

Annual Greenland mass trends from 2003-2015 from a Bayesian hierarchical modelling approach

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The Greenland Ice Sheet has seen increases in mass loss over the course of the satellite altimetry era and is currently the largest single contributor to global mean sea level rise. Accurate determination of recent ice sheet mass loss is key to providing closure to the sea level budget and as initial conditions for future projections. Determining mass trends from altimetry, gravimetry and the mass budget approaches all require corrections for unobserved processes; which are derived from geophysical models (e.g. surface mass balance and glacio-isostatic adjustment) and can introduce common sources of error and bias to the results. The differences in spatio-temporal resolution of each approach makes it challenging to combine results in a statistically rigorous manner.

To resolve annual mass trends and their components, we use a spatio-temporal Bayesian Hierarchical Model (BHM) approach. This approach is similar to that developed for the Resolving Antarctic ice mass TrEndS (RATES) project over Antarctica and aims to provide complementary results for the Greenland Ice Sheet. The framework combines the following observations: satellite altimetry (ENVISAT, ICESat and CryoSat-2), Gravity Recovery and Climate Experiment (GRACE), InSAR and GPS uplift rates using statistical source separation to accommodate the different spatio-temporal length scales of each observational dataset. Prior information from geophysical models (e.g. SMB) regarding the spatial and temporal smoothness of the processes governing mass changes are only used to aid source separation, making the solution completely data-driven. Therefore, results from this approach can be a useful independent validation of geophysical models.

Here we present results of mass trends from the BHM approach over the Greenland Ice Sheet between 2003-2015. Annual spatial fields are provided for i) ice dynamics ii) surface mass balance and iii) firn compaction at both the basin and ice sheet scale. Additionally, a time invariant GIA solution is presented which will be compared to model solutions, which show large variations at the regional scale. The results from this statistical approach will also be compared and discussed in context with mass trends from other methods. These results will be updated and extended into the future as new observations become available.

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