# A Modeling Study of Interannual Variability of Bay of Bengal Mixing and Barrier Layer Formation

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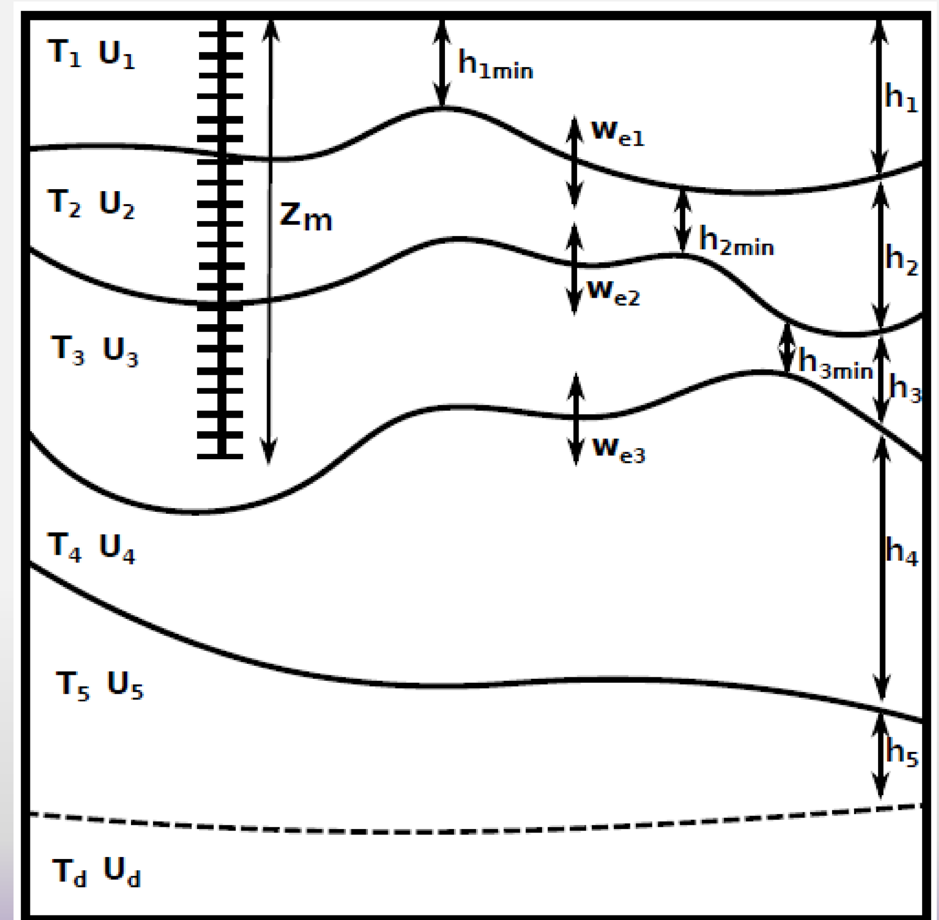
## Introduction

Bay of Bengal (BoB) is a semi-enclosed oceanic basin of tropical Indian Ocean having immense influence on the evolution of Asian monsoon. The surface oceanographic features of the BoB are warm SST and extremely low salinity ➔ strong stratification. As a result the oceanic mixed layer depth (MLD) of the bay is generally shallow and requires substantial amount of energy from atmosphere to accelerate the mixing. Often the mixed layer is so shallow that solar insolation is lost beneath the mixed layer, forming barrier layer (BL).

Since the SST in BoB is close to the threshold value necessary for atmospheric convection, even a subtle change in the MLD and BL can be crucial to monsoon prediction and other interannual events. This is an attempt to investigate the reason for weak interannual variability of BoB MLD as compared to its seasonal cycle from observations and a simple ocean general circulation model.

## Model Details




- Dynamic core is reduced gravity model, modified with thermodynamic terms.
- It incorporates a fine vertical mixing module, penetrating first few layers at very high resolution.
- At each time step the tendency due to mixing (both tracer and momentum) are updated to dynamic model.
- Large scale dynamics advects the MLM horizontally and vertically.

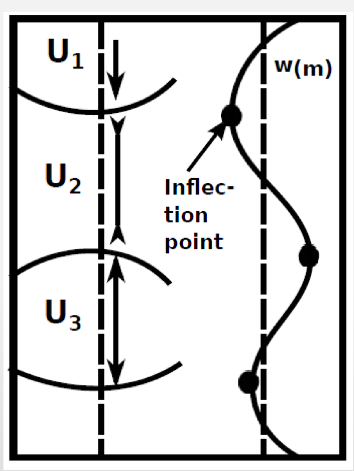
## Model configuration

### Model details

Free surface term; Overhead pressure term; Dynamic height term

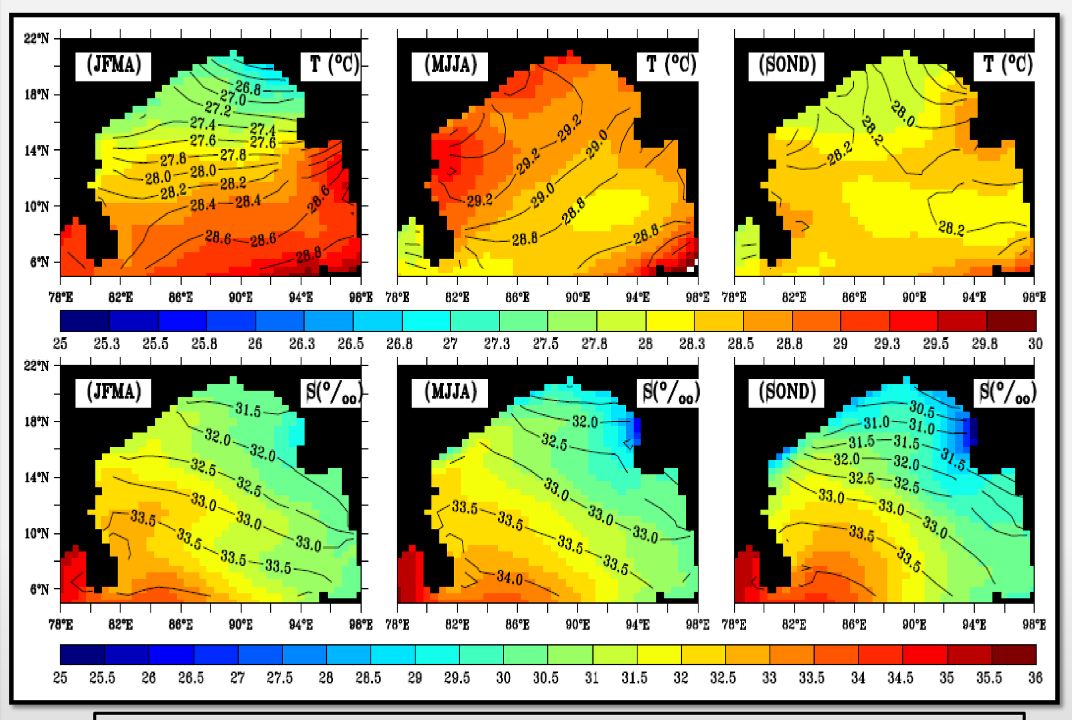
$$\nabla P = g\rho_k \Sigma_{i=1}^{N-1}\left[\frac{\rho_N-\rho_i}{\rho_N}\right]\nabla H^i - g\Sigma_{i=1}^{k-1}(\rho_k-\rho_i)\nabla H^i + \rho_k g\Sigma_{i=k}^{N-1}H^i\nabla_H\left[\frac{\rho_N-\rho_i}{\rho N}\right]$$

- Vertical velocity – from convergence / divergence of layers, interpolated to MLM grids at each time step.

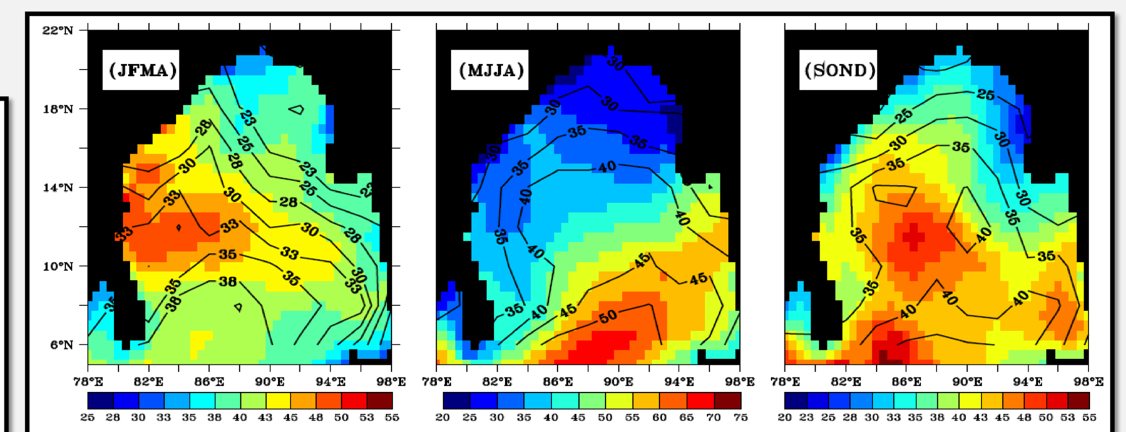



- Initial conditions – WOA-2013
- Surface forcing – CORE v2
- Model is simulated from 1950-2009.

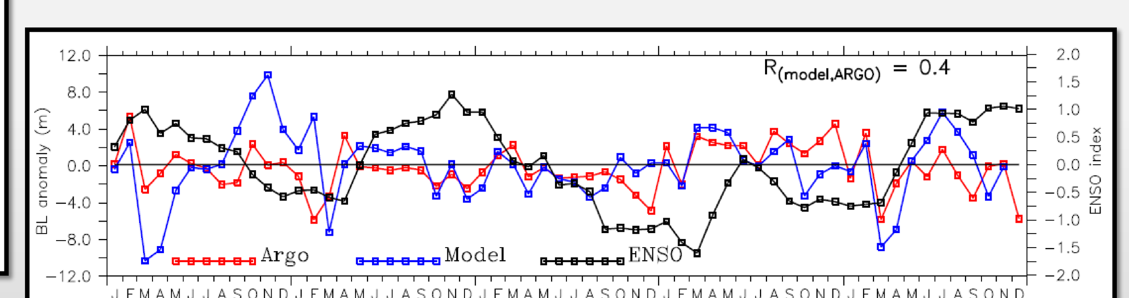
## Model Validation




Model SST and SSS (color) and WOA (contour) for BoB

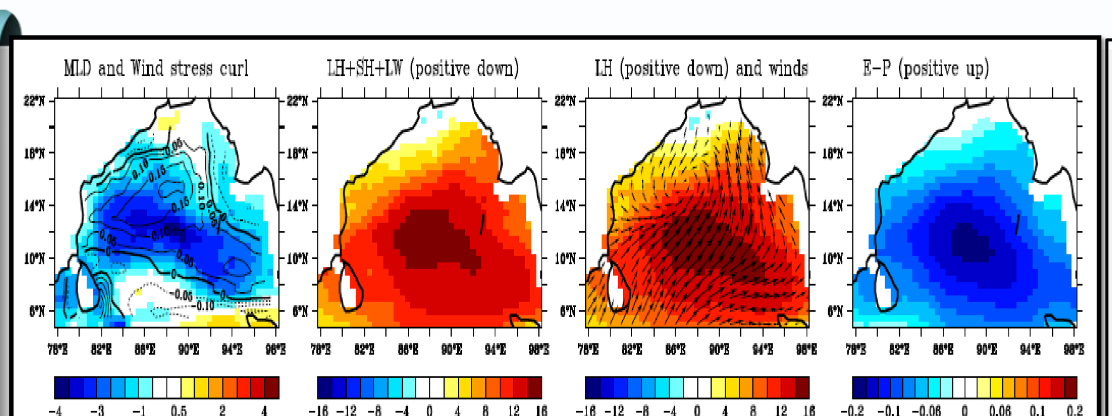



Mixed Layer Depth from ODTM (shade) and observations

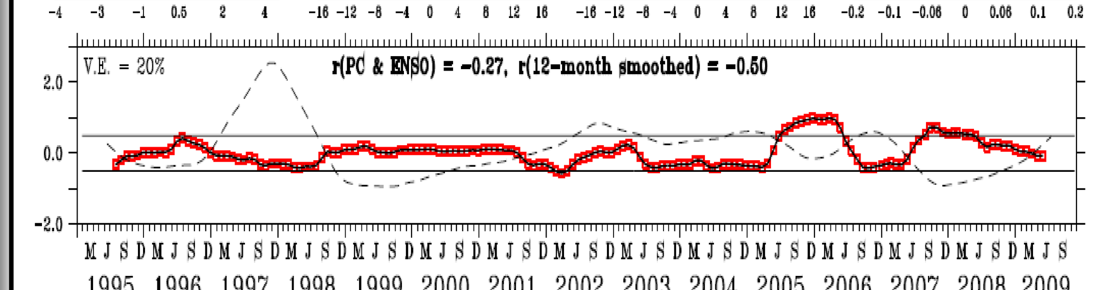



Comparison between ODTM and Argo derived BL anomalies

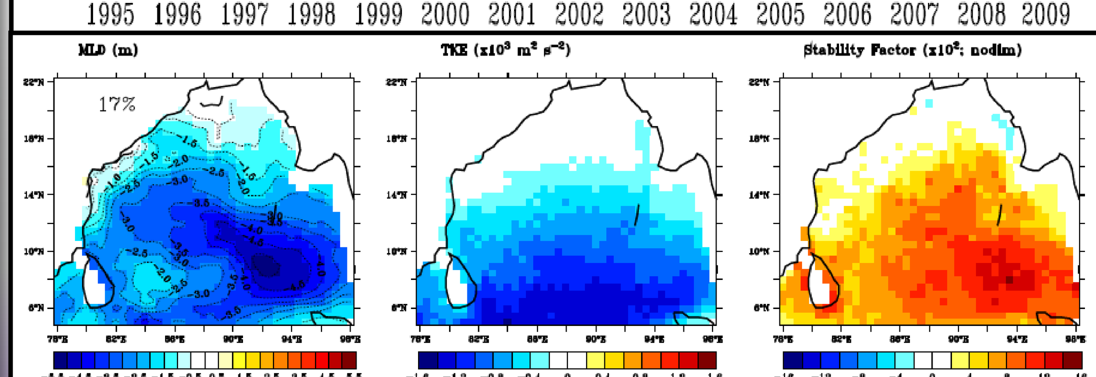
## Results



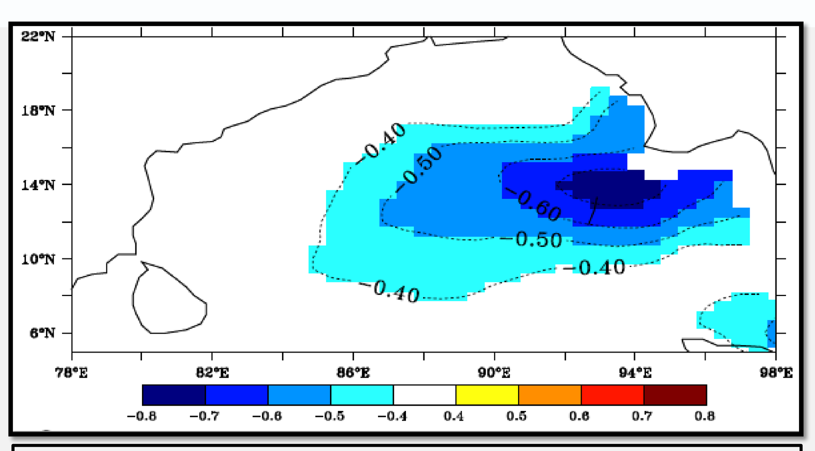

Mode-1 C-EOF of interannual anomalies of MLD and surface forcing.



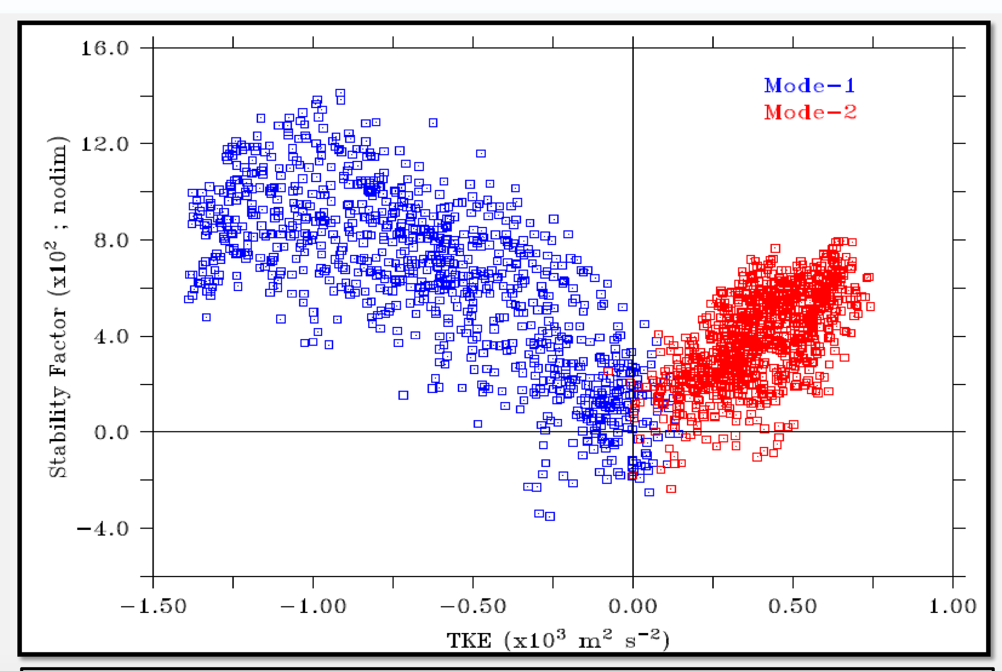

Corresponding PC (red-dotted line) overlaid with ENSO index(dash line). Negative correlation.




Mode-1 C-EOF of interannual anomalies of MLD, TKE and stability factor



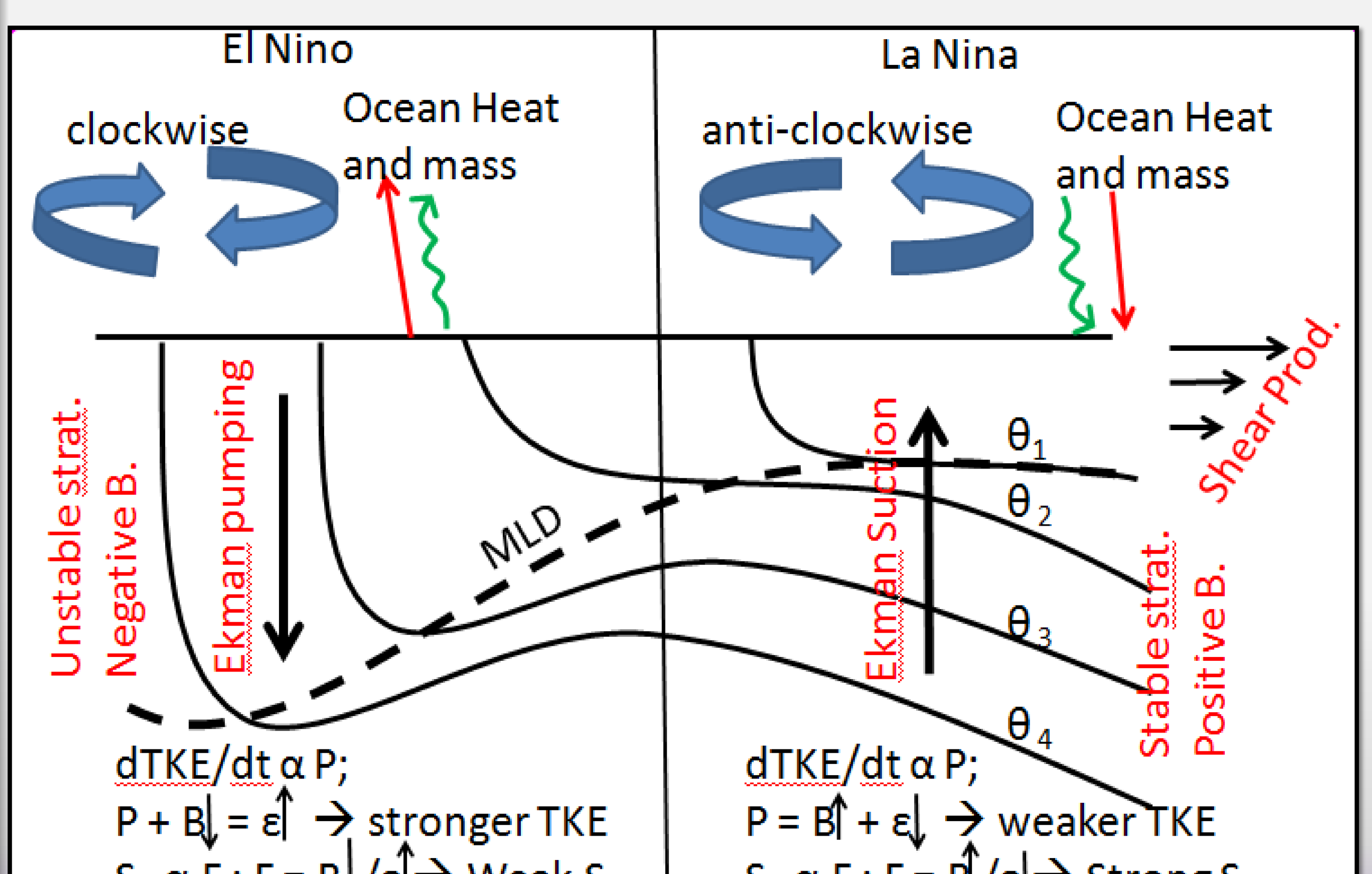
Interannual Correlation between BL anomalies and EMP anomalies.




Scatter of TKE vs stability factor of BoB basin for mode-1 and mode-2 type interannual variability of the MLD.

- During La-Niña, cyclonic surface winds → Ekman upwelling + strong convective activity ➔ leads to shallow MLD.
- Precipitation strengthens → stabilizes upper ocean→ less mixing ➔ stronger BL.
- The counteracting influence of TKE and $S_H$ may be responsible for weaker amplitude of MLD IAV in BoB.

## Conclusion




- A dynamic-thermodynamic reduced gravity ocean model embedded with a high resolution vertical mixed layer model is introduced. The model is utilized to study the Bay of Bengal mixing and variability.
- The year to year variability of Bay of Bengal mixing and barrier layer are predominantly controlled by ENSO.
- Turbulent Kinetic Energy (TKE) and Stability of water column dissociate and mitigate the variability of Bay of Bengal mixing interannual variability when ENSO is a controlling factor.
- The study has implications for fine tuning the state-of-the-art general circulation models and climate models in order to represent a robust spatio-temporal variability of surface mixing in the Bay of Bengal.