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S1B Presentation

S1B-1 (Invited Talk)

Accelerated increase in Arctic warming "episodes" and links to the changing climate

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Episodes of rapid warming in the Arctic disrupt mid-latitude weather patterns and produce extreme deviations from normal weather conditions. Two atmospheric origins of these Arctic warming events have been identified: the troposphere and the stratosphere. Historical cases of tropospheric warming and stratospheric warming in the Arctic reveal both tropical linkages and local forcings and feedbacks. The latest research indicates a recent and accelerated increase in the tropospheric warming type versus a flat trend in stratospheric warming type. Tropospheric events develop twice as fast as stratospheric events and are therefore more extreme yet less predictable. With observations of historically-low Arctic sea ice extent occurring alongside the increase of tropospheric warming events, computer simulations provided evidence that the two phenomena are likely linked. Along with observational evidence for enhanced/shifted transport of tropical energy helping fuel these Arctic tropospheric warming events, the results suggest that future mid-latitude weather is likely to undergo an increase in extreme, unseasonal weather patterns that are inherently less predictable at sub-seasonal time scales.

S1B-2

Impacts of Arctic warming on extratropical climate and ecosystem

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As a benefit of cold season warming, productivity in terrestrial vegetation over Norther Hemisphere has been increased. However, in spite of ongoing climatic warming, North America recently experienced unusually frigid winters and springs throughout the continent, which may affect terrestrial productivity. Here we first show significant impacts of Arctic warming on terrestrial productivity in North America by using different types of observations and process-based models. We found here, spring Arctic warming leads to a year-round decrease in gross primary productivity over the majority of North America by about 0.31 PgC yr-1 in both observation and model results. In spring, negative responses in terrestrial ecosystems are mainly explained by two climatic factors such as severe cold weather and less precipitation through large-scale atmospheric teleconnection associated with Arctic warming. Furthermore, decreases in springtime productivity by Arctic warming can be sustained during the course of the year due to aftereffects of springtime damages. It is demonstrated that the Artcic warming-induced diminution in terrestrial productivity is also apparently seen in croplands productivity. The United States crop yields data reveals that corn, soybeans, and wheat yield are declined by up to about 2.2, 1.5, and 1.4 bu/acre, respectively. Our results suggest the recent rapid Arctic warming could be a threat to productivity in natural and agricultural vegetation over the non-Arctic regions.

S1B-3

Response of sea ice to the winter Arctic Oscillation

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Arctic summer sea ice extent exhibits substantial interannual variability, as is highlighted by the remarkable recovery in sea ice extent in 2013 following the record minimum in the summer of 2012. Here, we explore the mechanism via which Arctic Oscillation (AO)-induced ice thickness changes impact summer sea ice, using observations and reanalysis data. A positive AO weakens the basin-scale anticyclonic sea ice drift and decreases the winter ice thickness by 15cm and 10cm in the Eurasian and the Pacific sectors of the Arctic respectively. Three reanalysis datasets show that the (upward) surface heat fluxes are reduced over wide areas of the Arctic, suppressing the ice growth during the positive AO winters. The winter dynamic and thermodynamic thinning preconditions the ice for enhanced radiative forcing via the ice-albedo feedback in late spring-summer, leading to an additional 8-10 cm of thinning over the Pacific sector of the Arctic. Because of these winter AO-induced dynamic and thermodynamics effects, the winter AO explains about 22% (r=-0.48) of the interannual variance of September sea ice extent from year 1980 to 2015.

S1B-4

Arctic cooling caused by increases of dimethyl-sulfide emission

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Climate change has a complex relationship with the marine ecosystem. One part of the marine micro biomass, marine phytoplankton, contributes to the change in climate by emitting the biological sulfur compound, dimethyl-sulfide (DMS), during the metabolism. When DMS is emitted to the air above the sea surface, it eventually becomes sulfate aerosols through oxidation processes and they become the major source of cloud condensation nuclei (CCN) over the oceanic regions remote from pollution sources. Increase in sulfate CCN concentration may cause global cooling; also known as the direct and indirect effects of the aerosol. CLAW hypothesis already depicted this climate negative feedback loop of phytoplankton-DMS-CCN-cloud albedo. Several previous studies also supported this idea through atmosphere-ocean coupled General Circulation model (GCM) under the global warming scenario, showing a small net increase in DMS flux. However, some other studies, using a coupled physical-ecosystem model, demonstrated that the increases in phytoplankton biomass could enhance global warming and amplify Arctic warming due to the increase in SST and hence the melting of the sea ice. Despite the importance of phytoplankton response mechanisms, most climate models do not include both the positive and negative feedback mechanisms that involve phytoplankton. Both the warming and cooling effects of marine phytoplankton should be properly reflected in future climate models for better estimation of climate change, especially over the polar regions.

In this study, four different sensitivity simulations have been carried out to examine the effects of the increased marine phytoplankton activity on climate, using Hadley Centre Global Environmental Model version 2-Atmosphere-Ocean (HadGEM2-AO). As the DMS emission flux from the ocean is increased more, cooling trend becomes stronger. This cooling trend is pronounced especially over the Arctic regions due to the increase of sea ice fraction and albedo, and it also shows seasonal differences.