Water Quality Time Series of Mississippi Sound: Insights from Satellite and Unmanned Aerial Systems Imagery, and Autonomous Surface Vessel Data

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In situ water sampling from manned boats provides accurate point-based measurements but lacks the spatial and temporal coverage required for comprehensive water quality management. In contrast, remote sensing offers broad-scale water quality observations with frequent revisit times. However, satellite data face limitations, such as cloud cover, which can result in extended periods without data, and insufficient spatial resolution for smaller water bodies. Unmanned aerial systems (UASs) can overcome these gaps, collecting ultra-high-resolution data beneath clouds. This research aims to generate a time series of water quality maps by integrating satellite and UAS imagery for effective management of small coastal systems.

To generate water quality maps, remote sensing algorithms are developed by correlating in situ water quality measurements with remotely sensed data. While manned-boat collected in situ data is suitable for satellite imagery, algorithm development using UAS data requires finer-scale measurements. To address this, a solar-powered autonomous surface vessel (ASV) equipped with water quality sensors was deployed. Operating at 3 knots, the ASV recorded data every 1.5 meters, offering high-resolution observations critical for UAS applications.

Mississippi's oyster landings have declined significantly due to poor water quality, highlighting the need for a system that provides spatially explicit water quality data. Field campaigns were conducted over oyster reefs in the Mississippi Sound, combining data from multiple platforms. A MicaSense RedEdge MX multispectral sensor on an Inspire-2 drone captured ultra-high resolution (7.5 cm) imagery, while the ASV simultaneously collected water quality data. Above-water reflectance measurements were also obtained using a spectroradiometer from a manned boat.

UAS imagery was processed into remote sensing reflectance maps using the drone's position, orientation, and field-of-view data. To minimize sun glint, mosaics were created with a custom software tool, Batch Mosaicker. Atmospherically corrected Satellite data from Landsat 8 and 9 Operational Land Imager, and Sentinel 2A and 2B Multispectral Imager were obtained from Google Earth Engine. Algorithms to estimate suspended particulate matter, turbidity, colored dissolved organic matter, chlorophyll-a, phycocyanin, total alkalinity, partial pressure of carbon dioxide, and salinity were developed using empirical and machine learning methods.

The algorithms were applied to imagery for a time-series analysis, exploring the impact of river discharges (Wolf, Jourdan, Pearl Rivers, and the Mississippi River via the Bonnet Carré Spillway) on water quality over oyster reefs. By integrating satellite, UAS, and ASV data, this study developed robust tools for assessing water quality dynamics and their influence on ecologically sensitive areas like the Mississippi Sound. This innovative approach offers valuable insights for managing and preserving coastal ecosystems.