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Influence of winter and summer surface wind anomalies on Summer Arctic sea ice extent

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Abstract:
Based on a statistical analysis incorporating 925-hPa wind fields from the NCEP/NCAR Reanalyses, it is shown that the combined effect of winter and summer wind forcing accounts for 50% of the variance of the change in September Arctic Sea ice extent (SIE) from one year to the next and it also explains roughly 1/3 of the downward linear trend over the past 30 years. In both seasons meridional wind anomalies to the north and east of Greenland are correlated with September SIE, presumably because they modulate the export of ice through Fram Strait. Anticyclonic wind anomalies over the Beaufort Sea during summer favor low September SIE and have contributed to the record-low values in recent summers, perhaps by enhancing the flux of ice toward Fram Strait in the trans-polar drift.

1. Introduction:
In this study, we consider how the winds in the atmospheric boundary layer force changes in September Arctic SIE from one year to the next and how they might have contributed to the observed multidecadal decline in ice extent. In contrast to most previous studies, we make use of estimated wind fields rather than estimated geostrophic wind fields inferred from pressure fields and the domain in our study extends beyond the Arctic Ocean to encompass the region of ice export through Fram Strait and southward along the east coast of Greenland.

2. Results:
The 925-hPa wind anomalies in the winter preceding a low September SIE year exhibit a strong northerly component to the north and east of Greenland in both for the one-year difference data and the detrended data. This pattern is suggestive of an enhanced rate of flow of sea ice along the climatological-mean wintertime ice edge from the Barents and Kara Seas and out through Fram Strait. Such a transport would act to reduce the areal coverage of Arctic sea ice. Although the winter trend pattern over the Arctic Ocean is by no means identical to the regression patterns, the features over the Barents Sea, Fram Strait and the subpolar North Atlantic are remarkably similar ; i.e., they are also suggestive of enhanced forcing of sea ice transport toward and out through Fram Strait.

The patterns of summer winds regressed on one-year difference September SIE and detrended September SIE are both characterized by anticyclonic 925-hPa wind anomalies over the Arctic Ocean. The anticyclonic flow is directed from the Chukchi Sea across the Arctic Ocean toward Fram Strait, thus favoring enhanced sea ice export into the Atlantic, as in winter, but with the ice coming from a different direction. In summer, when the Arctic sea ice is thin and there are large expanses of open water, the sea ice movement is close to free drift and hence the response of the sea ice to the wind forcing may be larger than in winter. In the summer pattern associated with the linear trend the anticyclonic gyre is more restricted to the Beaufort Sea, but it is also characterized by flow from the Chukchi Sea across the Arctic Ocean toward Fram Strait. The dominant feature

in the wind field is the anomalous northerly flow over and around Fram Strait.

3. Conclusions

We have shown results indicating that wind-induced, year-to-year differences in the rate of flow of ice toward and through Fram Strait play an important role in modulating September sea-ice extent on a year-to-year basis and that a trend toward an increased wind-induced rate of flow has contributed to the decline in the areal coverage of Arctic summer sea ice.

Keywords: Arctic sea ice, winter and summer winds