Inter-annual variability of *Emiliana Huxleyi* blooms depending on environmental parameters.

Gohin F.[1], Lampert L.[2, 3], Noblet L.[4], Le Bras E.[5]

[1] Coastal Ecosystem Dynamics Department, IFREMER BREST

[2] Military Oceanography Center, EPSHOM, Brest, France

[3] European University Institute of the Sea, Laboratory of Marine Environmental Sciences, Plouzané, France

[4] Director IP & Licensing & Hypermedia Research Labs at b<>com

[5] Biologist & scientific coordinator at Iodysséus

Introduction

Iodysséus is an NGO created in 2016, focused on ocean preservation. The first concrete action developed by Iodysséus are:

-A sailing oceanography program offering innovative solutions

-An awareness-raising program for future generations

-An ocean data mining program to increase understanding of certain oceanic phenomena

One of our missions is to study episodic blooms of the calcareous microalgae called *Emiliana huxleyi* (or Ehux), the majority species of coccolithophores in the North Atlantic.

Blooms of Ehux develop over a short period of time (from 6 to 9 weeks) and in a relatively small region of the ocean that is difficult to predict precisely. These blooms are of great importance because of their role in carbon absorption and oxygen production. Iodysséus has developed skills in digital data processing in order to better understand the periodicity of these biological phenomena and check this with field observations at sea.

The cooperation between society and governmental institutes dedicated to ocean observing, data access and modeling is crucial and it should lead to a better integrated ocean observing. This is the reason why Iodysséus is acting collectively in a participatory way for such data analysis. This ongoing initiative can be expanded at a global level, in order to meet societal, policy, and economic needs. Supported by two researchers from IFREMER and a team of voluntary data scientists spread around the globe, we have developed computer programs to process historical satellite images from a statistic perspective.

Coccolithophores are a type of nano-phytoplankton. They don't have a high chlorophyll content (rarely more than 2 microgram/L). They have been present on Earth for over 200 million years

and are at the origin of sedimentary layers in chalky soils, such as the cliffs of Etretat (hence the name of the geological period “the Cretaceous”).

Methods

Based on historical data from the Sextant IFREMER database, we have been investigating correlations between coccolithophores blooms and environmental parameters.

The blooms of Ehux are visible from satellites because these unicellular algae have an outer skeleton made up of limestone facets that reflect sunlight. The parameter of Ehux presence/absence is Suspended Particulate Matter (SPM). Environmental parameters are solar irradiance (SSI), sea surface temperature (SST) and the concentration of Chlorophyll-a (CHL-A). This last parameter is processed in order to look for presence indication of other species of phytoplankton (mostly diatoms).

We extract key parameters (features) from satellite data over 5 regions of interest, generating time series over 23 years (1998-2020). These 5 areas spread from the South of the Bay of Biscay (north of Spain) to the Celtic Sea (South and West of Ireland), along the continental shelf. These zones are of particular interest because of upwelling phenomena bringing nutrients to the upper layer. This phenomena, combined with ideal temperature condition, foster the emergence of blooms every other spring.

Zone 1 : Bay of Biscay West

Zone 2 : Bay of Biscay South

Zone 3 : Bay of Biscay North

Zone 4 : Celtic Sea

Zone 5 : Atlantic Ocean

These parameters were extracted using R scripts and QGIS masks and statistical analysis are performed through Python scripts.

Dataviz: Seaborn, ElasticSearch / Kibana, R / Python graphics libs. Acceleration: Google Cloud

We then draw up inter-annual comparison and look for conditions under which blooms develop. We try to answer that question «can we relate the inter-annual variability to climatic variations ?». We seek to have a holistic approach to ocean big data processing, looking for links between ocean physic and planktonic blooms, with the ultimate goal to model the intensity of blooms based on historical data.

Results

34000 images have been handled (resolution 1667x2401) with data extracted per zone, per day, per parameter (CHL-A, SMT, SSI, SST). In total, 20 time series have been generated for statistical analysis, search for correlations, cause and effect relationships, etc. The following analysis have been done on the period 1998-2020.

1- Can we say that there are less abundant coccolithophore blooms? We can observe a negative trend in abundance for all zones except for Zone 1 (south-east of the bay of Biscay), maybe because of the exceptional abundant bloom in springs 2013 and 2019.

Because 4 zones out of 5 are showing a negative trend in abundance, we can suppose that the coccolithophore blooms are getting fewer and fewer.

2- Is there a geographical drift of blooms over the time ? The coarse grain analysis over one year shows a chronological order in time period that seems logical : each year from the South to the North. This northward drift is due to the sea surface warming up from the south to the north every spring. It is not clear if blooms are tending to move northward and we can't draw conclusion on a potential climate change, because the analyzed period is too short (period 1998 to 2020).

3- Are blooms earlier every spring (inter-annual comparison, drift in the time)? It seems that there is a trend for peaks to happen earlier, no obvious change about amplitude, to be further investigated.

4- How are environmental parameters impacting the bloom ? This question still need to be more investigated with data over a longer period of time. On the 1998-2020 period, a linear relationship is observed between the SPM and CHL-A parameters. These two parameters are directly correlated and this could be understood as a co-development of coccolithophores together with diatoms' populations.

Conclusion

The analysis is still progressing, we plan to improve it with more parameters, for example the pH in order to see the impact of acidification on these calcareous microorganisms. We need to focus on investigating which parameter has the biggest impact, if any, over coccolithophore blooms and the reasons why the Ehux bloom doesn't happen, as it was the case in 2014 and 2020. Until now, we were able to achieve a very precise predictive model from a temporal perspective, and we still need to make progress with regard to intensity of predicted blooms.

The next steps are:

*Checking at sea the validity of the temporal prediction in May 2021.

*Improving the intensity prediction through the combined use of other data (pH, etc.).

*Developing a version for prediction over smaller areas.

*Trying to implement this model for other places in the world (for example the Great Calcite Bell).

These ongoing analysis shows that progress can be made in modelling key aspects of oceanic cycles, and to extend this collective work to other regions in the world in order to achieve predictive models at a global oceanic scale.

We are also working towards cross-checking with field reality. We will then ensure we are on the right path developing an efficient and reliable model for coccolithophores blooms.