Climate parameters influencing satellite-based volume and elevation changes of the Antarctic ice sheet

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Precisely quantifying the Antarctic Ice Sheet (AIS) mass balance remains a challenge as several processes compete at differing degrees in the basin-scale with regional variations. Understanding of changes in AIS has been largely based on observations from various altimetry missions and Gravity Recovery And Climate Experiment (GRACE) missions due to its scale and coverage. Analysis of linear trends in surface height variations of AIS since the early 1990s showed multiple variabilities in the rate of changes over the period of time. These observations are a reflection of various underlying ice sheet processes. Therefore understanding the processes that interact on the ice sheet is important to precisely determine the response of the ice sheet to a rapidly changing climate.

Changing climate constitutes variations in major short term processes including snow accumulation and surface melting. Variations in accumulation rate and temperature at the ice sheet surface cause changes in the firn compaction (FC) rate. Variations in the FC rate change the AIS thickness, that should be detected from altimetry, but do not change its mass, as observed by the GRACE mission. We focus our study on the seasonal and interannual changes in the elevation and mass of the AIS. We use surface elevation changes from Envisat data and gravity changes derived from the latest GRACE solutions between 10/2002 and 10/2010. As mass changes observed using the GRACE mission is strongly impacted by long term isostasy, as it involves mantle mass redistribution, we remove from all dataset an 8-year trend. We use weather variable historical data solutions including surface mass balance, temperature and wind velocities from the regional climate model RACMO2.3p2 as input to an FC model to estimate AIS elevation changes. We obtain a very good correlation between height change estimates from GRACE, Envisat and RACMO2.3p2 at several places such as along the coast of Dronning Maud Land, Wilkes land and Amundsen sea sector. Considerable differences in Oates and Mac Robertson regions, with a strong seasonal signal in Envisat estimates, reflect spatial variability in physical parameters of the surface of the AIS due to climate parameter changes such as winds.