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UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

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

Item 5 of the provisional agenda
**Research and systematic observation**

# Progress by space agencies involved in global observations in their coordinated response to the Global Climate Observing System and to relevant needs of the Convention

## Submission from the Committee on Earth Observation Satellites

1. The Conference of the Parties, by its decision 9/CP.15, encouraged the Committee on Earth Observation Satellites (CEOS) to continue coordinating and supporting the implementation of the satellite component of the Global Climate Observing System (GCOS).

2. At its thirtieth session, the Subsidiary Body for Scientific and Technological Advice (SBSTA) encouraged coordinated implementation of the cross-cutting space-based components of GCOS to continue over the long term, including the continued coordinated response to the needs identified in the GCOS implementation plan through CEOS. It also encouraged CEOS and the Parties that support space agencies involved in global observations to continue and if possible accelerate development of methodologies, and validation and inter-comparison of satellite-based applications for the terrestrial domain. At the same session, the SBSTA invited CEOS to report, at SBSTA 33, on progress made in its efforts to meet relevant needs of the Convention (FCCC/SBSTA/2009/3, para. 63).

3. In response to this invitation, Brazil has submitted such a progress report on behalf of the CEOS. An extended summary of this report is reproduced in this document. The full report is available at <http://www.ceos.org/images/CEOS-UNFCCC-2010.pdf> and <http://unfccc.int/3462.php>.

**FCCC/SBSTA/2010/MISC.11**

GE.10-63034

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Submission from Brazil on behalf of the Committee on Earth Observation Satellites

# 2010 Progress Report: Coordinated Response from Parties that Support Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan of 2004

## Extended Summary

Developed by the Committee on Earth Observation Satellites (CEOS)

October 2010

# Table of contents

# Preface

This report is an extended summary of the *2010 Progress Report: Coordinated Response from Parties that Support Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan of 2004*, which was submitted to the Subsidiary Body for Scientific and Technological Advice of the UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE at its 33rd session. Readers who wish to get more in-depth information are advised to read the full report.

# 1 Introduction

In 2004, the Conference of the Parties of the U.N. Framework Convention on Climate Change (UNFCCC) invited Parties that support space agencies involved in global observations to request these agencies to provide a coordinated response to the needs expressed in the Global Climate Observing System (GCOS) Implementation Plan. The UNFCCC Subsidiary Body on Scientific and Technological Advice (SBSTA) in 2005 welcomed and accepted the offer from the Committee on Earth Observation Satellites (CEOS), on behalf of Parties supporting space agencies, to provide a detailed report at its 25th session in December 2006. The SBSTA subsequently invited CEOS to provide an updated progress report (Coordinated Response from Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan: Update on Climate Actions), which was presented at its 29th session in December 2008. At the 15th session in December 2009 the UNFCCC Conference of the Parties expressed its appreciation for the report and encouraged CEOS to continue coordinating and supporting implementation of the satellite component of the GCOS, as well as actions in the CEOS report, in particular on long term continuity of observations and data availability. SBSTA invited CEOS to report on progress made in its efforts to meet the relevant needs of the Convention at its thirty-third session in November-December 2010. Furthermore, SBSTA welcomed the commitment by CEOS agencies to work towards improved availability of current and future data for forest carbon monitoring, and also encouraged CEOS to accelerate development of methodologies, and validation and inter-comparison of satellite-based applications for the terrestrial domain.

The 2010 progress report by CEOS is in response to this latest SBSTA request. This progress report builds on the 2008 update report. It contains inputs from CEOS climate action teams and other stakeholders on the current status of the 59 CEOS Climate Actions. The report reviews key accomplishments thus far and describes future plans. In addition, progress on carbon forest tracking, terrestrial validation, and early warning for disasters related to climate change is provided.

The report also summarizes additional satellite-based climate observation and data record activities by individual space agencies and other international coordination bodies such as the World Climate Research Program (WCRP), the World Meteorological Organisation (WMO), and the Coordination Group for Meteorological Satellites (CGMS).

The report emphasizes the importance of space observations for measuring changes in the climate system on a global basis. These measurements will provide governments throughout the world information essential to developing mitigation and adaptation strategies for climate change. The CEOS Climate Action Plan includes the development of several Constellations of satellites to provide critical information to countries throughout the world on changes in land cover, precipitation, atmospheric composition, global sea level, ocean surface vector wind, and ocean color.

The report also includes CEOS plans for reviewing and preparing a response to the 2010 update of the GCOS Implementation Plan, GCOS-IP 10. CEOS will capitalize on the organizational structure it established for implementing the Climate Actions responding to the 2004 GCOS-IP. The CEOS Climate Action Teams will be assigned to the appropriate domain (atmosphere, ocean, land) for reviewing the Plan. The CEOS Climate Coordinator will provide guidance to the teams to ensure comparable reviewing and reporting activities. CEOS Virtual Constellation Leads will play an important role in these activities. It is expected that leadership of the response will be a major project of the proposed new CEOS Working Group on Climate, if and when that Working Group is activated.

By supporting the space-based observations of the GCOS, the CEOS Climate Action Plan contributes to the SBSTA work in support of the Convention and the Kyoto Protocol process. The Convention calls upon the parties to promote and cooperate in research, systematic observation, development of data archives, and full, open and prompt exchange of relevant information related to the climate.

## 1.1 Background

Satellites in space offer a huge source of information for monitoring the climate system, but the full potential of this source has yet to be tapped. To help space agencies involved in Earth observation in that regard, the Global Climate Observing System (GCOS) Programme has prepared a detailed set of requirements for more systematic and coordinated observation of climate from space. Meeting the GCOS requirements will provide a vastly improved information basis from which nations can make more informed decisions on how to respond and adapt to climate change.

GCOS published its requirements in the Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (GCOS IP), GCOS-92, in 2004, and followed up, in collaboration with the World Climate Research Programme (WCRP), the World Meteorological Organization (WMO), and the climate community at large, with a more detailed Satellite Supplement to the GCOS Implementation Plan ("Systematic Observation Requirements for Satellite-based Products for Climate – Supplemental details to the satellite-based component of the GCOS Implementation Plan", GCOS-107, September 2006). The GCOS requirements are based on the Essential Climate Variables (ECVs, Table 1 from GCOS IP-10[2]) for which sustained, global and climate quality measurements are needed to track and analyze climate change, and to support the needs of the UNFCCC and the IPCC.

The 2006 Satellite Supplement specified targets for the accuracy, stability over time and spatial/temporal resolution of satellite-based Fundamental Climate Data Records and derived ECV satellite products. They also include the ten satellite-specific GCOS Climate Monitoring Principles. The GCOS satellite requirements will be updated in 2010/2011.

GCOS was established in 1992 to ensure that the observations and information needed to address climate-related issues are obtained and made available to all potential users. It is co-sponsored by

- World Meteorological Organization (WMO),
- Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization (UNESCO),
- United Nations Environment Programme (UNEP), and
- International Council for Science (ICSU).

[2] GCOS (2010): *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC (2010 Update)*, GCOS-138 (WMO/TD-No. 1523), Publication planned for August 2010.

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

| Domain | Essential Climate Variables | |
|---|---|---|
| **Atmospheric** (over land, sea and ice) | **Surface**[7]: | Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget. |
| | **Upper-air**[8]: | Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance). |
| | **Composition:** | Carbon dioxide, Methane, and other long-lived greenhouse gases[9], Ozone and Aerosol, supported by their precursors[10] |
| **Oceanic** | **Surface**[11]: | Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity. |
| | **Sub-surface:** | Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers, Phytoplankton. |
| **Terrestrial** | River discharge, Water use, Ground water, Lakes, Snow cover, Glaciers and ice caps, Ice sheets, Permafrost, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance, Soil moisture. | |

[7] Including measurements at standardized, but globally varying heights in close proximity to the surface.
[8] Up to the stratopause.
[9] Including $N_20$, CFCs, HCFCs, HFCs, $SF_6$ and PFCs.
[10] In particular $NO_2$, $SO_2$, HCHO and CO.
[11] Including measurements within the surface mixed layer, usually within the upper 15m.

In 2004, the Conference of the Parties of the U.N. Framework Convention on Climate Change (UNFCCC) invited Parties that support space agencies involved in global observations to request these agencies to provide a coordinated response to the needs expressed in the Global Climate Observing System (GCOS) Implementation Plan. The UNFCCC Subsidiary Body on Scientific and Technological Advice (SBSTA) in 2005 welcomed and accepted the offer from the Committee on Earth Observation Satellites (CEOS), on behalf of Parties supporting space agencies, to provide a detailed report at its 25th session in December 2006. In its document "Satellite Observation of the Climate System – the Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan", CEOS reviewed the requirements for satellite observations of the climate system as outlined in GCOS-107, evaluated the adequacy of the current observations system to meet these requirements, and developed an action plan to address inadequacies.

The CEOS report identified 59 actions that cover key aspects of climate-related observations of the atmosphere, ocean and land. The report emphasized the importance of satellite measurements of the highest reliability to provide the long-term records needed to monitor climate change. The CEOS Climate Actions fall into the following six key categories:

1. Ensuring continuity of climate-relevant satellite measurements (13 actions);
2. Taking a systematic approach to generating Fundamental Climate Data Records (FCDRs) (11 actions);
3. Preserving climate data records (4 actions);
4. Ensuring access to climate data products (10 actions);

5. Coordinating international communities and interaction with users (10 actions); and
6. Addressing future measurement needs (11 actions).

In 2007, CEOS Members initiated work in close coordination with GCOS and the Group on Earth Observations (GEO), and with other relevant fora, such as the Coordination Group for Meteorological Satellites (CGMS) and the WMO, to implement the climate actions. To this end, CEOS assembled international teams, representing all concerned CEOS agencies.

The CEOS Action Plan is part of a broader CEOS response to the observational requirements of the Global Earth Observation System of Systems (GEOSS). It deals specifically with the Climate Societal Benefit Area (SBA) of GEOSS under GEO Climate Work Plan activity **CL-09-02B[3]: Key Climate Data from Satellite Systems.** This Task is led by the USA, CEOS, GCOS and WMO and it establishes actions securing the provision of key data for climate studies and forecasting from satellite systems.

The SBSTA subsequently invited CEOS to provide an updated progress report (Coordinated Response from Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan: Update on Climate Actions), which was presented at its 29th session in December 2008. The SBSTA requested another update for its thirty-third session in November-December 2010, which is the subject of the present document.

# 2 Importance of Satellite Component of GCOS for Climate

Earth observation satellites provide a vital means of obtaining observations of the climate system from a global perspective and comparing the behaviour of different parts of the globe for a number of the Essential Climate Variables. Their global nature distinguishes satellite observations from ground-based and airborne measurements that are generally more limited in spatial coverage, but nevertheless vital to constrain and validate information derived from space.

Satellite climate data records meeting the GCOS requirements would have significantly added value for climate monitoring, studies of trends and variability, assimilation in models, and, ultimately, decision-making in many societal sectors including agriculture, water resource management, forestry and marine applications.

The conventional (non-satellite) observational systems contributing to the GCOS include atmospheric, oceanic, and terrestrial components. The atmospheric component includes the GCOS Surface Network (GSN), which provides a global baseline of the surface climate in which we live; the global baseline GCOS upper air network (GUAN), and the GCOS Reference Upper-Air Network (GRUAN), which measures temperature, humidity, and winds aloft; the WMO Global Atmosphere Watch (GAW) global baseline ozone networks and the WMO GAW Global Atmospheric CO2 and CH4 Monitoring Networks. The surface ocean network provides information about the patterns of ocean surface temperature, pressure, winds, salinity, sea level, waves and sea ice that are important both to the global climate and its regional distribution. Its main systems are: (a) the global baseline network of tide gauges; (b) an enhanced drifting buoy array; (c) an enhanced Tropical Moored Buoy network; (d) an enhanced Voluntary Observing Ships Climatology (VOSClim) network; and (e) a globally-distributed reference mooring network. The sub-surface ocean network provides critical information on ocean climate variability and change and includes: (a) the Argo

[3] Formerly CL-06-02C: Key Climate Data from Satellite Systems. Now under overarching task CL-09-02: Accelerating the Implementation of the Global Climate Observing System.

profiling float array; (b) the systematic sampling of the global ocean full-depth water column; (c) the Ship-of-Opportunity Expendable Bathythermograph (XBT) trans-oceanic sections; and (d) the Tropical Moored Buoy and reference mooring networks. The conventional climate observing system in the Terrestrial Domain remains the least well-developed component of the global system. GCOS is working to set up reference and baseline networks to measure terrestrial ECVs for the land surface, hydrosphere, and cryosphere. Satellite observations for the terrestrial domain are increasingly robust.

While the conventional observing networks provide critical climate measurements at a number of points around the globe, and observe some ECVs currently inaccessible from space at required accuracies, e.g., surface air temperature, they have limitations when it comes to observing global climate change. For the most part, the atmospheric observations are limited to the land areas of the Earth and are highly concentrated in the major population centers of the developed countries. Ocean areas – 70% of the globe – are largely under-sampled in terms of the atmospheric measurements. And there are also large holes in the coverage of surface and sub-surface ocean measurements. Developing a reliable picture of global climate change from an observing system that has such large gaps in coverage is a formidable task.

Only satellites provide the global coverage needed to observe and document global climate change. A single radiometer on a polar orbiting satellite observes the entire earth on a daily basis. Instruments on geostationary satellites monitor the diurnal cycle of the disk of Earth below them. Together the polar and geostationary environmental satellites maintain a constant watch on the entire globe. However, in many cases in-situ measurements are needed to validate satellite observations.

The global network of Earth observing satellites includes both operational and research satellites. The operational satellites include polar and geostationary satellites operated by the USA, Europe, China, Russia, Japan, India and soon Korea. Designed originally for weather observations, these satellites are now the core of the space component of GCOS. Since these satellites are operational, the operating agencies have a policy of constantly monitoring sensor health and launching replacement satellites prior to failure of key systems, thus providing the continuity of records needed to determine if the climate is changing and at what rate. The operational satellites are manifesting more special climate sensors – ozone, for example – and improving the accuracy of their observations to meet the stringent accuracy requirements for climate. Research satellites provide critical data, but only for the duration of their mission. They provide platforms for evaluating and demonstrating the capabilities of advanced instruments. Proven research sensors are eventually flown operationally, pending availability of funds, and result in the research to operations process. Examples of such research satellite programs include the National Aeronautics and Space Administration's (NASA) Earth Observing System (EOS), the European Space Agency's (ESA) Earth Explorers, and Japan Aerospace Exploration Agency (JAXA) Global Change Observation Mission (GCOM).

# 3 Development of the CEOS Climate Action Plan

## 3.1 The climate actions

The CEOS report "Satellite Observation of the Climate System – the Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan" identified 59 Climate Actions to support the necessary improvements in the space component of the GCOS. These actions comprise the CEOS Climate Action plan. CEOS teams, in coordination with GCOS, reviewed these actions and decided to initially focus on 20 of the highest priority actions, including specific actions for each climate domain – atmospheric, oceanic, or terrestrial – and more general cross-cutting actions. The domain-relevant actions were selected because they could be started immediately and were capable of

delivering significant outcomes within a 1-2 year timescale. The cross-cutting actions were chosen because they are critical, ongoing climate activities that involve all the CEOS agencies. An additional 32 actions were classified as priority 2 because they required additional information from potential contributors in order to be suitably defined and would not necessarily deliver significant results in the initial 1-2 year timescale. Five actions were initially labelled priority 3 because they were considered premature at the time the CEOS report was completed.

The subjects of the Actions for each climate domain and the cross-cutting Actions are listed in the following table.

**Table 2. Subjects of Actions for Each Climate Domain including Cross-Cutting Actions.**

| **Atmospheric Domain** | **Subject** |
|---|---|
| A-1 | Ocean surface winds |
| A-2 | GPS-RO observations |
| A-3 | Cloud properties and trends |
| A-4 | Global Precipitation Constellation |
| A-5 | Absolute, spectrally resolved measurements of radiance emitted and reflected by the Earth |
| A-6 | Earth Radiation Budget Sensor (ERBS) |
| A-7 | Total Solar Irradiance Sensor (TSIS) |
| A-8 | Ozone Mapping and Profiler Suite (OMPS) |
| A-9 | Aerosol Polarimetry Sensor (APS) |
| A-10 | Continuity of chemistry missions |
| A-11 | Reprocessing of geostationary satellite data |
| A-12 | Options for improving wind observations |
| **Oceanic Domain** | |
| O-1 | Microwave, visible and infrared observations of sea ice |
| O-2 | Reprocessing of microwave sea ice observations |
| O-3 | Ice thickness and drift |
| O-4 and O-5 | Ocean Surface Topography Constellation and continuity of the climate record for sea level |
| O-6 | Continuity of ATSR sea surface temperature missions |
| O-7 | Microwave observations of sea surface temperatures |
| O-8 | Continuity of 10-km-resolution sea surface temperatures |
| O-9 | Merged sea surface temperature data set |
| O-10 | Ocean color missions |
| O-11 | Continuity of 25-km-resolution ocean color data set |
| O-12 | Merged ocean color data set |
| O-13 | Continuity of the 1-km-resolution ocean color data set |
| O-14 | Sea state |
| O-15 | Sea surface salinity (and soil moisture) demonstration missions |
| O-16 | Ocean Salinity Constellation |
| O-17 | Reprocessing of legacy ocean data sets |
| O-18 | Calibration/validation of ocean sensors |
| O-19 | Follow-on to Global Ocean Data Assimilation Experiment (GODAE) |

| **Terrestrial Domain** | |
|---|---|
| T-1 | Land-Surface Imaging Constellation |
| T-2 | Fine resolution ECVs for land cover and glacier change |
| T-3 | Reprocessing of 1-km AVHRR data |
| T-4 | Enhancing quality of AVHRR-based data sets |
| T-5 | Biomass and leaf area index (LAI) |
| T-6 | Surface albedo and fraction of absorbed photosynthetically active radiation (fAPAR) |
| **Cross Cutting Actions** | |
| C-1 | Coordination of space-based climate missions |
| C-2 | Contributions to other GEO societal benefit areas (SBAs) |
| C-3 | Evaluation of climate requirements |
| C-4 | Adherence to the GCOS Climate Monitoring Principles (GCMPs): Satellite missions |
| C-5 | Adherence to GCMPs: Satellite data records |
| C-6 | GCMPs and relevant Essential Climate Variables (ECVs) as a foundation for CEOS Constellations |
| C-7 | Ensuring stability, accuracy, and inter-comparability of satellite observations |
| C-8 | Contributions to the implementation of the Global Space-based Intercalibration System (GSICS) |
| C-9 | In-situ networks for cal/val |
| C-10 | Coordination of data archives and dissemination systems |
| C-11 | Specifications for fundamental climate data records (FCDRs) and derived products |
| C-12 | Open access to FCDRs |
| C-13 | Independent processing of data sets and products |
| C-14 | Linkages to communities generating fundamental climate data records (FCDRs) |
| C-15 | Adequate funding for climate data records |
| C-16 | Transfer of research satellites to operations |
| C-17 | R & D to attain climate-quality measurements |
| C-18 | Full utilization of research satellites |
| C-19 | Reprocessing of fundamental data sets |
| C-20 | Access to climate data |
| C-21 | Documentation of access arrangements for FCDRs |
| C-22 | Capacity building |

These actions have led to the initiation of a CEOS Plan for Virtual Constellations in support of GEOSS and improved coordination within CEOS and of CEOS agencies with GEO and GCOS. A major accomplishment was the development by the CEOS Working Group on Information Services and Systems (WGISS) of a capability for climate data users throughout the world to access any data on Essential Climate Variables contributed to the CEOS International Directory Network by CEOS agencies. Also the CEOS Working Group on Calibration and Validation (WGCV) was instrumental in developing the Quality Assurance Framework for Earth Observations (QA4EO). The strategy underpinning QA4EO is based upon the

adoption of a set of key operational guidelines derived from "best practices" for implementation by the community. The success of QA4EO will result in the ability to assign a Quality Indicator (QI) to any "knowledge information product" based upon documented unequivocal evidence of traceability to an internationally accepted standard.

Another outstanding achievement is ESA's Climate Change Initiative (CCI) (see Section 5) in support of the GCOS. The CCI will "*systematically generate, preserve and give access to long-term data sets of the ECVs required to meet the needs of the Parties to the UNFCCC*". The first phase, which began in 2009, addresses the following eleven ECVs: sea-ice, sea-level, sea-surface temperature, ocean color, glaciers and ice caps, land cover, fire disturbance, cloud properties, ozone, aerosol properties, and green house gases (carbon dioxide, methane and other GHGs). Strong cooperation through CEOS is needed and foreseen.

## 3.2 Implementation process for climate actions

To carry out the Climate Actions, CEOS named a Climate Coordinator, organized Climate Action Teams consisting of representatives from the CEOS agencies, and selected a lead agency and leader for each Team. The Climate Coordinator is responsible for coordinating the Climate Action program, reporting to the CEOS Strategic Implementation Team, and preparing this report to the UNFCCC. CEOS developed reporting forms and a schedule for gathering progress reports from the Climate Action Teams. Each of the agencies contributing to the Climate Actions agreed to undertake tasks to implement the Actions. The Team Leaders coordinate the activities of agencies contributing to their Climate Actions, serve as liaisons between the CEOS Climate Coordinator and team members, and act as rapporteurs for their Climate Actions.

# 4 Status of Climate Actions

## 4.1 Introduction

This section discusses the status of the Actions in the CEOS Climate Action Plan for each Domain (Atmospheric, Oceanic, and Terrestrial) and the cross-cutting Actions. An overview of each Domain is presented, which includes a high level summary of the actions and results in that Domain, including the implications of the actions to monitoring, predicting, and understanding climate change. The full version of the *2010 Progress Report: Coordinated Response from Parties that Support Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan of 2004* contains a summary of each Climate Action in the Domain, which includes the Action Statement, the importance/significance of the Action for climate information, and the status of the Action.

## 4.2 Atmospheric domain

### 4.2.1 Overview of atmospheric domain actions: Key accomplishments

The Atmospheric Domain Climate Actions include improving information on ocean surface winds, upper air temperatures, clouds, precipitation, earth radiation budget, solar irradiance, ozone profiles, aerosols, greenhouse gases, and other important atmospheric components.

CEOS agencies have shown that passive polarimetric microwave observations cannot meet the required climate accuracy requirements for sea surface wind vectors. As a result, the agencies are focussing on an

Ocean Surface Vector Wind Constellation, based on radar (scatterometer) measurements to provide continuous, high quality data for this ECV.

CEOS agencies are working to maintain continuity of GPS-RO missions, which, because of their self-calibrating nature, are capable of measuring upper tropospheric and stratospheric temperatures with extremely high accuracy. Their fine scale vertical resolution also enables them to resolve vertical variations in atmospheric temperature trends and changes in tropopause structure. These data are complementing the decades - long series of temperature data from microwave instruments and will provide irrefutable measurements of atmospheric temperature trends. The International Radio Occultation Working Group (IROWG) was established in 2010 as a permanent Working Group of the Coordination Group for Meteorological Satellites (CGMS).

Cloud information is being improved by developing improved cloud data records from long-term records of the operational passive vis/IR imagers and sounders and by creating new datasets from recent research satellite missions that fly cloud radars and lidars. The radars and lidars provide unique data on the vertical structure of clouds and are also being used to validate cloud data from the passive sensors. In addition to improved long term data sets, these activities will also facilitate the development of improved cloud parameterization schemes in climate models. Uncertainty in the evolution of cloud systems in a warming climate is one the major impediments to reliable predictions of decadal climate change and these improvements in monitoring and modelling clouds will help to overcome this obstacle.

Planning for the CEOS Precipitation Constellation, which will include a precipitation radar and a network of passive microwave radiometers from different CEOS agencies continues on schedule. Particular emphasis is on developing programs to calibrate, intercalibrate, and validate all the instruments in the Constellation to meet the requirements for the precipitation ECV, one of the most important climate variables for society.

Assurance of continuity of long-term measurements of the Earth's radiation budget, solar irradiance, vertical ozone profiles, and aerosol amounts and characteristics, which was in jeopardy after the cancellation of the NPOESS program, is being addressed by CEOS agencies. CEOS agencies are also participating in the Atmospheric Composition Constellation to facilitate continuity of composition missions. These radiation budget, solar irradiance, and composition observations will provide critical data to track changes in the forces that control the Earth's climate.

Planning proceeds for a satellite mission (CLARREO) to obtain absolute, spectrally resolved measurements of radiance emitted and reflected by the Earth to space. These measurements will provide a long-term benchmarking data record for the detection, projection, and attribution of changes in the climate system. In addition, the International System of Units (SI) traceable radiances will provide a source of absolute calibration for a wide range of visible and IR Earth observing sensors, greatly increasing their value for climate monitoring.

CEOS agencies, in cooperation with the WMO's **S**ustained, **C**o-**O**rdinated **P**rocessing of **E**nvironmental Satellite Data for **C**limate **M**onitoring (SCOPE-CM)) program, has initiated reprocessing of geostationary (GEO) satellite data sets. Compared to polar orbiting satellites (LEOs), GEO refresh rates are unparalleled. For phenomena requiring certain observing conditions (e.g., clear skies for surface vegetation, temperature, and albedo, and snow/sea ice), GEOs offer an order of magnitude more opportunity to obtain a measurement. Additionally, the frequent observations can resolve diurnal variations, which are important for analyzing climate processes and for preventing aliasing.

CEOS agencies are deriving wind information from feature (cloud, water vapour) tracking in Polar Regions using polar orbiting vis/IR imager observations, since these regions are not accessible to the GEO vis/IR imagers. But the feature tracking method suffers from an inability to accurately determine the height of the measured winds as well as inability to provide more than one wind observation in a vertical column. CEOS agencies are working to place wind lidars in space, as early as 2011, which will provide the accurate three dimensional wind distributions needed for monitoring fluxes of heat, momentum, moisture and other variables within the climate system.

**NASA** and the UK's **National Centre for Earth Observation** (**NCEO**) have executed a Letter of Agreement (October, 2009) to facilitate cooperative investigations of a benchmark mission designed to provide highly accurate measurements of the Earth's reflected and emitted spectra which will be used to detect long-term climate change trends and to test and systematically improve climate predictions. Key mission studies are being performed by both the National Physical Laboratory (NPL) and Imperial College in support of this Agreement.

## 4.3 Oceanic domain

### 4.3.1 Overview of oceanic domain actions: Key accomplishments

Oceanic domain actions will result in improved observations and climate data records for sea ice, polar ice caps, sea level sea surface temperature (SST), and ocean color.

Polar sea ice extent is undergoing rapid change, and continuous, reliable measurements are needed to document this trend. Fortunately, sea ice is observable from space over the entire electromagnetic spectrum and is also accessible to satellite radar and gravity observations. CEOS agencies are continuing their passive and active observations to monitor sea extent and thickness. Among the new observing capabilities are the Soil Moisture and Ocean Salinity (SMOS) instrument that can monitor thin ice and the CryoSat-2 to measure polar ice thickness. In addition to continuing and improving observations, a key activity is generating reliable climate data records from the measurements of the different sensors. Among a number of CDR programs, CEOS agencies are reprocessing microwave observations of sea ice from the many satellites that manifest these instruments. The possibility of shrinking polar ice sheets is another growing concern. Changes in polar ice cap mass are now being monitored by continuing and new gravity and radar missions.

Since they have not been part of an operational satellite program, continuity of sea level measurements, a crucial climate response variable, has always been in jeopardy. A CEOS study team has now defined the basis for an Ocean Surface Topography Constellation that would assure sustained, operational sea level measurements far into the future. Many CEOS agencies will fly altimeters as part of the Constellation.

Sea surface temperature measurements are being continued from multi-frequency infrared and microwave imagers on the operational meteorological satellites of CEOS agencies. In addition, advanced IR instruments with both multi-frequency and multi-angle observing capabilities, and enhanced microwave imaging radiometers, will provide more accurate SST measurements. A proposal for a CEOS SST Virtual Constellation has recently been prepared. The proposed SST-VC would assure the coordination, consolidation and further development of satellite SST capability, products, user feedback and education/outreach activities using the recognized and well established Group for High Resolution SST (GHRSST) as the prime coordination mechanism.

The Ocean Color Radiometry Constellation includes current and future polar-orbiting global satellite missions that will provide calibrated ocean-color radiances (OCR) at key wavelength bands. OCR are used to derive data products related to ocean biology and biogeochemistry. The most common products are phytoplankton chlorophyll-a concentration, colored organic matter (a significant component of dissolved organic carbon in the ocean), particulate organic carbon, and suspended sediments. The Constellation also will address issues concerning product inter-comparisons, uncertainty analysis, and data merging to facilitate construction of high quality CDRs. Ocean biology is important not only for understanding ocean productivity and biogeochemical cycling, but also because of its impact on oceanic CO2 and the flux of carbon from the surface to the deep ocean.

The first-ever observations of ocean salinity from space will be obtained from the Soil Moisture and Ocean Salinity (SMOS) and Aquarius low frequency passive microwave instruments. Ocean salinity measurements are important because surface salinity and temperature control the density and stability of the surface water. Thus, ocean mixing (of heat and gases) and water-mass formation processes are intimately related to variations of surface salinity.

## 4.4 Terrestrial domain

### 4.4.1 Overview of terrestrial domain actions: Key accomplishments

CEOS agencies are evaluating approaches to filling the current Landsat-class (10s of meters horizontal resolution of vis/near IR (optical) imager observations) data gap and developing a plan for a future Land-Surface Imaging (LSI) Constellation. A primary objective of the LSI Constellation is to define *standards* (or guidelines) that describe optimal future LSI Constellation capabilities. As part of this initiative, an LSI Portal is being developed that serves as a single web location for information about current and previous mid-resolution (10 - 100 m) vis/near IR satellite systems and data. The Portal provides users with 1) basic information about the mid-resolution, optical LSI satellites and sensors 2) information helpful for applications of the data, and 3) active links to data search and order tools for CEOS agencies that offer open user access to mid-resolution, optical satellite data. The LSI Constellation would maintain continuity the mid-resolution land observations, which are necessary for monitoring ecosystem change at regional and local levels.

Continuity of global measurements of land surface properties from vis/IR imagers on polar satellites is being maintained through the operational satellites of CEOS agencies. Enhanced capabilities are resulting from the transition of advanced vis/IR imagers, e.g., MODIS, to operational satellites and the addition of vegetation sensitive bands to geostationary satellites, which allow more opportunities for obtaining a cloud-free look at the Earth's surface.

CEOS agencies are also reprocessing the 30 year AVHRR data record, with resolutions down to 1 km, and 40-year Landsat data set, with resolutions of 10s of meters. By using better satellite intercalibration methods, a more stable time series of AVHRR radiance measurements will be obtained leading to improved time series of land ECVs, in particular trends in global vegetation.

**ESA** is studying BIOMASS, a SAR mission for producing global estimates of above ground biomass. Its Project for On-Board Autonomy - Vegetation (PROBA-V), planned for 2012, will track global vegetation daily.

More than 30000 mid-spatial resolution scenes from visible/near IR and Synthetic Aperture Radar have been acquired by CEOS agencies to demonstrate forest tracking in Brazil, Guyana, Mexico, Cameroon, Tanzania,

Borneo, and Tasmania. As a result of these actions, societies throughout the world will be able to monitor regional trends in their land cover and develop prevention, mitigation, and adaptation programs.

New technologies, such as a multi-beam laser altimeter (lidar) and multipolarization L-Band radar, are also being developed for the first-ever observations of forest height (with meters accuracy) and three-dimensional forest structure

## 4.5 Cross Cutting Actions

### 4.5.1 Overview of cross cutting actions

The cross cutting actions are focused on improving international coordination mechanisms for space-based climate observations, developing and maintaining on-going working relationships with GEO and GCOS, assuring adherence to GCOS Climate Monitoring Principles, improving the accuracy, and intercomparability of satellite observations of the Earth, and providing easy access to climate data. These actions have already led to the initiation of CEOS Plan for Virtual Constellations in support of GEOSS, improved coordination within CEOS and of CEOS agencies with GEO and GCOS, and a satellite climate data access system for users throughout the world. The cross cutting actions encompass all the climate domains – atmosphere, ocean, and land. They represent community efforts that involve all CEOS agencies.

These cross-cutting actions are aimed at engaging all the CEOS agencies in creating satellite data sets of irrefutable quality for use by policy makers dealing with climate change prevention, mitigation, and adaptation strategies:

- Tying satellite measurements to the absolute international standards (SI) of units maintained by the international standards institutions such as NIST (USA) and NPL (UK)
- Implementation of the Global Space-based Intercalibration System (GSICS)
- Charging the CEOS Working Group on Calibration and Validation to support both research and operational projects to validate the climate quality of satellite observations.

The proposed new CEOS Working Group on Climate will coordinate CEOS activities on creation of Climate Data Records.

The WMO's new program on Sustained, Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) is establishing a network of facilities ensuring continuous and sustained provision of high-quality satellite products related to the Essential Climate Variables (ECV), on a global scale, responding to the requirements of the Global Climate Observing system (GCOS). In addition, new or enhanced programs at CEOS agencies are contributing to generation of Climate Data Records: NOAA's National Climatic Data Center's CDR Program, EUMETSAT's Satellite Application Facility on Climate Monitoring (CM SAF), and ESA's Climate Change Initiative.

Cross cutting actions directed by the CEOS Working Group on Information Services and Systems (WGISS) will establish an international climate information system that will enable all countries to easily access the accurate and relevant climate data sets that will result from the domain Climate Actions as well as past climate data records residing in national archives.

# 5 Additional Activities in Support of Climate Observations and Data Records

## 5.1 Introduction

In this section, we present an update on noteworthy climate initiatives and activities by CEOS and its associated member agencies. Further details may be found in the full version of the *2010 Progress Report: Coordinated Response from Parties that Support Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan of 2004*.

## 5.2 CEOS Support of Early Warnings for Disasters

Through the work of the CEOS Disaster SBA Team, a number of initiatives are going forward with potential impact on the long-term ability to measure parameters that indicate climate change. In addition, several initiatives relate to the ability to warn populations of the onset of disasters, which are likely to be more frequent in the future given population growth, settlement in fragile ecosystems, climate change and destruction of natural habitat and forested areas. In particular, increased flooding in coastal areas and increased wildfire hazards are expected as global temperatures increase.

## 5.3 CEOS Support of Forest Carbon Tracking & Terrestrial Applications, Intercomparisons and Validation

The CEOS Communiqué of March 2009 recognized the importance of a consistent global framework of forest carbon monitoring delivered by national governments, in support of national and international climate policy formulation, including the development of the Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (REDD), or similar future mechanisms under the UN Framework Convention on Climate Change (UNFCCC).

Since that time, CEOS has played a key role in support of the Group on Earth Observations (GEO) Forest Carbon Tracking (FCT) demonstration activities.

At the 25th meeting of the CEOS Strategic Implementation Team (SIT) in Tokyo, CEOS agencies agreed on a number of actions to continue and further develop the CEOS role within the GEO FCT framework:

- to develop a Strategy Report on satellite data continuity and coverage plans
- to conduct a study of the institutional arrangements needed for management of the continuing CEOS role in supporting GEO FCT activities as they continue to development and expand towards a global scale.

CEOS will, in addition, continue to provide substantial technical expertise in relation to the development of methods and guidance regarding use of satellite data for national MRV systems, and in support of carbon emissions estimates from forests. These include the application and interoperability of different sensors and sensor types, and the integration of satellite data with in-situ data and forest inventory for use with carbon models for the development of emissions estimates.

The Land Product Validation (LPV) sub-group of the CEOS Working Group on Calibration and Validation (WGCV) aims to address the challenges associated with global land product validation.

The joint activities of the CEOS WGCV and GTOS panel on Global Observations of Forest Cover and Land Dynamics have addressed the need for coordinated international activities on global land and forest observations.

## 5.4 ESA: Climate Change Initiative (CCI)

To meet its commitment to GCOS while making full use of the European EO space asset, ESA has developed a new programme, referred to as the CCI, to "*systematically generate, preserve and give access to long-term data sets of the ECVs required to meet the needs of the Parties to the UNFCCC*". This programme capitalizes on previous European investment in space (in particular already existing long-term archives of EO data)**.**

The CCI will aim to implement a coherent and continuous suite of actions that encompasses all steps necessary for the systematic generation of relevant ECVs, including long-term data preservation, recalibration, periodic reprocessing of the long-term records, algorithm development, product generation and validation, and quality assessment of climate records in the context of climate models.

## 5.5 EUMETSAT:

### 5.5.1 Satellite Application Facility on Climate Monitoring (CM SAF)

EUMETSAT established a Satellite Application Facility on Climate Monitoring (CM SAF) in order to generate and archive high quality data sets on a continuous basis for the following application purposes:

- Monitoring of the climate state and its variability;
- Analysis and diagnosis of climate parameters to identify and understand changes in the climate system;
- Input for climate models to study processes in the climate system on a European and global scale and for climate prediction, and
- Validation of simulation models (climate and NWP).

The CM SAF entered its Continuous Development and Operations Phase in 2007 after an initial operations phase had started in 2004. The CM-SAF's expanding suite of products is tailored for applications focusing on key aspects of the Earth's atmospheric water and energy cycles and includes cloud parameters, radiation budget parameters (surface and top of the atmosphere) as well as temperature and humidity (water vapour) in the atmosphere.

### 5.5.2 Sustained climate monitoring from space

For the analysis of climate variability as well as climate and environmental change detection, the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) member state agencies and scientists require reliable datasets collected over decades. Recently, the focus of EUMETSAT's mandate in the context of climate monitoring was substantiated when the EUMETSAT Council adopted a Resolution stating that the focus should be to take into account climate-specific requirements in the operations of the current EUMETSAT satellites and in the planning for future programmes. It also prioritised the generation of Fundamental and Thematic Climate Data Records. An Implementation Plan with dedicated tasks that addressed the Council Resolution targets was established and agreed by the EUMETSAT Council in June 2010.

## 5.6 JAXA: Earth Observation Data Products on Climate

The Global Change Observation Mission (GCOM) will serve as Japan's comprehensive Earth Observation system to support ECV development for the atmosphere, ocean, land, cryosphere and ecosystems. Most of its observations are expected to provide data that is commonly useful to climate research and meteorology. GCOM is designed to help identify and quantify human-induced environmental changes such as deforestation, forest fires, and air and water quality changes. It will help researchers to distinguish these changes from other natural cyclical changes with relative high spatial resolution and on a global scale. The integrated use of GCOM/GPM/EarthCARE and GOSAT/ALOS data is expected to improve the understanding of climate change processes and their impact in other areas, such as numerical weather prediction.

## 5.7 NASA

NASA research satellites, and, in particular, its Earth Observing Program (EOS) satellites have provided key observations on the Earth's climate system. Through its science teams and its Pathfinder data set program, it continues to support the creation of long term climate quality data sets from satellite observations, and to reprocess these data sets periodically. It has initiated a Research Opportunities in Space and Earth Sciences (ROSES) program to support external science activities.

More recently, it has joined with NOAA in the restructured Joint Polar Satellite System (JPSS) (formerly – National Polar-orbiting Environmental Satellite System (NPOESS)). NASA's role in the restructured program will be modeled after the procurement structure of the successful Polar Operational Environmental Satellite and Geostationary Operational Environmental Satellite programs, where NASA and NOAA have a long and effective partnership. The partner agencies are committed to maintaining collaborations towards the goal of continuity of earth observations from space.

## 5.8 NOAA

### 5.8.1 New Climate Service

To meet the rising tide of requests, from individuals and decision-makers across widely diverse sectors – from agriculture to energy to transportation – asking NOAA for information about climate change in order to make the best choices for their families, communities and businesses, U.S. Commerce Secretary Gary Locke announced the intent to create a NOAA Climate Service line office dedicated to bringing together the agency's strong climate science and service delivery capabilities. Unifying NOAA's climate capabilities under a single climate office will integrate the agency's climate science and services and make them more accessible to NOAA partners and other users. Planning has been, and continues to be, shaped by input from NOAA employees and stakeholders across the country, with close consideration given to the recommendations of the NOAA Science Advisory Board, National Academies, and National Academy of Public Administration.

NOAA's NESDIS will support the new Climate Service by striving for climate quality observations from its operational satellites, by leading the Global Space-based Inter-Satellite Calibration System, and by generating, validating, analyzing, archiving, and distributing high quality climate data records from environmental satellites under its recently enhanced Scientific Data Stewardship project.

### 5.8.2 NOAA's Climate Sensor and Climate Data Record (CDR) Projects

NOAA has restored climate sensors to the manifest for the future Joint Polar Satellite System (JPSS) to provide continuity of observations of the ECVs for solar irradiance, earth radiation and clouds, and sea level rise. This marks the transition of these observation and processing capabilities from research to operations to ensure their sustained production. Maintaining the high quality level required of ECVs entails the continued involvement of the research community as these observations are moved into the operational environment at NOAA.

NOAA's Climate Data Record Project provides for ongoing production of Climate Data Records (CDRs) and Climate Information Records (CIRs). CDRs and CIRs provide authoritative climate reference sets. They are required by scientists to detect, assess, model and predict climate change, and by decision-makers to devise effective strategies to respond, adapt, and mitigate the impacts of climate change. The programme is primarily executed through competitive grants and NOAA Cooperative Institutes and contracts. The programme leverages prior U.S. investment by transitioning research products from the National Aeronautics and Space Administration (NASA) and other agencies into sustained NOAA operations.

## 5.9 USGS Plans for Developing FCDRs and ECVs

The United States (U.S.) Landsat series of missions has compiled the longest record of satellite observation of the Earth's land surface, extending for more than 37 years and covering most areas of the globe. The Landsat series is particularly important to long-term climate data records because its measurements are acquired at a scale that enable users to differentiate between natural and human-induced influences on land cover change.

The United States Geological Survey (USGS) has established consistent radiometric calibration across Landsat's Thematic Mapper (TM) and Enhanced Thematic Mapper plus (ETM+) sensors. By the end of 2010 the USGS will have completed consistent radiometric calibration across the satellites' multispectral sensors. In addition to these technical achievements, the USGS changed its policy in 2008 to make standard products from all data in the Landsat archive available at no cost and without constraints on redistribution. User demand for Landsat data has since grown exponentially.

Building upon these technical and policy achievements, the USGS is currently formulating plans to derive FCDRs and ECVs from its Landsat data archive. Using GCOS guidance, a USGS team conducted a high level assessment of the algorithm maturity, USGS capability and readiness, and user demand from the research and applications community to identify those terrestrial ECVs that have the highest potential for being successfully derived from Landsat data. The ECVs that were identified include: land cover, albedo, fire disturbance, surface water, snow and ice, and leaf area index. Surface reflectance and land surface temperature were identified as priority FCDRs that either have direct application or are required as input to the generation of ECVs.

## 5.10 WMO

### 5.10.1 Global Space-based Inter-Calibration System (GSICS)

The Global Space-based Inter-Calibration System (GSICS) is a new international program to assure the comparability of satellite measurements taken at different times and locations by different instruments operated by different satellite agencies. Sponsored by the World Meteorological Organization and the Coordination Group for Meteorological Satellites (CGMS), GSICS will inter-calibrate the instruments of the

international constellation of operational low-earth-orbiting (LEO) and geostationary environmental satellites and tie these to common reference standards. The inter-comparability of the observations will result in more accurate measurements for assimilation in numerical weather prediction models, construction of more reliable climate data records, and progress towards achieving the societal goals of the Global Earth Observation System of Systems. GSICS includes globally coordinated activities for pre-launch instrument characterization, on-board routine calibration, sensor inter-comparison of near-simultaneous observations of individual scenes or overlapping time series, vicarious calibration using Earth-based or celestial references, and field campaigns.

The major output for users of satellite data will be the GSICS Correction. The GSICS Correction is an algorithm that the user applies to the original observations of a satellite instrument to adjust the data and make them comparable to the best available space-based reference standards. The first correction algorithm developed by GSICS allows users to correct the geostationary IR sensors so that they are consistent with the high accuracy AIRS and IASI observations.

### 5.10.2 Sustained, Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM)

The aim of the Sustained, Co-Ordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) is to establish a network of facilities ensuring continuous and sustained provision of high-quality satellite products related to the Essential Climate Variables (ECV), on a global scale, responding to the requirements of the Global Climate Observing system (GCOS).

The participating organizations in the SCOPE-CM initiative are initially:

- CMA, EUMETSAT (serving as Secretariat), JMA, NOAA, and USGS as technical agencies
- CGMS, CEOS, GCOS, GSICS and WMO providing oversight and support through the Executive Panel.

SCOPE-CM has selected five pilot projects for initial implementation:

- Pilot Project 1: AVHRR based cloud and aerosol properties
- Pilot Project 2: SSM/I total water vapour, precipitation and liquid water path
- Pilot Project 3: Surface Albedo/ aerosols from Geostationary Satellites
- Pilot Project 4: Atmospheric Motion Vectors and clear sky radiance
- Pilot Project 5: Upper Tropospheric Humidity

## 5.11 World Climate Research Program (WCRP)

The mission of the WCRP 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. To fulfill this mission, the WCRP has established a number of international core projects, some of which are developing long term data sets of ECVs, while others are major consumers of climate data records.

The Climate and Cryosphere (CliC) project's mission is to stimulate, support, and coordinate international research into how the cryosphere interacts with the rest of the climate system.

The Climate Variability and Predictability (CLIVAR) project addresses Climate Variability and Predictability, with a particular focus on the role of ocean-atmosphere interactions in climate. It will rely on the recently established Group for High-Resolution Sea Surface Temperature (SST) (GHRSST) to provides a new generation of global high-resolution (<10km) SST data products.

The mission of the Global Energy and Water Cycle Experiment (GEWEX) is to observe, understand and model the hydrological cycle and energy fluxes in the Earth's atmosphere and at the surface. The GWEX Radiation Panel is responsible for guiding production and evaluation of long term, globally complete atmospheric and surface water and energy budget products, including radiation, clouds, aerosols, precipitation, water vapor, and surface turbulent fluxes. It has recently established a new focus to evaluate the usefulness of water and energy budget data at local scales.

The Stratospheric Processes and their Role in Climate (SPARC) project studies stratospheric processes and their role in climate. SPARC is a key user of satellite measurements of ozone, and stratospheric temperature and water vapor.

In addition to its Core Projects the WCRP has a number of themes. The recently established Observation and Analysis Theme is making a concerted effort to assure creation of climate quality observations and data sets.

# 6 Future Plans

CEOS agencies have made great strides in implementing the CEOS Climate Action Plan and will continue to follow through on these actions. The CEOS climate coordinator and the CEOS Climate Action Teams will continue to monitor and report on status and progress.

To develop an effective response to the updated 2010 GCOS Implementation Plan (GCOS-IP 2010), CEOS will capitalize on the organizational structure it established for implementing the Climate Actions responding to the 2004 GCOS-IP. The CEOS Climate Action Teams will be assigned to the appropriate domain (atmosphere, ocean, land) for reviewing the Plan. The CEOS Climate Coordinator will provide guidance to the teams to ensure comparable reviewing and reporting activities. For each domain, a lead will be selected, who will be responsible for consolidating the recommendations of the domain team into a cogent response. CEOS Virtual Constellation Leads will play an important role in these activities. A key function of the domain teams will be the selection and acquiescence of a lead agency and its representative to assume responsibility and accountability for monitoring and reporting on progress on a particular climate action in response to the GCOS-IP 2010. The domain team responses will then be integrated into a final report by the CEOS Climate Coordinator.

CEOS will respond to requests from the UNFCCC and its Subsidiary Body on Scientific and Technological Advice (SBSTA) for future updates on its Climate Action Plan.

To ensure that the CEOS Climate Actions are meeting the needs of the climate user community and that this community is aware of the satellite data resources available to it, CEOS, in coordination with GCOS, will organize a series of workshops to bring together the providers and users of satellite-based climate data.

As indicated above, CEOS will prepare a response to the update of the GCOS Implementation Plan, when it appears in 2010.

As requested jointly by WCRP and GCOS, CEOS will also provide subject matter experts to assist GCOS in developing its Satellite supplement to the 2010 GCOS Implementation Plan.

# 7 Appendices

The full version of the *2010 Progress Report: Coordinated Response from Parties that Support Space Agencies Involved in Global Observations to the Needs Expressed in the Global Climate Observing System (GCOS) Implementation Plan of 2004* contains Appendices on The Committee on Earth Observation Satellites; CEOS Actions in Response to the GCOS IP of 2004; GCOS Climate Monitoring Principles; Acronyms; and Report Contributors.

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