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Total and mesoscale long-range offshore transport of organic carbon from the Canary Upwelling System to the open North Atlantic

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The ocean's biological pump is often simplified to a purely vertical process. Nevertheless, the horizontal transport of organic carbon can be substantial, especially in coastal regions such as the Canary Upwelling System (CanUS), one of the four major Eastern Boundary Upwelling Systems, characterized by high shelf productivity and an intense lateral exchange of mass and tracers with the adjacent oligotrophic waters. Despite its importance, the magnitude of this lateral flux has not yet been constrained. Here, we quantify the lateral export of organic carbon from the CanUS to the open North Atlantic using the Regional Ocean Modeling System (ROMS) coupled to a biogeochemical ecosystem module. The model is run on an Atlantic telescopic grid with a strong refinement towards the north-western African shelf, to combine an eddy-resolving resolution in the region of study with a full Atlantic basin perspective. Our results reveal that over the whole CanUS more than a third of the Net Community Production (NCP) in the nearshore 100 km is transported offshore, amounting to about 19 Tg C yr^{-1}. The offshore transport dominates the lateral fluxes up to 1500 km into the subtropical North Atlantic, along the way adding organic carbon to the upper 100 m at rates of between 8% and 34% of the alongshore average NCP. The remineralization at depth of this extra organic carbon leads to strongly negative vertically-integrated NCP throughout the whole offshore region of the CanUS, i.e. it makes the offshore region net heterotrophic. Substantial subregional variability shapes the spatial pattern of the fluxes in the CanUS. In particular, the central subregion surrounding Cape Blanc is the most efficient in terms of collecting and laterally exporting the organic carbon, resulting in a sharp peak of watercolumn heterotrophy. A decomposition of the organic carbon fluxes into a time-mean component and a time-variable, i.e., mesoscale component reveals a large contribution of the mesoscale activity to the offshore flux of organic carbon at every latitude. The mesoscale offshore transport ranges in intensity between 20% and 50% of the mean flux, reaching as far offshore as the mean transport. In its alongshore component, the mesoscale transport opposes the mean transport, recirculating laterally the organic carbon against the mean currents. Fundamental differences between the contributions of filaments, cyclonic and anticyclonic eddies to the transport of organic carbon are highlighted and discussed in a subregional perspective.