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On the existence of stable seasonally varying Arctic sea ice in simple models

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Within the framework of lower order thermodynamic theories for the climatic evolution of Arctic sea ice we isolate the conditions required for the existence of stable seasonally-varying solutions, in which ice forms each winter and melts away each summer. This is done by constructing a two-season model from the continuously evolving theory of Eisenman and Wettlaufer EW09 and showing that seasonally-varying states are unstable under constant annual average short-wave radiative forcing. However, dividing the summer season into two intervals (ice covered and ice free) provides sufficient freedom to stabilize seasonal ice. Simple perturbation theory shows that the condition for stability is determined by when the ice vanishes in summer and hence the relative magnitudes of the summer heat flux over the ocean versus over the ice. This scenario is examined within the context of greenhouse gas warming, as a function of which stability conditions are discerned.

Eisenman, I., and J.-S. Wettlaufer, “Nonlinear threshold behavior during the loss of Arctic sea ice,” Proc. Natl. Acad. Sci. USA, 106, 28–32, 2009.