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Data-driven estimate of past and present surface loading over North America: Bayesian Hierarchical Modelling approach applied to GPS and GRACE observations

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Glacial Isostatic Adjustment (GIA) and the hydrological cycle are both associated with mass changes, which are observed by GRACE, and vertical land motion (VLM), which is observed by GPS. Hydrology-related VLM results from the instantaneous response of the elastic solid Earth to surface loading by freshwater, whereas GIA-related VLM reveals the long-term response of the visco-elastic Earth mantle to past glacial cycles. Thus, observations of mass changes and VLM are interrelated and GIA and hydrology are difficult to investigate independently. Taking advantage of the differences in the spatio-temporal characteristics of the GIA and hydrology fields, we can separate the respective contributions of each process. In this work, we use a Bayesian Hierarchical Modelling (BHM) approach to provide a new data-driven estimate of GIA and time-evolving hydrology-related VLM for North America. We detail our processing strategy to prepare the input data for the BHM while preserving the content of the original observations. We discuss the separation of GIA and hydrology processes from a statistical and geophysical point of view. Finally, we assess the reliability of our estimates and compare our results to the latest GIA and hydrological models. Specifically, we compare our GIA solution to a forward-model global field, ICE-6G, and a recent GIA estimate developed for North America (Simon et al. 2017). Our time-evolving hydrology field is compared with WaterGAP, a global water balance model. Overall, for both GIA and hydrology, there is a good agreement between our results and the forward models, but we also find differences which possibly highlight deficiencies in these models.