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Time-varying mass changes of the Greenland and Antarctic ice sheets from radar and laser altimetry

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The mass balance of an ice sheet may be estimated using observed elevation changes from spaceborne altimeters. This requires interpolation of observations over the entire ice sheet and known surface densities and firn compaction rates. Previous mass change estimates based on satellite altimetry used relatively long epochs to calculate an average change rate. We use radar altimetry data from ERS-2 (1996-2002) and laser altimetry data from ICESat (2003-2008) to construct time series, at a higher temporal resolution than previous estimates, of elevation change rates over the Greenland ice sheet spanning the period 1996-2008. The temporal and spatial sampling characteristics of radar and laser altimetry are very different and therefore challenging to combine. A second challenge, especially for radar altimetry, is the sparse sampling in fast-flowing outlet glaciers where elevation changes are usually largest. We deal with both challenges by using spatio-temporal kriging with external drift (ST-KED) as the interpolation algorithm. ST-KED uses the spatial and temporal characteristics of the data to interpolate in space and time and thus employ data points from adjacent time periods to improve the interpolated fields at a given time. Additionally, it uses the spatial gradients of flow velocity as a proxy for the spatial pattern of elevation change in sparsely sampled areas. We show that this is a valid approach for Greenland's large outlet glaciers. Firn compaction velocities and surface densities are simulated using a simple surface mass balance (SMB) and firn compaction model, based on output from the regional climate model RACMO (1958-2008). We thus present an error-bounded, basin-scale, time series of annual mass changes for the Greenland ice sheet. Currently, this methodology is being extended to the Antarctic ice sheet as well, for which we will show preliminary results.