The Challenge

As we enter an era of satellite-based hyperspectral ocean color measurements, how can we better characterize the interactions between multiple, simultaneous dimensions (e.g. spatial-spectral-temporal variability and trends)? Here, we propose a simple methodology to employ a universal, unsupervised classification system by which to summarize Remote Sensing Reflectance (Rrs) data with a quantitative and mappable output of spectral shape.

Finding Your Spectral Match

Defining a specific optical water “type” implicitly assumes that different regions can present similar optical characteristics of marine components (Aλ + Bλ), which translate into similar Rrs. The process of spectral classification is not unique (see Moore et al. 2001, Wernand et al. 2013, Mooney and Vantrepotte 2015, Wilk et al. 2018, Yan et al. 2018), but these techniques often require training data sets, and/or yield dimensionality-reduced, regionally specific results. Here, we cluster spectral data using a simple weighted average of the Rrs wavelengths, constrained by the relative intensity of each channel, outputting an Apparent Visible Wavelength (AVW), in units of nm.

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Changes in Spectral Shape Over Time and Space

A time-series of the WoCIS [AERONET-OC] platform in Gulf of Mexico shows a “greening” trend in AVW, and is corroborated by examining the green shift in the average Rrs(λ) spectrum over each year. While the trend itself may be a short-term artifact (including temporal scaling bias), the sensitivity of AVW to detect changes in spectral shape demonstrates the utility in examining and quantifying integrated Rrs(λ) trends over time and space. Without an integrated picture of Rrs(λ), it is difficult to discern these trends using a single wavelength.

Potential Applications

- Simple and intuitive identification of optical water types
- Phytoplankton functional type distinction with iterations
- Analysis of spectral variance for targeted sampling
- Potential improvements to semi-analytical inversions
- A useful climatological metric of change in color
- Correlation of similar water types on global scales
- Functional display of multi/hyperspectral data
- Implementation of decision tree approaches for algorithm development
- Quality control check of algorithm performance (erratic spectral shapes)

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Hyperspectral Data Helps

Note that different heritage satellite sensors will inherently yield different spectral “shapes” when detecting the same absorption or backscattering event. Due to the band-center location (upper-right), this precludes the analysis of multi-sensor climatology trends in spectral shape, without applying a correction (gain) factor, which would introduce further uncertainty. However, with continuously placed band centers, a simulation of spectral resolutions ranging from 1-25 nm yields nearly the same results for overall spectral shape (bottom-right).