MESOSCALE OCEANOGRAPHY

Instructors: Igor Kamenkovich and Arthur Mariano, with other contributions (guest lectures)

The course will present a current view of our understanding of ocean mesoscale variability, including its properties in different oceanic regimes, the dynamics governing its origin and development, and its overall role in the oceans and climate. Lectures will present material covering theory, observations (both *in situ* and satellite), and numerical model results. Students will learn basic concepts on ocean mesoscale processes and perspectives on current research topics from lectures, assignments and research papers.

Topics:

1. Introduction: What is the oceanic mesoscale?
- General properties (definition, scales, distribution and properties)
- Measurements and observational capabilities
- Comparison of the atmosphere and ocean

2. Dynamical considerations
- Creation of the mesoscale: Linear instability theory
- Nonlinear regime (turbulence and energy transformation, interactions with large-scale and submesoscale currents)
- Coherent features (vortex stability and interactions, effects of topography)
- Lagrangian perspective
- Eddy transport (turbulent diffusion, Transformed Eulerian mean, parameterization in models)

3. How we learn about the mesoscale: Observations and models
- *In situ* observations (ship surveys, Lagrangian methods, sections)
- Remote sensing (temperature, chlorophyll, altimetry)
- Numerical models (idealized and comprehensive, eddy-permitting vs. eddy-resolving)

4. Regional characterization
- Geographical distribution (high-latitudes, mid-latitudes, tropics)
- Vertical distribution (surface, thermocline, deep ocean)
- Current systems (western and eastern boundary currents, recirculation gyres, Agulhas system, Antarctic Circumpolar Current (ACC), coastal zones, Arctic, marginal seas)

5. Importance of the mesoscale
- Mean stratification and circulation (mid-latitude thermocline, ACC, zonal jets)
- Biogeochemistry (transport and “pumping” of nutrients, ventilation of the deep ocean)
- Biology and fisheries (upwelling systems, fish habitat)
- Pollutants: Lessons from the Deepwater Horizon disaster
- Climate (response of ACC to winds, distribution of heat anomalies and carbon, sea ice)