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 thus the global overturning circulation. Here we use a series of JRA55-do forced, nested global ocean models with horizontal resolutions of 1/20° (~4.5 km) and 1/60° (~1.5 km) as well as a different handling of the model diffusion to show that the mesoscales improve when submesoscale features are permitted by the models. The usual validation of ocean models against observed vertical sections and gridded products of sea surface height (SSH) is covering only the large-scale circulation and the integrated eddy activity. Therefore, we extend the validation by a scale-dependent comparison of the time-mean horizontal wavenumber spectra of sea surface temperature (SST), SSH and surface kinetic energy (SKE) from the models with the one from satellite data (MODIS SST, JASON-2 SSH) and predictions by theory (SSH and SKE). The spectral validation shows for the 1/60° model very good agreement in the Agulhas ring path on all comparable spatial scales down to 10 km. Turbulence in the 1/20° models is found to be associated with too steep inertial range slopes and with too low mesoscale power levels for sea surface height – in particular in the Agulhas ring path. The discrepancy gets smaller when the model diffusion is reduced and some submesoscale features are permitted in the 1/20° model. The reason for the improvement is hypothized to be the upscale energy transfer associated with the more and more permitted submesoscales. 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 energy is transferred upscale at scales down to 10 km. This 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 in the 1/60° model 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.