Sensitivity of the wind-driven coastal and offshore upwelling across the Benguela Upwelling System to decadal climate changes

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Abstract

Time and space variability of the coastal and offshore upwelling in the eastern boundary upwelling systems are essentially controlled by the surface atmospheric flow with different and sometimes contrasting, impacts on coastal and offshore upwelling systems. Here, concurrently measured wind-fields, satellite-derived Chlorophyll-a concentration along with a state-of-the-art ocean model simulation spanning 2008-2018 are used to investigate the connection between coastal and offshore physical drivers of the Benguela Upwelling System. Our results indicate that the spatial structure of long-term mean upwelling derived from Ekman theory and the numerical model are broadly consistent and closely followed by the Chlorophyll-a pattern. The variability of the upwelling from the Ekman theory is diminished with offshore distance, whereas different structures are revealed in the model-derived upwelling. Our result suggests the presence of sub-mesoscale ocean dynamics across the entire system with a large modulating effect on the wind-stress-curl-driven upwelling off Lüderitz and Walvis Bay. In Kunene and Cape Frio upwelling cells the coastal upwelling and open-ocean upwelling frequently alternate each other, whereas they are modulated by the annual cycle and mostly in phase off Walvis Bay. Such a phase relationship appears to be strongly seasonally dependent in the Lüderitz cell and across the southern BUS. Thus, our findings suggest this relationship is far more complex than currently thought and seems to be sensitive to recent decadal climate changes with short- and far-reaching consequences for this vulnerable marine ecosystem.

Keywords: Benguela Upwelling System, Wind, Stress, Curl, Driven upwelling, Coastal Upwelling, Decadal Climate Change

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