Proposed metrics to evaluate coupled model performance in the Tropical Pacific

CLIVAR Pacific Panel

http://www.clivar.org/organization/pacific/pacific.php

The Pacific Panel is compiling a list of indices and diagnostics that can be used as metrics to evaluate the performance of coupled models in the tropical Pacific. In the work presented here, the emphasis is on the **interaction between mean state, intraseasonal and interannual (ENSO) variability.**

All the proposed indices can be calculated either from observations (OBS) and/or from atmospheric and reanalysis (RA). Error bars can be estimated by using multi-analysis approach.

Note: In what follows, the indices to be estimated appear in red.

ENSO INSTABILITY

- **Simple recharge oscillator relationships** (*Burgers et al.* 2005, GRL). T is the SST anomaly in Nino3, h is the equatorially averaged upper ocean heat content.

$$\frac{\partial}{\partial t}\begin{pmatrix}T_E\\ h\end{pmatrix}=\begin{pmatrix}a_{11} & a_{12}\\ a_{21} & a_{22}\end{pmatrix}\begin{pmatrix}T_E\\ h\end{pmatrix} \quad (1)$$

- **ENSO mechanisms** (*Burgers and van Oldenborgh*, 2002, JC)

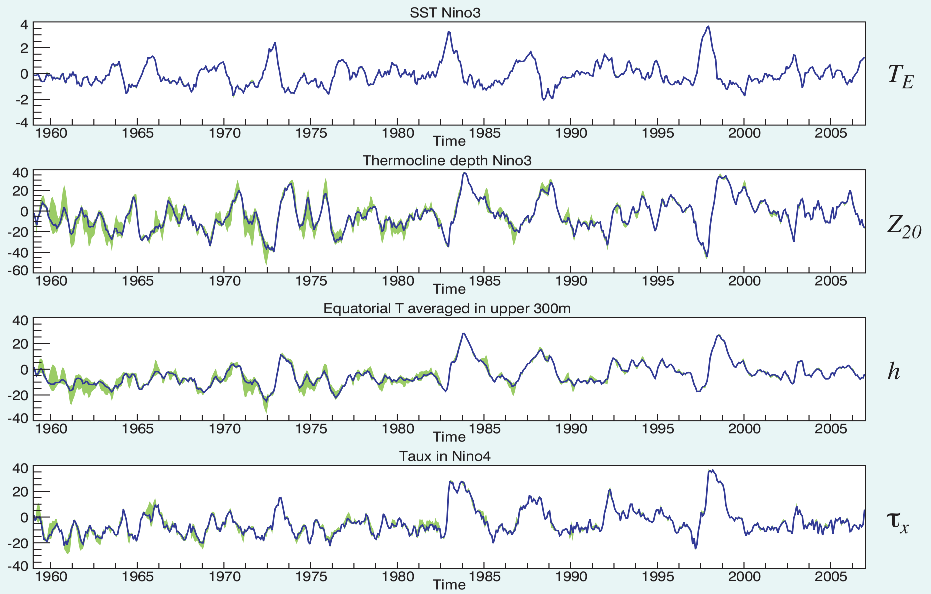
$$\frac{\partial T(x,y,t)}{\partial t}=\alpha(x,y)Z_{20}(x,y,t-\delta)+\beta(x,y)\tau_x(x,y,t)-\gamma(x,y)T(x,y,t) \quad (2)$$

$\alpha(x,y)$ = Thermoline Feedback $\gamma(x,y)$ = Damping term

$\beta(x,y)$ = Wind stress Feedback $\delta(x,y)$ = Upwelling time delay

Example of data records from the ECMWF ocean re-analysis

- Historical records are needed to estimate multivariate relations, PDFs (mean,variance, skewness...) and spectral characteristics
- Other re-analysis can be used (GSOP).
- Multi-analysis can give better estimates of the uncertainty.



Shaded areas are an estimation of the uncertainty

ENSO and Mean State

- **Instability (BJ index).** (*Jin et al.*, 2006. GRL):

The instability index I_{BJ} can be related to the mean state.

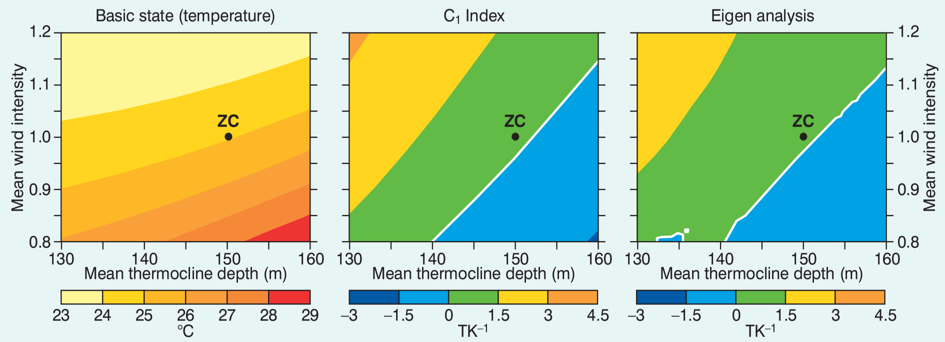
(In *Burgers et al.* 2005, the instability index is derived by linear regression)

The term F[h] determines the periodicity.

$$\frac{\partial T}{\partial t}=-(\bar u\frac{\partial T}{\partial x}+\bar v\frac{\partial T}{\partial y}+u\frac{\partial \bar T}{\partial x}+v\frac{\partial \bar T}{\partial y}+\bar w\frac{\partial T}{\partial z}+w\frac{\partial \bar T}{\partial z})+Q$$

$$\frac{\partial\langle T\rangle}{\partial t}\approx-(\frac{\langle\bar u\rangle}{L_x}+\frac{\langle -2y\bar v\rangle}{L_y^2}+\frac{\langle H(\bar w)\bar w\rangle}{H_m})\langle T\rangle -\langle u\rangle\left\langle\frac{\partial \bar T}{\partial x}\right\rangle+\langle H(\bar w)\bar w\rangle\frac{\langle T_{sub}\rangle}{H_m}-\langle w\rangle\left\langle H(\bar w)\frac{\partial \bar T}{\partial z}\right\rangle+\langle Q\rangle,$$

$$\frac{\partial\langle T\rangle}{\partial t}=2I_{BJ}\langle T\rangle+F[h]$$



$$2I_{BJ}=-\left(\frac{\langle\bar u\rangle}{L_x}+\frac{\langle -2y\bar v\rangle}{L_y^2}+\frac{\langle\bar w\rangle}{H_m}\right)-\alpha+\mu_a\beta_u\left\langle-\frac{\partial\bar T}{\partial x}\right\rangle+\mu_a\beta_w\left\langle\frac{\partial\bar T}{\partial z}\right\rangle+\beta_h\mu_a^*\left\langle\frac{\bar w}{H_m}a\right\rangle$$

(A) (B) (C) (D) (E)

A & B: dynamic and thermodynamic damping

C, D, E: three positive feedbacks, each depending on three factors:

(i) The nature of the basic state,

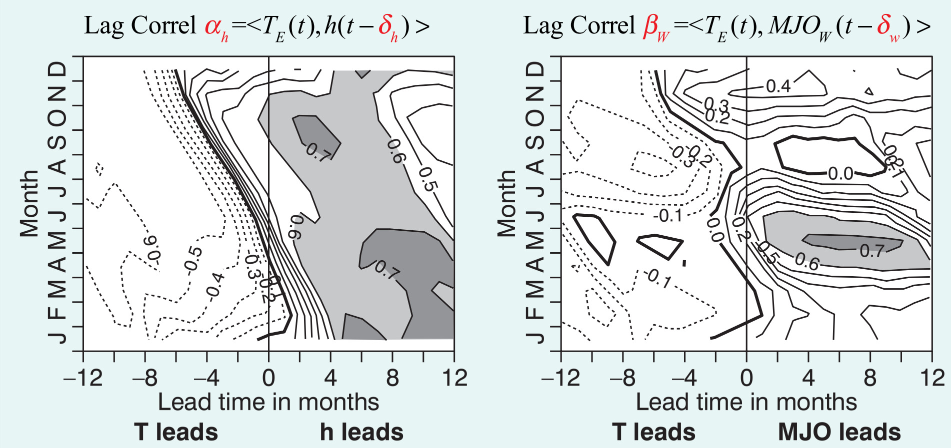
(ii) The sensitivity of the atmospheric surface wind responses to SSTA in the ENSO region.

(iii) The sensitivity of the oceanic responses to surface winds.

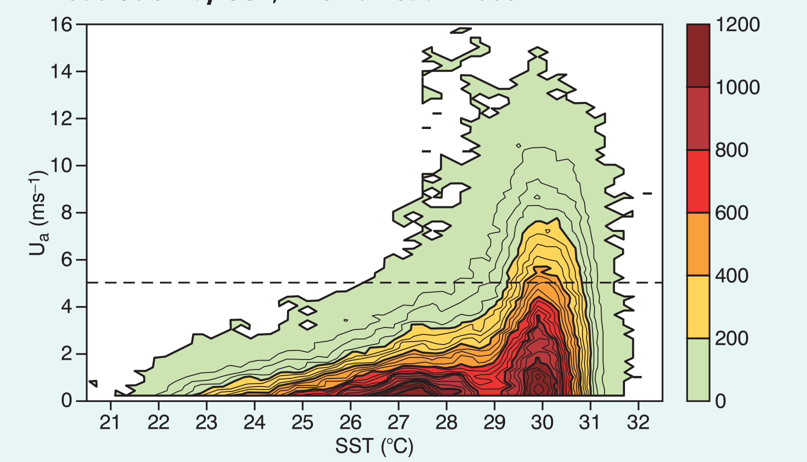
ENSO and Intraseasonal

- **MJO as a precursor of ENSO**, *McPhaden et al.* 2006, GRL

$$T_E(t)=\alpha_h h(t-\delta_h)+\beta_W MJO_w(t-\delta_w)$$



- **WWB Modulation by SST**, *Einsman et al.* 2005.



- **State dependent Stochastic forcing** (*Jin et al.*, 2006)

Multiplicative noise

$$\frac{dT}{dt}=-\lambda T+\omega h+\sigma b\xi(t)(1+BT),$$

$$\frac{dh}{dt}=-\omega T,$$

$$\frac{d\xi}{dt}=-r\xi+w(t)$$

$$\frac{d<T>}{dt}=-\lambda_E<T>+\omega<h>+\sigma^2 B/(r+\lambda+\omega^2/r)$$

$$\frac{d<h>}{dt}=-\omega<T>$$

$$\lambda_E\approx\lambda-\sigma^2 B^2/(r+\lambda+\omega^2/r)$$