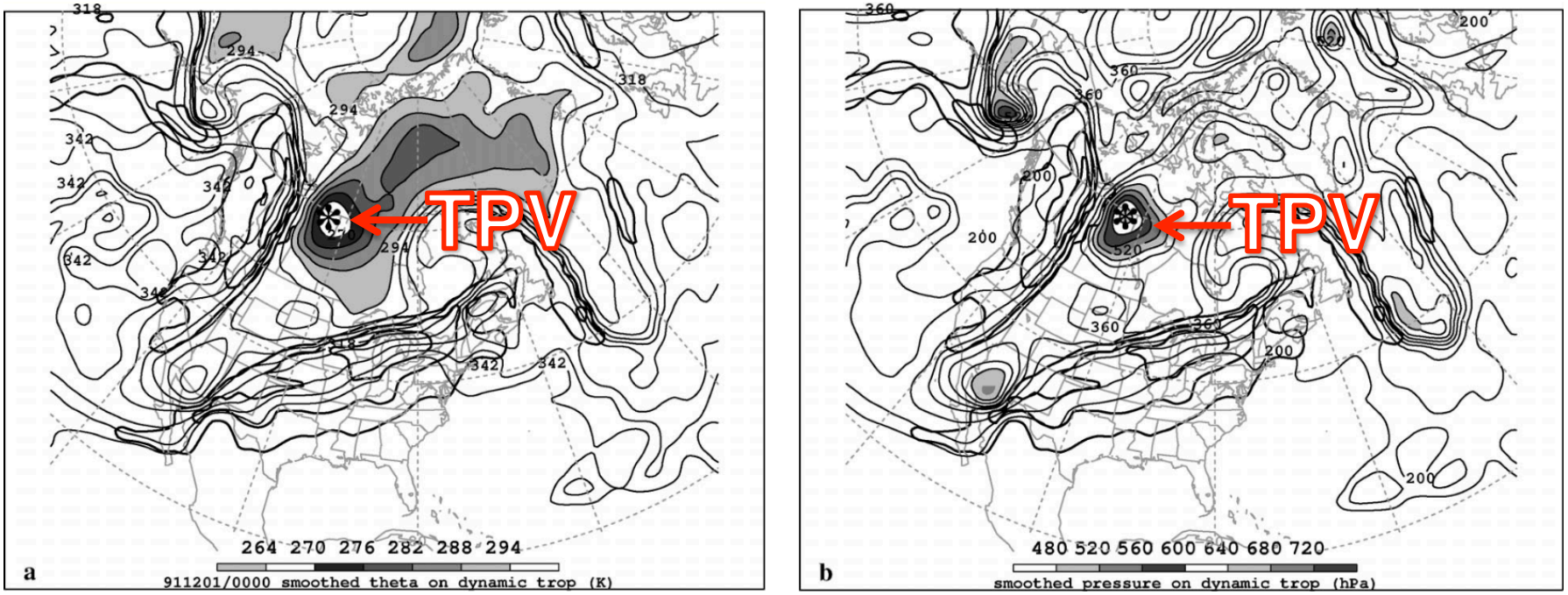
Linkages Between Tropopause Polar Vortices and Cold Air Outbreaks

Kevin Biernat

Friday Map Discussion (3 March 2017)

What are Tropopause Polar Vortices (TPVs)?

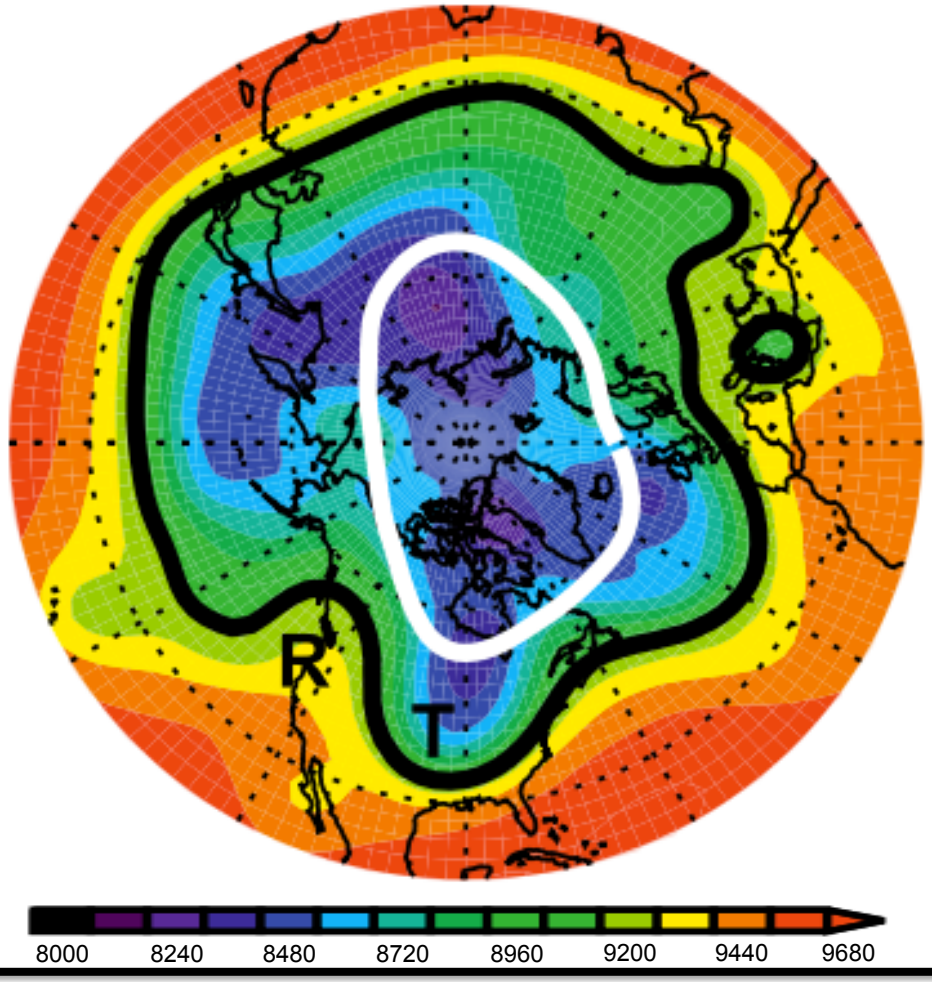
- TPVs are defined as tropopause-based vortices of high-latitude origin and are material features (Pyle et al. 2004; Cavallo and Hakim 2009, 2010)



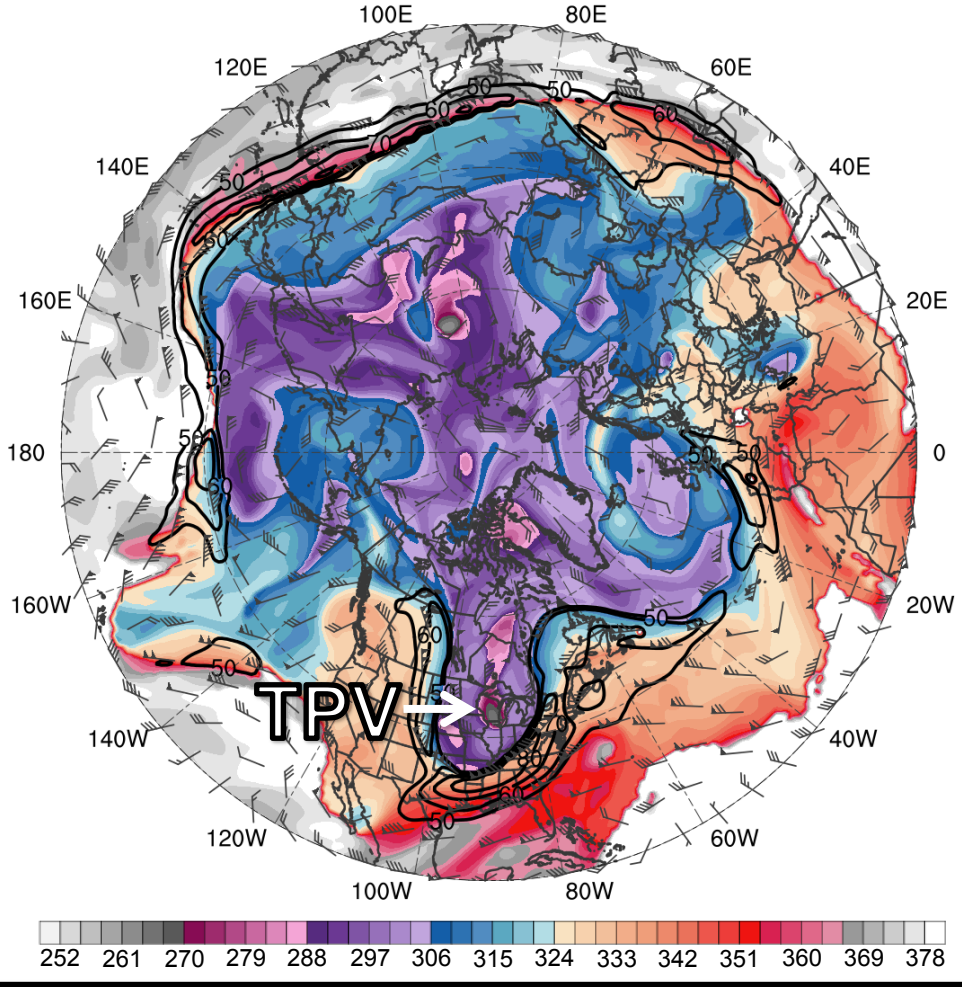
(left) Dynamic tropopause (DT) wind speed (every 15 m s^{-1} starting at 50 m s^{-1}, thick contours) and DT potential temperature (K, thin contours and shading) on 1.5-PVU surface valid 0000 UTC 1 Dec 1991; **(right)** same as left except DT pressure (hPa, thin contours and shading).
Adapted from Fig. 11 in Pyle et al. (2004).

TPVs in Relation to the "Polar Vortex"

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).



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"

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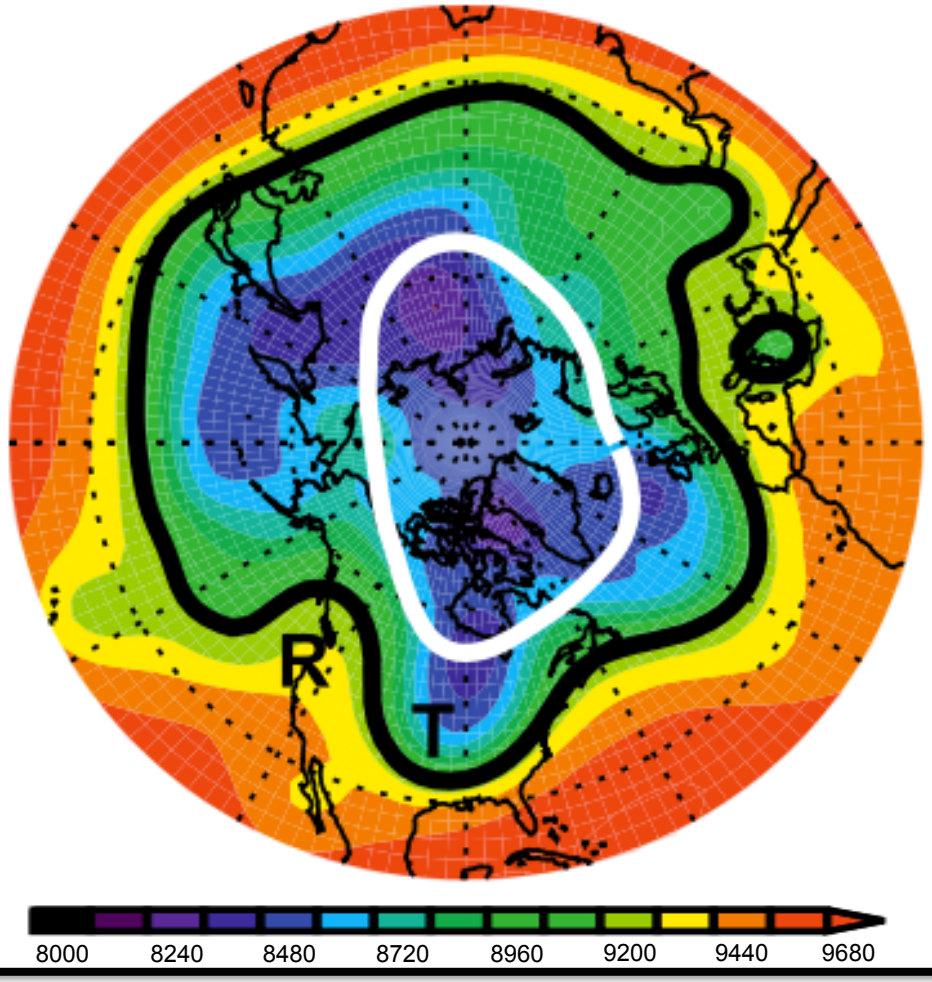

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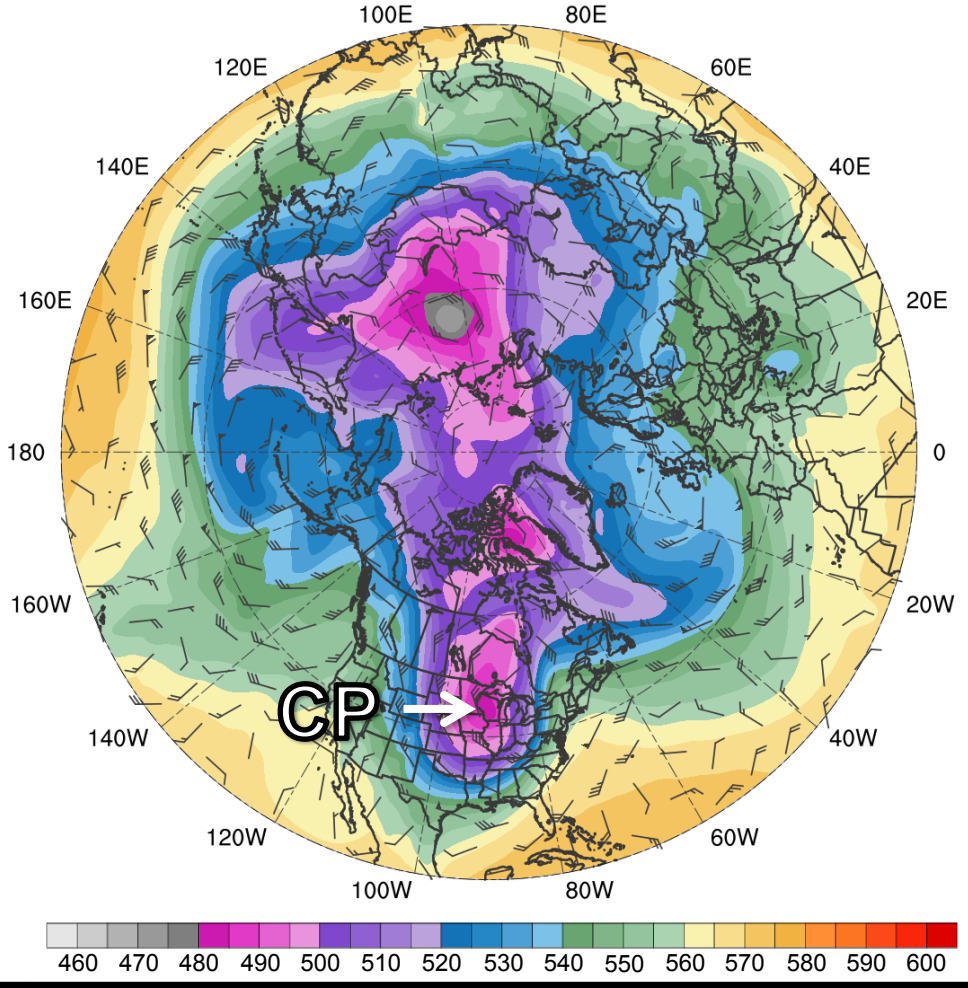
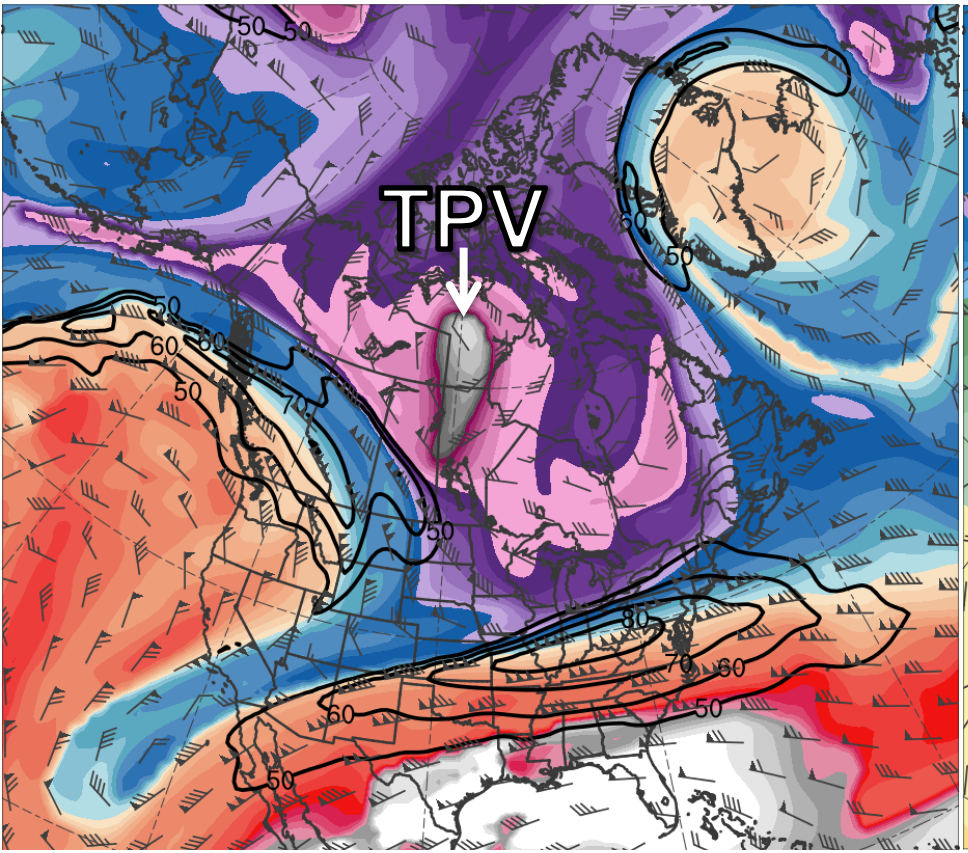


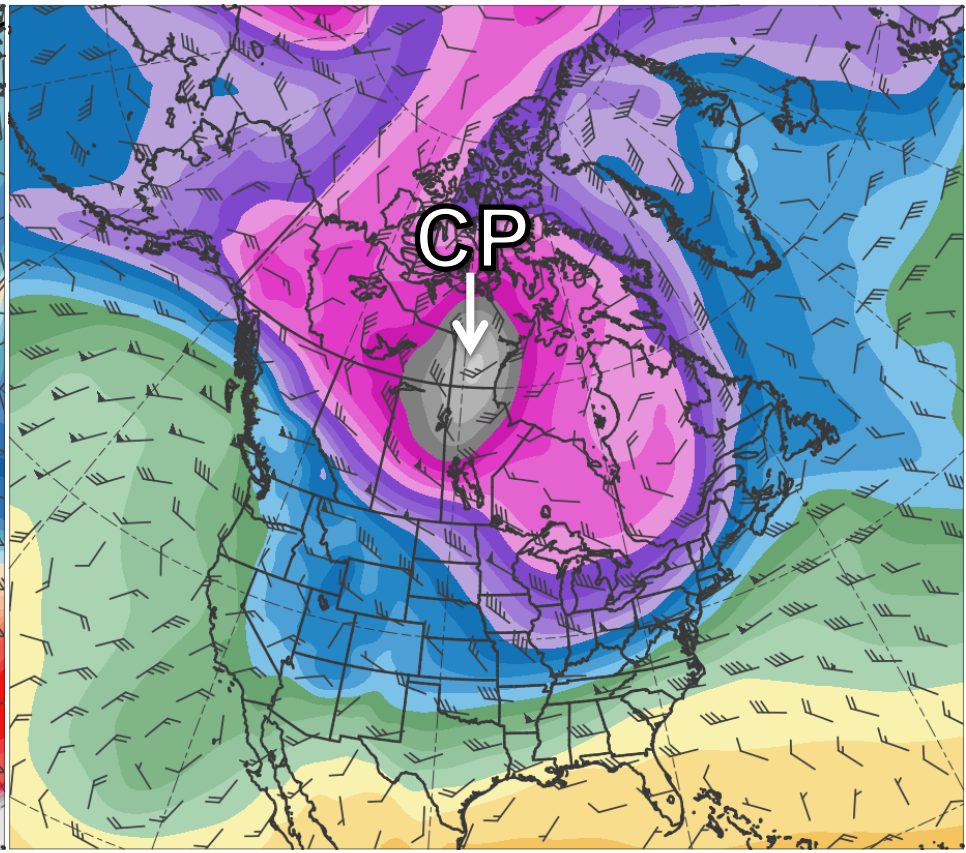
1000–500-hPa thickness (dam, shaded) and 700-hPa wind (m s^{-1}, flags and barbs); CP denotes "cold pool". Data source: ERA-Interim.

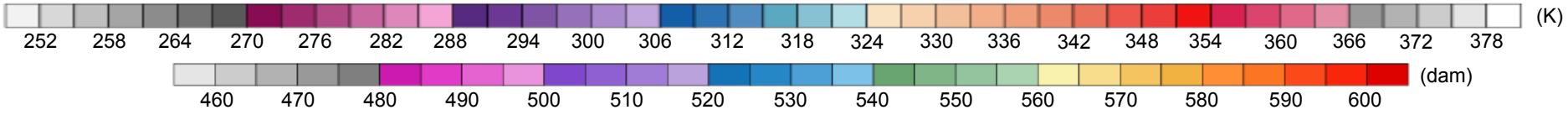
Example: 9–12 Jan 1982 CAO

0000 UTC 8 Jan 1982

Data Source: ERA-Interim







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0000 UTC 9 Jan 1982

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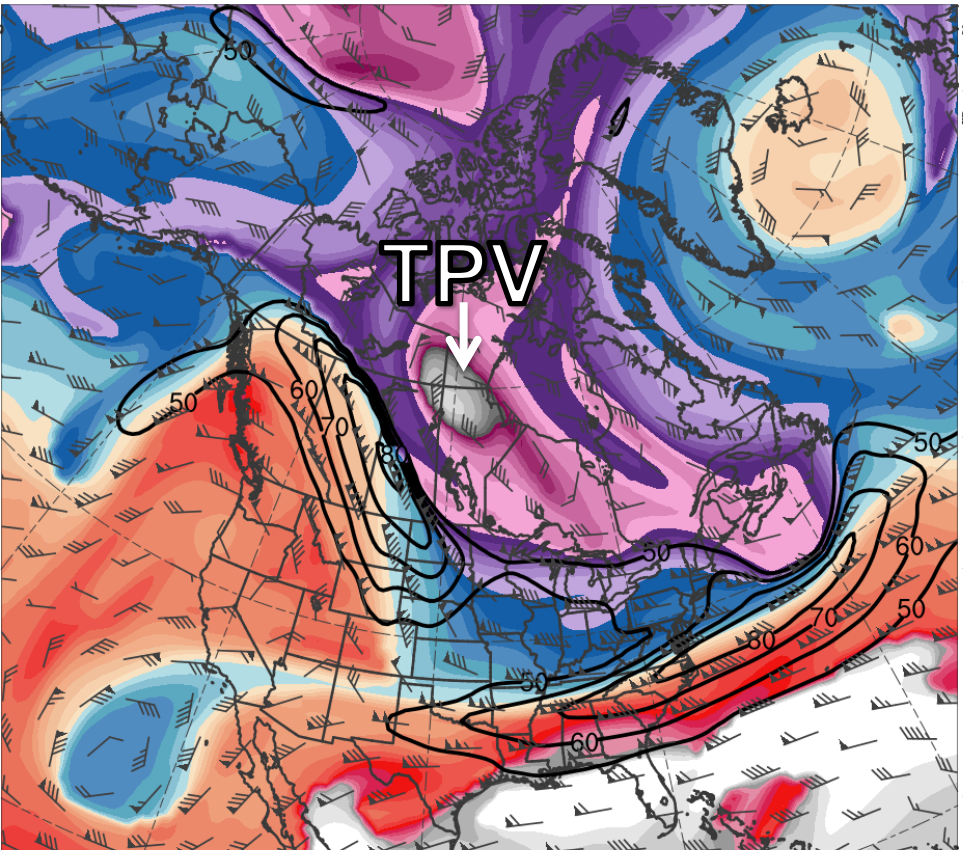

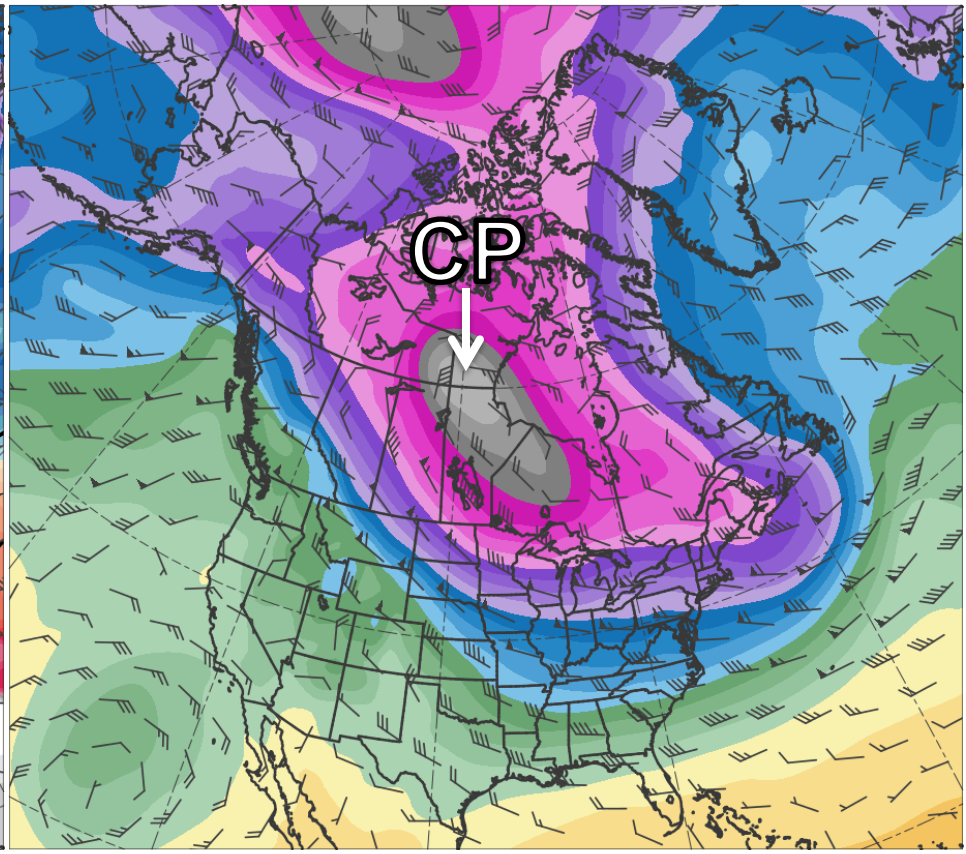

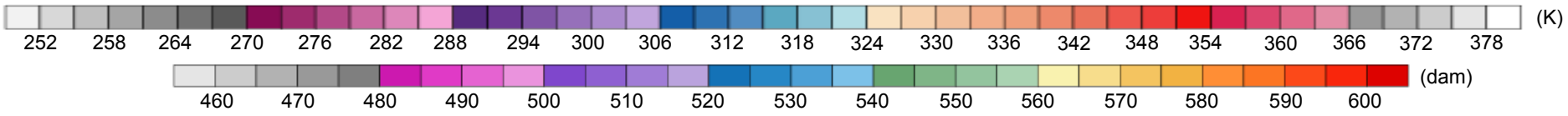

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Example: 9–12 Jan 1982 CAO

0000 UTC 10 Jan 1982

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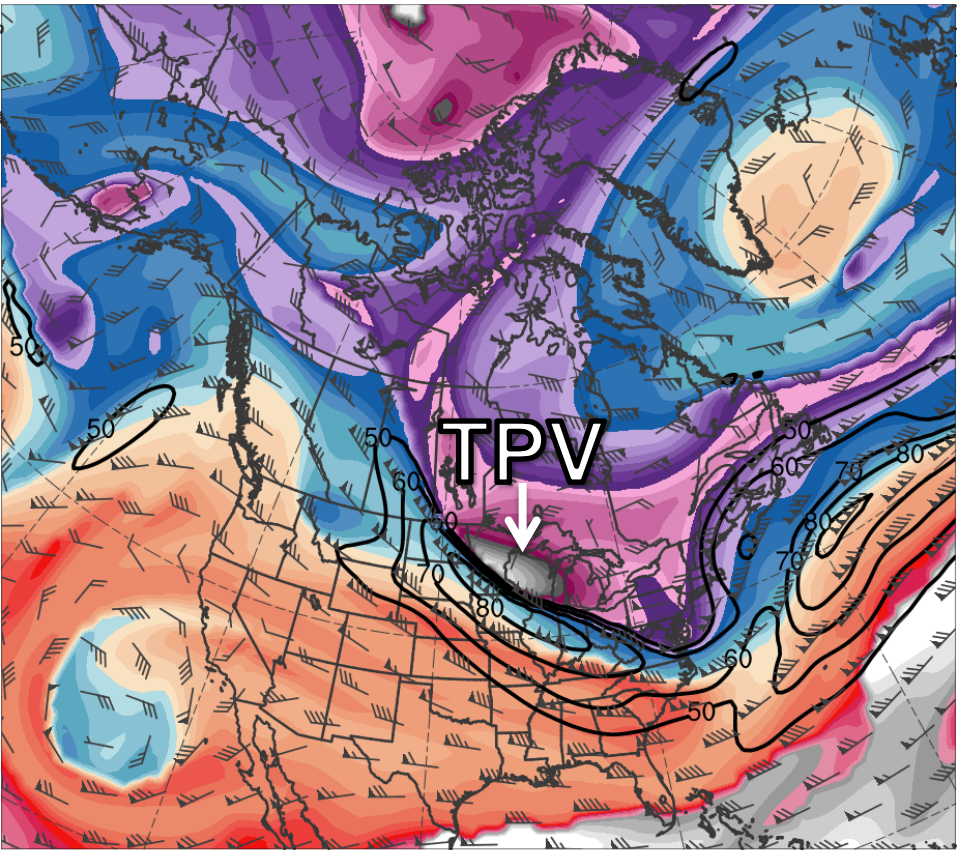

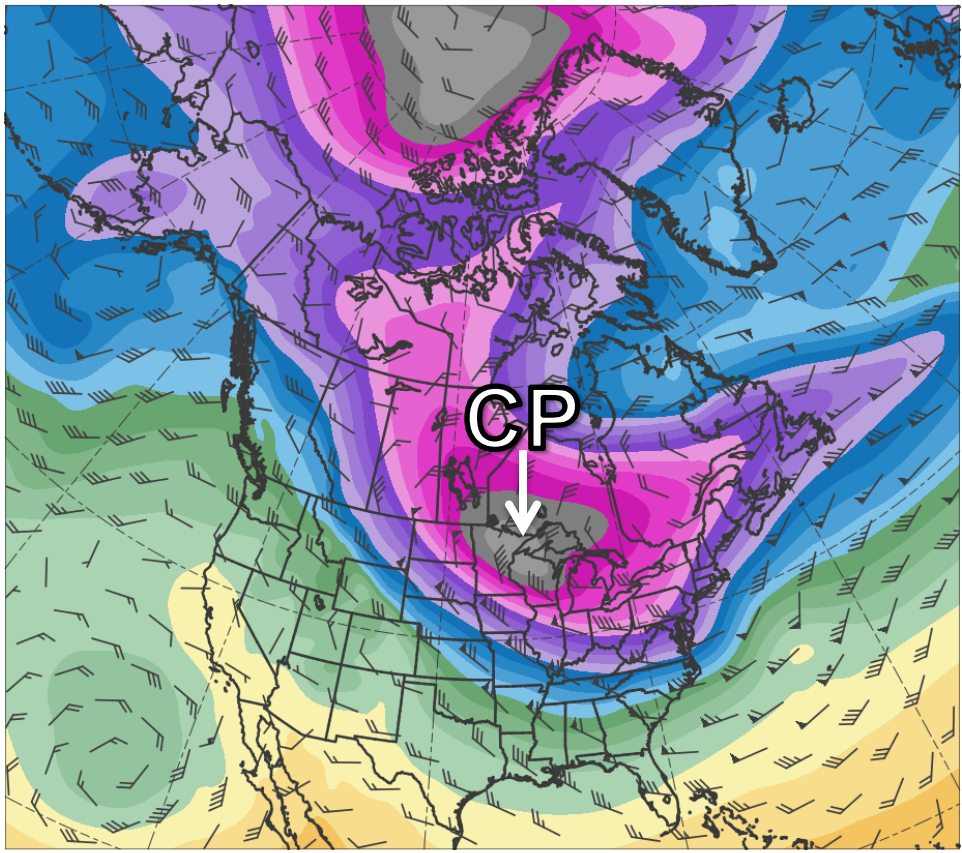

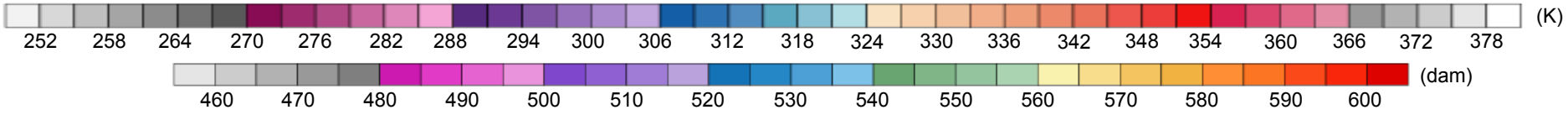

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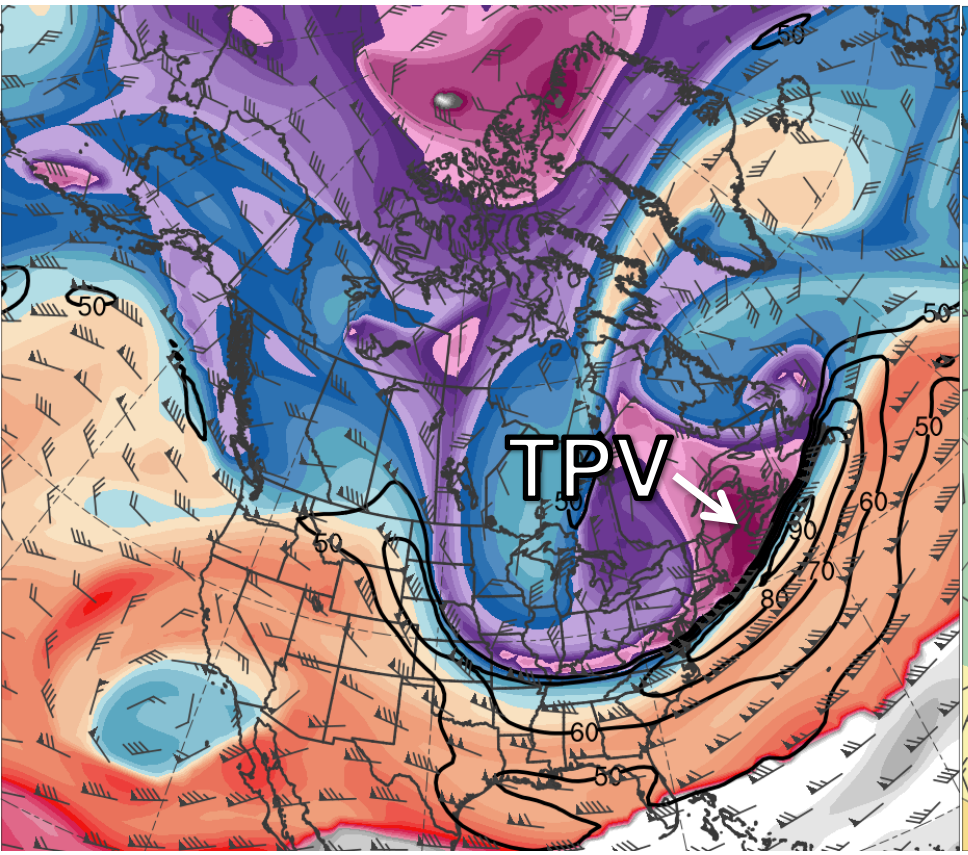
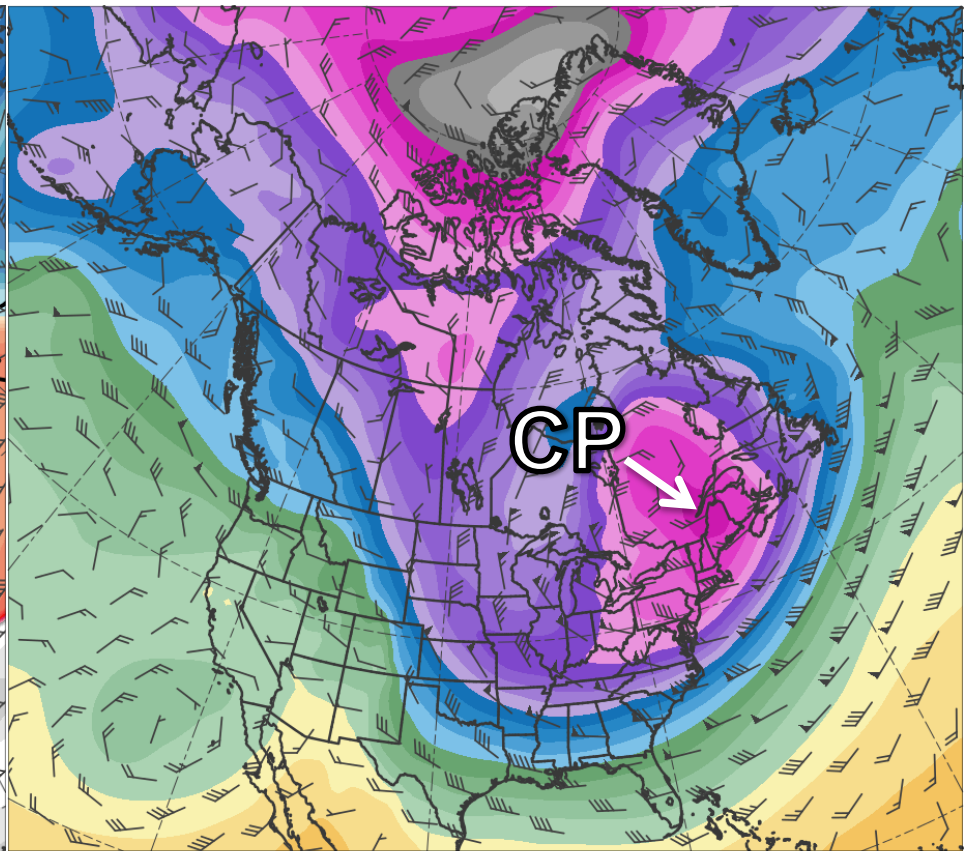
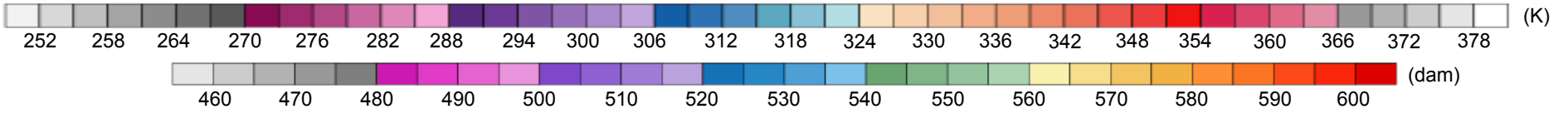
Example: 9–12 Jan 1982 CAO

0000 UTC 11 Jan 1982

Data Source: ERA-Interim







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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

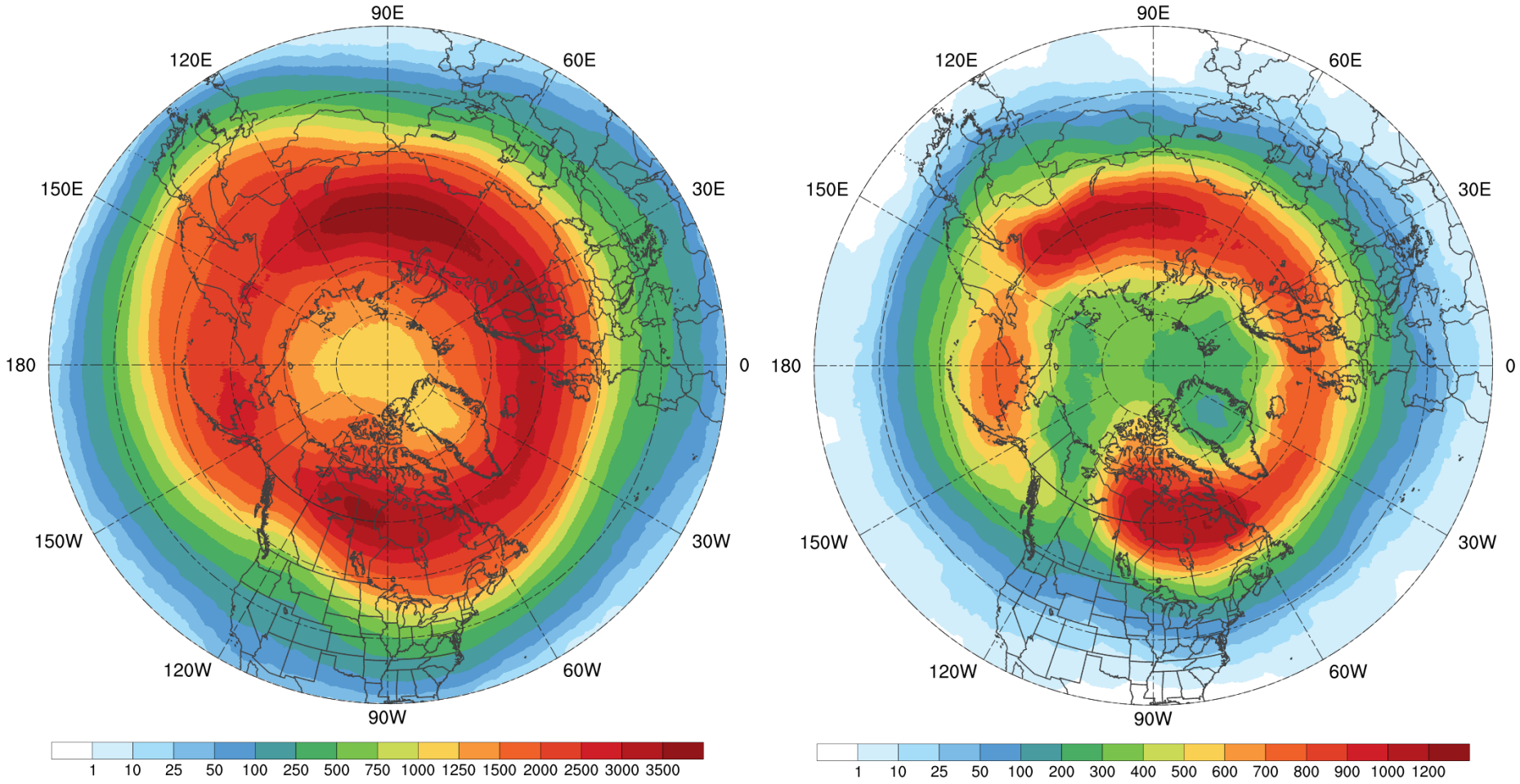
Link for Tracking Algorithm: https://github.com/nickszap/tpvTrack

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)

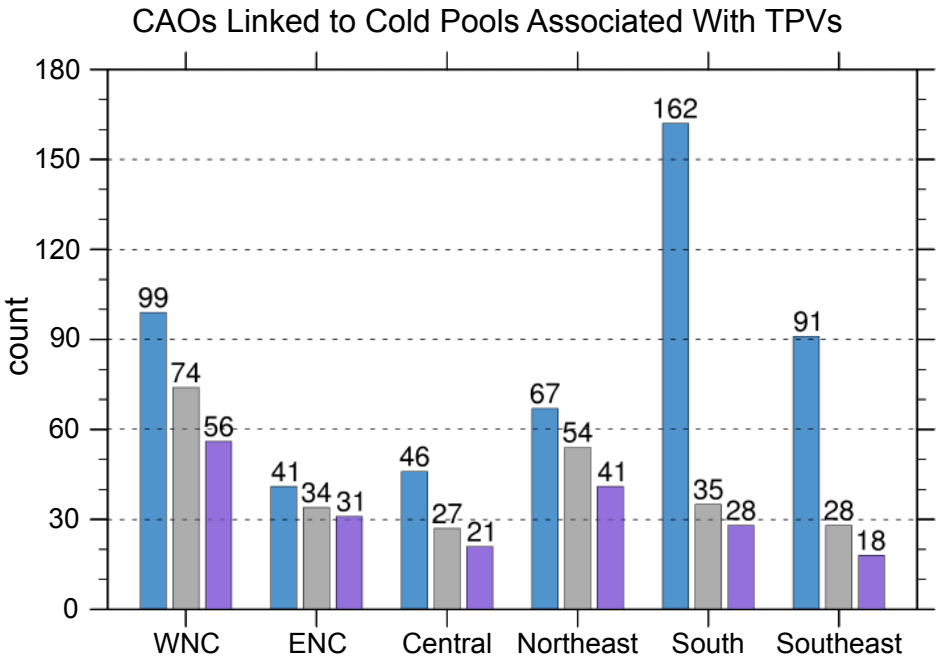
- Focus on TPVs and cold pools transported from high latitudes into middle latitudes
  - Require that TPVs and cold pools in high latitudes move equatorward of 60°N

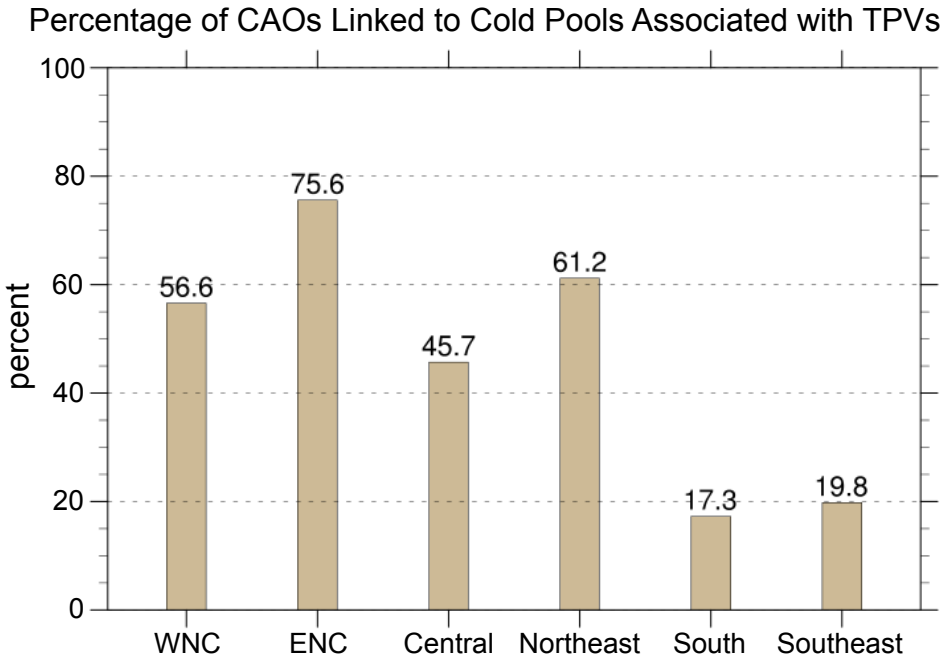
TPV and Cold Pool Track Density



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 [(purple/blue) × 100]