El Niño or La Niña-like global warming? - a case study with GFDL-ESM2M and MIROC5

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The majority of the models that participated in the Coupled Model Intercomparison Project phase 5 (CMIP5) exhibit El Niño-like responses to global warming. GFDL-ESM2M, however, is an exception that exhibits a La Niña-like response with strengthened trade winds. Our previous studies have shown that this La Niña-like trend could be a physically consistent warming response, and we proposed the Nonlinear ENSO Warming Suppression (NEWS) mechanism to explain this La Niña-like response to global warming. The NEWS hypothesis suggests that ENSO could be weakened nonlinearly, which causes the mean-state sea surface temperature (SST) to be rectified to become La Niña-like.

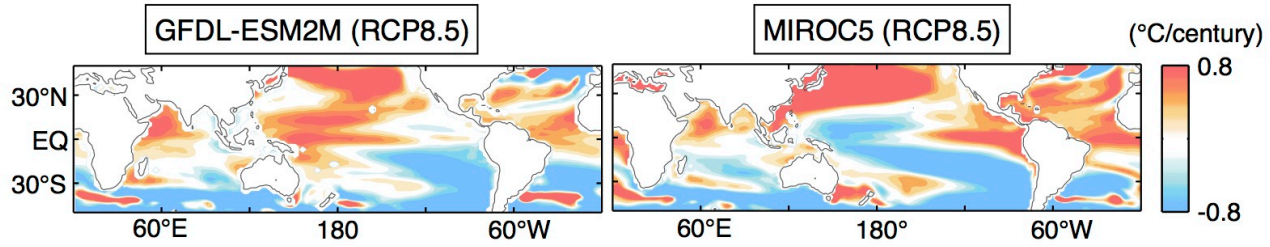
The most important necessary condition of NEWS is the ENSO skewness (El Niños are stronger than La Niñas). Most CMIP5 models do not reproduce the observed ENSO skewness, while GFDL-ESM2M exhibits the realistic ENSO skewness, which suggests that, despite being in the minority, the La Niña-like trend of GFDL-ESM2M could be a plausible equatorial Pacific response to warming. To test this idea further, in this presentation, we introduce another interesting model, MIROC5. This global climate model reproduces the observed skewness, yet exhibits an El Niño-like response.

To look for another necessary condition for NEWS, we have examined the ENSO amplitude response to global warming in GFDL-ESM2M and MIROC5. With quadrupled atmospheric carbon dioxide, the ENSO amplitude of GFDL-ESM2M decreases by about 40%, whereas that of MIROC5 remains almost constant. Because GFDL-ESM2M exhibits stronger climatological thermal stratification than MIROC5, greenhouse gas forcing increases the upper ocean stability and causes the thermocline to be less sensitive to wind perturbations. The stiffer thermocline of GFDL-ESM2M inhibits the nonlinear variations of SST so that the ENSO amplitude substantially weakens. As to MIROC5, on the other hand, due to the reactive thermocline, the nonlinear SST variability keeps its original amplitude. This difference appears to be why NEWS operates in GFDL-ESM2M but not in MIROC5. Idealized nonlinear recharge oscillator model experiments further support climatological thermal stratification as a determinant of the warming response.

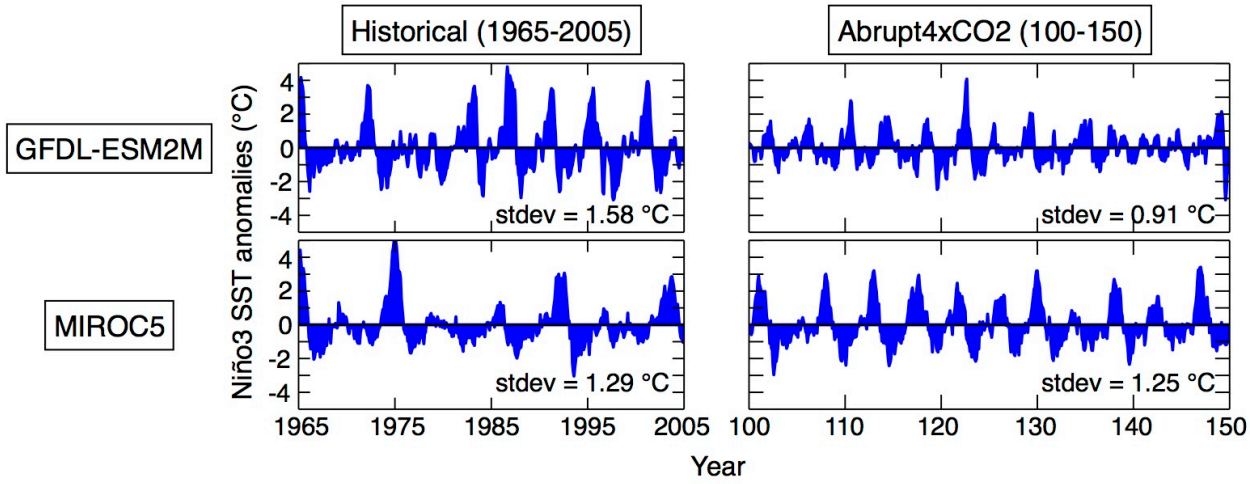
Observations exhibit stronger thermal stratification than both models, which supports the notion that the real world may terminate strong, nonlinear El Niños sooner than model-based projections. Hence, following the NEWS mechanism, the forced La Niña-like response to global warming may be detected during this century.

Keywords: mean-state SST response, global warming, ENSO

a) Mean-state SST trends relative to the global mean (2006-2100)



b) ENSO amplitude changes



c) Warming response of the thermocline-SST relationship