



Analysis of trends in coastal upwelling variability during the late 20th century

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This study presents linear trends of coastal upwelling intensity in the later part of the 20th century (1960-2001) employing various indices of upwelling, derived from meridional wind stress, sea surface temperature and surface chlorophyll concentration. The analysis was conducted in the four major coastal upwelling regions in the world which are off North-West Africa, off Lüderitz, off California and off Peru. We also did a correlation analysis of the upwelling indices with basin-scale oscillations like the North Atlantic Oscillation (NAO), the Atlantic Multi-decadal Oscillation (AMO) and the Pacific Decadal Oscillation (PDO). The correlation at different lags was estimated using cross-correlation. As a result the trends in meridional wind stress showed a steady increase of intensity from 1960-2001, which was also reflected in the SST index calculated for the same time period. The steady cooling observed in the instrumental records of SST off California substantiated this observation further. The correlation analysis also showed that the basin-scale oscillations like AMO and PDO cannot be directly linked to the observed increase of upwelling intensity off NW Africa and California respectively. The relationship of NAO with coastal upwelling off NW Africa seems to be ambiguous due to a negative correlation between the NAOI and the meridional wind stress and a lack of correlation with the SST index. Our results give additional support to the hypothesis that the coastal upwelling intensity increases globally because of raising greenhouse gas concentrations in the atmosphere and a subsequent increase of the land-sea pressure gradient and meridional wind stress.