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A link between Fram Strait sea ice export and atmospheric planetary wave phase

Donald J. Cavalieri
NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract

A link is found between the variability of Fram Strait sea ice export and the phase of zonal wave 1 in SLP for the period 1958–1997. Previous studies have found that the link between ice export through Fram Strait and the NAO is inconsistent over time scales longer than the last two decades. Inconsistent and low correlations are also found between Fram Strait ice export and the AO index. The phase of zonal wave 1 explains 60%–70% of the simulated ice export variance after the removal of two anomalous phases in 1966 and 1967. Unlike the NAO and AO links, these high variances are consistent for both the first and second halves of the 40-year period. This consistency is attributed to the sensitivity of wave-1 phase to the presence of secondary low pressure systems in the Barents Sea that serve to drive Arctic sea ice southward through Fram Strait.

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3. Discussion

[8] A comparison of a 40-year record of simulated Fram Strait ice export with both the NAO and AO indices reveals poor correlations both for the overall period as well as for the first (1958–1979) and second (1980–1997) periods separately. The results for the NAO index agree with previously reported correlations [e.g., *Vinje*, 2001] and reasons for the poor correlations have been discussed previously by *Häkkinen and Geiger* [2000], *Jung and Hilmer* [2001], and *Vinje* [2001]. Mean SLP maps for the first and second periods are shown in Figures 4a and 4b, respectively. The mean SLP pattern for the second period (Figure 4b) is indicative of a high NAO pattern. This and the presence of a secondary low in the Norwegian Sea (the mean SLP in the region was 8 hPa lower on average than during the first period) explain the positive correlations for the second period. This result is consistent with the findings of *Jung and Hilmer* [2001]. They suggest that the positive correlations reported result from an eastward shift in the NAO's center of interannual variability during this period. They also suggest that this NAO pattern and the high correlation for 1978–1997 are unusual at least in the context of natural climate variability. In a study of the atmospheric variability over the Norwegian and Barents Seas and its relationship to the AO, *Skeie* [2000] defines a Barents Oscillation (BO) in terms of the second EOF of monthly winter SLP anomalies, but finds that the BO is not well correlated to the NAO index. On the other hand, *Tremblay* [2001] asks whether the BO is independent of the AO. Using a toy model of North Atlantic atmospheric variability, *Tremblay* [2001] finds that an EOF analysis decomposes a non-stationary process (in this case, the secular shift of the NAO pattern in the mid 1970's) into orthogonal modes; thus, the BO appears in his analysis "as a way to represent the non stationarity of the AO spatial pattern." In contrast, by using a zonal wave decomposition approach, the secular shift in the North Atlantic atmospheric circulation in the 1970's appears simply as a shift in the phase of the two longest planetary waves in SLP [*Cavalieri and Häkkinen*, 2001].

[9] The phase of wave 1 explains 60%–70% (correlation is about 0.8) of the simulated Fram Strait ice export variance. The variances and positive correlations are consistent for the first and second periods examined as well as for the entire 40-year period. This consistency is attributed to the variation of the wave-1 phase between two extreme modes [*Cavalieri and Häkkinen*, 2001]. The extreme eastward mode is shown in Figure 4c and is characterized by the extension of the Icelandic Low into the Barents Sea, whereas the extreme westward mode shown in Figure 4d is characterized by a deeper Icelandic Low that does not extend into the Barents Sea. The latter mode is somewhat similar to the positive NAO pattern. As discussed by *Cavalieri and Häkkinen* [2001] and also noted by others [*Häkkinen*, 1993; *Hilmer et al.*, 1998], the extension of low pressure into the Barents Sea provides the forcing for ice export through Fram Strait. The results presented show that the phase of zonal wave 1 at high latitudes is a highly consistent measure of this extension of low pressure into the Barents Sea and as such provides a useful index for monitoring ice export through Fram Strait.

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D. J. Cavalieri, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA.