Project: IGCP Project #565

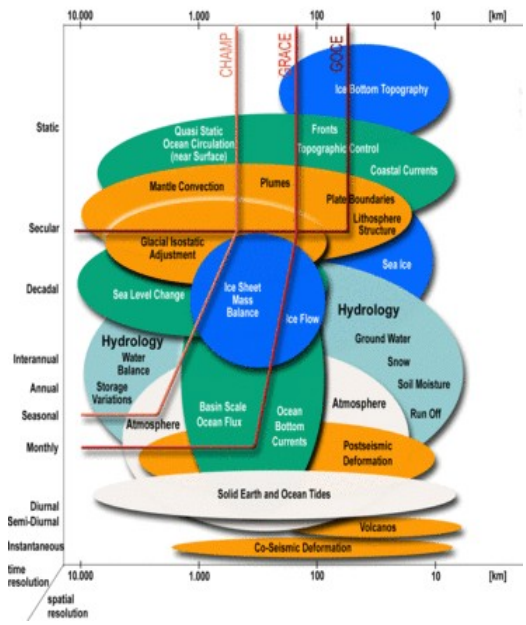
MEETING: Workshop 3: Separating Hydrological and Tectonic Signals in Geodetic Observations
Date: October 11-13, 2010
Place: Reno, NV, USA
Itinerary: see http://www.igcp565.org/workshops/Reno_2010
Report author: Hans-Peter Plag

SCOPE AND RESULTS OF MEETING:

Scope of Meeting (program or outline of geological study)

The workshop had the objective to make progress towards improved applicability of geodetic observations for hydrological and global change studies. The focus of the workshop was on the separation of hydrological and tectonic signals in geodetic observations of Earth's time-variable gravity field, surface displacements, and rotation. In regions like the Southwestern U.S., the Mediterranean, Northern India, East Africa, and large parts of East Asia, tectonic processes and changes in land water storage produce overlapping signals in geodetic observations. At the same time, these regions experience water scarcity and would benefit from improved water management informed by additional data on water storage changes. In order to fully utilize the potential of geodetic observations to provide estimates of land water storage changes in these regions, the tectonic and hydrological signals need to be separated. In other regions, geodetic signals of present-day changes in water storage are superimposed by contributions from large past changes in glaciers, ice sheets and large lakes hampering the use of geodetic observations as constraints for current climate change impacts.

The workshop considered processes in the Earth system that impact geodetic observations on sub-daily to secular time scales and on sub-kilometer to global spatial scales. As illustrated in the figure below, on the solid Earth side, these processes include volcanic and geothermal activities, post-seismic deformation, the response to surface loading, plate boundaries, and global geodynamics. In the fluid envelope, all mass redistribution in atmosphere, oceans, land water storage, and the cryosphere need to be considered. In scope, the workshop focussed on a few selected regions, where large tectonic signals have the potential to bias the hydrological information. Focal regions included the Southwestern U.S., where the EarthScope program provides insight into the relevant tectonic processes, and East Africa, where an extension of the AfricaArray may lead to improved observations.



Geodetic observations carry signals of a wide range of processes in the solid Earth and its fluid envelope. The geodetic fingerprints of these processes have temporal time scales from instantaneous to secular, and spatial time scales from local point movements to global. The figure illustrates the spatial and temporal scales for gravity, and a similar figure applies to surface displacements as well. From Ilk et al. (2005).

Achievements of Meeting

The workshop reviewed the current state knowledge with respect to the geodetic fingerprints of the tectonic and hydrological processes, and the main challenges in modeling and separating the various contributions were identified. There were 57 participants from eleven countries representing universities, national laboratories, and government agencies. A series of plenary presentations was followed by breakout sessions addressing topics ranging from the advances needed to improve modeling algorithms for applications of geodesy to hydrology, working with the Group on Earth Observations (GEO) Water Community of Practice, and developing a hydrogeodetic data portal. An important achievement is the establishment of a cross-disciplinary dialogue bringing together and linking experts in geodesy, tectonics, and hydrology.

The workshop made progress towards an agenda to address these challenges through focused research projects. Through presentations and discussion it became very clear there was added value in applying geodesy to support hydrologic cycle modeling and monitoring, especially terrestrial water storage. However, there remain challenges in the uncertainties of observations, data analysis, forward modeling, and synthesis of geodetic products before the full benefits of the emerging field of hydrogeodesy become exploitable. There is a need to reduce model uncertainty through validation with point to basin observations, increased consistency in processing and modeling displacement, gravity variations, and hydrologic processes, and new technologies that merge scale mismatches. Improving accuracy and stability of the geodetic reference frames will extend the applicability of geodesy to hydrologic problems. In tectonically active areas, joint interpretation of tectonic and hydrologic signals is required. Ground truth networks are needed at a higher density and with quality control protocols that ensure accuracy. A challenge within the hydrologic community is the application of remotely sensed gravity

measurements, such as the Gravity Recovery and Climate Experiment (GRACE), which can indirectly yield terrestrial water storage change at sub-monthly time scales and at 100,000 square kilometer space scales. To apply such technology at finer scales new data assimilation including geodetic observations of surface displacements and in situ gravity observations is required.

Outcome of Meeting

The outcomes of the meeting are documented in two workshop reports published in *Episodes* and *EOS* (Plag and Miller, 2010, 2011). Most importantly, the workshop produced a set of recommendations, which address the issues identified during the discussions. Two primary recommendations of the workshop are: (1) Capacity building with application of geodetic products that water resource decision makers can readily access and easily use; and (2) development of a demonstration project in California that merges geodetic information with hydrologic modeling via assimilation, leading to technology transfer to African nations through a similar project in the Nile Basin.

The proposed pilot project in California would demonstrate the utility of hydrogeodesy, as it is a region rich in groundwater and surface water observations. GRACE-derived terrestrial water storage variations for 2002-2009 have been calculated for the California Central Valley, a region where more than half of the US fruits and vegetables are grown. A dense GPS network provides high-resolution information on surface displacements. A key question is whether the same approach will also apply in regions of Africa, and whether such a pilot can bring together ongoing activities in Africa needed to build a science and decision-making interface for water management in Africa. Such a pilot should address region-specific issues that bring stakeholders and water managers into the activity. It was suggested that the Africa pilot involve the World Bank, USAID, UN Habitat, UNESCO IHP, WaterNet, NASA, and other groups already working in the Nile basin. The required science contribution includes tool development for end users and capacity building for operational activities and will need international participation from African countries within the Nile basin and data sharing through a common decision support framework.

Currently, efforts are underway to implement the recommended pilot projects.

References

Plag, H.-P., Miller, N., 2010. Third Annual IGCP 565 Workshop: Separating hydrological and tectonic signals in geodetic observations, *Episodes*, **33**(4), 273-277.

Plag, H.-P. & Miller, N. M., 2011. Applying Geodesy to Hydrologic Cycle Monitoring. *EOS, Trans. Am. Geophys. Union*, **92**, 136.