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Observed relationships between Antarctic sea ice concentration and large-scale climate variability

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Using observational and reanalysis datasets, the authors examine the physical relationships between seasonal-mean Antarctic sea-ice concentration (SIC) and large-scale climate variability such as the Southern Annular Mode (SAM) and the El Niño Southern Oscillation (ENSO). In all seasons we find a robust dipolar-pattern of decreasing (increasing) SIC in the general vicinity of the Antarctic Peninsula (Ross Sea) associated with positive SAM and La NiÒa events. Despite being present in all seasons, the dipole exhibits considerable seasonal variations in both location and strength, suggesting that it is important to consider SIC/atmospheric-mode co-variability at seasonal timescales. During DJF and MAM, negative (positive) SIC anomalies are largely located in the Bellinghausen (Ross) Seas, and these are generally of a fairly small magnitude. During JJA and SON, however, the anomalies shift westwards, such that negative (positive) anomalies are located primarily in the Bellinghausen into the Weddell (Amundsen) Seas and are of a much stronger magnitude. These SIC anomalies can largely be attributed to the anomalous meridional winds, and subsequent ice-drift, associated with the low pressure centres centred over the Amundsen Sea. We find that SIC anomalies associated with the SAM are of a considerably larger magnitude than those associated with ENSO. The SAM is shown to be strongly associated with the leading mode of SIC-variability during JJA and SON; in DJF and MAM, however, the leading mode of SIC-variability is not clearly associated with any single atmospheric pattern, hinting that the oceans may be forcing the leading SIC-modes during the warm seasons. Although SAM and ENSO have both been shown to be important factors influencing SIC-variability, with considerable seasonal variations, it is found that neither can explain the pronounced SIC trends exhibited over the past three decades. As such, it is argued that SIC trends, in addition to SIC-variability, may be related to longer-term changes in the oceans. Using ocean data assimilation products we begin to explore these inter-relationships over the 1980-2008 period.