National Aeronautics and Space Administration

Linking Solid Earth and Climate

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Program: R&TD

Project Objectives

Overall goal: The overall goal of this 3-year project was to strengthen JPL's capabilities to develop breakthrough scientific advances in the interdisciplinary domains of Solid Earth and Climate sciences. Specifically, we wanted to achieve the following key science and technological goals. **(1)** To improve upon existing Solid Earth and Sea Level capabilities of JPL/UC-Irvine Ice and Sea-level System Model (ISSM; https://issm.jpl.nasa.gov/). **(2)** To apply ISSM capabilities for solving interdisciplinary science problems that are related to Solid Earth, Cryosphere, and Sea Level processes.

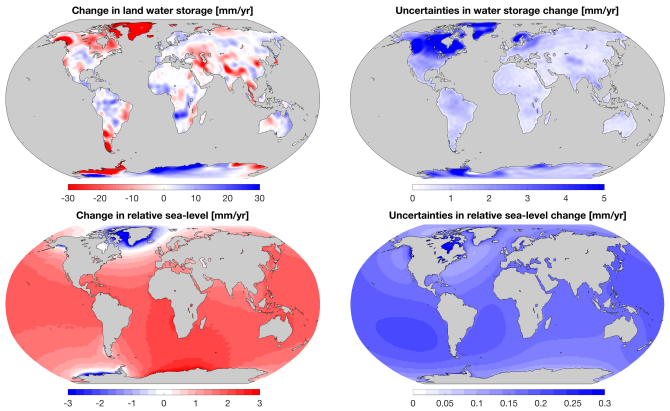
FY19 goals: In the final year of this project, we aimed at accomplishing the following two science goals. **(1)** To quantify global geodetic fields such as relative sea level, geoid height change, and vertical bedrock displacement that correspond to GRACE derived monthly changes in land ice/water mass. **(ii)** To explain the underlying geophysical causes of GPS derived secular crustal motions in Greenland.

Benefits to NASA/JPL and Relevance

Through this strategic initiative, we have been utilizing our significant talent, and modeling and remote sensing capabilities to further substantiate a solid presence of science leadership within NASA towards capturing new business opportunities in the areas of Solid Earth and Climate sciences.

Both of the proposed goals are accomplished. These and other research, enabled by this initiative, improve our understanding of multifaceted interactions between Solid Earth, Cryosphere and Sea Level sciences. Our research topics are directly related to priority questions set forth in the 2016 NASA CORE report, and are in concert with two foundational observables defined in the 2018 Decadal Survey: Mass change, and Surface deformation and change.

FY19 Goal #1: Example Results



Sea-level fingerprints. Land load function, relative sea level change, and uncertainties therein. Average rate of water equivalent height change in land water storage and associated change in relative sea level for the period April 2002 to March 2016 are shown with their corresponding 1-sigma uncertainties. These solutions are based on JPL Stokes coefficients and are computed in the center-of-mass reference frame with the rotational feedback included.

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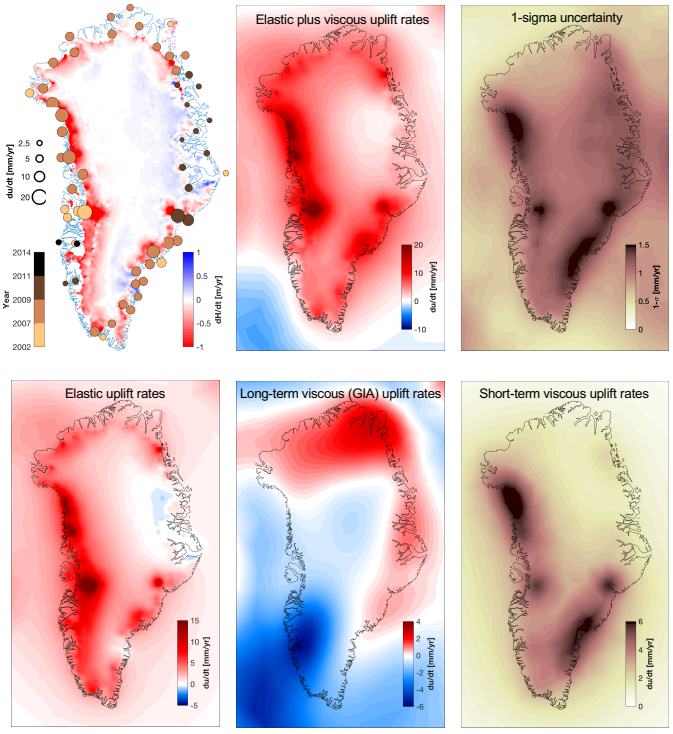
FY19 Goal #2: Example Results



Measured versus modeled crustal uplift rates, du/dt. Background map in (a) shows Cryosat-2 based estimate of ice height change, dh/dt, over 2011-2017. Color of the circles shows the year since GPS stations are in operation, and the circle size represents the measured uplift rates. We argue that short-term viscous response of the solid Earth to unloading of the Greenland Ice Sheet since the Little Ice Age (bottom-right panel) is a key component that is largely overlooked while investigating the geophysical causes of observed crustal motions.

FY19 Publications

1. S. Adhikari et al., 2019: Sea-level fingerprints emergent from GRACE mission data, *Earth System Science Data*, 11, 629-646.
2. E. Larour et al., 2019: Slowdown in Antarctic mass loss from solid-Earth and sea-level feedbacks, *Science*, 364, eaav7908.
3. S. Adhikari et al., 2019: A brief review of geodetically compliant ice-sheet geometry and its evolution and sea level contribution, to be submitted to *The Cryosphere*.
4. B.D. Hamlington et al., 2019, Acceleration of regional sea level rise during the satellite altimetry era, submitted to *Science Advances*.
5. E.R. Ivins et al., 2019: A linear viscoelasticity for decadal to centennial time scale mantle deformation, submitted to *Reports on Progress in Physics*.
6. T. Frederikse et al., 2019: Towards closure of the contemporary regional sea-level budget, submitted to *Environmental Research Letters*.
7. NASA Sea Level Change Team, 2019, Understanding of contemporary regional sea-level change and the implications for the future, submitted to *Review of Geophysics*.
8. T. Frederikse et al., 2019: Constraining 20th-century sea-level rise in the South Atlantic Ocean, submitted to *Journal of Geophysical Research*.
9. S. Adhikari et al. 2019: Explaining the causes of GPS-derived vertical crustal motion in Greenland, to be submitted to *PNAS*.
10. S. Adhikari et al., 2019: Computation of high-resolution planetary interior displacement and stress fields in the ISSM framework, to be submitted to *Geoscientific Model Development*.

Note: 1-2 published. 3-8 submitted. 9-10 in draft form to be submitted soon.
1,9,10 directly supported by this R&TD; others are enabled by it.

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