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Climatic impacts of a stochastic parameterization of air–sea fluxes

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The atmosphere and ocean are coupled by the exchange of fluxes across the ocean surface. Air–sea fluxes vary partly on scales that are too small and fast to be resolved explicitly in numerical models of weather and climate, making them a candidate for stochastic parameterization. This presentation proposes a nonlinear physical mechanism by which stochastic fluctuations in the air–sea buoyancy flux may modify the mean climate, even though the mean fluctuation is zero. The mechanism relies on a fundamental asymmetry in the physics of the ocean mixed layer: positive surface buoyancy fluctuations cannot undo the vertical mixing caused by negative fluctuations. The mechanism has much in common with Stommel's mixed-layer demon. The presentation demonstrates the mechanism in climate simulations with a comprehensive coupled atmosphere–ocean general circulation model (SINTEX-G).

In the SINTEX-G simulations with stochastic air–sea buoyancy fluxes, significant changes are detected in the time-mean oceanic mixed-layer depth, sea-surface temperature, atmospheric Hadley circulation, and net upward water flux at the sea surface. Also, El Niño Southern Oscillation (ENSO) variability is significantly increased. The findings demonstrate that noise-induced drift and noise-enhanced variability, which are familiar concepts from simple climate models, continue to apply in comprehensive climate models with millions of degrees of freedom. The findings also suggest that the lack of representation of sub-grid variability in air–sea fluxes may contribute to some of the biases exhibited by contemporary climate models.

Reference

PD Williams (2012) Climatic impacts of stochastic fluctuations in air–sea fluxes. *Geophysical Research Letters* **39**, L10705.