

G GLOBAL
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S SYSTEM



Report of the GCOS/GTOS/HWRP Expert Meeting on the Implementation of a Global Terrestrial Network - Hydrology (GTN-H)

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REPORT OF THE GCOS/GTOS/HWRP EXPERT MEETING ON THE IMPLEMENTATION OF A GLOBAL TERRESTRIAL NETWORK - HYDROLOGY (GTN-H), KOBLENZ, GERMANY, 21-22 JUNE 2001

1. BACKGROUND

There is a critical need for improved availability and access to global hydrological data, information and products for climate and hydrological research and applications in order to quantify key environmental change processes, identify significant trends, assess variability and develop response strategies.

The Terrestrial Observation Panel for Climate (TOPC), sponsored by the Global Climate Observing System (GCOS) and the Global Terrestrial Observing System (GTOS), identified ten hydrologic variables of importance to climate change monitoring in the GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 2.0 (GCOS-32), and the Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fourth session (GCOS-46) (<http://www.wmo.ch/web/gcos/gcoshome.html>), as follows:

- Seven variables are primarily of hydrologic concern - surface water discharge, surface water storage fluxes, groundwater storage fluxes, precipitation, evapotranspiration, relative humidity, and transport of biogeochemical materials from land to ocean;
- Two other variables - soil moisture and snow water equivalent - have important hydrological dimensions; and
- Water use, arising from socio-economic causes, is critical to better assess the impact of climate change on water resources.

TOPC also observed that there is no single entity that serves as a global or regional data centre for the above variables. Thus, the assembly of an adequate global information base will be a significant challenge.

In response, the World Meteorological Organization (WMO) Hydrology and Water Resources (HWR) Department, GCOS, GTOS, and TOPC organized an expert meeting in June 2000, hosted by the Deutscher Wetterdienst in Geisenheim, Germany to establish a global hydrological observing network for climate. The full Geisenheim report (WMO/TD-No. 1047) can be viewed at: <http://www.wmo.ch/web/homs/geisenheim.pdf>.

The outcome was a proposal for the establishment of a Global Terrestrial Network – Hydrology (GTN-H) which will consist of existing networks ("network of networks"), global databases and global data product centres, capturing the ten key hydrological variables mentioned above. The main objectives for the network were to:

- Respond to urgent information requirements with regard to climate prediction, impacts and adaptation, including the characterization of hydrological variability to detect climate change;
- Assess water sustainability as a function of water use versus water availability; and
- Improve understanding of hydrological processes.

A summary of other recommendations includes:

1. A Hydrological Observation Panel for Climate (HOPC) should be established, with its major responsibility being to guide the development and implementation of GTN-H and to ensure its effectiveness;
2. HOPC should act in close cooperation with sponsoring agencies, participating organizations, global observing systems (GCOS, GTOS, Global Ocean Observing System (GOOS), World Weather Watch (WWW)) and global research programmes, especially the International Geosphere-Biosphere Programme (IGBP) and the World Climate Research Programme (WCRP);
3. Near-term goals should include developing a plan for meeting the data and product requirements of the various applications-oriented communities and pursuing collaboration, such as with the Coordinated Enhanced Observing Period (CEOP);
4. The sponsors of this expert meeting, i.e., GCOS, HWR/WMO and GTOS, should undertake the implementation of the recommendations, with the interim assistance of TOPC.

2. GOALS FOR THE KOBLENZ MEETING

Following on from the Geisenheim report, a second expert meeting to develop an implementation strategy for the Global Terrestrial Network - Hydrology (GTN-H) was organized by the WMO/HWR, GCOS and GTOS and hosted by the Global Runoff Data Centre (GRDC), at the Federal Institute of Hydrology, in Koblenz, Germany, on 21 and 22 June 2001.

A major objective was to define specific actions for the initial implementation of GTN-H, including currently available products and desired short-term improvements. The implementation strategy would define common practices related, *inter alia*, to data and information management among the participating programmes and centres and procedures for harmonizing the products among the participants and the processes for their dissemination. In addition, the importance of having an integrated data management strategy was considered, including the monitoring of data availability and its collection, the quality controlling procedures, the archiving, and the dissemination of data from the participating centres of GTN-H.

Participants included representatives from three existing Global Data Centres - GRDC, Global Precipitation Climatology Centre (GPCC) and the Global Environmental Monitoring System Collaborating Centre on Water Quality (GEMS-Water) as well as scientists from national and university programmes. The list of participants is presented as Annex 1, and the meeting agenda as Annex 2.

3. INITIAL ESTABLISHMENT OF A GTN-H

Paramount attention at the workshop was given to the specific actions necessary to begin the establishment of a GTN-H. In particular, discussion centred on the core functions of GTN-H and the associated technical and administrative framework for the functioning of GTN-H. This included the governance of the GTN-H and its operation; the coordination and communication between network partners; specifying the technical issues relating to products; data management; and developing an approach to enhance the participation in and the knowledge of GTN-H.

3.1. Core Functions of GTN-H

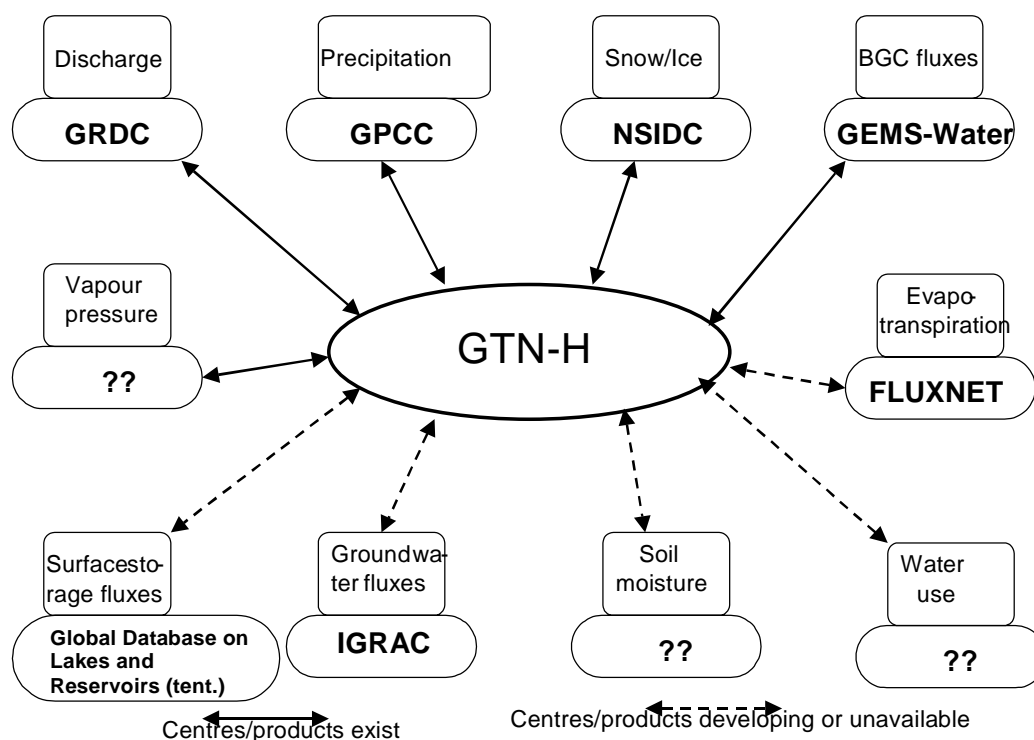
The experts refined the core functions that had been proposed for GTN-H to include:

- Provide timely access to global hydrological data and metadata for users;
- Generate relevant products and related documentation, satisfying timeliness and quality requirements of users;
- Promote standardization in observations and use of ‘best’ practices;
- Promote and facilitate free and unrestricted exchange of data and products within existing frameworks, e.g., WMO resolutions 40 (Cg-XII) and 25 (Cg-XIII);
- Solicit user feedback and ensure responsiveness to changing needs;
- Provide for monitoring and evaluation of GTN-H performance;
- Contribute to identifying the key observational requirements of GTN-H, including requirements for satellite observations; and
- Provide for capacity-building

3.2. Initial Configuration of GTN-H

The experts reviewed the initial configuration of GTN-H developed at the Geisenheim meeting and generally agreed on the applicability of this model and the potential participants. The underlying philosophy is to seek the inclusion of all possible participants in GTN-H that have contributions to make to the overall success of the network. See Figure below (from Geisenheim report, revised).

Proposed initial configuration of GTN-H



3.3. Responsibilities of GTN-H Partners

The responsibilities of GTN-H partners were reviewed and modified to reflect the overall philosophy of maximum participation. The experts concluded that GTN-H is a confederation of organizations that operate within the missions of their sponsors (including requirements of existing sponsors). These organizations are to provide cooperative service functions to the GTN-H including general information on their policies, products and operations, freely exchanging data within their existing policies and agreements, providing for the documentation of their products and information, making available updates of data and product catalogues, including metadata, and making available the data in their databases and product services, consistent with the agreements on data dissemination. Also, the partners are expected to be actively involved in product development both individually and collaboratively and to develop and utilize tools to support shared development of products. GTN-H partners as a whole and their sponsoring organizations will undertake joint activities to enhance the participation in and the knowledge of GTN-H (e.g., promotional activities/marketing strategy). Specific activities may include developing a logo, contacting professional activities, interest groups, funding agencies and donors, and the public. See Annex 3 for a complete list of responsibilities.

There was a strong need expressed to increase the number of partners and cooperating scientists and their institutions in the activities of GTN-H. In particular, participants expressed the need to involve the US National Snow and Ice Data Center (NSIDC), the Research Centre of the University of Kassel, and the International Atomic Energy Agency (IAEA), with regard to observations using natural isotopes. Likewise, national operational and research agencies and programmes that offer opportunities to enhance the databases, implementation of new analysis techniques and/or the development of new global products based on their national activities, should be encouraged to participate. Universities are also excellent sources of new methods and techniques, as well as research quality data sets.

3.4. GTN-H Products

Participants discussed at length GTN-H products, especially developing products that involved the cooperation of two or more partners. The following is an initial set of products, in addition to relevant current products for the individual centres:

- Development of a joint map product about availability of data (near real time and historical);
- Development of a map product, showing the state of the system;
- Establish tools (e.g., procedures) for data mining and (standardized) archiving; and
- Data and analysis products, including gridded runoff/discharge fields, biogeochemical (BGC) fluxes to the oceans, and surface storage fluxes.

The basic information, as listed in Annex 4, will be made available for each product.

3.5. Data Dissemination and End-to-End Data Management

In addition, since GTN-H is a 'network of networks', it is critical to develop common policies on data dissemination and end-to-end data management.

The meeting discussed various aspects of data dissemination including the internal exchange of data and products among the GTN-H partners. Participants agreed on the desirability of using electronic means and having easy access under gateway protection to products in development and products based on data that have restrictions of its 'open' use. A number of topics related to data policies and procedures were discussed and are summarized in Annex 5. Based on the work of the Atmospheric Observation Panel for Climate (AOPC), Annex 6 discusses a common approach to a data management process that may be applicable to GTN-H or at least to some of the sub-networks. This includes monitoring the availability of data, data quality control, analysis of data sets (and product development) and archiving of the final data sets.

3.6. Management/Coordination of GTN-H

The management/coordination framework will consist of a two-tiered structure of an overall Implementation/Coordination Group and implementing task teams. The core of the Implementation/Coordination Group will be partners who have ownership of GTN-H, e.g., GRDC, GPCC, and the GEMS/Water Collaborating Centre (GWCC). In addition, there will be members from the outside community, from national and regional operational agencies, and with ties to other scientific panels, such as AOPC. Implementing task teams, consisting of relevant individuals representing their organizations, will address specific issues and primarily work through electronic contact. Finally, the meeting reached agreement that an active Coordinator is required to move GTN-H issues forward. The meeting selected David Harvey of the Meteorological Service of Canada as interim Coordinator. Additional ideas that were discussed during the meeting are given in Annex 7. Annex 8 proposes initial membership on, and involvement in, the Coordination Panel.

4. RECOMMENDATIONS

The process of developing GTN-H will involve many steps, many individual participants and the direct and indirect support of many organizations. The meeting in Koblenz was the second in the implementation process and the participants developed a significant set of recommendations (see Annex 9). These included:

- Obtain endorsement of GTN-H by sponsoring agencies and other appropriate entities (e.g., by the United Nations Framework Convention on Climate Change, WMO EC);
- Complete membership of the Coordination Group, including furthering the ownership of GTN-H by the inclusion of other active partners such as NSIDC, IAEA, and Research Centre of the University of Kassel;
- Ensure documentation of Quality Control (QC) procedures, although much data QC may be governed by procedures of existing centres;
- Review the data functions specified at the Geisenheim meeting;
- Enhance collaboration with relevant programmes such as GEWEX and in particular through contact with CEOP;
- Solicit the involvement of WHYCOS in GTN-H;
- Develop an initial communication strategy, including a GTN-H website; and
- Complete a mission/vision statement, ToR, framework (by the Coordination Group).

Annex 1

List of Participants

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Annex 2

Agenda

Thursday, 21 June

- 09:00 Opening of the expert meeting
- 09:15 Adoption of the agenda

Theme 1: Conceptual issues

- 09:30 Review of the development of GTN-H
- 09:50 Response strategies to meet science and applications requirements
- 10:30 Coffee break
- 10:45 Development of data products

Theme 2: Managerial and governance issues of GTN-H

- 11:15 Relationship with partner programmes, networks and data centres
- 12:00 Requirements for network coordination
- 13:00 Lunch
- 14:00 Responsibilities of network partners
- 15:00 Inter-network communication
- 15:30 Coffee break
- 15:45 Public relations
- 16:00 Terms of reference for the panel and the network manager
- 16:45 Meeting adjourns

Friday, 22 June

Theme 2: Managerial and governance issues of GTN-H (continued)

- 08:30 Nomination of a core panel for GTN-H and a network manager
- 09:00 Development of a GTN-H portal
- 09:30 Data transmission to network partners

Theme 3: Data issues

- 09:30 Data transmission to network partners
- 10:00 Coffee break
- 10:15 Data quality control
- 10:45 Data formats
- 11:15 Development of a meta-database
- 11:45 Access to data
- 12:15 Lunch
- 13:15 Harmonization of data management and dissemination

Theme 4: Establishment of GTN-H

- 13:45 Conclusions and recommendations
- 14:15 Formal establishment of GTN-H
- 15:00 Meeting adjourns

Annex 3

Responsibilities of Network Partners - GTN-H

- ◆ **GTN-H is a confederation of organizations that operate within the framework of existing sponsor requirements**

- ◆ **Cooperative service functions**
 - ✓ General information
 - ✓ Data exchange
 - ✓ Documentation of information
 - ✓ Updates of catalogues, and metadata
 - ✓ Database and product services

- ◆ **Production function**
 - ✓ Active involvement in product development
 - ✓ Tools to support shared development of products

- ◆ **Promotional activities/Marketing strategy/Relevant international/global programmes**
 - ✓ Professionals
 - ✓ Interest Groups
 - ✓ Funding agencies and donors
 - ✓ Public

Annex 4

Initial Products of GTN-H

(in brackets: initial responsible partners)

- ◆ **Development of a joint map product about availability of data (on-line and historical) (GPCC, MSC, GWCC)**
- ◆ **Development of a map product, showing the state of the system. (USGS/GRDC)**
- ◆ **Establishment of tools for data mining and standardized archiving (UNH, all collaborating partners)**
- ◆ **Gridded runoff/discharge fields (GRDC, GPCC, UNH)**
- ◆ **BGC fluxes to the oceans (GWCC, GRDC)**
- ◆ **Surface water storage fluxes (UNH, Global Database on Lakes and Reservoirs under development by Russia)**

For each GTN-H Product the following minimum information is required:

- ◆ **Statement of objective(s)**
- ◆ **Description of outputs - current examples**
- ◆ **User relevance**
- ◆ **Scale of product (outputs)**
- ◆ **Timeframe of work**
- ◆ **Resources required - base/incremental**
- ◆ **Lead person(s) and their functions**
- ◆ **Active Centres/Institutions**

Annex 5

Data Policies and Procedures

- ◆ **Data Access/Exchange - Resolutions (e.g., #40 (WMO Cg-XII), 25 (WMO Cg-XIII))**
 - ✓ Expect free and unrestricted exchange
 - ✓ Certain agreements exist that limit access to unprocessed data, e.g., data at GWCC
 - ✓ Time series data from GPCC (GSN, 1000+ stations) will be available
- ◆ **Data QC**
 - ✓ Governed by procedures of existing centres but ensure documentation of procedures
 - ✓ Metadata documentation - important now, activities to standardize underway
 - ✓ Standardizing metadata underway in European Meteorological Services and in US agencies
- ◆ **Data Formats - harmonization and common data formats**
 - ✓ Important to assist interaction of partners
- ◆ **Data Dissemination - password access until product validated for open dissemination**
- ◆ **Data Transmission - internal to partners**
 - ✓ need for common formats
- ◆ **Data Harmonization**
 - ✓ Time series data from GPCC (GSN, 1000+ stations) will be available
 - ✓ GOSIC - data window for G3OS

Annex 6

Data Management Process

The following is a distillation of a GCOS data management process based on the work of GCOS Panels (primarily AOPC). It includes monitoring the availability of data, its quality control, the analysis of the data set (and product development) and archiving of the final data sets.

1. GCOS Monitoring Centre

The tasks of a GCOS Monitoring Centre are to:

- Monitor the availability, timelines and completeness of the incoming data/messages received via GTS or other communication medium to improve the performance of the GCOS Network;
- Perform basic quality control and assurance procedures for the incoming data (and metadata) to obtain high quality and ensure completeness of the data set; and
- Make quality-controlled data available to the National Meteorological and Hydrological Services (NMHSs) and World Data Centres (WDCs) and others for their use in a variety of climatic change assessment products.

2. GCOS Analysis Centre

A GCOS Analysis Centre will provide a higher level quality control of both the daily and monthly GCOS network data.

- For the daily data, this will include updating and quality controlling the daily data, applying bias corrections to the daily data, calculating monthly statistics (MONADS) from daily data; and providing daily and monthly data to users;
- For the monthly data, this will include analyzing the monthly data; improving bias adjustments to monthly data and the monthly station data base, creating global and regional monthly statistics; and developing and providing grid products with reduced biases; and
- Also a centre will provide products to users, improve the meta data, and report on historical and meta data reception.

3. GCOS Archiving Centre

A GCOS Archiving Centre should coincide with a World Data Centre (WDC) or recognized, established data centre, if possible.

- A GCOS Archiving Centre will archive both the monthly and the daily data in **delayed-mode** as well as historical data for each station;

- Historic monthly data in the WDC will come from either data available at WDCs, e.g., from the Global Historical Climatology Network (GHCN), from quality-controlled data available at the Monitoring Centres (MCs), or from data submitted, upon request, by national centres (e.g., NMHSs) and available digitally and updated on a routine basis. (Access in near real-time to the time series of historic monthly data is absolutely necessary/highly desirable for quality control.); and
- The daily historical data is important to assess better the impact of extreme events and its relation to climate change.

Annex 7

GTN-H Management/Coordination

Two-tiered approach to management/coordination

- ◆ **Overall Coordination Group**
 - ✓ Include partners (ownership)
 - ✓ Involve members from operational agencies and relevant programmes
 - ✓ Tie to AOPC

- ◆ **Implementing Task Teams**
 - ✓ Small, highly-dedicated teams
 - ✓ Address specific issues
 - ✓ Work mainly through electronic communication

- ◆ **Active Coordinator to move issues forward**

GTN-H Management/Coordination

Responsibilities

- ◆ **No restrictions to access data and information within GTN-H**
 - ✓ **Web access - Design of a joint Web page**
 - ✓ **Correspondence/Secretarial function**
 - ✓ **Responsibilities of GTN-H partners**
 - ✓ **Managing tasks**
- ◆ **Clients and users**
 - ✓ **Communication Strategy - outreach**
 - ✓ **Data and Product dissemination strategy**
 - ✓ **Collaboration with global programmes and projects, such as GEWEX and IGBP**
- ◆ **Sponsors**
 - ✓ **Build interest within present Sponsors**
 - ✓ **Extend to new Sponsors**
- ◆ **Providers**
 - ✓ **National Agencies**
 - ✓ **WHYCOS**
 - ✓ **Non-governmental organizations and research programmes**

GTN-H Management/Coordination

	Collect / Monitor	QC / Products	Archiving
◆ Discharge			
✓ GRDC	+	+	+
✓ UNH		+	
✓ USGS	+	+	+
◆ Precipitation			
✓ GPCC	+	+	+
◆ BGC fluxes			
✓ GRDC	+		
✓ GPCC	+		
✓ GWCC	+	+	+
◆ Surface water storage			
◆ Snow			
✓ NSIDC	+	+	+

Annex 8

Network Coordination Panel - GTN-H

◆ Members

- ✓ GRDC
- ✓ GPCC
- ✓ GWCC
- ✓ UNH
- ✓ NSIDC

◆ Technical/Scientific

- ✓ USGS/MSC
- ✓ WCRP

◆ User Representatives

◆ Sponsors

- ✓ WMO
- ✓ UNESCO
- ✓ GTOS
- ✓ GCOS

Network Sponsors - GTN-H

◆ International Agencies

✓ WMO - HWR, GCOS, WWW

✓ FAO - GTOS

✓ UNESCO - IHP

✓ Others - UNEP, IOC, ICSU

◆ Observing Systems

**✓ GCOS Steering Committee - TOPC,
AOPC**

✓ GTOS Steering Committee - TOPC

Annex 9

Actions/Recommendations

- ◆ **Establish a Web page for GTN-H by**
 - ✓ **Partners to comment on contents of Web page**
 - ✓ **MSC to host the server during development**
 - ✓ **Initial page for partner review**
- ◆ **For each product (initial 5), appropriate partner will prepare a short write-up in a common format (copy available)**
 - ✓ **Gridded discharge/runoff field**
 - ✓ **Map product on data availability**
 - ✓ **Map product on state of system**
 - ✓ **Tools**
 - ✓ **BGC Fluxes**
 - ✓ **Snow - National Snow and Ice Data Center (NSIDC)**
- ◆ **Obtain endorsement of GTN-H by sponsoring agencies and other appropriate entities**
- ◆ **Complete membership of the Coordination Group including furthering the ownership of GTN-H, e.g., NSIDC, IAEA, Kassel**

Actions/Recommendations

- ◆ **Ensure documentation of QC procedures. Data QC will be governed by procedures of existing centres**
- ◆ **Contact CEOP concerning interest of GTN-H in data from CEOP**
- ◆ **Develop an initial communication strategy**
- ◆ **Contact WHYCOS re involvement in GTN-H**
- ◆ **Prepare a short summary of GTN-H for report to UNFCCC**
- ◆ **Revisit the data functions chart (Fig. 3 in Geisenheim Report)**
- ◆ **Complete a mission/vision statement, ToR, framework for implementation etc. by Coordination Group**
 - ✓ **Complete draft Mission Statement**
 - ✓ **Develop set of ToRs**

Annex 10

List of Acronyms and Abbreviations

AOPC	Atmospheric Observation Panel for Climate
BGC	Biogeochemical
CEOP	Coordinated Enhanced Observing Period
CHy	Commission for Hydrology
FAO	Food and Agriculture Organization of the United Nations
FLUXNET	Flux Network
GCOS	Global Climate Observing System
GEMS	Global Environmental Monitoring System
GEWEX	Global Energy and Water Cycle Experiment
GHCN	Global Historical Climatology Network
GOOS	Global Ocean Observing System
GOSIC	Global Observing Systems Information Centre
GPCC	Global Precipitation Climatology Centre
GRDC	Global Runoff Data Centre
GTN-H	Global Terrestrial Network for Hydrology
GTOS	Global Terrestrial Observing System
GTS	Global Telecommunication System
GWCC	GEMS/Water Collaborating Centre
HOPC	Hydrological Observation Panel for Climate
HWR	Hydrology and Water Resources
HWRP	Hydrology and Water Resources Programme
IAEA	International Atomic Energy Agency
ICSU	International Council for Science
IGBP	International Geosphere-Biosphere Programme
IGRAC	International Groundwater Resources Assessment Center
IHP	International Hydrological Programme (of UNESCO)
IOC	Intergovernmental Oceanographic Commission
MC	Monitoring Centre
MSC	Meteorological Service of Canada
NMHS	National Meteorological and Hydrological Service
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
QC	Quality Control
TOPC	Terrestrial Observation Panel for Climate
ToR	Terms of Reference
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNH	University of New Hampshire
USGS	United States Geological Survey
WCRP	World Climate Research Programme
WDC	World Data Centre
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization
WWW	World Weather Watch

LIST OF GCOS PUBLICATIONS*

- GCOS-1** Report of the first session of the Joint Scientific and Technical (WMO/TD-No. 493) Committee for GCOS (Geneva, Switzerland, April 13-15, 1992)
- GCOS-2** Report of the second session of the Joint Scientific and Technical (WMO/TD-No. 551) Committee for GCOS (Washington DC, USA, January 11-14, 1993)
- GCOS-3** Report of the third session of the Joint Scientific and Technical (WMO/TD-No. 590) Committee for GCOS (Abingdon, UK, November 1-3, 1993)
- GCOS-4** Report of the fourth session of the Joint Scientific and Technical (WMO/TD-No. 637) Committee for GCOS (Hamburg, Germany, September 19-22, 1994)
- GCOS-5** Report of the GCOS Data System Task Group (Offenbach, (WMO/TD-No. 639) Germany, March 22-25, 1994)
- GCOS-6** Report of the GCOS Atmospheric Observation Panel, first session (WMO/TD-No. 640) (Hamburg, Germany, April 25-28, 1994)
- GCOS-7** Report of the GCOS Space-based Observation Task Group (WMO/TD No. 641) (Darmstadt, Germany, May 3-6, 1994)
- GCOS-8** Report of the GCOS/GTOS Terrestrial Observation Panel, first (WMO/TD No. 642) session (Arlington, VA, USA, June 28-30, 1994) (UNEP/EAP.MR/94-9)
- GCOS-9** Report of the GCOS Working Group on Socio-economic Benefits, (WMO/TD-No. 643) first session (Washington DC, USA, August 1-3, 1994)
- GCOS-10** Summary of the GCOS Plan, Version 1.0, April 1995 (WMO/TD-No. 666)
- GCOS-11** Report of the GCOS Data and Information Management Panel, (WMO/TD-No. 673) first session (Washington DC, USA, February 7-10, 1995)
- GCOS-12** The Socio-economic Benefits of Climate Forecasts: Literature (WMO/TD-No. 674) Review and Recommendations (Report prepared by the GCOS Working Group on Socio-economic Benefits), April 1995
- GCOS-13** GCOS Data and Information Management Plan, Version 1.0, (WMO/TD-No. 677) April 1995
- GCOS-14** Plan for the Global Climate Observing System (GCOS), Version 1.0, (WMO/TD-No. 681) May 1995
- GCOS-15** GCOS Plan for Space-based Observations, Version 1.0, June 1995 (WMO/TD-No. 684)
- GCOS-16** GCOS Guide to Satellite Instruments for Climate, June 1995 (WMO/TD-No. 685)
- GCOS-17** Report of the GCOS Atmospheric Observation Panel, second session (WMO/TD-No. 696) (Tokyo, Japan, March 20-23, 1995)

*GCOS publications may be accessed through the GCOS World Wide Web site at:
<http://www.wmo.ch/web/gcos/gcoshome.html>

- GCOS-18** Report of the GCOS/GTOS Terrestrial Observation Panel, second (WMO/TD-No. 697) session (London, UK, April 19-21, 1995) (UNEP/EAP.MR/95-10)
- GCOS-19** Report of the GCOS Data Centre Implementation/Co-ordination (WMO/TD-No. 709) Meeting (Offenbach, Germany, June 27-29, 1995)
- GCOS-20** GCOS Observation Programme for Atmospheric Constituents: (WMO/TD-No. 720) Background, Status and Action Plan, September 1995
- GCOS-21** GCOS/GTOS Plan for Terrestrial Climate-related Observations, (WMO/TD-No. 721) version 1.0, November 1995 (UNEP/EAP.TR/95-07)
- GCOS-22** Report of the fifth session of the Joint Scientific and Technical (WMO/TD-No. 722) Committee for GCOS (Hakone, Japan, October 16-19, 1995)
- GCOS-23** Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, (WMO/TD-No. 754) third session (Cape Town, South Africa, March 19-22, 1996) (UNEP/DEIA/MR.96-6) (FAO GTOS-1)
- GCOS-24** Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel (WMO/TD-No. 768) for Climate, first session (Miami, Florida, USA, March 25-27, 1996) (UNESCO/IOC)
- GCOS-25** Report of the GCOS Data and Information Management Panel, second (WMO/TD-No. 765) session (Ottawa, Ontario, Canada, May 14-17, 1996) (UNEP/DEIA/MR.96-5)
- GCOS-26** Report of the Joint CCI/CBS Expert Meeting on the GCOS Surface (WMO/TD-No. 766) Network (Norwich, UK, March 25-27, 1996)
- GCOS-27** Report of the Expert Meeting on Hydrological Data for Global (WMO/TD-No. 772) Observing Systems (Geneva, Switzerland, April 29-May 1, 1996) (UNEP/DEIA/MR.96-7)
- GCOS-28** *In Situ* Observations for the Global Observing Systems (Geneva, (WMO/TD-No. 793) Switzerland, September 10-13, 1996) (UNEP/DEIA/MR.97-3)
- GCOS-29** Report of the Global Observing Systems Space Panel, second session (WMO/TD-No. 794) (Geneva, Switzerland, October 16-18, 1996) (UNEP/DEIA/MR.97-4)
- GCOS-30** Report of the sixth session of the Joint Scientific and Technical (WMO/TD-No. 795) Committee for GCOS (Victoria, British Columbia, Canada, October 28-November 1, 1996)
- GCOS-31** Proceedings of the fifth meeting of the TAO Implementation Panel (WMO/TD-No. 803) (TIP-5) (Goa, India, November 18-21, 1996)

- GCOS-32** GCOS/GTOS Plan for Terrestrial Climate-related Observations, (WMO/TD-No. 796) version 2.0, June 1997
- GCOS-33** GHOST - Global Hierarchical Observing Strategy, March 1997 (WMO/TD-No. 798)
- GCOS-34** Initial Selection of a GCOS Surface Network, February 1997 (WMO/TD-No. 799)
- GCOS-35** Report of the second Joint CCI/CBS Meeting on the GCOS Surface (WMO/TD-No. 839) Network (De Bilt, The Netherlands, June 25-27, 1997)
- GCOS-36** Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for (WMO/TD-No. 844) Climate, second session (Cape Town, South Africa, February 11-13, (UNESCO/IOC) 1997)
- GCOS-37** Report of the Global Observing Systems Space Panel, third session (WMO/TD-No. 845) (Paris, France, May 27-30, 1997) (GOOS-10) & (GTOS-9)
- GCOS-38** Report of the Meeting of Experts on Ecological Networks (Guernica, (WMO/TD-846) Spain, June 17-20, 1997) (GTOS-10)
- GCOS-39** Report of the GCOS/GOOS/GTOS Joint Data and Information (WMO/TD-No. 847) Management Panel, third session (Tokyo, Japan, July 15-18, 1997) (GOOS-11) & (GTOS-11) (UNEP/DEIA/MR.97-8)
- GCOS-40** Report of the GCOS/WCRP Atmospheric Observation Panel for (WMO/TD-No. 848) Climate, third session (Reading, UK, August 19-22, 1997)
- GCOS-41** Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for (WMO/TD-No. 849) Climate (OOPC) Ocean Climate Time-Series Workshop, (Baltimore, (GOOS-33) MD, USA, March 18-20, 1997)
- GCOS-42** Report of the seventh session of the Joint Scientific and Technical (WMO/TD-No. 857) Committee for GCOS (Eindhoven, The Netherlands, September 22-26, 1997)
- GCOS-43a** TAO Implementation Panel, sixth session (Reading, U.K., November (GOOS-36) 4-6, 1997)
- GCOS-43b** International Sea Level Workshop (Honolulu, Hawaii, USA, June 10-11, (GOOS-55) 1997)
- GCOS-44** Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for (GOOS-61) Climate (OOPC), third session (Grasse, France, April 6-8, 1998)
- GCOS-45** Report of the Joint Meeting of the GCOS/WCRP Atmospheric (WMO/TD-No. 922) Observation Panel for Climate and the GCOS/GOOS/GTOS Joint Data (GOOS-58) & (GTOS-16) and Information Management Panel, fourth session (Honolulu, Hawaii, (UNEP/DEIA/MR.98-6) USA, April 28-May 1, 1998)

- GCOS-46** (GTOS-15) Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fourth session (Corvallis, USA, May 26-29, 1998)
- GCOS-47** (GOOS-67) (GTOS-20) Report of the Global Observing Systems Space Panel, fourth session, (WMO/TD-No. 941) (College Park, Maryland, USA, October 22-23, 1998)
- GCOS-48** Report on the Adequacy of the Global Climate Observing Systems (United Nations Framework Convention on Climate Change, November 2-13 1998, Buenos Aires, Argentina)
- GCOS-49** (GOOS-64) Implementation of Global Ocean Observations for GOOS/GCOS, first session (Sydney, Australia, March 4-7, 1998)
- GCOS-50** (GOOS-65) Implementation of Global Ocean Observations for GOOS/GCOS, second session (Paris, France, November 30, 1998)
- GCOS-51** (GOOS-66) Global Ocean Observations for GOOS/GCOS: An Action Plan for Existing Bodies and Mechanisms
- GCOS-52** (GOOS-68) TAO Implementation Panel, 7th Session (Abidjan, Ivory Coast, November 11-13, 1998)
- GCOS-53** (WMO/TD-No. 958) GCOS Surface Network (GSN) Monitoring Centre Implementation Meeting (Offenbach, Germany, January 19-20, 1999)
- GCOS-54** (WMO/TD-No. 953) Report of the eighth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Geneva, Switzerland, February 9-12, 1999)
- GCOS-55** Report of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC), fifth session (Silver Spring, MD, USA, April 20-23, 1999)
- GCOS-56** (GOOS-75) Special Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), fourth session (May 17, 1999); The CLIVAR Upper Ocean Panel (UOP), fourth session (May 21, 1999); A Joint Planning Meeting of the OOPC and the UOP for the OCEANOBS99 Conference (Woods Hole, MA, USA, May 18-20, 1999)
- GCOS-57** (WMO/TD-No. 978) (GOOS-79) Report of the OOPC/AOPC Workshop on Global Sea Surface Temperature Data Sets (Palisades, N.Y., USA, November 2-4, 1998)
- GCOS-58** (GOOS-71) Report of the 6th Session of the IOC Group of Experts on the Global Sea Level Climate Observing System (GLOSS)
- GCOS-59** (GTOS-22) Report of the GCOS/GTOS Terrestrial Observation Panel for Climate, fifth session (Birmingham, UK, July 27-30, 1999)
- GCOS-60** (WMO/TD-No. 1004) (GOOS-70) GCOS/GOOS/GTOS Joint Data and Information Management Plan, Version 1.0, May 2000

- GCOS-61**
(WMO/TD-No. 1031) Report of the ninth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS (Beijing, China, September 12-14, 2000)
- GCOS-62**
(WMO/TD-No. 1038) Report of the Pacific Islands Regional Implementation Workshop on Improving Global Climate Observing Systems (Apia, Samoa, August 14-15, 2000)
- GCOS-63**
(WMO/TD-No. 1047)
(GTOS-26) Establishment of a Global Hydrological Observation Network for Climate. Report of the GCOS/GTOS/HWRP Expert Meeting (Geisenheim, Germany, June 26-30, 2000)
- GCOS-64**
(GOOS-107) Report of the eighth session of the TAO Implementation Panel (TIP-8) (St. Raphael, France, October 15, 1999)
- GCOS-65**
(WMO/TD-No. 1055) Report of the sixth session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC) (Geneva, Switzerland, April 10-13, 2000)
- GCOS-66**
(GOOS-108) Report of the ninth session of the TAO Implementation Panel (TIP-9) (Perth, Australia, November 16-17, 2000)
- GCOS-67**
(WMO/TD-No. 1072) GCOS Implementation Strategy: Implementing GCOS in the New Millennium
- GCOS-68**
(WMO/TD-No. 1093) Report of the seventh session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC) (Geneva, Switzerland, April 30-3 May, 2001)
- GCOS-69**
(GOOS-98) Report of the fifth session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Bergen, Norway, June 20-23, 2000.
- GCOS-70**
(GOOS-113) Report of the sixth session of the Joint GCOS-GOOS-WCRP Ocean Observations Panel for Climate (OOPC), Melbourne, Australia, April 2-5, 2001
- GCOS-71**
(WMO/TD-No. 1099)
(GTOS-29) Report of the GCOS/GTOS/HWRP Expert Meeting on the Implementation of a Global Terrestrial Network - Hydrology (GTN-H), Koblenz, Germany, June 21-22, 2001

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