

## REGIONAL / SPECIALIZED SATELLITE CENTRES FOR CLIMATE MONITORING

This document describes the background to the R/SSC concept with reference to the associated discussions at CM-6 and CM-7.

The paper goes on to describe progress since CM-7, highlighting the actions taken by the participating agencies to refine the concept and develop an agreed Implementation Plan. CGMS will note that it is the intention to finalize that Implementation Plan at the meeting of the Participating Agencies at their meeting immediately following CGMS-35.

The views of ET-SUP, expressed at their September 2007 meeting, are detailed and the attention of CGMS is drawn to the proposals made to slightly amend the structure of the governance of the activity in addition to the significant proposal for CGMS to establish a new international science working group on the theme of climate and calibration.

The latest version of the Implementation Plan (v0.4) is included for information as an Annex.

## **REGIONAL / SPECIALIZED CENTRES FOR CLIMATE MONITORING**

### **1 BACKGROUND AND INTRODUCTION**

The concept of Regional / Specialized Satellite Centres (R/SSC) was first discussed at CM-6 in January 2006. It was considered by ET-SUP at its second session in September 2006 where the group noted that it had the potential to improve the quality and quantity of products available to WMO Members and further noted this to be particularly relevant to emerging areas such as climate monitoring. ET-SUP concluded that the concept should be further developed.

Further discussions took place at CM-7 in January 2007 where EUMETSAT presented a proposal for a high level concept of a global network of Regional / Specialized Satellite Centres as specific Centres of Excellence on the thematic area of operational climate monitoring (R/SSC-CM). An important feature of the network was that it would be largely based on, and would exploit, existing infrastructure and activities. It would utilize data from both environmental R&D satellites as well as operational meteorological ones and would take benefit from the operational activities of the Global Space-based Inter-calibration System (GSICS).

CM-7 agreed that the overall goal of a global network of R/SSC-CM would be the sustained and operational provision of high quality products relevant to the Essential Climate Variables (ECV) on a global scale and hence would directly address the requirements of the Global Climate Observing System (GCOS) as specified in the GCOS Implementation Plan and its Satellite Supplement.

A timetable towards the development and approval of an Implementation Plan for the R/SSC-CM network was presented. This included one workshop to further elaborate and refine the concept and two meetings of potential participants to assess the contributions of interested partners, and develop and finalize the Implementation Plan.

CM-7 strongly urged all participants to work towards the development and approval of an Implementation Plan in time for the GEO Ministerial Summit in November 2007.

### **2 R/SSC-CM CONCEPT WORKSHOP**

In line with the timetable agreed at CM-7, a workshop was convened by WMO on 15-16 March 2007, hosted by EUMETSAT. The meeting participants included CEOS, CMA, DWD, ESA, EUMETSAT, GCOS, JMA, NOAA-NESDIS, and WMO.

At the workshop the participants:

- Assessed existing climate monitoring activities and operational services in terms of products and coverage and identified potential initial contributions to a R/SSC-CM network;
- Identified actions to develop and finalize an Implementation Plan and clarified the various roles of possible contributors to a global network and its potential components;

- Refined the original concept as presented to CM-7 with a more elaborated technical and organizational structure to be used as the basis for the preparation of the Implementation Plan, a draft outline of which should be available for a first potential participants meeting to be held in spring 2007, with the finalized version available thereafter, for approval by November 2007.

In refining the concept, the workshop identified the following main tasks for the global network of the R/SSC-CM, which would include various Regional / Specialized Centres and an R/SSC-CM Coordination Centre (or Secretariat):

- 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;
- Deliver the products and meta data in agreed formats;
- Conduct validation and inter-comparison studies;
- Conduct necessary research for continuously improving algorithms and the scientific interpretation of products (Scientific Stewardship) and to develop new products filling gaps,
- Contribute to reanalysis and reprocessing of historical satellite data records;
- Generate documentation of algorithms, datasets and validation results;
- Provide user services and training;
- Support the overall R/SSC-CM Network management.

The workshop also noted that cooperation and coordination activities within the Global Network should include:

- Exchange of information, data and algorithms among the centres and with users;
- Standardization (formats, projections, definitions);
- Archiving and dissemination (distributed archive, centralized archive of meta data);
- Interaction with other bodies (most importantly with the WMO Space Programme, GCOS, GSICS, satellite operators, research institutes);
- Involvement of users (end-users, climate research community);
- Capacity building.

Furthermore, the following benefits and added value were expected:

- Monitoring the evolving coverage in terms of space and climate relevant parameters (ECVs);
- Facilitated identification of gaps and mechanism to close them;
- Effective generation of 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 on product quality;
- Exploiting to a maximum the existing expertise and infrastructures through a synergetic approach;
- Coordination of reprocessing and reanalysis activities;
- Combined efforts to achieve global coverage;
- Consistency and high quality of derived climate products, through inter-comparison and joint development;
- 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;
- Facilitated cost-effective exploitation by ensuring responsibilities and activities are distributed in the most appropriate way.

The participating satellite operators (CMA, EUMETSAT, JMA and NOAA) expressed their willingness to contribute to the setup of the R/SSC-CM global network and indicated the following as a potential initial contribution in terms of ECV satellite products:

ECV <sup>(1)</sup> satellite product	Related FCDR <sup>(2)</sup>
Upper-air temperature	IR/microwave sounding
Water vapour	Passive microwave
Cloud properties	VIS/IR imagery
Sea ice concentration	Microwave/VIS imagery
Sea surface temperature	IR/Microwave imagery
Albedo	VIS/IR imagery

<sup>(1)</sup>ECV=Essential Climate Variable

<sup>(2)</sup>FCDR=Fundamental Climate Data Records

Following the workshop the draft outline of an Implementation Plan was produced by EUMETSAT and circulated to participants.

### 3 FIRST POTENTIAL PARTICIPANTS MEETING

A first meeting of R/SSC-CM potential participants was convened by WMO on 16 May 2007 in Geneva, during the Fifteenth WMO Congress. The meeting focussed on the draft outline of an Implementation Plan and the schedule of activities culminating in an approved Implementation Plan by November 2007.

The draft Implementation Plan was then updated by EUMETSAT, taking account of comments and suggestions made at the First Potential Participants Meeting, and issued on 17 August 2007. The plan details the tasks of the R/SSC-CM Centres and

the Coordination Centre (or Secretariat) and proposes a stepwise implementation in three phases: (i) 2008-2010, (ii) 2010-2012 and (iii) beyond 2012. The current version of the Implementation Plan (v0.4) is attached in the Annex.

#### **4 SECOND POTENTIAL PARTICIPANTS MEETING**

A second R/SSC-CM potential participants meeting will take place immediately after CGMS-35 and will focus on finalizing the Implementation Plan, assessing the initial contributions of the respective partners and securing their commitment.

Subject to finalization of the Implementation Plan, the R/SSC-CM is expected to be progressively implemented from 2008 onwards and to deliver first products from 2010 onwards.

#### **5 VIEWS OF ET-SUP**

At their third session in September 2007, ET-SUP reviewed the evolution of the concept of Regional / Specialized Satellite Centres (R/SSC) and noted the progress of the R/SSC-CM through its Implementation Plan.

In reviewing the Implementation Plan, ET-SUP noted that the proposed structure was building on existing centres and expertise, and, whilst there was a strong management and governance structure, it was noted that the overhead expenses of this structure would be covered by the existing centres.

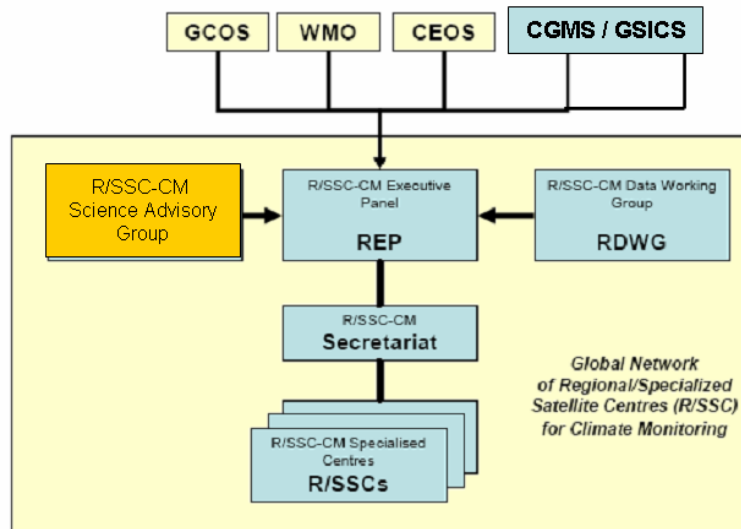
ET-SUP considered it important that acronyms are used consistently; WMO have previously been using "RSSC-CM" whilst the Implementation Plan uses "R/SSC-CM", at the suggestion of the participating agencies.

In supporting the proposed Implementation Plan, ET-SUP recommended the following two changes to the existing Schematic Organizational Structure of the R/SSC-CM network:

- Replace "GSICS" with "CGMS/GSICS" to maintain the same level of representation with the other organizations;
- Rename the R/SSC-CM Research Group (RRWG) to the R/SSC-CM Science Advisory Group to better reflect their role.

These changes result in a revised organizational structure as illustrated in the following figure:

## R/SSC-CM Schematic Organisational Structure



In addition to these changes, ET-SUP requested the Chair of OPAG-IO5 to request CGMS to form a new international science working group on the theme of climate monitoring and calibration to provide an open focus for collaboration and coordination on these important topics. The Terms of Reference for the new working group would be compatible with those from ITWG, IPWG and IWWW.

ET-SUP also recommended that point 8 of the Terms of Reference for the R/SSC-CM Executive Panel be reworded to read "Organize workshops on at least a biennial basis, and sessions at scientific meetings to advance the objectives of the R/SSC-CM and publicize the programme's achievements". It is expected that some of these meetings would occur in conjunction with the proposed CGMS climate monitoring and calibration working group.

ET-SUP noted that the original concept of R/SSC was described in generic terms and could be applied to many applications areas. Being the first to be defined, the global network of R/SSC-CM could be considered a "pilot" activity from which experiences can be gained that would feed into considerations for the establishment of further R/SSC addressing other application areas. ET-SUP recalled that, in its work programme as endorsed in 2006 by the extraordinary session of the Commission for Basic Systems (CBS Ext.06), it is expected to "Further the concept of Regional/Specialized Centres on Satellite Products". In considering this topic, the group felt that some time should be allowed to pass in order that lessons may be learned from the implementation of the R/SSC-CM.

The following is a summary of the actions ET-SUP identified from their discussions:

- WMO to forward to the R/SSC participants meeting the following proposals:
  - To replace "GSICS" with "CGMS/GSICS" in order to maintain the same level of representation with the other organizations. Additionally suggest that the CGMS representative on the R/SSC-CM Executive Panel be from GSICS;
  - To use consistent acronyms, either "R/SSC-CM" or "R/SSC-CM";

- To rename the “R/SSC-CM Research Group (RRWG)” to the “R/SSC-CM Science Advisory Group” to better reflect their role;
- To reword point 8 of the Terms of Reference for the R/SSC-CM Executive Panel to “Organize workshops on at least a biennial basis, and sessions at scientific meetings to advance the objectives of the R/SSC-CM and publicize the programme’s achievements”.
- The WMO Space Programme to inform the GSICS Executive Panel, CGMS and the R/SSC-CM potential participants, of these proposals;
- The Chair of OPAG-IOS to invite CGMS to form a new international science working group on the theme of climate monitoring and calibration to provide an open focus for collaboration and coordination on these important topics. The Terms of Reference for the new working group would be compatible with those from ITWG, IPWG and IWWW;
- The Chair of the OPAG-IOS to propose to CBS that two years after the R/SSC-CM commences as a pilot of the R/SSC concept, CBS review the outcomes and benefits of the concept prior to extending it to other areas such as Atmospheric Chemistry.

## **6 CONCLUSIONS**

CGMS members are invited to note the status and plans for the R/SSC-CM and the views of ET-SUP as outlined above. In particular CGMS are invited to consider the ET-SUP proposal for the formation of a new international science working group on the theme of climate monitoring and calibration.

**ANNEX**

**Implementation Plan for the Global Network  
of Regional/Specialized Satellite Centres (R/SSC)  
for Climate Monitoring**

**- Draft -**

Version 0.4

17 August 2007



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## 1. Purpose of this document

This document presents the plan to implement the Global Network of Regional/Specialised Satellite Centres for Climate Monitoring (R/SSC-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 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 Research Working 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, and the WMO is the natural body to coordinate such activities.

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 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 R/SSC-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”* (GCOS Implementation Plan, GIP) [2] was issued, defining priorities and identifying 131 actions necessary to fulfil the GCOS requirements for climate monitoring.

The R/SSC-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)”*

The *“Systematic Observation Requirements for Satellite-based Products for Climate – Supplementary Details to the GCOS Implementation Plan”* (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 6<sup>th</sup> 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 25<sup>th</sup> session of the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA) held in November 2006 in Nairobi. The concept of the global R/SSC-CM network is compliant and complementary to the relevant actions agreed by CEOS.

At the 7<sup>th</sup> 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 R/SSC-CM, which was welcomed by GCOS. 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.

### **3. OBJECTIVES AND BENEFITS**

#### **3.1 Objectives**

The aim of the distributed Global Network of Regional Specialized Satellite Centres for Climate Monitoring (R/SSC-CM) is to achieve the requirements of GCOS in a cost-effective, coordinated manner, capitalising upon the existing expertise and infrastructures.

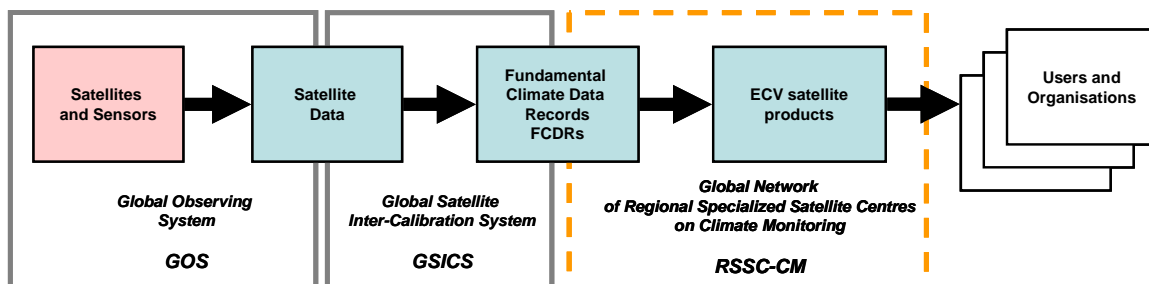
The overall objective of the Global Network of R/SSC-CM is the continuous and sustained provision of high-quality Essential Climate Variables satellite products (see Tables in Annex 4) on a global scale as specified in the GCOS Implementation Plan [2] and its Satellite Supplement [3].

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 GCOS “*Systematic Observation Requirements for Satellite-based Products for Climate*” [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 R/SSC-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 R/SSC-CM Global Network in the context of continuous and sustained climate monitoring with satellite observations (users: GCOS, WMO, IPCC, UNEP, FAO, etc.)**

Figure 1 is a schematic of the activities of the R/SSC-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 R/SSC-CM Network are entities such as WMO, GCOS, IPCC, GEO, UNEP as well as governments and research institutions.

## 3.2 Main functions

Once implemented, the R/SSC-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 and added value is envisaged with the Implementation of the R/SSC-CM:

- Monitoring of the evolving coverage in terms of space and in terms of climate relevant parameters (ECVs),
- Facilitated identification of gaps and mechanism to close them,
- Increased effectiveness in 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 on product quality,
- Maximum exploitation of the existing expertise and infrastructures through a synergetic approach,
- Coordination of reprocessing and reanalysis activities,
- Combined efforts to achieve global coverage,
- Consistent and high quality of derived climate products, through inter-comparison and joint development.
- 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,
- Facilitated cost-effective exploitation by ensuring responsibilities and activities are distributed in the most appropriate way.

## 4. COMPONENTS OF THE GLOBAL NETWORK OF R/SSC-CM

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

### 4.1 R/SSC-CM Centres

The infrastructures 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 R/SSC-CM could be 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 R/SSC-CM would be represented by a R/SSC-CM Manager.

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

It is recognized, that processing and analysis facilities for some climate variables are already in place. Thus, the initial global network will be built upon those existing infrastructures, **linking and coordinating** the activities in order to address **most** effectively the need of GCOS in terms of ECV satellite products.

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 R/SSC-CMs. This could ensure the important cross-checks and confidence level estimates.

Although having a global scope, the R/SSC-CM centres will be part of the regional meteorological infrastructure. The designation of R/SSC-CM would be submitted to the relevant WMO Regional Associations.

#### **4.2 R/SSC-CM Executive Panel (REP)**

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

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

#### **4.3 R/SSC-CM Secretariat**

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

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

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

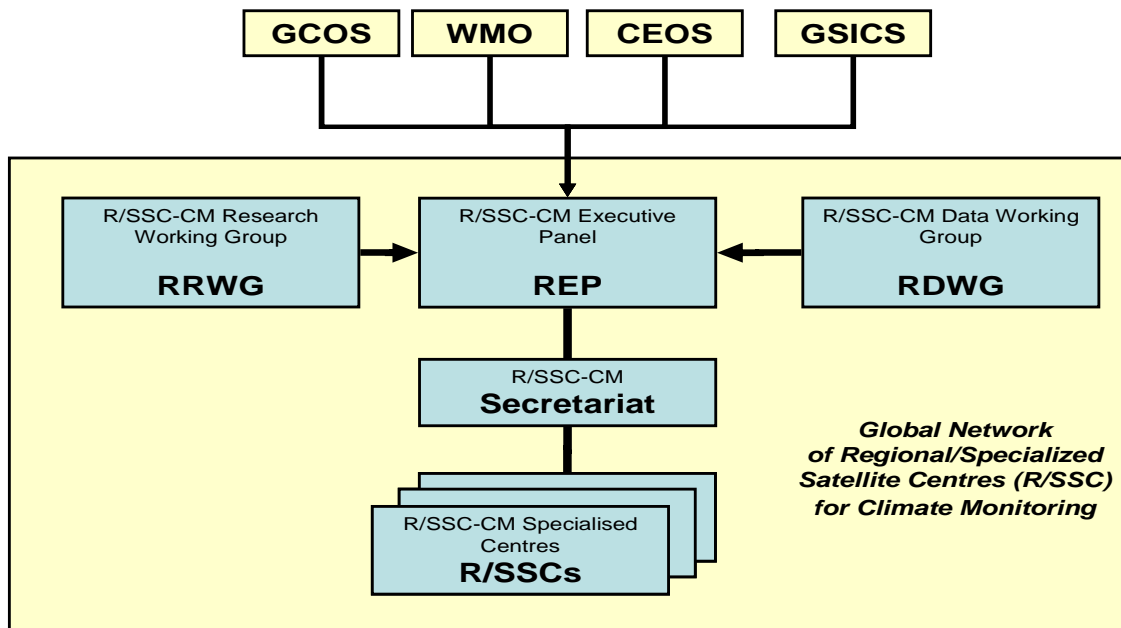


Figure 2: Schematic Organizational Structure of the R/SSC-CM Global Network

## 5. TIMEFRAME AND PHASING

The implementation of the global R/SSC-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
- assessment of the current satellite climate monitoring capabilities
- agreement on principles and standards
- first workshop focussed on the capability assessment and related research activities
- establishment of feedback mechanisms for stakeholders and scientists
- first assignment of responsibilities to R/SSC-CMs, submitted to relevant WMO Regional Associations.

**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 R/SSC-CM products including validation 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 the

- 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

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
1.1	Nominate an interim Secretariat	WMO	I
1.2	Establish the process for designating R/SSC-CM Centres	WMO	I
1.3	Prepare and issue a first Call for participation	WMO	I
1.4	Propose initial R/SSC-CM	WMO	I
1.5	Confirm initial R/SSC-CM	WMO Regional Associations	I
1.6	Nomination of the Centre Manager for each R/SSC-CM	R/SSC-CMs	I
1.7	Establish the R/SSC-CM Executive Panel (REP): (membership: Centre Managers, representatives from WMO, GCOS and CEOS, GSICS [TBC])	WMO	I
1.8	Confirm R/SSC-CM Secretariat	REP	I
1.5	Establish the R/SSC-CM Research Working Group RRWG (membership: key scientists of the individual centres)	REP	I
1.6	Establish the R/SSC-CM Data Working Group RDWG (membership: relevant experts of the individual centres)	REP	I

### 6.2 Network Management

#### 6.2.1 Network Coordination and Monitoring

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
2.1	Assume coordination and management of R/SSC-CM activities	Secretariat	I
2.2	Assume monitoring of the R/SSC-CM activities	Secretariat	I
2.3	Oversee and evaluate the R/SSC-CM activities and provide feedback and guidance	REP	I
2.4	Exchange of information, data and algorithms within the Network	Secretariat, RDWG, RRWG	II
2.5	Organise regular meetings of REP, RDWG and RRWG	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	REP, GCOS	I

#### 6.2.2 Supervision and Decision making

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
2.8	Agree on principles and standards for R/SSC-CM products, e.g., data set generation, documentation, quality indicators, format, projections, etc.	REP	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.	REP, GCOS	I
2.10	Appoint individual centres to take the lead for the generation	REP	I-II



	and provision of specific FCDRs and ECV satellite products according to the established list with contributions and support of the other centres.		
2.11	Oversee the process of creating FCDRs and ECV satellite products	REP	I
2.12	Review and oversee the utility and acceptance of FCDRs and ECV satellite products	REP	II
2.13	Assess the compliance of the R/SSC-CM ECV satellite products with GCOS requirements	GCOS	II

### 6.2.3 R/SSC-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 relevant WMO Regional Associations to be designated as Regional Specialized Satellite Centres for Climate Monitoring by WMO 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.

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
2.14	Assess the current capabilities of existing satellite climate monitoring activities which directly contribute to the GCOS ECV satellite products	RRWG	I
2.15	Designating R/SSC-CM and fostering the extension of the initial Global Network of Centres	WMO	II

### 6.3 Coordination of Research and Development

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

## 6.4 Data Availability and Quality

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
4.1	Assess sensor data availability and quality (Level 0 – 1) for the generation of FCDRs and ECV satellite products	RDWG	I
4.2	Retrieve information from GSICS on sensor characterisation (calibration) and inter-calibration performance and identify potential gaps	RDWG	I-III
4.3	Interface with GSICS on the generation of fundamental climate data records	RDWG	I-III
4.4	Ensure efficient access of relevant FCDRs for GCOS ECV satellite products generation.	RDWG	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 R/SSC-CM. The product generation should focus on the use of those FCDRs, which benefits from the GSICS efforts.

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

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
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	R/SSC-CMs	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.	R/SSC-CMs	II - III
5.3	Make data, meta-data and documentation widely available	R/SSC-CMs	I - III

### 6.5.2 Generation of GCOS ECV satellite products

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
5.4	Generate GCOS ECV satellite products with the highest possible validated accuracy and stability	R/SSC-CMs	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.	R/SSC-CMs	II - III
5.6	Make, meta data, generated products and documentation widely available.	R/SSC-CMs	II - III

## 6.6 Creation and Maintenance of User Services

<i>No.</i>	<i>Task</i>	<i>Implementer</i>	<i>Phase</i>
6.1	Create a web site for information on the R/SSC-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	R/SSC-CMs	II
6.4	User support for specific GCOS ECV satellite products	Relevant Lead R/SSC-CM	III
6.5	Support training activities	WMO	III
6.6	Advertise the products of the R/SSC-CM Network to the relevant communities	all	II-III

## 7. LIST OF ACRONYMS

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
RDWG	R/SSC-CM Data Working Group
REP	R/SSC-CM Executive Panel
RRWG	R/SSC-CM Research Working Group
RSMC	Regional Specialized Meteorological Centres
SAF	EUMETSAT Satellite Application Facility
SBSTA	UNFCCC Subsidiary Body for Scientific and Technological Advice
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 products 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/web/gcos/gcoshome.html](http://www.wmo.int/web/gcos/gcoshome.html))
- [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/web/gcos/gcoshome.html](http://www.wmo.int/web/gcos/gcoshome.html))
- [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/web/gcos/gcoshome.html](http://www.wmo.int/web/gcos/gcoshome.html))
- [4] GSICS Implementation Plan (available through [www.wmo.int/web/gcos/gcoshome.html](http://www.wmo.int/web/gcos/gcoshome.html))
- [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](http://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 R/SSC-CM Executive Panel**

1. Provide overall guidance for the R/SSC-CM
2. Oversee and evaluate the performance of the R/SSC-CM, including the activities of the R/SSC-CM Secretariat, the individual Centres (R/SSC-CMs), R/SSC-CM Research Working Group (RRWG) and the R/SSC-CM Data Working Group (RDWG)
3. Agree on principles and standards for R/SSC-CM products, e.g., data set generation, documentation, quality indicators, format, projections, etc.
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.
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 RRWG and RDWG among the designated members of these groups
7. Report to WMO Space Programme, on the status and accomplishments of the R/SSC-CM
8. Organize workshops and sessions at scientific meetings to advance the objectives of R/SSC-CM and publicize the program's achievements
9. Develop and implement mechanisms for obtaining feedback from users of R/SSC-CM results
10. Review and oversee the utility and acceptance of FCDRs and ECV satellite products
11. Ensure coordination with related initiatives and programs
12. Approve the R/SSC-CM Annual Operating Plan
13. Revise the R/SSC-CM Implementation Plan as necessary
14. Agree on the rules of procedure of the REP

**A.1.2 Terms of Reference R/SSC-CM Research Working Group (RRWG)**

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

**A.1.3 Terms of Reference R/SSC-CM Data Working Group RDWG**

1. Assess the sensor data availability and quality (Level 0-1) for the generation of R/SSC-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 R/SSC-CMs, and the R/SSC-CM Secretariat
3. Oversee and coordinate the data management activities of the R/SSC-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 R/SSC-CMs and assist with their (input) data management activities, as appropriate
6. Convene at least annually and more frequently if appropriate.
7. Provide the R/SSC-CM Executive Panel with a report on R/SSC-CM data management activities including recommendations as appropriate.
8. Propose to R/SSC-CM Executive Panel standards of formats, projections of R/SSC-CM products

*Effective monitoring systems for climate should adhere to the following principles<sup>1</sup>:*

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:*

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.

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<sup>1</sup> 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 17<sup>th</sup> Plenary in November 2003; and adopted by COP through decision 11/CP.9 at COP-9 in December 2003.



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.

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

Domain	Essential Climate Variables
<b>Atmospheric</b> (over land, sea and ice)	<p>Surface: Air temperature, Precipitation, Air pressure, Surface radiation budget, Wind speed and direction, Water vapour.</p> <p>Upper-air: Earth radiation budget (including solar irradiance), Upper-air temperature (including MSU radiances), Wind speed and direction, Water vapour, Cloud properties.</p> <p>Composition: Carbon dioxide, Methane, Ozone, Other long-lived greenhouse gases <sup>3</sup>, Aerosol properties.</p>
<b>Oceanic</b>	<p>Surface: Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Current, Ocean colour (for biological activity), Carbon dioxide partial pressure.</p> <p>Sub-surface: Temperature, Salinity, Current, Nutrients, Carbon, Ocean tracers, Phytoplankton.</p>
<b>Terrestrial</b> <sup>4</sup>	<p>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.</p>

<sup>2</sup> 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).

<sup>3</sup> Including nitrous oxide (N<sub>2</sub>O), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), sulphur hexafluoride (SF<sub>6</sub>), and perfluorocarbons (PFCs).

<sup>4</sup> Includes runoff (m<sup>3</sup> s<sup>-1</sup>), groundwater extraction rates (m<sup>3</sup> yr<sup>-1</sup>) and location, snow cover extent (km<sup>2</sup>) and duration, snow depth (cm), glacier/ice cap inventory and mass balance (kg m<sup>-2</sup> yr<sup>-1</sup>), glacier length (m), ice sheet mass balance (kg m<sup>-2</sup> yr<sup>-1</sup>) and extent (km<sup>2</sup>), permafrost extent (km<sup>2</sup>), 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).

GCOS ECVS LARGELY DEPENDENT UPON SATELLITE  
OBSERVATIONS <sup>5</sup>

<i>Domain</i>	<i>Essential Climate Variables</i>
<b>Atmospheric</b> (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.
<b>Oceanic</b>	Sea-surface temperature, Sea level, Sea ice, Ocean colour (for biological activity), Sea state*, Ocean salinity*.
<b>Terrestrial</b>	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*.

<sup>5</sup> Based on the GIP and covering all ECVs considered in this report. 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 R/SSC-CM.

**Table 1: ECV satellite products: Atmosphere**

<i>ECV</i>	<i>Global products requiring satellite observation</i>	<i>Fundamental Climate Data Records required for product generation (from past, current and future missions)</i>	<i>Product numbers (GCOS IP Reference Actions)</i>	<i>Potential product generator</i>
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 $\mu$ m band; Microwave soundings in the 183 GHz band	A.3.2	
Cloud properties	Cloud radiative properties (initially key ISCCP products) <ul style="list-style-type: none"> <li>• Cloud cover</li> <li>• Cloud ice profile (total column)</li> <li>• Cloud water profile (total column)</li> <li>• Cloud top height</li> <li>• Cloud top temperature</li> </ul>	VIS/IR imagery; IR and microwave soundings	A.4	
precipitation	Improved estimates of precipitation, both:	Passive microwave radiances;	A.5	

<i>ECV</i>	<i>Global products requiring satellite observation</i>	<i>Fundamental Climate Data Records required for product generation (from past, current and future missions)</i>	<i>Product numbers (GCOS IP Reference Actions)</i>	<i>Potential product generator</i>
	<ul style="list-style-type: none"> <li>as derived from specific satellite instruments and</li> <li>as provided by composite products</li> </ul>	High-frequency geostationary IR measurements;  Active radar (for calibration)		
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 CO <sub>2</sub> and CH <sub>4</sub> , 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**

<i>ECV</i>	<i>Global products requiring satellite observation</i>	<i>Fundamental Climate Data Records required for product generation (from past, current and future missions)</i>	<i>Product numbers (GCOS IP Reference Actions)</i>	<i>Potential product generator</i>
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**

<i>ECV</i>	<i>Global products requiring satellite observation</i>	<i>Fundamental Climate Data Records required for product generation (from past, current and future missions)</i>	<i>Product numbers (GCOS IP Reference Actions)</i>	<i>Potential product generator</i>
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	
	<i>Land-surface temperature, in conjunction with land cover type</i>	<i>High-resolution IR radiances</i>	<i>Supporting product to T.5.1. and T.5.2</i>	
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	
Fire Disturbance	Burnt area	VIS/NIR/SWIR/TIR moderate-resolution multi-spectral imagery	T.9	

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