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Uncertainties in ice sheet mass balance in Greenland and Antarctica from GRACE time-variable gravity

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The total time-dependent geopotential in gravimetric studies relates to several different components of mass transport. Here, we investigate how uncertainties in atmospheric pressure variations and sea level height affect estimates of ice sheet mass balance calculated using time-variable gravity. Changes in non-tidal atmospheric circulation are removed from the GRACE data using outputs from ECMWF operational forecasts. We estimate the uncertainty in atmospheric pressure by comparing the standard correction with independent atmospheric reanalyses. Equivalent atmospheric pressure uncertainties of 1 millibar (1 hPa) over Antarctica and Greenland result in a mass uncertainties of 116 and 24 Gt respectively. We find average uncertainties of 0.6–1.1 millibars over Antarctica and 0.3–0.8 millibars over Greenland. Investigations of ice sheet mass balance over short time scales will be affected by the atmospheric pressure uncertainty. One emerging component of mass change that will impact glacier and ice sheet estimates are variations in sea level. We use a least-squares mascon technique combined with solutions to the sea level equation to iteratively correct the GRACE data for the sea level change. We find that sea level variations affect gravimetric estimates of ice mass change between 3 and 5% when averaged over the entire ice sheet. This sea level correction will become increasingly important with continued glacier and ice sheet mass losses.