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The impact of multidecadal NAO variations on Atlantic ocean heat transport and rapid changes in Arctic sea ice

Thomas Delworth and Fanrong Zeng
Geophysical Fluid Dynamics Laboratory/NOAA, Princeton, United States (tom.delworth@noaa.gov)

The Arctic and North Atlantic have experienced pronounced changes over the 20th and early 21st centuries, including a rapid loss of Arctic sea ice over the last several decades, prominent multidecadal variability in both ocean temperatures and sea ice, and decadal-scale change in tropical storm activity. We use suites of coupled climate model simulations to probe some of the factors responsible for the observed multidecadal variability in the Atlantic/Arctic system. In our models we show that multidecadal fluctuations of the North Atlantic Oscillation (NAO) induce multidecadal fluctuations of the Atlantic Meridional Overturning Circulation (AMOC). A positive phase of the NAO is associated with strengthened westerly winds over the North Atlantic. These winds extract more heat than normal from the subpolar ocean, thereby increasing upper ocean density, deepwater formation, and the strength of the AMOC and associated poleward ocean heat transport. In model simulations the observed negative phase of the NAO in the 1960s and 1970s led to a weaker than normal AMOC, reduced poleward ocean heat transport, a cold North Atlantic, and an increase in Arctic sea ice extent in both winter and summer. The NAO strengthened from the 1970s to the mid 1990s, leading to an increase of the AMOC and a warming of the North Atlantic. The increased heat transport extended throughout the North Atlantic, into the Barents Sea, and finally into the Arctic, contributing to a rapid reduction of sea ice in the 1990s through the 2000s. Feedbacks involving shortwave radiation are an important component of the overall changes. The NAO-induced AMOC increase also led to hemispheric-scale atmospheric circulation changes and increased Atlantic hurricane activity, as well as atmospheric teleconnections to the Southern Ocean. Since the mid 1990s the strong positive phase of the NAO has weakened to a more neutral phase. Climate projections for the next decade that take into account recent behavior of the NAO as well as anthropogenic radiative forcing suggest a weakening of the AMOC and associated ocean heat transport, which would tend to moderate the rate of Arctic sea ice loss over the next decade. This effect is superimposed on the persistent and growing effects of anthropogenic climate change.