Impact of Interactive Westerly Wind Burst on the Community Climate System Model version 3 (CCSM3).

Hosmay Lopez[1] and Ben P. Kirtman[2]

[1,2] Rosenstiel School of Marine and Atmospheric Science, University of Miami, Fl, USA

Contact info : [1]hlopez@rsmas.miami.edu, [2]bkirtman@rsmas.miami.edu

1. Motivation

-How does state-independent and state-dependent stochastic forcing affects ENSO variability in a sophisticated coupled model?

-Westerly Wind Burst (WWB) do occurs, but are not well represented in Coupled General Circulation Models (CGCM) due to major bias in the mean state.

-WWBs are observed during the onset and development of major El Niño events (Kerr 1999).

-WWBs are known to have a deterministic component, modulated by the Sea Surface Temperature (SST).

-Proper representation of WWBs could improve ENSO prediction.

-Eventually reach a better understanding on ENSO prediction and predictability.

Table 1. DJF Nino 3.4 SSTA count of cold (a) and warm (b) events out of 201 years.

	°C	Control	State indep.	State-dep..
a)	<-1.00	40	30	61
	<-1.25	32	23	52
	<-1.50	22	15	40
	<-1.75	13	8	34
	<-2.00	7	7	21
b)	°C			
	> 1.00	41	31	73
	> 1.25	22	16	61
	> 1.50	9	6	48
	> 1.75	2	3	22
	> 2.00	1	1	4

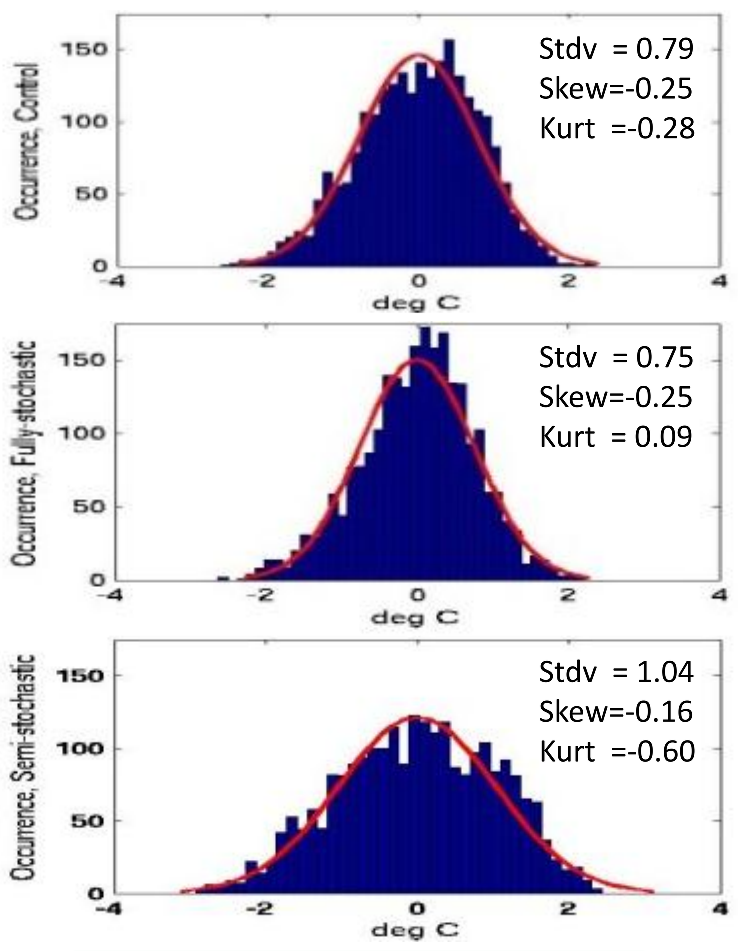

Figure 2. Histograms of Niño 3.4 SSTA for 201 model years. Control (top), state-independent (middle), and state-dependent (bottom). Normal distribution fitted (red). The y-axis represents the occurrence (in moths). Also showing the standard deviation, skewness and kurtosis coefficient

2. Background

-Westerly Wind Bursts (WWBs) are commonly viewed as completely stochastic processes, independent of any oceanic forcing.

-Recent work and observations have suggested that these events also contain a deterministic component, modulated by the SST.

-These events seem to result from various mechanisms:

1. The Madden-Julian oscillation (MJO; Chen et al. 1996).
2. Cold surges from mid latitudes (Chu 1988).
3. Tropical cyclones (Keen 1982).
4. Combination of the three (Yu and Rienecker 1988).

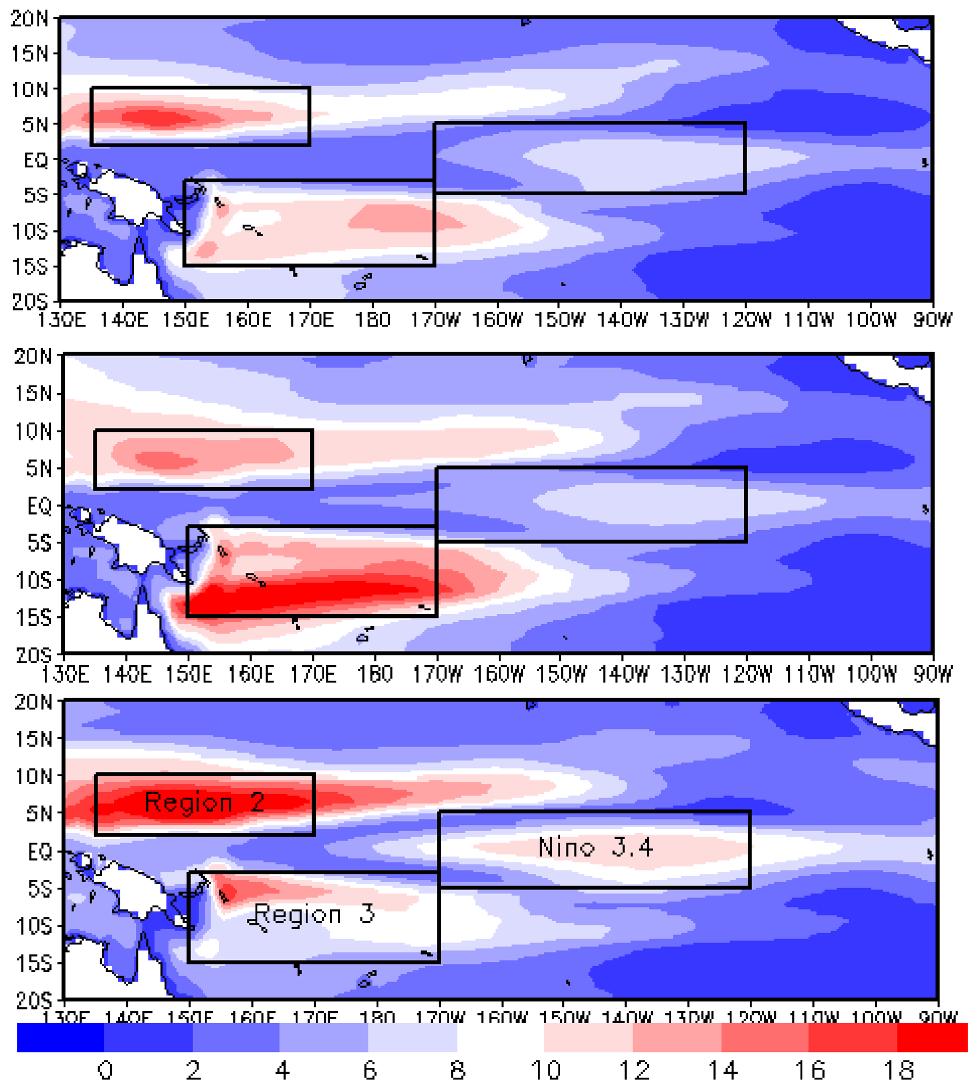

Figure 3. Sea Surface Height (SSH) variance, [cm^2]. Control (top), state-independent (middle), and state-dependent WWB (bottom).

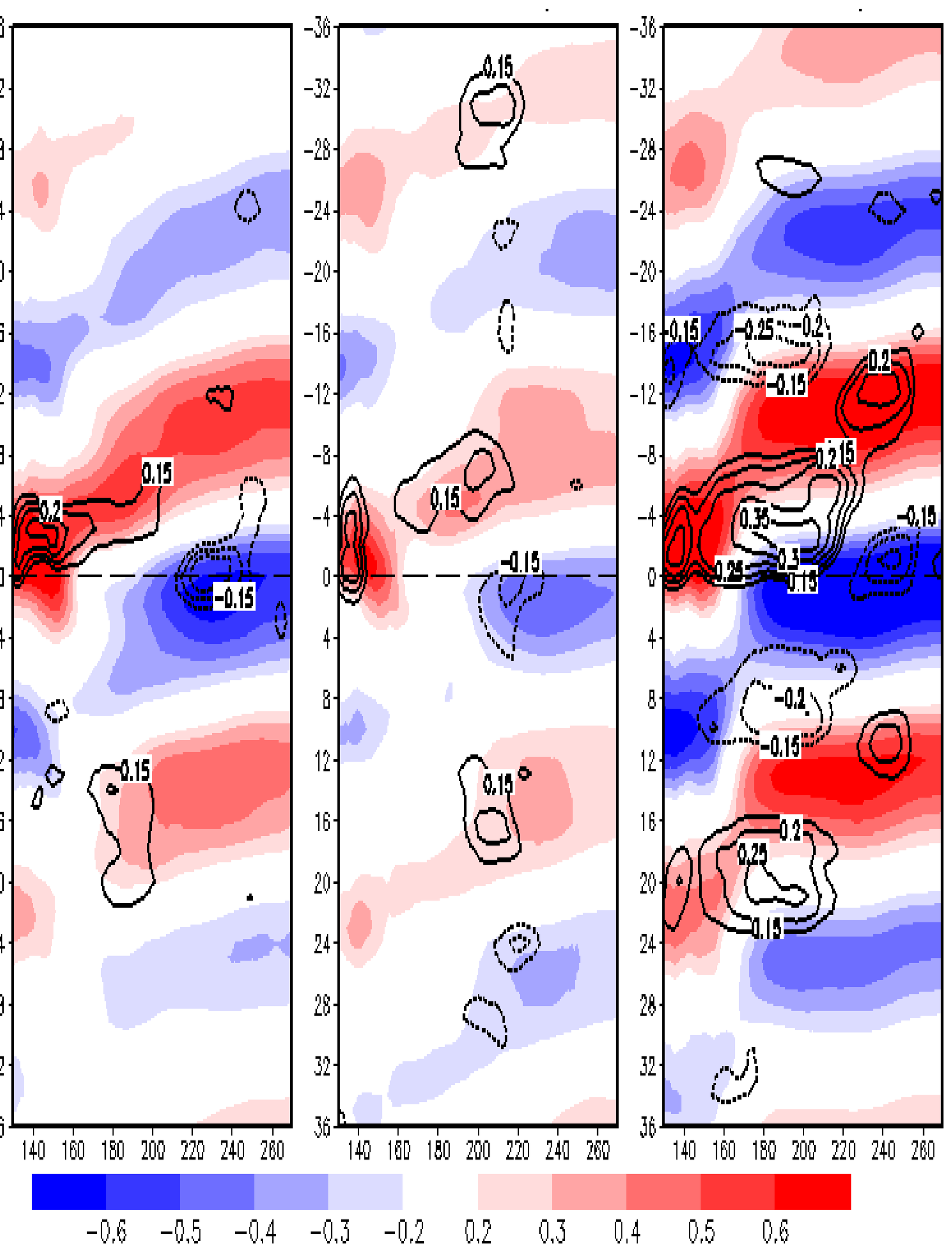

Figure 4. Lag-lead correlation of SSH (shaded), zonal wind stress (contour) along the equator with a SSH and wind stress index (region 2 on fig. 3) respectively. Positive lag means that indices on region 2 lags by as many months. Control (left), state-independent (middle), and state-dependent (right) case.

3. Experiment Design

-The Community Climate System Model version 3.0 (CCSM3), is integrated for several hundred years with three different initial conditions:

-No Westerly Wind Burst (WWB) event. This is our control run.

-The state-independent run, here the WWB are added to the model as additive noise and are parameterized based on 50 years atmospheric reanalysis data and observed estimates of tropical Pacific SST.

-The state-dependent run, here the WWB are introduced as multiplicative noise modulated by the SST, the probability of occurrence is different from the state-independent case in that it depends on the large –scale SST anomalies.

-The wind anomalies are always positive (eastward) with no westward counterpart

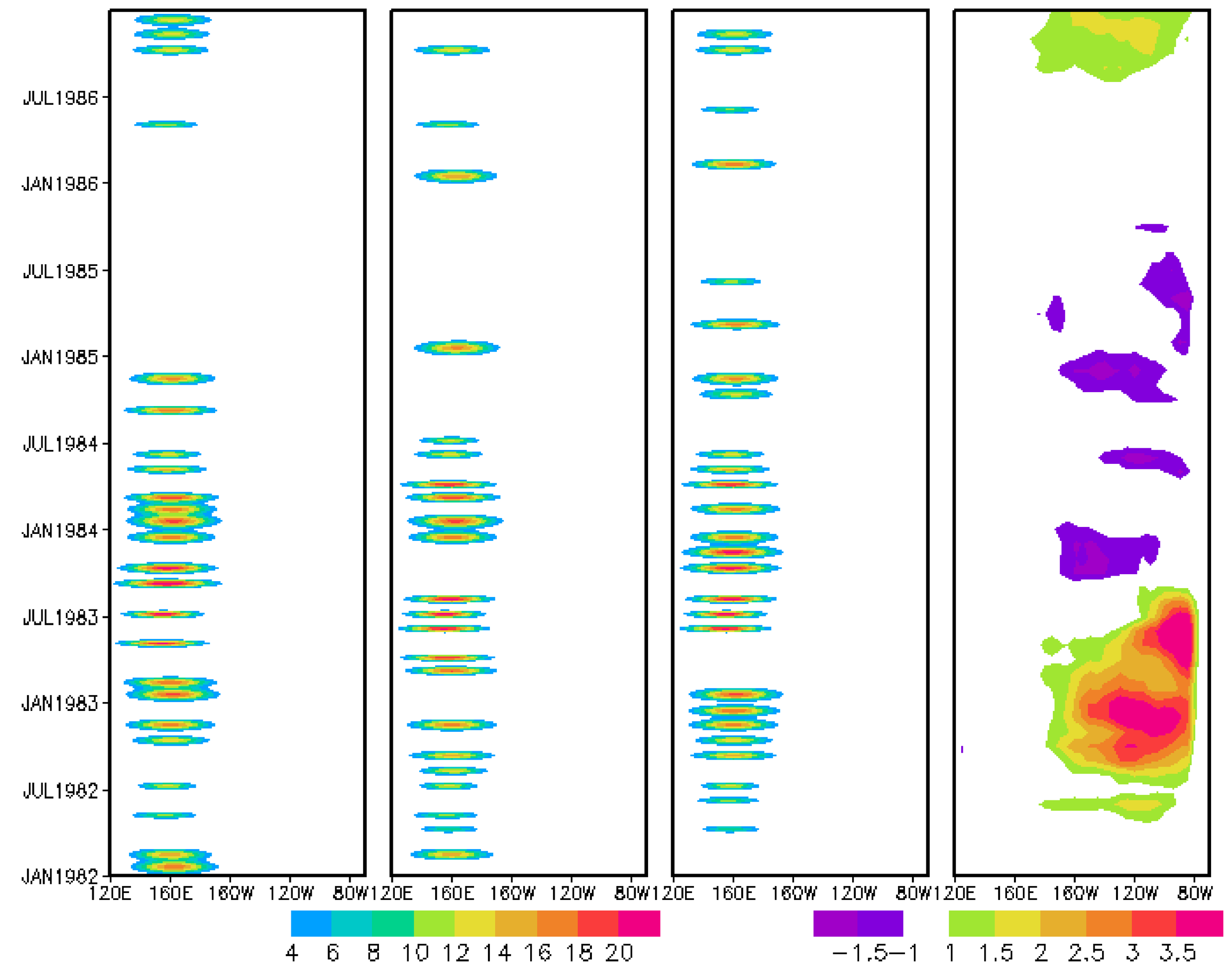

Figure 1. Three state-dependent WWBs realizations with the same observed SSTA [°C] (right), showing cross-section along the equator in the Pacific Ocean, units [m/s].

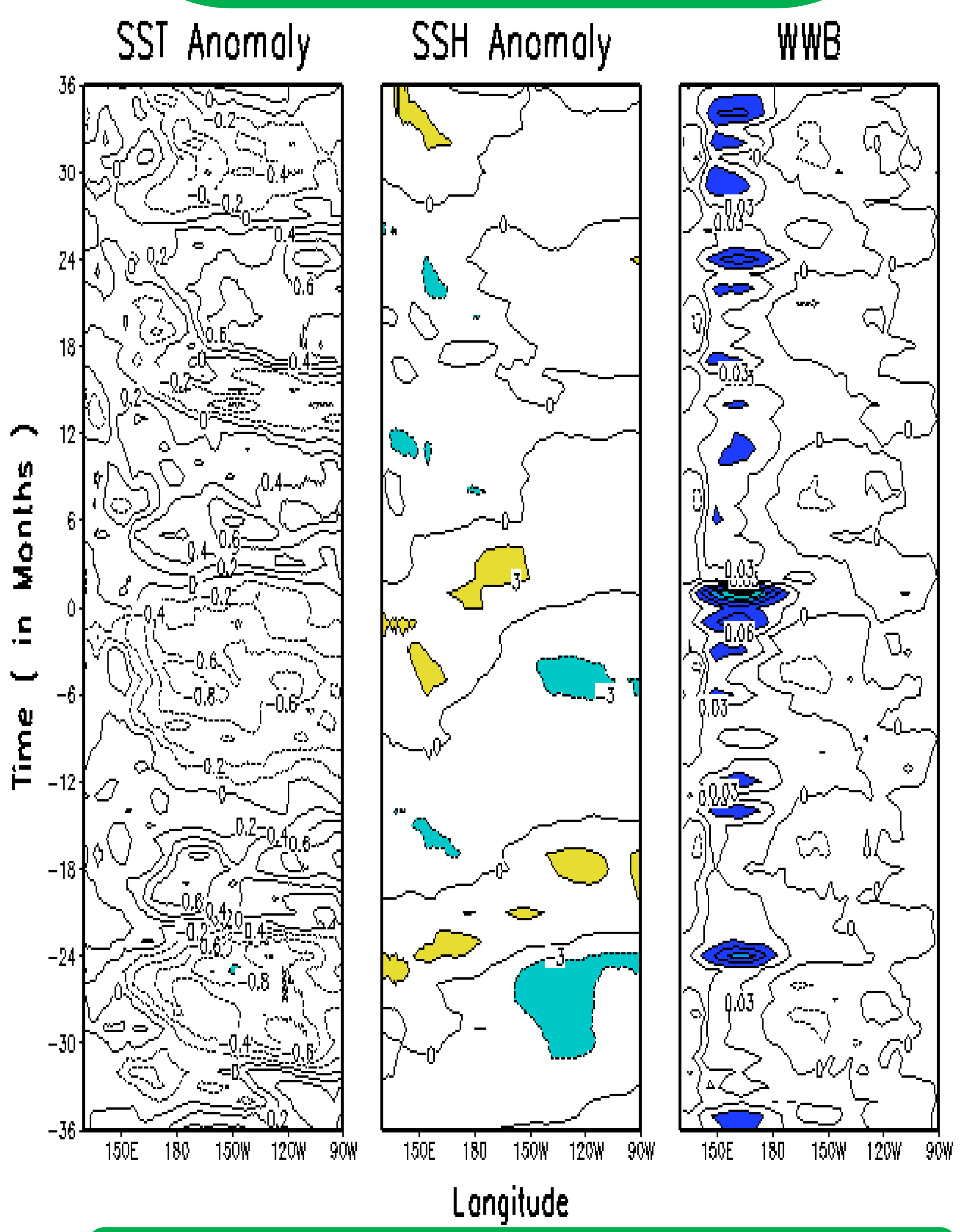

Figure 5. Composite of the top 5 strongest WWB events for the state-independent case.

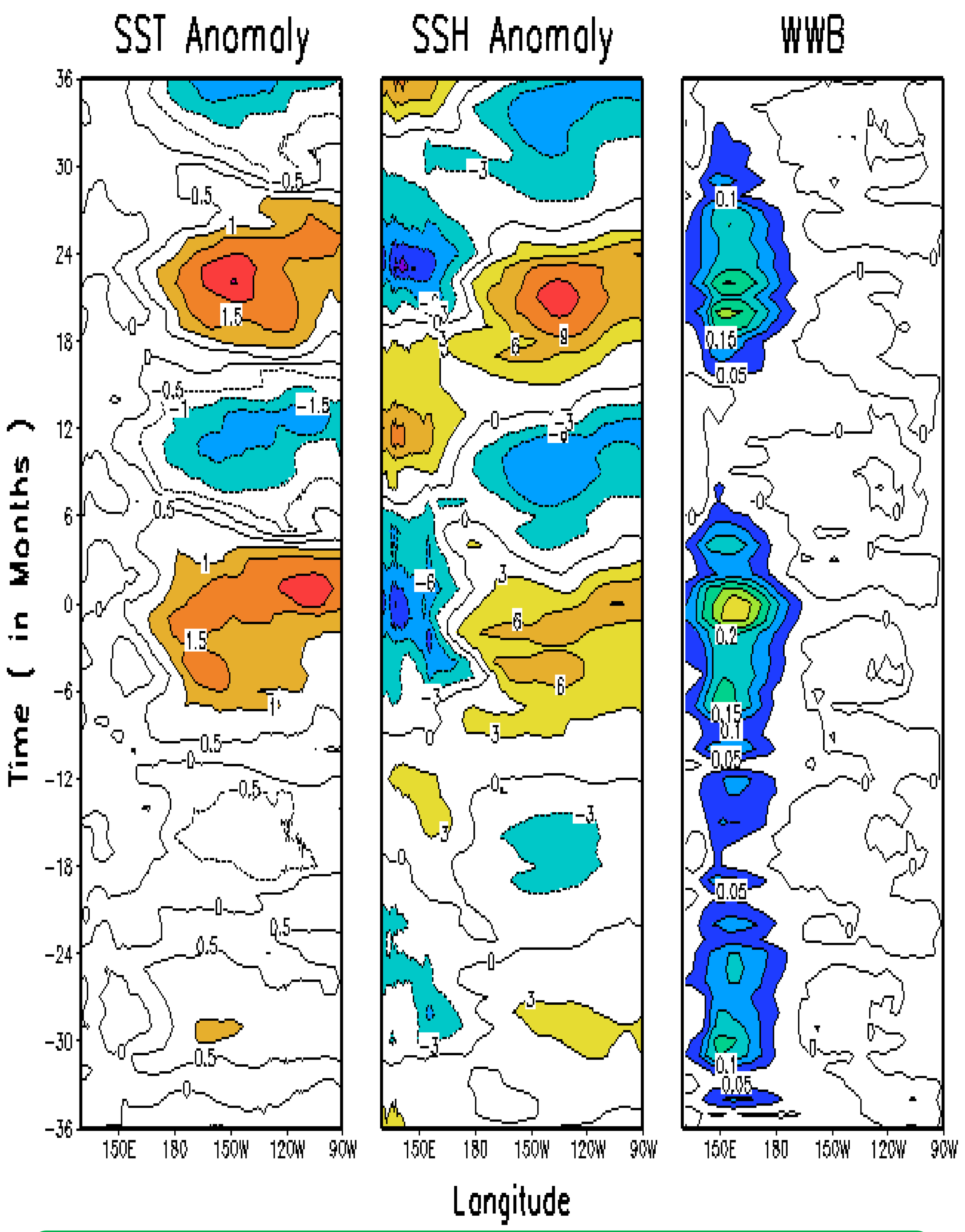

Figure 6. Composite of the top 5 strongest WWB events for the state-dependent case.

4. Conclusions

State-independent stochastic forcing in the form of WWBs has minimal effect on overall variability in the tropical Pacific ocean in CCSM3, but a degraded lag-coherence is observed with respect to the control case.

State-dependent WWBs significantly increase the number of ENSO events along with the fraction of warm versus cold phases.

The amplitude of ENSO events was increased with the inclusion of state-dependent forcing.

ENSO characteristics have shifted from an episodic event regime in the state-independent case to a more oscillatory regime in the state-dependent case. The control case appears somewhat in between.

5. References

Chen, S. S., R. A. Houze Jr., and B. E. Mapes, 1996: Multiscale variability of deep convection in relation to large-scale circulation in TOGA COARE. *J. Atmos. Sci.*, **53**:1380–1409.

Chu, P-S., 1988: Extratropical forcing and the burst of equatorial westerlies in the western Pacific: A synoptic study. *J. Meteor. Soc. Japan*, **66**:549–563.

Keen, R. A., 1982: The role of cross-equatorial tropical cyclone pairs in the Southern Oscillation. *Mon. Wea. Rev.*, **110,** 1405–1416.

Kerr, R. A., 1999: Atmospheric science: Does a globe-girdling disturbance jiggers el Niño? *Science*, **285,** 322-323.

Yu, L. and M. M. Rienecker, 1998: Evidence of an extratropical atmospheric influence during the onset of the 1997–98 El Niño. *Geophys. Res. Lett.*, **25**:3537–3540.

Acknowledge :

Eli Tziperman (Harvard), Zhiming Kuang (Harvard), and Jake Gebbie (Woods Hole Oceanographic Institution).