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Report of the GCOS/GTOS/HWRP Expert Meeting on Hydrological Data for Global Studies

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Executive Summary

Canada hosted a WMO Expert Meeting on Hydrological Data for Global Studies in Toronto on 18-20 November 2002. Environmental monitoring experts from eight countries met to address key issues related to accessing and sharing hydrological data around the world.

The Expert Meeting was linked to the recent initiation, by WMO, GCOS and GTOS, of a project to develop a global observing system for hydrological data, formally named the Global Terrestrial Network for Hydrology, or GTN-H. The GTN-H is intended to support a range of climate and water resource objectives, building on existing networks and data centres and producing value-added products through enhanced communications and shared development.

The objective of the Expert Meeting was to seek expert input and guidance on a number of technical and scientific issues related to the development of the GTN-H, including user requirements, challenges to data access, data quality, data integration and interpretation.

Requirements and Adequacy of "Current System"

There is a general understanding of the needs for hydrological data and information at the global scale, which has allowed us to move forward to establish an initial GTN-H observing system. We also understand the minimum requirements for hydrological data, and the priority of these requirements. However, we need to continually refine our understanding of both users and uses: whether project-specific or programme-specific, we need to seek clarification of the specific requirements for hydrological data at global and regional scales.

As a result, we can ascertain how well our existing observing systems can meet these requirements, and also the gaps (both spatial and temporal) where we fall short of meeting the needs. This implies having an on-going process to validate the understanding of what is required. An inventory of available networks and datasets is a critical part of this process.

Our understanding of the requirements that the GTN-H must meet enable us to objectively assess the adequacy of the current observing systems and how they can contribute to addressing questions related to global and regional climate change and variability and water resources issues. GCOS is undertaking such an assessment, and recommendations relevant to the GTN-H will be included in the forthcoming "Second Report on the Adequacy of the Global Observing Systems for Climate in Support of the UNFCCC" to be submitted to the UNFCCC's Subsidiary Body for Scientific and Technical Advice (SBSTA).

Regional Challenges to Data Collection, Management and Access

Data collection and management activities are typically undertaken at the national level, but there is a need for regionally-coordinated systems and actions. Smaller countries in particular benefit from supplemental information from regional sources, especially neighbouring countries. Regional projects are driven by region-specific requirements for data and information. The river basin, rather than political boundaries, needs to be considered as the appropriate geographical unit for regional-scale monitoring activities.

The challenges common to most regions include inadequate monitoring networks; gaps in the records; a general decline of number of stations; chronic under-funding; differences in processing and quality control; and differences in data policies. Political and technical challenges differ from region to region. Major problems in the poorer regions of the world include poor status or outright lack of monitoring networks and support infrastructure, especially in Africa, and data quality problems.

Strategies to address these challenges include interaction with existing international programmes such as IGOS–Water; set-up of regional data centres; more involvement of countries and regions in global projects; regional monitoring approaches (e.g., WHYCOS); improvement of communication facilities and communication culture; and preparation of common inventories, such as R-HydroNet in South and Central America.

Approaches for Data Collection, Management and Access

Technical challenges related to collecting, managing and accessing global datasets – and ensuring proper quality control – can be met by employing current and emerging technology and standards, best practices and available infrastructure. In particular:

1. Metadata is a very important component not only to describe the data, but provides a useful contribution to the data quality assurance procedures;
2. Communications systems and protocols and data standardized data formats are essential for transmitting and sharing data (e.g., Global Telecommunication System (GTS), File Transfer Protocol (FTP), Extensible Markup Language (XML)); and
3. Web services are becoming increasingly available to facilitate access to data from distributed and disparate sources.

The following is a list of data management challenges for the GTN-H, many of which can be addressed using these technologies and other tools:

(a) Setting GTN-H priorities;
(b) Coordinating data sources (e.g., satellite, data flow);
(c) Encouraging cooperation among data providers (e.g., network inventories);
(d) Transition from research to operational data;
(e) Standardization of monitoring and formats;

(f) Data and product access - redistribution restrictions;
(g) Reducing duplication of effort;
(h) Human dimensions feedback (e.g., socio-economic);
(i) Use of higher resolution data (spatial/temporal);
(j) Data archaeology and rescue;
(k) Simplifying data/metadata collection procedures;
(l) Encouraging regional initiatives for data standards and exchange; and
(m) Using pilot projects as a tool for developing measurements capabilities.

Development of Global-Scale Data Products

As a result of discussions and presentations at this Expert Meeting, we have a sense of the types of products that should be developed in conjunction with the GTN-H:

- Products that improve our understanding of what is available and how to access them (e.g., metadata, maps);
- Products that enhance baseline or core hydrological data and improve our knowledge of hydrology (e.g., gridded runoff datasets, mapped statistics);
- Products that result from the integration of existing datasets (e.g., biogeochemical fluxes); and
- Products that are designed to address specific science questions (e.g., reference hydrological datasets that can be used in detecting climate change).

Although priorities for product development were not extensively discussed, there were suggestions that, initially, projects be undertaken that are relatively simple and achievable in the short-term to enable the GTN-H to take shape.

All products need to be carefully designed and developed with the right expertise engaged. Sufficient resources (time and money) should be secured at the outset. A simple process for planning and managing the product development, and the subsequent deployment and maintenance, should be adopted.

Care should be taken to avoid duplicating the efforts of other international initiatives and those that provide data to us. The GTN-H should always try to build upon the experiences and best practices of other global, regional and national initiatives.

Follow-up to Expert Meeting

Immediately following the Expert Meeting, the GTN-H Coordinating Group met (21-22 November) to discuss the recommendations of the Expert Meeting and to define a set of projects to advance the GTN-H. The report of that meeting is available under separate cover.

Acknowledgements

Funding to offset the logistical costs of the Expert Meeting was provided by the Hydrology and Water Resources Programme of WMO. The participants of the meeting wish to thank the Meteorological Service of Canada (MSC) for hosting the meeting. A special thank you to Joseph McIlhinney for his excellent work in preparing the electronic version of this report and the meeting presentations.

Introduction

An Expert Meeting on Hydrological Data for Global Studies was convened in Toronto on 18-20 November 2002, the third such meeting since June 2000 aimed at addressing the need for improved availability and access to global hydrological data, information and products to support a wide range of climatic and hydrological objectives.

The concept of a Global Terrestrial Network for Hydrology, or GTN-H, is the result of the joint efforts of WMO's Hydrology and Water Resources (HWR) Department; the Global Climate Observing System (GCOS); and the Global Terrestrial Observing System (GTOS). The concept is fully described in the report of the Expert Meeting in Geisenheim, Germany, in June 2000 on the Establishment of a Global Hydrological Observation Network for Climate (WMO/TD-No. 1047).

The GTN-H is a global hydrological "network of networks" for climate that is building on existing networks and data centres and producing value-added products through enhanced communications and shared development. The goal of the GTN-H is to meet the needs of the international science community for hydrological data and information to address global and regional climate, water resources and environmental issues, including improved climate and weather prediction; detection and quantification of climate change; assessment of impacts of climate change; assessment of freshwater sustainability; and understanding the global water cycle.

The GTN-H was established at a second Expert Meeting in Koblenz, Germany in June, 2001 (WMO/TD-No.1099). The major objective of that meeting was to define specific actions for the initial implementation of GTN-H. Figure 1 presents an initial configuration of the GTN-H. A GTN-H Coordination Group was formed around four key partners:

Global Runoff Data Centre;
Global Precipitation Climatology Centre;
Global Environmental Monitoring System – Water; and the
Complex Systems Research Centre, University of New Hampshire.

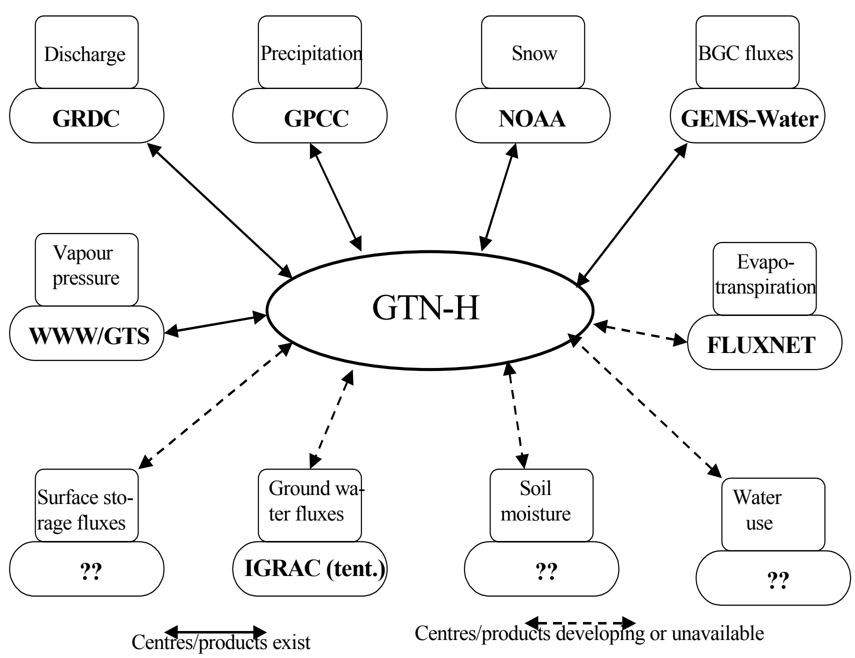
The core functions of the GTN-H are to address the following:

- Provision of timely access to global hydrological data to and metadata for users;
- Development of relevant products and related documentation, satisfying timeliness and quality requirements of users;
- Promotion of standardization in observations and the use of 'best practices';
- Promotion and facilitation of free and unrestricted exchange of data and products within existing frameworks, e.g., WMO Resolutions 40 (Cg-XII) and 25 (Cg-XIII);

- Solicitation of user feedback and measures to ensure responsiveness to changing needs;
- Monitoring and evaluation of GTN-H performance;
- Identification of key observational requirements of GTN-H, including requirements for satellite observations; and
- Provision for capacity-building.

Additional information is available in the report of the Expert Meeting in Koblenz, Germany, in June 2001 on the Implementation of a Global Terrestrial Network - Hydrology (GTN-H) (WMO/TD-No. 1099).

Figure 1: Initial Configuration for GTN-H



Objectives of the Expert Meeting on Hydrological Data for Global Studies

The purpose of this Expert Meeting was to bring together experts to further the development of a global observation system for hydrological data by discussing key issues related to data needs, data collection, quality, management, access and integration; and by determining how best to address these issues using technology, standards, policies, best practices, collaborative agreements and other means.

The expected results included:

- Identification of strategic approaches to identify and monitor observational requirements;
- Documentation of challenges and opportunities in hydrological observations, data management and access to data and information;
- Defining of means to promote standardization of observations, transmission and distribution of hydrological data; and
- Recommendations for enhancing collaboration between data providers, data centres and users.

The results of the Expert Meeting were immediately considered by the GTN-H Coordination Group at its business meeting on 21-22 November 2002. In particular, strategies recommended at the Expert Meeting were used in developing a workplan to advance the GTN-H in the short-term. Details of the GTN-H Coordination Group meeting and workplan may be found on-line at http://www.msc.ec.gc.ca/wsc/gtnh.

Format of the Expert Meeting

The agenda for the Expert Meeting was structured around four major themes:

I. Requirements and Adequacy of "Current System"
Framing a global observing system;
II. Approaches and Tools for Data Collection, Management and Access
Regional issues, metadata, communications;
III. Development of Global-Scale Data Products
Observation networks and product generation; and
IV. Stakeholder Collaboration*
International programmes and collaborative agreements.

Invited experts made formal presentations in each of these themes (see following page), after which there was extensive discussion of the issues. All presentations made at the Expert Meeting on Hydrological Data for Global Studies are available for viewing in electronic format on the CD-ROM accompanying this report. Alternatively, these presentations may be accessed via the following website: http://www.msc.ec.gc.ca/wsc/gtnh

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*The discussions on the first three themes were excellent and very productive, but unfortunately consumed more time than originally planned. As a result, a discussion on Theme IV (Stakeholder Collaboration) was deferred.

Expert Meeting Presentations

Opening Session

Welcome address of the Meteorological Service of Canada (Tom Nichols)

Welcome address by WMO (Alan Thomas)

Expert Meeting: Hydrological Data for Global Studies (Wolfgang Grabs)

Overview of the GTN-H (Dave Harvey)

Theme I: Requirements and Adequacy of "Current System"

The Global Distribution of Rainfall from Satellites and Gauges: The Global Precipitation Climatology Project (Phil Arkin, Arnold Gruber)

Global Precipitation Observations (Phil Arkin)

Report of GPCC (Wolfgang Grabs, Bruno Rudolf)

Global Runoff Observations (Thomas Maurer)

Global Observations of Water Quality (Andrew Fraser)

Theme II: Approaches and Tools for Data Collection, Management and Access

Technical Challenges to Collecting, Managing and Accessing Datasets in Africa, and on Current Opportunities to Improve this Capability (Julius Wellens-Mensah)

Water Resource Management & Hydrological Services in India (B. Lal)

Examples of Regional Approaches and Tools for Data Collection, Management and Access of Hydroclimatological Data in South America (Lelys Bravo de Guenni)

International Global Observing Strategy - Water (IGOS-Water) (Rick Lawford)

Approaches for the Management of Hydrological Data (S. Williams/J. Moore)

GAME Archive and Information Network (GAIN) (K. Takahashi)

GCOS Climate Monitoring Principles (Alan Thomas)

Theme III: Development of Global-Scale Data Products

Use of Global Data for an Emerging Programme: The Case of CliC (Climate and Cryosphere Programme) (Barry Goodison)

Reference Hydrological Networks (Paul Pilon)

NOAA/NESDIS Approach for Data Assimilation, Modelling and Product Generation (Jeff Arnfield)

GEWEX Approach for Data Assimilation, Modelling and Product Generation (Rick Lawford)

Experiences in Assembling Regional and Global-Scale Hydrological Datasets (Richard Lammers)

Theme I: Requirements and Adequacy of "Current System"

Objectives

The objective of this session was to understand the gaps and challenges and to develop a strategy to manage these. What is our current capability to meet the perceived need for hydrological data at the global scale? What are our immediate priorities?

Presentations

<u>The Global Distribution of Rainfall from Satellites and Gauges: The Global Precipitation Climatology Project</u> (Phil Arkin for Arnold Gruber)

<u>Global Precipitation Observations</u> (Phil Arkin)

Precipitation is currently deduced from a wide variety of *in-situ* and remotely-sensed observations. These include station gauges, ground-based rain radar, visible and infrared (IR) imagery from geostationary and polar orbiting meteorological satellites, passive microwave imagery and radar observations from polar orbiting satellites, and inferences from other meteorological observations. Each source of information is subject to random and systematic errors that vary in space and time, and provides coverage that is incomplete in space and time to varying degrees.

Gridded fields (analyses) of precipitation derived for any region from individual data sources are generally sub-optimal because of these errors and sampling problems. However, combining information from diverse observing systems has been shown to significantly improve the analyses. Current global products from the GPCC use estimates derived from IR and passive microwave satellite observations together with rain gauge observations to provide monthly, 5-day and daily time series of precipitation averaged over areas of 2.5° lat/long (1° x 1° for daily) for the globe (40°N - 40°S for daily). On regional scales, experimental analyses of daily precipitation for areas of 10 km x 10 km have been produced.

Many significant issues remain to be solved. The validation and characterization of the errors of both the global and regional analyses has proven to be a difficult challenge, particularly over the oceans. Furthermore, the analysis of precipitation in high latitudes and mountainous regions is still essentially an unsolved problem.

<u>Report of GPCC</u> (Bruno Rudolf)

<u>Global Runoff Observations</u> (Thomas Maurer)

<u>Global Observations of Water Quality</u> (Andrew Fraser)

Discussions

1. Key problems cited were *inter alia*:

   (a) Adequacy of networks;
   (b) Access to data and information;
   (c) Harmonization including policies, quality control, data formats, coding and transmission;
   (d) Data integration including both multiple platform observations as well as data from different networks; and
   (e) Generation of research and applications-oriented products.

2. It was observed that most of the information generated form global observation networks is used by developed countries and hardly by research and user communities in the developing world. Sharing information across regions becomes valuable especially for smaller countries to complement their spatially and/or technologically restricted national observation networks. This is especially important for hydrometeorological variables and hydrological data and information from shared river basins used for forecasting purposes.

3. Research requirements for data and information cover a wide range such as climate change, water resources variability and availability, extreme events and “vulnerable areas” (the latter including the notion of risk and adaptation capacity by the concerned population).

4. Heterogeneity of research fields make it difficult to prioritise requirements for data and information in terms of variables to be included as well as the required resolution in time and space.

5. As a consequence, network requirements also vary largely depending on requirements from the research and application communities.

6. It is therefore desirable to conceptualise a flexible network architecture that allows the definition of networks as subsets of a larger composite network.

7. Minimum operational baseline networks of routine observations (ground- and satellite-based) need to be augmented by research networks.

8. GTN-H should promote the harmonization, standardization of global datasets.

9. From a pragmatic viewpoint the network design for a global observing system should start up with variables, which combine the following criteria (non-exclusive):

   (a) Already routinely observed by national agencies or global research programmes;
   (b) Adequate length of records;
   (c) Adequate geographical coverage;

(d) Adequate parameters;
(e) High quality of data with comparable observation methods → compatible datasets; and
(f) Long-term commitment for continued observations.

10. With regard to c) above, methods of observation need to be standardized i.e., in accordance with WMO's standard observational procedures (e.g., WMO Guide to Meteorological Instruments and Methods of Observation; and Guide to Hydrological Practices).

11. To obtain a global picture of the availability and accessibility of selected variables, data providers (here primarily global data centres, global research programmes, global observing systems) should compile a comprehensive geo-referenced meta-database that includes descriptions of the observations in accordance with an agreed criteria for selected metadata.

12. The compilation of a meta-database necessitates the standardization of meta-data information to allow comparability and to maintain homogeneity and consistency of a comprehensive meta-database for a global observing system.

13. In its pragmatic implementation, a global observation network should start from a "minimum requirement" approach with regard to the number and complexity of observed variables (or derivatives such as fluxes of evaporation or soil moisture) and minimum temporal and spatial resolution: as an example, daily data on a 2.5 degree global grid or over a river basin.

14. This approach allows a multiple layer compilation of a virtual integrated meta-database for each grid-cell or river basin on a global basis. Likewise, this approach allows for the identification of observation gaps with respect to each variable in each grid-cell and for an assessment of the "adequacy" (based on minimum requirement standards) of all information available in each grid-cell both historically as well as on a continued basis.

15. For climate-sensitive hydrological observations, and discharge information in particular, a hydrological reference network needs to be defined with a minimum of human influence and/or stable conditions on the hydrological regime in the concerned basin. Scoping exercise proposed prior to undertaking this as a major project.

16. As a principle, global observing systems need to be designed to meet a practical set of priorities and requirements.

17. It needs to be understood that basic data for a global observing system is largely based on observations that are funded through national agencies. This is largely valid for terrestrial observations and for many satellite-based observations even though the latter are carried out increasingly in the framework of multinational agreements. (Question: Is it "thinkable" that selected terrestrial observations in the context of global observing systems

could likewise be carried out on the basis of multinational agreements? Examples are HYCOS projects).

18. Given the resource inputs into global observing systems from national agencies, product development and other derived services need to be responsive to national requirements to encourage continued national participation and funding of observation programmes. A close feed-back loop needs to be established between national data providers and the users of the global observing system.

19. In the case of developing countries, this means also an enhancement of country participation in global projects.

Conclusions and Recommendations

There is a general understanding of the needs for hydrological data and information (see the Geisenheim Report, WMO/TD-No. 1047) at the global scale, which has allowed us to move forward to establish an initial GTN-H observing system. We also understand the minimum requirements for hydrological data, and the priority of these requirements. However, we need to continually refine our understanding of both users and uses: whether project-specific or programme-specific, we need to seek clarification of the specific requirements for hydrological data at the global and regional scales.

As a result, we can ascertain how well our existing observing systems can meet these requirements, and also the gaps (both spatial and temporal) where we fall short of meeting the needs. This implies having an on-going process to validate the understanding of what is required. An inventory of available networks and datasets is a critical part of this process.

Our understanding of the requirements that the GTN-H must meet enable us to objectively assess the adequacy of the current observing systems and how they can contribute to addressing questions related to global and regional climate change and variability and water resources issues. GCOS is undertaking such an assessment, and recommendations relevant to the GTN-H will be included in the forthcoming "Second Report on the Adequacy of Global Observing Systems for Climate in Support of the UNFCCC" to be submitted to the UNFCCC's Subsidiary Body for Scientific and Technical Advice (SBSTA).

Theme II: Approaches and Tools for Data Collection, Management and Access

Objectives

The objective of this session was to understand the technical challenges and opportunities to collecting, managing and accessing global datasets, including near real-time data; to then develop a strategy that employs current and emerging technology and standards, best practices and available infrastructure to support a global observation system. The technical challenges and opportunities were considered first from a geographical regional perspective, and then in a more generic sense.

Presentations on Regional Issues

Technical Challenges to Collecting, Managing and Accessing Datasets in Africa, and on Current Opportunities to Improve this Capability (Julius Wellens-Mensah)

The presentation recalled previous assessments made on water resources assessment activities in Africa in 1991, 1992 and 1995. It also recalled the problems identified by the assessments and compared them with the current situation. The current technical challenges to collecting and managing hydrological data were identified as lack of basic equipment in both quality and quantity, low technology in hydrological data collection, lack of laboratories for re-calibration of equipment and water quality and sediment analyses, lack of adequately trained human resources at both professional and technician levels and lack of funding and capital to sustain the current level of operations and to acquire or access new technologies. The challenges in accessing datasets in Africa arise from reluctance and resistance of African countries to exchange data freely. This is because most African countries do not feel sufficiently involved in global studies. Other factors are the absence of protocols and conventions for sharing water in some shared or international basins and aquifers, low level of feedback from researchers and studies that use African data and the fear of losing ownership of data.

Opportunities to improve the capability of collecting, managing and accessing datasets in Africa are offered by initiatives such as the WHYCOS Projects, the Nile 2002 Programme and the GIWA International Waters Programme, which emphasize free data exchange and the WMO-funded Hydrological Data Rescue Pilot Project currently ongoing to reduce the risk of data loss in Africa. The promotion, implementation and practice of WMO Resolution 25 (Cg-XIII) and integrated water resources management will greatly improve free and unrestricted data exchange.

The presentation concluded that the challenges to collecting, managing and accessing datasets in Africa derive mainly from lack of, or inadequate, field and data-processing equipment, use of low technology, lack of laboratories and general logistics. Inadequately trained manpower and insufficient capital and funding are cross-cutting factors that affect all aspects of collecting, managing and accessing hydrological data. WHYCOS and other programmes like the GIWA International Waters and the Nile 2002 Programmes that emphasize the free exchange of data hold great promise to improving access to datasets in Africa

The promotion and implementation of WMO Resolution 25 (Cg-XIII), as well as, promotion and practice of IWRM and dialogue are the likely tools to overcome the resistance and reluctance of some African countries to commit themselves to free and unrestricted exchange of hydrological data.

<u>Water Resource Management & Hydrological Services in India</u> (B. Lal)

<u>Examples of Regional Approaches and Tools for Data Collection, Management and Access of Hydroclimatological Data in South America</u> (Lelys Bravo de Guenni)

The presentation focus is on describing an example of a Regional initiative for Data Collection, Management and Access. This initiative is called LBA-HydroNET. This is a regional initiative focused on the Amazonian countries and derived from a former continental initiative called R-HydroNET which involves all South America and Central America. Details about the strategies, workshops, working groups and goals related to this initiative are also given in this presentation.

An important issue is the active participation of the Latin American Meteorological services in the LBA-HydroNET workshops and data exchange and management activities. Some of the LA participants have presented their needs, applications of interest and organizational and institutional issues (Planning for El Niño in Ecuador; Rainfall-Runoff modelling applications in Peru; the VENEHMET project in Venezuela), including identification of common problems with data management issues; declining of the monitoring networks; serious underfunding of meteorological services; lack of common strategies for data management and quality control; lack of common inventories.

The final key point is to stress the support of Regional initiatives such as this. It needs more formal mechanisms to assure expansion of the data availability in the LBA-HydroNET data repository site from the national meteorological services (e.g., use of WMO data exchange resolutions). Major improvements of this initiative can be developed as, for example, the inclusion of more data management and application tools.

Finally, LBA-HydroNET may be a good example of a regional network strategy within the GTN-H concept.

Discussion of Regional Issues

Actions are typically undertaken at national level: there is a need for implementing systems and actions at regional levels.

Rationale: Small countries need to supplement information needs from regional sources (neighbouring countries).

Regional projects need to be driven by region-specific requirements and therefore region-specific needs for data and information.

Question: In each region, is there a regional infrastructure (regional centre, river basin organization, etc.) to do the business?

Reminder: Thinking in a regional and global context: River basins need to be considered as the appropriate geographical unit to implement planning and implementation of activities.

Major problems:

Poor status of networks and support infrastructure, especially in Africa;
Programmes in place such as WHYCOS and bilateral projects;
Support infrastructure often lacking;
Political versus technical challenges differ from region to region; and
Data quality problem.

Strategy:

Interaction with programmes such as IGOS – Water;
Start-up from data rich regions;
Regional data centres;
Involvement of countries and regions in global projects;
Regional monitoring approaches (such as WHYCOS, but also as spin-off from global projects);
Improve communication facilities (and communication culture); and
Preparation of common inventories (such R-HydroNet).

Presentations on Generic Data Issues

International Global Observing Strategy - Water (IGOS-Water)
(Rick Lawford)

Approaches for the Management of Hydrological Data
(Steve Williams/James Moore)

GAME Archive and Information Network (GAIN) (Kiyotoshi Takahashi)

GCOS Climate Monitoring Principles (Alan Thomas)

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

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

11. Rigorous station-keeping should be maintained to minimize orbital drift.

12. Overlapping observations should be ensured for a period sufficient to determine inter-satellite biases.

13. Satellites should be replaced within their projected operational lifetime (rather than on failure) to ensure continuity (or in-orbit replacements should be maintained).

14. Rigorous pre-launch instrument characterization and calibration should be ensured.

15. Adequate on-board calibration and means to monitor instrument characteristics in space should be ensured.

16. Development and operational production of priority climate products should be ensured.

17. 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. Continuing use of still-functioning baseline instruments on otherwise de-commissioned satellites should be considered.

19. The need for complementary *in-situ* baseline observations for satellite measurements should be appropriately recognized.

20. Network performance-monitoring systems to identify both random errors and time-dependent biases in satellite observations should be established.

Discussion of Generic Data Issues

1. Problems have been identified, as follows:

   (a) Inadequate monitoring;
   (b) Gaps in observations;
   (c) General decline of number of stations;
   (d) Chronic under-funding; and
   (e) Differences in processing and quality control
   but: Same problems in so-called "developed" countries.

2. Data policy levels.
   Political vs. technical challenges.

3. Global vs. regional networks.

4. Quality control levels.
   Researchers are reluctant to carry out quality control as they consider it is not their domain.
   QC and archiving must be included in research proposals.

5. Data management issues and opportunities:

   (a) Setting GTN-H priorities;
   (b) Coordination of data sources (e.g., satellite, data flow);
   (c) Encourage cooperation among data providers (e.g., network inventories);
   (d) Transition from research to operational data;
   (e) Standardization of monitoring and formats;
   (f) Data and product access - redistribution restrictions;
   (g) Reduce duplication of effort;
   (h) Human dimensions feedback (e.g., socio-economic);
   (i) Use of higher resolution data (spatial/temporal);
   (j) Data archaeology and rescue;
   (k) Simplify data/metadata collection procedures;
   (l) Encourage regional initiatives for data standards and exchange; and
   (m) Pilot projects as a tool for developing measurements capabilities.

6. No international commission to develop metadata standards exists, especially in the terrestrial domain for geophysical data.
   Recommendations to be produced to WCRP, IGOS, satellite agencies etc. based on the above list.

7. Standards.
   "The nice thing about standards is that there are so many to choose from".
   Formats will probably not be unified.
   "Community data portal".
   Requires metadata production by all users that adheres to standards.
   Separate data archiving and QC/QA but do it hand-in-hand.

8. What kind of data (quality) is allowed to come into GTN-H?

9. Lowest possible technical level.

10. Pragmatic approach.

11. Good metadata is a pre-requisite for data quality assessment.
    Inventory of existing data sources.

12. Near real-time aspect: reduces quality.

13. GTS transmission system, CREX-coding, free-of-charge.
    Today: multi-platform.
    Transmission protocol: to be clear and simple.
    Overview of common standards.
    RTH Regional Communication Hub.

Approaches for the Management of Hydrometeorological Data

This summary was prepared by Steve Williams and Jim Moore shortly after the Expert Meeting. It describes the issues and elaborates on the opportunities discussed during the meeting.

The University Corporation for Atmospheric Research (UCAR)'s Joint Office for Science Support (JOSS) provides scientific, technical and administrative support services to the research community for the purpose of planning, organizing and implementing research programmes and associated field projects worldwide. The three facets of this support includes the programme planning and field implementation, scientific data management, and logistics. JOSS has extensively participated in global field projects and supports data management activities in various WCRP programmes (i.e., GEWEX, CLIVAR, CliC, and CEOP).

Quality Control Issues

Data are made up of both continuous and discrete observations. This complicates the quality assurance process and procedures, since these parameters are analyzed (and gridded) differently. Issues such as reporting standards (e.g., time of day, averaging interval) and solid precipitation (e.g., wind effects, gauge differences) can present complications in combining these datasets. This becomes increasingly important as more of these combined datasets are being used for algorithm validation. The distribution of preliminary (real-time) vs. final datasets not only complicates data quality issues, but presents potential problems for the circulation of "multiple" datasets. Care must be ensured to document and control these datasets.

Use of Metadata to Help Manage Data Quality Issues

Metadata is a very important component not only to describe (and accompany) the data, but to provide a useful contribution to the data quality assurance procedures. There are standards for metadata (e.g., International Standards Office (ISO) TC 211 Standards for the management of geographic data [http://www.isotc211.org/scope.htm#scope/]). The Standardization of Monitoring procedures and associated metadata is becoming increasingly important as programmes such as GTN-H begin to combine or merge data from disparate networks. The first step in this process is to produce an inventory of Existing Data Sources, which will not only identify available data, but include appropriate metadata (or identify deficiencies). Standardized metadata will also facilitate data mining capabilities such as the University of Alabama's Algorithm Development and Mining System (ADaM) System [http://datamining.itsc.uah.edu/adam/index.html].

Use of Communications Protocols and Data Transmission Standards

The Global Telecommunication System (GTS) is currently used to transmit basic hydrometeorological data to both operational centres and archives. If GTS is to be used to transmit additional hydrological data, the current system protocols will have to be modified and augmented. The advantage of utilizing GTS is that it is an existing system and does not have to be implemented (just modified). The disadvantage is that GTS is a generally low bandwidth and has not been designed to transmit large datasets or higher resolution data. There has been considerable work to develop new standards and communications protocols to improve data distribution. The International Organization for Standardization (ISO) has published and maintains standards for various data applications such as the TC 211 Standards for the management of geographic data [http://www.isotc211.org/scope.htm]. Most research groups routinely use the Web and File Transfer Protocol (FTP) to exchange data. Some have proposed standards to easier allow the intercomparison of data and model output. Many of these protocols are diverse; designed specifically for the applications of the research needs (i.e., data analysis software and required formats). One such example project is the Assistance for Land-surface Modelling Activities (ALMA) [http://www.lmd.jussieu.fr/~polcher/ALMA/dataex_main.html]. Another recent development to exchange data was the development of Extensible Markup Language (XML) [http://www.w3.org/XML/]. XML is a set of conventions (and modules) for designing text formats that allow the structuring of data. Originally designed for large-scale electronic publishing, XML is now playing an increasing role in the exchange of a wide variety of data on the Web. Since it is impossible and impractical to think that all data source transmission will be "standardized", GTN-H will utilize a combination of existing (and future) data communications.

Use of Web Services to Improve Data Access

There are a variety of Web services available (and in use) to handle data from distributed, disparate, and distributed sources. A good example of an increasing popular system is based on the development of the Distributed Ocean Data System (DODS) [http://www.unidata.ucar.edu/packages/dods/]. The concept involves an object-oriented approach of a network of data servers linked through the use of clients (or work stations). This allows for the de-centralization of datasets, but retains the flexibility of selecting and subsetting data in an interactive mode. A variation of this system involves the addition of data/product display capabilities using the Gridded Analysis and Display System (GrADS). Further information on GrADS-DODS can be found at: [http://grads.iges.org/grads/gds/.] Examples of such implemented systems include the NOAA Operational Model Archive and Distribution System (NOMADS) in use at NCEP and NCDC [http://nomads.gfdl.noaa.gov/]; the NASA Data Assimilation Office (DAO) [http://polar.gsfc.nasa.gov/]; the NASA Land Information System (LIS) [http://lis.gsfc.nasa.gov/]; the NASA/GSFC Distributed Active Archive Center (DAAC) [http://daac.gsfc.nasa.gov/CAMPAIGN DOCS/UDRS/index.shtml]; the Land Data Assimilation Scheme (LDAS) [http://ldas.gsfc.nasa.gov/LDASnew/]; and the UCAR/NCAR Community Data Portal [http://dataportal.ucar.edu/]. In addition there are mechanisms (and software) to manipulate and integrate data such as the Geographic Information Systems (GIS) [http://www.usgs.gov/research/gis/title.html]. GIS allows the merging of geo-spatial relational databases. These data fields can be overlaid and displayed allowing the integration of various datasets.

Data Management Issues and Opportunities

The following list was offered to summarize issues raised from the above-described JOSS presentation and to list important challenges before GTN-H in the context of data management support and considerations. It is important that setting priorities and requirements for GTN-H data is a vital first step.

<u>Setting GTN-H Priorities (various science applications)</u>

The objectives of the project need to be clearly defined in an effort to help define needed parameters, time and space resolution of the data and related issues. It is hoped that high priority datasets can be identified early in the planning process. It is important to determine what existing global datasets will address project objectives. It is equally vital to highlight gaps in the data needed to answer critical questions. This will provide a focus for international cooperation/collaboration related to data collection, access and exchange components of GTN-H.

<u>Coordination of Data Sources (e.g., satellite, data flow)</u>

After data needs are clearly defined, the next step will be to identify the sources of those data and the strategy to access those datasets. Beyond the obvious use of the WMO GTS system for data access, the process of accessing new products from satellites and other remote sensing platforms needs careful consideration. It is apparent that the data volumes anticipated from GTN-H datasets will require innovative solutions for access, exchange and assimilation.

<u>Encourage Collaboration among Data Providers (e.g., network inventories)</u>

There are multiple global networks that collect various components of the needed GTN-H parameter set. The data centres responsible for this information need to work together to minimize duplication, fill in gaps and standardize processing and archives procedures, where possible.

<u>Transition from Research to Operational Data</u>

Care needs to be taken if there is a requirement to make certain data collected from research sites part of the operational database. Adding exhaustive requirements for documentation, metadata and reporting may preclude long-term collection of these data. Provision of resources for the long-term support of research stations is a consideration.

<u>Standardization of Monitoring and Formats</u>

The objective here is to simplify all manner of data handling where possible. Experience suggests that a wide variety of monitoring and measurement strategies are used around the world to collect “similar” data (e.g., streamflow, temperature, precipitation). This is also true of the format used for recording, archival and distribution. GTN-H could really help streamline the long-term assimilation of global datasets by determining procedures used for collection/quality control of critical parameters needed to meet GTN-H objectives. It may then be possible to recommend a few critical standards for these data (e.g., date/time stamp, location/height/time of observation, measurement units, documentation) that will serve GTN-H and national needs.

Data and Product Access - Redistribution Restrictions

The reality here is that many nations do restrict access of some or all of GTN-H required datasets. Work is required here to make arrangements for access to critical datasets. This can be done in the context of providing products from GTN-H activities, resources for enhanced instrumentation or training for national agencies responsible for hydrology dataset collection.

Reduce Duplication of Effort

The GTN-H planning process should work with data centres and participating national hydrometeorological agencies to minimize redundant tasks. Examples include quality-control procedures, dataset archival and exchange. It may be possible to use existing capabilities at data centres/agencies to collect, process, assemble and provide required GTN-H datasets.

Human Dimensions Feedbacks (e.g., socio-economic)

If GTN-H desires additional data from countries not providing data at this time, it is important that a major effort be made to return products and results from GTN-H that are relevant to the nation's needs (e.g., flood, drought forecasts, water quality changes). Understanding and responding to national/regional needs may help expedite access to GTN-H priority data on a national level.

Use of Higher Resolution Data (spatial/temporal)

There are implications to data transmission, communication, archival and distribution services if new requirements from GTN-H are implemented. Added resources would be required. Determining data resolution requirements within the "realities" of regional and global data communications capabilities is an important first step. The ability/necessity of using satellite-derived products instead of sparse surface observations is a big issue for GTN-H.

Data "Archeology" and Rescue

There may be many retrospective hydrometeorological datasets that have been collected by various nations and local agencies that are not routinely available but could be important for research purposes. This could be a substantial effort to locate and make available these data to the scientific community. In some cases extensive additional work (such as digitizing and quality control) must be performed on these datasets before they could be used.

Simplify Data/Metadata Collection Procedures

Nations will not be responsive if exhaustive new requirements are added with respect to metadata, data resolution and new instrumentation. Modest changes and simplifications should be considered whenever possible to streamline the collection process. Examples include Web-based forms using modest computer hardware and/or automated telemetry where feasible/affordable.

Encourage Regional Initiative for Data Standards and Exchange

There are several examples of regional projects (LBA and GAME) where agreements are in place to foster data exchange among participating countries. This includes formats and metadata. GTN-H must take advantage of these capabilities when organizing global datasets. The time and effort required now to establish standards will be rewarded in the long run when collecting and using regional/global datasets for GTN-H.

Pilot Projects as a Tool for Developing Measurement Capabilities

Take advantage of focused research projects as an opportunity to expand capabilities and expertise within participating countries. This includes entraining staff from local/national hydrometeorological services during the field campaign to improve their capabilities and experience. Explore opportunities for upgrading instruments used for critical GTN-H related measurements.

Theme III: Development of Global-Scale Data Products

Objectives

The objective of this session was to define the range of global-scale products (e.g., specialized datasets, derived variables, model outputs, statistical analyses, maps) that should be developed to help meet the needs described earlier; to develop a priority list of products; to discuss how best to develop these products (who needs to be involved, what tools are required, who maintains, etc); and to develop a course of action for the effort to develop and maintain a suite of global-scale data products.

Presentations

Use of Global Data for an Emerging Programme: The Case of CliC (Climate and Cryosphere Programme) (Barry Goodison)

Reference Hydrological Networks (Paul Pilon)

NOAA/NESDIS Approach for Data Assimilation, Modelling and Product Generation (Jeff Arnfield)

GEWEX Approach for Data Assimilation, Modelling and Product Generation (Rick Lawford)

Discussion

1. GTN-H needs to ensure the availability of metadata to provide the user with an understanding of the data and essential attributes, otherwise all data could erroneously be treated as equal.

2. GTN-H needs to include additional cryospheric variables, not just snow water equivalent. Snow products (e.g., snow cover) have improved immensely. The relationship between GTN-H and CliC needs to be further explored.

3. Web-based cryospheric products are being developed such as graphs for minimum, maximum, etc., and maps depicting “departures from normal values”, as requested by users.

4. A process was presented for identifying/developing reference hydrological datasets that can be used to address specific climate objectives (e.g., climate change detection, impacts, prediction, etc.). Canadian and American examples were discussed.

5. Two ways of looking at the climate change question: Basin approach and flux approach: Two recommendations for reference networks were put forth: pristine/stable basin network and the “flow-to-oceans” network concepts.

6. Such specialized networks could also be useful in planning new or expanded observing networks in data-scarce regions.

7. Integration of the data from reference networks (e.g., precipitation and streamflow) can lead to additional value-added products (e.g., trend analyses to understand cause and effect).

8. An initial set of data products has been proposed by the GTN-H Coordination Group (reference: the Koblenz Report, WMO/TD-No. 1099) that represents a first attempt at developing products using available core "baseline" datasets. These include:

- Gridded discharge/runoff field (University of New Hampshire has developed a first version);
- Map product on data availability;
- Map product on hydrological conditions, anomalies; and
- Biogeochemical fluxes based on assessment of water quality data (GEMS-Water) and streamflow data (GRDC).

9. It was suggested that a global database on hydrological extremes, both floods and droughts, is needed in support of the climate work. Apparently, this has been done to a certain extent by the Dartmouth Institute. CRED and GDIN identify disasters in their databases.

10. The initial 10 GTN-H hydrological variables include fluxes in the Koblenz Report. Caution was urged over the approaches to deriving these fluxes. In many cases, this is a fairly complex undertaking, requiring additional datasets not identified by the GTN-H. The GTN-H needs to work with the appropriate scientists and coordinate. Other parameters needed to determine flux values to be added to the list. FLUXNet initiative is trying to standardize approaches; primarily fluxes to oceans are being computed.

11. The initial GTN-H list does not include the development of specialized or "reference" networks as products – this needs to be discussed further.

12. It was noted that certain variables essential to hydrology (e.g., temperature, snow cover) are not part of the GTN-H. These may be addressed under other GCOS or GTOS initiatives.

13. There was a (repeated) suggestion for the GTN-H to undertake an inventory of available global datasets and related products as an initial step.

14. NOAA/NCDC has much experience and offers many insights into data management, assimilation and global product generation, and should be studied further (e.g., 10 principles, statistics, and maps).

15. NCDC is a major player in developing proposed map-based North American drought index.

16. GEWEX experiences have resulted in a good understanding of needs for hydrological data to answer many climate questions.

17. GEWEX has experience in producing several global datasets, such as soil wetness, radiation, precipitation, and aerosols, going back to the early 1980s.

18. GEWEX and CliC have good ideas about data needed to validate climate models, including streamflow, soil moisture, albedo, and snow water equivalent.

19. Challenges to the GTN-H: What are the best variables for detecting climate change? How do we integrate models and data to produce the best quality products?

Conclusions and Recommendations

As a result of discussions and presentations at this Expert Meeting, we have a sense of the types of products that should be developed in conjunction with the GTN-H:

- Products that improve our understanding of what is available and how to access them (e.g., metadata, maps);
- Products that enhance baseline or core hydrological data and improve our knowledge of hydrology (e.g., gridded runoff datasets, mapped statistics);
- Products that result from the integration of existing datasets (e.g., biogeochemical fluxes); and
- Products that are designed to address specific science questions (e.g., reference hydrological datasets that can be used in detecting climate change).

Although priorities for product development were not extensively discussed, there were suggestions that, initially, projects be undertaken that are relatively simple and achievable in the short-term to enable the GTN-H to take shape.

All products need to be carefully designed and developed with the right expertise engaged. Sufficient resources (time and money) should be secured at the outset. A simple process for planning and managing the product development, and the subsequent deployment and maintenance, should be adopted.

Care should be taken to avoid duplicating the efforts of other international initiatives and those that provide data to us. The GTN-H should always try to build upon the experiences and best practices of other global, regional and national initiatives.

References

1. Establishment of a Global Hydrological Observation Network for Climate. Report of the GCOS/GTOS/HWRP Expert Meeting, Geisenheim, Germany, June 26-30, 2000 (GCOS-63; GTOS-26) (WMO/TD-No. 1047).

2. 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 (GCOS-71; GTOS-29) (WMO/TD-No. 1099).

These and other GCOS publications may be accessed through the GCOS World Wide Web site at: http://www.wmo.ch/web/gcos/gcoshome.html

Expert Meeting Presentations

The presentations made at the Expert Meeting on Hydrological Data for Global Studies are available for viewing on the CD accompanying this report.

Alternatively, these presentations may be accessed via the following website: http://www.msc.ec.gc.ca/wsc/gtnh

Annex 1

EXPERT MEETING
HYDROLOGICAL DATA FOR GLOBAL STUDIES

TORONTO, 18-20 NOVEMBER 2002

Holiday Inn Yorkdale - Albany Room

Agenda

The purpose of this meeting is to bring together experts to further the development of a global observation system for hydrological data, by discussing key issues related to data needs, collection, quality, management, access and integration, and by determining how best to address these issues using technology, standards, policies, best practices, collaborative agreements, etc.

Monday, 18 November 2002

09:00 Registration
Registration desk set up in the ALBANY meeting room at 8:45; Dave Harvey and Cathy Anker register the participants; coffee, tea, juices available in meeting room

09:30 Opening of the Expert Meeting (Ted Yuzyk)
Ted Yuzyk (Hydrological Advisor for Canada) opens meeting, deals with housekeeping items, then introduces Tom Nichols, Director-General of MSC's Atmospheric Monitoring and Water Survey Directorate.

09:40 Welcome address of the Meteorological Service of Canada (Tom Nichols)
Tom Nichols welcomes the experts to Canada; briefly outlines Canada's interest in global monitoring, its support for developing global networks (e.g., GSN, GUAN), and its support of GCOS; and how this meeting is consistent with this.

09:50 Welcome address by WMO (Alan Thomas)
Ted Yuzyk introduces Alan Thomas; Alan also welcomes the experts to the meeting; briefly describes the context for this meeting, linking it to the several WMO programmes and initiatives that should or could be affected by the success of this meeting, including the GTN-H; Alan then introduces Wolfgang Grabs...

10:00 Introduction to Workshop (Wolfgang Grabs)
Wolfgang Grabs continues where Alan leaves off, describing the activities of the last several years relating to the requirements for and evolution of a global observation system for hydrological data; describes the work leading to the creation of the GTN-H and its expected

Monday, 18 November 2002 (continued)

role and its relationship to this Expert Meeting; clarifies the meeting objectives and expected results; explains how the agenda should enable us to achieve these results by noon on Wednesday. Wolfgang then introduces Dave Harvey…

10:15 Overview of the GTN-H (Dave Harvey)
Dave Harvey will then present on the GTN-H, outlining its role, the core functions and responsibilities as discussed at the GTN-H implementation meeting in June 2001.

10:30 Coffee break

Theme I: Requirements and Adequacy of "Current System"

Chairman: Wolfgang Grabs
Rapporteur: Dave Harvey
The objective of this session is to understand what the gaps and challenges are, and develop a strategy to manage these. What is our current capability to meet the perceived need for hydrological data at the global scale? What are our immediate priorities?

10:45 Summary of discussions held on requirements, sources and adequacy during the June 2000 GCOS/GTOS/HWRP Expert Meeting on "Establishment of a Global Hydrological Observation Network for Climate" (Wolfgang Grabs)
We do not need to repeat the discussions that were held then. This is a good starting place for us to proceed…

11:00 Global precipitation observations (P. Arkin, A. Gruber)
What is the current system for acquiring precipitation observations? What are the problems? What is the contribution of the GPCC to a global observation system for hydrological data ? What needs to be done to make the data centre more effective?

11:20 Global runoff observations (T. Maurer)
What is the current system for acquiring runoff observations? What are the problems? What is the contribution of the GRDC to a global observation system for hydrological data? What needs to be done to make the data centre more effective?

11:40 Global observations of water quality (A. Fraser)
What is the current system for acquiring water quality observations? What are the problems? What is the contribution of GEMS-Water to a global observation system for hydrological data? What needs to be done to make the data centre more effective?

12:00 Experiences in Assembling Regional and Global-Scale Hydrological Datasets (R. Lammers)

12:30 Lunch

14:00 Discussion: Data requirements for global studies
Questions to consider: Do we have a sufficient understanding of the need for hydrological data and information at the global scale? If not, what should be done? If so, how are we doing in meeting these needs? What are the gaps? What are the priorities?

Monday, 18 November 2002 (continued)

14:30 Discussion: Framing a Global Observing System
Questions to consider: What is the model for a "global observing system" that we should consider? What are the key components of such a system? What is the relationship between a global observing system and the National Hydrological and Meteorological Services? What is the role of the global data centres? What is the role of other international programmes?

15:15 Conclusions and recommendations
Presentation by rapporteur for this session (Dave Harvey). Consensus on recommended course of action that will ensure that requirements are properly understood and that an appropriate "global observing system " will evolve to meet these requirements.

15:30 Coffee break

Theme II: Approaches and Tools for Data Collection, Management and Access

Chairman: Alan Thomas
Rapporteur: Thomas Maurer
The objective of this session is to understand the technical challenges and opportunities to collecting, managing and accessing global datasets, including near real-time data; to then develop a strategy that employs current and emerging technology and standards, best practices and available infrastructure to support a global observation system

15:45 Regional issue Africa (W. Mensah)
Presentation is made on the technical challenges to collecting, managing and accessing datasets in Africa, and on current opportunities to improve this capability

16:05 Regional issue Asia (B. Lal)
Presentation is made on the technical challenges to collecting, managing and accessing datasets in Asia, and on current opportunities to improve this capability

16:25 Regional issue Latin America (L. Guenni)
Presentation is made on the technical challenges to collecting, managing and accessing datasets in Latin America, and on current opportunities to improve this capability

16:50 Discussion: Regional strategies to improve data collection, management and access for global studies
Questions to consider: What are the common technical barriers to ensuring the availability of good quality data? Are there programmes in place that can be leveraged to improve the situation? Is there flexibility to change? Is the required supporting infrastructure in place? Are the political challenges greater than the technical challenges?

17:30 International Global Observing Strategy - Water (IGOS-Water) (R. Lawford)
Case study

17:50 Meeting adjourns

18:00 **Reception for Meeting Participants**
(in the Atrium, off the hotel lobby)

Tuesday, 19 November 2002

Theme II: Approaches and Tools for Data Collection, Management and Access
(continued from Monday)

08:30 Approaches for the management of hydrological data (S. Williams/J. Moore)

09:00 GAME Archive and Information Network (GAIN) (K. Takahashi)

09:20 Discussion: Quality control and data management issues related to historical and real-time data acquisition
Given the vast number of sources of data used in global studies, the need for consistent, accurate, and comparable data is essential. There are likely more standards in place for the acquisition of traditional, non-real-time hydrological datasets than for real-time data. Nevertheless, we need to understand the level of quality of any dataset before we use it, and we need to implement standards-based data processing and management procedures to ensure the user acquires the most consistent, accurate, and comparable data. Questions to consider: To what extent are such standards-based procedures in place? What about automated QA/QC procedures for real-time data? Is this already being addressed by another international programme? What should be done?

10:00 Coffee break

10:15 Discussion: Use of metadata to help manage data quality issues
Hopefully, the first two presentations on Tuesday will provide an overview? Otherwise, a short presentation should be made here…Questions to consider: How do we define criteria for data quality? Should we develop criteria that can be used by each country and incorporated into metadata that will be available with the actual data? Is there an existing example? What is the effort to do this? What are the related international standards?

11:00 Discussion: Use of communications protocols and data transmission standards to improve data access
Hopefully the first two presentations will have touched on these. Otherwise, a short presentation should be made here…Questions to consider: What do we mean by improved data access and by whom? What principles do we need to respect? What are the technologies that need to be implemented, where and by whom? Is there an existing example of these in use? What is the effort to do this? What are the related international standards?

11:45 Discussion: Use of web services and xml formats to improve data access
Perhaps first two presentations will have introduced these concepts. Otherwise, a brief overview should be made here…Questions to consider: What is the effort required to implement these technological enhancements? Is there an existing example of these in use? What are the related international standards?

12:30 Lunch

14:00 Conclusions and recommendations
Presentation by rapporteur for this session (Thomas Maurer). Consensus on recommended course of action that is based upon employing current and emerging technology and standards, best practices and available infrastructure to build a global observation system

Tuesday, 19 November 2002 (continued)

Theme III: Development of Global-Scale Data Products

Chairman: Dave Harvey
Rapporteur: Harry Lins
The objective of this session is to define the range of global-scale products (e.g., specialized datasets, derived variables, model outputs, statistical analyses, maps) that should be developed to help meet the needs described earlier; to develop a priority list of products; to discuss how best to develop these products (who needs to be involved, what tools are required, who maintains, etc); and to develop a course of action for the effort to develop and maintain a suite of global-scale data products

14:30 Use of global data for an emerging programme: The case of CliC (Climate and Cryosphere Programme) (B. Goodison)

14:50 Reference Hydrological Networks (P. Pilon)

15:10 Discussion: Definition of global-scale products
What do we mean by global-scale products? In view of our understanding of the needs for hydrological data at the global scale (reference June 2000 Expert Meeting report), what are the products to be developed and their associated priority? Who determines the priority?

15:45 Coffee break

16:00 NOAA/NESDIS approach for data assimilation, modelling and product generation (J. Arnfield)

16:20 GEWEX approach for data assimilation, modelling and product generation (R. Lawford)

17:10 Discussion: Framework for development of global-scale products: from observation networks to product generation
What is the process for ensuring the proper development and subsequent maintenance of a global-scale product? Who needs to be involved in this process? Who is responsible for which aspects? What technologies are readily available? What about resources?

17:40 Conclusions and recommendations
Presentation by rapporteur for this session (Harry Lins). Consensus on recommended course of action that will ensure that the most needed products will be developed and maintained in a systematic, sustainable fashion.

18:00 Meeting adjourns

Wednesday, 20 November 2002

Theme IV: Stakeholder Collaboration: Users, Data Providers, Data Centres

Chairman: Wolfgang Grabs
Rapporteur: Alan Thomas
The objective of this session is to review the existing international programmes, policies and agreements that can be used to help build and maintain the global observation system for hydrological data; and to develop a strategy to ensure that these institutional measures will be applied to help promote maximum collaboration.

08:30 Discussion: International programmes, policies and experiences

09:00 Discussion: Improvement of collaborative agreements

09:30 Conclusions and recommendations
Presentation by rapporteur for this session (Alan Thomas). Consensus on recommended strategy to promote maximum collaboration.

10:00 Coffee break

Meeting Synthesis

10:15 Synthesis of findings and recommendations (Wolfgang Grabs)

10:45 Strategy for building a global observation system for hydrological data
Sum of the strategies developed for each of the four themes

11:00 Ensuring success: roles and responsibilities

- Hydrological Observation Panel for Climate
- GTN-H Coordination Panel
- National Hydrological and Meteorological Services
- Global data centres
- Other GTN-H partners

11:45 Defining an outreach process

12:15 Final comments by participants

12:30 End of meeting

EXPERT MEETING
HYDROLOGICAL DATA FOR GLOBAL STUDIES

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LIST OF GCOS PUBLICATIONS*

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

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

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GCOS-32 (WMO/TD-No. 796)	GCOS/GTOS Plan for Terrestrial Climate-related Observations, version 2.0, June 1997
GCOS-33 (WMO/TD-No. 798)	GHOST - Global Hierarchical Observing Strategy, March 1997
GCOS-34 (WMO/TD-No. 799)	Initial Selection of a GCOS Surface Network, February 1997
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GCOS-42 (WMO/TD-No. 857)	Report of the seventh session of the Joint Scientific and Technical Committee for GCOS (Eindhoven, The Netherlands, September 22-26, 1997)
GCOS-43a (GOOS-36)	TAO Implementation Panel, sixth session (Reading, U.K., November 4-6, 1997)
GCOS-43b (GOOS-55)	International Sea Level Workshop (Honolulu, Hawaii, USA, June 10-11, 1997)
GCOS-44 (GOOS-61)	Report of the Joint GCOS/GOOS/WCRP Ocean Observations Panel for Climate (OOPC), third session (Grasse, France, April 6-8, 1998)
GCOS-45 (WMO/TD-No. 922) (GOOS-58) & (GTOS-16) (UNEP/DEIA/MR.98-6)	Report of the Joint Meeting of the GCOS/WCRP Atmospheric Observation Panel for Climate and the GCOS/GOOS/GTOS Joint Data and Information Management Panel, fourth session (Honolulu, Hawaii, USA, April 28-May 1, 1998)

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Report on the Adequacy of the Global Climate Observing Systems (United Nations Framework Convention on Climate Change, November 2-13 1998, Buenos Aires, Argentina)

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GCOS-50 (GOOS-65)
Implementation of Global Ocean Observations for GOOS/GCOS, second session (Paris, France, November 30, 1998)

GCOS-51 (GOOS-66)
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GCOS-52 (GOOS-68)
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GCOS-53 (WMO/TD-No. 958)
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GCOS-54 (WMO/TD-No. 953)
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GCOS-56 (GOOS-75)
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GCOS-59 (GTOS-22)
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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)
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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.
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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
GCOS-72 (GOOS-95)	Report of the 7th Session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, April 26-27, 2001
GCOS-73 (WMO/TD-No. 1106)	Manual on the GCOS Surface and Upper-Air Networks: GSN and GUAN, April 2002
GCOS-74 (WMO/TD-No. 1109)	Report of the GCOS Regional Workshop for Eastern and Southern Africa on Improving Observing Systems for Climate, Kisumu, Kenya, October 3-5, 2001
GCOS-75 (WMO/TD-No. 1124)	Summary Report of the tenth session of the WMO-IOC-UNEP-ICSU Steering Committee for GCOS, Farnham, UK, April 15-19, 2002
GCOS-76 (WMO/TD-No. 1125)	Report of the eighth session of the GCOS/WCRP Atmospheric Observation Panel for Climate (AOPC), Wokingham, UK, May 20-24, 2002

GCOS-77 (GOOS-122)	International Workshop for Review of the Tropical Moored Buoy Network, September 10-12, 2001, Seattle, Washington, USA. Workshop Report
GCOS-78 (WMO/TD-No. 1126)	Report of the GCOS Regional Workshop for Central America and the Caribbean. "Observing Climate from Weather Extremes to Coral Reefs", San José, Costa Rica, March 19-21, 2002 (disponible también en español)
GCOS-79 (WMO/TD-No. 1133)	Interim Report to the Sixteenth Session of the Subsidiary Body for Scientific and Technological Advice of the UNFCCC by the Global Climate Observing System, Bonn, Germany, June 5-14, 2002
GCOS-80 (WMO/TD-No.1140)	Report of the GCOS Regional Workshop for East and Southeast Asia on Improving Observing Systems for Climate, Singapore, September 16-18, 2002
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GCOS-84 (WMO/TD-No.1156) (GTOS-32)	Report of the GCOS/GTOS/HWRP Expert Meeting on Hydrological Data for Global Studies, Toronto, Canada, November 18-20, 2002

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