Influence of atmospheric circulation and large-scale climate patterns on the Namibian upwelling system: analysis of atmosphere-ocean simulations

The Namibian upwelling region is one of the four Eastern Boundary Upwelling Ecosystems and among the most productive areas in the World Ocean. Upwelling indices have been defined in three ways. First, derived from EOF analyses of the Sea Surface Temperature (SST) of the simulations with the atmospheric model HadlSST1 and ocean models STORM and MOM4. Second, an index has been derived from water vertical velocity of STORM and MOM4. Third, the area between the 13°C isotherm and the coastline was used to indicate the intensity of the upwelling.
Correlations with observed atmospheric variables (NCEP reanalysis) over the whole southern Atlantic show which conditions favour upwelling: higher than normal South Atlantic anticyclone, strong and southerly wind/wind stress and pressure and air temperature contrast between ocean and land. Separating the coastal area off southern Africa at Lüderitz (28°S) depicts the differences between the northern and southern Benguela upwelling region. Northern Benguela is characterised by a negative trend over the last 60 year, Southern Benguela by a positive one. Furthermore, Northern Benguela upwelling seems to be influenced strongly by the conditions described above while the wind field correlated with the upwelling south of 28°S do not show stronger southerly winds. Additionally, the southern upwelling index of MOM4 do not reflected properly in the corresponding SST field. A reason for this could be an overlaying signal, possibly the advection of warm air from the Indian or the central Atlantic Ocean.
The sea level pressure gradient between land and ocean of NCEP reanalysis provide a contrary trend to the one postulated by Bakun. We did not find an indication for a stronger pressure contrast between land and ocean.
Correlations with oscillation indices El Niño Southern Oscillation (ENSO), the Antartic Oscillation (AAO) and an index of the tropical Atlantic SST variability, display a significant relationship between the summer upwelling and ENSO. The SST-based index is also significantly correlated with the tropical Atlantic. In contrast, the upwelling indices of the vertical velocities show significant correlations with the AAO. None of these correlations is strong enough to claim a detection of a main driver of upwelling.
Spectral analysis of the vertical velocity index (STORM) shows specially in summer a clear peak at timescales of 5 years. The longer series of HadlSST1 additionally displays decadal variability.