Potential Vorticity (PV)

- **PV can be approximated by** $PV = -g(\zeta_\theta + f)\frac{\partial\theta}{\partial p}$
- **A typical value of PV:**
  - $(\zeta_\theta + f) \approx 10^{-4}s^{-1}$
  - $\frac{\partial\theta}{\partial p} \approx \frac{-10K}{100\ hPa}$
  - **Hence,** $PV = 1\times10^{-6}Km^2s^{-1}kg^{-1}$
  - **1 PV unit (PVU) =** $1\times10^{-6}Km^2s^{-1}kg^{-1}$
  - **Midlatitude troposphere: -0.2 to 0.3 PVU**
  - **Midlatitude stratosphere: 1.5 to 10.0 PVU**
- **PV is conserved** $\left(\frac{dPV}{dt} = 0\right)$ **for frictionless, adiabatic flow**
- **Height/wind can be inferred from PV; PV changes by advection only (adiabatic case); if PV changes, height/wind changes**

Zonal Mean PV (dashed; PVU) and $\boldsymbol{\theta}$ (solid; K)

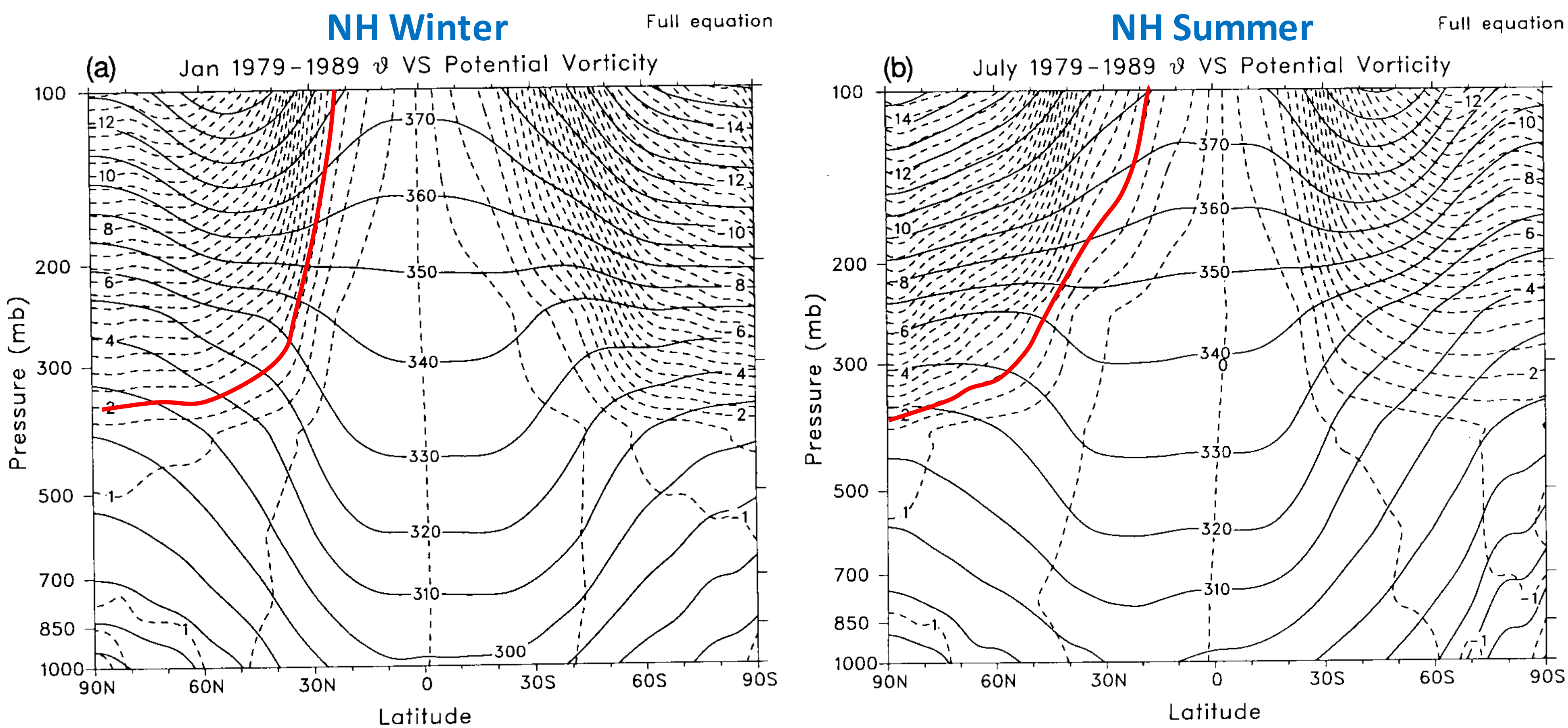

Fig. 1.137 in Bluestein (1993)

Structure of PV Anomaly and Cyclogenesis by "action-at-a-distance"

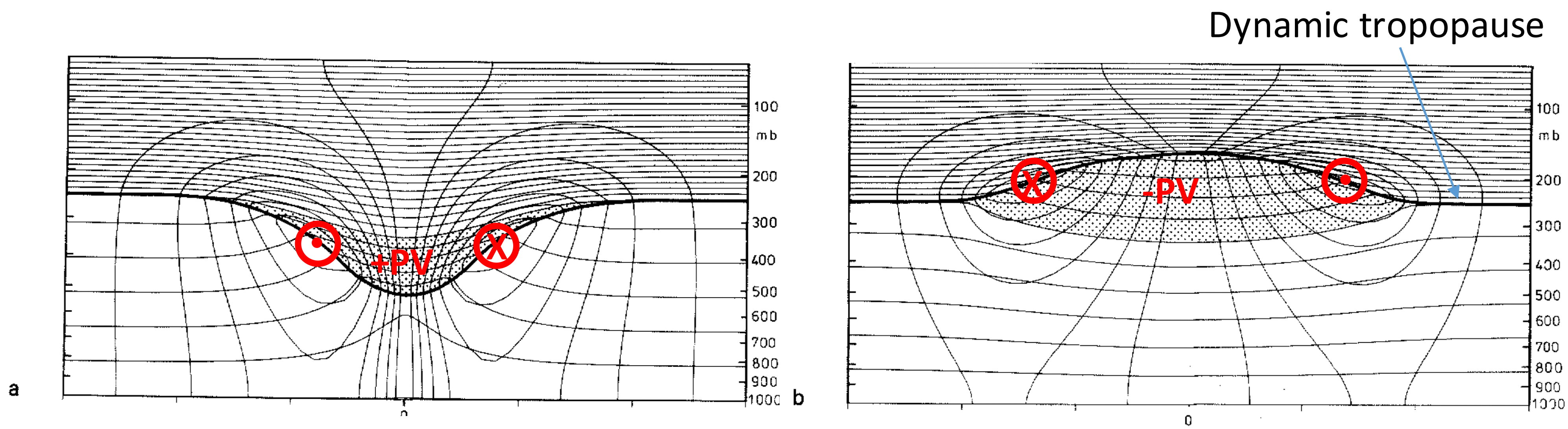

Fig. 15 in Hoskins et al. (1985)

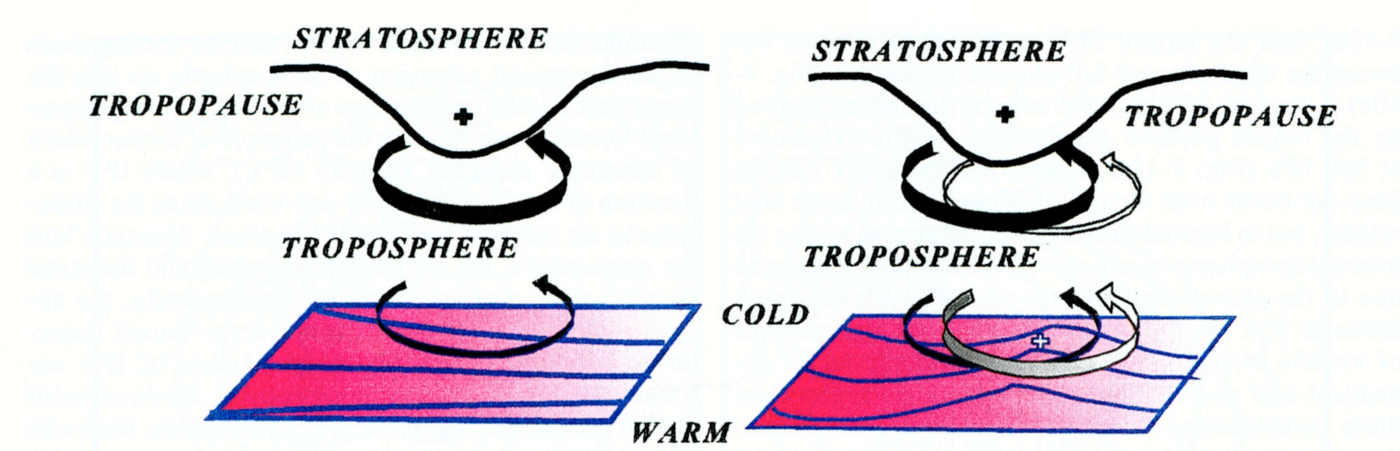

Fig. 7-12 in Kocin and Uccellini (2004)

PV and Weather Forecasting and Interpretation

- **Strong PV gradients:**
  - **J-E-T-S Jets Jets Jets!! (and jet streaks)**
  - **Vorticity gradients**
  - **Steep tropopause and tropopause folds**
  - **Large stability gradients**

- **Weak PV gradients:**
  - **Boring!**
  - **Small vorticity and wind variations**
  - **Flat tropopause**
  - **Small stability gradients**

Why use PV maps?

- **Pros and cons of conventional maps (e.g., 500 hPa chart):**
  - **Pros:**
    - **Features look familiar**
    - **Relationship between wind and vorticity**
    - **Use QG theory to infer vertical motion**
  - **Cons:**
    - **Hard to infer evolution and intensification**
    - **Impact of diabatic processes often hidden**
    - **Need maps at multiple pressure levels**
- **Pros and cons of PV maps (e.g., DT chart):**
  - **Pros:**
    - **PV is conserved (can see impact of latent heating when PV not conserved!)**
    - **PV knowledge gives you heights/winds at many levels**
    - **PV leads to clear dynamical interpretations**
    - **Jet streams are located at the dynamic tropopause!**
  - **Cons:**
    - **Unfamiliar**
    - **More complex calculations**