Lagrangian Coherent Superstructures in Stably Stratified Turbulence

Persistent coherent structures have been observed to appear in stratified turbulence with major impact on the transport of temperature and heat. However, progress in our understanding of the mechanics of these structures has been hampered by arbitrariness in the detection methods of coherent flow structures and little is known about how they determine global transport and mixing rates of the whole flow. Over the past few years, significant advancements in both measurement techniques and conceptual methods have become available to monitor and detect Lagrangian coherent structures, offering an opportunity to advance our understanding of their role in stratified turbulence. In previous work, we have shown how the outer boundaries of energetic turbulent flow regions, the so-called turbulent/non-turbulent interfaces, determine overall growth rates and momentum transfer in shearless, sheared and density stratified flow. The boundaries of coherent flow structures share several properties with such external interfaces, motivating an effort to objectively detect superstructures and determine their role for transport. In this effort, we seek to extend objective detection methods for Lagrangian coherent structures to their propagating boundary surfaces. A major advance will be the extension and testing of these methods on high resolution particle tracking experiments that offer access to the complete velocity gradient tensor and fluid density in the Lagrangian frame. Our main objectives are to develop an objective Lagrangian coherent structure detection method for superstructures and to apply it to experimental particle tracking and numerical simulation data to elucidate how these structures determine global transport in stratified turbulence. The work is conducted together with colleagues from nonlinear dynamical systems, experimental and computational fluid dynamics.