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Submesoescale processes in upper ocean fronts: a numerical study using a Reynolds Stress Turbulence Model

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Abstract

A computational model was implemented to describe upper ocean frontal processes using customized computational fluid dynamics tools (CFD), where Reynold Stresses were parametrized with a seven equation model (Reynold Stress Model (RSM)) which allowed capturing non-isotropic turbulence effects. Through a sensitivity analysis of vertical resolution it was observed that for vertical resolutions around 1 m results were found in agreement with theoretical predictions and experimental data available in the literature. In particular, both the vertical velocity scale as the slope of horizontal velocity wavenumber spectra agreed with the predictions of the surface quasi-geostrophic theory, where numerical model predictions reached vertical velocity magnitudes of O(10e-4) m/s and horizontal velocity wavenumber spectra slopes around k^{-2}. Regarding the front free time evolution, it was found characterized by an initial period of reaction of the flow in thermal wind balance against the front perturbation, where simulations showed large vertical velocities due to the ageostrophic circulation; and further wherein Reynolds Stresses and turbulent kinetic energy took values near zero, followed by period in which the balance is restored and submesocale turbulent structures are fully formed (from 20 days of simulation time) where took place lower vertical velocities, Rossby number of O(~1) and wherein the Reynold Stresses and turbulent kinetic energy start to take values of O(10e-4) m2/s2, i.e., large vertical velocities are only associated with the formation period of submesoscale structures and once they form vertical velocities are low, furthermore the formation of submesoscale structures entails energy dissipation towards the parametrized subgrid turbulent structures, and where after his formation this energy transfer seems to be null. Finally, the wavenumber spectrum of vertical velocity was also estimated.