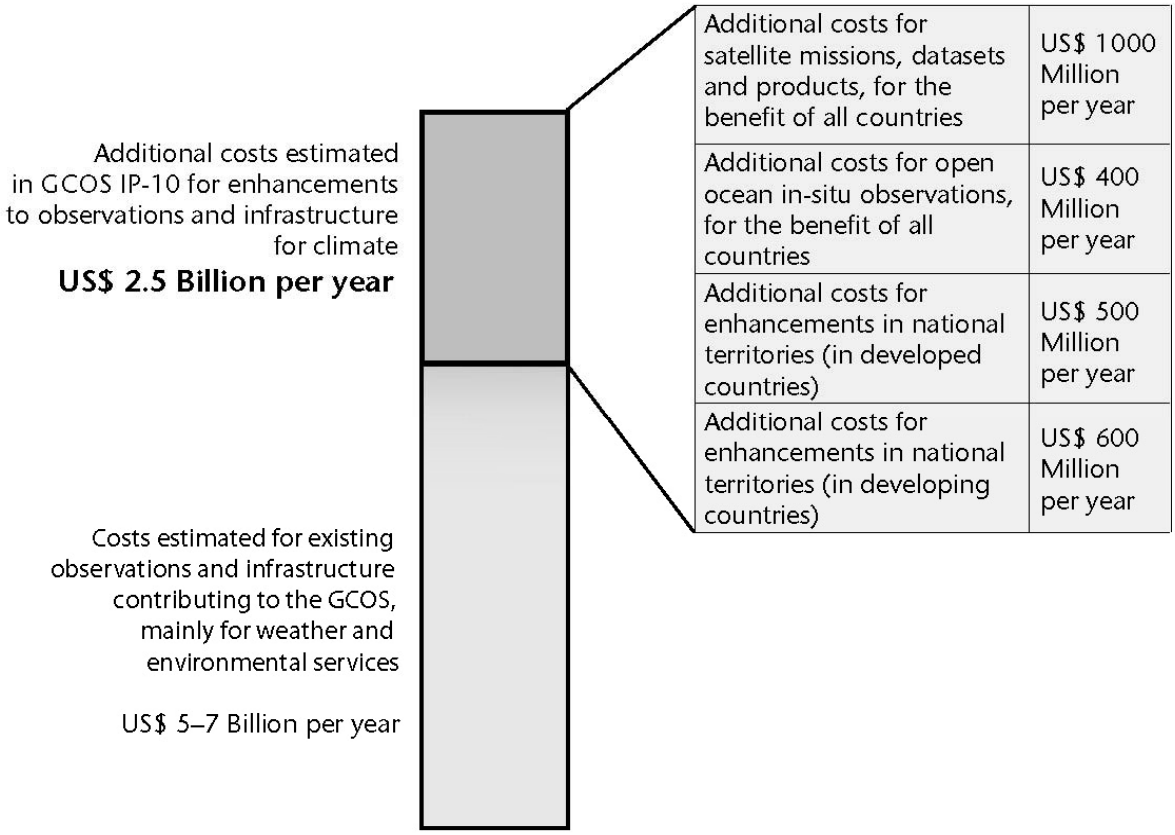

Figure 1: Estimates of the additional annual costs of implementing the IP-10 Actions (in orange), compared to estimates of total annual costs for existing observations and infrastructure contributing to GCOS (in blue).

The lower part of the bar in Figure 1 shows current expenditures for observing networks, systems and activities that are maintained primarily for weather and environmental monitoring purposes, but that are also important for climate. Table 2 provides a summary of the costs of undertaking all Actions proposed in this Plan within cross-cutting, atmospheric, oceanic and terrestrial domains.

Table 2: Summary of Actions in the IP-10, and estimated total annual implementation costs (in million (M) US dollars; see Figure 1 for context)

Cost Range	Number of Cross-Cutting Actions	Number of Actions in the Atmospheric Domain	Number of Actions in the Oceanic Domain	Number of Actions in the Terrestrial Domain	Total
<1M	3	5	6	7	21
1M-10M	7	10	23	23	63
10M-30M	6	13	5	7	31
30M-100M	1	3	7	3	14
100M-300M	0	3	0	0	3
Uncosted Actions[18]	6	0	0	0	6
Total Number of Actions	23	34	41	40	138
Estimated Total Annual Cost[19]	**200**	**1100**	**700**	**500**	**2500**

Of particular importance to support adaptation planning and the provision of national climate services in developing countries of all sizes are the observations related to measuring the local climate and the availability of water (e.g., surface temperature, precipitation, river runoff), as well as related to coastal marine sites including tide gauges. For these networks and systems, the Plan provides initial recommendations and associated cost estimates by assuming that developing countries will need national and regional observation densities comparable with those currently found in the most economically-advanced developed countries. Additional regional detail could be achieved through a specific call to non-Annex-I Parties to report on their climate observing systems and related needs and on the costs to address these needs.

Key Need 2: Parties need, both individually and collectively, to commit to the full implementation of the global observing system for climate; to sustain a mix of high-quality satellite, ground-based and airborne *in situ* measurements, and remote-sensing measurements; to sustain dedicated analysis infrastructure; and to undertake targeted capacity-building.

3. Agents for Implementation

The global observing system for climate requires observations from all domains – atmospheric, oceanic, and terrestrial – which are then transformed into products and information through analysis and integration in both time and space. Since no single technology or source can provide all the needed observations, the ECVs will be provided by a composite system of *in situ* instruments on the ground and on ships, buoys, floats, ocean profilers, balloons, samplers, and aircraft, as well as from all forms of remote sensing, including satellites. Metadata (i.e., information on where and how the observations are taken) are absolutely essential, as are historical and palaeoclimatic records that set the context for the interpretation of current trends and variability. Although these individual activities are to be coordinated internationally through a variety of

[18] Costs covered in domain Actions.

[19] Rounded to the nearest 100 million (M) US$; estimates assume average costs (in US$) of 0.5M (for <1M range), 5M (for 1-10M range), 20M (for 10-30M range), 65M (for 30-100M range) and 200M (for 100-300M range); cf. Appendix 6 of the full Plan for details.

programmes, organizations and agencies, success will depend mainly on national and regional entities to translate the Plan into reality. Collectively, all of these entities are referred to in the Plan as the "Agents for Implementation."

3.1. International, Regional and National Agents

The networks, systems, data centres and analysis centres identified within this Plan are almost all funded, managed, and operated by national entities to address their own requirements, plans, procedures, standards and regulations. This Plan calls on all contributing networks and systems to respond to the Actions contained in it and, where appropriate, to adjust their plans, procedures and operations to address the specified climate observing requirements. The GCOS Steering Committee, Panels, and Secretariat will continue to emphasize with all relevant international and intergovernmental organizations the need for their members to: (a) undertake coordination and planning for systematic climate observations where this is not currently being undertaken; and (b) produce and update on a regular basis plans for their contributions to the global observing system for climate, taking into account the Actions included in this Plan. For these Actions to be effective, it will also be essential for the Parties to ensure that their requirements for climate observations are communicated to the relevant international and intergovernmental organizations.

Key Need 3: International and intergovernmental organizations need to incorporate the relevant Actions in this Plan within their own plans and actions.

Recognizing the commonality of national needs for regional climate information, regional planning, and implementation of climate observing system components is particularly needed since it provides an effective means of sharing workloads and addressing common issues. Examples of needs that typically are best met on a regional basis include data management and exchange and related capacity-building.

Key Need 4: Parties should identify common needs related to climate data and information in their region, and work with neighbouring countries on a regional basis.

The needs of the UNFCCC and other users for global climate observations and products can be addressed only if plans are developed and implemented in a coordinated manner by national organizations. As noted in the Second Adequacy Report, with the exception of the main meteorological networks and the planning for individual activities, most climate-observing system activities are poorly coordinated, planned, and integrated at the national level (particularly in the ocean and terrestrial domains). All Parties need national coordination mechanisms and national plans for the provision of systematic observation of the climate system. Such mechanisms are usually best sustained when national coordinators or committees are designated and assigned responsibility to coordinate planning and implementation of systematic climate observing systems across the many departments and agencies involved. In 2009, the Executive Heads of all four sponsors of GCOS jointly urged countries to appoint GCOS National Coordinators[20] and/or establish GCOS National Committees.

Key Need 5: Parties are encouraged to establish effective institutional responsibilities for oceanographic and terrestrial observations at the national level.

Key Need 6: Parties should produce national plans on their climate observing, archiving and analysis activities that are encompassed by this Plan. This could be assisted by establishing National GCOS Coordinators and National GCOS Committees.

[20] There are currently 23 designated GCOS National Coordinators (31 May 2010). More details, including their Terms of Reference, are available at http://www.wmo.int/pages/prog/gcos/index.php?name=NationalActivities

Reporting by the Parties[21] on systematic climate observation activities as part of their National Communications under the UNFCCC is essential for planning and monitoring the implementation of the global observing system for climate. The response by Parties to the Second Adequacy Report emphasized that accurate and credible information relative to all aspects of climate observations must be exchanged, according to the relevant guidelines (Decision 11/CP.13).

Key Need 7: Parties are requested to submit information on their activities related to systematic observation of all ECVs as part of their national communications to the UNFCCC using the Reporting Guidelines[22] approved by COP 13 in 2007.

3.2. Participation by all Parties

The UNFCCC COP has recognised the importance of systematic observation in developing countries, particularly for adaptation to climate change, as highlighted for example in the UNFCCC Nairobi Work Programme. There are many ways that systems can be improved, including, for example, through developed country agencies working with organizations and personnel from developing countries, and by the donation of equipment and the training of personnel. The GCOS Cooperation Mechanism (GCM) has been established by interested developed countries to provide a coordinated, multi-governmental approach to address the high-priority needs for stable long-term funding for key elements of the global observing system for climate. The GCM is especially targeted at least-developed countries, small island developing states and some countries with economies in transition. To date, the GCM has been able to mobilize some resources for this purpose through limited additional national and donor support and by focussing on a small number of networks, but much more dedicated support and a broader perspective on all networks contributing to the GCOS is needed. Capacity-building in the ocean and terrestrial domains is particularly challenging due to the widespread lack of appropriate institutional structures in developing countries.

The GCM will complement and work in cooperation with existing funding and implementation mechanisms (e.g., the WMO Voluntary Cooperation Programme, the United Nations Development Programme (UNDP), and the many national aid agencies), many of which deal with climate-related activities and support capacity-building.

Key Need 8: Parties are requested to address the needs of least-developed countries, small island developing states, and some countries with economies in transition for improving systematic climate observations by encouraging multilateral and bilateral technical cooperation programmes to support global observing systems for climate, by participating in the GCOS Cooperation Mechanism, and by contributing to the GCOS Cooperation Fund.

The Plan outlines a comprehensive programme that requires contributions from virtually all countries and organizations dealing with Earth observations and requires continuing and strengthened coordination and performance monitoring.

The GCOS Regional Workshop Programme,[23] implemented in ten workshops between 2000 and 2006, established a framework for interested developing countries and economies in transition to work together to optimize their networks and to identify both national and GCOS network needs in each region. Regional

[21] Reports are available through the UNFCCC Secretariat at http://unfccc.int/methods_and_science/research_and_systematic_observation/items/4499.php and a synthesis report is available at http://www.wmo.int/pages/prog/gcos/Publications/gcos-130.pdf

[22] UNFCCC (2008): *Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007*; Addendum: Decision 11/CP.13 (Reporting on global observing systems for climate), FCCC/CP/2007/6/Add.2, http://unfccc.int/resource/docs/2007/cop13/eng/06a02.pdf#page=1

[23] For more information, see http://www.wmo.int/pages/prog/gcos/index.php?name=RegionalWorkshopProgramme

Action Plans, the principal outputs of these ten workshops, have been developed, and some elements of them have found support from Parties and donors for implementation.

Nevertheless, many of the priority projects included in the Regional Action Plans have not yet been implemented.[24] In addition to the continuing need for implementation of the existing projects in these plans, many projects may now need to be updated and refined to address current priority needs.

Key Need 9: Parties should continue to work on implementing the priority projects in the GCOS Regional Action Plans, and to update and refine the projects contained in them as necessary.

4. Availability of Climate Data and Products

4.1. High-Quality Climate Data: Exchange and Access

Ensuring that high-quality climate data records are collected, retained and made accessible for use by current and future generations is a key objective of this Plan. As a result, investment in the data management and analysis components of the system is as important as the acquisition of the data. The Plan calls for internationally-recognised data centres (International Data Centres (IDCs) henceforth)[25] that include the World Data Centres and are highly effective in: (a) actively collecting data (other than the very large satellite datasets that are usually managed by the responsible space agency), (b) ensuring consistency and quality of the data, (c) ensuring that adequate metadata are provided, (d) being functional on a long-term basis, and (e) maintaining effective user access and data dissemination mechanisms. These IDCs perform a critical function and are supported on a voluntary basis by a number of Parties. Parties are encouraged to recognise the important role these Centres play and to ensure that they are effectively managed and well-supported on a long-term basis. IDCs are complemented by national data centres which have an important role in data archiving at the national level. The Plan seeks to strengthen existing IDCs and national data centres and to encourage commitments for new Centres so that there is appropriate infrastructure in place for all ECVs or groups of ECVs.

The flow of data to the user community and to the IDCs is inadequate for many ECVs, especially for those of the terrestrial observing networks. Lack of national engagement and resources, restrictive data policies, and inadequate national and international data system (including telecommunication) infrastructure are the main causes of the inadequacy. The national reports to the UNFCCC on systematic observation should be taken as an opportunity to check whether these activities are undertaken to a satisfactory level.

Key Need 10: Parties should ensure regular and timely submission of climate data to International Data Centres for all ECVs.

In Decision 14/CP.4, the COP urged Parties to undertake free and unrestricted exchange of data to meet the needs of the Convention, recognizing the various policies on data exchange of relevant intergovernmental and international organizations. Yet, as the Second Adequacy Report and the IP-04 point out repeatedly with respect to almost all of the variables, the record of many Parties in providing full access to their data is poor. This Plan is based on the free and unrestricted exchange of all data and products and incorporates Actions to: (a) develop standards and procedures for metadata and its storage and exchange; (b) to ensure timely, efficient and quality-controlled flow of all ECV data to climate monitoring and analysis centres and

[24] As noted in the Conclusions by SBSTA 30 (FCCC/SBSTA/2009/3) and GCOS (2009): *Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008,* GCOS-129 (WMO/TD-No. 1489; GOOS-173; GTOS-70), August 2009, http://www.wmo.int/pages/prog/gcos/Publications/gcos-129.pdf

[25] International Data Centres are responsible for monitoring, product preparation and dissemination as well as archiving.

international archives; and (c) to ensure that data policies facilitate the exchange and archiving of all ECV data and associated metadata.

4.2. GCOS Climate Monitoring Principles

The GCOS Climate Monitoring Principles (GCMPs) provide basic guidance regarding the planning, operation, and management of observing networks and systems, including satellites, to ensure that high-quality climate data are available and contribute to effective climate information. The GCMPs address issues such as the effective incorporation of new systems and networks; the importance of calibration, validation, and data homogeneity; the uninterrupted operation of individual stations and systems; the importance of additional observations in data-poor regions and regions sensitive to change; and the crucial importance of data management systems that facilitate access, use, and interpretation of the data. These principles have been adopted or agreed by the UNFCCC, WMO, the Committee on Earth Observation Satellites (CEOS), and other bodies. The implementation Actions now call on all data providers to adhere to the GCMPs and to initiate effective programmes of data quality control. When calibrating observing systems, traceability to SI standards should be ensured where possible.

Key Need 11: Parties need to ensure that their climate-observing activities that contribute to GCOS adhere to the GCOS Climate Monitoring Principles.

4.3. Data Management and Stewardship

Climate observations that are well-documented, and that have good metadata about the systems and networks used to make them, become more valuable with time. The creation of climate-quality data records is a fundamental objective of the global observing system for climate. International standards and procedures for the storage and exchange of metadata need to be developed and implemented for many climate observing system components, including those of the operational satellite community. It is essential that all such data be properly archived and managed with the full expectation that they will be reused many times over in the future, often as a part of reprocessing or reanalysis activities. Good stewardship of the data also requires that data be migrated to new media as technology changes, be accessible to users, and be made available with minimal incremental costs. Data stewardship includes systems for quality control and feedback, proper data archival and access, sustained data preservation, rescue and digitization, and climate data management systems. Capacity-building is needed for all of these.

Key Need 12: International standards for metadata for all ECVs need to be adopted and maintained by the Parties in creating and archiving climate data records.

4.4. Products

Use of observations for policy and planning purposes depends on access to information beyond the basic observations. To meet the needs of all Parties for climate information, the global observing system for climate must support the generation of useful climate products. The preparation of climate products is sometimes based on single-source datasets, sometimes involves the integration of data in time and space and the blending of data from different sources. Experience has shown that detecting trends in products can be problematic and that the independent generation of a number of high-quality single-source datasets, as well as integrated products, is needed to ensure reliable conclusions.

Products need to be well-documented and accompanied by information which helps users to assess their quality and applicability.[26] Some products, such as reanalysis to climate standards, involve extensive dataset preparation and significant computing and data management resources. They also implicitly require estimation of uncertainties. Providing access to climate information for all Parties will involve significant information technology infrastructure. The best use of available resources will come as a result of international coordination of these activities. Therefore, a sustained and coordinated application of reanalysis is one of the key needs of this Plan for all domains.

Key Need 13: Parties are urged to adopt an internationally-coordinated approach to the development of global climate products and to make them accessible to all Parties. As far as possible, these products should incorporate past data covering at least the last 30 years in order to serve as a reference for climate variability and change studies.

Key Need 14: Parties are urged to give high priority to establishing a sustained capacity for global climate reanalysis, to develop improved methods for such reanalysis, and to ensure coordination and collaboration among centres conducting reanalyses.

5. Ensuring the Adequacy of Climate Observing Systems

The global observing system for climate in support of the UNFCCC is an integrated system comprised of complementary satellite and *in situ* components. With greater attention to climate monitoring issues, satellites are expected to become an increasingly important means of obtaining observations globally for comparing climate variability and change over different parts of the Earth. Therefore, a system of satellites and satellite sensors implemented and operated in a manner that ensures the long-term accuracy, stability, and homogeneity of the data through the adoption of the GCMPs is a high priority within the Plan. At the same time, some ECVs will remain dependent on *in situ* observations for data and information, including for the detection of long-term trends, for calibration and validation of satellite records, and for measuring variables not amenable to direct satellite measurement (e.g., sub-surface oceanic ECVs and surface air temperature). The *in situ* datasets also need to be continuously characterised in terms of their long-term accuracy, stability and homogeneity. Consistent with the role of satellites, the Plan details the substantial effort required to ensure the operation and refinement of *in situ* networks.

Describing and understanding Earth system cycles, such as the water, carbon, and energy cycles, generally requires knowledge of sets of ECVs and their variability in time and space, for example for the estimation and validation of fluxes. This requires an integrated view on these ECVs, sometimes across the domains (atmospheric, oceanic, and terrestrial) used in this Plan. Moreover, an individual variable often serves multiple application areas, or links with multiple cycles.

Some of the key domain-specific components are highlighted in the following paragraphs.

5.1. Atmospheric Domain

Many atmospheric observing systems, including some satellite components, are relatively mature, having been in existence for several decades or more. Although not established primarily for climate purposes, for example the systems coordinated by the WMO World Weather Watch (WWW), the data that they have provided are an essential part of the current climate record. As a result, a basic requirement for the atmospheric domain is to ensure the continuity of operation of the comprehensive atmospheric observing networks and systems, implementing improvements where required, and ensuring full international data exchange. Ground-based networks and some space-based measurements provide in particular the basic

[26] GCOS (2010): *Guideline for the Generation of Datasets and Products Meeting GCOS Requirements*, GCOS-143 (WMO/TD-No. 1530), May 2010, http://www.wmo.int/pages/prog/gcos/Publications/gcos-143.pdf

observations of the surface climate variables that most directly impact natural and human systems. These observations are needed to assess, at regional and (sub)national scales, vulnerabilities and adaptive responses to climate change. The surface networks that provide them need to be operated with a density of observation in space and time that is fit for this purpose. Reanalysis of the comprehensive and diverse observational record using data assimilation provides integrated products. Reanalysis needs sustaining and developing because of its capability and potential for meeting widespread requirements for processed and reprocessed data.

Baseline networks such as the GCOS Surface Network (GSN), the GCOS Upper-Air Network (GUAN) (subsets of the full WMO WWW/Global Observing System (GOS) surface and upper-air networks) and the WMO Global Atmosphere Watch (GAW) networks for ozone, plus related satellite observations, such as those provided for thirty years from microwave sounding, provide the basic observations for directly monitoring the global climate system. Extension of these networks to cover all atmospheric ECVs and full operation, including application of the GCMPs, is a continuing fundamental requirement. As recently recognised by steps taken towards establishing a GCOS Reference Upper-Air Network (GRUAN), the system of comprehensive and baseline measurements needs to be complemented by a limited number of sites providing highly-detailed and accurate data for reference purposes. There is also a corresponding need for sustained measurement of key variables from space traceable to reference standards. The establishment of the Global Space-Based Intercalibration System (GSICS) and deployment of rigorously-calibrated satellite instruments in orbit are two activities supporting that need. The unique value of historical satellite-based datasets, such as the 30-year record provided by the Advanced Very High Resolution Radiometer (AVHRR) should be fully exploited through coordinated and sustained reprocessing of those datasets.

Key Need 15: Parties need to: (a) sustain and refine the comprehensive atmospheric *in situ* and satellite-based observing systems, ensuring the provision of surface data adequate for assessing impacts and adaptive responses; (b) fully implement the baseline networks and systems and operate them in accordance with the GCMPs; (c) ensure timely and complete international exchange of data from both comprehensive and baseline networks; (d) establish the GRUAN network for reference upper-air measurements and a complementary system for reference measurements from satellites; and (e) support reanalysis and reprocessing activities.

Better observation of the water cycle is a general requirement for understanding and supporting the modelling and prediction of climate. Of the variables concerned, precipitation is of considerable importance because of the extent of its direct societal impact. Precipitation is, however, one of the most difficult quantities to observe to the extent needed to meet climate needs, because (a) its physical nature makes reliable point measurement challenging, (b) amounts can vary widely in space and time, and (c) the impacts themselves can depend critically on location, timing, and precipitation type. There is thus a pressing need to develop and implement improved observation and estimation of precipitation from local to global scales.

Key Need 16: Parties need to: (a) submit all national precipitation data, including hourly totals and radar-derived products where available, to the International Data Centres; (b) develop and implement improved methods for ground-based measurement of precipitation; (c) develop and sustain operation of a constellation of satellites providing data on precipitation, building on the system to be implemented in the Global Precipitation Measurement mission; and (d) support the continued development of improved global precipitation products.

Greenhouse gases and aerosols are the primary agents in forcing climate change. For greenhouse gases, elements of the required *in situ* networks are in place, but extension and attention to quality assurance are needed. Assessment and development of missions for complementary observations of carbon dioxide and methane from space are also needed, with emphasis required on use of data from the resulting composite observing system to meet needs for improved estimation of surface fluxes. Aerosol is a complex variable, and this Plan calls for development and implementation of a coordinated strategy to monitor and analyse the distribution of aerosol properties and precursor species. The strategy should address the definition of a

baseline GCOS network or networks for *in situ* measurements, assess the needs and capabilities for operational and research satellite missions, and propose arrangements for coordinated mission planning. Global baseline networks for ozone, a key atmospheric constituent, have been put in place, but major geographical gaps remain. Continuity of the existing long-term satellite record of ozone needs to be ensured, especially for high-resolution vertical profile measurements using the limb sounding technique.

Key Need 17: Parties need to: (a) develop further the comprehensive network for key greenhouse gases; (b) utilise and refine existing networks to establish a global baseline network for aerosol optical depth; and (c) develop and implement coordinated and complementary strategies for long-term satellite measurements of carbon dioxide, methane, aerosols, ozone and precursor species.

Measurements of total solar irradiance and the Earth radiation budget provide overall monitoring of the solar radiative forcing of climate and of the net greenhouse effect within the atmosphere. Clouds strongly affect the radiation budget and provide the most uncertain feedbacks in the climate system. It is vital to maintain continuity of long-term records and resolve uncertainties in measurements and analyses of radiation and clouds. Cloud properties, including their link with aerosols, are of particular importance, and there is a continuing need for research to improve their monitoring. Surface radiation measurements over land are an important complementary observation, and the baseline surface radiation network needs to be extended to achieve representative global coverage.

Key Need 18: Parties need to: (a) ensure the continued operation and analysis of satellite measurements of solar irradiance and the Earth radiation budget; (b) support research to improve current capabilities for monitoring clouds as a high priority; and (c) extend the network of supporting surface measurements.

5.2. Oceanic Domain

Substantial progress in implementing the IP-04 ocean domain Actions has been made: the ice-free upper 1500 metres of the ocean are being observed systematically for temperature and salinity for the first time in history. Commitments to continuity of a number of critical ocean satellite sensors have been made.

However, most *in situ* observing activities continue to be carried out under research agency support and on research programme time limits; thus, the financial arrangements that support most of the present effort are quite fragile.

There has been very limited progress in the establishment of national ocean or climate institutions tasked with sustaining a climate-quality ocean observing system. Thus, the primary Agents for Implementation for most *in situ* ocean observations and climate analyses remain the national and regional research organizations, with their project-time-scale focus and emphasis on principal investigator-driven activities.

Data sharing remains incomplete, particularly for tide gauges and biogeochemical ECVs. Data archaeology needs to continue. Although progress has been made on recovery of the ocean historical dataset, continuing efforts in data rescue, digitization and data sharing are needed.

Key Need 19: Parties need to: (a) designate and support national and regional Agents for Implementation with responsibilities for implementing the ocean observing system; (b) establish effective partnerships between their ocean research and operational communities towards implementation; and (c) engage in timely, free and unrestricted data exchange.

The ocean plays critical, but generally not obvious, roles in the fundamentally coupled ocean-atmosphere-land Earth climate system. The ocean varies strongly on interannual and decadal time scales, and will undergo much greater change due to these variations over the next few decades than will result from climate change alone over the same period. Sea level is a critical variable for low-lying regions; globally, it is driven

by volume expansion or contraction due to changes in sub-surface ocean density and by exchange of water between the oceans and other reservoirs, such as land-based ice, and the atmosphere. Developing confidence in forecasts of oceanic variability and change will require accurate datasets over the entire world ocean. The composite near-surface and sub-surface ocean observing networks described here include global monitoring of certain ECVs where this is feasible. In some other cases, monitoring of ECVs depends on observations from reference stations or sites, or in case of sub-surface ocean carbon, nutrients and tracers, on repeat ship-based surveys. A variety of Actions are necessary to sustain the progress made and to extend the capabilities of these networks.

Key Need 20: Parties need to ensure climate quality and continuity for essential ocean satellite observations of ocean surface ECVs: wind speed and direction, sea-surface temperature, sea-surface salinity, sea level, sea state, sea ice, and ocean colour.

Key Need 21: Parties need to provide global coverage of the surface network by implementing and sustaining: (a) an enhanced network of tide gauges; (b) an enhanced surface drifting buoy array; (c) an enhanced tropical moored buoy network; (d) an enhanced voluntary observing ship network including salinity measurements; (e) the surface reference mooring network, (f) a globally-distributed plankton survey network; and (g) international coordination of coral reef monitoring.

Key Need 22: Parties need to provide global coverage of the sub-surface network by implementing and sustaining: (a) the Argo profiling float array; (b) the systematic sampling of the global ocean full-depth water column; (c) ship of opportunity trans-oceanic temperature sections; and (d) the tropical moored buoy and reference mooring networks referred to in Key Need 21 above.

A number of important research planning and subsequent implementation Actions deal with the establishment of an observing network for the partial pressure of carbon dioxide (pCO_2), the measurement of the state and change of carbon sources and sinks in the oceans, and the measurement of the state and change of marine biodiversity and key ocean habitats.

Continuing climate research and technology programmes for the oceans are needed to enhance the efficiency and effectiveness of observing strategies, and to develop capabilities for important climate variables that cannot currently be observed globally. This need for enhanced capability is particularly acute for remote locations, and for improved understanding of ocean biogeochemistry and ecosystems. Continued research is also needed for improving the estimates of uncertainty, for understanding the mechanisms of climate change, to improve understanding of the impacts of climate change and variability, and to underpin decisions on adaptation to climate change.

Key Need 23: Parties need to support research and pilot project Actions to develop a sustained global observing capability for biogeochemical and ecosystems variables: carbon dioxide partial pressure, ocean acidity, nutrients, oxygen, tracers, marine biodiversity and habitat properties.

5.3. Terrestrial Domain

Increasing significance is being placed on terrestrial data for estimating climate forcing, for better understanding of climate change and variability, and for impact and mitigation assessment. The recognition of this has led to substantial progress in a number of areas in the terrestrial domain. There has also been significant progress in defining internationally-accepted standards for the terrestrial ECVs, forming the basis of an international framework for the development and promulgation of such standards in all countries. Progress in establishing institutional support for *in situ* networks has been slow, leading to networks that are still poorly coordinated and harmonized, despite the considerable effort of the research community to keep them running.

This Plan proposes Actions designed to achieve an initial coordinated and comprehensive observational programme for all terrestrial ECVs. Given the highly-variable nature of the land surface, most terrestrial ECVs have a particularly strong satellite component essential for global coverage, whereas *in situ* measurements provide key and detailed information at particular sites. A few terrestrial ECVs depend by their nature on *in situ* observations. This includes permafrost, soil carbon, river discharge, and groundwater.

Hydrological variables are of critical societal importance. Many are observed but not well-exchanged for the purposes of assessing global climate change. The Plan proposes specific Actions to continue the implementation of the global networks for hydrology (including specific lake and river components) and to develop the emerging networks for groundwater and soil moisture. Observations of the terrestrial cryosphere – snow cover, freshwater ice, glaciers, ice sheets, and permafrost – and of their changes over time are equally important.

Key Need 24: Parties are urged to: (a) submit current and historical terrestrial data, including hydrological data, to the International Data Centres; (b) provide support for the designated International Data Centres; and (c) fill the identified gaps in the global networks for terrestrial hydrology and the cryosphere, and maintain those networks.

In the terrestrial domain it is essential to obtain global products for most ECVs from a range of satellite sensors supported by *in situ* measurements. A coordinated *in situ* network of terrestrial reference sites is needed for: (a) observations of the fullest possible range of terrestrial ECVs and associated details relevant to their application in model validation; (b) process studies; (c) validation of observations derived from Earth observation satellites; and (d) to address intrinsic limitations in some of these, such as the saturation of LAI measurements.

Satellite instruments relevant for terrestrial ECVs range from high-resolution optical spectrometers and complex multi-spectral multi-angular imagers to radar and lidar systems. Many of these instruments are currently flying on research-type missions, and plans for continuity are needed to ensure sustained terrestrial observations.

Monitoring land-based carbon stocks and their variability is one of the critical tasks that a combination of satellite and *in situ* observations needs to meet. For example, *in situ* observations of carbon-related ECVs are critical in the measurement of carbon content of soils, as well as important for the calibration and validation of satellite-derived land cover-related products.

For the systematic monitoring of ecosystems and biodiversity and habitat properties at selected sites, an ecosystem monitoring network acquiring “Essential Ecosystem Records” should be initiated. Opportunities for the collocation of sites with the proposed terrestrial reference network and the network of validations sites should be exploited.

Key Need 25: Parties are urged to support the sustained operation of satellite instruments and the sustained generation of the satellite-based products relevant for terrestrial ECVs.

Key Need 26: Parties are urged to develop a global network of terrestrial reference and validation sites to monitor soil and land cover-related variables, to acquire essential ecosystem records, and to provide the observations required in the calibration and validation of satellite data.

6. Improving the System

Our ability to measure some key and emerging ECVs from *in situ* and remote-sensing systems (both surface- and satellite-based) is limited by the lack of suitable instruments and techniques. The limitation can vary all the way from difficulties with the fundamental observing technique to those associated with

instrumentation, measurement methodology, suitable calibration/validation techniques, spatial and temporal resolution, ease of operation, and cost.

The development, demonstration, and validation of existing and new techniques are vital to the future success of the global observing system for climate in support of the UNFCCC. It is critically important that as new global satellite-based observations of environmental variables are made, the validation of both the measurements themselves (e.g., radiances) and the retrieval algorithms be carried out under a sufficiently broad range of conditions that they can be confidently applied in the creation of global datasets.

Research is needed to improve the ability to blend different datasets and/or data sources into integrated products. As new types of data are assimilated into models, it will also be important to understand the error characteristics of the new data and of the models used. Data assimilation for climate purposes is still in an early stage of development and requires continued research support. As these developments occur, reprocessing of data to take advantage of the new knowledge will be vital to sustained long-term records.

GCOS Secretariat
Global Climate Observing System
c/o World Meteorological Organization
7 *bis,* Avenue de la Paix
P.O. Box No. 2300
CH-1211 Geneva 2, Switzerland
Tel: +41 22 730 8275/8067
Fax: +41 22 730 8052
Email: gcosjpo@wmo.int
Web: http://gcos.wmo.int