GCOS

GLOBAL CLIMATE OBSERVING SYSTEM

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Final Report - 7th Session of the GTN-H Panel

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1 Introduction

The 7th session of the GTN-H Panel was opened by Mr Grabs in his role as GTN-H coordinator and representing the Federal Institute of Hydrology (BfG). In his opening remarks, Mr Grabs welcomed all participants and highlighted the important role of GTN-H as the single existing entity of federated global data centres with a focus on hydrometeorological variables in support of the data needs of WMO, GCOS and the public at large that are served by the represented global data centres. He then briefly outlined the main objectives of the session, namely:

- Ways to strengthen the role and impact of GTN-H in programmes of WMO and GCOS as well as GEO;
- Improving access to data and information in a world with rapidly changing data needs and including data and information needs of the post 2015 sustainable development goals;
- Working towards multiple data source integrated data products

The agenda for the session was discussed and adopted subsequently (appendix 3). The list of participants is documented in appendix 4.

Action items resulting from the discussions during the session are documented in the Work Plan in appendix 1.

1.1 Background information: New Developments

Participants were reminded of the role of GTN-H as documented in the report of the fourteenth session of CHy (November 2012) and most recently in the report of the GCOS Terrestrial Observation Panel on Climate (TOPC) as a result of its meeting in March 2015.

With regard to CHy, participants recalled the interest of CHy in the role and activities of GTN-H as expressed in the report of the Fourteenth Session of CHy (2012) and documented in para 10.9 of the report: "The Commission noted the contribution made by the GTN-H thus far in support of climate research and applications. The Commission stressed the need for strong observational networks covering climate sensitive variables essential for climate- and water-related research and applications. The Commission noted that GTN-H served a number of essential climate variables as defined by the Global Climate Observing System (GCOS). The Commission expressed its appreciation to governments of Members that were sharing data from their networks and to those governments that provided the resources and infrastructure to host the global data centres and institutions that form the core of GTN-H".

Referring to TOPC, participants noted that GTN-H is fully anchored in activities of TOPC that reports directly to the GCOS Secretariat. In particular GTN-H continues to contribute to the data needs of research and development of applications on the basis of information gained from observations of Essential Climate Variables obtained from GTN-H federated global data centres. Participants welcomed the mentioning of GTN-H in the upcoming GCOS Status Report and expressed the need to enhance its role in activities of CHy, the 15th Session of CHy being planned for November 2016.

Within the context of the Global Earth Observing System of Systems (GEOSS), participants recognized the strong role of GTN-H in representing the observational arm of the Integrated Global Water Cycle Observations (IGWCO) Community of Practice that is central for the implementation of the GEO Water Strategy.

Participants were further informed that the UNEP Global Data Base on Water Quality (GEMStat) is now hosted at the Federal Institute of Hydrology in Germany, just as the Global Runoff Data Centre (GRDC) operating under the auspices of WMO, and that a Global Water Data Centre has been recently established that seeks to develop and publish joint products of GRDC and GEMStat.

With regard to earth observations in the post-2015 development agenda of the UN and in particular with regard to the envisaged Sustainable Development Goal – Water, GTN-H has shown its preparedness to contribute through its federated data centres especially in the UN Global Expanded Earth Monitoring Initiative (GEMI).

2 Review of status of network partners, individual reports

In response to the call from TOPC to provide an overview of the current status of networks federated in GTN-H, representatives of global centres taking part in the panel session provided their status reports including products and services provided, and planned activities over the next two years. The status reports are summarized in the paragraphs below. The figure below shows the current configuration of GTN-H and the overall status of data and information sources. At present, all networks federated in GTN-H operate normally with the noted exception that the International Soil Moisture Network (ISMN) will foresee a severe budget constraint once ESA stops its funding in 2016. Participants were alerted at this prospect and recommended to use all possible channels to seek securing funding for ISMN or any other viable option to keep its valuable activities operational. This could also include writing support letters to various agencies pledging for continued support after ESA funding will stop. On the side of the ISMN it is also required to clearly identify a user community and their needs to underpin the critical role that ISMN plays in the community of global data centres for research and applications related to hydrological modelling, water resources management climate change adaption, to name a few service areas.

Participants regretted that so far there is no institutionalized contact and access to both water vapour data and FLUXNET information. Participants requested GTN-H to enhance contact with AQUASTAT to close the apparent gap in available water use information.

Discussing network development issues further, there was the overall opinion that efforts should be expanded to seek identification of non-official networks such as those long-term observations carried out by research and academic programs and likewise to seek an overview of potentials to access and make use of crowd-sourced data and information and citizen-observations. In this regard, participants were informed of the WMO document on "Emerging Data Challenges for WMO Stakeholders", approved by 17th Congress in June that addresses similar issues. Participants requested GTN-H to cooperate with WMO in this regard mainly through the Commission for Hydrology (CHy).

On the level of metadata visualization, participants discussed possible ways to visualize station networks of cooperating data centres. This issue needs to be explored in more detail and proposals to be worked out and discussed. This will be undertaken off-line with data centres.

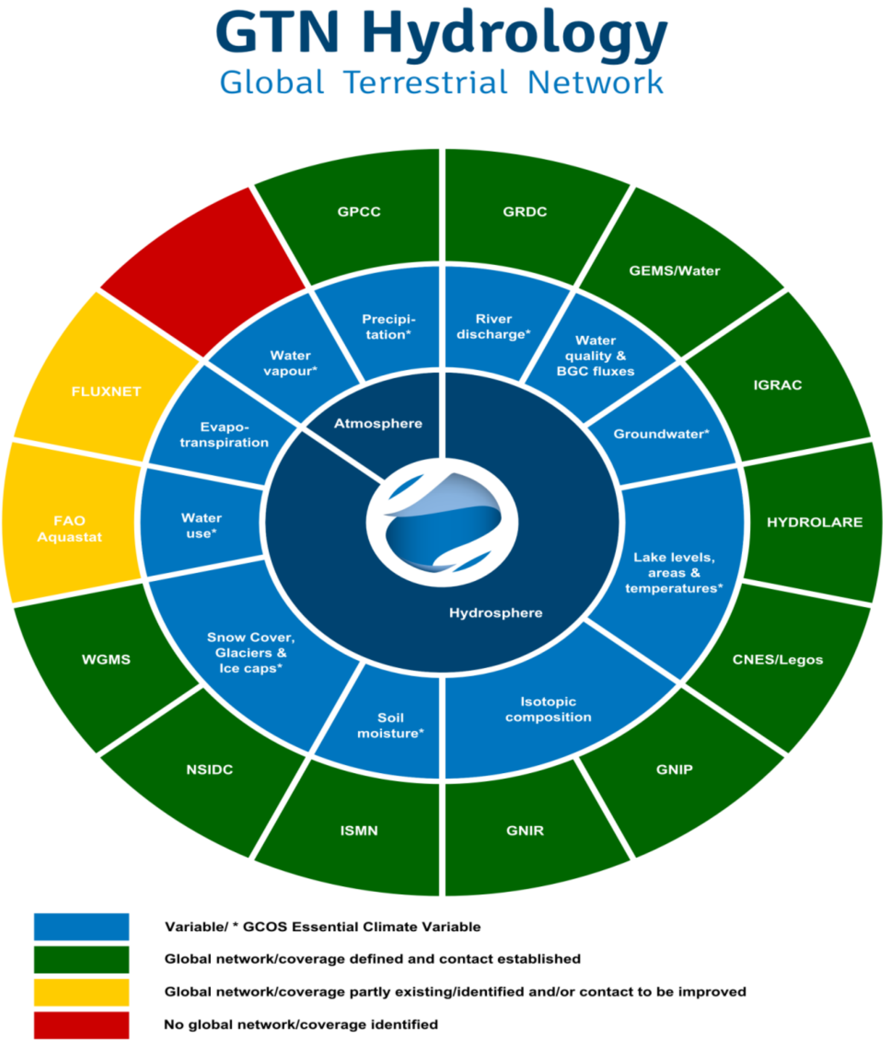

Figure 1 - Configuration of the GTN-H network, status June 2015

3 Status Reports of Data Centres present at the panel session

Representatives of the data centres provided their status reports. The presentations were followed by a discussion and conclusions as well as recommendations.

3.1 Global Runoff Data Centre (GRDC)

Mr Looser, Head of the Global Runoff Data Centre informed participants of the current GRDC activities.

3.1.1 Overview

The Global Runoff Data Centre (GRDC) was established in 1988 at the Federal Institute for Hydrology (BfG) under the auspices of the World Meteorological Organization (WMO). It is a contribution of the Federal Republic of Germany to the World Climate Programme of the WMO. WMO mandates and directly supports GRDC through its Resolution 21 (Cg XII, 1995: Request to the member states to provide GRDC with river discharge data) and Resolution 25 (Cg XIII, 1999: Free and unrestricted exchange of hydrological data).

3.1.2 Objectives

The main objectives of the GRDC are the world-wide acquisition, storage and dissemination of historical river discharge data in support of the predominantly water and climate related programmes and projects of the United Nations (UN), their specialized agencies and the scientific research community.

Additionally the GRDC has the following objectives:

- Operation and further development of the GRDC database, improvement of integration with external databases, contribution to the development and propagation of international standards for domain specific feature models, metadata and exchange of hydrological data.

- Preparation and maintenance of applied global data products and discharge-related geo-information, partly in collaboration with specialized external institutions.

- Collaboration with and consulting of international organisations, other world data centres and foreign institutions in the fields of hydrology, water resources as well as data management and data acquisition. This includes active participation in a number of national and international working groups, steering committees and panels.

3.1.3 Status

In June 2015 the GRDC database holds world-wide discharge data of 9,213 stations in 160 countries featuring around 386,000 station-years of monthly and daily values with an average time-series length of 42 years.

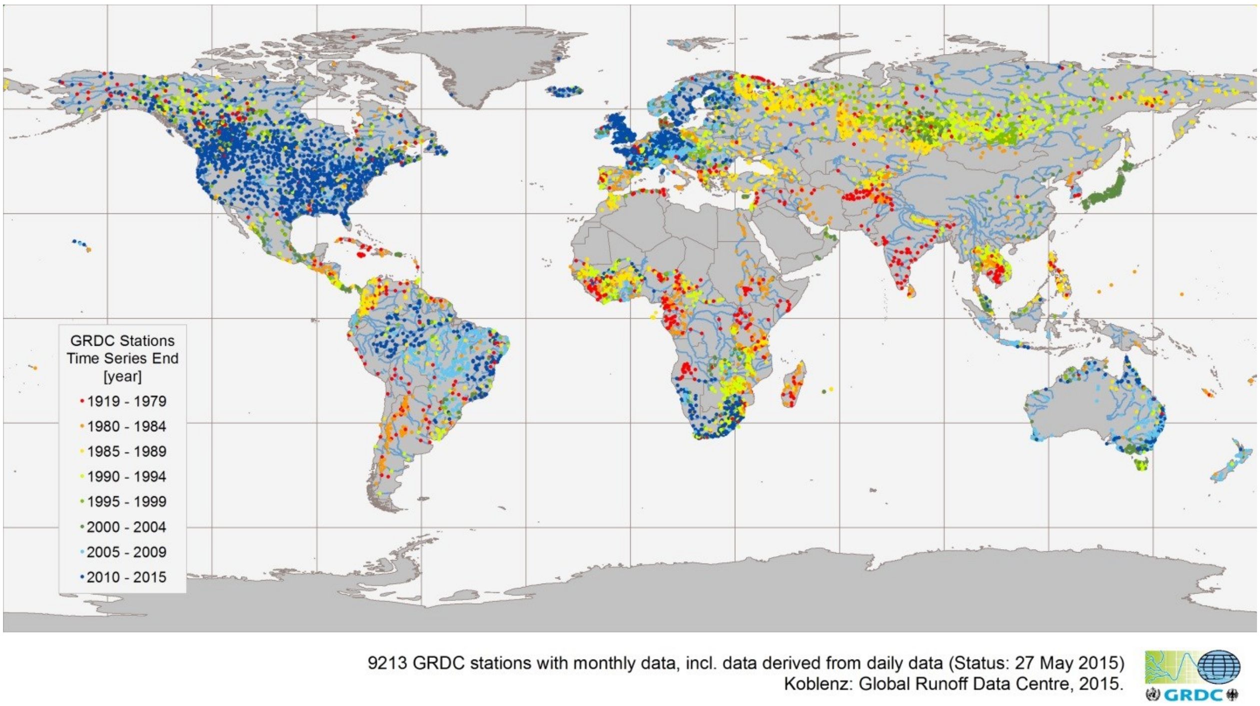

Figure 2 - Discharge gauges in the data archive from the Global Runoff Data Centre

Some selected specialized datasets that are maintained by the GRDC are the:

- Global Terrestrial Network for River Discharge (GTN-R) database for near real-time data, a contribution towards the Implementation Plan for the Global Observing System for Climate and to GTN-H.
- Climate Sensitive Stations Dataset of currently 1,198 GRDC stations from 27 countries identified by the countries as stations representing climate sensitive river basins having minimal disturbance.

Active involvement of the GRDC in the OGC Hydrology Domain Working Group is continuing, especially on conceptual models. The GRDC has represented WMO interests in this working group until June 2014 when the head of the GRDC stepped down as one of the co-chairs. Further developments are still closely monitored.

The Global Terrestrial Network for River Discharge (GTN-R) is still lacking support from several countries. However, almost 20 countries have agreed to make their GTN-R data freely available without restrictions. The GRDC is preparing the technology to make these data available through the GEOSS data portal and other portals.

3.1.4 Key results

- Consolidated data requests to many European countries with first results in repeated data provisioning
- Addition of over 1,000 stations to the GRDC database (currently 9,213 stations) and increase of dataset by 80,000 station years (currently 386,000 station years) since the 5th Session of the GTN-H in Tokyo, 2011.
- Negotiating the unrestricted access the time series data for almost 300 stations belonging to the GTN-R network
- Providing information and web-services from the Global Freshwater Fluxes into the World Oceans re-calculated in 2014, based on results from the global hydrological model *WaterGAP* (Doell et al., 2003) for 0.5° grid cell resolution. The annual fluxes are available for a 50 year period (1960 – 2009)
- Recalculation of Long Term Mean Monthly Discharges for more than 3,800 stations available on the Website. Provided information include mean, minimum, maximum monthly discharge, its standard deviation and time series of mean, minimum, maximum annual discharge.

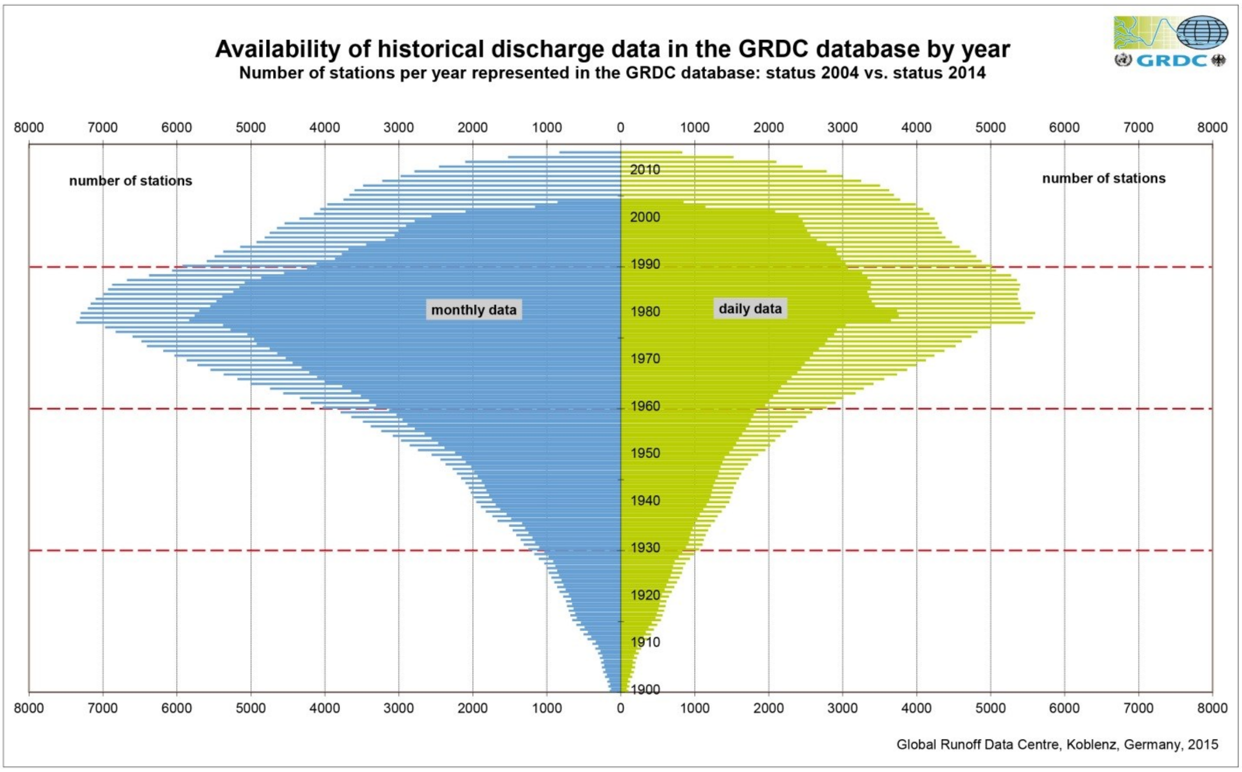

Figure 3 - Availability of historical discharge data in the GRDC database by year

3.1.5 Future activities

- Continued data acquisition strategy and initiatives on a regional basis to update and expand the excising historical database, at the same time try to institutionalize the provision of data and automate data downloads from National Hydrological Services that provide their discharge data via online services.
- Preparation of the GRDC IT infrastructure to ingest and redistribute time-series data using web services
- Continue to support the development implementation of standards for improved hydrological data exchange
- Support actively international programmes and initiatives for improved exchange and sharing of hydro-meteorological data
- Support the research community with relevant river discharge datasets and spatial products
- UNESCO IHP FRIEND-Water – Integrate river discharge database for the European FRIEND-Water and Southern African FRIEND-Water Programmes into GRDC database. Negotiate to incorporate river discharge databases from further FRIEND-Water Programmes (Himalaya-Hindukush, Asia-Pacific, etc.)
- WMO Commission for Hydrology (CHy) – Maintain and expand the river discharge data for WMO defined "Climate Sensitive Stations”

3.1.6 Discussion

Participants appreciated the status report of GRDC and encouraged GRDC to set the pace in the development of web-based services on adequate IT-platforms. Participants also requested GRDC to continue the ingestion of UNESCO- FRIEND data in the GRDC database and to further actively contribute to standardization efforts in the context of OGC and in close cooperation with WIGOS/WIS. Regarding global initiatives such as the computation of freshwater fluxes in the world oceans, GRDC was urged to renew its efforts to obtain data from identified relevant stations in cooperation with the WMO-Secretariat and to seek a scientific underpinning of its efforts to expand and update its database on pristine basins.

3.2 International Data Centre on the Hydrology of Lakes and Reservoirs (HYDROLARE)

Mr Vuglinsky, Director of HYDROLARE provided the Status Report of the Centre.

In 2014 and 2015 a collection of data from WMO member countries were continued. Additional lake and reservoir water level data from Armenia were received and included in the HYDROLARE database.

- Work has progressed on retrieval of data from the national websites of Switzerland and Slovenia, as well as on further identification, selection, analysis, preparation and conversion of these data, including encoding of water bodies and gauges.
- Level data for lakes of Australia, Mexico, Slovenia and Finland as well as data on Great Lakes (USA) were included in the database.

Altogether, up to the end of 2014 water level data for lakes and reservoirs of 19 countries were included into the database.

Table 1 - data collection for lakes and reservoirs

Country	Request sent	Data received	Country	Request sent	Data received
Europe					
ARMENIA	✉	✉	MOLDOVA	✉	✉
AUSTRIA	✉		ROMANIA	✉	
AZERBAIJAN	✉		SERBIA	✉	
BELARUS	✉	✉	SLOVENIA	✉	✉
CYPRUS	✉	✉	SPAIN	✉	
ESTONIA	✉		SWEDEN	✉	✉
FINLAND	✉	✉	SWITZERLAND	✉	✉
HUNGARY	✉		UKRAINE	✉	
ICELAND	✉				
Asia					
HONG KONG	✉	✉	MONGOLIA	✉	✉
INDIA	✉		TAJIKISTAN	✉	✉
KAZAKHSTAN	✉	✉	UZBEKISTAN	✉	
KYRGYZSTAN	✉	✉			
Africa					
MALI	✉		ZAMBIA	✉	
TANZANIA	✉				
North America, Central America and the Caribbean					
ANTIGUA AND BARBUDA	✉		DOMINICA	✉	
BELIZE	✉		MEXICO	✉	✉
CANADA	✉		USA	✉	✉
South America					
CHILE	✉		COLOMBIA	✉	
South-West Pacific					
AUSTRALIA	✉	✉			
✉ – request sent			✉ – data received		

The special HYDROLARE search and explore system which helps users to search information about main database content through Google Maps API were embedded. This system together with two databases and software tools comprises the core of the HYDROLARE software that continues to evolve further.

Within the HYDROLARE-LEGOS cooperation, activities were implemented aiming at the integration of in-situ and satellite data available from HYDROLARE and LEGOS (Hydroweb) respectively. A direct access from HYDROLARE to Hydroweb web site was enabled for acquiring information on availability of satellite data for selected lakes on Hydroweb web site and vice versa.

New data are available now at the HYDROLARE database - satellite data on Lake water levels for 47 lakes in 33 countries together with related metadata. For 34 lakes of 25 countries in Asia, Africa, North and South America for which satellite data are available, in-situ data are absent.

Table 2 - Availability of satellite data in the absence of accessible in-situ water-level observations

Waterbody	Countries	Period	Waterbody	Countries	Period
Eurasia			Victoria	Tanzania, Uganda, Kenya	1992 - 2011
Bosten	China	2002 - 2010	Tanganika	Tanzania, DR Congo, Zambia, Burundi	1992 - 2011
Dongting	China	1992 - 2010	Kyoga	Uganda	1992 - 2011
Hongze	China	1992 - 2011	North and Central America		
Hulun	China	1992 - 2010	Great Bear	Canada	2002 - 2010
Kokonor	China	1995 - 2011	Great Slave	Canada	1992 - 2011
Poyang	China	2002 - 2010	Manitoba	Canada	2000 - 2010
Har	Mongolia	2002 - 2010	Nettiling	Canada	1992 - 2011
Hyargas	Mongolia	2002 - 2010	Winnipeg	Canada	1992 - 2011
Uvs	Mongolia	2002 - 2010	Winnipegosis	Canada	2002 - 2011
Caspian	Russia, Kazakstan, Iran, Turkmenistan, Azerbaijan	1992 - 2011	Izabal	Guatemala	2002 - 2010
Beysehir	Turkey	2002 - 2010	Managua	Nicaragua	2002 - 2010
Van	Turkey	1992 - 2011	Nicaragua	Nicaragua	1992 - 2011
Africa			Champlain	USA, Canada	2002 - 2010
Chad	Chad, Cameroon, Niger, Nigeria	1992 - 2010	South America		
Albert	Congo, Uganda	2002 - 2010	Chiquita	Argentina	1992 - 2011
Turkana	Ethiopia, Kenya	1992 - 2011	Huapi	Argentina	1992 - 2005
Malawi	Malawi, Mozambique, Tanzania	1992 - 2011	Titicaca	Bolivia, Peru	2000 - 2010
Rukwa	Tanzania	1992 - 2011	Maracaibo	Venezuela	2002 - 2010

The table below shows selected lakes where both in-situ water level data are recorded and regularly updated satellite data are available

Table 3 - Lakes where both in situ and updated satellite data are available

Waterbody	Countries	Period
Europe		
Il'men'	Russia	2000 - 2010
Ladoga (Ladozhskoe)	Russia	1992 - 2011
Onega (Verkhne-Svirskoe rsv)	Russia	1992 - 2011
Peipus	Russia, Estonia	1992 - 2011
Asia		
Balkhash	Kazakstan	1992 - 2010
Sasykkol'	Kazakstan	1992 - 2010
Issyk-Kul	Kyrgyzstan	1992 - 2011
Baikal	Russia	1992 - 2010
Chany	Russia	1992 - 2010
North America		
Erie	USA	1992 - 2011
Huron	USA	1992 - 2011
Michigan	USA	1992 - 2011
Ontario	USA	1992 - 2011
Superior	USA	1992 - 2011

Regularly updated information on the status of the database is available on the HYDROLARE website (www.hydrolare.net). The figure bellow shows a screen-shot of the Great Lakes, where both in-situ as well as satellite information are available.

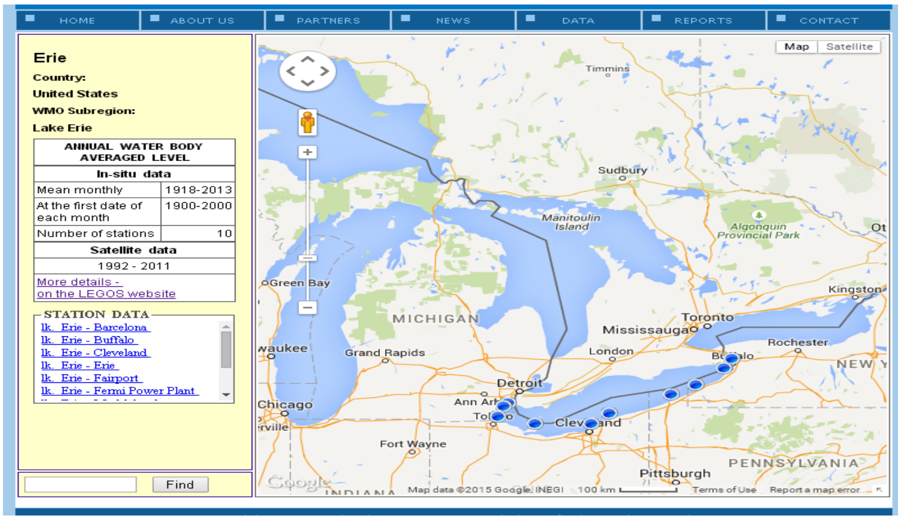

Figure 4 - HYDROLARE web site

3.2.1 Discussion

Participants appreciated the presentation noted progress made and encouraged HYDROLARE to further expand its data acquisition also in cooperation with other centres that have an interest in lakes and reservoirs. Participants further commented that as a parallel step it is necessary to seek access to bathymetric data from a set of selected lakes to start calculation of volumetric changes in selected lakes at least on a seasonal time scale.

3.3 International Groundwater Resources Assessment Centre (IGRAC)

Ms Ansems, representative IGRAC provided the status of the Centre.

IGRAC, the International Groundwater Resources Assessment Centre facilitates and promotes international sharing of information and knowledge required for sustainable development, management, and governance of groundwater resources worldwide. IGRAC is UNESCO's Global Groundwater Centre, working under the auspices of the World Meteorological Organization and cooperating closely with the International Association of Hydrogeologists. IGRAC continues to be financially supported by the Government of the Netherlands.

In 2014, IGRAC focused on the development of the new Global Groundwater Information System (GGIS) using open and extendable state of the art technology, making it possible to connect to more and varied external data sources and systems on the Internet. The publicly accessible, web-based system is meant for various categories of stakeholders, including both professionals and the general public. It leads the user from aggregated, global information in Global Overview (GO) via related information sources in the Meta-Information Module (MiM) towards a direct information exchange in a collaborative environment. The Global Groundwater Monitoring Network (GGMN) facilitates the monitoring of a global change of groundwater resources.

The system has been expanded by two project based modules designed to manage and view both aggregated and distributed information on transboundary aquifers. The third new module contains a comprehensive spatial database with detailed information on Managed Aquifer Recharge sites around the world. The new GGIS facilitates easy data uploads from external sources using OGC web services. At the same time, data in the system can easily be shared with other groundwater information systems and experts. To do this, the GGIS uses web mapping services (WMS) and web feature services (WFS) to distribute maps and data.

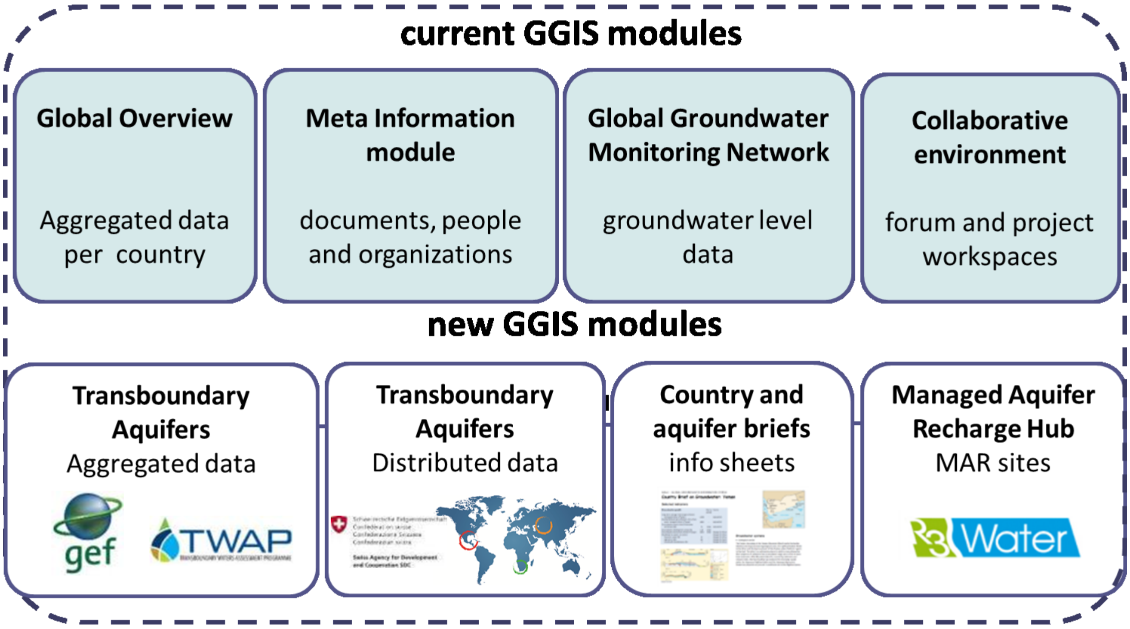

Figure 5 - Overview of the Global Groundwater Information System and its development

3.4 Global Groundwater Monitoring Network (GGMN)

The Global Groundwater Monitoring Network (GGMN) is a participative, web-based network of networks, set up to improve quality and accessibility of groundwater monitoring information and subsequently our knowledge on the state of groundwater resources. GGMN is a UNESCO programme, implemented by IGRAC and supported by many global and regional partners.

To strengthen and expand the GGMN People Network, multiple workshops were organized. 'Groundwater Monitoring in Latin America' in Montevideo, Uruguay, 11-12 December 2013; 'Advancing Groundwater Monitoring in China' in Beijing, 14-17 March 2014. Furthermore IGRAC contributed and introduced the GGMN programme, to the workshop 'Collation and Analysis of Multi-decadal Groundwater-levels Observations in Africa' held at the 41st IAH Congress in Marrakech, Morocco in September 2014.

Data collection and data upload to the GGMN system have taken place throughout the year, and agreements were signed with national focal points to formalize their role and contribution to the network.

3.4.1 Planned activities

In 2015, IGRAC will finalize the software update of the GGIS and GGMN and will continue implementation of the GGMN network. IGRAC will continue with the organisation of regional workshops in order to strengthen and expand the GGMN People Network. This includes a groundwater monitoring training for Pacific Small Island Developing States (Fiji, November 2015) and GGMN workshop for South-East Asia (Bangkok, December 2015).

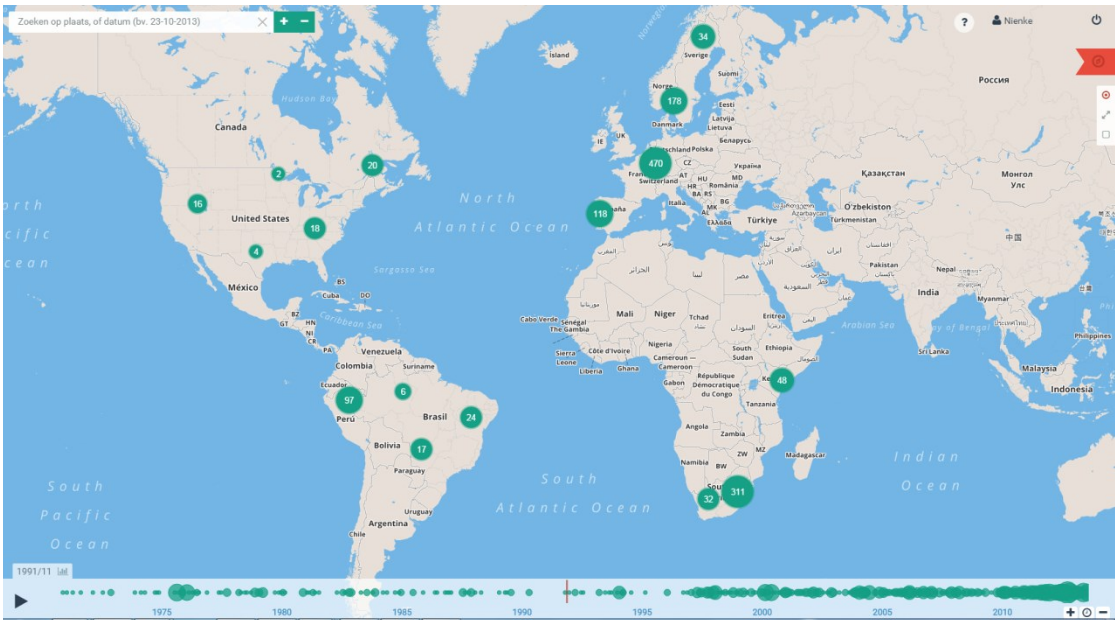

Figure 6 - The new GGMN application and groundwater data availability

3.4.2 Discussion

Participants were pleased about the progress made in the further development and operation of IGRAC. Participants recognized the potential using IGRAC information in closing the water budget over continents and contribute to a better integration of water resources assessments including groundwater resources. Participants felt that efforts need to be undertaken to develop groundwater management tools for an improved management of groundwater resources, in particular with regard to assessments of the recharge-withdrawal balance. Seeing the potential for IGRAC´s further development, participants specially highlighted the desirability of IGRAC´s participation in addressing GEOSS Water Strategy Recommendations as documented in annex 2. Specifically, IGRAC should facilitate the flow of groundwater information for actually managing the resource and could engage actively in the determination of user needs for groundwater information.

3.5 Global Precipitation Climatology Centre (GPCC)

Mr Udo Schneider, representing GPCC presented the status report of the GPCC spanning the period for first half of 2014 up to June 2015

3.5.1 Data Base

The GPCC has continued its efforts to further extend its data base. Its data base remains the largest compilation of global monthly *in situ* precipitation data world-wide. In 2014 the 95,000 stations threshold has been trespassed for monthly totals with more than 75,000 stations having time series of at least 10 years (Fig. 1). The geo-temporal coverage of the data allows for issuance of re-analysis products for the period from 1901-2013 at a well distributed station density.

Since 2012 also daily data is processed and by end of 2014 the archive held daily data for more than 35,000 stations (Fig. 2) with the aim to reach the same scope as for monthly data). In 2013 GPCC has commenced to extend its processing of daily data beyond the DAPACLIP period 1988-2008.

All archived data stems from various sources, mainly national meteorological/hydrological services of more than 190 WMO member countries and regional or global data collections (Fig. 3). They are stored in source specific slots, allowing cross-checks on redundant records. The GPCC highly appreciates the assistance by all countries having supplied observed precipitation data in monthly and in particular in daily resolution.

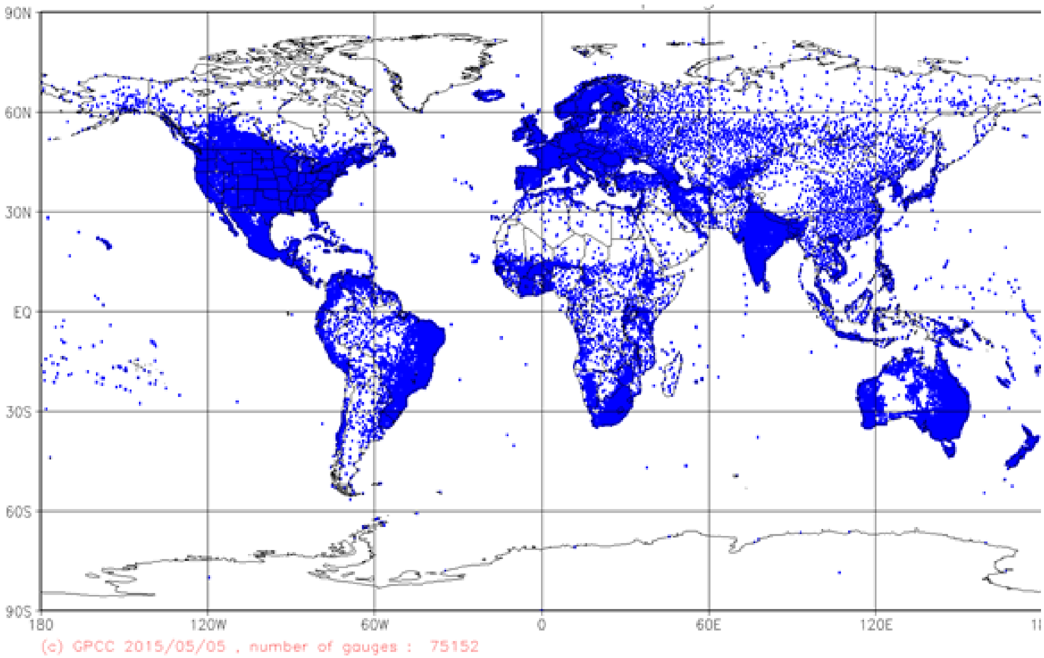

Figure 7 - Spatial distribution of in-situ stations with a climatological precipitation normal based on at least 10 years of data in GPCC data base (number of stations in July: 75,152)

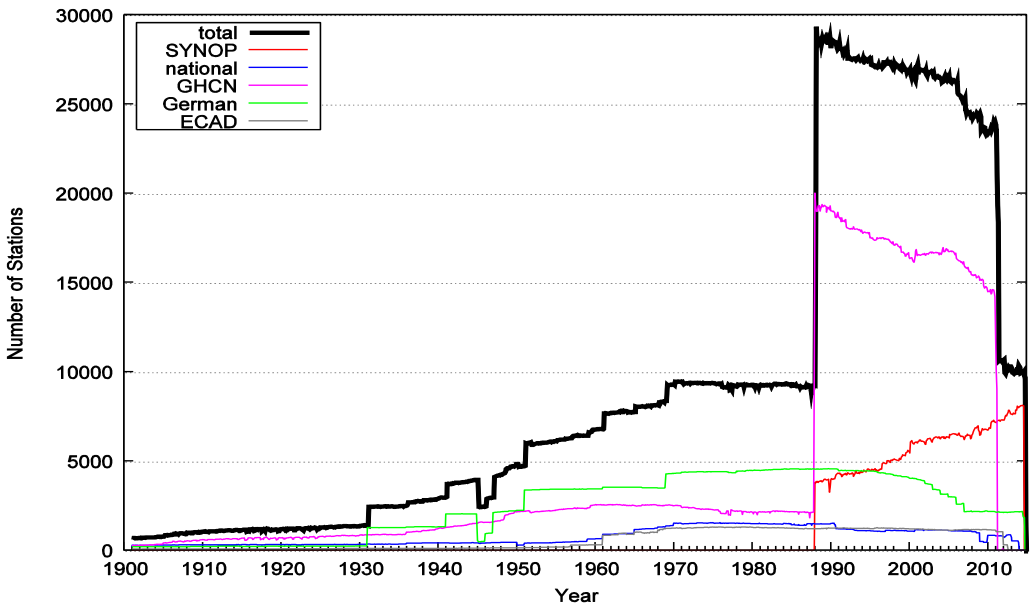

Figure 8 - Number of daily precipitation data in GPCC data base as of Sept. 2014 over time for the different data sources

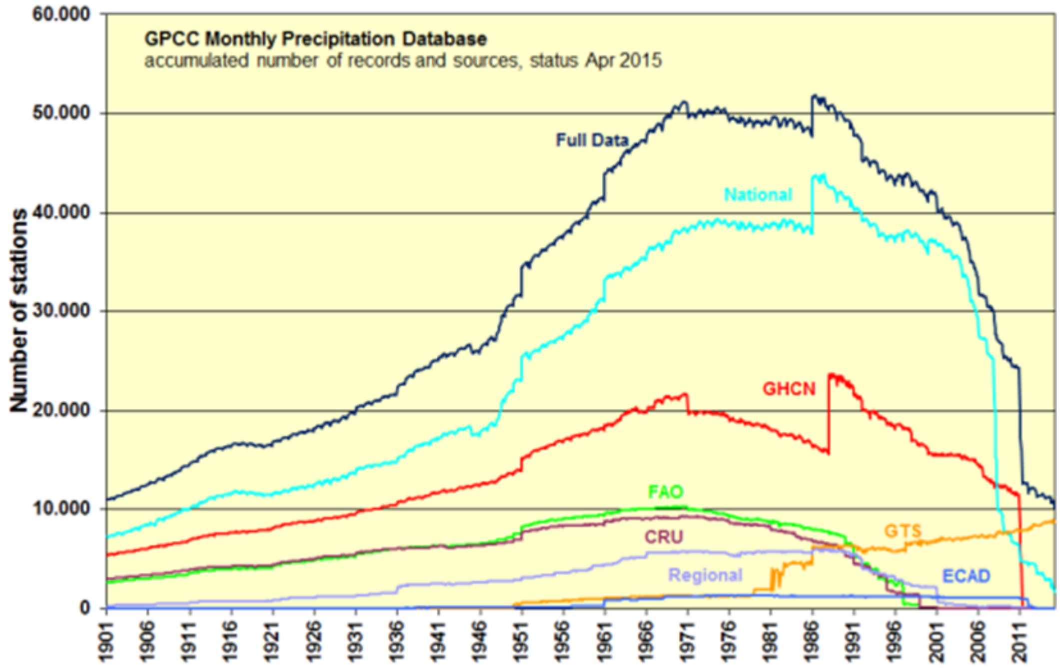

Figure 9 - Total number of stations in GPCC's full data base according to the different data sources

3.5.2 Quality-control of monthly and daily precipitation data at the GPCC

The long experience of the GPCC with the processing of precipitation data shows that a thorough quality-control (QC) is necessary to detect and correct/eliminate data errors which otherwise would have a significant impact on the analysis results. Owing to the large variability of precipitation and the skewness of its frequency distribution, a fully automatic QC would eliminate all data being classified as outliers including real extremes. These true extremes, however, are very important to describe the variability of precipitation. Therefore, QC processing at GPCC is semi-automatic in the way that data classified as questionable by the automatic QC procedures undergo additional visual checks (for more details on GPCC's QC processing see Schneider et al., 2014[1]). Typical errors in the raw data are factor*10 errors (data in 1/10 mm or shifted by 1 digit), factor*2.54 errors (errors in the conversion of inch to mm) and the problem of "0" instead of missing values.

All data reaching the GPCC are checked, pre-processed, reformatted and integrated into a Relational Data Base Management System (RDBMS). Since 2009 all data being imported into the RDBMS are checked against background statistics enabling the GPCC to detect and correct data errors in this early stage. Within the data bank, the records from the different sources (SYNOP, CLIMAT, national data etc.) are stored in parallel (source specific slots) under addition of quality flags indicating the results of data processing. This enables a cross-check being very helpful in the QC and product generation process.

[1] Schneider, U., A. Becker, P. Finger, A. Meyer-Christoffer, M. Ziese and B. Rudolf (2014): GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. Theor. Appl. Climatology 115, 15-40, DOI:10.1007/s00704-013-0860-x.

The import of the daily data into GPCC 's data base provides an additional way to check the data (i.e. cross-check the monthly totals calculated from there against the delivered monthly totals from different data sources).

3.5.3 Monthly and daily analysis products, including GPCC Drought Index

The GPCC has issued new Versions of its non-real-time monthly data products (Precipitation Climatology V.2015 based on ca. 75,100 stations (Version 2011 included 67,200 stations), the Full Data Reanalysis V.7 for the period 1901-2013 and V.5 of the Monitoring Product also extended backward to 1982.

Moreover GPCC continued to issue up to present the DOI referenced daily product (GPCC First Guess Daily[2]) using SYNOP reports received via GTS at DWD from about 8,000 stations. For the Monitoring Product in addition to that the monthly precipitation totals calculated from SYNOP reports received at NOAA and obtained from CLIMAT reports received at DWD, JMA and UKMO from a total number of 8,200 – 8,800 stations are used. Along with the monitoring product the new GPCC drought index (DI) product with look-back periods of 1, 3, 6, 9, 12, 24 and 48 months is issued. Given its dissemination in netCDF the DI product has been integrated in the web-services based Global Drought Portal Data viewer of NOAA's NCDC[3].

It remains the policy of GPCC not to redistribute or parse any original station data in order to respect the requests of the data owners. The gridded GPCC products, however, are publicly accessible via Internet for visualisation and download (http://gpcc.dwd.de).

As before, the GPCC continuously processed in 2014/2015 its two near-real-time analysis products, the First Guess of the monthly global land-surface precipitation anomalies (available within 3-5 days after the end of the month) and the traditional Monitoring Product (available about 2 months after the end of the month).

The GPCC First Guess daily product (Schamm et al., 2014) is published in netCDF. Therefore, any user can conveniently visualize and investigate special extreme events. In addition to that a 1st version of the Full Data Daily Product has been generated for the period 1988-2013.

3.5.4 Additional achievements

GPCC and EUMETSAT CM_SAF, both operated by Deutscher Wetterdienst, have jointly developed a bi-decadal satellite-gauge precipitation re-processing product from the combination of the follower of the HOAPS_3.2 data set and the GPCC Full Data Daily Reanalysis V.1 for the DAPACLIP period 1988-2008. For the combination an optimal merging of both sub datasets along the coastlines is conducted. The data products consist of daily data fields with several grid resolutions (1° and 2.5°; over Europe: 0.5°). As a specific feature, the data sets provide traceable uncertainty estimates for the retrieved precipitation quantities. The interpolation of the gauge data is done by ordinary block kriging using the daily fraction of the monthly precipitation totals. Monthly gridded background fields have been taken from the GPCC Full Data Reanalysis V.7. Across the ocean a 1D-Var retrieval is

[2] doi 10.5676/DWD_GPCC/FG_D_100

[3] http://gis.ncdc.noaa.gov/map/drought/Global#app=cdo

used to derive the precipitation along with a retrieval uncertainty estimate from passive microwave data of SSM/I, TMI and AMSR-E radiometers.

As a first check to characterize the data set for its extreme value behaviour the precipitation-related indices of the ETCCDI package of Klein-Tank et al. (2009[4]) have been applied on a global scale.

The issuance of the new Homogenized Precipitation Re-Analysis (HOMPRA) data set is still delayed for the global scale. Major challenge remains the proper correction of breakpoints in time series detected in the world-wide 17,500 stations collective with a data coverage of at least 90% over the period 1951-2005 by the automated version of the PRODIGE tool developed by Ms. Elke Rustemeier in course of her PhD thesis. However, for a sub-set of 5,500 stations for Europe a test run has been successfully accomplished. The effort will be repeated upon publication of the V.2015 of the Precipitation Climatology and the V.7 of the Full Data Reanalysis.

GPCC is participating in the ERA_CLIM2 project aiming at the production of a consistent 20th century reanalysis making maximum use of observations (in-situ and remote-sensed, airborne and ground-based). In doing so the project also delivers data rescue and a multi-decadal reanalysis of historical precipitation data for cross-validation of the centennial reanalysis against a purely observational data product of GPCC. Comparisons are important to identify the areas of strongest deviations in both analysis regimes, with the aim of targeted improvements in both, model development and data coverage and GPCC's product quality.

3.5.5 GPCC plans for the next year

GPCC will continue to merge the well-established workflows in data processing and quality-assurance for the monthly data with those required for daily data. It will continue software enhancement projects in order to import both kinds of data into its data base in a consistent manner. This encompasses facilitation of cross-checks of reported monthly totals against calculated ones based on the new daily data provided.

Continuation of loading of daily data and development and generation of quality assured daily data products. After completion of import from existing distributions (GHCN-daily and ECA&D) a new initiative to enhance the daily data compartment from national contributions (WMO NHMS) will be started in the 2nd half of 2015.

Along with the WCRP GC on Weather and Climate Extremes GPCC will continue its efforts towards improved GPCC products derived from historic daily precipitation data through an elaboration of ETCCDI kinds of extreme indices.

Development and release of a new HOMPRA Product (adjusted for climate variability and trend analyses) covering the time period 1951-2005 at spatial resolutions 0.5°, 1.0°, and 2.5°; HOMPRA is planned to become available in a Europe only version in course of year 2015 and in a global version later on.

[4] Klein-Tank, A.M.G., F.W. Zwiers and X. Zhang, 2009: Analysis of extremes in a changing climate in support informed decisions for adaptation., WCDMP-No.72, WMO-TD No. 1500, http://www.wmo.int/datastat/documents/WCDMP_72_TD_1500_en_1_1.pdf

GPCC is planning to add an import pre-processor for the OGC compliant XML standard Water ML 2.0 to its data base import software in order to explore data sources and providers beyond the WMO NMHSs.

3.5.6 Discussion

Participants voiced their full satisfaction with the operation of GPCC and the upgrade of products provided. With regard to the development of joint, integrated data products, GPCC has a key position such as in the generation of improved water balance models, calculation of groundwater recharge for large aquifers and the generation of products for improved water management on a regional and sub-regional scale. These are all areas of general interest to be pursued in GTN-H and also in activities geared to support the implementation of the GEO-Water Strategy and the UN-wide Global Framework for Climate Service, headed by WMO.

Participants also welcomed the move of GPCC to add an OGC compliant XML standard Water ML2 pre-processor to its data import software.

3.6 Global Network of Isotopes in Precipitation (GNIP)

Mr Terzer, representing GNIP presented current and planned network activities.

3.6.1 Introduction

The Global Network of Isotopes in Precipitation (GNIP, formerly known as IAEA-WMO Network of Isotopes in Precipitation) comprises the network for precipitation sampling and isotopic analysis (i.e. GNIP does not base on in-situ measurements) and the GNIP database for dissemination of data.

- The network encompasses ca. 120 collaborators. IAEA analyses ca. 1200 stable isotope and 600 tritium samples per year.
- The 'National Networks' component in GNIP is hard to estimate since a number of countries chose to publish their data outside GNIP or not at all.
- The core network consists (in 2014) of ca. 250 stations providing monthly samples or data and is growing (in numbers of stations).
- The GNIP database is growing at a rate of ca. 2,000 records per year (currently ca. 130,000 monthly records).
- IAEA employs ca. 2 full-time staff equivalents as laboratory technicians and ca. 1.5 full- time staff equivalents for scientific and administrative purposes.
- User groups: Mainly hydrological sciences (ca. 50 %), second big group is climatology-related (estimated at 30-35%), third (emerging) group is ecology etc. (ca. 10-15%). This is however based on a user survey in 2011/12 and not on publications.

3.6.2 Major recent developments

- Instrumentation:
  - Low-cost rainfall totalizer (requires maintenance only 1x per month) – should facilitate sampling, is available commercially since ca. 2011.
  - Laser Absorption Spectroscopy has lowered analytical infrastructure needs greatly (i.e. from several 100,000 EUR to ca. 70,000). Devices have matured over the last 10

    years. These are benchtop systems; however the rapid proliferation has also triggered quality concerns.
  - Further R&D currently ongoing to verify sampling methods' performance (incl. heated samplers for winter use, 2014-present).
- Network:
  - Establishment of GNIP contact point gnip@iaea.org (2012)
  - Sampling instructions revised and updated (2012-2014)
  - Work on a station metadata catalogue (i.e. instrument configuration, sampling strategy, storage etc.) commenced (2014-present)
  - Shipping modalities completely changed (i.e. one shipment per year
  - Internal workflows streamlined, reporting lags reduced (2012-present)
- Database:
  - Overhaul of GNIP database technical framework (2011-2013)
  - Revision and re-launch of the GNIP data dissemination portal (https://nucleus.iaea.org/wiser, 2012-2015)
- Derivative products:
  - Development of a gridded precipitation isotopic data product (RCWIP v.1, 2010-2013)
  - Development of version 2 started (RCWIP v.2, 2014-present)
- Sister network GNIR (Global Network of Isotopes in Rivers)
  - Collection of existing data (scheduled release 3Q/2015)
  - Several coordinated research projects (stable isotopes and tritium in rivers [2002-2006], baseflow and groundwater interactions [2004-2009], nutrient isotopes [2014-present], nitrogen pollution in surface waters [starting 2016])
  - Regularly operated network however more difficult than GNIP

3.6.3 Research frontiers

- Understanding the drivers of tropical precipitation
  - Coordinated research project incl. daily rainfall collections
- Exploring the roles of old and new isotopic tracers:
  - Tritium under near-natural conditions (seasonality, cosmogenic input)
  - Possibilities of Oxygen-17 (setup experimental so far)

3.6.4 Challenges / open issues

- Network
  - Station distribution spatially uneven – the number of stations running concurrently is rising but key areas are basically devoid of stations
  - Voluntary participation (IAEA not in position to fund actual sampling), occasionally lack of appropriate vehicles to fund start-up of new stations
  - Some of the regions devoid in GNIP stations are well covered by national networks or research institutions following different (i.e. other than open access) data policies. In other words, we know that the information exists but it might not be accessible.
- Organization

  - Collaboration with meteorological services: Manned rain gauges (the standard mode of operation of the early days) are decreasing, in many countries lack of liaison to the services operating GSN or GAW stations.
  - Right now seems that academia has higher appreciation for GNIP sampling than meteorological services.
  - Legal issues (contractual base for GNIP collaborations often lost in legalese and kills initiatives due to long lags)
- Technical
  - OGC compliance of data schema? Which OGC-compliant XML dialect is suitable for these non-in-situ measurements? Advice is needed.
  - Role of IAEA-GNIP in the future: data provider or data/web service provider? Interfaces (specifications?) needed for follow-up products (isotope mapping, isotopic assignments etc. – link to ecology, climate)
- Crediting:
  - of the GNIP database as well as
  - of our collaborators' contributions to it.
- Position in WMO system
  - Steering committee frustrating experience, only having the present situation rubber-stamped is not ideal
  - GNIP is currently set up in GTN-H – links to (paleo)climate community unclear

3.7 Comments on the Global Network of Isotopes in Rivers (GNIR),

The GNIR database encompasses 30,000 historic records compiled from various sources and was made public in late June 2015 (https://nucleus.iaea.org/wiser). The current GNIR network includes a low two-digit number of regular collaborators and a similar number of stations contributing monthly samples. Similar to GNIP, a GNIR contact point (gnir@iaea.org) was established and is serviced regularly by IAEA staff. Research frontiers include the calibration of isotopically enabled water balance models, and linkages to other biogeochemical tracers and isotopic species in dissolved and suspended constituents. Main challenge is to establish a regular, equally distributed network ('the interested groups do not sit on major rivers and vice versa'). Moreover, other riverine observation / sampling networks exist (e.g. global programmes but not including water isotopes or basin-targeted programmes including a suite of parameters but no global coverage), to which interfaces remain to be defined and sampling/data handling synergies need to be explored.

3.7.1 Discussion

Participants appreciated the comprehensive presentation of GNIP and encouraged GNIP to interact more closely with other GTN-H partners to seek solutions for the challenges mentioned including OGC compliance of data schemata and other issues. Likewise, GNIP is encouraged to seek access to national meteorological and hydrological services and relevant points of contact to enhance data collection and access to data and information relevant for GNIP. Participants encouraged a closer interaction between GRDC and GNIR with a view to enlarge the GNIR database and to potentially mark stations that are in common (or nearby in the same river basin) where both GRDC data and GNIR data are available.

3.8 International Soil Moisture Network (ISMN)

The ISMN status report was provided by the representative of ISMN, Ms Angelika Xaver.

The International Soil Moisture Network (ISMN) acts as a centralized data hosting facility for in-situ soil moisture measurements. Soil moisture observations are collected from operational networks all over the globe; the observations are harmonized in terms of unit and temporal resolution and stored in a database after undergoing several sophisticated quality control procedures (Dorigo et al, 2013). The datasets are available for registered users through a web interface (https://ismn.geo.tuwien.ac.at/) with different download options.

Since the official launch in February 2010, the International Soil Moisture Network evolved to a prominent and well established distribution platform not only throughout the user community, but also highly appreciated by the network operators. Within the last year, 7 new networks with more than 400 stations have been added, many existing networks have been updated and several new networks have expressed their willingness to share their data. Currently, data from 48 networks consisting of more than 2000 stations in Europe, North America, South America, Australia, Asia and Africa is hosted by the ISMN (Figure 10).

Figure 10 – Stations in the ISMN (Status June 2015)

The user community of the ISMN is growing continuously. Until June 2015, more than 1300 users had officially subscribed to the web portal to have full data access. Striking are the large user communities in China, India and other emerging and developing countries (Figure 11) where hardly any recent datasets of in-situ soil moisture are available. Therefore, future efforts should focus on bridging this gap.

In order to determine the user satisfaction and involve user wishes in further developments a survey addressed to all registered users of the ISMN was sent out in November 2014. The feedback from the users has been mainly positive and their expectations of the ISMN have been fulfilled in general. Still, some major wishes have been identified and will be taken care of in the upcoming years, such as the implementation of a forum for all registered users or provision of additional datasets such as land cover classes and climate classes for each station location.

A separate survey was conducted amongst all data providers of the ISMN in October 2014. Happily almost all organizations participated and the feedback has been positive. The main message is that the information flow from the users and the ISMN back to the data providers has to be improved. Large interest exists in receiving feedback on quality control results (performed during processing through the ISMN and performed by users) and on basic information from data users (e.g. number of downloads, data usage, etc.). Efforts have been started already to address both issues.

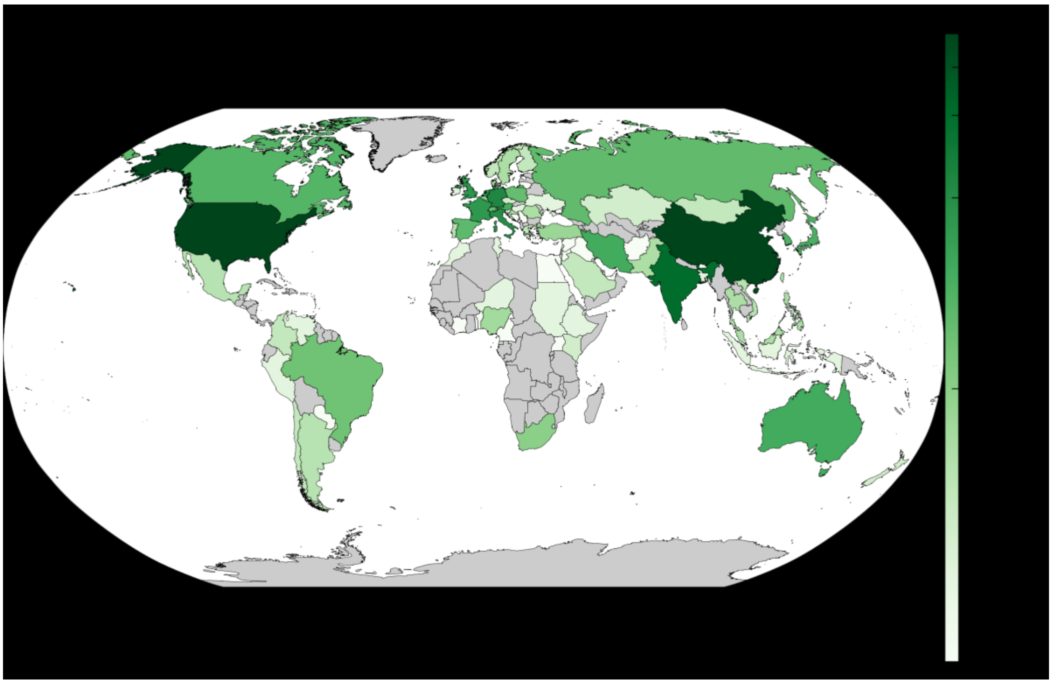

Figure 11 – Number of users/organizations by country subscribed to the ISMN

3.8.1 Challenges

Despite the success of the ISMN its future is unclear. The ISMN has been funded for many years by ESA's SMOS Earth Observation Program. This support will most likely be discontinued after June 2016.

Through the results of the provider survey it has been strongly outlined that only very few data providers would continue sharing data with the ISMN if it was taken over by a private company. Thus, future funding should be identified through operational programs, a data centre or a purely community-based effort.

<u>Publication</u>: Dorigo, W.A., Xaver, A. Vreugdenhil, M. Gruber, A., Hegyiová, A. Sanchis-Dufau, A.D., Zamojski, D. , Cordes, C., Wagner, W., and Drusch, M. (2013). Global Automated Quality Control of In situ Soil Moisture data from the International Soil Moisture Network. *Vadose Zone Journal*. doi:10.2136/vzj2012.0097

3.8.2 Discussion

Participants voiced their high appreciation over the rapid progress ISMN has made since its inception in 2010. They viewed the ISMN as essential component as Soil Moisture is linked to the hydrological cycle through evapotranspiration, precipitation, land use, melting snow and glaciers, lake levels and area – volume changes in lakes, and, to some extent, (agricultural) water use.

The GEO representative remarked that water cycle and soil moisture are areas where network coordination and data sharing will be important.

Panel members were concerned over the funding issue of ISMN. A community effort to sustain ISMN activities was viewed as not effective. More efforts need to be undertaken by network partners and organizations (GEO, WMO, UN Water, amongst others) to seek funding in time before the end of the current financial period for ISMN. This includes also contacts with the government of Austria.

3.9 World Glacier Monitoring Service (WGMS)

Mr. Nussbaumer, representing the World Glacier Monitoring Service (WGMS) provided a comprehensive presentation on the activities of the WGMS.

3.9.1 Worldwide glacier monitoring – background

Internationally coordinated glacier observation was initiated in 1894 with the foundation of the *Commission Internationale des Glaciers* at the 6th *International Geological Congress* in Zurich, Switzerland. Since 1986, the *World Glacier Monitoring Service* (WGMS) has maintained and continued the collection of standardized information about distribution and ongoing changes of glaciers and ice caps. Today the WGMS is a service of the *International Association of Cryospheric Sciences* (IACS) within the *International Union of Geodesy and Geophysics* (IUGG) as well as of the *World Data System* (WDS) of the *International Council for Science* (ICSU), and works under the auspices of the *United Nations Environment Programme* (UNEP), the *United Nations Educational, Scientific and Cultural Organization* (UNESCO), and the *World Meteorological Organization* (WMO).

The backbone of the WGMS is a scientific collaboration network of principal investigators and national correspondents in all the countries involved in glacier monitoring. Through a close collaboration and mutual exchange of knowledge and meta-data, glacier data is made accessible and freely available, principal investigators are given visibility, and data quality can be maintained at a high level. Versioning of the database (with DOI numbers) facilitates referencing of the data.

Detailed information about the WGMS, its partner organizations, monitoring strategy, and data products are available from the WGMS website: **http://www.wgms.ch**

3.9.2 Funding and administration of the World Glacier Monitoring Service (WGMS)

Based on a decision in 2009 relating to the participation of Switzerland in the *United Nations Framework Convention on Climate Change* (UNFCCC) and the *Global Climate Observing System* (GCOS), the *Swiss Federal Council* decided to provide long-term funding through GCOS Switzerland to the *Department of Geography* of the *University of Zurich* for the operational lead and coordination of the WGMS. In addition, WGMS products and projects have recently been supported by national and international organizations such as the *Cryospheric Commission* of the *Swiss*

Academy of Sciences, the *Swiss Agency for Development and Cooperation*, and the *United Nations Educational, Scientific and Cultural Organization*.

Since 2010, the WGMS has been operating with a total of about two full-time equivalents and an additional budget for travel and other expenses.

3.9.3 WGMS main activities since 2014

The operational tasks of the WGMS included the management of its databases and website, the publication of reported data, the response to data and information requests, and the periodical contact with its scientific collaboration network of national correspondents, principal investigators, and partner institutions. In addition, the WGMS was represented at various national and international conferences, meetings and workshops and involved in selected education and public outreach activities.

Additional working tasks included:

- Publication and release of a new **glacier thickness observations dataset**: Gärtner-Roer, I., Naegeli, K., Huss, M., Knecht, T., Machguth, H. and Zemp, M. (2014): A database of worldwide glacier thickness observations. Global and Planetary Change, 122: 330-344
- **GTN-G Evaluation** including self-evaluation report and site-visit at NSIDC in Boulder in June 2014
- Launch of a new **GTN-G *Global Glacier Browser***: http://gtn-g.org/data_browser.html
- Integration of WGMS glacier photographs (1,200 photographs of 500 glaciers) into NSIDC's ***Glacier Photograph Collection***: http://nsidc.org/data/glacier_photo/

3.9.4 WGMS capacity building and twinning activities

The *Swiss Agency for Development and Cooperation* (SDC) supports a project on *Capacity Building and Twinning for Climate Observing Systems* under the coordination of the *Swiss Federal Office of Meteorology and Climatology* MeteoSwiss. This project runs from 2011 to 2016 and aims at improving the capacity for measurements of greenhouse gases, aerosols and glacier mass balances in different regions of the world with data gaps. In close collaboration with regional partners, the glaciological work packages of the project aim at continuing and re-initiating *in situ* mass balance measurements in combination with new geodetic surveys of glaciers. Within this project, three *Summer Schools on Mass Balance Measurements and Analysis* are organized (Zermatt, Switzerland, 2013; Bishkek, Kyrgyzstan, 2015; La Paz, Bolivia, 2016).

Within another project also supported by SDC and running from 2014 to 2017, a new database is developed to map the global, scientific collaboration network of the WGMS and to increase the visibility of its principal investigators and sponsoring agencies in print and online products. Furthermore, a status report is elaborated to show the implementation degree of the international glacier monitoring strategy for each country as well as the related needs for future capacity building and twinning activities.

3.9.5 Global Terrestrial Network for Glaciers (GTN-G)

In close collaboration with the *US National Snow and Ice Data Center* in Boulder (NSIDC) and the *Global Land Ice Measurements from Space* (GLIMS) initiative, the WGMS has been in charge of the *Global Terrestrial Network for Glaciers* (GTN-G) since its creation in 1998. In 2008, the three bodies proposed a generic structure and terms of reference for a GTN-G *Steering Committee* (including an *Executive Board* and an *Advisory Board*) to the IACS Bureau. This proposal was approved in 2009 and at the beginning of 2011 the *Advisory Board* (under the lead of IACS) was finally staffed with representatives from data user and producer communities, as well as from international organizations (see **http://www.gtn-g.org**). GTN-G follows the *Global Hierarchical Observing Strategy* (GHOST) by the *Global Terrestrial Observing System* (GTOS).

Over the past years, periodical meetings of officers from NSIDC, GLIMS, and the WGMS were held to discuss and coordinate current key tasks. Joint conference sessions were set up dedicated to the monitoring of glaciers from *in situ* and remotely sensed observations at EGU, AGU, and other meetings.

3.9.6 Evaluation of GTN-G

In 2014, the GTN-G was **evaluated** by its *Advisory Board* under the lead of IACS. The major recommendations to GTN-G in general as well as to the WGMS, NSIDC, and GLIMS individually are in well agreement with our own views as detailed in the self-evaluation report. As such, the implementation of some key recommendations has started:

- The further development and better communication of a joint vision and monitoring strategy for GTN-G is set as an agenda item for the next *Executive Board* meetings which are continued to be held during major science conferences (e.g. AGU, EGU, IUGG).
- The GTN-G *Global Glacier Browser* was finalized (as reported above).
- The WGMS has completed the concept for a new biennial publication series merging the *Fluctuations of Glaciers* and the *Glacier Mass Balance Bulletin* series. The new *Global Glacier Change Bulletin* series will start in 2015 and aims at providing a more integrative assessment of worldwide and regional glacier changes, improving the visibility of our scientific collaboration network, and optimizing our reporting procedures.
- The WGMS has submitted a proposal for the extension and modernization of its geodetic glacier change dataset to the *European Space Agency* (approval pending).
- The GLIMS team was successful in getting NASA support for the integration of the Randolph dataset into the GLIMS database (at NSIDC) and for further developing the vision of GLIMS 2.0.

The evaluation report did also bring up new ideas such as jointly exploring funding prospects and coordinating proposals, more systematically organizing the data product at processing levels, or cloud and community-based glacier outline editing.

3.9.7 ICSU's World Data System (WDS)

The WGMS is a member of ICSU's World Data System (WDS), which promotes universal and equitable access to, and long-term stewardship of, quality-assured scientific data and data services, products, and information covering a broad range of disciplines from the natural and social sciences, and humanities. At bi-annual Members' Fora, WDS enables a vivid exchange of experiences and practices of its members, e.g. regarding data management and data quality, which might be of interest to other GTN-H partners. For more information, see: **https://www.icsu-wds.org/**

3.9.8 Discussion

Participants welcomed the presentation and discussed whether under the current dynamic development of the WGMS it would further be adequate to keep the cryosphere domain under the stewardship of WGMS and NSIDC or to outsource both under the domain of GTN-G and then maintain a close relationship between GTN-H and GTN-G with the expectation that GTN-G in its entity would be the network partner of GTN-H regarding glacier observations. The representative of the WGMS highlighted that WGMS is not responsible for the entire cryosphere. In this sense, the GTN-G would actually be an additional (meta) layer in the GTN-H configuration above, between "Snow Cover, Glaciers & Ice caps" and "WGMS"/"NSIDC", together with other GTN's (that do not (yet) exist).

Participants recommended that further discussions in this direction should be held between GTN-G and GTN-H to propose a viable approach to all network partners before the end of the year (2015).

3.10 Global Environment Monitoring System – Water

Mr Saile, representing GEMStat, informed participants on the status of GEMS/Water

3.10.1 Restructuring of the GEMS/Water Programme

Established in 1978, the UNEP GEMS/Water Programme[5] is a global multi-faceted water quality monitoring and assessment programme aiming at improving the knowledge about inland water quality through the collection and quality assurance of water quality monitoring data, the assessment of water quality at the regional and global scale and the development of monitoring and reporting capacities at the national level.

Formerly supported and operated by Environment Canada, GEMS/Water is currently transitioning towards a new governance and funding structure under global coordination through UNEP with two global thematic centres – the GEMS/Water Capacity Development Centre soon to be established at the University College of Cork (UCC), Ireland and supported by the Government of Ireland and the GEMS/Water Data Centre hosted by the Federal Institute of Hydrology in Koblenz Germany and supported by the Government of Germany (see Figure 12). The work of the global centres is supported through close collaboration with regional hubs (currently the Brazilian National Water Agency ANA is the only designated regional hub) that facilitate the communication with national and research partners and support the capacity development at the regional level.

[5] www.unep.org/gemswater

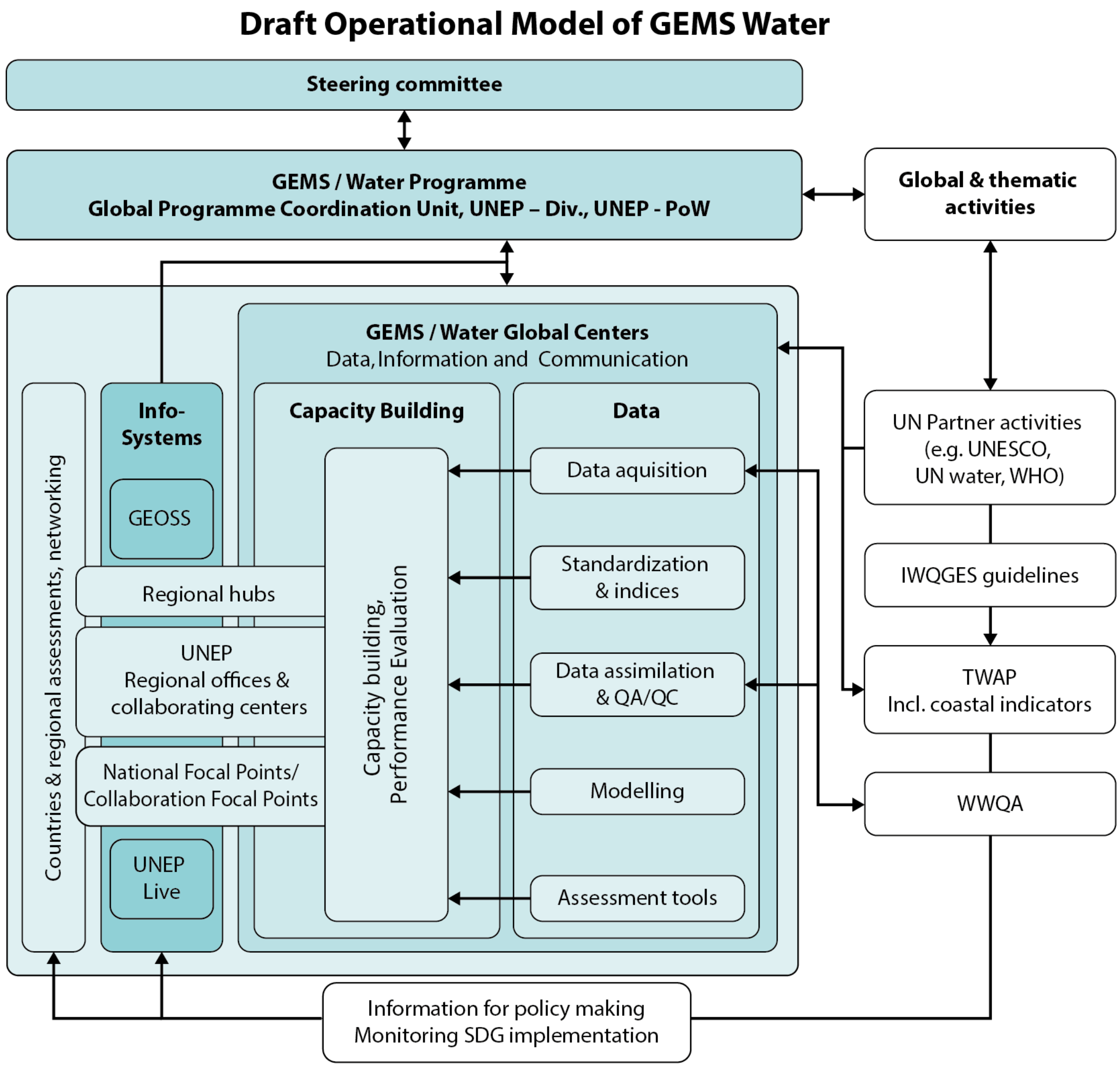

Figure 12 - New GEMS/Water Programme structure

3.10.2 Data & Products

The GEMS/Water Data Centre continues to maintain and extend the largest global water quality database and information system called GEMStat[6]. The water quality monitoring data contained in GEMStat covers rivers, lakes and reservoirs, groundwater and wetlands at 4144 monitoring stations in more than 130 countries with approximately 4.8 million sampling values for more than 250 water quality parameters for the period 1965 – 2013 (see Figure 13 and Table 4).

[6] www.gemstat.org

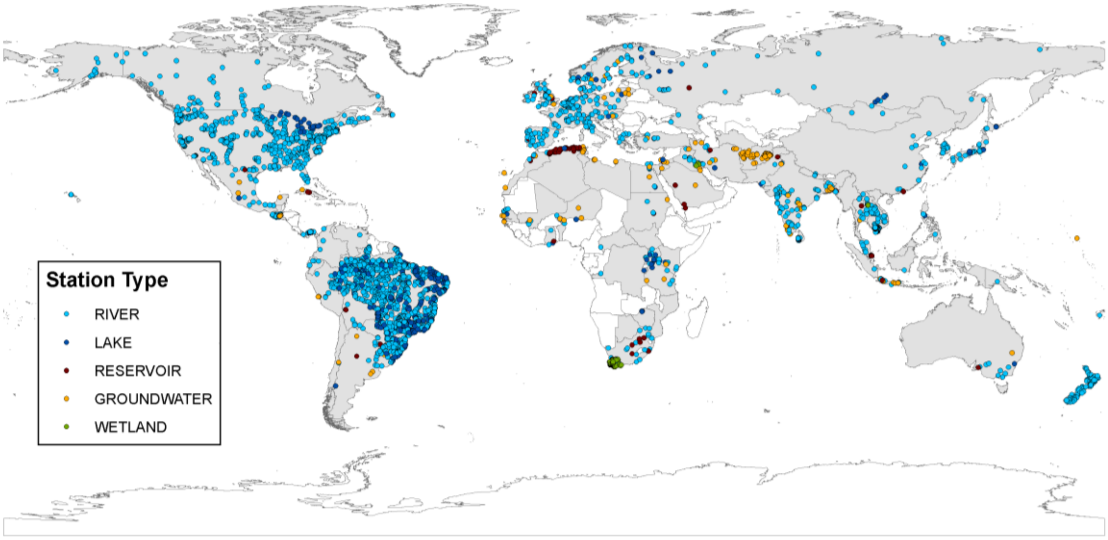

Figure 13 - The GEMS/Water Global Monitoring Network (monitoring stations per waterbody type, June 2015 not including recent data updates subject to data pre-processing)

Table 4 - GEMStat data availability by country (June, 2015 not including recent data updates subject to data pre-processing)

Region	Africa	Americas	Asia	Europe	Oceania	Totals
# Stations	368	2567	656	368	95	4144
# of Values	317884	1961640	979276	1086407	447336	4792543
Date Range	1977 – 2012	1965-2013	1969-2013	1974-2013	1979 – 2013	1965 - 2013

In addition to the collection and quality assurance of water quality monitoring data, GEMS/Water is also updating existing and developing new water quality data products.

In the context of the Sustainable Development Goals and the proposed target to improve water quality (target 6.3), GEMS/Water is currently adapting the existing global water quality index for biodiversity to assess the overall quality of inland surface water resources with respect to human and ecological health covering main water quality impairments (fecal pollution, oxygen depletion, nutrient pollution, acidification, and salinization) based on selected water quality parameters. The current spatial and temporal data availability in GEMStat only allows the provision of a contemporary water quality indicator for 19 countries. In order to support the evolving global monitoring and reporting systems for the SDGs with respect to the water quality indicator, major efforts will be necessary to support UN member countries in their water quality monitoring and reporting activities.

In addition to in-situ monitoring data, GEMS/Water is also exploring remote sensing techniques to derive water quality products from satellite data (optically measurable properties like turbidity, chlorophyll). Started in March 2015, the research project SPONGE[7] – funded by ESA – is testing the applicability of Sentinel 2 satellite data to derive water quality products for lakes, reservoirs and large rivers. GEMS/Water is coordinating the collection and quality control of ground-truthing in-situ data for the calibration and validation of the developed remote sensing algorithms. The resulting products can augment in-situ water quality monitoring with respect to certain impairments such as eutrophication/harmful algal blooms and sedimentation.

3.10.3 Discussion

Participants were pleased that the Federal Institute of Hydrology with significant government support is hosting GEMStat on a long-term basis after the transfer of the datacenter from Environment Canada that hosted the center for some 36 years. Participants commented positively on the restructuring efforts and on the inclusion of both in-situ water quality observations and satellite-based observations. Participants saw as priority actions the revival of data acquisition activities and the restoration of all basic data management functions including queries for data and the handling of requests for data and information. Participants also saw the large potential to engage closer with IGRAC to see synergies in the acquisition of groundwater quality data for inclusion in GEMStat and encouraged both GEMStat and IGRAC to intensify their cooperation in this regards.

4 Review of Quality Management issues of GTN-H network partners, recommendations for improvement

As part of the status reports of the GTN-H partners, mention was made on quality management issues. Different data centres handle quality management issues in diverse manners as a result of historic developments of these data centres and also due to the diversity of observations of a large variety of variables. Participants agreed on the necessity to compile a GTN-H Quality Management Overview document for user communities of GTN-H services. In essence, partners agreed to compile data management information on the level of the metadata and the level of the actually received data and information. Each contributing data centre will provide an overview of currently applied best practices in quality assurance and procedural steps involved. It is expected that as a next step, quality management procedures of the contributing data centres will lead to the identification of best practices and use of common standards as well as lessons learnt as a tool for quality management practices and also as valuable guidance for data users learning about possibilities and limits for quality assurance in global datasets. As the overall responsibility for the quality of data in most cases rests with the data providers, participants reiterated the need to provide feed-back to data providers on quality issues in their datasets as contributed of the data centres.

Mr Eggleston remarked that within GCOS, the terrestrial domain has the least well-developed international and global networks. Mainly due to the historical way national measurements have developed independently, there is less experience in data sharing, standards and common quality assurance. Thus, within GTN-H, quality assurance is an important issue. The experience, techniques and approaches used within GTN-H should be discussed by TOPC as a possible model to ensure

[7] http://www.odermatt-brockmann.ch/sponge

TOPC-wide quality assurance for in-situ measurements. Further, care should be taken to ensure compatibility with quality management practices and standards in WMO.

Participants further realized that the documentation of best practices and quality management tools and approaches would also serve as a first step towards the improvement of integrated observation networks such as those envisaged in WIGOS.

5 Access to data and information from GTN-H partners: New developments and plans (including standardization issues and web-based services)

Participants discussed the status of access to data and information amongst network partners of GTN-H. All data centers federated in GTN-H provide easy access to data and information through various services and several centres also provide data products in addition to data. All centres have an underlying data policy that generally allows access on a free and unrestricted basis that is in line with WMO Congress Resolutions and the data policy of GEO. Standardization issues are being tackled by all centres represented in GTN-H; however, the adoption of commonly agreed standards including metadata standards and the use of OGC endorsed standards such as marked-up languages (such as WaterML-2 and its derivates including “GroundwaterML”) are in the process of being gradually implemented by national services.

Participants felt that there is a need for closer communication between network partners regarding changes in data policies and processes leading to a higher degree of standardization especially with regard to metadata and the use of marked-up languages to ensure technical interoperability of data management systems.

The provision of web-based services is in its infancy and participants were of the opinion that further development needs to be tied to actual user requirements to ensure the effective use of web-based services such as the Sensor Observation Service (SOS). Likewise, participants discussed opportunities to provide services that are combined from data and information holdings of several of its federated data centres.

Participants requested the CHy-representative, Mr. Boston, to provide links for interaction with WMO´s Integrated Global Observing system (WIGOS) and, in so far it concerns data transfers and telecommunication with the WMO Information system (WIS). Both systems – dependant on each other – are highly formalized and standardized and participants viewed collaborative activities with WIGOS and WIS as essential as both systems are mandated by WMO´s member countries.

GRDC had pledged registration of station metadata with WIS as part of being recognised as a Data Collection or Production Centre (DCPC) before the end of 2015.

To improve data accessibility, participants also called on the GEO representative to clarify the process of registering data sets (such as GRDC data sets) on the GEOSS Common Infrastructure Platform specifically, the GEO Water Portal.

With regard to emerging data challenges and Future/Emerging Data Sources, Opportunities, Challenges and Risks, the meeting was informed of the WMO stand on these issues. Participants noted the decision of the recent WMO Congress to “undertake a review of the challenges and risks, opportunities and benefits related to ‘Big Data’, ‘Crowd-Sourced Data’, ‘Social Media’ as well as emerging and future data sources, and their potential impact on WMO Members, as the basis for production of a guidance document for Members”. Implementation would be entrusted mainly to WMO´s Technical Commission for Basic Systems and the Commission for Hydrology. (Cg-17/Doc. 9.1, 18 June 2015). At this moment, participants agreed to keep abreast of developments with regard to “Big Data” and “Crowd-Sourced” data, without undertaking own initiatives for the time being.

With the objective to inform participants on latest developments in the architecture and features of modern water information centres, cloud services and exploring data from multiple sources for further (statistical) processing and integrate observations and predictions into spatial data infrastructures on the basis of standards that allow the interoperability of data between different sources and centres, Messrs Jirka (52°North GmbH) and Natschke (KISTERS AG) made a joint presentation on state-of-the-art approaches for the interoperable exchange of observation and prediction data.

The joint presentation focused specifically on WaterML 2.0 and Sensor Web Standards.

Observation (and prediction) data, such as meteorological parameters or hydrological/hydrographical measurements are an important input for many decision-making processes, research activities, and information systems. Observation networks, for example those organized in the GTN-H, are a valuable source for such information.

For ensuring the efficient collection and delivery of these data sets, the World Wide Web (WWW) is an excellent communication layer. However, when sharing data over the WWW it is important to have a common approach how data sets can be requested and how they should be encoded (i.e. specification of data formats).

To facilitate discovery and sharing of observation data via the Web, the framework of Sensor Web Enablement (SWE) standards was developed by the Open Geospatial Consortium (OGC). These standards comprise (Web) service interface specifications as well as corresponding data models and (XML) encodings. In the context of the GTN-H, especially the following standards are relevant:

- Observations and Measurements (O&M) [1], [2]: A data model and XML encoding specification for observation data.
- WaterML 2.0 [3]: A specialization of O&M that specifically describes how to model and encode certain hydrological data.
- Sensor Observation Service (SOS) [4]: A (Web service) interface specification that describes how clients can request observation data. This also includes filters through which clients can specify which data sets shall be returned (e.g. temporal sub-setting, specification of the measurement parameters that are of interest, etc.)

While O&M is an important conceptual foundation for sharing observation data in general, it is designed in a domain independent manner. This is addressed by WaterML 2.0, which provides the necessary guidance how the concepts of O&M shall be applied to hydrological data. Currently, WaterML 2.0 comprises three parts.

- Part 1: Timeseries - Standard for modelling and XML encoding of time series data.
- Part 2 (in development): Ratings, Gaugings and Sections - Standard how to encode rating tables or rating curves used for the conversion of related hydrological phenomena (e.g. a stage-discharge relationship) as well as how to model the observations that are used to develop such relationships (gaugings, or gauging observations).

- Part 3 (in development): Water Quality: O&M and WaterML 2.0 profile for water quality data.

While, O&M and WaterML 2.0 describe how the returned data shall be encoded, the SOS specification (current version: 2.0) describes how a dataset can be requested by a client from a server implementing the SOS standard. Similar to O&M, also the OGC SOS standard was designed independent from a specific application domain. Thus, also for the SOS standard certain conventions are necessary, how it shall be used in the context of hydrological data. This does not only include conventions on terminology (e.g. “What is a sensor?”) but also additional functional requirements (e.g. determining available observation data sets, error messages if a client requests too large data sets, etc.). These specific conventions how to use the SOS 2.0 standard in hydrology are specified in the OGC SOS 2.0 Hydrology Profile Best Practice Paper [5].

There are different implementations available, which support the SWE standards:

KISTERS offers an implementation of the SOS 1.0 and 2.0 standards (including the SOS 2.0 Hydrology Profile) as an integrated part of its KISTERS Web Interoperability Solution (KiWIS). This makes it possible for users of KISTERS software to share their data in an interoperable manner. The server-side components are complemented by client implementations, for example the KISTERS Time Series Widget.

From 52°North, open source implementations of the SWE standards are available. The 52°North SOS server supports the SOS 1.0 and 2.0 standards (including the SOS 2.0 Hydrology Profile). Furthermore, the 52°North JavaScript SOS Client as well as the 52°North Sensor Web Client are comprehensive solutions that offer functionality for Web-based sensor data visualization and exploration.

In summary, the OGC Sensor Observation Service 2.0 (including the OGC SOS 2.0 Hydrology Profile) as well as WaterML 2.0 can be recommended as an interoperable access interface as well as data format to share observation (and prediction) data via the WWW. To gain further practical experience with this technology, we recommend to perform first installations/pilot activities in cooperation with interested observation networks. Based on this, further guidance and recommendations can be derived so that the first implementations may serve as blueprint for further deployments of SOS servers in the GTN-H.

5.1.1 References

[1] ISO TC 211 (2011). ISO 19156:2011 - Geographic information -- Observations and measurements - International Standard. Geneva, Switzerland, International Organization for Standardization.

[2] Cox, Simon (2011). OGC Implementation Specification: Observations and Measurements (O&M) - XML Implementation 2.0 (10-025r1). Wayland, MA, USA, Open Geospatial Consortium Inc.

[3] Taylor, Peter (2012). OGC Implementation Specification: WaterML 2.0: Part 1 - Timeseries (0-126r3). Wayland, MA, USA, Open Geospatial Consortium Inc.

[4] Bröring, Arne, Christoph Stasch and Johannes Echterhoff (2012). OGC Implementation Specification: Sensor Observation Service (SOS) 2.0 (12-006). Wayland, MA, USA, Open Geospatial Consortium Inc.

[5] Andres, Volker, Simon Jirka and Michael Utech (2014). OGC Best Practice: OGC Sensor Observation Service 2.0 Hydrology Profile (OGC 14-004r1). Wayland, MA, USA, Open Geospatial Consortium Inc.

5.1.2 Discussion

Participants welcomed the joint presentation made and expressed the timely and useful information provided that could help developing web-based services further in data centres federated in GTN-H.

The representative of GRDC mentioned that as a first step, GRDC is currently using a standard Sensor Observation Service (SOS) to enable access for GRDC stations corresponding to the GCOS Baseline River Network (GTN-R) for the period 2000 to 2012. To access the GTN-R SOS, a test client developed by 52° North is provided (http://www.bafg.de/GRDC/EN/06_nws/new_sos_gtnr.html).

On request of the participants, Messrs Jirca and Natschke agreed to prepare a concept note on next steps required for the development and implementation of a GTN-H platform providing web-based services to users of data and information provided by the federated data centres of the GTN-H.

5.1.3 Progress report on the Hydrological Features Model (HY_Features)

With regard to the development of a **Hydrological Features Model** that is under development in parallel to the advanced development of other standards including TimeSeries and WaterML, Ms Dornblut of GRDC made a presentation on the objectives and status of development.

The HY_Features model describes the most important hydrologic features by defining the fundamental relationships among the major components of the hydrosphere, including the hierarchy of basins and the segmentation of watercourses, to reflect hydrologic significance and topological connectivity of hydrologic features independent from geometric representation and scales. The conceptual model is described in an OGC Discussion Paper OGC 11-039r3: “HY_Features: a Common Hydrologic Feature Model”.

The principal goal of the HY_Features is to model the relationships of the Hydrologic Cycle conform to the common terminology endorsed by WMO and also by UNSECO, and recommended for use to their member countries. Thus, HY_Features is aimed to formalize the logical relationships defined within or inferred by the definitions documented in the WMO-UNESCO International Glossary of Hydrology (IGH) to provide a common model for referencing hydrologic features that can be used in terms of a high-level ontology.

The HY_Features model allows for a common and stable referencing wherever hydrologic features are required to be references,

- to assist hydrologic observations to identify the target feature-of-interest,
- to assist the aggregation of generated data represented in various data sets in current use into integrated suites of datasets on global, regional, or basin scales,
- to enable information systems to link distributed data across application domains,
- to enable cross-domain services to communicate by referencing common, shared concepts.

A new OGC Standards Working Group is being formed. The purpose of this Standards Working Group is to progress the *HY_Features* common hydrologic feature model to the state of an adopted OGC standard for a common and stable identification and referencing of hydrologic features.

This goal will be achieved by developing and publishing a draft standard, by processing comments received during a public comment period, and ensuring that the standard is consistent with the OGC Standards Baseline.

The Hydrologic Feature standard will be split into 3 parts, so that conceptual issues can be addressed separate from the GML schemas and machine-readable OWL versions of the model for practical use.

- Part 1: HY_Features conceptual model. The normative model is a machine-readable UML artefact published by OGC.
- Part 2: GML implementation schema suitable for data transfer of *HY_Features* object instances, based on ISO 19136 Annex E encoding rules for Application Schema.
- Part 3: OWL and RDF representation suitable for defining links between features that implement the *HY_Features* model, based on ISO 19150 encoding rules.

The final deliverable of the SWG will be separate versions of each intended part of the Hydrologic Feature candidate standard for consideration by the OGC membership for approval as an OGC standard.

5.1.4 Discussion

Participants welcomed the progress made in the development of the Hydrologic Features Model and recommended that the further development is underpinned by some practical examples that can be used to further promote the actual development and eventual use of the Model as a conceptual framework within the technical development and implementation of OGC/WMO standards including Water ML2.

6 Matching GTN-H activities with major programmes and initiatives including WMO/HWRP, WIS/WIGOS, GCOS/TOPC and GEO/IGWCO-CoP

Recognizing that GTN-H activities have been historically anchored in major programmes including GCOS, the hydrology branch of the WMO Water and Climate Department and in later developments with the water theme in GEO, participants updated to the present status of activities in WMO/HWRP, WIS/WIGOS, GCOS/TOPC and GEO/IGWCO-CoP that are relevant for GTN-H.

Mr. Boston, representing the WMO Commission for Hydrology (CHy), made a presentation on the activities of CHy in the areas of Hydrology and WIS/WIGOS.

Initiatives of WMO relevant to GTN-H include the proposed WMO Hydrological Observing System (WHOS), activities of the WMO/OGC Hydrology Domain Working Group and CHy AWG Data Operations and Management theme as well as WIS/WIGOS.

6.1 WMO Hydrological Observing System (WHOS)

Harry Lins, CHy President, discussed WHOS at the recent Congress-17 session. The need for WHOS is exemplified by:

- No analogue to World Weather Watch within hydrology;
- No current portal to real-time or historical data of National Hydrological Services (NHSs);
- WHYCOS to date has focused largely on monitoring networks and capacity building, not data delivery; and

- Increasingly NHSs are able to make their data available online using OGC web services and exchange standards such as WaterML2.0.

CHy AWG has proposed the WMO Hydrological Observing System (WHOS) to provide the hydrological component in fulfillment of the WIGOS objective of “an integrated, comprehensive, and coordinated system, which is comprised of the present WMO global observing systems”.

WHOS is conceived as a portal to facilitate access to already available on-line real-time and historical data, drawing from the water information systems of countries around the world that make their data freely and openly available, including HYCOS projects. WHOS Phase 1: Map interface (see below) with links to those NHSs that make their real-time and historical stage and discharge data available online. Initial implementation is planned for July 2015. WHOS Phase 2: A fully WIS/WIGOS compliant services-oriented framework linking hydrologic data providers and users through a hydrologic information system enabling data registration, data discovery, and data access (see Data Operations and Management pilot projects). Beta version is planned for CHy-15 review and endorsement (Nov 2016). Initial implementation is planned for EC approval in June 2017.

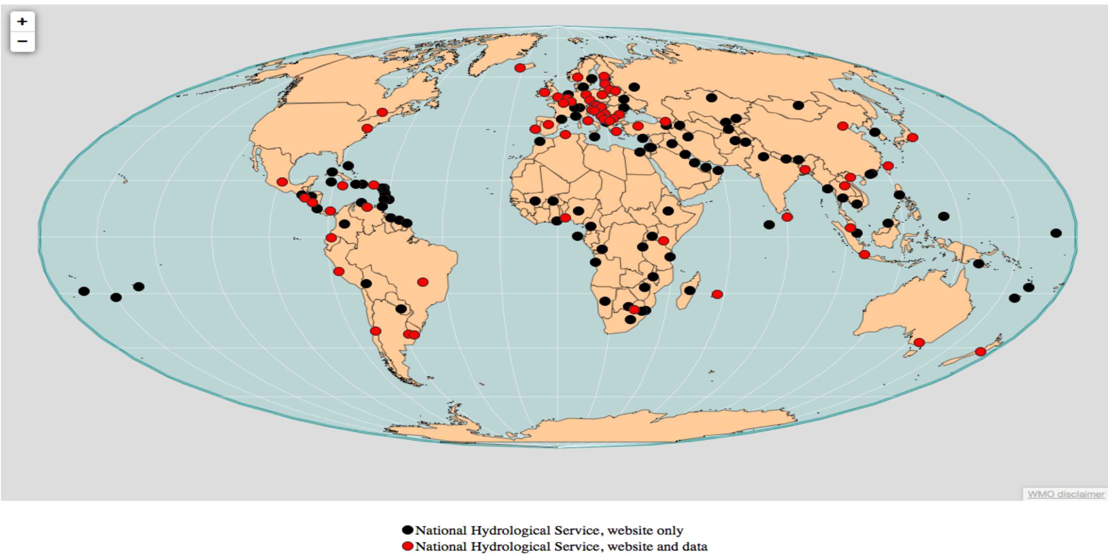

Figure 14 - WMO/OGC Hydrology Domain Working Group and CHy AWG Data Operations and Management

The WMO/OGC Hydrology Domain Working Group (HDWG) is developing a suite of water information standards for the exchange of water data, including time series observations, ratings, gaugings and section information, water quality and groundwater information.

WaterML2.0: Part 1 – Timeseries was the first HDWG-developed water information standard approved by the OGC. This standard is designed to support exchange between computer systems of timeseries hydrological observations encoded in XML. In combination with OGC web services, which provide standard interfaces such as the Web Map Service (WMS), Web Feature Service (WFS) and Sensor Observation Service (SOS), WaterML2.0 can be used for hydrological data sharing between computer systems. Since 2012, several governments around the world, including the USA and European Union, have endorsed the WaterML2.0: Part 1 standard.

WMO CHy-14 in November 2012 approved a resolution proposing "a process, including testing, that could see the potential adoption of the WaterML 2.0 as a WMO standard for information exchange managed by WMO (supported by the WMO/OGC MOU) and to register this standard as a joint WMO/ISO standard".

The AWG Data Operations and Management theme is testing the use of WaterML2.0 for the exchange of water data in a series of pilot projects using data obtained for NHSs from around the world. To date pilots have been undertaken in Italy, Sava Basin, Latin America, New Zealand, China and HYCOS regions: Artic, Niger, SADC.

Documentation on data sharing using WaterML2.0 and OGC web services is available on the WMO web site at: http://www.wmo.int/pages/prog/hwrp/chy/data-access-exchange.php.

The WMO/OGC HDWG and WMO CBS IPET-MDRD (CBS Inter Programme Expert Team on Metadata and Data Representation Development) are also coordinating development of TimeseriesML, which is a cross-domain implementation of the timeseries model developed within WaterML2.0. TimeseriesML will be applicable to any environmental observations across domains of interest to WMO, e.g. climate, weather, water, oceanography etc.

6.1.1 WIS/WIGOS

GTN-H data centres, such as GRDC, can register within the WMO Information System (WIS) as Data Collection and Production Centres. Full utilisation of WIS by GTN-H is a mechanism to increase global hydrological data sharing.

The WIGOS (observations) metadata standard was approved at Cg-17. CBS IPET-MDRD have begun a process to develop an information model and XML encoding for exchange of metadata defined in the WIGOS standard. This standard could be used across WMO Technical Commissions, including CHy, to share information collected in conjunction with environmental observations.

6.1.2 Conclusion

WMO CHy currently has three GTN-H data centres under its auspices: GRDC, IGRAC and HYDROLARE. GTN-H aims to improve access to data and information from these and other data centres in its network and aims to promote the development of joint, integrated data products. GTN-H is broader in scope than CHy WHOS but both have similar goals. GTN-H needs to evaluate how it interacts with WMO WIS, and WHOS as it develops.

6.1.3 Discussion

Participants thanked Mr Boston for the detailed presentation. GRDC and the representative of KISTERS expressed their preparedness to contribute towards the development and operation of WHOS. Likewise, participants expressed interest to cooperate with OGC in the Hydrology Domain Working Group and requested more information in this regard. There was the view that more datasets could be registered with WGOS/WIS and that closer direct interactions should be fostered with WIGOS/WIS in addition to existing links with the WMO Hydrology branch and specifically with CHy. Participants also called for the promotion of standards such as WaterML 2.0 amongst GTN-H partners to initiate a wide-spread adoption and application of these standards. The full implementation of WaterML 2.0 needs further developments that are specific for different data and observation types. For example, in its present form and Water ML 2.0 is not well capable of handling ex-situ data (i.e. samples taken and analysed at a later time).

Further, the session agreed to evaluate closer interaction with WIGOS/WIS and WHOS.

With regard to anchoring GTN-H activities, participants called on the representatives of CHy and GCOS to strengthen governance of GTN-H as a whole to ensure further development of this largest federated network of data centres in the domain of water. This would overcome obvious shortcomings of the governance of single data centres without the broader view of the interrelations of global data centres and their significant potential to serve different programs and user needs including specifically in the domain of climate services such as in the UN wide Global Framework for Climate Services (GFCS).

6.2 Global Climate Observing system (GCOS)

Mr Eggleston, representing the GCOS Secretariat provided an overview of current GCOS activities

The Global Climate Observing System (GCOS) was established in 1992 as an outcome of the Second World Climate Conference. GCOS is an internationally coordinated network of observing systems and a programme of activities that support and improve the network. It is designed to meet the evolving national and international requirements for climate observations. GCOS addresses the total climate system, including physical, chemical and biological properties, and atmospheric, oceanic, terrestrial hydrological and cryospheric components.

Table 5 GCOS Essential Climate Variables. Those of most interest to GTN-H are highlighted in red.

Domain	Sub-Domain	GCOS Essential Climate Variables
Atmospheric	Surface	Air temperature, Wind speed and direction, Water vapour, Pressure, Precipitation, Surface radiation budget
	Upper Air	Temperature, Wind speed and direction, Water vapour, Cloud properties, Earth radiation budget (including solar irradiance)
	Composition	Carbon dioxide, Methane, and other long-lived greenhouse gases, Ozone and Aerosol, supported by their precursors
Ocean	Surface	Sea-surface temperature, Sea-surface salinity, Sea level, Sea state, Sea ice, Surface current, Ocean colour, Carbon dioxide partial pressure, Ocean acidity, Phytoplankton
	Sub-surface	Temperature, Salinity, Current, Nutrients, Carbon dioxide partial pressure, Ocean acidity, Oxygen, Tracers
Terrestrial	Hydrology	River discharge, Water use, Groundwater, Lakes, Soil moisture
	Cryosphere	Snow cover, Glaciers and ice caps, Ice sheets, Permafrost
	Biological & Carbon	Albedo, Land cover (including vegetation type), Fraction of absorbed photosynthetically active radiation (FAPAR), Leaf area index (LAI), Above-ground biomass, Soil carbon, Fire disturbance

GCOS is a joint undertaking of the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational Scientific and Cultural Organization (UNESCO), the United Nations Environment Programme (UNEP) and the International Council for Science (ICSU) and is led by a steering committee. It has three Panels co-sponsored with WCRP, the Atmospheric Observation Panel for Climate (AOPC) and the Terrestrial

Observation Panel for Climate (TOPC) and the Ocean Observations Panel for Climate which is also sponsored by the Global Ocean Observing System (GOOS). In addition there is the GCOS Co-operation Mechanism that assists the maintenance, development and improvement of observing networks in developing countries.

In February 2015 TOPC-XVII met and amongst its conclusions are some actions relevant to GTN-H:

1. Provide a letter of support (covering Pristine Rivers monitoring, Hosting Ice Sheet ECV at NSIDC, use of DOI)
2. Continue to improve the Lakes ECV by improving the technique of satellite water level measurements by comparative analysis of the results of satellite and in situ observations to explore the impact of different factors on the accuracy of satellite water level measurements and by establishing trial products such as lakes surface temperature and ice thickness
3. Develop TOPC Work Plan
4. Discuss with GTNs about a potential Memorandum of Understanding
5. Assist in the development of the GCOS Status Report and Implementation Plan

6.2.1 GCOS Review

A GCOS Programme Review in 2014 by the GCOS sponsors WMO, IOC, UNEP and ICSU came to the main conclusion:

There is no doubt that the GCOS programme should be continued. It is indispensable. If it ceased to exist it would need to be recreated.

It made a number of strategic recommendations to ensure that GCSO remains fit for purpose into the future. These included a the need for a clear Mission Statement and revised Memorandum of Understanding with the sponsors, the sponsors and GCOS should increase the visibility of the programme, should work to improve terrestrial observations, should adopt a more strategic approach to capacity building, should improve relations with GEO, PROVIA, FUTURE Earth and GCFS, and GCOS' mandate should cover mitigation and adaption.

6.2.2 Adaption and Mitigation

While GCOS' role is focussed on global climate observations, there is an increasing emphasis on contributing to climate change adaption and mitigation. Climate observations underlie many climate services, assessments of climate change and policy development including mitigation and studies of vulnerabilities, impacts and adaption. Climate adaption requires an understanding of both climate variability and climate change. Adaption is usually local and often requires local information. Neither global climate models nor satellite-based forecasting systems are yet good enough to support decisions made at the local level. While it is unlikely that GCOS can provide local measurements it can consider how to facilitate their development. GCOS will need to consider how it can help. GCOS, jointly with the UNFCCC and IPCC, held workshop on adaption issues and a report of the meeting has now been published: *GCOS Workshop on Enhancing Observation to Support Preparedness and Adaption in a Changing Climate - Learning from the IPCC 5th Assessment Report*. Bonn, Germany, 10-12 February 2015.

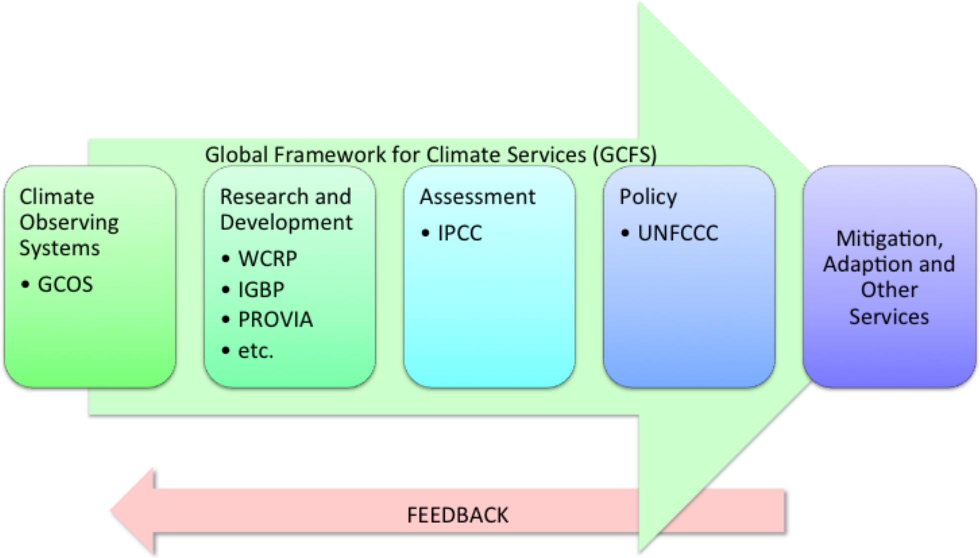

Figure 15 - GCOS underlies research, Assessment, policy development and climate services. GCOS Cooperates and coordinates with the relevant organisations involved in each step.

6.2.3 GCOS – Status Report and new Implementation Plan

GCOS is currently preparing a GCOS Status Report reviewing the status of the global climate observing system and the outcome of actions in the 2010 GCOS Implementation Plan. This Status Report will be open for public review in late July and members of GTN-H are encouraged to take part in this review. The aim is to present this to the UNFCCC for COP21 in Paris December 2015.

GCOS has also started work on producing a new Implementation Plan for December 2016. This will cover continuing and new requirements, including a restatement of the rationale for the list of ECVs and possible amendment of the list. It will be based on the adequacy of present arrangements and discuss additional actions needed, with indicative costs, performance indicators and potential agents for implementation. It should include statements of specific requirements for products from both in-situ networks and the space-based component and from integration of the data provided by both either embedded in the main Plan or as separate supplement(s).

In order to develop the new Implementation Plan GTN-H should consider whether or not the current definition of ECVs is appropriate and allows the water cycle to be monitored well. A specific issue is the definition of Water Use – this needs to be improved.

6.2.4 Conclusion

The recent GCOS Review underlined the importance of GCOS but also noted the need to strengthen terrestrial observation systems. The review of the current situation in the Status Report and the development of the new Implementation Plan provide GTN-H a way of contributing to the future of global climate observations and improving the monitoring of hydrological systems. GTN-H members are encouraged to contribute to the reviews and provide any ideas for the new implementation plan to the writing team or to TOPC.

In the future, with an increasing focus on adaption and mitigation, GCOS will aim to assist with the provision of observations for vulnerability, impacts and adaption either through more targeted global observations or guidance on compatible local observations.

6.2.5 Discussion

Session participants thanked Mr Eggleston for the presentation and confirmed the preparedness of GTN-H network partners to continue support to the objectives and activities of GCOS and the TOPC-Panel. Participants also called on GCOS to seek direct relations with the federated data centres for specific support of selected activities. Participants shared the view to strengthen terrestrial observing systems. On their part, partner centres of GTN-H already are engaged to promote the establishment and maintenance of terrestrial observation systems through their clients and partners.

With regard to governance, participants expressed their regret, that GTOS – hosted by FAO does no longer play an active role in the domain of terrestrial observation systems.

6.3 Group on Earth Observations (GEO)

Mr Berod, representing the GEO-Secretariat informed participants on GEO activities, focusing on water-related activities relevant for the GTN-H.

The intergovernmental Group on Earth Observations (GEO, www.earthobservations.org) was established in 2005 to build the Global Earth Observation System of Systems (GEOSS), through the coordinated efforts of its 98 Member governments and 87 Participating Organizations (June 2015). The full value of GEOSS lies in its ability to combine information across disciplines, providing easy, open and organized access to *in situ* and satellite observations that enable an increasingly integrated view of our changing Earth. For nearly a decade, GEO has been driving the interoperability of many thousands of individual space-based, airborne and *in situ* Earth observations around the world focused on nine Societal Benefit Areas: agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water and weather.

GEO water tasks address diverse areas such as: defining the data and systems needed for improved water-cycle forecasting; interlinking weather forecasting systems with other Earth observation systems, especially for flood and drought; supporting efforts to improve the monitoring of water quality; coordinating observation systems of cold regions; and capacity building. Similarly to the other GEO tasks, this action works towards the provision of coordinated, comprehensive and sustained Earth observations for sound decision-making and policy. Water activities are essentially developed and coordinate through effort of the GEO Integrated Global Water Cycle Observations Community of Practice (IGWCO - CoP), along with other contributors. GEO relies on two main organisations for coordinating water measurement networks: the Committee on Earth Observation Satellites (CEOS) and the Global Terrestrial Network - Hydrology (GTN-H).

Contribution of GTN-H and its members is crucial for providing data, considering that water crisis have been identified as the highest societal risk in 2015 by the World Economic Forum. Moreover, the process of sustainable developments goals foresees the definition of a specific goal on water: this would require Earth observations for defining, building and measuring indicators. GEO and thus GTN-H, have a role to play in this context.

The GEOSS water strategy report 2014 as well as the new GEO Work plan is good opportunities to shape and consolidate the contribution of GTN-H to GEO.

Earth observations can support political decisions and reduce risks through the provision of information, but there is a need to coordinate existing systems that may be very different. No matter how effective individual observations networks, their value multiplies when they work in synergy and are inter-operable.

6.3.1 Discussion

Participants welcomed the presentation of Mr. Berod, including sharing his information on the status of water as a priority issue as highest societal risk and the commitment of GEO to strengthen earth observations for enhanced policy and decision-making as we well as the management of water including extremes. Participants recalled that from the early stages of development of GEOSS, GTN-H branded itself as the observational arm of the Integrated Water Cycle Observations – Community of Practice (IGWCO-CoP).

In this regard, the session discussed at length and endorsed the document of GTN-H actions in support of the implementation of the GEOSS Water Strategy for the terrestrial observation component. This document is complementary to the ongoing satellite-based water-related activities undertaken by the Committee on Earth Observation Satellites (CEOS). The document "Addressing GEOSS Water Strategy Recommendations, GTN-H Activities Planned and Potential activities" is attached as annex 2 to the report.

6.4 International Center for Water Resources and Global Change (WRGC)

With the establishment of the International Centre for Water Resources and Global Change (WRGC) institutional developments have taken place, which are of direct interest to the GTN-H. Mr Cullmann, representing the WRGC briefed participants on the Centre:

The International Centre for Water Resources and Global Change has commenced work in Koblenz in July 2014. The Centre was founded by the German Federal Government under the auspices of UNESCO. Specialized centres of UNESCO are to pool competencies in single countries or regions and act as international reference centres.

The Centre works in close cooperation with partners from the scientific community, operational hydrological services, data centres and water-related UN organisations. It supplies these partners with customized products for information, as a basis for scientific investigations, to improve operational skills, for policy advice and the promotion of competencies in the water sector.

The Centre's general objectives include:

- promoting international cooperation by organizing and implementing inter-institutional and multinational research and development activities,
- estimating the impacts of global change and designing adaptive strategies,
- providing a reference for hydrological data,
- monitoring and analyzing of world water balance and water quality,
- supporting the international development agenda by providing indicators and information on water-relevant objectives,

- supporting national operational hydrological services,
- involvement in international networks on water,
- capacity development.

The Center is organized around 5 main pillars (see Figure 16)

1. Research projects: generating content, promoting technical and methodical developments, laying groundwork for international cooperation.
2. Capacity development: this field of work covers various aspects of knowledge transfer. Advancing new media, compiling learning material, organizing workshops and supporting young scientists.
3. Data: This is the field of action of the Global Water Quality Data Centre GEMStat. The data domain also comprises the development of data products by GEMStat and GRDC by means of the Global Water Data Centre, which is integrated here. Moreover, the Centres are involved in the international efforts to improve the global water information system
4. Networks: The involvement in national and international committees creates contacts. The Centre can draw attention to its work and adapt the products that it designs to the addressees' requirements. Information on education and training in the water sector is gathered and communicated.
5. IHP/HWRP Secretariat: Cooperation with the water programmes of UNESCO and WMO is one of the Centre's core tasks. This includes contributions to the current phase of the relevant programmes of the UN organisations.

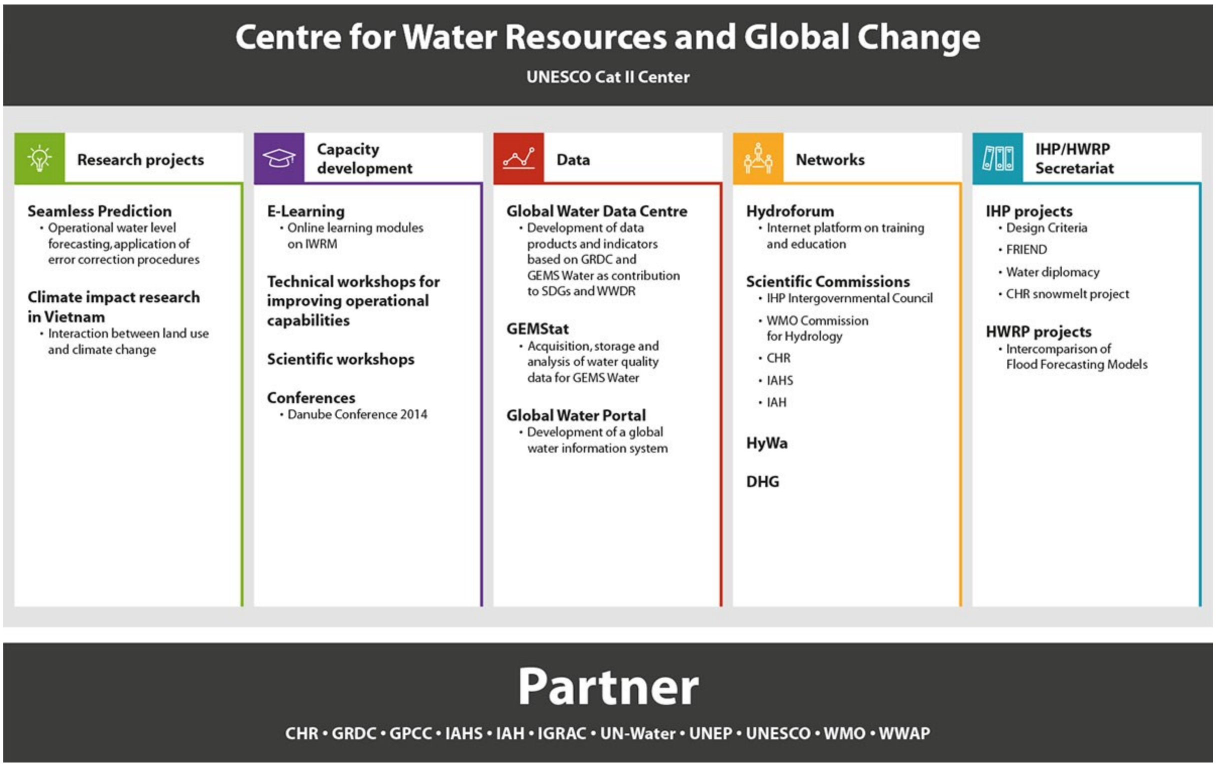

Figure 16 - Scheme of main activities of the International Center for Water Resources and Global Change

Providing and maintaining a reliable source of information for using water data for policy purposes is one of the Centre's contributions generated by the Global Water Data Centre. The possible benefit for GTNH arises from the main aspect of the GWDC, the provision of integrated information and services on the basis of products of different international data centers and data sets.

Key elements that are of interest for GTN-H are:

- **Harmonization of global water datasets**
  The data collected by the associated data centres originate from a plethora of organisations complying with various standards and data management processes while using various ontologies. Harmonizing the data collected and the resulting data products on a technical and semantic level is a central objective of the Centre.
- **Provision of data and data products for scientific applications**
  In addition to providing monitoring data for scientific studies and estimations on global change, the GWDC will establish data products and reference datasets for global and regional water balance studies, estimations on global change and reliable development strategies under changing conditions.
- **Supply of demand-oriented data products on** availability and variability of water resources; global water balances.

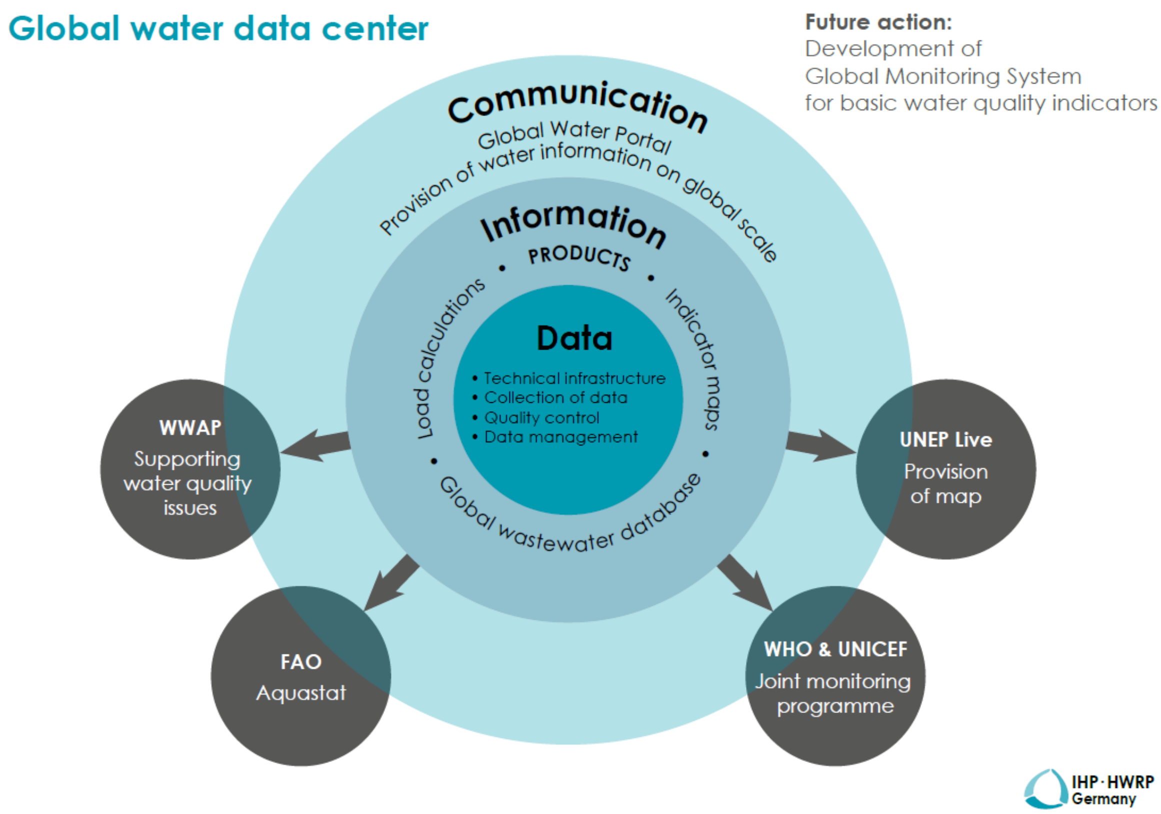

Figure 17 - Outline of the Global Water Data Center (GWDC)

6.4.1 Discussion

The session participants appreciated the establishment of the Centre. In particular, participants saw value in closely cooperating with the Global Water Data Centre (GWDC) as part of UNESCO Category

II Center on Water Resources and Global Change (WRGC) in view of the key elements of interest for GTN-H as outlined in the report of Mr. Cullmann. More broadly, GTN-H saw merit in keeping a close relation with WGRC as a support partner of GTN-H as outlined in the chapter below and as reflected in the Work Plan (annex 1)

Participants noted with interest that GEMStat is operating under the overall umbrella of the International Center for Water Resources and Global Change

7 Strategic positioning of GTN-H and opportunities for service delivery

Participants discussed this agenda item at length. The discussion followed in line with the consensus found with regard to matching activities of GTN-H with principal partners and governing bodies of GTN-H. The overall view of participants was that as a federation of global data centers with focus on hydrometeorological parameters, GTN-H needs to demonstrate its added value. Added value will also be shown in the development of data products and services as discussed in the agenda item below.

Participants agreed that rather than concentrating on the relative strengths of the individual network partners, a strategy paper needs to be developed addressing upcoming challenges and opportunities for GTN-H. Such opportunities include cooperation in the development and promotion of a Sustainable Development Goal – Water (SDG-Water) in the post-2015 development agenda that has a renewed focus on earth observations both in-situ, from satellites and new data exploration approaches (“Big Data” and “Crowd Sourcing” Concepts). Participants however reiterated that data exploration approaches will be observed (mainly through keeping in contact with CHy and the WMO Commission on Basic Systems (CBS) and not acted upon with own initiatives at this stage. Another opportunity is in support of water resources management through an improved quantitative knowledge of the spatial and temporal variations of the components of the hydrological cycle. Participants felt that this opportunity should be followed up by including the WMO co-sponsored World Climate Research Program (WCRP) and specifically the Global Energy and Water Cycle Experiment (GEWEX).

Participants realized that individual data centres have few resources to develop scientific products in addition to what these centres already deliver. This is mainly due to constraints in financial and personnel resources. In this regard, participants shared the view that GTN-H needs to broaden its support base, if not financially then through formalized cooperation with support partners such as though identified scientific centres of excellence. Starting from individual data centres, an overview should be prepared on science support opportunities to strengthen service capabilities of individual centres and GTN-H as a whole.

Based on the presentation of Mr Cullmann, participants agreed to develop cooperative ties with the newly established Global Water Data Centre (GWDC), hosted by the German Federal Institute of Hydrology. Participants recognized that the GWDC is in a developing phase at this moment.

7.1 Generation of integrated data products in cooperation with collaborating partner organizations

The session recalled that the generation of integrated data products has been regularly discussed at GTN-H Panel sessions. Integrated data products are mainly those applications – oriented products or services that are not confined to the holdings of data and information from a single global data centre but primarily from the wealth of data and information held at several data centres federated within GTN-H.

Participants realized that so far the outcomes have fallen far behind expectations and requirements. Again, this is a result of scarce resources especially the difficulty to have regular staff employed in the operation of core activities of the GTN-H partner centres to conduct scientific work and the development of products in addition to day-to-day activities.

In this respect the previous work plan was reviewed critically and only those activities related to the development of integrated data products were retained in the forthcoming work plan that participants considered to be practically achievable.

Again, participants were of the opinion that support-partners as discussed above need to be identified and linked to cooperate with GTN-H for the development of integrated data products. Once operational, the Global Water Data Centre could play a vital role in the development and provision of integrated data products.

8 Development of the GTN-H Work Plan 2015-2017

Participants agreed to develop and adopt the work plan for the inter-sessional period 2015-2017. Based on discussion results under the previous agenda items, the new GTN-H work plan was subsequently developed and adopted by the session. It was apparent that some of the action items need further consultation with GTN-H partners and other cooperating partners to make them executable. In this way, participants agreed that progress made on the work plan should be reviewed periodically with partners using email and teleconferences. The work plan is attached as annex 1 to the report.

9 Summary of conclusions and recommendations

To ensure consistency of the discussion results and agreed action items, the GTN-H coordinator provided a summary of the conclusions and recommendations and where necessary, amendments were made to recommendations that are reflected in this report.

10 Time and place of the 8th session of the GTN-H Panel

The session agreed that the 8th session of the GTN-H Panel should be held in Koblenz, Germany, unless another viable proposal would be brought forward. The date of the session will be in June 2017 with exact dates to be communicated in due course.

11 Closure of the 7th Session of the GTN-H Panel

The GTN-H Panel session adjourned at 4 p.m. on 17th June 2014

Appendix 1 WORK Plan 2015 - 2017

	Action	**Who**	**Status/ next steps**	**State**
1	Updated Meta-Database of "climate sensitive stations" basins available at GRDC	GRDC – Science-based paper to justify the need for climate sensitive station information should be developed by CHy in support of data acquisition activities – address president CHy again (Grabs)	Ongoing, incorporated in GRDC data acquisition activities.	Continue
2	Clarify role of AQUASTAT as water use database with FAO (K. Frenken), and establish dialogue with GTN-H	GTN-H, contact AQUASTAT also in context of SDG-monitoring , GCOS to clarify the primary use of water use data as ECV	Contact K. Frenken	Continue
3	Clarify how soil moisture network activities, including institutional data collection, move ahead	ISMN has been established (2010); there are funding issues in 2016	Check for potential hosts or alternate resources	Continue
4	Send new request letters on GTN-R and GTN-L to non-responding countries, and inform responding countries on progress	GRDC ; HYDROLARE	Develop and send letters	Continue
5	Identify and apply software product suitable to manage hydrological metadata; implement domain-specific metadata profile	GRDC	Completed, promote applications, check impact	
6	Develop concept for the implementation of a groundwater recharge project, jointly by GPCC, IGRAC, GTN-P, Water-Gap on a regional scale	IGRAC, Water Gap info on this subject are on IGRAC water portal, new development	Completed, new development to be continued periodically: Driver: Water-Gap	
7	explore the possibility of using GRACE and soil moisture for recharge estimates	IGRAC , ISMN	Continue further cooperation between IGRAC and ISMN in cooperation with Water-Gap	
8	Visualization of meta-data	All GTN-H partners	Exchanging ideas and know-how to visualize meta-data	
9	Expand data holdings on pristine basins and GTN-R	GRDC with WMO	Prepare letter of request in cooperation with CHy	
10	Ingest UNESCO-FRIEND data in database	GRDC in collaboration with FRIEND	Ongoing	
11	Seek access to bathymetric data for HYDROLARE	HYDROLARE	Identify sources for bathymetric data	
12	Develop groundwater management tools for an improved management of groundwater resources	IGRAC	Prepare a brief concept note on the issue and circulate amongst partners	

	Action	Who	Status/ next steps	State
13	Seek access to national meteorological and hydrological services to enhance data collection and access to data and information for GNIP	GNIP	GNIP and WMO to exchange information on hydrological services	
14	Provide information on isotopes in surface waters	GNIP	Circulate additional information on this component	
15	Re-organize affiliation of GTN-G to GTN-H	GTN-H, GTN-H	Discuss with network partners and TOPC, work towards GTN-G being an affiliated partner of GTN-H rather than an integral part as of now.	
16	Enable data acquisition activities and the restoration of all basic data management functions for water quality data	GEMStat	In progress; prepare concept notes on data acquisition strategy including choice of priority variables	
17	Seek access to groundwater quality data to be included in GEMStat	GEMStat and IGRAC	Identify sources for groundwater quality information	
18	Documentation of best practices and quality management tools and approaches	All GTN-H network partners	Preparation of a template of a best practice document	
19	Registration of data in the GEO Portal	All network partners, GEO	Provide clarification of the registration process of data in the GEO Portal	
20	Development and implementation of a GTN-H platform providing web-based services	KISTERS, 52 North	Preparation of a concept note	
21	Interact more closely with WIGOS, WIS and the development of WHOS	GTN-H and GRDC	Develop and circulate a concept note on this issue	
22	Registration of GTN-H datasets with WIGOS	CHy and GTN-H	Explore the potential to register GTN-H datasets	
23	Strengthen governance of GTN-H	CHy in cooperation with GTN-H partners including GCOS/TOPC	Initiate consultation on this issue. Prepare for text regarding GTN-H for CHY-session in late 2016	
24	Support of specific activities of GCOS	GCOS/TOPC, GTN-H	Initiate overview of activities that require direct support of GTN-H partner centres	
25	Addressing GEOSS Water Strategy Recommendations	GEO-Sec in cooperation with GTN-H	Action document endorsed by GTN-H session, starting up activities in accordance to the document	
26	Develop strategy paper addressing upcoming challenges and opportunities for GTN-H	GTN-H in cooperation with network partners and governing bodies	Initiate first contacts and consultations	
27	Support of water resources management	GTN-H with partners	Initiate contacts with WCRP/GEWEX	

	Action	Who	Status/ next steps	State
28	Develop a network of support partners to cooperate on the development of integrated data products	All GTN-H partners	Identify opportunities for and existing potential network partners	
29	Develop cooperative ties with the newly established Global Water Data Centre (GWDC)	GTN-H and network partners, GWDC	Seek cooperative opportunities and act on windows of opportunities such as with GRDC and GEMStat	
30	Jointly using river runoff and water quality data: new web-based flux computation	GEMStat	In progress, 2016	
31	Organize an expert meeting on geochemical fluxes and establishing the working group on that	GEMStat	Ongoing, not a priority at present	
32	Explore the contribution of GPCC to the precipitation task of IGWCO	Lawford ; Grabs to contact Lawford	Continue	
33	Enhance collection of lakes and reservoirs data by HYDROLARE and CNES in collaboration with all partner institutions; use SRTM-derived lake information dataset	HYDROLARE Team , CNES	Continue	
34	GRDC to chart a process how the metadata standard and associated technology is being promoted into other domains and ECVs	GRDC	Completed, check progress	
35	Define relationship between GTN-H and WIGOS /WIS	WMO , GTN-H	Enhance contacts; all data centers potentially become a DCPC platform in WIGOS/WIS	

Appendix 2 Addressing GEOSS Water Strategy Recommendations, GTN-H planned and Potential activities

Approved by 7th session of the GTN-H panel, 17th June 2015

Introduction

The 7th Session of the GTN-H Panel (Koblenz, Germany, 16-17 June 2015), provided the platform to discuss the GEOSS Water Strategy Recommendations with a view to formulate the GTN-H approach to support implementation of the Strategy. Both CEOS and GTN-H are expected to make major inputs to facilitate the implementation of the Strategy. While CEOS will mainly cover satellite-based earth observations, GTN-H is expected to cover significant domains of in-situ earth observations.

Planned and Potential GTN-H Activities in support of the GEOSS Water Strategy

In support of the GEOSS-Water Strategy Recommendations and in concurrence with the GEOSS Implementation Plan the following activities have been approved by the 7th Session of the GTN-H Panel and are proposed to be undertaken by the GTN-H partners. In the text below, the text in **bold** and ***italics*** represents relevant water strategy recommendations to which GTN-H agrees to contribute. CEOS is currently assembling its own document on CEOS contributions to earth observations and in an advanced draft stage of CEOS and GTN-H documentation it is expected that synergistic activities will be identified between CEOS and GTN-H. The full GEOSS Water Strategy can be downloaded from: **http://ceos.org/ourwork/ad-hoc-teams/wsist/** (click on "WSR" to obtain the report in pdf-format). The headings of the following paragraphs are based on the synthesized recommendations that were published in the Executive Summary of the GEOSS Water Strategy.

Enhancing User Engagements

A.2. GEO Water should develop and launch a continuous process to identify, articulate, and further refine user needs in the various water communities from the local scale to the global scale. The process should build upon existing work by GEO such as the Water SBA Needs report

Planned action: GTN-H has agreed to start an initiative in this area.

Potential actions: A number of interested individuals are expected to join GTN-H in an ad-hoc IGWCO-COP Task Team that may lead to an IGWCO working group on this topic.

A.4. An inventory of current data services supporting GEO Water should be developed. This inventory should include information on the characteristics of available services and their data needs.

Planned action: GTN-H is prepared to start an overview of current data services with guidance provided from members of the IPWG on the basis of a consensus-based technical approach to prepare such an inventory.

A.5. An evaluation should be undertaken of the data holdings of global data centres to determine which centres have and make available data that can be effectively used to assess the magnitude and frequency of extreme events and the ability of global and regional models to simulate water cycle processes.

Potential action: An inventory of data and information holdings is available from federated data centres, in cooperation with cooperating partners a position paper could be developed to assess the utility of data provided by the centres in water cycle process models. There may be no information on extreme events in any of the databases in the domain of GTN-H.

A.6. A review of the water resources managers' needs should be undertaken to gather water cycle information related to extreme values. Data collection and information systems should be assessed to ensure these data are available for research activities.

Potential action: GTN-H could be a partner in this exercise through its specialized data centres such as GPCC (precipitation), GRDC (runoff), GEMSTAT (water quality) and others, including IGRAC (groundwater). However, extreme values are presently not covered.

<u>Expanding data acquisition</u>

B.2. Based on the principles of participatory monitoring, in order to assess the state of groundwater and its changes, IGRAC's efforts to establish the Global Groundwater Monitoring Network should be accelerated and linked to the validation of remote sensing data. Special attention and support should be directed at developing a global hydro-geodetic repository that links directly to the GGMN, providing additional groundwater data and information.

Potential action: GTN- H will engage with IGRAC on the necessity to accelerate current IGRAC activities addressing the issues of the recommendation. A (draft) statement of needs could be initiated with IGRAC and experts from the GEO-Secretariat, WMO and UNESCO as well as from IHE in 2015.

B.3. The Global Climate Observing System's (GCOS) participants should be invited to undertake a joint study with GEO to assess the current prioritization of observational and modelling efforts for water cycle variables as part of its support to the UNFCCC.

Planned Action: GTN-H participates in TOPC-activities that look into the optimization of observational networks specifically with regard to Essential Climate Variables (ECVs). A case could be made to TOPC/GCOS to link with GEO on observational requirements to make use of synergies and avoid duplication of efforts.

<u>Strengthening in-situ data acquisition</u>

D.1. In-situ observational networks should be strengthened to ensure that the required data are collected and made freely available to the international community. GEO and WMO members should both engage in assessing gaps in their national networks and develop a plan for addressing those gaps. As an operational research activity, approaches should be studied to take advantage of the supplemental observational networks (for selected variables) that are maintained by volunteers, education systems, and local governments.

Potential action: In support of this recommendation, GTN-H will further encourage GRDC and related data centers to promote strengthening of networks and implementation of existing data policies and network management practices including improved access and data services. This could be undertaken together with WMO and in particular through the Hydrology Programme and the WIGOS/WIS programme focusing on standardization, integration of observations and including communication issues. In addition, GEO, IGWCO-COP, WMO and GTN-H could launch a study of the potential of observations from volunteers, education systems, and local governments.

D.3. National precipitation gauge networks should be strengthened and all measurements should be collected, archived, and made available to the international community. Special attention should be given to strengthening the gauge networks at high latitudes where more accurate snowfall information is needed for evaluating changes arising from climate change. A study should be undertaken of approaches to take advantage of the supplemental gauge networks that are maintained by volunteers, education systems, and local governments.

Potential action: GTN-H and GPCC could take a lead in this activity and come up with a position paper and possible practical actions to improve spatial coverage of precipitation observations and related issues to be determined.

D.6. GEO Water activities should include projects that will strengthen advanced monitoring networks, data-sharing, and quality control for groundwater measurements and data.

Potential action: GTN-H is prepared to come up with a positon document on this issue and is expected to partner with other data centres and in particular with IGRAC with a view to strengthen information flow from groundwater observations.

D.8. Given the many threats to groundwater quality that arise from salt water intrusion, seepage of contamination, nuclear waste, and fracking, among others, GEO Water should clarify the needs for groundwater quality data and develop a plan for collecting the required observations.

Planned action: This issue will be discussed in the context of GEMSTAT and its evolving strategy for water quality observations, both surface and groundwater.

D.9. A workshop should be organized to address the application of in-situ measurement techniques and data in water quality assessments. The workshop would explore ways to develop harmonized approaches and best practices for water quality measurements and ways to benefit from technological advances. Workshop contributors should include experts in the fields of sensors, data communication, and management, and practitioners operating sensor networks.

Planned action: GTN-H in cooperation with GEMSTAT will discuss the feasibility of taking the lead in organizing such a workshop in 2016

Encouraging and conducting research and product development

E.6. An inventory of all surface water data archives, including both natural and man-made lakes, reservoirs, and wetlands, should be developed. Based on the details of this inventory, a plan for implementing a process to establish protocols for collecting data and metadata on surface water stores should be developed.

Planned action: GTN-H through its partners in particular GRDC and HYDROLARE will be key to prepare such an inventory and prepare a position paper together with IGWCO for improved protocols for data collection.

E.7. A dataset including all bathymetry of all surface water bodies around the globe should be developed, possibly under the leadership of UN Water.

Planned action: HYDROLARE is seen as a key partner to assemble this data based on priorities to be established. Selected lakes and reservoirs

E.9. An initiative should be launched to assess the feasibility of combining in-situ measurements and GRACE satellite data to produce an integrated groundwater product on a regional basis.

Potential action: IGRAC could contribute in cooperation with CEOS to formulate such an initiative.

E.16. GEO should promote water cycle data model integration activities to support future water cycle observing system simulation experiments that can be undertaken in collaboration with the international GEOSS community to quantify the impact of each element in an integrated water cycle observing system.

Planned action: GTN-H through its federated data centres to facilitate the access to data and information for water cycle model integration activities.

<u>Facilitating data sharing and common standards</u>

F.1. Institutions maintaining archives of water cycle variables should apply modern standards of open data stewardship. High-quality products require consistently processed, long-term datasets that are readily available, preferably including one version in the original coordinates (for example, swath-footprint for satellite data). As new quality-control procedures and algorithms are developed, these archives should be reprocessed to ensure that the community has ready access to consistently processed estimates for the entire period of record.

Planned Action: GRDC is active in this area and potentially GTN-H could review the procedures of its centres until end 2016 to ensure that modern data management and dissemination capabilities are available including through web-based services. This could be undertaken in cooperation with other partners in support of GTN-H activities and in support of specific centres federated with GTN-H.

F.4. A review of the WMO regulations on hydrometeorological data exchange should be undertaken to assess their effectiveness in enabling the exchange of data with the Global Runoff Data Centre and the Global Precipitation Climatology Centre and enabling the exchange of data between countries.

Planned action: This is underway with respect to GRDC. GTN-H would be in a position to liaise with WMO´s WIGOS programme and promote a Task Team to prepare such a review with practical actions items associated with it. GTN-H in cooperation with WMO will consult with other GTN-H data centers to review current status of data sharing, policies and services.

F.5. Efforts by GEO members to support initiatives leading to interoperability should be accelerated. At the same time, users and dataset developers need flexible, low-burden standards at all levels to enable easy adoption of the interoperability concepts being developed.

Planned action: Through GRDC and in cooperation with OGC and WMO, GTN-H could play a facilitating role to support initiatives leading to an improved interoperability towards improved standardization and data reporting and sharing.

Appendix 3 Agenda of the 7th Session of the GTN-H Panel

Koblenz, Germany, 16-17 June 2015

Tuesday 16 June

08:30 – 09:00	Registration
09:00 – 09:15	Welcome and Introduction to the session
09:10 – 10:00	Background information: New Developments
10:00 – 10:45	Review of status of network partners, individual reports
10:45 – 11:00	Coffee Break
11:00 – 12:30	Review of status of network partners, individual reports (continued)
12:30 – 13:30	Lunch Break
13:30 – 14:15	Review of Quality Management issues of GTN-H network partners, recommendations for improvement
14:15 – 15:30	Access to data and information from GTN-H partners: New developments and plans (including standardization issues and web-based services)
15:30 – 15:45	Coffee Break
15:45 – 17:00	Matching GTN-H activities with major programmes and initiatives including WMO/HWRP, WIS/WIGOS, GCOS/TOPC and GEO/IGWCO-CoP
17:00	Session adjourns

Wednesday 16 June

09:00 – 10:00	Strategic positioning of GTN-H and opportunities for service delivery
10:00 – 10:30	Generation of integrated data products in cooperation with collaborating partner organizations
10:30 – 10:45	Coffee Break
10:45 – 11:30	Generation of integrated data products in cooperation with collaborating partner organizations (continued)
11:30 – 12:30	Development of the GTN-H Work Plan 2015-2017
12:30 – 13:30	Lunch Break
13:30 – 14:30	Agreement of the Work Plan for 2015-2017 with deliverables, milestones, and responsibilities
14:30 – 15:00	Coffee Break
15:00 – 15:30	Summary of conclusions and recommendations
15:30 – 15:45	Comments from GTN-H partners, time and place of next session
15:45 – 16:00	Closure of the 7th Session of the GTN-H Panel

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