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Search for drivers and causes of Arctic climate system: the relationship between the Arctic Oscillation/dipole anomaly and Arctic sea ice

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Based on the diagnosis of the NCEP/NCAR reanalysis dataset and using a coupled ice-ocean model developed by Wang et al. (2002), we investigate the response of the Arctic Ocean climate (or ice-ocean system) to the Arctic Oscillation (AO) and the second mode (or so-called dipole anomaly, DA). Seven high AO index winters and six low AO index winters (similarly, the high and low DA index winters) were simulated by the coupled ice-ocean model under forcing provided by the NCEP/NCAR reanalysis. Statistical analyses and tests were applied to the composite differences between the high and low AO indices. For the high AO index phase that predominated during the 1990s, the results showed a reduction of sea ice in the Arctic Basin accompanied by an increase of sea ice in the Labrador Sea. This pattern resembles the North Atlantic Oscillation seesaw pattern (Roger and van Loon 1979; Wang et al. 1994). During the high AO phase, the Arctic surface salinity increases and the surface temperature decreases, implying that more new ice was produced. The enhanced ice production is a consequence of greater ice export from the Arctic Ocean in response to anomalous cyclonic wind stress. From the subsurface layer to the Atlantic water layer, there is also a seesaw pattern in ocean temperature between the Barents and the Labrador Seas. During the high AO phase, the model reproduces the anomalous temperature intrusion of the Atlantic Water. While both the anomalous surface wind stress and the thermodynamical forcing contribute to sea ice and ocean variability, statistical analyses (EOF, regression, etc.) and significance tests (T- test and F-test) show that the wind stress accounts for a greater portion of these changes during the high AO phase than the thermodynamical forcing. During the DA positive phase, it is found that anomalous sea ice is transported to the Barents Sea and the Greenland

Sea, compared to its negative phase. A dynamic mechanism leading to this finding is interpreted using the coupled model results, which can be validated by observations.