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Gulf Stream transport and mixing processes via coherent structure dynamics

Chris Wilson (1), Yi Liu (2), Melissa Green (3), and Chris Hughes (4)

(1) National Oceanography Centre, Liverpool, United Kingdom , (2) University of Notre Dame, Notre Dame, United States, (3) Syracuse University, Syracuse, United States, (4) University of Liverpool, Liverpool, United Kingdom

The Gulf Stream has been characterized as either a barrier or blender to fluid transfer, involving processes relevant to the material exchange of heat, freshwater and carbon between the subtropical and subpolar gyres. However, previous characterization has depended on relatively sparse, in-situ Lagrangian float and drifter observations. The elegant kinematic model of Gulf Stream exchange developed by Bower (1991) is re-examined within a new diagnostic framework. The finite-time Lyapunov exponent (FTLE) is calculated from satellite altimetry to identify Lagrangian coherent structures (LCS) in the Gulf Stream region. The method provides dense sampling of the flow, the LCS capture dynamically-distinct regions associated with transport and mixing, and even represent some flow structure at finer spatial scale than the observational grid. Structures seen in independent observations of ocean colour match the LCS identified purely from surface velocity. The 22-year timeseries of diagnosed LCS supports the existing Bower kinematic model of the Gulf Stream, but also highlights fascinating new processes of comparable importance. Additionally, vortex pinch-off and formation of spiral eddies are clearly identified by LCS and may only be explained by considering changes to flow topology and the dynamics of shear-flow instability at both small and large Rossby number. Such processes, seen though LCS may enhance validation of climate models.

Bower, A. S. (1991), A simple kinematic mechanism for mixing fluid parcels across a meandering jet, Journal of Physical Oceanography, 21(1), 173–180.