SFB 754 | Ocean Deoxygenation: Drivers and Consequences · Past · Present · Future ·

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The impact of meso-scale eddies on oxygen variability in the Benguela upwelling system

Coastal upwelling systems, such as the Benguela upwelling system (BUS), are highly biologically productive regions that host extended oxygen minimum zones (OMZs) as consequence of strong subsurface oxygen consumption. OMZs are of particular interest for marine biogeochemistry because these are the places where bioavailable nitrogen is removed from the marine environment. Size and evolution of OMZs thus play an important role for global ecosystem structure, nutrient cycling and the marine carbon storage.

As for all Eastern Boundary Upwelling Systems oxygen distribution and variability in BUS are shaped by complex interplay of regional and large-scale ocean circulation and biogeochemistry. Long-term trends in oxygen are likely to be controlled by large-scale circulation, i.e. transport of nutrients, oxygen, and organic matter into BUS, and atmospheric boundary conditions, i.e. wind and temperature trends affecting upwelling dynamics and gas-exchange. The extent of the OMZ and higher frequency dynamics of oxygen are on the other hand expected to be altered by small-scale features such as meso-scale eddies, filaments, or local fronts. These hydro-dynamical features are, in general, not captured by global ocean biogeochemistry models. Due to their computationally expensive set-ups with a global extent and due to high process resolution including a large number of transported state variables these models tend to be affordable only at coarse horizontal and vertical resolution. However, by omitting the representation of small-scale features global ocean biogeochemistry models often overestimate the size of OMZs.

Here, we investigate the role of the temporal evolution of meso-scale eddy activities on shaping the oxygen distributions in BUS using the global ocean biogeochemistry model MPIOM/HAMOCC in eddy-resolving horizontal resolution. We conduct a transient simulation over the 20th century driven by reanalysis data (ERA20C, ERAinterim). This way we capture a wide (spatio-temporal) range of hydro-dynamical features and include local and remote responses of ocean biogeochemistry consistently.

Meso-scale eddy activity enhances locally cross shelf exchanges of all biogeochemical tracers. It affects as well the water mass composition in BUS which has an impact on oxygen distribution and variability. We find a good representation of the oxygen mean state with an OMZ limited to the shelf area (< 300 m) as has been observed. Low water mass ages indicate eddy induced high ventilation rates within the upper 400 m of the water column outside shelf areas.

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