

Can GRACE detect winter snows in Japan?

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Current spatial resolution of the GRACE (Gravity Recovery and Climate Experiment) satellites is 300-400 km, and so its hydrological applications have been limited to continents and large islands. The Japanese Islands have width slightly smaller than this spatial resolution, but are known to show large amplitude seasonal changes in surface masses due mainly to winter snow. Such loads are responsible for seasonal crustal deformation observed with GEONET, a dense array of GPS (Global Positioning System) receivers in Japan (Heki, 2001). There is also a dense network of surface meteorological sensors for, e.g. snow depths, atmospheric pressures, etc. Heki (2004) showed that combined effects of surface loads, i.e. snow (predominant), atmosphere, soil moisture, dam impoundment, can explain seasonal crustal deformation observed by GPS to a large extent. The total weight of the winter snow in the Japanese Islands in its peak season may reach ~50 Gt. This is comparable to the annual loss of mountain glaciers in the Asian high mountains (Matsuo & Heki, 2010), and is above the detection level of GRACE.

In this study, I use GRACE Level-2 Release-4 data from CSR, Univ. Texas, up to 2009 November, and evaluated seasonal changes in surface loads in and around the Japanese Islands. After applying a 350 km Gaussian filter and a de-stripping filter, the peak-to-peak change of the water depth becomes ~4 cm in northern Japan. The maximum value is achieved in February-March. The region of large winter load spans from Hokkaido, Japan, to northeastern Honshu, which roughly coincides with the region of deep snow in Japan. Next I compiled snow depth data from surface meteorological observations, and converted them to loads using time-dependent snow density due to compaction. By applying the same spatial filter as the GRACE data, its spatial pattern becomes similar to the GRACE results. The present study suggests that GRACE is capable of detecting seasonal mass changes on an island arc not wider than a few hundreds of kilometers.

References:

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