National Aeronautics and Space Administration

Flow of Water, Carbon, and Sediment within the Land-Sea Continuum

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Project Objective:

Our goal is to develop JPL's remote sensing and modeling capabilities to estimate transport of water, carbon, and sediment from land to coastal oceans. This is achieved through analysis of the data collected during the multi-instrument airborne campaign in the Wax Lake/Atchafalaya region of southern Louisiana. The objectives are to:

1. Demonstrate the robustness of sediment and carbon retrievals.
2. Demonstrate the potential for estimating land-to-ocean water, sediment and carbon fluxes from remote sensing methods.
3. Demonstrate the capability for remote sensing methods to further constrain the mass balance of water, sediment, and carbon.

FY19 Results:

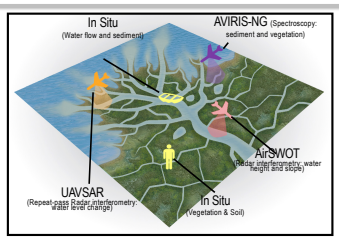
This project resulted in several papers based on the data and analysis generated during the course of this project (see list at the bottom of this poster). Other papers provide an overview of state-of-the-art remote sensing measuremetns. This project also generated a variety of new algorithms and products that will provide the foundation for future work:

a. Vegetation canopy height for the entire region covered by ASO.
b. Vegetation classification and biomass for the entire region using Sentinel-2 data (Thomas et al., 2018).
c. A rating curve to estimate river discharge using water surface elevation and slope from AirSWOT or ASO data.
d. A new algorithm to retrieve drag coefficient in vegetated wetlands using UAVSAR repeat-pass interferometry.
e. An updated digital elevation and bathymetry model for the Atchafalaya basin using existing DEMs with our own in situ data collected with sonar and ADCP transect during the 2016 campaign.
f. A set of fully functional numerical hydrological models of the Atchafalaya basin with Delft3D and X-Beach frameworks.

Most importantly, this project enabled the demonstration of JPL's remote sensing assets to measure hydrodynamic and ecological processes across a deltaic environment. These results were key to the successful EVS-3 proposal: Delta-X. Moreover, the extensive review of literature, along with the demonstration of remote sensing measurement and implementation of numerical models will serve in the design a future spaceborne mission dedicated to coastal regions.

Benefits to NASA and JPL (or significance of results:

This SR&TD project has been instrumental to the successful EVS-3 proposal: Delta-X. The demonstration of remote sensing measurements using 4 JPL instruments were a powerful argument for the feasibility of the proposed Delta-X investigation. The new results include several papers that support recommendations from the recent Decadal Survey (2019), calling for a new hyperspectral system (Surface Biology and Geology) and the need to understand various processes in coastal regions. Our analysis and results will directly support the development of the SBG mission in terms of tools and argument to select spectral bands, spatial resolution, and to optimize orbit. This SR&TD will also support new missions with objectives specific to coastal regions. It is our hope that coastal-specific mission can be developed and that JPL will play a leading role. Finally, the results of this Strategic R&TD are directly applicable to the SWOT and NISAR missions which are planned for launch in 2021. These missions will provide measurements along global coast that can partially mimic the results obtained during this project.



Left: Summary of JPL's airborne assets (UAVSAR, ASO and AVIRIS-NG) and field campaign that occurred in 2016 in the Mississippi River delta. **Center:** All aircrafts flew simultaneously, along with 2 boats carrying GPS, ADCPs, sonars, water sampling and spectrometers. A similar campaign was conducted in 2015 with UAVSAR, AirSWOT and AVIRIS-NG. The 2016 campaign was done in October in order to capture low water discharge and peak biomass period. Thus the 2 campaigns provided a wide range of flows (high and low discharge) and vegetation density (low and high density in spring and fall respectively). **Right**: The data processing and analysis performed during this Strategic R&TD led to the success of the Delta-X proposal to the NASA EVS-3 opportunity. Delta-X will evaluate the relative role of 1) vegetation and 2) allochtoneous sediment in building soil in the Mississippi River Delta, and forecast the resilience and vulnerability of its different regions to relative sea level rise. The airborne and in situ field campaign will occur in April and September 2020.This new NASA EVS-3 mission was awarded, thanks to measurement demonstrations and technical advances achieved during this Strategic R&TD.

Publications:

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2. Jensen, Daniel, Marc Simard, Kyle Cavanaugh, Yongwei Sheng, Cédric G. Fichot, Tamlin Pavelsky, and Robert Twilley. "Improving the Transferability of Suspended Solid Estimation in Wetland and Deltaic Waters with an Empirical Hyperspectral Approach." *Remote Sensing* 11, no. 13 (2019a): 1629.
3. Jensen, D., Kyle Cavanaugh, Marc Simard, Gregory Okin, Edward Castañeda-Moya, Annabeth McCall, Robert Twilley, "Integrating imaging spectrometer and synthetic aperture radar data for estimating wetland vegetation aboveground biomass in coastal Louisiana", *Remote Sensing*, in press October 2019b
4. Daniel J. Jensen, Marc Simard, Kyle C. Cavanaugh, and David R. Thompson, 2018, "Imaging Spectroscopy BRDF Correction for Mapping Louisiana's Coastal Ecosystems", *IEEE Transactions on Geoscience and Remote Sensing* 56 (3), 1739-1748.
5. Thomas, Nathan, Marc Simard, Edward Castañeda-Moya, Kristin Byrd, Lisamarie Windham-Myers, Azure Bevington, and Robert R. Twilley. "High-resolution mapping of biomass and distribution of marsh and forested wetlands in southeastern coastal Louisiana." *International Journal of Applied Earth Observation and Geoinformation* 80 (2019): 257-267.
6. Ross M., Yang, X., Butman, D., Appling, A., Kuh, C., Pavelsky, T., "Aquasat: a dataset to enable remote sensing of water quality for inland waters", AGU's *Water Resources Research*, in press October 2019.
7. Denbina, M., Simard, M., et al., "Mapping Water Surface Elevation in the Mississippi River Delta Using the AirSWOT Ka-Band Interferometric Synthetic Aperture Radar", *Remote Sensing*, Submitted, October 2019.
8. Simard, M., et al., "Delta-X: an airborne remote sensing framework to capture hydrodynamic processes at the coastal interface", in prep October 2019.
9. Ward, N.D. et al., "Representing the Function and Sensitivity of Coastal Interfaces in Earth System Models", submitted to *Nature Reviews*, September 2019
10. Robert R. Twilley, Andre S. Rovai, Douglas A. Edmonds, "Carbon sequestration in the world's deltas", *Nature*, in prep October 2019.
11. Andre S. Rovai, Robert R. Twilley, Alexandra Christensen, Gregg A. Snedden, Daniel J. Jensen, Christopher N. Janousek, James T. Morris , "Tidal freshwater wetlands adapt to multiple platform elevations in response to coastal dynamics", *Estuaries and Coasts*, in prep, October 2019.

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