Deciphering Sediment Dynamics in Evolving Aquatic Environments: Assessing the Hyperspectral Signatures

WHIRLab

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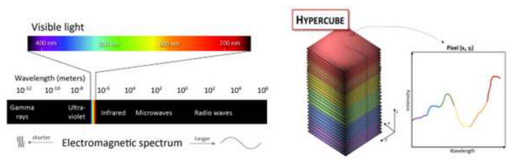
Introduction

About Hyperspectral Imaging

- Hyperspectral imaging (HSI) collects and processes information along the electromagnetic (EM) spectrum, capturing hundreds of bands of data in visible and non-visible wavelengths
- Reflected light from different objects and surface can have unique spectral signatures
- Our lab has a Hyspex Baldur V-1024 hyperspectral camera, which can capture 113 bands of visible and near infrared (VNIR, 400-1000um) data for each pixel in an image. The collected data is referred to as the hyperspectral cube (or hypercube), have X and Y spatial dimensions and a wavelength Z dimension.



Background

- Sediment transport is a key component in the evolution of river and coastal areas, but direct measurement of suspended sediment is expensive and provides data only at a point.
- There is a need for indirect measurements that can provide high spatial resolution. Hyperspectral systems could provide data, and these systems can readily be attached to aircraft or satellites. Such systems have provided insights in mineralogy, forestry, and crop health.

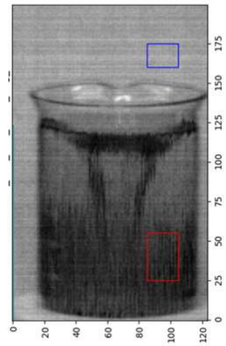
Research Hypothesis & Goals

- Working Hypothesis: Suspended sediments of different sizes and concentrations may have unique spectral signatures, and thus hyperspectral data of sediment-laden water could be used to back-calculate sediment size and concentration.

Methods and Materials

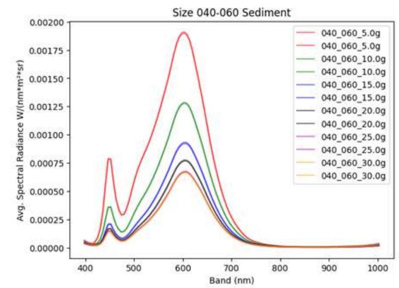
- Sand from a quarry in New Egypt, NJ was used for this experiment. The sand was washed to remove the fine particles, and sieved to separate the particles into different sizes: 75-150 um, 150-250 um, 250-425 um, and 425-850 um, corresponding to standard sieve sizes #200-#100, #100-#60, #60-#40, and #40-#20.
- The sediments were added to 500 mL of tap water in a beaker and stirred with a magnetic stirrer. Sediments were added in 5g increments up to 30g and images were captured for each increment. This was repeated for each size.
- Data was calibrated, and a subset of each image was taken near the bottom of the beaker where the sediment was suspended.
- For the subset of each image, the average and standard deviation of spectral radiance was calculated in X and Y for each band for a total of 113 average values and 113 standard deviation values per image.

Sediment and water in a beaker on the mixing apparatus. Too much mixing causes air bubbles, too little mixing provides poor suspension.

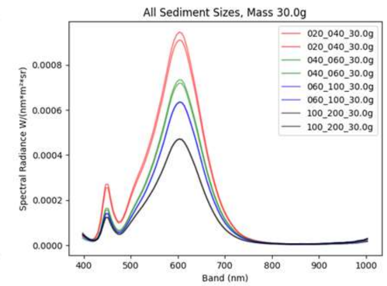


View of spectral data in python. A subset of the data is taken from the bottom of the flask. Control data is taken from the white background. For both regions, average and standard deviations are taken in the X&Y dimension for each channel.

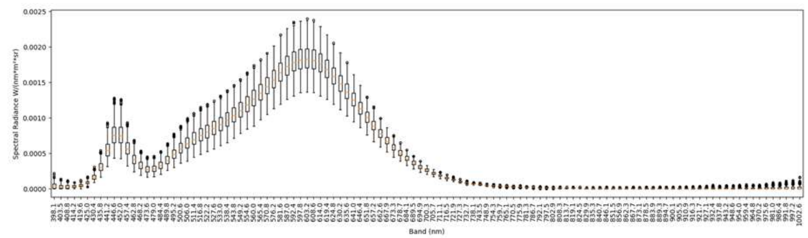
Results



Spectral curves of one size of sediment at different concentrations.



Spectral curves of different sediment sizes for the same concentration.



Example boxplots of radiance for the subset region of an image. The average data provides some information, but the standard deviation may also be significant.

- Preliminary results show that for a given size, the increased concentration shows a change in the spectral signature, and for a given concentration (g/mL), the different sizes produce different spectral signatures.
- Additional works needs to be performed to determine if the signals are unique: or can different sizes and concentrations produce similar signals?

Future Direction

- Work is ongoing to collect more data to generate a more robust dataset. Future experiments may involve combining different sizes of sediment into the flask to see if compound effects can be separated.
- There are 226 data collected for each image; more advanced statistical models will be employed as more data is collected to determine which features have the most predictive power.

Acknowledgements

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