

# INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)



## Annual Report of IGCP Project No. 565

IGCP project short title: Geodetic Monitoring of the Global Water Cycle

Prepared by:

Name: Prof. Dr. Hans-Peter Plag  
Address: University of Nevada, Reno  
Nevada Bureau of Mines and Geology and  
Seismological Laboratory, Mail Stop 178, Reno,  
NV 89557, USA  
Tel.: +1-775-6828779  
Fax: +1-775-7841709  
Email: [hpplag@unr.edu](mailto:hpplag@unr.edu)

# **Annual Report 2008**

## **1. Website address(es) related to the project**

The main web page of the project is located at <http://geodesy.unr.edu/igcp565/>. This web page is used for project documentation, workshop organization, and resource deposit in terms of electronic documents. The web page of the Global Geodetic Observing System is at <http://www.iag-ggos.org>. This page links to the IGCP 565 Project web page. It is planned to include a link to the project web page on the GEO web page under the Water Community of Practice.

## **2. Summary of major past achievements of the project**

N/A

## **3. Achievements of the project this year only**

### *3.1. List of countries involved in the project*

The following countries contributed actively during 2008: United States of America, Canada, Germany, Italy, Australia, Korea, South Africa.

### *3.2. General scientific achievements and social benefits*

The main focus in the first project year was (1) on a review of the state of the art in understanding the quantitative fluxes in the global water cycle, and (2) on the relation between geodetic observations and mass changes in the main reservoirs of the water cycle. The goal was to clarify the open science questions that the geodetic observations can help to reconcile, and, based on that, to detail the work program for the remaining four project years.

The review of the current knowledge of the water cycle relevant to regional water management concluded that deep groundwater is one of the major uncertainties in the budget of the water cycle. This uncertainty is a major obstacle for regional water management, particularly in regions where a main part of the water supply depends on groundwater mining.

With respect to the geodetic contributions, the on-going research projects addressed (1) the forward modeling of the signals of water mass redistribution in geodetic observations, (2) improvements in data processing and geophysical modeling inherent in geodetic analysis that are required in order to identify and/or preserve the unbiased water mass signals in the space-geodetic and in situ geodetic time series, (3) the validation of surface mass variations derived from geodetic observations, (4) the integration of in situ and geodetic remote sensing products for inversion and data assimilation, and (5) the relation between the geodetic signals and mass redistribution in the terrestrial hydrosphere.

Based on the research results, a concept for utilizing the geodetic observations for products relevant for regional water management was developed. This concept is based on a hybrid approach combining local implementation with space-borne global and in situ regional observations (both surface displacements and gravity) was proposed. Assimilation of the geodetic observations in regional hydrological models with predictive capabilities was identified as the ultimate goal.

We also addressed the question: To what extent space-geodetic observations of changes in Earth's shape and rotation could be used to bridge a gap in case the

current GRACE mission stops operation (anticipated lifetime of GRACE is 2012) before a follow-on mission is in space? We showed that, in particular, the global network of GPS stations could help to bridge the gap if these data are assimilated in well-calibrated hydrological models. This calibration benefits from the overlapping availability of GRACE and GPS observations. However, the distribution of dense regional GPS networks does not fully coincide with the regions for which GRACE shows the largest trends in surface mass (Figure 1). Therefore, within the GGOS community, we will promote the establishment of additional GPS/GNSS stations in these 'hot spots' in order to prepare for a gap in gravity satellite missions and/or to improve the data base for validation.

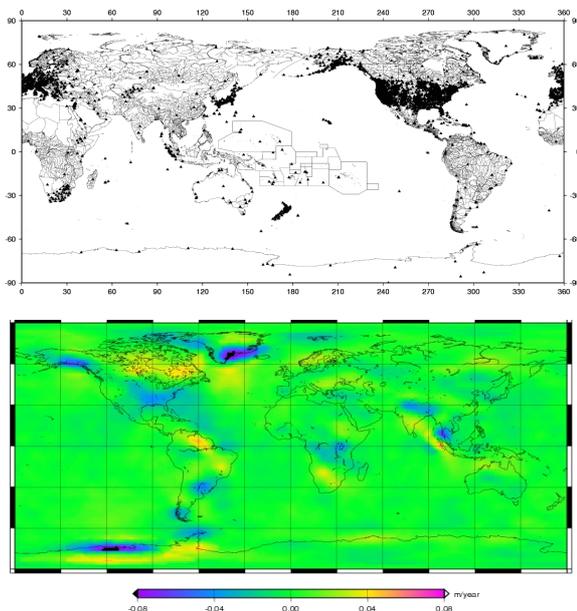


Figure 1: Global GPS network and areas with large surface mass changes. Upper diagram: Distribution of nearly 4000 GPS stations with publicly available data analyzed at the Nevada Geodetic Laboratory. Lower diagram: Secular trends in surface mass determined from GRACE. The scale is from -0.08 to 0.08 m/year. Courtesy M. Watkins, JPL.

Key validation areas for the IGCP 565 Project are the Central Valley, California, and the Colorado river basin; two regions with, on the one hand, rapidly increasing water management issues and, on the other hand, dense relevant data sets. Validation studies are also carried out in Australia and Europe. For applications in developing countries, we have decided to focus on regional water management in Africa. This decision was made in coordination with the activities in the Societal Benefit Area (SBA) "Water" of GEO. GEO has decided to have regional water management in Africa as a focal point for the Ministerial Summit on Earth Observations in late 2010, and the IGCP 565 Project will work towards a demonstration project showing the contribution of geodetic products to the database for regional water management.

It is emphasised here that the IGCP 565 Project in 2008 has developed into a framework that brings together a broad basis of experts from two separate scientific fields, and facilitates an interdisciplinary dialog between geodesy and hydrology and coordinated research involving both fields. The project has been recognized as a forum for dialog in both communities and stimulated interest in several relevant groups to participate and contribute.

### 3.3. List of meetings with approximate attendance and number of countries

#### *Specific Project Meetings:*

(1) Ad hoc Kick-off meeting on March 28, 2008, held at the GGOS Retreat, March 25-28, 2009, Bertinoro, Italy, 8 participants, six countries.

(2) First IGCP 565 Project Workshop "Science of geodetic monitoring of the hydrological cycle", December 11, 2008, San Francisco, USA. 15 Participants

from 5 countries. See <http://geodesy.unr.edu/igcp565/workshops/>. Co-located with the GRACE Science Team Meeting, December 12-13, 2008, same venue.

#### *Other meetings:*

A number of working meetings of project leaders, project participants, and potential contributors took place at several meetings of the GEO User Interface Committee (Toronto, Boulder, and Bucharest), the GEO Science and Technology Committee (San Francisco), and the UNESCO conference on water scarcity (Irvine, California). These meetings focused on coordination of research activity, new contributions, planning of the program of the First Workshop, and discussion of the scope and program of the Second Workshop.

#### *3.4. Educational, training or capacity building activities*

In 2008, no specific training courses were organized in the frame of the IGCP 565 Project. The most appropriate time for specific training courses and capacity building activities will be the last three years of the project, when focus will be on regional applications in Africa.

#### *3.5. Participation of scientists from developing countries, and in particular young and women scientists*

Besides other scientists from South Africa, Andiswa Mlisa, Umvoto Africa Ltd, Muizenberg, South Africa, works in the research project “GPS Application for Groundwater Resource Assessment, Hermanus, South Africa” (see the presentation linked to the First Workshop program at <http://geodesy.unr.edu/igcp565/workshops/>). The first project year has been used to establish a number of new links to institutions and individuals particularly in Africa. In the next years, a focus will be on increasing the number of young researchers from developing countries significantly, particularly in view of the anticipated training and capacity building activities in project years 3 to 5.

#### *3.6. List of most important publications (including maps)*

##### *Distinguish between peer review literature and other (no abstracts)*

The research projects contributing to the goals of IGCP 565 have already generated a number of publications in peer-reviewed literature. The GGOS community has finalized a community study which is now in press as a book (Plag and Pearlman, 2009). Although this book is not a direct outcome of the project, it has high relevance since it addresses the contribution of GGOS to water cycle monitoring in several chapters. In terms of manuscripts specifically reporting on the project, one manuscript has been submitted to conference proceedings (Plag et al., 2009). In the first year, main dissemination was focused on informing relevant communities (IGWCO, GEO, GRACE Science Team, etc.) about the IGCP 565 Project and to increase participation in this project. Below we list a few selected examples of presentations given.

#### *Manuscripts:*

Plag, H.-P., Gross, R. S., Miller, N. L., Rothacher, M., Zerbini, S., & Rizos, C., 2009. IGCP 565 Project: Developing the Global Geodetic Observing System into a monitoring system for the global water cycle. In: *Proceeding of the UNESCO Conference on Water Scarcity, Global Changes, and Groundwater Management Responses*, Irvine, December 1-4, 2008, 20 pages, in press.

Plag, H.-P., & Pearlman, M., eds., 2009. *The Global Geodetic Observing System: Meeting the Requirements of a Global Society on a Changing Planet in 2020*, Geoscience Books, Springer Berlin. 365 pages, in press.

Zerbini, S., Raicich, F., Richter, B., Gorini, V., and Errico, M., 2009. Climate-induced signals observed in height and gravity in Northeastern Italy. Submitted to *J. Geodynamics*.

*Presentations and Posters:*

Plag, H.-P., and Gross, R. S., 2008. Exploring the link between Earth's gravity field, rotation and geometry in order to extend the GRACE-determined terrestrial water storage changes to non-GRACE times, Invited presentation given at the GRACE Science Team Meeting, December 12-13, 2008, San Francisco, Ca., USA

Plag, H.-P., & the IGCP 565 Project Team and the Participants of the First IGCP 565 Workshop, 2008. Developing the Global Geodetic Observing System into a monitoring system for the global water cycle (IGCP 565 Project), Presentation given at the GRACE Science Team Meeting, December 12-13, 2008, San Francisco, Ca., USA

Plag, H.-P., Gross, R. S., Miller, N. L., Rothacher, M., Zerbini, S., Rizos, C., 2008. IGCP 565 Project: Developing the Global Geodetic Observing System into a Monitoring System for the Global Water Cycle. Presentation given at the Eighth Meeting of the *User Interface Committee* of the *Group on Earth Observations*, Boulder, CO, September 22-25, 2008.

Plag, H.-P., Gross, R. S., Miller, N. L., Rothacher, M., Zerbini, S., Rizos, C., 2008. Five Annual Workshops on Developing the Global Geodetic Observing System into a Monitoring System for the Global Water Cycle. Presentation given at the Implementation Meeting of the IGWCO, Geneva, March 2008.

Zerbini, S., Raicich, F., Gorini, V., and Richter, B., 2008. Space and time variability of height and gravity in Northeastern Italy. Poster presented at the Fall AGU Meeting, San Francisco, December 2008.

*Publication plan for 2009:* Besides continuing publication of results in the research projects contributing to the IGCP project in peer-reviewed journals, three specific project publications are planned:

- (1) A summary report of the First Workshop is under preparation for publication in *Episodes* and will be submitted in January 2009.
- (2) Based on the presentations given at the First Workshop, it was decided to produce in 2009 a (peer-reviewed) thematic issue of *Physics and Chemistry of the Earth* on the geodetic contribution to the monitoring of the water cycle. This thematic issue will include invited contributions only.
- (3) A roadmap for future satellite gravity mission is the anticipated result of the Second IGCP 565 Workshop to be held in September 2009. Publication of this roadmap by one of the major space agencies is anticipated for late 2009.

*3.7. Activities involving other IGCP projects, UNESCO, IUGS or others*

The project activities are closely linked with activities in the "WATER" SBA of GEO, the IGWCO, and GEWEX. Contacts to UNESCO's IHP have been established and will be explored in 2009.

## **4. Activities planned**

### *4.1. General goals*

The research projects contributing to the IGCP Project will continue to focus on the scientific issues that need to be addressed in order to support assimilation of

the geodetic observations in regional hydrological models. The relevant scientific problems are summarized in Section 3.2.

An urgent problem is the fact that GRACE is projected to stop operation in 2012. A lack of an operational gravity satellite mission would seriously deteriorate the geodetic component of the water cycle observing system. Therefore, the project activities will focus on two relevant aspects: (1) Defining a roadmap for future gravity satellite missions that can be endorsed by GEO and CEOS and agreed to by major national space agencies (see also the information about the Second Workshop below); (2) focusing research on the use of geodetic observations of Earth's shape and rotation for validation of models and the bridging of a potential gap in satellite gravity missions.

#### *4.2. Tentative list of specific meetings and field trips (please list the participating countries)*

The main meeting in 2009 will be the Second IGCP 565 Workshop: *Towards a road map for gravity satellite missions*. This Workshop will be organized together with GEO, GGOS, IAG, IGWCO, CEOS, and major space agencies. Participation of the UNESCO International Hydrological Program is anticipated. The workshop will have participation from an estimated twenty countries. The workshop tentatively will take place in the last week of September 2009. A Program Committee is currently being established.

Besides this Workshop, there will be a number of project-related meetings of subgroups of project participants organized in conjunction with relevant scientific conferences (EGU, AGU, IGOS-P Symposium) and GGOS and GEO meetings.