National Aeronautics and Space Administration

Assessing altimetry and optical remote sensing products to study global sediment transport dynamics in Earth's inland water bodies

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Objectives:

We seek to define the observational requirements necessary to best observe total suspended solids (TSS) in inland water bodies, with a long-term goal of developing a new space mission focused on inland water quality. To accomplish this primary objective, we addressed these specific objectives: Objective 1: Define the spatial, spectral, and temporal resolution trade-space for remote sensing of total suspended solids (TSS) transport dynamics (TSS concentration and flux). Objective 2: Quantify the observational requirements (spatial and temporal) for tracking TSS transport dynamics at the global scale. Objective 3: Develop a science-return function to identify existing observational requirements that can significantly improve our ability to understand global TSS transport dynamics within inland waters.

Background:

Given the ongoing global boom in dam construction, we hypothesize that more sediment is impounded by Earth's large lakes and reservoirs than is delivered to the ocean annually. Testing this hypothesis requires two types of measurements: (1) measurements of TSS concentration in inland waters; and (2) measurements of water discharge to estimate TSS flux. There is an opportunity to develop and propose an optical mission that would fill a gap in observation capabilities of current and planned optical sensors and innovatively pair with one or more altimetry missions.

Approach and Results:

We used high-resolution hyperspectral AVIRIS-NG data (~5 m, ~5 nm resolution) acquired from JPL's ongoing Delta-X mission over the Atchafalaya Basin in the Mississippi River Delta and built a partial least squares regression (PLSR) model to create a TSS retrieval algorithm using temporally paired in situ TSS measurements to calibrate the model (R2 = 0.88, RMSE = 3.57 mg/L). We then subsampled the AVIRIS-NG data both spatially and spectrally to simulate lower quality resolutions, and added Gaussian random noise to simulate SNRs ranging from 50 to 1000. New PLSR models were derived to evaluate the resulting data configurations. We found that spectral resolution plays a key role in retrieval accuracy, with finer spatial resolutions yielding significantly higher accuracies (Fig. 1). Finer spatial resolutions also yield higher accuracies, but with a weaker overall trend. While higher SNRs have higher retrieval accuracies, We found it levels off around SNR=500. To evaluate temporal resolution we used a wavelet analysis to understand how to best capture unique events, such as floods, in hydrologic time series data. We used 15-minute USGS turbidity gauge data for this analysis, using turbidity as a proxy for TSS. The wavelet analysis shows that a 5-day revisit period best captures unique events and overall variability, with larger rivers with higher discharge having a longer optimal revisit period (Fig. 2).

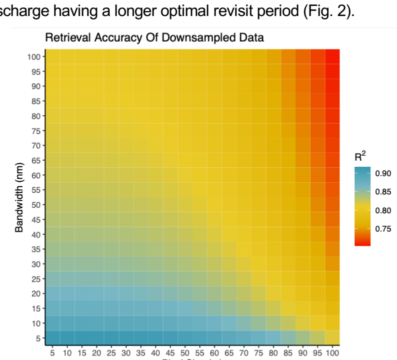

Figure 1. PLSR model performance at different combinations of spatial and spectral resolution.

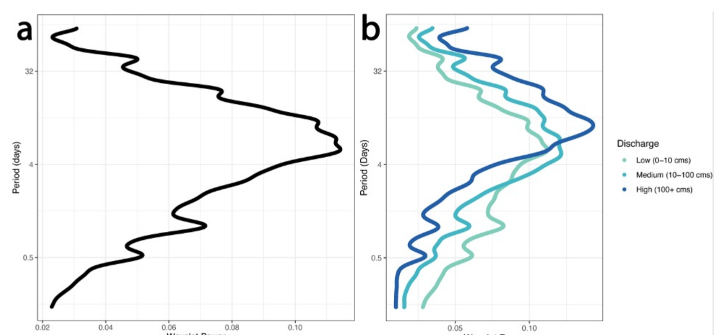

Figure 2. Wavelet analysis results. (a) Results from all USGS gauge records (n = 720). The wavelet power peaks at approximately 5.3 days. (b) Results from all USGS gauges, grouped by average discharge

Significance/Benefits to JPL and NASA:

The proposed research bridges several NASA-JPL satellite data products and has the potential of unlocking currently unrecognized mission synergies. Within JPL, the proposed research benefits the Delta-X mission, the SBG mission, and builds on previous JPL investments including the Coastal & Inland Water Science A-Team Study and potentially the SWIS instrument.

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