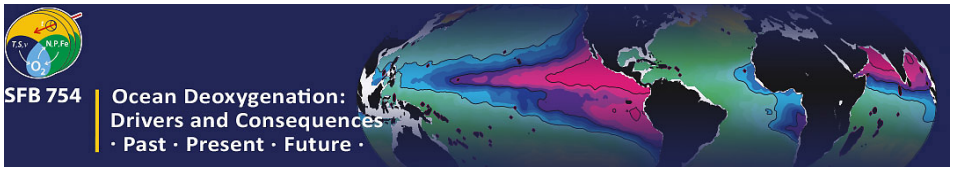

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Seasonal and annual variability of coastal sulphur plumes and forcing processes in the Benguela upwelling system

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We investigated the seasonal and annual variability of surface sulphur plumes in the Namibia Benguela upwelling system because of their significant impacts on the marine ecosystem, fishing industry, aquaculture farming and tourism due to their toxic properties. We identified the sulphur plumes in ocean colour satellite data for the 2002-2012 time period using the differences in the spectral properties of Namibian Benguela optical water types. The sulphur events have a strong seasonal cycle with pronounced main and off-seasons forced by local and remote-driven processes. The main peak season is in late austral summer and early austral autumn at the beginning of the annual upwelling cycle caused by increasing equatorwards alongshore trade winds. The sulphur plumes activity is high between February and April during the seasonal oxygen minimum associated with the seasonal reduction of cross-shore ventilation of the bottom waters, the seasonal southernmost position of the Angola Benguela Frontal Zone, the seasonal maximum of water mass fractions of South Atlantic and Angola Gyre Central Waters as well as the seasonal arrival of the downwelling coastal trapped waves. The off-season is in austral spring and early austral summer during increased upwelling intensity and enhanced oxygen supply. The annual variability of sulphur events is characterized by very high activities in years 2004, 2005 and 2010 interrupted by periods of lower activity in years 2002 to 2003, 2006 to 2009 and 2011 to 2012. This result can be explained by the relative contribution or adding effects of local (wind) and remote-driven forces (from the equatorial area). The probability for the occurrence of sulphur plumes is enhanced in years with a lower annual mean of upwelling intensity, decreased oxygen supply associated with decreased lateral ventilation of bottom waters, more southern position of the Angola Benguela Frontal Zone, increased mass fraction of South Atlantic Central Water and stronger downwelling coastal waves (Ohde and Dadou, 2018, PLoS ONE 13 (2): e0192140. https://doi.org/10.1371/ journal.pone.0192140)

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