NIR Reflectance and its Application to Fluorescence, Chlorophyll and Algal Bloom Retrievals in Coastal Waters

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In open ocean waters, with low [Chl] and turbidity, the height of the NIR reflectance peak above the baseline, dominated by its fluorescence component, has proved effective for chlorophyll fluorescence height (FLH) retrievals. In the more complex conditions typical of coastal waters, extensive parametric studies by us, including Hydrolight simulations, and hyper spectral field measurements (Satlantic, GER, AC-S, WET Labs) as well as sampling, in the Chesapeake, Georgia and Long Island, examination of NIR reflectance as a function of CDOM absorption, chlorophyll and mineral scattering/absorption, showed that as [Chl] and mineral concentrations increase, the NIR peak can be increasingly accounted for by elastic scattering, from chlorophyll and minerals, which is modulated by the confluence of rapidly changing chlorophyll and water absorption spectra, while the contribution of chlorophyll fluorescence becomes relatively insignificant. This improved understanding of NIR reflectance features, is shown to be effective, not only for defining better the range of FLH applicability, but also for the use of MODIS and MERIS band measurements in ratio algorithms for [Chl] and algal bloom retrievals, with minimal spectral interference from CDOM and minerals components.

In particular, we used NIR reflectances for the detection of toxic dinoflagellate Karenia brevis (K. brevis) blooms which have regularly been reported in the Gulf of Mexico, particularly in the West Florida Shelf (WSF). Increasing efforts have gone into their detection, which, from space, still remains a challenge in the coastal waters due to the interferences from land and bottom reflectance. Detection algorithms that use blue-green reflectance ratios often have more uncertainties than the red or red-NIR algorithms, due to spectral interferences from colored dissolved organic matters (CDOM), which furthermore, does not correlate with chlorophyll in the coastal waters. We proposed a bloom detection algorithm which uses the difference between two selected bands in the red (identified by us as the Red Band Difference (RBD)) technique, and a K. brevis classification technique, which uses the normalized difference of the two selected red bands (and identified by us as the K. brevis bloom index (KBBI)). We applied both of these approaches to satellite measurements by the Moderate Resolution Imaging Spectroradiometer (MODIS) and the Medium Resolution Imaging Spectrometer (MERIS) ocean color sensors, which have a couple of bands in the red and NIR regions. We also make a comparison between our approaches and Fluorescence Line Height (FLH) approach applied to bloom detection. Our analysis shows that although FLH can sometimes be used to detect blooms, it breaks down in highly scattering waters, often erroneously identifying other bloom like features, such as sediment plumes, as algal blooms, while our approaches generally correctly distinguish bloomed areas (give positive values) from non-bloom areas (give negative values) even in the highly scattering waters. Further analysis of the impact of CDOM on RBD and KBBI also shows that these techniques are less sensitive to CDOM. Applications of the proposed approaches to satellite measurements are considered successful, since we were generally able to detect, trace and classify different K. brevis blooms documented in the literature with only minor ambiguities.