Appendices to the Implementation Plan of the Global Framework for Climate Services – Observing and Monitoring Component

World Meteorological Organization
Weather · Climate · Water

GFCS
GLOBAL FRAMEWORK FOR CLIMATE SERVICES

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APPENDICES

TO THE

IMPLEMENTATION PLAN OF THE GLOBAL FRAMEWORK FOR CLIMATE SERVICES -

OBSERVATIONS AND MONITORING COMPONENT

LIST OF APPENDICES

APPENDIX 1

Relevant Existing Plans and Activities and Identification of Gaps

Table 5.3 at the end of Appendix 5 reviews the current status of observational networks and systems for important atmospheric, terrestrial, and oceanic variables needed to support the provision of climate services to user communities. Plans and activities addressing the need to improve these climate observing systems currently exist for a variety of requirements, and some of the most important of these are described in the following subsections.

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

The *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* is highly relevant to the implementation of the observing component of the GFCS, as many needs for observations have been elaborated in the Plan.[1] Updated in 2010, this Plan includes the acquisition of observational data for purposes directly aligned with those of the GFCS and highlights the need to encompass all components of the climate system. It is also based on extensive consultations with a broad and representative range of scientists and data users, and it has been developed in collaboration with the Group on Earth Observations (GEO).

The Plan pays special attention to the needs for observation of 50 Essential Climate Variables (ECVs) covering the three physical domains (atmosphere, land, and oceans) and includes observations related to the hydrological and carbon cycles and the cryosphere. The Plan was prepared at the request of the Parties to the UNFCCC. These Parties are essentially the same countries that requested the development of the GFCS, and implementation of the actions identified in it will address many of the needs for climate observations in support of the GFCS.

Implementation of the actions in the Plan will, among other things, enable projection of global climate change information down to regional and local scales and characterization of extreme events important for impact assessment, adaptation, and assessment of risk and vulnerability. The Plan was supplemented in 2011 by provision of details on its satellite-specific components in the report *Systematic Observation Requirements for Satellite-Based Data Products for Climate*. This report defines climate variable product requirements and needs for satellite missions, datasets, and reprocessing and represents an important step forward in integrating surface and space-based observations, thus partially filling gaps in the global observing system. However, the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC* and its satellite supplement do not address the whole range of non-physical climate-related data and information, in particular biological and socioeconomic data, that are needed to support the development of climate services.

World Climate Programme (WCP)

The World Climate Programme (WCP) aims, primarily, to enhance climate services, with adequate focus on user interaction, so as to facilitate ever more useful applications of climate information to derive optimal socioeconomic benefits. It is thus an integral part of the Global Framework for Climate Services (GFCS). The scope of the WCP is to determine the physical basis of the climate system that would allow increasingly skilful climate predictions and projections, to develop operational structures to provide climate services, and to develop and

[1] http://www.wmo.int/pages/prog/gcos/index.php?name=Publications

maintain an essential global observing system fully capable of meeting the climate information needs.

A new structure for the WCP was adopted by Resolution 18 of the Sixteenth WMO Congress. This new structure has three major components:

- The Global Climate Observing System (GCOS), which is aimed at meeting the full range of needs for climate observations. It is built on the WMO Global Observing System, Global Atmosphere Watch, and Global Cryosphere Watch (now brought together as part of the WMO Integrated Global Observing System), the IOC-led Global Ocean Observing System, and the FAO-led Global Terrestrial Observing System. It is co-sponsored by WMO, IOC, UNEP and ICSU and is particularly focussed on supporting the WCRP and the World Climate Services Programme, (introduced below);
- The World Climate Research Programme (WCRP), whose mission is to facilitate analysis and prediction of Earth system variability and change for use in an increasing range of practical applications of direct relevance, benefit, and value to society, with the overall objectives being to determine the extent to which climate can be predicted and the degree of human influence on climate;
- The World Climate Services Programme (WCSP), whose scope spans across climate data and analysis; climate monitoring, watch, and prediction; climate system operation and infrastructure; and climate adaptation and risk management. The WCSP contributes to improving the availability of and access to reliable data, the advancement of knowledge in the area of climate data management and climate analysis, the definition of technical and scientific standards, and development of activities to support them in countries. Climate data management will include the whole array of data rescue techniques (from data transfer into digital format to time series quality control and homogenization) and the development and coordination of a global climate data management system compatible with the WMO Information System (WIS). The WCSP serves the Climate Services Information System and the User Interface Platform components of the GFCS.

In addition, consideration is being given to adding the Programme on Research on Climate Change Vulnerability, Impacts, and Adaptation (PROVIA) to the World Climate Programme. PROVIA is a global initiative that aims to provide direction and coherence at the international level for research on vulnerability, impacts and adaptation. Current partners in this new programme include UNEP, UNESCO, and WMO. The Secretariat is hosted by UNEP in Nairobi.

An architecture for climate monitoring from space

The definition and implementation of an architecture for sustained climate monitoring from space will bring the same structures and rigor to climate monitoring that are currently in place for weather monitoring and forecasting. The architecture, based on requirements established by GCOS and as the key space component of the WMO Integrated Global Observing system (WIGOS), will be an essential building block of the GFCS Observations and Monitoring Pillar and will support all four priority sectors and all ECVs observable from space. It will be defined as an end-to-end system, involving the different stakeholders, including operational satellite operators and R&D space agencies, the Coordination Group for Meteorological Satellites (CGMS), the Committee on Earth Observation Satellites (CEOS), GCOS, WCRP, and GEO.

In building the architecture, synergies with surface- and space-based observing systems and with existing coordination mechanisms will be leveraged to fully exploit all available resources

and to fill observational gaps. Among these are the inter-calibration activities of the Global Space-based Inter-Calibration System (GSICS); additional calibration and validation activities to be conducted in coordination with the WMO Commission for Instruments and Methods of Observation (CIMO); CEOS calibration, validation, and virtual constellation efforts; product generation efforts like the Sustained, Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) initiative; and the training and capacity building activities of the Virtual Laboratory for Education and Training in Satellite Meteorology (VLab).

Rolling Review of Requirements

Observational requirements have been identified by WMO in twelve Application Areas including, among others, climate, hydrology, agricultural meteorology, oceans, atmospheric chemistry, and seasonal-to-interannual forecasting, which are each relevant to the GFCS. The Rolling Review of Requirements (RRR) process routinely updates these requirements, identifies gaps, and thus guides WMO Members in the evolution of both surface- and space-based global observing systems. The review process includes wide community consultation with scientific experts, WMO Technical Commissions, and other interest groups. Capabilities are examined and information is quantitatively recorded in an online database of observational requirements and observing systems capabilities. Table 1.1 lists WMO Applications Areas monitored through the RRR, assesses their relevance to the GFCS, highlights the types of observations required to support these areas, and flags their importance for various societal sectors.

Implementation Plans for the Evolution of Global Observing Systems (EGOS-IP) and WMO Integrated Global Observing System (WIGOS-IP)

The WMO Integrated Global Observing System Implementation Plan (WIGOS-IP) provides a new framework for WMO observing systems and the contributions of WMO to co-sponsored observing systems. WIGOS (see section 2.2.1.2 for additional detail) does not replace the existing observing systems, but is rather an over-arching framework for the evolution of these systems that will continue to be owned and operated by a diverse array of organizations and programmes. WIGOS will focus on the integration of governance and management functions, mechanisms, and activities to be accomplished by contributing observing systems in relation to the resources allocated on global, regional, and national levels.

A principal WIGOS document is the new Implementation Plan for the Evolution of the Global Observing Systems (EGOS-IP). This plan takes into account WIGOS and GFCS requirements and will provide WMO Members with clear and focused guidelines and recommended actions so that requirements of WMO programmes can be met in an integrated way by 2015 and beyond. The EGOS-IP also covers observational requirements for application areas, including those relevant to climate (see Table 1.1).

Development of a Framework for Ocean Observing

A Framework for Ocean Observing was developed following the international OceanObs'09 conference (September 2009, Venice, Italy) and adopted by the IOC Assembly in June 2011. The Framework for Ocean Observing seeks to deliver a collaborative ocean observing system based on a set of principles and best practices that can deliver needed physical, biogeochemical, and biological data to answer societal issues and scientific inquiry. More specifically, the Framework:

- Articulates a systems approach for sustained global ocean observing, introducing the “Essential Ocean Variables” (EOVs) as a common language;
- Fosters recognition and development of interfaces among all actors for mutual benefit;

- Provides the basis for transformation of observational data organized by EOVs into syntheses, analyses, assessments, projections, and scenarios that serve a wide range of societal needs.

The GOOS Steering Committee is working with international stakeholders to use the Framework to improve the ocean observing system, including the evaluation of new requirements imposed by climate services.

Table 1.1 Observational Requirements for Various Applications and Their Relevance to the GFCS across WMO-Defined Societal Sectors

The Societal Sectors are: 1 - Agriculture and Farming; 2 - Fisheries; 3 - Soil; 4 - Forestry; 5 - Water Regime, Coastal and Marine Protection - 6: Biological Diversity/Ecosystems; 7 - Infrastructure, Transport, Urban Settlements, Building; 8 - Health; 9 - Tourism Industry; 10 - Energy Industry; 11 - Trade and Industry; 12 - Financial Services Industry (see: http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html).

		Societal sectors													
Application Areas	***GFCS relevance***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***Main Domain(s)***	***Types of observations required***
Climate Monitoring	Very High	X	X	X	X	X	X	X	X	X	X	X	X	Atmospheric, Oceanic, Terrestrial	Surface, upper-air, atmospheric composition, terrestrial, ocean surface, ocean sub. surface
Climate Applications (incl. services)	Very High	X	X	X	X	X	X	X	X	X	X	X	X	Atmospheric, Oceanic, Terrestrial	Surface, upper-air, atmospheric composition, terrestrial, ocean surface, ocean sub. surface
Seasonal and Inter-Annual Forecasts	Very High	X	X	X	X	X	X	X	X	X	X	X	X	Atmospheric, Oceanic, Terrestrial	Surface, upper-air, atmospheric composition, terrestrial, ocean surface, ocean sub. surface
Atmospheric Chemistry	High	X		X	X	X	X	X	X	X	X			Atmospheric	Atmospheric composition, and ancillary variables
Global Numerical Weather Prediction	High	X	X		X			X	X	X	X	X	X	Atmospheric, Oceanic, Terrestrial	Surface, upper-air, ocean surface

		Societal sectors													
Application Areas	***GFCS relevance***	***1***	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***Main Domain(s)***	***Types of observations required***
Ocean Applications	High		X			X	X	X	X	X	X	X	X	Oceanic, Atmospheric	Surface, ocean surface, ocean sub surface
Agricultural Meteorology	High	X	X	X	X		X		X			X	X	Atmospheric, Terrestrial	Surface, terrestrial
Hydrology	High	X	X	X	X	X	X	X	X	X	X	X	X	Atmospheric, Terrestrial	Surface, upper-air, hydrological, biochemical
High Resolution Numerical Weather Prediction	Medium	X	X	X	X	X		X	X	X	X	X	X	Atmospheric, Oceanic	Surface, upper-air, ocean surface
Nowcasting and Very Short-Range Forecasting	Low	X	X	X	X	X		X	X	X	X	X	X	Atmospheric, Oceanic	Surface, upper-air, ocean surface
Aeronautical Meteorology	Low							X		X		X		Atmospheric	Surface, upper-air, atmospheric composition
Space Weather	Low							X	X					Atmospheric	Surface, upper-air, ionosphere, heliosphere, sun surface

Climate Monitoring Activities

The goal of Climate System Monitoring (CSM), a project of the World Climate Data and Monitoring (WCDMP) sub-programme of the World Climate Programme (WCP), is to deliver timely and authoritative information on the status of the climate system at multiple temporal (sub-monthly, monthly, seasonal, annual, decadal, and multi-decadal) and spatial (local, regional, and global) scales along with the ability to assess the uncertainty underlying this information. CSM outputs include high-quality climate datasets based on *in situ* and space-based observations, data recovered from old archives, and data processed from model outputs (reanalysis data) that provide historical references and baselines for assessing climate variability, changes, and extremes and can be integrated with data on risks, exposures, and impacts to prevent or mitigate disasters.

The World Weather Records (WWRs) global datasets compiled and published since 1927 by the World Data Centre for Meteorology at the US National Climatic Data Centre (NCDC) include monthly mean values of pressure, temperature, precipitation, and where available, station metadata notes documenting observation practices and station configurations. More than one-third of the 1990s station data included in global datasets, such as the Global Historical Climatology Network–Monthly, come from WWRs, greatly enhancing climate analyses. Since 1920, data have been updated on a decadal basis, and while once-a-decade provision of the WWRs has served the climate community's needs very well, annual dissemination of these data is now required to support improved climate assessment.

High-resolution gridded data sets and satellite data have become increasingly useful in agriculture and other key application areas, in addition to their important role in global climate monitoring. As a specific example, satellite-based monitoring of the Intertropical Convergence Zone (ITCZ) in West and East Africa would be very helpful in supplementing the scarce and low resolution *in situ* data traditionally used for this purpose. Systematic use of satellite data and products, reinforced by much-needed training and guidance, will permit better planning and operations for the crop season, contributing to improved food security in these regions. Regional Climate Centres, NMHSs, and agricultural institutions should be enabled to access and use these outputs.

In some countries, community operated networks are in place that represent potential sources of additional observational data, although many may not comply with WMO standards and practices. There is, therefore, a need within the GFCS to improve the quality of these observations in order to generate good quality climate data. The assignment of a data centre to host such data should be fostered.

Records can be extended, and gaps filled, by recovering, from various sources, older data that exist within countries, digitizing data that are held in paper or scanned records, and, where needed, converting data from older formats to modern digital formats. It is important to note that many climate records, particularly prior to 1960, are still in paper formats (including strip charts) and face the risk of degradation and loss. Such paper records should, as an interim measure, be securely stored (e.g. in acid-free boxes) to prevent further degradation until digitization or imaging can be undertaken. Important amounts of digital data also continue to be stored on obsolete or degrading media, such as microfiches, punch cards, magnetic tapes, and old floppy disks. To date, however, digitization efforts have focused on some archives and not on others. Data rescue and digitization of climate data needs to be pursued aggressively and should be expanded, where necessary, to address the rescue and recovery of other relevant data, such as oceanographic data (e.g., sea level measurements), and records of outbreaks of malaria and other diseases or of other impacts of climate.

The strategy recommended by the WMO Commission for Climatology (CCl) links Data Rescue and Digitization (DARE&D) to Climate Risk Management (CRM) and climate change assessment and adaptation. At the global scale, international data rescue efforts include, for example, those being coordinated and facilitated by the Atmospheric Circulation Reconstructions over the Earth (ACRE) initiative and its various regional foci (i.e., ACRE Chile, ACRE Pacific, ACRE Arctic, ACRE India, ACRE Africa, and ACRE China). These efforts, along with others under WMO and at the NOAA

National Climatic Data Centre (NCDC), are very useful in linking historical terrestrial and marine surface weather observations with the International Surface Pressure Databank (ISPD), the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), and global surface temperature datasets, which are used for monitoring and assessing global climate at various time scales. At the regional scale, the Mediterranean Data Rescue Initiative (MEDARE), aimed at developing high-quality long-term climate data sets for the greater Mediterranean region, represents a good model for other regions and sub-regions. Additional regional examples include the European Climate Assessment and Data (ECA&D) project (Europe), the DARE project of ACMAD (Africa), and the Pacific Island Countries data rescue project, supported by the Australian Bureau of Meteorology. The planned establishment of an International Climate Assessment and Data set initiative (ICA&D), which will build on regional components of DARE&D, will ensure harmonized, sustained, and cost effective implementation of the strategy recommended by CCl.

Summary of Gaps and Needs

Significant gaps and deficiencies related to observations can be summarized as follows:

- Shortcomings in atmospheric observations that include non-reporting by some climate stations (due to inability to sustain observational networks, lack of training and capability, inadequate communication systems or other factors), limited space and surface-based remote sensing capabilities, and the absence of operational monitoring of some important air quality, radiation, and other variables;
- Weaknesses in observational coverage of important oceanographic variables that include incomplete moored buoy networks for monitoring ocean currents, mass flux, ocean salinity, and sea ice parameters; uncertainties regarding the continuity of satellite monitoring programmes such as microwave sensing, high precision altimetry, and Light Detection and Ranging (LIDAR) and Synthetic Aperture Radar (SAR) coverage of sea ice parameters;
- Gaps in terrestrial observing networks, such as for river discharge, ground water, lake levels, permafrost, glaciers and ice caps; the absence of designated networks for soil moisture, Leaf Area Index (LAI), Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) and above ground biomass; and uncertainty regarding the continuity of satellite missions that monitor land cover;
- Needs for complementary biological, environmental, and socio-economic data (e.g., records of disease incidence, crop yield, energy demand, and disaster losses) to enable the production of indices and other products that assist the user communities in planning and management;
- Data policies and information infrastructures that need to be enhanced to improve data management and access to historical observational and other relevant data and derived products;
- Continuing needs to improve local, regional, and global monitoring systems to enhance efficiency and improve data management, including careful attention to minimization of data losses and inhomogeneities when observational systems change or are upgraded;
- Needs to rescue, digitize, and develop (e.g., time series quality control and homogenization) historical climate and sectorial user data that are currently held in perishable paper formats or available only on obsolete or degrading media and to place re-analysis, a substantial technical as well as scientific undertaking, on a firmer, operational footing.

APPENDIX 2

Engagement in the Working Mechanisms of Potential Partners at Global, Regional, and National Levels

The GFCS will require extensive engagement between and among global, regional, and national partners in the implementation of the Framework and its Pillars. The development of mechanisms to ensure effective coordination and partnership between stakeholders at all levels will be fundamental to the success of the GFCS in addressing the challenges posed by climate variability and climate change and responding to needs for climate services. Major stakeholders in the Observations and Monitoring Pillar are identified in the following sections.

Global Observing Systems

The following sections provide an overview of major, globally coordinated, observing networks and systems, noting the contribution made by real-time observing networks and space-based systems to the monitoring of the overall climate system. The effective engagement of these globally-coordinated observational programmes within the Observations and Monitoring Pillar will be essential to the success of the GFCS.

The Global Climate Observing System (GCOS): A Cross-Cutting Mechanism for Climate Observations

An adequate global climate observing system is an essential element of the GFCS, underpinning all other elements. The overarching framework for observing the climate is the Global Climate Observing System. Essentially a UN-wide system in partnership with ICSU, the GCOS also encompasses the entire non-governmental observations community and is intended to meet the full range of national and international requirements for climate and climate-related observations at global, regional, and national scales.

The success of the GFCS will be dependent on the adequacy of the component observing networks on which the GCOS is built: the Global Observing System (GOS) and Global Atmosphere Watch (GAW) (components of WIGOS); the climate-related networks of the Global Ocean Observing System (GOOS) and Global Terrestrial Observing System (GTOS); and a number of other domain-based and cross-domain research and operational observing systems. The GCOS includes both surface-based and space-based components and constitutes, in aggregate, the climate observing component of the Global Earth Observation System of Systems (GEOSS). The implementation of improvements in the climate observing system needed to support the GFCS will require the maintenance of close coordination with GCOS.

The WMO Integrated Global Observing System (WIGOS)

The WMO Integrated Global Observing System (WIGOS) is an integrated, comprehensive, and coordinated system that is comprised of the present WMO global observing systems, in particular of the *in situ* and space-based components of the Global Observing System (GOS), the Global Atmosphere Watch (GAW), the Global Cryosphere Watch (GCW), and the World Hydrological Cycle Observing System (WHYCOS). Through the mechanism of the WMO Information System (WIS), WIGOS will ultimately provide accurate, reliable, and timely climate observations for atmospheric, marine, and terrestrial domains as part of the GFCS.

As part of WIGOS, climate-relevant data and metadata will adhere to standards in order to facilitate the self-assessment of quality by data producers and will ensure transparency in the generation of climate datasets and products. This approach will enable users to judge the quality and fitness for purpose of climate datasets and products. In many cases, observing networks include stations operated independently by research or environmental institutions. Strengthening future interactions between research and operational observing communities through increased communication and enhanced partnerships is, therefore, important for sustaining and evolving observing systems and practices and should be pursued through existing forums that involve these communities.

The Global Observing System (GOS)

The Global Observing System (GOS) provides observations of the state of the atmosphere and ocean surface needed in real time for the preparation of weather analyses, forecasts, advisories, and warnings. These observations also support climate monitoring and environmental activities carried out under programmes of WMO and of other relevant international organizations. It is coordinated by the Commission for Basic Systems of the WMO. The main long-term objectives of the GOS are:

- To improve and optimize global systems for observing the state of the atmosphere and the ocean surface to meet requirements for the preparation of increasingly accurate weather analyses, forecasts and warnings and for climate and environmental monitoring, in the most effective and efficient manner;
- 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 the users with respect to observational quality, spatial and temporal resolution, and long-term stability and sustainability.

The Global Atmosphere Watch (GAW)

The Global Atmosphere Watch (GAW) programme is considered to be the atmospheric chemistry component of GCOS. Its operation is coordinated by the Commission for Atmospheric Sciences of the WMO. The GAW provides data and information on the chemical composition of the atmosphere, including natural and anthropogenic changes therein, to assist in improving understanding of interactions between the atmosphere, the oceans, and the biosphere. The GAW monitoring system focuses on six classes of variables (ozone, UV radiation, greenhouse gases, aerosols, selected reactive gases, and precipitation chemistry).

The Global Cryosphere Watch (GCW)

The WMO Global Cryosphere Watch (GCW) is intended to provide authoritative, clear, and useable data, information, and analyses on the past, current, and future state of the cryosphere to better meet the needs of partners in delivering services to users, including the media, the public, and policy makers. User needs discussed in the Cryosphere Theme Report (CryOS), prepared by the global cryospheric science community, and in GCW documents relate directly to issues to be considered within the GFCS and, in particular, to observational requirements in support of improved climate services.

The GCW is being built on strong partnerships with other UN bodies, international organizations, World Data Centres, scientific associations, and national and international institutes. Among these are UNESCO and its International Hydrological Programme (IHP) and its Intergovernmental Oceanographic Commission (IOC), international bodies such as International Permafrost Association (IPA), World Glacier Monitoring Service (WGMS), Global Precipitation Climatology Centre (GPCC), and national institutions such as the US National Snow and Ice Data Centre (NSIDC). Other important partners include the International Arctic Science Committee (IASC), which has been working with the Arctic Council to develop a suite of plans for cryospheric observations and Arctic Observing Networks. Strong relationships are also being forged with bodies such as CEOS and CGMS and with major satellite operators like CSA, ESA, EUMETSAT, JAXA, NASA, NOAA, ISRO, and USGS, since observations from satellite borne sensors provide uniquely valuable perspectives on cryospheric elements such as sea ice, snow cover, and glaciers.

The World Hydrological Cycle Observing System (WHYCOS)

The World Hydrological Cycle Observing System (WHYCOS) is a WMO global programme developed in response to the scarcity or absence of accurate, timely, and accessible data and

information in real or near real-time on freshwater resources in many parts of the world and, particularly, in developing countries. Regional components (HYCOSs) bring together several hydrological services that have common interests, either because they share a common drainage basin or are in a well-defined geographical and hydrological region. A regional HYCOS is launched when the countries concerned have expressed their collective desire for such a development along with their commitment to making it a success. To enable participating countries to perform this basic task is therefore a priority in the project implementation to establish the necessary data transmission and management infrastructure and create the required human capacity in the NHSs involved. WHYCOS aims at improving basic observation activities, strengthening international cooperation, and promoting free exchange of data in the field of hydrology.

The Global Ocean Observing System (GOOS)

Co-sponsored by IOC of UNESCO, WMO, UNEP, and ICSU, the Global Ocean Observing System (GOOS) coordinates a system of open-ocean and coastal observations for scientific and societal benefit, with active support from the International Maritime Organization (IMO) and shipping lines who contribute vital meteorological and oceanographic observations through their participation in the Voluntary Observing Ships (VOS), Automated Shipboard Aerological Programme (ASAP), Ship of Opportunity (SOOP) and other marine observation programmes. GOOS develops advice about requirements for observations, which for climate purposes are developed in cooperation with GCOS and for ocean services are developed through the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM). The GOOS provides a forum for coordinating ocean observing networks. Implementation and development of standards for many *in situ* networks are undertaken in partnership with JCOMM. Coordination of space-based ocean observations occurs through CEOS and CGMS.

The composite ocean surface and sub-surface observing networks include global monitoring of certain Essential Climate Variables (ECVs). Monitoring of other ECVs depends on observations from reference stations or sites, or, in the case of sub-surface ocean carbon, nutrients, and tracers, on repeat ship-based surveys. Very recently, there have been significant contributions to sub-surface ocean measurements, particularly in data-sparse areas near ice. Despite this recent progress, ocean observing networks and their associated infrastructure and analysis systems are not yet adequate to meet the specific needs for most climate variables in most regions of the planet, particularly in the Southern Hemisphere. Some of the specific gaps in ocean observing systems include:

- Sea surface temperature and upper ocean temperature (heat content) for short-term seasonal to interannual climate forecasts;
- Deeper measurements, including salinity and ocean currents, for decadal-scale climate forecasts;
- Sea level, waves, and sea ice for development of a coastal/marine climatology and climate change monitoring;
- Local bathymetry and social variables, such as population and infrastructure in vulnerable zones, for coastal inundation early warning;
- Ocean carbon variables for constraining mitigation action;
- Mapping of habitats, ocean biogeochemical variables, and ecosystem variables, among others, for identifying and projecting key vulnerabilities of living marine resources and key coastal and ocean ecosystems.

Overall, there is considerable scope for GFCS engagement with GOOS in addressing these matters, and the ocean community proposes to implement five broad actions through the GFCS:

- Refining specific requirements for climate services (GOOS and JCOMM);
- Sustaining and developing *in situ* observations (GOOS and JCOMM);

- Sustaining and developing satellite observations (CEOS and CGMS);
- Improving the data management system (IODE, JCOMM, GEO);
- Developing ocean information appropriate for climate services (many stakeholders).

The Global Terrestrial Observing System (GTOS)

Co-sponsored by FAO, ICSU, UNEP and WMO, the mission of the Global Terrestrial Observing System is to support sustainable development through a programme for observations, modelling, and analysis of terrestrial ecosystems.[2] GTOS liaises with relevant research and operational communities to identify terrestrial properties that control the physical, biological, and chemical processes that affect climate, are affected by climate change, and/or serve as indicators of climate change. Increasing emphasis is now being placed on terrestrial data for estimating climate forcing and for better understanding climate change and variability, as well as for impact and vulnerability assessment and for mitigation activities. The establishment of Global Terrestrial Networks (GTNs) in a number of topical areas (e.g., hydrology, glaciers, and permafrost), where data collection takes place largely through *in situ* measurements, has significantly improved the coordination and global coverage of these observations, although gaps remain. The Global Terrestrial Network for Hydrology (GTN-H), for example, was established as a "network of hydrological networks" that links existing global hydrometeorological data centres and systems for integrated observations of the global water cycle to support global and regional climate and water applications. The GTN-H covers such ECVs as precipitation, snow and glaciers, evapotranspiration, water use, water quality, soil moisture, ground water, lake level, and river discharge.

Improving understanding of the terrestrial components of the climate system and of the causes and responses of this system to change is vital to society, as is assessing the consequences of such change in adapting to and mitigating climate change. Mechanisms exist for both the *in situ* observing networks and the space-based components of the terrestrial domain ECVs, but these need to be strengthened. Furthermore, better observations of the terrestrial carbon-related variables have assumed greatly increased relevance in the context of implementing the UNFCCC Bali Road Map.[3]

Global Earth Observation System of Systems (GEOSS)

The Group on Earth Observations (GEO) is coordinating international efforts to build a Global Earth Observation System of Systems (GEOSS). GEOSS will provide decision-support tools to a wide variety of users, proactively linking together existing and planned observing systems around the world and supporting the development of new systems where gaps currently exist. It will, moreover, promote common technical standards so that data from the thousands of different instruments can be combined into coherent data sets. GEO is constructing the GEOSS on the basis of a 10-Year Implementation Plan that runs from 2005 to 2015.

Of immediate relevance to the GFCS initiative, GEO supports the realization of an effective and sustained operation of the GCOS, as the climate observing component of the GEOSS, including reliable delivery by 2015 of climate information of a quality needed for monitoring, predicting, mitigating, and adapting to climate variability and change and better understanding of the global carbon cycle. The GEO will also:

- Promote data sharing as well as coordination of data management and exchange systems;
- Contribute to major advances in the monitoring and prediction of climate on seasonal, interannual, and decadal time scales, including the occurrence of extreme events;

[2] As of the third quarter of 2012, the status of the GTOS Secretariat at FAO is uncertain. Nevertheless, many of the GTOS Panels (including the joint GCOS/GTOS Terrestrial Observations Panel for Climate (TOPC)) operate effectively. Indeed, their continued operation is necessary and important for the success of the GFCS.

[3] For details, including the first UNFCCC COP decision on reducing emissions from deforestation in developing countries, see UNFCCC (2008): *Report of the Conference of the Parties on its thirteenth session, held in Bali from 3 to 15 December 2007*, Addendum, Part two: Decision 2/CP.13 (Reducing emissions from deforestation in developing countries: approaches to stimulate action), FCCC/CP/2007/6/Add.1, http://unfccc.int/resource/docs/2007/cop13/eng/06a01.pdf#page=9.

- Strengthen GCOS support for the assessment role of the IPCC and the policy development role of the UNFCCC.

UN Agencies and Programmes

Many UN agencies and programmes have units whose mission it is to facilitate the availability of the various types of observations required for the development and provision of services for users within the four priority sectors -- water, health, agriculture, and disaster risk reduction:

- The UNEP Global Environment Outlook (UNEP/GEO), for example, was initiated in response to the environmental reporting requirements of Agenda 21 and to the UNEP Governing Council. At the 22nd session of the UNEP Governing Council/Global Ministerial Environment Forum (GC/GMEF) in 2003, governments requested UNEP to prepare an annual Global Environment Outlook statement to highlight significant environmental events and achievements during the year. Other UNEP/GEO outputs include regional, sub-regional, and national integrated environmental assessments, technical and other background reports, a website, products for young people (GEO for Youth), and a core online database – the UNEP/GEO Data Portal that holds information on more than 450 different variables addressing themes such as freshwater, population, forests, emissions, climate, disasters, health, and Gross Domestic Product (GDP);
- Other UN agencies, such the World Health Organization (WHO) and the UN International Strategy for Disaster Reduction (ISDR), are also important users of weather and climate data while some, such as the International Civil Aviation Organization (ICAO) and FAO, also facilitate the provision of important observational data by their members;
- WMO and its constituent bodies facilitate worldwide cooperation in the establishment of networks of stations for meteorological, hydrological, and other geophysical observations related to meteorology and promote the establishment and maintenance of centres charged with the provision of meteorological and related services. They also promote the establishment and maintenance of systems for the rapid exchange of meteorological and related information and endeavour to ensure standardization of meteorological and related observations and the uniform publication of observations and statistics.

Thus, UN agencies will be major contributors to the GFCS as both users and providers of observational data in addition to being sources of socio-economic information needed to produce and deliver climate services.

National Meteorological and National Hydrological Services (NMHSs)

The NMHSs are a fundamental part of national infrastructures and play an important role in supporting vital functions of governments. In particular, the climate observations and data gathered by NMHSs are the foundation for monitoring and prediction services and, in addition, make essential contributions to regional and global climate programmes and services. The engagement of the NMHSs with the GFCS is, therefore, vitally important. However, marked disparity exists between NMHSs' observation networks, with developing and least developed countries having sparse networks that do not adequately provide for the range of services that could be provided under the GFCS. In consequence, the observing networks in many countries, in particular in developing and least developed countries and in small island developing states, need upgrading and expanding if the GFCS is to succeed.

Many of the actions identified in this plan are intended to address networks operated by NMHSs. GCOS has engaged with developing countries' NMHSs at both national and regional scales to facilitate improvements in climate observations. Through the GCOS Regional Workshop Programme, 10 Regional Action Plans have been produced containing project proposals to address high-priority atmospheric, terrestrial, and oceanic climate observing needs as defined by the countries of each region. Implementation of these projects, which has been advocated both by the WMO Congress and the Conference of Parties to the UNFCCC, would make a significant contribution to the GFCS. The NMHSs also use telecommunications networks, vital for the timely exchange of climate data and products, which enable them to fulfil their national mandates.

Networks used by some NMHSs, however, are inadequate and obsolete, and this hampers the efficient flow of observations and products.

Space Agencies

Space agencies of the world have been contributing unique information on the state of our planet for more than half a century. This information has helped significantly to improve weather predictions, monitor the climate system, and inform societally-relevant decisions. Satellite agencies with a prime responsibility for research and development have been pioneering satellite observing capabilities and provide space-based measurements of ever more complex environmental phenomena. Operational satellite agencies are responding closely to the evolving needs of NMHSs and of other environmental user communities for monitoring and predicting weather, climate, water, and related environmental conditions. Telecommunication systems developed in conjunction with satellites provide a backbone for global exchange of meteorological and environmental data.

Effective coordination of common interests relating to the design, development, operation, and use of planned meteorological and environmental satellites is facilitated through two major international mechanisms – the Coordination Group for Meteorological Satellites (CGMS) and the Committee on Earth Observation Satellites (CEOS). Through the CGMS, for example, plans have been put in place for continuity in both polar and geostationary orbits, and existing or potential gaps in satellite coverage are being addressed. International agency collaboration in the areas of mission planning, intercalibration of sensors, comparison of processing algorithms, and standardization of telecommunication activities has led to more effective data utilization and better user services. Agencies also collaborate in the area of user preparedness, education, and training in the use of satellite data.

Following the model of collaboration in support of weather forecasting, space agency activities are increasingly converging in the area of climate monitoring. In the past six years, space agencies have been very responsive to requirements established by GCOS for the ECVs, and they are now collaborating to develop a Space-based Architecture for Climate Monitoring (described in section 1.4.3).

National Environmental and Natural Resources Agencies

In some countries, environment, agriculture, forestry, and other natural resources departments and agencies operate climate observation stations and networks, monitoring atmospheric, hydrologic, and terrestrial variables. While their observational activities are frequently undertaken in collaboration with NMHSs, this may not be the case in all instances. Within the framework of the GFCS, it will be important to engage the observational capacities of such departments and agencies, encourage the adherence of their data to appropriate standards, and gain optimum benefits for all users of climate services from their respective observational programmes.

For urban populations, air pollution represents a particular problem with pollutants of concern including, among others, gaseous compounds, ozone, NO_2 and SO_2, and aerosols. There is, moreover, growing evidence that airborne pollutants are contributing significantly to climate change in addition to harming human and environmental health and agricultural production. Conversely, climate variability and change influence atmospheric chemistry through factors such as temperature, surface properties, cloud cover, precipitation, and boundary layer mixing that affect the life cycle (sources, transport, chemical/physical transformation, and removal) of pollutants in the atmosphere. Consequences of climate change such as increased drought can, moreover, result in increases in biomass burning and in the emissions from fires. More accurate, quality-controlled and well-calibrated observations of atmospheric constituents are, therefore, needed to support the provision of information to the public, for inclusion in models, and in order to carry out studies of air pollution interactions with climate variability and change.

Local and regional scale air quality observations are made by many different organizations at the municipal level, under regional governments, and by national environmental agencies and are also supplied to regional bodies such as the European Environment Agency (EEA). NMHSs, however, often possess greater expertise in air quality modelling and forecasting than such agencies. There is, therefore, a need for close collaboration between different institutions involved in observing and

providing information on air quality, in particular between environmental agencies and NMHSs, if air pollution issues are to be addressed effectively. In the context of the GFCS, particular attention must be given to needs for improved air quality observations in urban areas.

Universities, Research Institutions, and Non-Governmental Organizations

In situ, surface-based observing networks operated by NMHSs and other government agencies are not comprehensive in all parts of the world. The largest gaps exist in remote locations (Polar Regions, high mountains, deserts, tropics, and oceans) and in developing and least developed countries and small islands. Universities and research institutes, however, operate several extremely important observing networks in these regions that partially fill the existing gaps. For example:

- The University of Wisconsin at Madison (USA) maintains a number of observing stations in Antarctica;
- Similarly, several universities and research institutes operate research sites in the Arctic and high-mountain regions that are invaluable not only for research purposes but also for providing services related to health, water supply, food production, transportation, hydropower production, and hazards, such as the risk of floods and droughts;
- The University of Hamburg (Germany) operates several observing stations in Africa, mainly in support of agriculture and food production, although data from those stations are also useful for health, water, and disaster risk reduction applications;
- Research observing networks, such as the Global Atmosphere Watch, also provide essential data needed to address health concerns, as they often monitor parameters not typically covered by NMHSs, such as air pollution, contaminants, and the chemical composition of the atmosphere, including greenhouse gases. A recent example is the development of the Monitoring of Atmospheric Composition and Climate (MACC) project under the auspices of the European Global Monitoring for Environment and Security (GMES) initiative.

Inventories of data from these university and research institute observing networks are, unfortunately, often not readily available. A need exists, therefore, to compile such inventories, ensuring that they include appropriate metadata to provide insight into the representativeness and quality of the data.

A large number of non-governmental and quasi-governmental organizations (NGOs) also exist that could potentially contribute to the Observations and Monitoring Pillar of the GFCS. An exhaustive list of these organizations is not attempted here, but early action should be taken to identify those NGOs that could contribute observational data to this pillar and are willing to be part of the GFCS working mechanism. The International Research Institute for Climate and Society (IRI) is an illustrative example of the type of organization that could usefully be involved in helping to implement this Pillar. IRI has played a leading role in establishing the Climate Services Partnership (CSP), an informal interdisciplinary network of climate information users, providers, donors and researchers. The CSP was represented by IRI at a recent workshop in South America, co-organized by the GCOS Secretariat and the Centro Internacional de Investigaciones para el Fenómeno El Niño (CIIFEN), to consider strategies and specific activities to improve observations to support climate services and adaptation to climate change. The workshop could serve as a model for similar meetings in other regions.

The Private Sector

Although NMHSs and NHSs have a pivotal role in the operation of multipurpose atmospheric and hydrological observing networks, some private-sector interests have also developed and deployed dense observational networks. The advent of inexpensive digital electronics and high bandwidth communications has enabled literally thousands of small private businesses, corporations, agricultural producers, recreation providers and many others to enter the field of observations, driven by a wide range of missions and markets at various investment levels. Typical private sector

entities that operate their own observing systems include those working in oil and gas, mining, insurance, farming, hydropower, shipping, tourism, media, sports, air transportation, roads, railways, and private weather companies.

There are existing initiatives to encourage cooperation and dialogue between NMHSs and the private sector, such as the Madrid Action Plan adopted by the International Conference on Secure and Sustainable Living: Social and Economic Benefits of Weather, Climate, and Water Services (Madrid, Spain, March 2007). This Plan includes several actions with a bearing on the issue of public-private relations. In the face of the demand for ever more detailed observations at much finer spatial and temporal resolutions than are widely available today from national, international and intergovernmental organizations, data from the private sector could potentially fill some of the existing observational gaps. At the same time, increased attention to quantity, quality, accessibility, instrumentation, site selection, and metadata of these observations could significantly enhance their utility. Inventories of private-sector networks are not generally available and will need to be compiled, including metadata that will provide insight into the representativeness and quality of the data. Moreover, the observational capacities and activities of the private sector vary significantly between countries, suggesting the need for initiatives to be undertaken at the country level by NMHSs and other national agencies if the private sector is to be engaged effectively in addressing overall requirements for observational data and products.

APPENDIX 3

Detailed Description of Implementation Activities and Projects

Project 1.1: Establishing a formal mechanism for consulting users

a) Description: By means of brainstorming workshops coordinating closely with liaison activities proposed in the four Exemplars, representatives of user communities and representatives of observation providers will convene to discuss mutual concerns on the global, regional and national levels. Linkages to the User Interface Platform and the Climate Services Information System will be especially important for identifying implicit observation needs;

b) Objective: Establishing a continuing mechanism, in line with GFCS Principle 8, whereby representatives of different user communities, including but not limited to the four focal areas of the GFCS Implementation Plan, can consult with providers of climate observations and access relevant socio-economic, biological, and/or environmental data to clarify data needs at the global, regional and national levels to orient climate service provision;.

c) Benefits: Among observation providers, an understanding of the needs of users is deficient. Moreover, requirements for socio-economic, biological and environmental data to support the provision of climate services are not as yet well defined. Establishment of a consultation mechanism will help to address these problems, ensure user needs are considered, and help clarify requirements for socio-economic, biological, and environmental data. All Exemplars draw attention to the need for close liaison and coordination between the observational and user communities across all geographical scales;

d) Deliverables: Initially, a mechanism for continuing consultation between observation and data users and providers will be agreed. Subsequent consultations will address critical issues including: (1) specific requirements for climate observations and for other socio-economic, biological, and environmental data at global, regional and national scales; and (2) data standards, formats, and protocols for the quality assurance, management, and exchange of these data types in support of the provision of climate services;

e) Prerequisites: Although most conditions specified in section 2.1 apply, the key for this activity is the effective engagement with different user communities, especially those representing the four focal areas of the Implementation Plan, and with data providers from relevant socio-economic, biological, and environmental sectors;

f) Timeframe and Costs: To be undertaken in 2013. Cost for initial workshop approximately $0.1M. Subsequent workshops would also cost about $0.1M annually.

Project 1.2: Assessing the role of observations in adapting to climate variability and change

a) Description: An international, multi-stakeholder workshop will be organized to assess the adequacy of, and future requirements for, observations to support adaptation to climate variability and change;

b) Objectives: Assess the adequacy of observations in supporting adaptation to climate variability and change. Identify the need for new observations useful in monitoring and supporting climate services that address adaptation needs. Identify requirements for observations to support research into adaptation, such as those offered by the Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) and/or the WCRP;

c) Benefits: Focuses on gaps in observing networks within atmospheric, terrestrial, and oceanic domains specifically related to the needs for adaptation to climate variability and change. User-provider partnerships will be strengthened (GFCS Principle 8);

d) Deliverable: An assessment report including strategic guidance on steps that can be taken in the coming years to address the needs for observations for adaptation to climate variability and change;

e) Prerequisites: Although most conditions specified in section 2.1 apply, the key for this activity is the effective engagement with different user communities, especially those representing the four focal areas of the Implementation Plan;

f) Timeframe and costs: To be undertaken in 2013. Cost approximately $0.2M.

Project 2.1: Rehabilitating silent stations and key stations in data poor areas

a) Description: Silent stations and key stations in data poor areas will be rehabilitated, including GSN and GUAN stations, in order to sustain, improve, and generally expand the comprehensive atmospheric, oceanic and terrestrial surface- and space-based networks, including air quality and cryospheric networks. Agreed standards for observing practices will be applied to ensure that data are suitable for climate purposes. Priority will be given to those stations whose data are needed for meeting observational needs derived from the four Exemplars;

b) Objectives: Enable improved climate service provision at national, regional and global levels. Silent stations and key stations in data poor areas, including GSN and GUAN stations, will be rehabilitated to address the need for basic climate services as well as the need expressed in all Exemplars for climate observations on appropriate temporal and spatial scales;

c) Benefits: This implementation activity addresses gaps identified in section 1.4 and Appendix 1. Acquisition of observational data will be better aligned with the GFCS, climate predictions and projections will be increasingly skilful, and the global observing system will be better able to meet climate information needs and to deliver timely and authoritative information on the status of the climate system at multiple temporal and spatial scales, thus addressing GFCS Principles 2 and 7;

d) Deliverables: Data from the previously silent and key stations in data poor areas are provided to GTS in real-time;

e) Prerequisites: (i) entities that operate observing networks (such as NMHSs, research institutes, universities, and the private sector) will need to make their data available for improved climate service provision at global, regional and national scales; (ii)technological developments and national, regional, or global economic circumstances must enable these entities to sustain the delivery of these data over the long term, and (iii) provision of adequate funding, human resources, and observing and IT technology to operate observing systems, to implement QA/QC procedures (including calibration and maintenance of the systems), to ensure reliability of data delivery, to ensure staff competencies, to ensure delivery using interoperable formats, and to distribute data and information worldwide in real or near real-time;

f) Timeframe and costs: 2 years; $5M.

Project 2.2: Designing baseline networks to underpin climate services

a) Description: In order to incorporate new observing requirements for GFCS sectors and to sustain and generally expand the comprehensive atmospheric, oceanic, and terrestrial surface- and space-based networks (including air quality and cryospheric networks) across all geographical scales, baseline (core) networks will be designed and included in global, regional, and national near- and long-term plans. These baseline networks will respect standard observing practices and will be managed according to agreed QMS to ensure that data are suitable for climate purposes;

b) Objectives: To enable and underpin improved, operational climate services using well-designed, sustained baseline (core) networks on national, regional and global scales;

c) Benefits: This implementation activity is addressing gaps identified in section 1.4 and Appendix 1. Climate predictions and projections will be increasingly skilful, the global observing system will be better able to meet climate information needs and to deliver timely and authoritative information on the status of the climate system at multiple temporal and

spatial scales, the evolution of global observing systems will be better linked to individual implementation plans, and all observational requirements for the GFCS will be properly addressed as observing systems evolve. This will contribute to addressing needs expressed in all Exemplars for climate observations on appropriate temporal and spatial scales and by adhering to GFCS Principles 2 and 7;

d) Deliverables: The baseline (core) national, regional and global networks are incorporated in the global observing systems and implemented;

e) Prerequisites: (i) entities that operate observing networks (such as NMHSs, research institutes, universities, and the private sector) will need to make their data available for improved climate service provision at global, regional and national scales; (ii) technological developments and national, regional, or global economic circumstances must enable these entities to sustain the delivery of these data over the long term, and (iii) Provision of adequate funding, human resources, and observing and IT technology to operate observing systems, to implement QA/QC procedures (including calibration and maintenance of the systems), to ensure reliability of data delivery, to ensure staff competencies, to ensure delivery using interoperable formats, and to distribute data and information worldwide i2 years for design plus 4 years to implement; $1.5M for the review process and design.

Project 2.3: Supporting the operation of baseline networks in LDCs and SIDS by setting up a Trust Fund

a) Description: In order to underpin improved climate service provision as discussed in the Exemplars, it is necessary to sustain, improve, and generally expand the comprehensive atmospheric, oceanic and terrestrial and surface- and space-based networks, including air quality and cryospheric networks as well as the related standard climate data management capabilities including data rescue and basic communication infrastructure. Support for operating baseline networks and related (climate) data management in LDCs and SIDS should be provided by the international community;

b) Objectives: To enable improved, operational climate services on the national scale that contribute to regional and global services by supporting the operation of baseline networks including related (climate) data management systems (CDMS) and basic communication infrastructure in LDCs and SIDS through a Trust Fund;

c) Benefits: This implementation activity is addressing gaps identified in section 1.4 and Appendix 1. It will, especially support sustainability of critical observing stations and related (climate) data management and basic communication infrastructure in LDCs and SIDSs that are essential for the GFCS and aligned with GFCS Principle 1. The project will contribute to addressing needs expressed in all Exemplars for climate observations on appropriate temporal and spatial scales;

d) Deliverables: Baseline networks including related (climate) data management and basic communication infrastructure in LDCs and SIDS are established through a Trust fund and contributions by the international community ;

e) Prerequisites: Provision of adequate funding, human resources, and observing and IT technology to operate observing and related (climate) data management systems, to implement QA/QC procedures (including calibration and maintenance of the systems), to ensure reliability of data delivery, to ensure staff competencies, to ensure delivery using interoperable formats, and to distribute data and information worldwide in real or near-real time;

f) Timeframe and costs: Initial support for 2 years of about $0.5 M; $3M would be needed in the next 10 years.

Project 2.4: Improving ground-based and space-based networks for measuring precipitation

a) Description: Measuring precipitation will be improved by filling gaps and enhancing surface- and space-based monitoring networks in order to respond to users' need, including that expressed in the Exemplars, for more accurate and representative precipitation data on

national, regional and global scales. Agreed standards for observing practices will be applied to ensure that data are suitable for climate purposes;

b) Objectives: Improved climate services based on reliable, spatially-representative precipitation data from atmospheric, oceanic, and terrestrial as well as surface- and space-based networks in near-real time;

c) Benefits: This implementation activity is addressing gaps identified in section 1.4 and Appendix 1. The Water Exemplar points out that "water security in a variable and changing climate continues to be a key concern at national, regional, and global scales" and that "addressing this concern has emphasized the critical importance of ongoing climate data for the assessment of fluctuations and trends in risks arising from exposure and vulnerability to natural hazards." The project adheres, in particular, to GFCS Principles 4 and 7;

d) Deliverables: Error-characterized, quality-controlled, spatially representative precipitation data derived from the integration of data from surface and space-based observing systems and made available in near-real time over the GTS and other data distribution mechanisms;

e) Prerequisites: (i) entities that operate observing networks (such as NMHSs, research institutes, universities, and the private sector) and space-based precipitation monitoring systems will need to make their data available; (ii) Technological developments and national, regional, or global economic circumstances must enable these entities to sustain the delivery of these data over the long term; and (iii) Provision of adequate funding, human resources, and observing and IT technology to operate observing systems, to implement QA/QC procedures (including calibration and maintenance of the systems), to ensure reliability of data delivery, to ensure staff competencies, to ensure delivery using interoperable formats, and to distribute data and information worldwide in real or near-real time;

f) Timeframe and costs: 4 years, $40M.

Project 2.5: Developing guidelines to improve discovery of climate observational data and products

a) Description: Guidance will be developed and training provided for GFCS contributors and users on how climate observations and products can be found, based on Discovery Metadata records, so that the benefits from investing in observations and products can be achieved. Further tools may be developed to assist users in easy data discovery. Once accessed, the data will only be usable if they can be exchanged and processed unambiguously. WMO achieves this within its own community by using standard data representations; however, this approach becomes increasingly complex when collecting and exchanging information from widely different communities. The increasing need for more frequent and more detailed climate information reporting means that these data standards must be enhanced using a flexible approach that adapts easily to representing new information but does not prevent those unable to make use of this additional information as yet from using other information within the same report;

b) Objectives: To provide guidance and training for potential user communities on how climate observations and products are described in WIS Discovery Metadata records. To enhance the usability of climate observations by developing an abstract data model that allows seamless transition between the data formats of different communities;

c) Benefits: Allows the benefits from investment in observations and products to be realized and reduces the cost of data processing. Also, the Health Exemplar, for example, points out that access to climate and health surveillance data is not always easy and openly available. This project promotes the improved coordination and trust that enables the data sharing the Health Exemplar advocates. The project is responsive, in particular, to GFCS Principle 2;

d) Deliverables: (i) enhanced abstract data model providing improved usability and interoperability of data; and (ii) training, guidance materials and tools for user communities on how to describe climate observations and products in WIS Discovery Metadata records;

e) Prerequisites: Provision of adequate funding, human resources, and observing and IT technology;

f) Timeframe and Costs: Two years, $0.7M.

Project 2.6: Developing an integrated global greenhouse gas information system, including enhancing regional scale chemical measurements

a) Description: Effective and cost-efficient adaptation requires an understanding of the anticipated rates and ultimate extent of climate change. Ground- and space-based observations, carbon-cycle modelling, fossil fuel use data, and land-use data will be combined by meta-analysis and modelling to provide an extensive distribution system of information on changing sources and sinks of greenhouse gases and their consequences on policy-relevant temporal and spatial scales. Climate system projections can be improved, on the basis of such information, to respond for example to the call from the UN World Food Summit for improved early warning and forecasting systems for food insecurity and vulnerability as highlighted in the Agriculture and Food Security Exemplar;

b) Objectives: To improve climate projections by improving information and understanding of greenhouse gas sources, sinks, transport, and impacts through enhanced research with increased, coordinated observations and improved analysis;

c) Benefits: Such improved integrated greenhouse gas information will enhance climate projections and directly contribute to humankind's climate change adaptation capacity, its cost-effectiveness, its overall effectiveness, and, ultimately, more informed decision-making at all levels. This implementation activity addresses gaps identified in section 1.4 and Appendix 1 and is especially responsive to GFCS Principles 2 and 7;

d) Deliverables: An integrated global greenhouse gas information system that supports timely, regionally-specific information related to the state of greenhouse gas-driven warming, the rate of increase, and projections for future decades, during which adaptation measures will take place and upon which the success of adaptation measures will depend. In a 2-year horizon the project will: (i) evaluate the status of current levels of information relative to societies' current and anticipated needs; (ii) develop a prioritized list of deliverables; and (iii) develop a work plan and timeline for delivering globally coordinated, regional-scale information of sufficient certainty in order to enhance observation networks and high resolution global-scale modelling;

e) Prerequisites: (i) coordination among WMO, GCOS, GEO-Carbon and regional projects such as ICOS in Europe, Carbon North America (CarboNA), and other similar efforts and existing networks around the world, along with their associated programmes, commissions and committees; (ii) technological developments to enable these entities to sustain the delivery of information products and services over the long term; and (iii) provision of adequate funding and human resources;

f) Timeframe and costs for initial 2 years: 5-6 meetings to scope out the project and deliver the above and salary for a consultant to prepare the plan, for a total of $0.35M.

Project 2.7: Establishing best practices for air quality observations and for monitoring in urban environments

a) Description: According to the World Bank (2008), to combat the effects of climate change, targeted research is needed at the city level to enable policymakers to understand the magnitude of the impacts and the alternatives to improve resilience of cities. In this project, case studies will be developed for understanding air pollution, health, and climate connections in large urban complexes in Africa, Asia, and Latin America. This will lead to improving and harmonizing air quality measurements and related modelling and to an international network of institutional partnerships supporting air quality-related services;

b) Objectives: To establish guidelines and networks of quality-assured air quality measurement sites in order to provide accurate knowledge of pollution levels in cities to support decision-making. The Health Exemplar cites "air quality, pollens and allergens,

ultra-violet radiation, and their impacts on human health, especially in cities," as a particular concern;

c) Benefits: The improved coverage and reliability of air quality observation systems will allow for better and more knowledgeable decision-making, for instance, in order to take appropriate precautionary/mitigation measures to address pollution problems related to health. This will result in better management of chronic disease burden associated with poor air quality. The project will also assist in the mitigation of short lived climate pollutants (SLCPs), such as ozone and black carbon, and thus both improve air quality and mitigate climate change. This implementation activity is addressing gaps identified in section 1.4 and Appendix 1and is responsive to GFCS Principles 4 and 7;

d) Deliverables: Starting with a few cities in different regions, harmonized measurements, information and data systems, and delivery will be developed. Environmental and air quality products and their dissemination will be improved. Guidelines will be developed based on this experience for the use of other institutes and authorities in the regions;

e) Prerequisites: (i) collaboration at the national level among institutes dealing with air quality, such as NMHSs and Environmental Agencies and Municipal Governments, and at the international level among WMO, WHO, UNEP; and (ii) provision of adequate funding and human resources;

f) Timeframe and costs for initial 2 years: 2 meetings in each Asia, Africa, and Latin America, salary for a consultant to prepare the Guidelines, total $0.35M.

Project 3: Large-scale data recovery, digitization, and homogenisation of climate records

a) Description: The project will provide support to global and regional Data Rescue, Digitization, and Homogenization (DARE&D&H) initiatives and develop new initiatives as required. The target initiatives are those using modern techniques, procedures, and tools to safeguard climate records risking damage or loss and to recover and digitize them. The project will promote the use of these techniques in developing and least developed countries, including through training workshops for NMHSs and other organizations working in climate data collection. Ensuring appropriate CDMS capabilities to integrate rescued data into the national climate record is an integral part of the project. The ultimate goals of the project are to enable access and use of high-quality long-term climate data with daily time resolution, to reconstitute and assess the changing behaviour of climate extremes affecting water, agriculture, and health, and to provide adequate databases on climate hazards to support DRR;

b) Objectives: Enabling and underpinning improved national, regional and global climate services based on historic climate data by: (i) enhancing the capacity of NMHSs and other climate data communities to accelerate the recovery, digitization, and homogenization of climate records, and to use modern data archiving and management tools including CDMS; and (ii) setting up an internationally coordinated initiative for Climate Assessment and Data sets (ICA&D) for the developing and providing high-quality climate assessments and data sets based on the output of enhanced DARE activities worldwide. This responds to the call for "strengthening data recovery and digitization to support disaster loss accounting and cost-benefit analysis" in the DRR Exemplar;

c) Benefits: Climate data rescue and the development of high-quality climate data sets are important areas of work described in section 1.4 and Appendix 1 (Climate Monitoring Activities). This project will feed climate data sets into the CSIS with the required quantity, quality, and coverage to support the provision of climate services, in particular at regional and local scales. It is especially aligned with GFCS Principles 1 and 7;

d) Deliverables: Provision of long-term high resolution high quality climate data sets and related products for climate assessment and sector applications;

e) Prerequisites: An effective engagement of NMHSs and supporting organizations at global and regional levels to carry out DARE in a sustained manner, including through international and regional collaborations; willingness of advanced NMHSs and other climate

institutions to provide the know-how and technological tools to accelerate DARE worldwide and to encourage use of modern climate data management tools and systems;

f) Time frame: 4 years, 1M/Yr.

Project 4: Providing information for sustainable water resources development and management in important shared international river basins

a) Description: The WHYCOS initiative, focusing on improving data collection, storage, dissemination and sharing as well as on developing water resources management products, provides an opportunity for implementing integrated hydrometeorological and climate-related networks aimed specifically at improving sustainable water resources management in a changing climate. WHYCOS is a global WMO Programme, developed in response to the scarcity or absence of accurate data and information on freshwater resources caused primarily by deteriorating observation networks and insufficient data management capabilities. The programme is implemented through various components (HYCOSs) at the regional and/or basin scale, three or four of which are the focus of this project, which is aligned with the pilot projects addressed in the Water Exemplar;

b) Objectives: Promoting and facilitating collection, analysis, exchange, dissemination and use of water-related information, using modern information technologies and capacity building;

c) Benefits: The HYCOS components are targeted at shared river systems and address the gaps in hydrological observations. Additional emphasis will be placed on improved integration of climate observation systems with hydrological observation systems. Managing access to and use of water in a variable and changing climate will benefit all sectors of society. The project contributes to addressing needs expressed in the Water Exemplar;

d) Deliverables: (i) strengthened hydrological observation networks; (ii) capacity development of NMHSs; (iii) data sharing in international shared river basins; (iv) integrated hydrological and climate observation systems; and (v) hydrological data and products in support of integrated water resources management;

e) Prerequisites: (i) agreement from, and cooperation between, the NMHSs to share the data and information collected; (ii) the adoption of agreed and common standards for the observation systems, data management systems, and products being developed; and (iii) long-term commitment from the NMHSs to maintain the systems and production of products and services into the future;

f) Timeframe and costs: Individual HYCOS Projects usually consist of an initial preparatory phase of 1 year, followed by an implementation phase of between 3 and 4 years. The proposed budget of $15M would provide sufficient resources for between 3 and 4 individual HYCOS components. At this stage, it is proposed to support the second stage of the Pacific HYCOS project with resources of $4M over a 4-year period, and the third stage of the Southern Africa Development Community (SADC) HYCOS with a similar level of resources, $4M over a 4-year period. The remaining $7M would be used to fund preparatory phase studies in 3-4 internationally shared river basins at most risk as determined through the User Interface Platform project proposed under the Water Exemplar and where feasible commence at least one additional project in Africa.

Project 5: Monitoring coastal regions to support adaptation and understanding of vulnerabilities

a) Description: This activity will address weaknesses in the observational coverage of climatically-important Essential Ocean Variables (EOV) and Essential Climate Variables (ECVs) needed for coastal region monitoring, thus responding to the requirements of the Framework for Ocean Observations in this regard (see section 1.4 and Appendix 1). This will allow better understanding and prediction of changes in the coastal environment (e.g., sea level rise, coastal erosion) and natural disasters (e.g., storm surges, extreme waves, tsunamis) to benefit coastal communities and to protect peoples' lives and property better;

b) Objectives: To improve coastal region monitoring and related services by increasing the percentage of completion from 62 to 80 per cent of the initial global ocean observing system, as defined by the JCOMM Observations Programme Area Implementation Goals. It addresses needs for strengthening the capacity for observations and monitoring in order to inform risk assessments as outlined in the DRR Exemplar;

c) Benefits: Benefits will be improved understanding of vulnerabilities, and prediction of changes and harmful events and disasters in coastal regions to help decision makers to adapt to such changes, and reduce related risks. GFCS Principles 4, and 7, in particular, are advanced through this project;

d) Deliverables: Deliverables will include prioritized national and regional plans for achieving enhanced coastal regions monitoring, and in particular the collection, and exchange of the required EOVs and ECVs;

e) Prerequisites: The understanding and prediction of changes, harmful events, and disasters is possible through appropriate monitoring of the costal regions. This requires appropriate atmospheric, ocean, and climate models and computing infrastructure, together with the routine observation of ocean and atmospheric variables analysed and assimilated in those models (see the observations needed for DRR described in section 2.4.4). As this activity only covers the observations part, prerequisites for this activity include: (i) commitment of IOC and WMO Members/Member States to undertake the necessary ocean observation programmes as reflected in the JCOMM Observations Programme Area Implementation Goals; (ii) open data policy and international exchange of the required data in real-time; and (iii) parallel development (or improvement) of the required ocean, atmospheric, and climate models;

f) Timeframe and costs: The project is expected to start with an initial phase of two years, costing about $8M annually. The goal in this period will be to increase the percentage of completion of the initial global ocean observing system, as defined within the JCOMM Observations Programme Area Implementation Goals from, 62 percent to 80 percent. Future efforts will be to complete of the observing system.

Project 6: Establishing a coordination mechanism for collecting, managing, and exchanging climate and related food security data

a) Description: This project will engage the climate community and the agriculture and food security sector in coordinated efforts to address needs for climate and related food security data, consistent with the High Level Recommendation to the Committee on World Food Security and Nutrition to “facilitate a dialogue on improved global data collection efforts for climate change and food security”. As indicated in the Exemplar on Food Security, effective delivery of climate services depends critically on the two communities working together and learning from each other;

b) Objectives: To achieve enhanced, better coordinated collection and international exchange of climate and food security data and derived products, maximizing all possible synergies by adopting agreed data and metadata standards and improving data analysis and exchange capacities;

c) Benefits: This implementation activity addresses a need identified in section 1.4 (see also Table 1.1) and Appendix 1. It is responsive to GFCS Principles 1, 4, 6, and 8;

d) Deliverables: High quality observations of the climate system, related socio-economic data and derived products are collected and exchanged, enabling the agriculture/food security sector to plan for and adapt to climatic variations, climatic extremes, and changes in climate;

e) Prerequisites: Sustained high-level engagement and commitment by the climate and agriculture and food security communities to addressing the challenges associated with improving coordination between the sectors; Provision of adequate resources and expertise to develop and authority to implement an effective coordination mechanism;

f) Timeframe and costs: 2 years; 0.1M.

Project 7: Establishing a coordination mechanism for architecture for climate monitoring from space

a) Description: A sustained, coordinated architecture for climate monitoring from space is an essential building building-block of the GFCS Observations and Monitoring Pillar, supporting all four priority sectors and all ECVs observable from space. A broad range of international partners contribute to this architecture, and their coordination was begun in 2011 with an ad hoc team including satellite mission operators and user representatives and involving WMO, GCOS, and WCRP. A standing coordination mechanism needs to be agreed and established over the next two years to bring the coordination of space-based observing systems, processing activities, and user services that support climate monitoring to the same level as currently in place for weather forecasting;

b) Objectives: A coordination mechanism will be internationally agreed and established;

c) Benefits: This implementation activity is addressing gaps identified in section 1.4 and Appendix 1. This will contribute to addressing needs expressed in all Exemplars for climate observations on appropriate temporal and spatial scales. The project is especially responsive to GFCS Principles 2 and 7;

d) Deliverables: (i) agreed procedures for analysing and addressing gaps in space-based climate monitoring; (ii) establishment of initial inventory of ECV-relevant observing systems, datasets, and user expert groups; (iii) identification of gaps and opportunities based on the ECV inventory; and (iv) prioritized action plan to implement the Architecture;

e) Prerequisites: (i) entities that operate observing networks (in this case, space agencies operating satellites and ground-based processing systems) will need to make their data available (this is a prerequisite for a system to be considered as part of the Architecture); and (ii) technological developments and national, regional, or global economic circumstances must enable these entities to sustain the delivery of these data over the long term. It can be expected that international coordination will mitigate the risks associated with implementing and sustaining the Architecture;

f) Timeframe and costs: 2 years; 0.5M/year.

APPENDIX 4

Enabling Mechanisms

Synergies with Existing Activities

Many stakeholders in the Observations and Monitoring Pillar have developed initiatives and programmes for observing the environment that, at the very least, include practices for collecting, distributing, and providing data to users. This Pillar should take maximum advantage of such initiatives and programmes, even if their practices differ, thus building synergies to overcome financial, technological, and human limitations. Close collaboration among programmes that address the physical domains of the Earth, namely GCOS as the overarching coordination mechanism for climate, GOOS (for oceans), GTOS (for land), and WIGOS (for atmosphere) is ongoing and must be continued. UN agencies have been active for decades in capacity building efforts. However, most agree more needs to be done. Building on the existing programmes of these UN organizations is an area for increased cooperation. Mechanisms like the WMO Voluntary Cooperation Programme (VCP) that address implementation, operations, and maintenance of observing systems should be leveraged and built upon.

Building National, Regional and Global Partnerships

Improving coordination for observations for climate services

The effective functioning of the observing system for climate services will depend greatly on the degree to which appropriate coordination mechanisms are put in place at national and regional levels. At the national level, the responsibility for implementation and operation of observing systems is typically distributed across many national departments and agencies, rather than being focused solely in a single agency such as an NMHS. While NMHSs usually play a central role in providing basic atmospheric observations, environmental agencies, agricultural agencies, research agencies, space agencies, and (where countries are not landlocked) national ocean services also provide important climate-relevant data and are engaged in the production of climate services. The requirements for biological, socio-economic and other non-physical data will, moreover, draw upon the capacities of even more agencies and institutions.

The establishment of national coordination mechanisms can lead to improved awareness of the importance of climate observations and related socio-economic and other data and to ensuring that the data needed for climate services are available. Where climate data are concerned, the designation of National Climate Observing Coordinators and the establishment of National Climate Observing Committees have long been advocated by the GCOS Steering Committee and supported by recommendations of the WMO Congress and the Conference of the Parties to the UNFCCC. To date, however, only twenty-three countries have established national coordinators, and most of these are in developed countries. The incorporation of requirements for biological, socio-economic, and environmental data will require further broadening of such initiatives. Promoting the establishment or improvement of both national and regional coordination mechanisms for observations for climate services will be an important activity of the Observations and Monitoring Pillar of the GFCS.

Promoting observing system improvements through partnerships

Just as strengthened coordination at national and regional levels will be important in fully implementing the Observations and Monitoring Pillar of the GFCS, so too will be the establishment of new partnerships and the enhancement of relevant existing ones. Partnerships may be among UN agencies, for example, the partnership among ICSU, UNEP, UNESCO/IOC, and WMO that has created the GCOS. This partnership may be enhanced in the future by adding additional members. In particular, with the evolving needs of the GFCS in mind, it will be important to develop close working partnerships with UN agencies and others who can bring socio-economic data and expertise to assist in the development and delivery of truly effective climate services that respond to user needs. This is one reason why this Annex has proposed establishing a formal mechanism for consultation with users as one of its initial priority implementation activities. Partnerships may

also be between or among regional climate centres and UN agencies, including those involved in the key sectors; among NMHSs within a given region; among NMHSs and co-sponsored programmes; among development banks and/or international cooperation agencies and regional climate centres; etc. It is useful to mention several in this Annex, but many more could be cited.

One of the most relevant examples of a partnership that will eventually lead to the improvement of climate observations and climate services is the Climate for Development in Africa Programme (ClimDev Africa). This Programme was conceived as an integrated programme with the objective of improving climate observations, climate services, and climate policy in Africa in support of mainstreaming climate concerns into development planning. Its principal partners are the African Union Commission (AUC), the UN Economic Commission for Africa (UNECA), and the African Development Bank (AfDB), but these African institutions have been joined by GCOS, UNEP and WMO, regional climate centres in Africa, and others.

If the goal of the ClimDev Africa partners is realized and donors, both internal and external to Africa, provide the needed funds to implement demand-led projects to improve climate observations and services in Africa, the Programme could have a substantial impact on Africa's ability to adapt to climate variability and change and to effectively address its development needs. The ClimDev Africa Programme, as it further develops, will be an important contribution to the GFCS in Africa. As with the GFCS itself, the active and continued involvement of partners will be required, as well as support by both national and international organizations.

A second example of a partnership that has been conceived to address needs for improved climate observations and climate services is that between the GCOS and the Centro Internacional de Investigaciones para el Fenómeno El Niño (CIIFEN). With the support of Spain and Switzerland and the participation of several international cooperation agencies, GCOS and CIIFEN organized a workshop for South American countries on Improving the Climate Observing System in South America to Enable Better Climate Services and Adaptation Strategies. The workshop, which convened both producers and users of climate information, had the following specific objectives: (1) to discuss and agree on the regional priorities for integrated projects with climate information providers, sectoral users, and technical cooperation agencies; (2) to identify possible pilot initiatives to demonstrate the benefits of an integrated approach and, thus, make it easier for national governments to use national resources to sustain improvements; and (3) to determine observational requirements for improving sector-specific climate services and climate change adaptation strategies in support of ongoing and emerging sustainable development initiatives.

Communications Strategy

A specific communications strategy for the Observation and Monitoring Pillar should nest within the overarching communications strategy for the GFCS. Elements of the specific strategy for the Pillar should, however, include:

- Reaching the users of climate data and information, predominantly through the User Interface Platform, through direct contact with relevant focal points, through newsletters, and through analysis and technical reports on the status of the system, its gaps, and its evolution;
- Reaching partners through the established coordination mechanisms for operation and development of observing systems (such as UN agency coordination, GCOS, and WIGOS);
- Reaching the general public through press releases and the media, including Internet and social networks;
- Reaching professionals involved in the operation of the observing systems through workshops and technical and scientific conferences;
- Including consideration of the need for capacity building and outreach;

- Building feed-back loops into the strategy to enable continuous improvement of observing system performance.

As a particular issue, the reluctance of some countries to exchange or provide easy access to their observational and climate-related data requires that an effective communications strategy for the Pillar must place strong emphasis on explaining the benefits of the GFCS and highlighting the need for open exchange of data to support its successful implementation.

APPENDIX 5

Additional Activity and Project Proposals

Table 5.1. Synthesis of Observation Initiatives Described in Table 5.2

	ACTIVITY AREAS	DELIVERABLES	TIMELINES	STAKEHOLDERS	COSTS/YR (USD)	POTENTIAL RISKS
1.	**ROLLING REVIEW OF REQUIREMENTS & ONGOING CONSULTATIONS WITH USERS**	Well-defined user requirements for observations -all climate system components	Ongoing	All climate system partners and user groups in key sectors	TBD	Poor coordination; lack of funding; inadequate user participation
2.	**ATMOSPHERIC OBSERVATIONS**	Physical and chemical atmospheric observations and databases that meet GFCS users' requirements	Various - final target date of 2020	WMO, GCOS, GAW, CEOS,CGMS, NMHSs, JCOMM, others	200 – 660M	Inadequate resources; Research requirements
3.	**OCEAN OBSERVATIONS**	Oceanic observations and databases that meet GFCS users' requirements	Various – final target of 10 years	UNESCO/IOC, JCOMM, GOOS, GCOS, Space Agencies, National Ocean Agencies, NMHSs, other partners	5 – 40M	Mobilization; Lack of national/regional coordination
4.	**TERRESTRIAL OBSERVATIONS**	Hydrological and other terrestrial observations and databases that meet GFCS users' requirements	Various - final target date of 2015	UNESCO, GCOS, GEO, FAO, WMO, Space Agencies, other partners	100 - 300M	Inadequate resources; Data policies
5.	**CRYOSPHERIC OBSERVATIONS**	Cryospheric observations, databases and products that meet GFCS users' requirements	2015	WMO, NMHSs, all national and international institutes / agencies / groupings with cryosphere responsibilities	40 - 130M	Inadequate resources; Data policies; Continuity of satellite records
6.	**CLIMATE SYSTEM MONITORING**	Enhanced data rescue; operational reanalysis; extreme weather/climate databases; improved climate products	2020	WMO, NMHSs, GCOS, IOC, national/regional/international agencies	10 – 30M	Inadequate resources; NMHSs' operational priorities

Table 5.2. Actions and Activities Related to Observations and Monitoring

1. ROLLING REVIEW OF REQUIREMENTS									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Time-lines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
1	Rolling consultations with users - Establish a formal mechanism.	(1) A plan to assist users and service providers developed; (2) A set of user requirements across all domains for the GFCS	Satisfaction of users with climate services	User Interface Platform	Biennial	All partners	Link with all WMO, co-sponsored and non-WMO programmes	TBD	Coordination, funding, communities' interest
2	Set up a "GFCS Observational Requirements Task Team".	(1) Up-to-date WMO Data Base; (2) Up-to-date SoGs; (3) Relevant EGOS-IP and updated GCOS-IP; (4) Plan for cost-effective evolution of existing obs. Stations; (5) Guidance to Members for the establishment of Regional and National observational requirements	Completeness of WMO Database and SoGs regarding GFCS requirements	GFCS Task Team, and community review	Biennial	WMO Members and partners	CBS ET-EGOS, GCOS, WIGOS, GCW, TCs, CEOS, CGMS, GEOSS	155 K	Coordination, communities' interest
3	Identify and implement priority GFCS-relevant actions from the EGOS-IP and the GCOS-IP.	(1) GFCS Compliant observing systems	Adequacy of observing systems	GFCS Community review	Ongoing	WMO Members and partners,	CBS ET-EGOS, GCOS, GCW, TCs, CEOS, CGMS, GEOSS	TBD	Coordination
4	Comprehensive networks: Sustain, fill gaps and generally expand the comprehensive atmospheric *in situ* networks, including air quality networks.	Provision of required surface-based data adequate for GFCS, including data from rehabilitated silent stations and station in remote areas	Availability and quality of data	World Data Centres	2015	WMO, its Members and Partners	All atmospheric networks	140 – 440 M	Research needed for optimal and cost-effective design of networks and data policies

2. ATMOSPHERE									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Time-lines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
4a	Rehabilitation of silent stations and key stations in data poor areas, with a special focus on GSN and GUAN stations (to include measuring instruments and related technology, consumables, and training.	Provision of data of required quality	Satisfactory monitoring reports of GSN and GUAN data	WMO and GCOS Monitoring	Ongoing	Respective WMO Members	WIGOS, GCOS, ClimDev Africa	5 M	Inadequate funding
4b	Baseline networks: fully implement the climate baseline networks and systems and operate them in accordance with CIMO practices and the GCMPs.	Provision of surface and upper-air data for global assessments and responses	Availability and quality of data	Reports from global data centres	2015	WMO, its Members and Partners	WIGOS, WCRP	40-130 M	Inadequate funding
5	Develop Standardization Database.	WIGOS Standardization Database	WIGOS Standardization Database operational	Easy availability of existing standards	2015	WMO, its Partners	All observing systems	1 M	Inadequate resources
6	Develop Operational Database.	WIGOS Operational Database	WIGOS Operational Database operational	Availability of metadata to users	2015	WMO, its Partners	All observing systems	1 M	Inadequate resources
7	Develop Architecture for Climate Monitoring from Space.	Strategy and Action Plan for Architecture for Climate Monitoring from Space	Endorsement of Architecture for Climate Monitoring from Space by all stakeholders	Architecture for climate monitoring in place	2015	WMO, its Partners, including CEOS, CGMS,	All observing systems	0.5 M	-

2. ATMOSPHERE (cont'd.)									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Time-lines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
8	Develop data management standards, principles and practices.	WIS data management standards, principles and practices; Build universal Database Management System capability based on existing initiatives; WIGOS Portal	WIS data management standards, principles and practices are applied through all WIGOS data management activities, incl. metadata; WIGOS Portal operational	Implementation started	2015	WMO, its Partners	All observing systems	0.5 M	-
9	Conduct workshops to assess the role of observations in adaptation to climate change.	Final report and strategy	Publication of report	--	early 2013	GCOS Sponsors, FAO, WHO, others	UNEP and IOC activities in adaptation	0.3M	None
10	Submit all national precipitation data, including hourly totals and radar-derived products where available, to global data centres.	Availability of precipitation datasets	Percentage of nations providing all precipitation data to global data centres. Percentage of stations for which hourly data available	Reports from global data centres	2013	WMO, its Members and Partners	Precipitation networks	1-10 M	Inadequate funding, data policies

2. ATMOSPHERE (cont'd.)									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Time-lines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
11	Develop, improve, and sustain ground-based and space-based networks for measurement of precipitation and provision of products.	Availability of long-term homogeneous surface-based and satellite-based global precipitation products	Improved measurement methods and analysis techniques developed; inventory and guidance on precipitation products available; implement-ation of Global Precipitation Mission and follow-on	Reports from global data centres; IPWG	2018	WMO, its Members and partners, CGMS	Ground-based and space-based systems to estimate precipitation	20-60 M	Inadequate funding, data policies
12	Develop standard & best practices.	Manual and Guide on WIGOS	Approved by Seventeenth Congress	Updated TR, Manual & Guide published	2015	WMO, its Partners, ISO, BIPM	All observing systems	1-5 M	Inadequate resources
13	Develop Core Metadata Standard, with emphasis on climate, and technical guidance.	WIGOS Core Metadata Standard applicable to climate; technical guidance	WIGOS Core Metadata Standard developed; technical guidance available	Initial core standard implemented	2015	WMO, its Partners	All observing systems	0.5 M	Inadequate resources
14	Develop QMS procedures.	Approved QMS procedures by WMO	Satisfactory quality of data	Monitoring of data quality	2015	WMO, its Partners	All observing systems	0.5 M	Inadequate resources
15	Develop Vision for integrated observing system & its implementation plan, incl. technical guidance.	Vision for WIGOS and its implementation plan, incl. technical guidance	Vision for WIGOS and its implementation plan, incl. technical guidance available	Implement-ation initiated	2015	WMO, its Partners	All observing systems	0.5 M	Inadequate resources for implement-ation
16	Implement a global system for traceability of measurements to SI.	Measurements traceable to SI	Quality of data	Reports from global data centres	2020	WMO, its Partners, ISO, BIPM	All observing systems	5-10 M	Inadequate resources

3. OCEAN									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
17	Marine Climate Data System.	Develop the Marine Climate Data System (MCDS) under the JCOMM Expert Team on Marine Climatology (ETMC) so that it properly addresses the GFCS requirements for ocean and marine meteorological data	MCDS implemented	JCOMM review	10 years	WMO/IOC	CCl	30 K	Low
18	Address needs to monitor coastal regions and support adaptation and understanding of vulnerabilities.	Prioritized national and regional plans	Publications by regions and nations of their plans	To be established by technical advisory bodies	Continuing	Coastal countries OOPC		1-10 M annually	Mobilization; lack of national/ regional coordination
19	Improve number and quality of climate-relevant marine surface obs. from voluntary observing ships.	Improved number of observations	Increased quantity and quality of VOS reports	Availability of data	Continuing	NMHSs and climate services with shipping cos.		1-10 M annually	
20	Ensure coordination of contributions to CEOS Virtual Constellations for each ocean surface ECV relative to *in situ* ocean observing systems.	Annually updated charts on adequacy of commitments to space-based ocean observing system from CEOS	Updated charts		Continuing	Space agencies, JCOMM, GCOS, GOOS	WIGOS	1-10 M annually	
21	Implement the GLOSS Core Network.	Additional and/or improved tide gauges for about 300 tide gauge stations	Tide gauges in place and operating	Availability of sea level data	End of 2014	National ocean agencies, coordinated thru GLOSS of JCOMM		1-10 M annually	

4. LAND									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
22	Establish prototype GTN-GW and a Global Groundwater Monitoring System (GGMS) as a web-portal for all GTN-GW datasets; deliver readily available data and products to the information system.	Prototype of GGMS operational To be completed by IGRAC	Reports to WMO CHy on the completeness of the GTN-GW record held in the GGMS, including the number of records in, and nations submitting data to, the GGMS; web-based delivery of products to the community.	Availability of data from GGMS	2014	IGRAC, in cooperation with GTN-H	UNESCO- IHP	1-10M	Inadequate resources, data policies
23	Achieve national recognition of the need to exchange hydrological data of all networks encompassed by GTN-H, in particular the GCOS/ GTOS baseline networks and hydrological networks, and facilitate the development of integrated hydrological products to demonstrate the value of these coordinated and sustained global hydrological networks for climate services.	Documented data sharing agreements from NMHSs for the sharing of selected station data in an institutionalized manner Documentation of functional, integrated data products for a variety of purposes and in particular for climate services on national and regional scales	Number of datasets available in global data centres; Number of available demonstration products; Documentation of integrated data products and demand for these products	Direct contact with NMHSs and including river basin organizations Requests for data products from a variety of user communities	2015	GTN-H Coordinator, WMO, GCOS, GTOS, in consultation with GTN-H Partners	GEO/IGWCO-COP	1-2 M	Inadequate resources, data policies

4. LAND (cont'd.)									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
24	Development of a subset of current LTER and FLUXNET sites into a global terrestrial reference network for monitoring sites with sustained funding and co-located measurements of meteorological ECVs.	FLUXNET sites operational	Plan for the development and application of standardized protocols for the measurements of fluxes and state variables	Availability of FLUXNET data	2014	National FLUXNET organizations US National Ecological Observatory Network (NEON) and the European Integrated Carbon Observation System (ICOS), in association with CEOS WGCV, CGMS-GSICS, and GTOS	Suggest that there must be linkages to WMO, NMHSs, research foundations and universities, etc	30-100M	Inadequate resources, data policies
25	Assess national needs for river gauges in support of impact assessments and adaptation, and consider the adequacy of those networks.	National reports on the adequacy of national hydrological networks	National needs identified; options for implementation explored	Assessment undertaken on the basis of sector-specific hydrological information requirements	2014	National Hydrological Services, in collaboration with WMO CHy and TOPC	Water Resources Assessment activities of WMO	10-30M	Inadequate resources, data policies

4. LAND (cont'd.)									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
26	Generate annual products documenting global land-cover characteristics and dynamics at resolutions between 250 m and 1 km, according to internationally-agreed standards and accompanied by statistical descriptions of their accuracy.	Generated Products	Dataset availability	Availability of products	2012	Parties' national services, research institutes and space agencies in collaboration with GLCN and GOFC-GOLD research partners and the GEO Forest Carbon Tracking task team.		1-10M	Inadequate resources
27	Implement agreed HYCOS initiatives in ten priority basins/regions of water scarcity to provide information for sustainable water resources development and management.	Information and products to support adaptation to climate variability and change	River Basin and regional water resources development and management needs met	Communities and sectors with access to water resources which mete identified needs	2014	National Meteorological and Hydrological Services, in collaboration with WMO CHy.	Information collected will support climate modelling and verification analyses.	10-15M	Inadequate resources, data policies

5. CRYOSPHERE									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
28	Implement Global Cryosphere Watch, which will include among others: • Inventory of existing networks • Further development & completion of a network of sites/ reference sites/ supersites.	GCW Implemented and operational	Availability of Cryo data through GCW Portal and WIS	Integrated data & products available for GFCS through GCW Portal and WIS	2015	WMO and Members, all national and international institutes / agencies / groupings with cryosphere responsibilities	All Domains	2-10M	Lack of resources, data policies
29	Strengthen and maintain existing snow-cover and snowfall observing sites; ensure that sites exchange snow data internationally; establish global monitoring of those data through WIS; and recover historical data.	Data & products available through GCW Portal	Data submission to national archives, World Data Services and international bodies such as GPCC	GCW Portal and WIS	2015	NMHSs and research agencies, in cooperation with WMO GCW and WCRP and with advice from TOPC, AOPC, and the GTN-H	Atmospheric & Terrestrial Domains	1-10M	Lack of resources, data policies
30	Maintain current glacier observing sites and add additional sites and infrastructure in data-sparse regions, including South America, Africa, the Himalayas, and New Zealand; attribute quality levels to long-term mass balance measurements; complete satellite-based glacier inventories in key areas.	Data & products available through GCW Portal	Completeness of database held at NSIDC from WGMS and GLIMS	GCW Portal and WIS	2015	Parties' national services and agencies, with international coordination through GTN-G partners, WGMS, GLIMS, NSIDC and GCW.	Atmospheric & Terrestrial Domains	10-30M	Lack of resources, data policies

5. CRYOSPHERE (cont'd,)									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
31	Ensure continuity of *in situ* ice sheet measurements and fill critical measurement gaps.	Data & products available through GCW Portal	Integrated assessment of ice sheet change supported by verifying observations.	GCW Portal and WIS	2015	Parties, working with IACS, IASC, SCAR, GCW, and WCRP CliC	Atmospheric & Terrestrial Domains	10-30M	Lack of research funding
32	Ensure continuity of the existing GTN-P borehole and active layer networks, upgrade existing sites, build “reference sites”, initiate operational permafrost temperature network at met. stations.	Data & products available through GCW Portal	Number of sustained sites; completeness of database.	GCW Portal and WIS	2015	Parties’ national services/ research institutions and International Permafrost Association. IPA/GTN-P and WMO GCW	Atmospheric & Terrestrial Domains	10-30M	Lack of resources
33	Reprocess historical satellite data for consistent records of sea ice and snow properties. Facilitate intercomparisons of similar products.	Climate data records for sea ice extent, concentration, thickness, and motion, and snow cover extent and snow water equivalent	Number of CDRs from different satellite systems	GCW and World Data System	2015	Satellite agencies, WMO Members, Intl. Scientific bodies, e.g. WCRP, GCOS, IASC, SCAR	Atmospheric, terrestrial and oceanic domains	5-10M	Continuity of satellite records

6. CLIMATE SYSTEM MONITORING									
No.	***Activity***	***Deliverables***	***Indicators***	***Assessment measures***	***Timelines***	***Stakeholders***	***Linkages with other activities***	***Costs/yr USD***	***Potential Risks***
34	Large scale data recovery and digitization, with the integration of data from community observation networks.	-Establishment of initiatives and mechanisms for accelerating data recovery and digitization - Universal Climate Database Management System capability built, based on existing initiatives	Percent of climate records recovered and digitized (baseline: 2012)	Climate data flow into national, regional, and global data centres	2020	CCl, GCOS, CBS, CHy, CAgm, RAs, All Members ACMAD, RCCs, CLIMDEV, UNFCCC, UNEP, MEDARE, ACRE	Climate Data Management Systems (CDMSs), WIS DCPCs, CSIS, Nairobi Work Programme	400K year	Availability of funds
35	Establish a sustained capacity for global climate reanalysis and ensure coordination and collaboration among reanalysis centres.	Reanalysis on an operational basis	Reanalysis centres endowed with long-term and coordinated programmes	Cyclical flow of products of improving quality and widening range	2014; expansion into coupled reanalysis by 2016	National and international agencies		10-30M (Mainly developed countries)	Availability of funds
36	Provision and dissemination of new climate data sets and products, including *in situ* and space based.	- Yearly updates of World Weather Records - New products, including for monitoring from space	Countries implementing/ using these products	Data received by WMO, WDCs, RCCs and NMHSs	2016	CCl, GCOS, CBS, all Members, key priority sectors	CSIS, UIP, Climate Data Management Systems (CDMSs)	80K	Members Commitments
37	Ensuring better monitoring of the occurrence of climate extremes and their socioeconomic impacts data bases on climate hazards in support of climate early warnings.	Establishment of regional and national data bases on extreme weather and climate events	Number of RCCs and NMHS data bases on extreme weather and climate events	Reports from Countries, RCCs, and NMHSs	2020	CCl, CBS, RAs, all WMO Members	CSIS, UIP, Nairobi Work Programme	140K	Lack of funds, organi-zational structures, and operational priorities at NMHSs

Table Status of Implementation of Networks and Identified Gaps

ATMOSPHERE				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Temperature	GCOS Surface Network (subset of full WWW/GOS surface synoptic network)	At least 95% of stations are active, but only about 80% transmit CLIMAT reports.		Operationally supported .
	Full WWW/GOS surface synoptic network	Need data from entire network to be available for climate purposes; data receipt from many countries is inadequate.		
	Buoys and ships	Over 200 meteorological buoys worldwide plus the Global tropical moored buoy network (completed in Pacific & Atlantic; Indian 50% completed). Over 400 VOSClim class VOS ships (i.e. 20%).	Sea-surface temperature (IR, microwave) has strong influence on analysis of air temperature over the ocean.	
	Additional national networks (see also Oceanic section, Sea-surface Temperature ECV)			
Pressure	GCOS Surface Network (subset of full WWW/GOS surface synoptic network)	At least 95% of stations are active, but only about 80% transmit CLIMAT reports.		
	Full WWW/GOS surface synoptic network	Some inconsistencies in pressure reduction methods to mean sea level.		
	Additional national networks	Some national networks inadequate for climate studies.		
	Buoys and ships (see Ocean Surface section)	50% of 1250 drifters with barometers. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data. Ice buoys with relatively good coverage in the Arctic in ice-covered regions (72 units), except in the Eurasian sector; retreating ice becoming a challenge for maintaining ice buoy network; ice buoys episodically deployed around Antarctica.		

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Wind Speed/ Direction	GCOS Surface Network (subset of full WWW/GOS surface network) WWW/GOS surface synoptic network Additional national networks Buoys and ships (see Ocean Surface section)	Wind is still not included in GSN. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data. Ice buoys with relatively good coverage in the Arctic in ice-covered regions (72 units), except in the Eurasian sector; retreating ice becoming a challenge for maintaining ice buoy network; ice buoys episodically deployed around Antarctica.	Scatterometer. Passive microwave for wind speed. Polarimetric microwave radiometry for wind vectors	Uncertain operational continuity of two-scatterometer constellation
Precipitation	GCOS Surface Network (subset of full WWW/GOS surface synoptic network) Full WWW/GOS surface synoptic network Additional national meteorological and hydrological gauge networks; island networks Surface-based radar networks Buoys	At least 95% of stations are active, but only about 80% transmit CLIMAT reports. Quality of data and quantity of reports are variable. Most countries operate national high-resolution precipitation networks, but data are often not available internationally, or available only with time delay. Radar data not globally exchanged; spatial and temporal sampling limitations. Over 200 meteorological buoys worldwide, plus the Global tropical moored buoy network (completed in Pacific & Atlantic; Indian 50% completed)	Passive microwave, VIS/IR on GEO. Precipitation radar.	High priority for climate applications Uncertain continuity of precipitation radar, Temporal and spatial sampling limitations.

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Water Vapour	GCOS Surface Network (subset of full WWW/GOS surface synoptic network); Full WWW/GOS surface synoptic network	Water vapour is only partly included in CLIMAT reports, and not monitored.		
	Ships and moored buoys	Over 200 meteorological buoys worldwide, plus the Global tropical moored buoy network (completed in Pacific & Atlantic; Indian 50% completed). Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data; however, limited number of VOS making humidity measurements.		
Surface Radiation Budget	BSRN	High-quality data, but coverage should be extended and continuity secured.	GEWEX Surface Radiation Budget project	Solar from satellites For long-wave, satellite data are used to estimate cloud parameters and near-surface thermodynamics fields are typically taken from NWP models
	WWW/GOS surface synoptic network	Quality and coverage of routine radiation data is inadequate for climate purposes.		
	Additional national networks	Limited availability of high-quality data in national networks.		
Upper-Air Temperature	WWW/GOS radiosonde network (including GCOS Upper-Air Network--GUAN)	About 90% of GUAN stations are reporting regularly. Totally, about 71% of stations are reporting regularly.	Microwave sounders GNSS radio occultation. Infrared sounders	Need to ensure continuity of MSU-like radiance bands. Continuity for GNSS RO constellation needs to be secured
	Commercial aircraft ASAP ships	Aircraft observations are valuable but limited to specific routes and levels except near airports. 6000 profiles per year, mainly in the North Atlantic.		

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Upper-Air Wind Speed and Direction	WWW/GOS radiosondes network (incl. GCOS Upper-Air Network) Radar (profilers) Commercial aircraft ASAP ships	About 90% of GUAN stations are reporting regularly. Totally, about 71% of stations are reporting regularly. Radar data are not globally distributed. Aircraft observations are valuable but limited to specific routes and levels except near airports. 6000 profiles per year, mainly in the North Atlantic.	Visible and infrared (atmospheric motion vectors) from geostationary and polar orbit satellites. Lidar	Continuity of some polar winds at risk. Awaiting ADM/Aeolus demonstration; no continuity planned.
Upper-Air Water Vapour	Reference network of high-quality and high- altitude radiosondes (GRUAN) WWW/GOS radiosondes network (incl. GCOS Upper-Air Network) Ground-based GNSS receiver network Commercial aircraft, e.g., CONTRAIL and IAGOS NDACC with Raman and DIAL LIDARs, as well as microwave instruments ASAP ships	International cooperation continues to work towards establishing the reference network as accurate reference radiosondes measuring upper-tropospheric and lower-stratospheric humidity are needed. Accuracy of water vapour measurements is improving, but is still inadequate for climate purposes in the upper troposphere and lower stratosphere. Wider international exchange of data is needed. Aircraft data are potentially useful. 6000 profiles per year, mainly in the North Atlantic.	Microwave imagers and sounders; Infrared sounders GNSS radio occultation; Infrared and micro-wave limb sounders Solar occultation NIR images over land	Continuity assured for operational microwave and IR sounders; Continuity uncertain for microwave imagery Continuity uncertain for research satellites and GNSS constellation.

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Cloud Properties	Surface observations (GSN, WWW/GOS, VOS) Cloud radar and lidar	Surface observations of cloud cover provide an historical but uncertain record, and continuity is a concern; reprocessing of cloud data is needed. Research-based networks.	Visible, infrared and microwave radiances from geostationary and polar orbiting satellites; Cloud radar and lidar (research).	Cloud top temperature, microphysical properties and coverage are all operational.
Earth Radiation Budget			Broadband short- and long-wave and total solar irradiance GERB geostationary measurements provide high time resolution broadband data.	Continuity and good calibration of measurements is of critical importance NPP/JPSS will provide a CERES-like record starting in 2010. GERB useful for process studies, but no follow-on instrument.
Ozone	WMO GAW GCOS Global Baseline Profile Ozone Network (GAW ozonesonde network, including NASA SHADOZ and NDACC). WMO GAW GCOS Global Baseline Total Ozone Network (GAW column ozone network (filter, Dobson and Brewer stations) and profile ozone network (ozonesondes)). NDACC	Mature operational balloon sonde network. Mature operational ground-based total column network. Operational; Operational data management.	UV nadir and limb sounders IR nadir sounders IR and MW limb sounders	Operational continuity for column ozone; No future operational or research high vertical resolution profiling currently planned after 2015.

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Carbon Dioxide	WMO GAW Global Atmospheric CO_2 Monitoring Network (major contribution to the GCOS comprehensive network for CO_2) consisting of: WMO GAW[4] continuous surface monitoring network. WMO GAW surface flask sampling network Airborne sampling (CONTRAIL, CARIBIC) WMO GAW TCCON network (ground-based FTIR)	Operational; Operational data management. Operational; Operational data management. Limited operational aircraft. Operational	SWIR and high-resolution IR	Continuity in IR operational instruments but products are immature and limited; A dedicated research satellite mission to provide better global products has been launched in 2009 (GOSAT), but continuity of such SWIR measurements need to be assured.
Methane and other long-lived greenhouse gases[5]	WMO GAW Global Atmospheric CH_4 Monitoring Network ((major contribution to the GCOS comprehensive network for CH_4), consisting of: GAW continuous surface monitoring network GAW surface flask sampling network AGAGE, SOGE and University of California at Irvine, USA Airborne sampling (CONTRAIL, CARIBIC, IAGOS) WMO GAW TCCON network (ground-based FTIR) NDACC	 Operational; Operational data management. Operational; Operational data management. Operational; contributing to the GAW Programme network; Operational data management. Limited operational aircraft vertical profiling initiated. Operational, column measurements. Operational; column and profiles; Operational data management.	IR nadir sounders SWIR nadir sounders IR and microwave limb sounders	Satellite measurements on CH_4 are maturing and are part of operational satellites. Continuity of the observational needs is to be assigned. MLS, HIRDLS performs N_2O measurements in the stratosphere as well as of the other GHGs. Future research satellites might continue this, but there is uncertain continuity of profiling limb sounders.

[4] GAW includes networks operated by NOAA ESRL, CSIRO and many other WMO Members.

ATMOSPHERE (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Precursors (supporting the Aerosol and Ozone)	WMO GAW observing network for CO (continuous and flasks measurements) WMO GAW network for reactive nitrogen EMEP (GAW contributing network) Research programmes using MAXDOAS, SAOZ, FTIR and other techniques (for NO_2) *In situ* network from environmental agencies Aircraft (IAGOS) NDACC	Operational; Operational data management Currently in the stage of establishment, several stations world-wide. Operational European network for monitoring of primary pollutants. Sparse, research-oriented. Operational at national level, limited quality. Limited operational aircraft vertical profiling initiated. Operational (column and vertical profiles). Operational data management.	UV/VIS/NIR/SWIR sounders Nadir IR sounders	Precursors are measured by research satellites and operational satellites in future. Information on high spatial and temporal resolution is limited
Aerosol Properties	BSRN WMO GAW and contributing networks (AERONET) backscatter lidar networks (GALION and contributing networks) NDACC (aerosol lidar)	Operational. Operational; Global coordination in progress. Operational.	Solar occultation VIS/ IR imagers Lidar profiling UV nadir Polarimetry Multi-angular viewing	Planned operational continuity for column products; No operational missions planned for aerosol type and aerosol size Research missions for profiling tropospheric aerosols; No plans for continuity of stratospheric profiling.

[5] Including N_2O, CFCs, HCFCs, HFCs, SF_6 and PFCs.

OCEAN				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Sea surface heat flux	Global tropical moored buoy network (~120) implemented through JCOMM/DBCP Global reference mooring network (30-40) Sea-ice buoys implemented through JCOMM/DBCP Sustained and repeated ship-based hydrography network Critical current & transport monitoring	Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Relatively good coverage in the Arctic in ice-covered regions (72 units), except in the Eurasian sector; retreating ice becoming a challenge for maintaining ice buoy network; ice buoys episodically deployed around Antarctica. Repeat hydrography and carbon inventory (10 year survey) 62% completed. CLIVAR, OceanSITEs (over 100 sites), and IOCCP providing data for the critical current & transport monitoring.	VIS/IR radiometry MW radiometry Scatterometry	Operationally supported Continuity uncertain for microwave imagery Operationally supported
Significant wave height	Meteorological moored buoys VOS fleet (25% of VOSClim class ships in the VOS fleet) implemented through JCOMM/SOT	Over 200 moored buoys worldwide, mainly in USA, Canada, Europe Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data with additional QC flag and metadata.	Radar altimetry Synthetic aperture radar	Continuity assured, subject to data sharing Continuity assured, subject to data sharing and timely processing
Sea State			Radar altimetry	Continuity assured, subject to data sharing
Sea surface height anomaly			High-precision satellite altimetry Radar altimetry	Continuity to be confirmed Continuity assured, subject to data sharing
Sea Level	GLOSS Core Sea-level Network, plus regional/national networks	85% active stations; 71% fast delivery; 48% with GPS/DORIS; will increase with tsunami warning upgrades in Pacific, Caribbean.	High-precision satellite altimetry Radar altimetry	Continuity to be confirmed Continuity assured, subject to data sharing

OCEAN (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Sea Surface Temperature (SST)	Global surface drifting buoy array on 5°×5° resolution (1250) implemented through JCOMM/DBCP Global tropical moored buoy network (~120) implemented through JCOMM/DBCP VOS fleet (25% of VOSClim class ships in the VOS fleet) implemented through JCOMM/SOT Carbon VOS Global reference mooring network (30-40)	Drifter network achieved required global density. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data with additional QC flag and metadata. See http://cdiac.esd.ornl.gov/oceans/VOS_Program/ for status of Carbon VOS. Global reference mooring network 34% complete.	VIR/IR radiometry MW radiometry	Operationally supported Continuity uncertain for microwave imagery
Sea Surface Salinity	Global tropical moored buoy network (~120) implemented through JCOMM/DBCP VOS fleet (25% of VOSClim class ships in the VOS fleet) implemented through JCOMM/SOT Carbon VOS Global reference mooring network (30-40)	Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Over 400 VOSClim class VOS ships (i.e. 20%) providing climate quality data with additional QC flag and metadata. See http://cdiac.esd.ornl.gov/oceans/VOS_Program/ for status of Carbon VOS. Global reference mooring network 34% complete.	Low-frequency MW radiometry (active or passive)	Demonstration phase
Ocean surface currents vector	Global surface drifting buoy array on 5°×5° resolution (1250) for monthly means Global tropical moored buoy network (~120) Global reference mooring network (30-40) Sustained and repeated ship-based hydrography network	Drifter network achieved required global density. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Repeat hydrography and carbon inventory (10 year survey) 62% completed.	Contribution from radar altimetry	Continuity assured, subject to data sharing

OCEAN (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Sea surface mass flux	Global reference mooring network (30-40) Sustained and repeated ship-based hydrography network Critical current & transport monitoring	Global reference mooring network 34% complete. Repeat hydrography and carbon inventory (10 year survey) 62% completed. CLIVAR, OceanSITEs (over 100 sites), and IOCCP providing data for the critical current & transport monitoring.	N.A.	
Ocean temperature	Argo profiling float network 41 repeat XBT line network implemented through JCOMM/SOOPIP Global tropical moored buoy network (~120) implemented through JCOMM/DBCP Global reference mooring network (30-40) Sustained and repeated ship-based hydrography network Critical current & transport monitoring	Argo array maintained at the targeted global density but some issues to be addressed in marginal seas, polar areas; Active work on float enhancements based on OceanObs'09 recommendations. 80% of XBT lines occupied. Continuing work on XBT fall-rate equation bias – more metadata needed. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Repeat hydrography inventory (10 year survey) 62% completed. CLIVAR, OceanSITEs (over 100 sites), and IOCCP providing data for the critical current & transport monitoring.	N.A.	

OCEAN (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Ocean salinity	Argo profiling float network Global tropical moored buoy network (~120) implemented through JCOMM/DBCP Global reference mooring network (30-40) Sustained and repeated ship-based hydrography network	Argo array maintained at the targeted global density but some issues to be addressed in marginal seas, polar areas; Active work on float enhancements based on OceanObs'09 recommendations. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Repeat hydrography inventory (10 year survey) 62% completed.	N.A.	
Ocean currents	Argo profiling float network Global tropical moored buoy network (~120) implemented through JCOMM/DBCP Global reference mooring network (30-40) Sustained and repeated ship-based hydrography network	Argo array maintained at the targeted global density but some issues to be addressed in marginal seas, polar areas; Active work on float enhancements based on OceanObs'09 recommendations. Global tropical moored buoy network completed in Pacific & Atlantic; Indian 50% completed. Global reference mooring network 34% complete. Repeat hydrography inventory (10 year survey) 62% completed.	N.A.	
Ocean Colour			Narrow-band VIS/NIR imagery	Continuity assured, challenges in data integration
Ocean dissolved oxygen concentration	Sustained and repeated ship-based hydrography network	Repeat hydrography inventory (10 year survey) 62% completed.	N.A.	

OCEAN (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Partial pressure oceanic CO_2 (pCO_2)	Carbon VOS Sustained and repeated ship-based hydrography network Critical current & transport monitoring	See http://cdiac.esd.ornl.gov/oceans/VOS_Program/ for status of Carbon VOS. Repeat hydrography and carbon inventory (10 year survey) 62% completed; 5.2M measurements of pCO2 from global oceans during 1957–2010 in LDEO database. CLIVAR, OceanSITEs (over 100 sites), and IOCCP providing data for the critical current & transport monitoring.	N.A.	
Ocean Chlorophyll concentration	Sustained and repeated ship-based hydrography network	Repeat hydrography inventory (10 year survey) 62% completed.	Narrow-band VIS/NIR imagery	Continuity assured, challenges in data integration
Sea ice thickness	Sea-ice buoys implemented through JCOMM/DBCP	Limited number of ice-buoys with Ice Mass Balance (IMB) capability in the Arctic in ice-covered regions; retreating ice becoming a challenge for maintaining ice buoy network; ice buoys episodically deployed around Antarctica.	Lidar altimetry and interferometric Synthetic Aperture Radar	No continuity assured
Sea ice temperature	Sea-ice buoys implemented through JCOMM/DBCP	Relatively good coverage in the Arctic in ice-covered regions, except in the Eurasian sector; retreating ice becoming a challenge for maintaining ice buoy network; ice buoys episodically deployed around Antarctica.	IR imagery MW imagery	Operationally supported Continuity uncertain
Sea ice cover			VIS/IR imagery Passive MW imagery Synthetic Aperture Radar	Operationally supported Operationally supported Continuity assured, subject to data sharing and timely processing
Sea ice elevation			Lidar altimetry and interferometric Synthetic Aperture Radar	No continuity assured

LAND				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
River Discharge	GCOS/GTOS Baseline GTN-R based on TOPC priority list	Stations selected and partly agreed by host countries, non-contributing stations approached.	Research concerning laser/radar altimetry for river levels and flow rates.	Operational laser altimeters not scheduled; EO-based network only research.
Lakes	GCOS/GTOS Baseline Lake Network based on TOPC priority list. To include freeze-up/break-up	Stations selected, approached by HYDROLARE; GTN-L needs to be established.	Altimetry, high-resolution optical and radar imagery and reprocessing of archived data.	Operational laser altimeters not scheduled. Question mark over high-resolution systems continuity. EO-based network only research.
Ground Water (Levels, Use)	None, but framework for GGMN exists; many national archives of ground-water level exist.	Collection of aggregated data for GGMN has started; GTN-GW needs to be established.	Gravity missions	Gravity measurements operat'l, continuity needs to be secured
Water Use (Area of Irrigated Land)	No network, but a single geo-referenced database exists .		Any high-/medium-resolution optical/ radar systems.	Lack of high-resolution optical continuity.
Snow Cover (incl. depth and snow water equivalent)	WWW/GOS surface synoptic network (depth) National Networks (depth and snow water equivalent)	Synoptic and national networks have significant gaps and are ALL contracting. Northern and Southern Hemisphere monitored operationally for extent and duration.	Moderate to high resolution optical for extent/duration. Passive microwave for snow water equivalent. Geostationary satellites	Moderate to high resolution optical and microwave sensor system follow-on is programmed.

LAND (cont'd.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
Glaciers and Ice Caps	GTN-G coordinates national monitoring networks	Major geographic gaps still need to be closed; especially concerning glacier mass balance measurements inadequate.	Visible and infrared high-resolution; Stereo optical imagery; Synthetic Aperture Radar Satellite altimetry.	Lack of high- resolution optical satellite continuity. Satellite altimetry research missions will help; Lack of laser altimetry mission continuity .
Ice Sheets	Program for Arctic Regional Climate Assessment International Trans-Antarctic Scientific Expedition	Large uncertainty in mass balances and dynamics. Ocean ice interaction major weakness.	Gravity mission, Synthetic Aperture Radar and laser altimetry	Satellite altimetry research missions will help; Lack of laser altimetry mission continuity
Permafrost	GTN-P coordinates National Monitoring Networks	Major geographical gaps. National data centres need to be established.	Derived near-surface temperature and moisture (e.g., from ERS/Radarsat, MODIS, AMSR-E).	No direct operational sensors to detect permafrost; no products.
Albedo	CEOS WGCV MODLAND Atmospheric Radiation Measurement sites	No designated reference network.	Multi-angular sensors. Geostationary Polar orbiters. GCMPs applied to measurements.	Use of operational meteorological satellites (SCOPE-CM Pilot Project) and moderate-resolution optical polar orbiters; Continuation of multi-angular missions required
Land Cover	FAO Global Land Cover Network GOFC-GOLD	First generation products available.	Any high-/medium-resolution optical/ radar systems.	Moderate resolution good; High-resolution optical system continuity required.
FAPAR	CEOS WGCV FLUXNET GTOS Net Primary Productivity	Still no designated baseline network exists.	Optical, multi-spectral and multi-angular.	Moderate spatial resolution multi-spectral good; Continuation of multi-angular measurements required.

LAND (cont'.)				
Variable	**Contributing Network(s)**	**Status**	**Contributing Satellite Data**	**Status**
LAI	CEOS WGCV FLUXNET GTOS	Still no designated baseline network exists.	Optical, multi-spectral and multi-angular.	Moderate spatial resolution multi-spectral good; Continuation of multi-angular measurements required.
Above ground Biomass	FAO's FRA; FLUXNET; No global data centre for non-forest biomass	No designated baseline network exists; FRA data not currently applicable for high-resolution spatial analysis.	Low-frequency radar, optical and laser altimetry.	Laser/radar missions currently planned; need to be implemented
Soil Carbon	National soil carbon surveys	No designated global network or data centre exists; major geographical gaps; FAO-IIASA world soil map.	Not directly applicable	
Fire Disturbance	GOFC Regional Networks, GFMC	Some geographical gaps exist.	Optical and thermal.	Geostationary and moderate to high-resolution optical systems continuity required.
Soil Moisture	FLUXNET; GTN-SM needs to established WWW/GOS surface synoptic network	No designated baseline network exists.	Active and passive microwave missions	Continuity after the research missions required

APPENDIX 6

Acronyms and Abbreviations

ACMAD	African Centre for Meteorological Applications for Development
ACRE	Atmospheric Circulation Reconstructions over the Earth
ADM-AEOLUS	Atmospheric Dynamics Mission (ESA)
AERONET	Aerosol Robotic Network
AfDB	African Development Bank
AGAGE	Advanced Global Atmospheric Gases Experiment
AMSR-E	Advanced Microwave Scanning Radiometer for EOS
AntON	Integrated Antarctic Observing Network
AOPC	Atmospheric Observation Panel for Climate
AquaFed	International Federation of Private Water Operators
ARGO	Global Array of Profiling Floats that Measure Ocean Temperature and Salinity
ASAP	Automated Shipboard Aerological Programme
ASECNA	L'Agence pour la Sécurité de la Navigation Aérienne en Afrique et à Madagascar
AU	African Union
AUC	African Union Commission
BAPMON	Background Air Pollution Monitoring Programme
BIPM	Bureau International des Poids et Mesures
BOD	Biochemical Oxygen Demand
BSRN	Baseline Surface Radiation Network
CAgM	Commission for Agricultural Meteorology (WMO)
CARIBIC	Civil Aircraft for the Regular Investigation of the Atmosphere Based on an Instrument Container
CBS	Commission for Basic Systems (WMO)
CDMS	Climate Data Management System
CDR	Climate Data Record
CEOS	Committee on Earth Observation Satellites
CEOS WGCV	CEOS Working Group on Calibration and Validation
CERES	Clouds and the Earth's Radiant Energy System
CFS	Committee on World Food Security and Nutrition
CGMS	Coordination Group for Meteorological Satellites
CHy	Commission for Hydrology (WMO)
CIIFEN	Centro Internacional de Investigaciónes para el Fenómeno El Niño
CIMO	Commission for Instruments and Methods of Observation (WMO)
CGMS	Coordination Group for Meteorological Satellites
CLIMAT	Report of monthly means and totals from a land station
ClimDev Africa	Climate for Development in Africa Programme
CLIVAR	Climate Variability and Predictability (study, programme or project)
CONTRAIL	Comprehensive Observation Network for Trace gases by Airliner
COP	Conference of the Parties (UNFCCC)
CRM	Climate Risk Management
CSA	Canadian Space Agency
CSIS	Climate Services Information System
CSM	Climate System Monitoring
CSP	Climate Services Partnership
DARE	Data Rescue
DARE&D	Data Rescue and Digitization
DBCP	Data Buoy Cooperation Panel
DCPC	Data Collection or Production Centre

DIAL	Differential Absorption Lidar
DORIS	Doppler Orbitography and Radio Positioning Integrated by Satellites
DRR	Disaster Risk Reduction
ECA&D	European Climate Assessment and Data
ECVs	Essential Climate Variables
EMEP	Co-operative Programme for Monitoring and Evaluation of the Long-range Transmission of Air Pollutants in Europe
EOVs	Essential Ocean Variables
ERS	European remote sensing satellite
ESA	European Space Agency
ET-EGOS	Expert Team - European Group on Ocean Stations
EUMETNET	Network of European Meteorological Services
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EWIGOS-P	Implementation Plan for the Evolution of Global Observing Systems
FAO	Food and Agriculture Organization (UN)
FAO FRA	FAO Global Forest Resources Assessments
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
FLUXNET	Global Network for Monitoring Fluxes CO_2, Water Vapour, and Energy between Terrestrial Ecosystems and the Atmosphere
FTIR	Fourier Transform Infra-Red Spectrometer
GALION	GAW Aerosol Lidar Observation Network
GAW	Global Atmosphere Watch
GAWSIS	GAW Station Information System
GCMP	GCOS Climate Monitoring Principles
GCOS	Global Climate Observing System
GCW	Global Cryosphere Watch
GDP	Gross Domestic Product
GEO	Group on Earth Observations
GEOSS	Global Earth Observation System of Systems
GERB	Geostationary Earth Radiation Budget Experiment (EUMETSAT)
GEWEX	Global Energy and Water Cycle Experiment
GFCS	Global Framework for Climate Services
GFMC	Global Fire Monitoring Center (ISDR)
GGMN	Global Groundwater Monitoring Network
GHG	Green House Gas
GLCN	Global Land Cover Network
GLIMS	Global Land Ice Measurements from Space
GLOSS	Global Sea-Level Observing System
GMEF	Global Ministerial Environment Forum (UNEP)
GMES	Global Monitoring for Environment and Security
GNSS	Global Navigation Satellite System
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
GOOS	Global Ocean Observing System
GOS	Global Observing System
GOSAT	Greenhouse gases Observing Satellite Project
GPC	Global Producing Centre
GPCC	Global Precipitation Climatology Centre
GPS	Global Positioning System
GRUAN	GCOS Reference Upper-Air Network
GSICS	Global Space-based Inter-Calibration System

GSN	GCOS Surface Network
GTN	Global Terrestrial Network
GTN-G	Global Terrestrial Network for Glaciers
GTN-GW	Global Terrestrial Network – Groundwater
GTN-H	Global Terrestrial Network - Hydrology
GTN-L	Global Terrestrial Network - Lake Level/Area
GTN-P	Global Terrestrial Network for Permafrost
GTN-R	Global Terrestrial Network - Rivers
GTN-SM	Global Terrestrial Network for Soil Moisture
GTOS	Global Terrestrial Observing System
GUAN	GCOS Upper-Air Network
GWP	Global Water Partnership
HIRDLS	High Resolution Dynamics Limb Sounder
HLPE	High Level Panel of Experts on Food Security and Nutrition
HYCOS	Hydrological Cycle Observing System
HYDROLARE	International Data Centre on the Hydrology of Lakes and Reservoirs
IACS	International Association of Cryospheric Sciences
IAGOS	In-service Aircraft for a Global Observing System
IAHS	International Association of Hydrological Sciences
IASC	International Arctic Science Committee
ICAO	International Civil Aviation Organization
ICOADS	International Comprehensive Ocean Atmosphere Data Set
ICOS	Integrated Carbon Observation System (European)
ICSU	International Council for Science
IGOSS	Integrated Global Ocean Services System (WMO/IOC)
IGRAC	International Groundwater Resources Assessment Centre
IGWCO	Integrated Global Water Cycle Observations
IMO	International Maritime Organization
IOC	Intergovernmental Oceanographic Commission
IOCCP	International Ocean Carbon Coordination Project
IODE	International Oceanographic Data and Information Exchange
IPA	International Permafrost Association
IR	Infra-Red
IRI	International Research Institute for Climate and Society
ISO	International Organization for Standardization
ISRO	Indian Space Research Organisation
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
ISO	International Standards Organization
ISPD	International Surface Pressure Data Bank
IT	Information Technology
ITCZ	Intertropical Convergence Zone
JAXA	Japan Aerospace Exploration Agency
JCOMM	IOC/WMO Joint Technical Commission for Oceanography and Marine Meteorology
JCOMM/SOT	JCOMM Ship Observations Team
LAI	Leaf Area Index
LIDAR	Light Detection and Ranging
LDEO	Global Ocean Surface Water Partial Pressure of CO_2 Database
LTER	Long Term Ecological Research
MACC	Monitoring of Atmospheric Composition and Climate

MAX-DOAS	Multi axis Differential Optical Absorption Spectroscopy
MCDS	Marine Climate Data System
MEDARE	Mediterranean Climate Data Rescue Initiative
MHEWS	Multi-Hazard Early Warning Systems
MLS	Microwave Landing Systems (ICAO)
MODIS	Moderate Resolution Imaging Spectroradiometer
MODLAND	MODIS Land
MW	Microwave
NASA	National Aeronautics and Space Administration (USA)
NCDC	National Climatic Data Center (US)
NDACC	Network for the Detection of Atmospheric Composition Change
NEON	National Ecological Observatory Network (US)
NGO	Non-Governmental Organization
NHS	National Hydrological Service
NIR	Near Infra-Red
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration (US)
NPP/JPSS	National Polar-orbiting Partnership/Joint Polar Satellite System
NSIDC	National Snow and Ice Data Center (US)
OceanSITES	International Ocean Sustained Interdisciplinary Timeseries Environment Observation System Programme
OOPC	Ocean Observations Panel for Climate
QA	Quality Assurance
QC	Quality Control
RA	Regional Association (WMO)
RADARSAT	Canadian Earth Observation Satellite Programme
RBCN	Regional Basic Climatological Network
RCC	Regional Climate Centre
RRR	Rolling Review of Requirements
SAOZ	Système d'Analyse par Observations Zénithales
SBI	Subsidiary Body for Implementation (UNFCCC/COP)
SBSTA	Subsidiary Body for Scientific and Technological Advice (UNFCCC/COP)
SCAR	Scientific Committee on Antarctic Research (ICSU)
SCOPE-CM	Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring
SHADOZ	Southern Hemisphere Additional Ozonesondes
SOGE	System for Observation of Halogenated Greenhouse Gases in Europe
SOOP	Ship-of-Opportunity Programme
SOOPIP	Ship-of-Opportunity Programme Implementation Panel (JCOMM)
SWIR	Shortwave Infrared
TC	Technical Commission (WMO)
TCCON	Total Carbon Column Observing Network
TOPC	Terrestrial Observation Panel for Climate
UIP	User Interface Platform
UNECA	United Nations Economic Commission for Africa
UNEP	United Nations Environment Programme
UNEPGC	UNEP Governing Council
UNEP/GEO	UNEP Global Environment Outlook
UNEPGMEF	UNEP Global Ministerial Outlook Forum
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNESCO IHP	International Hydrological Programme (UNESCO)

UNFCCC	United Nations Framework Convention on Climate Change
UNSGAB	UN Secretary-General's Advisory Board on Water and Sanitation
UNISDR	UN International Strategy for Disaster Reduction
USD	United States Dollars
USGS	United States Geological Survey
UV	Ultra Violet
VIS	Visible
VOS	Voluntary Observing Ship Programme
VOSCLIM	Voluntary Observing Ship Climate
VCP	Voluntary Cooperation Programme
WCP	World Climate Programme
WCRP	World Climate Research Programme
WCRP - CLIC	Climate and Cryosphere Project (WCRP)
WCSP	World Climate Services Programme
WDC	World Data Centre
WGCV	Working Group on Calibration and Validation
WGMS	World Glacier Monitoring Service
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing System
WIGOS	WMO Integrated Global Observation System
WIAG	WHYCOS International Advisory Group
WIS	WMO Information System
WMO	World Meteorological Organization
WWRs	World Weather Records
WWW	World Weather Watch (WMO)
XBT	Expendable Bathythermograph

APPENDIX 7

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