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ASAMPLE

Analysis of submeso- and mesoscale dynamics of phytoplankton blooms in coastal waters influenced by river plumes

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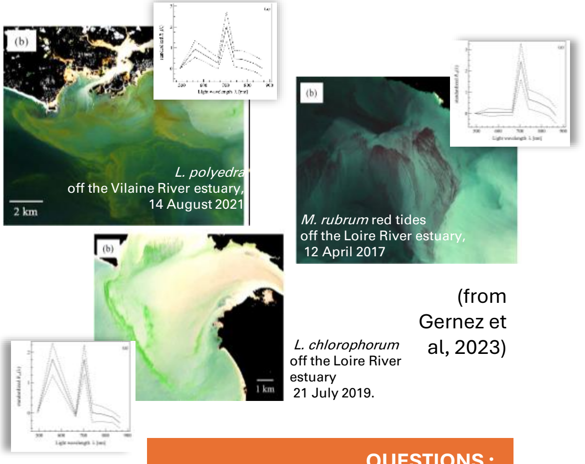
Phytoplankton blooms: why to study?

- *Phytoplankton is the base of marine food chain*
- *It plays a special role in the Earth carbon system: fixes CO_2 and produces oxygen*
- *Especially important for the coastal ecosystems, but also brought into open ocean*
- *Can be toxic and create hypoxia areas*

Recent advancements in optical imagery algorithms allow the **optical bloom type** detection with *high-resolution* satellite data (as different plankton species have different pigments, thus, spectral signatures).

Some blooms, identified as "harmful algal bloom" (toxic for the environment) are also called "*red tide*". They can last from hours or months and might be difficult to predict.

Depending on the plankton species, the impact on environment will be different: toxins absorbed by mollusks, anoxia for fish and marine mammals, - they disturb coastal fishing, tourism and aquatic activities, and often need special management.



(from Gernez et al, 2023)

PROJECT GOALS

- observe plancton blooms at high resolution (satellite & in situ)
- describe the environmental conditions of blooms (water mass state & dynamics)
- adapt/propose algorithms for satellite data to distinguish a particular *optical bloom type* (a proxy for plankton species)
- find the descriptors to predict some phytoplankton blooms with satellite data

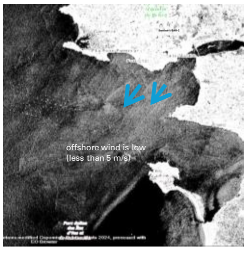
QUESTIONS :

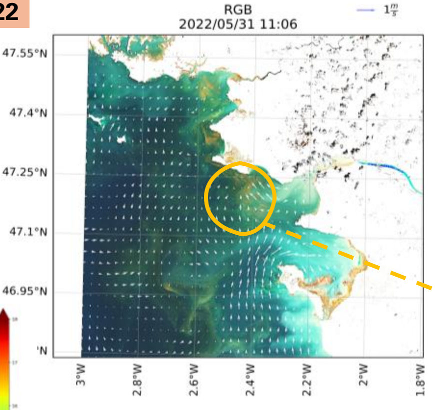
- What is seasonal and interannual variability of phytoplankton blooms in estuary area? Can we define the optical type of bloom ("species")?
- What are the environmental conditions: temperature, optical properties, tidal dynamics?
- Can we relate the small-scale dynamics to the phytoplankton bloom predictions?

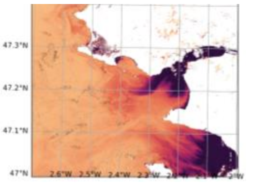
DATA

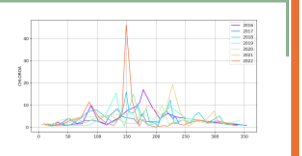
Satellite:
(passive) Optical, NIR, IR : Sentinel-2 (20 m), Sentinel-3 (300 m), Landsat 8&9 >> chl-a, SPM (suspended particulate matter) +SST
(active) SAR+ : Sentinel-1, SWOT (winds, surface water dynamics)
In Situ: ILICO (Infrastructure de recherche Littorale et Côtière)/REPHY data: phytoplankton, temperature, salinity
Auxiliary: Bathymetry (SHOM), currents (CMEMS Marine Copernicus), ROMAR (3D fields with physical conditions

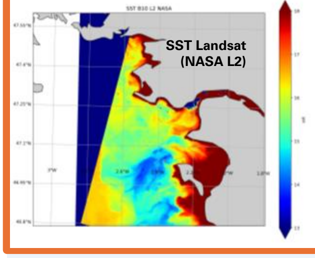
Case study: May 31, 2022

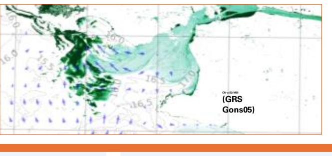










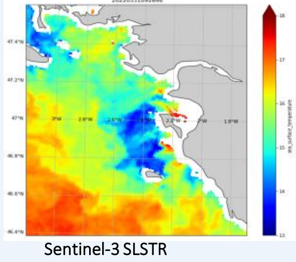


Possible explanation:

The ***Lingulodinium p.*** **bloom** area* is situated between the Loire waters (**warm, rich in SPM**) and rising tide (**colder and clearer Atlantic waters**). *Bloom has started about a week before.

Bloom is observed within resulting vertical stratification & convergence of 2 flows (Loire and Atlantic) - local vertical stirring at the shallow banc (7-15 m)

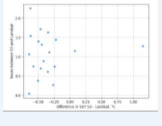
Overall, these are good conditions for the plancton development: clear waters for photosynthesis + initial stratification where plancton is situated within thermocline.

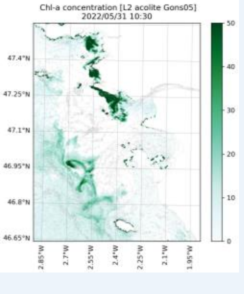


Sentinel-3 SLSTR
[L2 ESA WST,
3.74, 10.85 and 12 µm]
1000 m

Sea surface temperature
[S3 SST – LS SST] small study
(19 cases with time difference [0 – 2 hours])
Good agreement offshore, but statistically **Landsat ST > S3 SST (+0.5°C)**

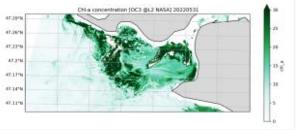
(!) No coastal S3 SST data, problems within river plume area





- same chl-a algorithm for S2& S3 (derived from *Gons, 2005* using 779, 705, 665 nm bands), but with different atmospheric corrections. S3 overestimate the bloom due to its spatial resolution
- Landsat lacks 705 & 779 bands, thus, OC3 algorithm is used (less precise, crucial for optical types retrieval)

(!) TRISHNA data will allow similar to L8&9 measurements and help to get longer time-series of chl-a, SPM & SST simultaneous data



References:
Gons, Herman J., Machteld Rijkeboer, and Kevin G. Ruddick. "Effect of a waveband shift on chlorophyll retrieval from MERIS imagery of inland and coastal waters." *Journal of Plankton research* 27.1 (2005): 125-127.
Gernez, Pierre, David Doxaran, and Laurent Barillé. "Shellfish aquaculture from space: potential of Sentinel2 to monitor tide-driven changes in turbidity, chlorophyll concentration and oyster physiological response at the scale of an oyster farm." *Frontiers in Marine Science* 4 (2017): 137.
Gernez, Pierre, et al. "The many shades of red tides: Sentinel-2 optical types of highly-concentrated harmful algal blooms." *Remote Sensing of Environment* 287 (2023): 113486.

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