

Interactive comment on “Evolution of the Arabian Sea upwelling in the past centuries and in the future as simulated by Earth System Models” by Xing Yi et al.

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We thank the reviewer for detailed reading of the manuscript and for the suggestions for improvement. In the following, we quote the reviewer’s comment for each point and then sketch how we plan to revise this manuscript to address these suggestions.

1. “I would be very cautious about the choice of the models resolutions to be appropriate to investigate coastal upwelling in the Arabian Sea. The spatial extent (e.g., Figs. 1 a and b) shows that coastal areas are largely blank, especially for MPI-ESM, but also for CESM-CAM5. It is clear from previous studies that coastal upwelling is restricted to the vicinity of the coast, approx. 90 km offshore (Rixen et al., 2000). In fact, the

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authors mention this issue on p.4 l.3 but miss to discuss what implications this might have on the reliability of the results. It was further discussed by Praveen et al. (2016 Geophys.Res.Lett.), that changes in upwelling under future warming scenarios are regionally limited and spatially inhomogeneous, finding that 1x1 degrees atmospheric resolution is not adequate for studying the coastal current system. The study of Yi et al. uses models with more than four times coarser resolutions and it has to be discussed if a potential increase of coastal vertical water transport might not be obscured by the coarse resolution.”

We thank the reviewer for sharing this concern. We agree with the reviewer that the resolution might not be high enough to study the upwelling. However, as already mentioned in the manuscript, it is the best we can have so far. The models we chose have the highest resolution within the CMIP5 model pool which has been used by previous works to study upwelling systems (Wang et al., 2015 Nature). Our results, and the results of other previous studies that look into upwelling simulated in CMIP5 models, are conditioned on the limitations of these models. However, these results can still be useful to better interpret future studies with higher resolution models. In the revised manuscript, we will discuss in more detail how the resolution of the models affects the results.

2. “Although the approach of testing the models against observational data seems to be of minor importance in the study, I highly question the approach used here with *G. bulloides* data. My first concern is, that it is not clear from Fig. 2c) if cores RC2730 and RC2735 are actually within the modelled grid cell or outside. If the stations are covered, they are at the very edge of the models coverage anyway. Secondly, the actual correlation of the two time series, Oman margin upwelling intensity and *G. bulloides* abundance, is not given in Table 1, where I would expect it. It seems from the colour coding in Fig. 2 c) and d) that it is in the range of $r=0.2$ to 0.4 . However, both models show a significant positive correlation only in the northern part of the basin, an area of open-ocean upwelling and outside the area that was used for calculating the time series. This is not explained in the text and I suppose that it is not appropriate to

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verify the model results in this manner. I would also expect to see the *G. bulloides* data parallel to the upwelling time series data, as this would give a more obvious connection of the relationships. Especially as the authors discuss a “flip” at 1550 also be evident in the *G. bulloides* record, it has to be illustrated in a clearer way.”

We appreciate the reviewer for these thoughts. We are aware that the location of the sediment records might not be optimal but we do not have many to choose from. The purpose of the comparison between the upwelling and the *G. bulloides* abundance is not to validate the model results against observation but to show the effect of external forcing over the last millennium. We also agree with the reviewer that the correlation should be shown more clearly. In the revised manuscript, we will also include a plot to illustrate the evolution of the *G. bulloides* record.

3. “The finding of increased upwelling favourable winds under RCP8.5 scenario together with a negative trend in upwelling intensity is explained with a likely overriding effect due to increased surface water stratification and warming SST. However, I miss a discussion of the results in context to previous studies of modelled upwelling in the Arabian Sea. Although using historical simulations over a much shorter period of time, Roxy et al. (2016 *Geophys. Res. Lett.*) for example found decreasing trends of phytoplankton productivity by using a similar set of simulations and also inferred an overriding effect of near-surface stratification as the main cause.”

We thank the reviewer’s suggestion. We will discuss the work of Roxy et al. (2016) in the revised manuscript. We would also like to point out that the validity of the study of Roxy et al. is also limited by the coarse spatial resolution of the models analysed in that study. Actually, that resolution is broadly similar to the spatial resolution of the models we have analysed in our manuscript and the models that were analysed in the Wang et al. manuscript cited in our previous response. Unfortunately, this is a limitation that can only be overcome when higher resolution simulation become available.

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