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Role of the internal climate variability in the atmospheric response to a sudden summer Arctic sea ice loss

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The retreat of Arctic sea ice for the last four decades is a primary manifestation of the climate system response to increasing atmospheric greenhouse gas concentrations. This retreat is frequently considered as a possible driver of atmospheric circulation anomalies at mid-latitudes. However, the year-to-year evolution of the Arctic sea ice cover is also characterized by significant fluctuations attributed to internal climate variability. It is unclear how the atmosphere will respond to a near-total retreat of summer Arctic sea ice, a reality that might occur in the foreseeable future. This study uses sensitivity experiments with higher and lower horizontal resolution configurations of three global coupled climate models to investigate the local and remote atmospheric responses to a reduction in Arctic sea ice cover during the preceding summer. Recognizing that these responses likely depend on the model itself and on its horizontal resolution, and that the model's internally-generated climate variability may obscure the atmospheric response, we design a protocol to compare each source separately. After imposing a 15-month albedo perturbation resulting in a sudden summer Arctic sea ice loss, the remote mid-latitude climate response has a very low signal-to-noise ratio such that internal climate variability dominates the uncertainty of the response, regardless of the atmospheric variable. Indeed, more than 28, 165 and 210 members are needed to detect a robust response in surface air temperature, precipitation and sea level pressure to sea ice loss in Europe, respectively. Finally, we find that horizontal resolution plays a secondary role in the uncertainty of the atmospheric response to substantial perturbation of Arctic sea ice. These findings suggest that even with higher resolution model configurations, it is important to have large ensemble sizes to increase the signal to noise ratio for the mid-latitude atmospheric response to sea ice changes.