Developing the Global Geodetic Observing System into a Monitoring System for the Global Water Cycle

IGCP 565 Workshop 3 Questions

How can we bridge the gap in spatial scales between regional/global and point/catchment measurements?

Reference Frame

•Promote the development of an improved International Terrestrial Reference Frame. Densify network, produce consistent processing of 1000s of stations. Use to geo-reference InSAR etc. (VLBI, SLR, GPS, DORIS)

•Need to improve the robustness of the observation framework (by developing away to quickly access observations in a unified reference frame)

Modelling

•Develop a consistent modelling framework for assimilating gravity, surface displacement, and rotation over a range of scales, efficiently treating problems of variable spatial and temporal density of data. Community modelling framework for geodesy similar to the surface processes framework was suggested.

•Geodesy is at intersection of many fields (solid earth, tectonics, volcanology, hydrology, oceanography, atmospheric science, geotechnical, etc.). We need to tie geodetic observations to a range of physical processes and observations from other fields.

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Modelling Continued...

•Need to better understand the physics of processes and develop modelling techniques to improve smoothing and fill gaps in observation. An example is how to combine data for the separation of GIA from more recent surface load induced deformation processes.

•An Earth system approach is needed for understanding the physics of several processes whose geodetic signals may overprint one another. This will help better tie down the sensitivity of observations to differing spatial and temporal scales.

• Need a way to provide the uncertainties of models. This will facilitate more robust data fusion and inversion exercises. We especially need to quntify errors from GLDAS and other hydrology models.

Infrastructure Needs

•Need complementary terrestrial observations (water well data, GPS, gravity, moisture, etc.)

•Need to encourage local assistance in installing new instrumentation in developing countries (e.g. Africa).

•Encourage collocation of observation platforms to meet science goals and improve sustainability of long term measurements.

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Outreach

- Need to define what we need to do to support hydrology with geodesy. We need to increase interactions and mutual understanding of our science and learn hydrologic jargon.
- The concept of a geodesy center or portal was suggested. In particular for GRACE, IGS and other data products. Currently there is no one stop shopping. Need to consider a range of models including GLDAS, WGHM, LaD that have different input data, different conceptualization of model, etc.
- It was suggested to contact the Hydrology Focus Group and CUASHI
- Collaborate with other geodetic groups and coordinate plans. For example, see The Long Range Geodesy Plan (UNAVCO web site)

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How can we isolate long-term hydrological changes from secular effects due to tectonics, GIA, etc

- Use hydrologic models to estimate secular effects. Need improved resolution and to be able to separate different hydrologic effects
- GRACE can provide secular in places like Africa where contamination from GIA is minimal.
- Our understanding of long term hydrological signals is changing (not really secular).
- Establish validation points. (Example: absolute gravity in Fennoscandia). Perhaps tie down one point precisely? Would this be useful for GRACE? (see previous question)
- The ratio between vertical and gravity changes helps resolve the origin of mass changes.
- GRACE provides the hydrological storage term.
- International Ground Water Assessment Center in Utrecht source of long term secular signal model (currently in use for hind-casting aquifer depletion).

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• We can compare coherence of tectonic vs. hydrological models at times to help separate sources of deformation. We can use the component-wise separation of deformation (horizontal vs. vertical) to test competing hypotheses for the origin of strain and strain-rate anomalies.

• We need to promote acquisition of long-term time series. This can be a problem with space systems like GRACE, ICESat, DESDynI, etc.and we need follow on systems. A similar problem can exist for terrestrial observations and we need to explicitly state this. We must encourage long-term funding with high level document. We need to ensure possibilities for using and reprocessing older data sets.

• We need to encourage more local involvement in “on the ground” measurements. Promote meaning and usefulness of new data for local country: AFREF is working to get two open stations/country. Also make use of AfricaArray, AMMA, GHYRAF.

• Also need to encourage international sharing of data, a key goal for GEO. The GEO portal a source of data. Governments realizing this is a problem. The ISO standard is accepted in GEO registry and user feedback is requested.

-Capacity building is critical for sustainability.

- Need multiple complementary observations for comparisons. E.G. GPS and GRACE.

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How can we isolate long-term hydrological changes from secular effects due to tectonics, GIA, etc (Continued)

- Capacity building is critical for sustainability.
    1. Provide local structure for maintenance and operation
    2. Promote permanent instrumentation (rather than campaign)

- We need multiple complementary observations for comparisons (GPS and GRACE in Greenland ice mass balance problems is an excellent example). LiDAR is also useful. In fact, leverage the strength of multiple data types wherever possible. Local and regional scale gravity, short and long-wavelength deformation information are highly complementary.

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IGCP 565 Workshop 3 Questions

How can we improve measurement accuracy and robustness to seasonal and other artefacts?

• Use combination of techniques, understand multiple processes such at Atmospheric pressure loading. Bring the cryosphere into hydrological modelling. Need improved models for Antarctica as well as Greenland.

1. Also, comprehensive ocean monitoring is essential for global mass balance models
2. We must emphasize the need for consistency in data analysis and modelling. The same processing methods should be used when comparing different data sets (e.g. GRACE vs. GPS tidal loading correction).

• Catalogue artefacts in geodetic data. Develop interoperability of observing systems. Develop and implement metadata standards and publish metadata about datasets. Need to publish metadata about datasets

• Not all seasonal effects are simple sums of Fourier components. Things vary from year to year in complex ways. We need to have models that allow for this type of variability (see model section above).

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How can we improve infrastructure to build reliable services?

- We need sustained long term funding.
- Encourage and provide support to planned new systems (DESDynI, GRACE follow-on, ICESatII, Sentinel, SWOT). Promote 'recent' systems (CryosatII, GOCE, TerraSAR X, etc.) We should promote creative new technologies that have 'game changing' potentials.
- Encourage data sharing (great example is ESA and anticipated Sentinel open data policy). Individually and through groups such as WInSAR. Note the international Charter for InSAR might be built upon for other observations. Note the Supersites effort. Could extend to include hydrology.
- Strive to do seasonal predictions for sustainability. In particular for the Drought Index, and for early warning for hydrology related disaster mitigations, such as disease forecasting and landslide detection. This will help to increase societal relevance. Speak to sponsors and other stake holders with applications of interest to them. This can be used for leveraging access to data.
- Landslide detection, seismic hazard, coastal degradation, flooding, tsunami, volcanic eruption, other geo-hazards. Use InSAR and other deformation measurements for monitoring carbon sequestration projects, filling / emptying of large dam reservoir.

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How can we improve infrastructure to build reliable services? (Continued)

- Geodetic infrastructure can help with resilience to disasters (response, management and planning).
- Workforce development. Integrate geodesy into hydrological programs. Requires provision of near real-time data / products to users.
- Multiple use of techniques should be emphasized. For example GPS multipath detection of snow, moisture, and plant growth. Also coordinate efforts with GPS meteorology as this has synergies with the atmospheric corrections needed for InSAR ground deformation detection.

Additional Notes from plenary discussion:

1. Matt Rodell noted that you can get a conservative estimate of the uncertainty in the modeled water storage variations by taking the standard deviation of 4 GLDAS models (NOAH, CLM, VIC, Mosaic)
2. They are working on a 1948-present simulation with a more consistent meteorological forcing (input) dataset, which should enable more reliable assessment of interannual variability.
3. Near-future GLDAS runs with the Catchment land surface model and CLM 3.5, which include groundwater components, will enable better assessment of long term interannual variations and trends. Currently, the dynamic range of the modeled terrestrial water storage is often not large enough to characterize such variations/trends. Another issue is that models will miss trends associated with human impacts, such as groundwater mining, which are not modeled.

Additional Notes :

For the point validation site(s) consider other areas such at Wetzel. Want locations where point scales to local/regional so they are represenative of larger areas. Not Karst area for example.