

# INTERNATIONAL GEOSCIENCE PROGRAMME (IGCP)



## Annual Report of IGCP Project No. 565

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

Duration: 2008 - 2012

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

The web page of the project is at <http://www.igcp565.org>. This web page is used for project documentation, outreach, workshop organization, and resource deposit in terms of electronic documents. Several web pages link to the IGCP 565 Project web page.

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

In the past two years (2008 and 2009), the research projects coordinated in the IGCP 565 Project focused on the basics of hydrogeodesy in terms of identifying the key contributions, determining the spatial and temporal resolution, and addressing the combination of geodetic observations for the monitoring of global water cycle. Deep groundwater (both total quantity and changes) emerged as one of the largest uncertainties in the budget of the water cycle. Particularly in regions where a main part of the water supply depends on groundwater mining, this is a major obstacle for water management. Progress towards a utilization of hydrogeodesy for groundwater monitoring was achieved through improved forward modeling of the geodetic signals resulting from tectonic processes, atmosphere and ocean loading, and changes in land water storage. Improvements in data processing and geophysical modeling inherent in geodetic analysis further helped preserve an unbiased water mass signals in space-geodetic and in situ time series.

With the growing importance of GRACE for the monitoring of the water cycle, in 2008 concerns about the absence of an immediate follow-on mission mounted and we addressed the question to what extent space-geodetic observations of changes in Earth's shape and rotation could be used to bridge a potential gap between GRACE and a future gravity mission. 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.

A number of studies carried out by project participants demonstrated the high potential of GRACE to detect changes in major components of the water cycle. Several of these examples are described in “one-page stories” available at [http://www.iag-ggos.org/workshops/Graz\\_2009/](http://www.iag-ggos.org/workshops/Graz_2009/) and there under the link “Workshop Outputs.”

In 2009, an effort was made to emphasize the scientific rationale for an immediate follow-on GRACE mission, resulted in a Road Map for future gravity satellite missions. This Road Map was distributed to the participants of the VI Plenary of the intergovernmental Group on Earth Observations (GEO) in November 2009 in Washington, D.C. In 2010, NASA put a GRACE follow-on mission in its plans with the launch scheduled for 2016.

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

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

The following countries contribute to the project (\* indicates active contributions in 2010): Australia(\*), Austria, Canada(\*), China, Ethiopia(\*), France(\*), Germany(\*), Italy(\*), Japan(\*), Poland(\*), Republic of Korea, South Africa(\*), The Netherlands(\*), United States of America (\*), Zimbabwe(\*).

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

The research in 2010 further underlined the potential of hydrogeodesy, and at the same time identified the challenges for fully utilizing the benefits of hydrogeodesy and ways to address these. Scientific progress has been made towards validation of the hydrological signals extracted from geodetic techniques through inter-comparison with independent data (e.g., Becker et al., 2010) and integrated processing of geodetic data (e.g., Wu et al., 2010; Hammond et al., 2010). With respect to hydrogeodetic applications of GRACE, the GRACE Science Team has continued to make progress in the determination of hydrological signals and the interpretation of these signals, with the IGCP 565 project team contributing to this progress.

The uniquely large database of GPS-derived time series of surface displacements has been used to improve the characterization of surface displacements and the models predicting these displacements. Together with results produced by other IGCP 565 research teams, these results provide a basis to improve the separation of the hydrological signal from other signals, which is a prerequisite for the next step: assimilation of geodetic observations in land water storage models.

Considerable progress has also been made in terms of demonstrating the value of hydrogeodesy for regional water management. A particular example is the Central Valley in California, where the combination of GRACE, GPS and InSAR provides constraints for trends in groundwater storage that can be related to climatic and anthropogenic changes. The project is now in the position to carry out a demonstration project as an outreach to regional water managers.

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

3<sup>rd</sup> IGCP 565 Workshop "Separating hydrological and tectonic signals in geodetic Observations", Reno, Nevada, USA, October 11-13, 2010. 55 participants from 12 countries and 3 continents. See [http://www.igcp565.org/workshops/Reno\\_2010](http://www.igcp565.org/workshops/Reno_2010).

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

In 2010, 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 two 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". She also is the P.I. a project-related proposal to a CfP published by GEO. Jean-Marie Kileshye Onema is a young scientist now at WaterNet, Zimbabwe, and he will take a leading role in local organization of the next workshop and two projects related to water management. Elias Lewis Teklemariam, Ethiopia provides a link to hydrogeodetic research and water management authorities in Ethiopia. Through the Lake Victoria and East Africa projects of Miller and Calais, respectively, a number of African scientists are linked to project activities and contribute to the project goals.

3.6. List of most important publications in 2010 (including maps)  
Peer-reviewed articles are marked with (\*)

- Aslam, O., L.L. Dale, V. Mehta, and N.L. Miller, 2010: Climate Change Vulnerability and Infrastructure Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin, Report to the UN Habitat, 81pp.
- (\*) Becker, M., L.Lovel, W., Cazenave, A., Güntner, A., Cretaux, J.F.: Recent hydrological behavior of the East African great lakes region inferred from GRACE, satellite altimetry and rainfall observations, *Comptes Rendus Geoscience*, **342**(3), 223-233 , 2010.
- (\*) Wu, X., M. B. Heflin, H. Schotman, B. L. A. Vermeersen, D. Dong, R. S. Gross, E. R. Ivins, A. W. Moore, and S. E. Owen, Simultaneous estimation of global present-day water transport and glacial isostatic adjustment, *Nature Geosci.*, **3**, 642–646, doi:10.1038/NCEO938, 2010.

*2010 Bibliography (listed by author in alphabetical order with the most recent work listed first)*

- (\*) Brown, N. and P. Tregoning, 2010. Quantifying GRACE data contamination effects on hydrological analysis in the Murray-Darling Basin, southeast Australia, *Aust. J. Earth Sci.*, **57**, 329-335.
- (\*) Hammond, W. C., Kreemer, C., Blewitt, G., Plag, H.-P., 2010. Effect of Viscoelastic postseismic relaxation on estimates of interseismic crustal strain accumulation at Yucca Mountain, Nevada. *Geophys. Res. Lett.*, **37**, doi:10.1029/2010GL042795.
- Hammond, W.C., Z. Li, H.-P. Plag, C. Kreemer, and G. Blewitt, 2010. Integrated InSAR and GPS studies of crustal deformation in the western Great Basin, western United States. The International Archives of the Photogrammetry, Remote Sensing, and Spatial Information Sciences. Volume XXXVIII, Part 8, Kyoto, Japan, ISSN 1682-1777.
- Miller, N.L. and N.J. Schlegel, 2010. Analysis of Climate Change in the Lake Victoria Region, Climate Change Vulnerability and Infrastructure Investment Assessment and Analysis for Small Scale Water Utilities in the Lake Victoria Basin. A Report to the UN Habitat, 33pp.
- (\*) Plag, H.-P., Rizos, C., Rothacher, M., Neilan, R., 2010: The Global Geodetic Observing System (GGOS): Detecting the Fingerprints of Global Change in Geodetic Quantities. In Chuvieco, E., Li, J., and Yang, X. (eds): *Advances in Earth Observation of Global Change*, Springer Verlag, Berlin, 125-143.
- Killeshye Onema, J.-M., 2010. Separating Hydrological and Tectonic Signals in Geodetic Observations Workshop, 11 - 13 October 2010, Reno, United States of America  
. *WaterNet News*, **6**(3), 13.
- Plag, H.-P., and Miller, N.L., 2010. Third Annual IGCP 565 Workshop: Separating hydrological and tectonic signals in geodetic observations. *Episodes*, **33**. Submitted for publication in the December 2010 issue.
- Plag, H.-P. and Miller, N.L., 2010. Third Annual UNESCO IGCP 565 Workshop on Developing the Global Geodetic Observing System into a Monitoring System for the Global Water Cycle. *EOS Trans. AGU*. Submitted.

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

The IGCP 565 project was presented at the Joint workshop of the GEO Coastal Zone Community of Practice and UNESCO's International Hydrological Program, Cotonou, Benin, February 15-18, 2010. This workshop had a participation involving many African countries.

The project was also presented at the International African Water and Sanitation Congress and Exhibition, March 15-18, Kampala, Uganda. The Project status was also presented (by Plag and Miller) at a Workshop on Water Resource Assessment and Applications on February 23-24, 2010 in New York, and the subsequent meeting of the Integrated Global Water Cycle Observations (IGWCO) Community of Practice of GEO at the same venue.

Project participants used the AfricaArray Workshop held on June 2-4, 2010 in Washington, D.C., USA, for coordination of the project activities with the extension of AfricaArray for (among others) hydrological applications.

The cooperation developing between the project and WaterNet is of particular relevance for the project goals in terms of regional water management. IGCP 565 will closely cooperate with the DEWFORA (Improved Drought Early Warning and FORecasting to strengthen preparedness and adaptation to droughts in Africa) project, which is funded by the European Commission and coordinated with WaterNet. This cooperation will link the IGCP project to many of the national water authorities in Africa.

The Project is also closely coordinated with activities in the Group on Earth Observations (GEO) and there in particular the Water Cycle Community of Practice. GEO also issued a Call for Proposals in the Water Societal benefit Area, and two of the proposals with African P.I.s are supported by experts from the IGCP 565 core team.

#### **4. Activities planned**

##### *4.1. General goals*

A key recommendation of the 2010 Workshop was the implementation of two demonstration projects, one in an area with well developed hydrogeodetic infrastructure, and a second subsequent one in Africa. A key activity in 2011 will be the demonstration of hydrogeodesy for the Central Valley, California to the Water management authorities in California. This demonstration will provide the basis for the development of a proposal for a demonstration project in a larger river basin in Africa to be implemented in 2012. A smaller demonstration project centered in Windhoek, Namibia is already under preparation for a start on 2011.

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

The Fourth IGCP 565 Annual Workshop will be held in Maputo, Mozambique, most likely October 25-28, 2011. This workshop will focus on the assimilation of geodetic observations in land water storage models. The workshop is open for participation of all interested scientists. It is anticipated that all countries active in IGCP565 will be present. Since the workshop will be organized in co-location with the annual meeting of WaterNet, strong participation from African countries is also expected.

A training course in hydrogeodesy and its application to regional water management will be held prior to the IGCP 565 Workshop in October 2011 in Africa. Current planning is to organize the training course at one of the five African Universities participating in a Integrated Water Resource Management (IWRM) master program organized in the Frame of WaterNet.