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Measuring Terrestrial Water Storage Change Using GPS, Absolute Gravity and GRACE in Scandinavia

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For Scandinavia, terrestrial water storage change estimates from Gravity Recovery and Climate Experiment (GRACE) would be seriously affected by the process of glacial isostatic adjustment (GIA) . The effects of GIA are typically removed using modeled values. However, the uncertainty in current GIA models is very large. To solve this problem, we calculates the measured linear ratio of GIA gravity rates and vertical displacement rates according to the data from collocation stations for absolute gravity and GPS in Scandinavia. Using the linear ratio and uplift field derived from GPS observation network, we get the gravity signal of GIA. Gravity change rates from GRACE RL05 data can be corrected for GIA using independent gravity rates derived from GPS vertical velocities, and then we can calculate corresponding equivalent water thickness in Scandinavia and the uncertainties are evaluated by considering the uncertainties from data. Our method utilizes observational data only and can avoid the enormous uncertainty from GIA models.The results are compared with that of two hydrological models. The ratio of gravity versus uplift obtained by ground-based measurements in Scandinavia is $0.148\pm0.020\mu$Gal/mm, which validates Wahr's approximate theoretical ratio (Wahr et al., 1995) and is very close to the result from North America (Mazzotti et al., 2011). From January 2003 to March 2011, terrestrial water storage shows obvious increase in Scandinavia. The main signal locates at the Vänern lake which is in the southern tip of the peninsula. The rate of total water storage change is 4.6 ± 2.1 Gt/yr and the corresponding cumulative quantity is 38 ± 17 Gt for the period 2003-2011. Results from hydrological models are consistent with our result very well. The correlation coefficient between GRACE and WGHM hydrological model can reach 0.69, while for GLDAS model the correlation coefficient is slightly smaller(0.57)