Increased rotational Coupling between Antarctic Sea Ice and the Atmosphere Over the Last 30 Years

Antarctic sea ice has been characterized by high temporal and spatial variability since the inception of reliable satellite records. The complex oceanic and atmospheric mechanisms driving this variability present ongoing challenges in determining their respective contributions. In this study, we examine the cyclonic and anticyclonic rotation dynamics within the sea ice and overlying atmosphere at daily timescales from 1991–2020 using the new generation of remote-sensing product for sea-ice drift. A two-dimensional pattern similarity comparison between the ice and atmospheric vorticity fields demonstrated a noteworthy increase in pattern similarity over the past three decades, despite the absence of any discernible trends within each component over the same period. This escalating coupling suggests an increasing susceptibility of sea ice to atmospheric forcing, a phenomenon observed across all regions of the Southern Ocean and independent of the sea-ice extent. Notably, the Weddell Sea experienced a sudden regime shift after 2001, marked by a sharp decline in the intensity of sea-ice rotation, persisting in this weakened state from 2002 onwards. The increased coupling of sea-ice drift at the synoptic scale with no discernible trends in the atmospheric forcing points to a plausible role of the ocean. These features are analyzed in relation to the Southern Annular Mode (SAM) trends from atmospheric reanalysis. SAM's impact is evident in the vertically integrated atmospheric eddy kinetic energy but revealed no distinct differences during positive or negative phases on surface levels, explaining the absence of long-term sea-ice rotation trends. Our findings underscore once again the predominant role of the atmosphere in driving rotation within Antarctic sea ice, while highlighting a knowledge gap on the possibly increasing influence of the upper ocean on ice drift dynamics.

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