Atmospheric rivers and warm-conveyor belts in Antarctica: complex interplay, climatologies and impacts

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Abstract

Atmospheric rivers and extratropical cyclones are the two weather systems that can substantially modulate ocean-ice-atmosphere dynamics over Antarctica. Atmospheric rivers can produce intense precipitation events, either when they are forced to ascend by orographic features along the Antarctic coast or when they interact with the warm conveyor belts (WCBs) of extratropical cyclones. WCBs are rapidly ascending airstreams in extratropical cyclones that transport warm and moist air to higher latitudes and account for a significant proportion of the surface precipitation within these cyclones. Consequently, these two weather systems can be associated with extreme temperature and moisture anomalies over Antarctic sea-ice regions, that modulates the synoptic-scale variability in sea-ice concentration.

A notable example of such an extreme event over Antarctica where both systems were present is the event of March 2022, which resulted in unprecedented temperature anomalies and had significant implications for the Antarctic ice sheet mass balance. This underscores the need for a detailed understanding of the interplay between these two weather systems. Specifically, key questions such as the frequency of their co-occurrence in the polar regions and the precise role of WCBs in modulating ARs into high-impact precipitation events near the Antarctic coast, need to be investigated.

In this study, we systematically identify ascending airstreams that reach the Antarctic coast and construct a climatology to understand their spatial distribution, seasonal variability, and associated impacts. Emphasis is placed on quantifying the precipitation linked to these airstreams and examining their relationship with Antarctic ARs. We aim to understand how frequently ARs contribute to ascending airstreams and on the other hand how often WCBs serve as the lifting mechanism of the moisture. The findings have the potential to enhance predictive capabilities for extreme weather events and improve understanding of polar dynamics.

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