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

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Subsurface coherent eddies: Tracer cannonballs, hypoxic storms, and microbial stewpots?

Subsurface eddies are known features of ocean circulation, but the sparsity of observations prevents an assessment of their importance for biogeochemistry. Here we use a global eddying (0.1°) ocean-biogeochemical model to carry out a census of subsurface coherent eddies originating from eastern boundary upwelling systems (EBUS) and quantify their biogeochemical effects as they propagate westward into the subtropical gyres. While most eddies exist for a few months, moving over distances of hundreds of kilometers, a small fraction (<5%) of long-lived eddies propagates over distances greater than 1,000 km, carrying the oxygen-poor and nutrient-rich signature of EBUS into the gyre interiors. In the Pacific, transport by subsurface coherent eddies accounts for roughly 10% of the offshore transport of oxygen and nutrients in pycnocline waters. This "leakage" of subsurface waters can be a significant fraction of the transport by nutrient-rich poleward undercurrents and may contribute to the well-known reduction of productivity by eddies in EBUS. Furthermore, at the density layer of their cores, eddies decrease climatological oxygen locally by close to 10%, thereby expanding oxygen minimum zones. Finally, eddies represent low-oxygen extreme events in otherwise oxygenated waters, increasing the area of hypoxic waters by several percent and producing dramatic short-term changes that may play an important ecological role. Capturing these nonlocal effects in global climate models, which typically include noneddying oceans, would require dedicated parameterizations. Without such parameterizations, models may miss potential non-linear effects of subsurface coherent eddies under global warming, for instance arising from the interplay of changes of productivity, the depth of the oxygen minimum zones, and the depth of the density layer hosting such eddies.

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