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ICESat-2 Ice Sheet Mass balance: Going below the surface

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We use the land-ice surface height data product (ATL06 release 5) from NASA's latest satellite laser altimetry, the Ice, Cloud, and Land Elevation Satellite-2 (ICESat-2) to compute surface elevation changes (SEC) from October 2018 to September 2021 over both Antarctica and Greenland. To convert the SEC to mass change we need to remove the non-ice related SEC processes. To remove the signal from the firn compaction, we use an offline surface energy and firn model. The model is driven by outputs from the atmospheric regional climate model HIRHAM5, forced with reanalysis dataset ERA5, and it simulates the physics of the firn pack. The vertical bedrock movement also creates non-ice related signals, the glacial isostatic adjustment has been computed using the ICE-7G model and SELEN4, and the elastic rebound has been computed using a modified version of the REAR code.

When the SEC are corrected for signals that are not associated with a change in snow or ice mass, we convert to mass change by multiplying the height change with an appropriate density. The corrected SEC can result from a change in either melt, snow accumulation, or dynamical behavior, this means that the appropriate density depends on which physical processes are driving the observed SEC. In this study, we have made a new density parametrization to convert the volume change into mass change. The density parametrization determines if one should multiply with snow densities (250-350 kg/m³) or ice density (917 kg/m³) based on a number of criteria; the sign of SEC, ice flow velocity, and the altitude of the area.
With our new density parametrization, we get that the Greenland Ice Sheet has lost 237.5±10.3 Gt/year and the grounded Antarctic Ice Sheet has lost -137.6±27.2 Gt/year in the period. These results are in agreement with other mass balance estimates derived with different methods.