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What is the Wind Stress over the Tropical Pacific?

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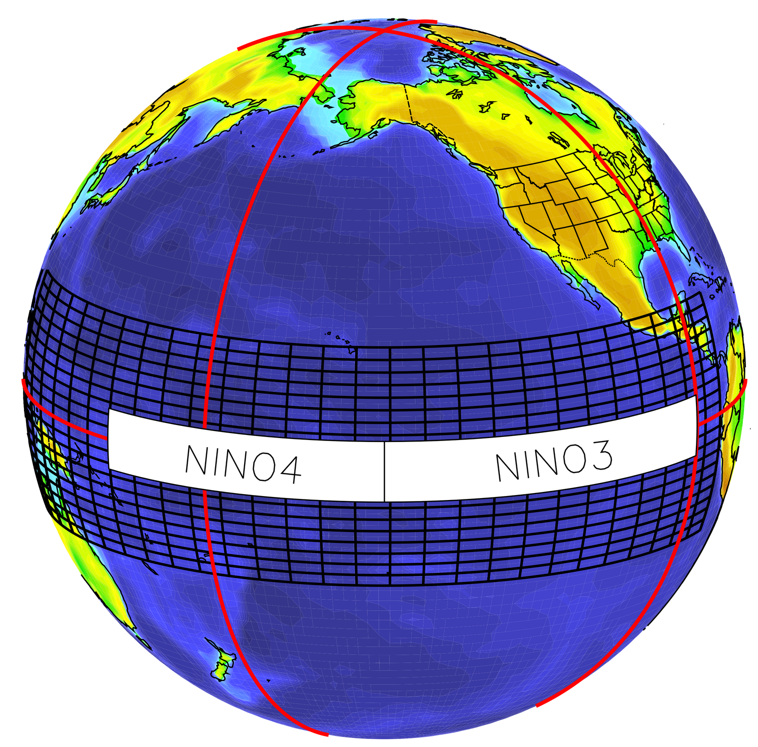
1. Introduction

Tied to sea surface temperature (SST), thermocline depth, and equatorial upwelling, the surface wind stress over the tropical Pacific is key for understanding and predicting global climate, including the El Niño / Southern Oscillation (ENSO). How has the stress changed over recent decades? How do existing stress analyses differ?

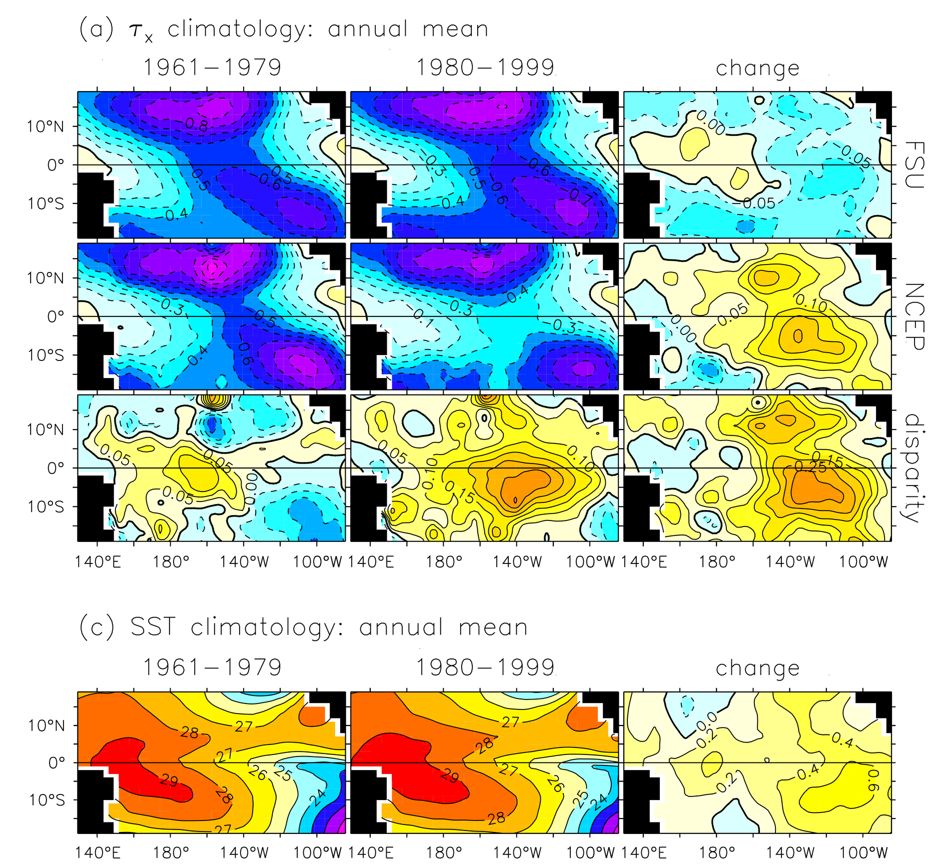
2. Data

We shall focus on the monthly-mean tropical Pacific zonal wind stress (τ_x) over the 1961–1999 period, comparing two of the most widely-used analyses: Florida State University (FSU, Stricherz et al. 1997) and the NCEP/NCAR Reanalysis-I (NCEP, Kalnay et al. 1996). SSTs are from the Reynolds Reconstruction (Smith et al. 1996). The FSU pseudostress is converted to stress using $\rho_{air} c_d = 1.56 \times 10^{-3}$ kg m^{-3}. Each dataset is averaged onto the grid at right, and then for each period of interest, split into a 12-month climatology and anomalies from that climatology.



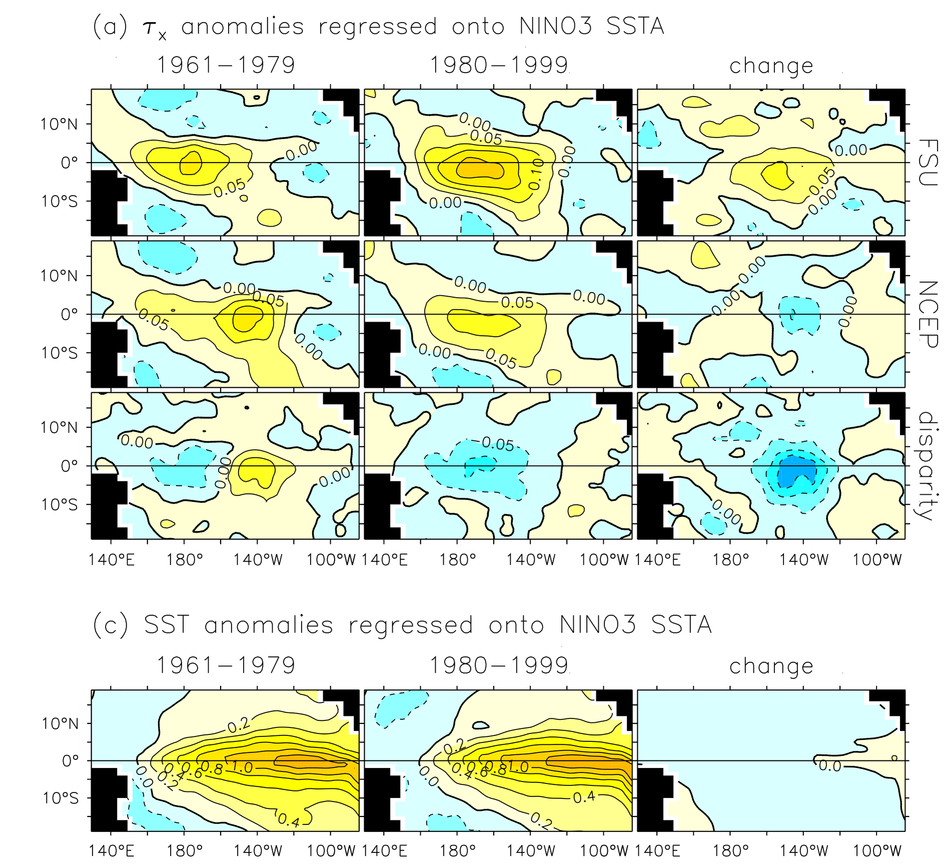
The analysis grid and averaging regions.

3. Annual Mean



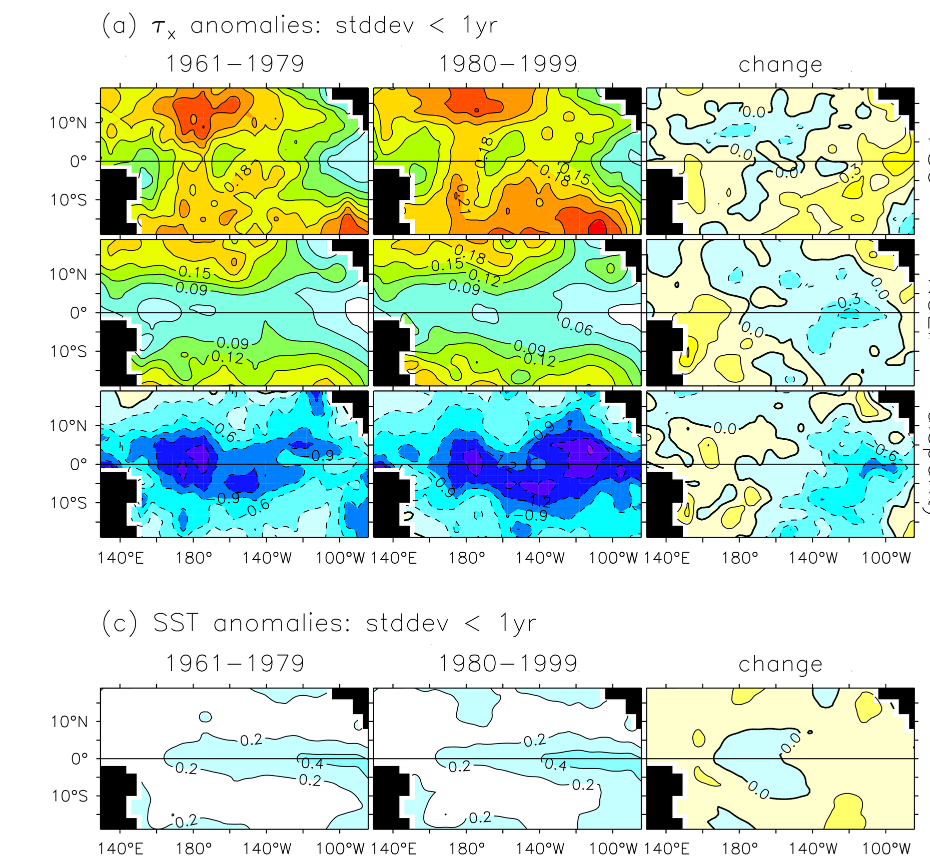
Annual-mean τ_x (barie) and SST (°C). The equatorial trades are weaker in NCEP than FSU, especially in recent decades. And while FSU indicates the trades strengthened and shifted eastward, NCEP suggests they slackened and shifted westward! The zonal gradient of SST, meanwhile, weakened (consistent with the NCEP τ_x) and shifted eastward (consistent with the FSU τ_x).

4. ENSO Response



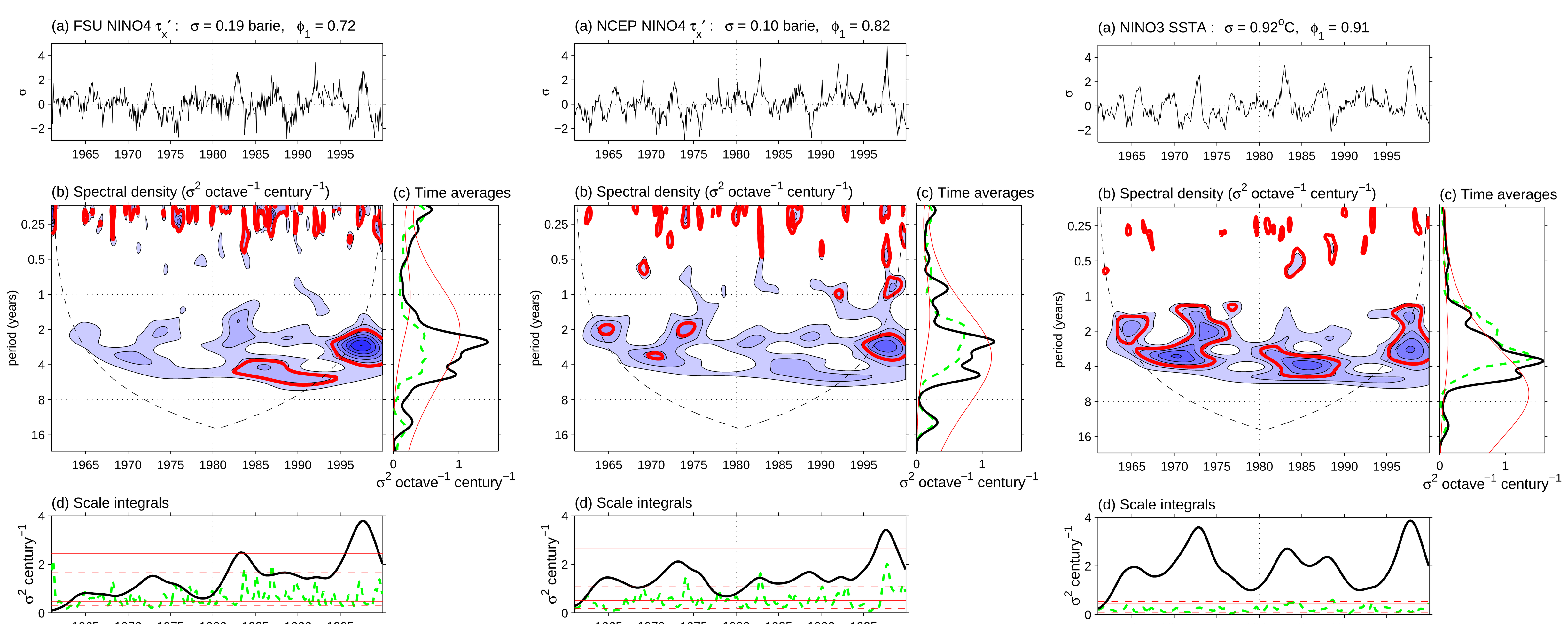
Anomalies regressed onto NINO3 SST anomalies (SSTAs). Both analyses indicate a meridional broadening of the El Niño westerlies in recent decades. FSU shows a stronger ENSO response, and unlike NCEP, shows a strengthening and eastward shift of the response since 1980 — which appears to be consistent with the small changes in the ENSO-related SSTA pattern.

5. Intraseasonal Variability



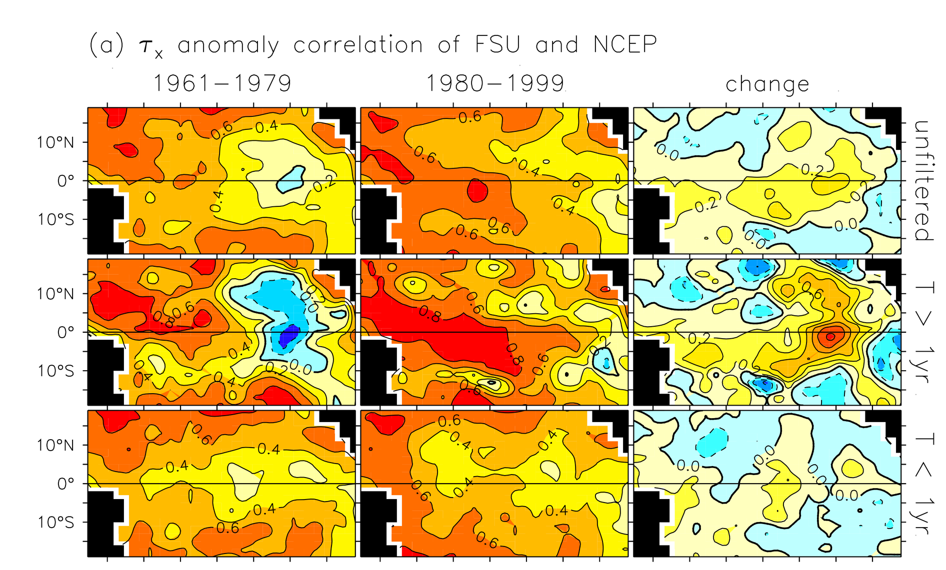
Standard deviation of anomalies at subannual time scales. Intraseasonal SST activity peaks in the cold tongue, while τ_x is most active off-equator. Note that the FSU τ_x is much noisier than NCEP, especially near the equator. Both stress products show more activity in the western equatorial Pacific during recent decades — an artifact of a changing observing system?

6. Timeseries Analysis



NINO4 τ_x anomalies from FSU & NCEP, and NINO3 SSTAs. (a) Timeseries, with standard deviation σ and lag-1 autocorrelation ϕ_1. The NCEP timeseries shows more pronounced westerly spikes than FSU, notably in 1982 and 1997. (b) Spectral density (blue), with the 0.95 quantile for red noise. The NCEP spectrum is more stationary in time than FSU, and exhibits a recent shift toward longer periods that is more consistent with the SSTA spectrum. (c) Average spectra for 1961–79 (green dashed) and 1980–99 (black), with a 90% interval for red noise. (d) Variance in the 0–1 yr (green dashed) and 1–8 yr (black) bands, with 90% intervals for red noise.

7. Local correlation of analyses



Gridpoint correlation of FSU and NCEP τ_x anomalies. The agreement is best where the ENSO signal is strongest, i.e. for interannual periods and in the western equatorial Pacific. The analyses have come into better agreement since 1980, presumably thanks to the TAO array. Yet much uncertainty remains — especially for the intraseasonal component of the stress. A key challenge will be to produce a consensus wind stress product that incorporates the best aspects of objective, subjective, and model reanalyses into a single dataset for climate modelers and forecasters.

8. Extensions

A more detailed analysis, including extensions to the meridional stress and the annual cycle, may be found in Wittenberg (2002b). This study sets the stage for understanding the sensitivity of ENSO to long-term climate changes (Wittenberg 2002a), and supports current efforts to develop a statistical/dynamical hybrid coupled GCM at the Geophysical Fluid Dynamics Laboratory (GFDL).

Acknowledgments

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