# Space Agency Response to GCOS Implementation Plan

WGClimate | CEOS CGMS

# Executive Summary



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# Executive Summary

The Committee on Earth Observation Satellites (CEOS) and Coordination Group for Meteorological Satellites (CGMS), in the form of the Joint CEOS/CGMS Working Group on Climate (WGClimate), are pleased to present a response to the 2016 GCOS Implementation Plan, reiterating their commitment to address the Actions required for the implementation of the Global Climate Observing System (GCOS). CEOS and CGMS, international organizations of 60 Members and Associates and 15 Members respectively, have had the honour to report on Space Agency activities to GCOS on several previous occasions.

Space Agencies have continued to evolve their systematic observation of the climate system, now spanning several decades, strengthening scientific knowledge on climate, and supporting the provision of knowledge-based information to climate services to under-pin informed decision-making. Space Agencies are framing their activities through the implementation of the Strategy Towards an Architecture for Climate Monitoring from Space, 2013 – developed by a team comprised of representatives from CEOS, CGMS, and the World Meteorological Organization (WMO).

## The Role of the Architecture for Climate Monitoring from Space

In response to the continuing challenge of monitoring climate variability and climate change from space, CEOS, CGMS and WMO have accelerated development of the global Architecture for Climate Monitoring from Space. A recent, substantial, advance in the development of the ECV Inventory has led to an unprecedented insight into the activities of Space agencies across the ECV spectrum, resulting in the detailed characterisation of over 900 Climate Data Records (CDRs) that directly respond to the GCOS ECV requirements. The ECV Inventory enables the identification of existing and potential future gaps in the provision of the climate data requested by GCOS.

An analysis of the gaps between GCOS needs and the CDRs delivered by Space Agencies is currently underway, and will include the identification of actions to close any identified gaps. We are pleased to leverage this activity for the direct benefit of GCOS, thereby more accurately targeting, and responding to, GCOS needs.

The Architecture for Climate Monitoring from Space is central to our response to the GCOS Implementation Plan, and frames our response to both the Broad Context and Detailed Implementation actions articulated by GCOS.

## Broad Context

Space Agencies are implementing programmes explicitly aimed at producing CDRs that respond to the ECVs requested by GCOS. Moreover, climate services directly benefit from the wealth of space-derived climate data products being systematically generated by Space Agency programmes. The continuing implementation of the global Architecture for Climate Monitoring from Space, and in particular the ECV Inventory, provides strong evidence of the on-going commitment of Space Agencies in terms of the application of sustained resources and investments.

Efforts have accelerated at a regional level also. For example, the WMO designated Regional Climate Centres (RCCs) are being implemented to generate and deliver more regionally-focused high-resolution data and products, as well as training and capacity building. The WMO has been making concerted efforts to implement RCCs, in close coordination with its Regional Associations, Commission for Climatology and Commission for Basic Systems.

On mitigation, CEOS continues to support the Global Forest Observations Initiative implementing the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation or REDD+.

## Detailed Implementation including Preliminary Identification of Gaps

The overall response by Space Agencies to Atmosphere-related Actions is strong, although some important gaps remain. The meteorological satellite constellation, coordinated by CGMS, provides strong heritage and a backbone for satellite data characterising atmospheric physics, dynamics, and composition. Many agencies have launched programmes for generating satellite CDRs, and international coordination through SCOPE-CM has improved efficiency. Space Agencies are also enhancing coordination of a satellite constellation for monitoring CO2 and CH4, and are stepping up their investments. Unresolved gaps include the uncertain future of satellite-based measurements of precipitation, of the upper troposphere and stratosphere profile (for better understanding the Earth's radiation balance). In addition, a space-based calibration mission could not be realized in full, and shortfalls have been identified in the continuing key research missions that have revolutionised our understanding of atmospheric processes (e.g., aerosol-cloud interaction by measuring the 3D structure of clouds and aerosol layers).

Our uncertainty of Terrestrial ECV products is a function of the temporal resolution of satellite data acquisition and the availability of in situ observations. Due to cloud cover, and low illumination conditions at high latitudes, significantly higher errors occur when optical data are used in isolation. Uncertainty is also difficult to assess, as in situ data are extremely limited and, in general, not consistent in space and time. Satellite multi-sensor and multi-product inter-comparisons have been minimal so far for lake temperature, as the availability of a reasonable set of overlapping products is a pre-requisite for such activities. Lake *in situ* monitoring and satellite observation targets need to be extended, and a common database derived on which to focus production and subsequent validation activities for all products. A higher spatial resolution is required for monitoring lake ice extent. Temporal resolution has considerably improved for many Arctic regions as more daily data are acquired. There is a strong need to establish lake sites for algorithm development and validation, for the purpose of long-term monitoring.

A major drawback for the true monitoring of constantly changing glaciers in steep high-mountain topography is the missing availability of Digital Elevation Maps (DEMs) from high-resolution sensors for ortho-rectification of the related satellite data. For Glacier area the requirement for annual frequency is unnecessary because decadal change is sufficient. For glacier elevation change this is opportunistic and depends on DEM availability, quality and characteristics. For glacier flow velocity, observations on a sub-annual basis are possible using SAR and optical sensors especially for surge events, other instabilities, and seasonal velocity variations. Existing Fire ECV products are approaching target requirements for spatial resolution, although may not reach temporal requirements, but merged products derived from multi-sensor data may be close to satisfying both requirements. The International Land Surface Temperature and Emissivity Working Group (ILSTE, ilste-wg.org) has been initiated to bring developers and producers together to improve coordination and to make products more accessible to users.

Space Agencies intend a strong response overall to actions related to Oceans, with some gaps. Meteorological and operational optical and thermal missions will provide a strong instrumental backbone for sea surface temperature, with areas requiring stronger action focussed around maximising the quality of long records and integrating diurnal cycle observations from geostationary platforms. For SST and sea ice, the absence of plans across many agencies for low-frequency passive microwave radiometry remains concerning. An increased emphasis on evolving better ocean heat flux and sea surface dynamic state products constrained by observations needs to be sustained. Co-operation and continuity in sea surface height / sea level are strong, although validation and uncertainty estimation remain challenging. Observational continuity for ocean surface reflectance observation for ocean biogeochemistry looks secure from polar orbiting platforms, and effort is strong in radiometric validation. Further product evolution is needed for phytoplankton biomass estimation and long-term climate data record stability. The global salinity record from L-band microwave frequencies is progressing, with multi-mission synthesis a priority. Salinity mission extensions are planned or under review that will extend the record beyond a decade, although no new salinity missions are in the pipeline thereafter.

As Agencies continue to invest in the efforts necessary to create CDRs from their archives of observations it is also understood that CDRs must have stringent quality characteristics that enable quantitative analysis of climate change and variability over decades. Therefore Space Agencies are addressing in situ fiducial reference measurements for verifying the accuracy and stability of satellite CDRs, integration of CDRs across evolving constellations of sensors for a particular ECV, assessment of consistency between variables, and reducing the knowledge gaps in the understanding of uncertainty in CDR products across all spatial/temporal scales relevant to climate. These activities have been applied across the atmospheric, oceanic and terrestrial domains, and substantial progress has been made for a significant number of CDRs.