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Guideline for the Generation of Satellite-based Datasets and Products meeting GCOS Requirements

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1. Introduction

This document provides a short summary of GCOS requirements for satellite-based climate monitoring that can serve as a guideline for the generation of satellite-based datasets and derived products in order to meet the requirements for climate monitoring and the long-term aspects of climate research.

These guidelines are intended to help space agencies and other relevant institutions in the way they process and analyze datasets obtained from satellite instruments, to subsequently generate Essential Climate Variable (ECV) products (cf. Annex I and III).

As noted in GCOS-107, satellite observing systems should, for the purpose of climate monitoring, adhere to the GCOS Climate Monitoring Principles (see Annex II) to the greatest extent possible. Datasets obtained from such satellite systems ("Fundamental Climate Data Records, FCDRs") will be of maximum value for monitoring the state of the Earth's climate, through, e.g., trend analyses, assimilation in climate models, use in reanalyses, and validation of model outputs. Satellite systems include both instruments with plans for sustained operation and continuity, as well as instruments mainly intended to support research interests of limited duration.

It is recognized that, given the complexity of some ECV-related products, additional expertise and guidance may be needed for the generation of FCDRs and ECV satellite products, depending on the specifics of each case and application.

2. Background

In 2006, GCOS provided supplemental detail to the space-based requirements of the *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*[1] (GCOS-92, October 2004, the 'GCOS Implementation Plan') by issuing the document *Systematic Observation Requirements for Satellite-based Products for Climate*[2] (GCOS-107, September 2006, hereafter called the 'Satellite Supplement').

The GCOS Steering Committee, at its 15th session in October 2007, requested "the GCOS Secretariat, in collaboration with the GCOS science panels, to develop guidelines for datasets and products meeting GCOS requirements, in response to the needs of […] space agencies."

Before that, the GCOS Atmospheric Observation Panel for Climate, at its 13th session in April 2007, had recognized that "it could be beneficial for GCOS to develop a process through which it might formally or informally recognize products that meet the requirements expressed in the Second Adequacy Report and the Implementation Plan. As an example, it was suggested that a data set might be formally recognized once it had been described in the peer-reviewed literature and made freely available to users."

The need for guidelines to support such a recognition process has been identified by space agencies, for example, in the context of the SCOPE-CM initiative (Sustained Coordinated Processing of Environmental Satellite Data for Climate Monitoring).

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[1] GCOS (2004): *Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC*, GCOS-92, October 2004, http://www.wmo.int/pages/prog/gcos/Publications/gcos-92_GIP.pdf

[2] GCOS (2006): *Systematic Observation Requirements for Satellite-based Products for Climate* – Supplemental details to the satellite-based component of the GCOS Implementation Plan, GCOS-107, September 2006, http://www.wmo.int/pages/prog/gcos/Publications/gcos-107.pdf

3. The Satellite Supplement (GCOS-107)

The Satellite Supplement stated requirements for datasets and products addressing 26 ECVs (see Annex I) with a major satellite component, as well as nine cross-cutting needs, for the purpose of systematic observation of climate from space. The document made indications in terms of expected accuracy, stability and resolution of ECV satellite products. It also included indications for the Fundamental Climate Data Records (FCDRs) required for the generation of products, relevant satellite instruments, necessary involvement of expert groups, supplemental needs for non-FCDR-type data records, and other application areas of ECV satellite products.

As such, the Satellite Supplement already provides a substantial body of guidance for the generation of datasets and products with the intention to meet GCOS requirements. These requirements are being updated by GCOS science panels on a regular basis, with involvement of relevant expert groups as appropriate. These updates are also provided to WMO as input to the Rolling Review of Requirements of the WMO Global Observing System (GOS)[3]. In addition, given the complexity of climate variability and, in part, limited knowledge of the expected variability of ECVs over space and time, several caveats apply to the use of requirements as such. For example, it is possible that a combination of data records from two satellite instruments, neither of which meeting any of the requirements given in the Satellite Supplement, could usefully meet the needs for climate monitoring if applied together in careful analysis.

4. Guideline

A guideline for the generation of FCDRs and derived ECV satellite products, and subsequent quality assessment by providers as well as users, is given by adherence to the following:

- Fundamentally, the GCOS Climate Monitoring Principles, in particular those specific to satellite systems (see Annex II)

- In expanded form, the Satellite Supplement (see Annex III); wherever target requirements for particular ECV satellite products are given in the Satellite Supplement, it is expected that the producer as well as the user of these products will be able to judge whether the product meets these requirements, provided adequate documentation (metadata etc.) is available

In line with the GCMPs and the Satellite Supplement, the GCOS Steering Committee recommends particular attention to the following needs related to the generation of ECV satellite datasets and products:

1.	Full description of all steps in the generation of datasets and products, including algorithms used, specific FCDRs used, and characteristics and outcomes of validation activities
2.	Information on publications in peer-reviewed journals, covering both the description and the application of datasets and products
3.	Statement of expected accuracy, stability and resolution (time, space) of the product, including, where possible, a comparison with the requirements stated in the Satellite Supplement (or any subsequent revision)
4.	Arrangements for access to the datasets, products and all documentation
5.	Version management of datasets and products, particularly in connection with improved algorithms and reprocessing
6.	Long-term stability and homogeneity of the product
7.	Full application of all appropriate calibration/validation activities that would enhance product quality
8.	Global coverage where appropriate

[3] The WMO/CEOS database requirements, including those by GCOS, can be found at http://www.wmo.int/pages/prog/sat/Databases.html#UserRequirements (26 March 2009)

9. Timeliness of data release to the user community to enable monitoring activities
10. Facility for user feedback
11. Application of a quantitative maturity index if possible
12. Publication of a summary (preferably on-line) documenting point-by-point the extent to which this guideline has been followed

Experience with historical satellite data records has shown that continuous, cyclical improvement of the quality of datasets and product is generally needed, since historical records usually have challenges in terms of homogeneity. A one-time assessment of quality/maturity of datasets and products must not preclude this improvement over time.

Annex I

Essential Climate Variables (ECVs) largely dependent upon satellite observations[4]

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*.

[4] 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 II

GCOS Climate Monitoring Principles (GCMPs)

Effective monitoring systems for climate should adhere to the following principles [5]:

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.

[5] 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.

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 III

Satellite Supplement – Summary of Cross-cutting Requirements and ECV Satellite Products

Cross-cutting Needs

C.0 Systematic and continuous attention given to the GCMPs for each of designated Fundamental Climate Data Records

C.0.1 Ensure that remits of space agencies include the responsibility for maintaining Fundamental Climate Data Records, including past records

C.0.2 Establish structural arrangements and responsibilities (within space agencies) to ensure attention to the GCMPs

Remarks:

a. The GCOS Implementation Plan (GIP) and this report provide a list of satellite data records (FCDRs and products) which need attention to the GCMPs with the highest priority;
b. While space agencies have recognised the GCMPs, and notwithstanding valuable and encouraging examples of best-endeavour practise within some space agencies, they have generally not built appropriate mechanisms into their planning and operating processes that are needed to ensure adequate adherence to the GCMPs;
c. Reference: GIP Action C10.

C.1 Comprehensive and routine calibration of satellite instruments

Remarks:

a. The raw digital counts recorded by a satellite instrument can only be converted into physical quantities (mostly radiance or reflectance), if instrument calibration coefficients are available. These physical quantities can then be used for the derivation of geophysical parameters. Because instrument characteristics can change with time, absolute calibration and radiometric stability must be determined at regular intervals; the accuracy of any such measurement defines how well a measurement is known compared to an internationally-agreed standard or scale, e.g., SI units. Consequently, well-defined accuracy and stability of individual data records are prerequisites for the generation of homogeneous satellite climate data records and products. They are also vital for consistent comparison and validation of these records with other data sources, such as *in situ* observations;
b. If the signal measured by a satellite instrument cannot be made traceable to an agreed standard, vicarious calibration methods can help specifying radiometric and spectral stability of an instrument over time. For that purpose, repeated satellite-based observations of radiometrically-stable calibration sites, typically salt pans and deserts, are compared with contemporaneous *in situ* radiometric measurements;
c. The Global Space-based Inter-Calibration System (GSICS), currently under development by CGMS and WMO, is a good example of a proposal expressing the needs for instrument calibration, and may be considered for wide adoption by space agencies. The GSICS proposal contains recommendations for:
    - Ensuring traceable pre-launch and on-board calibration;
    - Exploiting opportunities for calibration against external targets, e.g., Earth-based reference sites and the Moon;
    - Exploiting opportunities for instrument cross-calibration, e.g., by maintaining a database of common satellite viewpoints, including designated radiosonde and surface-based measurement sites, and airborne measurements.

d. The effectiveness of the *in situ* observations in this context would be improved by adopting the call in the GCOS Implementation Plan for:
   - The establishment of a high-quality radiosonde network and associated ground-based measurements; and
   - The provision of a set of key terrestrial reference sites, providing measurements of key biomes according to agreed standards.

e. See Appendix 6 [of Satellite Supplement] for definitions;
f. Reference: GIP Action C10.

C.2 Archiving and Dissemination

C.2.1 Develop modern distributed data services that

- handle the increasing volumes of data
- allow timely feedback to observing network management (e.g., early detection of errors and biases)
- make access to increasingly large volumes of data more effective; this is especially important for countries with inadequate IT infrastructure or technical skills in using complex data
- provide access to metadata, as well as physical data
- maintain access to historic data

C.2.2 Ensure that data policies facilitate the exchange and archiving of all ECV products, FCDRs, associated metadata, and ancillary data

Remarks:

a. Implementation needs in this context involve archiving of all satellite metadata, so that long-term sensor and platform performance is traceable;
b. The creation of FCDRs from all relevant satellite systems requires the organization of data service systems that ensure ongoing accessibility to the data into the future;
c. Reference: GIP Actions C20, C21.

C.3 Detailed Specification of Fundamental Climate Data Records and Derived Products

Establish detailed specifications for each product in consultation with appropriate scientific and user advisory groups. This document provides a starting point for this ongoing process.

C.4 Generation of Fundamental Climate Data Records and Derived Products

C.4.1 Establish and ensure access to Fundamental Climate Data Records (FCDRs)

C.4.2 Update these FCDRs periodically by addition of new data or by reprocessing complete records when calibration methods or calibration data improve

C.4.3 Generate homogeneous derived products from the FCDRs

C.4.4 Sustain regeneration (or reprocessing) to derive improved products when FCDRs or generation methods improve

C.4.5 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

Remarks:

a. While observations of the variables are an essential pre-requisite, users of climate information generally require analysed outputs and products;
b. Whenever possible, the required data records for the generation of products, including historical data records, should cover as many years as possible (at least the most recent 30 years, if possible) in order to serve as a reference for climate variability and change studies;

c. Operational[6] analysis centres for some atmospheric variables are in place, but additional operational analyses are required for these activities, especially for oceanic and terrestrial variables;
d. International coordination of activities under C.4 is highly desirable, to take advantage of progress, and to promote efficiency, complementarity and cooperation while recognizing the value of independent product generation (see also C.3);
e. In many climate applications, the FCDRs themselves, mostly calibrated radiances, are the critical and required observables. This necessitates open access to those FCDRs, including their comprehensive metadata. It is understood that the derivation of the FCDRs is generally the responsibility of the satellite instrument operators, since in-depth knowledge of the instrument specifics is required;
f. Although satellite data are a primary source for observing many ECVs, *in situ* and/or other remotely-sensed data are generally needed to (inter-)calibrate, validate and assess the long-term stability of the satellite data;
g. See Appendix 6 for definitions;
h. Reference: GIP Action C8, C10, C11, C12, GIP Executive Summary Key Action 23.

Additionally, in the context of climate products, the following need has been identified:

C.5 International Coordination of Reanalysis Activities

Strengthen links between space agencies and the major reanalysis centres, e.g., through the GCOS Observing Panels for Climate and the WCRP Observations and Assimilation Panel, to ensure clear specification of current and future needs for reprocessed satellite datasets, and to feed experience back to space agencies on the quality of satellite datasets. The requirements for datasets for reanalysis specified below will be refined by this process.

Remarks:
a. Real-time data assimilation and reanalysis are increasingly powerful tools for generating integrated products which exploit the physical relationships among a number of the variables, and thus integrate many of the available types of observation (e.g., *in situ* and satellite-based measurements);
b. Coordination is vital, since the extension of data assimilation and reanalysis activities to the study of long-term climate trends places particular demands on the accurate calibration of key elements of the observational data used in reanalysis;
c. The availability of national holdings of historical datasets, including comprehensive metadata, to International Data Centres is vital for the effective conduct of reanalysis;
d. Reference: GIP Action C13.

C.6 Emerging Products

Intensify efforts to further develop emerging operational capabilities for research-based variables

Remarks:
a. Research is needed to overcome the current scientific and technical limitations to climate-quality measurements (in terms of, e.g., instruments, algorithms, calibration/validation, resolution, cost) of some key and a few emerging ECVs (including both *in situ* and satellite-based observations);
b. Many research satellites (mostly one-off, short-term missions) have demonstrated their potential to overcome these limitations and should therefore make a significant contribution to the improvements in the measurement of all ECVs and the creation of reliable FCDRs;
c. Ensure, through appropriate scientific coordination, the existence of strong links between research and operational communities;
d. Reference: GIP Action C7, GIP Section 3.8, GIP Executive Summary Section 6.

[6] "Operational" within the context of this report means observational activities that are undertaken according to internationally-agreed standards, on a routine and on-going basis, and with plans in place for continuity and homogeneity. It also implies compliance with the GCOS Climate Monitoring Principles

Finally, in addition to the needs noted above with direct connection to the GCMPs, two additional, more indirectly related, but nevertheless important needs are raised:

C.7 Unique Fundamental Datasets

Exploit the unique value of historical datasets through reprocessing to derive multi-decadal products, for example land cover, fire disturbance and aerosols from AVHRR

Reference: GIP Action C10, A31

C.8 Improved Community Awareness of Available and Planned Satellite Missions and Data Records

Maintaining a public domain database of past, current and planned satellite missions, including for each mission current status and information on data availability and access mechanisms

Overview of Products

Overview of Products – Atmosphere

ECVs	Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)	Product Numbers (GCOS IP Reference Actions)
Surface Wind Speed and Direction	Surface vector winds analyses, particularly from reanalysis	Passive microwave radiances and scatterometry	A.1 (A11)
Upper-air Temperature	Homogenized upper-air temperature analyses: Extended MSU-equivalent temperature record; New record for upper-troposphere and lower-stratosphere temperature using data from radio occultation; Temperature analyses obtained from reanalyses	Passive microwave radiances; GPS radio occultation; High-spectral resolution IR radiances for use in reanalysis	A.2.1 A.2.2 A.2.3 (A19, A20)
Water Vapour	Total column water vapour over the ocean and over land; Troposphere and lower- stratosphere profiles of water vapour	Passive microwave radiances; UV/VIS radiances; IR imagery and soundings in the 6.7 μm band; Microwave soundings in the 183 GHz band	A.3.1 A.3.2 (A7, A21)
Cloud Properties	Cloud radiative properties (initially key ISCCP products)	VIS/IR imagery; IR and microwave soundings	A.4 (A22, A23)
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 (A6, A7, A8, A9)
Earth Radiation Budget	Top-of-atmosphere Earth radiation budget on a continuous basis	Broadband radiances; Spectrally-resolved solar irradiances; Geostationary multispectral imagery	A.6 (A14, A24)
Ozone	Profile and total column of ozone	UV/VIS and IR/microwave radiances	A.7 (A25, A26)
Aerosol Properties	Aerosol optical depth and other aerosol properties	VIS/NIR/SWIR radiances	A.8 (A25, A26, A31)
Carbon Dioxide, Methane and other GHGs	Distribution of greenhouse gases, such as CO_2 and CH_4, of sufficient quality to estimate regional sources and sinks	NIR/IR radiances	A.9 (A25, A26, A27)
Upper-air Wind	Upper-air wind analyses, particularly from reanalysis	VIS/IR imagery; Doppler wind lidar	A.10 (Section 4.2.2)
Most upper-air and some surface ECVs	Atmospheric reanalyses	Key FCDRs and products identified in this report, and other data of value to the analyses	A.11 (C13)

Overview of Products – Oceans

ECVs	Global Products requiring Satellite Observations	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 (O23, O24)
Sea Level	Sea level and variability of its global mean	Altimetry	O.2 (O12)
Sea Surface Temperature	Sea-surface temperature	Single and multi-view IR and microwave imagery	O.3 (O9, O10)
Ocean Colour	Ocean colour and oceanic chlorophyll-a concentration derived from ocean colour	Multispectral VIS imagery	O.4 (O18)
Sea State	Wave height and other measures of sea state (wave direction, wavelength, time period)	Altimetry	O.5 (O19)
Ocean Salinity	Research towards the measurement of changes in sea-surface salinity	Microwave radiances	O.6 (O15)
Mainly sub-surface and some atmospheric ECVs	Ocean reanalyses utilizing altimeter and ocean surface satellite measurements	Key FCDRs and products identified in this report, and other data of value to the analyses	O.7 (C11, C12, C13)

Overview of Products – Terrestrial

ECVs	Global Products requiring Satellite Observations	Fundamental Climate Data Records required for Product Generation (from past, current and future missions)	Product Numbers (GCOS IP Reference Actions)
Lakes	For lakes in the Global Terrestrial Network for Lakes: Maps of lakes; lake levels; and surface temperatures of lakes	VIS/NIR imagery and radar imagery; Altimetry; High-resolution IR imagery	T.1.1, T.1.2, T.1.3 (T5, T6, T8)
Glaciers and Ice Caps	Maps of the areas covered by glaciers other than ice sheets; Ice-sheet elevation changes for mass-balance determination	High-resolution VIS/NIR/SWIR optical imagery; Altimetry	T.2.1, T.2.2 (T13, T14)
Snow Cover	Snow areal extent	Moderate-resolution VIS/NIR/IR and passive microwave imagery	T.3 (T11, T17)
Albedo	Directional-hemispherical (black sky) albedo	Multispectral and broadband imagery	T.4 (T21)
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 multispectral VIS/NIR imagery; High-resolution multispectral VIS/NIR imagery;	T.5.1, T.5.2 (T24, T26, T27)
fAPAR	Maps of fAPAR	VIS/NIR imagery	T.6 (T28)
LAI	Maps of LAI	VIS/NIR imagery	T.7 (T28)
Biomass	Research towards global, above-ground forest biomass and forest-biomass change	L band / P band SAR; Laser altimetry	T.8 (T31)
Fire Disturbance	Burnt area, supplemented by active-fire maps and fire-radiated power	VIS/NIR/SWIR/TIR moderate-resolution multispectral imagery	T.9 (T33)
Soil Moisture[7]	Research towards global near-surface soil-moisture (up to 10cm soil depth)	Active and passive microwave	T.10 (T37)

[7] Soil moisture was not listed in the GIP as an ECV, but was recognized as an emerging ECV and has been included here.

LIST OF GCOS PUBLICATIONS* (2008-2009)

GCOS-117 (WMO/TD-No. 1418)	Future Climate Change Research and Observations: GCOS, WCRP and IGBP Learning from the IPCC Fourth Assessment Report (4-6 October 2007)
GCOS-118 (WMO/TD-No. 1421)	Summary Report of the Tenth Session of the GTOS/GCOS Terrestrial Observation Panel for Climate (Rome, Italy, 15-16 November 2007)
GCOS-119 (WMO/TD-No. 1424)	Report of the Implementation Strategy Meeting for Central America and the Caribbean (Belize City, 28-30 January 2008)
GCOS-120 (GOOS-No.)	Report on the Meeting of "IOC Group of Experts on the Global Sea Level Observing System (GLOSS), tenth session (Paris, France, 6-8 June 2007)
GCOS-121 (WMO/TD-No. 1435)	GCOS Reference Upper Air Network (GRUAN). Report of the GRUAN Implementation Meeting (Lindenberg, Germany, 26-28 February 2008)
GCOS-122 (WCRP 9/2008) (WMO/TD-No. 1436)	Fourteenth Session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC-XIV) – Conclusions and Recommendations (Geneva, Switzerland, 21-25 April 2008)
GCOS-123 (WMO/TD-No. 1444)	Report of the Fourth Meeting of the GCOS Cooperation Board (Bonn, Germany, 12 June 2008)
GCOS-124 (WMO/TD-No. 1463)	Report of the Sixteenth Session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Geneva, Switzerland, 14-17 October 2008)
GCOS 125 (WCRP)	Report of the WOAP-III Meeting (Boulder, CO, USA, 29 September to 1 October 2008)
GCOS-126 (WMO/TD No. 1464)	GCOS Annual Report 2007-2008
GCOS-127 (WMO/TD No. 1477)	Practical Help for Compiling CLIMAT Reports
GCOS-128 (WMO/TD No. 1488)	Guidelines for the Generation of Satellite-based Datasets and Products Meeting GCOS Requirements (GCOS Secretariat, March 2009)
GCOS-129 (WMO/TD No. 1489)	Progress Report on the Implementation of the Global Observing System for Climate in Support of the UNFCCC 2004-2008
GCOS-130 (WMO/TD No. 1490)	Synthesis of National Report on Systematic Observation for Climate
GCOS-131 (WMO/TD No. 1492)	Report of the First GCOS Reference Upper Air Network Implementation and Coordination Meeting (GRUAN ICM-1) (Oklahoma City, USA, 2-4 March 2009)

*GCOS publications may be accessed through the GCOS website at:
http://gcos.wmo.int

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