Richon et al. analyzed the biogeochemical response of the Mediterranean Sea to the transient SRES–A2 climate change scenario, by using the coupled high resolution model NEMOMED8/PISCES. The main objective is to quantify separately the effects of biogeochemical forcings (external nutrient inputs, i.e., coastal runoff, river discharge and Atlantic inputs through Gibraltar) and climate change (which influences physical processes, e.g., deep convection and thermohaline circulation, vertical mixing and stratification…) on the Mediterranean biogeochemistry. This type of analysis is crucial to predict the response of the Mediterranean Sea to the climate change, because, as mentioned by the authors, this semi–enclosed oligotrophic basin with short residence time of water masses is particularly responsive to climate change and highly sensitive to external nutrient inputs.

Authors point out that by the end of the simulated period (2090s) there is a reduction in the phytoplankton production, mainly in eastern regions. The changes in surface nutrient concentrations are weaker in the western basin because of the strong regulating impact of Gibraltar nutrient exchange, and nutrient runoff and river discharges influence mostly coastal regions of the Mediterranean Sea.

The approach is interesting and can provide significant scientific advances. However, I have concerns on the way the analysis has been conducted and presented in the paper. In addition, the manuscript presented major mistakes and structural issues that made the reading and the review complicated. Therefore, the paper will likely be a significant scientific contribution with major revisions.

The major revisions that are required are summarized below in my major comments, followed by a non-exhaustive list of corrections.

Major comments:

1) Line 68 - “Being a semi–enclosed oligotrophic basin, the Mediterranean is highly sensitive to external nutrient inputs. Their origins are mainly from coastal runoff, river discharge (Ludwig et al., 2009), Atlantic inputs through Gibraltar (Gómez, 2003), and atmospheric deposition (Richon et al., 2017, 2018).”

Line 143 - “External nutrient supply for the biogeochemical model include inputs from the Atlantic Ocean and from Mediterranean rivers.”

Line 501 – “No atmospheric deposition was considered in this study because there is, to our knowledge, no transient scenario for atmospheric deposition evolution over the Mediterranean Sea.”

Line 598 - “Finally, this study accounts for the changes in all external biogeochemical forcings except atmospheric deposition. However, Richon et al. (2017, 2018) showed that atmospheric deposition can account for up to 80 % of phosphate supply in some Mediterranean Sea regions and has significant impacts on surface productivity.”

As mentioned by the authors, the atmospheric deposition have a significant impact on the Mediterranean Sea. The first author quoted two of its own papers to support this. Even if no transient scenario for atmospheric deposition exists, did the model contain a present-day atmospheric deposition component? (As for example, the model analysis of Herrmann et al. (2014) and Macias et al. (2015) that used continued present–day discharge of nutrients)

If yes, the influence of the atmospheric depositions should be include in the discussion of the results. If not, I suggest use of continued present–day atmospheric depositions in the model.

2) Line 174 - "The control run CTRL is performed with present–day conditions forcing (1966–1981). The scenario simulation is referred to as HIS/A2 as in Adloff et al. (2015). HIS is the name of the historical period (in our case between 1980 and 1999), and A2 is the name of the 2000–2099 scenario simulation."

The present-day period (1966–81) cannot be older than the historical period (1980-99). Therefore, the CTRL simulations does not correspond to the present–day conditions, and because condition forcing between the periods 1966–81 and 1980-99 are different, results from the control simulation (CTRL) differed from those of the scenario simulation (HIS/A2) during the first simulated decades (from 1980 to now). Authors need to justify and clarify this choice.

3) The section 3.1 "Evaluation of the NEMOMED8/PISCES mode"

- "The model correctly reproduces the main high–chlorophyll regions such as the Gulf of Lions and"

- "The west–to–east gradient of productivity is also reproduced by the model with values that agree with satellite estimates."

- "In spite of some underestimation of nutrient concentrations that are probably linked with the features of the simulated intermediate and deep waters characteristics"

-"The average chlorophyll concentration observed at the DYFAMED station in the top 200 m is 227 ± 136 10^{-9} g L^{-1} (average over the 1991–2005 period), while the model value for the HIS period is 173 ± 150 10^{-9} g L^{-1}."

-"the PISCES model reproduces the main characteristics of the Mediterranean biogeochemistry, including a salient west–to–east gradient in nutrient concentrations, low surface nutrient concentrations and a deep chlorophyll maximum (DCM)."

In this section, the comparison of the model results with in situ data have been incorrectly conducted. The main issue is that no values to support the comparison between the model and the in situ data are provided (e.g., correlation coefficients, percentage of

differences…). For example, the chlorophyll-a concentration in the Gulf of Lion seems two times lower in the model simulations than the estimates from satellite.

There is no information on the spatial variability of the nutricline depths (i.e., nitracline and phosphacline), and of the DCM.

The figure 1, associated with this section, compares data from the satellite and the model results during two different periods 1980-99 and 1997-2012.

The units are not coherent:

- "1 K colder than observations", temperature in Kelvin?
- Figure A1 – "Chla 10^{-9} g m^{-3}", in the text: "227 ± 136 10^{-9} g L^{-1}", not consistent between them, and in the literature the most common unit is mg/m3 (or microg/L).

Maybe, model values do not agree well with the in situ data, but spatial and temporal variabilities that exist between the different Mediterranean regions have to be simulated by the model. Unfortunately, quantitative information to support this hypothesis are not provided by the authors.

4) In the introduction, I understand that the authors want to study the effects of biogeochemical forcings and climate change on,

a- the nitrate and phosphate concentrations in the Mediterranean Sea.
b- the phytoplankton production.
c- the nutrient limitation (nitrate and phosphate).

But, the results are not well presented and discussed.

- Most of the time, there is no quantitative estimates associated with the words "increase", "decrease", "substantial"…

- Figures and tables have to be improve:
  - need to adjust the axes,
  - units are wrong,
  - it is better to represent the anomalies when you compare the model with data (or between two periods) by using a map.

- There are major mistakes, for example: authors provided values for chlorophyll concentration instead of Net Primary Production…

- There is a lack of references in the discussion.

Below, I review sections of the manuscript mainly associated with the first objective of the manuscript, (a) the effects of biogeochemical forcings and climate change on the nitrate and phosphate concentrations in the Mediterranean Sea. I cannot provide a review for

the other two objectives (b and c) because they required a better analysis and discussion of the results associated with this first objective (a).

Section 3.3.1 Evolution of phosphate and nitrate concentrations

Figure 3-4 – Adjust the y-axis, it is impossible to evaluate the results.

Line 259 – "A slight accumulation of phosphate is observed in the deep western basin" - For which simulations? Provide values.

Line 268 – "The evolution of nitrate concentration shows a marked accumulation over the century in all regions of the intermediate and deep Mediterranean waters" - For which simulations?

Line 279-289 – Confusing, mixing general results (for both nitrate and phosphate) with results specific to the nitrate that should have been present in previous paragraphs.

This sections need to be clearer. Stay with the same logic when you present your results. Compare CTRL with HIS/A2, western basin with eastern basin, depth by depth…

3.3.2 Exchange fluxes of nutrients at Gibraltar

Figure 5 – Keep the same x-axis as in the figures 3 and 4.

Line 293 – "We observe similar trends in phosphate and nitrate fluxes linked to the Redfieldian behavior of the primary production in PISCES." - What do you mean, where can we see this?

Line 295 – "the incoming fluxes decrease" - fluxes of what?

Line 295 - "According to the HIS/A2 simulation, the incoming fluxes decrease slightly until the middle of the century and then increase to reach values higher than the control in the last 25 years of simulations. Outgoing fluxes follow the same trends as incoming fluxes" – For the incoming fluxes, I see, a peak in the 90s, then stable incoming fluxes until a decrease in the 2030s, and then an increase in the last 25 years with a peak in the 2080s. For outgoing fluxes, I see, a slight increase in the first half of the 21st century and a decrease after. Not you?

Line 298 – "We observe a drift in the nitrate outgoing flux in the control." – Provide a value

Line 305 – "Figures 3a and 5b show that the evolution of phosphate concentration in the western basin is linked with Gibraltar inputs (Pearson's correlation coefficient is 0.63, p–value=10−14)" - Correlation between what and what, surface, intermediate or deep concentration of phosphate?

Section 3.3.3 River fluxes of nutrients

Figure 6 – Keep the same x-axis as in the figures 3 and 4.

All tables – In the result section you only wrote in percentages. Therefore, provide percentages values in tables.

Line 311 – "River discharge is the main external source of nutrient for the eastern part of the basin." – Need references.

Line 315 – "Nitrate discharge in the HIS/A2 simulation is significantly higher than in CTRL" – How much? Provide a value.

Line 315 – "nitrate total discharge in the Mediterranean has continuously increased from the 1960s (see the CTRL values for the years 1966–1981)." - What was the value in the 1960s? The model simulations start in 1980.

I see that there is no internannual variability in the HIS/A2 simulations. You have to say something about it. Phosphate concentrations mainly decrease between 1980 and 2000. Why? Nitrate and Phosphate concentrations mainly increase between 2030 and 2050. Why?

Section 4.4 Climate versus biogeochemical forcing effects

Line 559 – "They found a general decrease in plankton biomass that is lower than in our severe climate change scenario". – Provide a value.

Table 4 – "Simulated integrated chlorophyll production (10^9 mol)"

Line 564 – "Results from Herrmann et al. (2014) indicate that chlorophyll production" – Chlorophyll production? Are you sure... I think you want to study Primary Production, or Net Primary Production. It is a major mistake…

Line 567 – "may lead to a decrease in chlorophyll and plankton biomass" - Provide values

Figure 14 & 15 – "nanophytoplankton and diatoms concentration (10^{-3} mol m^{-3})" "mesozooplankton concentrations (10^{-3} mol m^{-3})" – A mol of diatoms? A mol of mesozooplancton? Wrong units…

Line 571 – "In particular, nutrient inputs at Gibraltar have substantial consequences on the western basin." – Provide an estimate.

There are only four references in this crucial section (Lazzari et al., 2014; Herrmann et al., 2014; Macias et al., 2015). It is not enough…

List of corrections:

1) Line 7 – "socio-economic", you used both socio-economic and socioeconomic in the text, choose the good one.

2) Line 10 – "lead to changes in phytoplankton nutrient limitation factors.", which ones?

3) Line 26 – "known as sapropels, have been recorded through the last 10 000 years", It is the most recent sapropel events that apparently lasted for 3000 years, other events occurred before. Please clarify.

4) Line 33 – "and had biogeochemical impacts", which ones? Where? Need references.

5) Line 35 – "The modification of water transport led to modified nutrient distribution that can alter local productivity.", Need references.

6) Line 36 – "short residence time of water." How long? Need references.

7) Line 38 – "that changes in these conditions can trigger important circulation changes, ultimately leading to changes in", three times the word "change" in the same sentence.

8) Line 40 – "The Mediterranean is connected to the global ocean by the narrow Strait of Gibraltar through which transport contributes substantially to its water and nutrient budgets.", Transport of what? The link between the Strait of Gibraltar and the rest of the paragraph is unclear.

9) Line 42 to 46 – "Future climate projections yield […] the western basin for greenhouse gases high-emission scenarios and…" Modify, "Future climate projections with greenhouse gases high-emission scenarios…"

10) Line 47 – "In one of these MTHC weakening scenarios, Herrmann et al. (2014) show, in addition, a vertical stratification increase (Adloff et al., 2015)." Herrmann et al., 2014 or Adloff et al., 2015?

11) Line 52 – "mixing that bring together available nutrients and phytoplankton", not clear.

12) Line 65 – "as a result of density changes", not clear, do you mean less stratify?

13) Line 74 – "…chlorophyll–a concentrations, plankton biomass…", Chlorophyll-a concentration is a proxy of phytoplankton biomass, please clarify.

14) Line 83 – "In section 3.3, we expose the temporal evolution of the main nutrients, their budgets in present and future conditions and discuss their impact on the biogeochemistry of the Mediterranean Sea.", You should discuss your result in the section 4 discussion.

15) Line 117 – "by up to 3 K by", temperature in Kelvin scale?

16) Line 121 – "0.5 (practical salinity scale)", not in pratical salinity unit?

17) Line 127 – "reduced vertical mixing may also reduce nutrient supply to the surface waters. A reduction in deep convection may also tend to reduce the loss of P and N to the sediment.", Is it not what you want to test? Why do you present this assumption here, in the section "2.2 The SRES–A2 scenario simulation"?

18) Line 178 – "the effects of climate and biogeochemical forcings". You used the expressions "climate and biological forcings" and "climate and biological changes", choose one of them.

19) Line 201 – "surface average chlorophyll concentrations in the top 10 meters of the CTRL and HIS simulations, and from satellites estimations", it is chlorophyll-a concentration, source of data?

20) Line 225 – "analysis reveals much greater variability depending on the region", for which regions? It is important for your results.

21) Line 386 – "For instance, the P rich area between Crete and Cyprus is no longer observed in the 2080–2099 period (Figure 9). Moreover,Figure 10 shows that this area matches a productive zone observed in the 1980–1999 period.", It is the only area in the Levantine basin with some phosphate, nitrate and production values different from zero simulated in 2080-99. Are you sure about your observation?

22) Line 388 – "The primary production integrated over the euphotic layer (0–200 m) is reduced in our simulation by 10 % on average between 1980–1999 and 2080–2099. However, Figure 10 shows a productivity decrease of more than 50 % in areas such as the Aegean Sea and the Levantine Sea.", Provide time series, as in figure 3.

23) Line 397 – "For instance, around Majorca Island, Corsica and Cyprus, changes in local concentrations of nutrients have substantial effects on primary productivity.", Ok for Majorca, but I cannot see something with Corsica and Cyprus. There is also no values provided to evaluate these changes.

24) Line 413 – "Sea, the northern Levantine basin and the South Adriatic.", In Fig 11, it is the South of the Levantine Basin and the North of the Adriactic which are P-limited.

25) Line 418 – "Figure 12 shows the average depth of the simulated DCM for the period 1980–1999 and for the period 2080–2099.", results for the CTRL not shown, why?

26) Line 429 – "At the DYFAMED station, the average DCM depth is unchanged but surface concentration is reduced." A change from 1.10^{-7} to $0.75.10^{-7}$ g m^{-3} = 1.10^{-4} to $0.75.10^{-4}$ mg m^{-3}. Units are certainly wrong…

27) Line 432 – "the subsurface maximum in the present and future periods is located at the same depth (100–120 m), but the average productivity is reduced by almost 50 %," Where can we see this? Chlorophyll-a concentration ≠ productivity.

28) Line 439 – “Table 4 reports total chlorophyll production in the 1980–1999, 2030–2049 and 2080–2099 periods of all the simulations in all Mediterranean subbasins Adloff et al. (Figure 2 2015).” Why did you quote this reference here?

29) Line 496 – “and modification of the physical ocean (vertical mixing, horizontal advection, ...)..” Modification of physical processes. Need references.

30) Line 497 – “Nutrient fluxes from these sources.” Which ones?

31) Line 514 – “In these regions, the effects of nutrient runoff changes seem more important than climate change effects (see Table 4).” provide the percentages, and discuss these results.

32) Section 4.2 Climate change scenario. I do not see the point of this section. You decide to use the A2 scenario and already justified it in the introduction.

33) Line 537 – “Nutrient concentrations in the intermediate and deep layers were shown to be slightly underestimated in comparison to measurements (see appendix).” Provide values.

34) Line 543 – “Model values were not corrected to match data, and we are therefore conscious that the uncertainties in the representation of present–day biogeochemistry by the PISCES model may be propagated in the future.” This is an important decision that needs to be justify.

35) Line 571 – “In particular, nutrient inputs at Gibraltar have substantial consequences” Provide the percentages, and discuss them.