**Preface: Towards Improving Understanding and Prediction of Arctic Change and its Linkage with Eurasian Mid-latitude Weather and Climate**

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The dramatic changes in the Arctic climate system during the recent decades are one of the most prominent features of global climate change. Two most striking and fundamental characteristics are the amplified near-surface warming at a rate twice the global average since the mid 20th century (e.g., Blunden and Arndt, 2012; Huang et al., 2017), and the rapid decline of sea ice extent at a pace of 12.9% per decade and thinning of ice thickness by 40% since 1979 (e.g., Meier et al., 2012; Kwok and Rothrock, 2009). In conjunction with these changes, the frequency of occurrence of extreme climate and weather events has ostensibly increased across the Northern Hemisphere mid-latitudes, including adverse cold spells, severe heat waves, destructive floods, and persistent droughts (e.g., Coumou and Rahmstorf, 2012). The fact that Arctic climate changes coincided with an increase in the frequency of occurrence of extreme events inspired broad interest in possible linkages—not only in the climate community, but also the general public, media agencies, and decision makers, in particularly considering the projected future continuation and acceleration of Arctic warming and sea ice decrease (e.g., Zhang and Walsh, 2006; Zhang, 2010; Wang and Overland, 2012; Stroeve et al., 2012).

In general, it is possible that Arctic warming decreases meridional temperature gradients and thereby weakens zonal winds, which may result in a wavier jet stream and cause an increase in occurrence frequency of extreme events (e.g., Francis and Vavrus 2012; also reviews by Cohen et al., 2014, Vihma, 2014, and Overland et al., 2016). However, a strong debate emerged, which continues until today and is partly associated with conflicting results depending on which observations or models were used and what analysis metrics were employed (e.g., Barnes, 2013; Wallace, et al., 2014). The inconsistency and controversy surrounding the scientific discussion could be attributed to complex processes and pathways of anomalous Arctic thermal forcing on the overlying atmosphere circulation dynamics and the “tug-of-war” between anomalous Arctic and tropical (or even other) forcings. At the same time, the continuing controversy has fueled numerous activities related to the possible impact of Arctic climate change on mid-latitudes, including a series of workshops such as a National Academy of Sciences (NAS) workshop in Washington DC in September 2013, a NOAA Arctic workshop in Boulder, Colorado, in May 2014, and international workshops in Reykjavik, Iceland, in November 2013, Barcelona, Spain, in December 2014, Washignton, DC., U.S., in Feburary 2017, and in Aspen, U.S., in June 2017.

In fact, research into the influence of the Arctic on mid-latitude atmospheric circulation has been a long-standing topic during the last three decades (e.g., a review by Vihma, 2014). In this context, it is worthwhile mentioning a pioneering study from China about impacts of anomalous Arctic sea ice on Asian monsoon circulations in the early 1990s (Huang et al., 1992). Admittedly though, the majority of research on atmospheric teleconnections was occupied with tropical-extratropical linkages associated, for example, with the El Nino phenomenon. In early studies on Arctic-midlatitude linkages the maximum warming anomaly considered occurred over the Eurasian landmass and the magnitude of sea ice changes was limited. Thus, model simulations usually employed artificially exaggerated sea ice anomalies to detect forced signals in the atmospheric circulation. However, since the mid 1990s, the amplified warming has occurred over the central Arctic Ocean and the sea ice decline has accelerated, leading to an emergence of a new thermodynamic forcing and the conjecture that Arctic climate may have transitioned or would be going to transition to a new state (e.g., Comiso 2008; Zhang et al., 2008; Jeffries et al., 2013).

Concurrently with the emerging Arctic forcing, linkages between the Arctic and Eurasian midlatitude weather and climate have apparently been enhanced, which could be manifested by a radical, systematic spatial shift of the hemispheric-scale atmospheric circulation (e.g., Zhang et al., 2008). Associated with the shifted pattern, named the Arctic Rapid Change Pattern (ARP), the Siberian high intensifies and expands northwestward and the Aleutian low strengthens. As a consequence, poleward atmosphere heat and moisture transport into the Arctic Ocean along with poleward intrusions of warm ocean water have been significantly increased, which may have played decisive roles in driving amplified central Arctic warming and accelerated sea ice decrease. At the same time, anomalous southward advection of cold polar air extends to the Eurasian mid-latitudes, which is consistent with a “warm Arctic and cold Eurasia” pattern. Note that the intensification and northwestward expansion of the Siberian high has been considered as the most conspicuous feature of the mid-latitude atmospheric circulation in response to Arctic change. Studies have also identified tropospheric and stratospheric pathways, by which sea ice-change-induced stationary Rossby wave train propagation and troposphere-stratosphere interaction are governing mechanisms, respectively, to convey Arctic forcing signals to the midlatitudes (e.g., Honda et al., 2009; Kim et al., 2014).

As mentioned above, changes in the atmospheric circulation and associated processes have been identified in a variety of studies. In particular, a number of recent studies employing fully coupled models have presented the ARP-like pattern in response to anomalous Arctic sea ice forcing (e.g., Blackport and Kushner, 2017). However, controversy continues to exist. Atmosphere-only models show different responses of the Arctic Oscillation to sea ice anomalies (Smith et al., 2017). It is also suggested that the Eurasian cooling is a result of natural atmospheric circulation variability, instead of responses to Arctic warming (e.g., McCusker et al., 2016). The short observational record and uncertainties in prescribing forcing in numerical modeling experiments hamper progress in our understanding and prediction capability of Arctic-midlatitude linkages.

This special issue is a timely contribution to the ongoing discussion. It presents a selection of the recent research outcomes that augment existing knowledge. These studies further investigated how Eurasian, as well as North American, midlatitude atmospheric circulation and associated surface parameters respond to Arctic warming using both statistical analysis and numerical models. Noted progresses include studying linkages from a weather or seasonal climate prediction perspective. Semmler et al. conducted two sets of 14-day weather forecast experiments using the ECMWF model with one set relaxed to the reanalyzed Arctic atmosphere and the other without relaxation during the model integration. They found strong Arctic-midlatitude linkage over the Eurasian and North American continents when strong stationary planetary waves are present during winter. However, when using the atmospheric stand-alone version and fully coupled version of the NOAA’s Climate Forecast System version 2 (CFSv2), Collow et al. found that sea ice forced Eurasian temperature variability is not distinguishable from internal variability on seasonal scale.

Cheung et al. employed the singular value decomposition (SVD) approach to examine winter relationship between Arctic sea ice and atmospheric circulation properties in 11 CMIP5 models. They found that when models show stronger decline of sea ice, weaker polar and Ferrell cells and anomalously higher sea level pressure over the Urals-Siberia region occur. At the same time, midlatitude westerlies weaken. Han and Li also examined CMIP5 model simulations along with atmosphere-only model simulations. They found that winter Labrador Sea ice and SST anomalies play different roles in influencing spring precipitation in southeastern North American and Western Europe. When analyzing the CMIP5 pre-industrial simulations using lead-lag regression analysis approach instead, Kelleher and Screen found that anomalously high polar cap height leads, rather than lags, low sea ice anomaly, suggesting that both could be attributed to enhanced midlatitude eddy heat flux, and sea ice change may not be responsible for Eurasian cooling.

Impacts of changes in midlatitude circulation on Arctic climate are also presented in this special issue. Since August 2014, additional warming has occurred in Alaska Arctic waters. Overland et al. attribute this change to increased sea surface temperature in the North Pacific and associated shifts in predominant winds towards southerlies. Gian et al. analyzed changes in atmospheric moisture transport, which is an important component of static energy and has recently been considered as a major player for Arctic amplification due to moisture induced increase in cloudiness and downward longwave radiation. They found that changes in storm track and associated atmospheric circulation have enhanced poleward moisture transport into the Arctic Ocean.

This special issue provides new insights into the challenging question regarding the linkage between the Arctic and Eurasian midlatitudes. However, these latest results continue to show lack of convergence. To narrow existing understandings, identify solid physical processes, and improve prediction capability, stronger effort towards coordinated observations, analyses, and modeling experiments have been recommended by the U.S. CLIVAR workshop on Arctic Change & Its Influence on Mid-latitude Climate and Weather (https://usclivar.org/meetings/2017-arctic-midlatitude-workshop).

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