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On the subduction of oxygenated surface water in submesoscale cold filaments off Peru.

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The Peruvian upwelling regime is characterized by pronounced submesoscale variability including filaments and sharp density fronts. Submesoscale frontal processes can drive large vertical velocities and enhance vertical tracer fluxes in the upper ocean. The associated high temporal and spatial variability poses a large challenge to observational approaches targeting submesoscale processes.

In this study the role of submesoscale processes for both the ventilation of the near-coastal oxygen minimum zone off Peru and the physical-biogeochemical coupling at these scales is investigated. For our study we use satellite based sea surface temperature measurements in combination with multiple high-resolution glider observations of temperature, salinity, oxygen and chlorophyll fluorescence carried out in January and February 2013 off Peru near 14°S during active upwelling. Additionally, high-resolution regional ocean circulation model outputs (ROMS) are analysed.

At the beginning of our observations a previously upwelled, productive and highly oxygenated body of water is found within the mixed layer. Subsequently, a cold filament forms and the waters are moved offshore. After the decay of the filament and the relaxation of the upwelling front, the oxygen enriched surface water is found within the previously less oxygenated thermocline suggesting the occurrence of frontal subduction. A numerical model simulation is used to analyse the evolution of passive tracers and Lagrangian floats within several upwelling filaments, whose vertical structure and hydrographic properties agree well with the observations. The simulated temporal evolution of the tracers and floats support our interpretation that the subduction of previously upwelled water indeed occurs within cold filaments off Peru.

Filaments are common features within eastern boundary upwelling systems, which all encompass large oxygen minimum zones. However, most state of-the-art large and regional scale physical-biogeochemical ocean models do not resolve submesoscale filaments and the associated downward transport of oxygen and other solutes. Even if the observed subduction event only reaches into the still oxygenated thermocline the associated ventilation mechanism likely influences the shape and depth of the upper boundary of oxygen minimum zones, which would probably be even shallower without this process.