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Evidence of a substantial contribution of natural non-ENSO-like multidecadal SST variability to observed tropical SST trends over the last half century

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Distinguishing anthropogenic signals from natural climate variations is a central concern in global change research. Evidence is accumulating that most of the effects of the changes in greenhouse gases and other radiatively active species will be transmitted globally through changes in the tropical SSTs. Some long-term tropical SST trends are already evident in observations. These observed trends, however, differ substantially from the multi-model mean SST trends in the IPCC AR4 simulations. The question is, are the differences mainly due to natural variations in the statistics of ENSO events, or is another kind of natural multidecadal SST variability also involved ? Modeling groups are attempting to answer this question by examining the natural variability of global coupled climate models without specified changes in GHG and other radiative forcings. The existence of substantial mean tropical biases, as well as misrepresentations of ENSO variability, however, prevents them from reaching a definite conclusion.

Here we take an alternative approach, using a linear inverse model (LIM) of tropical SST variability derived from the observed zero-lag and 4-month lag covariances of SSTs over the last half century. The model can be integrated forward in time using a linear evolution operator determined as above, and a stochastic forcing whose amplitude and spatial structure are also estimated from those same observed covariance statistics. We have made a 100,000 year integration of this LIM and split the simulated SST time series into 2000 separate 50-year segments. At each tropical location, the trend over 50 years was calculated in each of the 50-year segments, and the probability distribution of these trends was estimated from the results for the 2000 segments. At most locations, the observed 50-year trend was found to lie at the extreme end of the distribution of the simulated trends. Our analysis thus leads us to conclude that the observed 50-year trends of SST at most tropical locations, and especially in the Indian and west Pacific oceans, are not consistent with naturally occurring 50-year trends expected from the observed statistics of interannual SST variability. This, together with the fact that the observed trends are also inconsistent with the radiatively forced trends in the IPCC AR4 simulations, suggests that they have had a significant contribution from some as yet poorly understood mechanism of natural non-ENSO-like multidecadal tropical SST variability.