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Synoptic weather influence on Southern Annular Mode variability in East Antarctic ice cores

Content

Despite the Southern Annular Mode (SAM) representing the dominant mode of Southern Hemisphere atmospheric variability, the relationship between SAM, weather conditions and coastal ice core records in East Antarctica (e.g. Law Dome and Mount Brown South) is weak. Assuming a hemispheric symmetric SAM structure, we would expect negative SAM to be associated with increased snowfall and positive SAM with increased westerly wind strength near the Antarctic coastline and therefore increased sea salt deposition. However, the annual variability in accumulation and sea salt records from Law Dome and Mount Brown South ice cores are not significantly related with annual SAM variability. This discrepancy is likely due to asymmetric variability in the expansion and contraction of the westerly wind belt being lost between daily weather patterns and annual averages.

To capture the daily variability of regional weather systems, we used synoptic typing (Self-Organising Maps) to group weather patterns based on similar features. We found that key weather regimes that influence snowfall and wind conditions along the East Antarctic coastline represent only part of the SAM variability, explaining the weak connection. For the snowfall accumulation proxies, negative SAM is associated with weather systems that enhance polar easterlies and orographic snowfall but misses extreme precipitation events at Law Dome and Mount Brown South driven by meridional nodes. The meridional nodes, which often contain atmospheric rivers, contribute between 30-40% of annual precipitation along the East Antarctic coastline but have limited seasonal and annual relationships with SAM. For the sea salt proxies, the asymmetry in the westerly wind belt contraction results in part of the positive SAM variability being missed as only two out of the three weather regimes representing positive SAM conditions are favourable for increased wind and sea salt aerosol production near the East Antarctic coastline. The other weather type is associated with westerly winds arcing away from the East Antarctic coastline, potentially causing these positive SAM conditions to appear similar to negative SAM conditions from a sea salt perspective.

These different types of positive SAM conditions mean that the commonly used hemispheric Marshall index often fails to capture the regional variability in surface weather conditions in the southern Indo-Pacific region, including East Antarctica. Our results show the importance of considering different synoptic set ups of SAM conditions, particularly positive SAM, and identify conditions that are missed by SAM variability (e.g. extreme precipitation events). Our results are particularly important to consider for East Antarctic ice core interpretation (i.e. potential dating errors) and SAM reconstructions in the southern Indo-Pacific region.

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