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**Uncertainties and complexities in small-scale ocean surface mixing processes**

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Ocean mixing and dispersion processes are intermittent in time, nonlinear, and inhomogeneous in space. Much is known about processes with a spatial scale of a few tens of km (that can be studied using satellite data) and about very fine-scale processes (turbulent motions of milimeters to meters that can be studied using microstructure turbulence profilers). However, there is a lack of both observations and understanding of the so-called "submesoscale" processes, composed of motions on a scale of a few kilometers. It is well recognized that submesoscale processes play a critical role in modulating large-scale circulation, ecological functioning, and the dispersion of pollutants. Due to limited computer power, present day ocean and climate models resolve processes on scales down to a few tens of km, so submesoscale processes have to be parameterized. Accurate parameterizations of these processes are critical in simulating and predicting ocean circulation and changes in the climate. In this talk, I will focus on submesoscale horizontal mixing. Recent advances in ocean observation systems enable us to reconstruct quasi-synoptic maps of the ocean surface velocity field, over large areas and at high spatial (100s of meter) and temporal (30 min) resolutions. These surface current observations allow the computation of Lagrangian trajectories of many virtual particles. Based on these trajectories, one can compute various measures for mixing and identify Lagrangian Coherent Structures (LCS) using various methods (such as Finite Time and Finite Size Lyapunov Exponents). I will demonstrate, using surface current measurements by High Frequency radar, the existence of temporary submesoscale barriers to mixing. This has important implications for a wide range of predictions. We were also able to verify the existence of these barriers using aerial-photographs. Using a non-stationary Lagrangian stochastic model, I will present a method for estimating the upper bound of the horizontal eddy diffusivity based on the existence of such barriers.