The Integrated Global Water Cycle Observations (IGWCO) Community of Practice (CoP) brings together the interests of a number of representatives from nations and organizations, experts, and resource managers who are interested in the use of water cycle data in the management of the world’s water on local, regional, and global scales. It involves people who are interested in the development of water cycle understanding, data products and information systems, the demonstration and assessment of the usefulness of these systems, the dissemination of the results through capacity-building and technology transfer, and the deployment of these systems and products through regional networks. The relationships among these elements are shown in Figure 1.

**Figure 1.** The links between the components of the IGWCO CoP.
The IGWCO Community of Practice has its roots in the former Integrated Global Observation Strategy Partnership (IGOS-P) and the community that implemented the IGOS-P water cycle theme. It now has strong ties to the Group on Earth Observations (GEO) but also fosters the development of broader global and regional networks that deal with science and applications issues. The objectives of the IGWCO CoP include:

1) Providing a framework for guiding decisions regarding priorities and strategies for the maintenance and enhancement of water cycle observations.

2) Promoting strategies that facilitate the acquisition, processing, and distribution of data products needed for effective management of the world’s water resources.

3) Coordinating and facilitating the inputs of the global water community into the Global Earth Observation System of Systems (GEOSS).

4) Developing tools, applications, and systems that facilitate the inclusion of water cycle information into decision-making.

The IGWCO theme was first introduced to IGOS-P in 2000 and a full proposal was accepted in 2001. The full plan was prepared through a series of regional workshops in 2002 and 2003, approved in 2003, and published in 2004. In October 2007, IGWCO transitioned from an IGOS-P theme to an element of GEO through an exchange of letters between the Secretariats of the IGWCO and GEO. It became a GEO Community of Practice in 2008 when it merged with a fledgling Global Water Cycle CoP within the User Interface Committee. This CoP provides the leads of the various GEO water subtasks with an opportunity to discuss their progress and plans. It carries forward a number of activities that have not yet been “vested” in the GEO work plan although they take advantage of GEO capabilities and help to maximize the CoP’s contributions to GEOSS.

As with most GEO activities, the IGWCO CoP is a “best efforts” activity. Although the CoP has a core membership, it is open for anyone to join. The successes described here are the result of efforts of individuals who often draw upon the support of organizations and networks of experts or, in a few cases, programme managers who are implementing initiatives approved by their agencies.

Background to GEO

GEO was formed to implement the Global Earth Observation System of Systems (GEOSS) by 2015. Currently more than 80 countries and 55 organizations are working toward this goal. GEO is coordinating international efforts to build GEOSS. This emerging public infrastructure is bringing together observational systems for monitoring and forecasting changes in the global environment. The main components within GEOSS are the Common Infrastructure where all of the data sets and data links that nations have contributed to GEO are accessible, the nine Societal Benefit Areas (SBAs) from which users and experts are gathered to help build the GEOSS, and the four committees that oversee the GEO activities. The wide range of activities generated within this structure are coordinated by the GEO Secretariat. Once complete, GEOSS will provide a distributed system of observational and information systems, improved coordination, links between all observational platforms, more effective data exchanges, assessments of gaps in our global capacities, improved abilities to use Earth Observations to address policy and services and research priorities for the Societal Benefit Areas.

Water is recognized within this structure through the Water SBA. Water is one of the priorities for GEO, in part as a response to the announcement at the G8 Summit in Hokkaido, Japan in 2008, during which leaders of the world’s most advanced countries stated, “we will accelerate efforts within the Global Earth Observation System of Systems (GEOSS), [...] in priority areas, inter alia, climate change and water resources management, by strengthening observation, prediction and data sharing. [...] capacity building for developing countries [...] interoperability and linkage…”. In 2009, GEO redefined the target for the Water SBA as follows: “by 2015, produce comprehensive sets of data, information products and services to support decision-making for efficient management of the world’s water resources, based on coordinated, sustained observations of the water cycle on multiple scales.” The 2009-2011 GEO work plan contains three specific tasks that relate to water. A large part of this brochure identifies the IGWCO’s role in these tasks and in achieving the overall water target for GEOSS.

GEO facilitates the transition of new developments to operations and provides user-friendly tools and information to help decision-makers and end users (such as farmers). Many of these decision-support tools are provided through the GEO Common Infrastructure and are accessible online.
DEVELOPMENT: INTEGRATED WATER CYCLE VARIABLES

Current capabilities of water cycle observations and systems are inadequate for monitoring long-term changes in the global water system and constrain decision-making for the sustainable development of water resources. Integrative initiatives have been launched to combine different types of satellite and in-situ observations to produce integrated data products for key variables of the water cycle (see Figure 2 for key components). Aggregating multiple types of data, such as in-situ data, satellite data, and model output data, gives them more value than they have when considered separately. Improving and expanding in-situ networks, combined with new and existing satellite missions and emerging assimilation and prediction capabilities, could introduce a new era in water management. Many of these activities contribute to the integrated products for the Water Resource Management and Research GEO task.

The IGWCO CoP provides a capability to facilitate and assess progress towards GEO goals. It has played a critical role in addressing the integration of in-situ and remote-sensing data for individual water cycle variables. For example, at a November 2009 workshop at the European Space Agency (ESA), it assessed the current state of progress in developing merged products and made recommendations for efforts to accelerate this process.

Precipitation

Precipitation is the Earth’s fundamental source of fresh water and determines the habitability of various areas. Variations in precipitation affect the consistent, dependable fresh water resources required for humans and the natural environment. Over land, in-situ point measurements of rain and snowfall are collected with precipitation gauges. Global analyses of precipitation over land and ocean with short update intervals are only possible using estimates from the global constellation of precipitation-relevant satellite sensors. To date, the IGWCO has focused on the development of multi-sensor satellite-based precipitation estimates.

Long-term, fully global analyses have been developed for the three-decade satellite record for use in long-term climate analyses and in the assessment of Earth system climate models. More recently, “high-resolution” datasets that support detailed studies typically covering only the last five to ten years have become available, thanks to the U.S./Japan Tropical Rainfall Measurement Mission (TRMM) and the French/Indian Megha Tropiques Mission. Both sets of analyses are improved by incorporating precipitation gauge data and by using these gauge data for calibration and ground validation. Substantial work remains to be done, particularly in providing accurate estimates at high latitudes and in complex terrain, and in establishing surface validation of the satellite data over oceans. The work on global precipitation products has been supported by a number of intercomparison studies that are being undertaken by the International Precipitation Working Group (IPWG) in collaboration with IGWCO.

Figure 2. Components of the global water cycle. (Courtesy of NASA)

Figure 3. Global Precipitation Climatology Project (GPCP) Version 2.1 precipitation climatology, 1979-2008, in mm/d. Developed within the Global Energy and Water Experiment (GEWEX), the GPCP products combine IR, microwave, and sounding data with gauge analysis. (Courtesy of George Huffman, NASA)
Given the long history of product development, the successful merger of data from many disparate sources, and the network of cooperating national organizations, precipitation has served as the pathfinder for other integrated variables. The high value of precipitation data to users has driven the development of increasingly open, accessible, and integrated datasets and allowed developing countries to take advantage of the data with increasingly user-friendly tools as well as new missions such as the planned Global Precipitation Mission (GPM). Agencies are working with developing countries to process the precipitation data to support monitoring and prediction of water and crop yields, droughts, floods, and landslides.

Contact: George Huffman, george.j.huffman@nasa.gov

**Soil Moisture**

Soil moisture is a critical variable because it controls the rate at which rain percolates into the ground or runs off. It affects the partitioning of energy between sensible and latent heat that is transported into the atmosphere. In some situations water is retained for weeks in some soils, creating a reserve of water for plant growth and strongly affecting plant productivity during the growing season. Due to the recent maturation of soil moisture observational activities (see Figure 4), soil moisture has been adopted by the Global Climate Observing System (GCOS) as an Essential Climate Variable (ECV). Through its links with the International Soil Moisture Working Group (ISMWG), IGWCO CoP has been helping to coordinate these soil moisture efforts.

Within GEO, the soil moisture focus has been on the development of a global soil moisture network and a data archive. This effort has been advanced by hosting workshops to promote the development of a global *in-situ* soil moisture monitoring network that could provide validation data for the recently launched Soil Moisture and Ocean Salinity (SMOS) mission and the NASA-planned Soil Moisture Active and Passive for Weather and Water Cycle Processes (SMAP) mission. Since soil moisture data must be archived to be of use, an archive is being organized at the University of Vienna. The extensive historical soil moisture dataset developed by Rutgers University has been added to this archive.

ESA launched its SMOS mission on November 2, 2009 to observe soil moisture over the Earth’s land masses and salinity over the oceans. As well as demonstrating the use of a new radiometer, the data acquired from this mission will contribute to furthering our knowledge of the role of soil moisture in the Earth’s water cycle. SMOS features a novel instrument that is capable of observing both soil moisture and ocean salinity by capturing images of emitted microwave radiation and carries the first ever polar-orbiting, space-borne, two-dimensional, interferometric radiometer.

Contact: Peter van Oevelen, peter.vanoevelen@gewex.org

**Runoff and Surface Water Storage**

Surface water is a critical source of water for domestic use, irrigation, energy production, and ecosystems. Runoff and river discharge are critical measurements for flood prediction and evaluating the hydrologic impacts of drought. They are highly relevant for the detection of climate variability and change. Through its links with the Global Terrestrial Network - Hydrology (GTN-H), the World Meteorological Organization (WMO), and GEO, Global Climate Observing System (GCOS), IGWCO strives to improve the network of hydrologic measurements and encourage more extensive use of these data.

Efforts in this domain have focused on obtaining data from a core network of 380 major global runoff stations which monitor continental freshwater fluxes into the world’s oceans. A project proposal known as HARON developed for the European Union (EU) forms the basis for actions in this area. In addition, satellite data are being used to produce experimental lake level data (see Figure 5).

**Figure 4.** Satellite Soil Moisture in Vol.%. Version 0.1. Multisensor (active+passive) soil moisture climatology (1992-2008). (Courtesy of ESA)

**Figure 5.** Historical variations in lake levels for Lake Victoria (Africa). The decreases during the last decade have been derived from satellite data. They reflect regional drought, excessive water releases for power generation after 2001, and non-compliance of the 1954 Nile Treaty. (Courtesy of Charon Birkett, University of Maryland, College Park)
To support this initiative, technical activities related to the calibration and rating curves for select rivers and storage volume changes for large lakes and reservoirs are being implemented primarily through WMO’s Global Runoff Data Centre (GRDC). In addition, a country-by-country inventory of stream flow measurement status and data transfer issues is being developed.

Contact: Wolfgang Grabs, wgrabs@wmo.int

Groundwater

As surface water supplies diminish in volume or become more contaminated, people in many parts of the world will increasingly rely on groundwater for their water supply. Groundwater data are essential for assessing changes in groundwater resources and evaluating the vulnerability and sustainability of strategic aquifers. Experts from the GEO Geohazards community and the United Nations Educational, Scientific and Cultural Organization (UNESCO) International Hydrology Programme (IHP) and WMO support the IGWCO and GEO Water Cycle efforts in this area.

Currently, scientists use three complementary approaches to estimate the state of groundwater resources, including terrestrial site-specific groundwater monitoring, satellite remote-sensing systems (e.g., the Gravity Recovery and Climate Experiment, GRACE), and hydrological models. Given the stage of development of these last two approaches, IGWCO is giving some priority to use of existing data, information gaps in the availability of in-situ groundwater data, and the use of these data in the calibration of other techniques.

Even in-situ measurements pose some challenges. Groundwater is monitored in many parts of the world mainly by measuring groundwater levels, groundwater abstraction, spring discharge, and groundwater quality. Although these measurements can be interpolated and combined with other information to produce various groundwater thematic maps, they are rarely standardized or made available across jurisdictions. To fill this gap, the International Groundwater Resource Assessment Centre (IGRAC) and its partners are working with IGWCO to establish a sustainable Global Groundwater Monitoring Network (GGMN; see Figure 6). This activity will involve setting up a network of regional and national groundwater experts, choosing adequate groundwater variables to be reported, and choosing derived variables or indicators to describe the state of groundwater resources and trends (see http://www.igrac.net/publications/281 for further details).

Work on merging in-situ groundwater data with other data types also is being encouraged by IGWCO. The twin GRACE satellites sponsored by the USA and Germany, launched in March 2002, are the only remote-sensing technique currently able to monitor changes in groundwater quantity at a very large scale. GRACE measures changes in the Earth’s gravity field on a monthly basis. By accounting for changes in atmospheric mass, it is possible to generate global and monthly fields of terrestrial water storage (see Figure 7). Hydrologic models aid in isolating groundwater from GRACE-derived total terrestrial water storage changes. A future step will bring the IGRAC Global Groundwater Monitoring System (in-situ) data and the remote-sensing (GRACE) and global hydrological modelling datasets together to produce an integrated groundwater product.

Contacts: Sophie Vermooten, sophie.vermooten@deltares.nl
Matt Rodell, matthew.rodell@nasa.gov
Water Quality

The deterioration of surface water quality through the effects of contaminants, nutrients, excess heat, and other factors is arguably the greatest threat to future water availability. Health studies show that water-related illnesses are a major global problem. Clearly, having and maintaining suitable water quality is critical to sustaining life on our planet. Operational systems using remotely-sensed global-scale freshwater quality are non-existent. Operational observation systems need to be developed and the resulting information systems made compatible and interoperable as part of the system of systems. Monitoring water quality using remote sensing, in conjunction with strategic in-situ sampling, is needed to determine the current status of water quality conditions and to help anticipate, mitigate, and even avoid future water catastrophes. Satellite remote sensing offers a promising alternative for scientists and managers who need assessments of a large number of water bodies in an economical and timely fashion.

Figure 8. Moderate Resolution Imaging Spectroradiometer Satellite (MODIS) image of river plume entering the Great Barrier Reef after significant rainfall, February 9, 2007. (Courtesy of CSIRO)

IGWCO recognizes the importance of bringing together satellite and in-situ measurements to determine if tools could be developed for estimating water quality in areas with a few or no measurements. To explore these possibilities, a GEO Inland and Nearshore Coastal Water Quality Remote Sensing Workshop was held in Geneva, Switzerland. Subsequently, a water quality working group was established. This group links the research and development communities developing remote-sensing-based techniques for coastal and inland water quality assessment and the different user groups that require such information. Related activities and discussions have identified the need for the continuity of existing satellites, development of new and improved sensor/platform technology, algorithm development and calibration/validation activities, improvements in data accessibility, education, demonstration projects, and the formation of a scientific group dedicated to inland and coastal water quality remote sensing.

Contact: Steven Greb, steven.greb@wisconsin.gov

Evaporation and Evapotranspiration

Measurements of evapotranspiration (ET) are important for understanding the influence of the plant canopy on the water vapour content of the atmosphere and for estimating the rate of plant growth. Evaporation from the ocean is a large problem; it is addressed through SEAFLUX and other projects. Evaporation from inland lakes, however, is less well documented. FLUXNET provides in-situ eddy correlation estimates from flux towers, which are concentrated in developed countries, while Land Data Assimilation Systems (LDAS) provides model estimates of evapotranspiration without strong validation in the more remote areas. The Global Energy and Water Cycle Experiment (GEWEX) has launched a new project known as LANDFLUX to estimate evapotranspiration from satellite data for a grid covering the land areas of the world. Added to these efforts are regional and national methods for producing evapotranspiration estimates for irrigation planning and other purposes.

Figure 9. NASA Aqua mission. (Courtesy of NASA)

ET is a complex surface water flux that can be estimated in a number of ways. While IGWCO has been tracking progress in this area, it has not developed a concerted effort for data product development. Thanks to the interest of the National Aeronautic and Spacy Agency (NASA), however, an activity has been started that could lead to a GEO task related to evapotranspiration. This task will involve bringing together data and experience from different sources to meet the needs of users and to promote the exchange of technical information among the researchers who focus on different approaches to estimating regional and global ET.

Contact: David Toll, david.l.toll@nasa.gov
Data Integration and Analysis

Building on the work of the GEWEX Hydrometeorology Panel (GEWEX GHP), formerly known as the Coordinated Energy and Water Cycle Observations Project (CEOP), this activity tests out the potential benefits of integrated data and analysis systems in a science environment. The distributed CEOP archives include reference station data, satellite data, and Numerical Weather Prediction (NWP) model data, all quality-controlled and made available through a common interface. It is maintained through reliance on international cooperation and the commitment of reference site operators, scientists, and data processors.

The first phase of this activity was designed to demonstrate the value of a fully integrated data system to support research and applications. It involved the development and population of a distributed archive for datasets from the 2001 to 2004 period. Currently, the system holds quality-assured data from 35 terrestrial reference centres (archived at the National Center for Atmospheric Research (NCAR)), 12 NWP/Data Assimilation Centres (archived at the World Data Center for Climate, Max-Planck Institute for Meteorology, Germany), and data from nine satellite platforms (archived at the University of Tokyo and Japan Aerospace Exploration Agency (JAXA), Japan). The data system is fully compliant with the ISO TC/211 19115 metadata standard.

A new water portal is currently being developed under the Committee on Earth Observing Satellites (CEOS) and Working Group on Information Systems and Services (WGISS). This web-based portal system will provide data access to a variety of hydrological and water-relevant data scattered all over the world for hydrologic scientists and non-researchers or operational users who are dealing with these data. The portal will retrieve data from distributed data centres, enable analysis of the data, and let users download the results and display them as images and plots.

Contacts: Toshio Koike, tkoike@hydra.t.u-tokyo.ac.jp
Wolfgang Grabs, wgrabs@wmo.int

Promotion of Hydrologic Data Exchange

Efforts are under way to develop better interactions between water cycle data centres. Recently, as part of an Architecture and Data Committee Task, surveys were completed by 16 water cycle data centres. A preliminary analysis of these surveys has identified ways in which they could become more interoperable and how alliances between centres could be developed to increase the access by users to hydrologic data from all parts of the world. The schematic below (see Figure 10) suggests a pathway for developing this interoperability.

\[ 	ext{Figure 10. Pathway for developing interoperability between data centres. (Courtesy of Richard Lawford, University of Maryland Baltimore County)} \]

Contact: Richard Lawford, lawford@umbc.edu

Water Cycle Multi-mission Observation Strategy

The integration of observational systems is being assessed as another way of providing an understanding of the role of the global water cycle in the Earth system. In this context, ESA, in collaboration with GEWEX, launched the Water Cycle Multi-mission Observation Strategy (WACMOS) project early in 2009. WACMOS seeks to integrate systems to provide space-based measurements of hydro-climatic variables for all components of the water cycle. This initiative’s objective is to develop and validate a product portfolio of novel geo-information products responding to the GEWEX scientific priorities and exploiting the synergic capabilities between ESA Earth Observations data and other non-ESA missions, and to explore and assess different methodologies to exploit different observations in a synergic manner with a view to developing long-term consistent datasets of key (essential) variables describing the water cycle. WACMOS focuses on four components of the water cycle, namely: transpiration, soil moisture, clouds, and water vapour. This concept, the selection of the primary variables, and planning for the next phase of development were the focus of a November 2009 workshop at ESA.

Contact: Diego Fernandez, diego.fernandez@esa.int
DEMONSTRATION:
PILOT PROJECTS

Forecasting and Early Warning Systems for Droughts and Floods

Users of hydrologic predictions need reliable, quantitative forecast information, including estimates of uncertainty, for lead times ranging from less than an hour during flash flooding events to more than a year for long-term water management. Research advances in areas such as hydrologic modelling, data assimilation, ensemble prediction, and forecast verification need to be incorporated into operational forecasting systems to ensure that the state-of-the-art products are reaching the forecast user community. Operational agencies with hydrological ensemble forecast techniques are best able to account for sources of uncertainty in their forecasts and utilize the results of ensemble prediction research. The Hydrologic Ensemble Prediction Experiment (HEPEX) has been formed to develop and demonstrate new hydrologic forecasting technologies and to facilitate the implementation of beneficial technologies in operational environments.

HEPEX has developed an implementation plan and is making progress through 20 testbed projects and the collaboration that occurs among them. These testbeds either have a focus on a geographical area or on a science issue important to a given region or cross-cutting a number of regions. Recent advances include the launch of the development of an ensemble forecast based decision support system to support the operation of the New York City water supply system and planning for a November workshop on hydrological uncertainty.

Contact: John Schaake, john.schaake@noaa.gov

Regional Drought Impact Assessment

Drought impacts are regional and local, and represent a complex interaction between natural causes and human factors such as land use, water use, and climate change. Drought has very large economic impacts on society due to crop loss, lower water quality, water scarcity, forest fires, and reduced hydropower generation, among many others. This task is critical for demonstrating the use and value of Earth Observations to aid society in addressing drought conditions.

The task is developing linkages between those regions around the world that are affected by drought and gathering information on drought impacts. In particular, it tracks and analyzes impacts from drought (including feedbacks such as soil drying) to provide a tangible and practical demonstration of the value of integrated water cycle observations.

A number of these connections have been documented by the Drought Research Initiative (DRI), which has shown that drought, as represented by water demand indices, reduces both the quantity and quality of grain grown on the Canadian Prairies. Improved drought monitoring could help provincial governments assess the extent and severity of drought impacts and support federal-provincial discussions regarding drought relief programs. DRI has also been advancing work on the use of streamflow, soil moisture, and wetland counts in monitoring hydrological droughts.

Structured interactions between the research community and food producers are occurring through the Drought Preparedness Project (DPP) and the Drought Early Warning System (DEWS), a “table top” exercise designed to gather input from the agricultural community regarding its needs for drought-related data products. Based on these experiences, project leads plan to develop a framework for assessing value added by the full data cycle of drought information from “producer-to-consumer”/“source to sink,” with a special emphasis on the agriculture sector.

Contact: Richard Lawford, lawford@umbc.edu

Global Drought Monitoring

International workshops, conferences, and panels have for many years noted the importance of drought monitoring in a globally changing climate and have called for the creation of drought early warning systems. A global-scale drought monitoring, mitigation, and response system would provide important benefits to all nations affected by drought, and in particular those most at risk as global climate regimes shift, and those least able to develop their own early warning system. National and regional drought monitoring networks have been created in many areas around the globe, but a Global Drought Early Warning System (GDEWS) remains elusive. The creation of a GDEWS faces many hurdles, including but not limited to station density, data timeliness, international data-sharing, lack of applicable indicators, and resource constraints. The North American Drought Monitor (NADM) integrates national assessments from the U.S., Canada, and Mexico into a continental product using continental drought indicators computed using the same methodology and standardizing period as a guide.

For a GDEWS to be successful, Drought Monitors for each continent or region will need to be prepared using a model uniquely adapted to
the requirements and resources of each region or continent. As a first step, it was recommended at a recent Global Drought Assessment Workshop in Asheville, North Carolina, USA, that a web-based foundation should be created upon which a GDEWS could be built. This foundation – a Global Drought Monitoring portal (GDMP) – would concentrate on providing a few representative in-situ depictions of drought on the global-scale, as well as leveraging and consolidating remotely-sensed data and products for continental-scale analyses (see Figure 11 for a conceptual framework of the GDMP). It would also serve as the mechanism through which the continental Drought Monitors could be consolidated into a global service. While it was noted that WMO and GEO play an important role in global drought monitoring, it was recognized that they may not have the resources in-house to develop and maintain such a clearinghouse. One solution focused on extending U.S. Drought Portal capabilities to provide a coordination and delivery mechanism for the GDMP. This work focuses on the initial stages of integrating the various drought data and monitoring activities but it is anticipated the GDMP will be expanded to include impacts, mitigation, forecasts, research, education, and planning.

Figure 11. Concept for a Global Drought Monitoring Portal (GDMP). (Courtesy of Richard Heim, NOAA)

Contacts: Richard Heim, richard.heim@noaa.gov
Michael Brewer, michael.j.brewer@noaa.gov
Chad McNutt, chad.mcnutt@noaa.gov

AIP-3 Global Drought Monitor

Drought monitors generally use drought indices based on one or more water cycle variables to delineate areas of drought. The current approach to a global drought monitor involves bringing together a number of operational or quasi-operational drought monitors and making them interoperable to provide a comprehensive assessment of global conditions. At present, the European Drought Observatory (EDO), the USA National Integrated Drought Information System (NIDIS), and the Princeton University Experimental African Drought Monitor (PADM) are being made interoperable to demonstrate how this monitor could work. Interoperability will be achieved by having common input requirements, so that drought and climatology maps can be shared among the systems or by a software “broker” that can exchange information among the systems. Plans are already under way to extend coverage to South America and the Russian Federation (as well as Pakistan, India, Bangladesh, China, and other countries in South Asia) and Australia. A GEO Global Drought Monitor that will provide access to historic maps is also being developed by several agencies and as a contribution to the GEOSS Common Infrastructure.

Contact: Will Pozzi, will.pozzi@gmail.com

Pilot Projects for Improved Water Discovery and Quality Assessments

In support of GEO goals and a vision for needs of humans in developing countries, the Institute of Electrical and Electronics Engineers (IEEE), in collaboration with IGWCO, has launched a “Water for the World” activity. In addition to providing direct assistance in developing countries, it also helps to shape the advance of Earth Observations in positive and demonstrable ways. The IEEE activity has stimulated the water science community to produce 12 project proposals for development of applications that will benefit developing countries. IEEE has initiated the first phase of selected pilot projects in cooperation with local, regional, and national groups and other organizations to provide water quantity and quality assistance where they are needed but not available. In particular, IEEE encourages those projects that are realizable in the field within one year and meet the criteria of being sustainable, reusable, repeatable, and scalable. One of the projects in the village of Melva in northern India has been funded and has produced beneficial results by enabling a community with unreliable water supplies to gain access to quality water on a year-round basis through water harvesting. Earth Observations are used for site selection and management. Development of water quality monitoring is planned for 2011.

Contact: Tom Weiner, t.weiner@ieee.org

Mountain Water Resources

This GEO task seeks to analyze the future of water resources in vulnerable mountain regions in the context of climate change and more frequent extreme events. It builds upon an European project, Assessing Climatic Change and Impacts on the Quantity and Quality of Water (ACQWA) for developments in downscaling techniques for hydrological modelling and water policy recommendations for decision-makers. A hierarchy of models will be used, including hydrologic models to project the influence of climatic change on river discharge and regional climate models to provide information
on shifting precipitation and temperature patterns. Environmental and socio-economic responses to changes in hydrological regimes are being analyzed in terms of hazards and impacts on aquatic ecosystems and local economies. The European Alps, with their relatively high level of economic development and robust institutional structure, are being compared with the Andes and Central Asia, where poverty and latent conflict compromise effective water management.

Contact: Douglas Cripe, dcripe@geosec.org

**Flood Warning Systems**

IGWCO has begun to work with the WMO Flood Forecasting Initiative (FFI), which is building its capacity to provide expertise to support warning systems. This activity contributes to GEO through its key deliverables, which include the development of integrated forecasting products and the development and implementation of demonstration projects. Among ongoing activities are the conduct of a flood forecasting model intercomparison project and the development of a framework for the assessment of the efficiency of flood forecasting services. In terms of integration, the major expected outcome of the Coastal Flood Inundation Demonstration Project (CFIDP) is expected to provide software to couple meteorological (tropical cyclone), hydrological (river), and ocean (storm surge) forecasting models. WMO co-leads the implementation of this project. WMO, together with its partners, also leads the regional implementation of a Flash Flood Guidance System (FFGS) with global coverage, using terrestrial and satellite-based real-time observations. These systems are intended to provide early awareness of impending local flash flood threats, enhanced collaboration with meteorologists and hydrologists and disaster management agencies, and improved community awareness of flash flood disaster threats.

The Asian Water Cycle Initiative (AWCI) is contributing to flood relief on a regional basis. They are supporting relief activities and recovery planning in Pakistan after heavy rains caused extensive floods in the summer of 2010. The inundation area was continuously observed by the Advanced Land Observing Satellite (ALOS, “Daichi”) of JAXA. The processed data sets overlaid on the ASTER Global Digital Elevation Model (ASTER GDEM) and the Google Map have been offered to the government of Pakistan.

![Figure 12. Data products developed by GEOSS/AWCI to assist Pakistan in planning its flood relief efforts. (Courtesy of Toshio Koike, University of Tokyo)](image)

Contacts: Wolfgang Grabs, wgrabs@wmo.int
Toshio Koike, tkoike@hydra.t.u-tokyo.ac.jp

**Indicators and Applications**

Adequately addressing socio-economic concerns and sustainable water development requires comprehensive datasets built upon a broad range of data types, sources, and collection methodologies. Socio-economic data, such as demographic data, in combination with products derived from the IGWCO water cycle variables, provide value-added data products with a wide range of applications. For example, work is ongoing to correlate regional drought severity indices with the production of grain on a regional basis. IGWCO envisions a two-step process for these developments, including interactions with users, and the development of indicators.

Contact: Charles Vorosmarty, cvorosmarty@ccny.cuny.edu
IGWCO has launched an active capacity-building program that focuses on Central and South America, Southeast Asia, and Africa. This effort has been advanced through a series of capacity-building workshops and the implementation of regional training programs.

Centre of Hydrologic and Spatial Information for Latin America and the Caribbean (CIEHLYC in Spanish)

Countries in Latin America, including Caribbean countries, have major problems with the management of water. IGWCO Capacity Building workshops have been held in Argentina and, more recently, in Peru. Initially, work was directed at developing a Capacity Building plan modelled after the TIGER project. Subsequently it was felt that a better understanding of the full scope of research under way in Latin and Caribbean America was needed. As a result of this latest workshop, a group known as Comunidad para la Información Espacial e Hidrológica en Latinoamérica y el Caribe (CIELHYC) has been established. Together with the Comisión Nacional de Investigación y Desarrollo Aeroespacial (CONIDA), this group has now begun to develop a dynamic bilingual webpage that will include a list of the many water cycle data services and projects in Latin and Caribbean America. The group has also applied to be recognized as a working group under GEOSS in the Americas. Based on discussions held at the 2009 Peru workshop, the priority water issues for this area are floods and drought, adapting to the effects of climate change in melting tropical glaciers (see Figure 13), water quality, and other environmental changes. These efforts will build on existing capabilities such as the SERVIR platform, which has been very successful in Panama and throughout Central America. Given that the IGWCO capacity-building discussions have not yet involved all countries in the region, plans are in place for undertaking a survey of the priority development needs in the missing nations. The group has also developed a working relation with the U.S. UNESCO group and is developing links with other international bodies.

Contacts: Richard Lawford, lawford@umbc.edu
Angelica Gutierrez-Magness, angelica.gutierrez@noaa.gov

African Water Cycle Coordination Initiative

The African Water Cycle Coordination Initiative (AWCCI) develops synergies and cooperation between the various water cycle projects that cover Africa, assists African countries to overcome problems faced in the collection, analysis and dissemination of water-related geo-information, and exploits the advantages of Earth Observations (EO) to build the basis for an independent African capacity and establish sustainable water observation systems. In addition, these activities will build on the extension of the Central American SERVIR (visualization and monitoring using Earth science data) for hydrologic applications (e.g., flood warning) to East Africa and possibly other parts of Africa. NASA and USAID (United States Agency for International Development) are preparing to launch eight new SERVIR nodes in Africa and the Middle East. Other important projects include the hydrologic data integration and the Land Information System (LIS). Japan has also funded work in Africa that will increase the number of capacity building projects.

In the coming years, efforts to provide adequate water resources for Africa will face several challenges, including population pressure, problems associated with land use (erosion/siltation), and possible ecological consequences of land-use change on the hydrological cycle. Climate change – especially changes in climate variability through droughts and flooding – will make it more complex to address these problems. The first AWCCI symposium concluded that although the "quantity and quality of available freshwater is crucial for the planning and efficient and sustainable water resources development and management in Africa, the status of the hydrological network is generally inadequate to satisfy the minimum needs for
TIGER Initiative

The TIGER Initiative was launched by ESA, the Canadian Space Agency (CSA), the Council of Scientific and Industrial Research (CSIR), and UNESCO in 2002. From 2005 to 2008, TIGER supported African partners by providing access to space-borne data and products, and dedicated training on EO applications for water management, by funding North-South collaborative projects aimed at developing and demonstrating EO-based water information systems, and by facilitating system operationalization and technology transfer to African water authorities. TIGER has involved more than 150 African organizations (water authorities, universities, technical centres) through its projects and capacity-building activities. Based on these results, the second phase was launched at the Fifth World Water Forum in Istanbul in March 2009. The main objective of this second phase is "to contribute to support the development of a sustainable African Water Observation System making the best use of EO technology to improve the collection of water information, to enhance knowledge of water cycle and to improve monitoring of water resources for effective adaptation and mitigation measures against impacts of climate change." It involves 20 African projects distributed all around the continent. These projects are supported by the TIGER Capacity Building Facility, involving a consortium of African and European expert centres led by the Faculty of Geo-Information Science and Earth Observation (ITC) of the University of Twente, which provides training and capacity-building support to all the teams.

Contact: Diego Fernandez, Diego.Fernandez@esa.int

Capacity Building in Asia

Aided by funding from the Asian Pacific Network, the AWCI has launched a very successful capacity-building activity that provides training to technical and scientific staff in order to develop sustainable mechanisms for use of advanced Earth Observations systems, associated data, and tools for water cycle research and water resources management under the GEOSS framework. Priority issues being addressed through these efforts include downscaling regional and global information to basin scale; improving forecast accuracy for operational water management applications through a combination of numerical forecasting and fusion of local observations; and identifying reliable and efficient tools to convert the available observations and data to useful information for flood management.

Given the disparity in existing capabilities among different countries as well as their varied needs, AWCI devotes considerable effort to
priority needs assessments. Based on these assessments, floods, droughts, and water quality are the three primary focus areas for AWCI. AWCI has surveyed the capacity development needs of the member countries. The participating universities, space agencies, and research institutes have already registered modules for training. AWCI can design unique training courses by aggregating several modules. Various types of training courses have already been offered responding to actual needs.

Mode 2: Training module-based presentations (modules in intensive workshop designed by professional trainers held at training institutes).

Mode 3: Using country data for analysis and training (module-based presentations and hands-on courses that involve some problem-solving and specific applications, often including people from a number of countries).

As Figure 17 indicates, EO training activities are very popular in Southeast Asia.

Contact: Toshio Koike, tkoike@hydra.t.u-tokyo.ac.jp

User Needs Assessments

The design of all aspects of the IGWCO CoP activities depends on users’ views of what is important. In response to a user needs assessment exercise by the GEO User Interface Committee, NASA and IGWCO CoP led an exhaustive analysis of user needs for water cycle data as documented in earlier literature. Under the guidance of a distinguished panel of international experts, the study leader reviewed end-user requirements in (a) water resources management; (b) climate and global change; (c) weather and extremes; (d) seasonal to inter-annual climate prediction; (e) industrial and economic aspects, including agriculture and energy, among others; (f) environmental and ecosystem aspects; (g) emergency management; (h) transportation (air, land, water); (i) human health with a focus on water-related disease vectors; and (j) tourism and recreational activities.

Contact: Sushel Unninayar, sushel.unninayar@nasa.gov

In addition, a generic template is used for each problem area to plan capacity-development and training activities. The training is provided in three modes:

Mode 1: Country-based presentations (roving seminars in a local catchment with a number of training modules from within a country).
DEPLOYMENT: REGIONAL COMMUNITIES OF PRACTICE

The deployment of integrated systems that consider the developmental and research components of systems and their architecture and user integration are often designed at the regional level. This development aspect is addressed by regional Communities of Practice which exist either permanently or for a limited time linked to a sustaining grant.

**GEOSS Asian Water Cycle Initiative Community of Practice**

Building on the AWCI, this activity develops competencies among water management practitioners, researchers, and administrators (AWCI addresses climate change monitoring in Asia through the integration of in-situ and satellite/remote sensing). In addition, it builds on Sentinel Asia to develop disaster management support systems in the Asia-Pacific region and builds capacity for use of satellite images.

Approximately 40% of the world’s population lives in Southeast Asia, creating great pressure on nations to keep their citizens safe and fed. Better systems for warnings and information on floods, droughts, and other natural hazards are urgently needed. The improved use of integrated satellite and in-situ observations together with advanced data assimilation and prediction systems is critical for ensuring that these information services adequately meet the needs of nations for warning systems and for planning tools. Furthermore, training and education is needed so people in every country will have access to information and use it to avoid disasters and take full advantage of opportunities provided by the freshwater in their natural environment.

To address these common water-related issues, Asian country representatives established the Global Earth Observation System of Systems Asian Water Cycle Initiative (GEOSS/AWCI) in 2005. The GEOSS/AWCI promotes the Integrated Water Resources Management by making maximum use of the GEOSS. Twenty member countries work together to use EO to address regional problems. The hydrological data is archived under a fully open data policy. Satellite data, weather and climate prediction model outputs, and ground-based observed data are integrated to generate information to make sound water resources management decisions.

Contact: Toshio Koike, tkoike@hydra.t.u-tokyo.ac.jp

**EUGENE: Consolidating Europe’s Role in GEO Water**

EUGENE (European GEO Network) is funded under the Seventh EU Framework Programme (FP7/2007-2013) under grant agreement FP7-244165. EUGENE is designed to improve the coordination, visibility, and impact of European GEOSS contributions to the Water SBA and Climate and Disaster SBAs. Assessment reports were developed for each SBA. They were reviewed and European strengths, existing gaps, challenges, and future opportunities were discussed. The results of these workshop discussions will form the basis for proposals on a further refined European approach to GEO.

Europe plans to contribute to the Water SBA through improved operational hydrological networks, several pan-European Earth Observation data archives—such as the Water Information System for Europe (WISE) in support of the European Water Framework Directive (WFD), and Integrated Water Resources Management (IWRM)—and remote sensing technologies that deliver relevant hydrological parameters. Priorities for EUGENE’s water activities include water quality and groundwater observations; coordination of in-situ observations of water cycle variables; increased access to hydrological data; enhanced European involvement in GEO water-related tasks; and capacity-building, especially through Global Monitoring for Environment and Security (GMES) Africa.

Contact: Michael Nyenhuis, michael.nyenhuis@uni-bonn.de http://www.eugene-fp7.eu/

**Emerging Canada GEO - U.S. GEO Community of Practice Activities**

As a result of workshops and meetings, U.S. GEO and Canada GEO have combined their efforts to explore water-related topics in three testbeds along the Canada-U.S. border. The Great Lakes testbed coordination group focuses on the registration of data between the U.S. and Canada. It is coordinated by a diverse group of scientists from the U.S. and Canada involved with water data related to the lakes. This group has developed a plan to consolidate ice cover, water level, groundwater, and beach closure data from around the Great Lakes in an internet-accessible, interoperable, standardized format as a first step. A common infrastructure portal will advance the implementation of international treaty obligations in the fields of environment and sustainable development and will provide stable, reliable, and long-term operations of land, sea, atmosphere, and space-based EO networks and systems within the framework of national policies and international obligations.
The Prairies testbed focuses on soil moisture. During the spring of 2010, AAFC collected 24 RADARSAT-2 fully polarimetric images over the Brunkild watershed site in Manitoba. These data are being used to test radar models to estimate surface soil moisture. Products on crop type and crop condition monitoring using multi-frequency radar data also have been collected and will be used to assess the application of these data for crop type identification.

Contacts: Ken Korporal, kenneth.korporal@ec.gc.ca
Peter Colohan, Peter.Colohan@noaa.gov

**WaterNet Community of Practice**

WaterNet is a NASA-funded solutions network that brought together researchers, stakeholders, and end-users of remote-sensing tools that will benefit the water resources management community. As such, it functions as a NASA Water Cycle CoP by bringing together researchers and decision-makers involved in water cycle-related work. WaterNet was designed to improve and optimize the sustained ability of water cycle researchers, stakeholders, organizations, and networks to interact, identify, harness, and extend NASA water-related research results to augment decision support tools that address national needs.

The network demonstrated the capability to move initiatives from project definition to conceptualization, infrastructure development, and increased system interoperability. As such, it was considered a regional CoP. When active, the regional CoP engaged more than 50 agencies from the United States to Europe and Asia.

Contact: Lydia Gates, lydiagates@aol.com

**Partners**

The Global Terrestrial Network – Hydrology (GTN-H) (see http://gtn-h.unh.edu) provides a strong basis for WMO-IGWCO interactions: managers from the data centres and networks provide the data services upon which IGWCO relies. Most GTN-H networks are active in supporting the goals of IGWCO. Both WMO and the new GTN-H Secretariat at New York City University facilitate the coordination of these activities.

WMO (see http://www.wmo.int), the specialized United Nations agency for weather, climate, hydrology, and water resources, organizes projects and sets standards and best practices for many water cycle variables. It also coordinates interactions with the National Meteorological and Hydrological Services (NMHSs) of its 189 members. In addition to the initiatives described earlier, WMO benefits IGWCO through the WMO Integrated Global Observing Systems (WIGOS), the WMO Information System (WIS), the Global Framework for Climate Services (GFCS), and the WMO Technical Commission for Hydrology (CHy), which stated that contributions to the objectives of GEO Water Tasks would use the IGWCO as the principal platform for its contributions.

GEWEX is a core project of the World Climate Research Programme. It deals with observations, modelling, field campaigns, and applied research in water cycle sciences (see http://www.gewex.org). GEWEX has been a leading organization in the launch and development of IGWCO and the IGWCO CoP since 2000.

The National Oceanic and Atmospheric Administration (NOAA) (see http://www.noaa.gov) has a mandate to improve forecast capabilities and information services for weather, water, and climate, and has a responsibility for national stewardship of marine resources. NOAA has supported IGWCO development activities and, more recently, its capacity building activities in Latin America.

NASA (see http://www.nasa.gov) has provided long-term support to water cycle activities in the U.S. and internationally. Many NASA systems and research activities support the development of data products, models, and information systems used in IGWCO. Both the NASA Energy and Water Study (NEWS) and the NASA Applied Sciences Program–Water Resources provide direct support to IGWCO activities.

JAXA (see http://www.jaxa.jp) continues to strongly support the development of observational and data exchange systems. It plays an important role by coordinating water cycle activities in CEOS. It supports GEO water cycle activities by funding research and investigations for GEO Water SBA activities.

ESA (see http://www.esa.int) is a leader in developing new observational systems that support water cycle measurements and support for topics such as soil moisture. They have also provided considerable in-kind support for IGWCO.

Many other agencies and organizations that provide ongoing support for IGWCO have been mentioned in the text. The above-mentioned agencies and organizations have been given special mention because IGWCO would not exist in its present form without their involvement and support.

**Invitation**

The IGWCO is looking for more end-user involvement. As its name implies, it is a Community of Practice and is open to all. If you would like to become involved as a regional community of practice, an organization, or an individual, please contact Rick Lawford at lawford@umbc.edu.
To learn more about the IGWCO Community of Practice and IGWCO theme

visit the GEO website at

http://www.earthobservations.org/wa_igwco.shtml