Implementation Plan for the Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM)

Version 1.3

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1. Purpose of this document

This document presents the plan to implement the global network of Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM). The purpose of this document is to describe objectives of the global network and to define the tasks and responsibilities for setting up its initial components.

Section 2 gives an introduction and provides background information on this initiative, Section 3 presents the objectives and expected benefits and section 4 the governing bodies of the SCOPE-CM followed by a timeframe and phasing for the network development summarised in Section 5.

Specific tasks for the implementation of the network structure and the early operations are defined in Section 6. Terms of references for the Executive Panel, the Scientific Advisory Group and the Data Working Group are presented under Annex 1.

2. Introduction and Background

Climate is a global phenomenon. Observation of the global climate should therefore be a common responsibility among global partners. Global climate monitoring nowadays depends increasingly on continuous and sustained observation of the Earth system from space and products that are derived from satellite data records. The WMO is the natural body to coordinate such activities because of its history in worldwide coordination of climate-related activities and observing systems for weather and climate in general, as evidenced by the preamble to the WMO convention as revised by the XV. WMO congress to include Climate Monitoring.

The mission of the Global Climate Observing System (GCOS), sponsored by WMO, UNESCO/IOC, UNEP and ICSU is to ensure availability of global observations for climate for monitoring the climate system, detecting and attributing climate change, assessing impacts of and supporting adaptation to climate variability and change, application to sustainable development, and supporting climate research. GCOS has already established the GCOS Climate Monitoring Principles (GCMP), towards the delivery of global, long-term, high-quality, sustainable and reliable climate products. These GCMPs are included as Annex 2. The SCOPE-CM addresses in particular GCMP number 16:

- *"Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate."*

The *GCOS Second Adequacy Report* [1] identified gaps in the systematic observation of climate, established a priority list of 44 Essential Climate Variables (ECV) and called for integrated global analysis products.

In October 2004, the "*Implementation Plan for the Global Climate Observing System in Support of the UNFCCC*" (hereafter called "GCOS Implementation Plan" or "GIP") [2] was issued, defining priorities and identifying 131 actions necessary to fulfil the GCOS requirements for climate monitoring.

The SCOPE-CM and this Implementation Plan directly address in particular two actions from the GCOS Implementation Plan, which are:

- *"Ensure an orderly process for sustained operation of research-based networks and systems for ECVs (Action C7)"*
- *"Ensure continuity and overlap of key satellite sensors, recording and archiving of all satellite meta-data; maintaining currently adopted data formats for all archived data; providing data service systems that ensure accessibility; undertaking reprocessing of all data relevant to climate for including in integrated climate analysis and reanalysis. (Action C10)"*

In 2006, the document "*Systematic Observation Requirements for Satellite-based Products for Climate – Supplementary Details to the GCOS Implementation Plan*" (hereafter called "GIP Satellite Supplement") [3]) supplemented the GIP and identified a priority list of 35 satellite-based geophysical products addressing Essential Climate Variables. These products are based on consistent, homogeneous observations from space (Fundamental Climate Data Records (FCDR)). The document also expressed nine cross-cutting recommendations on climate observations from space and stated the need for reanalysis and reprocessing of historical satellite data records.

To address the more accurate observations needed for continuous and sustained climate monitoring, a concept for a Global Space-based Inter-calibration System (GSICS) [4] was agreed in June 2006 by the heads of the participating space agencies and is operational since April 2007. It enables the generation of Fundamental Climate Data Records (FCDRs),

and thus will provide the basis for sustained climate monitoring and the generation of ECV satellite products.

The 6th session of the WMO Consultative Meetings on High-level Policy on Satellite Matters (CM-6) [5] discussed the concept for Regional/Specialized Centres on Satellite Products, expressing the possibility to "*…identify specific Centres of Excellence in thematic areas that could be designated Regional/Specialized Meteorological Centres for Satellite Products (Regional Specialized Satellite Centres).*"

The session (CM-6) recalled the criteria to be met for the designation as a R/SSC by WMO, which are:

> "*1) there must be a statement of requirements for product and services initiated and endorsed by a WMO constituent body; 2) identification of a centre capable to meet the requirements; 3) determination of the need to establish the centre; 4) a formal commitment by a Member or a group of cooperating Members to fulfil the required function; 5) demonstration of the capabilities; 6) recommendation by CBS; and 7) acceptance by either Congress or Executive Council.*"

Furthermore, the EUMETSAT SAF Network was identified as an example of a potential R/SSC to be designated.

The Committee on Earth Observation Satellites (CEOS) submitted on behalf of space agencies involved in global observations, a coordinated response [6] to the space related needs expressed in the GCOS Implementation Plan to the 25th session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) held in November 2006 in Nairobi. The concept of the global SCOPE-CM network is compliant and complementary to the relevant actions agreed by CEOS.

At the 7th session of the WMO Consultative Meetings on High-level Policy on Satellite Matters (CM-7) [7], EUMETSAT presented a high-level concept for a Global network of Regional/Specialized Satellite Centres for Climate Monitoring (R/SSC-CM), which was welcomed by GCOS representatives. CM-7 strongly urged all participants to work towards development and approval of an Implementation Plan before the forthcoming GEO Summit in November 2007.

A first workshop on the finalisation of a R/SSC-CM concept paper [8] was held in Darmstadt 15-16 March 2007, which was sent to the participants of the CM-7 for approval. The outcome of this workshop was presented to the thirteenth meeting of the GCOS-WCRP Atmospheric Observation Panel for Climate (GCOS/AOPC XIII) on 25 April 2007.

The first Meeting of Potential Participants of the R/SSC-CM was convened in Geneva on 16 May 2007 and discussed a preliminary outline of the R/SSC-CM Implementation Plan. The second meeting of Potential Participants, which took place in Cocoa Beach, USA, on 9 November 2007, approved version 1.0 of the Implementation Plan.

The Executive Panel held its first meeting on 25 and 26 February 2009 in Geneva and agreed to change the name from R/SSC-CM to Sustained and Coordinated Processing of Environmental Satellite Data (SCOPE-CM).

3. Objectives and Benefits

3.1. Objectives

The aim of the distributed global network of Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring (SCOPE-CM) is to address the requirements of GCOS in a cost-effective, coordinated manner, capitalising upon the existing expertise and infrastructures.

The overall objective of the Global Network of SCOPE-CM is the continuous and sustained provision of high-quality Essential Climate Variables satellite products (see Tables in Annex 5) on a global scale as specified in the GCOS Implementation Plan [2] and its Satellite Supplement [3].

These activities will be undertaken on a routine and ongoing basis according to internationally agreed standards and in compliance with the principles and requirements of the Global Climate Observing System (GCOS), such as the GCMPs (see Annex 2).

This initiative responds in particular to the following cross-cutting needs as expressed in the GIP Satellite Supplement [3],:

- Develop modern distributed data services
- Ensure that data policies facilitate the exchange and archiving of all ECV satellite products, FCDRs, associated metadata and ancillary data
- Generation of Fundamental Climate Data Records
- Generate homogeneous products derived from the FCDRs
- Sustain regeneration (or reprocessing) to derive improved products when FCDRs or generation methods improve
- Sustain the independent generation of derived products as a means of determining the confidence that can be placed in products, in particular in trends estimated from these products
- Intensify efforts to further develop emerging operational capabilities for research-based variables

The SCOPE-CM initiative has very much in common with several cross-cutting actions listed in the CEOS document [6] and the contributions by satellite operators/space agencies to its implementation will also serve the purpose of CEOS in its coordinated response to the space-related component of the GCOS IP.

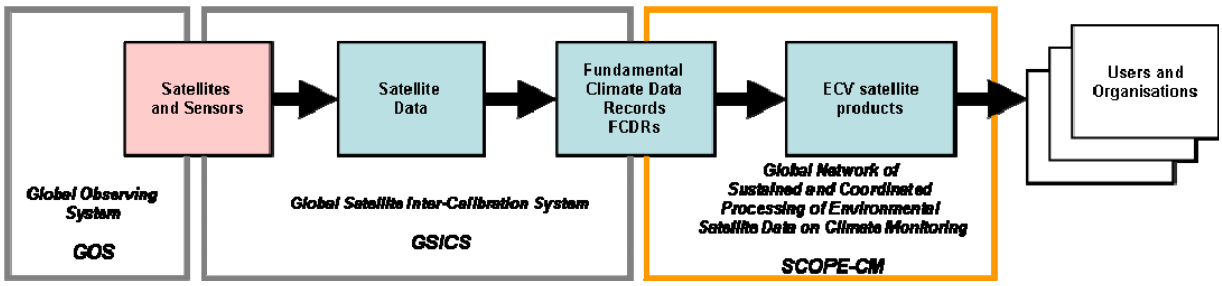

Figure 1: Schematic role of the SCOPE-CM Global Network in the context of continuous and sustained satellite-based climate monitoring (users: GCOS, WMO, IPCC, UNEP, FAO, etc.)

Figure 1 is a schematic of the activities of the SCOPE-CM network in the context of continuous and sustained climate monitoring using satellite observations. In the frame of WMO's Global Observing System in which the availability of satellite platforms and sensors is coordinated, GSICS is focussing on the inter-calibration of data from various satellite sources which is an essential step for the generation of FCDRs, which themselves provide the basis for the derivation of ECV satellite products (as also expressed in the GCOS Climate Monitoring Principles in Annex 2). Targeted users of these products provided by the SCOPE-CM Network are entities such as WMO and its members, the climate community represented by IPCC and GCOS, the wider range of GEO stakeholders and participating organisations across all areas of society benefiting from earth observations.

3.2. Main functions

Once implemented, the SCOPE-CM would include production, support and coordination functions.

3.2.1. Production functions

- Generate and make available FCDRs which provide the basis for ECV satellite products.
- Generate and make available ECV consistent high quality ECV satellite products, in the assigned area of responsibility, by using state of the art algorithms, bearing in mind the GCOS Climate Monitoring Principles,
- Archiving and dissemination of products and metadata in agreed formats,
- Conduct validation and inter-comparison studies,
- Contribute to reanalysis and reprocessing of historical satellite data records,
- Generate documentation of algorithms, datasets and validation results,

3.2.2. Support functions

- Conduct necessary research for continuously improving algorithms and the scientific interpretation of products (Scientific Stewardship) and to develop new products filling gaps,
- Provide user services and training
- Seek user interaction and feedback

3.2.3. Coordination

- Exchange of information, data and algorithms among the centres and with users,
- Standardization (Formats, Projections, Definitions)
- Interaction with other bodies (most importantly with the WMO Space Programme, GCOS, GSICS, satellite operators, research institutes),

3.3. Benefits

The following list of benefits is envisaged with the Implementation of the SCOPE-CM:

- Monitoring of the evolving coverage in terms of space and in terms of climate relevant parameters (ECVs),
- Facilitated identification of gaps in satellite observing systems, satellite-based climate datasets and derived products, and mechanism to close them,
- Increased effectiveness in routinely generating derived climate products by exchange of data, information, tools and algorithms,
- Prevention of unnecessary duplication of efforts,
- Fostering complementary efforts that lead to increased confidence in product quality,
- Maximum exploitation of the existing expertise and infrastructure through a synergetic approach,
- Coordination of reprocessing and reanalysis activities,
- Combined efforts to achieve global coverage,
- Achieving consistent and high quality of derived climate products, through inter-comparison and joint development.
- Supporting continuous research and development by strengthening research based activities related to ECV satellite product generation
- Coordination of validation activities,
- Capture of the needs through direct involvement of users and the climate research community,
- Strengthening of national and international infrastructures,

4. Components of the Global Network of SCOPE-CM

The global network of SCOPE-CM will include SCOPE-CM centres supported by a Secretariat and overseen by an Executive Panel.

4.1. SCOPE-CM Centres

The facilities able to provide significant contributions to ECV satellite products generation committed to be part of the global network will be designated as a R/SSC for Climate Monitoring with dedicated tasks and responsibilities.

A single SCOPE-CM centre could be a component of an organization (e.g. space agency, Met-Service, Research Institute, Data Centre), or a newly formed entity as well as a consortium of those elements. Each SCOPE-CM centre would be represented by a SCOPE-CM Centre Manager.

For each ECV satellite product, one or two SCOPE-CM centres will be responsible to lead the generation and provision of the relevant product with the understanding that other R/SSCs may contribute as necessary.

It is recognized, that well established processing and analysis facilities for some climate variables are already in place. Thus, the global network will build upon existing and future contributing facilities and **link and coordinate** the activities in order to **most** effectively address GCOS requirements in terms of ECV satellite products. [3]

It is also recognised, that there might be several ECV satellite products related to the same ECV, but generated with different approaches (algorithms, input data, etc) by different SCOPE-CM centres. This could ensure the important cross-checks and confidence level estimates.

The relevant Regional Associations, Technical Commissions and other relevant bodies of WMO will be informed of the designation of SCOPE-CM centres.

4.2. SCOPE-CM Executive Panel (SEP)

The SCOPE-CM Executive Panel (SEP) will be established to monitor, evaluate and guide the network. The Executive Panel will be composed of the SCOPE-CM CENTRE Managers, representatives of WMO and GCOS as full members, as well as representatives of CGMS/GSICS and CEOS as associated members to assure communication and coordination between the initiatives.

The SEP will be supported by two working groups: The SCOPE Scientific Advisory Group (SSAG) will identify and coordinate necessary research activities within the network. The SSAG will inform the SEP on relevant scientific issues and recommend related decisions to be taken by the SEP as appropriate. The SCOPE Data Working Group (SDWG) will coordinate activities related to the availability and quality of data necessary to produce the FCDRs and ECV satellite products. The SDWG will recommend related decisions to be taken by SEP as appropriate. Furthermore, the SDWG will assist the SCOPE-CM global network with their data management activities.

4.3. SCOPE-CM Secretariat

The Global Network of SCOPE-CM will include a Secretariat, tasked with the overall coordination and management of SCOPE-CM Network activities. It is expected that the Secretariat would be hosted by one of the SCOPE-CM centres.

The Secretariat will coordinate and support SCOPE-CM network activities. It will provide a coherent information system on available SCOPE-CM network products, related meta data and documentation. It will act for the SEP as a secretariat supporting the preparations of reports, the organisation of meetings/workshops and the evaluation of SCOPE-CM achievements.

Figure 2 provides a schematic overview of the organisational structure of the global SCOPE-CM network and its reporting/decision relationships.

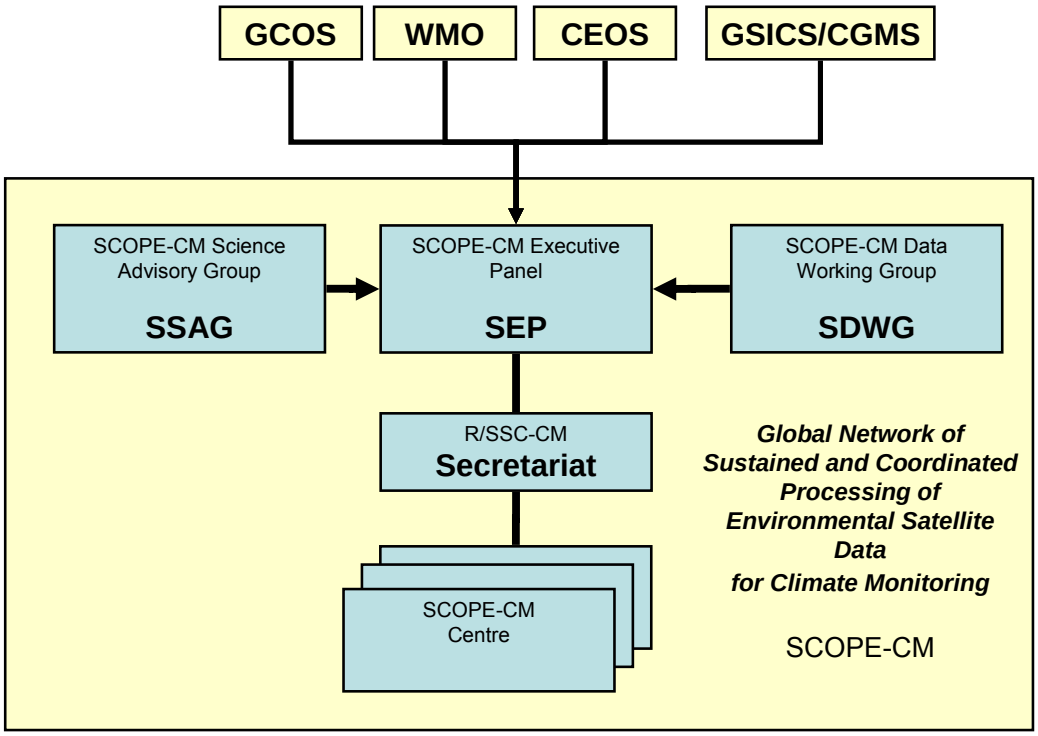

Figure 2: Schematic Organizational Structure of the SCOPE-CM Global Network

5. Timeframe and Phasing

The implementation of the global SCOPE-CM network will be approached in three phases:

PHASE I (2008-2010) will focus on the following activities and events:

- establishment of the initial network and structure, including governance, and terms and conditions for all SCOPE-CM Centres
- assessment of the current satellite climate monitoring capabilities
- agreement on principles and standards
- first workshop focussed on the assessment of capabilities and related research activities
- establishment of feedback mechanisms for stakeholders and scientists
- first assignment of responsibilities to SCOPE-CM centres.

PHASE II (2010-2012) will focus on the following activities and events:

- establishment of structures for sustainable generation of FCDRs and ECV Satellite Products.
- generation of first SCOPE-CM products including validation and data set assessment activities
- set up user services
- increased coverage of products in terms of ECVs, time and spatial dimension.
- fostering extension of the network

PHASE III (from 2012) will focus on:

- full deployment of the sustained system of product generation
- certification of products
- continuous product improvement

6. Implementation tasks

6.1. Establishment of network structure and components

No.	*Task*	*Implementer*	*Phase*
1.1	Nominate an interim Secretariat	WMO	I
1.2	Establish the process for designating SCOPE-CM Centres	WMO	I
1.3	Prepare and issue a first Call for participation	WMO	I
1.4	Propose initial SCOPE-CM	WMO	I
1.5	Confirm initial SCOPE-CM	SEP	I
1.6	Nomination of the Manager for each SCOPE-CM Centre	SCOPE-CM centres	I
1.7	Establish the SCOPE-CM Executive Panel (SEP): (membership: Centre Managers, representatives from WMO, GCOS and CEOS, CGMS/GSICS)	WMO	I
1.8	Confirm SCOPE-CM Secretariat	SEP	I
1.9	Establish the SCOPE-CM Scientific Advisory Group SSAG (membership: key scientists of the individual centres, GSICS Research Working Group representative)	SEP	I
1.10	Establish the SCOPE-CM Data Working Group SDWG (membership: relevant experts of the individual centres, GSICS Data Working Group representative)	SEP	I

6.2. Network Management

6.2.1. Network Coordination and Monitoring

No.	*Task*	*Implementer*	*Phase*
2.1	Assume coordination and management of SCOPE-CM activities	Secretariat	I
2.2	Assume monitoring of the SCOPE-CM activities	Secretariat	I
2.3	Oversee and evaluate the SCOPE-CM activities and provide feedback and guidance	SEP	I
2.4	Exchange of information, data and algorithms within the Network	Secretariat, SDWG, SSAG	II
2.5	Organise regular meetings of SEP, SDWG and SSAG	Secretariat	I
2.6	Organise biennial international workshops to review and discuss research progress (potentially together with GSICS or other conferences workshops)	WMO	I
2.7	Establish mechanism where scientists, and stakeholders (climate community, GCOS) provide feedback	SEP, GCOS	I

6.2.2. Supervision and Decision making

No.	*Task*	*Implementer*	*Phase*
2.8	Agree on principles and standards for SCOPE-CM products, e.g., data set generation, documentation, quality indicators, format, projections, etc.	SEP	I
2.9	Establish and update the list of targeted FCDRs and related ECV satellite products and related requirements and assign priorities taking into account existing capabilities within the network.	SEP, GCOS	I
2.10	Appoint individual centres to take the lead for the generation and provision of specific FCDRs and ECV satellite products according to the established list with contributions and support of the other centres.	SEP	I-II
2.11	Oversee the process of creating FCDRs and ECV satellite products	SEP	I
2.12	Review and oversee the utility and acceptance of FCDRs and ECV satellite products	SEP	II
2.13	Provide guidance for the generation of SCOPE-CM CENTRE ECV satellite products meeting GCOS requirements.	GCOS	II-III

6.2.3. SCOPE-CM Network Development

A detailed assessment of the current capabilities of existing satellite climate monitoring facilities will be the basis for a plan to distribute the responsibility for the processing of ECV satellite products to the existing entities. Such entities would then be proposed to the Executive Panel to be designated as Regional Specialized Satellite Centres for Climate Monitoring committed to particular development, processing and archiving activities.

The extension of the initial Global Network of Centres should be fostered according to the identified gaps in the coverage of the existing activities.

No.	*Task*	*Implementer*	*Phase*
2.14	Assess the current capabilities of existing satellite climate monitoring activities which directly contribute to the GCOS ECV satellite products	SSAG	I
2.15	Designating SCOPE-CM Centres and fostering the extension of the initial Global Network of Centres	WMO	I-II

6.3. Coordination of Research and Development

No.	*Task*	*Implementer*	*Phase*
3.1	Coordination and discussion of necessary research activities at SCOPE-CM centres	SSAG	I
3.2	Conduct necessary research for continuously improving algorithms and products.	SCOPE-CM centres	I
3.3	Develop new algorithms filling gaps in the ECV satellite products coverage of the Network	SCOPE-CM centres	II
3.4	Conduct validation and inter-comparison studies	SCOPE-CM centres	II
3.5	Conduct studies on scientific interpretation and consistency of the products	SCOPE-CM centres	II
3.6	Present and discuss research progress at annual international workshops (potentially together with GSICS workshops)	SCOPE-CM centres	I

6.4. Data Availability and Quality

No.	*Task*	*Implementer*	*Phase*
4.1	Assess sensor data availability and quality (Level 0 – 1) for the generation of FCDRs and ECV satellite products	SDWG	I
4.2	Retrieve information from GSICS on sensor characterisation (calibration) and inter-calibration performance and identify potential gaps	SDWG	I-III
4.3	Interface with GSICS on the generation of fundamental climate data records	SDWG	I-III
4.4	Ensure efficient access of relevant FCDRs for GCOS ECV satellite products generation.	SDWG	I-III

6.5. Product Generation

6.5.1. Generation of Fundamental Climate Data Records

The essential pre-requisite for the ECV satellite product generation is the availability of "Fundamental Climate Data Records (FCDR)", which will be addressed by the collaborative effort of the Global Space-based Inter-calibration System (GSICS) and SCOPE-CM. The product generation should focus on the use of those FCDRs, which benefits from the GSICS efforts.

The SCOPE-CM activities will include processing of data from operational as well as research and development satellite systems.

No.	Task	Implementer	Phase
5.1	Generate FCDRs with the highest possible validated accuracy and stability as the basis for ECV satellite products in close coordination with GSICS activities	SCOPE-CM centres	I-III
5.2	Reprocessing of FCDRs as new information and improved algorithms are available and/or to support model based reanalysis, while maintaining the forward processing of data.	SCOPE-CM centres	II – III
5.3	Make data, meta-data and documentation widely available	SCOPE-CM centres	I –III

6.5.2. Generation of GCOS ECV satellite products

No.	Task	Implementer	Phase
5.4	Generate GCOS ECV satellite products with the highest possible validated accuracy and stability	SCOPE-CM centres	II– III
5.5	Reprocessing of GCOS ECV satellite products as new information and improved algorithms are available and/or to support/complement model based reanalysis.	SCOPE-CM centres	II – III
5.6	Make meta data, generated products and documentation widely available.	SCOPE-CM centres	II – III

6.6. Creation and Maintenance of User Services

No.	Task	Implementer	Phase
6.1	Create a web site for information on the SCOPE-CM Network, its status, plans and data access.	Secretariat	I
6.2	Provide coherent information system on available products, related meta data and documentation	Secretariat	I
6.3	Generate documentation of algorithms, datasets and validation results	SCOPE-CM centres	II
6.4	User support for specific GCOS ECV satellite products	Relevant Lead SCOPE-CM	III
6.5	Support training activities	WMO	III
6.6	Advertise the products of the SCOPE-CM Network to the relevant communities	all	II-III

7. List of Acronyms

CBS	WMO Commission for Basic Systems
CEOS	Committee on Earth Observation Satellites
CGMS	Coordination Group for Meteorological Satellites
CM	WMO Consultative Meetings on High-level Policy on Satellite Matters
CMA	China Meteorological Administration
ECV	Essential Climate Variable
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAO	Food and Agriculture Organization of the United Nations
FCDR	Fundamental Climate Data Record
GCMP	GCOS Climate Monitoring Principles
GCOS	Global Climate Observing System
GEO	Group on Earth Observation
GIP	Implementation Plan for the Global Climate Observing System in support of the UNFCCC (GCOS Implementation Plan)
GOS	Global Observing System
GSICS	Global Space-based Inter-calibration System
IPCC	Intergovernmental Panel on Climate Change
ICSU	International Council for Science
IOC	Intergovernmental Oceanographic Commission
JMA	Japan Meteorological Agency
NOAA	National Oceanic and Atmospheric Administration
R/SSC-CM	Regional/Specialized Satellite Centres for Climate Monitoring
RCC	Regional Climate Centres
RSMC	Regional/Specialized Meteorological Centres
SAF	EUMETSAT Satellite Application Facility
SBSTA	UNFCCC Subsidiary Body for Scientific and Technological Advice
SCOPE-CM	Sustained and Coordinated Processing of Environmental Satellite Data for Climate Monitoring
SDWG	SCOPE-CM Data Working Group
SEP	SCOPE-CM Executive Panel
SSAG	SCOPE-CM Scientific Advisory Group
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization
WWW	World Weather Watch

8. Definitions of terms

Fundamental Climate Data Record:

The term “Fundamental Climate Data Record” (FCDR) is used to denote a long-term satellite data record, involving a series of instruments, with potentially changing measurement approaches, but with overlaps and calibrations sufficient to allow the generation of homogeneous products providing a measure of the independent variable that is accurate and stable enough for climate monitoring. FCDRs include the ancillary data used to calibrate them.

Thematic Climate Data Record:

Thematic Climate Data Records (TCDR) are geophysical variables derived from the FCDRs, specific to various disciplines, and often generated by blending satellite observations, in situ data, and model output.

Essential Climate Variables:

Essential Climate Variables (ECVs) are variables that are currently feasible for global implementation for the global climate observing system, and have high impact on the UNFCCC and IPCC requirements.

Essential Climate Variable satellite products (ECV satellite products)

In the context of this document, the ECV satellite product are those 35 TCDRs, that are identified in the GIP Satellite Supplement as priority products based on satellite observations.

9. References

[1] Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC April, 2003, GCOS-82 (WMO/TD No. 1143) (available through www.wmo.int/pages/prog/gcos/)

[2] Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC, October 2004, GCOS – 92 (WMO/TD No. 1219) (available through www.wmo.int/pages/prog/gcos/)

[3] Systematic Observation Requirements for Satellite-based Products for Climate, Supplemental details to the satellite-based component of the “Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC”, September 2006, GCOS-107 (WMO/TD No. 1338) (available through www.wmo.int/pages/prog/gcos)

[4] GSICS Implementation Plan (available through www.wmo.int/pages/prog/gcos/)

[5] Final Report Consultative Meetings on High-Level Policy on Satellite Matters, Sixth Session, Buenos Aires, Argentina, 16-17 January 2006

[6] Satellite Observation of the Climate System: The Committee on Earth Observation Satellites (CEOS) Response to the Global Climate Observing System (GCOS) Implementation Plan (IP), September 2006 (available through www.ceos.org)

[7] Final Report Consultative Meetings on High-Level Policy on Satellite Matters, Seventh Session, Geneva, Switzerland, 19-20 January 2007

[8] Concept for the Global Network of Regional Specialized Satellite Centres (R/SSC) for Climate Monitoring (1st Workshop 15 – 16 March 2007 at EUMETSAT in Darmstadt)

Annex 1 Terms of Reference

A.1.1 Terms of Reference SCOPE-CM Executive Panel

1. Provide overall guidance for the Global Network of SCOPE-CM centres

2. Oversee and assess the performance of the SCOPE-CM, including the activities of the SCOPE-CM Secretariat, the individual SCOPE-CM centres, the SCOPE-CM Scientific Advisory Group (SSAG) and the SCOPE-CM Data Working Group (SDWG)

3. Agree on principles and standards for SCOPE-CM products upon proposals from SSAG or SDWG.

4. Approve the list of targeted FCDRs and related ECV satellite products and its updates and assign priorities taking into account existing capabilities within the network, user needs and maturity.

5. Appoint individual centres to take the lead for the generation and provision of specific FCDRs and ECV satellite products according to the established list with contributions and support of the other centres

6. Nominate the chairpersons of the SSAG and SDWG among the designated members of these groups

7. Report to WMO Space Programme, on the status and accomplishments of the SCOPE-CM

8. Organize workshops and sessions at scientific meetings to advance the objectives of SCOPE-CM and publicize the program's achievements

9. Develop and implement mechanisms for obtaining feedback from users of SCOPE-CM deliverables

10. Review and oversee the utility and acceptance of FCDRs and ECV satellite products by the climate community

11. Ensure coordination with related initiatives and programs

12. Approve the SCOPE-CM Annual Work Plan

13. Maintain the SCOPE-CM Implementation Plan

14. Agree on the rules of procedure of the SEP

A.1.2 Terms of Reference SCOPE-CM Scientific Advisory Group (SSAG)

1. Identify and coordinate necessary research activities within the SCOPE-CM Network
2. Ensure and facilitate the agreed upon exchange of information, data and algorithms
3. Review the overall scientific maturity and quality of the generation of SCOPE-CM Fundamental Climate Data Records and GCOS ECV Satellite Products, and to provide recommendations and advice to the SCOPE-CM Executive Panel.
4. Review the SCOPE-CM research activities.
5. Recommend to the SCOPE-CM Executive Panel topics for scientific workshops and sessions at scientific meetings to advance the objectives of SCOPE-CM
6. Convene at least annually and more frequently if appropriate.
7. Provide the SCOPE-CM Executive Panel with a report on SCOPE-CM research activities, accomplishments and plans, including recommendations as appropriate.

A.1.3 Terms of Reference SCOPE-CM Data Working Group SDWG

1. Assess the sensor data availability and quality (Level 0-1) for the generation of SCOPE-CM Fundamental Climate Data Records and GCOS ECV Satellite Products, including related data policies
2. Specify formats and procedures for exchange of data between the satellite agencies, the SCOPE-CM centres, and the SCOPE-CM Secretariat
3. Oversee and coordinate the data management activities of the SCOPE-CM
4. Ensure and facilitate the efficient access of relevant FCDRs for GCOS ECV satellite products generation.
5. Establish and maintain cooperation with the research programs at the SCOPE-CM centres and assist with their (input) data management activities, as appropriate
6. Convene at least annually and more frequently if appropriate.
7. Provide the SCOPE-CM Executive Panel with a report on SCOPE-CM data management activities including recommendations as appropriate.
8. Propose to SCOPE-CM Executive Panel standards of formats, projections of SCOPE-CM products

Annex 2 GCOS Climate Monitoring Principles (GCMPs)

Effective monitoring systems for climate should adhere to the following principles [1]:

1. The impact of new systems or changes to existing systems should be assessed prior to implementation.

2. A suitable period of overlap for new and old observing systems is required.

3. The details and history of local conditions, instruments, operating procedures, data processing algorithms and other factors pertinent to interpreting data (i.e., metadata) should be documented and treated with the same care as the data themselves.

4. The quality and homogeneity of data should be regularly assessed as a part of routine operations.

5. Consideration of the needs for environmental and climate-monitoring products and assessments, such as IPCC assessments, should be integrated into national, regional and global observing priorities.

6. Operation of historically-uninterrupted stations and observing systems should be maintained.

7. High priority for additional observations should be focused on data-poor regions, poorly-observed parameters, regions sensitive to change, and key measurements with inadequate temporal resolution.

8. Long-term requirements, including appropriate sampling frequencies, should be specified to network designers, operators and instrument engineers at the outset of system design and implementation.

9. The conversion of research observing systems to long-term operations in a carefully-planned manner should be promoted.

10. Data management systems that facilitate access, use and interpretation of data and products should be included as essential elements of climate monitoring systems.

Furthermore, operators of satellite systems for monitoring climate need to:

(a) Take steps to make radiance calibration, calibration-monitoring and satellite-to-satellite cross-calibration of the full operational constellation a part of the operational satellite system; and

(b) Take steps to sample the Earth system in such a way that climate-relevant (diurnal, seasonal, and long-term interannual) changes can be resolved.

Thus satellite systems for climate monitoring should adhere to the following specific principles:

1 The 10 basic principles (in paraphrased form) were adopted by the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) through decision 5/CP.5 at COP-5 in November 1999. This complete set of principles was adopted by the Congress of the World Meteorological Organization (WMO) through Resolution 9 (Cg-XIV) in May 2003; agreed by the Committee on Earth Observation Satellites (CEOS) at its 17th Plenary in November 2003; and adopted by COP through decision 11/CP.9 at COP-9 in December 2003.

11. Constant sampling within the diurnal cycle (minimizing the effects of orbital decay and orbit drift) should be maintained.

12. A suitable period of overlap for new and old satellite systems should be ensured for a period adequate to determine inter-satellite biases and maintain the homogeneity and consistency of time-series observations.

13. Continuity of satellite measurements (i.e. elimination of gaps in the long-term record) through appropriate launch and orbital strategies should be ensured.

14. Rigorous pre-launch instrument characterization and calibration, including radiance confirmation against an international radiance scale provided by a national metrology institute, should be ensured.

15. On-board calibration adequate for climate system observations should be ensured and associated instrument characteristics monitored.

16. Operational production of priority climate products should be sustained and peer-reviewed new products should be introduced as appropriate.

17. Data systems needed to facilitate user access to climate products, metadata and raw data, including key data for delayed-mode analysis, should be established and maintained.

18. Use of functioning baseline instruments that meet the calibration and stability requirements stated above should be maintained for as long as possible, even when these exist on de-commissioned satellites.

19. Complementary in situ baseline observations for satellite measurements should be maintained through appropriate activities and cooperation.

20. Random errors and time-dependent biases in satellite observations and derived products should be identified.

Annex 3 GCOS Essential Climate Variables [2]

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: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour. Upper-air: Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties. Composition: Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases [3], Aerosol properties.
Oceanic	Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure. Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.
Terrestrial [4]	River discharge, Water use, Ground water, Lake levels, Snow cover, Glaciers and ice caps, Permafrost and seasonally-frozen ground, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI), Biomass, Fire disturbance.

2 The Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC, GCOS-82, April 2003 (WMO/TD No. 1143).

3 Including nitrous oxide (N_2O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF_6), and perfluorocarbons (PFCs).

4 Includes runoff ($m^3\ s^{-1}$), groundwater extraction rates ($m^3\ yr^{-1}$) and location, snow cover extent (km^2) and duration, snow depth (cm), glacier/ice cap inventory and mass balance (kg $m^{-2}\ yr^{-1}$), glacier length (m), ice sheet mass balance (kg $m^{-2}\ yr^{-1}$) and extent (km^2), permafrost extent (km^2), temperature profiles and active layer thickness, above ground biomass (t/ha), burnt area (ha), date and location of active fire, burn efficiency (%vegetation burned/unit area).

Annex 4 GCOS ECVs largely dependent upon satellite observations [5]

Domain	***Essential Climate Variables***
Atmospheric (over land, sea and ice)	Precipitation, Earth radiation budget (including solar irradiance), Upper-air temperature, Wind speed and direction, Water vapour; Cloud properties, Carbon dioxide, Ozone, Aerosol properties.
Oceanic	Sea-surface temperature, Sea level, Sea ice, Ocean colour (for biological activity), Sea state*, Ocean salinity*.
Terrestrial	Lakes*, Snow cover, Glaciers and ice caps, Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (fAPAR), Leaf area index (LAI)*, Biomass*, Fire disturbance, Soil moisture*.

5 Based on the GIP [2] and covering all ECVs considered in [3]. ECVs denoted with an asterisk (*) were not included in the original table in the GIP. Note that soil moisture was not listed in the GIP as an ECV, but was recognized as an emerging ECV and has been included here.

Annex 5 GCOS ECV Satellite Products

The tables in this annex present the list of the 35 products that are recommended by GCOS in the atmospheric, ocean and terrestrial domain in the GIP Satellite Supplement [3]. The generation of these global satellite products is the ultimate target of the SCOPE-CM.

Table 1: ECV satellite products: Atmosphere

ECV	***Global products requiring satellite observation***	***Fundamental Climate Data Records required for product generation (from past, current and future missions)***	***Product numbers (in [3])***
Surface Wind Speed and Direction	Surface vector winds analyses, particularly from reanalysis	Passive microwave radiances and scatterometry	A.1
Upper-air Temperature	Extended MSU-equivalent temperature record	Passive microwave radiances	A.2.1
	New record for upper-troposphere and lower-stratosphere temperature using data from radio occultation	GPS radio occultation; High-spectral resolution	A.2.2
	Temperature analyses obtained from reanalyses	IR radiances for use in reanalysis	A.2.3
Water Vapour	Total column water vapour over the ocean and over land	Passive microwave radiances; UV/VIS radiances;	A.3.1
	Troposphere and lower-stratosphere profiles of water vapour	IR imagery and soundings in the 6.7 □m band; Microwave soundings in the 183 GHz band	A.3.2
Cloud properties	Cloud radiative properties (initially key ISCCP products) • Cloud cover • Cloud ice profile (total column) • Cloud water profile (total column) • Could top height • Cloud top temperature	VIS/IR imagery; IR and microwave soundings	A.4

ECV	***Global products requiring satellite observation***	***Fundamental Climate Data Records required for product generation (from past, current and future missions)***	***Product numbers (in [3])***
precipitation	Improved estimates of precipitation, both: • as derived from specific satellite instruments and • as provided by composite products	Passive microwave radiances; High-frequency geostationary IR measurements; Active radar (for calibration)	A.5
Earth Radiation Budget	Top-of-atmosphere Earth radiation budget on a continuous basis	Broadband radiances; Spectrally-resolved solar irradiances; Geostationary multi-spectral imagery	A.6
Ozone	Profiles and total column of ozone	UV/VIS IR/microwave radiances	A.7
Aerosol properties	Aerosol optical depth and Single scattering albedo	VIS/NIR/SWIR radiances	A.8
Carbon Dioxide, Methane and other GHGs	Distribution of greenhouse gases, such as CO2 and CH4, of sufficient quality to estimate regional sources and sinks	NIR/IR radiances	A.9
Upper-air Wind	Upper-air wind analyses, particularly from reanalysis	VIS/IR imagery; Doppler wind lidar	A.10

Table 2: ECV satellite products: Oceans

ECV	***Global products requiring satellite observation***	***Fundamental Climate Data Records required for product generation (from past, current and future missions)***	***Product numbers (GCOS IP Reference Actions)***
Sea ice	Sea ice concentration	Microwave and visible imagery	O.1
Sea Level	Sea level and variability of its global mean	Altimetry	O.2
Sea Surface Temperature	Sea-surface temperature	Single and multi-view IR and microwave imagery	O.3
Ocean colour	Ocean colour chlorophyll-a concentration derived from ocean colour	Multi-spectral VIS imagery	O.4
Sea State	Wave height and other measures of sea state (wave direction, wavelength, time period)	Altimetry	O.5
Ocean Salinity	Research towards the measurement of changes in sea-surface salinity	Microwave radiances	O.6

Table 2: ECV satellite products: Terrestrial

ECV	*Global products requiring satellite observation*	*Fundamental Climate Data Records required for product generation (from past, current and future missions)*	*Product numbers (GCOS IP Reference Actions)*
Lakes	Maps of lakes; for lakes in the Global Terrestrial Network for Lakes (GTN-L)	VIS/NIR imagery, and radar imagery	T.1.1
	Lake levels for lakes in the GTN-L	Altimetry	T.1.2
	Surface temperatures of lakes in the GTN-L	High-resolution IR imagery	T.1.3
Glaciers and Ice Caps	Maps of the areas covered by glaciers other than ice sheets	High-resolution VIS/NIR/SWIR optical imagery;	T.2.1
	Ice-sheet elevation changes for mass-balance determination	Altimetry	T.2.2
Snow Cover	Snow areal extent	Moderate-resolution VIS/NIR/IR and passive microwave imagery	T.3
Albedo	Directional-hemispherical (black sky) albedo	Multi-spectral and broadband imagery	T.4
Land Cover	Moderate-resolution maps of land-cover type; High-resolution maps of land-cover type, for the detection of land-cover change	Moderate-resolution multi-spectral VIS/NIR imagery;	T.5.1
	High-resolution maps of land-cover type, for the detection of land-cover change	High-resolution multi-spectral VIS/NIR imagery	T.5.2
	Land-surface temperature, in conjunction with land cover type	*High-resolution IR radiances*	*Supporting product to T.5.1. and T.5.2*
fAPAR	Maps of fraction of Absorbed Photosynthetically active radiation (fAPAR)	VIS/NIR imagery	T.6
LAI	Maps of Leaf Area Index (LAI)	VIS/NIR imagery	T.7
Biomass	Research towards global, above-ground forest biomass and forest-biomass change	L band / P band SAR; Laser altimetry	T.8

ECV	***Global products requiring satellite observation***	***Fundamental Climate Data Records required for product generation (from past, current and future missions)***	***Product numbers (GCOS IP Reference Actions)***
Fire Disturbance	Burnt area	VIS/NIR/SWIR/TIR moderate-resolution multi-spectral imagery	T.9
	Active-fire maps	*VIS/NIR/SWIR/TIR moderate-resolution multi-spectral imagery*	*Supplementing product to T.9*
	fire-radiated power (FRP)	*VIS/NIR/SWIR/TIR moderate-resolution multi-spectral imagery*	*Supplementing product to T.9*
Soil Moisture	Research towards global near-surface soil-moisture map (up to 10cm soil depth)	Active and passive microwave	T.10