Monitoring harmful algal blooms off California using SGLI

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HABs in the California Current Ecosystem (CCE) are common and caused by **specific species**, e.g. diatom *Pseudo-nitzschia* spp. (with neurotoxin domoic acid), dinoflagellates *Alexandrium* spp. (with saxitoxin causing Paralytic Shellfish Poisoning), *Dinophysis* (Diarrhetic Shellfish Poisoning), *Akashiwo sanguinea, Lingulodinium polyedra* (*L. polyedra*).

Our ability to monitor these HABs using satellite Ocean Color is very **LIMITED!** Satellite CHLA product is **not** a good measure of a HAB!

PROBLEMS:

- High CHL events (up to 500 mg m^{-3}) are too close to the coast and they are outside the range of standard CHLA algorithms.

- Current algorithms for the detection of **phytoplankton functional types** (PFTs), **phytoplankton size classes** (PSCs) and taxonomic composition are **not able to provide sufficient accuracy for the task of monitoring HABs**.

OPPORTUNITIES:

- High concentration *L. polyedra* blooms can be detected by using their **high absorption of UV light** (Fig. 1) by Mycosporine-like Amino Acids (MAAs).
- **Rrs380/Rrs443 < 1 may be considered an indicator of a *L. polyedra* bloom** with high concentration of MAAs, whereas Rrs380/Rrs443 > 1 with high Chl-a is likely an indicator of a bloom dominated by diatoms. Based on *in situ* data Kahru and Mitchell (1998) showed that the reduced Rrs380/Rrs443 ratio was able to distinguish a dinoflagellate-dominated bloom at Chl-a greater than ~1-2 mg m^{-3} (Fig. 2). Using the reduced UV reflectance in red tides was proposed for GLI.

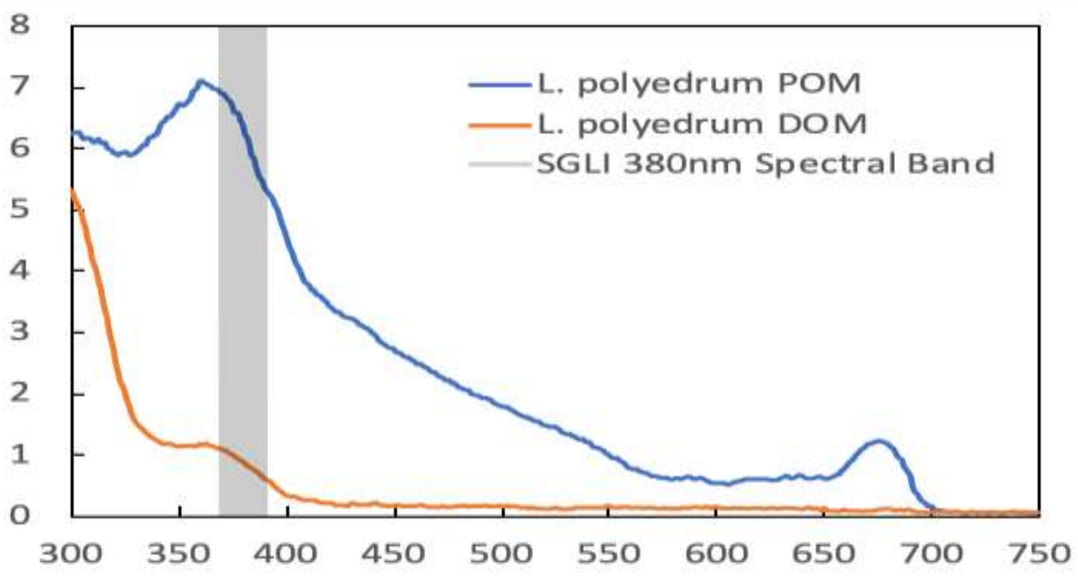
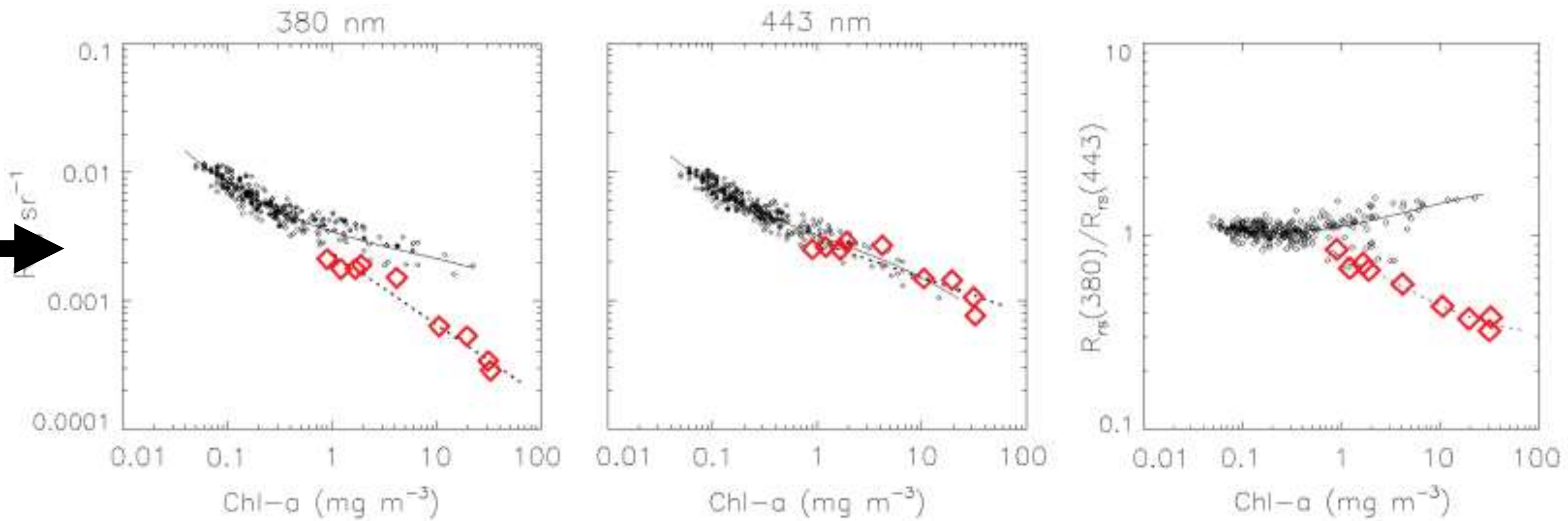


Fig. 1. **Absorption spectra from a culture of *L. polyedra:*** particulate fraction (POM; blue line), dissolved fraction (DOM; orange line) from Vernet and Whitehead (1996). The gray band shows the approximate location of the SGLI 380 nm spectral band.

Fig. 2. **Rrs at 380 and 443 nm and their ratio as functions of Chl-a** *in situ* from a bloom of *L. polyedra* (large diamonds) and from typical phytoplankton assemblages.



OPPORTUNITIES:

- Kahru et al. (2021) used the Rrs380/Rrs443 < 1 algorithm applied to SGLI data to monitor the spatial and temporal distribution of a massive *L. polyedra* bloom in CCE in 2020 (Fig. 3-4). SGLI has the 380 nm band.

- However, uncertainty of the Rrs (LWN) products, particularly of the 380, 412 and 443 nm bands is limiting the reliability of the algorithm.

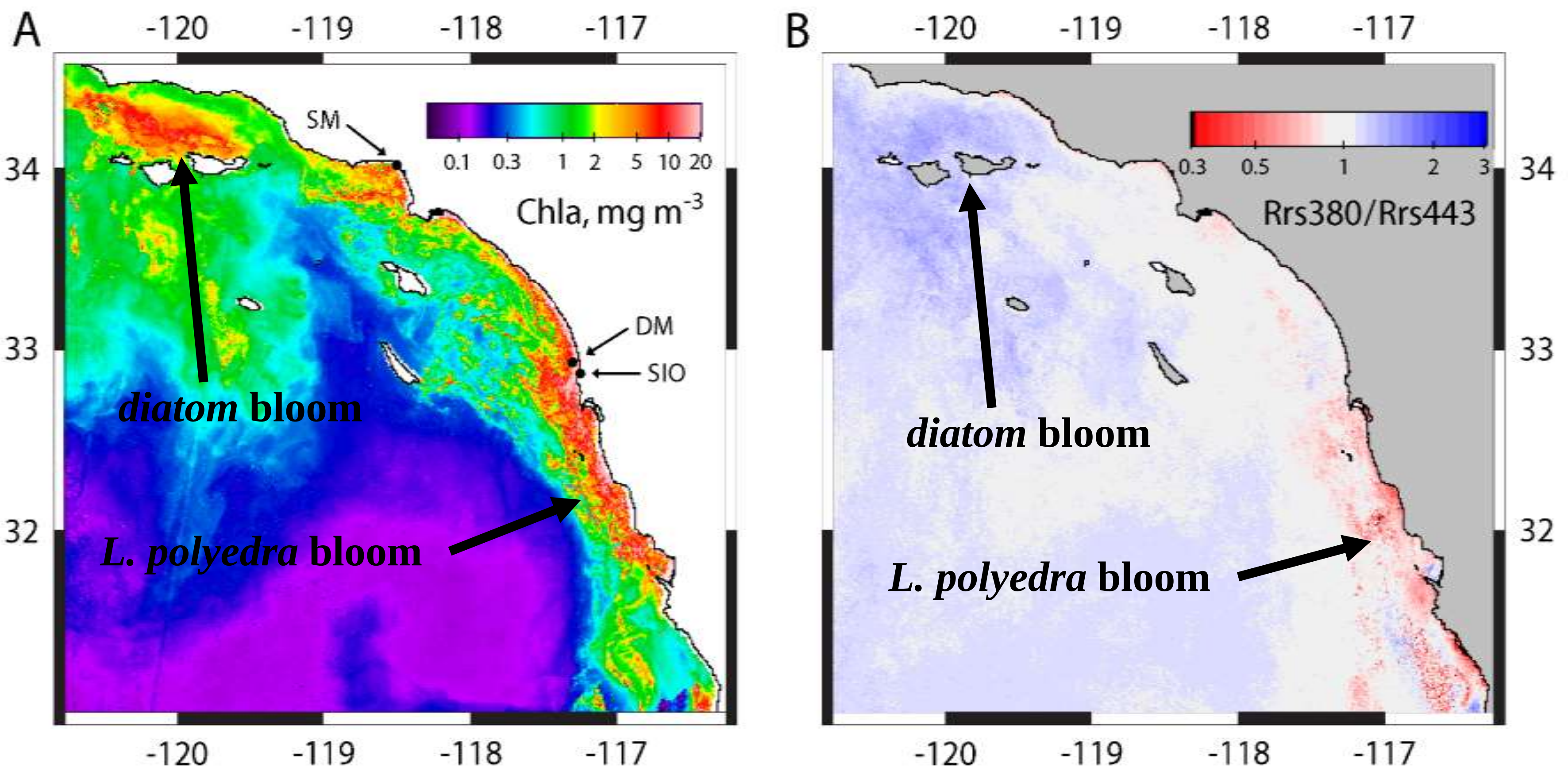


Fig. 3. Chl-a and Rrs380/Rrs443 from SGLI data during a *L. polyedra* bloom.

(A) Chl a and (B) Rrs380/Rrs443 off Southern California during April 7 –May 20. Both panels were created using SGLI 250 m version 2.0 data.

PROBLEMS:

- Uncertainty of the Rrs (LWN) products, particularly of the 380, 412 and 443 nm bands is limiting the reliability of the algorithm.
- No validation of Rrs380 but comparison of the SGLI Rrs412 with other sensors, e.g. MODISA (Fig. 5) shows high uncertainty that is probably even higher for Rrs380.
- Analysis of VIIRS data (Fig. 6) by Mélin (2021) confirms that uncertainty increases drastically at shorter wavelengths.

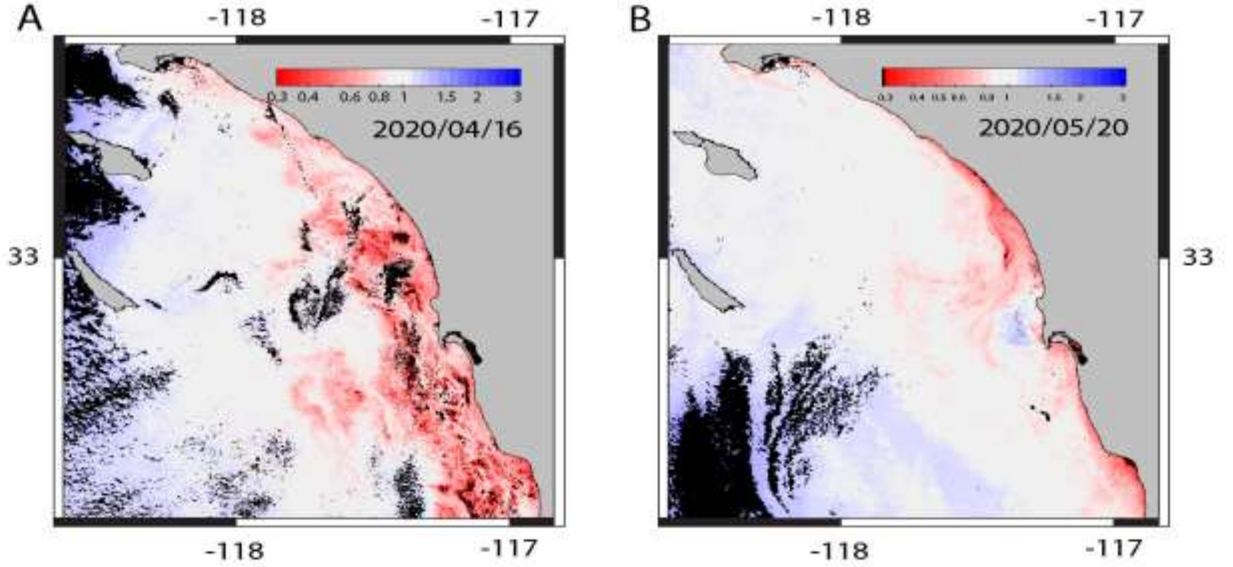


Fig. 4. Examples of Rrs380/Rrs443 ratio images on April 16 (A) and May 20 (B). Black areas are clouds.

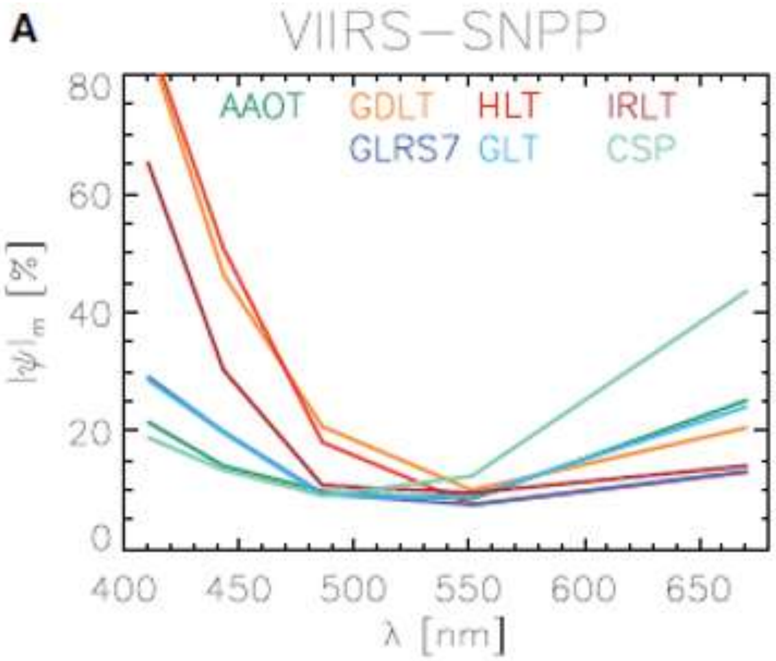


Fig. 6. Spectra of median absolute relative difference |ψ|m, % between AERONET-OC and VIIRS-SNPP data from *Mélin F* (2021).

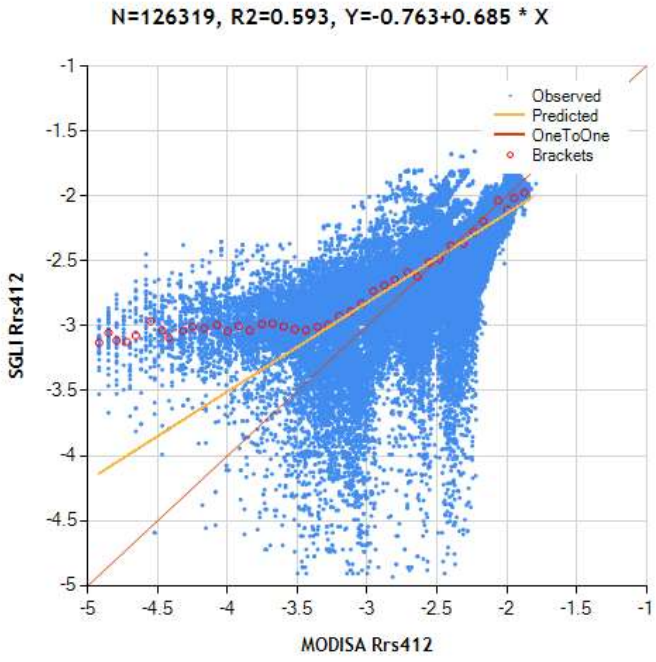
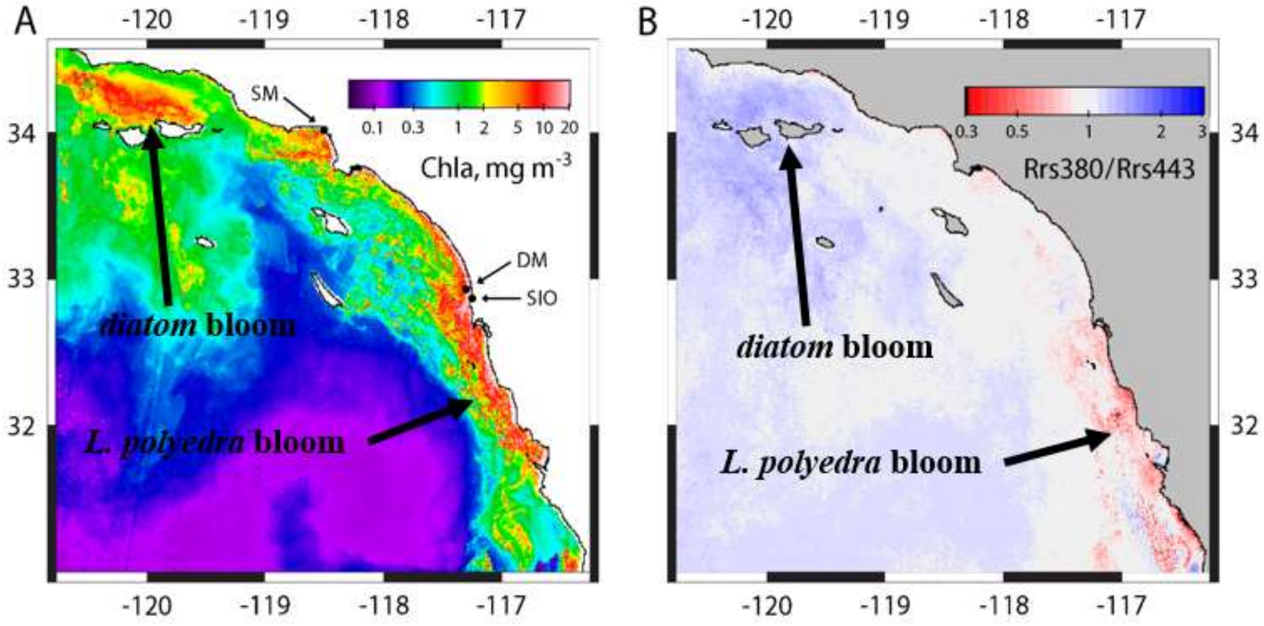


Fig. 5. SGLI Rrs412 versus MODISA Rrs412 for 1 month (April 2021).

Conclusions

- The reduced ratio of Rrs380/Rrs443 measured by SGLI coincided qualitatively well with *in situ* observations of a historic dinoflagellate *L. polyedra* bloom.
- More work is needed to improve the accuracy of the Rrs values, particularly of the 380 nm band.
- Algorithm development using UV bands is promising, particularly as the NASA PACE sensor with have spectral range from 340 nm and higher spectral resolution.
- More detailed ***in situ*** observations in the UV together with MAAs and other optically important constituents are needed to allow more advanced algorithm development, e.g. for remote discrimination of different phytoplankton taxa.



References

Kahru M, Mitchell BG (1998) Spectral reflectance and absorption of a massive red tide off southern California. J Geophys Res 103(C10): 21601–21609.

Kahru M et al (2021) Satellite detection of dinoflagellate blooms off California by UV reflectance ratios. Elementa: Science of the Anthropocene 9(1). DOI: https://doi.org/10.1525/elementa.2020.00157.