Geophysical Research Abstracts
Vol. 14, EGU2012-12635, 2012
EGU General Assembly 2012

Measuring local water storage variations with a superconducting gravimeter at the Geodetic Observatory TIGO, Concepción, Chile

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Superconducting gravimeters (SGs) measure temporal variations of the Earth's gravity field with very high precision. A superconducting spherical test mass is kept in a constant position in a very stable magnetic field of a superconducting coil. The electrical current that has to be applied to keep this constant position is continuously measured and is an expression of variations in the gravity field. SGs have traditionally been used in geodetic applications, such as the acquisition of Earth tides for deriving elastic parameters, the assessment of gravity variations due to polar motion, the detection of seismically induced oscillations of the earth. Oceanic, atmospheric and hydrological mass displacements in the surroundings of an SG have often been considered as disturbing components of the measurements that have to be reduced for geodetic applications.

Some studies in recent years, however, have shown that the disturbing signal component in SG time series can inversely be used as the signal of interest, turning a SG into a hydrological monitoring device. Being sensitive to water mass changes in their surroundings, SGs provide unique measurements of total water storage variations (sum of storage variations in the snow cover, the unsaturated soil, and the groundwater) at local scales of several hundreds of meters, not accessible by other observation techniques. In this study, we investigate the relationship between local hydrology and gravity for the SG located in a highly seasonal climate at the Geodetic Observatory TIGO in Concepción, Chile. SG time series are compared to the gravimetric response calculated by a geodetic model using soil moisture measurements to a depth of 2.6 meters and a Digital Elevation Model for an area of 2 km around the SG. The results show that variations in moisture and gravimetric response are related to the topography and the depth of analysis. A large residual SG signal gives indication of important water storage variations in the deeper unsaturated zone and the groundwater.