Ocean Sci. Discuss., 12, C1506–C1510, 2016
www.ocean-sci-discuss.net/12/C1506/2016/

Ocean Science Discussions

Interactive comment on "Imprint of external climate forcing on coastal upwelling in past and future climate" *by* N. Tim et al.

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Received and published: 26 January 2016

We thank the reviewer for commenting on our manuscript. Below we respond to the main concerns.

The main and big problem of the paper is that the authors do not go enough into details in their explanations and reasoning. The reader needs to make a strong effort to understand the logical reasoning and the conclusion induced by a given explanation. A big effort of explanation and clarity is necessary, requiring to explain clearly the objective of each section, to provide more details, to go deeper in the analysis and to improve the link between sentences, paragraphs and sections. This is true throughout the whole paper.

This concerns has been shared by most of other reviewers and we will try to produce a manuscript that can be read from a large fraction of the scientific community, we will rewrite and clarify our explanations and reasoning throughout the whole manuscript.

The results found by the authors for the evolution of EBUS in the rcp8.5 scenario are not in agreement with previous studies made with other models (Wang et al., 2015, Rykaczewski et al., 2015). First, it is necessary that the authors develop their discussion about these differences, trying to understand them.
We will include a more detailed discussion of the differences and similarities of our results compared to Wang et al. (2015). Wang et al. (2015), extended data figure 3, the long-term trends in the period 1950-2100 in the EBUS are shown. For all regions there are positive and negative trends (blue and red squares), so that clearly not all models agree in the sign of the trend. Wang et al. (2015) define a level of consensus among models (if 80% of the models agree) to claim robust trends. In our study, we calculate the trends in the period 2006-2100 (in contrast to 1950-2100 in Wang et al. (2015)). We additionally show that for some regions, e.g. Humboldt, this discrepancy in the trend may be due not the different model structure, but also to internal variability, as we find in the MPI-ESM model. It is not easy to identify the trends simulated in individual models, as their figure 2 show only the ensemble-mean together with confidence intervals, specifically for California, the long term trend seems to be mainly not robust across the models.
We agree with the reviewer that our manuscript should explain more clearly the differences between the Wang et al. (2015) study and ours and also how our conclusions complement the conclusions reached by Wang et al. (2015).

Second, this suggests that the choice of the model is a source of uncertainty resulting in a range of variability that can be as large as the one associated to the variability of external or internal origins. The authors should therefore examine the possibility to extend their study to other models of CMIP5, that gathers 20 modeling groups (as seen on Fig. 1, 42 models were used to perform histor-

ical simulations, and 25 to 42 to perform scenarios simulations). This does not require to run additional simulations, but to gather 2D fields of SST, mean SLP, velocity/transport at 50m depth and wind stress. This would greatly increase the robustness of their conclusions. It seems possible to use other ensemble to estimate effect of external forcing (for example by comparing trends) even if initial conditions differ across models. The authors could examine the correlation between simulations performed with different models, as they do here for simulations performed with the same model. Note that the authors mainly use here results from MPI-ESM, and do not discuss a lot results from CESM-CAM5, though they say at the beginning that they will examine the effect of the model.
We only used these two earth system models because these are the only ones available with ensembles of simulations where the simulations are driven by the same model and the same external forcing over the past millennium. Our focus is not only the future scenarios, as in Wang et al. (2015), but also the paleo climate context, where ocean sediment cores indicative of upwelling intensity have also been interpreted as a response to external forcing. This point is key of our analysis, leading to the possibility to directly detect the influence of the external climate forcing on the upwelling in the EBUS. Therefore, analysing other models would not be a benefit for this purpose.
In addition, there seems to be a misinterpretation of the Wang et al. (2015) study, as the reviewer seem to indicate that virtually all CMIP5 models used in Wang et al. (2015) agree in the sign of the simulated upwelling trend in all EBUS. This is not the case, as it can be seen in the Extended Figure 3 of Wang et al. (2015). The agreement between CMIP5 models is not as strong, although the ensemble mean does indicate a general intensification of upwelling.
In our study, by using ensemble of simulations, we expand the conclusions reached by Wang et al. (2015), by showing that model disagreement can be due not only to different model structure but also simply to random trends caused by internal climate variability.

The authors show that the variability of the upwelling over the past periods in

mainly internally driven. They should explain more clearly what are the mechanisms involved (some of the explanation is already present in Sections 5 and 6, but needs to be developed).
We will further try to expand this in the revised version, but the core of this concern is very difficult to address here. The main reason why upwelling is not responding to the variations of external forcing is that the atmospheric circulation, the wind stress, has a very small signal-to-noise ratio. In other words, it is the atmospheric dynamics that does not respond to the external forcing as other thermal variables do. For instance, focusing on the simulated trends in the large-scale atmospheric circulation patterns like the North Atlantic Oscillation or the Antarctic Oscillation, models tend to produce future trends of different sign, although in general, taken the CMIP5 model as an ensemble, the tendency is towards an intensification of these modes. However, there is a non-negligible number of models that do not agree, even more so when considering not only the atmospheric circulation at the surface but in the mid- troposphere as well. Related to this, these large-scale circulation patterns have displayed large-decadal variations over the 20th century that cannot be attributed to the external forcing. Detection and attribution studies do find a response of the atmospheric circulation to future forcing, but this response is weak and rather limited to the low-latitudes (see e.g. Gillett and Stott, doi:10.1029/2009GL041269.)

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Interactive comment on Ocean Sci. Discuss., 12, 2899, 2015.