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Multiple Equilibrium Thickness and Flow States of Arctic Sea-Ice using Pre-Industrial Forcing

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Due to the nonlinear nature of plastic sea-ice rheology, under somewhat cooler conditions than present, multiple thickness and flow states of Arctic sea-ice are possible. These states are formed by the constrained nature of the Arctic Basin in conjunction with cohesive strength of plastic rheologies describing sea ice fracture and flow. Under appropriate atmospheric forcing two stable and one unstable state typically exist in which over a seasonal cycle net ice outflo from the Arctic balances net annual ice growth. The two stable states are a thick state with mainly summer outflo occurring and a thin ice state with significant outflow occurring in all seasons. If multiple states are possible initial conditions near the intermediate unstable thickness state will tend toward either a thicker or thinner ice state over time. To examine the potential for these thickness states, pre-industrial atmospheric forcing from a paleoclimate simulation with thermodynamic sea ice and oceanic boundary layer are used to force a dynamic thermodynamic sea ice model with cohesive strength adequate to cause stoppage of ice flow from the Arctic basin. Short term simulations with different initial conditions demonstrate the potential of multiple states of the ice cover. The actual thickness and outflow characteristics of these states are examined by longer term $\tilde{5}0$ year simulations from different initial conditions which also demonstrate time scales for the establishment of the different equilibrium states.