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On regional ice sheet mass balance from GRACE, the mass budget method, and ICESat

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Space-geodetic observing systems have enabled us to continuously and comprehensively survey the Polar Ice Sheets, helping us to better understand their current evolution in changing climate. Of particular interest is the mass balance of the ice sheets, characterizing their dynamical state, and governing the related "fingerprint' of sea-level change. In this talk, we present a comparison of regional-scale ice-mass balance estimates from GRACE, the mass budget method (hereafter, SMB-D), and ICESat. For the Greenland ice sheet (GrIS), we obtain consistent ice-mass balance estimates from GRACE, SMB-D and ICESat for the six major drainage basins, in the common observation period (October 2003 to March 2008). This agreement yields new insight into the complex mass loss behaviour of the GrIS within the last decade; we find that all mass balance components, i.e. precipitation (P), melting/run-off (M/R) and ice discharge (D) are relevant in determining the regional mass budget. In particular, M/R production during 2002-2010 has more than doubled in the west, whereas D increased by 50 % in the east (both w.r.t 1961-1990 mean). In addition, interannual variability in P along the northwest and west coasts of the GrIS partially explains the apparent regional acceleration of mass loss observed with GRACE during 2002 to 2010, and, therefore, obscures increasing M/R and D prevailing since the 1990s. For the Antarctic Ice Sheet (AIS), we find high correlations also between the interannual mass variations reflected by GRACE and SMB-D. As for the GrIS, these interannual variations are mainly caused by the varying amount of P, which is, for the Antarctic Peninsula (AP) and the Amundsen Sea Sector (AS), closely related to the El Niño Southern Oscillation. Regions with a pronounced ice mass trend (e.g. AP and AS) are consistently captured GRACE, SMB-D and ICESat. But continent-wide estimates remain challenging, owing to considerable unknowns associated with the observations from GRACE (e.g. mass movement in the Earth interior due to glacial-isostatic adjustment), SMB-D (e.g. limited spatial coverage of ice flow measurements) and ICESat (e.g. snow/ice density distribution). Since these uncertainties are spatially very heterogeneous, we present a regional combination of the three observation types, allowing us to place a tighter constraint on the total sea-level contribution of the AIS within the last decade.