Westerly Wind Bursts (WWB) revisited: Implications for Central Pacific (CP), Eastern Pacific (EP) and extreme El Niño events

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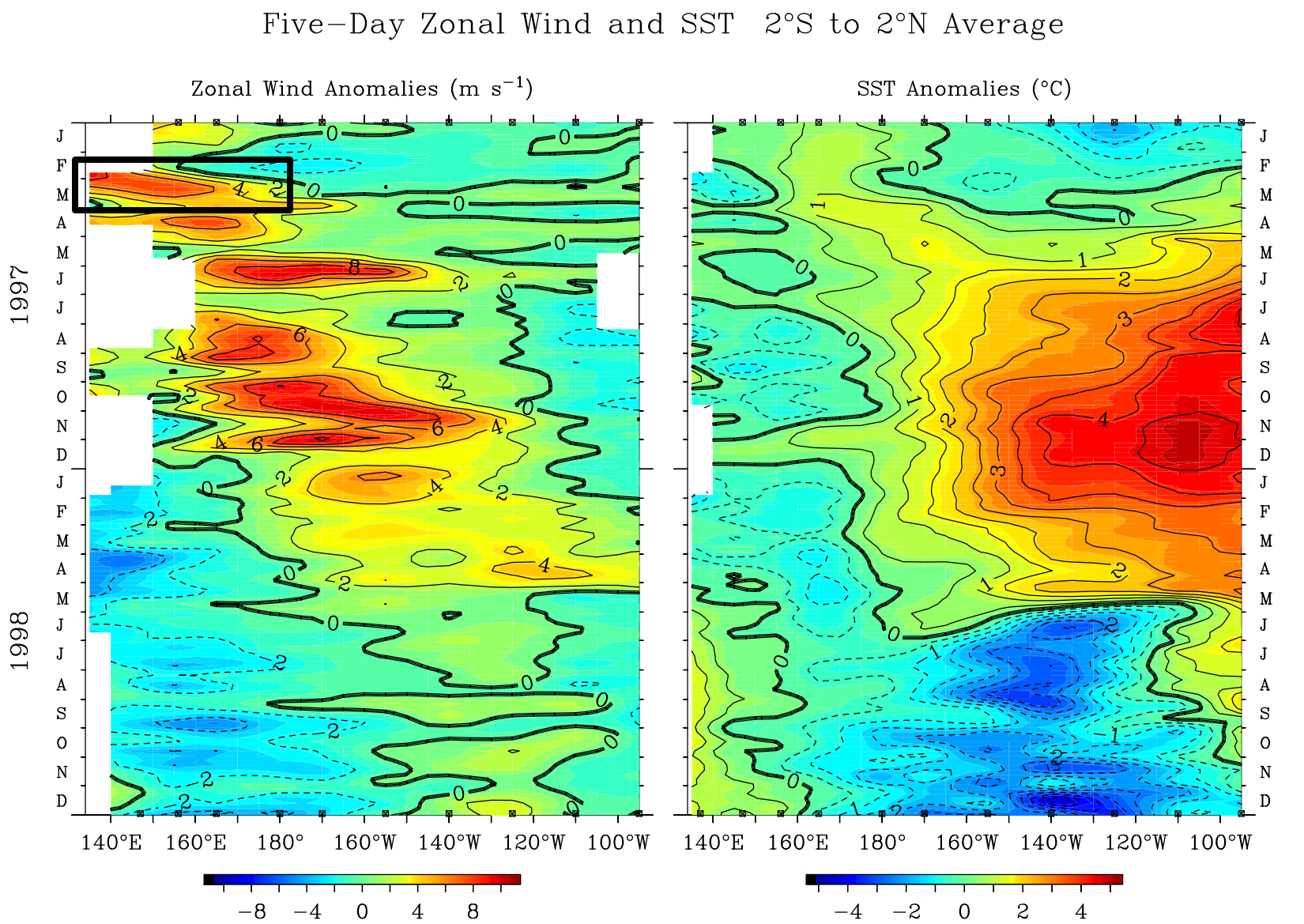
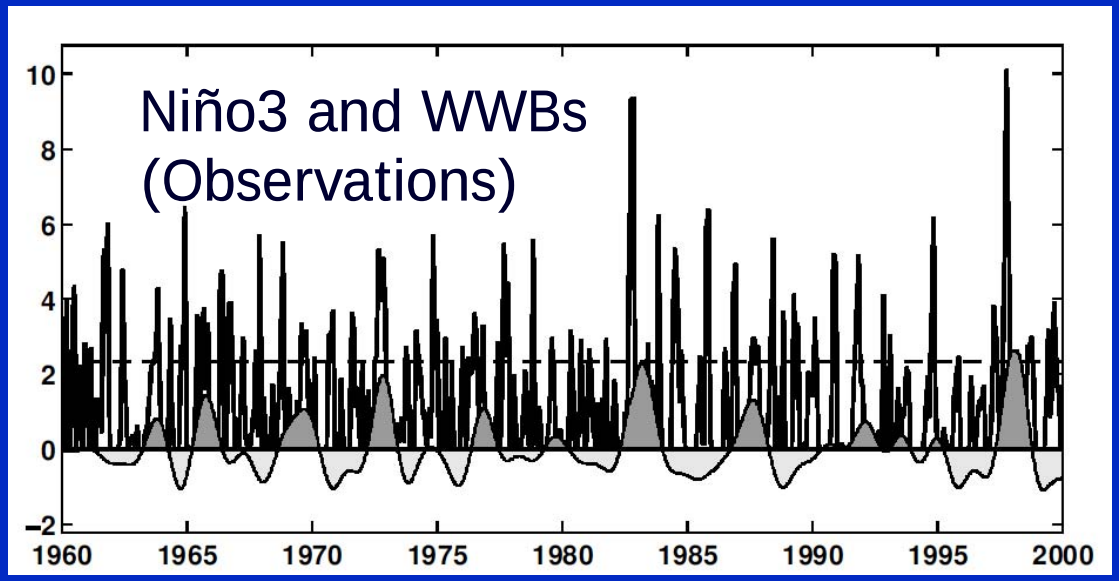
Westerly Wind Burst (WWB) in Feb-Mar 1997, preceding El Niño

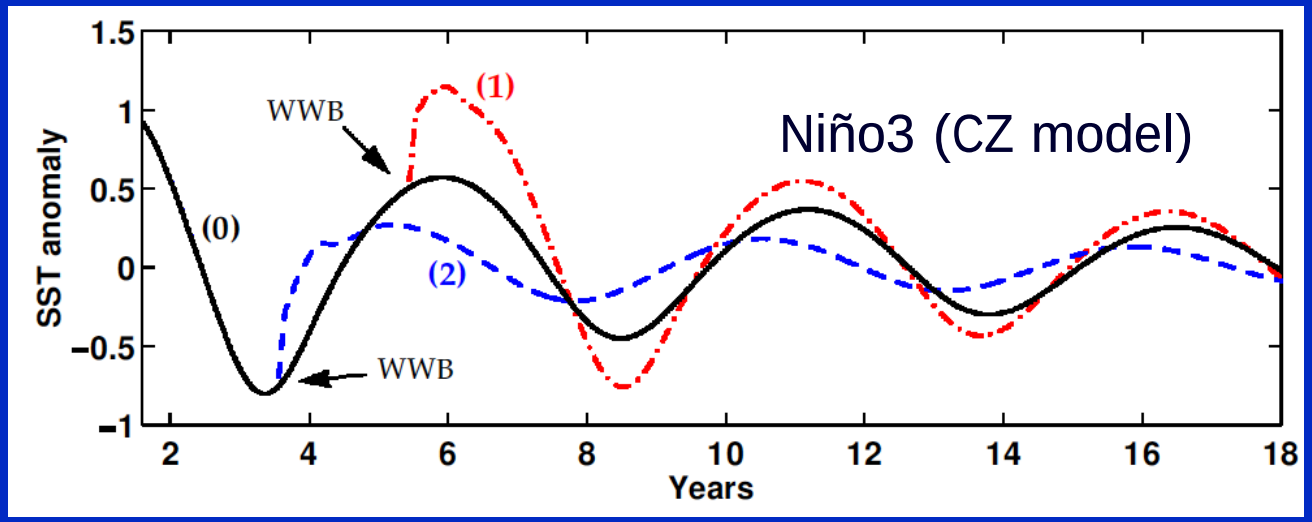


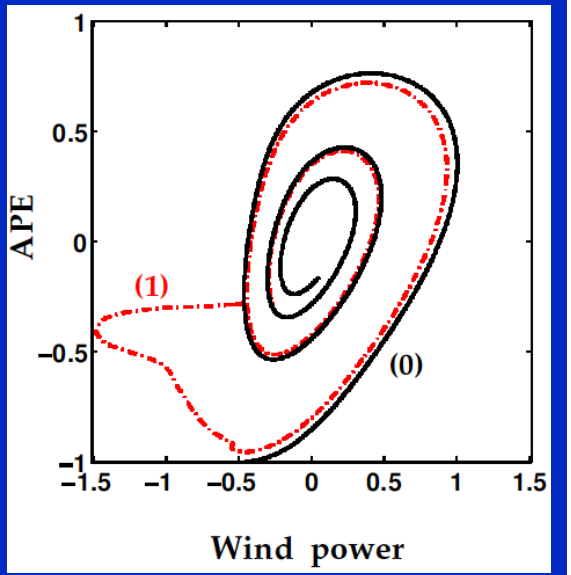
Q. J. R. Meteorol. Soc. (2002), **128**, pp. 1–23

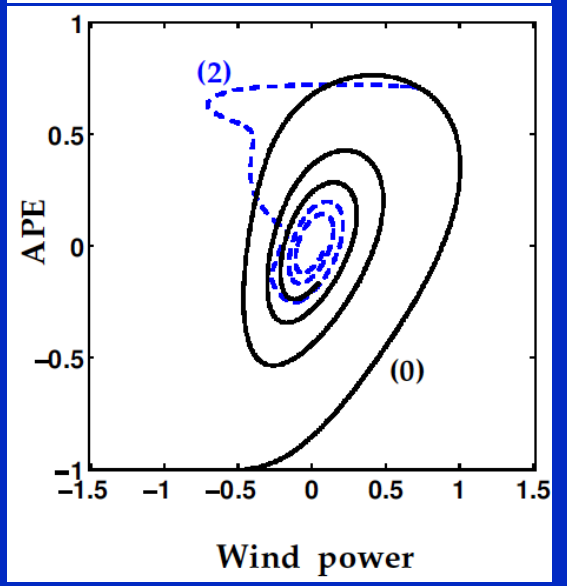
The response of the coupled tropical ocean–atmosphere to westerly wind bursts

By ALEXEY V. FEDOROV*









Climate Dynamics (2004) 23: 601–620
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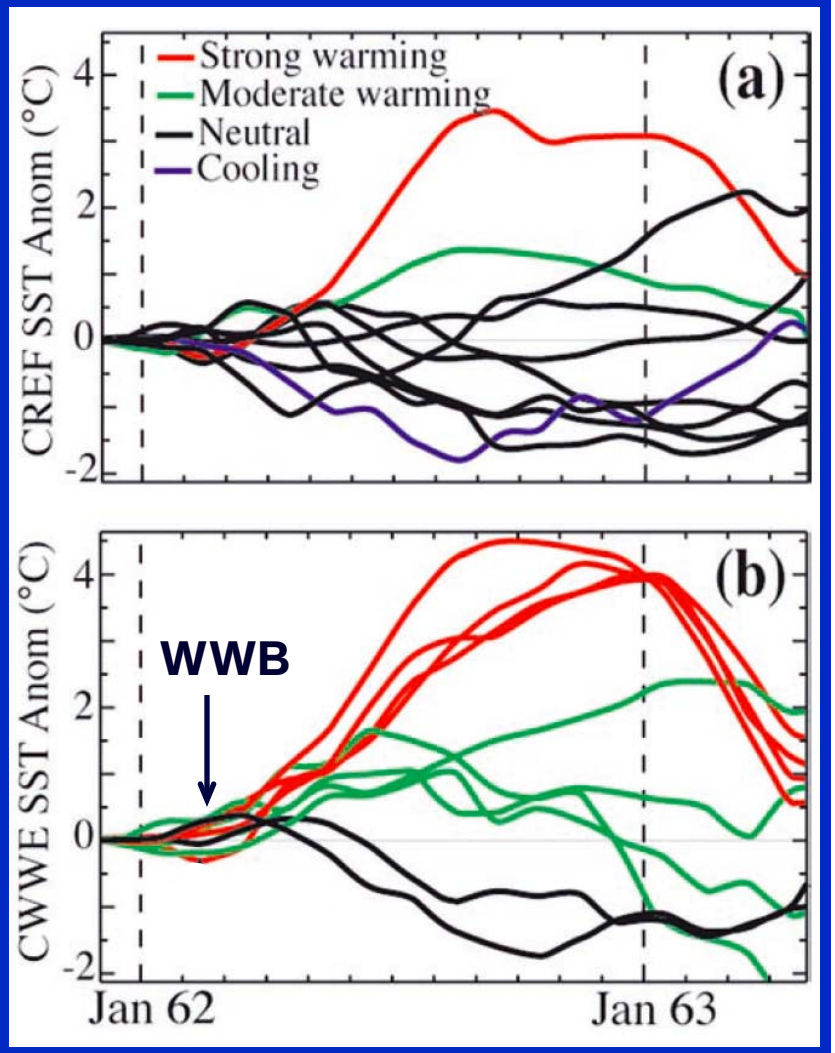
Triggering of El Niño by westerly wind events in a coupled general circulation model

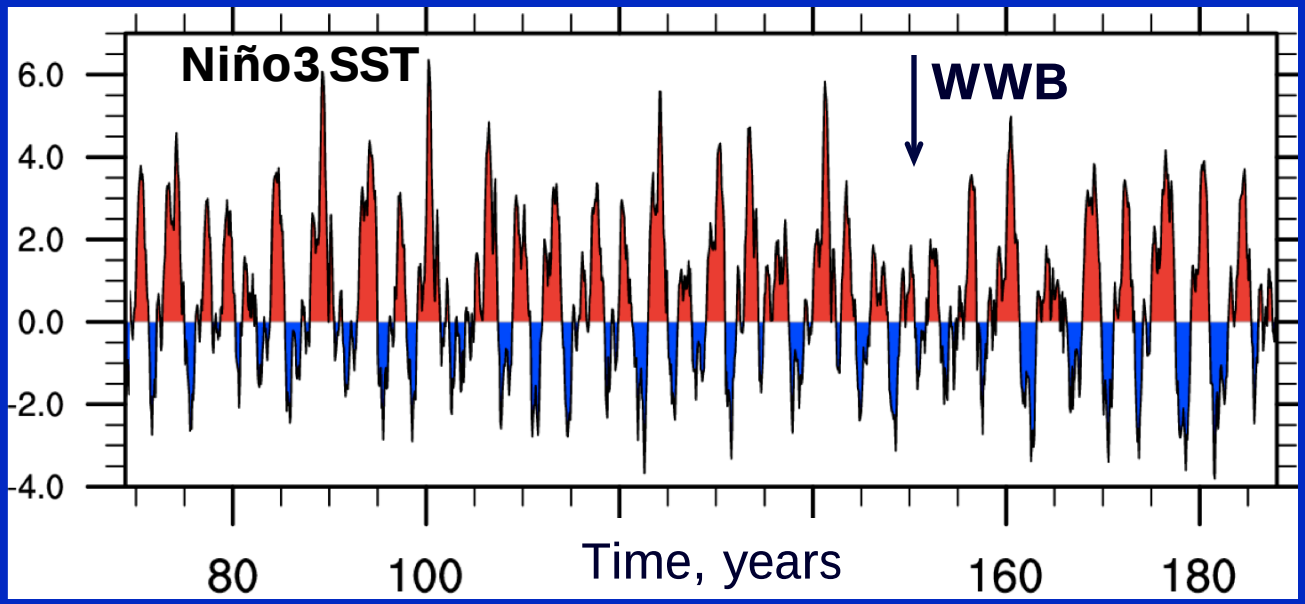
The HadOPA coupled model

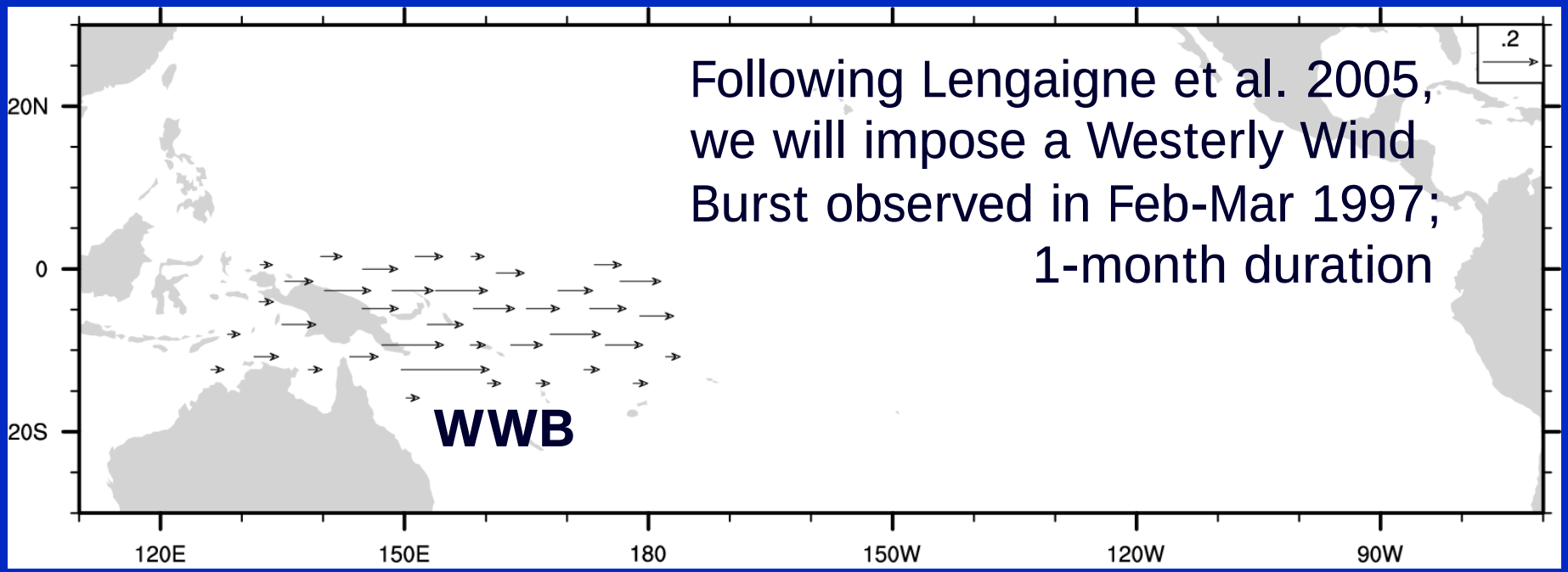
The OGCM used in this study is the OPA model (Madec et al. 1998, see documentation at http://www.lodyc.jussieu.fr/opa/) in its global configuration, known as ORCA2. The horizontal mesh is based on a 2° by 2° Mercator grid (i.e., the same zonal and meridional grid spacing). However, a local transformation is applied to the model grid in the tropics to refine the meridional resolution to up to 0.5° at the equator. The

Niño3 in two suites of experiments – with and without **WWB**



Experiments





Following Lengaigne et al. 2005, we will impose a Westerly Wind Burst observed in Feb-Mar 1997; 1-month duration

Experimental set-up:

Two sets of ensemble experiments:

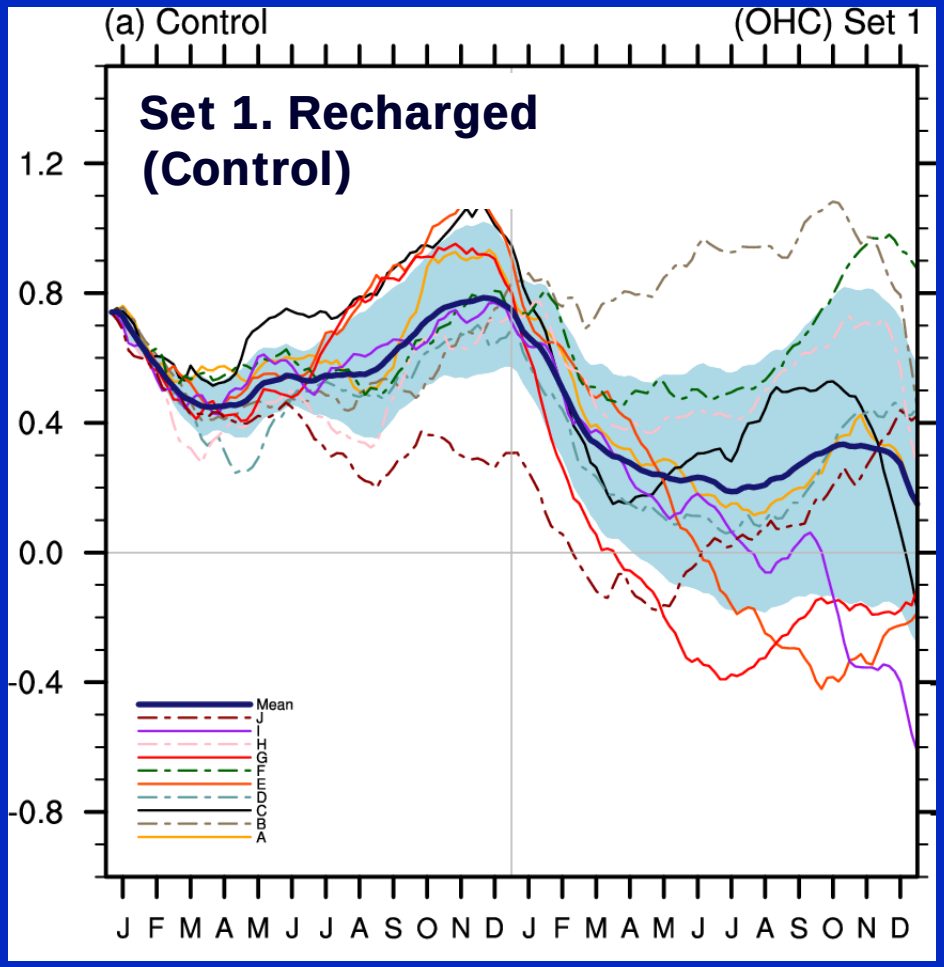
Set 1. Recharged. Ocean Heat Content (OHC) initially recharged
Set 2: Neutral. Ocean Heat Content (OHC) initially neutral

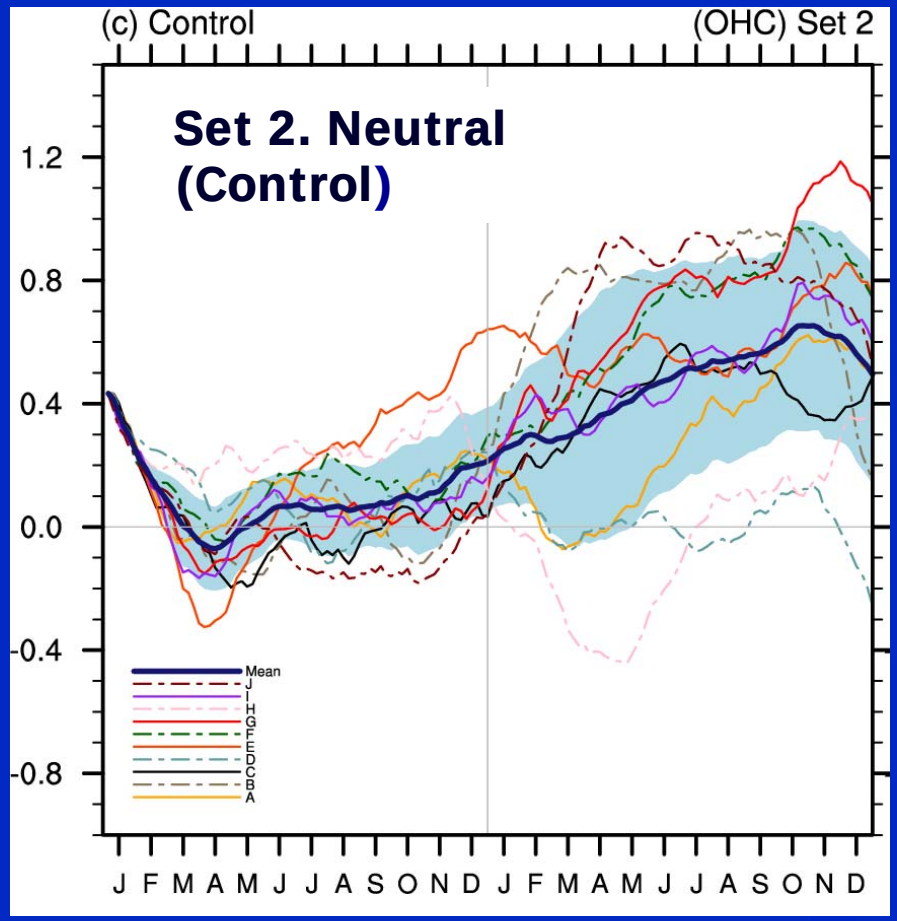
Each set has

10 control experiments
(the same initial ocean; atmospheric state shifted by a few days)
and
10 perturbed experiments
(a WWB is superimposed in Feb-Mar)

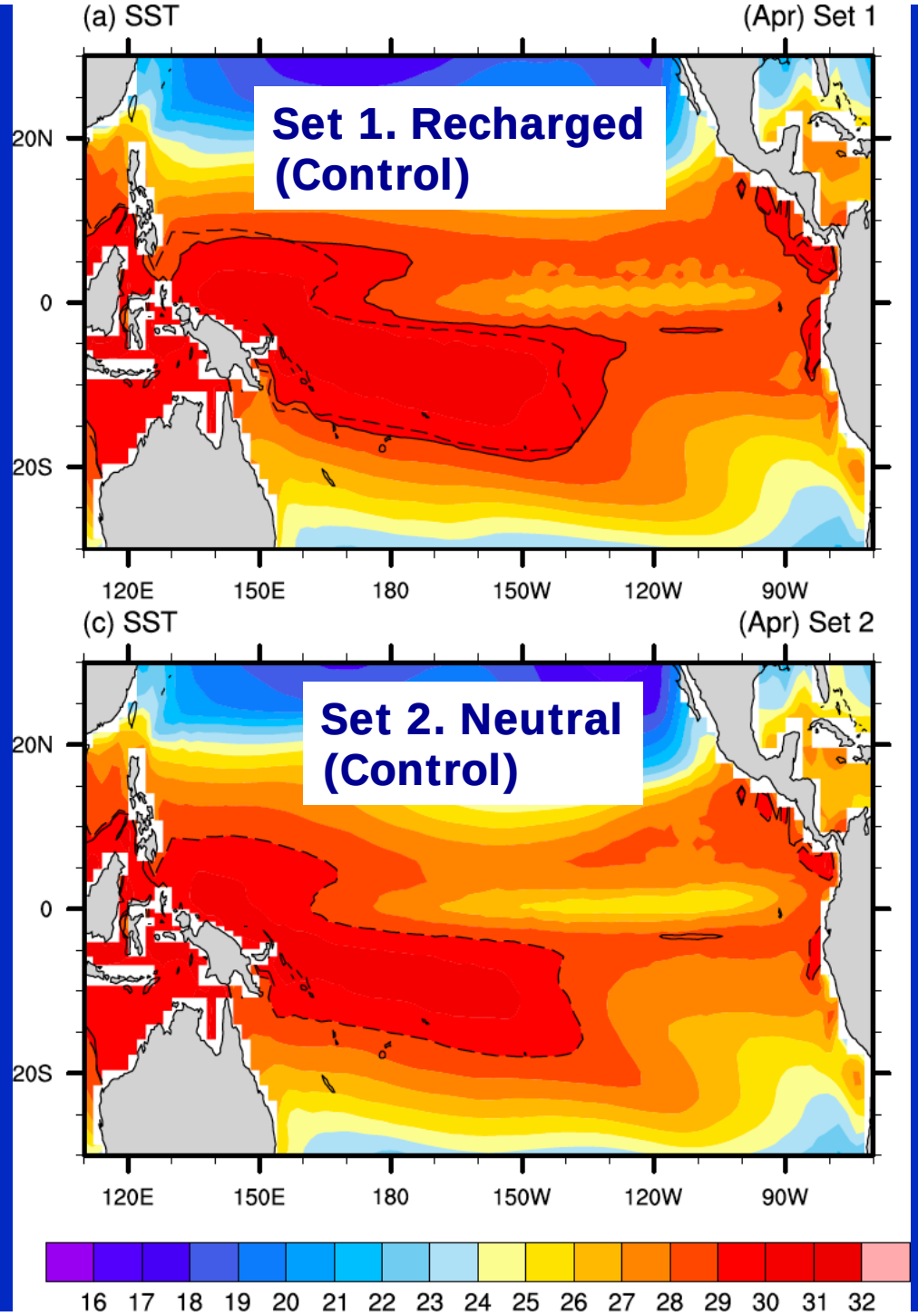
40 experiments total. Each lasts for 2 years. Model HadOPA.

Variations in Ocean Heat Content





OHC = temperature (^{o}C) averaged
5N-5S, East-West, 0 – 300m
Each thin line – one experiment
Blue line – ensemble mean



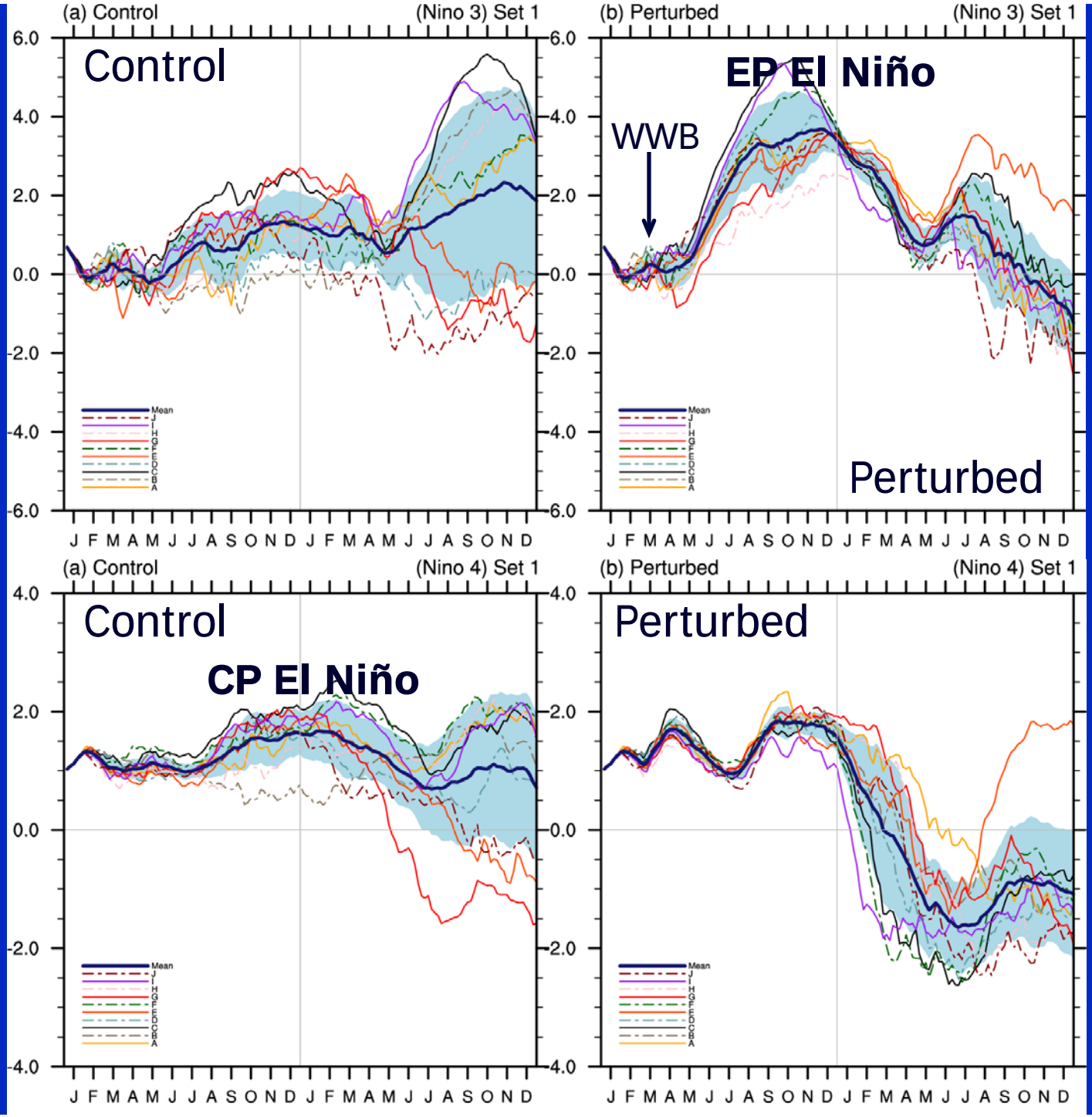
Set 1 (Recharged):
The Warm pool is extended farther eastward;
The Cold tongue is warmer!

Set 2 (Neutral):
Generally colder!

Set 1. Recharged

Niño3:

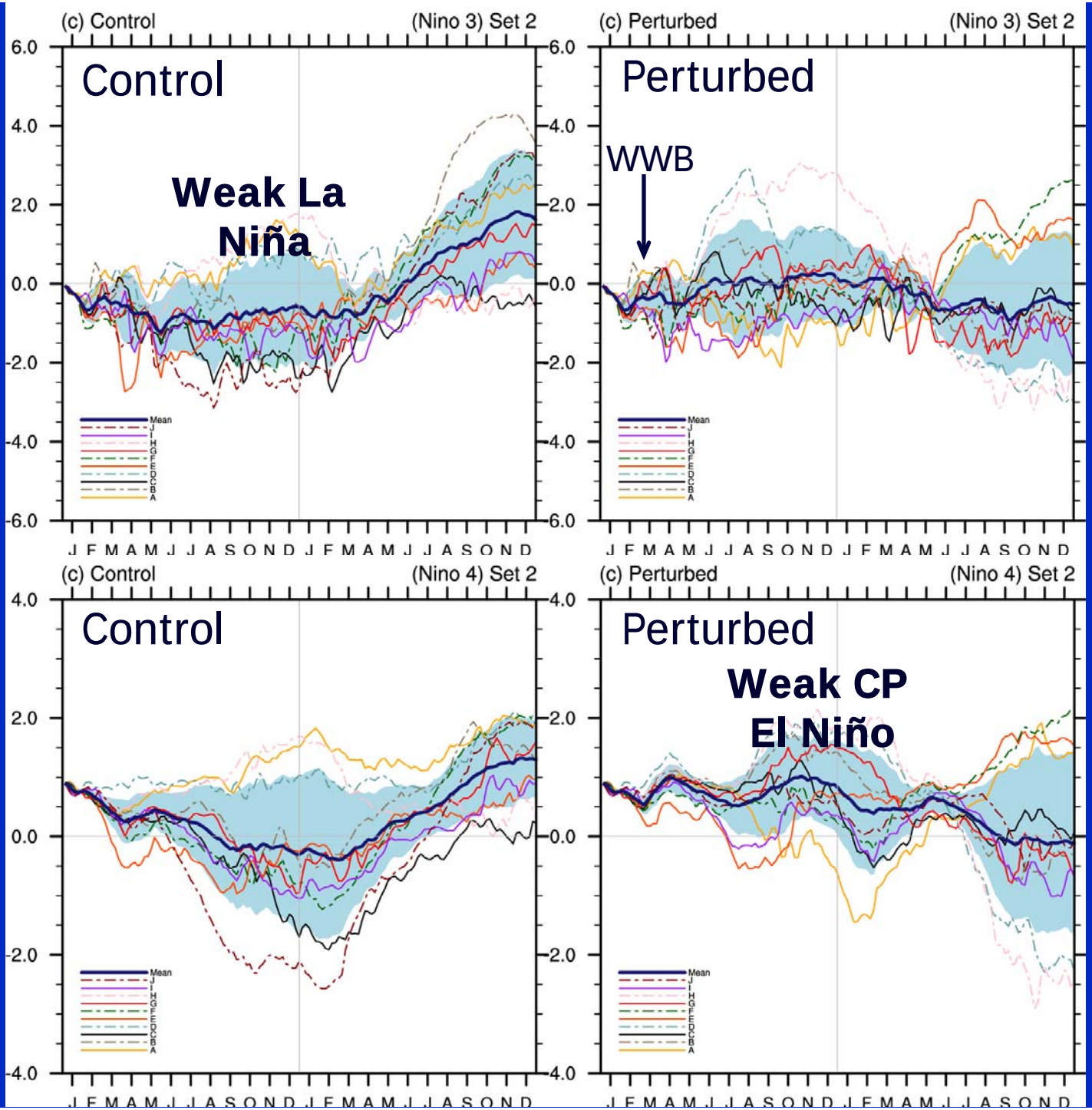
Niño4:



Set 2. Neutral

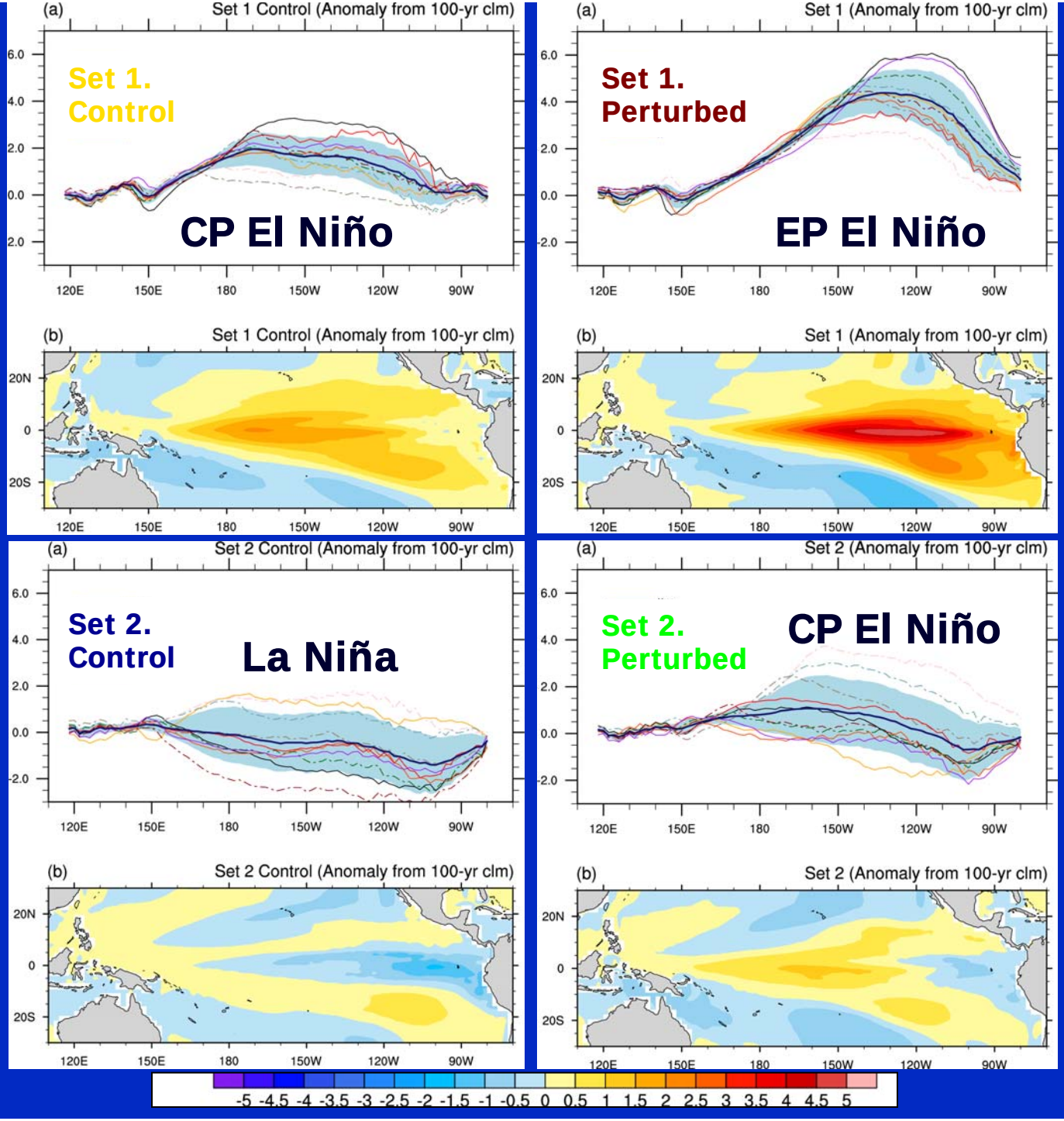
Niño3:

Niño4:

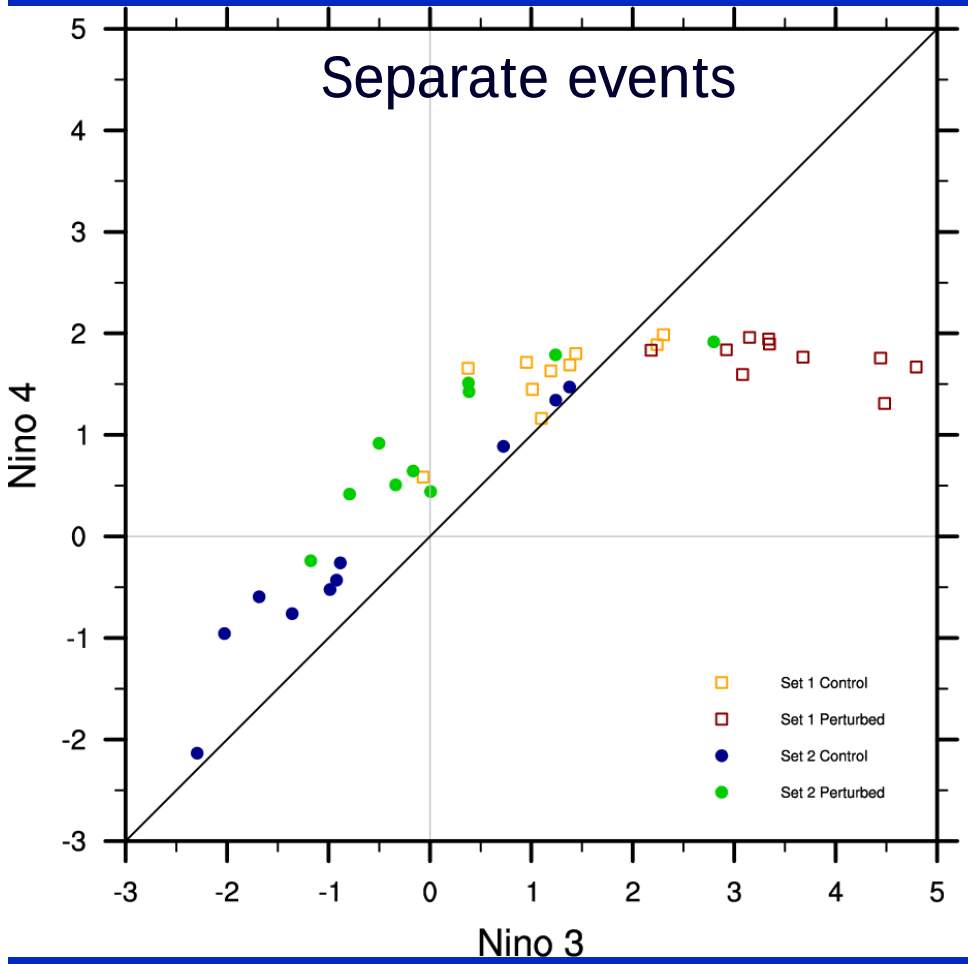


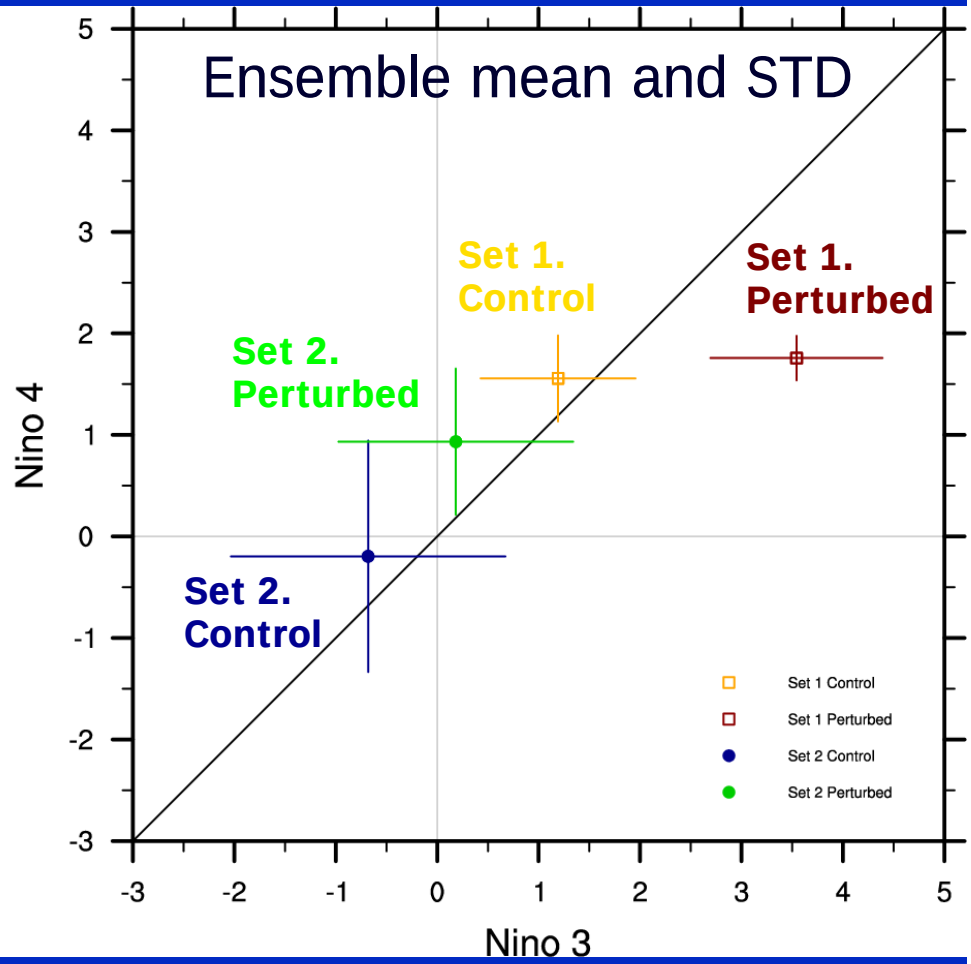
Events at their peak:

SST along the equator in December

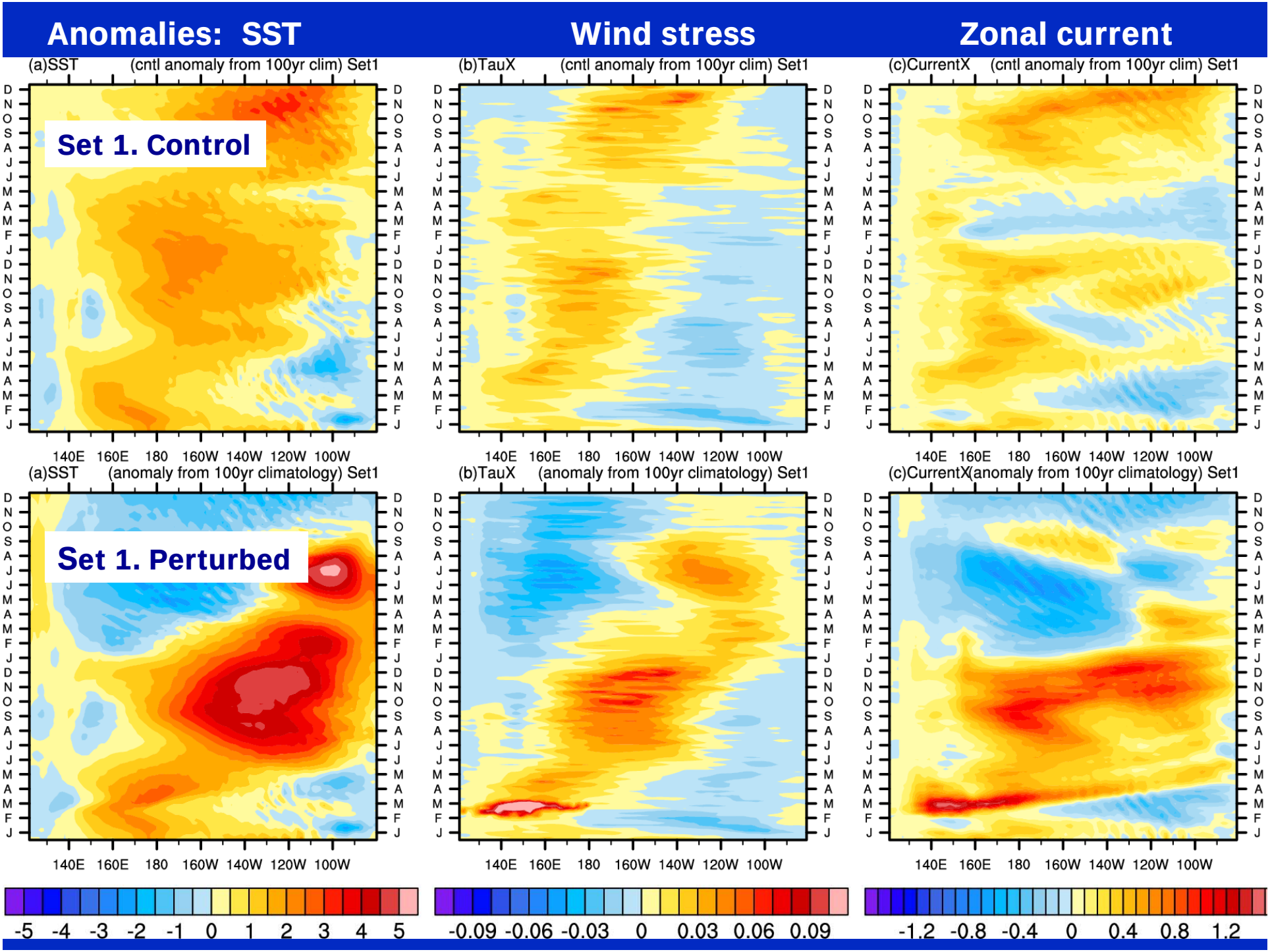


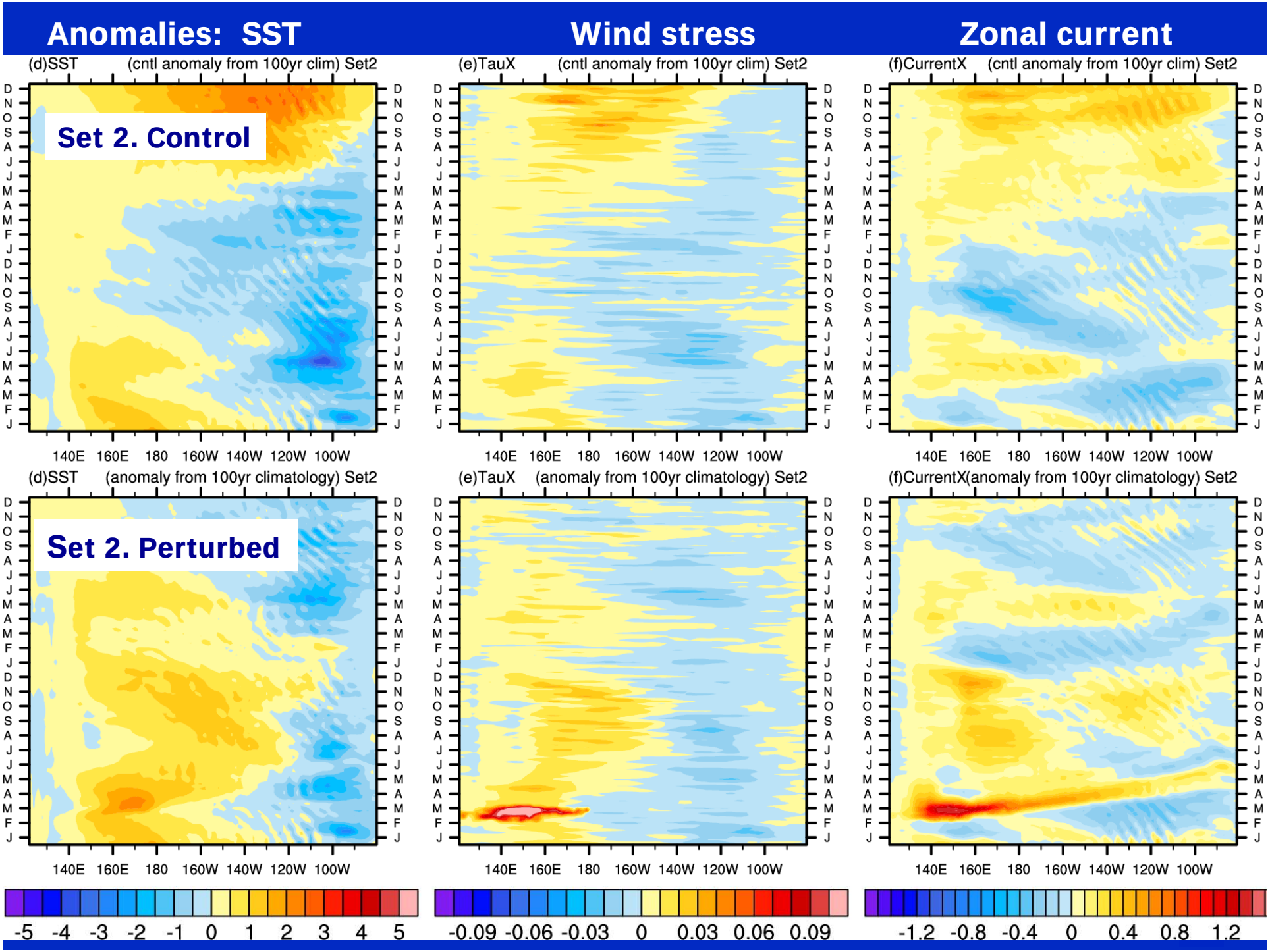
SST indices at the peak of events (Oct-Dec)

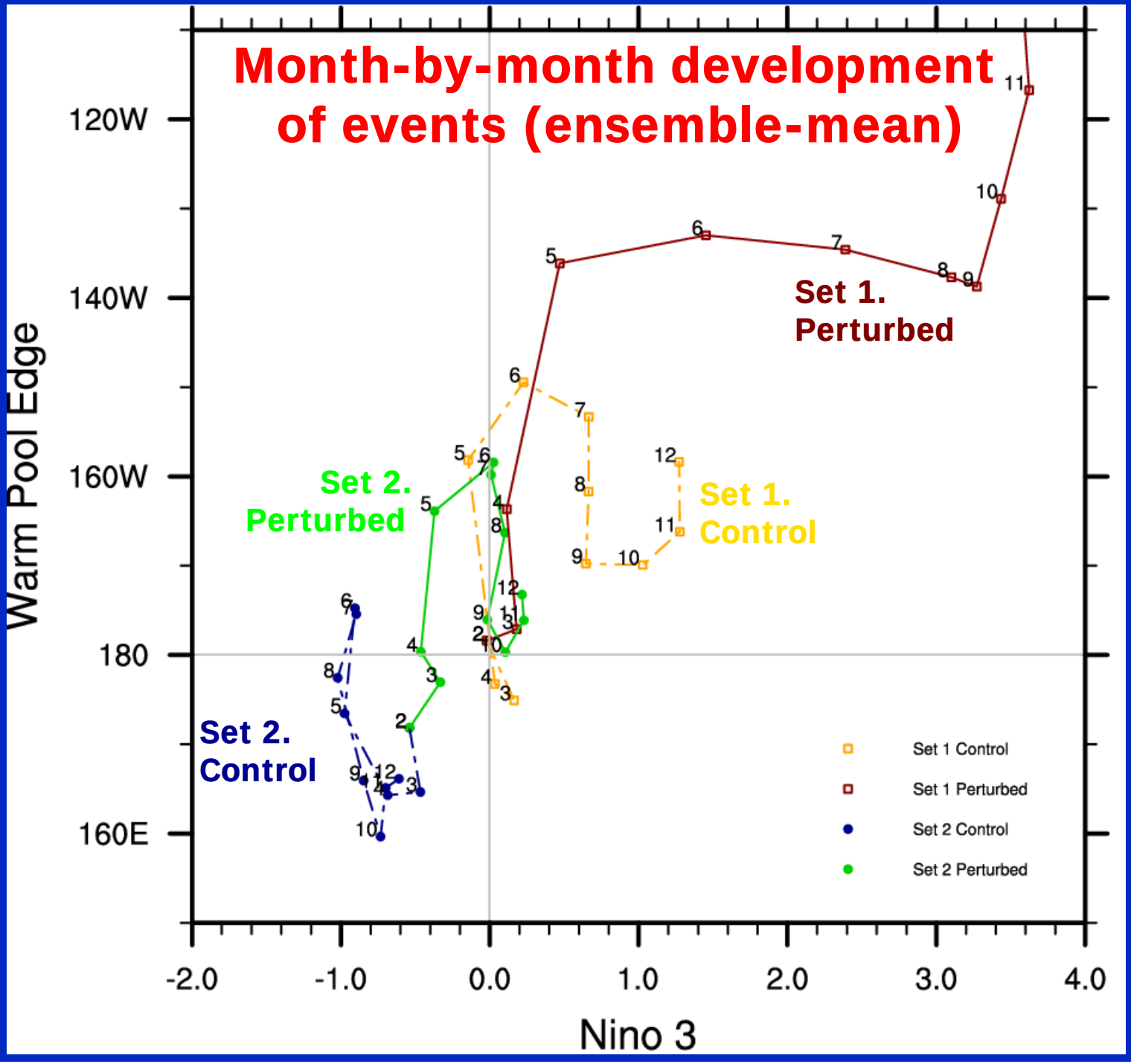


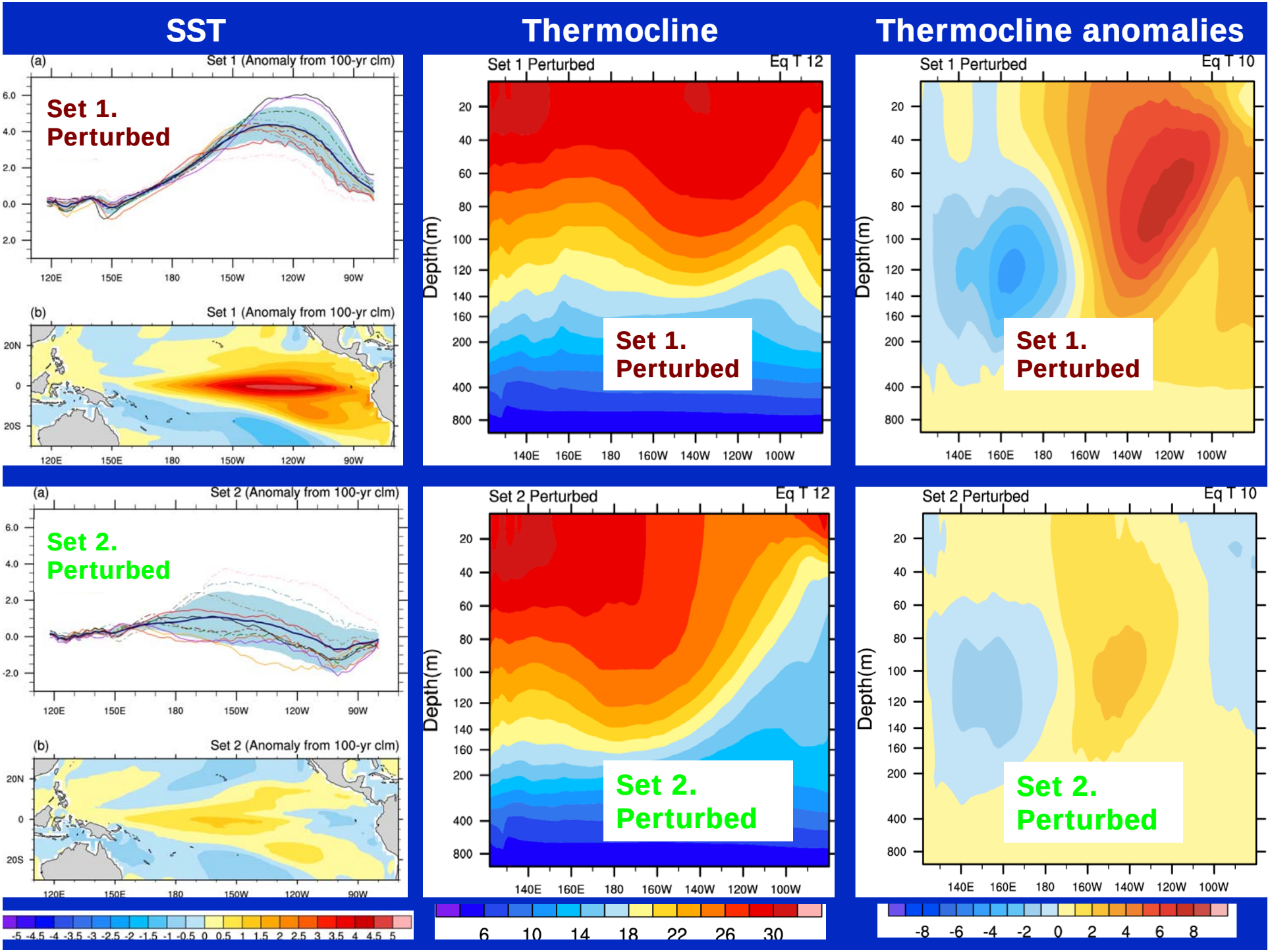


Left: separate events
Right: ensemble mean and STD


Anomalies: SST
Wind stress
Zonal current
(a)SST (cntl anomaly from 100yr clim) Set1
(b)TauX (cntl anomaly from 100yr clim) Set1
(c)CurrentX (cntl anomaly from 100yr clim) Set1
Set 1. Control
(a)SST (anomaly from 100yr climatology) Set1
(b)TauX (anomaly from 100yr climatology) Set1
(c)CurrentX(anomaly from 100yr climatology) Set1
Set 1. Perturbed
D N O S A J J M A M F J D N O S A J J M A M F J
140E 160E 180 160W 140W 120W 100W
-5 -4 -3 -2 -1 0 1 2 3 4 5
-0.09 -0.06 -0.03 0 0.03 0.06 0.09
-1.2 -0.8 -0.4 0 0.4 0.8 1.2


Anomalies: SST
Wind stress
Zonal current
(d)SST (cntl anomaly from 100yr clim) Set2
(e)TauX (cntl anomaly from 100yr clim) Set2
(f)CurrentX (cntl anomaly from 100yr clim) Set2
Set 2. Control
(d)SST (anomaly from 100yr climatology) Set2
(e)TauX (anomaly from 100yr climatology) Set2
(f)CurrentX(anomaly from 100yr climatology) Set2
Set 2. Perturbed
D N O S A J J M A M F J D N O S A J J M A M F J
140E 160E 180 160W 140W 120W 100W
-5 -4 -3 -2 -1 0 1 2 3 4 5
-0.09 -0.06 -0.03 0 0.03 0.06 0.09
-1.2 -0.8 -0.4 0 0.4 0.8 1.2


Month-by-month development of events (ensemble-mean)
Set 1. Perturbed
Set 1. Control
Set 2. Perturbed
Set 2. Control
Set 1 Control
Set 1 Perturbed
Set 2 Control
Set 2 Perturbed
Warm Pool Edge
120W
140W
160W
180
160E
Nino 3
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0


SST
Thermocline
Thermocline anomalies
(a)
Set 1 (Anomaly from 100-yr clm)
Set 1.
Perturbed
(b)
Set 1 (Anomaly from 100-yr clm)
Set 1 Perturbed
Eq T 12
Depth(m)
Set 1.
Perturbed
Set 1 Perturbed
Eq T 10
Depth(m)
Set 1.
Perturbed
(a)
Set 2 (Anomaly from 100-yr clm)
Set 2.
Perturbed
(b)
Set 2 (Anomaly from 100-yr clm)
Set 2 Perturbed
Eq T 12
Depth(m)
Set 2.
Perturbed
Set 2 Perturbed
Eq T 10
Depth(m)
Set 2.
Perturbed
-5 -4.5 -4 -3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5
6 10 14 18 22 26 30
-8 -6 -4 -2 0 2 4 6 8

Conclusions

- For recharge states: a timely occurrence of WWBs can transform an upcoming CP El Niño into a strong EP El Niño (even extreme)

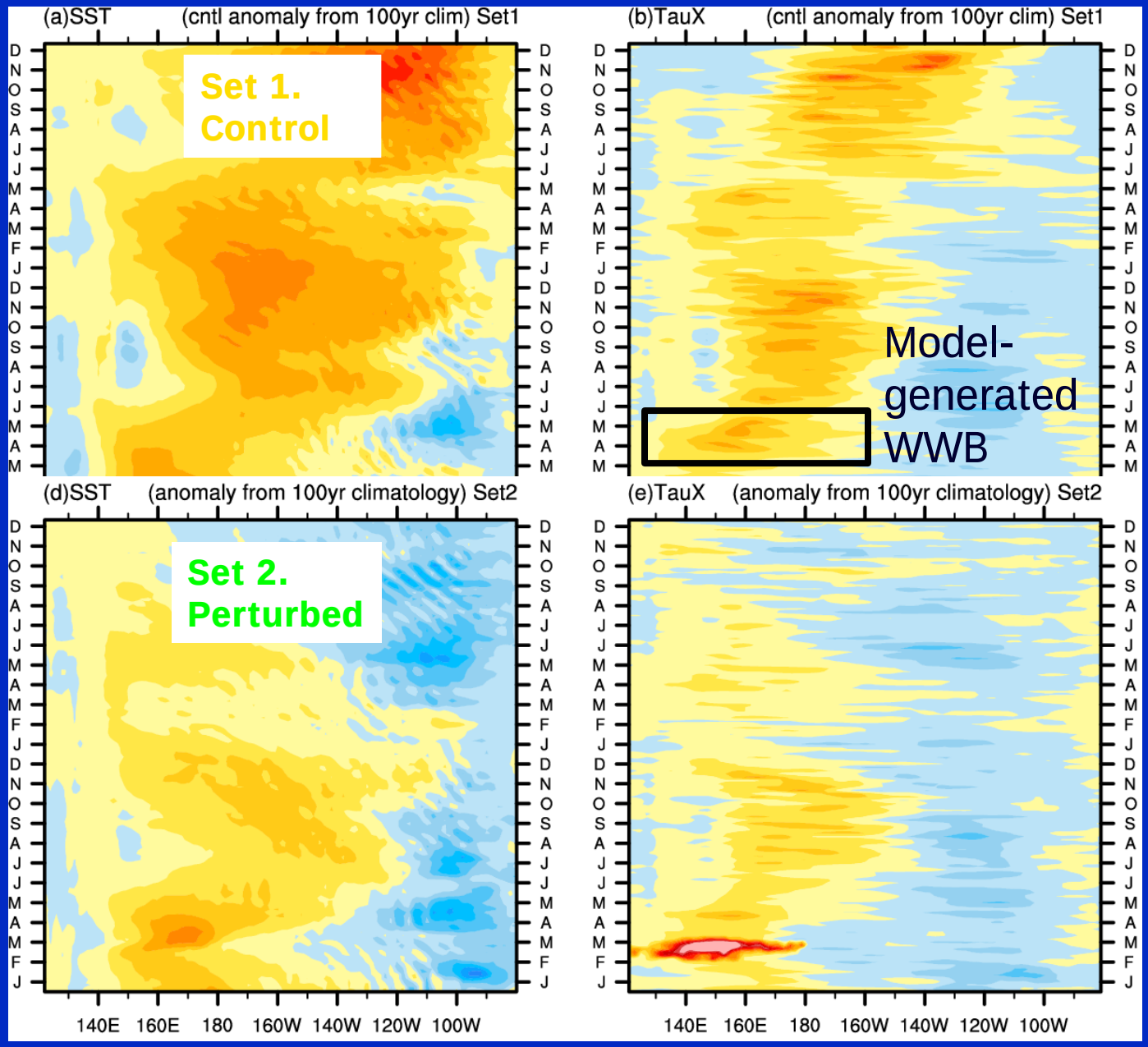
- For neutral states: a WWB can transform a weak La Niña into a weak CP El Niño

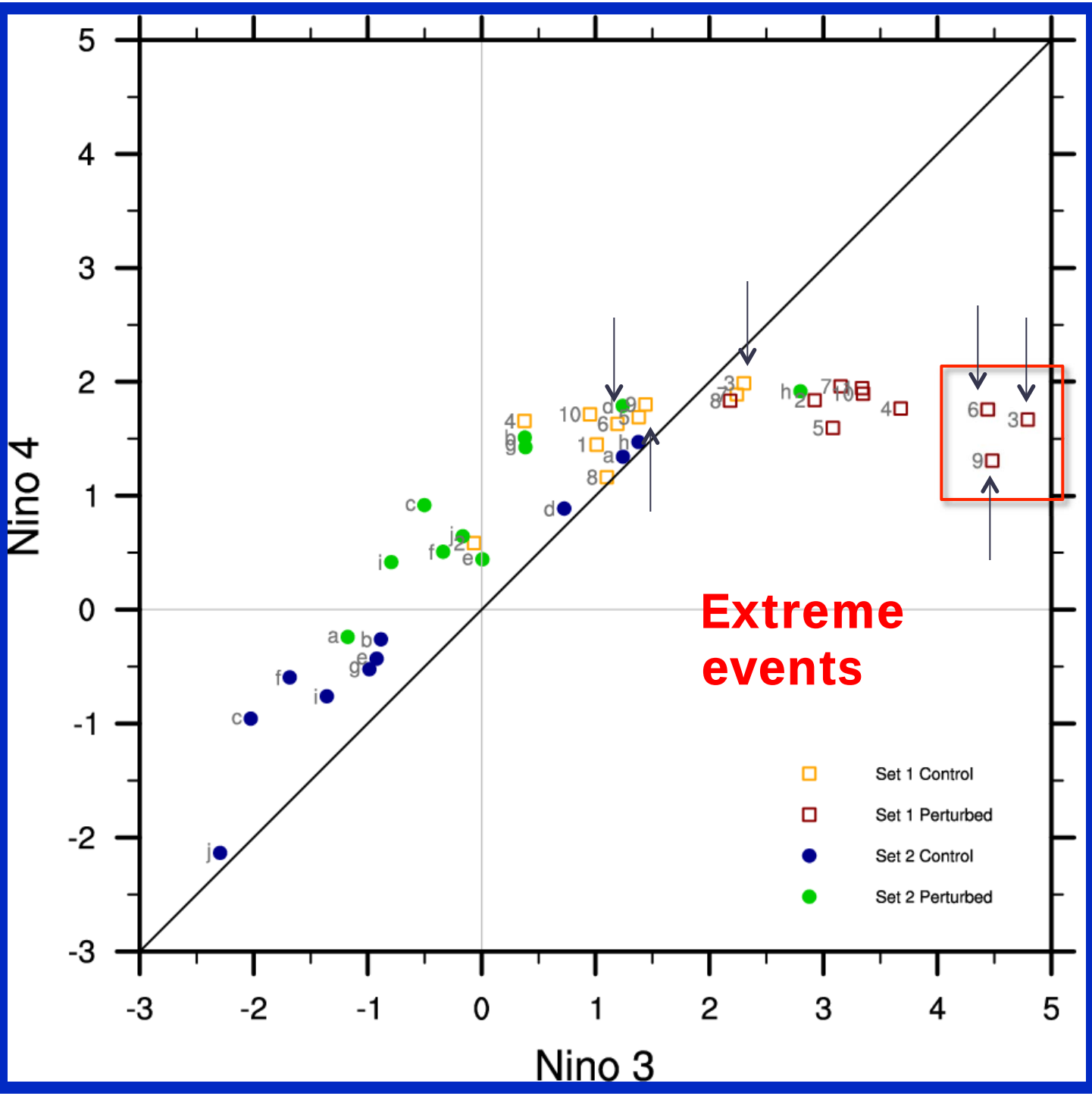
- Whether a CP El Niño evolves into an EP El Niño depends on how far the Warm Pool edge can move eastward (facilitated by WWB) before the growth of the Niño3 SST anomaly can start

- Thermocline depth anomalies in the central Pacific are indeed important for CP El Niño events

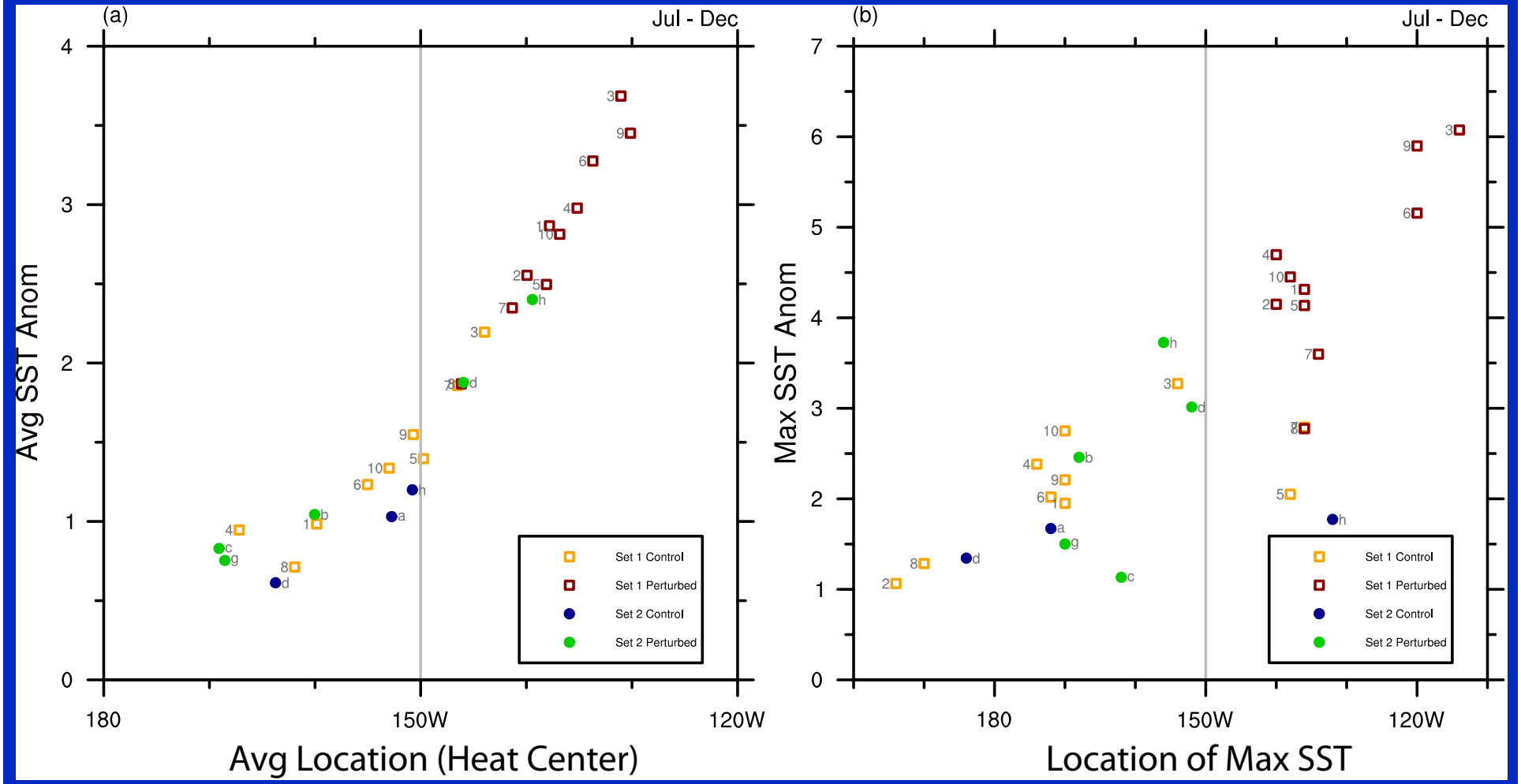
- Evolution of the neutral state is much more uncertain (with or without WWBs)

Why Set 1 (Control) and Set 2 (Perturbed) are so similar?

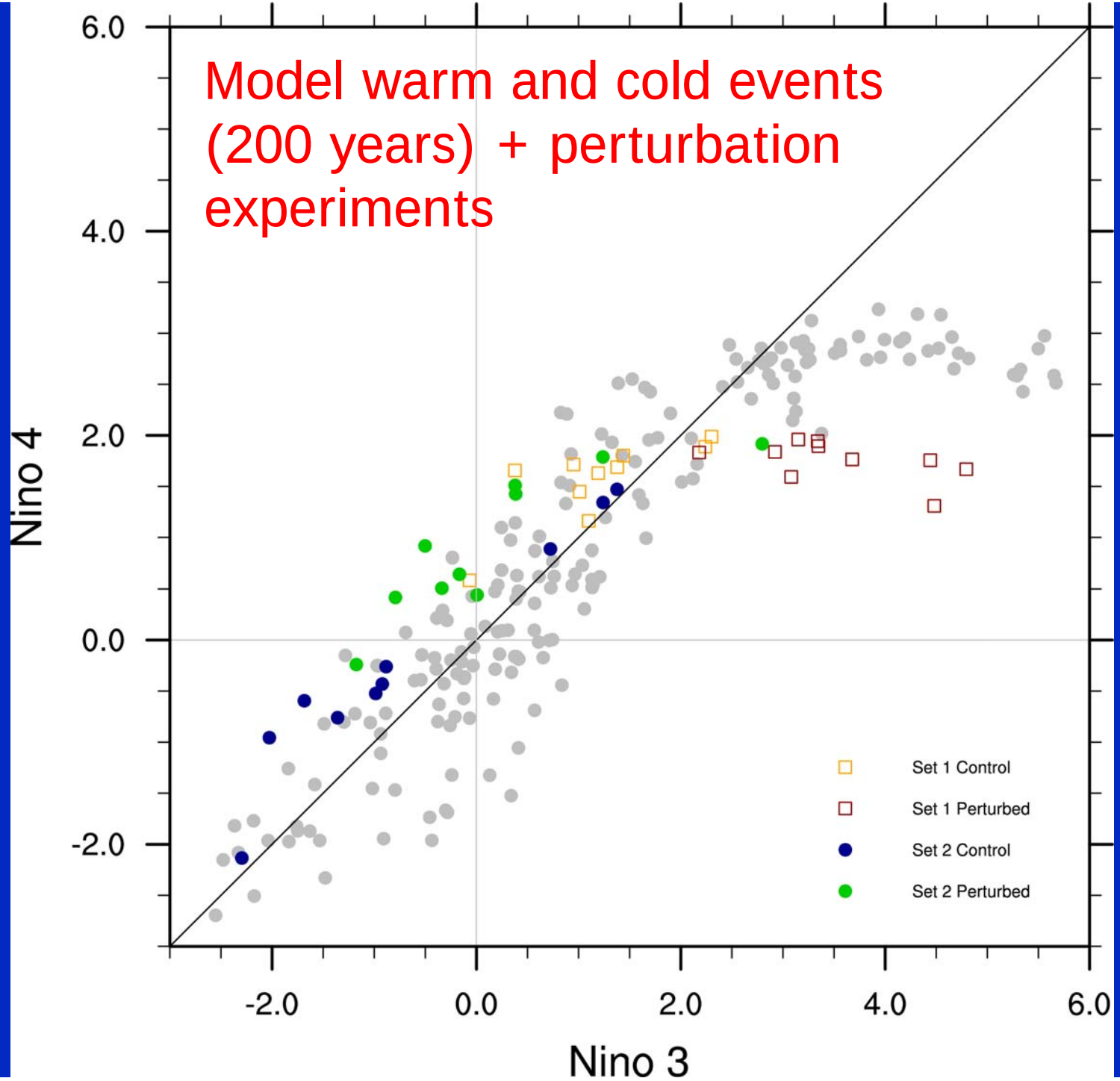


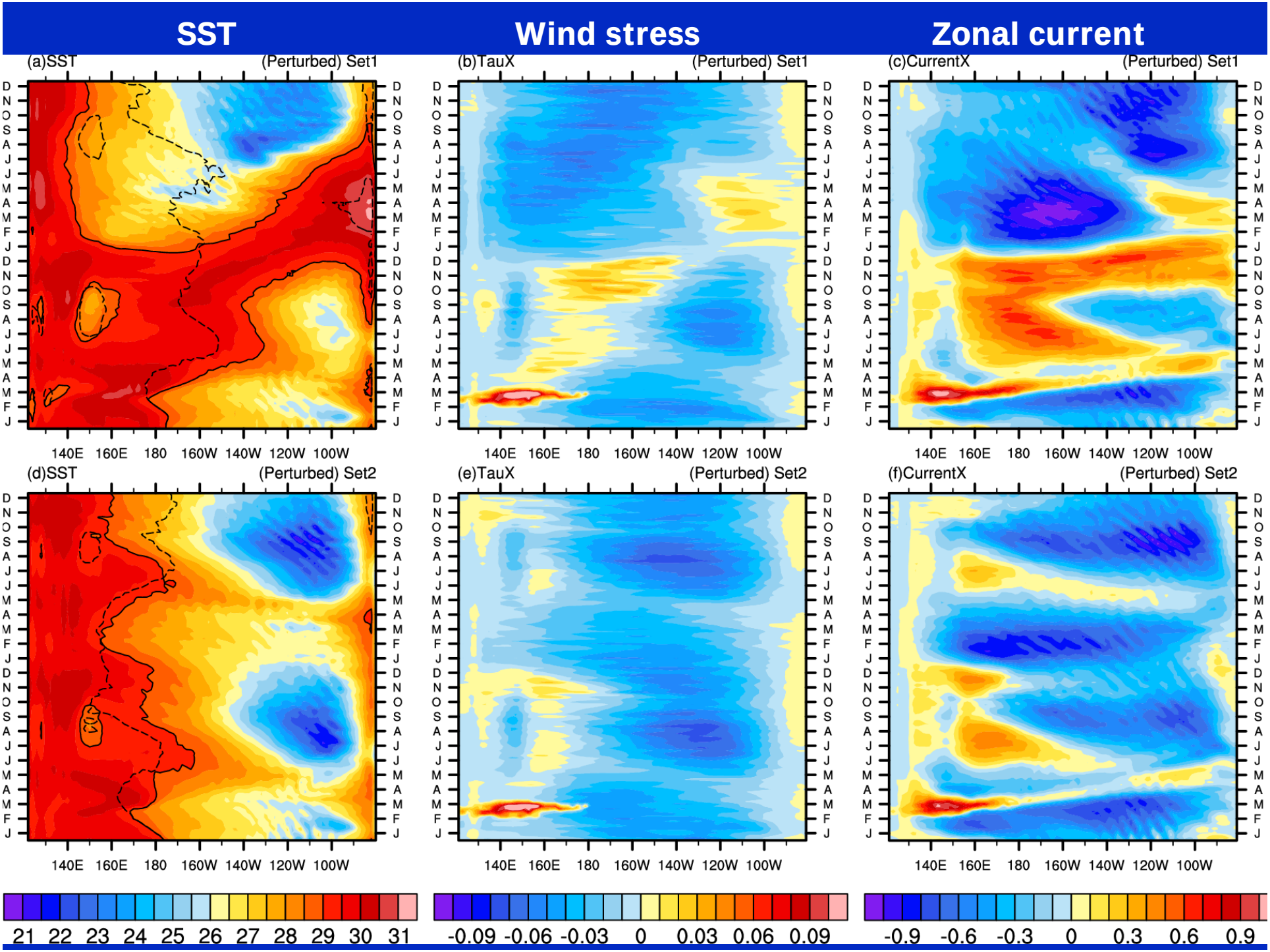

Nino 4
Nino 3
Extreme events
Set 1 Control
Set 1 Perturbed
Set 2 Control
Set 2 Perturbed

Is distribution of events unimodal or bimodal?



Model warm and cold events (200 years) + perturbation experiments




SST
Wind stress
Zonal current
(a)SST
(Perturbed) Set1
(b)TauX
(Perturbed) Set1
(c)CurrentX
(Perturbed) Set1
(d)SST
(Perturbed) Set2
(e)TauX
(Perturbed) Set2
(f)CurrentX
(Perturbed) Set2
D N O S A J J M A M F J
140E 160E 180 160W 140W 120W 100W
21 22 23 24 25 26 27 28 29 30 31
-0.09 -0.06 -0.03 0 0.03 0.06 0.09
-0.9 -0.6 -0.3 0 0.3 0.6 0.9