(EGU2020-2284) Memory effects of Eurasian land processes cause enhanced cooling in response to sea ice loss

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Nakamura et al., 2019, Nature Communications

Arctic Challenge for Sustainability

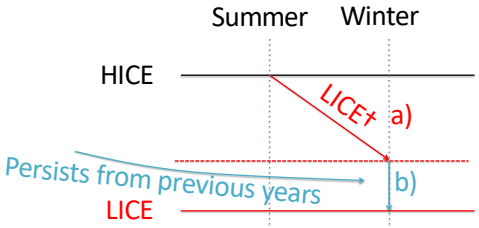
Abstract Amplified Arctic warming and its relevance to mid-latitude cooling in winter have been intensively studied. Observational evidence has shown strong connections between decreasing sea ice and cooling over the Siberian/East Asian regions. However, the robustness of such connections remains a matter of discussion because modeling studies have shown divergent and controversial results. Here, we report a set of general circulation model experiments specially designed to extract memory effects of land processes that can amplify sea ice–climate impacts. The results show that sea ice–induced cooling anomalies over the Eurasian continent are memorized in the snow amount and soil temperature fields, and they reemerge in the following winters to enhance negative Arctic Oscillation-like anomalies. The contribution from this memory effect is similar in magnitude to the direct effect of sea ice loss. The results emphasize the essential role of land processes in under- standing and evaluating the Arctic–mid-latitude climate linkage.

Experimental design to extract the memory effect

Run	Integration	Sea ice boundary condition	Initial condition
HICE	Serial, 100 years	1979–1983 average	10-year spin-up
LICE		2005–2009 average	
HICE†	100 iterations of 1 year	Same as HICE	Every 1 July of LICE
LICE†		Same as LICE	Every 1 July of HICE

The SST boundary condition is commonly defined as the climatological mean of the 1981–2010 period for all runs.

Ensemble averaged state vector of the system



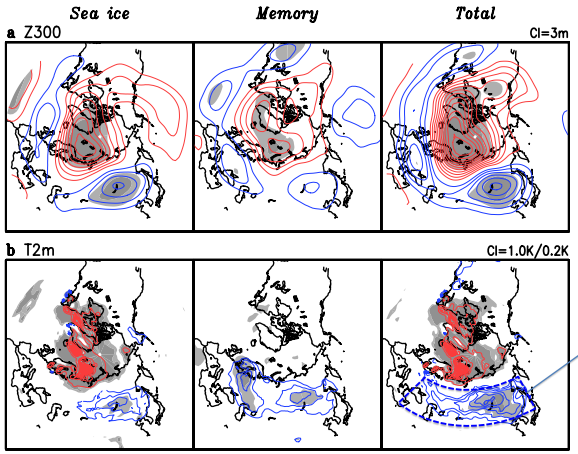
a) + b) ***Total***: LICE − HICE

a) ***Sea ice***: ([LICE† − HICE] + [LICE − HICE†])/2

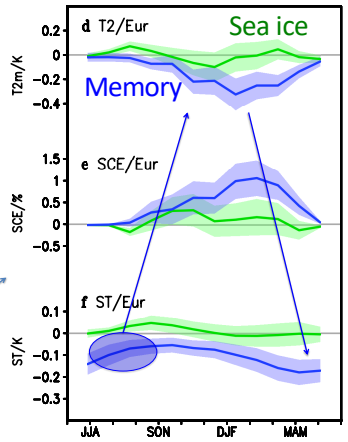
b) ***Memory***: ([LICE − LICE†] + [HICE† − HICE])/2

If LICE ≠ LICE†, residuals should be explained by anomalies that persists from previous years, that is **memory effect**.

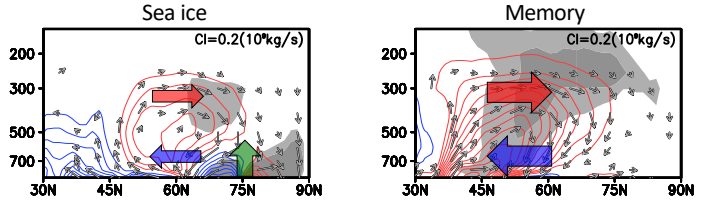
Evolution of the Memory effect and its contribution on Arctic warming/Eurasian cooling



Winter **negative AO**-like Total resp. is evenly contributed by Sea ice and Memory effects.



In Memory effect, **changing players**
Air temp. -> Snow cover -> Soil temp.



Contour: Stream function of the residual mean circulation
Grey arrows: Residual mean flows (v*, w*)

Winter (DJF) averaged column-heating rate in unit of W m^{-2}

	Heat transport into mid-lat. ←		Heat Transport into high-lat. →	Sfc. turbulent heat flux ↑
Sea ice	−0.41	Doubling	0.77 20%	2.86
Memory	−0.35		0.92 20%	−0.24
Total	−0.76		1.69 40%	2.62 60%

Eurasian cooling could be doubled and Arctic warming could be accelerated (about 20% increase of heating) by "Memory effects"