Linkages Between Tropopause Polar Vortices and Cold Air Outbreaks

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Friday Map Discussion (3 March 2017)
What are Tropopause Polar Vortices (TPVs)?

- TPVs are defined as tropopause-based vortices of high-latitude origin and are material features (Pyle et al. 2004; Cavallo and Hakim 2009, 2010)

(Left) Dynamic tropopause (DT) wind speed (every 15 m s\(^{-1}\) starting at 50 m s\(^{-1}\), thick contours) and DT potential temperature (K, thin contours and shading) on 1.5-PVU surface valid 0000 UTC 1 Dec 1991;

(Right) same as left except DT pressure (hPa, thin contours and shading).

Adapted from Fig. 11 in Pyle et al. (2004).
TPVs in Relation to the “Polar Vortex”  

300-hPa geopotential height (shaded, m) for 6 Jan 2014. Black edge marks tropospheric polar vortex edge at 300-hPa and white contours mark stratospheric vortex edge at 50 hPa. R and T represent locations of ridge and trough, respectively. Adapted from Fig. 4 in Waugh et al. (2017).

Potential temperature (K, shaded), wind speed (black, every 10 m s\(^{-1}\) starting at 50 m s\(^{-1}\)), and wind (m s\(^{-1}\), flags and barbs) on 2-PVU surface. Data source: ERA-Interim.
TPVs in Relation to the “Polar Vortex”  
Waugh et al. (2017)

300-hPa geopotential height (shaded, m) for 6 Jan 2014. Black edge marks tropospheric polar vortex edge at 300-hPa and white contours mark stratospheric vortex edge at 50 hPa. R and T represent locations of ridge and trough, respectively. Adapted from Fig. 4 in Waugh et al. (2017).

1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s^-1, flags and barbs); CP denotes “cold pool”. Data source: ERA-Interim.
Potential temperature (K, shaded), wind speed (black, every 10 m s\(^{-1}\) starting at 50 m s\(^{-1}\)), and wind (m s\(^{-1}\), flags and barbs) on 2-PVU surface.

1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s\(^{-1}\), flags and barbs); CP denotes “cold pool”
Potential temperature (K, shaded), wind speed (black, every 10 m s\(^{-1}\) starting at 50 m s\(^{-1}\)), and wind (m s\(^{-1}\), flags and barbs) on 2-PVU surface.

1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s\(^{-1}\), flags and barbs); CP denotes “cold pool”.
Example: 9–12 Jan 1982 CAO

0000 UTC 10 Jan 1982

Data Source: ERA-Interim

Potential temperature (K, shaded), wind speed (black, every 10 m s\(^{-1}\) starting at 50 m s\(^{-1}\)), and wind (m s\(^{-1}\), flags and barbs) on 2-PVU surface

1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s\(^{-1}\), flags and barbs); CP denotes “cold pool”
Example: 9–12 Jan 1982 CAO

Data Source: ERA-Interim

Potential temperature (K, shaded), wind speed (black, every 10 m s⁻¹ starting at 50 m s⁻¹), and wind (m s⁻¹, flags and barbs) on 2-PVU surface

1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s⁻¹, flags and barbs); CP denotes “cold pool”
TPV and Cold Pool Tracking

• Data:
  – 0.5° ERA-Interim (Dee et al. 2011)
  – 1979–2015, every 6 h

• Utilized TPV tracking algorithm developed by Nicholas Szapiro and Steven Cavallo to identify and track TPVs
  – Track dynamic tropopause potential temperature minima

• Adapted TPV tracking algorithm to track cold pools
  – Track 1000–500-hPa thickness minima

Link for Tracking Algorithm: https://github.com/nickszap/tpvTrack
Filtering TPV and Cold Pool Tracks

• TPVs and cold pools must last at least 2 days and spend at least 6 h poleward of 60°N (adapted from criteria of Cavallo and Hakim 2010)

• Focus on TPVs and cold pools transported from high latitudes into middle latitudes
  – Require that TPVs and cold pools in high latitudes move equatorward of 60°N
Total number of unique TPVs (left) and cold pools (right) within 500 km of each grid point (using a 0.5° grid) for TPVs and cold pools that move equatorward of 60°N during 1979–2015
CAOs Linked to Cold Pools Associated with TPVs

- **Total number of CAOs**
- **Number of unique CAOs linked to at least one cold pool**
- **Number of unique CAOs linked to at least one cold pool associated with a TPV**
- **Percentage of unique CAOs linked to at least one cold pool associated with a TPV**

![Bar chart and map showing the distribution of CAOs linked to cold pools associated with TPVs across different regions of the United States.](image)