Strong and moderate El Niño regimes in the GFDL CM2.1 model

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Abstract

Very strong El Niño events have been shown to present a different evolution and patterns to moderate events, with a strong signature in the eastern Pacific (Takahashi et al., 2011). However, observational records may be too sparse to allow for meaningful statistical analysis that can shed light on the conditions that favor such events. In the present study we present an analysis of a 500-year simulation with the GFDL CM2.1 climate model focusing on the conditions that favor the different magnitudes of El Niño. Strong and moderate El Niño events in CM2.1 present a similar initial evolution, with surface warming in the central-eastern Pacific and westerly wind stress anomalies in the western Pacific, but the moderate events peak and decline around 6 months earlier than the strong events, which continue their growth in the eastern Pacific. The strong events appear to be favored by additional off-equatorial heat content that generates equatorial Kelvin waves during the onset phase and provides extra warming in the eastern Pacific. A non-linear response in the zonal wind stress, could lead to enhanced growth of the event once the SST anomalies become large enough.

The strong and moderate El Niño also differ in terms of their seasonal evolution, with strong events preferentially peaking around November in terms of SST, whereas moderate events show a clear bimodality, with some events showing maxima in July and others in January. The moderate events with SST peaking in January tend to present the associated SST anomalies farther to the west than those peaking in July, while the reverse is true during the onset period (6 months earlier), so that events peaking in January have a stronger initial warming in the eastern Pacific, reminiscent of the "canonical" El Niño of Rasmusson and Carpenter (1982). A heat budget analysis is also carried out in order to identify the oceanic mixed-layer processes favouring the divergence in event evolution and investigate their sensitivity to slow changes in background state.