The stratospheric signature of warming Arctic and its impacts on mid-latitude climate change

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Recent evidence from both observations and model simulations suggests that an Arctic sea ice reduction tends to cause a winter negative Arctic Oscillation (AO) phase, which is indicative of the Arctic warming and the severe winter weather in the mid-latitude Northern Hemisphere. The negative phase of AO is often preceded by weakening of the stratospheric polar vortex (i.e., sudden stratospheric warming, SSW). We performed a time-slice experiment using a high-top AGCM, in which only the Arctic sea ice loss is responsible to altering the climate state (Nakamura et al., 2015). The results show a negative AO-like pattern that brings more heat transport into the Arctic and cold air outbreak over the mid-latitudes (positive feedback) via dynamically induced secondary circulation in the meridional plane. The simulated responses show high similarity with observed climate change signals of the recent decades, seen in an increased SSW frequency and its downward influences (Jaiser et al., 2016) as well as dynamical properties (Hoshi et al., 2017).

Such a sea ice-AO linkage largely disappears when model’ s stratospheric representation is artificially deteriorated (i.e., mimicking low-top model), confirming a crucial role of the stratosphere-troposphere (S-T) coupling in the current Arctic climate changes (Nakamura et al. 2016a). Even in an extreme climate of the ice-free (Blue Arctic Ocean) simulation there appears a negative AO response but the S-T coupling process becomes absent (Nakamura et al., 2016b).

The complexity arising from positive feedback mechanism of the heat transport and non-linearity of the stratospheric response may be a cause of uncertainty of the Arctic and mid-latitude climate linkage. More extensive studies about S-T coupling process will help to understand underlying mechanisms for this complexity.

Reference: Nakamura et al. (2015), JGR, 120, 3209-3227; Nakamura et al. (2016a), GRL, 43, 3494-3501; Jaiser et al. (2016), JGR, 121, 7564-7577; Nakamura et al. (2016b), GRL, 43, 10394-10402; Hoshi et al. (2017), GRL, 44, 446-454.

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