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Factors affecting the variability of the Arabian Sea OMZ over seasonal, interannual and climate-change time scales

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The combination of high biological production and weak oceanic ventilation over coastal upwelling systems cause large-scale oxygen minimum zones (OMZs) that profoundly affect marine habitats and alter key biogeochemical cycles. These low subsurface oxygen levels are determined by a balance between remineralization and ventilation, which both vary over multiple time-scales and have local as well as remote sources.
In this presentation, I will highlight key factors affecting the variability of the Arabian Sea OMZ over seasonal, interannual and climate-change time scales, using high-resolution model simulations of the Northern Indian Ocean performed using a range of physical (NEMO, ROMS) and biogeochemical (NPZD, PISCES) models.
The Arabian Sea OMZ has unusual characteristics compared to the two other main OMZ, which are found in Eastern Boundary Upwelling Systems, along the eastern Pacific and Atlantic, respectively. In the Arabian Sea, the strongest coastal upwelling is driven in summer by southwest monsoon winds and is located along the western coast, while the OMZ is shifted eastward from this region of highest productivity and reaches the Indian coastal waters. Furthermore, the Arabian Sea OMZ is the thickest of the three oceanic OMZ, with near-total depletion of oxygen (suboxia) at depths 200-1000m associated with intense denitrification. Suboxic events are particularly dramatic when they occur along coastal areas, as they induce episodes of fish mortality and shorter fishing season, inducing a sharp decline in fish catches. The economy based on fisheries of these dense population regions is thus highly vulnerable to the variability in the strength of this OMZ and to the frequency of suboxic events.
I will examine several factors that were found to prevent and/or limit anoxia, over intra-seasonal to interannual time-scales. First, eddy-driven ventilation strongly limits their extent, limiting the associated denitrification. This has a positive feedback on primary production with the counter-intuitive consequence of increasing the extent of hypoxia. Second, anoxia occurs when the OMZ is raised toward the surface. This is reinforced by remineralisation fluxes that occur essentially in the upper twilight zone. Over inter-annual time-scales, the strongest coastal anoxic events occur essentially during negative Indian Ocean Dipole events which are associated with an upwelling of the thermocline and of the oxycline. Finally, over climate change time scale, variations in monsoon wind intensity and large-scale ventilation both affect the volume occupied by the OMZ.

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