North Atlantic Oscillation implicated as a predictor of Northern Hemisphere multidecadal climate variability

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Northern Hemispheric and regional climates show prominent multidecadal variability. Observational analysis shows that the North Atlantic Oscillation (NAO) leads the oceanic Atlantic Multidecadal Oscillation (AMO) by 15-20 years and the latter also leads the former by around 15 years. The Community Climate System Model (CCSM) version 4 is employed to investigate the relevant mechanism in the linkage between the NAO and AMO. The results show that the positive North Atlantic Oscillation (NAO) forces the strengthening of the Atlantic meridional overturning circulation (AMOC) and induces a basin-wide uniform sea surface temperature (SST) warming that corresponds to the Atlantic multidecadal oscillation (AMO). The SST field exhibits a delayed response to the preceding enhanced AMOC, and shows a pattern similar to the North Atlantic tripole (NAT), with SST warming in the northern North Atlantic and cooling in the southern part. This SST pattern (negative NAT phase) may lead to an atmospheric response that resembles the negative NAO phase, and subsequently the oscillation proceeds, but in the opposite sense. This implies a NAO-AMO-AMOC coupled mode in decadal scale. Based on these mechanisms, a simple delayed oscillator model is established to explain the quasi-periodic multidecadal variability of the NAO. The magnitude of the NAO forcing of the AMOC/AMO and the time delay of the AMOC/AMO feedback are two key parameters of the delayed oscillator. For a given set of parameters, the quasi 60-year cycle of the NAO can be well predicted. This delayed oscillator model is useful for understanding of the oscillatory mechanism of the NAO, which has significant potential for decadal predictions as well as the interpretation of proxy data records. The NAT-NAO-AMO-AMOC coupled mode has important influences on hemispheric and regional climates.

Key words: North Atlantic Oscillation, Atlantic multidecadal oscillation, Northern Hemisphere climate