GFDL's CM2 Global Coupled Climate Models: Tropical Pacific Climate and ENSO

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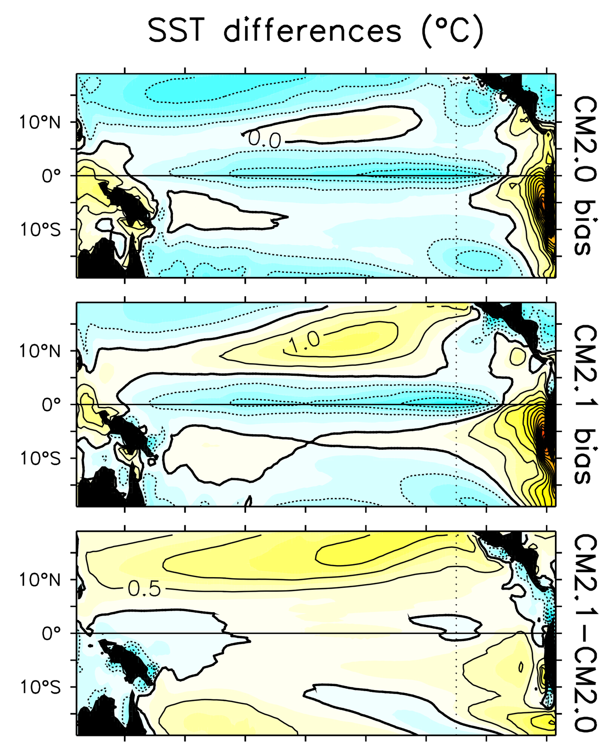
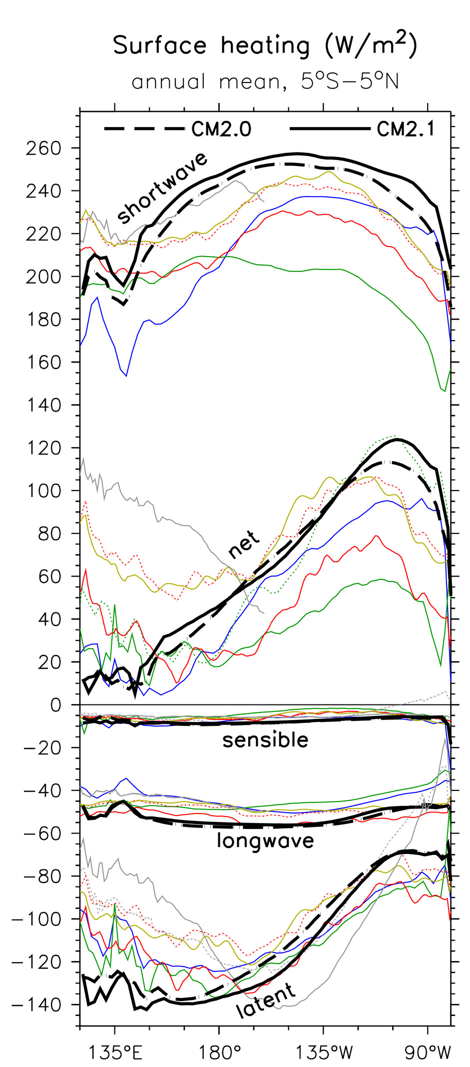
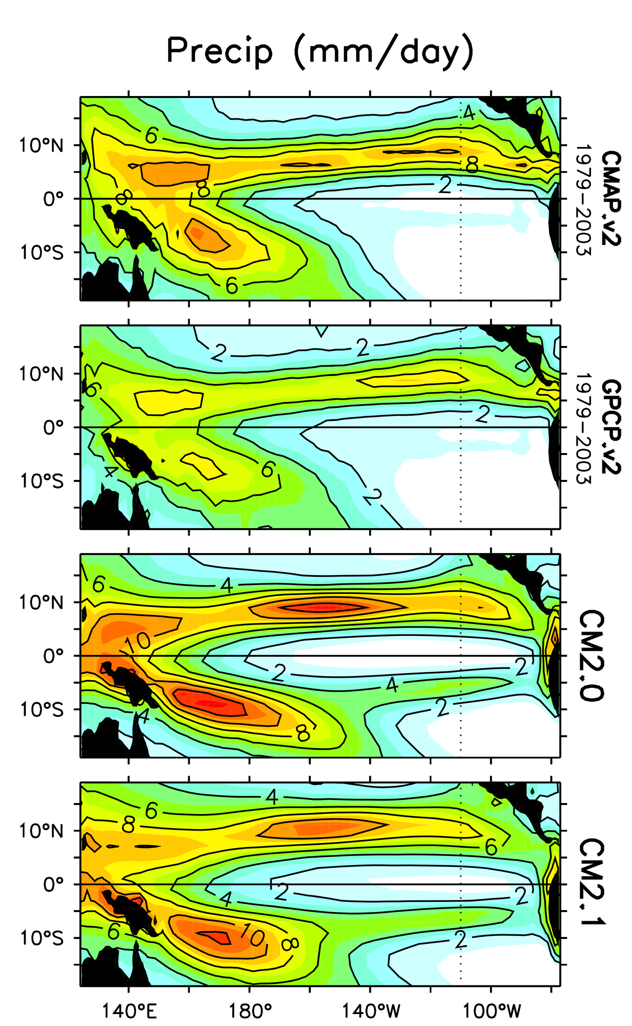
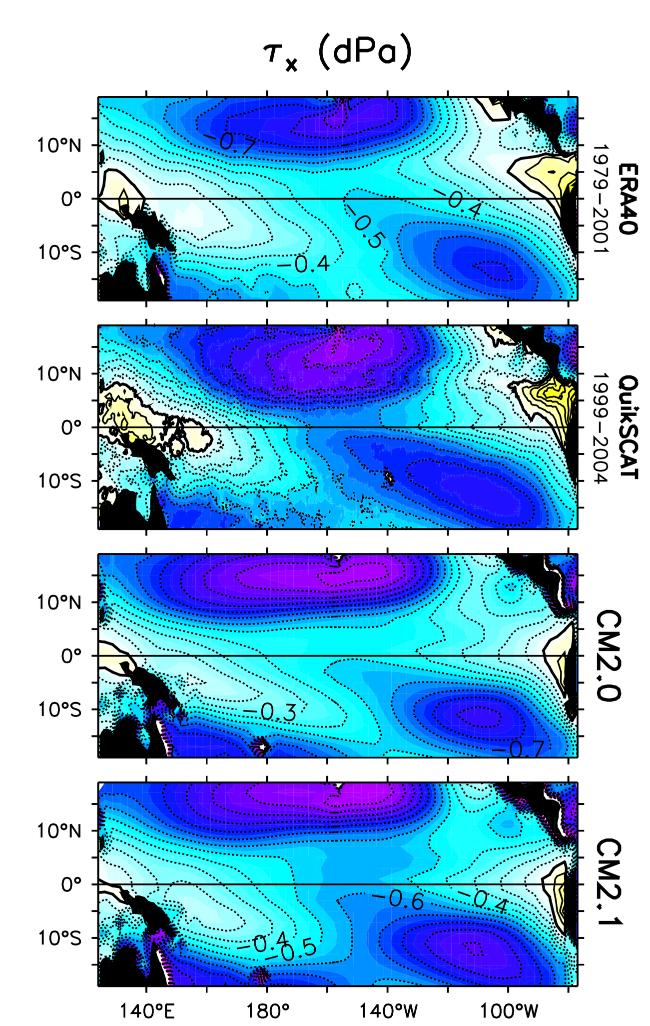
1. Annual-Mean State

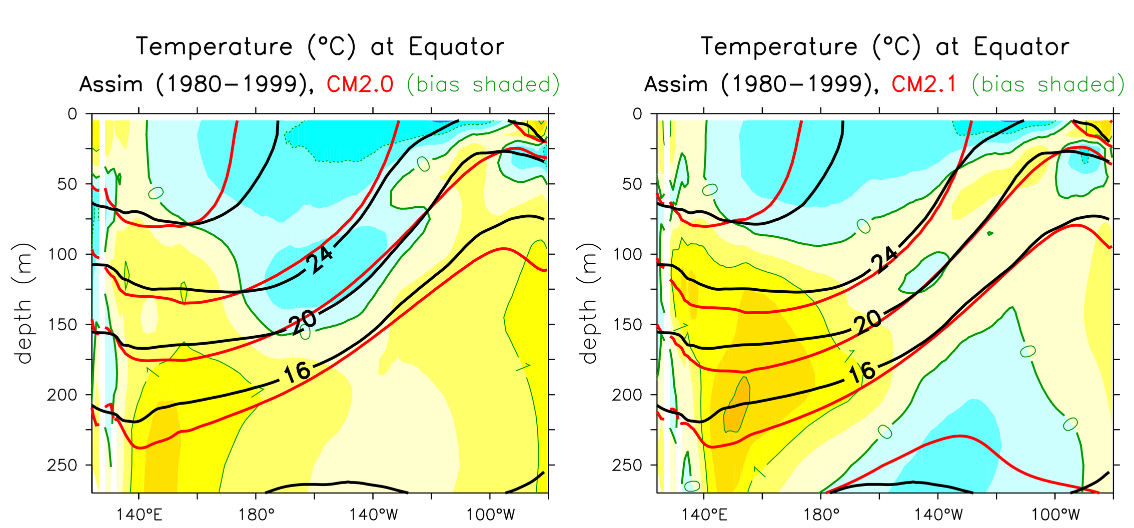
GFDL has developed two new global coupled ocean-atmosphere-land-ice models: CM2.0 and CM2.1. Here we examine 300-year simulations, run with 1990 values of insolation, trace gases, aerosols, and land cover. No flux adjustments are employed. The models show good simulations of tropical Pacific climate, including the annual-mean SST, trade winds, precipitation, air-sea heat fluxes, currents, and subsurface thermal structure. Some biases are evident: SSTs are too cold at the equator and too warm near South America; the southern ITCZ is too strong; the trade winds extend too far west; the surface currents are too weak in the east; and the thermocline is meridionally too flat and slightly too diffuse. The mean equatorial thermocline slope and undercurrent core are well simulated.

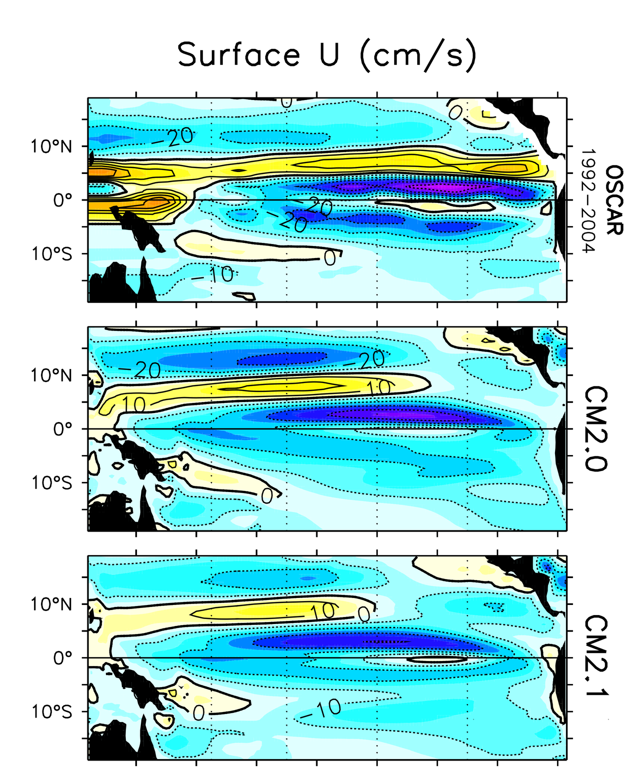


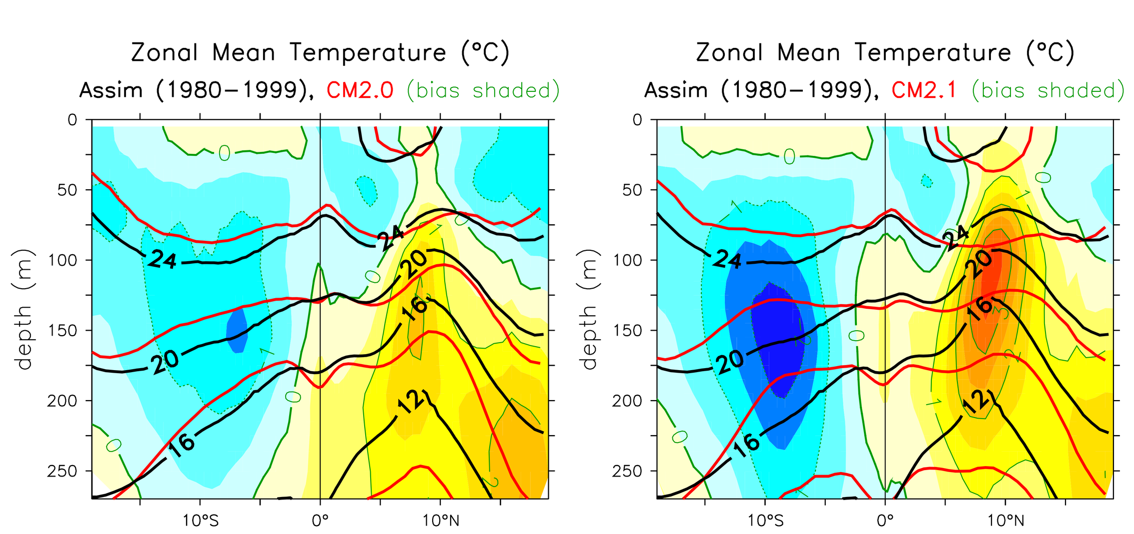


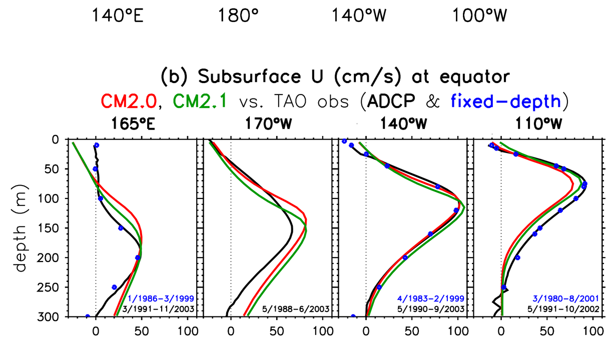






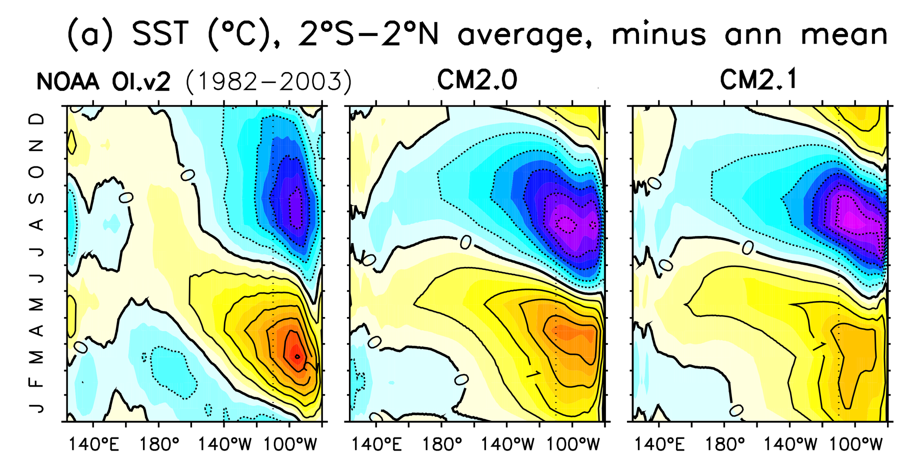


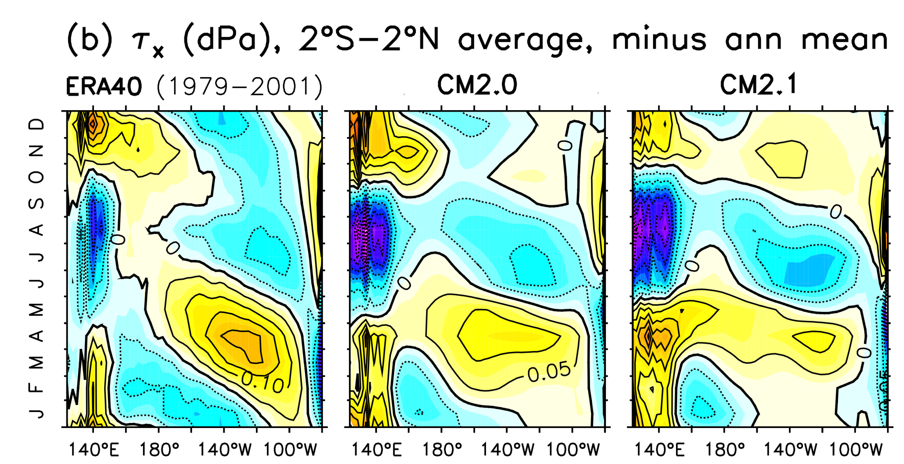




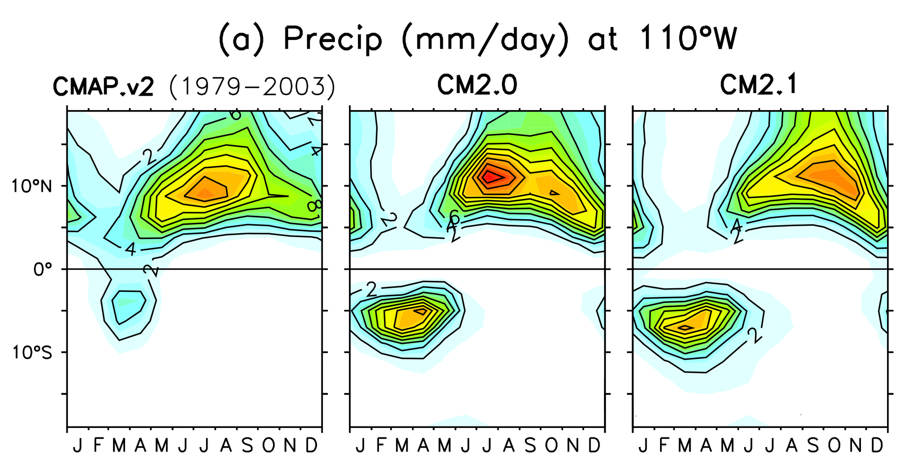
2. Seasonal Cycle

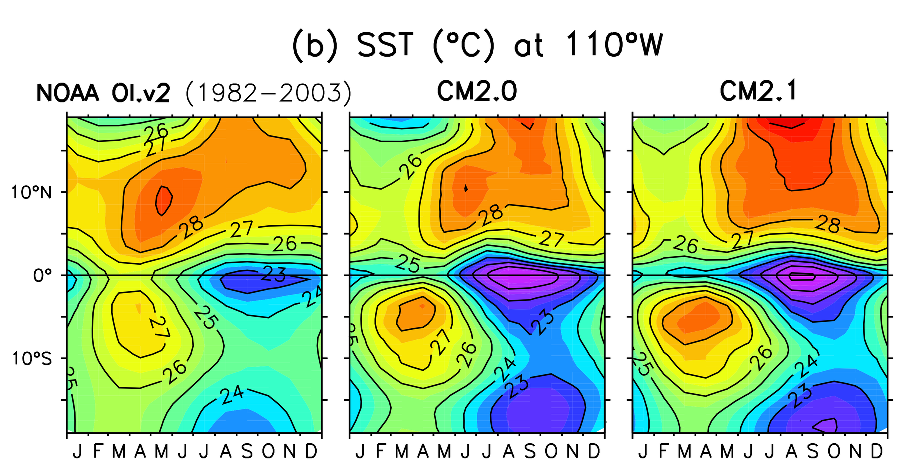
Along the equator, the models exhibit a robust, westward-propagating annual cycle of SST and zonal winds. An overly strong semiannual signal is evident in the equatorial SST, winds, and currents.

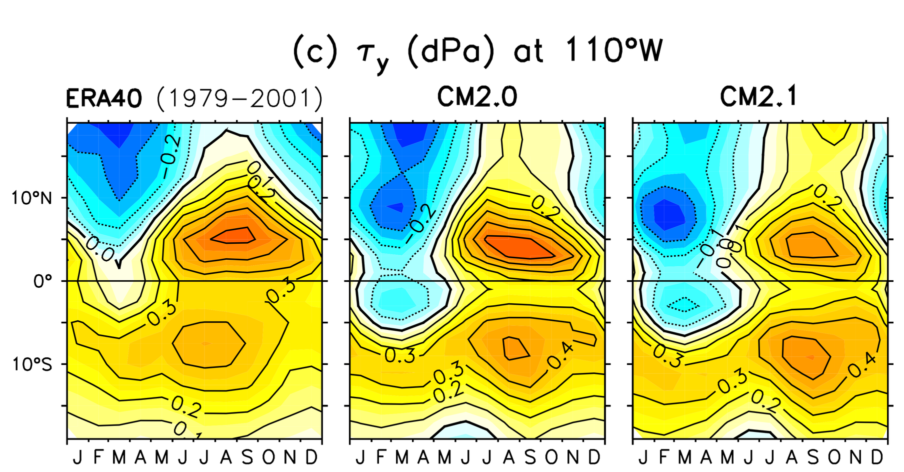




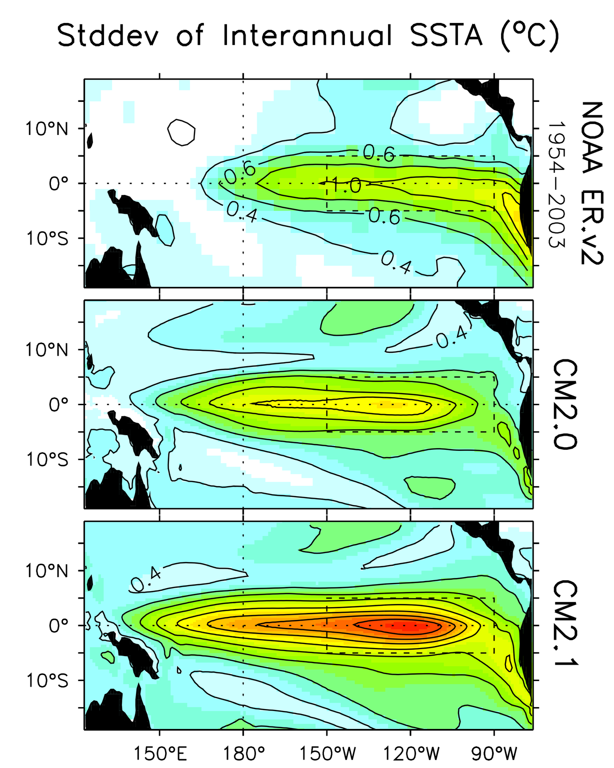
In the east Pacific during boreal spring, strong rainfall south of the equator is linked to an unrealistic reversal of the simulated meridional SST gradient and meridional winds.



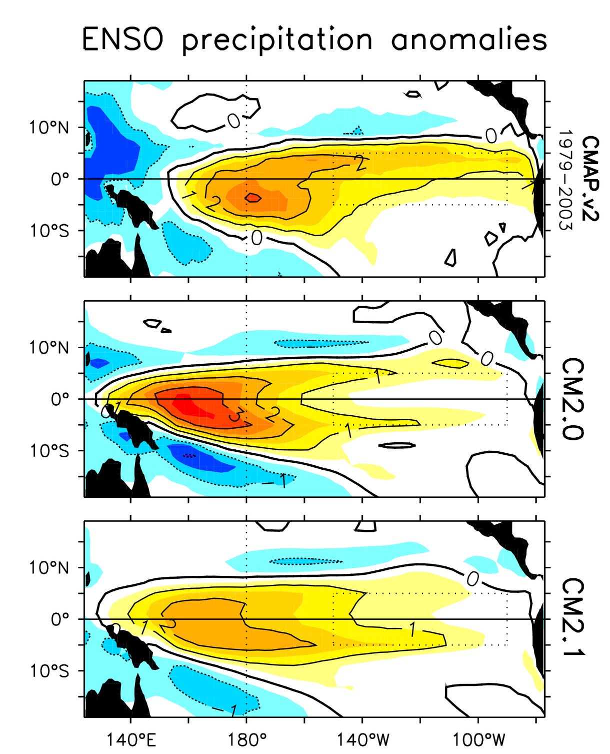


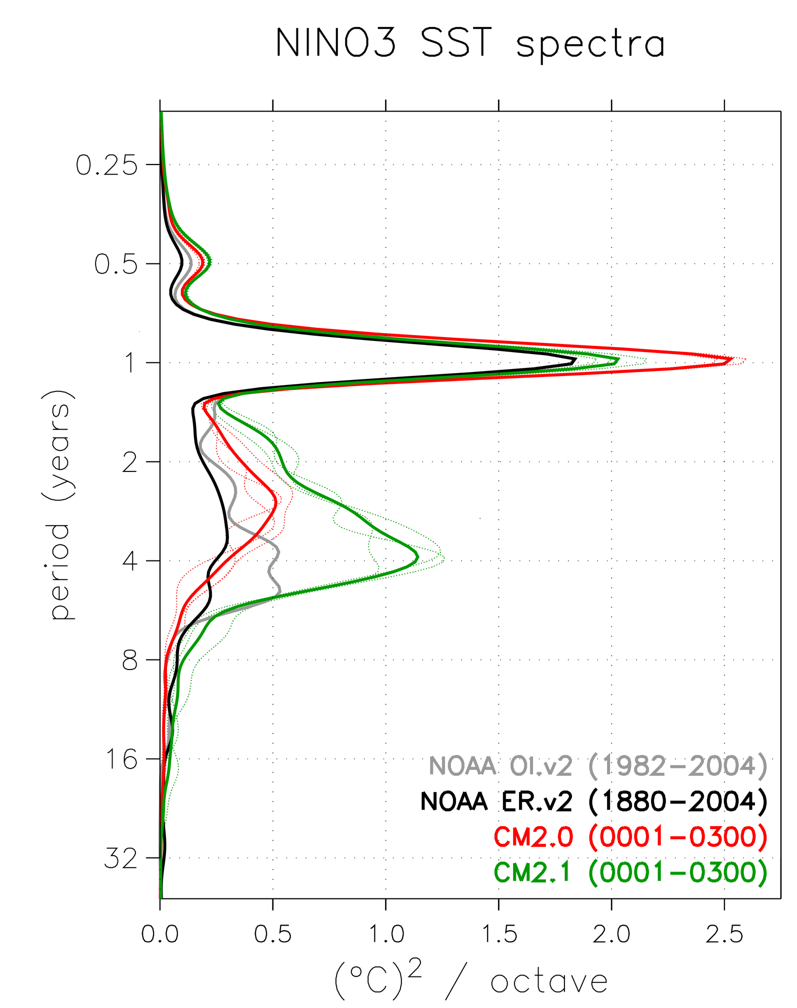


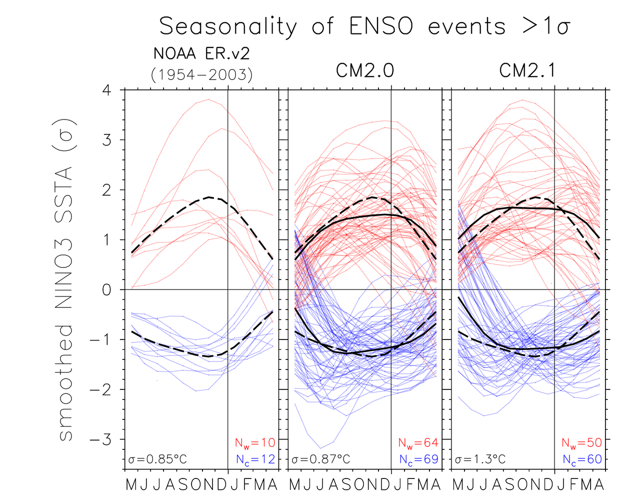
3. Interannual Variability

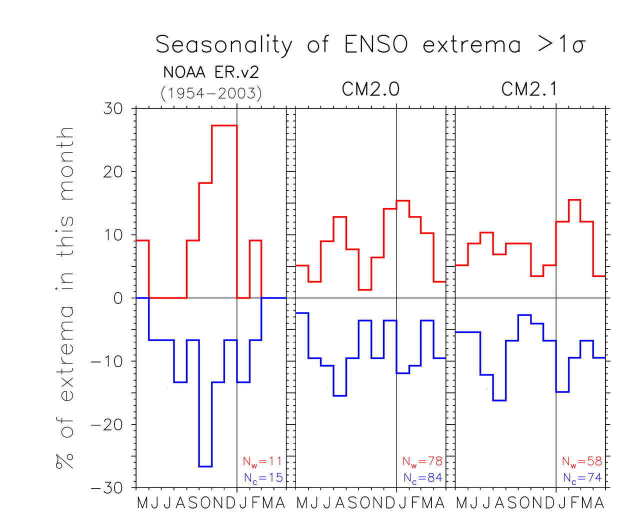


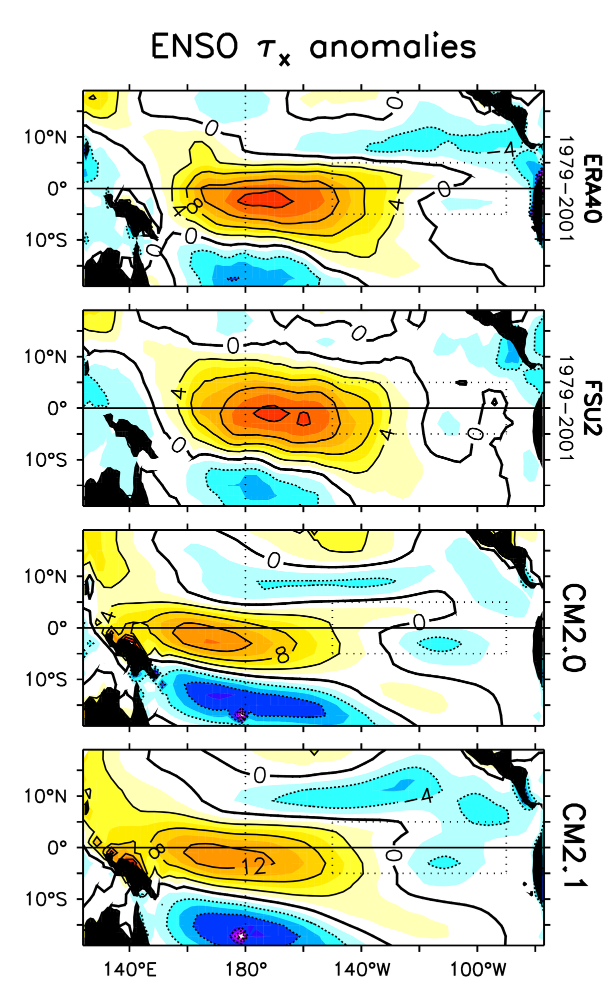
Both models show a robust ENSO with multidecadal variations in amplitude, an irregular period between 2 and 5 years, and positively-skewed SST anomalies as observed. The evolution of ENSO subsurface temperatures and currents is also realistic. But the SSTAs are too strong, too weakly damped by surface heat fluxes, and less clearly phase-locked to the end of the calendar year than the observations, and the simulated patterns of SST, wind stress, and precipitation variability are displaced 20°–30° too far west.

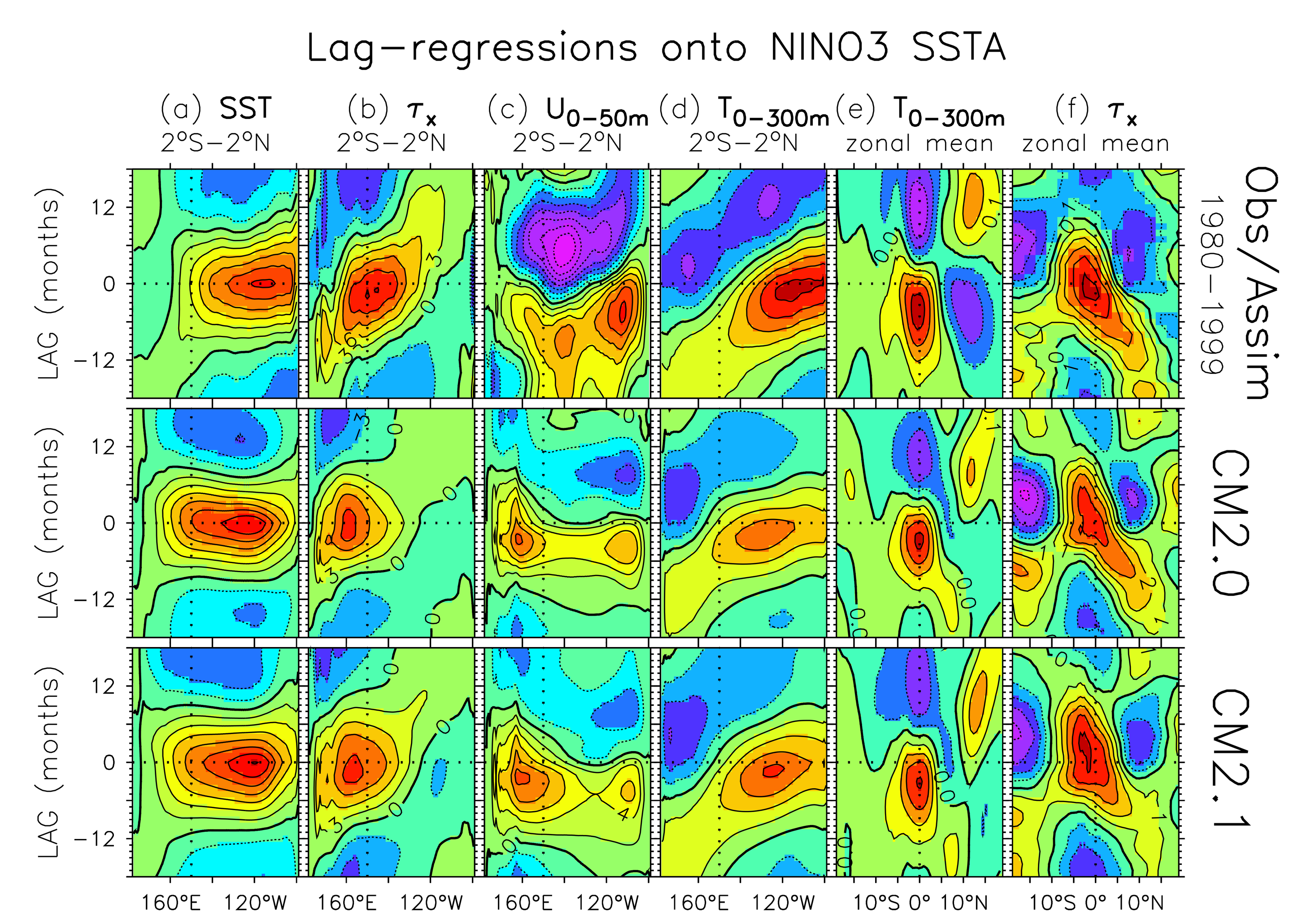


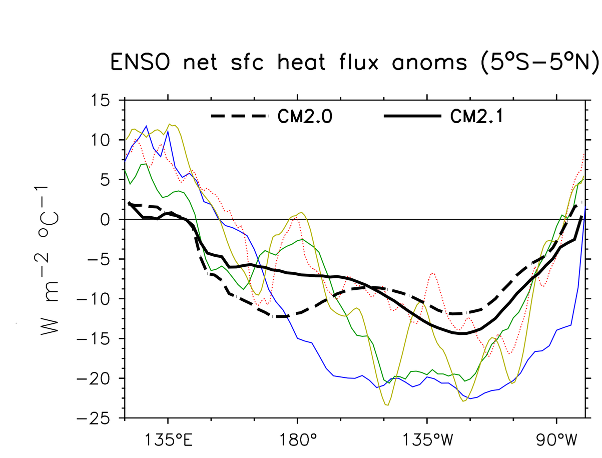












By some measures, CM2.0 outperforms CM2.1 in the tropical Pacific, with reduced SST biases at the equator and South American coast, less insolation at the equator, reduced off-equatorial subsurface temperature biases, a less intense double ITCZ, stronger surface currents, a better annual cycle, and a less intense ENSO. But CM2.1 has a reduced warm bias below the equatorial thermocline, less intense rainfall in the SPCZ and northern ITCZ, a longer-period ENSO with less of a westward shift, and a strong positive skewness of ENSO SST anomalies as observed. ≪*J. Climate*, in press≫

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