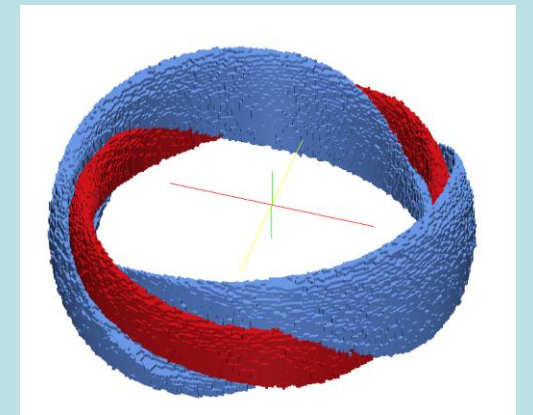
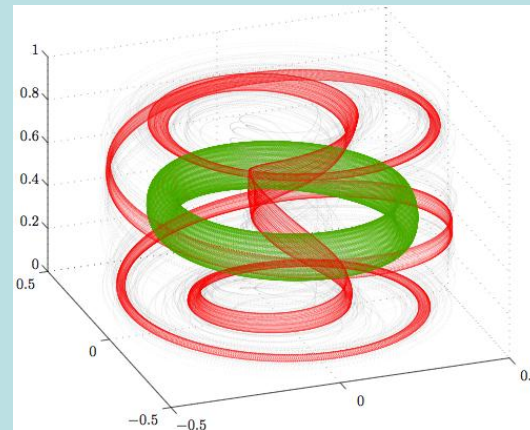
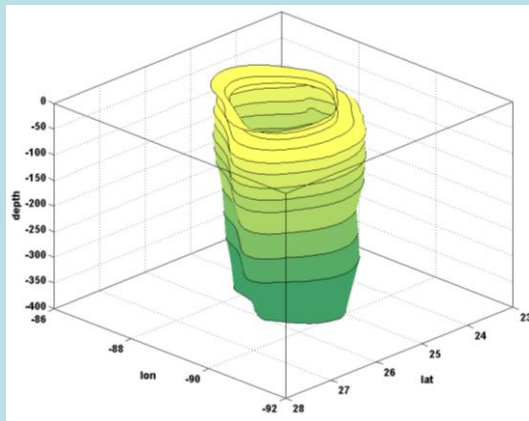
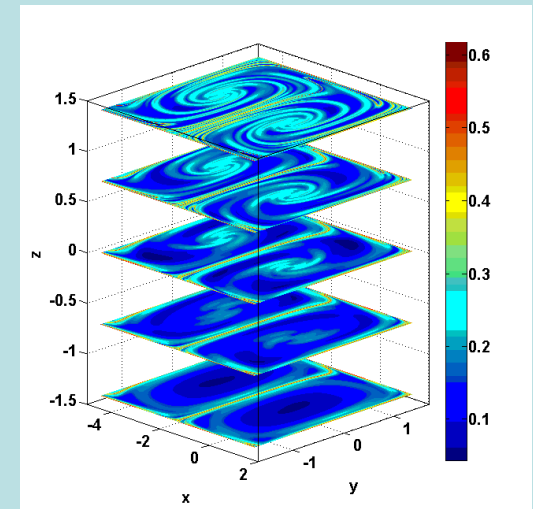
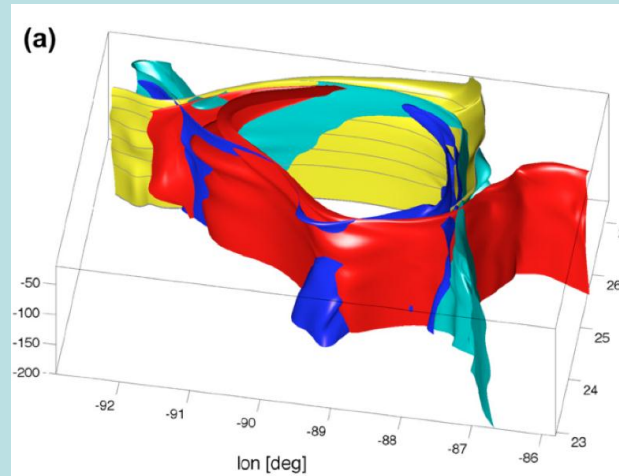
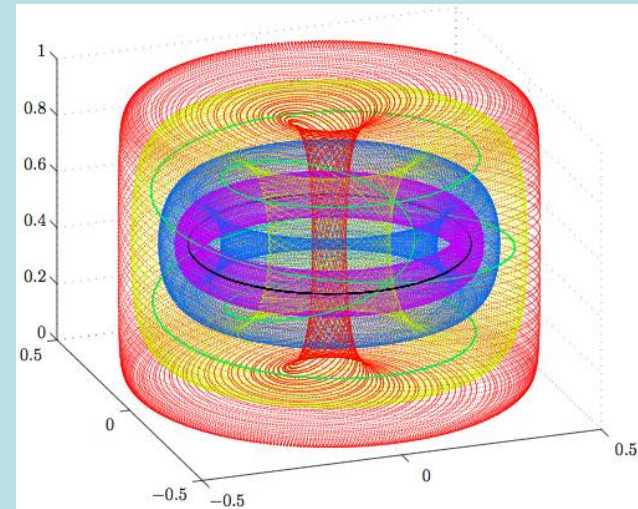
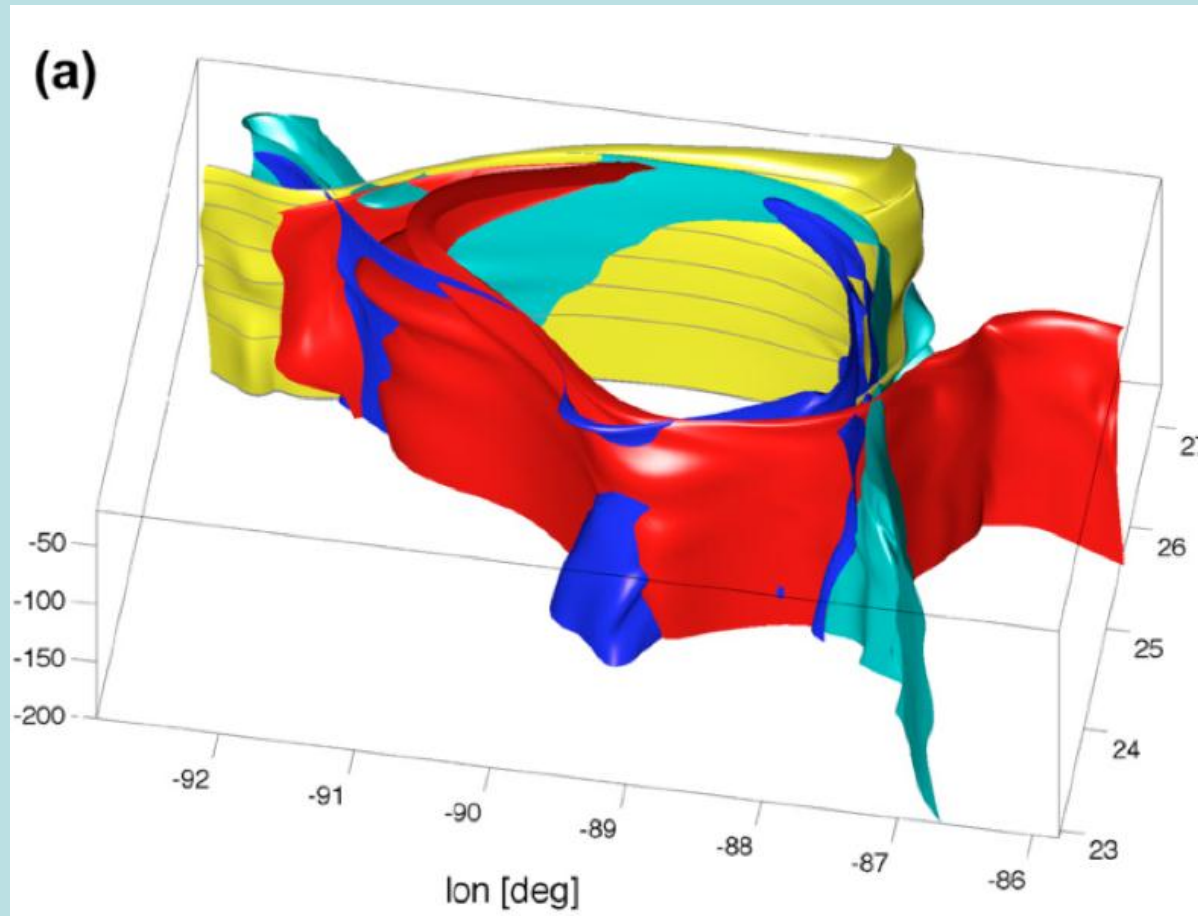


Lagrangian Coherent Structures in 3D+1.

Simple models suggest that mixing within ocean jets, fronts, and eddies may be delimited by barriers that travel and evolve in time. The terms ‘manifolds’ and ‘Lagrangian coherent structures’ (or LCS) are sometimes applied these surfaces. Although mixing may be strong away from the barriers, it is difficult for temperature, salinity, and biological quantities to be transported across them.

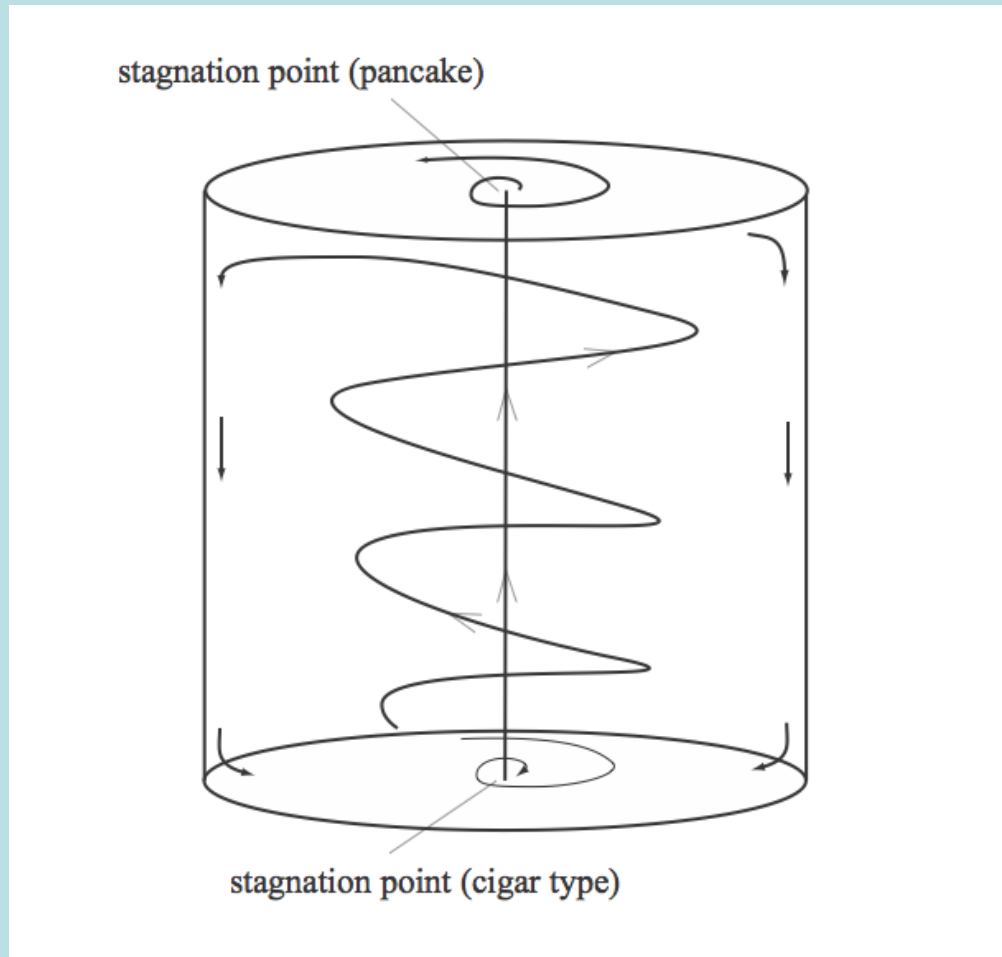


Gulf of Mexico Loop Current Ring



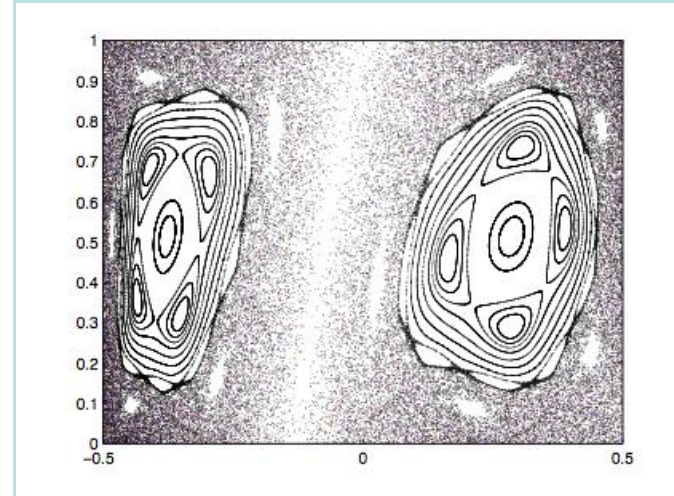
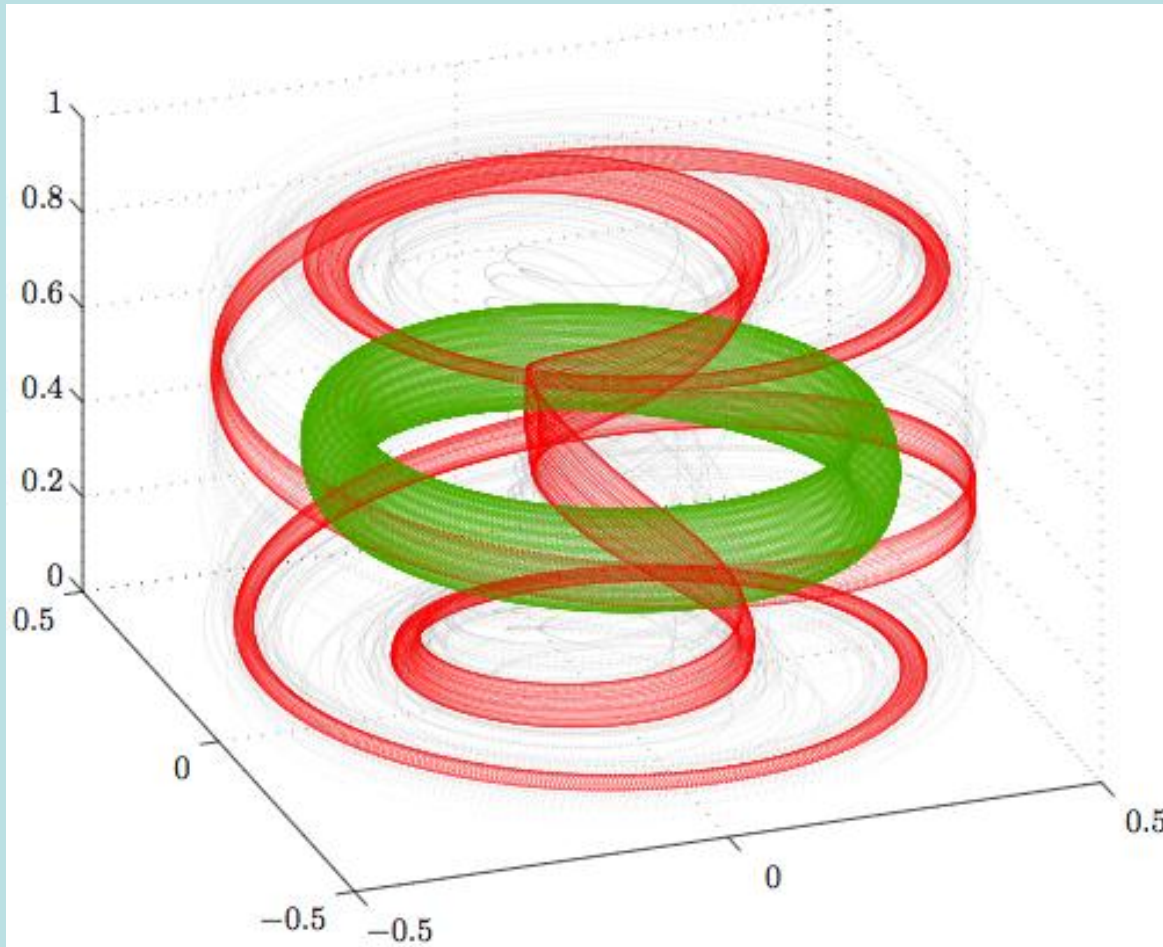
Manifolds can also control fluid exchange between an eddy, here a Gulf of Mexico Loop Current ring, and its surroundings. The blobs of fluid trapped between the colored surfaces (stable and unstable manifolds) are being transported into or out of the ring. (Branicki and Kirwan, 2010.)

Model of 3D Circulation in an Ocean Eddy



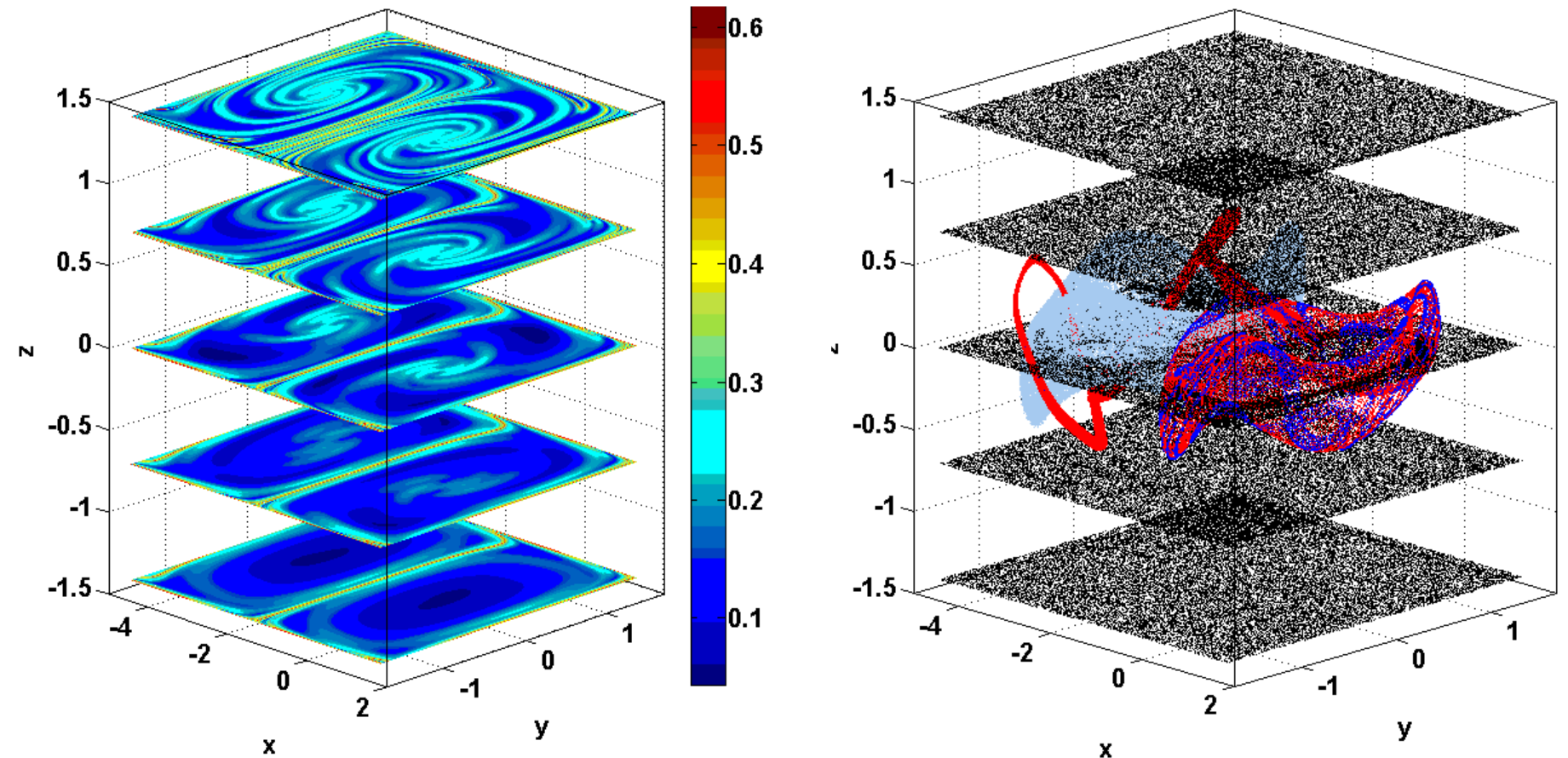
The swirling, overturning circulation observed in ocean eddies can be modeled in a rotating cylinder driven by a stress at the top surface. (Pratt and Rypina)

Barriers and Chaos in the Rotating Cylinder



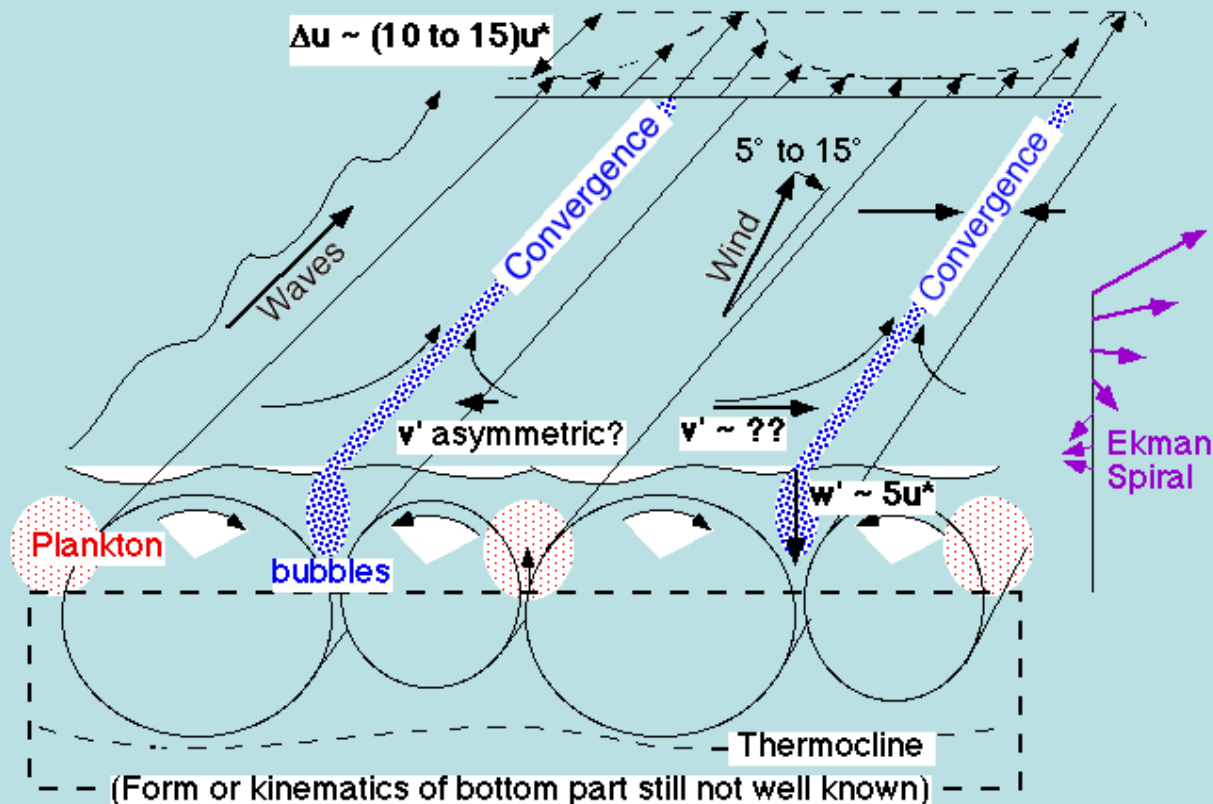
Fluid trajectories in the rotating cylinder model stay on the colored toroidal barriers and do not mix with surroundings. Other regions of the eddy have chaotic trajectories that roam over large volumes of the eddy and lead to rapid mixing. These trajectories occupy the cloudy regions in the cross section (Poincaré map) at the right. (Pratt and Rypina)

Twin Eddies



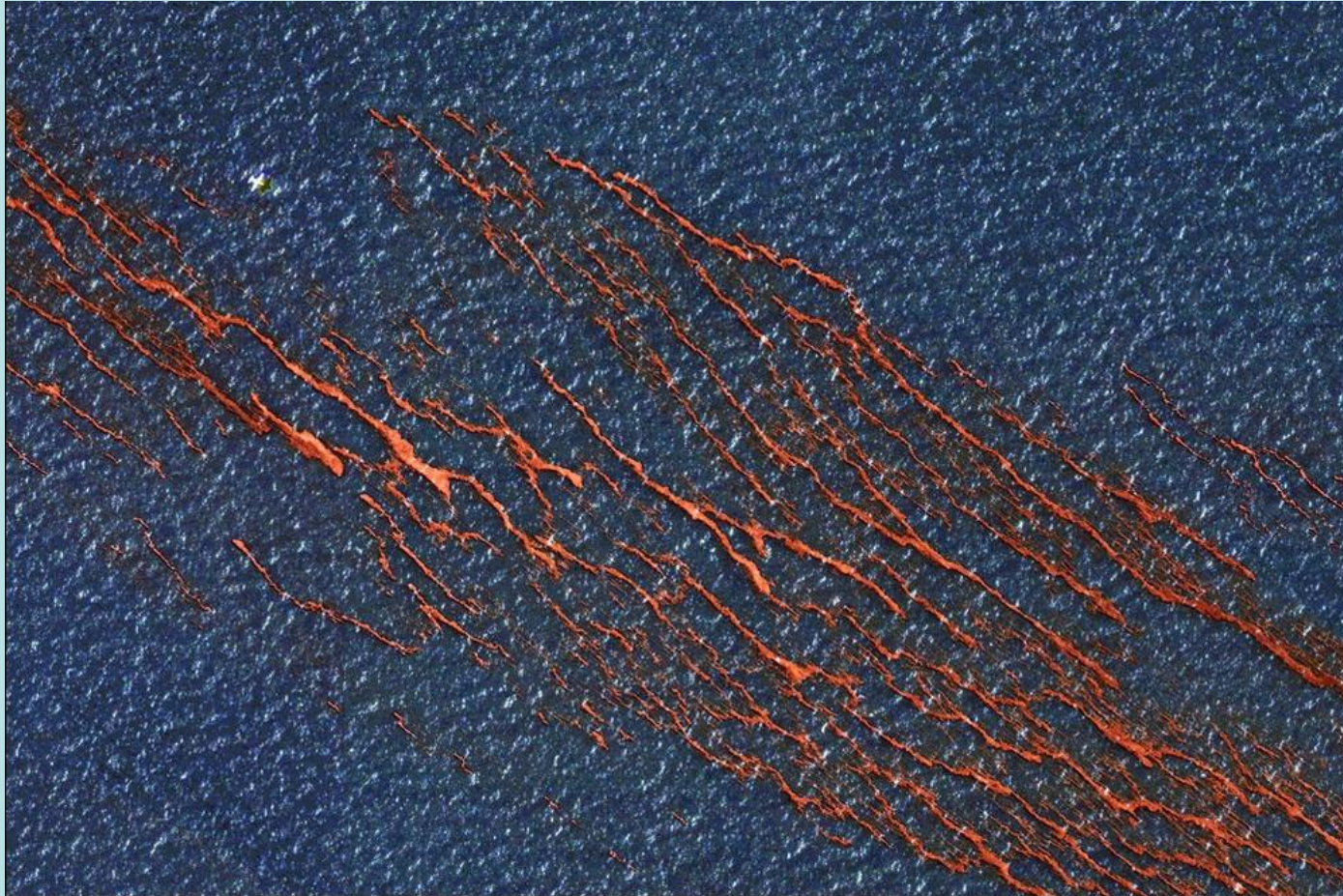
Two eddies, side-by-side, give rise to even more complicated Lagrangian coherent structures (colored surfaces at left). (R. Chabreyrie)

Langmuir Cells



These cells are just one example of an ocean feature that is three-dimensional in space and varying with time. One of the objectives of our MURI is to map out barriers within these and other organized structures.

Langmuir cells and the BP Oil Spill



Langmuir cells are seen all over the world. These surface oil slicks generated by the Deep Horizon oil spill were aligned into long filaments by Langmuir cells. (source: npr.org)