Lamont-Doherty Earth Observatory
COLUMBIA UNIVERSITY | EARTH INSTITUTE

Natural Centennial Tropical Pacific Variability in Coupled GCMs

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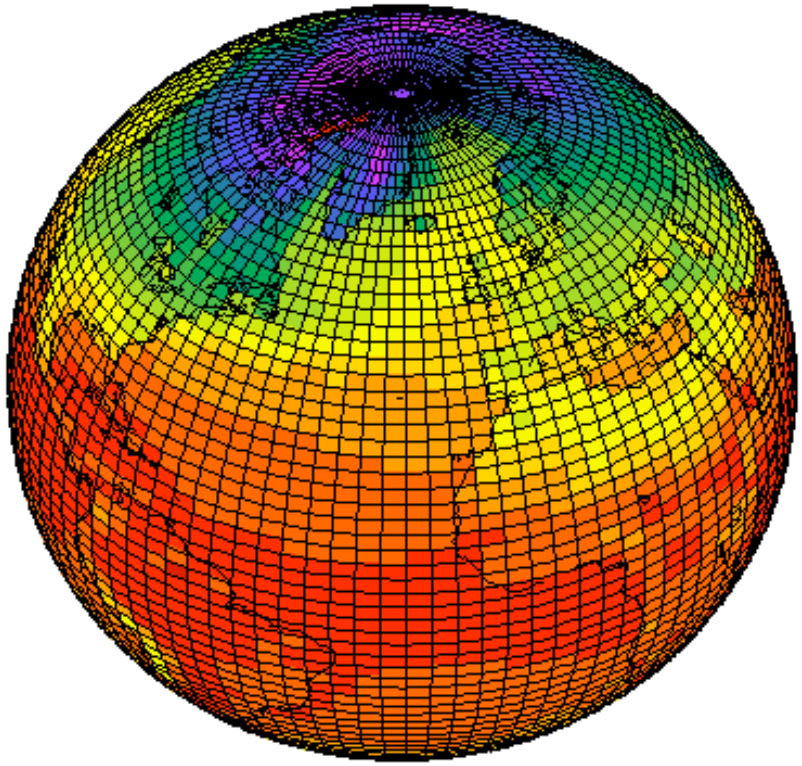
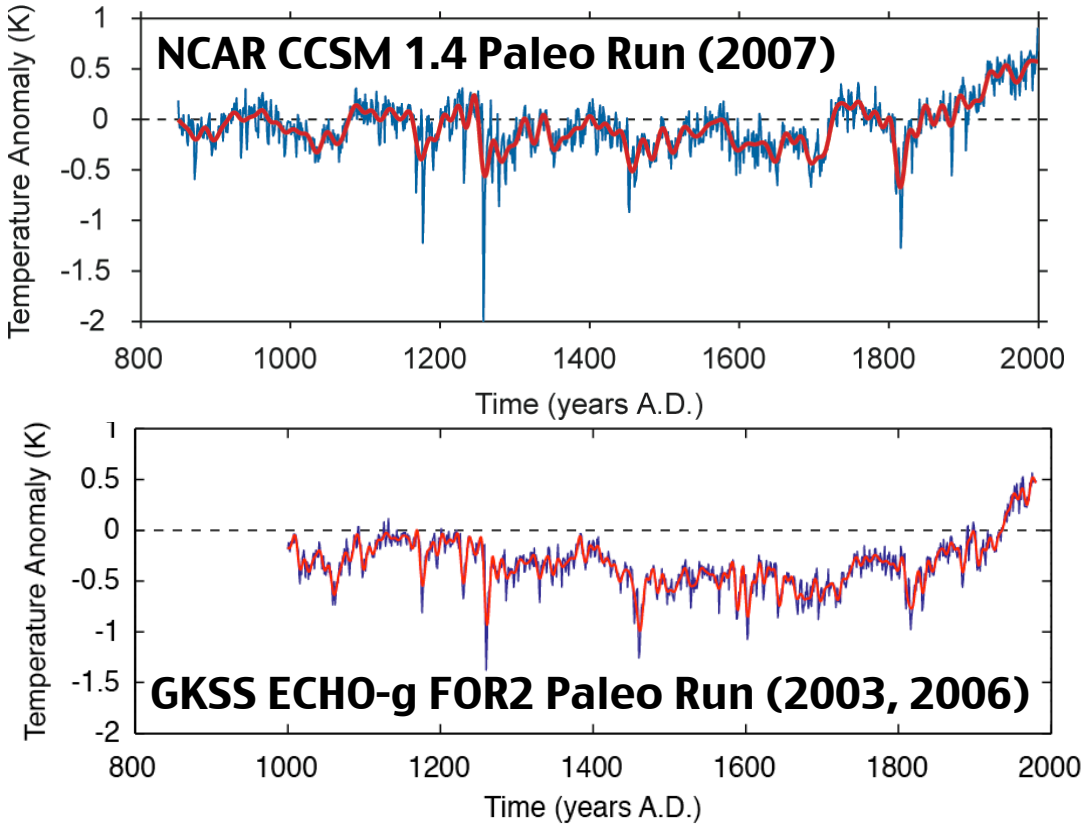
[1]LDEO, [2]WHOI and [3]UCM

Millennial Climate Model Simulations

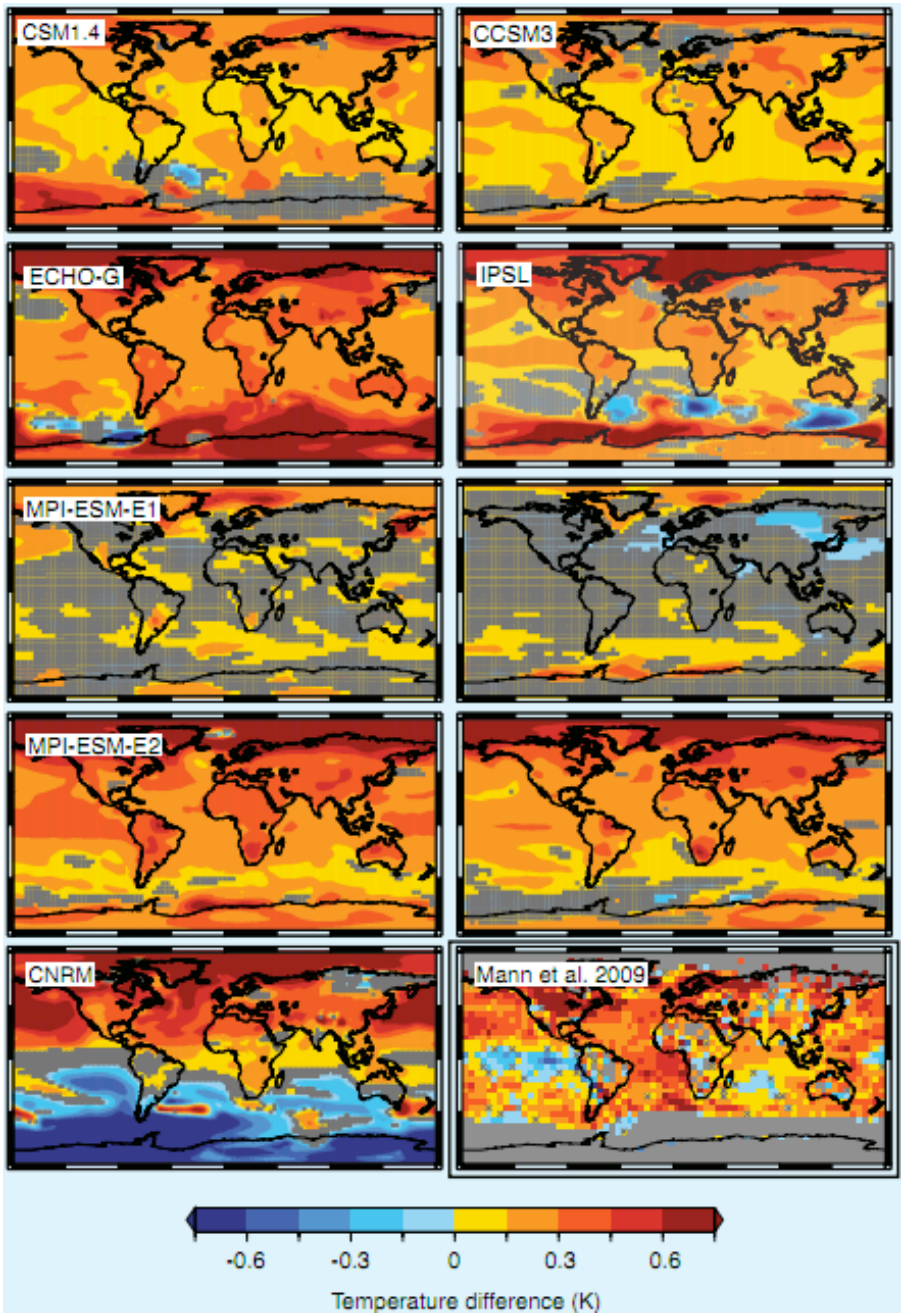




Coupled Model Intercomparison Project Phase 5 (CMIP5)

21 Modeling Groups Performing "Long-Term Experiments"

10 Groups Performing (multiple) Last Millennium Experiments



Current Collection of Forced Transient Millennial Runs

CSM1.4 and CCSM3
ECHO-G: ERIK1 and 2
IPSL
MPI-ESM E1 and E2
CNRM

Gonzalez-Rouco et al., Medieval Climate Anomaly to Little Ice Age transition as simulated by current climate models, PAGES news, 19(1), 2011

Model Forcings Since 850

GHG Concentrations

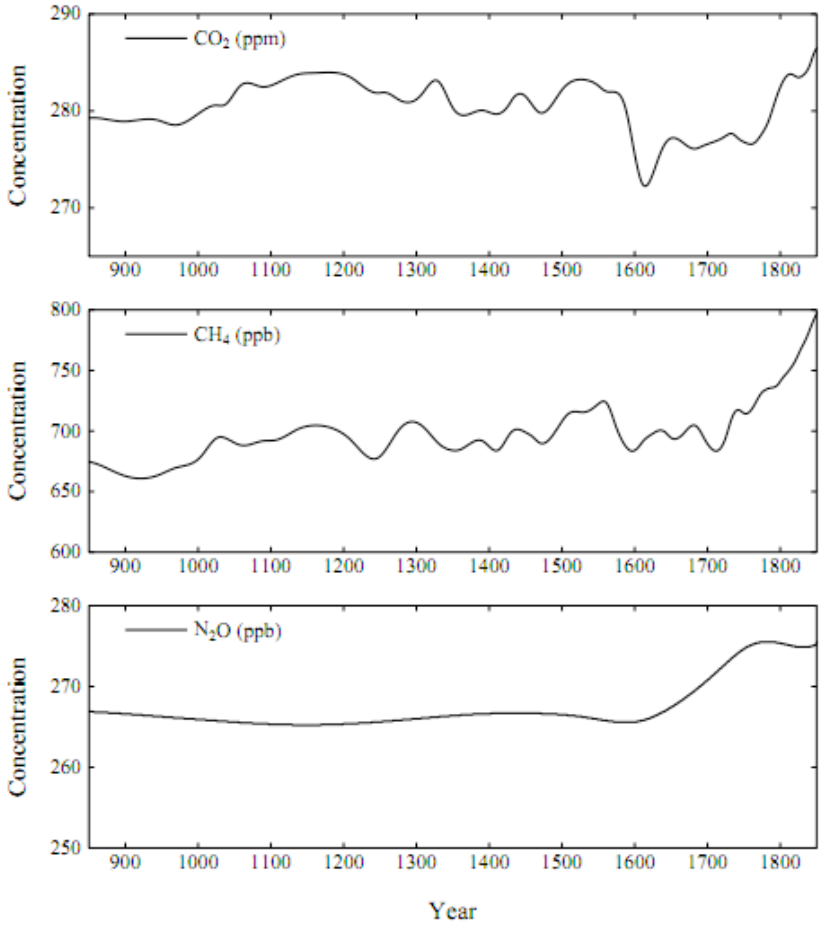


Fig. 2. Well-mixed greenhouse gas concentration changes from 850 to 1850 CE.

Global Cropland/Pasture Area

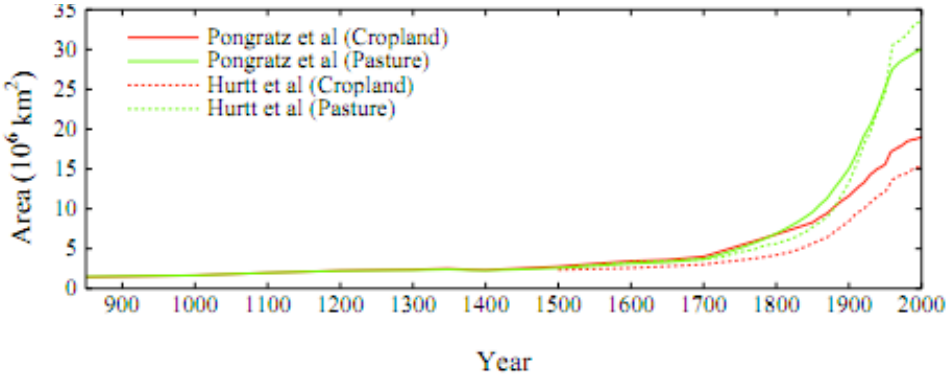


Fig. 3. Global mean cropland and pasture area in the Pongratz and Hurtt datasets.

Schmidt, G. A., et al., 2011: Climate forcing reconstructions for use in PMIP simulations of the last millennium (v1.0), Geosci. Model Dev., 4, 33-45, doi:10.5194/gmd-4-33-2011.

Model Forcings Since 850

Volcanic Stratospheric Aerosols

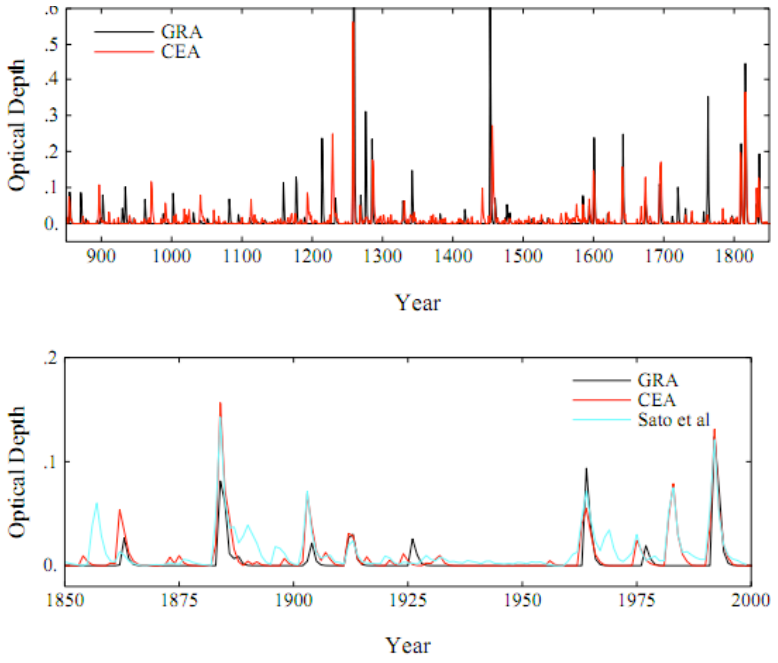


Fig. 4. The two volcanic reconstructions of aerosol optical depth (at 550 μm) (GRA and CEA) (top), with a comparison to the modern estimates of Sato et al. (1993) (bottom) (note the different vertical scales in the two panels).

Schmidt, G. A., et al., 2011: Climate forcing reconstructions for use in PMIP simulations of the last millennium (v1.0), Geosci. Model Dev., 4, 33-45, doi:10.5194/gmd-4-33-2011.

Total Solar Irradiance

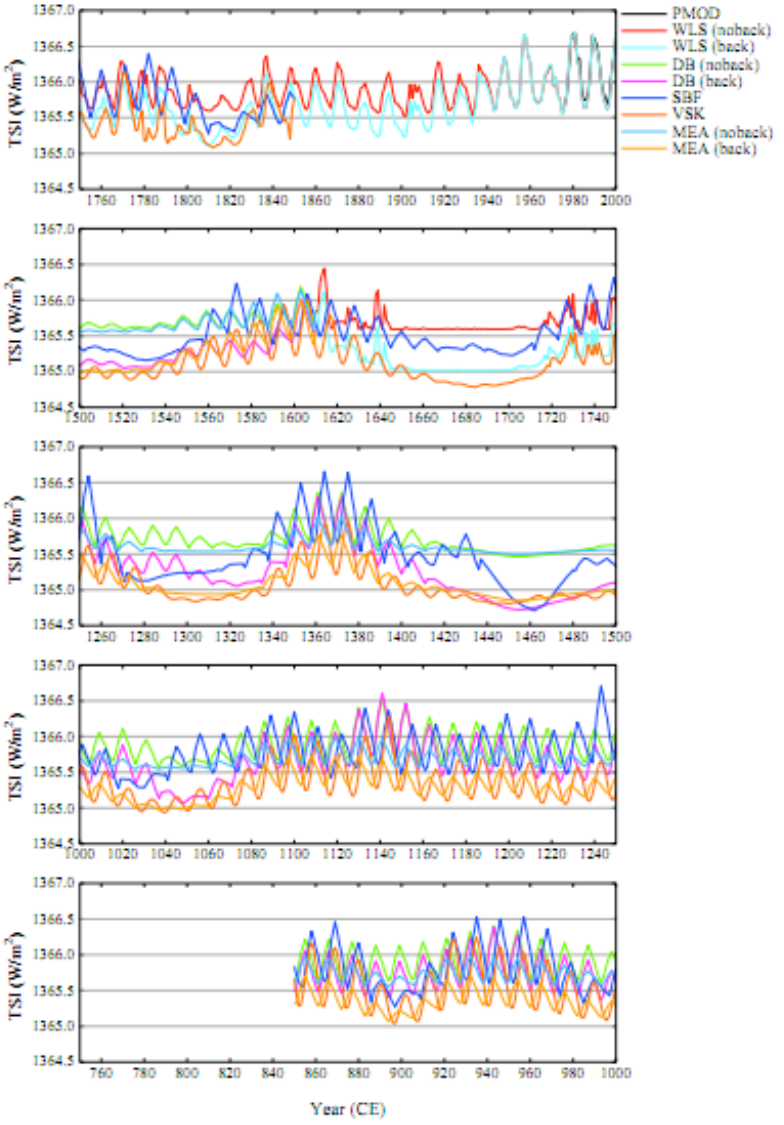
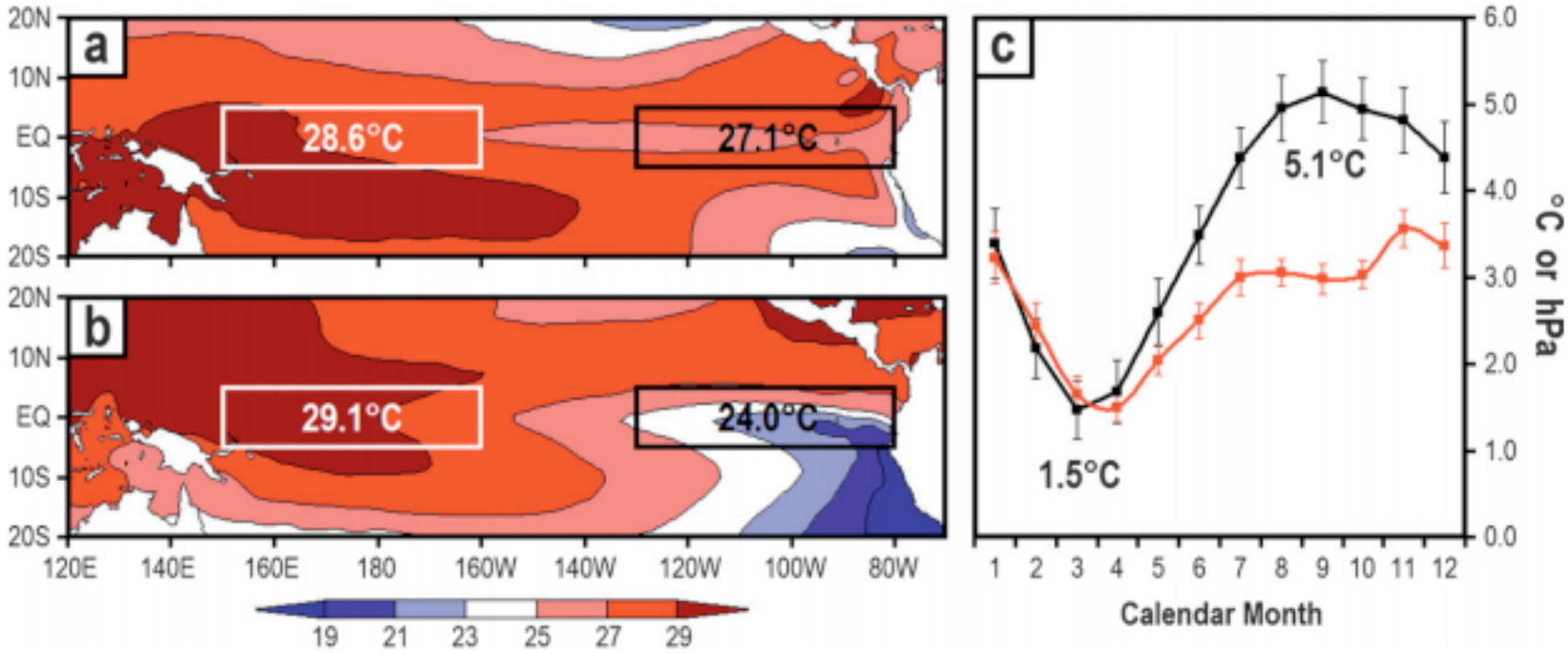


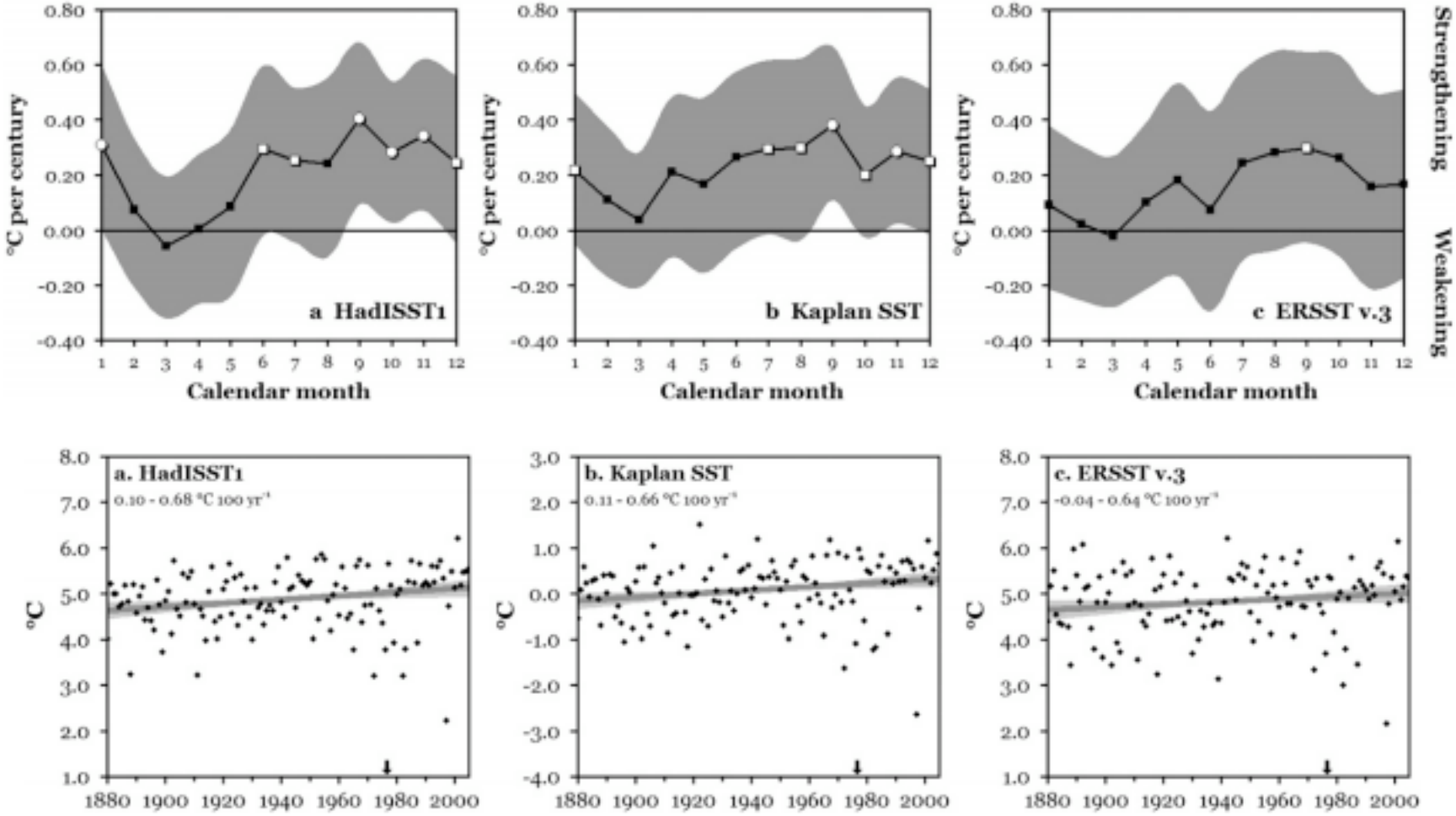
Fig. 8. Multiple TSI reconstructions from 850 CE onwards, with the PMOD satellite-based TSI composite as reference.

Observational SST and SLP Gradients



Karnauskas, K. B., R. Seager, A. Kaplan, Y. Kushnir, M. A. Cane, 2009: Observed Strengthening of the Zonal Sea Surface Temperature Gradient across the Equatorial Pacific Ocean. J. Climate, 22, 4316–4321.

Observed Trends in the SST Gradient



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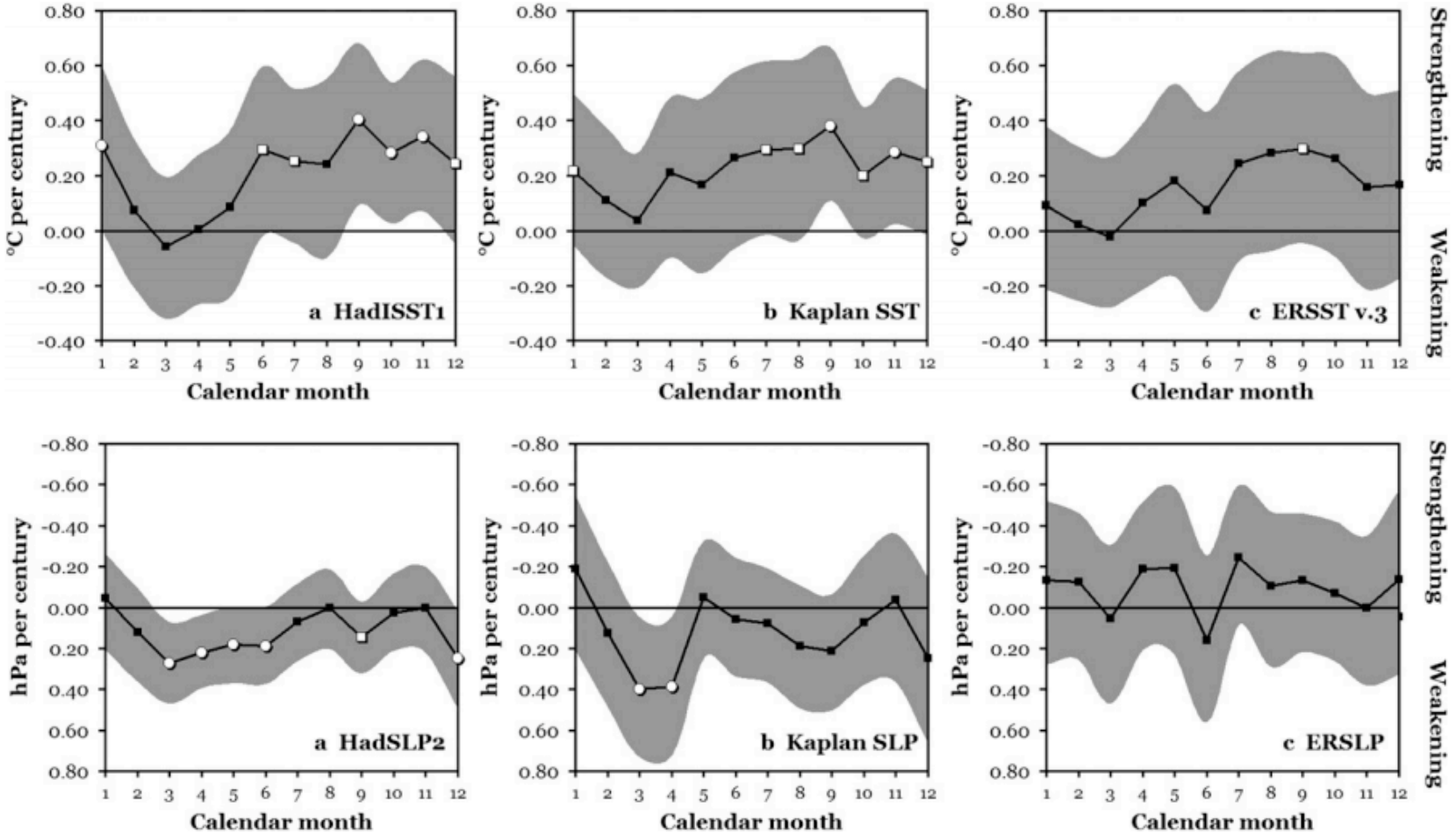
Observed Trends in SST and SLP Gradients



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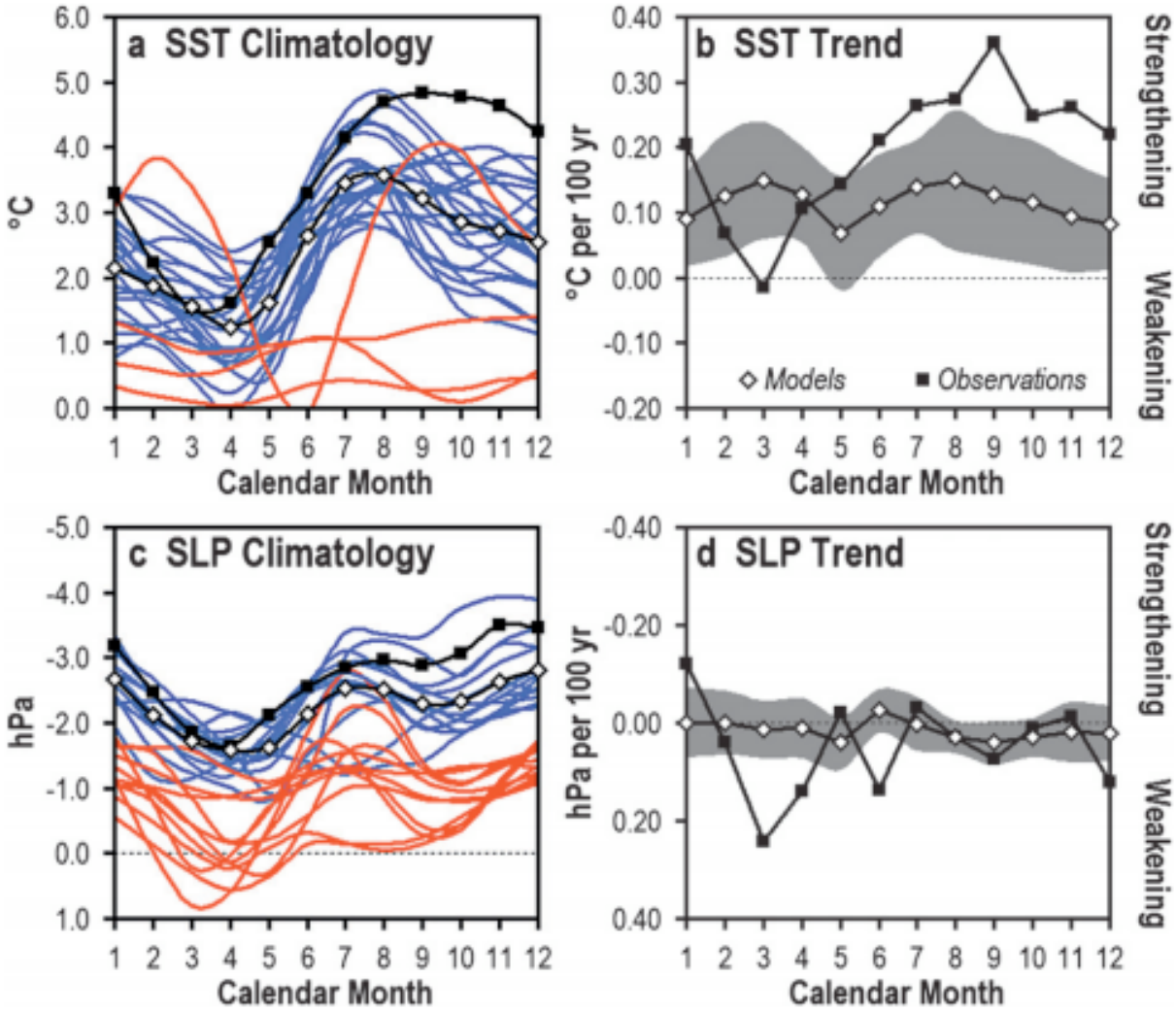
Modeled SST and SLP Climatology



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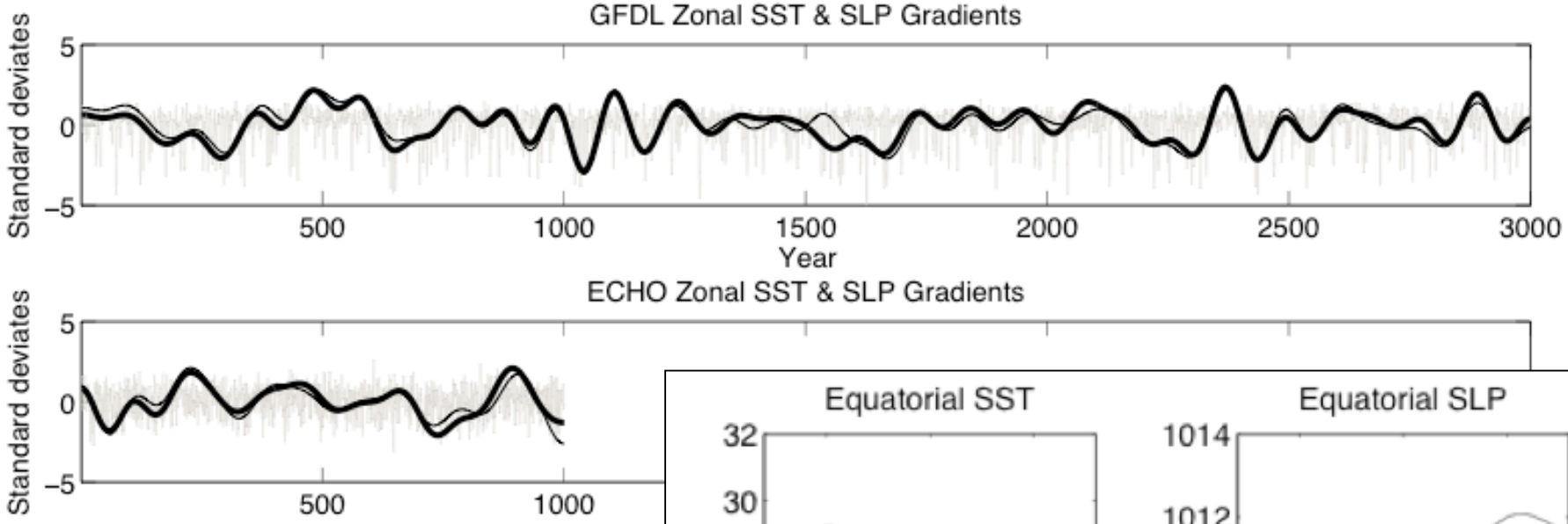
Simulated Zonal SST and SLP Gradients (Control Runs)

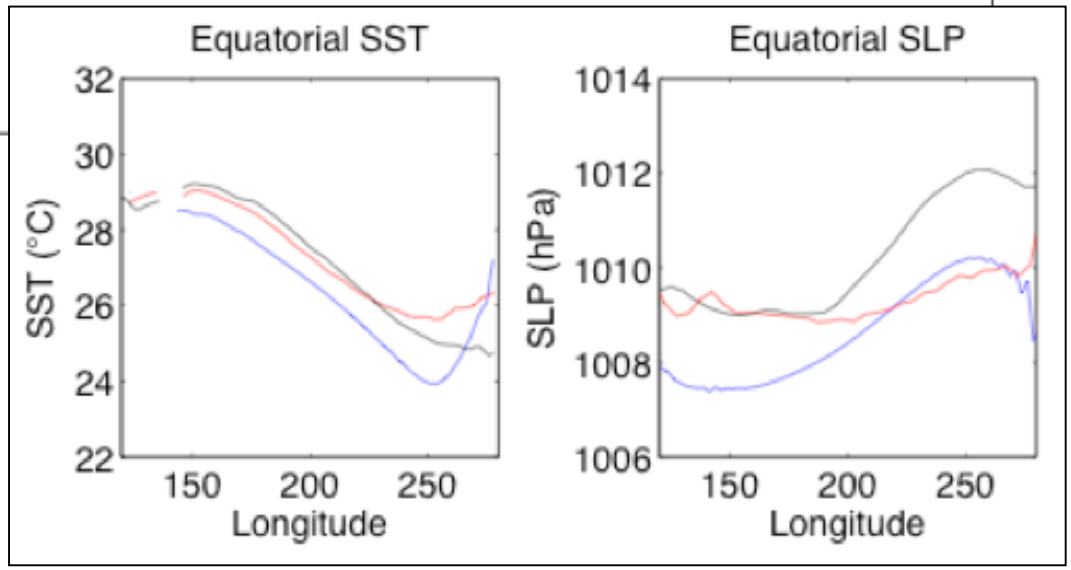


ECHO–G Coupled Climate Model
ECHAM4 atmospheric & **HOPE–G** ocean models

Atm. Resolution: **T30** (~3.75°) by **19 levels**

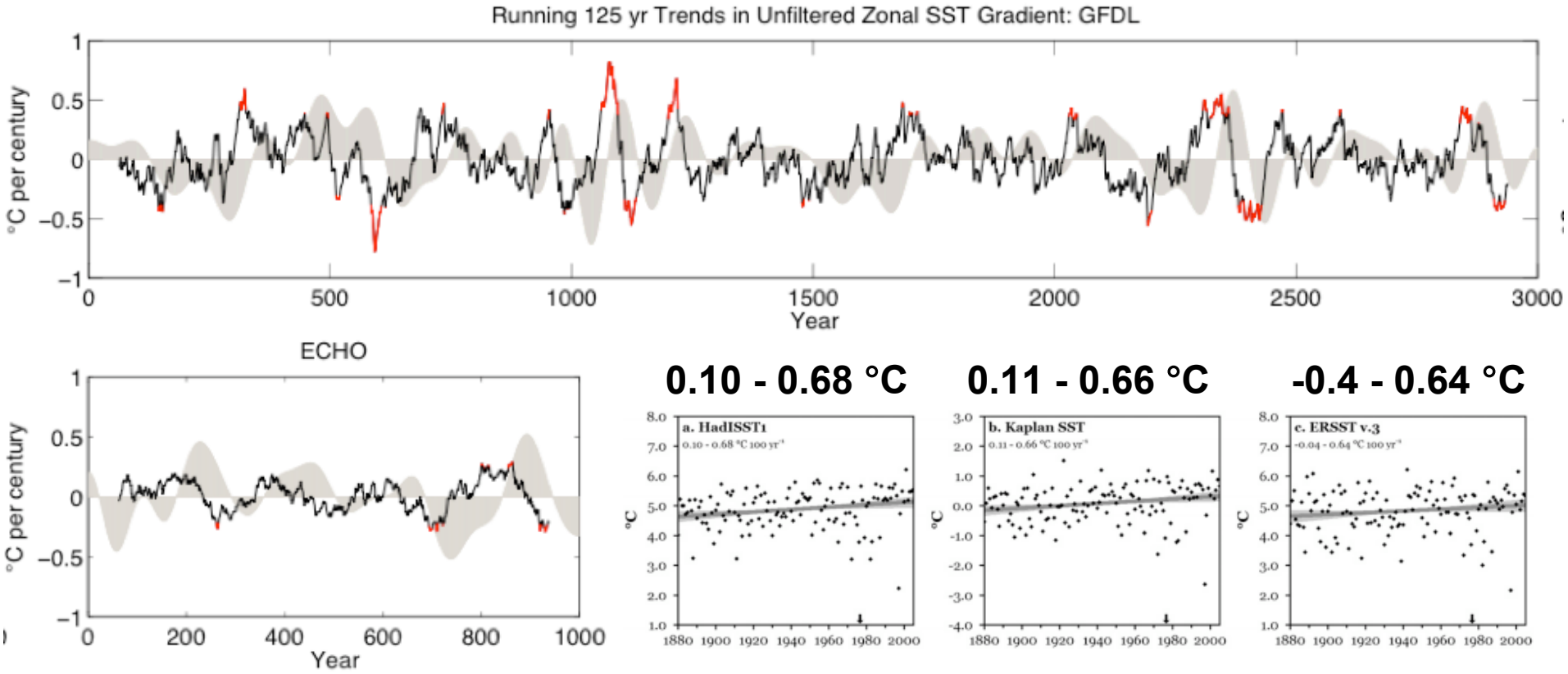
Ocean Resolution: **T42** (~2.8°; meridional resolution increasing to ~0.5° near the equator) by **20 levels**

The ECHO–G applies a time-invariant **flux adjustment** (heat and freshwater fluxes) to avoid climate drift



Karnauskas, K. B., J. E. Smerdon, R. Seager and J. F. Gonzalez-Rouco, Patterns of Unforced Centennial–Scale Climate Variability in the Tropical Pacific, in preparation.

Trends in Simulated SST Gradients



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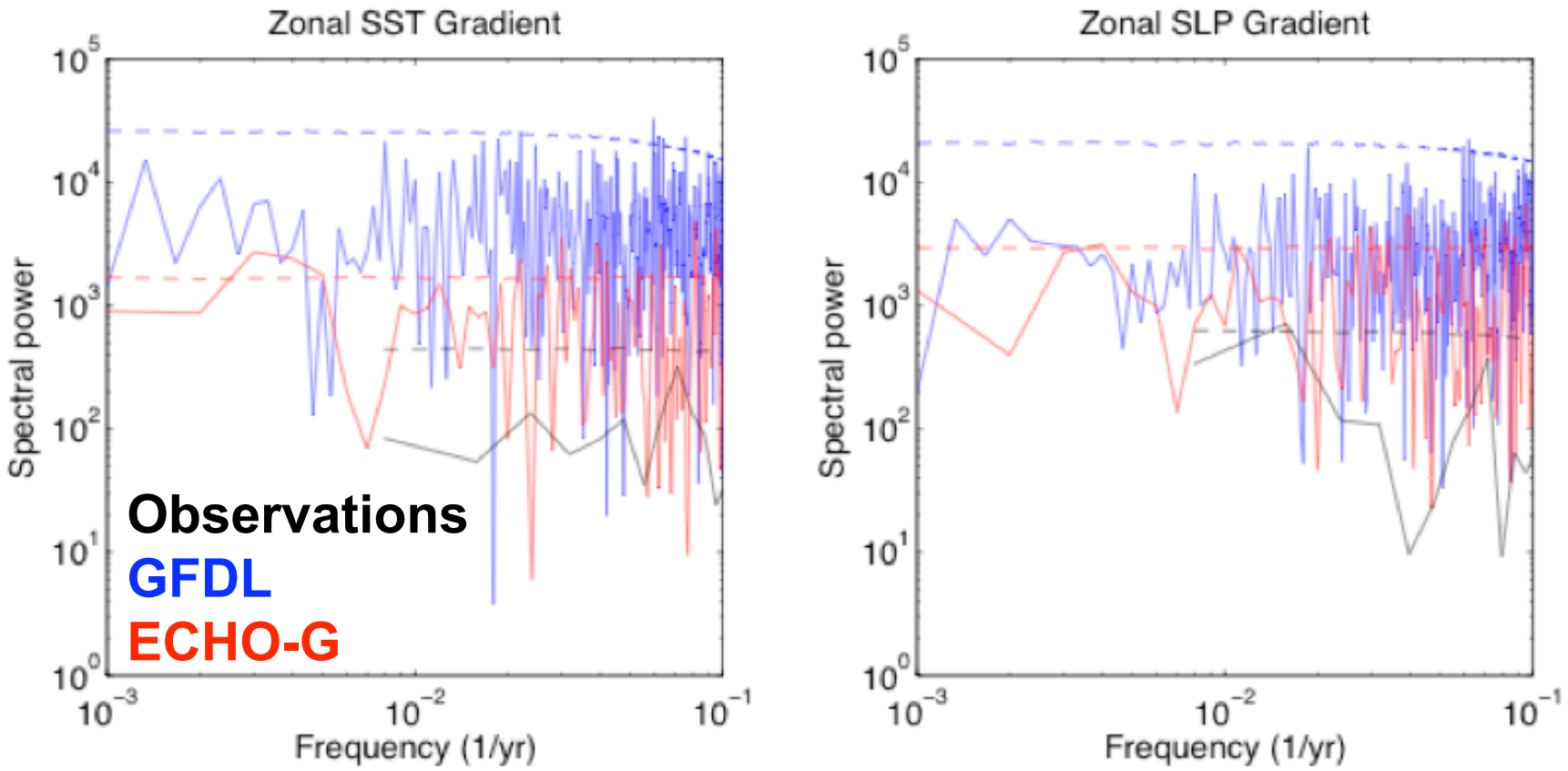
Are Low-Frequency Oscillations Just ENSO Modulation?



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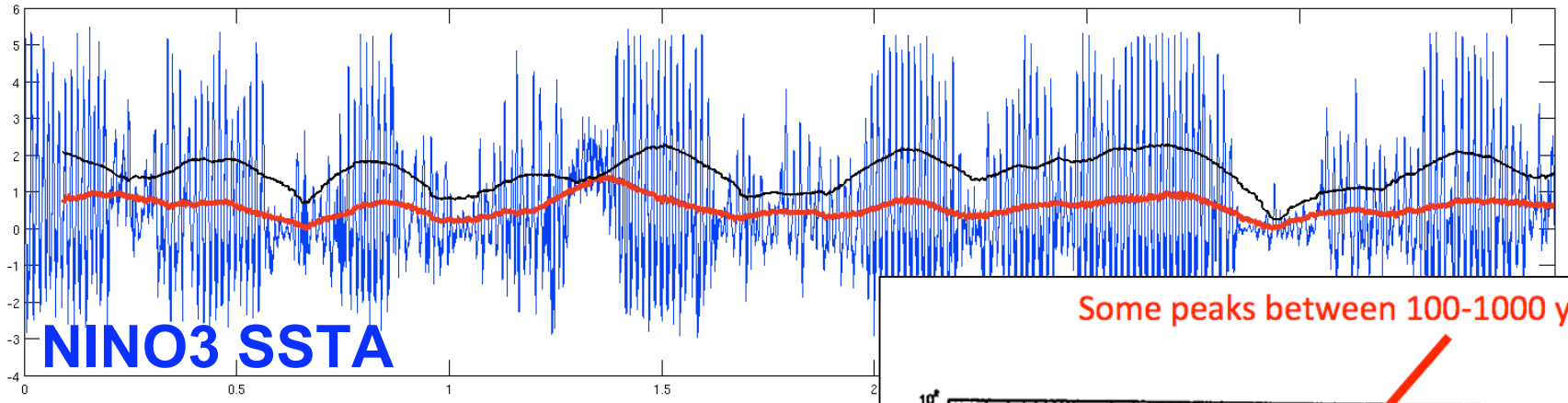
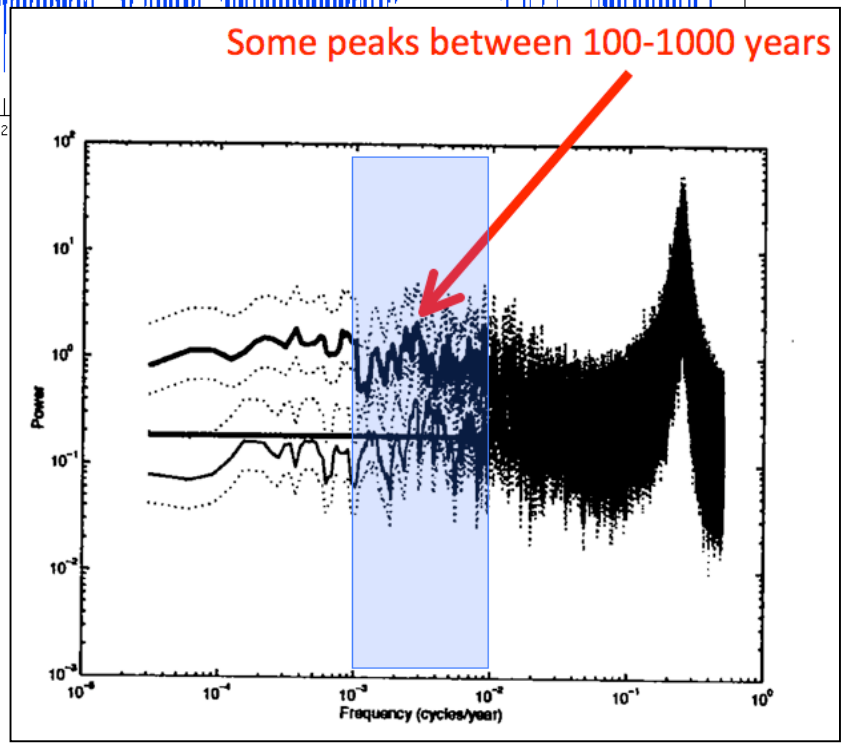
Amplitude Modulations in the Zebiak-Cane Model





Clement, A. and M. A. Cane, 1999: A role for the tropical Pacific coupled ocean-atmosphere system on Milankovitch and millenial timescales. Part I: A modeling study of tropical Pacific variability. In: P.U. Clark and R.S. Webb (Editors), Mechanisms of Millennial-Scale Global Climate Change. 29 Am. Geophys. Union, pp. 363.

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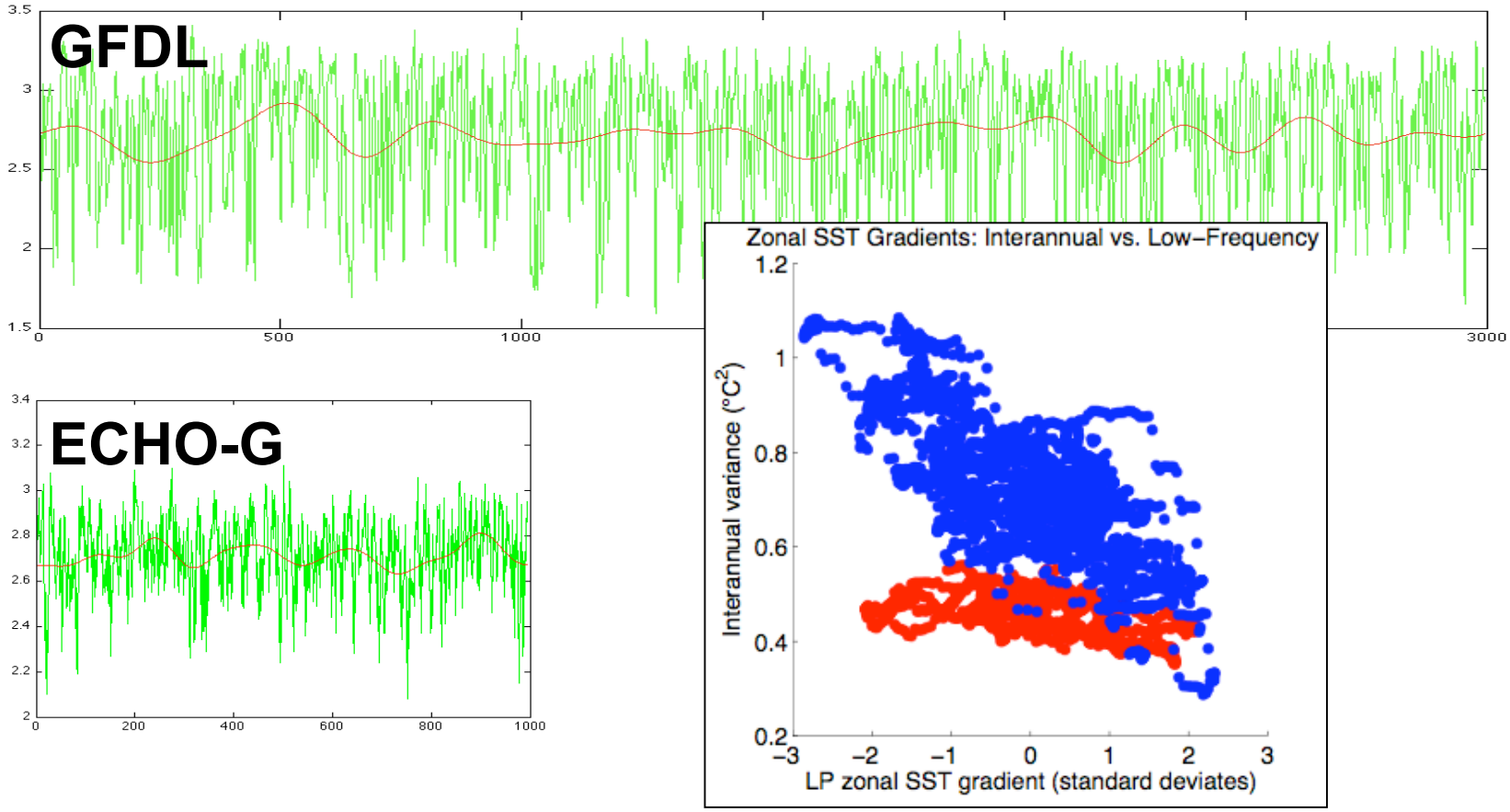

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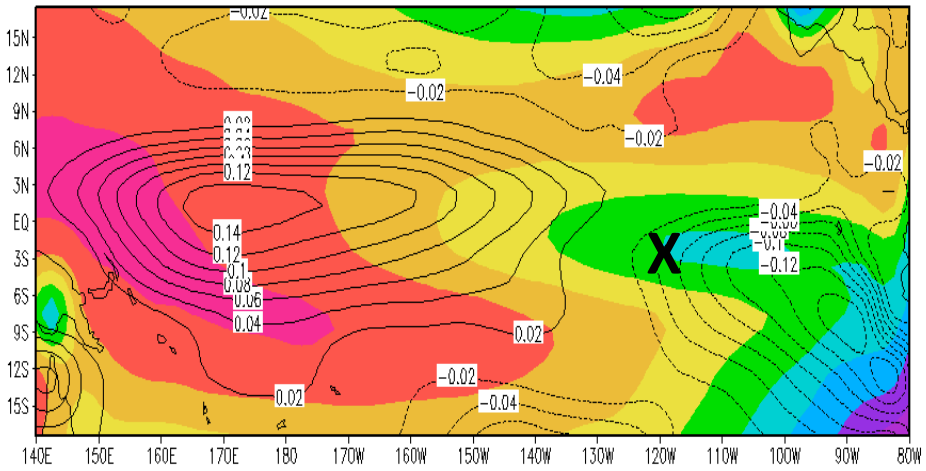
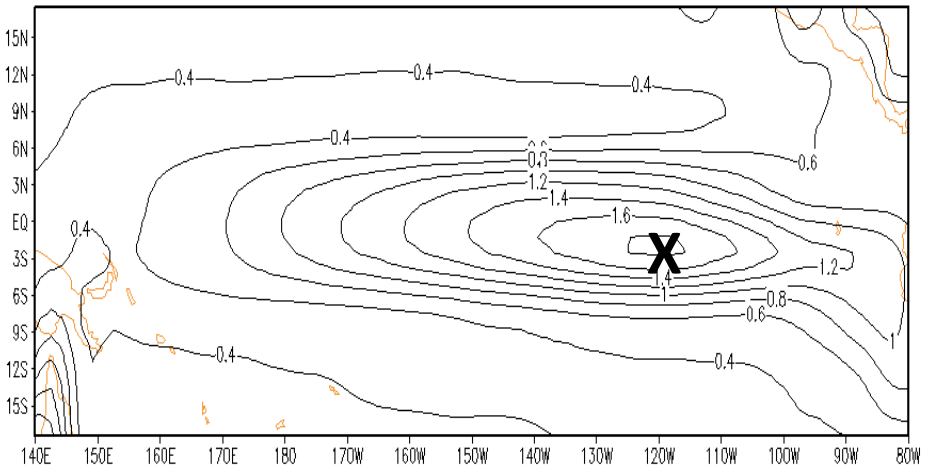
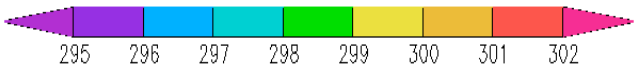
ECHO-G LF Composite



ENSO Variability





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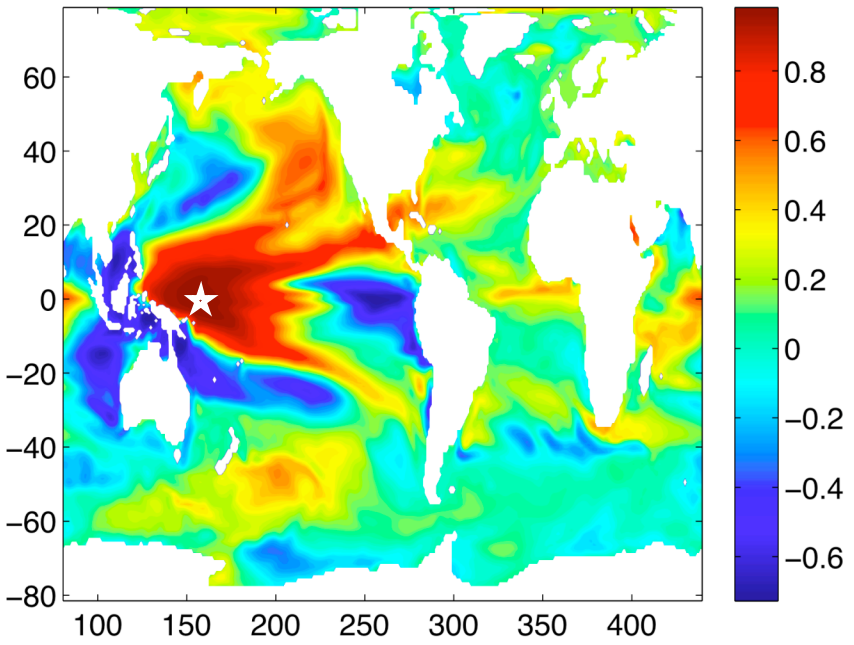
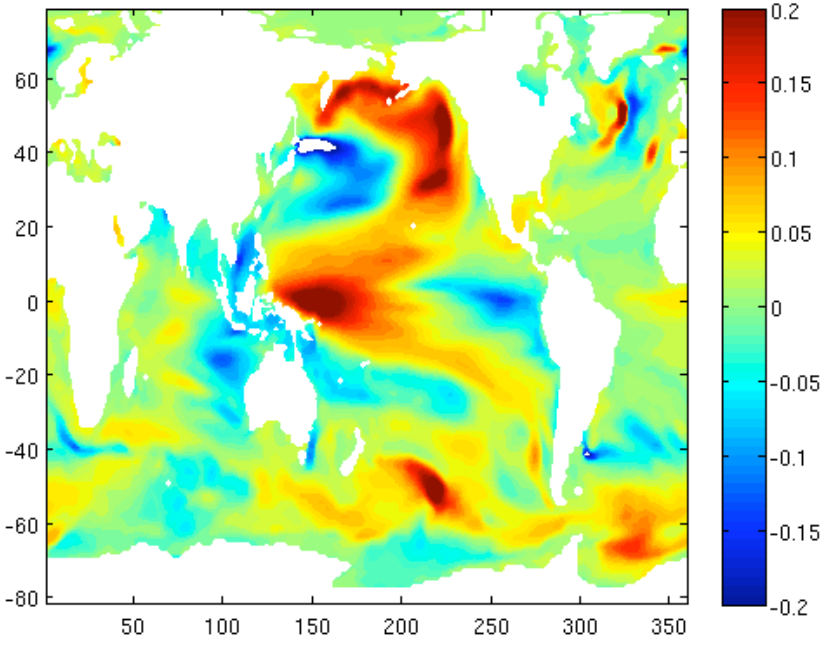
Global Patterns

GFDL Low-pass Filtered WP SST Correlations



GFDL Composite Pattern



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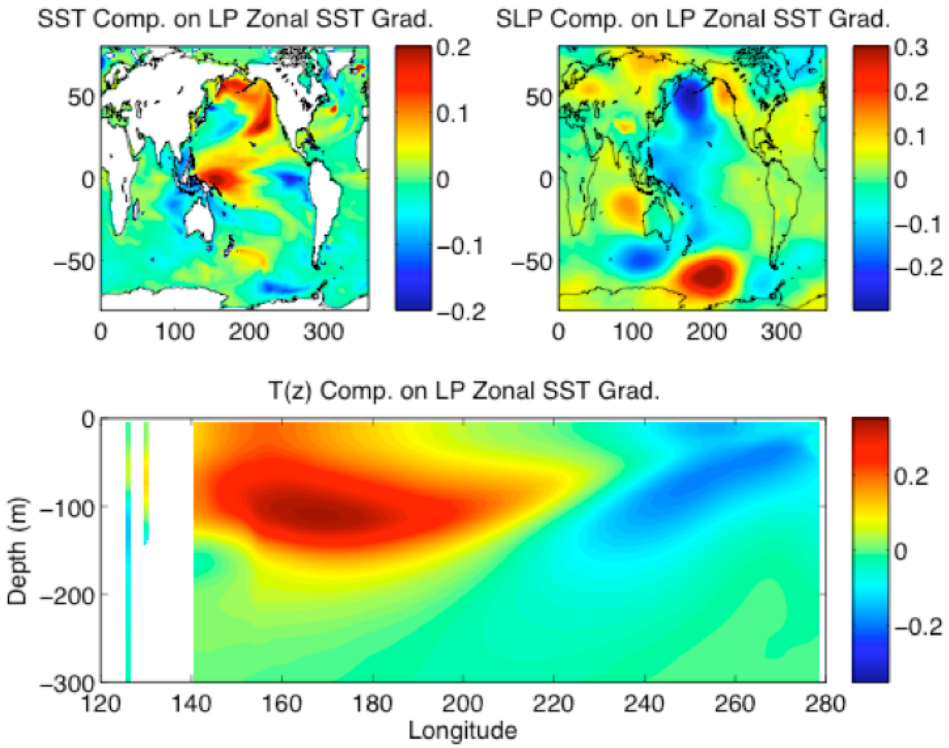
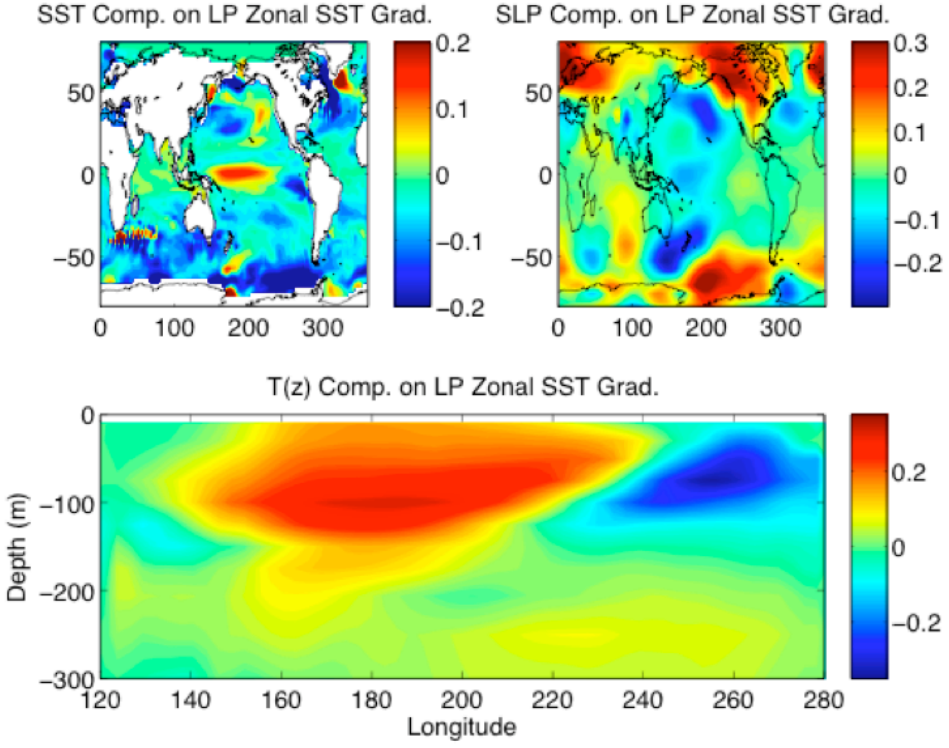
Composite Patterns

GFDL



ECHO-G



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Conclusions

- If nature exhibits strong natural variability in tropical Pacific SSTs on centennial time scales, then the assumption that the observed centennial trend in the SST gradient is a response to radiative forcing is difficult to defend. Nevertheless, the natural variability could strengthen or weaken in the future as the natural variability evolves and combines (interacts?) with any forced response, clearly having implications for tropical Pacific and global climate.
- If the centennial variability in the models is spurious, it is nevertheless a component of the models and will continue to influence coupled GCM projections of future climate, as well as initialized decadal hindcasts and forecasts that are being conducted with these models. In both cases, the natural centennial variability must be properly phased at the beginning of the forecast or projection to isolate the forced change from the spurious modeled natural variability.
- Increasing numbers of millennial-length forced transient runs from fully coupled GCMs will become available over the next several years and should be an important resources for understanding these simulated periods of variability. These simulated periods of variability must also be validated against proxy evidence.