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Submesoscale Impacts on Mesoscale Agulhas Dynamics

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Mesoscale dynamics in the Agulhas Current system determine the exchange between the Indian and Atlantic oceans, and thereby influence the global overturning circulation. Here we show that the representation of the Agulhas mesoscales and in particular the Agulhas rings in global ocean models with horizontal grid refinements for the Agulhas region improves, the more submesoscale features are simulated. A comparison of the time-mean horizontal-wavenumber spectra of sea-surface temperature (SST), sea-surface height (SSH) and surface kinetic energy (SKE) from the models with those from satellite data (MODIS SST, JASON-2 SSH) and predictions by theory (SSH and SKE) reveals that turbulence in a model with a 1/20° (∼4.5 km) grid refinement for the Agulhas region is found to be associated with too steep inertial-range slopes and with too low mesoscale-power levels for SSH, in particular in the Agulhas ring path. The discrepancy gets smaller when the model diffusion is reduced and the 1/20° grid spacing begins to permit submesoscale features. The implementation of a further grid refinement down to 1/60° (∼1.5 km) leads to a very good agreement in the Agulhas ring path on all comparable spatial scales down to 10 km. The reason for the improvement is hypothized to be the upscale energy transfer associated with the more and more resolved dynamics at scales around the Rossby radius of deformation. Surface-scale energy transfers derived with the coarse-graining approach of Aluie et al. (2018) show for the 1/60° model that in the Agulhas ring path the scale energy transfer changes its direction around scales of 10 km from upscale at larger scales to downscale at smaller scales. Our results suggests that there the model diffusion in the 1/20° configurations extracts energy at scales where an energy supply would be realistic. In the 1/60° configuration, the additional energy cascades upscale and leads in the greater Agulhas region at the surface to a 25 % increase in energy transfer into mesoscales larger than 100 km compared to the 1/20° model without submesoscale activity. In the Agulhas ring path, where the model improves most, this energy transfer is found to be even five times larger.