

Growing Non-Linearity in Arctic Sea Ice Loss

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Abstract:

The sequence of extreme September sea ice extent minima observed since 2002 point to a growing non-linear response to a forcing in the Arctic sea ice system, hastening the transition towards a seasonally open Arctic Ocean. This growing non-linear response is associated with three inter-connected processes. First, in response to extensive open water in recent Septembers, ice cover in the following spring is increasingly dominated by thin, first-year ice that is particularly prone to melting out in summer. Second, the positive ice albedo feedback has grown in strength. Specifically, a thinner spring ice cover allows open water areas to develop earlier in the melt season. Earlier development of open water areas fosters enhanced absorption of solar radiation in the upper ocean, which in turn accelerates summer ice loss. Third, since the Arctic is warming, the likelihood of especially cold conditions that could bring about recovery through natural climate variability has declined. Events leading to the extreme September extent minima of 2007 and 2008 exemplify this growing non-linear response and have profound implications for the future trajectory of the Arctic sea ice cover. Climate model simulations have shown that a rapid transition to a seasonally ice free Arctic can occur once the ice has thinned to a point that the positive ice-albedo feedback results in rapid decay in the remaining ice cover. Findings from the present paper suggest that if this rapid transition is not already underway, we are at its threshold.

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