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Mesoscale Eddy Kinetic Energy budgets and transfers between vertical modes in the Agulhas Current

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Western boundary currents are hotspots of the mesoscale oceanic variability and of energy transfers, channeled by topography, toward smaller scales and eventually down to dissipation. Here, we assess the main mesoscale eddies energy sinks in the Agulhas Current region, with an emphasize on the different paths of energy toward smaller scales, from a regional numerical simulation.

We derive an eddy kinetic energy (EKE) budget in the framework of the vertical modes. This comprehensive method accounts for energy transfers between energy reservoirs and vertical modes, including transfers channeled by topography and by a turbulent vertical cascade.

The variability is dominated by mesoscale eddies (barotropic and 1st baroclinic modes) in the path of intense mean currents. Eddy-topography interactions result in a major mesoscale eddy energy sink (50 % of the total EKE sink). They represent energy transfers both toward higher baroclinic modes (27 % of the total EKE sink) and mean currents (23 % of the total EKE sink). Energy transfers toward higher baroclinic modes take different forms in the Northern Agulhas Current, where it corresponds to non-linear transfers to smaller vertical eddies on the slope (5 % of the total EKE sink), and in the Southern Agulhas Current, where it is dominated by a (linear) generation of internal-gravity waves over topography (22 % of the total EKE sink). The vertical turbulent cascade is significant in offshore regions, away from topography and intense mean currents. In these regions the direction of the turbulent vertical cascade is inverse - energy transferred from higher baroclinic modes toward mesoscale eddies - and it can locally amounts for most of the mesoscale eddies energy gain (up to 68 % of the local EKE source).

However, the Agulhas Current region remains a net source of mesoscale eddy energy due to the strong generation of eddies, modulated by the topography, especially in the Southern Agulhas Current. In the complex Agulhas Current system, which includes an intense mean oceanic current and mesoscale eddies field as well as strong topographic constraint and stratification gradients, the local generation of mesoscale eddies dominates the net EKE budget. It is in contrast with the paradigm of mesoscale eddies decay upon western boundaries, suggested as being due to topographically-channeled interactions triggering a direct energy cascade.