Impact of AMOC on Arctic Sea Ice and Atmosphere Heat Transport into the Arctic

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The observed decline trend in September Arctic sea ice extent (SIE) since 1979 has often been attributed in large part to the increase in greenhouse gases. The observed decline trend and future projections of ice-free summer bring up the potential for trans-Arctic shipping in the near future. However, the detail mechanisms causing the low frequency variability of summer Arctic SIE is still unclear. The most rapid observed decline actually occurred during the recent hiatus in global warming, and CMIP5 multi-model ensemble mean response to changes in radiative forcings exhibit much less decline trend in September Arctic SIE, but stronger warming trend in global mean surface temperature than that observed during this hiatus period.

In this study, it is shown that AMOC and the associated poleward Atlantic heat transport have played a significant role in the low frequency variability of summer Arctic SIE using the GFDL coupled climate model. At low frequency the March Barents Sea SIE anomaly is dominated by anti-correlated Atlantic inflow anomaly, thus is also significantly correlated with September Arctic SIE anomaly. The observed March Barents Sea SIE has a very similar normalized decline trends as the observed September Arctic SIE from 1979 to 2013, consistent with an increasing trend in Atlantic inflow and the multidecadal variability of AMOC implied by its fingerprints over the same period. This study estimated that a positive trend in the Atlantic inflow have contributed a substantial portion of the observed summer Arctic sea ice extent decline trend since 1979. The results also provide a clue of why most CMIP underestimate the observed summer Arctic SIE decline in recent decades which might have been substantially affected by internal variability. If the AMOC and the associated Atlantic heat transport into the Arctic were to weaken in the near future, then there would be a slowdown in the decline trend of September Arctic SIE, and we may not have ice-free Arctic summer that soon in a few decades. This plausible scenario with enormous social and economical impacts cannot be ignored.

This study also shows that at low frequency, changes in poleward atmosphere heat transport across the entire Arctic Circle are compensating to and dominated by AMOC induced Atlantic heat transport anomalies into the Arctic, hence a stronger AMOC and associated enhanced Atlantic heat transport into the Arctic ocean leads to both reduced summer Arctic SIE and reduced poleward atmosphere heat transport into the Arctic. Most of the anomalous heat transported into the Arctic region by the Atlantic Ocean is released into the atmosphere, then transported southward out of the Arctic region by the anomalous atmosphere heat transport. Previous studies attribute the observed changes in the atmosphere circulation pattern and eddy heat transport in recent decades to the observed Arctic sea ice decline. However, if the recent observed Arctic sea ice decline since 1979 is also accompanied by strengthened AMOC and enhanced Atlantic Ocean heat transport into the Arctic Ocean, then changes in the atmosphere circulation pattern and eddy heat transport might have been dominated by the response to enhanced poleward Atlantic Ocean heat transport, not dominated by Arctic sea ice decline.