Resolution 19 (Cg-XVI) - DEVELOPMENT OF AN ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE

THE CONGRESS,

Noting:

(1) Article 2 of the Convention of the World Meteorological Organization,

(2) Resolution 5 (Cg XIV) - WMO Space Programme,

(3) Resolution 30 (Cg-XV) - Towards enhanced integration between WMO observing systems,

(4) Paragraph 9.2.5 of the *Abridged Final Report with Resolutions of the Fifteenth World Meteorological Congress* (WMO-No. 1026) reaffirming the Executive Council decisions to provide full support for the GEO process and resulting GEOSS and to support its implementation to the maximum extent possible within the WMO mandate,

(5) Resolution 3 (Cg-XVI) - Global Observing System,

(6) Resolution 48 (Cg-XVI) - Global Framework for Climate Services,

Considering:

(1) The benefits that have been achieved through the coordinated, collaborative and cost-effective approach to the planning and operation of an end-to-end system for weather observations, modelling, analysis and forecasting,

(2) The increasingly important role that space-based observations are playing in the long-term monitoring of the Earth's environment,

(3) The substantial investment that Members have made in Earth-observation satellites to monitor and study weather, water, climate and related natural disasters,

(4) The importance of long-term, sustained and coordinated observations of the Earth's climate, climate change and variability for the world's population, and particularly those at most risk,

(5) The benefits in efficiency, sustainability and cost-effectiveness that could be achieved through increased coordination of efforts among all parties involved in the planning and implementation of space-based observational capabilities and related operational processing activities for climate monitoring,

(6) The underpinning role that observations will play in the Global Framework of Climate Services (GFCS),

(7) The importance of integration of ground-based and space-based observations in the successful implementation of the WMO Integrated Global Observing System (WIGOS),

Appreciating:

(1) The important contributions Members, their satellite operators, international partner organizations and programmes make toward observing, and coordinating observations of the Earth from space,

(2) The relevant work undertaken by the Global Climate Observing System (GCOS) to identify the requirements associated with the Essential Climate Variables (ECVs) for the long-term and sustained observation of the Earth's climate system,

(3) The invitation made by the sixty-second session of the Executive Council to the WMO Space Programme, in coordination with GCOS and with the support of relevant technical commissions, to work with space agencies, the Coordination Group for Meteorological Satellites (CGMS), the Committee on Earth Observation Satellites (CEOS), and the Group on Earth Observations (GEO) in order to develop an architecture for sustained, space-based climate monitoring as a component of the future WIGOS and GFCS, for consideration by the Congress,

(4) The early work done by the WMO Space Programme to develop a concept and initiate a dialogue among interested parties for an architecture for climate monitoring from space,

Recognizing:

(1) The WMO Space Programme provides Members with an appropriate framework to advance, in partnership with CEOS, CGMS, GCOS, GEO, the World Climate Research Programme (WCRP) and other partner organizations the development of an architecture for climate monitoring from space,

(2) The end-to-end system implemented by Members to support weather monitoring and forecasting, which includes the review of observational requirements, satellite observations, intercalibration, as well as product generation and training and user-engagement, can be leveraged for climate monitoring,

(3) The different, but complementary roles and responsibilities, of satellite operators and their coordinating mechanisms for activities which cover the spectrum of research and development and operational missions,

(4) That, in this architecture, space-based observations have to be supported by surface-based observations,

Decides that an architecture be developed using as a starting point the concept given in the annex to this resolution to provide a framework for the sustained and coordinated monitoring of the Earth's climate from space;

Decides further:

(1) That the development be undertaken as a major initiative of the WMO Space Programme, as an important component of WIGOS, with the support of relevant technical commissions, and in coordination with satellite operators, CEOS, CGMS, GCOS, GEO and WCRP;

(2) That the results will be made available for the deliberations and final approval by the Executive Council;

Requests the Executive Council to monitor, guide, support and consider approving, at its sixty-fourth session, the development of an architecture for climate monitoring from space;

Requests the technical commissions:

(1) To guide the technical aspects of the development activities;

(2) To update WMO Regulatory Material, including development of the Manual on WIGOS;

(3) To provide the technical lead for the architecture through the Commission for Basic Systems, the Commission for Instruments and Methods of Observation, the Commission for Climatology and the Commission for Atmospheric Sciences;

Requests Members to:

(1) Provide experts to participate in the development, implementation and operation of an architecture for climate monitoring from space;

(2) Provide voluntary contributions to the WMO Space Programme Trust Fund for the further advancement of the architecture development efforts;

(3) Share relevant experience and cooperate with one another in leveraging the existing end-to-end weather monitoring system to serve climate monitoring needs;

(4) Continue to enhance and integrate their national climate monitoring capabilities;

Requests the regional associations to support and coordinate efforts of Members in the development and eventual implementation of an architecture for climate monitoring;

Requests the Secretary-General to:

(1) Ensure management and support of the architecture for climate monitoring from space development efforts;

(2) Support the review and update of WMO Regulatory Material, including the development of the Manual on WIGOS;
(a)

Invites CEOS, CGMS, GCOS, GEO and WCRP to collaborate with the WMO Space Programme on the development of an architecture for climate monitoring from space.

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Annex: 1

Annex to Resolution 19 (Cg-XVI)

ARCHITECTURE FOR CLIMATE MONITORING FROM SPACE
CONCEPT DOCUMENT (Version 1.1)

1. Introduction

The purpose of this document is to provide a basis for consultation and, ultimately agreement, on processes and capabilities to be implemented or maintained, and activities to be pursued, in order to monitor climate from space in a globally coordinated and efficient framework.

Section 2	recalls the motivation for such an architecture.
Section 3	describes key building blocks of the architecture in an end-to-end approach.
Sections 4 to 8	describe the contents of each component.
Section 9	suggests roles and responsibilities to lead this process.

2. Motivation

Facing the need to know and understand the evolution of climate in order to alleviate or prepare for its impact, e.g. for programmes like the Global Framework for Climate Services (GFCS), monitoring climate variables is a prerequisite, and space-based observation has an essential role in this respect.

Meteorological satellites have considerably evolved over the past fifty years and are now used for a variety of applications that span time scales from nowcasting to climate prediction, and include land, ocean, atmosphere and environmental applications. Instruments on research satellites have laid the groundwork for the development of operational satellite systems and resultant environmental applications are growing vigorously.

Specific climate payloads have been flown with success by both operational and research agencies over the last several decades. Operational meteorological missions are enhanced with some climate monitoring instruments, for example for Earth Radiation Budget or ozone monitoring. In response to the Global Climate Observing System (GCOS) Implementation Plan and its Satellite Supplement, the Committee on Earth Observation Satellites (CEOS) presented a comprehensive assessment of satellite capabilities for selected Essential Climate Variables (ECVs). There remain, however, challenges regarding the sustainability and/or continuity of selected missions and measurements to provide a continuous, long-term record of climate.

Responding to these challenges requires defining and implementing an architecture through a mechanism that accounts for the different roles and responsibilities of the respective entities while responding to the essential need for continuous and sustained operation. Given the important contribution of R&D programmes to climate observation, compounded with the increasing convergence of operational and research activities, the future space-based observing system has to rely on a strong partnership between research and operational entities.

3. A structured approach

3.1 Functional components

Taking as a starting point the requirements expressed by GCOS, and possible additional requirements in the future, the following functional components are considered:

- Analysis of user requirements;
- Observing capabilities;
- Essential Climate Variable (ECV) product generation and analysis;
- Data management, access and dissemination;
- User interface;
- Coordination and governance.

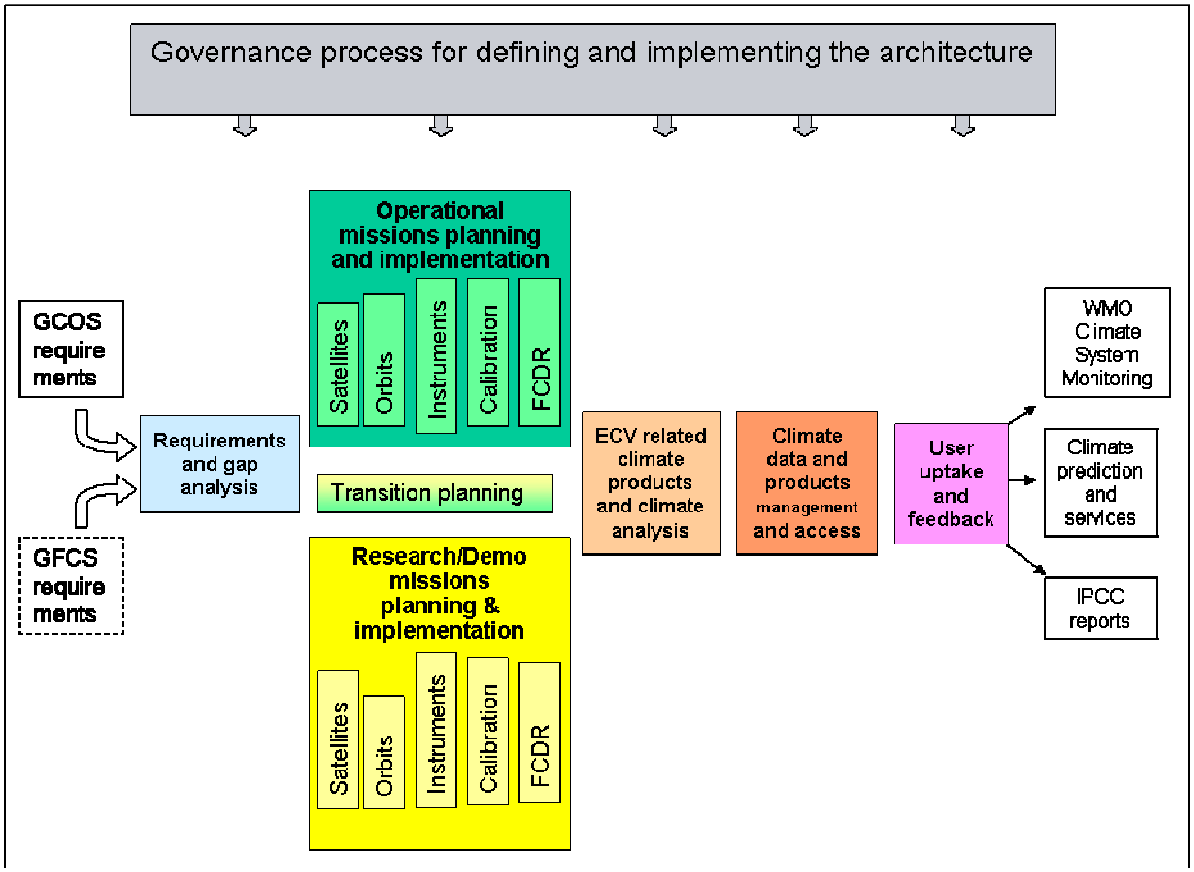

Figure 1: Key components of an end-to-end architecture

3.2 Cross-cutting considerations

The present concept document stays deliberately at high-level, since the detailed design will be developed at a later stage and should be evolving. The architecture should be defined in a long-term perspective. Building on existing assets, and taking into account the currently existing or planned capabilities, it should highlight the incremental effort needed.

In its concept, it should acknowledge:

- The evolving science and the need to ensure linkage with the science community;
- The evolving technology, avoiding being bound to current technical approaches;
- A Research-and-Operations (R&O) process, to be integrated in the evolving architecture.

The architecture should recognize and build upon the leadership exerted by CEOS, the Coordination Group for Meteorological Satellites (CGMS), the Group on Earth Observations (GEO),

and the WMO Space Programme. Noting the necessary balance between best-effort and commitment, agreement should be sought on a process, supported by an implementation plan.

The development process should be responsive to evolving user needs. Robustness of systems and processes are necessary to support sustained acquisition and processing of mature observations and products. Quality assurance should be an integral part of each sub-system.

4. User requirements analysis component

4.1 Input

User requirements for observations are expressed by representative user communities, and kept under regular review following well established processes (GCOS Implementation Plan and Satellite Supplement, Rolling Review of Requirements (RRR)).

The requirements address geophysical variables (e.g. ECVs) rather than value-added products. Requirements are not for specific instruments either; they are in principle technology-free, thus not limited to space-based observation. Requirements should specify: variables, units, resolution (space and time), accuracy, continuity. They are consolidated in a database maintained by WMO and linked to the CEOS Missions, Instruments and Measurements (MIM) database.

The GCOS Implementation Plan reflects the needs of the United Nations Framework Convention on Climate Change (UNFCCC). Additional observational requirements for climate monitoring, however, may be driven by the WMO Climate System Monitoring and by climate applications for mitigation and adaptation purposes in the context of GFCS (e.g. for downscaling). The World Climate Research Programme (WCRP) requirements may also provide a relevant input.

4.2 Requirements analysis

An analysis is needed to select the subset of requirements that can be addressed from space, compare the requirements with the inventory of existing/planned observation capabilities, and perform a Gap Analysis.

5. Observation capabilities component

A comprehensive architecture should encompass operational capabilities and research or demonstration capabilities. In addition to these research and operational capabilities, a process should also be defined to facilitate transition from research to operational status when appropriate, and also recognize both research and operational activities are essential. Quality assurance should be inherent to these elements.

5.1 Operational capabilities

Operational status is understood as offering a clear long-term continuity perspective, which entails the in-principle commitment that the capability, or an equivalent one, will be maintained, enabling to serve an operational community in a sustained manner.

Operational missions should address all ECVs including atmosphere, ocean, land, and cryosphere, to the extent there are mature observation capabilities. They should follow the GCOS Climate Monitoring Principles for satellite observations. An important feature is mission robustness, which may imply provisions for relaunch, contingency planning, and overlap between consecutive missions when appropriate.

CGMS is providing technical coordination of operational programmes. The current baseline agreed by CGMS defines committed elements in geostationary and low-Earth orbit. An evolution of the CGMS baseline is underway to better serve climate monitoring, guided by the WMO Vision for the Global Observing System (GOS) in 2025. The baseline for the space-based observing system can be described in terms of actual constellations (sets of satellites with coordinated orbits), or in terms of virtual constellations (sets of instruments distributed on different satellites but supporting similar missions) mapped with the ECVs. The future CGMS baseline, detailing missions, orbits and assignments, should ultimately be the foundation of the space-based component of the WMO Integrated Global Observing System (WIGOS).

5.2 Research and demonstration capabilities

R&D missions are twofold: missions for climate research (atmospheric/climate process studies) and missions for technology demonstration. By definition, R&D missions are not bound to any firm perspective of continuity. Research missions respond to a science plan developed in consultation with the climate community.

Space agencies have developed plans at the national level or in international partnerships. CEOS is leading a coordinated response on behalf of space agencies to climate needs, and has implemented several Virtual Constellations mapped with selected ECVs.

5.3 Transition process

Attention is required to avoid misunderstanding of the “Research to Operations” paradigm.

Research and operations are equally important to successfully deliver climate-related measurements. An operational follow-on should be considered for capabilities that have been successfully demonstrated from the point of view of performance, reliability, affordability, maturity, user uptake, and societal benefit. This does not prejudge any transfer of tasks or budgets among entities, which is an internal matter for each agency or country. Joint ventures among R&D and operational entities are strongly encouraged.

The goal is that parties are ultimately in a position to make long-term commitment. The appropriate level for a long-term commitment may be the national government (e.g. WMO Member through its Permanent Representative) since an individual agency may not have the mandate to commit beyond a programme life cycle or a budget cycle.

5.4 Quality assurance: calibration/intercalibration

Quality assurance considerations are applicable to all observation components (See the Quality Assurance Framework for Earth Observation (QA4EO)). The aim should be to generate Fundamental Climate Data Records (FCDRs). This shall build on:

- Global Space-based Inter-Calibration System (GSICS) involving CMA, CNES, EUMETSAT, ISRO, JAXA, JMA, KMA, NASA, NIST, NOAA, ROSHYDROMET;
- CEOS Working Group on Calibration Validation (including Cal/Val sites);
- GCOS Reference Upper-Air Network (GRUAN) and national initiatives such as the ARM (USA), SADE (France) etc. may support this activity;
- WMO-BIPM collaboration plans addressing measurement challenges in observations for climate monitoring (see proceedings of the first WMO-BIPM workshop, Geneva, 30 March-1 April 2010, WMO/TD-No. 1557).

6. ECV product generation and analysis component

The goal is to ensure sustained provision of validated and quality-controlled ECV products (Thematic Data Records). A number of initiatives are currently contributing to that goal, including:

- Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM);
- Climate Change Initiative (CCI) of the European Space Agency;
- World Data Centres (e.g. GAW DLR Data Centre on Aerosols).

These initiatives, however, are not addressing all the ECVs. There is a need for maintaining a mapping of the available/planned production of ECV products as well as "Additional Climate Variables (ACVs) if required.

For established, peer review validated products, production should be ensured in a sustained mode and quality controlled. New products shall be developed to fill gaps on priority needs, with a process for transitioning to a sustained mode according to their maturity, as assessed by a maturity index. Plans should be made for reprocessing. These products are inputs for climate monitoring analyses as part of, for example, the WMO Annual Statement of the Global Climate or the Intergovernmental Panel on Climate Change (IPCC) Assessment Reports.

7. Data management, access and dissemination component

The scope is to ensure timely accessibility of observations and products in compliance with agreed interoperability standards.

Metadata, catalogue interfacing, and formats should be standardized in compliance with the Global Earth Observation System of Systems (GEOSS) interoperability standards (e.g. the WMO Information System (WIS) standards for WMO Members). Data should be properly catalogued and openly retrievable from data centres. In addition, acknowledging dual use of many data for both climate applications and real-time services, active data distribution should also be considered in accordance with standard practices and protocols (e.g. Direct Readout or rebroadcast).

8. User interface component

User interface should be maintained in order to seek feedback, monitor deliverables and compare with user requirements. Linkages shall be maintained in particular with the science community, the WMO Climate System Monitoring, climate assessment and climate prediction, and the GEOSS user community. Provisions shall be made to support user uptake, through capacity building including training. The annual WMO Statements on the Status of the Global Climate are an example of operational deliverables to the WMO Members, UN agencies and the general public.

9. Coordination functions

At the level of each component, coordination is needed. Tentative leads are suggested below for the respective components:

Function	Suggested WMO involvement
Requirement identification	GCOS and WCRP
User requirements analysis	(To be determined, involving CBS)
Observation capabilities	CGMS, GSICS, and CBS and CIMO Working Groups

ECV Product generation	SCOPE-CM
Data Dissemination and Access	(To be determined, involving CBS and WIS)
User Interface	GCOS, WCRP, and GFCS

An overall governance mechanism will be needed in order to:

- Manage evolution of the plan and maintain a long-term Vision;
- Monitor the commitments of each contributor, ensuring a smooth interaction among components;
- Maintain a proper link with GEO/GEOSS, support communication, outreach, and provide visibility to this collaborative endeavour.

Document Change Record		
Version	Date	
Draft Outline 1	14 October 2010	Update for CBS-Ext.(10)/Doc. 4.2(3) discussion
Draft Outline 2	15 October 2010	Creation of document for CGMS discussion as CGMS WMO-WP-09
Draft Outline 3	6 December 2010	Update for CEOS discussion
Version 1	20 December 2010	Creation report for WMO/GCOS Workshop discussion
Version 1.1	March 2011	Update for Cg-XVI/Doc. 3.7 discussion

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