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Climate of the Past Discussions

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Interactive Comment

Interactive comment on "Marine productivity response to Heinrich events: a model-data comparison" *by* V. Mariotti et al.

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Response to Referee #1

We thank Referee #1 for the interesting comments and address the questions raised below.

Referee:
Main point: The PISCES model is forced offline by the climate model IPSL-CM4 and the biogeochemical changes are studied. For Heinrich-like events, changes in marine productivity are mainly driven by changes in SST, sea-ice, mixed-layer and upwelling strength. The climate changes obtained for the Heinrich-like event with the IPSL-CM4

are not described in the paper and the reader is referred to Kageyama et al. 2009. It is a concern not to see the important changes in climate parameters in the manuscript but it becomes an even greater problem when changes in SST and surface winds over the whole globe are not shown in Kageyama et al. 2009. I understand the authors do not want to discuss the climate change induced by Heinrich-like events in the IPSLCM4, particularly in the atmosphere as it is well described in Kageyama et al. 2009. However, for a better understanding of the changes in marine productivity the authors should show a map of SST changes and sea ice edge as well as one with surface wind anomalies. A map of the climate changes could probably help to understand the structure of the marine productivity changes in the Southern Ocean and the EEP for example.

Response:

We agree with the referee. We added to the manuscript a figure of SST anomalies (Fig.1a) shaded area) and sea ice edges (Fig.1a) contours), a figure of the mixed layer depth (Fig.1b) shaded area) and wind stress anomalies (Fig.1b) contours) and a figure of Ekman pumping anomalies (Fig. 1c) shaded area). All these anomalies are yearly anomalies.

Referee:

1) Even though they have been performed under pre-industrial conditions, the authors could mention the experiments performed by Obata 2007 and Bozbiyik et al. 2011. Particularly they could include the results of Obata 2007 in part 4.1. As seen in Menviel et al. 2008, the structure of the marine productivity changes obtained under pre-industrial and LGM conditions is fairly similar.

Response:

Aknowledged and addressed (see Introduction and 4.1 parts).

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2) The authors could take a little more advantage of the fact that they have a nice ecosystem model with iron parametrization to show a map of the changes in silicate export.

Response:

Aknowledged and addressed. We added to the manuscript a figure of global silicate export (Fig.3).

Referee:

3) p565, L.18, 19: The acronyms should be defined.

Response:

Aknowledged and addressed.

Referee:

4) p566, 3.2.2 ; L27-29: As seen in fig.3, the silicic acid content is greater in the upper 100m between 57S and 62S in Austral winter. This could be due to a deepening of the mixed layer, which in turn could be due to the warmer conditions in Austral winter in that region. I am not sure about the greater upwelling as the silicic acid in FWF is lower under 150m. Maps of Ekman pumping and SST anomalies would be necessary to conclude on this part. As mentioned in 2) a map of opal production would be nice too In addition, if you had a greater upwelling, wouldn't it be associated with greater iron input (as mentioned for the EEP), which would lead to a change in the Si/C ratio?

Response:

The referee is right by pointing out a possible deepening of the mixed layer. We added to the manuscript a figure of the anomalies of mixed layer depth for the months of August and September in the NZL area (see Figure 5d)). We plotted as well the August-September averaged sea ice extent (Figure 5d)). We looked at August-September SST anomalies in the same area (not shown in the manuscript) and it is exactly as the referee hypothesized: during the Austral winter, we simulate

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an increased SST in the NZL area, accompanied with a sea ice extent that goes southward. The insulation effect of sea ice is thus reduced and the momentum flux increases between the atmosphere and the ocean, which induces a deepening of the mixed layer. Nonetheless, we also simulate an enhanced upwelling in this same area (positive anomalies in the Ekman pumping, see Figure 5c)). As mentioned in 2), we added to the manuscript a figure of silicate export (Figure 3), and we can see that in the NZL region, the silicate export does increase in our FWF simulation compared to our GLA simulation. We plotted a map of the Si/C but the signal is not easy to interpret. In the NZL area we simulate a slightly increased Si/C ratio which is counterintuitive if we hypothesize an increased upwelling of both Si and iron. At the same time, in the SEP region where we have negative Ekman pumping anomalies, we have a more important increase of Si/C, which there is perfectly intuitive: a decreased upwelling limits the diatoms in iron, so they incorporate more silicic acid. So there might be some mixing between those two adjacent regions that we cannot constrain.

Referee:

5) p572, L6-16: In LOVECLIM: - in the Southern Ocean there is a competing effect of increased SST & reduced sea ice with weaker westerlies. In the idealized experiments (Menviel et al. 2008) this induces no significant changes in export production but when the insolation and CO2 forcings are taken into account the export production actually increases (Menviel et al. 2011 QSR). - in the EEP, it is actually fairly complex as the northeasterly trades strengthen while the southeasterly trades weaken. The export production decrease is mainly due to a change in nutrient content of the source water. The authors should mention that the EEP region with the positive EXP anomaly they are referring to is fairly narrow and that it is bounded to the north and south by negative EXP anomalies. It is actually quite interesting to note that the EXP anomaly structures obtained in the EEP for this study and the Menviel et al. 2008 study have some similarities.

Response:

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Aknowledged and addressed (see part 4.1).

Referee:
6) p573, L.11-16. These sentences could be replaced by: " The greater EXP obtained in Menviel et al. 2008 off the Mauritanian coast is due to both a greater upwelling and an increase in nutrient content in the source water. Indeed, the stratification generated in the North Atlantic by the freshwater input leads to a subsurface positive nutrient anomaly, which is advected to lower latitudes. In Schmittner et al. 2005, as the surface winds are constant, the EXP increase in MAU is mainly due to a greater nutrient content in the source water." Is there a subsurface positive nutrient anomalies generated in PISCES in the North Atlantic?
Response:
Aknowledged and addressed (see part 4.1). We do not have a significant increase in the subsurface nutrients anomalies in the North Atlantic, so this, added to the lid effect, make an increase of productivity impossible in the MAU region in our simulations.

Referee:
7) Could add Cartapanis et al. 2011, Paleoceanography reference. Marine sediment core off the coast of Baja California.
Response:
Aknowledged and addressed (see Table 1 and Figure 2).

Interactive comment on Clim. Past Discuss., 8, 557, 2012.