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Removing ENSO-related variations from the climate record

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An important question in assessing twentieth-century climate change is to what extent have ENSO-related variations contributed to the observed trends. Isolating such contributions is challenging for several reasons, including ambiguities arising from how ENSO itself is defined. In particular, defining ENSO in terms of a single index and ENSO-related variations in terms of regressions on that index, as done in many previous studies, can lead to wrong conclusions. This paper argues that ENSO is best viewed not as a number but as an evolving dynamical process for this purpose. Specifically, ENSO is identified with the four dynamical eigenvectors of tropical SST evolution that are most important in the observed evolution of ENSO events. This definition is used to isolate the ENSO-related component of global SST variations on a month-by-month basis in the 136-yr (1871-2006) Hadley Centre Sea Ice and Sea Surface Temperature dataset (HadISST). The analysis shows that previously identified multidecadal variations in the Pacific, Indian, and Atlantic Oceans all have substantial ENSO components. The long-term warming trends over these oceans are also found to have appreciable ENSO components, in some instances up to 40% of the total trend. The ENSO-unrelated component of 5-yr average SST variations, obtained by removing the ENSO-related component, is interpreted as a combination of anthropogenic, naturally forced, and internally generated coherent multidecadal variations. The following two surprising aspects of these ENSO-unrelated variations are emphasized: 1) a strong cooling trend in the eastern equatorial Pacific Ocean and 2) a nearly zonally symmetric multidecadal tropical-extratropical seesaw that has amplified in recent decades. The latter has played a major role in modulating SSTs over the Indian Ocean.