Diagnosing the role of dynamic tropopause wave breaking for synoptic-scale buildups in Northern Hemisphere zonal available potential energy

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Zonal available potential energy ($A_z$) is an estimate of the amount of potential energy in the atmosphere available for conversion to kinetic energy, providing a good proxy for the overall strength of the general circulation. Previous studies have estimated total hemispheric $A_z$, $A_z$ generation, and conversion to kinetic energy, and proposed physical mechanisms to describe the annual $A_z$ cycle as well as short term (sub-seasonal to synoptic) APE depletion events. Large, short term modulations of $A_z$ have been shown to be associated with impactful weather events in the mid- and high-latitudes, including severe cyclones and high-amplitude ridging and blocking events.

In this study, we examine the association of significant synoptic time-scale winter season increases in $A_z$ with dynamic tropopause wave break events. $A_z$ buildup events are determined using a 1979-2011 daily Northern Hemisphere (20°-85° N) $A_z$ climatology calculated from the National Centers for Environmental Prediction (NCEP) Department of Energy (DOE) Reanalysis 2 global reanalysis dataset in an isobaric framework. To diagnose the importance of wave breaks in the troposphere, we objectively identify wave breaks using potential temperature on the dynamic tropopause, identifying and tracking both anti-cyclonic (LC1) and cyclonic (LC2) wave breaks during the 1979-2011 period. Our results indicate that LC1 wave break events in the equatorward North Pacific jet exit regions appear to play an important role in $A_z$ buildup events. We further assess the large-scale environmental factors leading to the onset of anomalously high LC1 wave breaking in the Pacific basin, as well as examining the role of these wave break events in not only warming the subtropical air mass but also modifying the arctic environment resulting in rapid lower-tropospheric cooling events.