GFDL One-Page Research Summary

Mean climate controls on the simulated response of ENSO to increasing greenhouse gases

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ENSO is by far the dominant player in global year-to-year climate variability, with worldwide impacts on weather, natural disasters, agriculture, fisheries, and natural ecosystems. Understanding and predicting the future behavior of ENSO is thus central to NOAA's mission and highly relevant to society.

Prior studies had shown divergent results for the projected future behavior of ENSO over the next century, with some model projections showing amplification, others diminution, and others showing almost no change at all in ENSO. Understanding this diversity of model sensitivities is necessary to improve future model projections and manage climate risks associated with ENSO.

To assess how changes in mean climate can affect ENSO variability, this study presents the first comprehensive, pointwise, multi-model upper-ocean heat budget analysis of the pre-industrial control and doubled CO2 climate change experiments from the global coupled GCMs contributed to the Coupled Model Intercomparison Project 3 (CMIP3). Among its key findings:

1. Weaker equatorial Pacific upwelling at 2xCO2, linked to a weaker Walker Cell, tends to weaken ENSO by reducing the "thermocline feedback" associated with the SST sensitivity to thermocline fluctuations.

2. Stronger subsurface zonal temperature gradients at 2xCO2, linked to a more intense thermocline, tend to amplify ENSO by increasing the "zonal advection feedback" associated with the SST sensitivity to zonal current fluctuations.

3. The strengths of these two feedbacks differ substantially among the CMIP3 models, as do their sensitivities to the simulated climate changes associated with CO2 doubling.

4. The subtle balance between these large and opposing feedback changes can explain much of the diversity of the simulated ENSO responses to climate change.

Though observations (where available) were presented alongside the model results, the study's observational component was necessarily constrained by the absence of long and detailed historical records needed to compute the relevant heat budget terms. As observational records, paleo records, model realism, and forcing scenarios improve, future studies should follow up with further analysis of the ENSO heat budget and its sensitivity to climate change.