HYCOM APE Skill Testing using Historical Records

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Outline

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Definition

Available Potential Energy (APE) is the amount of potential energy available for conversion into kinetic energy.

Important for ...

- determining the structure of the pycnocline
- mixing parameterization
- energy budget calculations

There are several methods for computing APE [Kang and Fringer, 2010]

Most suitable and direct method

$$APE = \frac{g^2 \rho'^2}{2\rho_0 N^2}$$

- ρ' $\longrightarrow$ a density anomaly time series
- ρ_0 $\longrightarrow$ mean seawater density
- N $\longrightarrow$ Brunt-Vaisala frequency

Still not perfect, ρ' is observationally challenging.

$$APE \propto \frac{\rho'^2}{N^2}$$

- Get N^2 term from WOA
- ρ' presents difficulty, use temperature as proxy

$$\rho' \approx \frac{T'}{\partial T/\partial z}\frac{\partial \rho}{\partial z}$$

- $\eta = \frac{T'}{\partial T/\partial z}$
- Can get T' as a mean centered timeseries from CMA
- Can get $\partial T/\partial z$ as time average from WOA
- Can get $\frac{\partial \rho}{\partial z}$ as time average from WOA

For the skill test we will check each term from HYCOM output against the Observationally Informed (OI) data.

$$APE \propto \left(\frac{\mathrm{d}T}{\partial T/\partial z} \frac{\partial \rho}{\partial z} \right)^2 \frac{1}{N^2}$$

$$N^2_{HYCOM} \implies N^2_{OI}$$
$$\eta^2_{HYCOM} \implies \eta^2_{OI}$$
$$APE_{HYCOM} \implies APE_{OI}$$

CMA Data Mining
Scott and Furnival [2012]

Expansive archive

- A lot of records (8826 with Temperature records)

Developed an interface system using MATLAB features.

- Slow to access
  - MATLAB is for data processing not data mining
- Interface seems unfamiliar for scientists and MATLAB users in particular

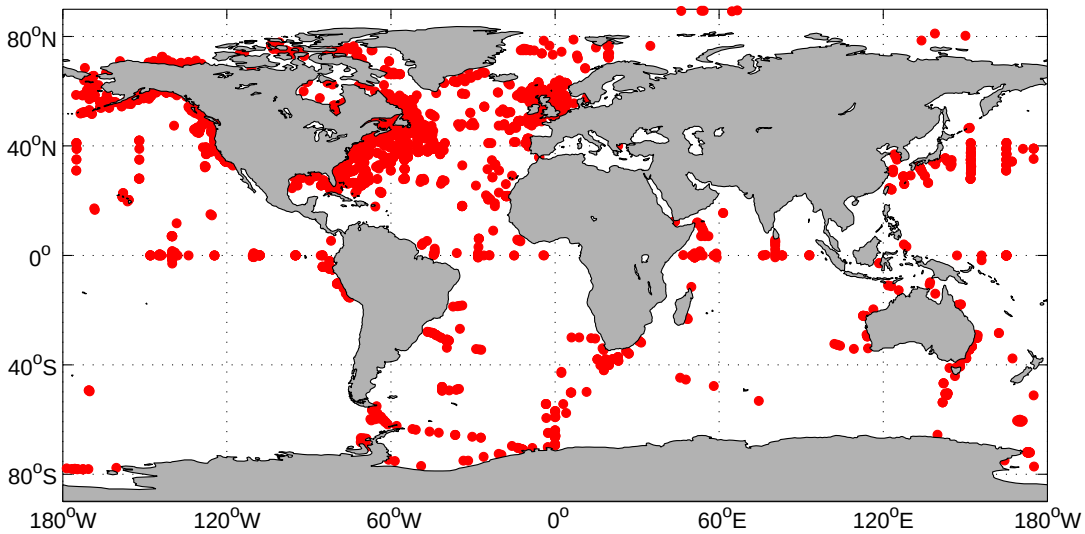
A distributable rewrite is in progress using industry best practices, but is not a top priority.

CMA Results

Statistics about the CMA Data with temperature records

- Number of moorings: 4235
- Number of instruments: 8826
- Number above 1500 m: 7889
- Number with $>$ 10% missing values: 113

CMA Instrument Locations

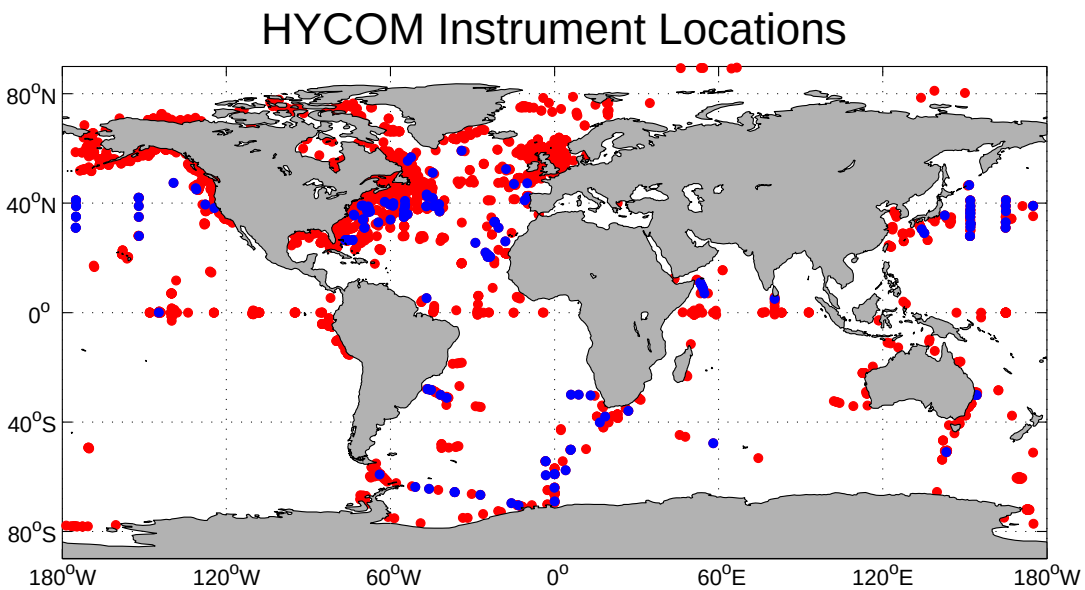


- Considered removing records in coastal waters
- Notice North Atlantic data bias

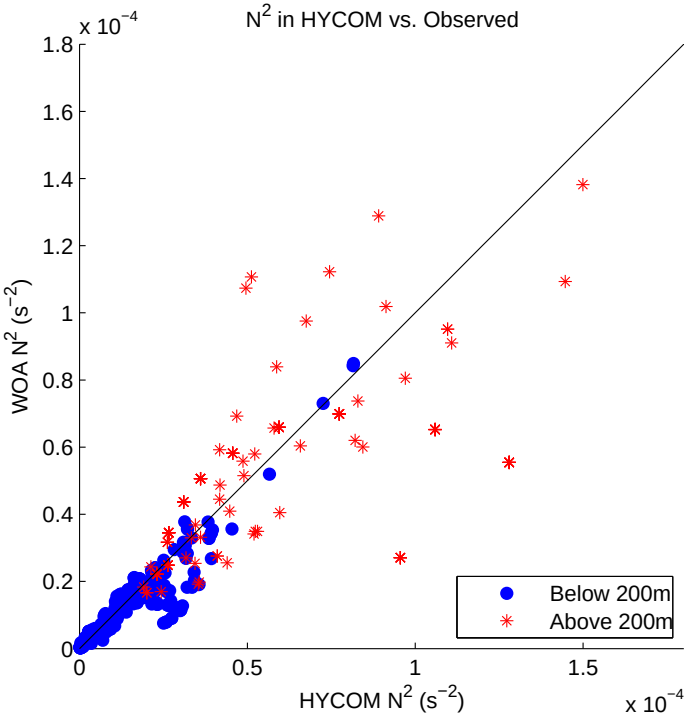
About WOA

- Using the 2009 release
- Several averaging periods available
  - Annual (Using these)
  - Quarterly
  - Monthly
- Temperature and Salinity [Locarnini et al., 2010] [Antonov et al., 2010]

Low Frequency Results (Model year 2003)

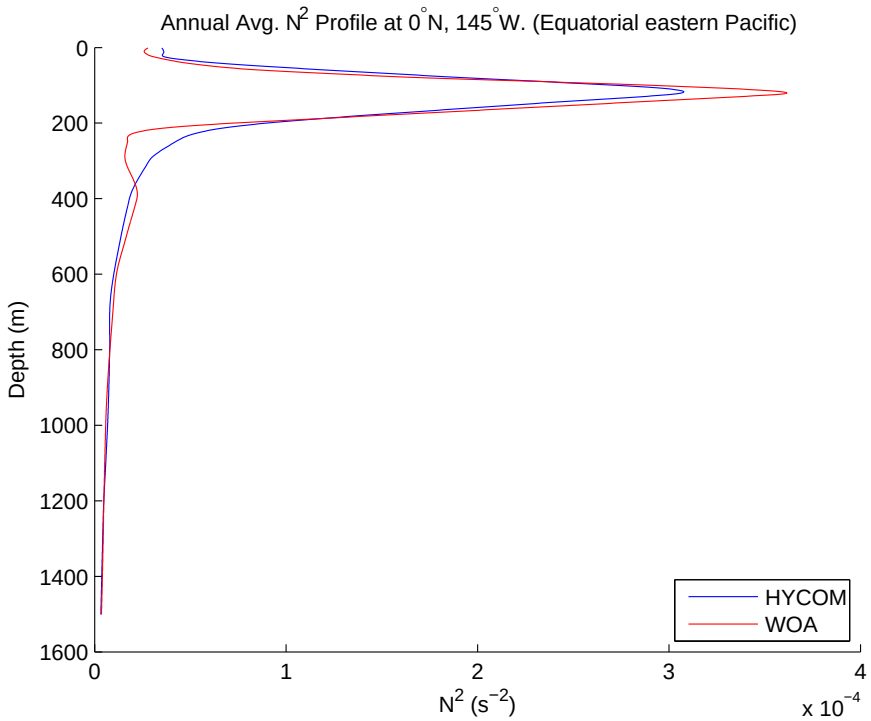


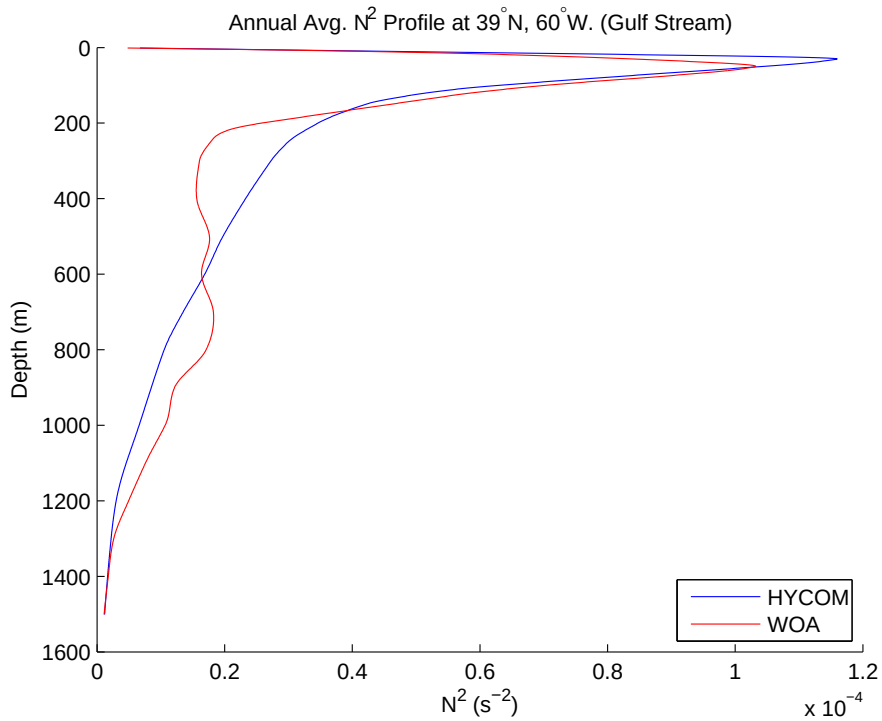
- Limited locations to date
- Biased to Western Boundary Current



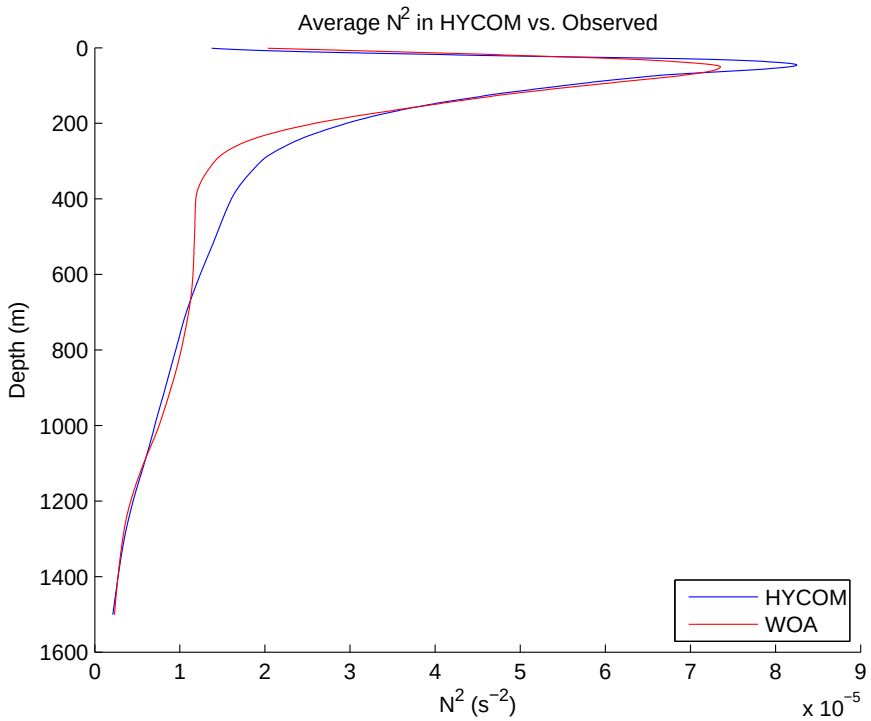
- Fairly good agreement between WOA and HYCOM
- Largest discrepancy is in upper ocean

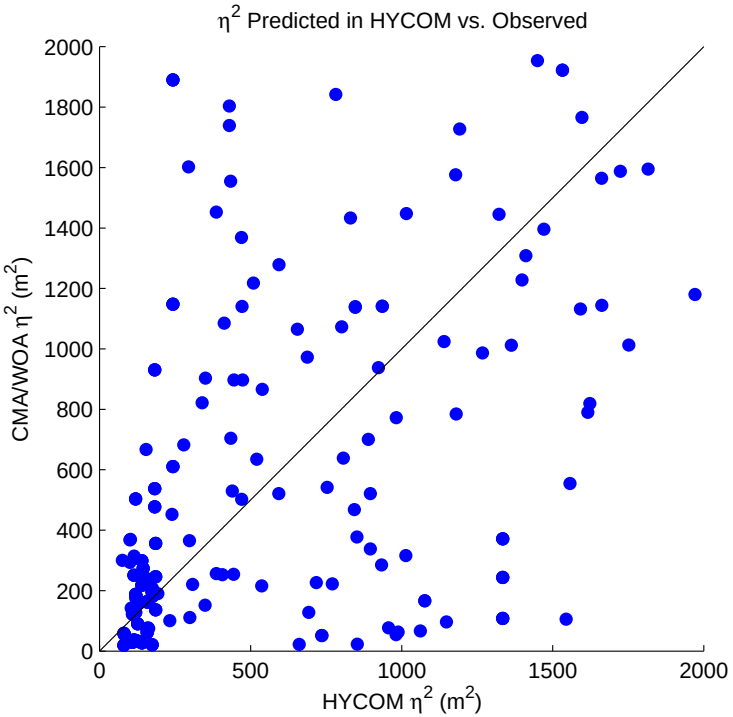
Individual location – N^2 comparison



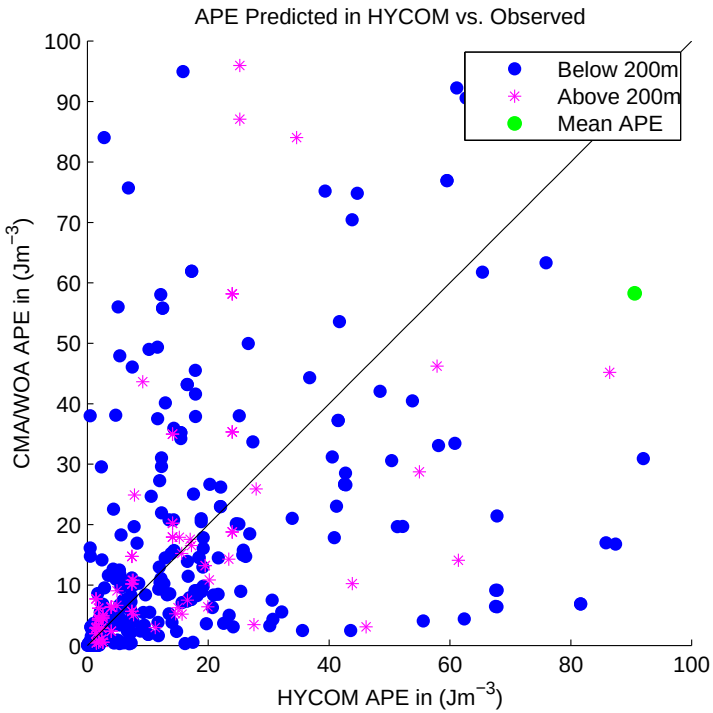


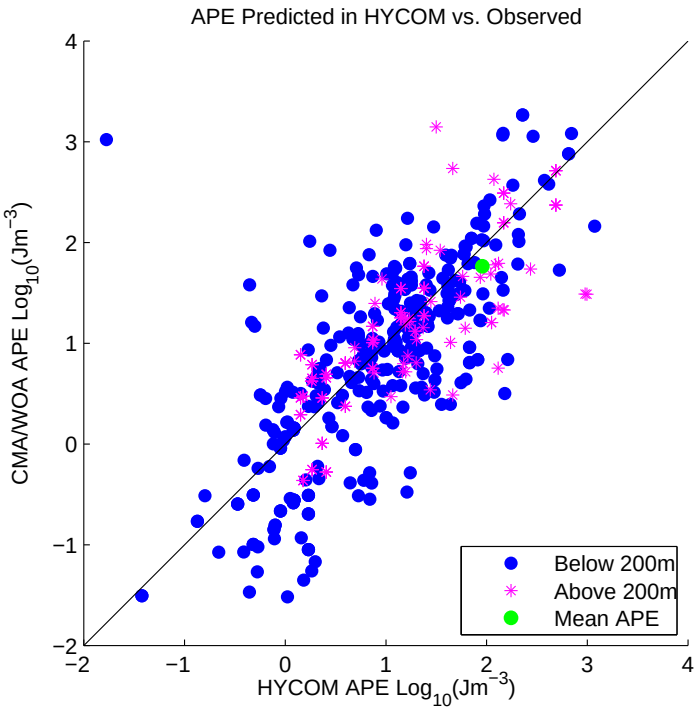
Average N^2 comparison





- Small bias but large mean square error





- Small bias but large mean square error
- APEs results are depth binned into <200m and >200m

Tidal Results

Presently using old HYCOM run (expt 18.5) — only 1 month of hourly output

- Longer run has too much output (8 TB in expt 18.5)
- Can only validate 6 tides
- Skill test has aliasing issues

Will use newer run of several years

- Save hourly output at CMA locations to reduce file size
- Save hourly maps at lower resolution

For the skill testing (Current Project)

- Work through a longer tidal HYCOM run
- More parameter comparisons?
- Scrutinize code and results that we have to date

After skill testing (Future Projects)

- Generate global maps of the low freq. and tidal APEs
- Compute globally integrated low freq. and tidal APE for energy budgets

J. I. Antonov, D. Seidov, T. P. Boyer, R. A. Locarnini, A. V. Mishonov, H. E. Garcia, O. K. Baranova, M. M. Zweng, and D. R. Johnson. *World Ocean Atlas 2009, Volume 2: Salinity*. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 2010.

Dujuan Kang and Oliver Fringer. On the calculation of available potential energy in internal wave fields. *J. Phys. Oceanogr.*, 40:2539–2545, 2010.

R. A. Locarnini, A. V. Mishonov, J. I. Antonov, T. P. Boyer, H. E. Garcia, O. K. Baranova, M. M. Zweng, and D. R. Johnson. *World Ocean Atlas 2009, Volume 1: Temperature*. NOAA Atlas NESDIS 68, U.S. Government Printing Office, Washington, D.C., 2010.

Robert B. Scott and Darran G. Furnival. *A guide to GMACMD*. April 2012.