Planetary wave-driven enhanced NO descent into the top of the Arctic polar vortex during major and minor SSWs

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The polar vortices play a central role in vertically coupling the Sun-Earth system by facilitating the descent of reactive odd nitrogen ($NO_x = NO + NO_2$) produced in the atmosphere by energetic particle precipitation (EPP-NO_x). Downward transport of EPP-NO_x from the mesosphere-lower thermosphere (MLT) to the stratosphere inside the winter polar vortex is particularly impactful in the wake of prolonged sudden stratospheric warming events. This work is motivated by the fact that state-of-the-art global climate models severely underestimate this EPP-NO_x transport in the Arctic. As a step toward understanding the transport pathways by which MLT air enters the top of the polar vortex, we explore the extent to which Lagrangian Coherent Structures (LCS) impact the geographic distribution of NO near the polar winter mesopause in the Whole Atmosphere Community Climate Model eXtended version with Data Assimilation Research Testbed (WACCMX+DART). We present planetary wave-driven enhanced NO descent near the polar winter mesopause during 14 case studies from the Arctic winters of 2005/2006 through 2018/2019. During all cases the model is in reasonable agreement with SABER temperatures and SOFIE and ACE-FTS NO. Results show consistent LCS formation at the top of the polar vortex during minor and major SSWs. LCSs act to confine air with elevated NO to high latitudes as it descends into the top of the polar vortex. Descent of NO tends to be enhanced in traveling planetary wave troughs. These results present a new conceptual model of transport in the polar winter mesosphere whereby regional-scale, long-lived LCSs, coincident with the troughs of planetary waves, act to sequester elevated NO_x at high latitudes until the air descends to lower altitudes.