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Long-term trends of terrestrial water storage in south-east Australia revealed by GRACE and superconducting gravimeter

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South-east Australia is experiencing a severe multi-year drought in this decade. In particular, historic drought struck this area in 2006. Australian Bureau of Meteorology reported that the year 2006 was one of the driest years and agriculture suffered extensive damage from the drought. To understand the severity of current water crisis in south-east Australia, monitoring terrestrial water storage (TWS) changes is demanded. For this purpose, we investigated gravity changes associated with the drought in south-east Australia using data from GRACE satellite gravimeter and superconducting gravimeter (SG) at Mt. Stromlo, Canberra, over the period from 2003 to 2008.
In 2006 and 2007, GRACE gravity solutions released from CNES/GRGS showed significant TWS decreases at south-east Australia. Areal extent of the TWS decreases showed good consistence with that of rainfall deficiencies. Therefore, it is clear that the TWS decreases estimated from GRACE data are attributed to the 2006 drought.
SG data from Canberra also indicated gravity decreases during the 2006 drought period, after correcting for effects of atmosphere, tides, height variations and instrumental drift and steps. Comparison of GRACE and SG data showed good agreements in interannual variations, although some differences were found in seasonal components. Furthermore, both GRACE and SG data indicated that TWS in 2008 still remained at low levels, although annual precipitation returned to average before the drought. It implies TWS is possibly decreasing with longer time scale due to recent climate changes.
Finally, the results from GRACE and SG observations were compared with TWS estimates from Noah land surface model, forced by output from the Global Land Data Assimilation System (GLDAS) developed by NASA. The model TWS estimates were the sum of soil moisture (2m column depth) and snow water equivalent. The comparison showed that the model underestimated the TWS decreases due to the 2006 drought. The differences between gravity data and model estimates probably indicate groundwater changes which are not calculated in the model, although we cannot rule out the possibility that erroneous model soil moisture calculation caused the discrepancies. Our results indicate long-term gravity observations provide a useful measurement for monitoring TWS trend and constraining unspecified factors in hydrological model.