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ENSO diversity in the NCAR-CCSM4 climate model

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As highlighted by several studies using the Climate Model Intercomparison Project 3 (CMIP3) archive, simulation of the El Niño-Southern Oscillation (ENSO) by climate models is challenging due to the inherently coupled nature of ENSO, and the difficulty of representing with fidelity the complex atmosphere-ocean feedbacks. Recent analyses of a long control integration using the latest version (version 4) of the National Center for Atmospheric Research Community Climate System Model (NCAR-CCSM4) showed significant improvements in the simulation of ENSO relative to the previous version of the model (NCAR-CCSM3), as well as many of the CMIP3 models. In particular, the ENSO time evolution in CCSM4 has shown to have a much richer and realistic behavior, making it a suitable tool for understanding ENSO dynamics and variability. Over the last few years a large literature has developed to describe a type of El Niño in which the maximum sea surface temperature (SST) anomalies are located in the central equatorial Pacific rather than in the eastern Pacific, as in the canonical El Niño. The central-western Pacific warming is associated with different atmospheric teleconnections than the canonical El Niño, and can have important consequences on several aspects of the global climate. However, some studies have shown that many models in the CMIP3 archive fail to reproduce this aspect of ENSO diversity. In this study we examine the spectrum of El Niño flavors in the NCAR-CCSM4, with a focus upon the longitudinal location of maximum warming. We explore the different definitions of the "non-canonical" El Niño provided in the recent literature, and investigate whether there is a clear bimodality between eastern vs. central Pacific warming, or rather a continuum of longitudes where warming occurs. Variations in atmospheric fields as well as in subsurface ocean characteristics associated with the different flavors are examined to elucidate differences in the underlying dynamics. The set of diagnostics outlined in this study can be extended to the rest of the CMIP5 archive.