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Tectonic and climate induced mass changes- competing signals in long term gravity signals

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Several mountain ranges as Alps, Himalaya and Tibet are presently subject to uplift, as documented by GNSS vertical movement rates. Uplift occurs in response to climatic mass loss (deglaciation or hydrologic mass loss) or due to the dynamic forces (crustal compression or mantle inflow below uplifting crust). The uplift generates a mass change, which produces a time variation of the gravity field. The deglaciation and changes in the subsurface hydrologic budget, also generate a mass change, which sums to the tectonic change. Satellite remote sensing is useful in determining the shrinking outlines of glaciers, using both multispectral imaging as well as Radar observations, thus allowing to determine the surface geometry change. The essential value for climate change and estimate of the hydrologic budget is though the total volume budget estimate, which requires also the thickness variation. Remote sensing catches the surface height changes, but these must be corrected for the crustal uplift. The geodetic measurements of the crustal dynamics of the Alpine and Himalayan mountain ranges in terms of height and gravity changes, are therefore in close relation to the estimate of the climatic changes inducing glacier and hydrologic budget changes. We estimate the hydrologic and glacier signal for the Alps and Himalaya-Tibet, using results from remote sensing and subsurface hydrologic observations, where available (for the methodological rationale see Chen et al. 2018). We estimate the contribution of the dynamic uplift by direct observations of GNSS. We find that the hydrologic and glacier gravity signal calculated at satellite heights of GRACE and GOCE are superposed to the tectonic signal, and discuss to which amount the signals can be resolved by gravity measurements. We compare the predicted signals with the satellite observations of GRACE and GOCE, finding that the tectonic uplift signal is small relative to the expected glacier/hydrologic signals, but that it cannot be neglected. We define the requirements to future gravity satellites in order to make a significante contribution to the detection of hydro-glacial mass changes and the separation of the tectonic signal.

Reference:

Chen W., Braitenberg, C., Serpelloni, E. (2018) Interference of tectonic signals in subsurface hydrologic monitoring through gravity and GPS due to mountain building, Global and Planetary Change, Volume 167, August 2018, Pages 148-159.