Forecasting Marine Environmental States Including Algal Blooms

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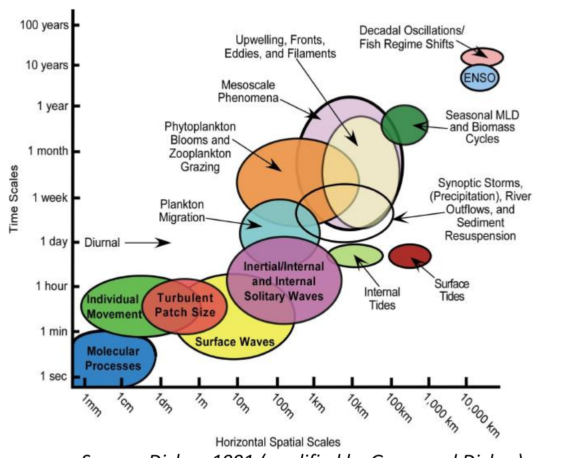
1. Introduction

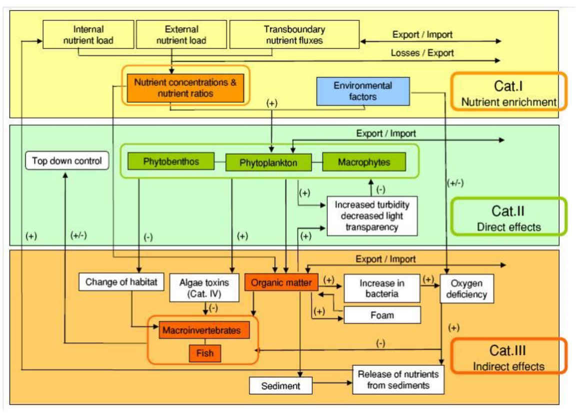
Coastal ecosystems are evolving with the increase of anthropogenic activities. **H**armful **A**lgal **B**looms have intensified over the last decades causing detrimental environmnetal and economical effects.
Causes of HABs and eutrophication: Excess Nutrients (N & P) from agricultural run off & sewage

Effects of Harmful Algal Blooms:
- Release Toxins in water
- Reduce Biodiversity, and ecosystem services
- Recreational activities

The dynamics of algal blooms involves spatial and temporal scales, and complex pelagic and benthic compartements.



Source: Dickey, 1991 (modified by Grace and Dickey)



Source: Claussen U. (stagesproject.eu)

Algal blooms are caused mainly by *Phyaeocytis globosa* and *pseudonitzschia spp.* in the eastern English Channel, and other diatom species in the Sea of Iroise.

Monitoring the marine ecosystem is necessary to mitigate the effects of HABs. Historically, monitoring was performed using Niskin bottles and field sampling. With the advancement of sensor technology several high frequency measurements were performed throught the implementation of buoys (plateforms) in the coastal ecosystems. Besides, satellite and modeling data became available sources that aid in understanding and revealing the complexity of the marine ecosystem.

2. Research Objectives

- ✓Identify **normal, recurring events and associated environmental statuses.**

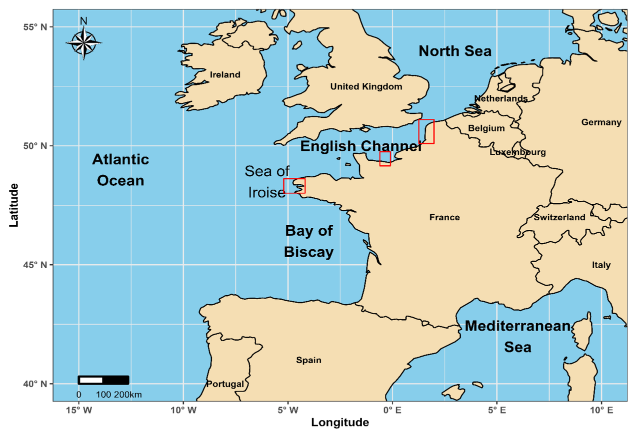
Based on the acquired knowledge about the dynamics of environmental statuses, we will then develop.

- ✓A warning system of **harmful or potentially toxic algal blooms**
- ✓An expert decision-making system to improve environmental evaluations, and thus contribute to a better definition of monitoring and measurement programs in support of the needs of Marine Directives and Regional Seas Conventions

3. Method

Study Area

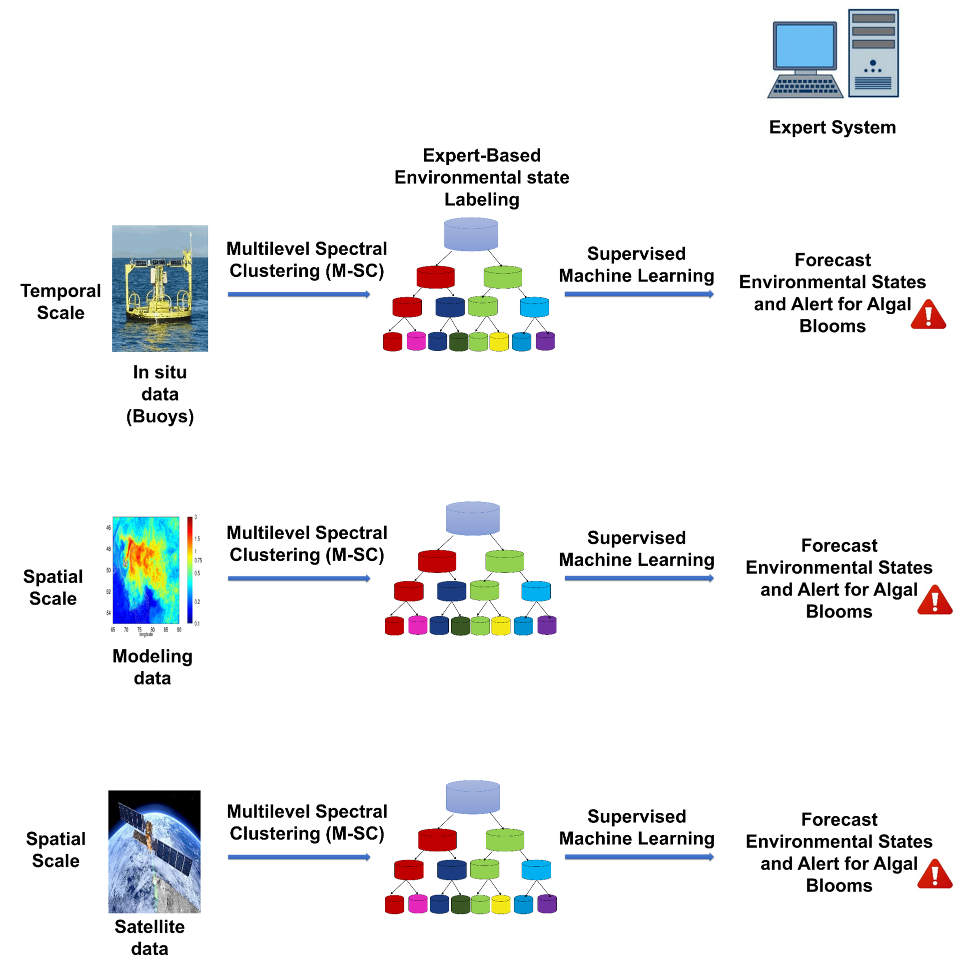
1- Eastern English Channel
2- Central English Channel
3- Sea of Iroise (Atlantic)



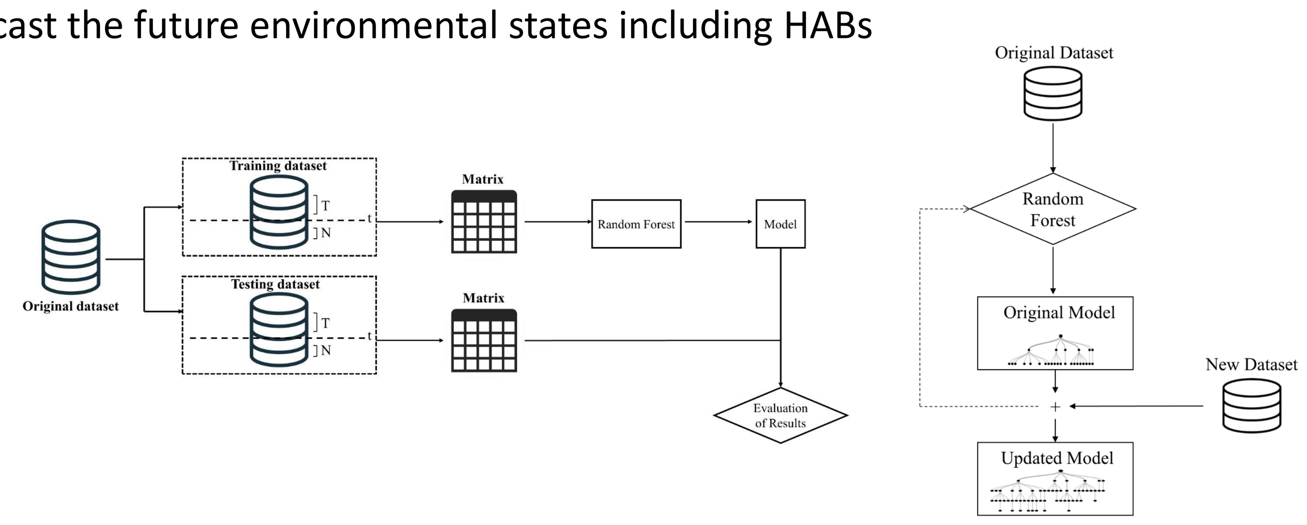
Methods

1- Data Collection: 3 main types of data were collected from Coriolis and Copernicus databases: In-situ, Satellite, and Modeling The insitu data includes MAREL Carnot, MAREL IROISE and SMILE. (IR-ILICO)

2- Data pre-processing was carried out for in-situ data only, and includes: Offset correction, NA transformation, sensor and expert range correction, time alignment. Following that, data completion was performed as follows: isolated holes were completed by local average. Small-size holes corresponding to 1 day were completed using weighted moving average, and large-size hall corresponding to 7 days were completed using **D**ynamic **T**ime **W**arping **B**ased **I**mputation (DTWBI) (Phan et al., 2017) . Our data imputation approach is



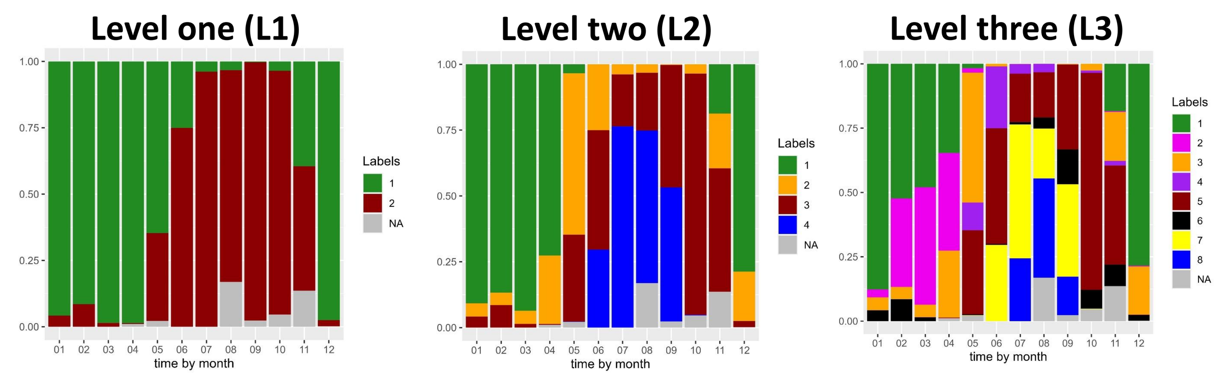
3- Then, Multilevel Spectral Clustering (M-SC) was applied (Grassi et al., 2019; 2020)
4- Each of the clusters obtained were labeled based on our expertise of each region
5- After labeling, Random Forest, a supervised algorithm, was applied in order to forecast the future environmental states including HABs

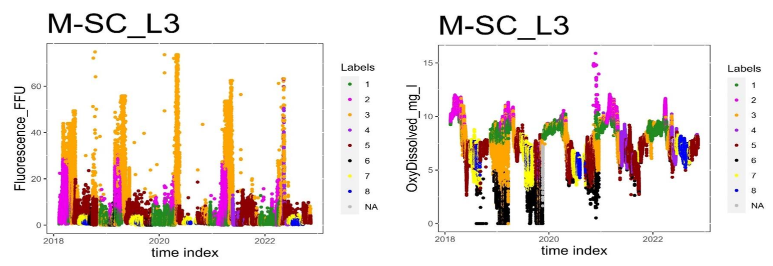


4. Results and Discussion

In-situ data (Temporal scale)

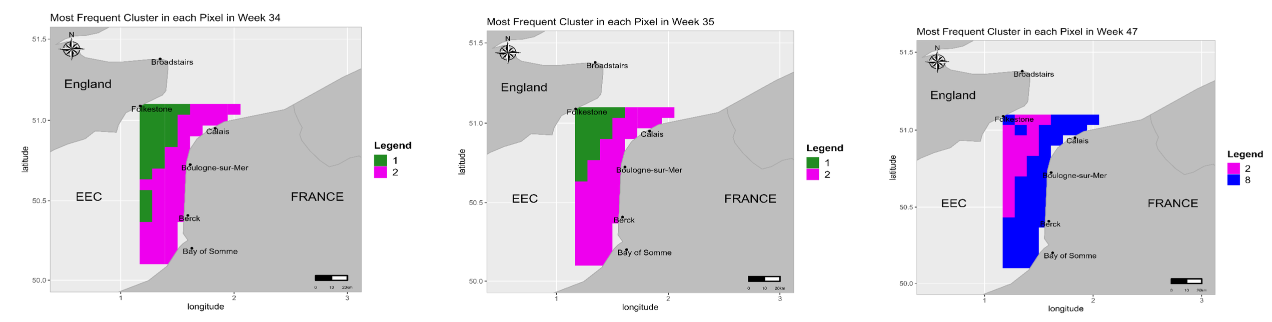
Our results show two, four, and eight clusters at level one (L1), two (L2) and three (L3) respectively. At level one, the two clusters correspond to productive and non productive periods. At level two, the four clusters correspond to bloom, pre-bloom and post bloom periods. It is imperative to highlight that the first two levels of clustering are not sufficient enough to clearly differentiate between environmental states. Thus, a third level of clustering is needed to differentiate between environmental states.
Here, cluster 3 at level 3 corresponds to algal blooms. It is characterized by high levels of fluorescence as well as low levels of dissolved oxygen.

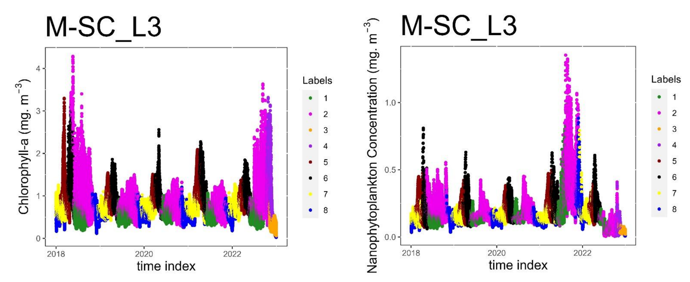


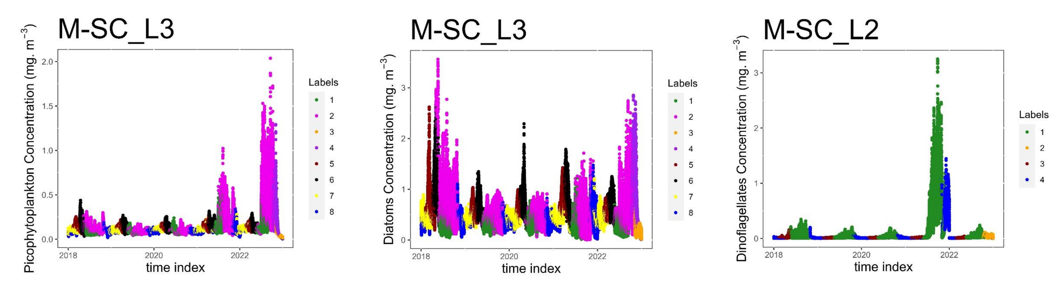


Modeling Data (Spatial or Spatiotemporal Data)

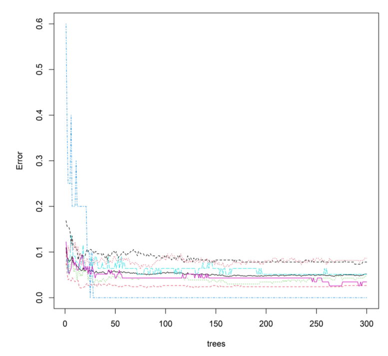
The modeling data allowed to reveal how environmental states change at the spatial scale. They also allowed to determine algal blooms. Here, cluster 2 corresponds to algal bloom events, and it can be seen how bloom events expand during week 34 and 35, and then diminish to be replaced with a postbloom event (cluster 8)







Following that, Random Forest was applied and we were able to Forecast future environmental states up to 10 days. .



5. Conclusion and Perspective

In conclusion, Multilevel spectral clustering (MSC) can be used to: define, detect, identify and characterize the environmental states. The developed forecasting system was capabale of forecasting harmful algal bloom events in the eastern and central English Channel as well as Sea of Iroise. In the future, this forecasting system shall be tested on other regions.

References

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Sharing is encouraged

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