Geophysical Research Abstracts
Vol. 21, EGU2019-14208, 2019
EGU General Assembly 2019

What can we learn by combining GPS and Gravity?

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Measurements of vertical crustal motion from and or gravity can be used to constrain present day mass changes in water storage, ice mass, and perhaps even magma.

In Greenland, interpreting any observed crustal displacement around the ice sheets in terms of present-day changes in ice is complicated, however, by the glacial isostatic adjustment (GIA) signal. By making measurements of both gravity and surface motion at a bedrock site, the viscoelastic effects could be removed from the observations and we would be able to constrain present day ice mass changes. Alternatively, we could use the same observations of surface displacements and gravity to determine the GIA signal. After developing some new theory, we combined 20 yrs of GPS observations of uplift with eight absolute gravity observations over the same period to determine the GIA signal near Kulusuk, a site on the southeastern side of the GrIS.

Over the continents, GRACE has provided valuable insight into the changes in the Earth's water cycle. Changes in continental water storage control the regional water budget and can, in extreme cases, result in floods and droughts that often claim a high toll on infrastructure, the economy and human life. In a fairly recent study, EGSIEM (European Gravity Service for Improved Emergency Management), monthly gravity solutions provided by the various GRACE processing centers were combined and Level-3 gravity products, e.g. gravity fields were produced. To evaluate the quality of the EGSIEM data, were compared to Global GNSS time series. Comparisons of GNSS and GRACE has been undertaken since the first GRACE data releases. And while the agreement improves with improvements in the GRACE data and the GNSS reprocessing, removing the GRACE vertical from the GNSS signals is only moderately effective at removing reducing the WRMS of the GNSS signals.

In Yellowstone, we are using absolute gravity and surface displacements to determine the cause of the cyclical uplift and subsidence observed in the GPS time series there. GPS time-series data show that points in and around the caldera have gone through cycles of uplift, followed by subsidence. A dramatic increase in the uplift rate started in 2004 at the GPS station LKWY near Yellowstone Lake. Since 2010, the site subsided, then began uplifting again in 2014 after a M 4.8 earthquake near the Norris Geyser Basin, and then started subsiding again in 2016. The cause of the episodic uplift and subsidence and the spatial pattern of the surface displacement are not yet well understood. The 2003-2009 episode of rapid uplift is believed to result from deep source magma intrusion simultaneous with depressurization of the hydrothermal systems beneath the Norris Geyser Basin. But whether it is caused by the intrusion of magma from a distant reservoir, or by the expulsion and localized trapping of pressurized water and gas from rock that is already in-place, is not known. Comparing gravity and uplift should provide some insight into these questions.

The findings of all of these projects will be reported on during this presentation.