

Changes in the lifecycles of Tropopause Polar Vortices from Arctic sea ice loss

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Sea ice in the Arctic is declining with an accelerating pace, and six of the lowest sea ice extents during the satellite era have occurred since 2007. It has become increasingly evident that reductions in sea ice could impact the jet stream and global storm tracks, particularly during the autumn and early winter months, when large areas of newly open water change the surface energy balance through enhanced upward heat and moisture transfer into the atmosphere. However, the physical mechanisms leading from these changes in the surface energy balance to changes in synoptic-scale events are unclear. One key factor that has not been previously considered is the role of tropopause polar vortices (TPVs). TPVs are important precursors to surface cyclogenesis, and their intensity is best maintained over land or ice surfaces so that radiative processes can dominate over latent heating processes. Here, we will examine the changes that can be expected in the composite structure of TPVs as sea ice decreases in a modeling study using an idealized approach to isolate the physical processes, and a regional downscaling approach to examine the composite changes from a large sample.

Results show that TPVs weaken when located over open water instead of over ice. This weakening process originates from the increase in upward sensible heat flux, increasing the lower atmospheric temperatures and saturation vapor pressure, while the latent heat fluxes provide an additional moisture source for cloud formation. This increases the amount of water vapor available to convert to cloud ice, and reduces the upper-tropospheric vertical water vapor gradient, altering the radiative response that maintains TPV intensity. Regional downscaling composites show substantial shifts in the locations and characteristics of TPVs. Changes in mean storm tracks are primarily associated with the different locations in which TPVs interact with the low-level baroclinic zones. Possible feedback mechanisms between TPVs, sea ice, and storm tracks will be discussed.