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First results from an integrated approach for estimating GIA, land ice, hydrology and ocean mass trends within a complete coupled Earth system framework

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Correctly separating the sources of sea level rise (SLR) is crucial for improving future SLR predictions. Traditionally, changes in each component of the integrated signal have been tackled in isolation, which has often lead to inconsistencies between the sum of these components and sea level observations by satellite radar altimetry. To address these issues, the European Research Council has funded the five-year "GlobalMass" project (www.globalmass.eu), aimed at producing the first physically-based and data-driven solution for the complete coupled land-ocean-solid Earth system that is consistent with the full suite of observations, prior knowledge and fundamental geophysical constraints. GlobalMass is based at the Bristol Glaciology Centre and Department of Mathematics, University of Bristol.

Observed mass movement from the Gravity Recovery and Climate Experiment (GRACE) mission and vertical land motions from a global network of permanent GPS stations are used in a data-driven approach to estimate the glacial isostatic adjustment (GIA) without introducing any assumptions about the Earth structure or ice loading history. Satellite data and in-situ observations are combined using a multivariate spatio-temporal model within a Bayesian Hierarchical Modelling (BHM) framework. Prior distributions and linear constraints are used to incorporate the physics of the coupled system, such as conservation of mass, together with the characteristic length scales of different processes in both space and time. The BHM enables dimensional reduction of the observations so that a simultaneous solution can be obtained at a global scale. It will be used to produce a consistent partitioning of the integrated SLR signal into its steric (temperature and salinity) and barystatic component for the satellite era. The latter component is caused by land hydrology and melting ice sheets and glaciers, all of which are solved for simultaneously. The BHM was developed and tested on Antarctica, where it has been used to separate surface, ice dynamic and GIA signals simultaneously. A similar study is also being conducted over Greenland. We illustrate the approach and concepts with examples from this test case and present the first results where we assess the consistency of the ICE6G GIA model against the integral of sea surface height anomalies, ARGO derived steric variations and GRACE-derived mass exchange.