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The Role of Atmosphere Feedbacks During ENSO in AMIP CMIP3 Simulations

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Although most present-day GCMs exhibit ENSO-like variability, there is still room for improvement. For example, models exhibit a large diversity in ENSO amplitude and time scale, as well as SST variability that extends too far westwards, the reasons for which are difficult to pin down. However, recent results suggest that the atmosphere model plays a dominant role in determining ENSO properties in GCMs.

Theory separates the main ENSO atmospheric processes into two linear feedbacks: 1) the Bjerknes positive feedback (μ), and 2) the thermodynamical damping (α). These respectively measure the remote zonal wind stress and local heat flux response to an eastern Pacific SST anomaly.

We analyse μ and α in AMIP simulations in order to isolate the atmosphere model errors. We find that the AMIP runs generally have improved feedbacks compared to the coupled runs previously studied. The shortwave (αSW) and latent heat (αLH) flux feedbacks are the two dominant components of α, and biases in αSW are the main source of α errors.

Most models underestimate the negative αSW in the East Pacific, primarily due to an overly strong low-cloud positive feedback. Using a 'feedback decomposition method' we show that biases in the cloud response to dynamical changes dominate the αSW biases. Analysis of the cloud radiative forcing in the East Pacific reveals model biases in low cloud amount and optical thickness that may affect αSW.

We further show that the AMIP αLH feedback exhibits less diversity than αSW and is primarily driven by variations in the near-surface specific humidity difference.