



THE INTEGRATED GLOBAL WATER CYCLE OBSERVATION (IGWCO) THEME

3RD ANNUAL PLANNING MEETING REPORT

FINAL, 23 MAY 2007

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The Integrated Global Water Cycle Observation (IGWCO) Theme, one of the themes of the Integrated Global Observing Strategy Partnership (IGOS-P), held its third annual planning meeting from 13-17 March 2007 at the National Academy of Sciences in Washington DC, in conjunction with the Coordinated Energy and Water Cycle Observation Project (CEOP). The following report follows the agenda for the meeting, and provides a brief resume of each of the sessions that were held.

Wednesday, 14 March 2007

1. Introductory Session (Chair: Chu Ishida)

Rick Lawford presented the "Introduction to the IGWCO and the Goals of the Workshop." He introduced the IGWCO structure, project status, 2006 highlights and 2007 prospects, and presented the following workshop objectives:

- to develop strategies to advance the IGWCO plans during 2007-2008
- to define/refine tasks and obtain commitments for specific projects
- to review the status of actions addressing the IGWCO report and decide on the way forward
- to develop recommendations and actions for:
 - capacity building and integration
 - how the IGWCO will link with other IGOS Themes

Wolfgang Grabs next presented "Perspectives from the IGWCO Executive." He introduced the close relationship of the Global Terrestrial Network-Hydrology (GTN-H) with the IGWCO and World Meteorological Organization's (WMO's) contribution to the IGWCO. He also proposed, based on the Assessment Report, developing a new roadmap with distinct milestones focusing on integration of observations and data assimilation strategies, with a strong applications-oriented research and applications module.

Toshio Koike presented two Coordinated Enhanced Observing Period (CEOP) campaigns, and reviewed their major achievements. The CEOP has successfully integrated satellite data, *in-situ* data of 35 reference sites, and model output data from 12 National Weather Prediction (NWP) centers, enabling research on Water and Energy Simulation and Prediction (WESP) and CEOP Inter-Monsoon Comparison Study (CIMS). He then introduced the Coordinated Energy and Water Cycle Observation Project (the new "CEOP") which evolved by combining the Global Energy and Water Cycle Experiment (GEWEX) panel functions with the previous CEOP data infrastructure. The new CEOP provides a unique opportunity for coordination among Regional Hydrological Projects (RHPs).

Chu Ishida presented an update of the Committee on Earth Observation Satellites (CEOS). CEOS is developing its Implementation Plan for space-based observations of the Group on Earth Observation System of Systems (GEOSS) which consists of a near-term focus to respond to the Group on Earth Observations (GEO) work plan, a mid-term focus to respond to the Global Climate Observation System (GCOS) Implementation Plan, and a long-term focus to develop an Implementation Framework for the GEOSS Societal Benefit Areas (SBAs), including CEOS Constellations.

2. Discussion of Drought Phenomenon (Chair: Toshio Koike)

Dr. Peter van Oevelen, of the European Space Agency (ESA), instead of Dr. Eric Wood, explained a new drought index calculation by using simulated soil moisture, and application of the index to assess historic global drought events and global real-time drought monitoring. Dr. Jin Huang, of the National Oceanic and Atmospheric Administration (NOAA), introduced the drought research activities in the Climate Prediction Program for the Americas (CPPA) consisting of predictability, land surface, and hydrological studies. The impacts of the Indian Ocean on droughts in the United States, the climate regime shift to more frequent extreme events, and drought prediction coupled

with down-scaling are now being investigated. Dr. Mark Brusberg, of the United States Department of Agriculture (USDA), reported the state of the National Integrated Drought Information System (NIDIS) including its objectives, governance and schedule, and also discussed issues surrounding the design of the “Early Warning” system.

Through the discussion, the participants recognized:

- the importance of the integration of *in-situ*, satellite data, and numerical prediction model outputs, and the fusion of the natural science and social information;
- the impacts of climate regime shift and global warming should be investigated.

3. Capacity Building (Chair: Rick Lawford)

The first part of this session provided a review of the IGWCO capacity building activities. Chu Ishida of the Japan Aerospace Exploration Agency (JAXA) reported on the Asian water resource Management Capacity Building Workshop held September 26 to 28, 2006 in Bangkok, Thailand. The workshop noted the need for sharing successful experiences and to document tools and methods in successful capacity building. In particular, successful programs in the region on drought management need to be documented and circulated, highlighting the gaps and need for improving the tools and methods. In addition, the Water Quality group decided to propose a GEO task on water quality monitoring and it was incorporated to the GEO 2007-2009 work plan. This activity will proceed initially through the formation of a demonstration project, calling for a collaborative and cooperative effort between national and local agencies, institutions, non-governmental organizations (NGOs) and space agencies. The participants to the workshop decided to include the Capacity Building workshop under the Asian Water Cycle Initiative (AWCI).

An update on the efforts to develop a Latin American capacity building effort was outlined by Rick Lawford. He reported on a workshop held in Buenos Aires on November 23 to 24, 2006 to develop a capacity building process for Latin America. This effort will seek to facilitate the development of sustainable Earth Observation information services for integrated water resource management in Latin America. It will focus on encouraging a sustainable program of observations utilizing appropriate observational technologies. The planned program will engage Latin American scientists and data users in collaborative applications projects with experts and data providers from other countries. A central role is seen for the Comision Nacional de Actividades Espaciales (CONAE) within this structure.

Dr. Bob Su reported on the Terrestrial Initiative in Global Environment Research (TIGER), an ESA/UNESCO project designed to assist African countries to overcome problems faced in the collection, analysis, and dissemination of water-related geo-information by exploiting the advantages of Earth Observation technology. The program contributes to supporting improved governance and decision making contributing to the enhancement of institutional, human and technical capacity and fostering sustainability. More than 50 projects are supported through TIGER in areas such as surface water mapping, groundwater, water pollution and quality, hydrology and environmental monitoring (e.g., erosion). He also reported on the TIGER Capacity Building facility located at the International Institute for Geo-Information Science and Earth Observation (ITC) in the Netherlands.

Dr. Antti Herlevi presented an overview of capacity building in GEO. In addition to supporting capacity building in the water area as well as cross-cutting activities, he outlined GEO efforts related to building human capacity, institutional capacity, and infrastructure capacity. He also reported on a recently completed survey that showed Europe, Africa, and Asia all have active capacity building through demonstration projects. He noted that GEO provides a framework for improved international cooperation around water management issues.

Dr. Nguyen Thi Tan Thanh presented the needs of Viet Nam for capabilities in monitoring flood conditions. She proposed a demonstration project for improving flood monitoring through an operational real-time warning system for the Huong river basin. This development would rely on the improvement of the prediction of extreme events to mitigate disaster damages. Implementation

of the project has policy issues and will require national and international understanding and effective collaboration.

The capacity building activities of the Monsoon Asia Integrated Regional Study (MAIRS) Integrated Study were presented by Dr. Congbin Fu. In keeping with the mandate of the SysTem for Analysis, Research and Training (START), the program responsible for implementing MAIRS, the program is striving to increase the research capability in areas which are not as advanced. MAIRS efforts are building capacity for education, data system development and modelling studies. Both undergraduate and graduate studies in Earth System Sciences (ESS) need to be promoted at universities across monsoon Asia. Data collection and management functions need to be developed and the ability of scientists to access and use state-of-the-art models must be improved.

The goals of the National Aeronautic and Space Agency (NASA) capacity building activities were described by David Toll. He noted that NASA is funding eight capacity building projects in the water sector dealing with droughts, water quality, floods and streamflow forecasting, and irrigation and water delivery. These capacity building activities include data available through the Land Information system (LIS), the Global Land Data Assimilation System (GLDAS), a collaborative Land Data Assimilation System for South America, and a regional monitoring and visualization system. New directions include sponsorship for Latin American visitors to NASA, the establishment of a NASA Water Management Capacity Building Team for Latin America, and coordination with other Agencies' capacity building efforts (EPA, NOAA, etc.).

Thursday, 15 March 2007

4. [Water Quality](#) (Chair: Steve Greb)

Steve Greb from the Wisconsin Department of Natural Resources described some of the recent research in the water quality/remote sensing area, in addition to the water quality activities that the IGWCO has been involved with this past year and new activities proposed for the coming year. Recent advances in remote sensing mapping tools and theoretical considerations have suggested that the amount of terrestrial surface freshwater has been previously underestimated. The total number of lakes over 0.01 km² is 3x10⁸, with a total surface area covering approximately 2.8 percent of the land surface. Reservoirs constitute 2.6 x 10⁵ km². Little is known about the cumulative water quality impact of these impoundments. An empirical approach to measuring water clarity from space-borne sensors was presented. This method is currently being used by the state of Wisconsin to measure lake health in over 7500 lakes on an annual basis. This data is also being used to examine regional differences as well as long-term trends. This technique is currently being modified and applied to a subset of global lakes through a grant from the NASA Energy- and Water-Cycle Sponsored Research (NEWS) program. The project will acquire both field observations (from the Global Environmental Monitoring System [GEMS] and other databases) and atmospherically-corrected satellite imagery. Lakes will then be classified using spectral and physical factors, and models will be developed relating satellite measurements to water clarity and other in-lake conditions.

This past year, Steve Greb participated in the water quality working group of the workshop on Capacity Building in Asia Earth Observations in the Service of Water Management. This working group endorses water quality as an integral component of water management and development. The group further proposes an Asian Water Quality initiative under the GEO framework. The GEO members as well as non-member countries should be encouraged to agree to provide the required support and cooperation.

Another activity was the Remote Sensing Methods for Lake Assessment workshop held November 7, 2006 in Indianapolis, Indiana. This was a full day of instruction on sensors, data analysis, costs, and expected results. It was slated for state and federal water quality managers and supported by a grant from US Environmental Protection Agency (EPA), and hosted by the North American Lake Management Society. A guidance manual is currently being published which may be an excellent tool for use in future international capacity building workshops.

A major near-future activity is the GEO Inland and Nearshore Coastal Water Quality Remote Sensing Workshop to be held 27-29 March 2007 in Geneva, Switzerland. This is a joint effort between GEO and the IGWCO. The goal is to bring together remote sensing data providers and expert users to improve our ability and capacity to remotely assess and monitor inland and nearshore coastal water quality. This is an exciting opportunity to collaboratively chart a course for the future of this emerging science. The objectives are to assess existing and planned remote sensing capabilities, identify gaps relative to user needs in the acquisition, processing, distribution, and utilization of remote sensing data and derived products for water quality research and applications, and formulate potential solutions to address these gaps and other related challenges. The outcomes are recommendations to data providers and GEO Members and Participating Organizations on short-term priorities for improving remote sensing capacity and utilization for water quality assessment and monitoring, as well as formulating short and long term strategies to identify, enable and implement enhanced capabilities.

Lastly, the Global Water Watch (GWW) program was introduced and discussed. This non-profit group strives to educate communities about watershed issues and environmental impacts of human activities by conducting workshops for monitoring and evaluating the physical, chemical, and biological characteristics of water.

Richard Smith of the US Geological Survey reported on the USGS water quality assessment programs currently implemented for rivers and streams. It is important to first know what questions are being asked to properly address the monitoring strategy. Monitoring is needed to answer such questions as "Is the water meeting the beneficial uses? Are regulatory requirements being met? What are the current trends"? The USGS is one of several agencies involved in water quality assessment. Others include US EPA, state and local agencies. The two major assessment programs that USGS currently directs are the National Water-Quality Assessment Program (NAWQA) and the National Stream Quality Accounting Network (NASQAN). Annual appropriation for NAWQA is \$63M. These programs focus on status and trends monitoring and modelling and additionally, focused topical studies. Geographically, these programs monitor 140 sites distributed across the US, in eight major hydrologic regions. The sizes of the watersheds vary from 10 to 3 million km². NASQAN has been operating for 33 years, NAWQA for 13 years. Examples of products that come out of these programs include the yield of nitrogen from major watersheds in the US, important in the study of the Gulf hypoxia.

Recently there have been greater actions towards integrating their monitoring and modelling efforts, making use of data from multiple sources. This effort deals with problems of non-representative samples, helps with understanding cause and effect, and feeds back into the monitoring design. An important initiative of this integrated approach is the program called SPARROW (SPATIally Referenced Regression on Watershed Attributes). This effort links landscape attributes with receiving waters and water quality impacts, quantifying concentrations, fluxes, yields, and describes origins and fates of pollutants, all in a mass balance framework.

Antti Herlevi from the GEO Secretariat's office spoke on selected water quality activities of GEO. The first is WA-07-01: Global Water Quality Monitoring. Initial support has been expressed by the IGWCO, NASA, JAXA, ESA, CSIRO, ICSU, CEOS and POGO. The premise of this task is that many aspects of water quality monitoring and assessment, both *in-situ* and remotely sensed, are severely deficient. Many countries lack the technical, institutional, and financial resources to conduct proper assessments using *in-situ* water quality monitoring methods for terrestrial sources and in the coastal ocean. Operational observation systems need to be developed, and the resulting information systems should be made compatible and interoperable as part of the system of systems. This Task is partly built on the outcomes of the water quality workshop in 2007 (GEO Inland and Coastal Water Quality workshop) and first pilot projects are being planned to begin in Asia as a result of the Asia Water Resource Management Capacity Building Workshop. This Task has relevant synergies with HE-07-02.

The joint GEO/IGWCO water quality workshop was further described. The scope of this workshop within the GEOSS Framework consists of several functional components including: addressing identified common user requirements; acquiring observational data; processing data into useful products; exchanging, disseminating, and archiving shared data, metadata and products; monitoring performance against the defined requirements and intended benefits, infrastructure requirements (e.g. sensors, hardware, software), and address data/information access and dissemination issues. The outcomes will consist of immediate, 2 year and 10 year recommendations to space agencies and water quality management agencies.

Bilqis Amin reported on water quality issues in developing countries, particularly Bangladesh. The Safe Drinking Water Millennium Development goal and its target is a recognized milestone for effective progress in sustainable development. Bangladesh, a least developed country of approximately 140 million, is an example of supposedly safe drinking water being supplied to its population. However, some 40 to 60 million inhabitants run the risk of being exposed to arsenic contaminated water through the use of groundwater-based hand pumps. Arsenic contamination in sources of drinking water has been reported by several countries in Asia and other regions the last few years of the century. Although various health and social impacts of drinking arsenic contaminated water were known, the millions of population in Bangladesh and other countries faced with similar water quality problems were not recorded among those who needed safe drinking water during the UNICEF-WHO 2000 report. Bangladesh was shown among the countries having more than 90% access to safe drinking water in the 2000 report. Other global maps on water resources have also included the country among those who have high volumes of accessible ground water and surface water. But in reality arsenic contamination of ground water has severely and widely challenged access to safe water. The country promoted use of water sources which does not contain arsenic (alternative technologies), in absence of appropriate arsenic removal technologies. But most of the alternative technologies address micro-biological contaminated water. Implementation of poorly planned and supported alternative technologies has further complicated and hampered the national program for safe drinking water supply. The initiatives to supply safe drinking water to the arsenic affected population, most of them of very low income, have been slow or poor in Bangladesh. The mid-term assessment of the Millennium Development Goals (MDG) reported Bangladesh among those countries of the world which will not reach the MDG if continues in the same trend.

Bangladesh is also faced with annual floods and droughts due to lack of proper management of its water sources. Almost all of its rivers are international or branches of international rivers. There is limited sharing of water. Wide arsenic contamination of ground water has further limited the access to the available water. GEO has 9 goals including societal, health, agricultural, water quality, disaster mitigation and other issues. But the goals are yet to be implemented in most of the developing countries including Bangladesh. Proper monitoring and dissemination of the information collected on water quality data, distribution of the various water options, distribution and prediction of various water sources and other important parameters among the community can contribute to the access to safe drinking water among the arsenic affected populations. The country cannot afford regular and proper monitoring of water quality and its sources. Therefore, research on arsenic mitigation of the water supply for drinking and irrigation based on *in-situ* and satellite based data collection in Bangladesh will help to develop models for achieving the GEO goals in a developing country. The monitoring of indicators and its measurement methods and partners may be developed to connect water quality and opportunities for sustainable development.

5. Groundwater (Chair: Norman Miller)

Session 5 consisted of presentations focused on remote-sensed and *in-situ* groundwater measurements, monitoring, and data coordination plans. The groundwater recommendations from 2nd the IGWCO Meeting in February 2006 include: exploring the use of data from the Gravity Recovery and Climate Experiment (GRACE), the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE), and related satellites in inventorying ground water resources and monitoring; inter-comparing techniques related to the measurement of groundwater; and evaluating the capability of the current network of groundwater wells to determine groundwater change over land areas. The proposed Groundwater Working Group should be composed of members from the

Geological Application of Remote Sensing (GARS), UNESCO, and the IGWCO, and a workshop in September 2007 is proposed.

The following summarizes the highlights of these presentations.

Jaroslav Vrba presented an overview of the status of groundwater monitoring programmes around the world. Groundwater monitoring programmes operate on global, national, regional, and local levels. The objective of each of the above programmes governs design of monitoring networks, construction of monitoring wells, methods and frequency of groundwater observation and sampling, and a number of variables to be measured and analysed. Basic principles of establishment and operation of national monitoring programmes were compared and analysed in eleven countries, which represent more than half of the global population and inhabited world territories with occurrences of many large transboundary and national aquifers, as well as globally significant groundwater resources. Several suggestions to the national groundwater monitoring programmes were presented. Standardization of monitoring methods and implementation of Quality Assurance / Quality Control procedures to acquire internationally comparable and consistent data sets were particularly emphasized.

Matt Rodell presented the NASA Land Model Working Group and data assimilation of CEOP products to improve global energy and water budget predictions. The Global Land Data Assimilation Systems (GLDAS) is mostly a NASA activity, but it looks to expand. The current four LSMs; the Community Land model (CLM), Noah, Mosaic, and VIC will have output data for the period 1980 – 2010 for CEOP.

Ken Dennehy presented the United States Geological Survey (USGS) groundwater monitoring activities. Groundwater represents 50% of the US drinking water and 42% of irrigation water. The USGS has more than 850,000 groundwater records, with about 20,000 wells measured annually, and about 1000 wells in real-time. The primary measurement is water level via direct techniques, but also using micro-gravity and Interferometric Synthetic Aperture Radar (InSAR). The Climate Response Network (CRN) has 554 wells, with 51% in real-time.

Neno Kukuric presented the status of the International Groundwater Resources Assessment Centre (IGRAC) and its Global Groundwater Monitoring System (GGMS). IGRAC is a non-profit, WMO, and UNESCO initiative launched in 2003, hosted by Netherlands Organisation of Applied Research (TNO) at Utrecht, The Netherlands. IGRAC's user interface has an attributes profile, with pull-downs for sub-regions described within a metadata file. IGRAC intends to establish a sustainable GGMS for a periodic assessment of the global change of groundwater resources. GGMS is based on existing networks and aggregates data using expert knowledge and proxy values based on monitoring density, frequency, and variables. Further, IGRAC has expressed its willingness to organise the second meeting of IGWCO/UNESCO/GARS Groundwater Working Group in autumn this year.

Gene Whitney gave a brief overview of the status of the USGEO. USGEO is based on observations, data, and communities. It integrates across multiple themes (disasters, water, weather, ecosystems, etc.) and has 9 social benefit areas, including the protection and monitoring of water resources. Like GEO, USGEO has an interoperable, service oriented architecture, with an integrated observing system and data management system that feeds into the 9 societal benefit areas. USGEO has 3 major functions: planning and policy, architecture and data management, and user communications. USGEO is co-chaired by the Office of Science and Technology Policy (OSTP), NASA, and NOAA, and reports to the National Science and Technology Council (NSTC).

6. [National Links to the IGWCO](#) (Chair: Jared Entin)

Mr. Kazuo Umezawa of the JAXA Satellite Application and Promotion Center provided an overview of the ways in which Japan Aerospace Exploration Agency (JAXA) is linked to the IGWCO. In essence, these links include:

- JAXA Earth Observation Program and GEO Societal Benefit Areas

JAXA plans to contribute to the GEO Water Societal Benefit Area through its Earth Observation Program. This advanced, low Earth-orbit satellite program features dual-frequency precipitation radar, cloud profiling radar, and scatterometers for measurement of hydrometeors.

- JAXA's Water Related Projects

Existing projects supported by JAXA that pertain to measurements of the hydrological cycle include the Advanced Microwave Scanning Radiometer for EOS (AMSR-E[Aqua]), the Tropical Rainfall Measuring Mission (TRMM), the Global Precipitation Mission (GPM), and Global Change Observing Mission (GCOM) initiatives.

- CEOP Related Activities

JAXA contributes to CEOP by handling satellite dataset production and distributed integrated database development (featuring spatial and temporal data integration of in-situ, satellite, and model output)

- IGWCO Secretariat

Along with GEWEX and the WMO, JAXA forms an integral part of the tri-partite secretariat for the IGWCO. Its tasks have included organizing water management workshops and joint CEOP-IGWCO meetings, as well as providing travel funds, producing IGWCO information brochures, and handling teleconferencing needs for the IGWCO.

The Asian Water Cycle Initiative (AWCI) was introduced by Mr. Toshio Koike, as part of the Earth Observation Data Integration and Fusion Research Initiative (EDITORIA) of the University of Tokyo. The AWCI was designed to meet several needs identified throughout Asia, such as:

- to develop comprehensive and effective integrated water management;
- to share timely, quality, long-term information on water quantity and quality for sound national water policies and management strategies decisions;
- to construct a comprehensive, coordinated and sustained observation system of systems, including prediction systems and decision support capabilities;
- to develop capacity building for making maximum use of globally integrated data and fused information for local purposes as well as for observation and collecting data.

The AWCI aims to address these needs in a unique fashion, through accomplishing the following objectives:

- combining the architecture, data framework, and the capacity building strategy of GEOSS;
- mounting a cooperative implementation body by linking science community, space agencies, and water-related decision makers;
- providing coordination among existing operational systems, and international and national projects on research and capacity building;
- emphasizing strategic approaches by shifting scientific achievements to operational use, dedicated to societal benefits;
- clearly describing a baseline plan for implementation, including the agreed upon data policy and timeline;
- sharing advanced data infrastructure and downscaling methods for bridging between global data and local information;
- assembling capacity building components for a broader community to generate, interpret, and utilize value-added products from the observations, beyond training of qualified technical personnel to operate the observing instruments;
- striving for convergence of observations, interoperability arrangement, and data management based on the heritage of and the experience through CEOP, which is closely related to MAIRS of the Earth System Science Partnership (ESSP);
- designing capacity building in water management based on the precedent discussions led by the IGWCO.

Mr. Jared Entin gave a presentation on NASA's Earth Science Decadal Survey which is the first comprehensive survey of all Earth sciences that could benefit from space-borne observations. The study was requested and supported by NASA, NOAA, and USGS, and was initiated 2004. A preliminary report was released in 2005, and the final report was released 15 January 2007. The goal of the Decadal Survey is to provide scientific priorities indirectly through a time sequencing of recommended missions. Several recommendations stemming from the Decadal Survey include:

- the US Government should work in concert with the private sector, academia, the public, and its international partners to renew its investment in Earth observing systems and restore its leadership in Earth Science and Applications;
- NOAA should restore several key climate, environmental, and weather observations capabilities to its planned NPOESS and GOES-R missions;
- NOAA should develop a strategy to restore the previously planned capability to make high temporal and vertical resolution measurements of temperature and water vapor from geosynchronous orbit.
- NASA should ensure continuity of measurements of precipitation and land cover by:
 - launching the GPM in/before 2012
 - replacing Landsat 7 before 2012
 - NASA should continue to seek cost-effective, innovative means for obtaining land cover change information.
- NASA should continue to seek cost-effective, innovative means for obtaining land cover change information.
- NASA should increase investment in both mission-focused and cross-cutting technology development in order to decrease technical risk in the recommended missions and promote cost reduction across multiple missions.
- in order to restore more frequent launch opportunities and to facilitate the demonstration of innovative ideas and higher-risk technologies, NASA should create a new Venture class of low-cost research and application missions (\$100M - ~\$200M). These missions should focus on fostering revolutionary innovation and training future leaders of space-based Earth science and applications.

Finally, Mr. Jay Famiglietti gave an overview of the very recent Workshop on Satellite Observations of the Global Water Cycle, held 7-9 March 2007 at the University of California, Irvine. The objectives of the workshop were bring together experts in remote sensing, modeling, data assimilation and analysis to assess the state-of-the-art in characterizing global water cycle variability, and also to discuss strategies for integrated observation, with a particular focus on space-based contributions, and understanding global water cycle behavior across all its branches. Various themes were explored, such as the global water budget, atmospheric hydrometeorology, terrestrial hydrology, prediction challenges, and implications of NASA's Decadal Survey for space-based global water cycle research. Some of the sub-topics discussed under each of the themes focused on specific issues including new methods for tracing water vapor transport using isotopes, the need for characterizing spatial and temporal variations in storage, hydrometeorological prediction requirements, virtual water trade, definition of integration, and the importance of continuing NASA's GPM, soil moisture, surface water, cold processes, and GRACE initiatives as highlighted in the Decadal Survey. His presentation concluded with a call for a Groundwater Workshop to be jointly sponsored by the IGWCO/GARS/UNESCO in the autumn 2007. Potential objectives for the workshop could center around:

- reviewing the state of global *in-situ* and remote sensing for assessing groundwater availability and monitoring storage change;
- promoting coordination of international efforts and enabling new research collaborations;
- making recommendations for support and acceleration of a coordinated global effort.

7. [International Links with the IGWCO in the USA](#) (Chair: Chu Ishida)

Charles Vörösmarty gave an update of Global Water System Project (GWSP). The Implementation strategy of the GWSP was presented. The GWSP Atlas has been developed and three new activities: the Global Scale Initiative, the Global Catchment Initiative, and the Global Water Need: Nature and Human, are being launched.

Matthew Larsen presented an update of UNESCO International Hydrology Programme (IHP) and potential interaction of the U.S. National Committee for UNESCO IHP with the IGWCO. He outlined the IHP's objectives and the role of the US National Committee of UNESCO. Potential interactions and collaborations with the IGWCO should be discussed at the next Committee meeting and could include topics such as water management and climate, climate change and long range forecasting,

drought, and water quantity and water quality issues. The U.S. National Committee for UNESCO IHP web site is: <http://water.usgs.gov/nrp/IHP/index.html>.

During the discussion that followed, the need to strengthen the IGWCO's links with international programs, as well as supporting its function of combining national activities, was stressed.

8. [The IGWCO Assessment Report](#) (Chair: Rick Lawford)

The assessment session involved a number of presentations and some lively debate. Wolfgang Grabs led off the session with a description of the relationship between WMO and IGOS-P and GEO. WMO is making a major contribution through its WMO Information System (WIS) which provides a single coordinated global infrastructure for the collection and sharing of information in support of all WMO and related international programs. He also noted the WMO Observing system roadmap and the plans of WMO contributions to specific GEO tasks.

Wolfgang Grabs and Douglas Cripe presented the results of an assessment of the implementation of the IGWCO theme in the context of the original the IGWCO report. The assessment identified some areas where significant advances had been made, other where more modest progress was evident, and some where progress was lacking. In the case of these deficiencies, they reflected weaknesses in the "best efforts" framework that the IGWCO operates under. There is the need to ensure that a broader effort is made to capture the baseline information and in other cases a need to transfer these activities to other themes or programs. These presentations were followed by a discussion which emphasized:

- The linkage of the IGWCO activities with international water programs.
- It was recognized that although the IGWCO has strong links with the WMO and the WCRP, it would benefit from stronger links with UNESCO and UN Water.
- The Assessment Report and other areas where the IGWCO has made contributions. There was a feeling that the report should have a position on activities that are now being dealt within other themes such as cryosphere and should be expanded to include more satellite activities in the IGWCO such as the Tropical Rainfall Measuring Mission (TRMM) and the Global Precipitation Mission (GPM) in precipitation and in other areas where these were lacking.
- The link to climate needs to be reviewed.
- It should be recognized that the IGWCO is contributing through the World Climate Programme (WCP-Water) and the pristine basins activity, although there is a need to distinguish between what is the IGWCO and WMO.
- The uniqueness of the IGWCO lies in the community of scientists that it has brought together and its efforts to address the global water cycle budget rather than just terrestrial component.
- Opportunism versus management by objectives.
- The view was expressed that the IGWCO had strayed a bit from the objectives because it pursued new opportunities that were presented. Given that this is a "best efforts" activity another view was that we had no option but to be opportunistic and this was strength, not a weakness.
- The contributions of the IGWCO to GEO and research programs should be highlighted in the assessment report. The IGWCO may be more credible if it could develop a set of milestones.
- Although the water theme has potentially strong linkages with all of the other IGOS themes, the linkages are slow to develop.
- The IGWCO also needs to develop a clearer strategy for its interactions with GEO tasks. The IGWCO could have benefits if it redefined itself as a project within GEO but in a way that doesn't impact the other IGOS themes.
- It was recommended that GEO make travel money available to those working in IGOS themes in a volunteer capacity to ensure they can fully function in the GEO framework.
- The IGWCO may wish to consider using the Community of Practice model as a way to embed itself in the GEO process. The IGWCO is already leading the development of the GEO Water Cycle Community of Practice.

Antti Herlvi presented a perspective on the GEO view of the IGWCO. He reviewed the various GEO tasks related to water and indicated that the IGWCO could contribute by: 1) participating to GEO water tasks as needed, 2) providing people to serve as task leads, and 3) using its network of contacts to identify suitable participants for the various tasks.

Lawrence Fridel presented the requirement for a GEO user surveys for each societal benefit area and proposed that the Water Cycle Community of Practice undertake the review of water cycle variables.

Rick Lawford presented an overview of the current status of the Water Cycle Community of Practice being developed for the GEO User Interface Committee. When operational, this Community of Practice will bring together users from a number of different communities in the water sector (emergency planners, managers, infrastructure operators, etc) to define their requirements for water cycle information.

Friday, 16 March 2007

9. Surface Water Measurement (Chair: Wolfgang Grabs)

Water in all its aggregate forms is a key variable in Global Observing Systems. The session addressed specific issues related to surface water observations both in situ and from space as well as concerns related to data sharing and availability.

Mr. W. Grabs made a presentation on "Surface Water measurements - Concerns and Issues." In his presentation he provided technical information different on-site observation techniques and their relative reliability as well as global repositories of hydrological data including the Global Runoff Data Center (GRDC), operating under the auspices of the WMO, Flow Regimes from International Experimental and Network Data (FRIEND) operating under the IHP of UNESCO, and the Global Environment Monitoring Program (GEMS-Water) that is operating under UNEP. The World Hydrological Cycle Observing System (WHYCOS) programme of WMO aims to establish a core basin-wide hydrological information system for improved water resources management and hydrological forecasting. An effort to build an integrated observing system of hydrometeorological variables including surface runoff is the GTN-H. One its main tasks are to ensure access to hydrological data and information for a large variety of purposes. In arriving at an integrated hydrological observing system, opportunities for data integration are, amongst others the merger of data streams, Geographic Information systems, Data Mining techniques, regional and global data assimilation systems, models and periodic re-analysis.

Mr. Grabs concluded by saying that despite all efforts in the past to improve water-related data and information, huge gaps exist especially for terrestrial hydrological observations. Major investments are necessary by governments to enable their National Hydrological and Meteorological Services to provide essential information on national, regional and global observation levels. Decision-making and adaptation to changes in freshwater availability depend to a large degree on our global understanding of the hydrological cycle processes including our knowledge in ocean-processes.

Matthew Larsen, USGS Chief Scientist for Hydrology, informed the participants of activities related to "Surface water monitoring by the U.S. Geological Survey." In his presentation he noted that "the USGS has about 7,500 gages operating, with about 97% providing real-time data on the web." (See <http://waterdata.usgs.gov/nwis>) With many partners cooperating and providing funding for the operation of the stations, the USGS operates the network on behalf of all. The information collected nationwide is critical to support the WaterWatch website that is updated using real-time data (<http://water.usgs.gov/waterwatch/>). He further presented methods of terrestrial observations and highlighted the current technological shift to use more extensively hydroacoustic measurement techniques to make the discharge measurements that are used to calibrate the streamflow stations and their relative advantages over more traditional, mechanical observation methods. He provided information on river- as well as velocity-index profiling methods in this

regard. Dr Larsen also emphasized the goal to further develop and apply non-contact discharge measurement methods for future measurement, including the use of radars.

Messrs. J. Famiglietti (UC Irvine) and D. Alsdorf, (Ohio State University) made a presentation on "Remote Sensing of Freshwater Discharge." The goal in the further development of space-based observation techniques is to determine where water is stored on Earth's land surfaces (lakes reservoirs, large rivers), and how this storage and flow varies in space and time.

A new radar altimetry imager termed "Water and Terrestrial Elevation Recovery Hydrosphere Mapper (WATER HM)" is presently under development. The Kay-Band Radar Interferometer (KaRIN) would consist of a Kay-band SAR interferometric system with 2 swaths, 50 km each that, using 200 MHz bandwidth (0.75 cm range resolution), would produce heights and co-registered all-weather imagery. In contrast to profiling altimeters that repeat 1D, in-situ gauge approaches, WATER's KaRIN will provide two-dimensional h , dh/dt , and dh/dx about once a week, and thus yields ΔS and Q globally. Mr Famiglietti pointed out that these water elevation measurements are entirely new, especially on a global basis, and thus will represent a truly significant step forward in oceanography and hydrology. He also demonstrated the already available possibility to estimate Arctic freshwater discharge using gravimetric observation techniques such as GRACE.

As a major step towards an integrated, multi-platform global hydrological information system, Messrs. W. Grabs (WMO) and M. Rast (GEO) provided information on the current concept on a "Conceptual Framework for a Hydrological Applications and Run-Off Network (HARON)." Through WMO - IGWCO/GEO, a coordination mechanism for global *in-situ* and remote sensing water observations is being developed and funds sought for its implementation. GEO is the principal facilitating partner whereas WMO and IGWCO are seen as the executing partners in this innovative project. Drivers for the development of the project are present major constraints on sustainable water resource development and management that include amongst others: inadequate long-term water cycle observations, lack and inaccessibility of crucial data, insufficient interoperability of observing systems, and the need for standardization of metadata for data sharing. Mr. Grabs pointed out that in line with the IGWCO, GCOS, and GEWEX, and the drive to substantially contribute towards the societal benefit areas of GEO, the main objectives for the development and implementation of the HARON project are to:

- improve and support the closure of the global water budget, to
- support water resources management (for example in context of food security), and to provide
- support to scientific problems and challenges including improved long-term forecasting of freshwater availability in space and time, validation of regional precipitation and moisture fields, biogeochemical fluxes, and the scientific interface problems between continental runoff and the oceans (for example, related to sea-level rise).

The implementation of the project identifies three distinct phases:

1st Initial Phase: Upgrade and sustained maintenance of major global run-off stations building on a core of 380 already identified terrestrial gauging stations to monitor continental freshwater fluxes into the world's oceans;

2nd Phase: Combine hydro-meteorological and related *in-situ* components with satellite observations, and in particular radar altimetry and potentially gravimetric observations;

3rd Phase: Produce an implementation plan for broad global water cycle data integration system combining *in-situ*, satellite data and model outputs.

Mr Grabs concluded that the successful completion of the HARON initiative will result in an integrated global hydrological observing system, with its distinct components such as Runoff, Precipitation, Lakes/Reservoirs, Ground Water, Cryosphere, and Soil Moisture. This would for the first time provide an integrated and interoperable global hydrological observing system contributing in a cross-cutting fashion to all societal benefit areas of GEO.

10. [Breakout Groups](#)

Three breakout groups were designated to discuss what the user requirements and expectations were with respect to the IGWCO in the areas of Earth Observations, Data Integration, and Application/Capacity Building. All meeting participants chose one of these three breakout groups to attend, and were given a set of questions for guiding the discussions, pertaining to the role of the IGWCO. The reports from each of the groups are attached as appendices C, D, and E, respectively.

11. [Soil Moisture](#) (Chair: Peter van Oevelen)

Four presentations were given in this session. The first one, presented by Peter van Oevelen, dealt with the current status of ESA's Soil Moisture and Ocean Salinity Mission (SMOS). A short overview of the instrument and measurement techniques was given. An important note is that as part of the Calibration Validation effort for this instrument, ESA is sponsoring to set up a data hosting facility for soil moisture measurements that could operate in the near future as a global soil moisture data center. The SMOS current launch date is for the middle of 2008. The second presentation was given by Micheal Cosh also on behalf of Tom Jackson on the Cloud and Land Surface Interaction Campaign (CLASIC) and US soil moisture experiments. A short overview of measurement techniques and history of US soil moisture experiments was given. The upcoming CLASIC campaign, in which the cloud and land surface interaction is central, was extensively presented. A large array of measurement techniques, both *in-situ* as well as remote sensing, covering both land and atmosphere will be employed during the summer of 2007 in the US Midwest. The third presentation was given by Peter van Oevelen in his second presentation this session on the development of a global *in-situ* soil moisture network. The programme and objectives of the International Soil Moisture Working Group were presented as well as plans for the 2nd workshop which will be held in Beijing November 14-15, 2007. In cooperation with the Portuguese Meteorological Institute as well as CEOP, a data hosting facility will be established with sponsorship from the ESA. The fourth and last presentation was given by Paul Houser on Land Data Assimilation and Soil Moisture in which he showed the difficulties related to assimilation of soil moisture measurements (be it from space or *in-situ*) in a land surface scheme. The various aspects of assimilation were treated and the presentation was concluded with examples of assimilating the Advanced Microwave Scanning Radiometer for EOS (AMSR-E) Land products into the NOAA Land surface model using NASA's Land Information System (LIS)

12. [Precipitation](#) (Chair: Phil Arkin)

The session summarizing precipitation status and ongoing research was chaired by P. Arkin and included 3 additional speakers: R. Adler, A. Hou and K.-L. Hsu. S. Shimizu was unable to attend and so his presentation was canceled. Arkin began the session by describing the current status of progress toward an Integrated Precipitation Product (IPP) that can be used for the IGWCO applications and research. While several realistic candidates with nearly appropriate time and space coverage and resolution are now available, a careful assessment and evaluation of these products is still underway. The Program for Evaluation of High Resolution Precipitation Products (PEHRPP), originally motivated by the need for an IPP, is jointly sponsored by the IGWCO and the International Precipitation Working Group (IPWG). At the recent meeting of the IPWG in Melbourne Australia, it was recommended that a PEHRPP Workshop be held to summarize progress and findings in the evaluation, and to make recommendations that the IGWCO might act upon in selecting or creating an IPP. The World Meteorological Organization (WMO) Space Programme has agreed to host this meeting at WMO headquarters in Geneva Switzerland in December 2007.

Adler provided a summary of Global Precipitation Climatology Project (GPCP) products and organization, and then a more detailed description of the high resolution product under development as a joint venture of the GPCP and the Tropical Rainfall Measuring Mission (TRMM). The TRMM Multi-Satellite Precipitation Analysis (TMPA) offers a spatial resolution of 25 km and is available at 3-hour intervals beginning in 1998 in a real-time version roughly 6 hours after observation time and in a post-processed version that uses additional observations from rain gauges following the end of each month. The TMPA is being used experimentally in applications such as hydrological modelling and flood analysis, and is being integrated into GPCP planning for

future product generations. Adler finished his presentation with a plea to improve coordination among the many groups working on precipitation products and analyses, as well as applications, so as to reduce the meeting pressure on those involved.

Hou gave a summary of the highly successful TRMM joint effort between NASA and the Japanese agency JAXA, and then segued into a description of the concepts, hardware and progress on the successor mission - Global Precipitation Measurements (GPM). GPM will include a core satellite with dual frequency radar of advanced capability relative to the TRMM radar, and a constellation of microwave radiometer-bearing satellites including both research and operational platforms. He summarized the most recent schedule, which has been affected by budget pressures in the U.S., and current status of instruments as well as data and science planning. He concluded with a discussion of GPM in the context of the GEOS Precipitation Constellation.

Hsu described the applications and recent developments related to the Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks (PERSIANN) project, the high resolution precipitation product invented and produced by the research group led by S. Sorooshian at the University of California at Irvine. The fundamental approach relies on the integration of multiple sources of information using an advanced neural network based on infrared geostationary satellite observations of cloud top temperatures, and trained using passive microwave-based estimates of precipitation from polar orbiting satellites, including TRMM. PERSIANN is available since about 2000 in a relatively coarse time and space resolution comparable to TMPA, and in a much finer resolution of 4 km and hourly for a limited region and time period. Hsu described several validation studies that are contributions to PEHRPP, and applications of PERSIANN to diagnostic analyses of the diurnal cycle and hydrological basin-scale simulations. He concluded with a discussion of initial efforts to develop methods to merge PERSIANN estimates with rain gauge observations on a fine scale.

The session showed that several excellent candidates exist for an IPP, suitable for at least initial the IGWCO applications. Along with TMPA and PERSIANN, a relatively mature candidate includes the U.S. Climate Prediction Center Morphing technique (CMORPH), available since 2002 at 8km and 30-minute resolution, along with a version (RMORPH) that merges rain gauge observations with the satellite estimates. Other potential candidates that are still being developed include the Hydroestimator, an operational product generated by NOAA's National Environmental Satellite, Data, and Information Service (NESDIS), the Global Satellite Mapping of Precipitation (GSMaP), which is being developed and implemented by an extensive group of Japanese scientists, and several others. The PEHRPP Workshop in December should provide useful advice to the IGWCO on future actions.

Saturday, 17 March 2007

13. [Country Presentations](#) (Chair: Rick Lawford)

On the final session of the workshop there were a number of presentations regarding progress and needs in capacity building in developing countries and the NASA solutions network. Also, two demonstrations of operational data systems were provided. Dang Mai from Viet Nam demonstrated some of the water related impacts of typhoons in Viet Nam and highlighted the need to develop typhoon prediction systems and the need for more satellite and weather radar data to support these prediction programs. She emphasized that better typhoon prediction systems are needed, in turn would require better observations systems including satellite systems and radar and international collaboration for capacity building.

Stephen Opoku-Duah, focused on analysis activities in West Africa and Volta River Basin. Although there are a number of international programs in place to support hydrometeorological data needs, it is also clear that more national infrastructure is needed. He also noted that west Africa needs new research and operational partners, more funding opportunities and support in developing research proposals.

Flaviana Hilario presented some analysis that assist with the prediction of rainfall reversals in the Philippines. An increased moisture flux associated with El Nino events leads to heavy precipitation in the central Philippines followed by a dry autumn while an La Nina leads to the reverse conditions (light summer precipitation events followed by a wet autumn).

Weidong Guo presented an analysis of arid trends over northern China. This study emphasizes the long-term intensified observation of land surface, ecological and hydrological process to look at regions with transitional and abrupt change of the aridity trend in the impact assessment and integrated modeling study.

Debbie Beleveder presented the WaterNet program, a NASA-funded initiative being led by Center for Research on Environment and Water and George Mason University, and its purpose to explore research capabilities and support needs and to identify candidate solutions. The Project will assemble and analyze water-cycle research results and water-cycle relevant decision support to identify candidate solutions, and determine the configuration required to build the solution (pre-evaluation report). She noted that there are opportunities for the needs for international capacity building to be integrated into this network.

14. [Demonstrations](#) (Chair: Rick Lawford)

For some of the participants the highlight of the session were demonstrations of the NASA Goddard Distributed Active Archive Center (DAAC) website for accessing satellite data and a demonstration of ways to access all of the data sets in the CEOP archives by Ben Burford. The NASA Goddard site offers Earth science data, information, and services to research scientists, applications scientists, applications users, and students, the Goddard Earth Sciences Data and Information Services Center provides data services (such as OPeNDAP), laboratory project information, data access and an image gallery. The CEOP site was also demonstrated. It describes the WTF-CEOP (WGISS Test Facility for Coordinated Energy and Water Cycle Observation Project) task team, associated with the Committee on Earth Observation Satellites (CEOS) and the Japanese Aerospace Exploration Agency (JAXA), which is designed to support the CEOP science community in the development of data services. One action coming out of these demonstrations is the preparation of summary pages listing all of the websites referred to in these and other talks.

15. Meeting Summary

Three years ago, when the IGWCO 2004 Reference Guide was published, a comprehensive list of water cycles and attending objectives were laid out. The IGWCO primarily focuses on three areas: Development and support of global, water-related observing systems; science-based, applications-oriented and demand-driven products; and capacity building. With the current 2007 Assessment Report, it has become evident that a number of these objectives have been, or are in the process of being, met. Indeed, significant progress has been made with respect to accomplishing objectives for water cycle variables such as Precipitation, Soil Moisture, Streamflow and Surface Water Storage, Groundwater, Water Quality, and Capacity Building. On the other hand, some objectives have been less successful regarding water cycle variables such as the Cryosphere, Clouds and Water Vapor, and Energy-Water Interactions and Climate. These findings should be viewed from the perspective that the IGWCO is a "best efforts" enterprise, and thus depends on the good will of those willing to participate to drive activity. In light of the Assessment Report, it is now the task of the Science Advisory Group (SAG) to:

- derive a strategy to address the gaps that have been identified;
- determine the appropriate action that should be taken for those items which have not been developing as rapidly;
- use the Assessment Report as a guide to an action plan for the next 2-3 years.

A parallel discussion that hovered over the Planning Meeting was the IGWCO's role vis-à-vis GEO. In the very recent past, the IGWCO has proven to be a principal partner with GEO, having cooperated in both the definition and implementation of GEO Water Tasks. The unique characteristic of the IGWCO is that it sets up strategies, identifies partners, and then attempts to foster collaboration between them. It was widely recognized that, in many respects, GEO is trying to accomplish the same thing, albeit on a

larger and more all-encompassing scale. Given the very broad political and funding mandate behind GEO, the question thus is whether there is a continued role for an independent the IGWCO to play, or if instead the activities of the IGWCO should be gradually phased into GEO to avoid redundancy and streamline efforts. It was decided that, for the next 12 months at least, the IGWCO leads will remain intact for the 2007-2009 work plan, and that the IGWCO will develop a strategy to serve both GEO and IGOS-P. To that end, the IGWCO is prepared to align its work plan to focus on GEO requirements on the basis of the current the IGWCO Assessment Report and other relevant considerations, such as input from experts in the fields of clouds and energy budgets. Simultaneously, the IGWCO is prepared to act as a strategic think tank, and to make use of the technical, scientific and supporting institutional infrastructure of its partners in support of GEO.

IGWCO has been made a number of contributions to GEO during the past year including Capacity Building workshops in Asia and the launch of the Asian Water Cycle Initiative. As part of its intent to build linkages with GEO, IGWCO will continue to advance the Water Cycle community of Practice and support the development of a Capacity Building proposal for Latin America. IGWCO will also support GEO Water Quality workshop and its follow-up.

Relative to progress on the individual water cycle variables the advances in soil moisture monitoring through the in-situ soil moisture workshops and SMOS planning are making significant contributions. The precipitation product development has made advances, particularly through the involvement of the International Precipitation Working Group.

Finally, it was recommended that the IGWCO reinforce its links with the GTN-H project, and also with GCOS/GTOS activities, while seeking wider linkages with the HWRP, WCRP/GEWEX and CEOS. Three pillars are seen here to be those of Capacity Building, the development/support of global observing systems including the HARON project, and the development of products that could be of value for water resources assessment as well as climate change.

16. Annex A: Agenda and Presentations

Wednesday, 14 March 2007

1. Introductory Session (Chair: Chu Ishida)

- 1.1 Welcome and Introductions (Rick Lawford)
- 1.2 Introduction to the IGWCO and the Goals of this Meeting (Rick Lawford, GEWEX)
- 1.3 The IGWCO: View from the Chair (Wolfgang Grabs, WMO)
- 1.4 The IGWCO and CEOP (Toshio Koike, University of Tokyo)
- 1.5 Update of CEOS (Chu Ishida, JAXA)

2. Discussion of Drought Phenomenon (Chair: Toshio Koike)

- 2.1 Strategy for an the IGWCO Real-time Drought Monitoring Product (Peter van Oevelen, ESA)
- 2.2 CPPA Drought Research (Jin Huang, NOAA)
- 2.3 The State of the NIDIS (Mark Brusberg, USDA)
- 2.4 Discussion

3. Capacity Building (Chair: Rick Lawford)

- 3.1 International Workshop on Capacity Building in Asia (Chu Ishida, JAXA)
- 3.2 Latin America Capacity Building (Rick Lawford, GEWEX)
- 3.3 TIGER and Possible Links to the IGWCO (Bob Su, ITC)
- 3.4 GEO Goals for Capacity Building and Water (Antti Herlevi, GEO)
- 3.5 Needs For Capacity Building for Flood Warning and Forecasting in Vietnam (Nguyen Thi Tan Thanh, Vietnam NHMS)
- 3.6 Capacity Building planned in Monsoon Asia Integrated Regional Study (MAIRS) (Congbin Fu, Chinese Academy of Sciences)
- 3.7 NASA Water Management Program for Capacity Building Programs in Latin America (David Toll, NASA)
- 3.8 Discussion

Thursday, 15 March 2007

4. Water Quality (Chair: Steve Greb)

- 4.1 Status of Water Quality Activities in the IGWCO (Steve Greb, Wisconsin Department of Natural Resources)
- 4.2 Water Quality Towards Sustainable Development: Local and Global Perspectives (Bilqis Amin Hoque, EPRC)
- 4.3 GEO Plans for Water Quality (Antti Herlevi, GEO)
- 4.4 USGS Water Quality Assessment of Rivers and Streams (Richard A. Smith, USGS)
- 4.5 SNOTEL and SCAN Data Collection Networks (Claudia Hoefft, USDA-National Water and Climate Center)
- 4.6 Discussion

5. Groundwater (Chair: Norman Miller)

- 5.1 Overview of the Status of Groundwater Monitoring Programmes (Jaroslav Vrba, UNESCO)
- 5.2 Land Model Working Group (Matt Rodell, NASA GSFC)
- 5.3 Monitoring the Nation's Ground-Water Resources (Ken Dennehy, USGS)
- 5.4 Global Groundwater Monitoring System (GGMS) (Neno Kukuric, IGRAC)
- 5.5 USGEO Status & Update (Gene Whitney, USGEO)
- 5.6 Proposed Groundwater Working Group (Rick Lawford, GEWEX)

6. National Links to the IGWCO (Chair: Jared Entin)

- 6.1 NASA NEWS and its Possible Links to the IGWCO (Paul Houser, CREW/GMU)
- 6.2 European Space Agency (ESA) Links to the IGWCO (Einar Herland)
- 6.3 JAXA links to the IGWCO (Kazuo Umezawa, JAXA)
- 6.4 Asian Water Cycle Initiative (Toshio Koike, University of Tokyo)
- 6.5 NASA & the Decadal Survey (Jared Entin, NASA)
- 6.6 Satellite Observations of the Global Water Cycle (Jay Famiglietti, University of California, Irvine)

7. International Links with the IGWCO in the USA (Chair: Chu Ishida)

- 7.1 Advances in The Global Water System Project (GWSP) and Implications for the IGWCO (Charles J. Vörösmarty, University of New Hampshire)
- 7.2 UNESCO IHP and the IGWCO: Potential Interactions (Matthew C. Larsen, U.S. National Committee for UNESCO IHP)
- 7.3 Discussion

8. The IGWCO Assessment Report (Chair: Rick Lawford)

- 8.1 WMO Links with GEO and IGOS (Wolfgang Grabs, WMO)
- 8.2 The IGWCO Assessment Report: Overview (Wolfgang Grabs, WMO)
- 8.3 The IGWCO Assessment Report: Findings & Agenda for Discussion (Douglas Cripe, WMO)
- 8.4 Discussion of the Assessment and Next Steps
- 8.5 GEO Expectations for the IGWCO (Antti Herlevi, GEO)
- 8.6 Summary of topics for GEO Water SBA (Task US-06-01) (Lawrence Friedl, NASA)
- 8.7 Status of a Water Cycle Community of Practice (Rick Lawford, GEWEX)

Friday, 16 March 2007

9. Surface Water Measurement (Chair: Wolfgang Grabs)

- 9.1 Surface Water Measurements Concerns and Issues (Wolfgang Grabs, WMO)
- 9.2 Remote Sensing of Freshwater Discharge (Jay Famiglietti, University of California, Irvine)
- 9.3 Surface water monitoring by the U. S. Geological Survey (Matthew C. Larsen, USGS)
- 9.4 Conceptual Framework for a Hydrological Applications and Run-Off Network (HARON) (Wolfgang Grabs, WMO)
- 9.5 Discussion

10. Breakout Groups

- 10.1 Earth Observations (Co-chairs: Einar-Arne Herland, Jurate Landwehr)
- 10.2 Data Integration (Co-chairs: Toshio Koike, Paul Houser)
- 10.3 Applications/Capacity Building (Co-chairs: Nguyen Thi Tan Thanh, Ted Engman)

11. Soil Moisture (Chair: Peter van Oevelen)

- 11.1 The European Space Agency (ESA) Soil Moisture and Ocean Salinity Mission (SMOS) (Peter van Oevelen, ESA)
- 11.2 Soil Moisture Experiments in the U.S. (Michael Cosh, USDA-ARS)
- 11.3 ISMWG Activities and the SMOS Project Contribution (Peter van Oevelen, ESA)
- 11.4 Data Assimilation and Modeling (Paul R. Houser, CREW/GMU)
- 11.5 Discussion

12. Precipitation (Chair: Phil Arkin)

- 12.1 Precipitation and the IGWCO (Phil Arkin, University of Maryland)
- 12.2 Global Precipitation Climatology Project (GPCP) (Bob Adler, NASA Goddard)
- 12.3 TRMM and Beyond: The Global Precipitation Measurement (GPM) Mission (Arthur Y. Hou, NASA Goddard)
- ~~12.4 JAXA Precipitation and Water Cycle Products (S. Shimizu, JAXA) cancelled~~

- 12.5 PERSIANN Global Precipitation Estimates (Kuolin Hsu, University of California, Irvine)
- 12.6 Discussion

Saturday, 17 March 2007

13. Country Presentations (Chair: Rick Lawford)

- 13.1 WaterNet: The NASA Water Cycle Solutions Network (P. Houser, GMU/CREW)
- 13.2 Seasonal Reversal of the ENSO Rainfall Signal in the Philippines (Flaviana Hilario, Philippine Atmospheric, Geophysical, and Astronomical Services)
- 13.3 Impact of Tropical Storms in Viet Nam (Dang Thi Mai, Vietnam NHMS)
- 13.4 Study on Arid Trend over Northern China in Relation to the IGWCO (Congbin Fu, Chinese Academy of Sciences)
- 13.5 EO Applications in the Context of West Africa (Stephen Opoku-Duah, Durham University, UK & UNESCO/GARS)
- 13.6 Discussion

14. Demonstrations (Chair: Rick Lawford)

- 14.1 [MIRADOR](#) Search Tool and [GIOVANNI](#) Online Data Analysis Tool
(Chris Lynes, NASA-Goddard)
- 14.2 [CEOP Data Analysis System](#) (registration required)
(Ben Burford, JAXA/RESTEC)

17. Annex B: List of Participants

(Joint CEOP-IGWCO participants highlighted)

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18. Annex C: Report from IGWCO Earth Observation breakout group

16 March 2007

Participants:

Chairs: Einar-Arne Herland, Jurate Landwehr

Douglas Cripe (minutes)

Chu Ishida

Weidong Guo

Stephen Opoku-Duah

Jaroslav Vrba

Gianni Tartari

Neno Kukuric

Norman Miller

Jared Entin

Peter Van Oevelen

Robert Adler

1. Where can space based water measurements have the greatest societal benefit? What types of spatial/temporal products will be of best benefit?

Space-based measurement important where in-situ not possible. Caveat is to not repeat what is currently being done.

Important issues to be strengthened are the study of water vapor in the atmosphere and precipitation networks.

Cryospheric measurements have large potential for societal benefits. Himalayas, glaciers and mountain snow have large impact on local populations.

Important promising future capabilities are the assessment of changes in groundwater storage, soil moisture and water levels. Overall estimation of water storage key to evaluate evaporation as well as anthropogenic effects on surface waters.

Other promising atmospheric parameters are aerosols, pollution (?) and atmospheric composition; promising water quality variables include temperature, turbidity, clarity and color.

2. What enhancements/changes to in-situ networks are needed to fully supplement the current capabilities of remote sensing to provide sustainable monitoring of the Earth's water condition?

Need to reinforce the importance of current in-situ networks (discharge, water quality) to counteract global declines as well as to encourage capacity building.

Need to encourage standardization and sharing of data internationally.

Need for ground-truthing, supersites for validation and enhancement of monitoring activities in transboundary monitoring.

In-situ networks need both hydrological and meteorological components. Certain water quality measurements - notably stable isotopes of water and electrical conductivity - can serve as tracers for assessment and modeling and should also be included.

Emphasis on transitioning research networks to operational.

Should strengthen high altitude in-situ networks.

Importance of collecting all regional in-situ data into national databank (with international support) as soon as possible, then make it available internationally.

3. Given the activities of GEO, what value added activities can IGWCO contribute to advance the development of observational systems?

-- see question 6.

4. What steps are needed to promote interoperability between in situ and remote sensing capabilities?

Should promote the collaboration of in-situ and remote sensing people on some specific, well-defined and highly visible projects that need to make use of both remote and in-situ measurements. Examples: prediction or assessment of regional drought such as drought in northern China; prediction or assessment monsoon variability in Asia.

Aggregation of information across scales is a problem, including the issues of differences in resolution of various in situ and remote measurements, as well as error propagation across scales.

Need to define substantive hydrologic products which can make use of remote sensing capability - which is spatially broad but has a temporally limited life-span.

Need to bring research committees together for dialog.

A technical issue is the problem of data ownership. Must often deal with several countries. Need to encourage sharing of data internationally.

5. In the IGWCO there were a number of atmospheric water cycle variables that did not show much advance. What priorities should IGWCO assign to individual atmospheric water cycle variables over the next three years (eg water vapor vs clouds vs precipitation vs evaporation)?

In climate projections, cloud height-to-area ratios are a key issue.

Need to identify those atmospheric aspects of water cycle most vulnerable to climate change.

Some attention should be paid to emerging concepts which are not understood, such as 'atmospheric rivers' (very narrow-band high moisture jets) or the issue of Saharan dust having negative feedback on Atlantic hurricane activity.

Priority remote sensing research areas are oceanic evaporation, precipitation (especially high latitude), and accurate measurements of near land-surface air temperature in Africa.

6. What would be the implications of merging the IGWCO in GEO for IGWCO earth observation activities? What factors should be considered in following this path?

--includes question 3

There was not a complete consensus in the group on this issue.

Some held that GEO is a different sort of entity than IGWCO, a political entity operating on a different level. GEO provides a political umbrella for IGWCO, but work that has been accomplished needs to be maintained. Some things can map into GEO, but not all. The IGWCO strategy is much broader than GEO, thus much would be lost if IGWCO merged into GEO. All activities of IGOS are

still relevant and should carry on. IGWCO leads to scientific advances, which then feed into GEO societal benefits.

Some noted that IGOS was created by CEOS to pose politically relevant earth science questions to the community. GEO has now come along from the political community, after many years of work has been accomplished. Thus, GEO is directly enhanced by the past work of IGOS, and this function is still relevant and should carry on.

It was noted that many of the activities are being done by the same people - there is an overlap.

IGWCO can reinforce the user interface with GEO, this is where GEO is weak. Also IGWCO can provide strategy and oversight/monitoring of GEO.

19. Annex D: Report from IGWCO Data Integration breakout group

16 March 2007

1. What concept of integration should IGWCO adopt?

Integration target, purpose:

Need a managed, focused integration effort(s)

Enable science

Contribute to societal benefit

Improve interaction between scientists and stakeholders, research and operations

Application-oriented products: flood, drought, water resource management

Integration process:

Converge observations, data & science

Interoperability of data and observation systems

Communication/sharing of science and observations amongst community

Types of integration:

1) Common data formats

2) Spatial rectification (interpolation)

3) Physical rectification (based on errors, data assimilation, etc.)

3) Data visualization

4) Tools to combine data to create new products

5) People integration & requirements

Integration tools:

Data mining/exploring tools

Assimilation/merging tools

Shared data center platforms

Integration issues:

Need to provide motivation to get partners to participate (what is merit).

- We lack a “factory” that “integrates” the observation systems to meet the information needs of the user communities. NWP may provide a good example.

What is the first step? Examples: Precipitation Data, Land Data Assimilation

2. What platforms can effectively be used for data integration?

Distributed systems:

WTFCCCEOP

Centralized Systems:

Metadata registration systems, such as GCMD

NASA Distributed Archive Centers

NOAA Climate Data Center

Steve William’s big disks at NCAR

1pb disk at U. Tokyo

NASA-NEWS data integration center at CREW.

**3. How can integration best be achieved? By region? By variable?
By measurement and analysis platform?**

There are necessarily many dimensions required for integration:

By Variable: Precipitation is a good example of a well integrated product.

By Decision/user/community need: Water management system

- Open integration concept: providing integration tools, enabling many different types of integration or development of many types of integrated products.

4. What are the key elements for an integrated observing system over the next decade? To what extent will GEO be able to achieve this level of integration?

Google-based data searching – event based searching, very fast, etc.

Needs to be extremely user-friendly and well-known.

5. What steps should IGWCO undertake to help GEO and IGOS-P with their ambitions to create an integrated system (Specific projects and activities should be proposed)?

This could be done under GEO's DA07-06 task.

6. What would be the implications of merging IGWCO into GEO for IGWCO Integration activities? What factors should be considered in following this path?

If we get to cooperation of all the country partners, we will be able to do all the IGWCO integration activities under GEO – no need to worry about this.

IGWCO may have a larger scope than GEO, and therefore the IGWCO activities may have to be scaled back a bit to fit in GEO.

20. Annex E: Report from IGWCO Capacity Building/Applications breakout group

16 March 2007

Break-out session participants:

Dave Toll, US (Minutes)

Flaviana Hilario, Phillipines

Dang Thi Mai, Vietnam

Congbin Fu, China

Bilqis Amin Hogue, Bangladesh

Bob Su, The Netherlands

Rick Lawford, Canada

Nguyen Thi Tan Thanh, Vietnam (Session Co-Chair)

Ted Engman, US (Session Co-Chair)

Report

After introductions and expectations, we agreed to address the six questions that were given to the committee. At the end, we would add additional items if they had not already been covered. We also agreed that applications and capacity building could be addressed together

1) The Asian water cycle initiative is mobilizing a community with strong interests in using satellite and in situ data in water management. Is there potential for building on this model in the Americas and in Africa? What obstacles are there to implementing this concept in these regions?

- Need to go beyond the Asian W C initiative and identify demonstration projects. Asian group coming together, essentially through networking. Limitation come from lack of funding.
- Obstacles – funding and political.
- Need to have a regional approach that involves several different countries. Need demonstration projects to make it work. Establish regional centers. That share a certain structure – establish sites in Asia Africa and South and Central America to provide satellite data freely that otherwise would cost money (e.g., Radarsat). These would be IGWCO test sites and get ESA, Canadians on-board to provide data freely.
- Available of data (satellite) for river basin is crucial and often only data available.
- There are no obstacles to implementing this type of capacity building elsewhere.

2) How can IGWCO capacity building activities best interface with those of GEO?

We think they do! IGWCO can support GEO by GEO id the areas and IGWCO try and implement them. Asia – to document data avail. Of the nonominated river basins and 2) to list the capacity building needs for e issues to GEO for support.

3) What opportunities exist for the application of Earth Observations to global assessments (MDGs)?

- The MGDs are based on knowledge. Knowledge is based on data which come from EO.

4) What mechanisms work most effectively in engaging water resources management groups in applying Earth observations in decision making?

- Document data availability
- Identify Capacity Building Needs

5) How can benefits of Earth observations be measured? What are the criteria for experiments that will unambiguously and quantitatively show Earth observation benefits?

- Use of models and/or DSTs to demonstrate improvements using EO data.
- Improvements can be translated into monetary benefits such as lives saved, drought assistance, world food program.

- Also, EO data may provide the only data, not just improved data
- Societal Benefits are more difficult to document, may be limited to showing examples
- EO can provide basic data fields such as soil moisture, topography, limited data, GPM data.

6) What would be the implications of merging IGWCO and GEO for IGWCO applications and capacity building? What factors should be considered in following this path?

- No problem with merging. GEO is a framework.
- Should IGWCO be merged? All make contributions to GEO.
- GEO may provide better leverage for funding than IGWCO. GEO not under UN.

7) Other points of our discussions include:

- Capacity Building needs to be sustainable. Need a strategy to get continued support
- Structure needed that is built on successful examples
- Regional Centers may be the best way to go because they would be more sustainable and perhaps easier to get NGO funding
- Lessons learned need to be documented and distributed so that we do not repeat ourselves and make the same mistakes again
- Inventory of Capacity Building capabilities and funding possibilities

Inventory of web sites dealing with all aspects of the issues (EO data sources, Capacity Building resources, successful examples, funding sources, etc.)

21. Annex F: Acronyms

AMSR-E	Advanced Microwave Scanning Radiometer for EOS
AWCI	Asian Water Cycle Initiative
CEOP (old)	Coordinated Enhanced Observing Period
CEOP (new)	Coordinated Energy and Water Cycle Observation Project
CEOS	Committee on Earth Observation Satellites
CIMS	Inter-Monsoon Comparison Study
CLASIC	Cloud and Land Surface Interaction Campaign
CMORPH	Climate Prediction Center MORPHing technique
CONAE	Comision Nacional de Actividades Espaciales
CPPA	Climate Prediction Program for the Americas
CRN	Climate Response Network
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAAC	Goddard Distributed Active Archive Center
EO	Earth Observations
EOS	Earth Observing Systems
EPA	Environmental Protection Agency
ESA	European Space Agency
ESS	Earth System Sciences
ESSP	Earth System Science Partnership
FRIEND	Flow Regimes from International Experimental and Network Data
GARS	Geological Application of Remote Sensing
GCOM	Global Change Observing Mission
GEMS	Global Environment Monitoring Program
GEWEX	Global Energy and Water Cycle Experiment
GEO	Group on Earth Observations
GEOSS	Group on Earth Observation System of Systems
GCOS	Global Climate Observation System
GEMS	Global Environmental Monitoring System
GLDAS	Global Land Data Assimilation System
GGMS	Global Groundwater Monitoring System
GOCE	Gravity Field and Steady-State Ocean Circulation Explorer
GPCP	Global Precipitation Climatology Project
GPM	Global Precipitation Mission
GRACE	Gravity Recovery and Climate Experiment
GRDC	Global Runoff Data Center
GSMaP	Global Satellite Mapping of Precipitation
GTN-H	Global Terrestrial Network-Hydrology
GWSP	Global Water System Project
GWW	Global Water Watch
ICSU	International Council for Science
IGOS-P	Integrated Global Observing Strategy Partnership
IGWCO	Integrated Global Water Cycle Observations
IHP	International Hydrology Programme
InSAR	Interferometric Synthetic Aperture Radar
IPP	Integrated Precipitation Product
IPWG	International Precipitation Working Group
ITC	International Institute for Geo-Information Science and Earth Observation
JAXA	Japan Aerospace Exploration Agency
KaRIN	Kay-Band Radar Interferometer
LIS	Land Information System
MAIRS	Monsoon Asia Integrated Regional Study
MDG	Millennium Development Goals
NASA	National Aeronautic and Space Agency
NASQAN	National Stream Quality Accounting Network
NAWQA	National Water-Quality Assessment Program

NESDIS	National Environmental Satellite, Data, and Information Service
NEWS	NASA Energy- and Water-Cycle Sponsored Research
NGO	Non-Governmental Organizations
NIDIS	National Integrated Drought Information System
NOAA	National Oceanic and Atmospheric Administration
NWP	National Weather Prediction
PEHRPP	Program for Evaluation of High Resolution Precipitation Products
PERSIANN	Precipitation Estimation from Remotely Sensed Information using Artificial Neural Networks
POGO	Partnership for Observation of the Global Oceans
RHP	Regional Hydrological Project
RMORPH	Rain Gauge Data Merged with CMORPH
SBA	Societal Benefit Area
SPARROW	SPAtially Referenced Regression on Watershed Attributes
START	SysTem for Analysis, Research and Training
SMOS	Soil Moisture and Ocean Salinity Mission
TIGER	Terrestrial Initiative in Global Environment Research
TMPA	TRMM Multi-Satellite Precipitation Analysis
TRMM	Tropical Rainfall Measuring Mission
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific, and Cultural Organization
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WATER HM	Water and Terrestrial Elevation Recovery Hydrosphere Mapper
WCP	World Climate Programme
WCRP	World Climate Research Programme
WESP	Water and Energy Simulation and Prediction
WGISS	Working Group on Information Systems and Services
WIS	WMO Information System
WHYCOS	World Hydrological Cycle Observing System
WMO	World Meteorological Organization