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# On mechanisms of interdecadal climate variability: Coupled and uncoupled integrations with a simplified climate model

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## Abstract

An idealized coupled ocean-atmosphere-land-ice model has been developed to study climate variability at interannual to interdecadal and longer time scales and to identify mechanisms of ocean-atmosphere interactions. The model uses the three-dimensional primitive equations for both ocean and atmosphere, but is simplified in two respects: the model uses simplified physics and parameterization schemes, especially in the atmosphere, and the geometry and geography are very idealised. These simplifications provide considerable savings in computational expense and, perhaps more importantly, allow mechanisms to be investigated more cleanly and thoroughly than with a more elaborate model.

In our control integration an interdecadal oscillation of a period of around 20 years is found involving the oceanic meridional overturning circulation and propagating surface buoyancy anomalies. The oscillation is studied in the context of its dependence on the vertical diffusivity and geometry of the basin. The oceanic variability is found to imprint itself on the atmosphere, which covaries affecting an atmospheric state similar to the North Atlantic Oscillation at the preferred period. The atmospheric coupling seems necessary to catalyze the oscillation, the mechanisms of which are further investigated with uncoupled integrations of the atmospheric and oceanic components of the idealized climate model.

We find that the atmosphere-only integrations do not support natural interdecadal variability. The spectrum of most dynamical fields at timescales greater than a few months is almost white, with, unlike the coupled integrations, no enhanced power on decadal timescales.

The ocean-only integrations can produce decadal scale variability, however, the presence of an atmosphere amplifies oscillations that may exist already or allows oscillations to take place when they do not exist in the ocean-only case, because an interactive atmosphere effectively reduces the damping felt by the ocean. In addition, stochastic forcing from the atmosphere also helps sustain the oceanic oscillations, suggestive of a damped oscillator that is excited by stochastic heat fluxes. Comparisons with the natural variability of a state-of-the-art CGCM shows encouraging similarities.