Center for Environmental & Applied Fluid Mechanics

“Marine Boundary Layers with Submesoscale Surface Heterogeneity: LES Results”

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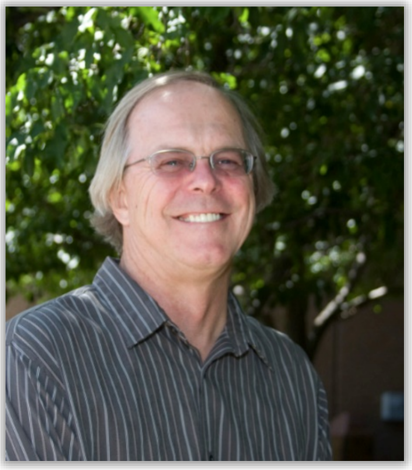

Abstract: The upper ocean is a busy place abundant with vortices, density filaments, fronts and surface waves spanning horizontal scales in the range 0.1 to 10 km, \ie the so-called ocean submesoscale regime. To investigate possible mechanical and thermodynamical impacts of a heterogeneous ocean surface we have carried out process studies using large eddy simulations with nearly 10^10 gridpoints with varying ocean surface boundary conditions. In one family of simulations atmospheric boundary layer dynamics are coupled to a circular ocean eddy. As expected ocean currents generate heterogeneity in momentum fluxes but surprisingly also generate swaths of heterogeneity in the surface temperature fluxes. As a result ocean currents can indirectly induce secondary circulations that impact the full atmospheric boundary layer; the impact depends on the stratification. Next we examine the evolution and role of ocean turbulence in the instability, arrest, and decay (\ie the lifecycle) of a cold dense filament undergoing frontogenesis in the upper-ocean boundary layer. Two control parameters are explored: the initial frontal strength $M^2 = \partial_x b$ and the surface flux Q_*. The former is more consequent: initially weaker fronts sharpen more slowly and become arrested at a later time with a larger width. This reflects a competition between the frontogenetic rate induced by the secondary circulation associated with horizontal and vertical momentum mixing by the turbulence and the instability rate for the along-filament shear flow. The frontal turbulence is energized by the shear production of the latter, is non-locally transported away from the primary production zone at the filament centerline, and cascades to dissipation in a broad region surrounding the filament. The turbulent momentum fluxes arresting the frontogenesis are supported across a wide range of horizontal scales. We briefly discuss the role of surface waves in the frontogenetic process.

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