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The influence of Antarctic and Greenland ice loss on polar motion: an assessment based on GRACE and multi-mission satellite altimetry

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Increasing ice loss of the Antarctic and Greenland Ice Sheets (AIS, GrIS) due to global climate change affects the orientation of the Earth's spin axis with respect to an Earth-fixed reference system (polar motion). Ice mass changes in Antarctica and Greenland are observed by the Gravity Recovery and Climate Experiment (GRACE) in terms of time variable gravity field changes and derived from surface elevation changes measured by satellite radar and laser altimeter missions such as ENVISAT, CryoSat-2 and ICESat. Beside the limited spatial resolution, the accuracy of GRACE ice mass change estimates is limited by signal noise (meridional error stripes), leakage effects and uncertainties of the glacial isostatic adjustment (GIA) models, whereas the accuracy of satellite altimetry derived ice mass changes is limited by waveform retracking, slope related relocation errors, firn compaction and the density assumption used in the volume-to-mass conversion.

In this study we use different GRACE gravity field models (CSR RL06M, JPL RL06M, ITSG-Grace2018) and satellite altimetry data (from TU Dresden, University of Leeds, Alfred Wegener Institute) to assess the accuracy of the gravimetry and altimetry derived polar motion excitation functions. We show that due to the combination of individual solutions, systematic and random errors of the data processing can be reduced and the robustness of the geodetic derived AIS and GrIS polar motion excitation functions can be increased. Based on these investigations we found that AIS mass changes induce the pole position vector to drift along the 60° East meridian by 2 mas/yr during the study period 2003-2015, whereas GrIS mass changes cause the pole vector to drift along the 45° West meridian by 3 mas/yr.