Ocean 3D+1 Transport

Challenge: Synoptic Lagrangian observations are not feasible. We must rely on models.

Process models

Algorithm development
Relate to ocean observations

CUNY Staten Island

LES models

Full 3D dynamics
Submesoscale resolved
Limited domain size

RSMAS

Data-assimilating ocean models

3D process studies
Ring formation/multipoles

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Challenge: Ocean models are imperfect.

Initial condition and forcing uncertainties

How much Lagrangian uncertainty is captured by ensembles?

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Unreliable/missing vertical velocities

How accurate are 3D FTLE approximated with 2D velocities?

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Submesoscale is parameterized

Are submesocales represented accurately?

RSMAS

Focus for 2 Years

- Ocean Transport Barriers from Fields
  - **Koopman Operator Theory extended to realistic ocean flows – CUNY-SI, UCSB**
  - **Spectra of Tracer Fields - CUNY, UD, RSMAS**

- Multiscale Interactions
  - Barotropic mixing boundaries for large deep water structures vs baroclinic submesoscale boundaries – UD, CUNY, RSMAS
  - **Simple models accounting for vertical velocities in vortex interactions – CUNY, UCSD, WHOI, St. Andrew**
  - **Quantify roles of w, S_w and S_v (velocity gradients) near mixing boundaries – UD, CUNY, RSMAS**

- **Uncertainty in Model mixing Boundaries**
  - Comparison of z vs isopycnal LCS – CUNY, RSMAS, UD
  - Lagrangian Parameterization of Unresolved Scales – RSMAS, CUNY
  - LCS uncertainty comparisons from multi-model ensembles vs single model ensembles - UD, NRL-SSC

Technical Challenges

Tedious calculations and data management issues with 3D+1 Lagrangian analyses.

Visualization of 2D surfaces imbedded in a 3D volume crude and cumbersome.

Automated ridge detection needed for quantitative LCS comparisons.

NCOM ensemble perturbations should be modified so that most observed trajectories (not ~35%) are encompassed by the ensemble trajectory spread.

Benchmark diagnostics from Ocean 3D + 1 program.