Geophysical Research Abstracts
Vol. 21, EGU2019-11607, 2019
EGU General Assembly 2019

The imprints of contemporary mass redistribution on regional sea level and vertical land motion observations

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Sea-level observations from tide gauges are commonly corrected for vertical land motion (VLM) using data from permanent GNSS stations. While these corrections are necessary to fully understand global, regional, and local sea-level changes, one critical assumption that is frequently made is that VLM trends derived over the short GNSS records are representative for the full tide-gauge record length. While this assumption is generally valid for motions associated with Glacial Isostatic Adjustment (GIA) or long-term sediment compaction processes, for elastic solid-earth deformation due to ongoing mass redistribution in the earth system it is not.

We derive trends and monthly anomalies in global and regional sea-level and solid-earth deformation that result from mass redistribution observed by GRACE and an ensemble of GIA models. With this ensemble, we do not only compute mean changes, but we also derive uncertainty estimates of all quantities. We find that over the GRACE era, mass redistribution has led to a global sea-level trend of 1.28-1.82 mm/yr, mostly driven by ice mass loss, while the amount of liquid water stored on land has increased over the GRACE period, causing a sea-level drop of 0.11-0.47 mm/yr. This redistribution of mass causes sea-level and deformation patterns that do not only vary in space, but also in time.

We find that for many GNSS stations, including GNSS stations in coastal locations, solid-earth deformation resulting from this observed present-day mass redistribution causes trends in the order of 1 mm/yr or higher. This deformation is not only caused by changes in the cryosphere, but to a large extent by changes in land hydrology. This land hydrology record shows considerable decadal variability on global and regional scales, especially in South America and Australia. Therefore, the trends derived over the GNSS records are often not representative for the full GRACE record, and as such, cannot be extrapolated to correct tide-gauge records that often span multiple decades.

To avoid this issue, we computed trends and associated uncertainties for 8228 GNSS stations after removing deformation due to GIA and present-day mass redistribution. With this separation, we are able to explain a large fraction of the discrepancy between observed sea-level trends at multiple long tide-gauge records and the reconstructed global-mean sea-level trend from recent reconstructions.