Mid-Latitude Dynamics and Atmospheric Rivers

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Analysis of the global integrated water vapor (IWV) from SSMI satellite imagery highlights the filamentary structures of poleward extrusions of enhanced regions of IWV that have been defined in previous literature as tropospheric rivers or now known as atmospheric rivers (ARs). These filamentary structures are found in the warm sector region of cyclones along the low-level jet stream (LLJ) ahead of surface cold fronts; we attribute their existence to high-frequency synoptic-scale circulations embedded within the midlatitude storm track and the development of midlatitude cyclones. Herein we investigate the high-frequency synoptic-scale processes that comprise the midlatitude storm track and their relationship to ARs.

The synoptic-scale eddies that comprise the midlatitude storm track largely take on the form of baroclinic "Rossby" wave life cycles. Rossby wave breaking in the exit regions of midlatitude jet streams can result in penetration of midlatitude troughs into subtropical latitudes where they can be implicated in the development of tropical cloud plumes, enhanced convection downstream of the trough, midlatitude cyclogenesis, and the initiation of poleward water vapor flux out of the tropics along possible ARs following a pathway similar to a tropical moisture export (TME).

The genesis of individual cyclones downstream of midlatitude troughs creates a circulation that is able to mobilize and aggregate large amounts of water vapor in the lower troposphere. For example, the Norwegian Cyclone Model (NCM) that generally applies to cyclones that develop in the time-mean exit regions of midlatitude jet streams commences with a small-scale cyclonic disturbance along the polar front that results in the advection of cold air equatorward to the west of the cyclone center and advection of warm air poleward to the east of the cyclone center. Contraction of the baroclinic zone by the temperature advection and deformation patterns results in the development of the cold and warm fronts. These frontal features favor a meridional elongation and zonal contraction as the background flow is likely highly amplified and diffluent in the jet exit region. The NCM thus describes a cyclone evolution that favors the meridional elongation of a cyclone cold front along the axis of dilatation in a field of deformation, a contraction of the thermal and moisture gradients along the cyclone cold front (i.e., frontogenesis) that can aggregate water vapor, enhanced southerly flow in the cyclone warm sector along a LLJ that can mobilize water vapor, and thus a developing corridor of enhanced IWV and poleward water vapor flux.

This presentation will serve as a brief review of midlatitude storm-track dynamics and the development of midlatitude cyclones from a quasi-geostrophic and potential vorticity perspective. The discussion will focus on the components of the synoptic-scale and mesoscale flow associated with the evolution of the storm track and cyclones that are also associated with the development, maintenance, and dissipation of synoptic-scale water vapor flux along ARs.