Sayers & Schuchman

Challenges arise when attempting to validate remotely sensed products in optically complex waters with significant horizontal and vertical variability (sub-meter) in particle assemblages. In these cases, it is challenging to collect coherent in water and above water observations of the same particle fields that can be used in model calibration and validation. For example, in the case of high biomass harmful algal blooms, particles can congregate within 0.5 meters of the surface which are observed by above water radiometers but are not sampled with traditional optical property instruments (e.g. ac-s) which often begin measurement a meter or more below the surface which creates uncertainty in the measured particle fields. To attempt to understand these potential uncertainties we are conducting closure analyses using radiative transfer modeling (i.e. Hydrolight) to determine how well above water radiometry measurements agree with measured in water optical properties. In cases where measured above and modeled below water radiometry do not achieve closure, we are exercising our algorithms on both measured and modeled reflectance to determine the effect of vertical particle heterogeneity on our algorithm output products. These results also provide feedbacks into how to optimize vertical profile optical measurement binning. In these cases, we also use the modeled reflectances in our algorithm optical property retrieval evaluations as we know there will be agreement between the reflectances and measured IOPs without the contribution of varying vertical particle distributions, thus we are assessing only the errors in the inverse model.

The presence of significant vertical structure in the upper few meters, or first optical depth, of the water column in optically complex waters is likely one of the largest contributors of uncertainty and error in measurements and models. We struggle with how to vertically aggregate spectral IOPs for algorithm validation because the particle composition and biomass within the first optical depth for each wavelength can be different as some wavelengths will have “see” deeper than others and thus representing different particle assemblages.

We plan to validate our products using a robust independent in situ dataset with each parameter retaining measurement uncertainties (i.e. standard deviations). We run our models on in situ measured and modeled reflectance and compare with coincident matchups of parameters our algorithms retrieve (i.e. chlorophyll-a, IOPs, light extinction). We can use the measurement uncertainty in a Type II robust regression scheme to achieve a more reasonable estimate of model performance.

Sayers, Michael J., Karl R. Bosse, Robert A. Shuchman, Steven A. Ruberg, Gary L. Fahnenstiel, George A. Leshkevich, Dack G. Stuart, Thomas H. Johengen, Ashley M. Burtner, and Danna Palladino. "Spatial and temporal variability of inherent and apparent optical properties in western Lake Erie: Implications for water quality remote sensing." *Journal of Great Lakes Research* 45, no. 3 (2019): 490-507.

Bosse, Karl R., Michael J. Sayers, Robert A. Shuchman, Gary L. Fahnenstiel, Steven A. Ruberg, David L. Fanslow, Dack G. Stuart, Thomas H. Johengen, and Ashley M. Burtner. "Spatial-temporal variability of in situ cyanobacteria vertical structure in Western Lake Erie: implications for remote sensing observations." *Journal of Great Lakes Research* 45, no. 3 (2019): 480-489.