Abstract

The goal of this study is to determine the effects of the North Atlantic Oscillation (NAO) and Arctic Oscillation (AO) on Arctic sea ice extent. Sea ice extent oscillates annually. Wavelet analysis was used to determine the frequencies that the NAO and the AO oscillate at. Results show that the AO will lead changes in the NAO and the AO has a stronger effect on sea ice extent than the NAO because of this relationship. The AO and NAO were very strongly correlated for a period of about 20 years where they shared a 3 year oscillation period. They became decoupled in 2005 and 2007 sea ice minimum may have resulted from the decoupling. A local sea ice minimum occurred every 5 years, which wavelet analysis did not indicate. This period suggests a relationship to El Niño-Southern Oscillation. It is very likely that ENSO affects sea ice extent, but sea ice extent should follow the AO and NAO more closely than ENSO.

Results and Discussion

The NAO and AO index cross wavelet transform (Fig. 7; left) is confirmed the AO and NAO index wavelet coherence test (Fig. 8, right). As well, the NAO and AO index cross wavelet (Fig. 7; right) and AO and Sea ice cross wavelet (Fig. 7; right) are confirmed by their associated coherence tests (Fig. 8 right and middle, respectively). Theses wavelet transforms show that the AO and NAO shared a common oscillation of a 3 year period until about 2001. The arrow direction on the NAO and AO cross wavelet transform (Fig. 7, left) suggests that the AO dominates the relationship between the two oscillations. This assertion makes sense because the AO would affect the Polar Front Jet (PFJ) which in turn affect the sea ice extent on Arctic sea ice extent (Ambaum et al., 2001).

In order to determine the frequency and potential climate effects of the NAO and AO on Arctic sea ice extent, a mathematical method was used. The NAO Index and the AO Index (Fig. 5) were compared to monthly Arctic sea ice extent (Fig. 6) using wavelet analysis in an attempt to reveal trends, and draw a connection to Arctic climate, potentially to predict future changes in Arctic sea ice extent.

Arctic Sea Ice extent oscillates seasonally between a winter maximum and a late summer minimum. Since 1979 late summer sea ice extent by over 40% with record lows in 2007, 2008, 2010, and 2011 (Fig. 1 & 2). Previous studies have shown both NAO and AO (Fig. 3 & 4) can influence Arctic sea ice extent (Ambaum et al., 2001).

Conclusions

The cross wavelet transforms show that the NAO and AO leads the phase of the NAO. Beginning in 2001 the AO and NAO begin to decouple; rapid decoupling occurred in 2005. The record sea ice minimum in 2007 may have resulted from the decoupling of the NAO and AO. Results also show that ENSO may influence Arctic sea ice extent and NAO and AO do not affect ice same the same during an El Niño event. It is not apparent from the results that ENSO has a direct effect on the NAO or AO. This implies that, compared to ENSO, the NAO and the AO dominate the effects on sea ice extent. This study serves as a jumping off point for further analysis using wavelets analysis to research Arctic climate scenarios.