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The Effect of ENSO Events on the Tropical Pacific Mean Climate: Insights from an Analytical Model

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To better understand the causes of climate change in the tropical Pacific on decadal and longer time scales, the authors delineate the rectification effect of ENSO events into the mean state by contrasting the time-mean state of a low-order model for the Pacific with its equilibrium state. The model encapsulates the essential physics of theENSO system, but remains simple enough to allow for the obtaining of its equilibrium state. The model has an oscillatory regime that resembles the observations. In this oscillatory regime, the time-mean SST in the eastern equatorial Pacific is found to be significantly different from the corresponding equilibrium SST, with the former being warmer than the latter. The difference is found to be proportional to the amplitude of ENSO. In addition, the zonal SST contrast of the time-mean state is found to be less sensitive to increases in external forcing than that of the equilibrium state, due to warming effect of ENSO events on the eastern Pacific. It is further shown that this rectification effect of ENSO events results from the nonlinear advection term in the heat budget equation. The study elucidates the role of ENSO events in shaping the tropical mean climate state and suggests that decadal warming in the recent decades in the eastern tropical Pacific may be more a consequence than a cause of the elevated ENSO activity during the same period. The results also provide a simple explanation for why it is difficult to detect an anthropogenically forced trend in the zonal SST contrast in the observations.