

## ***Interactive comment on*** “Trends in coastal upwelling intensity during the late 20th century” **by N. Narayan et al.**

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### **Response to review from anonymous referee**

We would like to thank the anonymous reviewer for his thorough review and suggestions on the manuscript. In the following, the lines in italics are comments/suggestions from the reviewer.

*The reader would wonder why the data have been smoothed in the first place ? The estimation of trends can be perfectly carried out with annual data, avoiding all the possible pitfalls that may be caused by the smoothing.*

Even though not discussed in the original manuscript, we have done the same analysis on unsmoothed annual time series obtained from COADS, NCEP, ERA 40 and

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HadISST. The results of which are summarized in the table in the supplement file. For the unsmoothed datasets, the trend and significance obtained from COADS and HadISST (1960-2004) does not show any difference (except for the slope). So the trends in datasets which provides the key comparison to support the conclusion do not depend on whether the dataset is smoothed or not.

*In some cases, the existence of statistically significant trends is due just because the initial or final years are far from the otherwise flat mean behavior of the series.*

We have also done the analysis by removing apparent outliers (if the corresponding residual is larger than 95% of new observations, the data point is considered an outlier) which also showed statistically significant trends for both COADS and HadISST dataset. This indicate that the trends obtained are robust and is not due initial and final years being far from otherwise mean behavior of the series.

*It seems to me that all three data sets look very different, and this is worrying since they purportedly represent the same variable.*

We agree to the fact that its indeed worrying that the datasets which represent the same variable looks very different. NCEP and ERA 40 are produced from different reanalysis schemes with different boundary condition, whereas, COADS is primarily a dataset based on in situ measurements. So we try to make the case based on previously published work that COADS dataset is most reliable for the purpose of our study.

*The Peru case could be explained by the ENSO phases and the strong smoothing (a reason to not smooth in my opinion).*

The unsmoothed time series for Peru also shows a decreasing trend in coastal upwelling. As we have shown in the manuscript, ENSO is the cause for this anomalous behavior in the Peru coastal upwelling region (See Fig. 9 in manuscript). Similar observation have been made by Wyrтки (1987) for the Calloa coast in Peru.

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*What could be the reason for the COADS series and the HadISST series to disagree at decadal time scales and agree in their linear trend?*

In the unsmoothed time series the SST index and COADS wind stress are comparable. Moreover the SST index was presented as a secondary evidence to support the apparent trends in COADS wind stress. The lack of one-to-one relationship of SST with wind stress along the coastal segment where upwelling exists could result from the fact that SST is a mixed signal. SST along the coast could also be altered by decrease in surface mixing, offshore storm activity etc. It must be also noted that Nykjær and Vancamp (1994) using a cross-correlation analysis found that there exists a lag of 2-3 months between the periods of high wind stress and cooler SST. All these factors will affect the agreement between the two time series at decadal time scales. But the increasing offshore SST gradient should be useful as a proxy for coastal upwelling intensity, when it is backed by a corresponding increase in wind stress.

*I would recommend to analyze the correlations between the COADS indices and the HadISST indices after different degrees of smoothing.*

We did the trend analysis with different degrees of smoothing (3, 4, 8 and 12 years) on COADS and HadISST datasets, all of which showed significant increasing trends, which indicate that the trend analysis is robust. The computation of correlation coefficient between two dataset assume that each data point contributes independent information. Therefore, correlation coefficient between two smoothed datasets have no statistical meaning (since smoothing destroys the validity of this assumption). However, there exists a correlation between the unsmoothed datasets (an example for the Luederitz coastal upwelling area is shown in the supplement file), so we have decided to include the unsmoothed time series also into the figures. The updated figure from COADS dataset is shown in the supplement file.

Please also note the supplement to this comment:

<http://www.ocean-sci-discuss.net/7/C272/2010/osd-7-C272-2010-supplement.pdf>

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