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Mass contribution of ice sheets and land glaciers to sea level rise

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Present day sea level rise is strongly influenced by density and mass changes in the oceans. This paper focuses on the mass effect estimated from Gravity Research And Climate Experiment (GRACE) level-2 data collected between Feb 2003 and June 2013. For this purpose we implement a global mascon model consisting of 10242 elements where we solve for geo-center motion, we replace a gravitational flattening term from a time series determined by satellite laser ranging, and we rely on the GLDAS model to implement a hydrologic correction on land. To validate the level of systematic errors on the mass loss rates seen for Antarctica and Greenland we use several global isostatic adjustment (GIA) models based on radially stratified (1D) Earth models. In those we allow for different viscosity profiles with ice loads from different paleo ice heights. We also considered a new set of 3D finite element GIA models for Antarctica that allow lateral variations in the rheologic parameters in the set-up of the Earth model. Our conclusion is that the ice sheets and land glaciers presently result in a global sea level change of 1.51 ± 0.10 mm/yr or 540 ± 34 Gt/yr. This estimate is more than half of the sea level rise seen by satellite altimetry over the some time period (2.78 mm/yr). Since altimetry observes a combination of steric and mass driven effects the conclusion is that approximately 54% of the present day sea level change signal comes from mass fluxes originating from ice sheets and land glaciers. Between 2003 and 2013 Greenland contributed 281 ± 19 Gt/yr whereby an increase in mass loss is seen since 2009. Antarctica contributed 95 ± 27 Gt/yr and it shows a steady acceleration in the Amundsen sea sector. Dronning Maud land on East Antarctica has seen an increase in mass since June 2009 counteracting the total Antarctic mass loss. In the analyzed time frame land glaciers and ice caps have contributed 162 ± 11 Gt/yr.