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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GLOBAL MASS
Attributing global sea level rise to its component parts

University of BRISTOL

1. Introduction

• The GlobalMass project will – for the first time at a global scale – rigorously combine satellite and *in-situ* data related to different aspects of the sea level budget.
• It uses a Bayesian Hierarchical Model (BHM) framework to combine prior knowledge with observations to solve for sea level change on a global scale, and to attribute this change to its component parts.
• The overall aim of the project is to produce simultaneous, consistent and statistically-rigorous estimates of glacial isostatic adjustment (GIA), land ice mass, land hydrology and sea level trends with global spatial coverage for a common epoch.
• This poster summarises progress to date and signposts where to go to find out more.

3a. BHM FRAMEWORK

• We are developing a Bayesian model-data synthesis method for global geophysical processes (the BHM framework)
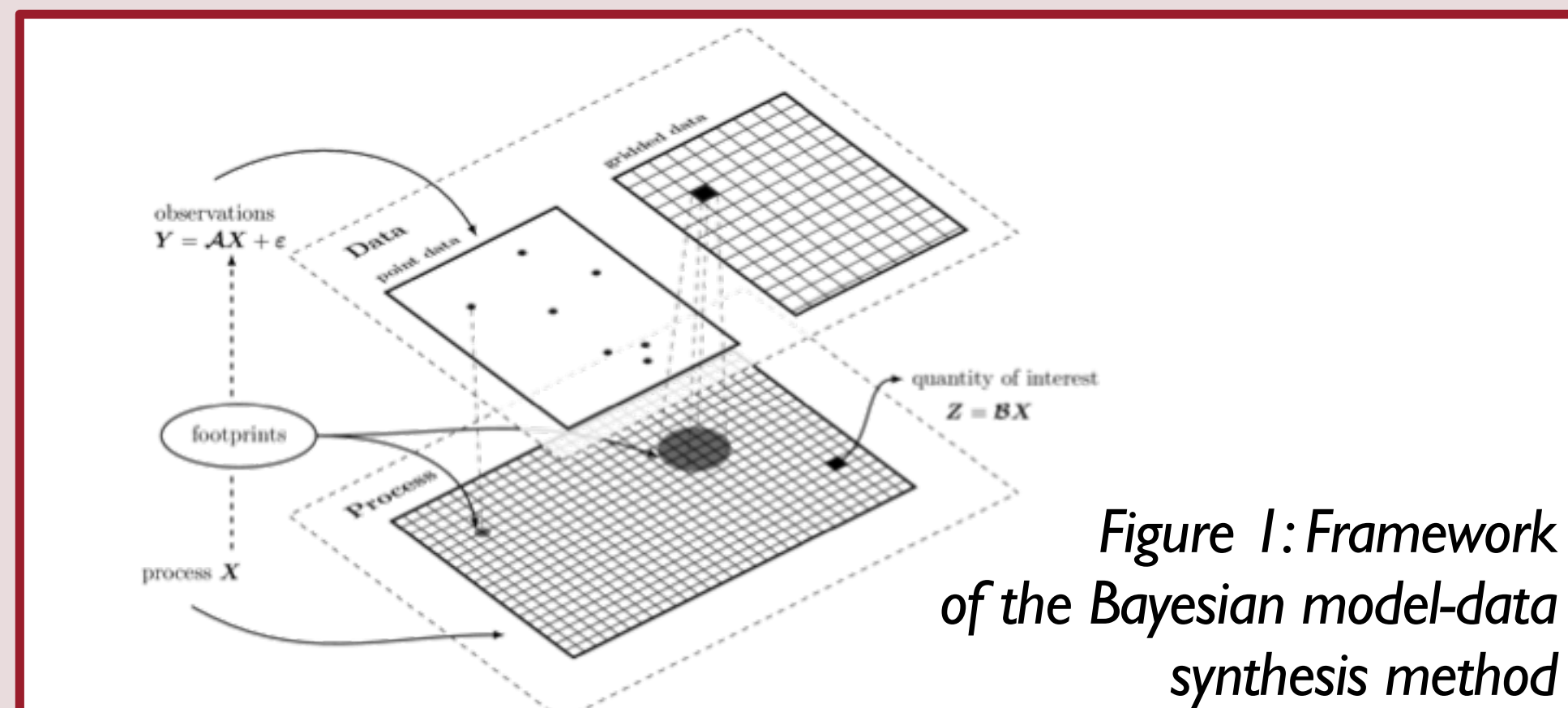

Figure 1: Framework of the Bayesian model-data synthesis method

• It reduces computational cost of massive scale Gaussian updates on a sphere through sparse approximation
• We have extended it to cover non-stationary processes
• Find out more: **www.globalmass.eu/statistical-framework**
Latest output
• Sha, Z. *et al.* (2018) Bayesian model-data synthesis with an application to global Glacio-Isostatic Adjustment. Poster at Bayes Comp 2018, Barcelona, 26-28 Mar 2018.
www.globalmass.eu/bayes-comp-2018-bayesian-model-data-synthesis-poster

3b. LAND ICE

• Common sources of uncertainty and bias exist between mass balance estimates from different approaches.
• We use a BHM framework to produce statistically-rigorous estimates of ice sheet mass balance and the contribution of component parts at the drainage basin scale.
• Annual mass trends for Antarctica have been updated from [1], and are now available for 2003-2015.
• Annual mass trends for Greenland for 2003-2015 are currently in development, though some preliminary results have been produced.
• Find out more: **www.globalmass.eu/land-ice**
Latest output
Chuter, S. *et al.* (2018) Annual Greenland mass trends from 2003-2015 from a Bayesian hierarchical modelling approach. Presentation at EGU General Assembly 2018, Vienna, 8-13 Apr 2018.
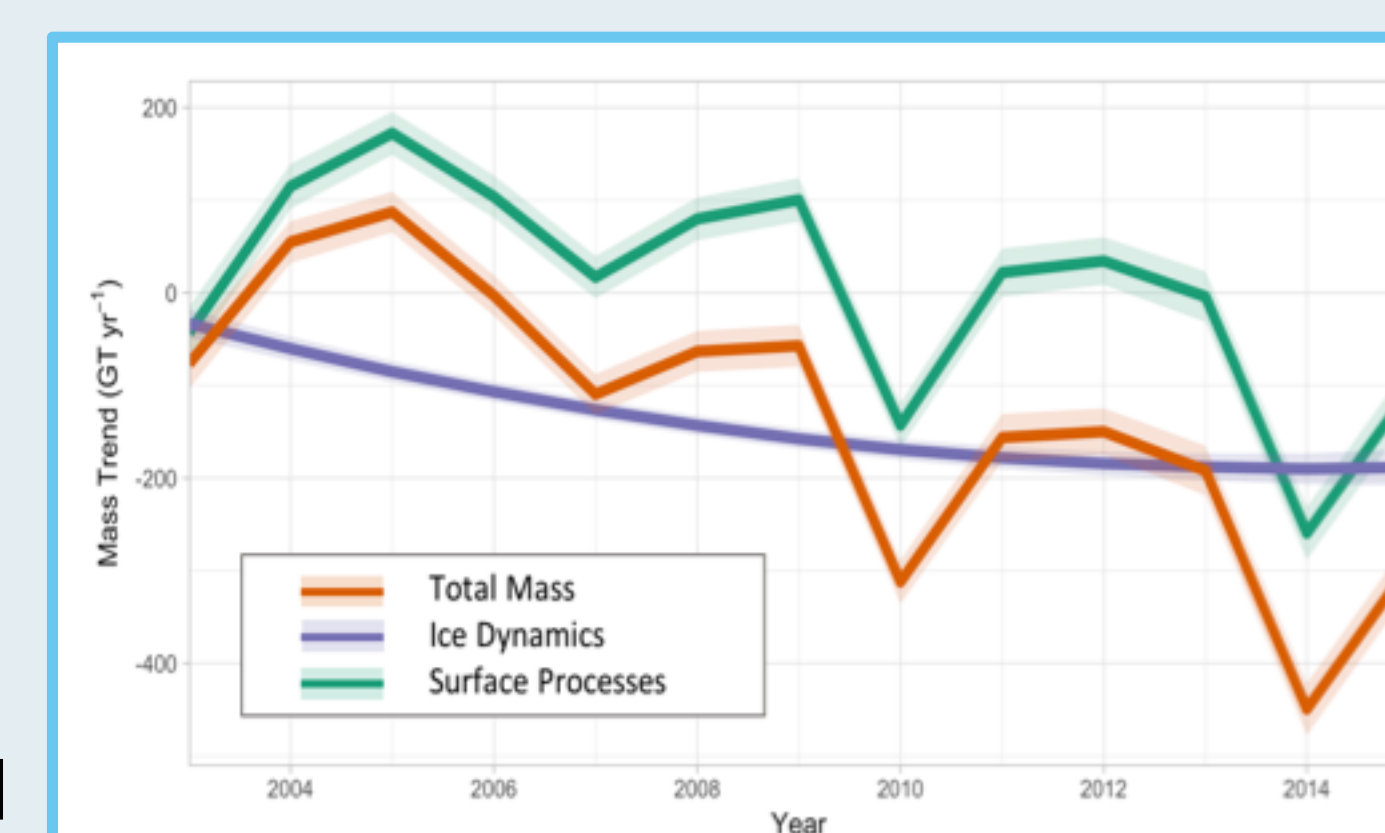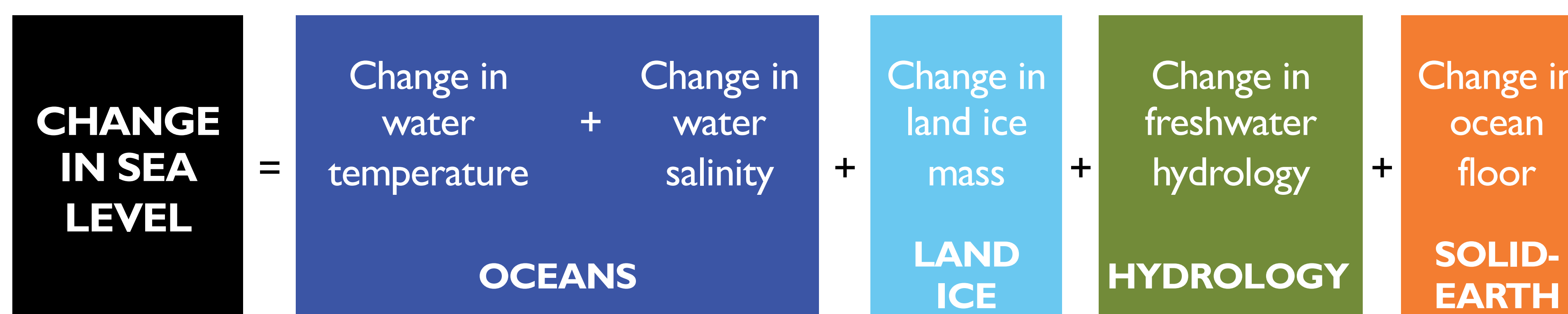www.globalmass.eu/egu18-greenland-bhm-presentation

Figure 2: Annual Antarctic mass trends for 2003-2015, including component parts

Reference [1] Martin-Espanol, A. *et al.* (2016), Spatial and temporal Antarctic ice sheet mass trends, glacio-isostatic adjustment and surface processes from a joint inversion of satellite altimeter, gravity and GPS data, J. Geophys. Res., 121(2), 182-200. DOI: 10.1002/2015JF003550

2. Overview of BHM framework

Observation layer (direct observations from satellites and *in situ* data)

Process layer (latent geophysical processes that define the sea level budget)

$$\text{CHANGE IN SEA LEVEL} = \begin{array}{c}\text{Change in water temperature} + \text{Change in water salinity} \\ \textbf{OCEANS}\end{array} + \begin{array}{c}\text{Change in land ice mass} \\ \textbf{LAND ICE}\end{array} + \begin{array}{c}\text{Change in freshwater hydrology} \\ \textbf{HYDROLOGY}\end{array} + \begin{array}{c}\text{Change in ocean floor} \\ \textbf{SOLID-EARTH}\end{array}$$

Parameter layer (prior information/assumptions about geophysical processes)

3d. OCEANS

• As part of BHM framework development, we estimate steric sea level trends (due to temperature and salinity) for 2005-2015 on a global scale.
• Based on observations and prior knowledge about trends in sea surface height (SSH; from altimetry), GIA (from the ICE-6G forward model) and ocean mass (from GRACE), the residual SSH signal (i.e. altimetry minus mass) should reflect steric changes.
• We compare our solution with four established gridded datasets to assess their performance, focusing on basin-scale trends and under-sampled ocean areas such as polar regions.
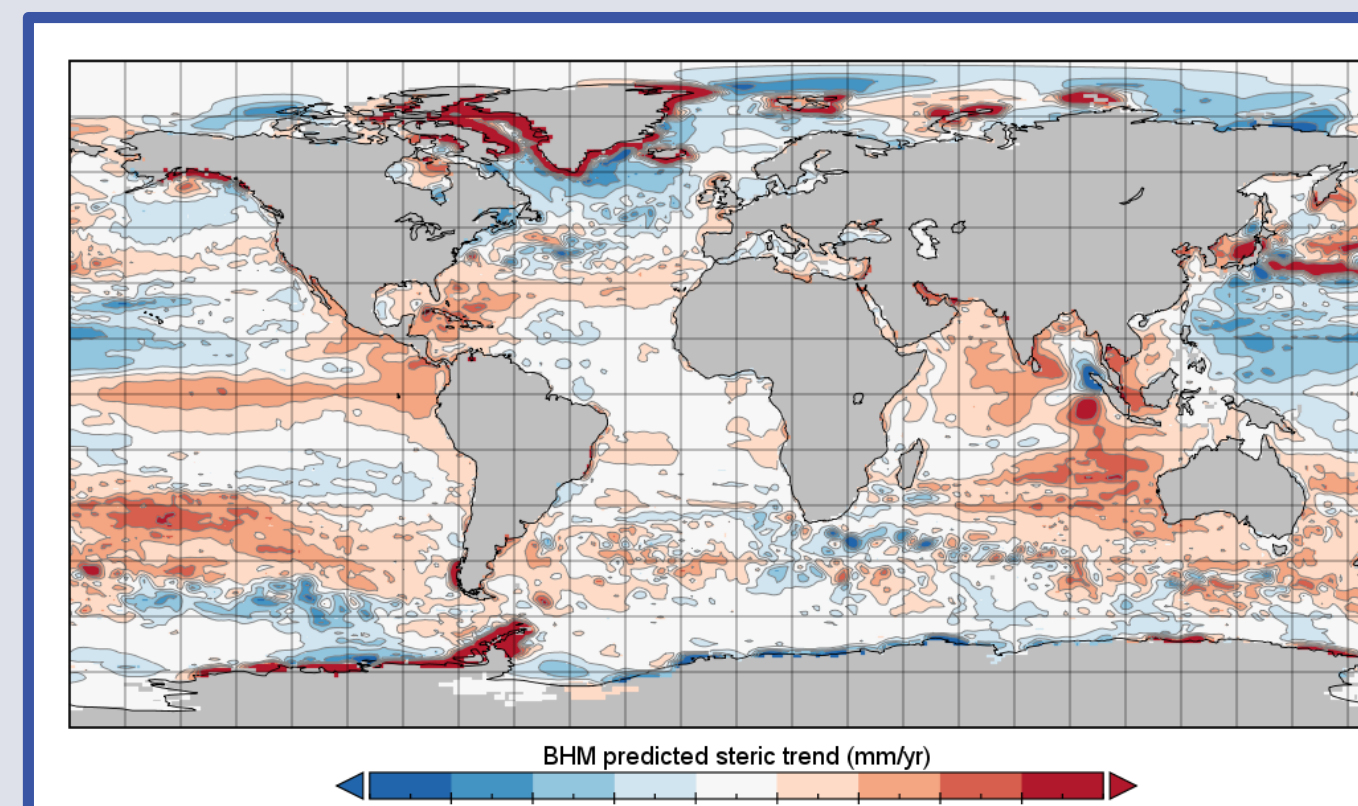• Find out more: **www.globalmass.eu/oceans**

Figure 4: Early version of BHM-estimated steric sea level trend for 2005-2015

3c. SOLID-EARTH

• Glacial isostatic adjustment (GIA) is a fundamental geophysical process that has important implications for the sea level budget.
• We have developed a fully-automatic approach to remove non-GIA artefacts from GPS data.
• Using this, we have created a dataset of 4,000 GPS stations to provide an observational estimate of GIA.
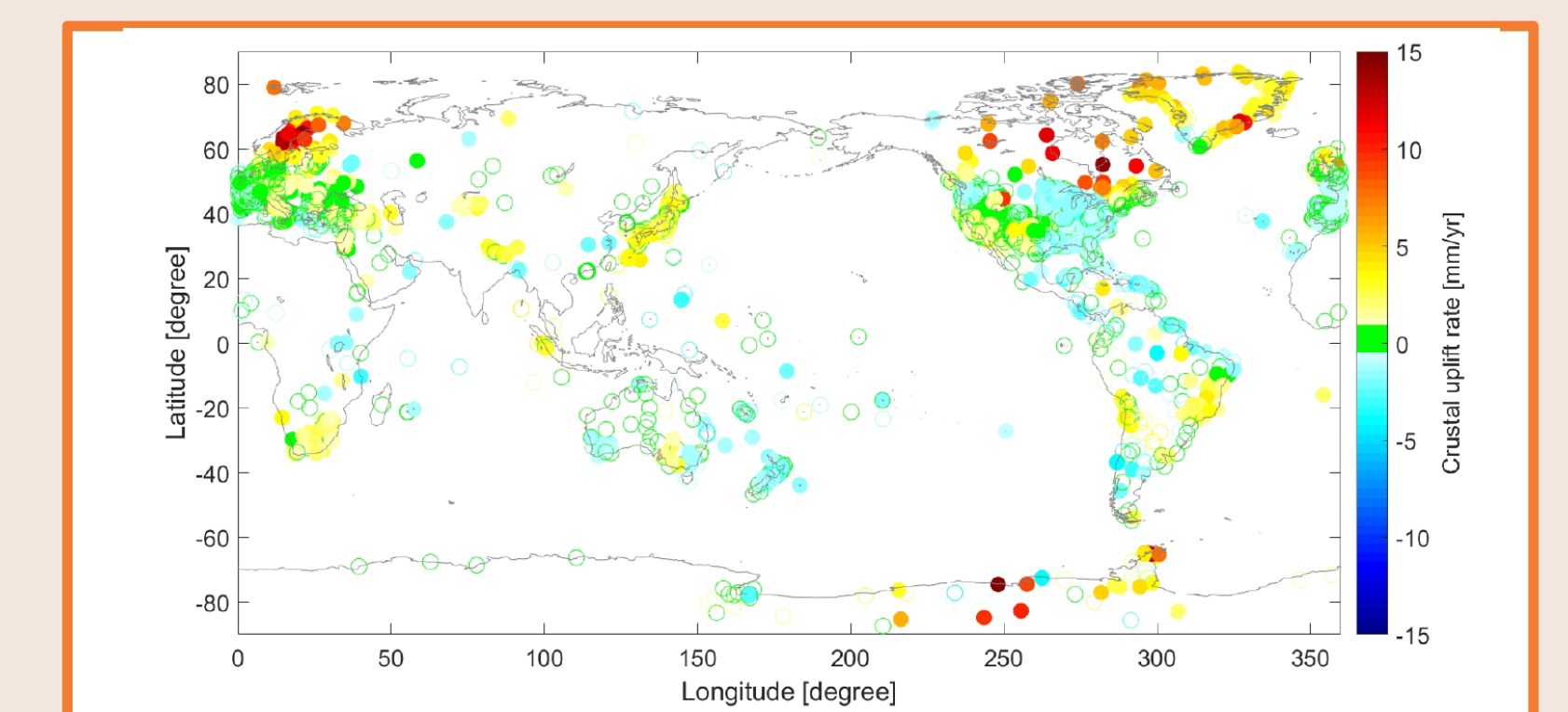

Figure 3: The 'clean' global GPS dataset for GIA

• We will next use this dataset to update global GIA forward model solutions within the BHM framework.
• Find out more: **www.globalmass.eu/solid-earth**
Latest output
• Schumacher, M. *et al.* (2018) A new global GPS dataset for testing and improving modelled GIA uplift rates. Poster at EGU General Assembly 2018, Vienna, 8-13 Apr 2018. **Wed 11 Apr, 17:30-19:00, Hall X3, X3.136**
www.globalmass.eu/egu18-new-gps-dataset-poster

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