National Aeronautics and Space Administration

Improving the infrastructure for regional sea level studies and related mission formulations by including time-varying cryospheric and hydrological forcings and their uncertainties

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Objectives

To enhance the capabilities to conduct research on regional sea level attribution & prediction and to support the related missions by introducing time-varying cryospheric & hydrologic forcings into JPL's Estimating the Circulation and Climate of the Ocean (ECCO) global ocean state estimation system.

Background

Earth system elements are linked together through interactions. Oceanic changes (incl. SL) are linked to atmospheric, hydrologic, and cryospheric forcings. ECCO already has time-varying atmospheric forcings, but had not included time-varying hydrologic (river discharge) and cryospheric (ice-shelf and iceberg melt waters) forcings. This SRTD effort introduced the missing forcings to enable quantification of relative contributions of cryospheric, hydrologic, and atmospheric forcings to regional changes of sea level and ocean circulation.

Approach and Results

Approach:

- Incorporate a reanalysis-based JRA55-do daily global river discharge product into ECCO as the prior river-discharge forcing, thereby accounting for effects of river discharge variations associated with flood/drought and synoptic storms on the ocean.
- Introduce an idealized ice-shelf model coupled to ECCO ocean model to estimate ice-shelf melt rate in response to ocean warming; constrain the model's ice-shelf melt rate using altimeter-derived ice-shelf melt rate estimates and ocean observations..
- Implement iceberg melt forcing into ECCO using satellite-derived iceberg trajectory data and iceberg mass flux estimates.

Results:

- Daily river discharge improved ECCO representation of sea level and ocean salinity near major river mouths in comparison with observations; inverse estimation enabled optimization of river discharge that contains errors using ocean salinity measurements (e.g., from SMAP).
- Idealized ice-shelf model coefficients are optimized through inverse estimation using ocean observations and altimeter-derived ice-shelf melt rate estimates; incorporated into ECCO production (and time extension) of ocean state estimation to improve representation of ocean-ice shelf interaction.
- Iceberg melt forcing allows the melt water forcing to impact the state of the ocean interior away from ice shelves.

Significance/Benefits to JPL and NASA

- Enhanced JPL's competitiveness to win proposals from NASA and other agencies. Examples: the SRTD effort has led to successful proposals under various ROSES calls, incl. Sea Level Change Team, Physical Oceanography, and Ocean Biology and Biogeochemistry. A proposal leveraging on this SRTD effort has also been submitted recently to the National Academies (under review).
- Put us at a better position to support SWOT mission science by utilizing SWOT river discharge estimates and SL measurements near the coasts to study land-sea linkages, both for physics and biogeochemistry.
- Improved the capability to conduct Observing System Simulation Experiment in support of future effort related to Earth Venture Sub-orbital mission concept for ocean-ice shelf interaction.

Publications (in FY21)

[A] Ou Wang, Tong Lee, Chris Piecuch, Ichiro Fukumori, Ian Fenty, Hong Zhang, "Local and remote forcings of sea-level variability at Nantucket Island", Geophysical Research Letters., submitted, 2021.

[B] Hrishikesh Chandanpurkar , Tong Lee, Xiaochun Wang, Hong Zhang, Severine Fournier, Ian Fenty, Ichiro Fukumori, Dimitris Menemenlis, Chris Piecuch, J.T. Reager, Ou Wang, and John Worden, "Influence of nonseasonal river discharge on seas surface salinity and height", Journal of Advances in Modeling Earth Systems, in revision, 2021.

[C] Severine Fournier and Tong Lee, "Seasonal and interannual variability of sea surface salinity near major river mouths of the world ocean inferred from gridded satellite and in-situ salinity products". Remote Sensing. *doi.org/ 10.3390/rs13040728,* 2021.

[D] Ichiro Fukumori, Ou Wang, and Ian Fenty, "Causal mechanism of Beaufort Sea's sea level and freshwater content variation. Journal of Physical Oceanography, DOI:https://doi.org/10.1175/JPO-D-21-0069.1, 2021.

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