How do eddies mix coastal water offshore?

Investigating the role of mesoscale eddies for the coast-to-basin exchange in the Baltic Sea

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In Short

• Exchange between shallow and deep waters is restricted
• Mesoscale and submesoscale eddies contribute to the turbulent mixing
• Our project investigates what controls this mixing intensity in the Baltic Sea

Exchange of water masses between coastal and open-ocean regions is inhibited by a dynamical barrier. Mean currents are typically directed alongshore, parallel to the lines of constant depth. So only intermittent features like upwelling filaments and mesoscale eddies are typically responsible for the across-shelf mixing.

From an ecosystem perspective, this mixing is of high relevance: The coastal waters are typically rich in nutrients, since these enter the sea with river discharge. The cross-shelf mixing also transports them into the open sea. It is therefore a key process since it strongly influences primary production in the deep central basins.

To understand the functioning of marine ecosystems like the Baltic Sea, marine ecosystem models can be used, these represent the real ocean by a large number of grid cells. The models simulate both physical processes (e.g. currents transporting the water) and the most important biogeochemical processes (e.g. algal blooms). Typical regional ocean models with a resolution around 1 or 2 nautical miles are, however, not able to resolve the coast-to-basin transport processes, even if they permit some mesoscale eddies to be formed. Therefore, the effect of the horizontal exchange by smaller structures needs to be included by a "sub-grid-scale parametrisation", e.g. a Smagorinsky scheme, which describes the effect of turbulent structures which are smaller than the grid resolution.

The problem is that choosing a specific parametrisation does not account for possible variations in the mixing intensity. The question how the exchange between coast and open sea can change between seasons, years or decades with different climate might strongly affect the ecosystem response of the open sea to these changes. Our study therefore aims at estimating the influence of external drivers, like changes in upwelling frequency, river runoff or storminess onto the intensity of the coast-to-basin coupling. We apply a very-high-resolution model of the Baltic Sea physics (200 m grid size) in which the small eddies can evolve from the hydrodynamic equations solved by the model. We can then compare statistical properties of the turbulence created by the model to high-resolution satellite images to check if these processes are realistically represented. Finally we want to use our model to estimate how strong the exchange between coast and open ocean really is, and how it is affected by different external drivers. This knowledge will help us to correctly represent the coast-to-offshore mixing in ecosystem models and improve our understanding of the functioning of the Baltic Sea ecosystem.

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