Geophysical Research Abstracts
Vol. 17, EGU2015-5651, 2015
EGU General Assembly 2015

The relationship between Arabian Sea upwelling and Indian Monsoon revisited

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Coastal upwelling is important to marine ecosystems and human activities. It transports nutrient-rich deep water mass that supports marine biological productivity. In this study, we aim to characterize the large-scale climate forcings that drive upwelling along the western Arabian Sea coast. Studies based on ocean sediments suggest that there is a link between this coastal upwelling system and the Indian summer monsoon. However, a more direct method is needed to examine the influence of various forcings on upwelling. For this purpose, we analyse a high-resolution (about 10 km) global ocean simulation (denoted STORM), which is based on the MPI-OM model developed by the Max-Planck-Institute for Meteorology in Hamburg driven by the global meteorological reanalysis NCEP over the period 1950-2010. This very high spatial resolution allows us to identify characteristics of the coastal upwelling system.

We compare the simulated upwelling velocity of STORM with two traditional upwelling indices: along-shore wind speed and sea surface temperature. The analysis reveals good consistency between these variables, with high correlations between coastal upwelling and along-shore wind speed (r=0.85) as well as coastal sea surface temperature (r=-0.77). To study the impact of the monsoon on the upwelling we analyse both temporal and spatial co-variability between upwelling velocity and the Indian summer monsoon index. The spatial analysis shows that the impact of the monsoon on the upwelling is concentrated along the coast, as expected. However, somewhat unexpectedly, the temporal correlation between the coastal upwelling and the monsoon index is rather weak (r=0.26). Also, the spatial structure of upwelling in the Arabian Sea as revealed by a Principal Component Analysis is rather rich, indicating that factors other than the Monsoon are also important drivers of upwelling. In addition, no detectable trend in our coastal upwelling is found in the simulation that would match the prediction of a strengthening of upwelling under anthropogenic radiative forcing.