Biogeosciences Discuss., referee comment RC2 https://doi.org/10.5194/bg-2022-86-RC2, 2022

Comment on bg-2022-86

Anonymous Referee #2

Referee comment on "Interannual variability of the initiation of the phytoplankton growing period in two French coastal ecosystems" by Coline Poppeschi et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-86-RC2, 2022

Main manuscript modifications are highlighted in red.

Main findings of the study

In this manuscript, the authors describe the interannual variability of the phytoplankton blooms contrasting two coastal eutrophic French bays. By using a combination of high-frequency in situ information (buoys) and simulation model (IDV) they attempted to identify main environmental drivers (climatic – hydrological) that modulate variations in observed and estimated parameters of the phytoplankton growth given some explanations of the role of water temperature and turbidity variables. Here a main time delay in triggering phytoplankton blooms was detected during the 2010-2020 period. The authors also pointed out the strong influence of "extreme events" such as cold spells and floods over phytoplankton blooms during winter.

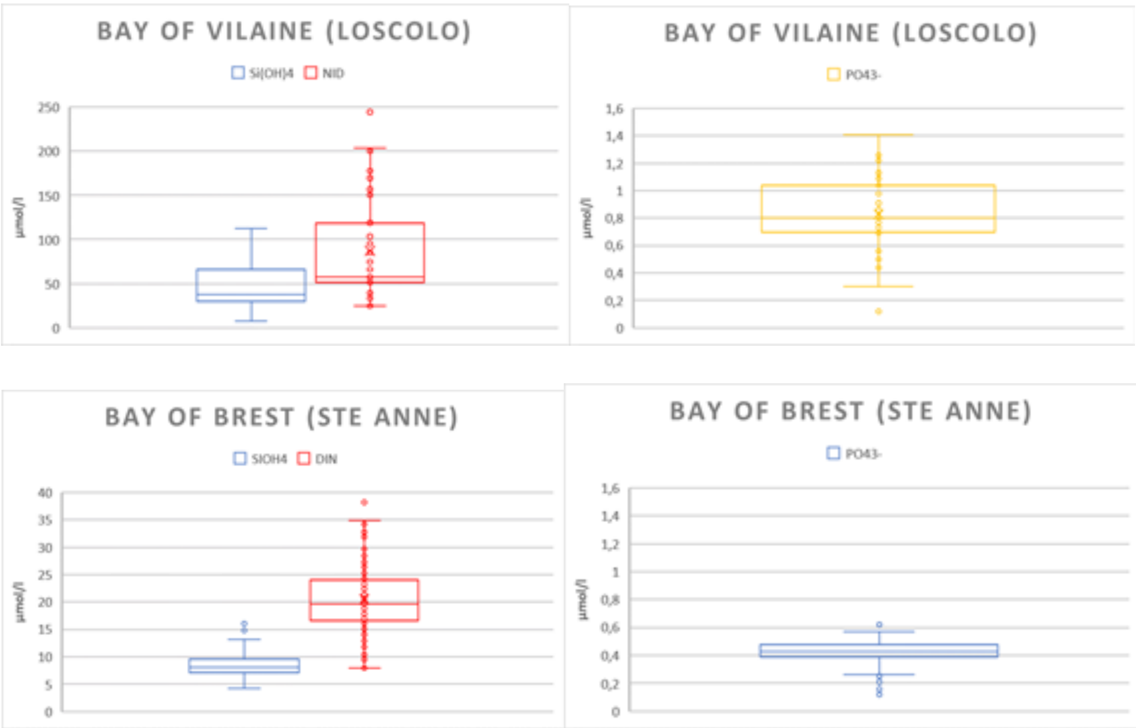
Thank you for this comprehensive summary of our study. We appreciate your constructive comments taken into account below in our answers.

Although the authors do some interesting observational/modeling approaches with the data available, the manuscript is mostly presented as a description of the data, thus, their interpretations remain mostly speculative. I strongly suggest using additional information such as inorganic nutrients since both bays are defined as eutrophic systems.

We know that some studies have shown the importance of nutrients in the development of phytoplankton blooms (Labry et al., 2001; Del Amo and Brzezinski, 1999). However, our two temperate coastal bays differ in that they are not nutrient limited and this is the case for inorganic nutrients. We have represented the nutrient concentrations in Figure 1. In the Bay of Vilaine and in the Bay of Brest the nutrient concentrations remain high until late March. When Labry et al. (2001) observed phosphate concentrations close to the limit of detection of the analytical method (< 0.05 µmol/l) in February, the median phosphate concentration is equal to 0.83 µmol/L in the bay of Vilaine and to 0.43 µmol/L in the Bay of Brest (Figure 1). The median silicate concentration (Figure 1, respectively 38.1 and 8.1 µmol/L in the Bay of Vilaine and the Bay of Brest) is highly above the half-saturation constant required for their assimilation by diatoms (Ks = 2 µmol/L, Del Amo and Brzezinski 1999).

(a)

(b)



<u>Figure 1: Box-plot representation of nutrient concentrations (DIN, PO43- and Si(OH)4) between January and March (day 0 to day 69) measured (a) at the REPHY West Loscolo station (bay of Vilaine) during the period 2011 -2019, (b) at the SOMLIT Ste Anne station (bay of Brest) during the period 2001-2019</u>

Del Amo Y., Brzezinski M.A. (1999) The chemical form of dissolved Si taken up by marine diatoms, Journal of Phycology, 35, 1162-1170.

Labry Claire, Herbland Alain, Delmas Daniel, Laborde P, Lazure Pascal, Froidefond J, Jegou Anne-Marie, Sautour B (2001). Initiation of winter phytoplankton blooms within the Gironde plume waters in the Bay of Biscay. Marine Ecology Progress Series, 212, 117-130.

We agree that this information of non-limitation in nutrients was not clearly enough presented in the manuscript. We therefore decided to present it more clearly by adding:

Table 4: addition of nutrient concentrations

Abstract - “coastal temperate ecosystems under the influence of rivers highly rich in nutrients”

Introduction - “The river influence induces waters highly rich in nutrients.”

Results part 4.1 - “However, at the beginning of the phytoplankton growing period (IPGP), the system is not nutrient limited in terms of nitrate, phosphorus and silicates.”

The main objective is not clearly defined, it should be written as a major one;

We have therefore restated the objectives more clearly in the manuscript as follows:

In this study, we aim to better understand interannual local changes in the IPGP in coastal temperate ecosystems in the current context of global climate change over the last 20 years. We first detect and analyze the temporal variability of the IPGP and we then quantify how environmental forcings influence its dynamics. To detect and analyze IPGP in coastal environments, we develop a method, combining high-frequency decadal in situ observations and modeling, based on a 1DV hydro-sedimentary and biogeochemical coupled numerical model. The potential impact of hydro-meteorological extreme events, such as cold waves, flood events and wind bursts, on the IPGP is then investigated.

there are statements very descriptive at the Results section with too many figures, hard to understand showing different years, etc.

We agree and we have lightened the result part by rephrasing sentences for a more fluent reading. We also rewrite some paragraphs like in the 3.3.1, 3.3.2 and 4.3 sections of the manuscript in order to make it more fluid. To illustrate our results, we decided to keep existing figures.

In addition, I strongly recommend that the authors should make a major effort to write a general hypothesis or conceptual model for a future version.

In the introduction and in the results, our general view of the studied system and controlling factors has been rephrased and more explicitly stated.

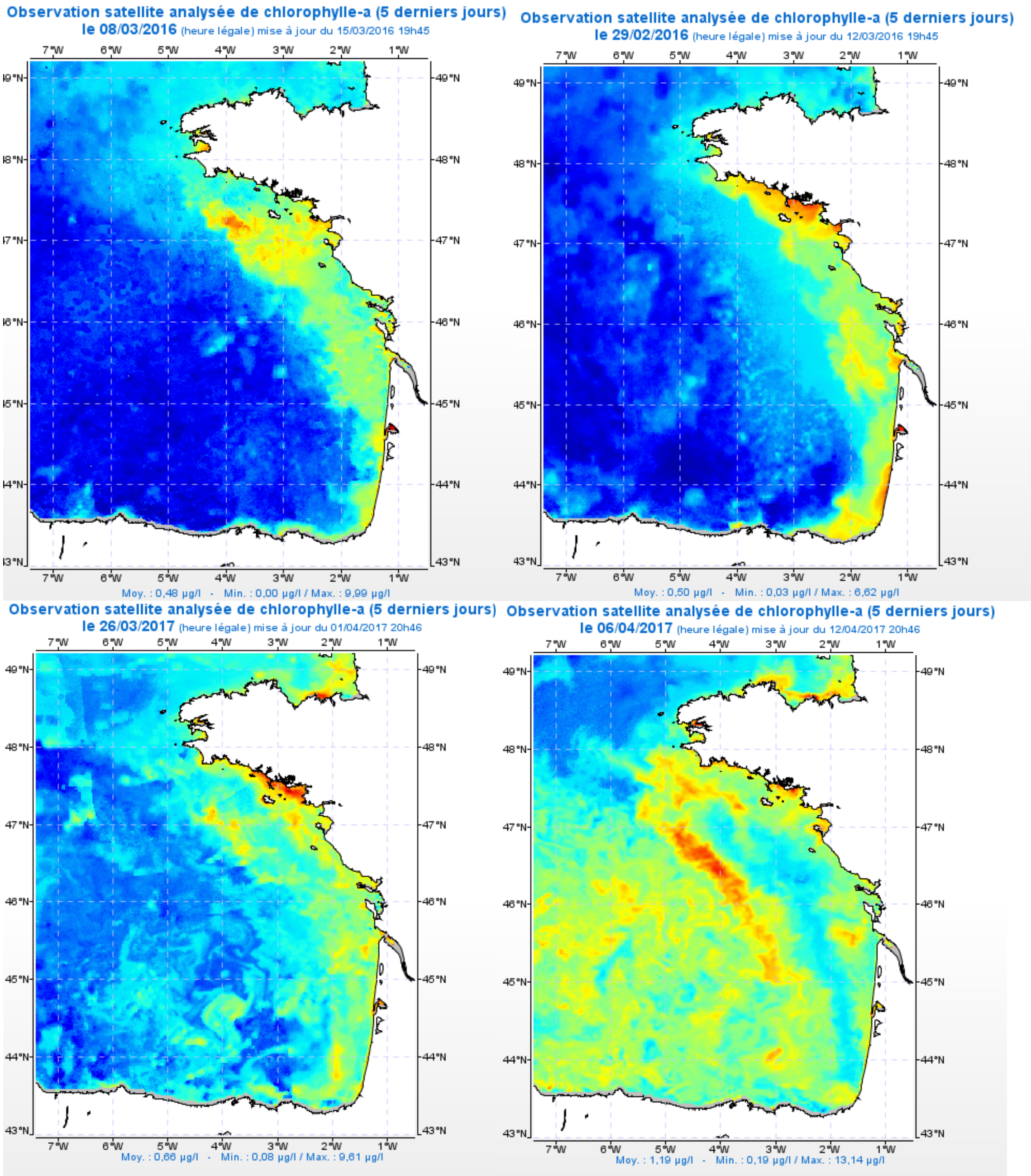
Especific comments:

1.- The first limitation that comes to mind is the low sampling effort carried out in Bay of Vilaine for the chlorophyll-a (as fluorescence) variable, with only the second period survey completed. Would be possible to fill the gap of the first period with satellite images? In Bay of Brest appears to be an increase trend during the second period and probably both bays may be affected by similar drivers.

We agree that this would be interesting but the temporal sampling of the satellite is not high and values are not necessarily comparable (i.e. larger errors in satellite observations than in in situ observations) or available (Figure below). Here, we use *in situ* data from buoy measurements, so we cannot extend our series using satellite observations. Indeed, we also thought of investigating the effect of larger scale forcings (as climate indices - as the North Atlantic Oscillation - NAO) related to the similarities between the two bays but it appeared that local forcings are controlling the dynamics of the IPGP.

Example of available satellite observations at IPGP dates identified in HF *in situ* observations
(warning: illustrations are L4 sea surface temperature build from different satellites - Saulquin et Gohin, 2010)
(not shown but satellite observations are not available for every IPGP)

VILAINE BREST



Gohin Francis (2021). Long-Term Surveillance and Monitoring of Natural Events in Coastal Waters. In Remote Detection and Maritime Pollution: Chemical Spill Studies. 2021. Stéphane Le Floch, Frédéric Muttin (Eds). Print ISBN:9781786306395 |Online ISBN:9781119801849

Saulquin, B., & Gohin, F. (2010). Mean seasonal cycle and evolution of the sea surface temperature from satellite and in situ data in the English Channel for the period 1986–2006. International Journal of Remote Sensing, 31(15), 4069-4093.

2.- Inorganic nutrients: Although both bay are classified as eutrophic areas, the manuscript does not present data on N and Si; Si:N ands Si:P are interesting ratios to explore in the near surface layer, especially for diatoms, a groups that needs silicic acid for the frustule and for dinoflagellates which are associated to nitrogen sources. Species/functional groups could respond more to ratios than concentrations; for example, cryptophythes and dinoflagellates may respond better to N sources (i.e. nitrate, ammonia), whereas diatoms could respond better to silicic acid concentrations.

We agree and we insert nutrient concentrations in Table 4 of the article (measured before the median IGPG date,day 68, by SOMLIT and REPHY).

We did not include data concerning the N/P and Si/N ratios because these parameters do not show interesting variations before the IPGP date: their median values are respectively 90.0 and 0.6 in the Bay of Vilaine, and 44.6 and 0.4 in the Bay of Brest (measured at REPHY and SOMLIT stations). All the ratio values are superior to 35 and inferior to 0.9 in the Bay of Vilaine, and superior to 20 and inferior to 0.65 in the Bay of Brest. These high N/P ratios and low Si/N ratios, compared to Redfield ratios (16 and 1), are characteristic of ecosystems subject to high winter nitrogen fluxes. The phytoplankton growth is not limited by nutrients before the IGPG date in both ecosystems. The phytoplankton population is then dominated by diatoms such as Skeletonema spp. and Chaetoceros spp.

3.- Model: There are several not clear issues in the parametrization of the model (Table 1), mainly in the methodology section: some restrictions on some parameters could be explained in more detail; for example, the initial value of O for dinoflagellates at the Bay of Vilaine; the starting values for N and Si nutrients, are they coming from a observed data base ?

We thank you for this comment. Indeed it was a typing error. The initial concentration of dinoflagellates in the Bay of Vilaine is equal to 0.1 micromolN L^{-I} and not to zero so we corrected it in Table 1 of the article.

Parameters	Bay of Brest	Bay of Vilaine
Dissolved O_2 *(mg L^{-1})*	9	10
Mesozooplankton *(µmolN L^{-1})*	0.05	0.1
Microzooplankton *(µmolN L^{-1})*	0.05	0.05
Dinoflagellates *(µmolN L^{-1})*	0.05	0.1
Diatoms *(µmolN L^{-1})*	0.5	0.5
Soluble reactive phosphorus *(µmol L^{-1})*	0.5	0.8
Silicic acid *(µmol L^{-1})*	10	30
Nitrate *(µmol L^{-1})*	16	30
Ammonium *(µmol L^{-1})*	0.5	0.25
Coarse sand *(g L^{-1})*	0	0
Fine sand *(g L^{-1})*	0	0
Mud *(g L^{-1})*	0.03	0.05

Table 1 Initial conditions in the water column for the MARS-1DV model for the beginning of the simulation the 15th February

Nutrient data like all the initial values come from the MARS-3D model which was validated and then brought to equilibrium (Plus *et al.*, 2021). We clarified this in section 2.3.2 by adding the citation.

Plus Martin, Thouvenin Benedicte, Andrieux Francoise, Dufois Francois, Ratmaya Widya, Souchu Philippe (2021). Diagnostic étendu de l'eutrophisation (DIETE). Modélisation biogéochimique de la zone Vilaine-Loire avec prise en compte des processus sédimentaires.

Description du modèle Bloom (BiogeochemicaL cOastal Ocean Model). RST/LER/MPL/21.15. https://archimer.ifremer.fr/doc/00754/86567/

4.- Functional groups: Authors stated that *Skeletonema* spp. and *Chaetoceros* spp. as dominant species during both periods; would be possible that the increase in fluorescence is due to changes in taxonomical groups? Since both bays are under the influence of nutrient loading (mainly nitrogen), would be possible that the toxic dinoflagellates dominance would be part of the seasonal succession or interannual variability? Any evidence of more frequent and intense Harmful Algal Blooms (HABs) during the annual cycle or during climatological-hydrological extreme events ?

Skeletonema spp. and *Chaetoceros* spp. are the dominant species at the date of each annual IPGP in both ecosystems. It is generally at the end of the first bloom that a shift is observed in the phytoplankton population dominance (Si or Si+P limitation). This study is only based on the IPGP because the fluorescence parameter is not robust enough to be able to study the whole growing period and to be linked with the seasonal phytoplankton succession. Quantifying *in vivo* phytoplankton communities using spectral fluorescence (Escoffier *et al.*, 2015) is still complex because it depends on factors such as the total levels of Chl-*a* and certain physiological states, such as those associated with light acclimation and/or nutrient stress and the species compositions of mixed assemblages. Fluorescence is used here only as a proxy for chlorophyll-a. Some toxic phytoplankton species (*Dinophysis sp., Alexandrium sp., Pseudo-nitzchia sp.*) may appears before the IPGP date but these species are not dominant (thresholds for HAB alerts are quite low; 100 cell/L for Dinophysis, 5000 cell/L for Alexandrium, 100 000 cell/L for Pseudo-nitzchia).

Nicolas Escoffier, Cecile Bernard, Sahima Hamlaoui, Alexis Groleau, Arnaud Catherine, Quantifying phytoplankton communities using spectral fluorescence: the effects of species composition and physiological state, Journal of Plankton Research, Volume 37, Issue 1, January/February 2015, Pages 233–247, https://doi.org/10.1093/plankt/fbu085

5.- According to authors, Temperature and Turbidity were the main drivers (I should prefer to say factors) of the variability of phytoplankton growth, however there is poor mechanistic explanation for their effects: to the mixing/stratification process such as Sverdrup hypothesis? Turbidity could affect in both ways to phytoplankton growth: large concentrations of terrigenous particles could decrease light penetration or increase inorganic nutrients (N, P) flux adjacent coastal land.

We agree with the referee and we developed in the manuscript the processes we consider behind "Temperature and Turbidity". The manuscript has been modified in the introduction, results and discussion to clearly state observed processes.

Concerning the mixing/stratification processes, classical theories can not be directly applied in our case. Indeed, the critical depth hypothesis formalized by Sverdrup (1953) is based on the fact that phytoplankton blooms occur when surface mixing shoals to a depth shallower than a critical depth. In our studied region, the ecosystem does not evolve with mixed layer dynamics as observed in deeper environments (i.e. deep mixed layer depth in winter mainly due to wind forcings and shallower mixed layer depth in spring linked with the onset of stratification and weakening of wind induced mixing). Shallow waters(< 30m depth) in both bays are permanently vertically mixed mainly by the tides and the intensity of the mixing mainly fluctuates with tidal amplitude and wind intensity. The vertical stratification only occurs on a thin surface layer due to river runoffs in those bays for short time scales (few hours to few days during a flood event for example).

Concerning the turbidity, before the beginning of the growing period, the system is not nutrient limited (as explained above) then the sensitivity if the system is only related to the effect of turbidity on light penetration in the water column. This point has also been clarified in the manuscript (introduction, results and discussion).

Following the referee's suggestion, we also changed the word “drivers” to “factors” in the entire manuscript as we agree with this terminology.