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ENSO in the CMIP5 simulations: lifecycles, diversity, and responses to climate change

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Focusing on ENSO seasonal phase locking, diversity in peak location and propagation direction, as well as the El Niño-La Niña asymmetry in amplitude, duration and transition, a set of empirical probabilistic diagnostics (EPD) is introduced to investigate how the ENSO behaviors reflected in SST may change in a warming climate.

EPD is first applied to estimate the natural variation of ENSO behaviors. In the observations El Niños and La Niñas mainly propagate westward and peak in boreal winter. El Niños occur more at the eastern Pacific while La Niñas prefer the central Pacific. In a pre-industrial control simulation of the GFDL CM2.1 model, the El Niño-La Niña asymmetry is substantial. La Niña characteristics generally agree with observations but El Niños do not, typically propagating eastward and showing no obvious seasonal phase locking. So an alternative approach is using a stochastically forced simulation of a nonlinear data-driven model, which exhibits reasonably realistic ENSO behaviors and natural variation ranges.

EPD is then applied to assess the potential changes of ENSO behaviors in the 21st century using CMIP5 models. Other than the increasing SST climatology, projected changes in many aspects of ENSO reflected in SST anomalies are heavily model-dependent and generally within the range of natural variation. Shifts favoring eastward propagating El Niño and La Niña are the most robust. Given various model biases for the 20th century and lack of sufficient model agreements for the 21st century projection, whether the projected changes for ENSO behaviors would actually take place remains largely uncertain.