

A comparative study of gravity and crustal deformation performed through Superconducting Gravimeter and GPS in the Garhwal Himalayan

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Abstract

Simultaneous observations of gravity measurements and vertical crustal deformation are being carried out at Multi-Parametric Geophysical Observatory (MPGO), Ghuttu, Garhwal Himalaya since 2007. The observation site (30.53°N , 78.74°E) is located at 1800 m above the mean sea level which is situated within high Himalayan Seismic Belt (HSB) on Himalayan Wedge under which Indian plate is thrusting towards NNE. This part of Himalayan region is also demarcated as Central Seismic Gap (CSG) between the rupture zones of devastating M 7.8 Kangra earthquake of 1905 located to its west and M 8.2 Bihar Nepal earthquake of 1934. Recently, two strong earthquakes (Ms6.6 Uttarkashi, 1991 and Ms6.4 Chamoli, 1999) occurred nearby to MPGO which are located in the seismic gap. The temporal variation of gravity measurements are monitored by a superconducting gravimeter while the crustal deformations are observed using a dual frequency GPS antenna and receiver system.

The simultaneous data collected by both instruments during a period of ~5 years from 2007 to 2012 is evaluated. Both data show apparent seasonal/annual changes with clear phase difference of few months causing negative correlation between the two time series. Temporal records of gravity clearly exhibit annual changes as high as $300\text{-}350 \text{ nms}^{-2}$ with stronger variations mainly during rainy season. These seasonal variations are due to hydrological load changes, the region has high rainfall precipitation during monsoon (July – September) which influences the level of underground water table. Loading effects on the Earth's uppermost crust due to the hydrological cycle, as measured from local water table records through 68 m deep borehole advocated for the explanation of the observed seasonal displacements in GPS time series. Similarly there is a prominent annual cycle of the gravity variation which is in phase with the water level variation. However, the vertical crustal motion has opposite phase with these two time series. Analysis suggests that the gravity and vertical displacement have negative correlation with extrema during the rainy seasons.

We quantified the correlation between gravity and vertical displacement for different time periods. The loading effect due to increased level of underground water exerts force on the earth surface pushing it downwards, which is visible in low vertical displacement values during the rainy season. Therefore, gravity increases in the rainy season, which is interpreted in terms of Newtonian attraction and vertical displacement. In summer, reverse behavior is noticed in both time series due to less water load. Corrections are applied to remove the effects underground water or the Newtonian effect from the gravity data. The variation in gravity to the order of ± 38

nms^{-2} in the remaining residual gravity may be the causes of vertical displacement. We will discuss the aspects adopted to relate the three time series of gravity, crustal deformation and underground water precipitation for quantification and assessing different possibilities of interconnected geophysical fields.

Key words: Gravity, Himalaya, Superconducting Gravimeter, crustal deformation, Seasonal variation.

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