Scientific Background

- **Particulate Organic Matter (POM)** produced in the mixed layer is composed of a wide range of particle sizes and sinking velocities (10 - 1000 m/day). Small particles (i.e. slow sinking) tend to be the most abundant.

- The flow field in the mixed layer is expected to have a greater impact on smaller particle size classes, which spend more time in the mixed layer due to slower sinking speeds, resulting into a sorting effect on the particle size spectrum.

- Submesoscale features ($O(0.1-10)$ km) play an important role in driving the flow field in the mixed layer:
  - In the horizontal, submesoscale features are associated with strong vorticity and strain rates that enhance mixing and stirring, generating "hot spots" of POM.
  - In the vertical, submesoscale features are associated with large vertical velocities ($O(10^{-3}$ m/s)) capable of subducting patches of POM below the mixed layer.

Research Objectives

**Export of POM**

- Develop a mechanistic and predictive understanding of the export of POM to depth as a function of:
  1. the spatio-temporal variability in the production of particles,
  2. a range of particles with a spectrum of sizes, masses, and sinking velocities,
  3. the physical setting comprising mixed layer depth, stratification, presence of fronts and eddies, air-sea fluxes, and the flow field.

- This will be achieved by:
  1. Developing a model for meso- and submeso-scale ocean dynamics statistically representative of ocean conditions.
  2. Seeding Lagrangian particles with a range of properties in the model to simulate POM.

**Observing System Simulation Experiments (OSSEs)**

1. Assess feasibility of statistically estimating the export flux with point measurements.
2. Test Eulerian and Lagrangian sampling strategies using virtual autonomous platforms.
3. Examine scale-up of virtual observations to represent the integrated export flux.

Data Mining and Numerical Simulations

**Model vs. Observations**

- After spin-up, the power spectral density (PSD) shows an increase at submesoscales of the order of $O(10)$ km.
- Observations show good statistical agreement between numerical simulation and glider observations.

- **Submesoscale features in PSOM**

  - Model is run for 90 days after initialization to spin-up an eddy field.
  - Filament-like features can be observed at submesoscales of the order of $O(10)$ km.
  - Submesoscale features are associated with high vorticity, suggesting large vertical velocities.

Observations

- **ARGO floats**: used to prescribe temperature and salinity gradients for model initialization.
- **Station PAPA**: Time series of wind stress and heat fluxes used for model forcing.
- **Underwater Gliders**:
  - Measured T, S, O₂, Chl F and backscatter for 18 months (2008-2010).
  - Used for tracking both seasonal cycle and spatial gradients in the region.
  - Used to validate both model physics and particle dynamics.

**Particle Tracking**

- Particles are seeds in PSOM and advected with the model flow field.
- Particles are prescribed a range of sinking velocities to simulate size spectrum.
- Slow-sinking particles are more affected by the horizontal flow.
- Physical and dynamical conditions affect the horizontal and vertical transport of particles as they are sinking.