Can coupled models be used to study ENSO diversity?

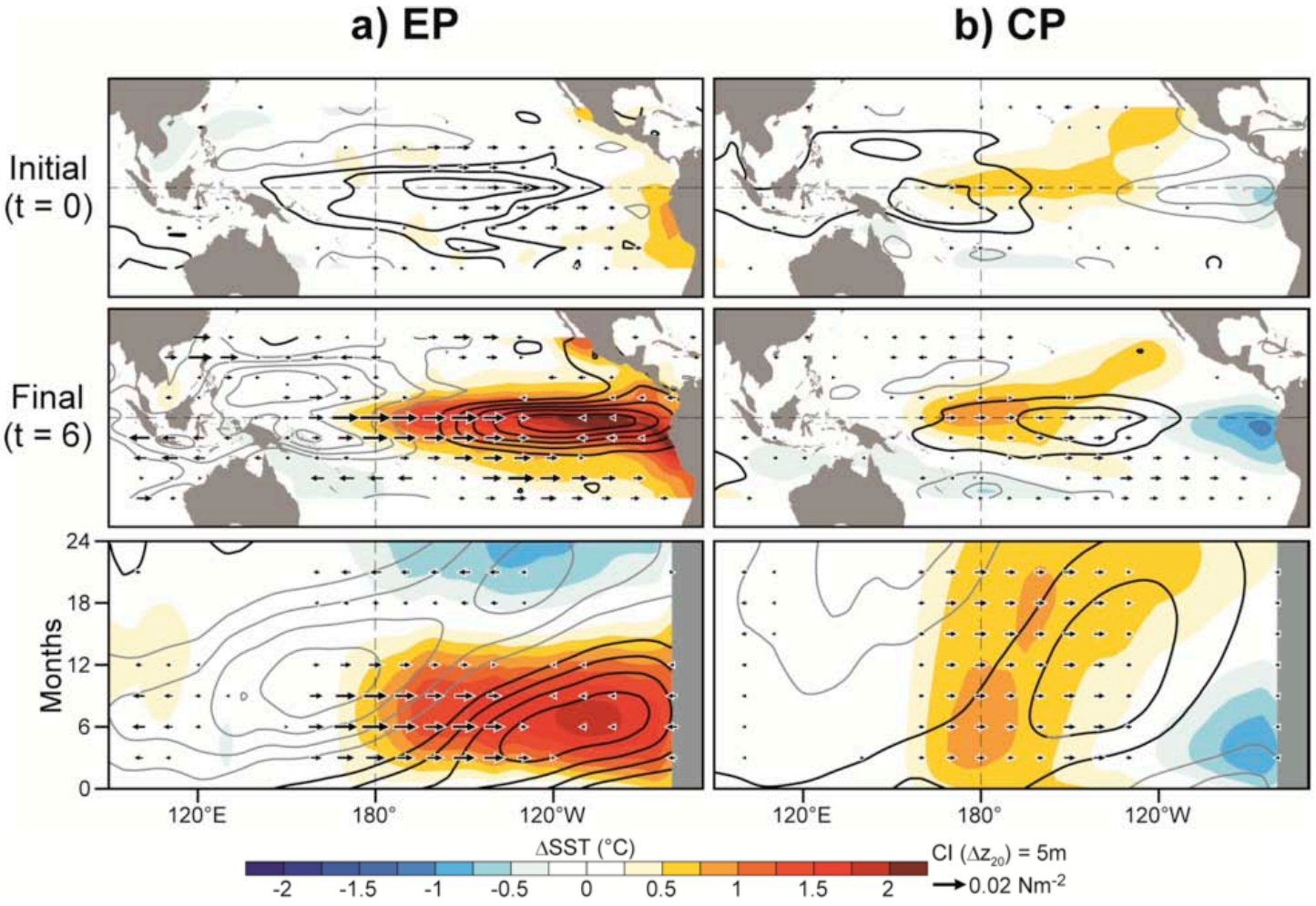
Matt Newman

CIRES, University of Colorado and NOAA/ESRL/PSD

Issues:

- Models shift ENSO variability westwards so that “EP” ENSO has mixed “CP/EP” characteristics
- CP ENSO in models may also be shifted farther westward
  - Too weak (as a result?)
  - Swamped by EP ENSO?
- Effects of subsurface (e.g., Z_{20}) feedbacks can be opposite to observed

Linear inverse model (LIM) of 1958-2000 data, $d\mathbf{x}/dt = \mathbf{B}\mathbf{x} + \mathbf{F}_s$, captures optimal evolution of "EP" and "CP" ENSO



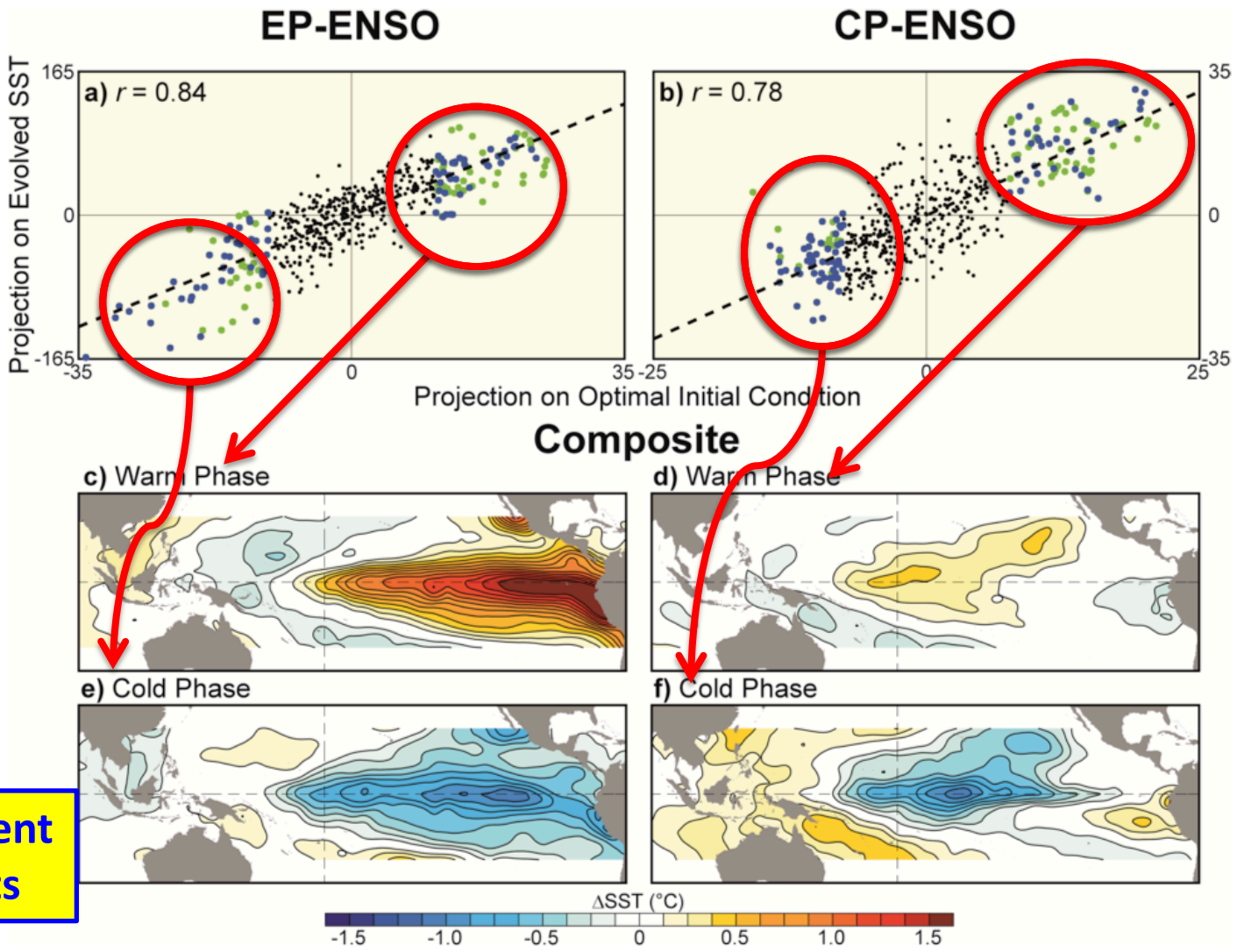
Equatorial Hovmuller, time running from 0 to 24 months

SST: shading
Thermocline depth: contours
Zonal wind stress: vectors

Optimal structures are relevant to observed EP and CP ENSO events

Composite:
Six months ***after*** a > ± 1 sigma projection (blue dots) on ***only*** the first **or** second optimal initial condition, constructed separately for warm and cold events

Green dots represent mixed EP-CP events



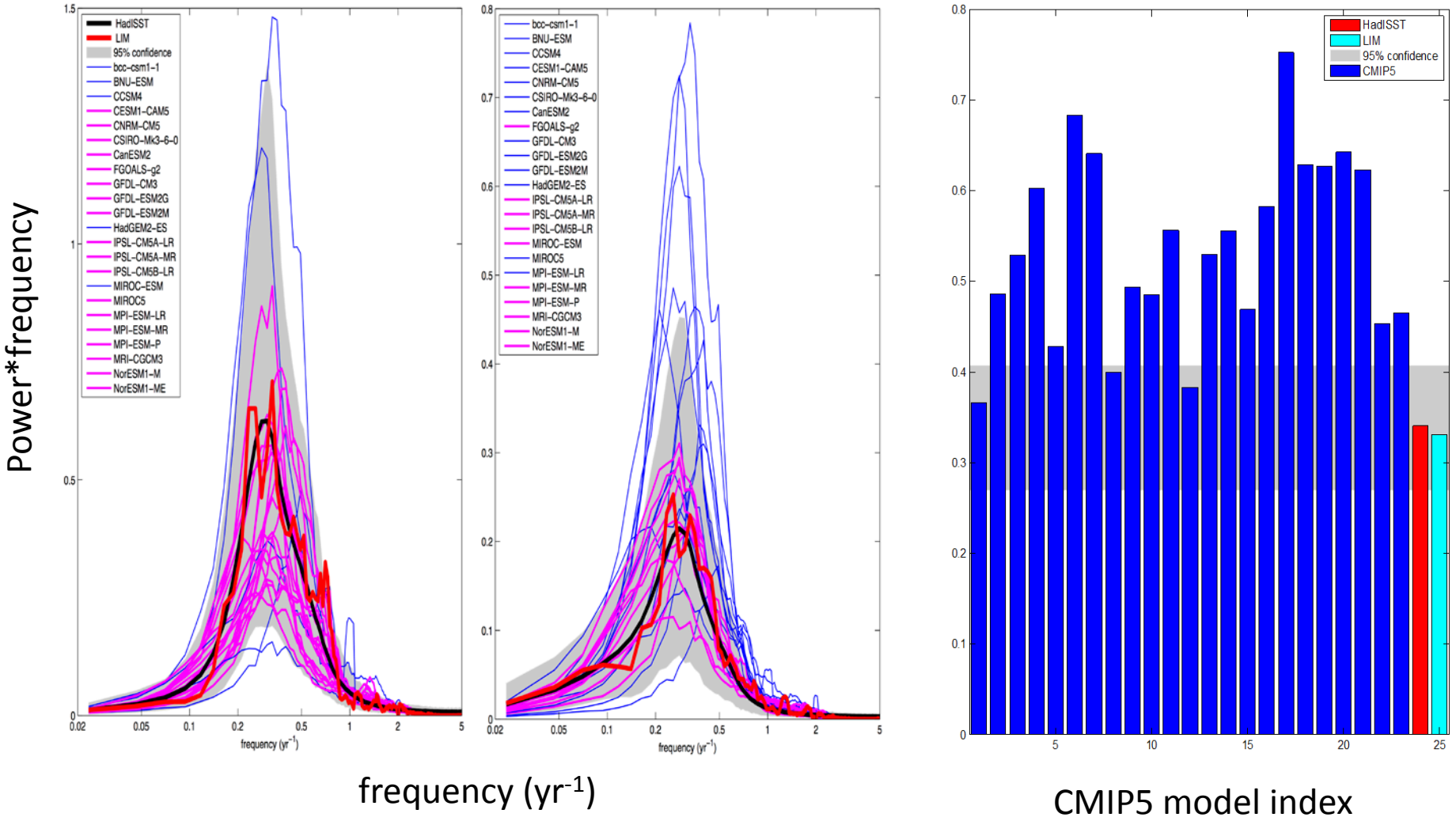
LIM based on one-season lag reproduces observed spectra and can be used for significance testing

In CMIP5, Nino4 is significantly too strong compared to Nino3

Nino3

Nino4

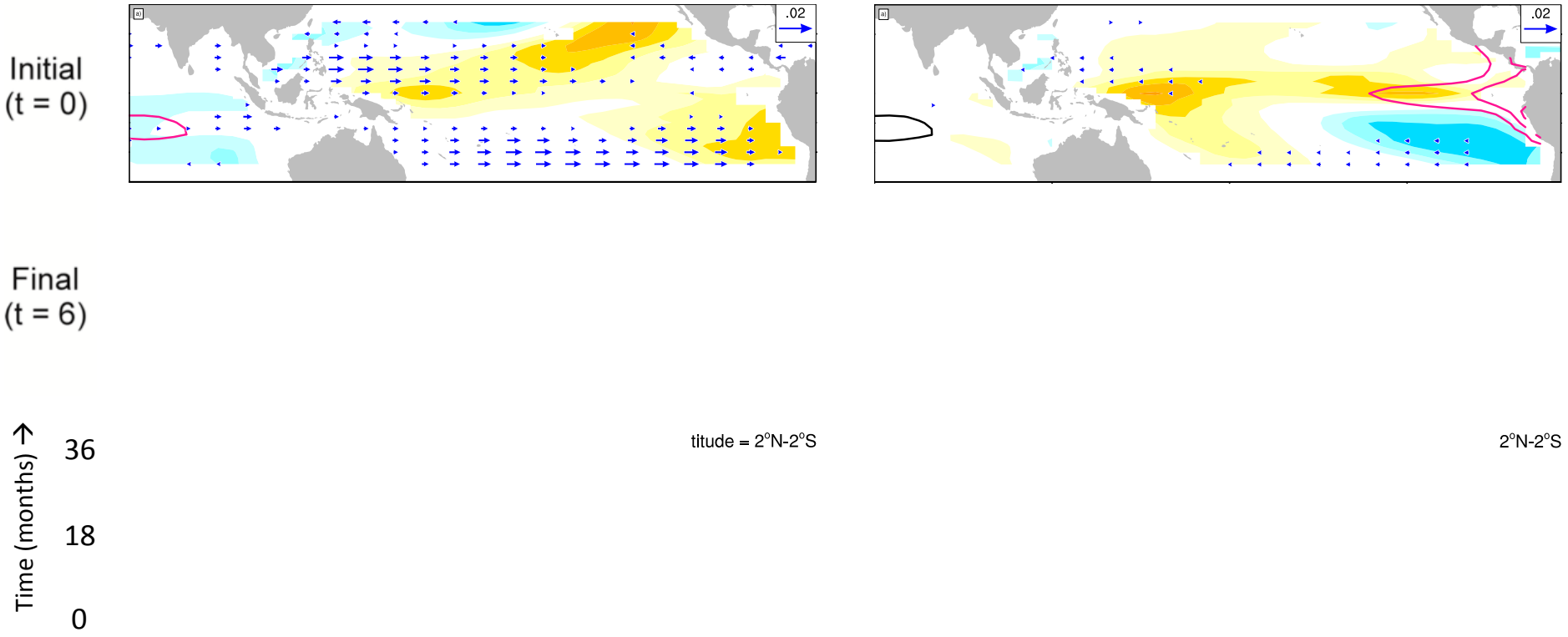
Ratio of Nino4/Nino3 highpass (<10yr) variances



CESM-CAM5 LIM captures “optimal” evolution of both ENSO types, but shifted well to west

Optimal EP

Optimal CP



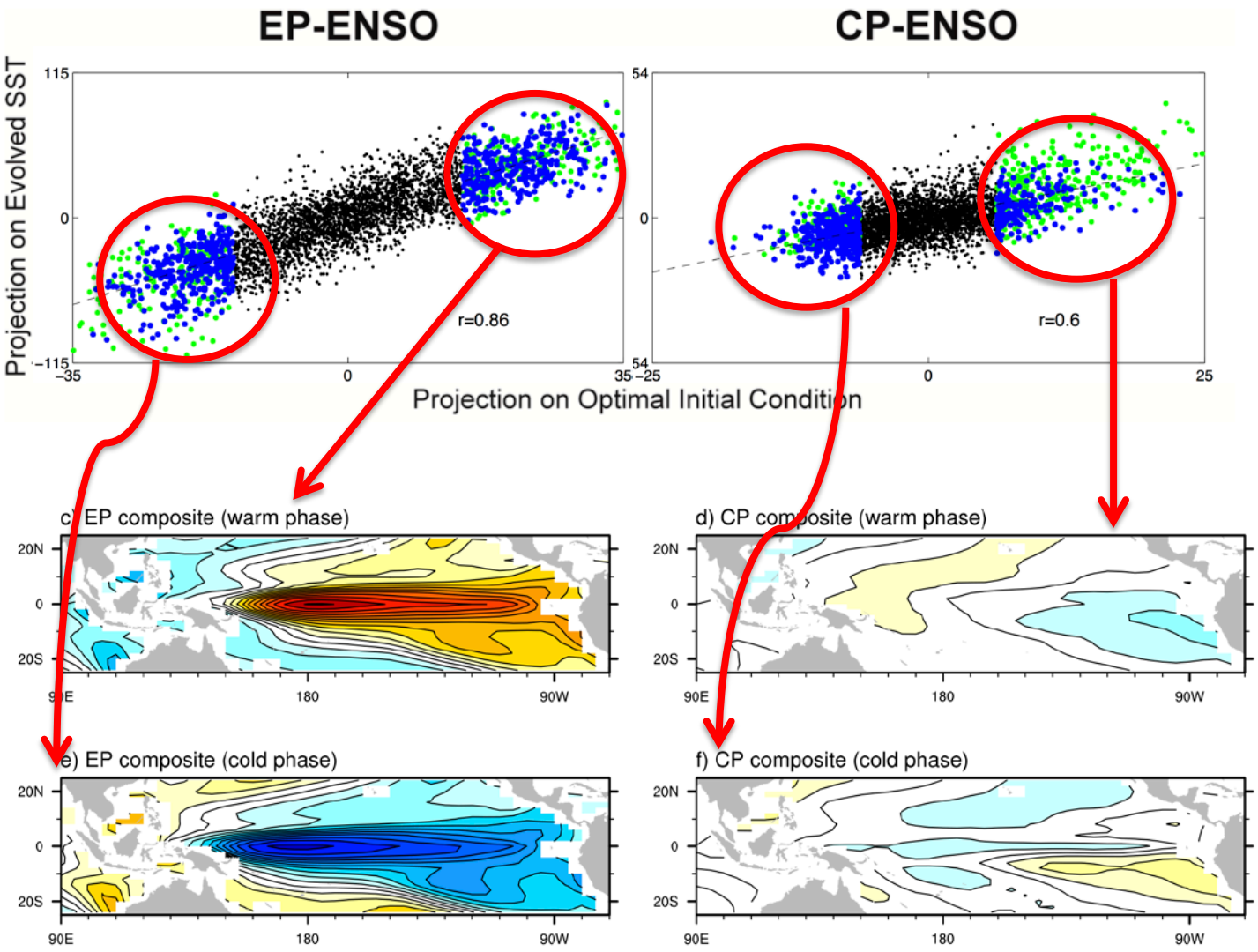
CCSM4-LIM very similar but EP amplifies more and CP is more persistent

SST: shading
Thermocline depth: contours
Zonal wind stress: vectors

CP optimal structures are overwhelmed by EP ENSO events

Composite:
Six months ***after*** a > ± 1 sigma projection (blue dots) on ***only*** the first **or** second optimal initial condition, constructed separately for warm and cold events

Green dots represent mixed EP-CP events



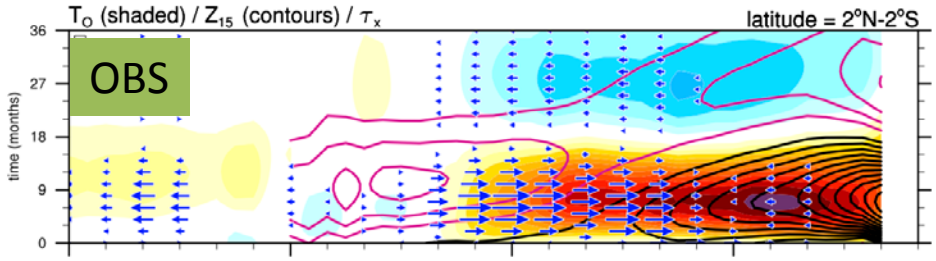
Evolution of 6-month optimal structure

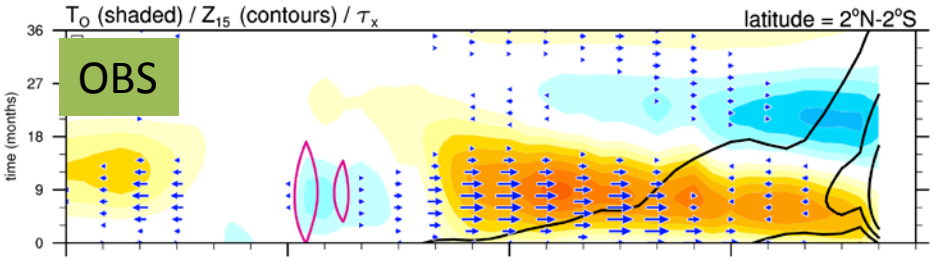
SST: shading
Thermocline depth: contours
Zonal wind stress: vectors

Equatorial Hovmuller, time running from 0 to 36 months

FULL

No thermocline term ("Slab-like" LIM)





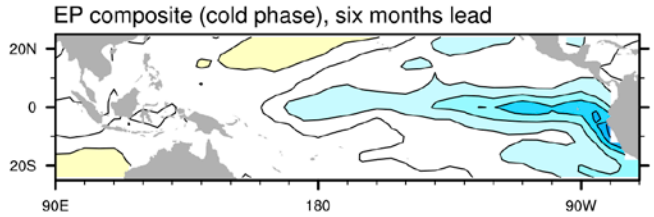
Thermocline term (all effects) strengthens ENSO and keeps it east

Time →

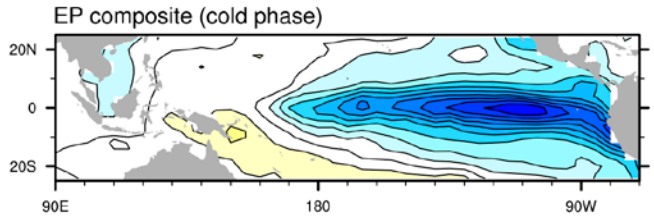
Thermocline term *weakens* ENSO

EP cold composite

OBS

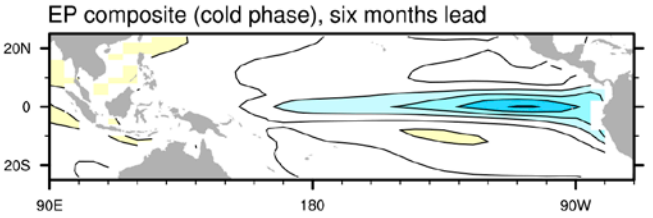


t=-6 months

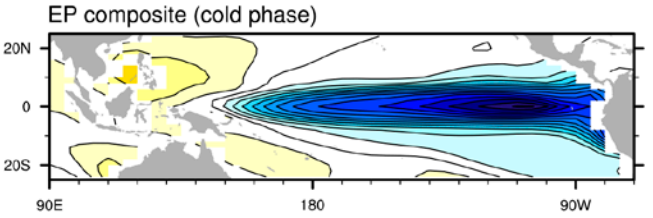


t=0

CCSM4



t=-6 months



t=0

Conclusion

- **Coupled GCMs may not represent observed dynamics sufficiently well enough to study ENSO diversity if they have:**
  - Strong and unrealistic Nino4 variability within “east Pacific” ENSO events that swamps more purely “central Pacific” ENSO variability
  - Optimal structure for central Pacific ENSO in west Pacific
  - Thermocline term acting as *damping* in central Pacific (so far: CESM1-CAM5, CCSM4, GFDL-MSM2M, NorESM1-EM, not CNRM-CM5), opposite to observed LIM