Geophysical Research Abstracts
Vol. 19, EGU2017-2414, 2017
EGU General Assembly 2017

Using combined GRACE and GPS data to investigate the vertical crustal deformation at the northeastern margin of the Tibetan Plateau

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In this paper, two types of geodetic measurements, GRACE and GPS, are combined to study the vertical crustal deformation on the northeastern margin of the Tibetan Plateau. The GRACE and GPS derived results show that significant seasonal variations occur at 40 regional continuous GPS stations of the Crustal Movement Observation Network of China (CMONOC). The consistency between the seasonal variations in the GRACE and GPS data can be efficiently enhanced by decreasing the nonlinear deformation in the GPS time series with applying longer observation period. The vertical components of more than 78% of the total number of GPS stations exhibit correlations of more than 0.8 with respect to the corresponding GRACE components, and approximately 73% of the GPS vertical time series exhibit a significant root mean square reduction of approximately 40%, which increases to 60% when corresponding seasonal components derived from the GRACE measurements are subtracted. We consider that the vertical seasonal variations in the study area are caused by mass transfer related to hydrological loading, whereas the horizontal components are related to both mass transfer and other factors, such as the thermal elastic response of the GPS monuments and GPS data processing strategical deficits. These factors distinguish the main differences between the two measurements and exert larger influences in the eastward direction than in the northward direction, contributing to the total displacement. Finally, we use seasonal variations derived from the GRACE results to modify the vertical time series of corresponding GPS campaign stations to mitigate the influences of seasonal loading as much as possible in the dispersed time series. The results show that this modification can significantly reduce the scatter of campaign time series and improve the derived velocities uncertainties remarkably.