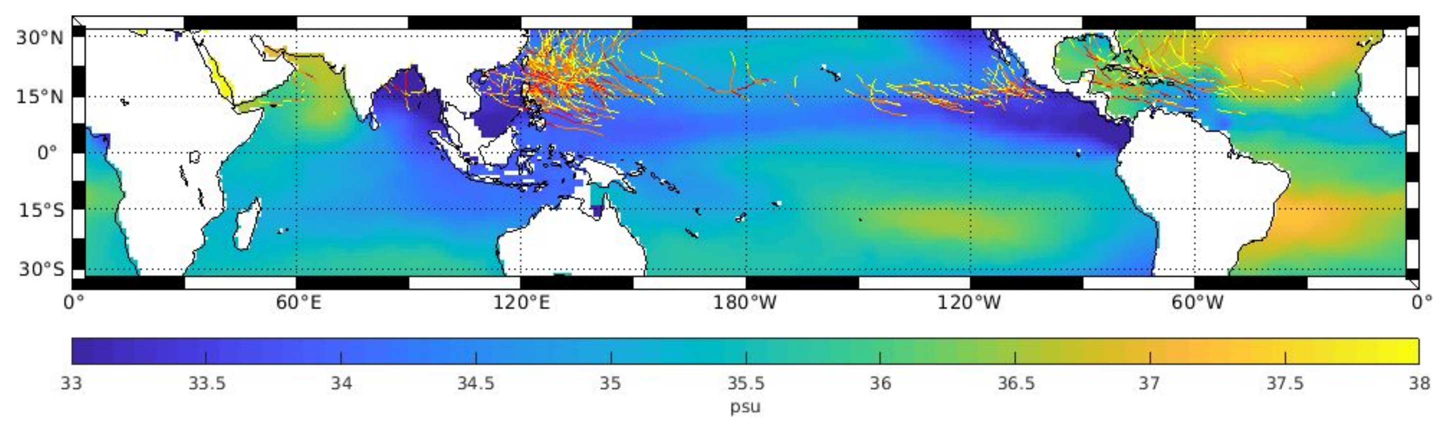
A GRIDDED UPPER-OCEAN STRATIFICATION DATASET FOR TROPICAL WEATHER AND CLIMATE STUDIES

Nguyen Dac Da[1,2], Gregory Foltz[1]
Corresponding: gregory.foltz@noaa.gov

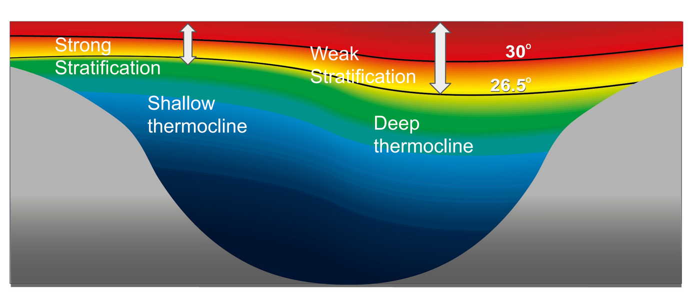
(1) Atlantic Oceanographic Meteorological Laboratory (AOML) - NOAA
(2) Cooperative Institute for Marine & Atmospheric Studies (CIMAS) - University of Miami



Tropical Cyclone Tracks (category 3 and higher, from Hurdat) and SSS (August-Oct) from 2004 - 2017. (Data from Hurdat and WOD)

I. Introduction

- Ocean provides the major heat source for Tropical Cyclones (TC) via surface enthalpy (turbulent heat) flux.
- Ocean stratification also impacts TC intensity by modulating SST via:
  - stronger stratification resists vertical mixing -> keeping warmer SST -> favorable for TC intensification
  - stronger stratification associated with shallower thermocline -> cooler temperature near surface -> mixing cause stronger SST cooling -> TC weaken



Ocean vertical temperature distribution

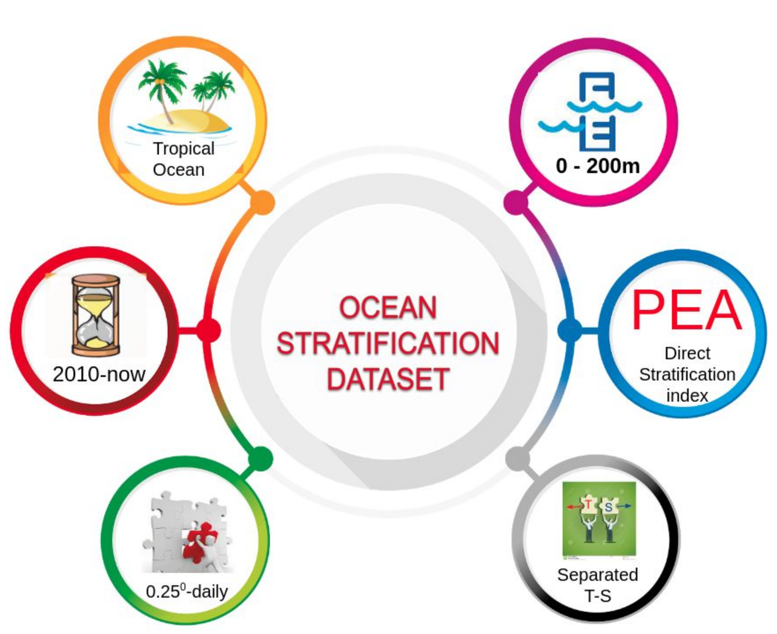
- While stratification due to temperature can increase or decrease TC-induced SST cooling, stratification due to salinity can only reduce cooling. There is growing evidence on the significant role of salinity to TC rapid intensifications.

Motivation:

1. Previous stratification datasets based purely on in-situ observations have low spatio temporal resolutions and used indirect stratification indexes (Mixed Layer Depth, Ocean Heat Content …)

2. Respective contributions of temperature and salinity to ocean stratification were not explored

GOALS!



$$PEA(TS) = \int_{-h}^{0} (\rho - \bar{\rho})\, g z\, dz$$

$$PEA(T) = \int_{-h}^{0} (\rho_{s10} - \overline{\rho_{s10}})\, g z\, dz$$

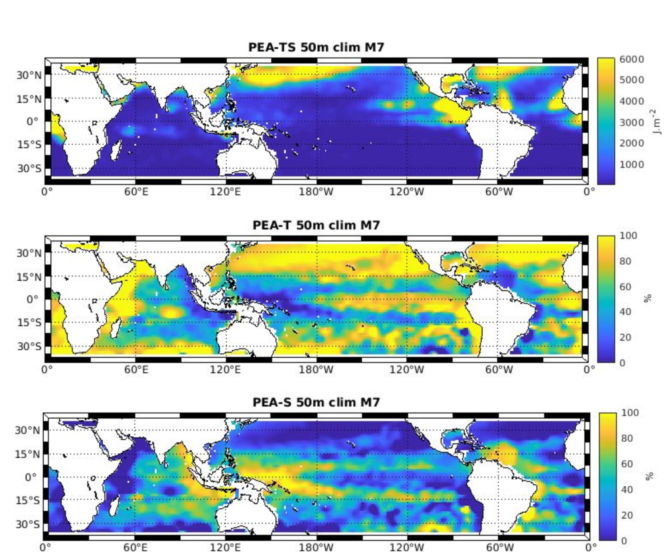
$$PEA(S) = PEA(TS) - PEA(T)$$

ρ	sea water density
ρ_{s10}	density computed using constant salinity at 10m
g	Gravity constant (9.81 m/s^2)
z	water depth
PEA(TS), PEA(T), PEA(S)	total, temperature, salinity stratification

II. Method

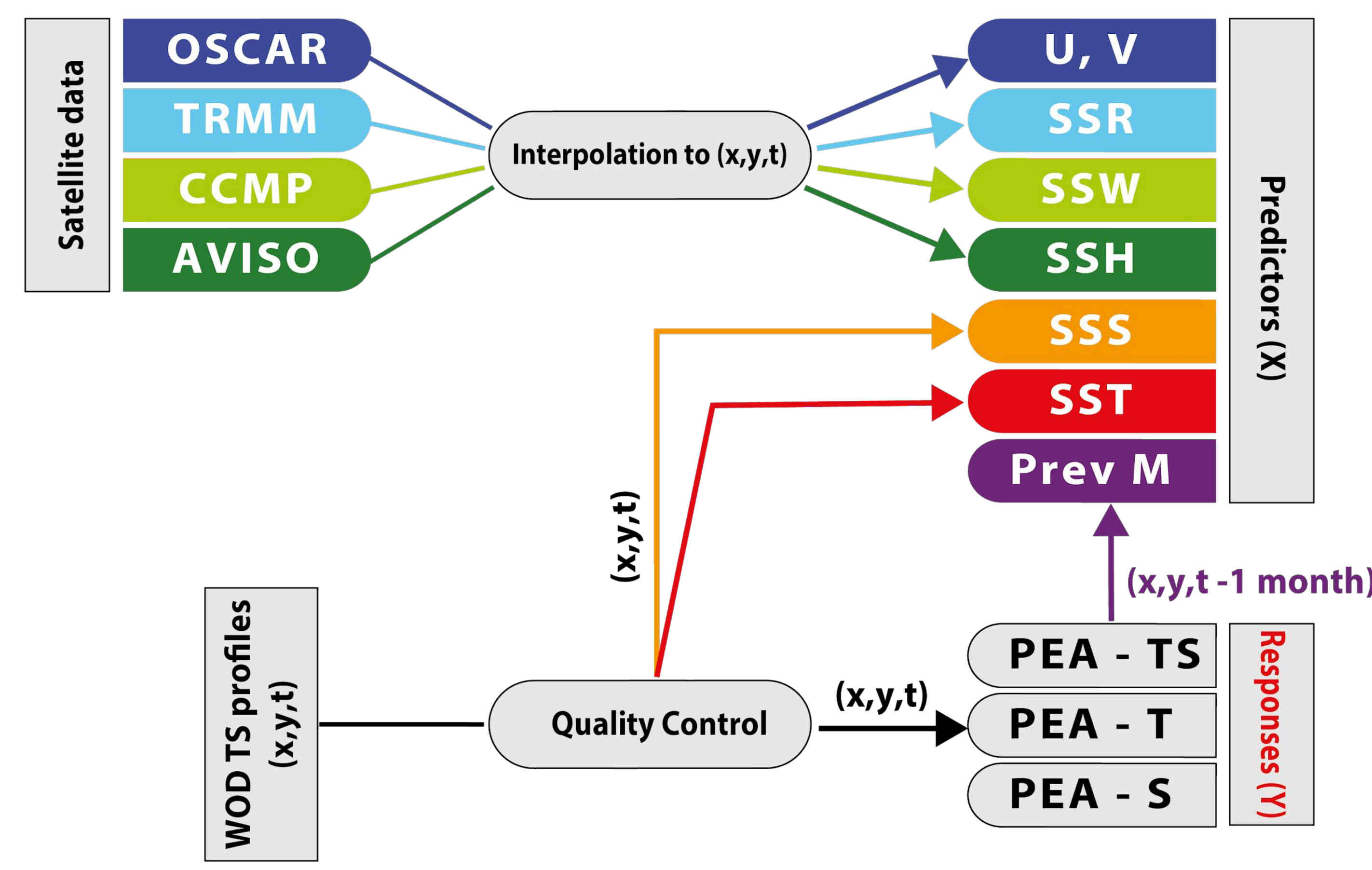
2.1 Stratification index

Integrated Potential Energy Anomaly (PEA) is the total energy (J/m2) required to mix the whole water column from surface to a certain depth (h).

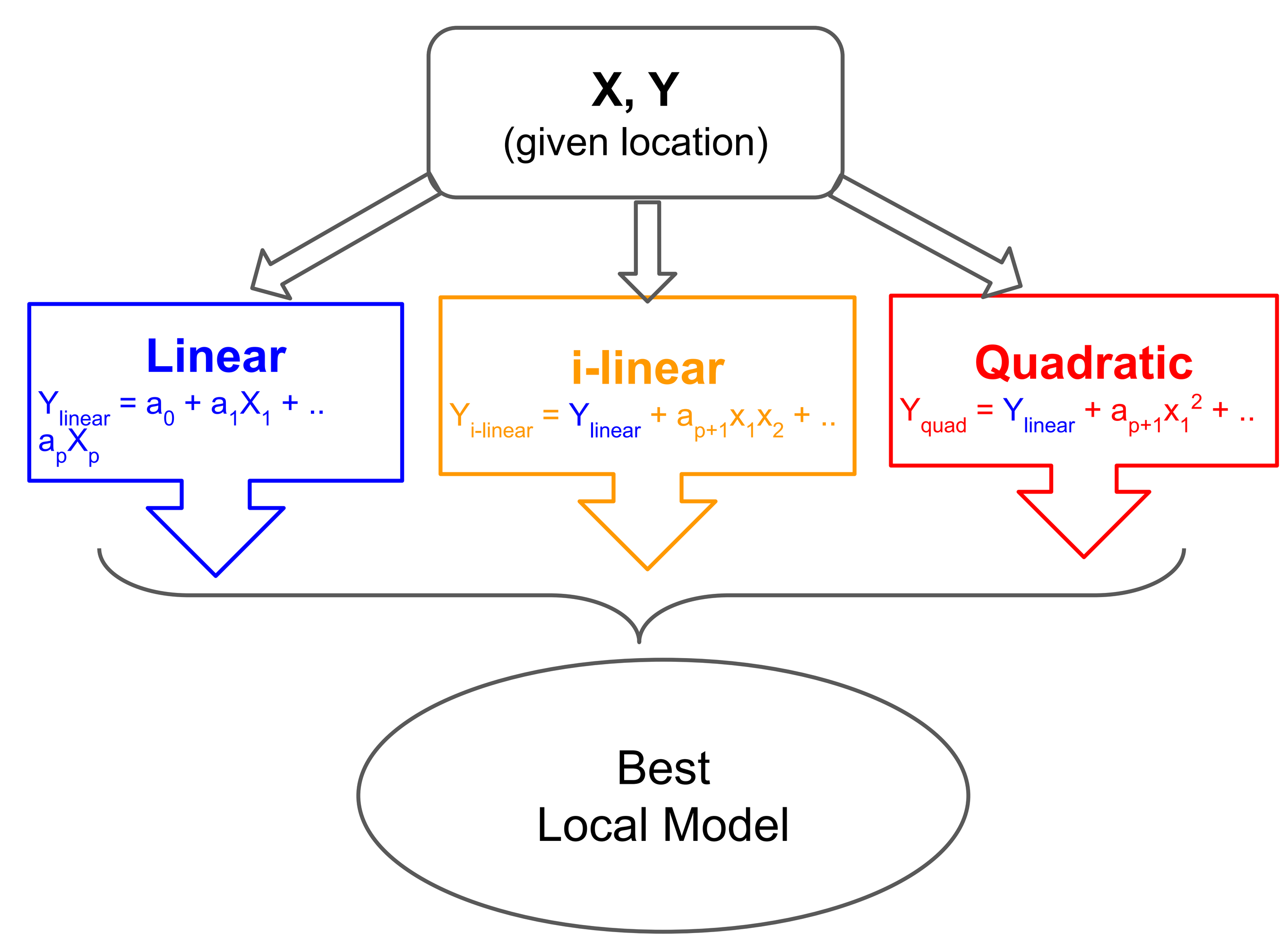


July climatology of total stratification and relative contribution of temperature, and salinity stratification (derived from WOD18)

2.2 Data Preprocessing



2.3 Building statistical model

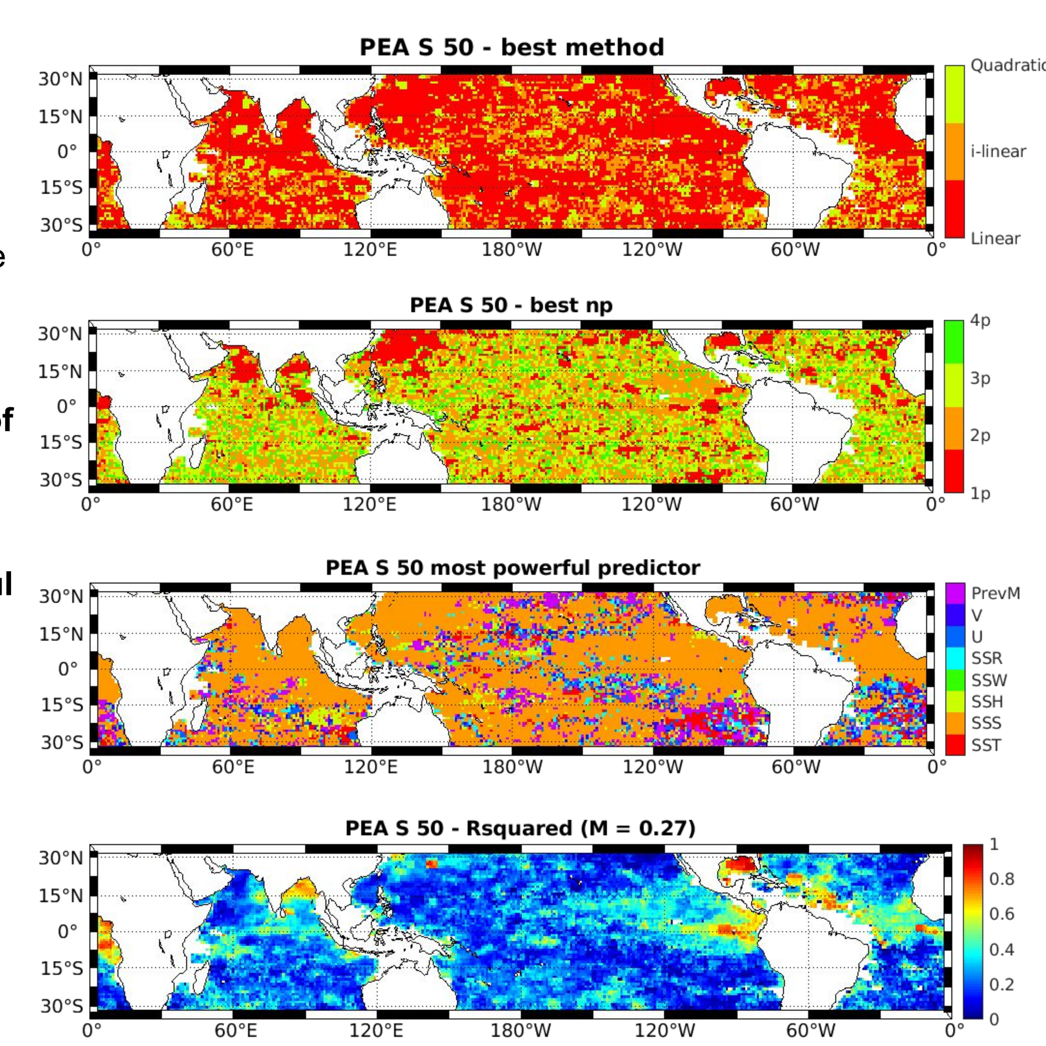


III. Results

3.1 Best models

a) PEA-S 50m:

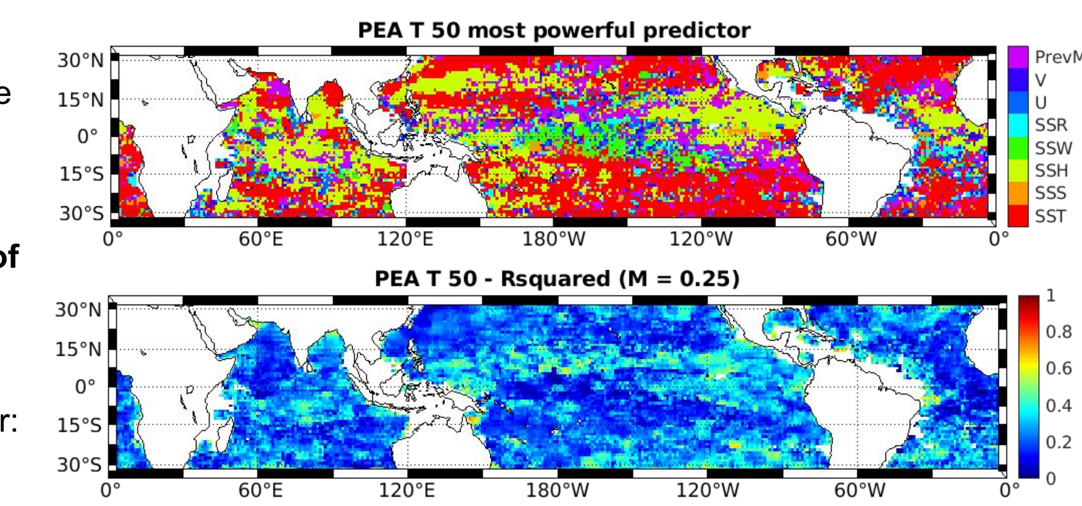
- **Best method:** Simple linear regression
- **Best number of predictor (np):** 1p - 3p
- **Most powerful predictor:** SSS, PrevM
- Global mean R^2: 0.27



Best configuration of regression model for PEA-S 50m and respective predictive performance (R-squared).

b) PEA-T 50m:

- **Best method:** Simple linear regression
- **Best number of predictor (np):** 1p - 3p
- Most powerful predictor: SST, SSH, PrevM.
- Global mean R2: 0.25

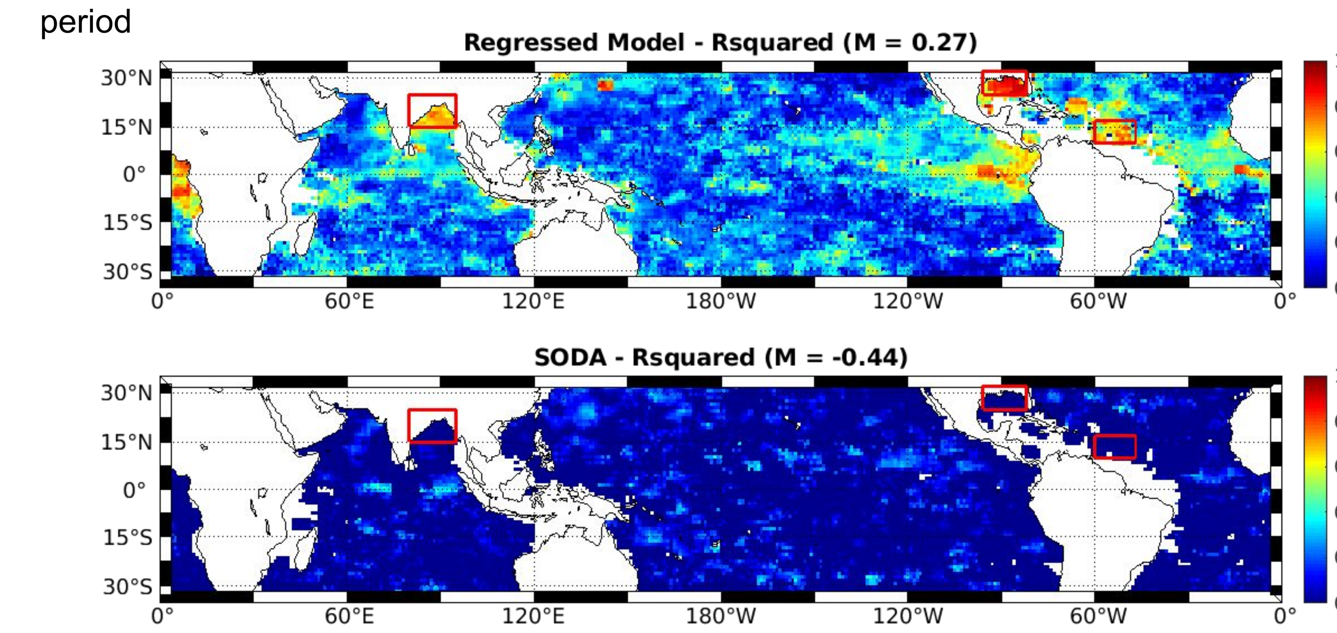


Best configuration of regression model for PEA-T 50m and respective predictive performance (R-squared). The best method and number of predictors map are similar to PEA-S 50m and not shown.

3.2 Regression Model vs. SODA

a) SODA data sampling

- SODA data at 0.5 deg, 5-day resolution is interpolated to WOD profiles locations for 2004-2016 period

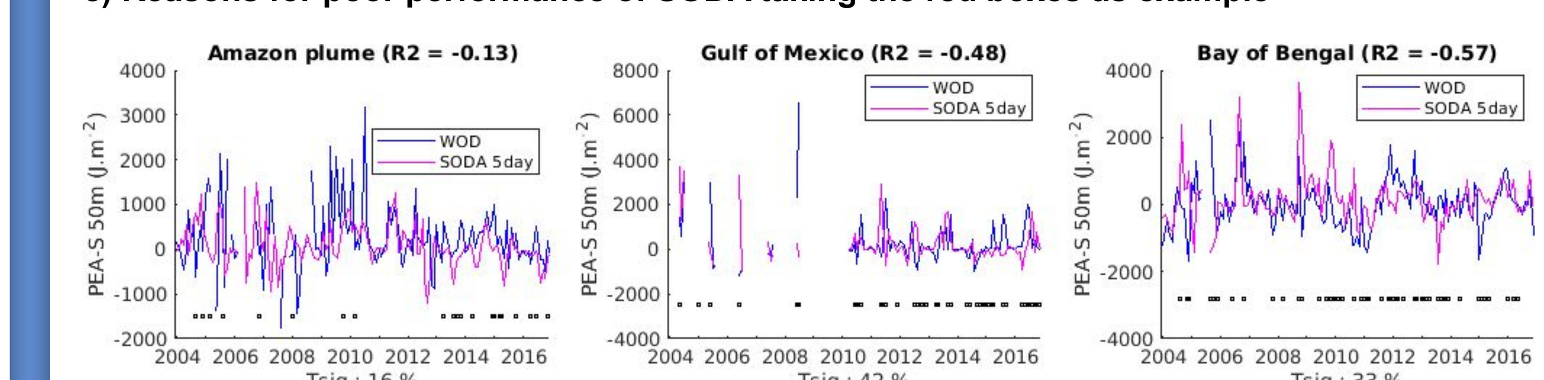


R-squared computed between PEA-S 50m of Regressed model predictions and SODA reanalysis vs. WOD18 data. Red boxes shows the locations where regressed model outperform SODA, from left to right: Bay of Bengal, Gulf of Mexico and Amazon Plume

b) Performance comparison

- Regressed models have better performance especially over areas of low SSS such as Bay of Bengal, Gulf of Mexico, Eastern Pacific
- This performance holds for 100m layer as well as for PEA-T in all layers (figure not shown)

c) Reasons for poor performance of SODA taking the red boxes as example



Monthly mean of all individual PEA-S 50m anomalies within the red boxes (solid lines). Black dots represents the months where the mean values are significantly different between SODA and WOD (using Student t-test). Tsig indicates percentage of black dots over the whole period.

- The monthly mean of PEA-S 50m between SODA and WOD are out of phase.
- Partly because WOD data contains high frequencies whereas SODA has 5-day average as well as due to the representativeness of number of profiles in the areas
- About 20-40% of the time SODA significantly failed to reproduce the monthly mean anomalies of PEA-S

IV. Conclusions

- **Globally, regression model can predict 25-30% of PEA-T and PEA-S within 50m, and up to 40% within 100m layer (figure not shown).**
- **The predictibility of PEA-S is particularly high (R2 = 0.7 - 0.9) in some areas (Bay of Bengal, Gulf of Mexico etc.)**
- **Statistical model outperform SODA**

V. Future Work

- **Comparison with other high resolution reanalysis (HYCOM)**
- **High resolution stratification dataset based on satellite data**
- **Using more sophisticated machine learning methods: Neural Network, Random Forest**
- **Application for improving TC's intensity forecast**