

Interactive comment on “Response of O₂ and pH to ENSO in the California Current System in a high resolution global climate model” by Giuliana Turi et al.

Anonymous Referee #1

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1. Summary

Turi et al. use a high-resolution fully-coupled global earth system model (GFDL-ESM2.6) to uncover the O₂ and pH response of the California Current System (CalCS) to El Niño/Southern Oscillation (ENSO). Despite significant variations of the response to individual events due to ENSO diversity, composite means for warm/cold events reveal consistent physical and biogeochemical changes along the US West Coast. While the O₂ response to ENSO is wide-spread and differs between the surface (driven by changes in the solubility) and at 100m (driven by changes in the thermocline structure), the pH response is mainly confined to the coastal environment, highlighting the domi-

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nant role of changes in dissolved inorganic carbon (DIC) and upwelling associated with ENSO.

2. General comments

The influence of ENSO on the physical and biogeochemical environment of the CalCS is evidenced both in observational and model-based data. Investigating the associated changes in the current system improves our understanding of the ecosystem functioning, its sensitivity to change and is relevant for ocean management. Even though the imprint of ENSO on the CalCS has been thoroughly studied, the diversity among ENSO events and the lack of high-frequency 3-dimensional observational records render modeling studies (such as the one presented) extremely valuable in providing opportunities to study ecosystem changes on interannual time scales. The paper presents results on O₂ and pH changes in the CalCS based on a global high-resolution fully coupled earth system model, which is, to my knowledge, unprecedented. In my opinion, it thus addresses relevant scientific questions within the scope of Ocean Science. The work is generally well presented and structured. I recommend this manuscript for publication with Ocean Science after addressing the few minor comments on the manuscript listed below.

3. Specific and purely technical comments

Methods

Page 5, Line 1: What do you mean by “interannual standard deviations”? I assume you apply the Lanczos filter as described, deseasonalize the data which yields time series that retain only anomalies on interannual time scales, right? From these time series, you compute standard deviations and use them to normalize the response? I guess the term “interannual standard deviations” got me confused and you might want to clarify this passage, as the normalization of all the data is key to interpreting your results

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The authors demonstrate that ESM2.6 shows an improved coastal ENSO response compared to ESM2M. They also compare their model results to a data-assimilative ROMS hindcast. Can the authors elaborate on the reason of using the data-assimilative regional model for means of comparison? Would e.g. the long (though not as high-frequent) CalCOFI records provide an additional opportunity for a model-independent evaluation of the presented response?

Page 6, Lines 5-10: Nino 3.4 variance seems substantially overestimated in the global models. Moreover, ENSO seems to be more periodic with a maximum in the frequency spectrum at 3 years return time (Figure A1). I would like to encourage the authors to elaborate on this fact and the potential implications of this particular issue in the model for their interpretation of the presented results in more detail.

Figure 5: Plot a) showing SSTs could basically be backed up by satellite observations, not? I was surprised to see such a large spread among different events, in particular in the phasing of the peak anomalies (is this ESM specific, or does it really reflect the ENSO diversity?). It would be interesting to see whether observations show similar differences, or whether the phasing is more synchronous.

Page 7, Line 19: Just out of curiosity, why is it that the ESMs do not reproduce the asymmetry in Nino3.4 indices we find in observational records?

Results

Page 7, Line 32 and Page 8, Line 6: I think it is important to be more specific about the “subsurface process” that is likely dominating the response you observe at 100m. Using a hindcast simulation on a regional model setup covering the period from 1979-2016, Frischknecht et al. 2017 discussed forcing mechanisms that are also relevant for the findings you present (see their Figure 4). They showed that the bulk part of the coastal response to ENSO is due to changes in the density structure of the water col-

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umn. While these changes are mainly driven by oceanic forcing (i.e. through coastally trapped waves), changes in the wind forcing do not explain the deepening of isopycnals during El Nino, but cause changes in upwelling velocities.

Page 8, Line 11: Maybe worth remembering the reader that you are discussing EN-LN differences. I got confused here when I first read through it and wasn't sure what this "largely positive" refers to.

Page 9, Line 25: This "potential upwelling increase in the northern CalCS during El Nino" seems puzzling to me. What forcing mechanisms would actually be the cause? I am not aware of other studies that would support this finding, and if there are, please refer to them. I think backing up this finding, if possible, would be great.

Discussion and Conclusions: The end of this section could benefit from a more accentuated take home message that goes beyond the presentation of the scientific findings. What did we learn from using this high-resolution earth system model compared to the low-resolution ESM2M or regional setups (e.g. Jacox et al. 2015,2016, Frischknecht et al. 2015,2017). I think the paper discussion could benefit from adding a comment to the implications the authors already state.

Figures

Generally, the figures all have very cryptic titles and headings (e.g. GFDL ESM2.6 FMA SST (shaded) SLP (contour) Hipass Seas StdAnom, Figure 4). I think cleaning up the figure titles/headings and including the necessary information in the figure caption (while explaining used acronyms and abbreviations) would ease the reader's understanding and greatly help to focus on the relevant things.

Figure 5: In the caption, it says "(see gray boxes in Fig. 6)". These boxes are however not visible in Fig. 6, right? I assume this comment needs to be removed.

Figure 5: The notation of (0/1) reflecting the evolution of an event before and after its peak is hard to grasp in the beginning. Make sure to better introduce this notation or

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change the x labels in the figures.

Figure A1: What do the dashed lines in the plots to the right represent?

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