SST Simulations from HYCOM in the Equatorial Pacific Ocean

By

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MOTIVATION

- **The vertical mixing models in HYCOM**

KPP	$\rightarrow$	**Large et al. (1994)**
GISS	$\rightarrow$	**Canuto et al. (2002)**
MY2.5	$\rightarrow$	**Mellor and Yamada (1982)**
KT	$\rightarrow$	**Kraus and Turner (1967)**
PWP	$\rightarrow$	**Price et al. (1986)**
No ML	$\rightarrow$	**No mixed layer model**

- **Implementation to HYCOM (Halliwell 2004)**

We would like to answer the question:

How do these different mixed layer models perform for a given atmospheric forcing: ERA–15?

MODEL SETUP

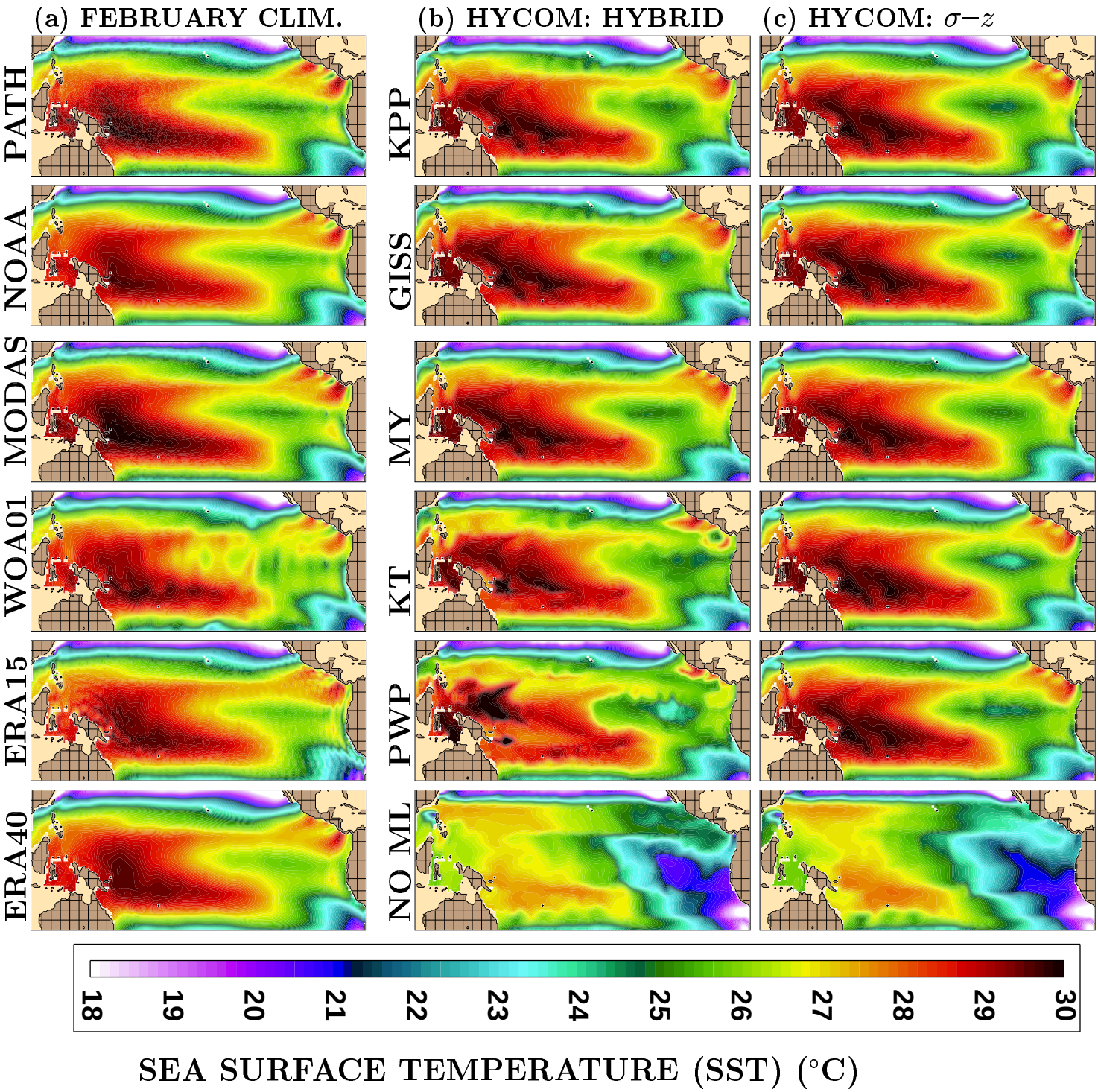
- **Ocean Model: HYCOM**
  - **20–layer HYBRID**
  - **40–level $\sigma - z$**
- **Ocean Basin: Equatorial Pacific**
- **Model domain: 30°N–30°S and 70°W to 110°E**
  - **Relax to GDEM3 climatology near 30°N and 30°S**
- **Model Resolution: $0.72^\circ \times 0.72^\circ \cos(\text{lat})$**
  - **Latitudinal resolution near equator is 0.36°**
  - **to improve HYCOM's equatorial dynamics**

MODEL INPUT

- **Atmospheric forcing: ECMWF Re–Analysis (ERA–15)**
- **Model spin–up: A 5–year climatological run**
- **Model initialization: $1/8^\circ$ GDEM3 climatology**
    - **temperature and salinity**
- **Data assimilation: NONE**
    - **NO relaxation to any SST**
    - **Weak sea surface salinity relaxation to GDEM3**
- **River discharge: NRL data base (Barron and Smedstad 2002)**

- **Subsurface heating parameterization: Kara et al. (2005a,b,c)**
    - **Shortwave radiation attenuation via water turbidity**
    - **Blackbody longwave radiation correction**
    - **Bulk formulae for latent and sensible heat fluxes**

CLIMATOLOGICALLY–FORCED HYCOM SST



“NO” SST assimilation or “NO” relaxation to any SST clim

MODEL–DATA COMPARISONS

- **Statistical metrics (Murphy 1988)**
  - o **Mean error (ME) and RMS difference (RMS)**
  - o **Conditional and unconditional biases**
  - o **Correlation coefficient (R) and skill score (SS)**

- **Monthly Pathfinder SST (X) versus HYCOM SST (Y)**

$$\mathbf{ME} = \overline{Y} - \overline{X},$$

$$\mathbf{RMS} = \left[\frac{1}{12}\sum_{i=1}^{12}(Y_i - X_i)^2\right]^{1/2},$$

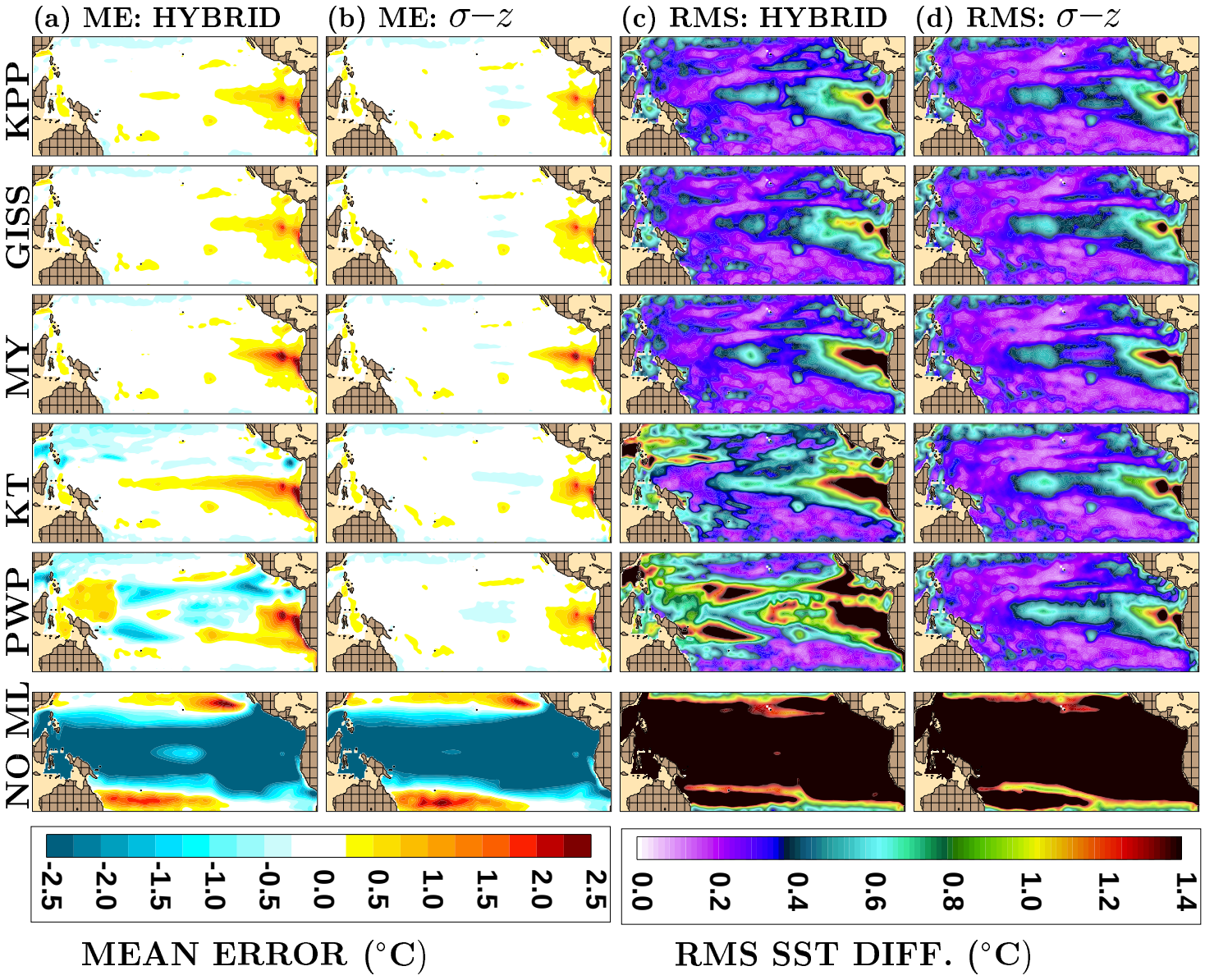
$$R = \frac{1}{12}\sum_{i=1}^{12}(X_i - \overline{X})\,(Y_i - \overline{Y})\,/\,(\sigma_X\,\sigma_Y),$$

$$\mathbf{SS} = R^2 - \underbrace{[R - (\sigma_Y/\sigma_X)]^2}_{\text{CONDITIONAL BIAS}} - \underbrace{[(\overline{Y} - \overline{X})/\sigma_X]^2}_{\text{UNCONDITIONAL BIAS}}$$

  - o **SS=1.0 for perfect HYCOM SST prediction**
  - o **SS < 0 for poor HYCOM SST prediction**

MEAN SST ERROR AND RMS SST DIFFERENCE

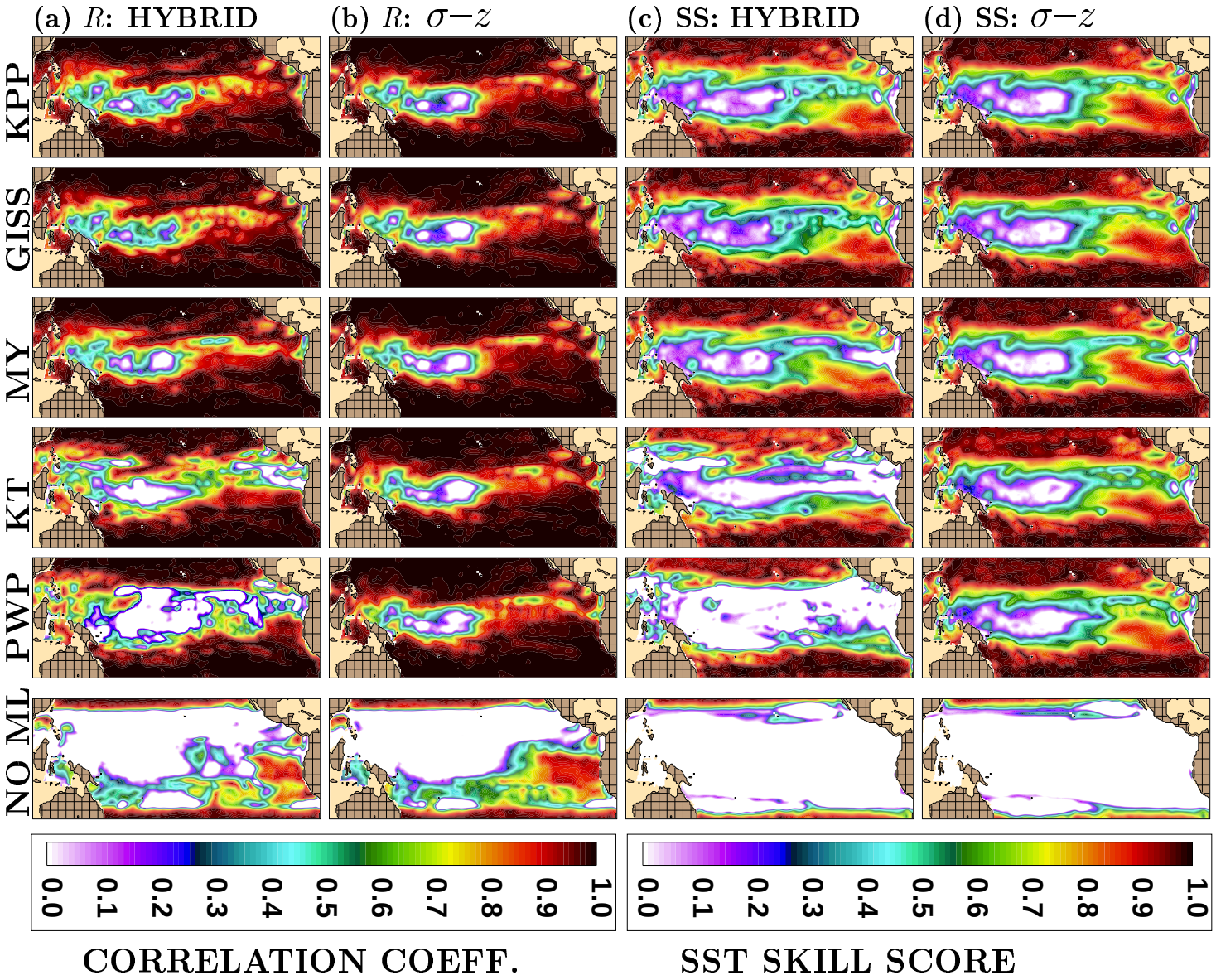
HYBRID: 20–layer and $\sigma-z$: 40–level versus Pathfinder SST



“NO” SST assimilation or “NO” relaxation to any SST clim

CORRELATION AND SKILL SCORE

HYBRID: 20–layer and $\sigma-z$: 40–level versus Pathfinder SST



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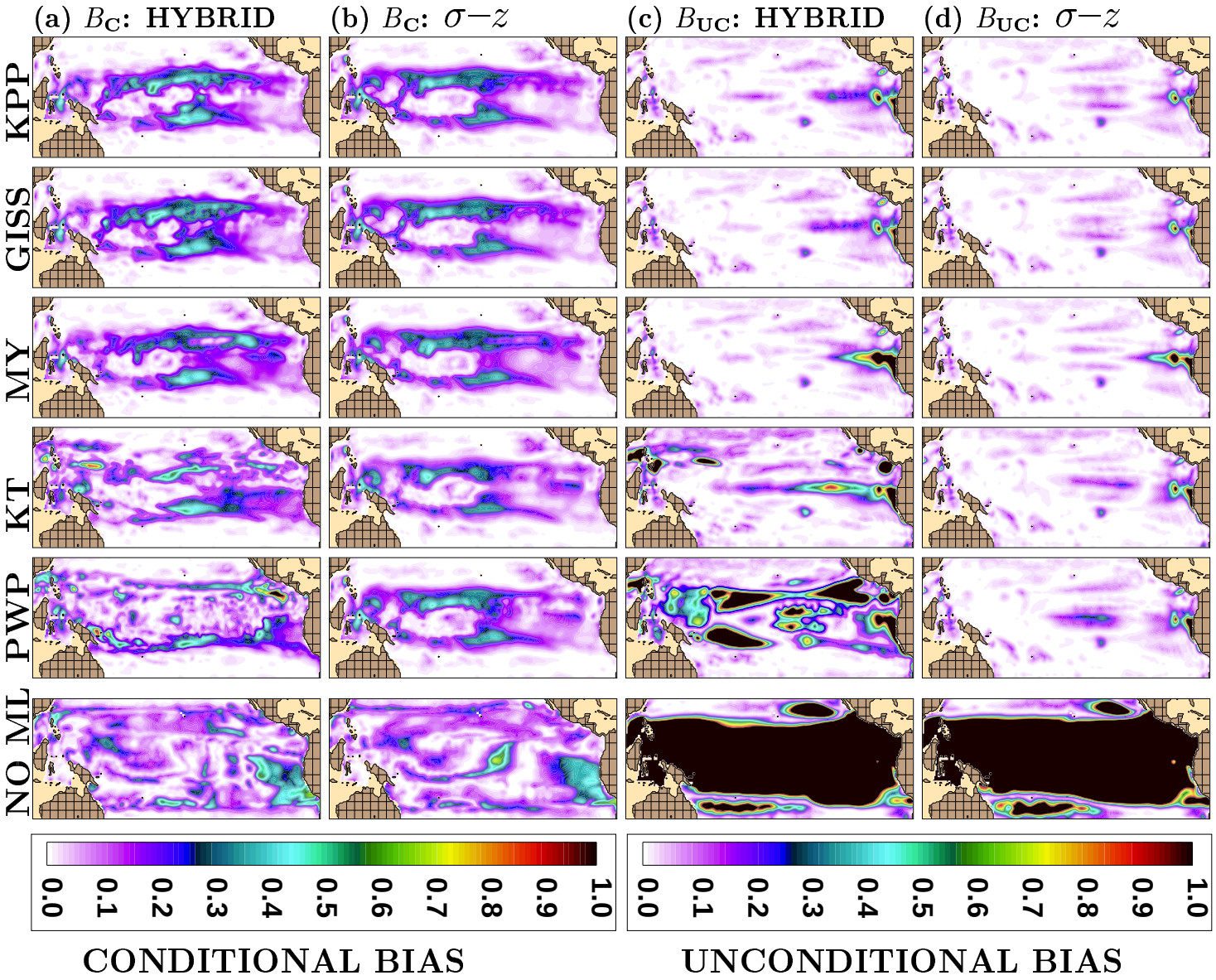
CONDITIONAL and UNCONDITIONAL BIAS

HYBRID: 20–layer and $\sigma-z$: 40–level versus Pathfinder SST



“NO” SST assimilation or “NO” relaxation to any SST clim

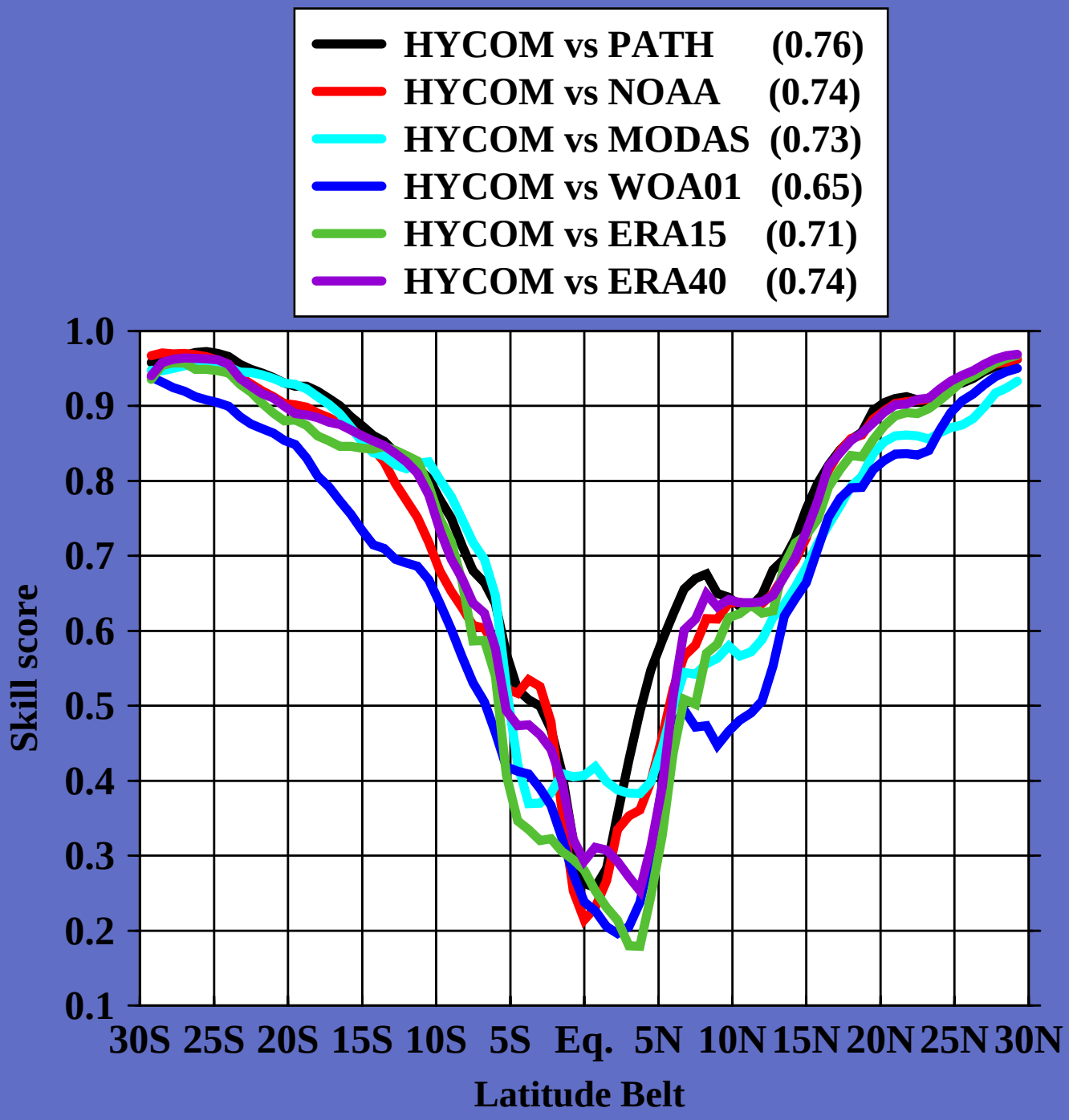
HYBRID: 20–layer and $\sigma-z$: 40–level versus Pathfinder SST

BASIN–AVERAGED STATISTICAL VALUES

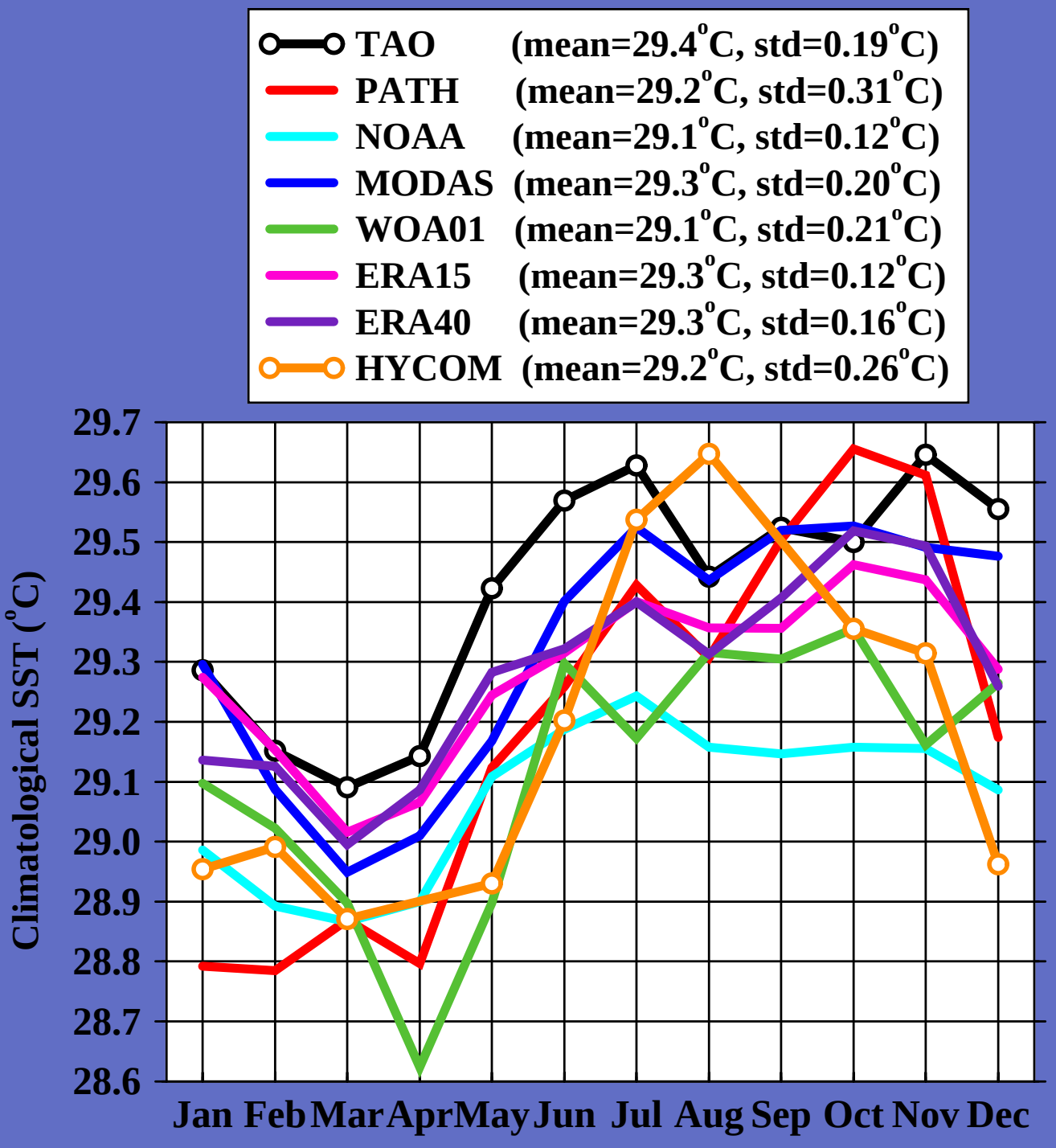
		HYCOM	KPP	GISS	MY2.5	KT	PWP	No ML
ME (°C)	**Hybrid**	**0.04**	**0.05**	**0.06**	**–0.06**	**–0.12**	**–1.56**
	$\sigma-z$	**0.03**	**0.04**	**0.04**	**0.01**	**0.03**	**–0.58**
RMS (°C)	**Hybrid**	**0.37**	**0.36**	**0.37**	**0.56**	**0.75**	**2.26**
	$\sigma-z$	**0.32**	**0.33**	**0.33**	**0.35**	**0.35**	**1.76**
B_{COND}	**Hybrid**	**0.07**	**0.08**	**0.07**	**0.09**	**0.10**	**0.12**
	$\sigma-z$	**0.07**	**0.07**	**0.07**	**0.07**	**0.07**	**0.14**
B_{UNCOND}	**Hybrid**	**0.03**	**0.03**	**0.04**	**0.11**	**0.31**	**4.43**
	$\sigma-z$	**0.02**	**0.02**	**0.03**	**0.03**	**0.03**	**1.90**
R	**Hybrid**	**0.91**	**0.91**	**0.91**	**0.81**	**0.71**	**0.12**
	$\sigma-z$	**0.92**	**0.92**	**0.92**	**0.92**	**0.91**	**0.04**
SS	**Hybrid**	**0.75**	**0.75**	**0.74**	**0.55**	**0.27**	**–4.12**
	$\sigma-z$	**0.78**	**0.78**	**0.78**	**0.78**	**0.76**	**–1.61**

EVALUATION AGAINST OTHER CLIMATOLOGIES

SKILL SCORE: 40–level $\sigma - z$ simulation using GISS

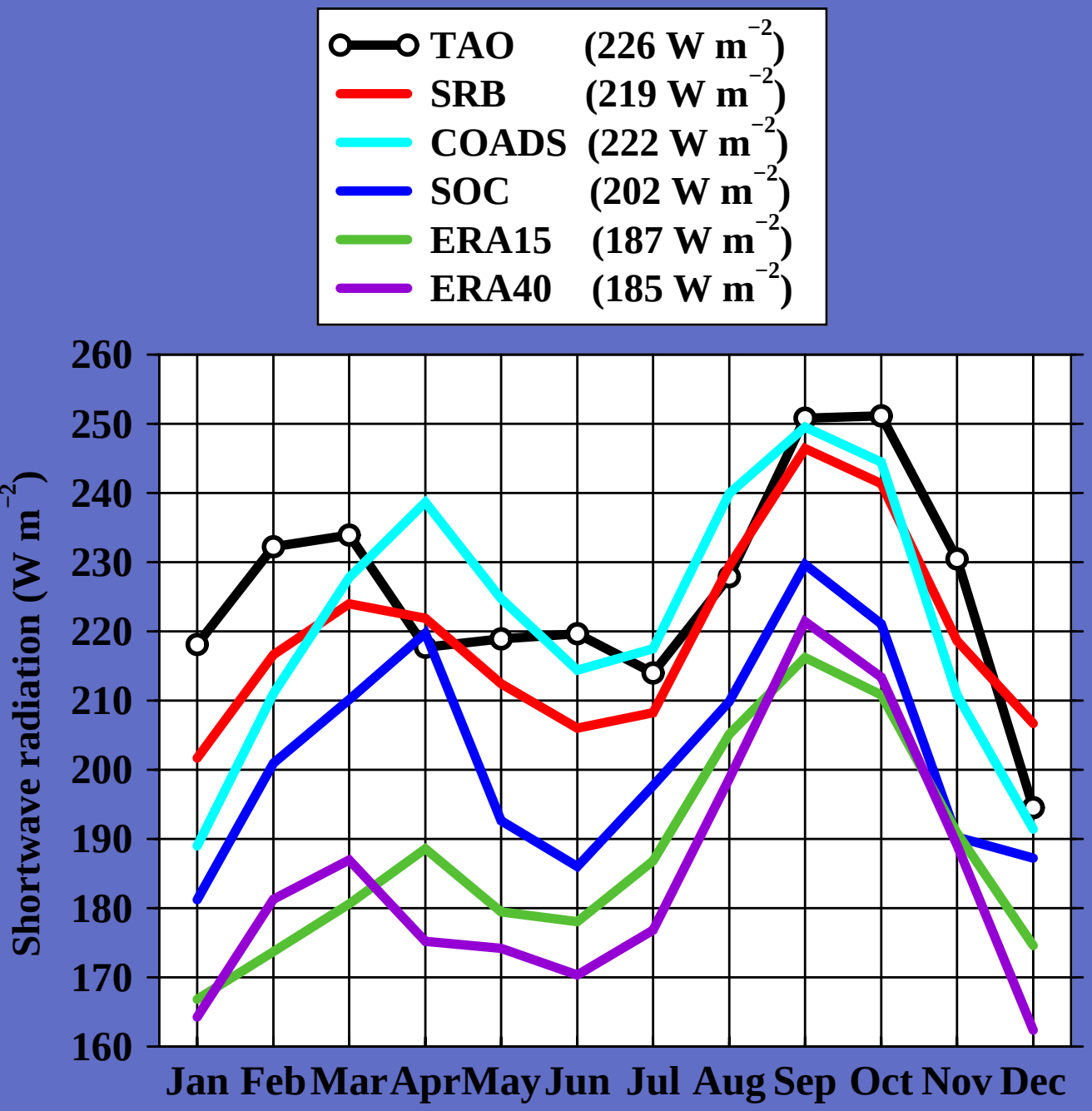


SST CLIMATOLOGY AT (2°N, 165°E) IN THE WARM POOL



HYCOM does NOT assimilate or relax to any SST climatology

SHORTWAVE RAD. CLIMATOLOGY AT (2°N, 165°E)



CONCLUSIONS

- **KPP, GISS and MY2.5 slightly outperform KT and PWP**
- **No mixed layer simulation: Unrealistic SST!!**
- **Two problematic regions in predicting SST**
    - **(1) Warm pool (small error but less skill)**
    - **(2) Eastern Pacific (large error but good skill)**

This is NOT a mixed layer model problem (All perform same) !!

- **atmospheric forcing problems**
- **correction to the radiation fields**