

Review to

**Phenological shifts in the North Atlantic net primary production detected in the 21st century. Results from two Earth system models.**

Jenny Hieronymus et al

General comments:

The authors did a great job in revising the analysis. By dividing the North Atlantic into Longhurst provinces, the results are much more consistent and meaningful. Interestingly, the most of the provinces show an increase of NPP until the end of the century except two regions in both models (disregarding the small changes in SARC and NADR in NorESM2-LM). This result was masked in the previous analysis where a declining trend in NPP was postulated for the entire domain over SSP8.5. This finding has to be included in the Summary and Conclusion section which still mentions an overall NPP decrease (L408). In addition, I do feel that many of the final findings are related to results from the EC-Earth, e.g. “phenological shifts occurring in the early 21st century “ is not true for NorESM (in 6 out of 8 regions the changepoint is after 2048). Please critically review the entire manuscript to see if the final statements apply to both ESMs.

A general remark on the quality of the figures:

- the increment of contour lines should be specified for the subplots in the caption; e.g. in Fig 3 each of the SON panels has different increment
- contour lines in Fig.8 are horrible – delete or omit the entire Fig. (see specific comments)
- I plea for a,b,c notation in the figures for more readability

In general, I recommend the publication of the manuscript after my specific comments have been addressed.

Specific comments:

L25: Please correct: Net Primary Production (NPP) is the rate of photosynthetic carbon fixation minus cellular respiration

L82-83: “We divide the region into biogeochemical provinces (Longhurst et al., 1995) in order to see how localities with similar biogeochemical functioning differ across the region.” This sentence is confusing. What do you mean by “localities”? Do your provinces really have a similar biogeochemical functioning? Delete “Furthermore”.

L85-88: Please motivate here the purpose of MLD analysis and reorder the sentences - first: change point analysis for MLD as for peak NPP; second: all about cross-correlation and what we learn from it.

L94: typo: in section 2.4 is the change point analysis

L96: “maximum” instead of “max”

L97: “found in your data” ESM data or CAFE or all data sets?

L117: replace “external concentration in nutrients” by “nutrient concentrations of the ambient water”

L118: Please give the same information for both BGC modules. i.e. delete :“PISCES is suited for a wide range of spatial and temporal scales, including quasi-steady state simulations on the global scale.”

And add for iHAMOCC, that iHAMOCC also simulates the carbon system, as well as dissolved and particulate organic matter”

L119-120: “Net primary production is the growth of phytoplankton thus the term excludes mortality, excretion and grazing.” Why is this mentioned here? By definition, NPP excludes mortality, excretion and grazing. Don’t mix it up with NCP = net community production. Delete sentence?

L163: Rephrase your sentence to e.g. : “The seasonality of NPP depends, among other things, on local physical conditions of the ocean” ?

L168: Longhurst defined the static boundaries – “made” is a strange word?

L171: You never use “coastal, westerlies and polar” – delete; The North Atlantic domain is divided in the provinces shown in Fig. 1.

L176 delete: The west wind regions;

L209ff: I recommend to show and discuss only MAM and JJA and omit SON. It shows a more or less a uniform pattern for the entire domain and complicates the data processing due the lack of data in CAFE in winter. SON gives no additional information. In addition, please find a better color scale. It is surprising, that your scale ends at 1000 but Fig.3 shows numbers higher than 1200. Please correct.

L226: Instead of using daily ESM data, use a 8-day running mean for the comparison to 8-day mean data from CAFE. Results in Fig.3 are difficult to compare. Please reorder the seasonal cycles by region instead of data sets: e.g. BPLR+ARCT for CAFE and both models, and so on. Adjust axes to maximum values. Make sure that all lines have the same starting point if you mask the ESM data with available CAFE data.

L264: make sure, that you don’t use the word “region” for both, the entire North Atlantic and the provinces; use e.g. the words “domain” and “provinces” throughout the manuscript.

L265ff: could you improve the readability by shorten the name of the 3 periods: e.g. 1865s = 1850-1879, 2000s= 1985-2014, 2085s= 2070-2999? Then you can omit to write “period” or “early/late period”

Fig 5: Please use a standard statistical test (e.g. student’s t-test) to determine the significance. With the given information, it is difficult/impossible to interpret the results. Please show results of EC-Earth on the left side as usual.

L277 “ size of NPP” – delete “size of”

L284: you don’t average over different provinces, rephrase.

L285: Fig. 6 shows .... together with the largest (.... sentence incomplete

L304: The posed question was reasonable for the previous analysis, but I cannot see the benefit when using Longhurst provinces. Isolines in Fig. 8 should be removed, if not the whole figure is omitted or transferred to the supplement. In the supplement you could also add the discussion on the difference between the PELT method and Fig.8 and why one has blanks and the other not.

L316: province averaged instead of area-averaged? Or just write: “between the time series in Fig 6 and 7” because it is clear how they were archived.

L320: Typo? NADW is not defined

L323: “Looking at Fig. 8 ..... you mean Fig 9 ?

L329: you never show the “size of peak NPP”. delete “size of peak” or explain what you mean

L351: use “finding” instead of “observation”

L352: replace “then that...” with “when the warming is the strongest in the SSP5-8.5”

L392: replace “realistic physics” with “consistent physics”

L400-401: rephrase: you don't use Longhurst provinces to look at spatial averages, but to account for the different areal conditions

L408: As already mentioned above, the NPP increases for many provinces. Revise!