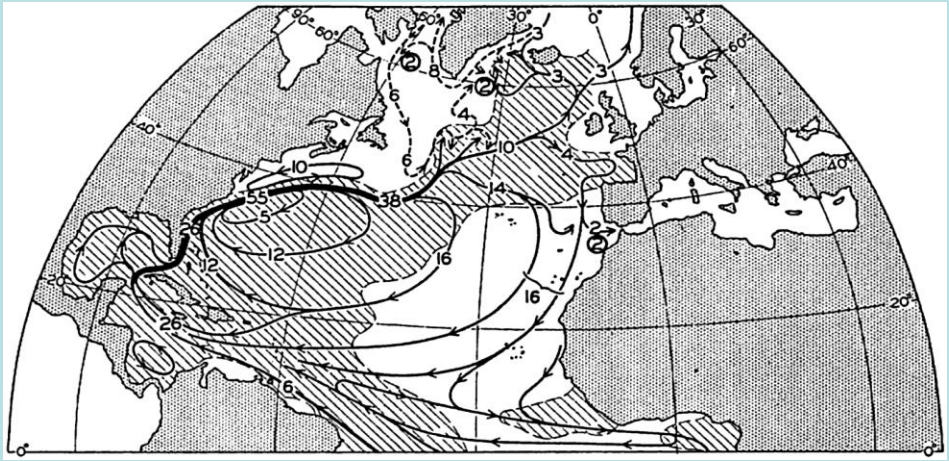
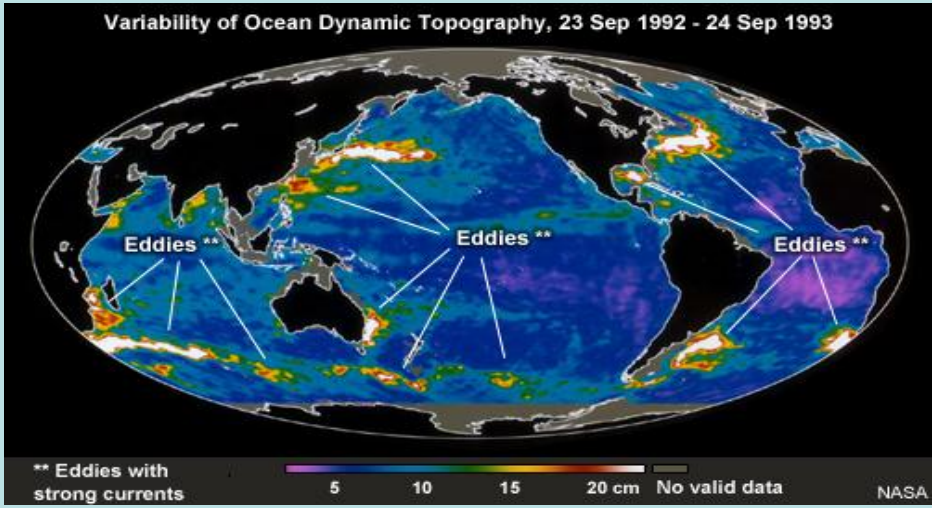
Coherent oceanic features

The discovery of vigorous motion at the oceanic mesoscale in the 1970s changed the oceanographic community's picture of the ocean as a slowly-evolving gradual feature. Prominent features are fronts, eddies, rings, which have a strong impact on the distribution of chemicals, nutrients and heat in the ocean.



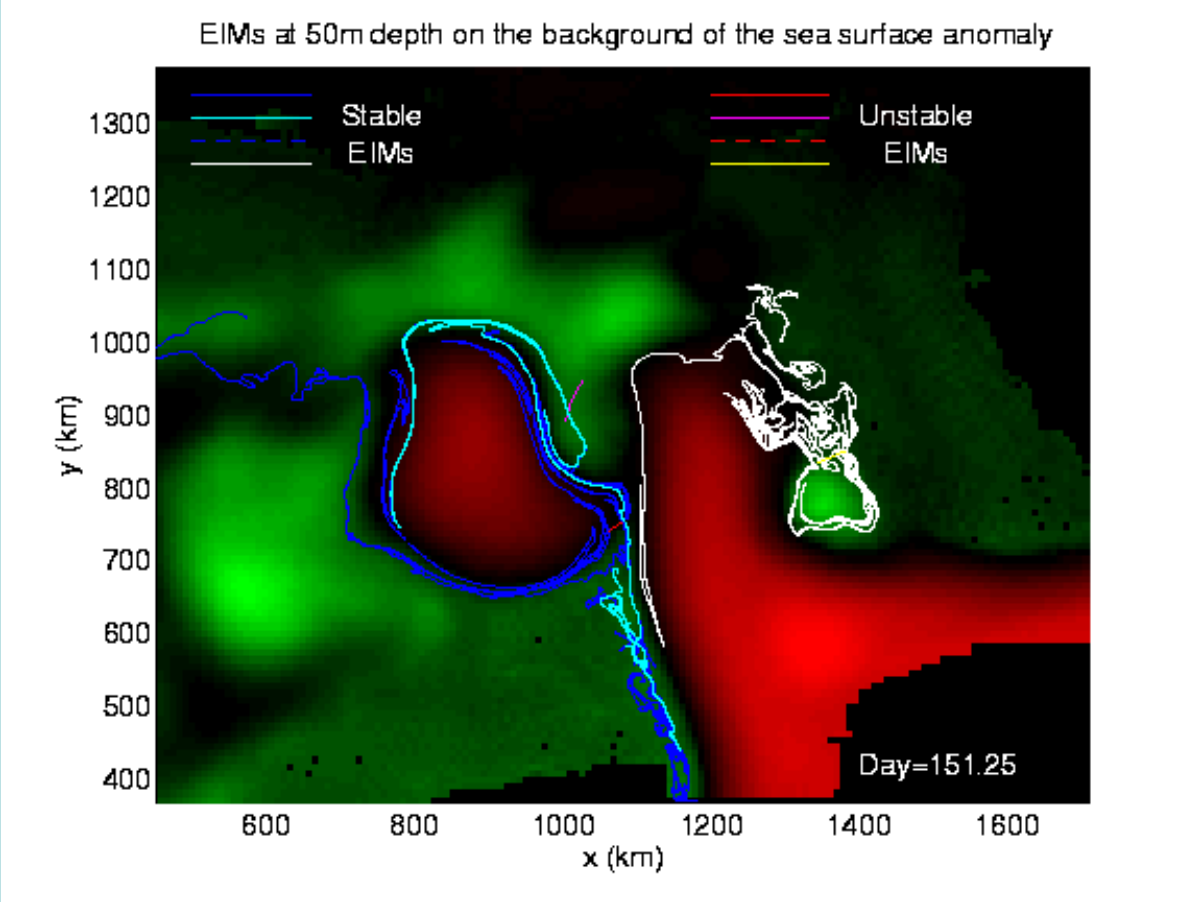
A pre-mesoscale picture of ocean circulation.
(Sverdrup, Johnson and Fleming, 1942.)



Satellite altimetry picture showing regions of strong activity. (eumetsat Jason-2 page.)

These features are long-lived and have stronger velocities than the water around them. They are reminiscent of what are called Lagrangian Coherent Stuctures (LCS) in the theory of dynamics systems, that are known to control transport in two-dimensional flows. In what follows we give examples of such features in the ocean.

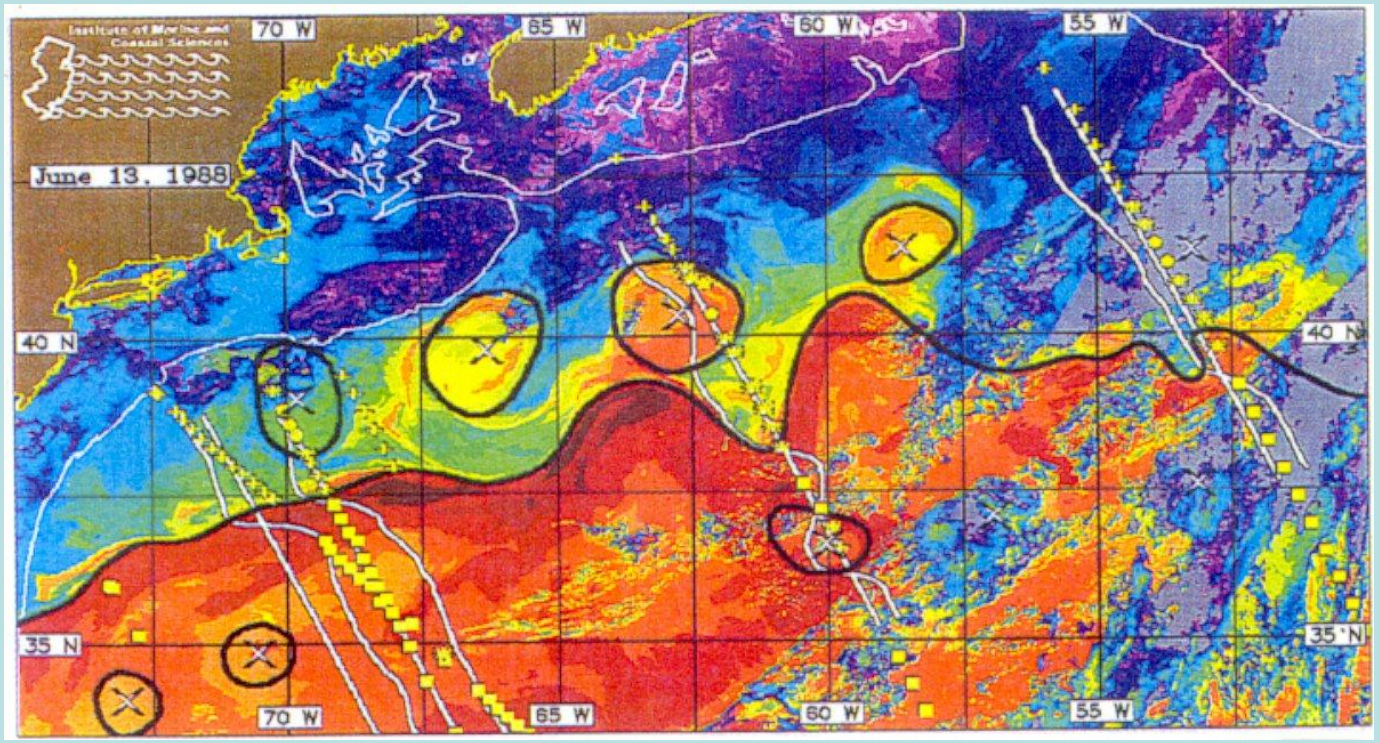
Gulf of Mexico Loop Current Ring



Exchange between ring and surroundings (the Gulf coast of Florida is visible at the right of the picture). The numerical calculation is based on the theory of LCS. (Kuznetsov, Jones, Toner, Kirwan, Kantha and Choi.)

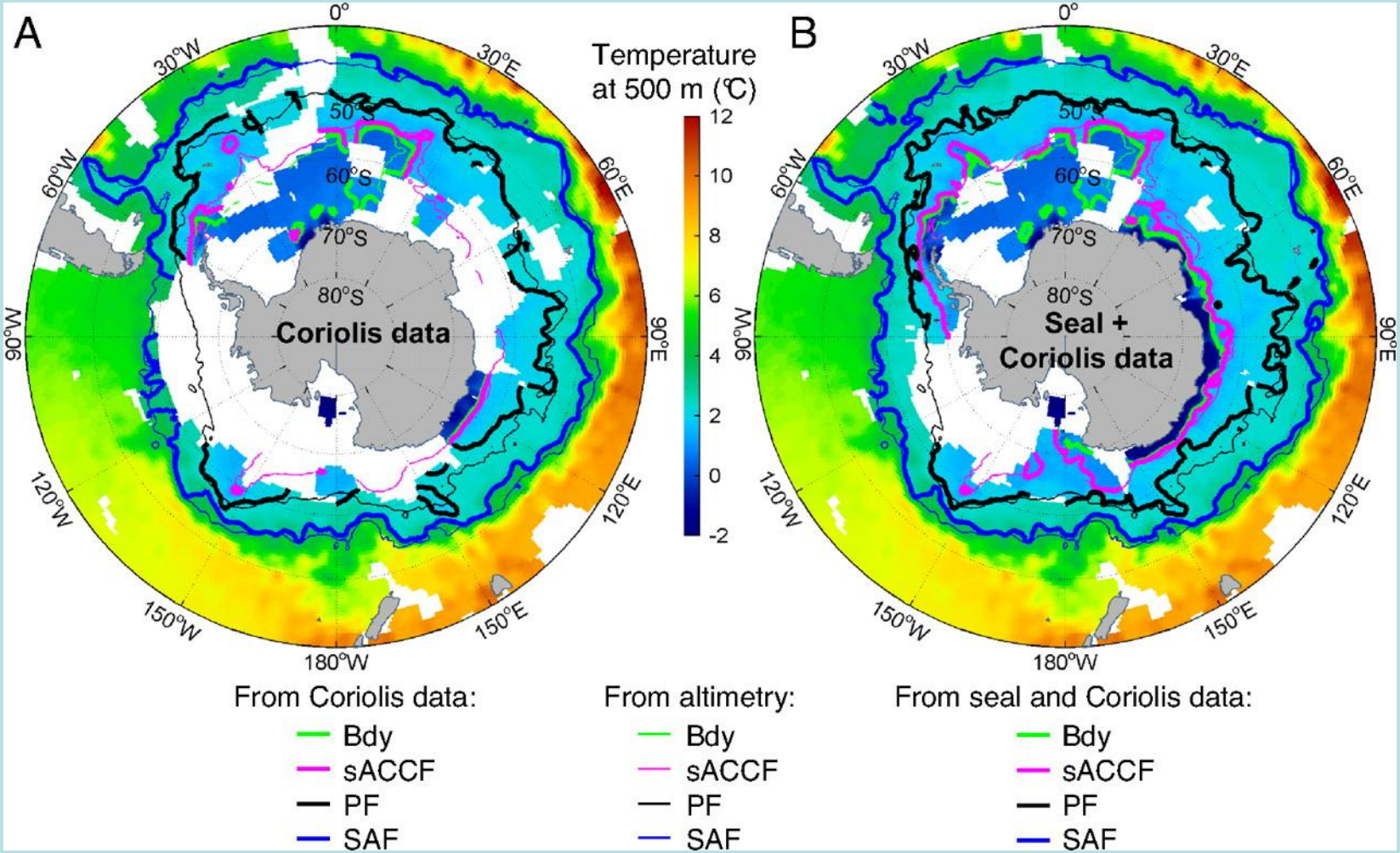
The Gulf Stream: eddies and fronts

The Gulf Stream separates water masses with different properties. Gulf Stream Rings are shed by the current and can survive for extended durations, trapping water of different properties. The idea of the Gulf Stream as a Barrier to Mixing (or a Blender) has had a strong impact on ideas of transport in the ocean.



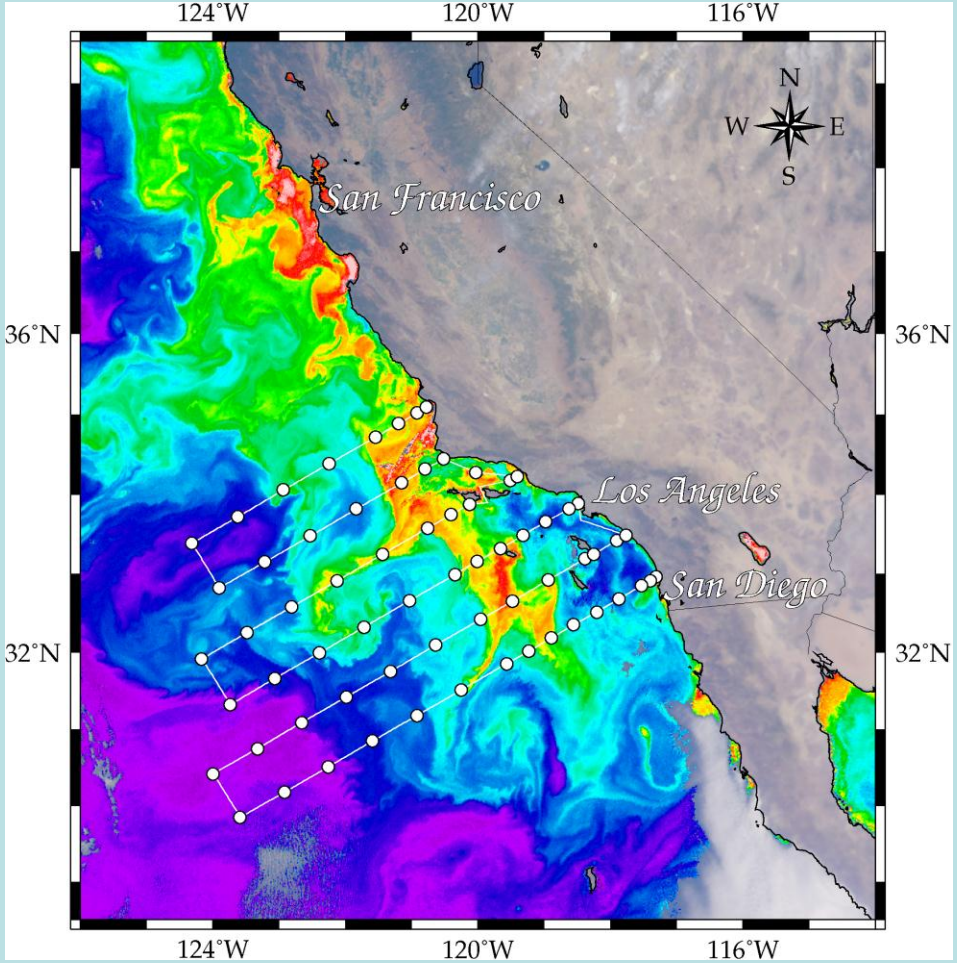
Composite remote sensing/in-situ data set and the locations of the Gulf Stream North Wall and rings for June 13, 1988. (From Paola Rizzoli's project Modeling of the oceanic circulation.)

Temperature field at 500 m during 2004–2005 from the Coriolis database and from the merged Coriolis and elephant seal databases.



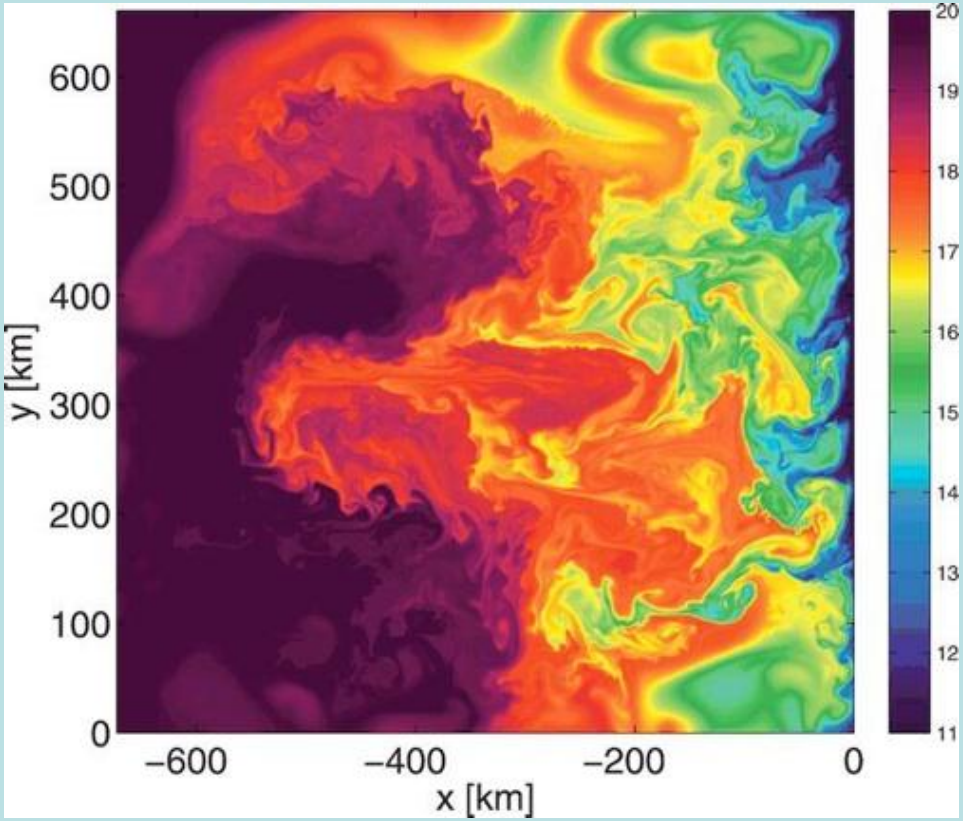
Charrassin J et al. PNAS 2008;105:11634-11639

Southern California Bight



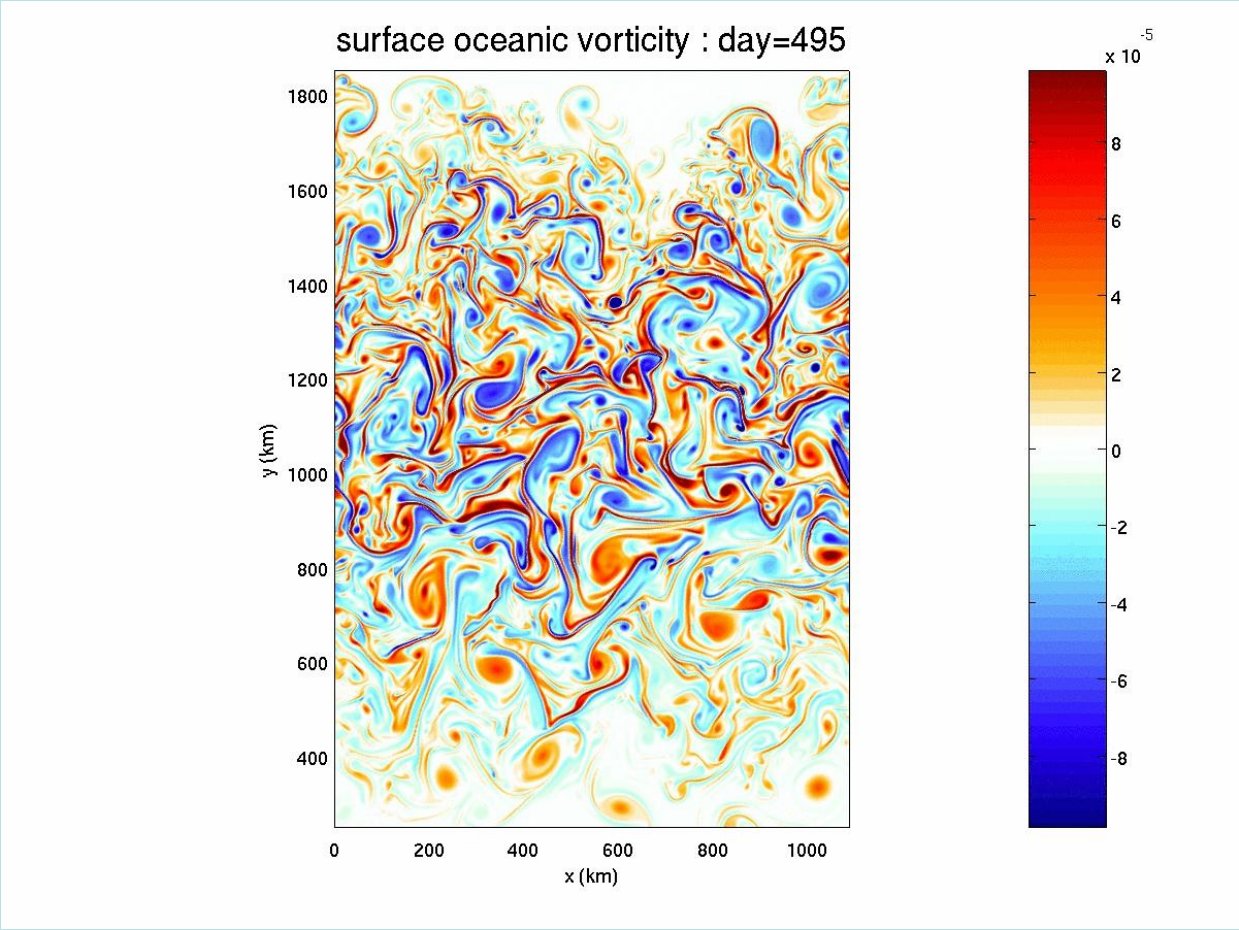
Satellite ocean color image illustrating elevated phytoplankton concentrations close to the coastal boundary, highlighting mesoscale spatial structure. (From http://cce.lternet.edu/data/maps.php.)

The submesoscale



There is now increasing evidence of vigorous motion at scales smaller than the Rossby radius. The governing dynamics are no longer balanced and non-hydrostatic, three-dimensional effects are now important. One of the goals of the MURI is to understand such effects. (Picture from the Sub-mesoscale Dynamics in Eddying Flow Regimes project.)

Idealized submesoscale numerical simulation



High-resolution simulations show front dynamics with important vertical velocities. (Presentation by Patrice Klein at Ocean Surface Topography Science Team 2011 meeting.)