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Internal variability in simulated 21st century Arctic sea ice evolutions: Climate forcing and response

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Continued declines in Arctic sea ice volume and summer sea ice extent are generally anticipated for the coming decades, based upon their trajectory in available observations and within a wide variety of future model simulations. Simulated differences in the evolution of sea ice extent and volume can be attributed to different specified boundary conditions, different model physics and / or variability that is internal to the simulation. This study examines the transient climate response and forcing of a model's internal ice variability using a fully-coupled 39-member ensemble of the Community Climate System Model version 3 forced by the A1B SRES GHG scenario during 2000-2061. The individual members of the ensemble were initialized with slightly different atmospheric conditions. The evolution of both Arctic sea ice extent and volume varies considerably between the ensemble members, as evidenced by the fact that the ensemble spread and the ensemble mean have comparable magnitudes at the end of the simulation. The ensemble spread in ice loss is consistently related to ensemble spread in both dynamic (e.g., atmospheric circulation) and thermodynamic (e.g., surface radiative and turbulent flux) quantities. A Northern Annular Mode-like pattern of sea level pressure anomalies consistently precedes large year-to-year changes in September sea ice extent, but the strength of this relationship depends on the ensemble member. Taken together, these results suggest that internal atmospheric variability is an important and hitherto neglected source of uncertainty in Arctic sea ice projections for the 21st century.