National Aeronautics and Space Administration

Hydrodynamics Across the Land-Ocean Aquatic Continuum (LOAC)

Principal Investigator: Marc Simard (334); Co-Investigators: Alexandra Christensen (334), Adriana Parra Ruiz (334), Raphael Savelli (329), Sarah Flores (334) Dimitris Menemenlis (329), Eric Larour (329), Benjamin Hamlington (329)

Program: FY22 R&TD Topics
Strategic Focus Area: Water and carbon cycles

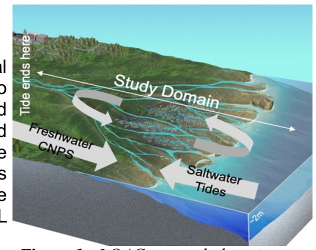

Figure 1: *LOAC research domain*

Objectives:
We define the LOAC as the transition zone between terrestrial ecosystems and the very near-shore coastal ocean, which includes tide-impacted inland waters and wetlands, estuaries and near-shore coastal waters (no more than a few kilometers on coastal shelf) (Fig. 1). The longer-term goal of this study is to estimate and monitor the exchange of water and its constituents across the LOAC with hydrodynamic models calibrated and validated with altimeter and interferometric radar missions—essentially upscaling Delta-X globally. The objectives leverage ongoing Delta-X, SWOT and NISAR projects:1-Demonstrate the retrieval of instantaneous (i.e. observed) water fluxes across the LOAC using altimeter data and hydrodynamic models.2-Evaluate the potential and limitations of current missions in calibrating hydrodynamic models:3-Develop and publish a JPL database and software library specific to the LOAC.4-Support the Design of a LOAC-specific mission.

Background:
Altimetric instruments typically focus on offshore measurements of water surface elevation with kilometer-scale resolutions. What about estuaries, river networks and wetlands along the coast? Studying the LOAC requires resolving complex coastal landscapes with hydrological features (ie. lake, lagoons, wetlands, rivers, channels and estuaries) that are impacted by the perpetual dance of river discharge and ocean tides.

Approach and Results:
Our innovative approach combines altimetry and radar interferometry to advance our understanding of hydrodynamic processes across the LOAC, and ultimately evaluate role in the regional and global water and carbon cycles. This work couples altimetry and hydrodynamic models, and support evaluation of technological capabilities and identification of data gaps. We focus on the cal/val of hydrodynamic models with spaceborne altimetry (eg. GEDI, ICESAT-2, SWOT) and repeat-pass interferometry (ALOS/PALSAR-1/2, Sentinel-1a/b, NISAR) using existing and future spaceborne sensors. Altimetry is used and evaluated as 'virtual gauges' in main (ie. large) channels, lagoons, lakes, wetlands and near-shore, and available InSAR isused in wetlands. We quantitatively evaluate each altimetric source from gauged deltas and estuaries, and upscale to ungagged deltaic parts and other deltas using the time-series of altimetric measurements to calibrate and validate our hydrodynamic model implementations. We collected, processed, and archived global datasets of GEDI and ICESAT-2 along global coastline regions. A first version of the LOAC website was developed and published and a few coastal datasets were uploaded (https://landscape.jpl.nasa.gov/cgi-bin/data-search.pl). We evaluated retrieval of bathymetry using green lidar (ICESAT-2 and airborne) along several coasts and estuaries. The technology works in clear and shallow tropical waters (<50m). We used data from green (ICESAT-2 and airborne) and red (GEDI and airborne) altimetric lidar instruments and demonstrated high potential for single water surface elevation measurements (i.e., snapshot) with sparse repeat measurements. See water surface elevation retrievals with GEDI and ICESAT-2 compared to USGS gauges in the Mississippi River Delta (Figures 4 and 5). Water surface elevation from Interferometric Synthetic Aperture Radar (InSAR) was performed with several sensors that include ALOS-1/PALSAR-1, ALOS-2/PALSAR-2, Sentinel-1, and TerraSAR-X. We found L-band InSAR to work particularly well, while C- and X-band data do not provide water level change in wetlands.

Significance/Benefits to JPL and NASA:
The goal is to ultimately upscale Delta-X to global river deltas and estuaries using multi-source spaceborne remote sensing,composed of altimeters, repeat-pass radar interferometer and optical sensors. Global hydrodynamics of the LOAC is anunoccupied science and applications niche which JPL could easily lead with minimal investment. We begin with developing methodologies with existing and upcoming altimetric and radar missions, essentially creating a "virtual" LOAC mission, tocapture data gaps and to assert JPL leadership before proceeding to the design of a LOAC-specific mission. The quantitative aspects of the tasks will be useful to determine an Science and Applications Traceability Matrix to define a future LOAC mission.

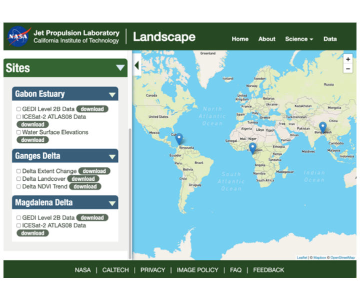

Figure 2: Website interface with initial set of coastal (LOAC) datasets.

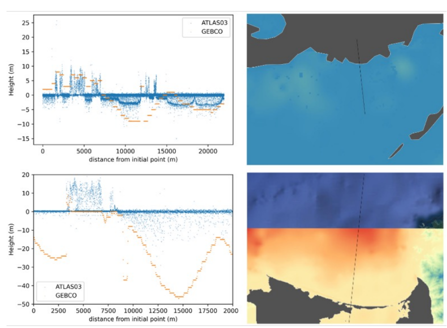

Figure 3: ICESAT-2 transects (blue dots) to map shallow water bathymetry in clear (Everglades top) and turbid (CGSM, Colombia) waters, compared to the GEBCO bathymetry map (red dashes).

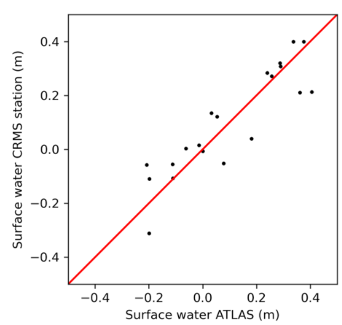

Figure 4: Water Surface Elevation with GEDI (right) and ICESAT-2 (left) compared to USGS gauges in the Mississippi River Delta

National Aeronautics and Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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PI/Task Mgr. Contact Information:
Email: Marc.Simard@jpl.nasa.gov