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GTN Hydrology
Global Terrestrial Network

8th Session of the GTN-H Panel

Koblenz, Germany
20-21 June 2017

GCOS-216

UNITED NATIONS
ENVIRONMENT PROGRAMME

INTERNATIONAL COUNCIL
FOR SCIENCE

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1. INTRODUCTION AND ADOPTION OF THE AGENDA

The 8th session of the GTN-H Panel was opened by Mr Grabs in his role as GTN-H coordinator and representing the German Federal Institute of Hydrology (BfG). In his opening remarks, Mr Grabs thanked the BfG to host once again this meeting and appreciated the generous support of both the GRDC and GEMStat hosted by BfG as two of the federated data centers of GTN-H.

Mr Grabs further reminded participants that GTN-H is recognized by WMO's Technical Commission for Hydrology (CHy), and its federated data centres have played a vital role in the development of the GCOS Implementation Plan including its Rolling Review of Requirements undertaken by its Terrestrial Observation Panel on Climate Observations (TOPC). GTN-H is also seen as a component of WMO's Integrated Global Observing System (WIGOS).

GTN-H is recognized by the Global Earth Observations System of Systems (GEOSS) and in particular with reference to its role in the Integrated Global Water Cycle Observations Community of Practice (IGWCO-CoP) and its support to the GEO Water Strategy.

Data and information provided by GTN-H global data centres continue to be essential sources of information for UN, regional and national programmes and projects in support of development and science.

With the availability of satellite-based information, steps had already been undertaken to merge satellite-based information with terrestrial observations. This is a continuing trend that needs closer attention.

Therefore, after consultation with Panel members prior to the meeting, the 8th session of the GTN-H Panel has a focus on 5 topics that are reflected in the agenda (annex 1):

- GTN-H and its support to the GCOS Implementation Plan;
- GTN-H and its support to the WMO Technical Commission for Hydrology (CHy);
- GTN-H and its support to the GEO Water Strategy;
- Data Quality and Access to Data;
- Augmentation of in-situ observations with satellite-based earth observations.

In her welcome address, Ms Birgit Esser, Director General of the German Federal Institute of Hydrology (BfG) stated that monitoring of water resources and related variables are critical to achieve the objectives of sustainable development as stipulated in the Sustainable Development Goal 6 – Water, and the data that is needed to calculate the indicators of this Goal.

In this context Ms Esser highlighted that the Federal Republic of Germany is home to three of the global data centers, namely the Global Runoff Data Centre (GRDC) under the auspices of WMO, the Global Water Quality Data Centre under the governance of UNEA, and the Global Precipitation Climatology Centre (GPCC) also under the auspices of WMO. The BfG hosts the Global Runoff Data Centre directly overseen by the BfG, as well as the Global Water Quality Database - GEMStat within the framework of the UNESCO-Category II Centre on Water Resources and Global Change in the premises of the BfG.

Ms Esser further informed participants that the German Federal Institute of Hydrology is nationally and internationally leading in the development and application of the observation of components of the water cycle and the environment. This includes hydrometric and hydrological observations and modeling, water quality analysis and assessments, environmental investigations and research and development of adequate methodologies on national and European level to support water-related adaptation to climate change. The competence of the BfG is maintained and even widened through its active network of experts at national and international levels.

Ms Esser concluded in wishing participants fruitful deliberations and conclusions that facilitate the achievement of the objectives of the GTN-H.

The agenda for the session was discussed and subsequently adopted (annex 1). The list of participants is documented in annex 2.

2. BACKGROUND INFORMATION AND NEW DEVELOPMENTS

2.1 Information related to WMO

Participants were made aware of the continuing interest of the WMO Technical Commission for Hydrology (CHy) in the activities and services of GTN-H through its federated data centres. In the fourteenth session of CHy (2012) this was 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 centers and institutions that form the core of GTN-H”.

In the 15th session of the CHy (2016), Resolution 5 on Data Operations and Management recognizes the growing need of Members for appropriate hydrological data and data management. This is not just related to surface waters but includes in more general terms hydrometeorological data. The resolution acknowledges the long-standing contribution to CHy by the global data centers, namely the Global Runoff Data Centre (GRDC), Global Precipitation Climatology Centre (GPCC), International Groundwater Resources Assessment Centre (IGRAC) and the International Data Centre on the Hydrology of Lakes and Reservoirs (HYDROLARE). The Commission further requested the president of the Commission to „form a small task team in charge of preparing a report to the Executive Council on the evolving role of the GRDC, IGRAC and HYDROLARE, and their relationship with WMO, with respect to the monitoring and measurement of the achievement of the Sustainable Development Goals, their contributions to the Global Framework for Climate Services and support to the WMO Hydrological Observing System, Global Hydrometry Support Facility and other CHy initiatives“. All the aforementioned data centers are operating under the auspices of WMO; IGRAC is also a UNESCO center. The president of CHy was requested to liaise with the president of the Commission for Climatology so as to reach an agreement on including the GPCC in the task team and in the review of its evolving role.

2.2 Information related to WMO - GCOS

WMO and GCOS as a co-sponsored program realize clearly the value of global observing systems, including terrestrial and space-based observations, the management of these observations and value-added services to users. This becomes evident in a number of Resolutions by WMO Congress and its Executive Council.

In Resolution 39, the seventeenth session of the World Meteorological Congress (Cg-17) in 2015 requested technical commissions to lead the development and implementation of the components of GCOS for which they are responsible in the light of advice from the GCOS Steering Committee. In this regard, the Commission appreciated the substantive contributions towards the GCOS Implementation Plan by the Global Terrestrial Network – Hydrology (GTN-H) through its federated global data centers.

At its 69th Session (EC-69, 2017), the WMO Executive Council in its Decision 14 (Support the Development of Actions based on the Global Climate Observing System Implementation Plan) requested the Secretary-General „to facilitate identification of a suitable institution amongst Members to take over the coordination of the Global Terrestrial Network – Hydrology at the earliest, to ensure the continued provision of services provided by GTN-H“.

The 19th session of the GCOS/WCRP Terrestrial Observation Panel for Climate (TOPC-19, April 2017) reiterated the importance to review the performance of Essential Climate Observations (ECVs) and progress on actions in the GCOS Implementation Plan as well as the need to consider adaptation needs and what it means for observations.

TOPC-19 agreed that the broader community, and including existing observation networks, should be involved in the process to determine ECV product requirements as also proposed by the GCOS secretariat.

2.3 Information related to UNESCO

UNESCO's IHP-VII Programme has dedicated focal area 1.3 specifically to "Benefitting from Global and Local Earth Observations systems". The objectives are to adapt models to the continuously changing hydrology, remote sensing and in situ data availability, and to the different needs of water managers.

- Support actions aimed at increasing availability of hydrological data in near real-time coming from remote sensing and in situ monitors to enable a more integrated approach to continuously calibrate/update models and water management;
- Develop new analytical methods, such as sequential processing of data and diagnostic evaluation of model consistency or data assimilation and other quality-assurance tests of real-time data;
- Share experiences with data platforms to facilitate more rapid model adaptation and increase monitoring in critical areas.

Flagship IHP research initiatives in this regard are FRIEND-Water (Flow Regimes from International experimental and Network Data) and ISARM (Internationally Shared Aquifer Resources Management).

2.4 Information related to GEO

GTN-H continues to serve as observational arm of the GEO-Water activities.

The GEO Integrated Global Water Cycle Observation - Community of Practice (IGWCO-CoP) had decided to cooperate closely with the GEO Global Water Sustainability (GEOGLOWS) initiative. As stated during the XVI World Water Congress, Cancun, Quintana Roo, Mexico, May 29 – June 2, 2017, the GEOGLOWS initiative provides a framework for effectively mobilizing Earth Observation assets to contribute to mitigating water challenges on various scales and across different climates and landscapes around the world. Amongst others, the GEOGLOWS framework includes activities focusing on:

- Essential Water Variables (EWV);
- Understanding water quality and use; water cycle variables);
- Earth Observations, Integrated Data Products and Applications, and Tool Development;
- Data Sharing, Dissemination of Data, Information, Products, and Knowledge.

(cited from: Angelica Gutierrez et al, 2017: GEO Global Water Sustainability (GEOGLOWS): Earth Observations for sustainability in water management in the Americas and around the world (XVI World Water Congress, Cancun, Quintana Roo Mexico May 29 – June 2, 2017).

The activities of GTN-H are closely related to all GEOGLOWS activities and more direct liaison should be established between GEOGLOWS and GTN-H in cooperation with the GEO - Secretariat.

GEO is working with GCOS and ICSU to address the lack of coordination in the terrestrial domain (as GTOS does not exist anymore). A one-day strategy meeting was held in Frascati in March 2017 to develop an overall strategy. In the GEO Work Programme, a Foundational Task on "In situ observations" has been established. The task is led by UNESCO-IOC with support from the GEO Secretariat. A bottom-up approach is being envisaged by bringing on board the system/network owners and coordinators in order to work with those who have an actual mandate.

GEO is looking at GTN-H to become the GEO coordination body for in-situ hydrological observations. This could be achieved by assuming a coordination role for Subtask C1. Appropriate linkages with relevant Initiatives such as GEOGLOWS will be ensured.

3. REVIEW OF STATUS OF NETWORK PARTNERS, INDIVIDUAL REPORTS

The review of the status of network partners is a means to mutually inform partners of progress made and issues of the global data centres that might be of common interest. The status of networks is also a means to report to TOPC and GEO.

Representatives of global centres taking part in the panel session provided their status reports including products and services offered, and planned activities over the next two years. Issues regarding quality management of data are summarized separately in chapter 4 of the report. 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. Panel members showed concern that the funding status of the ISMN is only secured until the end of 2017. Participants were informed that there might be an option that - on the condition of available resources - the German Federal Institute of Hydrology (BfG) might host the ISMN if it becomes apparent that ISMN is no longer funded from other sources after 2017. ISMN and BfG are in direct contact on this matter.

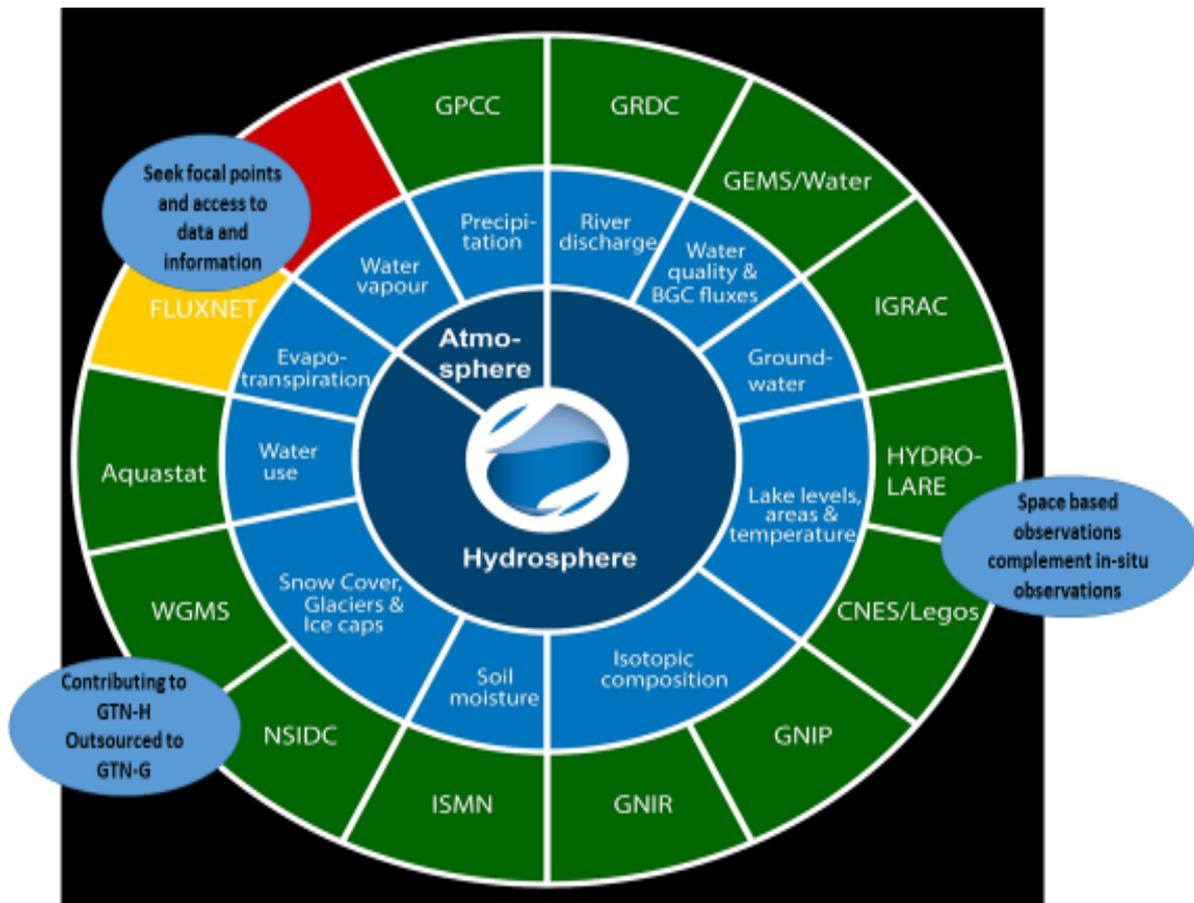
Participants noted with appreciation that FAO has agreed that its global database on water use AQUASTAT join the GTN-H as an active partner. This is of utmost importance since the membership of AQUASTAT provides the sole source for water use information and thus complements data and information available from observations-oriented global data centres with respect to the availability and quality of water resources. Participants urged GTN-H to further communicate with AQUASTAT with the view to fully engage AQUASTAT in GTN-H and related activities.

FLUXNET and Water Vapour are now the only areas not federated with GTN-H. Rather than dropping activities to get access to such information after many years of unsuccessful efforts, participants requested the GTN-H Coordinator to make another effort to get access to FLUXNET information, possibly through the Global Energy and Water Cycle Experiment (GEWEX) of WMO's World Climate Research Program (WCRP) and to Water Vapour information through WCRP and GCOS partners.

With regard to cryosphere issues, participants recognized the further development of the World Glacier Monitoring Center, (WGMS) its widening affiliation with other cryosphere activities programs and initiatives including WMO's Global Cryosphere Watch (GCW).

The Panel therefore decided to outsource WGMS and partly NSIDC activities to GTN-G in cooperation with the WMO Global Cryosphere Program. Thus, GTN-G (and potentially GTN-P –Permafrost) will have the function of **contributing** networks to GTN-H, and close contact and cooperation will continue.

Participants appreciated the growing cooperation between the French Space Agency represented by CNES/LEGOS and HYDROLARE. Although the focus of GTN-H is on terrestrial observations, it becomes evident that merging of in-situ and space-based observations provide significant benefits. CNES/LEGOS is therefore also considered as contributing source to GTN-H and in particular to HYDROLARE with regard to lake observations and to GRDC with regard to gauge heights and derived discharge estimations once SWOT has been launched and is in full operation.



Configuration of GTN-H, status July 2017

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) and the Commission on Basic Systems (CBS).

Participants found best potential to facilitate progression of research networks into operational networks, thus largely enhancing the observation base of terrestrial observations.

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.

3.1 Emerging requirements of global data Centers

Participants discussed emerging requirements of global data Centers. These are summarized below:

GPCC:

- Need for daily products
- Need for better temporal resolution

GEMStat:

- Water quality demand on country level, and complementing satellite observations
- New approaches for data acquisition
- Are Global Centres entitled to calculate indicators, is this not a national responsibility
- Harmonizing views on indicators: global vs. national, regional
- Sediment data required to complement water quality observations

International Soil Moisture Network (ISMN):

- Strengthening Up-to-date data acquisition both in-situ and satellite-based
- Better spatial coverage needed
- Agricultural applications to be developed
- Complement in situ with satellite data

WGMS:

- Modellers ask for glacier thickness data
- How should disintegrating glaciers be monitored, stop or carry on observations after ice is gone?

HYDROLARE:

- New letter from WMO with questionnaire needed for data acquisition
- Lake levels needed with complementary altimetric observations
- Lake temperatures needed

IGRAC:

- Capacity building
- Best practices of Aquifer Management systems
- Sustainable aquifers

GRDC:

- Near Real-Time data
- Additional variables such as temperature and water level
- Rating curves
- Info on catchment (e.g. glacier, reservoirs, etc.)
- Cal/Val for SWOT approx. 250 stations
- Citizen based observation from mobile phones etc. and integration into datasets
- Apps for floods, drought, water quality etc.

3.2 Status Reports of Data Centers present at the panel session

Global Runoff Data Centre (GRDC)

In the past two years, GRDC has continued to expand on its database, improvement of its data quality assurance and affiliation with numerous scientific and international programs. The summary database statistics are depicted below.

Global Runoff Database – Status January 2017 Database Summary Statistics

WMO Region	data from 165 countries	number of stations	station-years	individual values	average time series length	shortest record	longest record	earliest data	latest data	latest import	
		[-]	[-]	[-]	[year]	[year]	[year]	[year]	[year]	[year]	
all	World	monthly data (total)	5,323	387,288	4,767,216	42.6	1	288	1906	2016	2017
		original monthly data	5,623	182,993	1,962,626	29.8	1	192	1907	2016	
		original daily data	7,092	218,658	116,309,440	44.9	1	288	1906	2016	
1	Africa	monthly data (total)	1,688	43,162	517,944	27.7	1	116	1959	2016	2016
		original monthly data	885	16,369	196,308	19.1	1	116	1969	2012	
	(47 countries)	original daily data	1,185	33,990	12,369,850	29.1	1	110	1903	2016	
2	Asia	monthly data (total)	1,918	86,182	874,954	29.3	1	122	1966	2011	2016
		original monthly data	1,795	51,895	622,740	30.4	1	122	1966	2010	
	(26 countries)	original daily data	643	9,627	2,566,856	16.3	1	82	1910	2011	
3	South and Central America	monthly data (total)	734	34,947	399,364	34.8	2	113	1901	2016	2016
		original monthly data	679	14,066	169,600	24.3	1	113	1901	2016	
	(13 countries)	original daily data	650	21,458	7,832,170	34.1	1	113	1901	2016	
4	North America	monthly data (total)	2,322	136,797	1,541,964	66.9	1	146	1900	2016	2017
		original monthly data	1,136	33,237	400,644	30.1	1	137	1900	2012	
	(16 countries)	original daily data	2,284	136,917	49,672,206	59.8	1	146	1900	2016	
5	Australia and Oceania	monthly data (total)	663	22,291	266,772	40.2	2	123	1966	2016	2017
		original monthly data	407	13,431	161,172	33.9	2	116	1966	2010	
	(14 countries)	original daily data	619	21,349	7,790,826	41.1	2	123	1966	2016	
6	Europe	monthly data (total)	2,238	113,949	1,367,366	60.9	1	288	1906	2016	2016
		original monthly data	971	33,728	404,712	34.7	1	192	1907	2011	
	(44 countries)	original daily data	1,651	96,219	26,166,426	52.0	1	288	1906	2016	



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Migration to a new data management system has been the main focus to build a platform for a series of web-based services to be developed in the upcoming future. The migration was completed in June 2017 and conforms to OGC and other standards including WMO requirements.

GRDC has been instrumental in the development of metadata standards and the Hydrologic Feature Model in close cooperation with OGC. OGC membership has expired in 2017. It is hoped that OGC membership can be renewed as soon as possible.

The number of users is also continuously rising with now over 700 data requests in the past two years and over 300.000 time series of data being delivered in 2016 alone.

GRDC Web Services Future Facilitator between Data Provider and Data User

**Data providers
National Hydrological Services**

ORKUSTOFNUN National Energy Authority

WIVde

Centre for Ecology & Hydrology

SMHI

USGS

Environment Canada

**Data users
Portals, Scientific Programmes,
Research Community**

GROUP ON EARTH OBSERVATIONS

CEOS

GELEX

WORLD METEOROLOGICAL ORGANIZATION

CLIAHSI HIS

GEOOWOW

ICCSU

Gmes

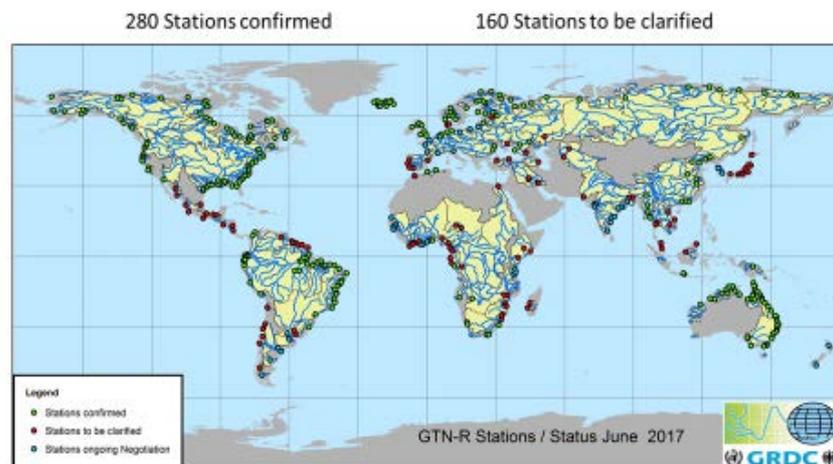
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The further development of the Global Terrestrial Network for River Discharge (GTN-R) remains a high priority as the database of GTN-R is an important baseline to calculate continental freshwater fluxes into the world oceans that is need for many scientific applications. Activities include:

- Compilation of the GCOS Baseline River Network (In compliance with the GCOS Implementation Plan);
- Regular provision of near real-time data to the evolving GTN-R;
- Automated collection and harmonization of near real-time data;
- Service for automated provision of river discharge data, e.g. using SOS.

The figure below provides an overview of the current status of GTN-R:

GRDC Station Selection for the Global Terrestrial Network for River Discharge (GTN-R)



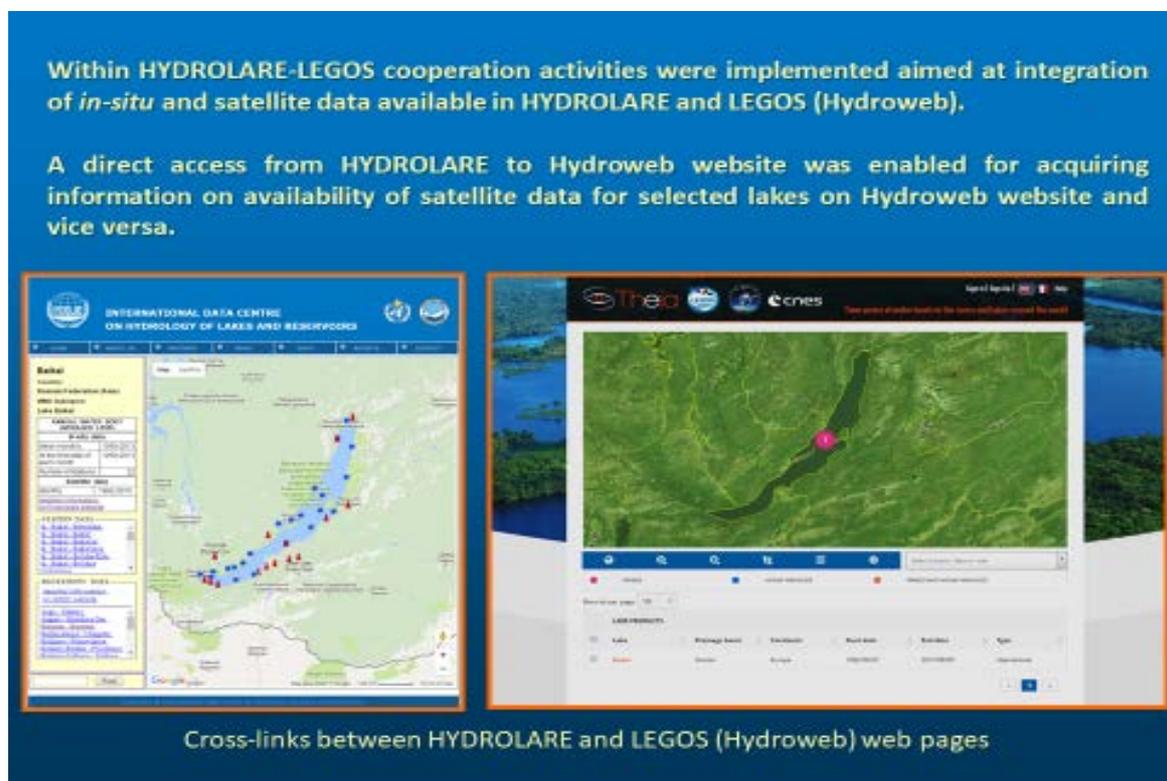
As a strategic plan, the development of joint data products in particular with GPCP and GEMStat is vigorously addressed. It is expected that first products will be for use before end of 2018. In terms of using the database for water resources assessments, cooperation is continued with the University of Frankfurt and the recalculation of the WaterGap model is considered. (View GRDC home page and <http://www.watergap.de/>).

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

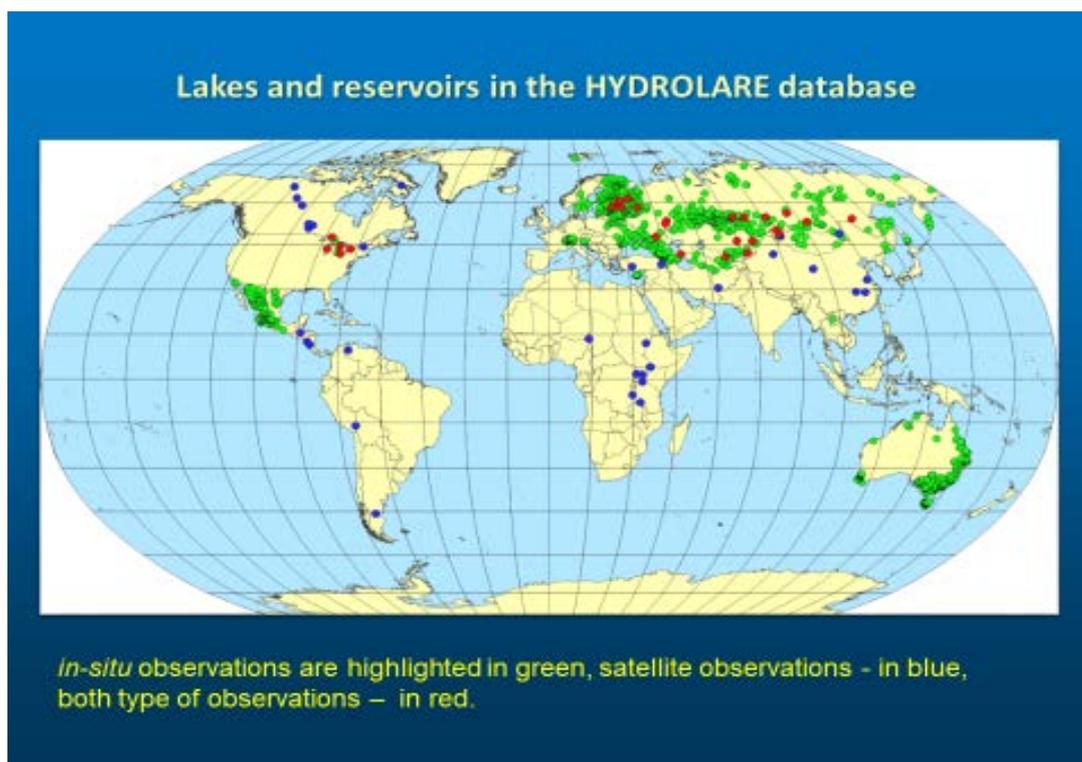
Activities of HYDROLARE have been expanding over the past years in terms of improvements of the database system, data holdings and capabilities to serve users' needs. Currently the HYDROLARE database holds data for 1103 lakes and reservoirs and 1121 stations from 48 countries of the world.

Until 2015 the only type of data in the database was *in-situ* and remote sensing water levels of lakes and reservoirs. In 2016 HYDROLARE started updating its database with *in-situ* water temperature data. In 2017, the IT-infrastructure has been further developed to include new type of information - maximum ice cover thickness - to the database. It is now possible to display not only lake gauges but also stations on rivers inflowing to and outflowing from these lakes. 70 lakes of Russia are linked to 166 GRDC stations to calculate inflow and outflow in/out of lakes. For these stations, cross-links were established between HYDROLARE and GRDC websites enabling to obtain runoff data.

The acquisition of terrestrial observations from lakes and reservoirs continues to be difficult. In part, because data holdings at national level are dispersed amongst a host of organizations and national lake archives are usually not existing at national levels. Thus, a special feature of HYDROLARE is to link *in-situ* observations with satellite-based observations made available by close cooperation between HYDROLARE and the French Space Agency CNES/LEGOS. This is illustrated in the figure below:



The combined data holdings of in-situ and space based observations for HYDROLARE are documented below:



HYDROLARE is embedded in the GCOS Implementation Plan addressing a number of action items including

Action: Assess accuracy of satellite water level measurements by a comparative analysis of in situ and satellite observations for selected lakes and reservoirs.

Benefit: Improved accuracy.

Timeframe: 2017 -2020

Who: Legos/CNES, HYDROLARE.

Performance Indicator: Improving accuracy of satellite water level measurements.

Action: Continue submitting to HYDROLARE historical and current monthly lake level data for the GTN-L lakes and other lakes weekly /monthly water temperature and ice thickness data for the GTN-L.

Benefit: Maintain data record.

Timeframe: Continuous.

Who: National Hydrological Services through WMO/CHy and other institutions and agencies providing and holding data.

Performance Indicator: Completeness of database.

Action: Establish satellite based ECV data records for Lake Surface Water Temperature, Lake Ice Coverage, and Lake Water Leaving Reflectance (Lake Colour) Implement and sustain routine production of these new satellite based products; Sustain efforts on improving algorithms, processing chains and uncertainty assessments for these new ECV Products, including systematic in situ data sharing and collection in support of ECV validation; Develop additional products derived from Lake Water leaving Reflectance for turbidity, chlorophyll, and coloured dissolved organic matter.

Benefit: Add additional Lake ECV products for extended data records. Providing a more comprehensive assessment of climate variability and change in Lake systems.

Timeframe: Continuous.

Who: Space Agencies and CEOS. Copernicus Global Land Service, GloboLakes and ESA CCI+

Performance Indicator: Completeness of database.

International Groundwater Resources Assessment Centre (IGRAC)

The Global Groundwater Information System (GGIS) is an interactive, web-based portal to groundwater-related information and knowledge and is one of IGRAC's flagship products. The GGIS consists of several modules structured around various themes. Each module has its own map-based viewer with underlying database to allow storing and visualizing geospatial data in a systematic way.

Global Groundwater Information System (GGIS)

Continuous development leading to GGIS becoming one of IGRAC's flag ship products

IGRAC GGIS:

- Web portals
- Map based
- Open standards
- Flexible in setup
- Public & password protected viewers
- Information in one place

Transboundary groundwater, Global Country Data, Project Related Information, Managed Aquifer Recharge, Small Islands, Groundwater monitoring

igrac

For the past 2 years IGRAC collected and developed new global groundwater maps. Also the collaboration with partner institutes has resulted into improved availability of groundwater information on different scales (national, regional, continental and global level) and for different themes: Islands States, Managed Aquifer Recharge, Quality & quantity assessments. New data and information built into IGRAC include viewers on

- GRACE derived groundwater depletion
- Groundwater Africa Portal
- SADC Groundwater Information Portal
- Groundwater in Small Islands Developing States (SIDS) Portal
- Global Managed Aquifer Recharge (MAR) Portal

The MAR Portal in June 2016 is the first structured database on Managed Aquifer Recharge sites globally. (MAR = climate change adaptation tool making use of underground water storage). About 1200 case studies from over 50 countries from around the world were collected, analyzed and compiled in the global inventory of MAR schemes. In 2017, these data will be further analyzed, (e.g. use of abstracted water originating from MAR per sector at each continent).

The Global Groundwater Monitoring Network (GGMN) portal gives insights on the availability of groundwater monitoring data through space and time. Groundwater level data and changes occurring in groundwater levels can be displayed on a regional scale. Additional data layers and information are

available to understand the monitoring data in a broader water-related context. The web-based software application assists in the spatial and temporal analysis of monitoring data.

- The GGMN is set up to improve quality and accessibility of groundwater monitoring information worldwide.
- Member states are encouraged to contribute to the GGMN representative groundwater monitoring data.
- GGMN application offers additional services to analyze data and generate regional groundwater maps

Plans for the period 2017 – 2019 include:

- Connecting the GGMN with countries worldwide will be one of IGRAC’s main targets. With new GGMN application - more chances to attract new participants. Possible involvement in WHYCOS, GHSF Innovation hub and formalization of GGMN with countries via WMO.
- The GGMN can be offered as a tool in specific project or programs (e.g. SADC GMI)
- IGRAC will continue to organize GGMN-related workshops to strengthen and expand the GGMN People Network.

IGRAC also provided an overview of the technology used in its operations as depicted in the diagram below:



Global Precipitation Climatology Centre (GPCC)

The Global Precipitation Climatology (over land) is the background for all other GPCC precipitation analysis products and is based over 75,100 stations with climatological normal. Overall, the GPCC data base consists of over 110,000 stations.

Data sources for Near Real-time data provided through WMO’s Global Telecommunication System (GTS) are:

- GTS SYNOP (DWD RTH Offenbach)
- GTS CLIMAT (DWD RTH Offenbach)
- GTS CLIMAT (JMA RTH Tokyo)
- GTS CLIMAT (UKMO RTH Exeter)
- SYNOP-based (NOAA RTH Washington)

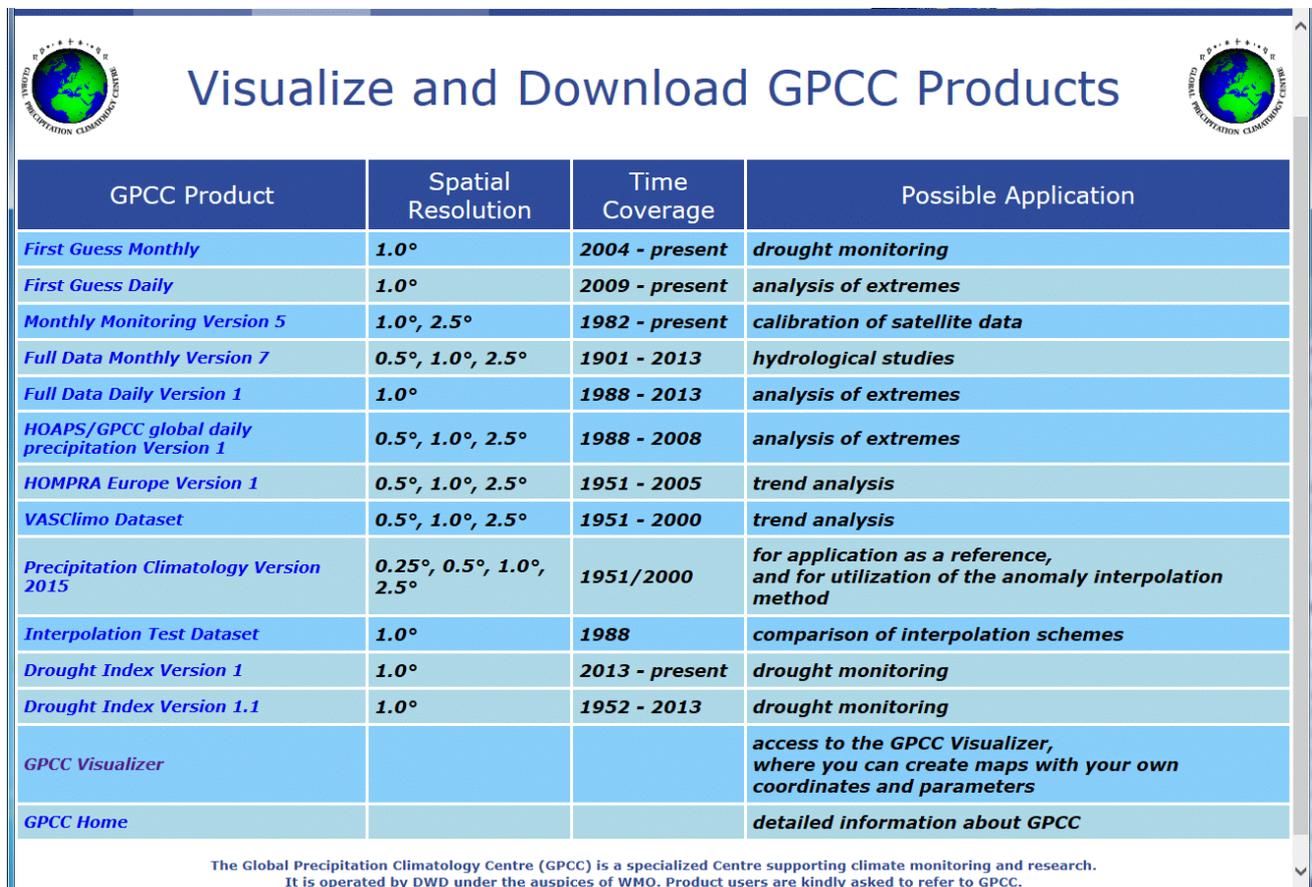
Data sources for Non real-time data include:

- Additional data from ca. 190 countries
- International project data (GEWEX-related and other)
- Historical data collections (CRU, FAO, GHCN, ECA&D) and GHCN (Global Historical Climatology Network (GHCN))

The provision of data products is focused on user requirements including

- Timeliness (for drought monitoring)
- High resolution (for regional structures in global maps)
- High accuracy (for verification of model results) and
- Homogeneity (for climate change and variability analysis)

These user requirements are met by an array of different products as illustrated in the figure below.

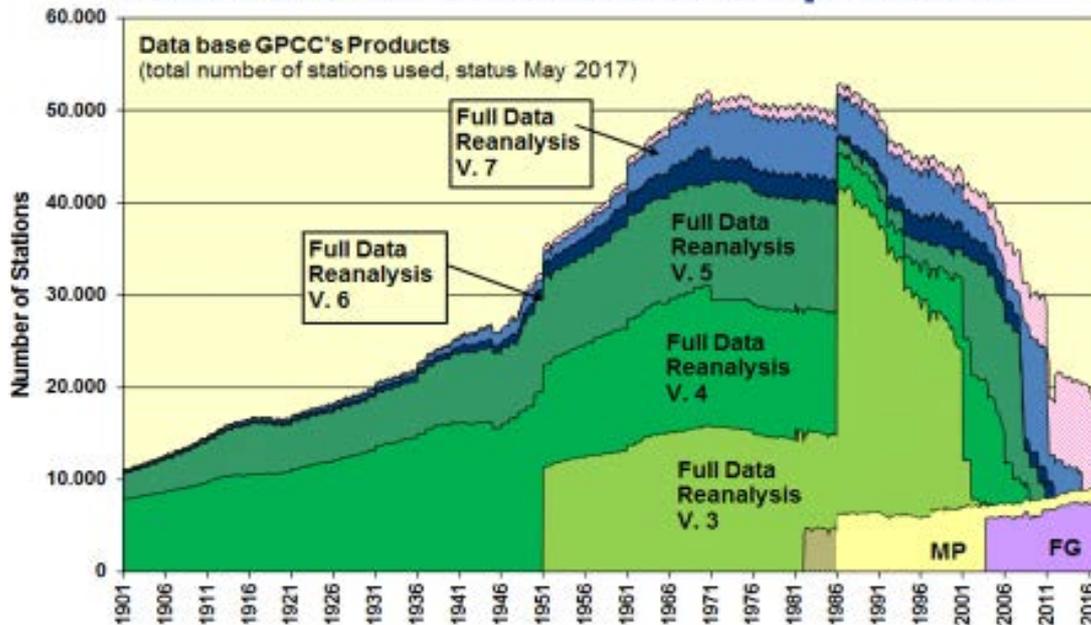


GPCP Product	Spatial Resolution	Time Coverage	Possible Application
First Guess Monthly	1.0°	2004 - present	drought monitoring
First Guess Daily	1.0°	2009 - present	analysis of extremes
Monthly Monitoring Version 5	1.0°, 2.5°	1982 - present	calibration of satellite data
Full Data Monthly Version 7	0.5°, 1.0°, 2.5°	1901 - 2013	hydrological studies
Full Data Daily Version 1	1.0°	1988 - 2013	analysis of extremes
HOAPS/GPCP global daily precipitation Version 1	0.5°, 1.0°, 2.5°	1988 - 2008	analysis of extremes
HOMPRA Europe Version 1	0.5°, 1.0°, 2.5°	1951 - 2005	trend analysis
VASCLimo Dataset	0.5°, 1.0°, 2.5°	1951 - 2000	trend analysis
Precipitation Climatology Version 2015	0.25°, 0.5°, 1.0°, 2.5°	1951/2000	for application as a reference, and for utilization of the anomaly interpolation method
Interpolation Test Dataset	1.0°	1988	comparison of interpolation schemes
Drought Index Version 1	1.0°	2013 - present	drought monitoring
Drought Index Version 1.1	1.0°	1952 - 2013	drought monitoring
GPCP Visualizer			access to the GPCP Visualizer, where you can create maps with your own coordinates and parameters
GPCP Home			detailed information about GPCP

The Global Precipitation Climatology Centre (GPCC) is a specialized Centre supporting climate monitoring and research. It is operated by DWD under the auspices of WMO. Product users are kindly asked to refer to GPCC.

The database for different GPCP products is shown below:

Data base for different GPCP products



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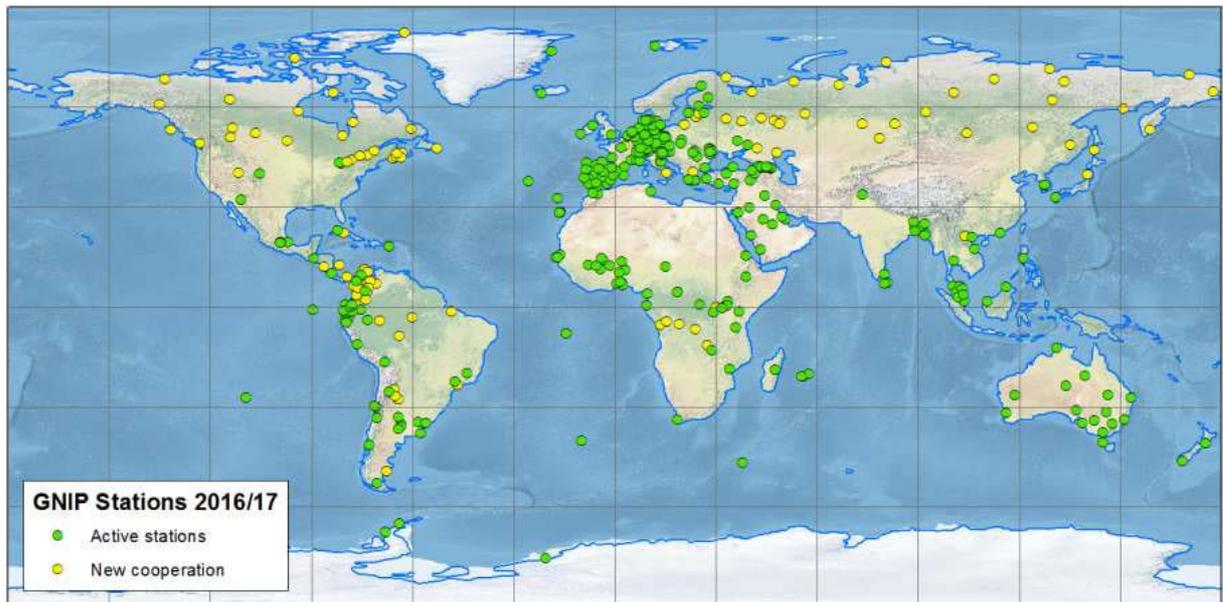
Aside from the regular GPCP products, GPCP strives to generate the following new products:

- Homogenized Precipitation Analysis (HOMPRA) for 1951-2005 for Europe (in cooperation with Met. Institute of Univ. Bonn) has been completed in April 2017, and will be generated on a global scale later;
- A new release of GPCP's product portfolio (Precipitation Climatology, Full Data Monthly V.8 for 1901-2016, Monitoring Product (V.6) is now planned for December 2017, Full Data Daily for 1982-2016;
- GPCP is also contributing to the European Flood Awareness System (EFAS)

In cooperation with other global data centers federated in GTN-H, GPCP and GRDC are currently defining a suite of joint products to be delivered in the time 2018-2019, thus addressing a key GTN-H requirement.

Global Network of Isotopes in Precipitation (GNIP)

The Global Network of Isotopes in Precipitation (GNIP) is a worldwide observation network of hydrogen and oxygen isotopes in precipitation, initiated in 1960 by the International Atomic Energy Agency (IAEA) and the World Meteorological Organization (WMO), and operated in cooperation with numerous partner institutions in member states. The analysis of the temporal and spatial variations of environmental isotopes in precipitation (mainly oxygen-18 and deuterium) provides basic data for the use of isotopes in hydrological investigations within the scope of water resources inventory, planning and development. It is also used extensively in climate-related studies.



GNIP faces challenges in several domains:

Organizational

Voluntary participation (IAEA tries to handle a lot of expenditures but cannot provide grants/remuneration for routine GNIP operation)

Longevity

It is desirable to set up stations for a minimum period of 2-3 years; even longer periods may be desirable in regions under strong ENSO influence.

Awareness

Still insufficient awareness of the program and its importance amongst national meteorological and hydrological services.

Weather station automation and inclusion of tracer sampling: GNIP is not comprehensively aware of inclusion of tracer sampling at weather stations.

Technical

Totalization as an option but maybe not only in remote areas?

Current topics

The origin of GNIP were the thermonuclear tritium released into the atmosphere during the 1950s and 1960s, but levels are back to or near normal by now. Current topics relevant to the use of tritium include:

- Study of inter-annual or decadal variations
- Tritium as a tracer for cosmogenic contributions
- Aquifer and catchment characterization by high-precision ^3H
- Tritium mapping in precipitation (IAEA, ongoing)

Sampling and analysis

Sampling and analysis: IAEA maintains a large operational component within GNIP to facilitate isotope data collection also for institutions which do not have their own analytical facilities. Through collaborative efforts with the IAEA Technical Cooperation Programme, a number of additional GNIP stations, as well as stable isotope and tritium analytical facilities, have been established in several developing country Member States, bracketed by relevant training and HR capacity building.

Where do we go?

- Importance of GNIP is undisputed, however: There is a need to address the challenges mentioned above and also the need for incorporation of other potential data contributors;
- Addressing awareness issues in national meteorological and hydrological services is a top priority;
- Station automatization is becoming an issue;
- Looking beyond meteorology and including the development of products

Global Network of Isotopes in Rivers (GNIR)

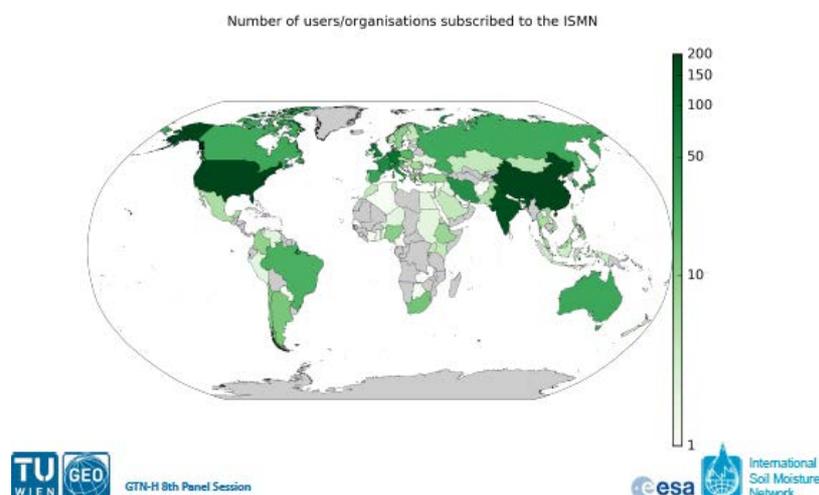
To complement the GNIP, a Global Network of Isotopes in Rivers (GNIR) was initiated in 2002. GNIR is a global environmental observation program dedicated to the compilation of isotopic assays of river waters, but also to the ongoing collection and analysis of water samples. The GNIR is aimed at an improved understanding of stream-aquifer interactions in the river plains, impacts of climate changes on river runoff, and human impacts on river discharge with the use of isotope data. Recent studies suggest that the impacts of storages, diversions and redirection of streamflow for water supply, hydropower, and irrigation might surpass the impact of recent and anticipated future climate changes on river runoff. Consequences of these effects include changes in frequency and extent of flooding, increased sediment load, altered groundwater recharge, and degradation of water quality and riparian ecosystems, often resulting in political disputes or upstream-downstream inequities.

International Soil Moisture Network (ISMN)

ISMN has expanded significantly in the period 2015-2017 including 8 new networks, getting access to over 250 new stations and 1.100 soil moisture data sets. Currently data are available from

- 56 networks
- 2250 stations
- 8800 soil moisture datasets and historical data sets since 1952
- Almost half of all stations provide real-time updates

There has also been a strong increase in subscribed users of the ISMN to over 2.100 users which is an increase of 800 users within the past 2 years.



Pending on the funding situation of ISMN upcoming plans include

- Expansion by integrating new networks (focus on data sparse regions) and extending existing datasets
- Transferring processing chain from programming language IDL to Python
- Continue investigating and improving quality control procedure

Future opportunities could include citizen science support as thousands of citizens maintain soil moisture stations in Europe using low cost soil moisture sensors (<http://growobservatory.org/>)

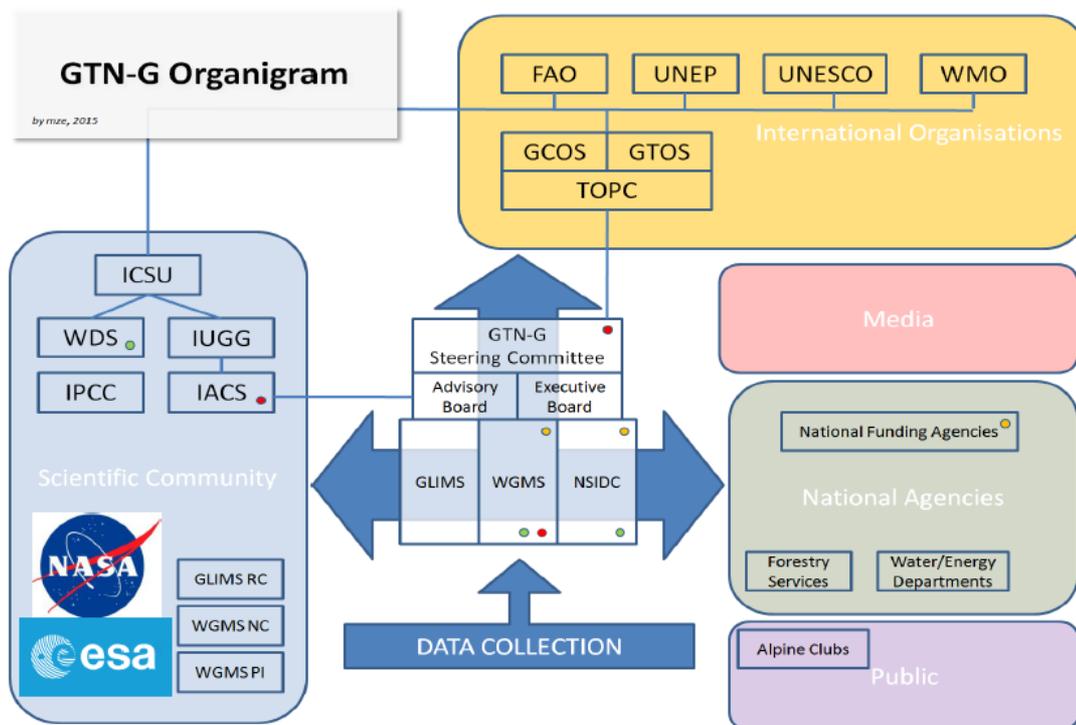
World Glacier Monitoring Service (WGMS)

For more than a century, the World Glacier Monitoring Service (WGMS) and its predecessor organizations have been compiling and disseminating standardized data on glacier fluctuations. Thereto, the WGMS annually collects glacier data through its scientific collaboration network that is active in more than 30 countries. WGMS is one of three operational bodies that run the Global Terrestrial Network for Glaciers (GTN-G). The other organizations are the US National Snow and Ice Data Center (NSIDC), and the Global Land Ice Measurements from Space (GLIMS) initiative.

The Global Terrestrial Network for Glaciers (GTN-G) is the framework for the internationally coordinated monitoring of glaciers and ice caps in support of the United Nations Framework Convention on Climate Change (UNFCCC). The network, authorized under the Global Climate/Terrestrial Observing Systems (GCOS, GTOS), is jointly run by the World Glacier Monitoring Service (WGMS), the U.S. National Snow and Ice Data Center (NSIDC), and the Global Land Ice Measurements from Space initiative (GLIMS).

It forms a unique Global Terrestrial Network in the family of GTNs, monitor the Essential Climate Variables of GCOS. It also is closely affiliated with WMO's Global Cryosphere Watch (GCW) initiative.

Global Terrestrial Network for Glaciers GTN-G

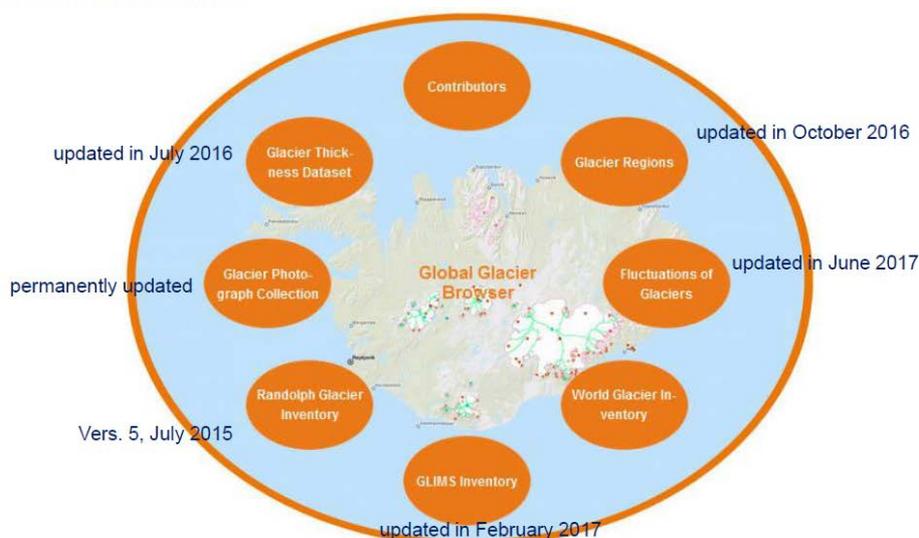


<http://www.gtn-g.org>

Global Environment Monitoring System – Water

The following datasets are provided by GTN-G:

GTN-G datasets



Overall achievements:

WGMS has the mandate for long-term stewardship (preservations, work with data repositories and seeks to undergo a certification process.

Through WGMS, stewardship is provided over products valuable within and beyond glaciology fostering a community that is willing to contribute data.

It also helps to secure long-term funding for data access and provides a highly visible and user friendly one-stop portal for data.

The growing number of remote sensing data have a a great potential for boosting glacier monitoring but requires joint efforts of research and monitoring to fully tap the potential of such observations and link in-situ observations wit new technologies.

Further achievements include:

- ✓ Secured long-term service (staff and financial resources)
- ✓ Data management (database, meta-data versioning, archiving)
- ✓ Open access (entire database, online data browser, Glacier App)
- ✓ DOI's for publications and data sets including versioning
- ✓ Capacity building and twinning (provision of trainings)

Global Environment Monitoring System for Water (GEMS/Water) - GEMStat

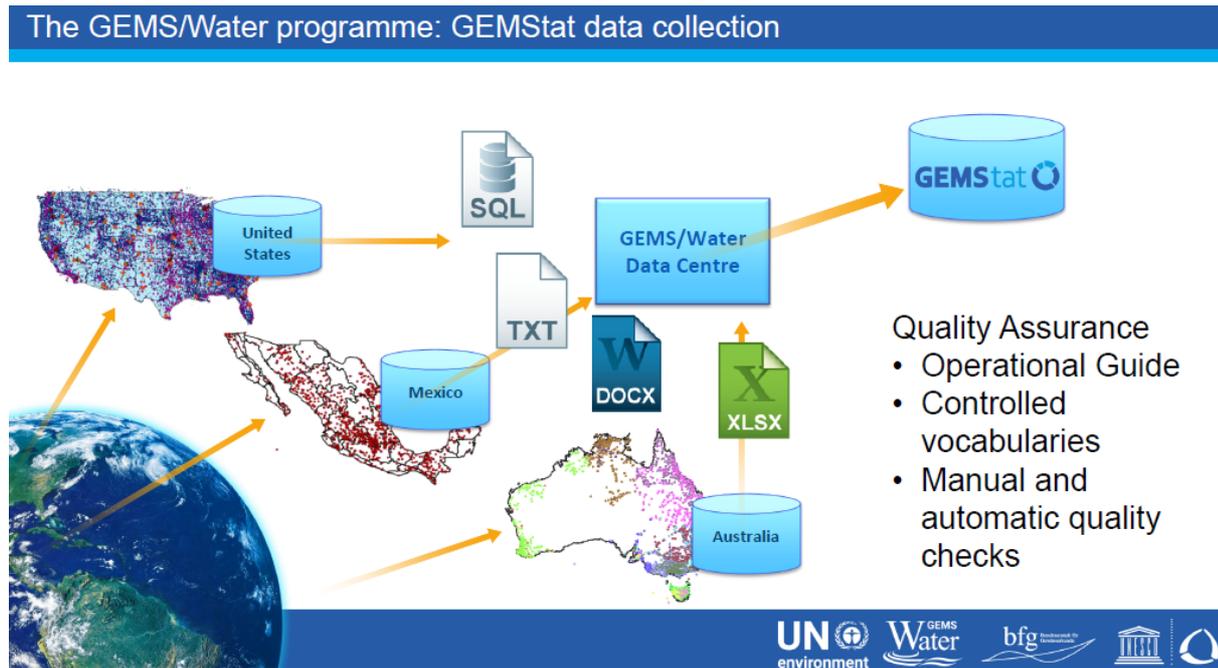
The Global Environment Monitoring System for Water (GEMS/Water) is a programme of the United Nations Environment Assembly that aims at collecting world-wide freshwater quality data to support scientific assessments and decision-making processes. As an impotant component of GEMS/Water, the Global Water Quality database and information system GEMStat is hosted, operated, and maintained by the International Centre for Water Resources and Global Change (ICWRGC) in Koblenz, Germany, within the

framework of the GEMS/Water Programme (UN Environment), and in cooperation with the German Federal Institute of Hydrology.

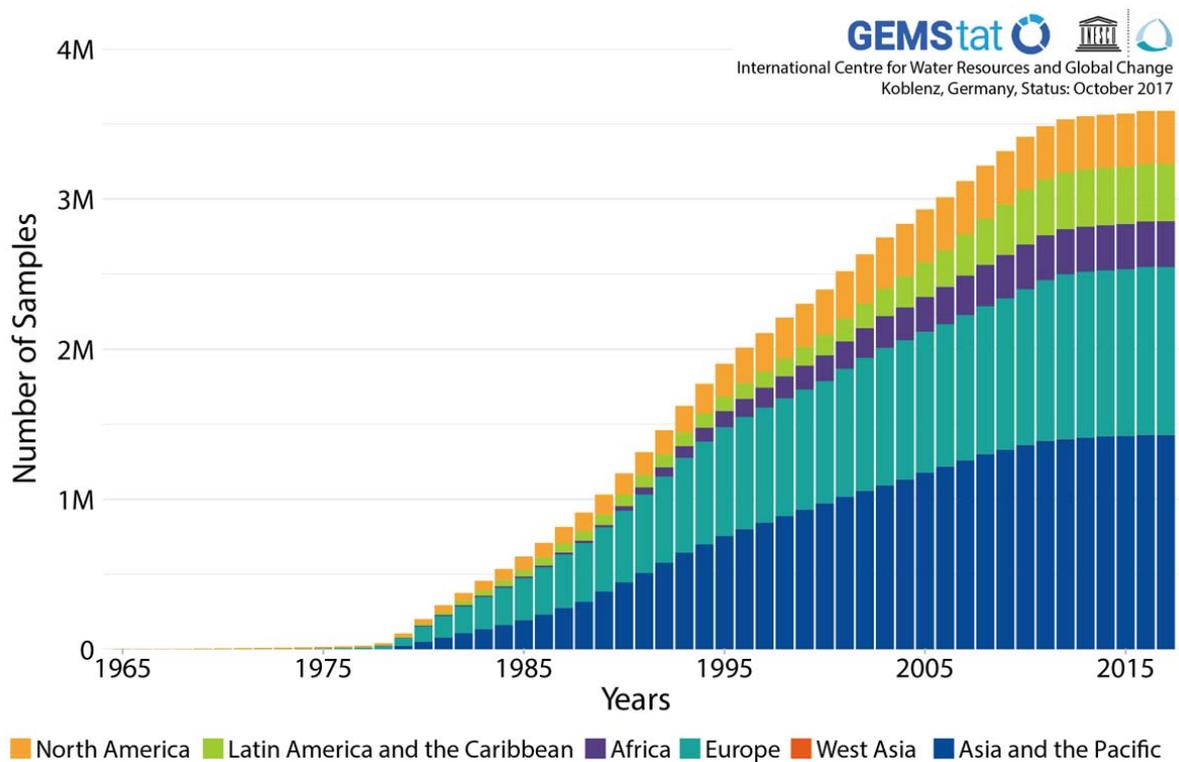
Aside from national focal points that support GEMS/Water, the following entities are part of the overall structure of GEMS/Water:

- Germany - BfG/ICWRGC, GEMS/Water Data Centre
- Ireland – UCC, GEMS/Water Capacity Development Centre
- Nairobi, Kenya – UN Environment, Global Programme Co-ordination Unit
- Regional Hubs - ANA Brasilia, Brazil

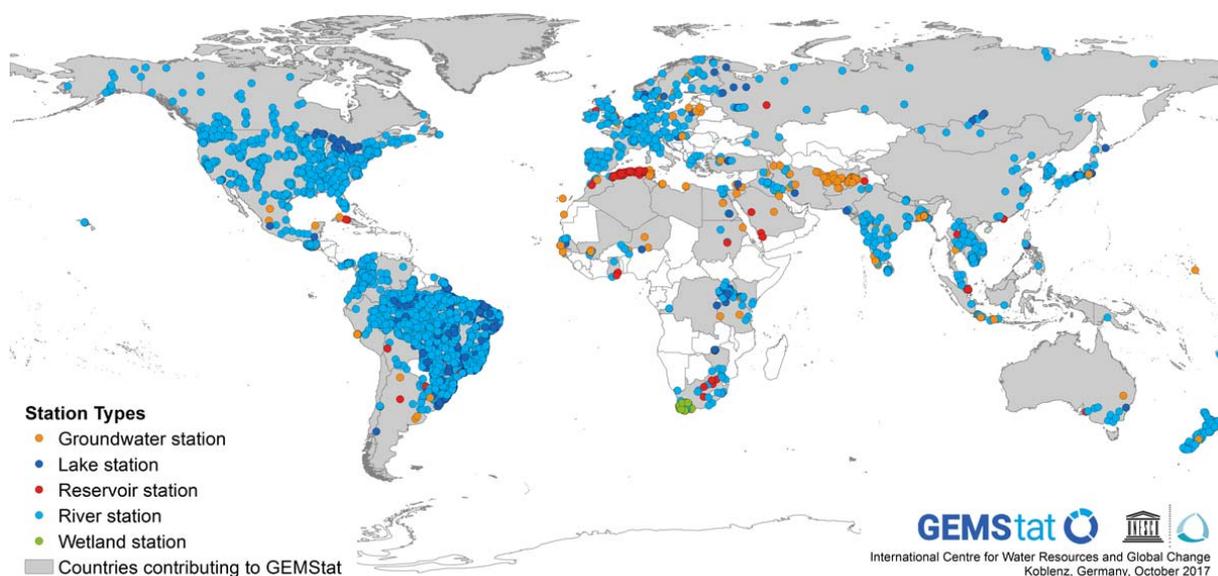
The GEMStat data collection is summarized in the figure below:



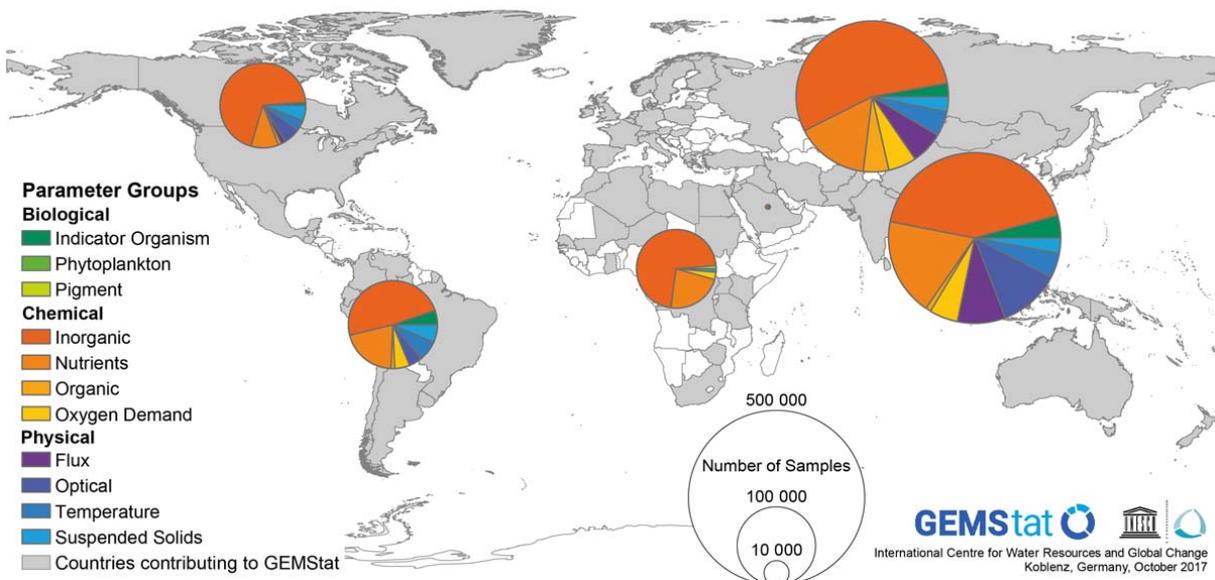
At the moment, GEMStat contains more than 3.5 million entries from approximately 3000 stations in 75 participating countries. The greatest coverage of stations is currently in Latin America and the Caribbean. The highest number of sample values is currently available from Asia and the Pacific.



GEMStat has data from different types of stations: groundwater, lake, reservoir, river, and wetland stations. Currently, the largest number of the data by far comes from rivers stations, followed by data from lakes and groundwater.



Parameters in GEMStat are classified following the [CUAHSI Hydrosphere Ontology](#). In total, about 250 parameters are available, which are classified into a hierarchical system of groups and subgroups. Currently, most GEMStat data falls within the category chemical parameters, followed by physical parameters, while biological parameters represent only a minor proportion. The largest proportion is thereby contributed by inorganic compounds and nutrients.



GEMStat is also exploring new sources of water quality data, namely through SPONGE – Spaceborne Observations to Nourish Gemstat. Development of water quality monitoring products for selected water bodies in Guatemala, Ghana, Finland, Japan and Tanzania have been undertaken.

Sharing of data follows an established data policy promoting free and unrestricted exchange of water quality data

- Revision of GEMS/Water Data policy
- Open: Data is publicly available
- Limited: Data is shared on written request for non-commercial research
- Restricted: Data is not shared but used for UN assessments and data products
- Supporting the development and promoting the use of open international data and metadata exchange standards

A flagship activity of GEMStat is the provision of support to the SDG goals, and in particular SDG 6: Water.

The GEMS/Water programme: SDG 6.3.2 Monitoring and Reporting

Development of methodology for indicator 6.3.2 which monitors the state of ambient water quality

Supporting the roll-out of the methodology to approximately 60 countries

Gathering data during the roll-out to create a baseline data set for 2017



Overall status

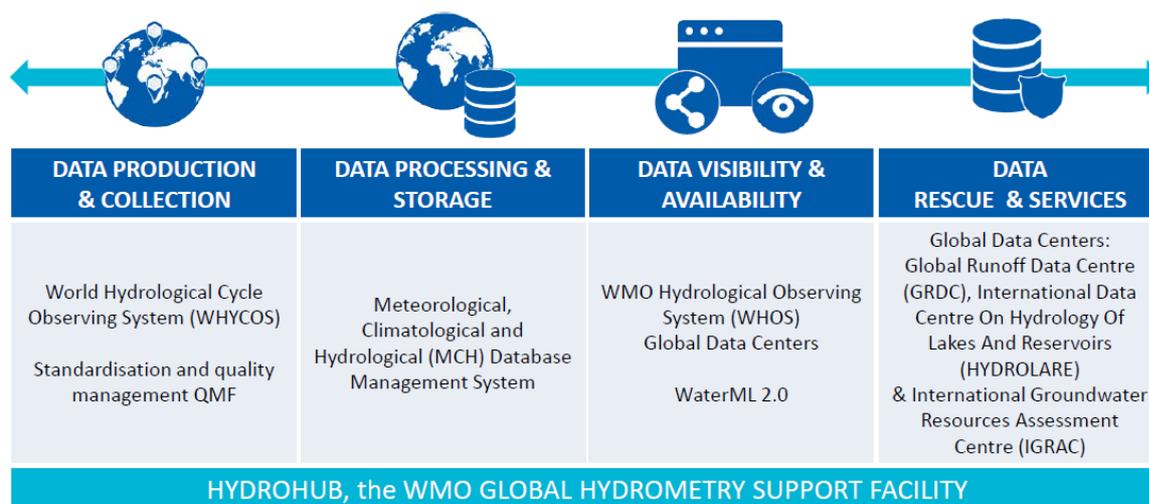
Participants realized that the data centres had so far not fully delivered the envisaged overview of their data quality management procedures as proposed in the 7th Panel Session. The objective had been to produce a GTN-H Quality Management Overview document for user communities of GTN-H services. Panel members highly appreciated the documented data quality management activities of GPCC, GRDC, ISMN and GNIP. An overview is provided below and in the presentations of these centres.

4. DATA QUALITY AND ACCESS TO DATA

Participants stressed the importance of access to data as a priority. Participants noted that this issue had been discussed in detail during the 7th session of the GTN-H Panel in 2015 and is documented in chapter 5 of the Report (<http://www.gtn-h.info/documents/>). While data centers strive to provide easy access to data and information it remains difficult in many cases to obtain data from original data providers.

The WMO Technical Commission for Hydrology had noted that many countries had not yet met the requirements in terms of monitoring networks and standards to ensure that hydrological data can be used in water management decisions. Free and unrestricted access to hydrological data is not yet a general common practice. For these reasons, data and information management issues are one of the priorities of the WMO Regional Associations. Likewise, enhanced support is required to help countries meet their needs. This can be achieved inter alia through support for the modernization of hydrometeorological networks. In this context, particularly in the domain of production and management of data, WMO provides its Members support through HYDROHUB which is WMO's Global Hydrometry Support Facility.

WMO Activities in Basic systems in Hydrology



Especially the WMO Hydrological Observing System (WHOS) that is being implemented in phases, strives to ease access to hydrological data with a focus on web-based information available from National Hydrological Services.

Concerning the monitoring and reporting on new developments dealing with data management issues, such as observations, data exchange and protocols, data transfer formats, data information, as well as the WMO Information System (WIS) and WIGOS, participants were informed of an awareness-raising article that was published in the WMO Newsletter, *MeteoWorld*, entitled *Towards a new standard for sharing hydrological data*, <http://public.wmo.int/en/resources/meteoworld/towards-new-standard-sharing-hydrological-data>. An update to the Global Runoff Data Center's (GRDC) Hydrological Metadata profile of ISO 19115 has also been released, (http://www.bafg.de/GRDC/EN/02_srvcs/24_rprttrs/report_39r2.pdf). The *HY_Features: Common Hydrological Feature Model* was updated and released as an OGC Discussion Paper. This work has been extensively tested and will form the basis of the WaterML 2.0: Part 3 standard. GTN-H has contributed to the development of the draft WIGOS Metadata Standard mainly through the work of GRDC.

On the side of GEO, the figure below documents the supported standards in the GEO Data Access Broker (DAB)

GEO DAB Supported Standards

DGC CSW 2.0.2 AP ISO 1.0	INPE
DGC CSW 2.0.2 eBRIM EO	CKAN
DGC CSW 2.0.2 eBRIM CIM	DCAT
ESRI GEOPORTAL 10	GI-cat
DAI-PMH 2.0	ESRI GEOPORTAL 10
OpenSearch 1.1	NCML-OD
OpenSearch 1.1 ESIP	BCODMO
OpenSearch GENESIS DR	NCML-CF
CKAN	NetCDF-CF 1.4
CLIAHSI HIS-Central	FTP populated with supported metadata types
ESRI REST API 10.3	WAF Web Accessible Folders
DGC WCS	GeoNetwork (2.2.0 or greater)
DGC WMS	Ecological Markup Language 2.1.1
DGC WFS 1.0.0, 1.1.0, 2.0.0	NERRS (National Estuarine Research Reserve System)
DGC WMTS	HMA CSW 2.0.2 eBRIM/CIM
DGC SOS 1.0.0, 2.0.0, 2.0.0 Hydro Profile	HDF
DGC WPS 1.0.0	IADC DB (MySQL)
DGC CSW 2.0.0 Core	GrADS-DS
DGC CSW 2.0.2 AP ISO 1.0	FedEO
DGC CSW 2.0.2 eBRIM/EO AP	ARPA DB (based on Microsoft SQL)
DGC CSW 2.0.2 eBRIM/CIM AP	ESRI Map Server
IRIS Station	SHAPE files (FTP)
IRIS Event	KISTERS Web - Environment of Canada
HYRAX THREDDS SERVER 1.9	Environment Canada Hydrometric data (FTP)
DAI-PMH 2.0 - Harvesting	OpenSearch 1.1
GBIF	Earth Engine
DIF	RASAQM
HYDRO	EGASKRO
UNAVCO	SITAD (Sistema Informativo Territoriale Ambientale Diffuso)
CDI 1.04, 1.3, 1.4	File System
ISO19115-2	GDACS
THREDDS 1.0.1, 1.0.2	GeoRSS 2.0
THREDDS-NCISO 1.0.1, 1.0.2	Degree catalog service 2.2
THREDDS-NCISO-PLUS 1.0.1, 1.0.2	OpenSearch GENESIS DR

Source: <http://www.geodab.net/>

Supported Standards by the GEO Data and Access Broker (DAB)

While participants welcomed advances made in the registration of data in the GEO portal, participants also urged GEO to improve the retrieval services of registered data.

4.1 Management of data quality

Participants reiterated that a complete overview of data quality procedures should be produced by all centers to improve transparency and approaches of data quality management practices for the purpose of information, exchange of good practices and to provide information to users who need to know more details about quality management at the side of the centers. Participants agreed that an overview should suffice at present as detailed information can then be provided by the data center upon specific requests.

Working experience of data centers show that data provided from original suppliers (usually national services) need to be screened as they contain errors that need to be eliminated as best as possible to enhance data quality. Participants recognized that the ultimate ownership of original data and data quality remains the responsibility of the original data providers.

As a matter of principle in in quality management of data, participants were in line with the view of GPCC that

- Almost every large data set is containing more or less frequently erroneous data
- Efforts should be made to correct such data and
- “Bad data” should not simply be thrown away, but corrected where possible (data errors are often obvious and thus can be corrected (data maybe important in data sparse areas)
- True extreme values must not be eliminated by “QC” (therefore semi-automatic QC at GPCC and GRDC; automatic pre-checks and visual control)
- Corrected data always archived together with the original data

GRDC and GPCC provided detailed information on their data quality management procedures.

4.2 Quality management at GRDC

GRDC data provided by National Hydrological Services (NHS)

GRDC acts as a custodian of the data provided by NHSs. The NHSs remain the owner of the data and metadata. Responsibility for the quality of metadata and discharge data lies with the provider, who should be maintaining quality management procedures in their services as laid down by WMO regulations.

When receiving data and metadata from the NHSs, the GRDC is carrying out a set of plausibility checks to identify potential errors in the data and ensure that the stored time series data are linked to the correct corresponding station in the GRDC database.

a) Station metadata

- Coordinates are inspected and checked against stated reference system.
- Station and river name are transcribed into ASCII-128 character set.
- International river names are determined using GEOnet Names Server where possible.

b) Discharge time series data

- Unit of measures are checked and if needed converted to m³/sec
- Missing value code is checked and adjusted to GRDC missing value code (-999)
- “0” flow readings are checked if plausible or mistakenly used as “missing value”.
- Old and new time series are graphically overlaid and checked whether they match the same station.
- If no old time series are available, the time series are compared with downstream station or stations in the vicinity to assess discharge pattern.

Any uncertainties regarding metadata and discharge data are reported to the data provider for him to clarify or make corrections.

GRDC data products (statistics)

For the stations in the GRDC database a number of statistical values are determined. Station metadata are identical to the station metadata provided by the NHSs.

Statistical calculations are utilizing plausibility checked time series provided by NHSs and calculations are based on the Manual for Water Level Gauging and Discharge Measurements (1990), the English version of the "Deutsche Pegelvorschrift".

4.3 Quality management at GPCC

As in GRDC, GPCC makes use of semi-automatic quality checks of incoming data. The first steps include pre-control and reformatting of input data.

A sophisticated check of station meta information (WMO-ID, national number, station name, geographical coordinates and elevation) is performed when loading station data into the Oracle-based relational data base management system:

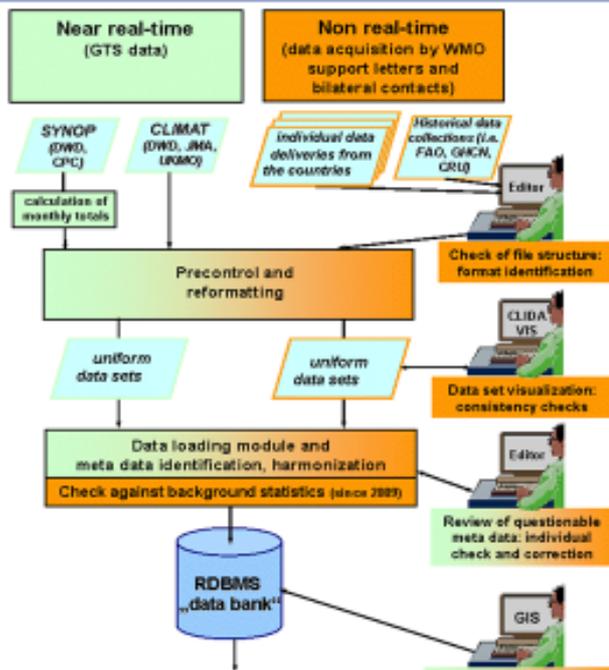
- Unequivocal identification of the station data to be loaded is necessary in order to classify:
 - The data belong to a station already existing in the data base
 - The station is a new one
 - It is an unclear case (some information in the data set being loaded is identical with information in the data base, but not all)

All clarified cases are stored in a library (system memory).

All station-related precipitation data are checked against background statistics for the station or, if not available, for the corresponding 2.5° grid (since 2009). Data being flagged as questionable (below the 1% or above the 99% percentile) are being checked manually by an expert.

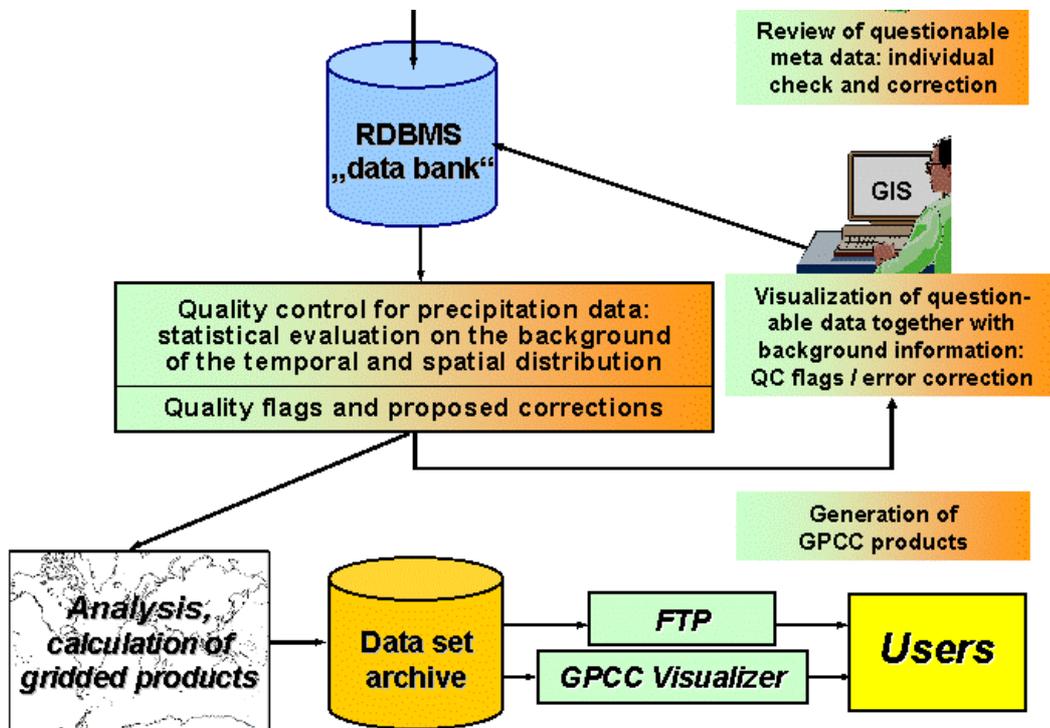
Before generation of each new product release, statistical check of the entire data base is performed as well as visual check by experts of the data flagged as questionable.

Schematic diagram of QC processing at GPCC



GTN-H VIII, 20-21 June 2017, Koblenz, Germany

GPCC's analysis products are then generated on the basis of the qc'ed data in the RDBMS (relational data base management system)



4.4 Quality management at ISMN

All datasets are subject to a series of quality control procedures, which are part of the automated processing chain. The quality management framework had been developed by Dorigo et al., 2013.

Consistent with data quality control practices of GPCC and GRDC, dubious soil moisture readings are not deleted or changed, but flagged (in accordance to the CEOP standards)

Currently three different approaches for quality checks are in use:

- Geophysical Dynamic Range
- Geophysical Consistency
- Spectrum-based approach

Geophysical Dynamic Range:

A simple **threshold method** detects observations exceeding the geophysical plausibility range. This quality control method is **applied for several variables**:

- Soil moisture
- Air/soil temperature
- Precipitation
- Soil suction
- Snow depth
- Snow water equivalent

Geophysical Consistency:

- additional variables including information of the reliability of soil moisture observations
- if no additional in situ variables are available, the modelled GLDAS-Noah data is used

Examples:

- Flagging soil moisture where soil temperature is below 0°C;
- Flagging soil moisture if a rise in soil moisture exists without significant rainfall in the preceding 24 hours.

Spectrum-based approach:

A variety of erroneous measurements exist, which occur within plausible geophysical ranges, therefore detection is much more difficult: These could be spikes, constant values or breaks in the time series.

The existing spectrum-based quality control procedures are currently investigated. Five new flags were defined to detect the following dubious events:

- Suspicious Values Before/After Missing Values
- Severe Soil Moisture Drops
- Alternating Values
- Perfectly Constant Values
- Highly flagged Spectrum

These few new quality checks are currently under investigation and are not implemented into the processing chain yet.

GNIP data quality assessment and control

Given the nature of GNIP data being ex-situ observations, QA/QC is two-fold:

- Data attribute consistency check
- Plausibility check of the analytical results

Clearly the focus is on acquiring and presenting ex-situ data; given the complexity and cost of these activities, occasional trade-offs in the presentation an attribute completeness of isotopic samples are accepted (the balance is between over-constraining the requirements and finding a compromise with a low entry level yet providing sufficient-quality data). For example, the Halley Bay station (Antarctica) has not

been reporting precipitation amount numbers in years (for high measurement uncertainties); yet isotopic determinations are continued for its unique setting and importance for the GNIP network.

Given the nature of GNIP data being ex-situ observations, QA/QC is two-fold:

1. Data attribute consistency check
2. Plausibility check of the analytical results

1. Data attribute consistency

By default, the GNIP data format uses the following attributes. 'Initial' refers to the time when the station is established.

Attribute	Data type	Frequency of QA/QC	QA/QC applied
Station Name	Text	Initial or if notified of change	Verification of spelling
Country code	Text	Initial or if notified of change	Verification of coordinates being positioned in the country using remote sensing data.
WMO (GNIP) code	Text	Initial	Verification of eventual new sites against list of WMO registered weather stations; derivation of GNIP code as WMO code plus 2 numbers suffix.
Latitude	Float	Initial or if notified of change	Verification of coordinates being positioned at the site mentioned using remote sensing data.
Longitude	Float	Initial or if notified of change	Verification of coordinates being positioned at the site mentioned using remote sensing data.
Altitude	Float	Initial or if notified of change	Verification of coordinates being positioned at the site mentioned using remote sensing data.
Type of site	Attribute list	Initial or if notified of change	Verification of the reported sampling site configuration against eventual photos. Note: This attribute may be filled with a generic type if details are not known (because all collection methods recognized as being compliant with the GNIP protocol should give the same results)
Source of information	Text	Initial or if notified of change	Must be specified as either a partner institution or as a published bibliographical reference.
Sample name	Text	Annually for new data	<ul style="list-style-type: none"> For monthly samples, this is derived from the sampling data in the form YYYYMM. For shorter period samples, we propose a consecutive numbering per sample year, such as YYYY/xxx (where xxx is the consecutive number). However, this is not thoroughly enforced for legacy data.

Media type	Attribute list	Annually for new data	If the media type (rain, mixed or snow) is reported during the sample collection, it is used in the database. If this attribute is not available, it is replaced by a generic value ('unknown'). If the type is not reported but snow is not likely under the climatic conditions of the station, then 'rain' is assumed. If a month has zero precipitation, 'dry' is used.
Sample date	Date	Annually for new data	<ul style="list-style-type: none"> • For integrative monthly samples, the 15th of a month is used as a reference date. • For shorter-term sampling periods, the middle of the period (derived as average of beginning and end time of the sample collection) should be used. (However, this is not consistently enforced, especially for older data.)
Begin of sampling period	Date	Annually for new data	<ul style="list-style-type: none"> • For integrative monthly samples, the 1st of a month is used as starting date unless specified otherwise by the observers. • For shorter-term sampling periods, the exact timestamp must be recorded.
Begin of sampling period	Date	Annually for new data	<ul style="list-style-type: none"> • For integrative monthly samples, the last of a month is used as starting date unless specified otherwise by the observers. • For shorter-term sampling periods, the exact timestamp must be recorded.
Comment	Text	Annually for new data	The comment field is only filled eventually if there have been any remarkable observations. If isotope data has been taken out, they are put into the remark field text with a justification.
O18*	Float	Annually for new data	$\delta^{18}\text{O}$ measurement of the sample. Left blank if there is (a) no sample, (b) no result or (c) the result has been rejected (see comment). For plausibility check of the isotope measurements, see section 2.
O18 Laboratory	Text	Annually for new data	Laboratory which conducted the isotopic assay. Usually a mandatory field.
H2*	Float	Annually for new data	$\delta^2\text{H}$ measurement of the sample. Left blank if there is (a) no sample, (b) no result or (c) the result has been rejected (see comment). For plausibility check of the isotope measurements, see section 2.

H2 Laboratory	Text	Annually for new data	Laboratory which conducted the isotopic assay. Usually a mandatory field.
H3*	Float	Annually for new data	³ H measurement of the sample. Left blank if there is (a) no sample, (b) no result or (c) the result has been rejected (see comment). For plausibility check of the isotope measurements, see section 2.
H3 Error	Float	Annually for new data	Per-sample uncertainty of the ³ H measurement as reported by the laboratory. (Note that while stable isotope measurements are usually benchmarked against the longer-term performance record of a dedicated control sample in a three-point calibration scheme, tritium uncertainties vary highly and need to be reported on a per-sample basis.)
H3 Laboratory	Text	Annually for new data	Laboratory which conducted the isotopic assay. Usually a mandatory field.
Precipitation*	Float	Annually for new data	Mandatory information as supplied by the partner institution. (If the information is not available, data may be posted nevertheless if spatially indispensable.) Amounts are cross-checked against the most recent years' curves in case of monthly samples. Screening for evident blunder or confusion.
Air temperature*	Float	Annually for new data	Optional information and entered if provided. Basic plausibility check for evident mistakes.
Vapour pressure*	Float	Annually for new data	Optional information and entered if provided. If needed, calculated from temperature and humidity. Basic plausibility check for evident mistakes.

*) Note that the inclusion of a measurement technique attribute and including the source of information for meteorological data is planned, following similar QA/QC procedures to those specified above.

2. Isotope data plausibility check

The plausibility check is the best-possible proxy and its setup is done under the following rationales and facing the following constraints:

- The IAEA is hosting the GNIP data repository; however it is no 'isotope police' concerning the analytical performance of laboratories involved in the GNIP measurement.
- Every laboratory whose measurements end up in the GNIP database is expected to verify their measurements based on established QC routines and/or peer-reviewed analytical techniques.
- In any case we urgently recommend 3-point calibrations (adequate upper and lower measuring ranges and an independent control sample in the middle).
- There are no common standards for the measurement of GNIP samples – lack of commitment and resources.
- There is, however a quadrennial global intercomparison exercise with samples sent out by IAEA. All labs participating in GNIP are strongly encouraged to participate. However, participation is again voluntary (see first bullet).

Isotope data plausibility checks include:

- Availability of data – isotope results should cover at least 75% of the precipitation fallen in a given year. Otherwise, data may still be presented online but won't enter into the calculation of annual and multi-annual means.
- Assessment of the individual records (screening for evident mistakes) – this has become drastically better with (a) the rapid proliferation of laser spectrometry and hence simultaneous measurement of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ (hence the dissociated assay of each isotopic species individually has become less) and (b) the growing popularity of consolidated Laboratory Information and Management Systems with automated export function. Both these aspects have reduced risky copy-and-paste procedures.
- Assessment of the correlation of $\delta^{18}\text{O}$ and $\delta^2\text{H}$ using the first-order derivative deuterium excess ($d = \delta^2\text{H} - 8 \delta^{18}\text{O}$) as a screening for signs of excessive evaporation (a disequilibrium enrichment between $\delta^{18}\text{O}$ and $\delta^2\text{H}$ which often occurs when samples have been improperly collected and/or stored). This is an expert decision since d may also reflect formation conditions and/or sub-cloud evaporation along the travel path to the ground surface. In general, measurements for both isotopic species are not included in the database (more precisely: put into the remark field) if d is negative (for comparison: the d of seawater is around zero) and the rain amount associated with the sample is $> 5\%$ of the total annual rain.
- Plotting of $\delta^{18}\text{O}$, $\delta^2\text{H}$ and d against the established seasonal curve – some climates exhibit more predictable curves than others but this check is suited to identify systematic offsets (i.e. a systematically lowered d over the whole year compared to previous recordings may be indicative of operator neglect). In this case, the need for action is triggered. Irrespective of that, data exhibiting a systematic shift greater than the standard deviation is to be considered suspicious.
- In terms of tritium, the focus has shifted to observing natural ^3H of cosmogenic origin. Tritium results are screened for spikes, e.g. from any kind of nuclear activities. These measurements are usually off the established seasonal distribution curve by a factor 2-3 or more. (Again, expert interpretation and usually the sites which may be subject to that are known.) Outlying measurements are usually kept in the database but excluded from some aspects of the statistical processing (e.g. from the derivation of monthly mean curves).

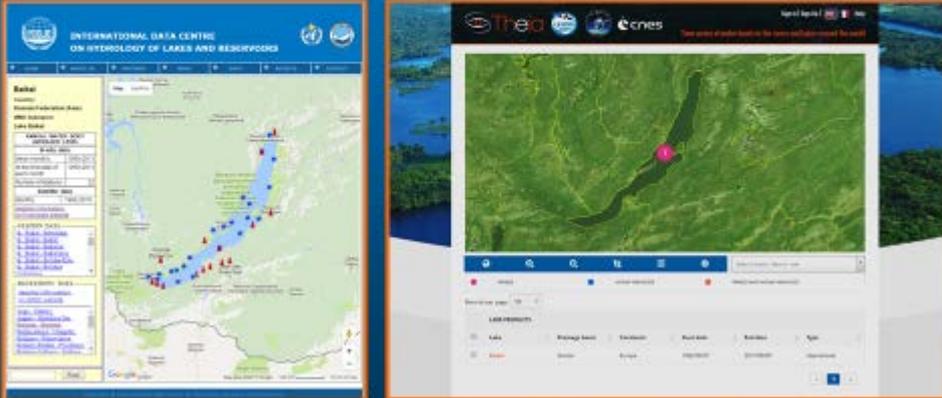
5. AUGMENTATION OF IN-SITU OBSERVATIONS WITH SATELLITE-BASED EARTH OBSERVATIONS

The difficulties in access to in-situ data and information from national services are well known to the data centres. With the availability of high-quality remote sensing information, there is the opportunity to augment in situ-observations with remote sensing information. HYDROLARE has been the first data centre

to step in this direction in close cooperation with the French Space Agency (CNES-LEGOS). This allows a direct cross-link between the websites of HYDROLARE and the LEGOS HYDROWEB sites, thus substantially augmenting the terrestrial observations on lakes and reservoirs.

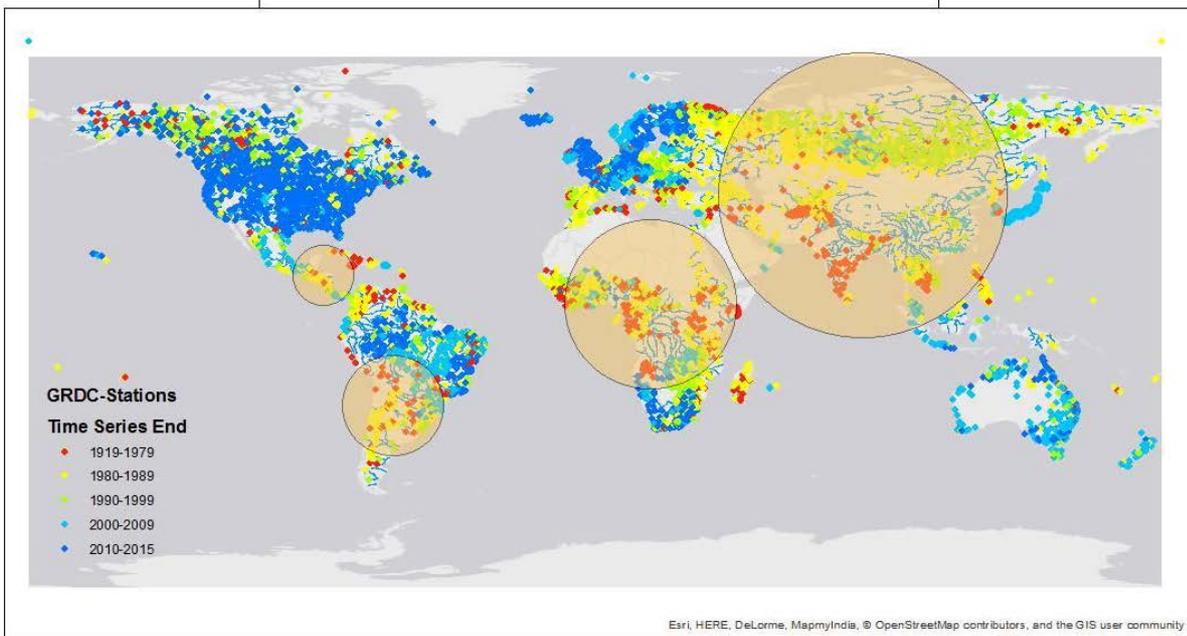
Within HYDROLARE-LEGOS cooperation activities were implemented aimed at integration of *in-situ* and satellite data available in HYDROLARE and LEGOS (Hydroweb).

A direct access from HYDROLARE to Hydroweb website was enabled for acquiring information on availability of satellite data for selected lakes on Hydroweb website and vice versa.

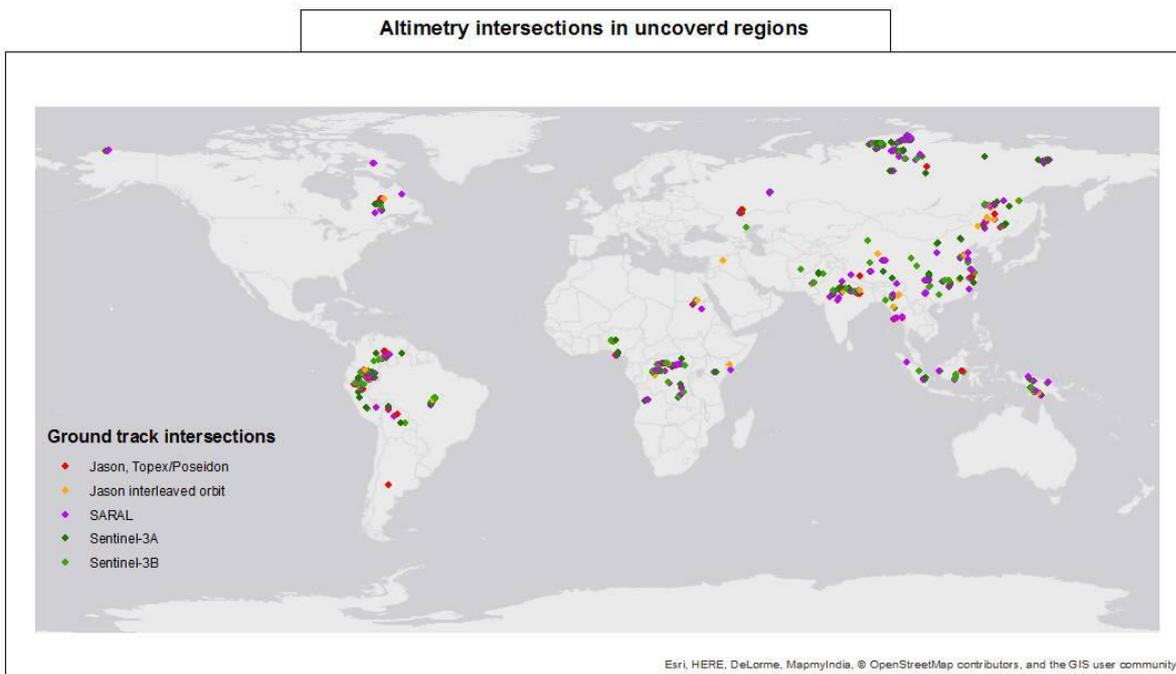


Cross-links between HYDROLARE and LEGOS (Hydroweb) web pages

Recently, the concept of “virtual gauging stations” has been developed with GRDC where altimeter information should lead to the definition of a complementary station network in addition to the in-situ network of GRDC. First results were demonstrated during the meeting by Mr Simon Jungbluth and GTN-H partners discussed the potential of making use of remote sensing information to augment in-situ observations on a complementary basis. Participants welcomed these activities as a milestone and encouraged close liaison between LEGOS and NASA to make full use of upcoming SWOT products that are just a few years ahead at this time. Participants encouraged GRDC to define a list of priority virtual stations to obtain historical altimeter data and pave ways to receive derived discharge data from SWOT in future for selected virtual discharge stations. The figure below shows areas where satellite data would be useful for GRDC:



Areas in need to obtain additional hydrological information

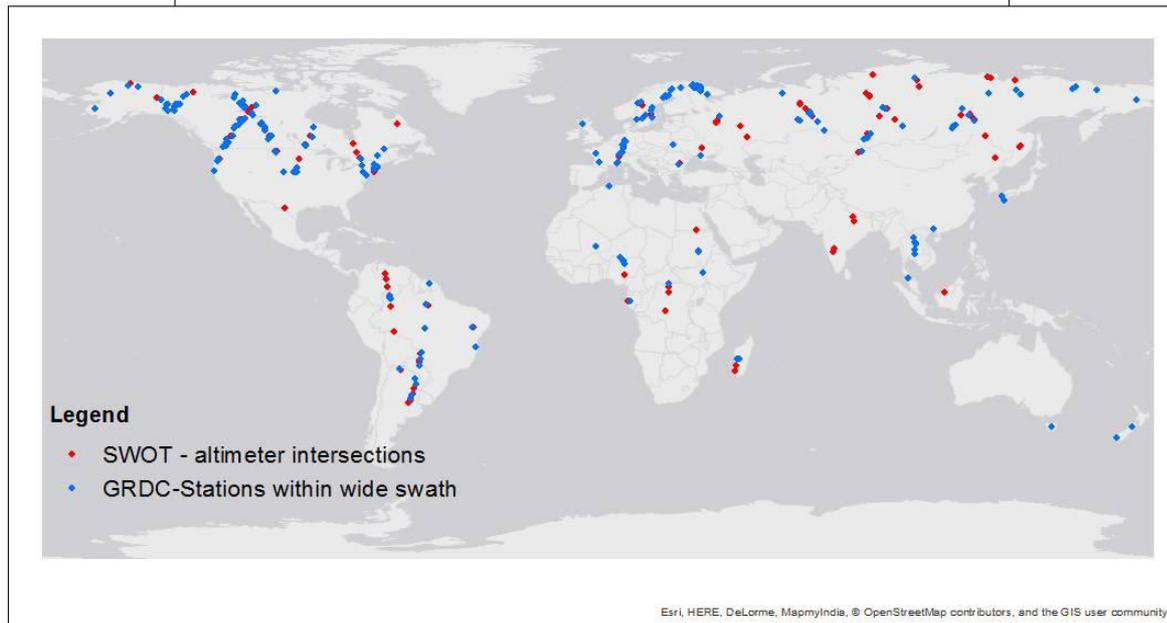


1102 possible virtual stations based on altimetry in uncoverd regions with a minium distance of 200 kilometers to any GRDC Station and a minium river width of 300 m



The map above shows possible virtual stations for GRDC that intersect with current altimeter- equipped satellites

SWOT Calibration/Validation Orbit



243 GRDC Stations with a minimum river width of 50 m in swath range of SWOT during Calibration/Validation Orbit.
110 altimeter intersections (37 in 25 km range of GRDC Stations)



Possible virtual gauging stations with SWOT altimeter path intersections and repetition time of about 7-10 days.

Specifically with regard to GRDC and HYDROLARE and the inclusion of SWOT data in future, Jean-Francois Cretaux from CNES-LEGOS contributed the following thoughts:

SWOT will measure water height, width and slope along the rivers worldwide. For rivers with a width larger than 100m for reaches of 10 km, the accuracy on slope which is requested is 1.7 cm/km. These set of 3 measurements (width, height, slope) will be:

- Assimilated in a rainfall/discharge model at basin scale in order to determine discharge along all reaches of 10 km that have been previously established (a work which is very hard due to the complexity and diversity of river morphology around the world).
- Using the measurement to directly calculate the discharge using manning equations and some a priori assumption on bathymetry and friction coefficient on each river reaches of 10 km.

Work is under way to determine what will be the potential efficiency of such methodologies and the associated errors on the final product, the discharge. Discharge does not have any requirements in the mission design (in term of accuracy) but this is however extremely important to produce the most precise as possible discharge, this is one of the main objective of SWOT so this is crucial for credibility and success of the mission. Not less crucial is to develop means and tools to be able to perform good cal/val of the mission, including discharge. On discharge there is at present no commitment on accuracy, so no real classical cal/val activities are associated to this product, but instead the term "characterization" of the quality of the product is used. To do such characterization, some field work on dedicated sites will be necessary. During the 3 first months of the missions there will be a phase named "fast sampling" phase, on which the orbit will not be the nominal one, but an orbit with large inter-track and a high revisit on each site (1 day). Along many rivers, during this 1-D phase we will need to validate the different measurements and products.

For the nominal phase (after the fast sampling phase) we are also building the cal/val activities, and this would also be an excellent result of our collaboration if one would be able to get these NRT (at nominal phase monthly latency would already be nice) data along the set of selected gauges for cal/val.

For SWOT project because it increases the visibility and allows setting up dedicated projects with GRDC, for GRDC I let you say what could be the interest but I think there are many.

We are now 4 years before the launch; this let us time to enhance and strengthen the interactions between our project and GRDC and GTN-H.

Another example of complementary satellite observations to in-situ observations was demonstrated by WGMS to enrich data availability on glaciers and snow fields.

Conclusion of the discussion of participants was that:

Overall, opportunities for cooperative activities in terrestrial observations and complementary satellite-based observations need to be consequently augmented and used. However, many questions are still open with regard to archiving satellite observations vis-à-vis terrestrial observations.

A coordination with GRDC and GTN-H (and thus WMO) could be setup in order to make available to the project a set of in situ river gauges with delivering of near real time discharge measurements. A very high expectation would be to have 1-day data latency, one week would be perfect also, and 1 month acceptable;

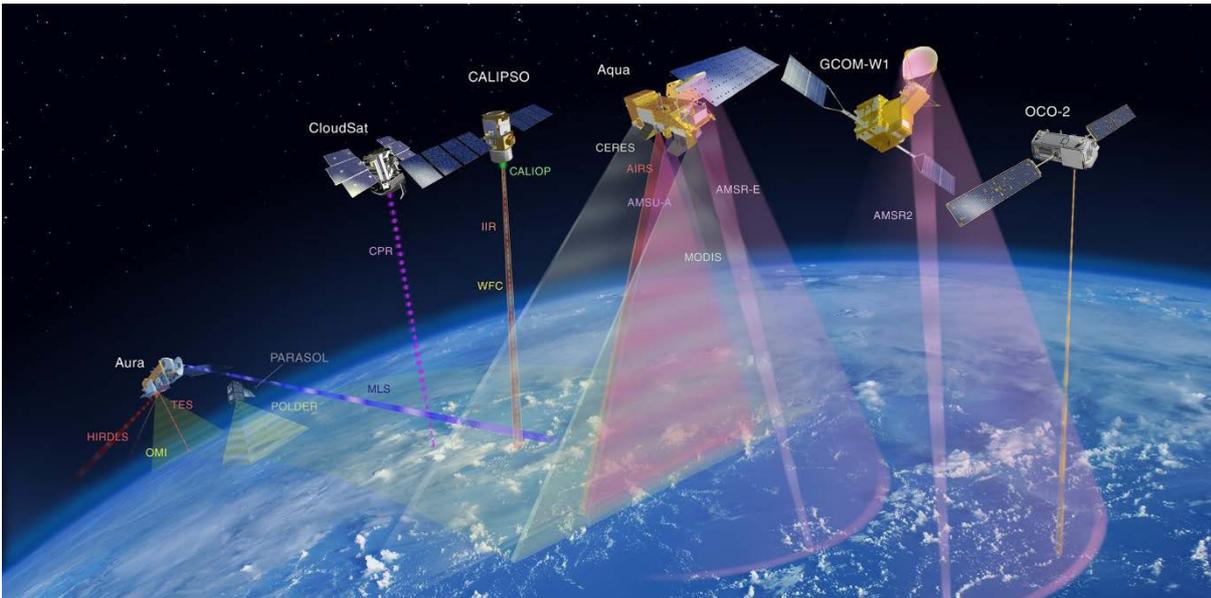
Between the SWOT project and GRDC there need to be dedicated ways of interaction using the interaction between HYDROLARE and CNES-LEGOS as template. There will be obviously at NASA and CNES level a platform to release all products (height, storage change on lakes & reservoir, water mask, discharge, data themselves etc ...), but it is likewise necessary to have specific linkage with existing data centers including GRDC and HYDROLARE which are focusing on specific variables on which SWOT could contribute.

Four years before the launch of SWOT it is now necessary to enhance and strengthen the interactions between the SWOT project, GRDC and GTN-H.

Looking at GEOSS water strategy with regard to space-based observations, participants recognized that CEOS has been one of the major contributors to the implementation of the recommendations in the GEOSS Water Strategy. GEO Water Strategy Recommendation C1:

The feasibility of developing a Water-Train satellite constellation should be assessed. This suite of satellites would be modelled after the A-Train, providing a space segment of an observation system that would capture all fluxes and stores of the water cycle using a diverse suite of platforms and instruments. This system would operate as a Virtual Water Cycle Constellation.

Towards this recommendation, CEOS has formed a Water Strategy Implementation Study Team (WSIST) which is addressing this recommendation.



The A-Train satellite constellation

The link below leads to the CEOS response to the GEOSS Water Strategy:

http://ceos.org/document_management/Publications/CEOS-Strategy-for-Water-Observations-from-Space.pdf

This had been followed up by the CEOS Water Constellation Feasibility Study in 2016:

https://www.earthobservations.org/uploads/517_6_20161108geo_side_event_ishida_water_constellation_fs.pptx

Participants also realized the growing potential for complementary space-based observations to terrestrial observations including for groundwater, soil moisture, precipitation and water quality, all in the realm of GTN-H.

6. GTN-H AND ITS SUPPORT TO THE GCOS IMPLEMENTATION PLAN

Participants were briefed about current priority activities of GCOS and the contributions GTN-H has made in the intersessional period to support GCOS, and in particular activities of its implementation plan. The discussion focused on ways how GTN-H could be even more effective in support of GCOS activities.

One of the main tasks of GTN-H is to support GCOS in its core activities. Participants were reminded that GTN-H is reporting directly to the Terrestrial Observation Panel on Climate (TOPC).

The current GCOS Implementation Plan aims to improve monitoring of Global Climate Cycle

- Global Water Cycle
 - Close water cycle globally within 5% on annual timescales
- Carbon Budget
 - Quantify fluxes of carbon-related greenhouse gases to +/- 10% on annual timescales
 - Quantify changes in carbon stocks to +/- 10% on decadal timescales in the ocean and on land, and to +/- 2.5 % in the atmosphere on annual timescales
- Global Energy Balance
 - Balance energy budget to within 0.1 Wm⁻² on annual timescales
- Explain changing conditions of the biosphere
 - Measured ECVs that are accurate enough to explain changes of the biosphere (for example, species composition, biodiversity, etc.)

Based on the Implementation Plan, the main GCOS actions are:

- For Science panels:
 - Monitor progress on actions in the Implementation Plan
 - Ensure someone reviews performance of ECV observation systems
- WMO OSCAR and Rolling Review of Requirements (RRR)
- Terrestrial coordination – (since GTOS is defunct).
- GCOS Surface Reference Networks
- Regional Workshops – water and adaptation
- Access to data (Metadata, standards, data exchange, open data...)

Related to these actions, GTN-H has been contributing mainly to:

- Coordination of terrestrial observations within the framework of GTN-H since the Global Terrestrial Observation System (GTOS) is defunct;
- Rolling Review of Requirements through its specific recommendations based on the expertise of the federated data centers;
- Access to data through its work towards the standardization of data representations and meta-data as well as facilitating the free and open access to data and information based on existing data policies.

GTN-H has continued to make progress in the following areas:

- Improvement of data availability and exchange
 - Exchange of hydrological data
 - Submission of historical and current monthly lake-level data (for a limited number of lakes and sites at present only)
 - Establish sustained production and improvement for the Lake ECV products (HYDROLARE works on this)
 - Confirm GTN for River Discharge sites (further stations verified)
 - Establish full-scale Groundwater monitoring Information System (under work at IGRAC)
- Satellites
 - Use of satellite data for lakes and rivers (under work)
 - Operational ground water monitoring from gravity measurements (in cooperation with IGRAC)
 - Satellites for soil moisture in cooperation with ISMN.

GCOS would welcome an even closer collaboration with GTN-H and specifically through its work undertaken in TOPC.

GCOS is deeply involved in updating product requirements for the Essential Climate Variables (ECVs). Thus, ECV product requirements will be entered into WMO's OSCAR and the Rolling Review of Requirements process. GCOS now needs to start a process for the next update in 2021/2022 for which it requires professional assistance from GTN-H members. The aim is to have an open and transparent process for reviewing and refining ECV product requirements.

The Role of GTN-H in coordinating observations was highlighted in the 19th Session of TOPC in April 2017.

Specifically TOPC recognized that ***a critical requirement for water-related ECVs is the definition of global core networks for essential in-situ observations and including linkages with satellite-based observations.*** This would go a long way to focus data acquisition from Members for the global data centers. Likewise, through the involvement of a wider GCOS community, the actual use of the data provided through the federated global data centers of GTN-H needs to be documented in a transparent manner.

TOPC 19 agreed that the broader community, and including existing observation networks, should be involved in the process to determine ECV product requirements as also proposed by the GCOS secretariat.

7. GTN-H AND ITS SUPPORT TO THE WMO TECHNICAL COMMISSION FOR HYDROLOGY (CHY)

The Fifteenth Session of the WMO Technical Commission for Hydrology (CHy) in December 2016 appreciated the substantive contributions towards the GCOS Implementation Plan by the Global Terrestrial Network – Hydrology (GTN-H) through its federated global data centers including those global data centers that operate under the auspices of WMO, namely GRDC, GPCC, IGRAC, HYDROLARE.

In terms of data management and including the adoption of standards to facilitate and promote data exchange, WMO provides its Members support through the Global Hydrometry Support Facility (GHSF) and WHYCOS. In this regard vital support is provided through GTN-H federated data centers under the auspices of WMO.

GTN-H is contributing to the WMO Hydrological Observing System as well as other WMO programs that are vital in terms of Integrated Observations and Information Systems. This contribution also relates to the provision of metadata into the Observing Systems Capability Analysis and Review Tool.

In the domain of production and management of data, GTN-H global data centers provide support to WMO with regard to the dissemination and rescue of data.

Recognizing fast moving new requirements, the Commission will form a task team on the evolving role of the GRDC, IGRAC and HYDROLARE, (and GPCC) and their relationship with WMO, with respect to the monitoring and measurement of the achievement of the Sustainable Development Goals, their contributions to the Global Framework for Climate Services and support to the WMO Hydrological Observing System and Global Hydrometry Support Facility.

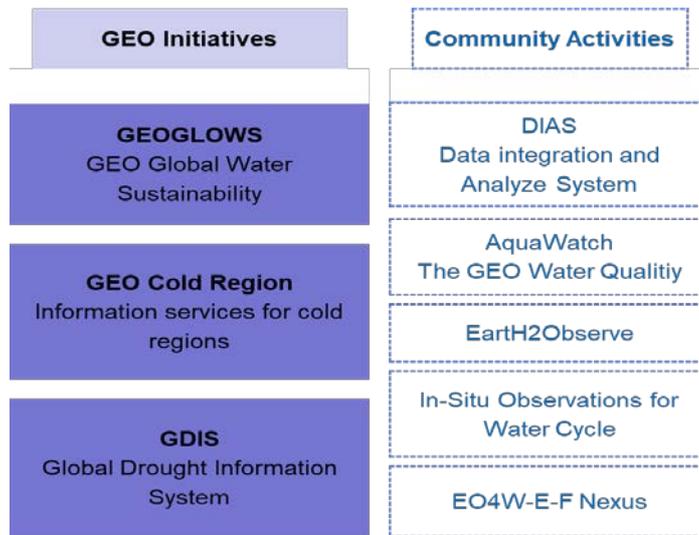
GTN-H expects a firm anchoring of GTN-H activities in the Water Program and activities of WMO.

8. GTN-H AND ITS SUPPORT TO THE GEO WATER STRATEGY

The representative of the GEO-Secretariat explicitly conveyed the appreciation of GEO of the GTN-H activities to address the actions in the GEOSS Water Strategy.

Over the past years, GTN-H has contributed to the GEO Water Strategy through the Integrated Water Cycle Observations – Community of Practice (IGWCO-CoP) in a number of ways including contributions to the Rolling Review of Requirements for Essential Water Variables in a larger WMO/GCOS framework, standardization issues including metadata standards, promotion of the free and open access to data for the federated global data centers of GTN-H and the promotion of integrated data products.

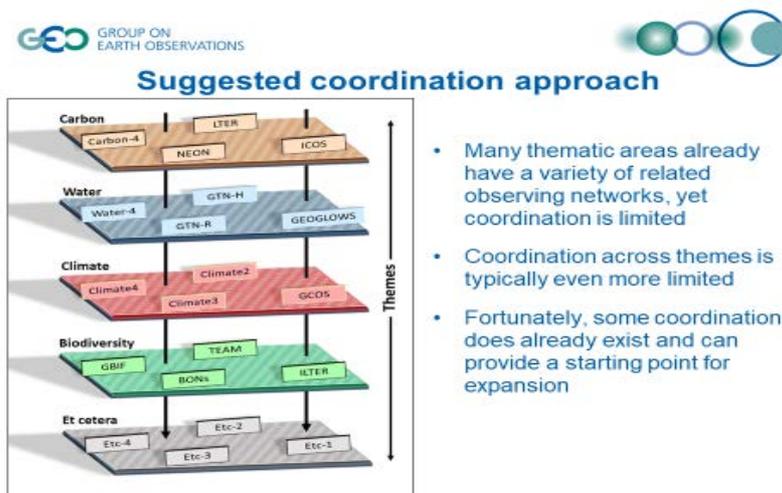
An overview of GEO Initiatives and Community activities is shown in the figure below with the explicit mentioning of In-Situ Observations for the Water Cycle as Community Activity.



The GEO Secretariat proposed that GTN-H and GEOGLOWS coordinate their interactions with user groups. This is in its infancy, since up to date contacts between GTN-H and GEOGLOWS have not much progressed. GTN-H attributes this situation mainly to the development process of GEOGLOWS and issues related to responding focal points in GEOGLOWS.

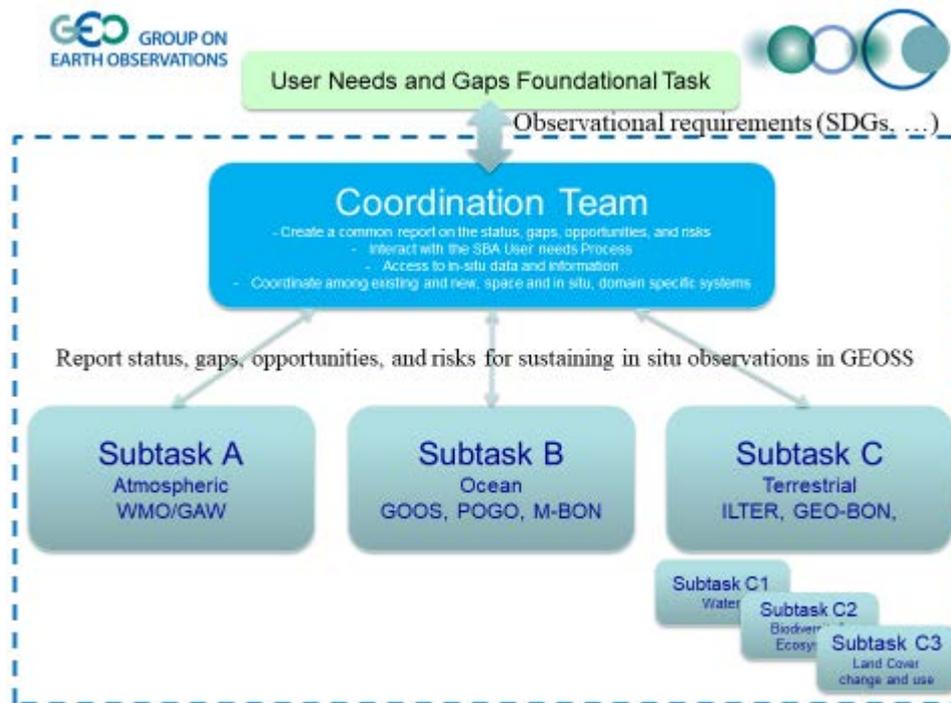
Partly as a result of the Frascati meeting in March 2017, GEO is looking at GTN-H to become the GEO coordination body for in-situ hydrological observations. This could be achieved by assuming a coordination role for Subtask C1. (Integrated Water-cycle Products and Services). Appropriate linkages with relevant Initiatives such as GEOGLOWS need to be ensured.

GEO is working with GCOS and ICSU to address the lack of coordination in the terrestrial domain as GTOS is defunct. The Frascati meeting developed an overall strategy. The figure below on terrestrial observations shows the suggested coordination approach (with reference to GTN-H). As mentioned above, there is a close liaison with GCOS as action item T1 (Improve Terrestrial Coordination) in the GCOS IP lists GEO as an implementing agent. GCOS and GEO have a common interest in this matter and will work closely together.



An essential component to kick-start improved coordination of terrestrial observations has been the establishment of a Foundational Task on "In situ observations" in the GEO Work Program. The task is led by

UNESCO-IOC with support from the GEO Secretariat. A bottom-up approach is being envisaged by bringing on board the system/network owners and coordinators in order to work with those who have an actual mandate. A structure for this task has been established with three main tasks according to the observational domains. For the terrestrial domain, a subtask on Hydrology is being envisaged (Subtask C1).



GEO is now looking at GTN-H to become the GEO coordination body for in-situ hydrological observations. This could be achieved by assuming a coordination role for Subtask C1.

Participants discussed this development and concluded that

- GTN-H already provides a light coordination of in-situ observations in the domain of ECVs and EWWs that overlap to a large degree. GEO is invited to enter into discussion with GTN-H to develop a requirements document for enhanced coordination activities of terrestrial observations that also needs to match with resource availability at the level of the GTN-H and essential partners including the federated data centers and GEOGLOWS. Likewise, interaction mechanisms between GTN-H, GEO Secretariat and UNESCO-IOC need to be explored and established.
- GTN-H actions to address the GEOSS Water Strategy need to be refined in the light of new developments in the water sector in GEO and expectations. Next to the consolidation of the configuration of GTN-H this would also include a more vigorous progress in the development of integrated data products.
- There needs to be a much closer interaction between GEOGLOWS and GTN-H and joint efforts to map and interact with respective user groups, an area that so far has not much progressed. Participants observed that at present, most user groups are characterized by the fact that data providers and users are the same and few user groups have been identified in the public domain outside academic circles.
- The relationship between Essential Water Variables and Essential Climate Variables has been discussed above and participants see a vital role of GTN-H to harmonize requirements for ECVs and EWWs in cooperation with WMO.

9. COOPERATION OF GTN-H WITH GCOS AND GEO

Aside from GTN-H activities for GCOS and GEO, there has been the interest of the GTN-H community that both GCOS and GEO would find ways of closer cooperation to minimize separated paths of activities of GTN-H and its federated data centers.

This has been a long standing issue. In the past, GTN-H strived to respond to the needs of both, the GCOS Program and the GEO community; the latter mostly through its contributions towards the Integrated Global Water Cycle Observations – Community of Practice (IGWCO-CoP). At several occasions in the past, GTN-H had expressed its interest for an enhanced cooperation between GCOS and GEO with the aim to synergize GTN-H activities for the benefit of both, GCOS and GEO.

Consultations between GCOS and GEO resulted in a new approach to closer cooperation that will be reflected in GTN-H activities and its liaison and cooperation with both GCOS and GEO.

There is also potential to link GCOS with other GEO entities (e.g., IOC, EPOS, IRIS). GCOS data are available to GEOSS, and GCOS shall have an improved visibility in GEO.

GEO is working with GCOS and ICSU to address the lack of coordination in the terrestrial domain since GTOS is defunct. The Frascati meeting mentioned above developed an overall strategy.

A structure for the terrestrial domain Subtask C1, Hydrology has been established with three main tasks according to the observational domains.

9.1 Coordination goals are:

1) Acquisition:

- Shared sites (e.g., integrated site system)
- Shared site database
- Identify and fill gaps
- Eliminate overlaps
- Coordinated observing methods and protocols (e.g., standards)

2) Delivery:

- Harmonized parameter formats and units (e.g., standards)
- Harmonized systems with increased interoperability
- Improved discovery and access of related cross-theme and cross-system observations

9.2 Coordination approach:

1) General:

- Agree on an overall framework within which terrestrial observation systems collectively operate (e.g., analogous to the Framework for Ocean Observations)

2) Specific:

- Create thematic working groups for within-theme discussion
- Focused workshops, online forums, discussions
- Clear identification of benefits to participants
- Create cross-theme discussion mechanisms

Based on current developments and including efforts of GTN-H (and specifically GRDC and HYDROLARE at this point), participants reiterated the necessity to **promote the integration of in situ observations with space based observations.**

The coordination of terrestrial observations has been a pressing issue and is also addressed in the GCOS Implementation Plan.



GCOS Implementation Plan

Action T1: Improve coordination of terrestrial observations	
Action	Establish mechanism to coordinate terrestrial observations: this will be particularly important for climate change impacts and adaptation where local information will be critical and will not be provided through GCOS directly. It includes biodiversity and natural resources information and could also incorporate socio-economic components (e.g. health) so as to become fine-tuned with post-2015 frameworks. This would be based on discussions with stakeholders and could include a formal framework or regular meetings to exchange ideas and coordinate observational requirements.
Benefit	Efficient observing systems with minimal duplication, delivering consistent and comparable data to a range of different users
Time frame	2017: Hold workshops to discuss way forward 2019: Mechanism in place.
Who	All involved in terrestrial observations. Initially TOPC, GEO, ICSU, GOFCC-GOLD, FluxNet, NEON
Performance indicator	Presence of active mechanism
Annual cost	US\$ 100 000–1 million

Aside from the existing capabilities of GCOS and including GTN-H, an option is also to use GEO’s convening power to facilitate, link, optimize, and integrate different observation networks.

A recurring issue has been the co-occurrence of Rolling Review of user Requirements that is undertaken by WMO for all observation variables in its domain, GCOS for the Essential Climate Variables (ECVs) and GEO for its Essential Water Variables (EWVs). The value of ECVs and EWVs is acknowledged. EWVs and ECVs overlap but have different requirements.

In the WMO domain, using the Rolling Review of Requirements (RRR) process defined by the Manual on the Global Observing System (WMO-No. 544) (Part II, Requirements for observational data), user requirements for observations are compared with the capabilities of present and planned observing systems. User requirements are collated in a comprehensive, systematic and quantitative way in the WMO Observing Requirements database, which attempts to capture observational requirements to meet the needs of all WMO programs.

In a similar way, GCOS and GEO perform their review of user requirements. Although the ECVs and the EWVs overlap to a large degree, the user requirements are differing. Discussing this issue at some length, participants recommended that GCOS and GEO, in consultation with WMO should strive to harmonize the requirements and provide transparent information on choices made in stating the requirements in such a way, that differences in requirements can be understood by the different user communities.

The latter could be done through adopting the process of preparing a Statement of Guidance (SOG), the main aim of which is to draw attention to the most important gaps between user requirements and observing system capabilities, in the context of the application (more to read under: <http://www.wmo.int/pages/prog/www/OSY/GOS-RRR.html>).

10. POSITIONING OF GTN-H

Panel members confirmed the essential function of GTN-H to link existing terrestrial observation networks for integrated observations of the global water cycle and facilitating access to data and information from its federated data centers.

GTN-H provides the global hydrometeorological network of networks of GCOS Essential Climate Variables and plans and implements activities through its federated data centres that facilitate access to hydrological and hydrometeorological data. The Panel reiterated that through its federated data centres, GTN-H provides the data-basis for integrated global and regional products covering most ECVs.

GTN-H supports GCOS and specifically the Global Terrestrial Observation Panel on Climate (TOPC) through:

- Provision of data and information from ECVs global data centers
- Contributions to the GCOS Implementation Plan
- Contributions to the Rolling Requirement Reviews for ECVs

With regard to WMO Programs and through federated data centers, GTN-H contributes in support of:

- Delivery of baseline data for Climate Services
- Water resources assessment and management at various scales
- Calibration of climate and water models

Support to GEO has significantly grown in importance including in the context of the EWVs through

- Observational “monitoring” of key elements of the global and regional/local water cycle
- Observations required by diagnostic and/or land surface/hydrological prediction models that are used to generate derived products for the end-user communities, and
- Observational and model-derived variables and parameters required by users of water data/information products as applied to various inter-disciplinary decision support systems and tools.

A new Community Activity “Terrestrial in-situ observations, standards, archiving, analysis and dissemination” has emerged in GEO with the principal objective “To provide general and specific, as well as selected tailor-made services to the GEOGLOWS program through the provision of data provided in standard formats to users including dissemination in accordance to agreed data policies, upkeep of data archives, and the further development of standards in cooperation with the Open Geospatial Consortium (OGC) and WMO”.

The strategic positioning of GTN-H and opportunities for service delivery had been a key topic for discussion of the 7th Session of the GTN-H Panel. Panel members at that session had 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 the Sustainable Development Goal – Water (SDG-Water) that has a renewed focus on earth observations both in-situ, from satellites and new data exploration approaches (“Big Data” and “Crowd Sourcing” concepts).

Panel members confirmed this view and further were seeking ways to back up this strategic approach with actual actions. Such actions are included in the Work Plan 2017-2019 below.

Panel members also urged the coordinator to further work towards an improved anchoring of GTN-H in ongoing programs of WMO, GCOS and GEO and in particular with regard to harmonizing ECVs, EWVs, the Rolling Requirements Review, standardization issues, and new data exploration approaches. This requires close cooperation especially with WMO (CHy, WIGOS, Commission of Basic Systems (CBS)) and the TOPC of GCOS. In the GEO context, close linkage is required with GEOGLOWS as a new development in the water sector that is administered by IGWCO-CoP.

These activities also require the development of user products, based on concrete requirements of GCOS, WMO (CHy, WIGOS, CBS) and GEO.

Panel members also reiterated the conclusion of GTN-H 7th session that it 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. Panel members were of the opinion that the UNESCO CAT II Centre “International Center for Water Resources and Global Change”, hosted by the German Federal Institute of Hydrology could be an important partner in this regard, but recommended that more efforts for the identification of support partners need to be undertaken.

11. GENERATION OF INTEGRATED DATA PRODUCTS IN COOPERATION WITH COLLABORATING PARTNER ORGANIZATIONS

The Generation of Integrated Products and integrated Web-based Services has been on the agenda since a number of years with slow progress. In part, this has been attributed to the scarcity of funds and resources but it is realized that there is an ever growing demand for additional services and products especially modelled products on the basis of multiple data centers’ holdings.

Participants welcomed that almost all data centers federated in GTN-H provide center-specific data products and in part also web-based services. All data centers reported a high demand for products. Supply of user-driven products is limited mostly through available resources at the level of the data centers.

A new window of opportunity is opening for the development of joint products generated through GRDC and GPCC and a list of potential products that are going to be resourced has been discussed recently between GRDC, GPCC and their hosting institutions, namely The German Weather Service (DWD) and the German Federal Institute of Hydrology (BfG).

Likewise, the GRDC – GEMStat centers are close to finalize the joint product on global geochemical fluxes from continents into the oceans.

Participants also saw the potential of using GRACE (or successor) and information from the ISMN and potentially GPCC for estimates of groundwater recharge.

Participants recommended that a pro-active effort should be made to identify centers of excellence (research institutions) to develop such integrated products and continue to seek external funding. Participants realized that the centers themselves will not have sufficient research staff to engage in research jointly with other centers.

12. WORK PLAN OF GTN-H 2017-2019

The Work Plan lists the actions agreed in the work plan 2015-2017 and steps undertaken / to be undertaken to close the action items. Considering the extended list of actions, the Panel decided to add only critical new actions and otherwise use the intersessional period to finalize pending action items. Action items 36 to 38 in the table below are new in this regard.

While the actions listed in the table below relate to actions towards GTN-H, GCOS, GEO, WMO and the federated centers of GTN-H, another document had been updated related specifically with regard to GTN-H contributions to the GEO Water Strategy. See below.

No.	Action	Who	Status/ next steps	State
1	Updated Meta-Database of “climate sensitive stations” basins available at GRDC	GRDC; WMO and inputs expected from TOPC Science-based overview 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 and TOPC (GTN-H Coordinator)	Ongoing, incorporated in GRDC data acquisition activities.	Continued action
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	Done. AQUASTAT is formally a member of GTN-H	Communication with Mr Jippe Hoogeveen, Administrator of AQUASTAT
3	Clarify how soil moisture network activities, including institutional data collection, move ahead	ISMN has been established (2010); there are funding issues in 2017 <i>Note: by finalizing this report, funding is secured until June 2019</i>	German Federal Institute has stated general interest to take over ISMN if necessary and appropriate	Funding issue by end of 2017, ISMN will further inform
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	GRDC, HYDROLARE will inform: renew activity.
5	Identify and apply software product suitable to manage hydrological metadata; implement domain-specific metadata profile	GRDC		Completed, promote applications, check impact continues

No.	Action	Who	State
6	Develop concept for the implementation of a groundwater recharge project, jointly by GPCC, IGRAC, ISMN, 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, partially pending, see IGRAC developments; GRDC to inform. Seek details; seek alternatives to Water-Gap, seek potential to make this a yearly updated product that is important for Water resources Assessment.
7	Explore the possibility of using GRACE and soil moisture for recharge estimates	IGRAC, ISMN	Renew efforts to communicate more closely 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: Informally ongoing, prepare an action plan
9	Expand data holdings on pristine basins and GTN-R	GRDC with WMO; Interest of GCOS and GEO?	On-going: GRDC requests data from climate sensitive stations in its data requests. Explore interest of GCOS and GEO
10	Ingest UNESCO-FRIEND data in database	GRDC in collaboration with FRIEND	Ongoing activity; clarify data use policy to match with that of GRDC/WMO
11	Seek access to bathymetric data for HYDROLARE	HYDROLARE and in cooperation with LEGOS-CNES	Identify sources for bathymetric data: HYDROLARE informing; alternates through altimetry observations undertaken Explore approaches using satellite information (LEGOS-CNES)
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: see IGRAC progress presentation; activities ongoing and partially completed
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: Done; but needs improvement to have focal points in NHSS. Same applies to Isotopes in Rivers

No.	Action	Who	State
14	Provide information on isotopes in surface waters	GNIP	Circulate additional information on this component: Pending. Resource issues at GNIP
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 This is completed, see WGMS presentation; change GTN-H configuration figure
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. New data management software has been installed and is in operation.
17	Seek access to groundwater quality data to be included in GEMStat	GEMStat and IGRAC	Identify sources for groundwater quality information. Research groups to be involved
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: In progress, not yet completed Partners to contribute overview papers; partially reflected in status presentations of data centers in 8 th GTN-H Panel session
19	Registration of data in the GEO Portal	All network partners, GEO	Provide clarification of the registration process of data in the GEO Portal: Done for GRDC. Other GTN-H partners to provide status information
20	Development and implementation of a GTN-H platform providing web-based services	KISTERS, probably also 52 North	Prepare concept note
21	Interact more closely with WIGOS, WIS and the development of WHOS	GTN-H and GRDC in cooperation with WMO	Develop and circulate a concept note on this issue: In progress, interaction is working
22	Registration of GTN-H datasets with WIGOS	CHy and GTN-H	In progress through federated data centers; request status of registration progress
23	Strengthen governance of GTN-H	CHy in cooperation with GTN-H partners including GCOS/TOPC	Done. GTN-H needs to be integrated in CHy Task Team to explore CHy links with data centres under the auspices of WMO

No.	Action	Who	State
24	Support of specific activities of GCOS		Initiate overview of activities that require direct support of GTN-H partner centres: In progress, mainly with TOPC
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: slow development, resource issues at GTN-H; see status below
26	Develop strategy paper addressing upcoming challenges and opportunities for GTN-H	GTN-H in cooperation with network partners and governing bodies	Re-start as a result of 8 th GTN-H Panel Session
27	Support of water resources management	GTN-H with partners	Initial contacts with WCRP/GEWEX: Failed in first attempt; restart, and also with WMO/CLW
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: slow start, needs to be further discussed and acted upon
29	Develop cooperative ties with the newly established Global Water Data Centre (GWDC)	GTN-H and network partners, GWDC	Stopped, as the Global Water Data Centre has ceased activities
30	Jointly using river runoff and water quality data: new web-based flux computation	GEMStat and GRDC	Deadline end of 2017 was missed, pursue further
31	Organize an expert meeting on geochemical fluxes and establishing the working group on that	GEMStat	Ongoing, not a priority at present: Not implemented
32	Explore the contribution of GPCC to the precipitation task of IGWCO	GPCC with IGWCO coordinator Rick Lawford	GPCC, GEO to follow up on this

No.	Action	Who	State
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	Continued : Is in full progress
34	GRDC to chart a process how the metadata standard and associated technology is being promoted into other domains and ECVs	GRDC	Completed, document results
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: Needs to be discussed further (HYDROLARE, IGRAC)
36	Cooperate with GCOS, WMO and GEO in the Rolling Review of Requirements	GTN-H, GCOS, WMO, GEO (GEOGLOWS, IGWCO, GEO-Sec)	Prepare overview of current state of RRR for related WMO variables, ECVs and EWVs prepare concept not with a proposed action plan to harmonize RRR where appropriate
37	Cooperate with GEO to define further actions related to the coordination of terrestrial observations	GTN-H, IGWCO, GEOGLOWS, GEO-Sec	Clarify roles of organizations/programs; develop strategy document with expected outcomes and based on common agreement, an action plan
38	Seek membership with OGC	GTN-H	Seek funding to pay annual membership fees for OGC

Planned and Potential activities

The GTN-H activities had been approved by the 7th session of the GTN-H panel, 17th June 2015. The information below provides an update with status June 2017 and activities for the intersessional period 2017 to 2019.

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. This needs to be undertaken within the scope of the Rolling review of requirements (RRR) process and harmonized with the RRR of GCOS, WMO and GEO. GTN-H is already contributing to the RRR of GCOS and its ECVs.

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. Explore feasibility.

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. This activity needs to be re-started as a result of resource issues at GTN-H.

A.5. An evaluation should be undertaken of the data holdings of global data centers to determine which centers 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 centers, in cooperation with cooperating partners a position paper could be developed to assess the utility of data provided by the centers in water cycle process models. There is presently no information on extreme events in any of the databases in the domain of GTN-H. Discuss further way to follow-up.

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.

Expanding data acquisition

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 GGMMN, 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 before end of 2018.

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 will be made to TOPC/GCOS at its next session in 2018 to link with GEO on observational requirements to make use of synergies and avoid duplication of efforts.

Strengthening in-situ data acquisition

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.

Planned action: Link up with FLUXNET and other research observation networks with a view to transfer such academic observation networks from research into on-going observation infrastructures. This would also mean to seek information on academic, long-standing observation activities in different domains through the federated data centers to be inclusive of academic observations that are in addition to regular, national observation networks funded by national governments or INGOS.

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.

Planned action: Link up with the WMO Global Cryosphere Watch (GCW) to identify high latitude stations as well as high mountain stations, all referring to stations representing the cryosphere environment.

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.

Action: GTN-H to continue in this field of activities and is prepared to partner with other data centers 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 is being discussed in the context of GEMSTAT and its evolving strategy for water quality observations, both surface and groundwater in close cooperation with IGRAC.

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 again discuss the feasibility of organizing a workshop in 2019.

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 selected lakes and reservoirs. This is being undertaken in close cooperation with CNES.

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.

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

Facilitating data sharing and common standards

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 2018 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. Federated data centres will be requested to document progress in this regard as a first step.

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.

Ongoing action: This is underway with respect to GRDC. GTN-H would be in a position to liaise with WMO's WIGOS and CHY 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.

Ongoing action: Through GRDC and in cooperation with OGC and WMO, GTN-H facilitates initiatives leading to an improved interoperability towards improved standardization and data reporting and sharing. *Membership in OGC is mandatory to pursue in this effort!*

13. 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 that are reflected in the text of the report and especially the agreed Workplan 2017-2019. Likewise, the activity plan of GTN-H in support of the GEO Water strategy was endorsed by the Panel members.

14. TIME AND PLACE OF THE 9TH SESSION OF THE GTN-H PANEL

Participants agreed that the 9th 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 2019 with exact dates to be communicated in due course.

15. CLOSURE OF THE 8TH SESSION OF THE GTN-H PANEL

The GTN-H Panel session adjourned at 4 p.m. on 21st June 2017

ANNEX 1: AGENDA

Tuesday 20 June

8:30 – 09:00	Registration (with tea and coffee)
09:00 – 09:15	Introduction and adoption of the agenda
09:15 – 10:00	Background information: New Developments
10:00 – 10:20	Coffee Break
10:20 – 12:30	Review of status of network partners, individual reports
12:30 – 13:30	Lunch
13:30 – 14:00	Data Quality and Access to Data
14:00 – 14:20	Augmentation of in-situ observations with satellite-based earth observations
14:20 – 14:45	GTN-H and its support to the GCOS Implementation Plan
14:45 – 15:15	Coffee Break
15:15 – 16:00	GTN-H and its support to the WMO Technical Commission for Hydrology (CHy)
16:30	Meeting adjourns
19:00	Dinner (hosted)

Wednesday 21 June

09:30 – 10:30	GTN-H and its support to the GEO Water Strategy
10:30 – 11:00	Cooperation of GTN-H with GCOS and GEO
11:00 – 11:30	Positioning of GTN-H
11:30 – 11:45	Coffee Break
11:45 – 12:30	Generation of integrated data products in cooperation with collaborating partner organizations
12:30 – 13:30	Lunch
13:30 – 14:30	Development of the GTN-H Work Plan 2017-2019
14:30 - 15:00	Agreement of the Work Plan for 2017-2019 with deliverables, milestones, and responsibilities
15:00 – 15:20	Coffee Break
15:20 – 15:40	Summary of conclusions and recommendations
15:40 – 15:50	Comments from GTN-H partners, time and place of next session
15:50 – 16:00	Closure of the 8th Session of the GTN-H Panel

ANNEX 2: LIST OF PARTICIPANTS

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