Improved Mixed Layer Depth and Upper Ocean Structures via Turbulent Mixing Advancements

U.S. NAVAL RESEARCH LABORATORY

AT A GLANCE

What is it?

Develop and incorporate a unified upper ocean mixing parameterization into the Navy's operational ocean models by building on new theories and improving on the shortcomings of each.

How does it work?

Extensive numerical studies using Navy's HYbrid Coordinate Ocean Model (**HYCOM**); wave model **WAVEWATCH III**, and large eddy simulation (**LES**) model;

Quantify Pros and Cons of existing new theories on turbulence;

Develop/implement a unified turbulent mixing parameterization in HYCOM

Demonstration in 1D, regional and global HYCOM experiments against field observations

What will it accomplish?

Better resolving the dynamics, thermodynamics, optics, acoustic, chemistry and biology processes in the upper ocean and advance ocean predictions.

Accurate air-sea fluxes in coupled models and advance atmosphere predictions
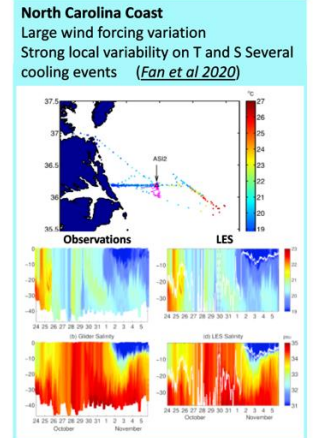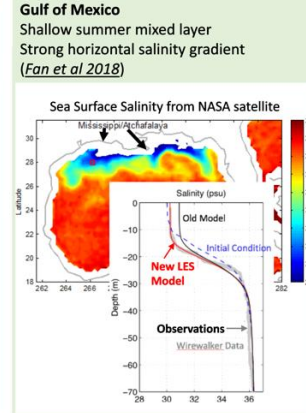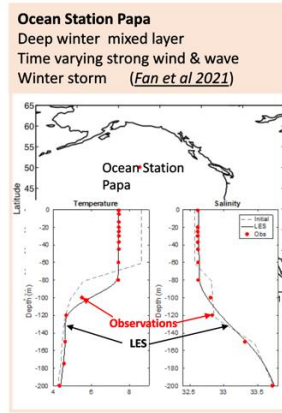
R&D Sponsor(s)

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Ocean Station Papa
Deep winter mixed layer
Time varying strong wind & wave
Winter storm (*Fan et al 2021*)

Gulf of Mexico
Shallow summer mixed layer
Strong horizontal salinity gradient
(*Fan et al 2018*)

North Carolina Coast
Large wind forcing variation
Strong local variability on T and S Several cooling events (*Fan et al 2020*)

The National Center for Atmosphere Research's LES model will be used to guide the development of the new mixing parameterization and build baseline for HYCOM evaluations. Through our 6.1 and 6.2 projects, we have expanded the LES model capability to real ocean simulations, and added the model ability to simulate interactions with submesoscale features. The new model has been applied to Ocean Station Papa, NRL field measurements in the Gulf of Mexico, and off the North Carolina Coast with a range of dynamical processes and turbulent regimes and demonstrated excellent accuracy in reproducing in situ observed transient evolution of the upper ocean structures.

Major Tasks for this project
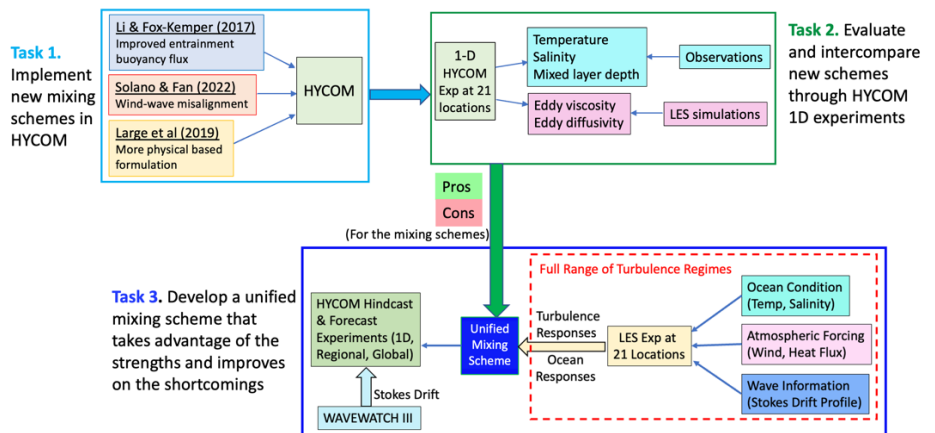
Task 1, 3 representative newly developed mixing schemes will be implemented in HYCOM and evaluated through 1D experiments at 21 locations globally. **Task 2**. Model generated T, S, MLD, and eddy viscosity/diffusivity will be evaluated through observations and LES studies. Pros and cons of each scheme will be quantified. **Task 3**. New mixing scheme will be developed based on the pros & cons, and under the guidance of LES experiments conducted across the full range of turbulence regimes. Model skill will be demonstrated HYCOM-WAVEWATCH III coupled experiments and against gliders, moored buoys, drifter buoys and satellite measurements.