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On ocean-atmosphere time scales

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We consider an elementary model coupling a three-"box" ocean and two-"box" atmosphere to explore what time-scales of variability may arise distinct from those of the ocean or atmosphere individually: adding degrees of freedom necessarily adds new time-scales. Building in the present form of largest-scale overturning circulation, and with temperatures and transports as the only variables, the model has a unique steady state. Relative to this, all perturbations decay; thus the unique state is stable. However, new relaxation time-scales of decades are found, corresponding to adjustment of ocean temperature above the main thermocline. This time-scale is intermediate between atmosphere-only relaxation times of days to months and relaxation times of centuries for ocean-alone overturning. No oscillatory modes are found, probably because the model has little spatial description; it lacks propagation of anomalies. Addition of salinities as oceanic variables, together with exchanges of water with the atmosphere, raises the possibility of instability in a limited range of relative "box" sizes. Overall this evidence suggests that (ocean) models should allow spatial propagation if internal (climate) variability is to be represented.