Atmospheric response to simulated historical sea ice loss

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ABSTRACT

Changes in Arctic sea ice play an important role in modulating surface fluxes of heat and moisture, and therefore local near-surface temperatures and precipitation. Whether or not historical sea-ice retreat has had a marked influence on weather patterns, particularly outside the local region, remains an open and important question. Here the effect historical sea-ice loss has on the atmosphere is isolated by prescribing observed sea-ice concentrations and local sea surface temperatures in an atmosphere model. A suite of 120-year simulations is carried out to temper natural variability. We find that observed boundary conditions produce a lowering of Arctic sea level pressure in Autumn that is robust and consistent with other studies, but no clear signal in patterns of variability emerge. Furthermore, the response to observed sea-ice changes is compared to a suite of simulations in which boundary conditions are obtained from an ensemble of historical simulations from a coupled global climate model. We find that whereas near-surface temperature responds in accordance with the amount of sea ice loss — more loss yields larger warming — sea-level pressure and geopotential heights remain slave to natural variability. Individual ensemble members have regions and seasons of statistically significant circulation changes in response to sea-ice loss, however those regions and seasons are not robust across ensemble members. Thus, it is likely that 1. historical sea-ice loss played a minimal role in setting circulation trends and 2. any detectable effect sea-ice loss had is due to @@ Thus, caution must be taken when interpreting even long time-slice simulations @@. Notably, the observed forcing produces a response that is outside the bounds of the

1. Introduction

Arctic sea ice has made a dramatic transformation over the late 20th and early 21st century due in large part to increasing greenhouse gas concentrations. Sea ice concentrations are at record lows since at least 1900@@, multi-year ice is declining, and the ice overall is thinner. These changes are both caused by greenhouse warming and help to amplify greenhouse warming in the high northern latitudes such that the Arctic is warming at a rate 2-3 times as large as the rest of the globe (@@). The reduction in sea-ice area unmasks the ocean below, allowing more heat to flux from the warmer waters to the relatively cold atmosphere. The question remains as to how large of an influence this loss of sea ice has on the atmosphere, both locally and remotely.

Much study has

An important question

Lit review here. Studies that implement time-slice simulations with similar prescribed boundary conditions from comparable time periods

It is worth noting that the vast majority of previous studies investigating the response of the atmosphere to changes in sea ice have been accomplished under two model lineages: National Center for Atmospheric Research Community atmosphere models, and atmosphere models developed by the Hadley Centre. Thus, a primary motivation for undertaking this study is to add a much-needed third data point from the Canadian Centre for Climate Modelling and Analysis atmosphere model to the growing literature about the influence of sea ice loss on the atmosphere. Moreover,

2. Model and simulations

To isolate the effect of sea ice, we use the Canadian Centre for Climate Modelling and Analysis fourth-generation atmosphere general circulation model (CanAM4) with prescribed surface boundary conditions and a freely evolving atmosphere. The model is run at T63 horizontal resolution with 37 vertical levels from the

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TABLE 1. Model simulations

Exp	SIC	SIT	SST	Source	Notes
hadCTL	1979-89	1979-89	1979-89	HadISST1.1	
hadPT	2002-11	1979-89*	2002-11	HadISST1.1	*SIT set to 0 where SIC 0 and @@
modCTLeavg	1979-89	1979-89	1979-89	CanESM2 historical ensemble mean	
modPTeavg	2002-12	2002-12	2002-12	CanESM2 historical ensemble mean	
modCTLe1-5	1979-89	1979-89	1979-89	CanESM2 historical ensemble members 1-5	
modPTe1-5	2002-12	2002-12	2002-12	CanESM2 historical ensemble members 1-5	

surface up to 1hPa. Further model details can be found in @@cite. We execute a suite of 121-year time-slice simulations and analyze the last 120 years in the results. Each simulation is prescribed with an annually repeating seasonal cycle of sea-ice concentration (SIC), sea-ice thickness (SIT), and sea surface temperatures (SST) as described below.

obtained from and historical simulations of the second generation Canadian Earth System Model (CanESM2).

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