Three-dimensional structure of turbulent transport by Ocean mesoscale turbulence

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Ocean mesoscale eddies are vortices of typical scale tens of kilometers that enhance the transport of heat, salt and other flow tracers across latitudes. This process is especially crucial in the Antarctic Circumpolar Current, where it contributes to setting the deep stratification of the neighboring ocean basins. Despite this significant impact on ocean transport properties, mesoscale vortices remain unresolved in global climate models and the associated transport needs to be parameterized.

Leveraging the scale separation between the small mesoscale eddies and the large ocean basins, the parameterization takes the form of a diffusion tensor relating the turbulent fluxes to the background gradients. The most common choice for this diffusion tensor is the Gent-McWilliams/Redi parameterization scheme, which was designed based on the intuition that rapidly rotating density-stratified fluids flow along density surfaces [1,2].

We propose a direct derivation of the Gent-McWilliams/Redi parameterization from the dynamics of a rapidly rotating strongly stratified patch of ocean, that hinges on the identification of a new material invariant of the dynamics. The derivation provides new relations between the two unknown coefficients of the parameterization that constrain the vertical profiles of the turbulent fluxes within the water column.

We validate these findings by comparison to numerical simulations of idealized patches of ocean [3].

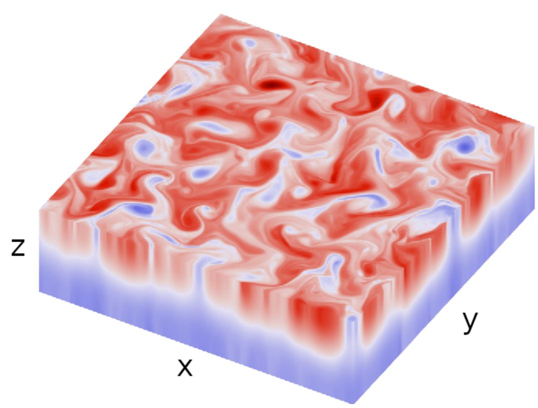

Figure 1. Visualisation of mesoscale eddies in a simulation of an idealized patch of ocean using the departure temperature field.

References

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