FY24 Strategic University Research Partnership (SURP)

Remote VSWIR Imaging spectroscopy for global aquatic environment monitoring

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Objectives: A shallow coastal ecosystem at the land-water interface is a critical component of the global ecosystem. It includes a majority of high biodiversity areas which support habitats like coral reefs, seagrass, and mangroves. New techniques including monitoring through Remote Visible / ShortWave InfraRed (VSWIR) imaging spectrometers are critically needed to increase the resilience of coastal environments in the coming decades. We will establish a global coastal water in situ and remote spectral dataset by including ASU GAO imaging spectroscopy data, CORAL, SeaBASS, GLORIA (Lehmann et al., 2023), Casey et al. (PANGAEA 2019), and other public datasets; and build relevant retrieval protocols for imaging spectroscopy in shallow coastal water regions to monitor shallow water environments and potential terrestrial impacts. (Li et al, RSEC 2022).

Background: Coral reefs, seagrass, mangroves, and associated shallow-water ecosystems provide habitat for thousands of species, offer a variety of goods and services (i.e., seafood, tourism, flood protection) to millions of people living in coastal regions, and support marine organisms. Global mapping of shallow coastal ecosystems is critical for the Surface Biology and Geology (SBG) investigation called for by the National Academies 2017 Earth Science and Applications Decadal Survey. At the time of this proposal, this JPL-led mission is now in Phase A, making this a critical time to establish and demonstrate core retrieval algorithms.

Approach and Results: In the first project year, we pursued a several interrelated avenues in development of benthic retrieval algorithms.

- PhD student Thomas Ingalls has conducted a thorough literature survey of remote spectroscopy of coastal aquatic systems. This study has now been published in Remote Sensing of Environment (Ingalls et al., RSE 2024). It provides a taxonomy of different science themes and techniques for shallow water remote sensing. Figure 1 shows the locations of different studies considered in the survey.
- A student paper (Van Woesik, et al. in prep) illustrates the value of remote sensing of these coastal ecosystems for conservation science. This work aims to inform strategic conservation efforts to maintain critical coastal seascapes and the ecosystem services they provide using remotely sensed data. Figure 2 shows a result from this paper, showing seascape change at different spatial scales in a Belize study area.
- We developed a novel deep learning model (i.e., Seagrass DenseNet: SGDenseNet) for benthic classification. We focused initially on the problem of seagrass, which is particularly important for carbon sequestration. We developed a solution based on the DenseNet architecture to overcome these challenges. Our model achieves an overall accuracy of 90% for seagrass extent mapping. Future work will expand this model to spectroscopic data and other benthic cover types.

Significance/Benefits to JPL and NASA: The project is well positioned to infuse new algorithms into the SBG-VSWIR mission workflow. The JPL SURP project has also played a role in advancing academic and research achievements within ASU.

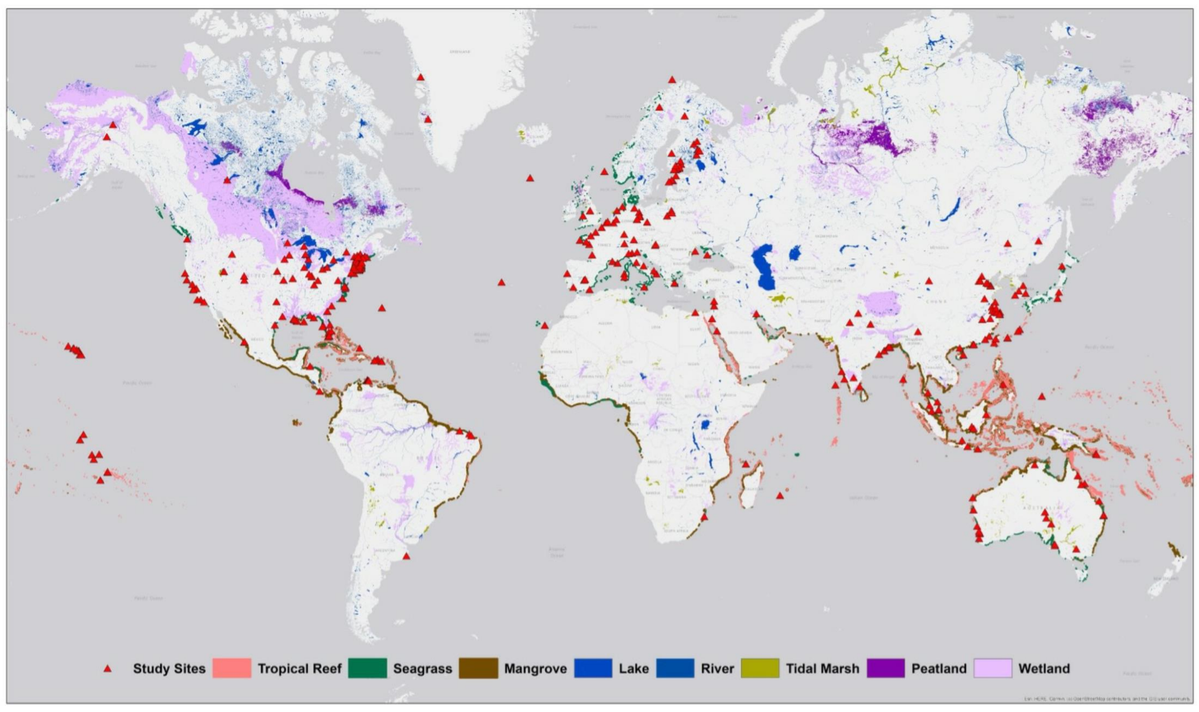

Figure 1: Survey of studies on shallow water ecosystems with remote imaging spectroscopy. From Ingalls et al. (RSE 2024).

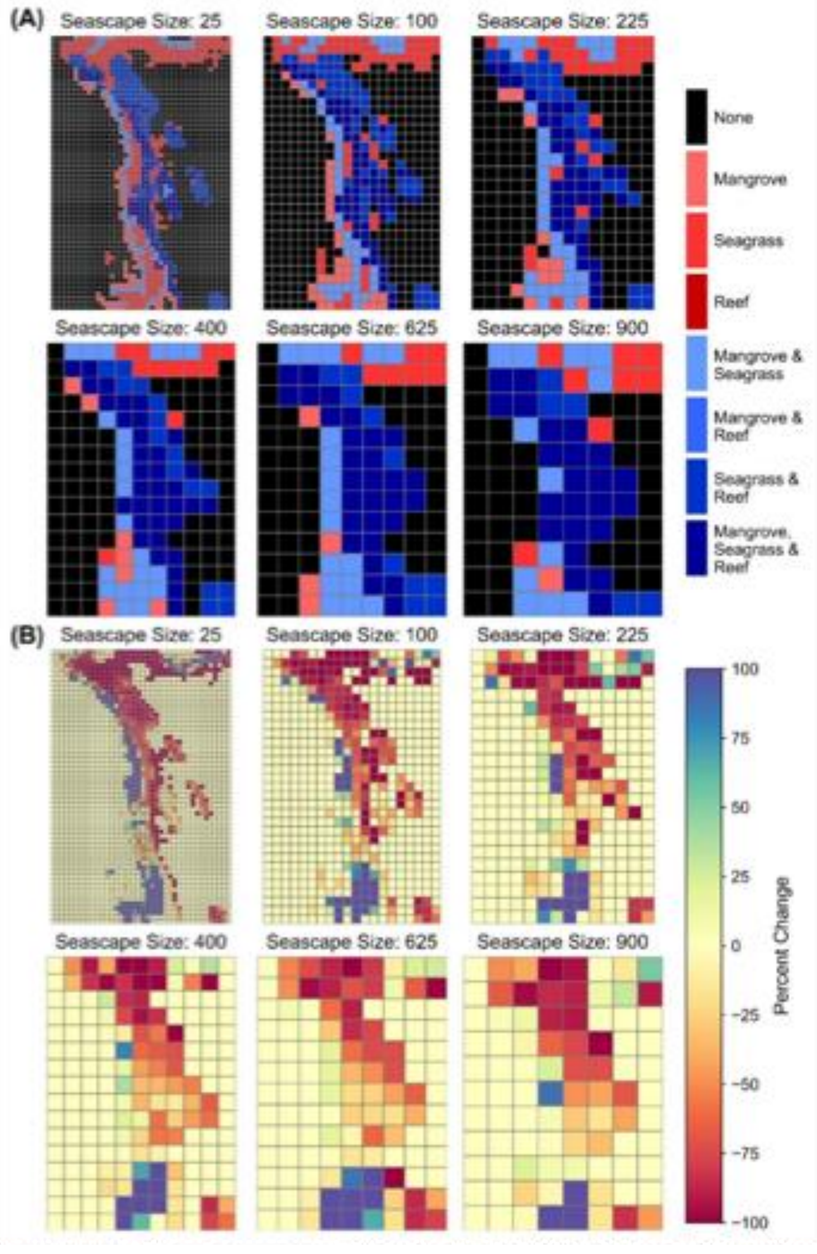

Figure 2: Maps of each seascape type (inclusion threshold 0.0%) for the six different sized seascapes. From Van Woesik et al. (in prep).

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Publications:

- Ingalls, Thomas C., Jiwei Li, Yvonne Sawall, Roberta E. Martin, David R. Thompson, and Gregory P. Asner. "Imaging spectroscopy investigations in wet carbon ecosystems: A review of the literature from 1995 to 2022 and future directions." Remote Sensing of Environment 305 (2024): 114051.
- Van Woesik, et al., “Alterability of Coastal Poly- and Mono-Habitat Seascapes: A Belizean Case Study,” *in preparation.*

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