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Interlinked and changing effects of major climate oscillations on snow cover, polar sea ice, and land surface phenology over the northern hemisphere

Warming in the far northern hemisphere not only significantly affects Arctic Sea ice cover but also snow melt and land surface phenology. We investigated how these three phenomena are related to three major climate oscillations: the Atlantic Multidecadal Oscillation (AMO); the North Atlantic Oscillation (NAO); and the Arctic Oscillation (AO). First, we assembled time series of two daily sea ice products to calculate the first day of open water in the spring, the first day of freeze onset in the fall, the length of time with open water, and the length of time with ice cover. The Sea Ice Concentration product is derived from Nimbus-7 SSMR and DMSP SSM/I-SSMIS Passive Microwave data (v.1) and has a 25km spatial resolution with data available between October 1978 and December 2015. The second sea ice dataset is the IMS product from the National Snow and Ice Data Center based on POES/GOES data, SSMI/I and AMSR-E data, and other ancillary data. We selected the 4km product that has data available between 2004 and 2016. We correlated the results with the climate oscillation indices for the entire time period (1979-2015, 2004-2015), and for overlapping 10-year segments. In addition, we used a time series (2001-2015) of Moderate Resolution Imaging Spectroradiometer (MODIS) Nadir BRDF-Adjusted Reflectance (NBAR) data and land surface temperature data at 0.05o spatial resolution. We then derived land surface phenology metrics focusing on the peak of the growing season by fitting convex quadratic regression models connecting the NDVI time series with the seasonal progress of Accumulated Growing Degree-Days (AGDD) derived from land surface temperature data. We linked the annual information on the peak timing, the thermal time to peak, and the peak magnitude with the three climate oscillation indices and evaluated the effects of nearby ice cover and winter snow cover.