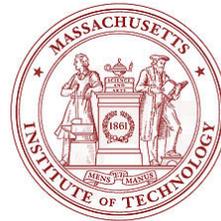


Quantifying, Predicting and Exploiting Environmental and Acoustic Fields and Uncertainties

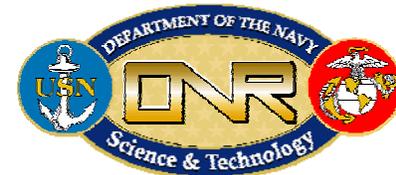
Pierre F.J. Lermusiaux et al.

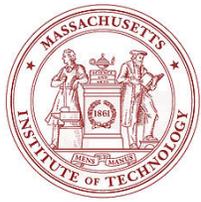
Mechanical Engineering, Ocean Science and Engineering, MIT



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1. Introduction
 2. Overall Goal
 3. Results of DRI-QPE Planning Year
 4. Proposed Research
 5. Specific Objectives

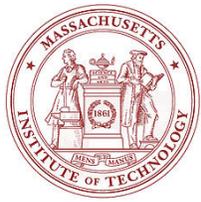
<http://mseas.mit.edu>
Taipei, March 11, 2008





INTRODUCTION – Dynamical Focus

- **Regional ocean dynamics and modeling focus**
 - Continental shelf and slope northeast of Taiwan, especially
 - Cold Dome, its dynamics, variabilities and uncertainties,
 - Impacts on low-frequency (100 to 1000Hz) acoustic propagation
 - **This dynamics is influenced by various processes that can occur simultaneously, very energetically and on multiple scales**
 - Kuroshio: western boundary current interacting with complex topography and influenced by larger-scale Pacific variability;
 - Ocean responses to atmospheric forcing including Typhoons;
 - Mesoscale and sub-mesoscale variability
 - Kuroshio's meanders and eddies, semi-permanent features (Cold Dome) and sub-mesoscale eddies, filaments and thin layers;
 - Taiwan Strait shelf jets/currents and their effects on Kuroshio intrusions;
 - finally, surface and internal tides, internal waves and solitons.
- => Uncertainties!



INTRODUCTION – Methods Focus

- **Methods and schemes will be generic, but driven by regional dynamics**
- **Methodological research**
 - New scientific computations and sensitivity studies;
 - Predictability quantification using ESSE;
 - Multiply nested high-resolution ocean and acoustic modeling;
 - Uncertainty estimation using new prognostic equations and ESSE ensembles;
 - Coupled data assimilation and model improvements;
 - Observation system simulations and adaptive sampling to exploit uncertainties;
 - End-to-end multi-model systems
 - Real-time uncertainty prediction and exploitation

Overall Goal

Better understand, model, forecast and exploit environmental and acoustic fields and uncertainties for efficient sonar operations

and research, integrate and demonstrate concepts for end-to-end prediction and DA systems to do so

Results of DRI-QPE Planning Year

Mesoscale Modeling and Taiwan Straits/Kuroshio effects

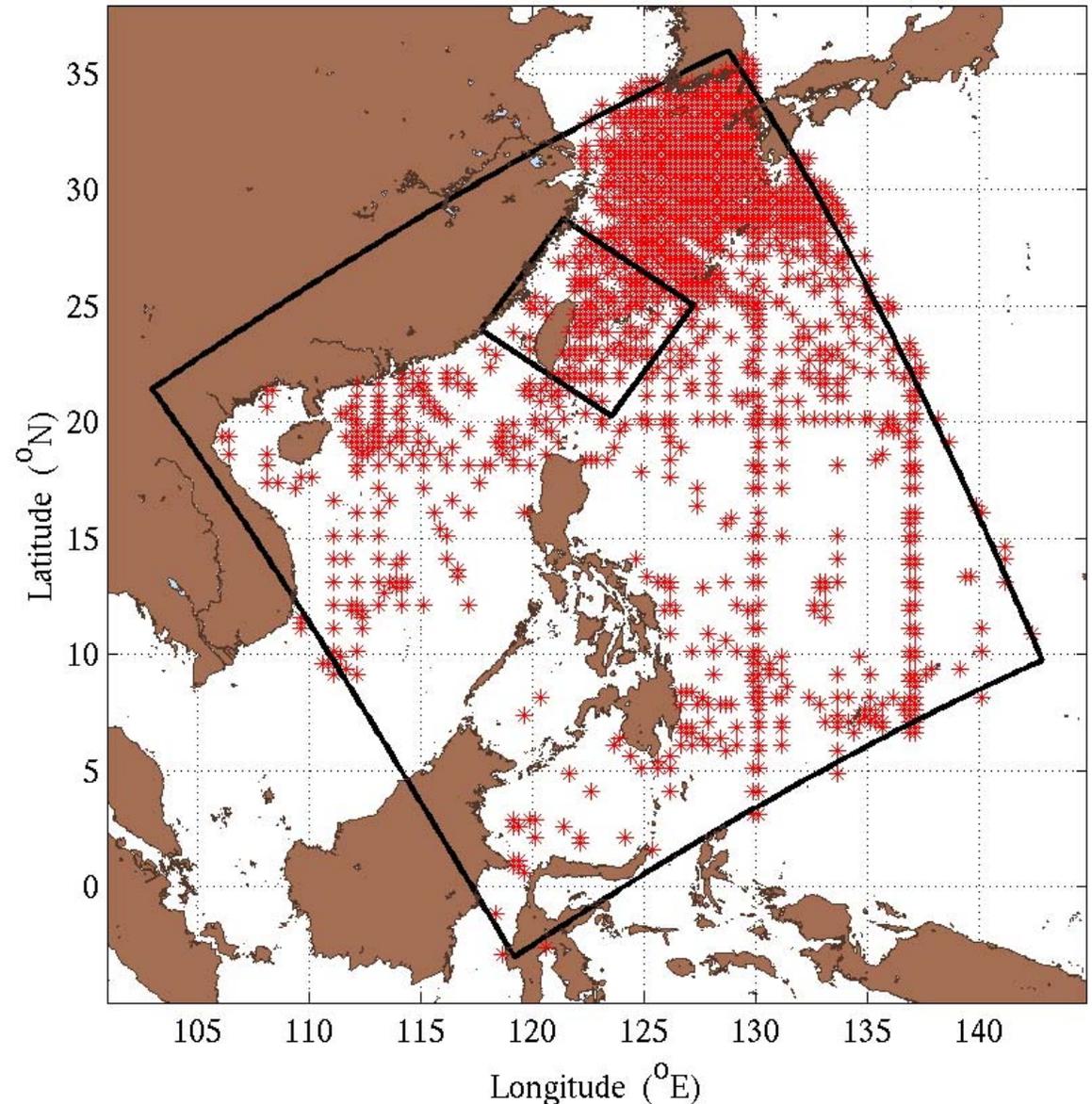
Summer, HydroBase2, 1/4deg, 3pt min

Lermusiaux and Haley

What controls the cold dome north of Taiwan?

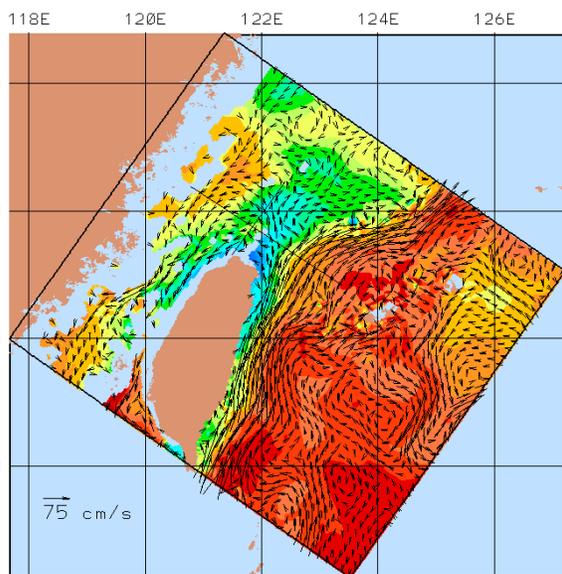
Where to sample and to locate moorings?

Position of hydrographic profiles used to build a climatology (with HydroBase and LOC software)



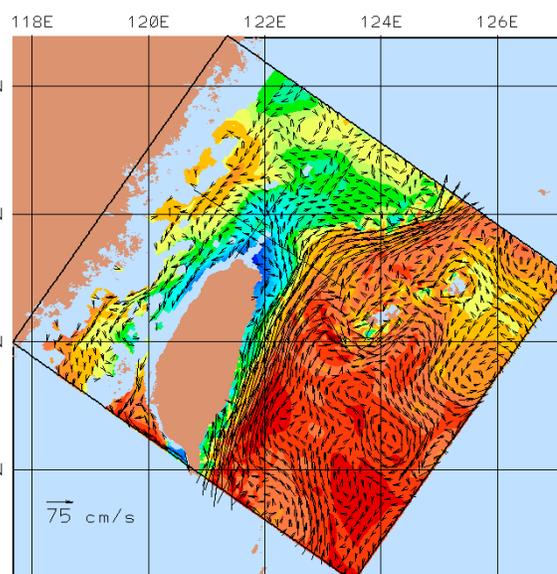
Temperature at 50m, **No/Weak** Taiwan Strait Northward Flow

50m Temperature (C)



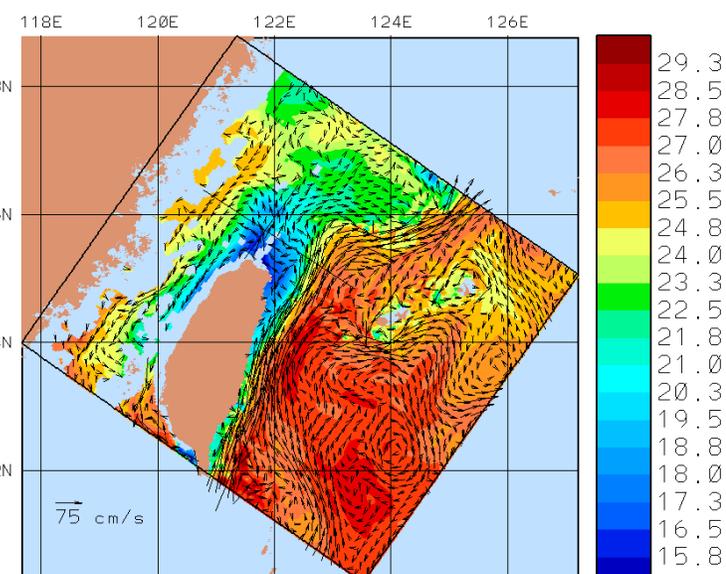
0:00:00Z 19 Jul 2007

50m Temperature (C)



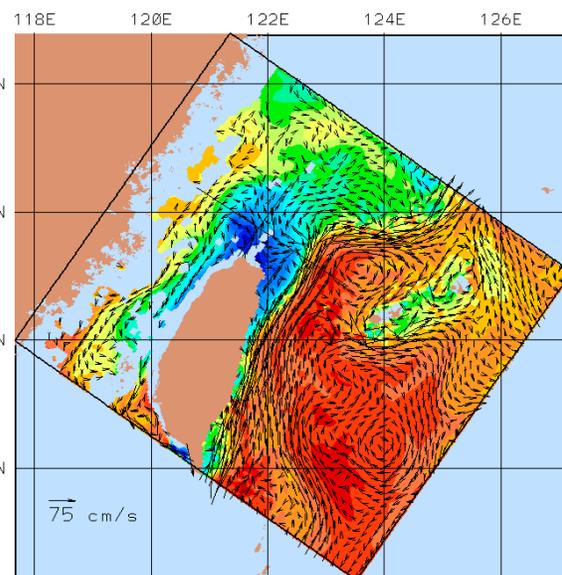
0:00:00Z 21 Jul 2007

50m Temperature (C)



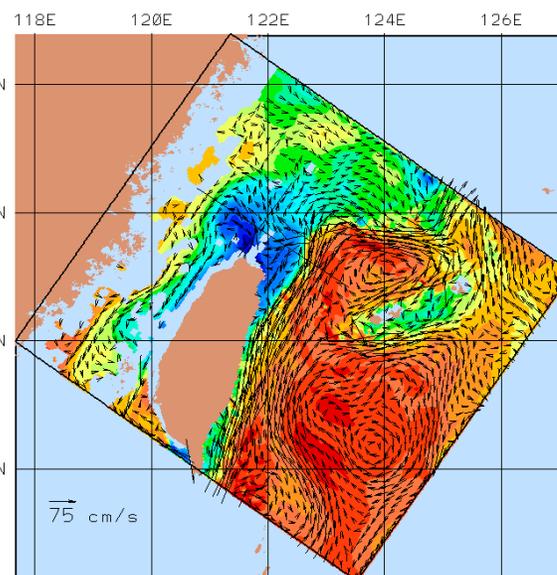
0:00:00Z 23 Jul 2007

50m Temperature (C)



0:00:00Z 25 Jul 2007

50m Temperature (C)



0:00:00Z 27 Jul 2007

Cold Dome forms

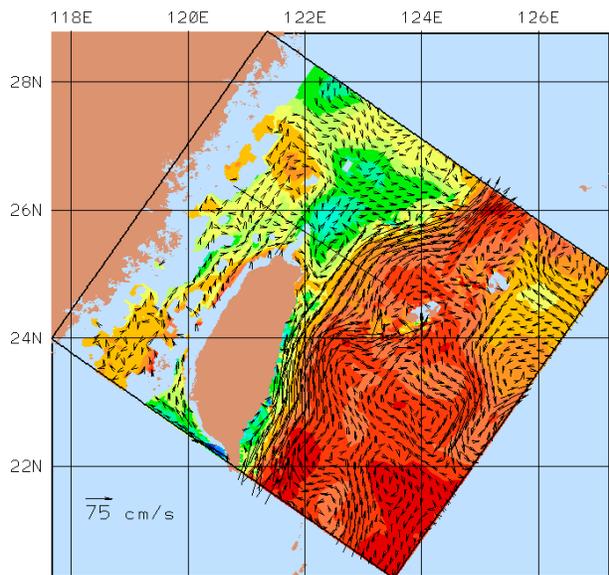
Ageostrophic effect of Jet
above topography and
with no shelf support

Vertical upwelling cell

Intrusion

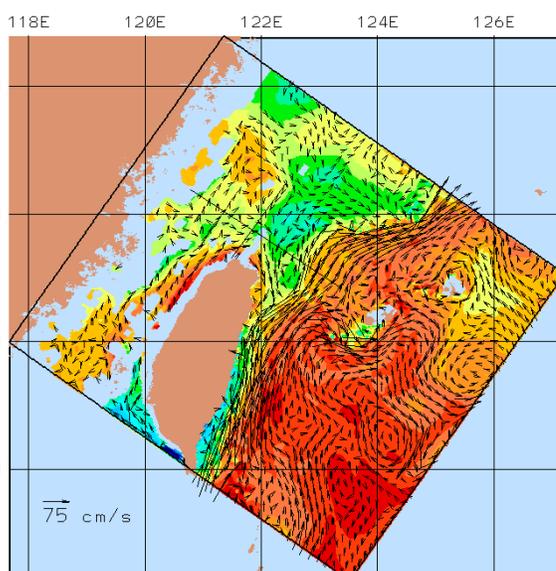
Temperature at 50m, 1Sv Taiwan Strait Northward Flow

50m Temperature (C)



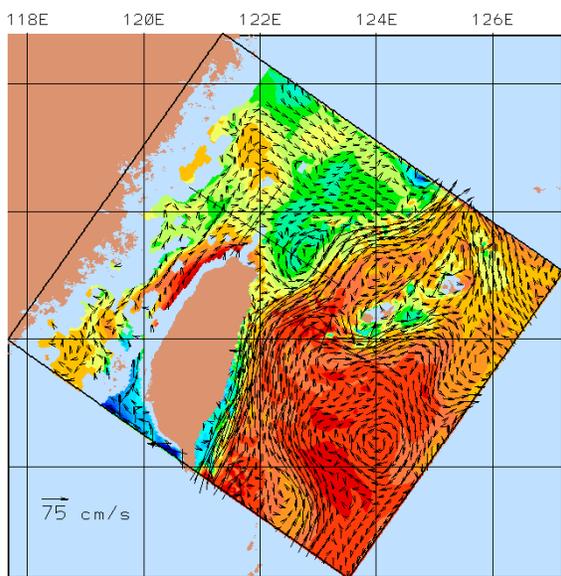
0:00:00Z 19 Jul 2007

50m Temperature (C)

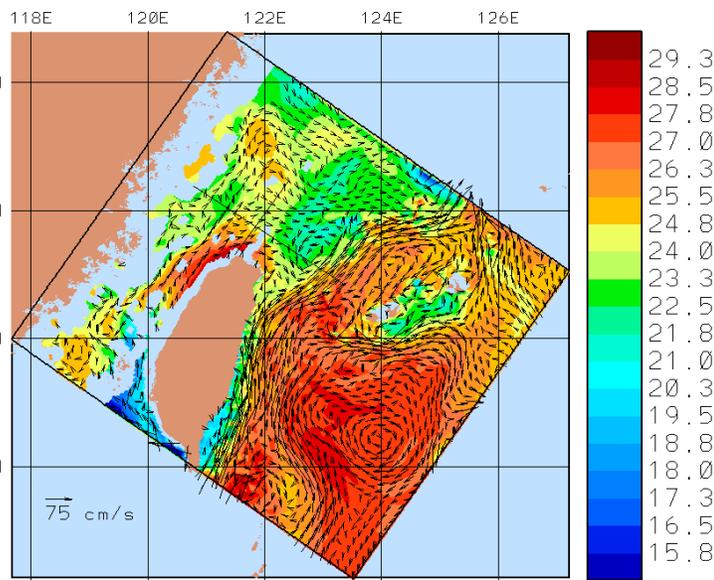


50m Temperature (C)

0:00:00Z 23 Jul 2007



0:00:00Z 25 Jul 2007



0:00:00Z 27 Jul 2007

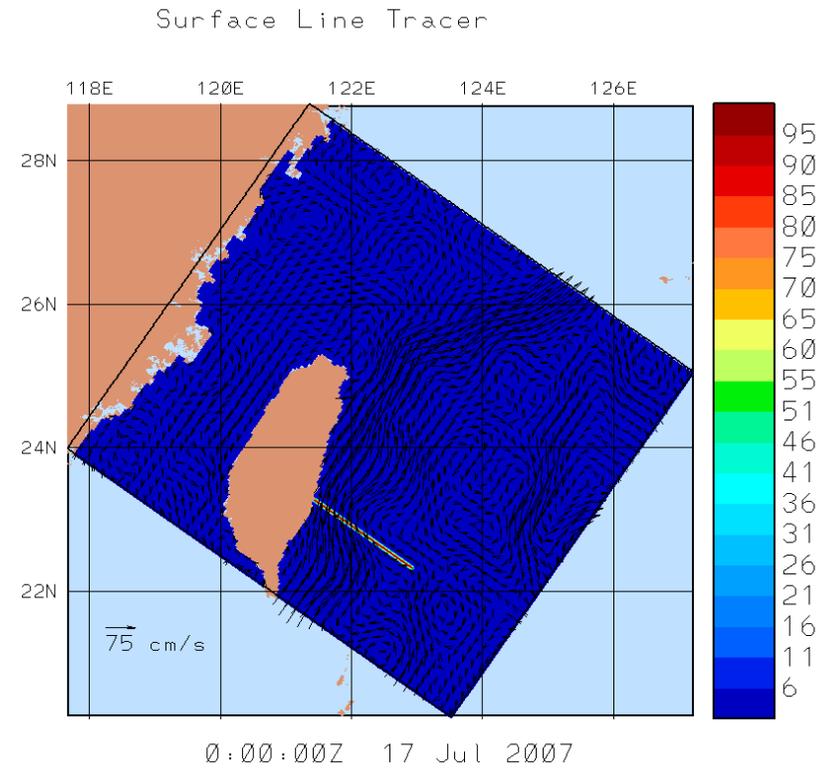
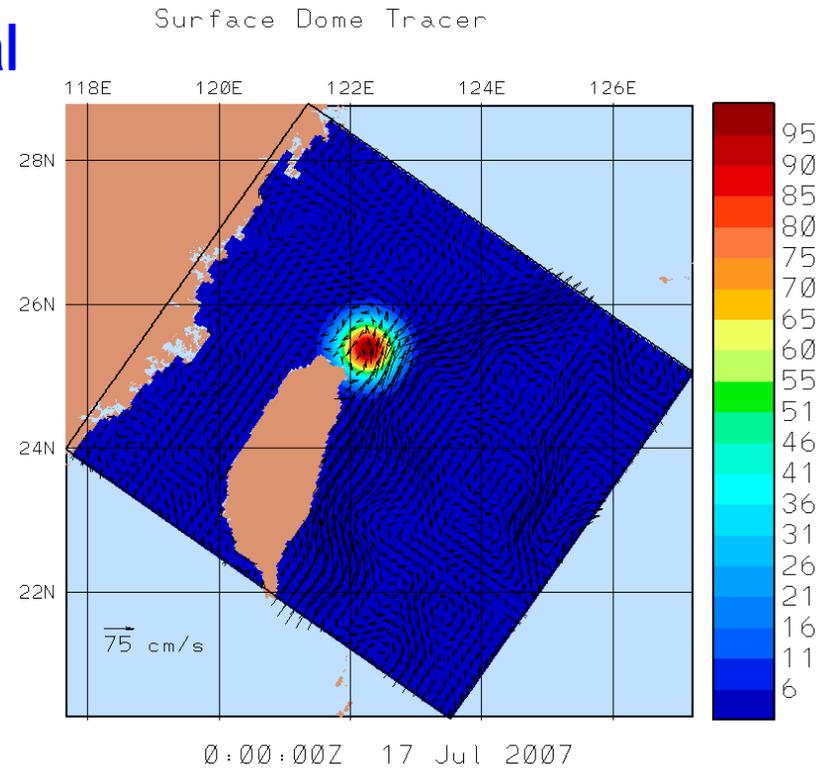
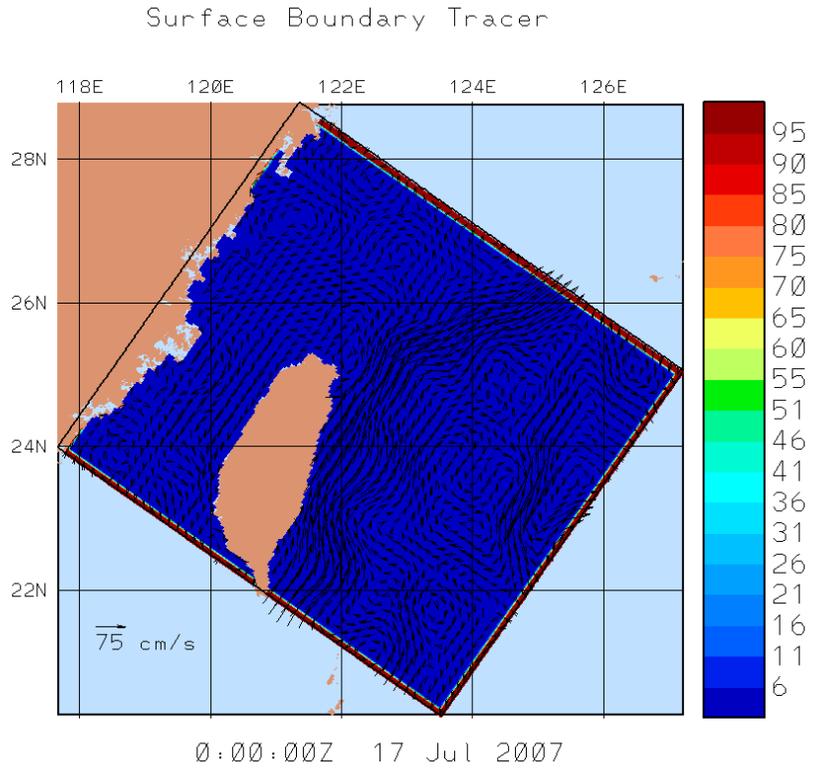
Eddies (Cyclonic) form and are advected

Limited Kuroshio Intrusion

OSSEs: Impacts of Open Boundary, Local (Dome) and Remote (Kuroshio) Measurements

“Fake Tracer” Simulations

- “ 5 days ” Taiwan tracer scale
- Cross-Kuroshio and OBC data key for predictions



For Ren-Chieh Lien (UW), also estimated ideal locations of moorings and the influence of their data near the Mien Hwa Canyon, see:

http://modelseas.mit.edu/Research/QPE/Lien_mooring_loc/index.html

Proposed Research (collaborative)

1. Ocean Dynamics, Features and Predictability

- Main focus: Cold Dome and its interactions with other features.
- Some dynamical questions in which we are interested include:
 - Is the Mien-Hwa Canyon the inflow route to the Cold Dome?
 - Does the transport in the Taiwan Strait control the formation of the Cold Dome, as our simulations initialized from mean historical conditions indicate?
 - If the Cold Dome is permanent, what controls it and makes it permanent (creation, maintenance and decay)?
 - What is the variability (time/space scales) of the Cold Dome and what are its structures?
- Scientific computations and sensitivity studies
- Predictability studies

Proposed Research (collaborative)

2. Realistic Ocean and Acoustic Modeling

- Ocean Modeling (Nested, multi-models)
- Barotropic Tidal Modeling
- Acoustic Modeling (NPS, RAM, C-Snap; 2-3D)

3. Uncertainty Estimation and Reduction by Data Assimilation and Model Improvements

- Uncertainty Modeling and Predictions via ESSE
- New Uncertainty Prognostic Equations
- Coupled Data Assimilation via ESSE
- Measurement Uncertainties and Models
- Towards Integrated Acoustic-Environmental Model Evaluations and Adaptive Model Improvements

Proposed Research (collaborative)

4. **Observation System Design and Adaptive Sampling to Exploit Uncertainties**
 - OSSEs
 - Adaptive Sampling
5. **End-to-end Multi-Model and Data Assimilation Systems**
6. **Collaborations**
7. **Real-time Modeling**