Dynamic drivers of Arctic warm events

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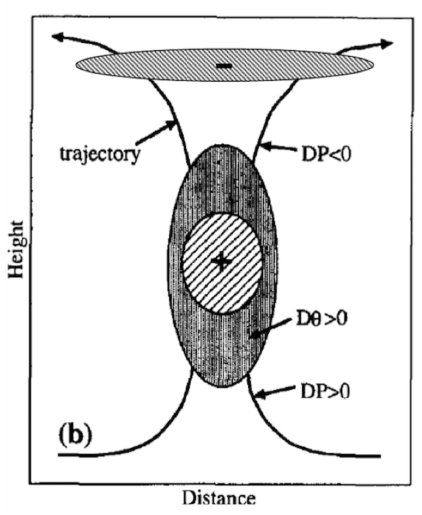
Motivation & Theory

- Concept of PV (potential vorticity):
  - Conserved when adiabatic, frictionless atmosphere
  - PV measure of stability and vorticity
  - 2 pvu as dynamical tropopause (1 pvu $= 10^{-6}\ \frac{m^2K}{s\ kg}$)
  - PV modified by friction or **diabatic processes**:

$$\frac{DPV}{Dt} \simeq \frac{1}{\rho}(\zeta + f)\frac{d\theta}{dz}$$

→ Proportional to the vertical gradient of the diabatic heating rate

→ Diabatically produced positive (negative) PV anomalies: intensifying of low level cyclones (upper level ridges)



Positive and negative PV anomalies (hatched areas) produced by steady diabatic heating (dark shading)[4].

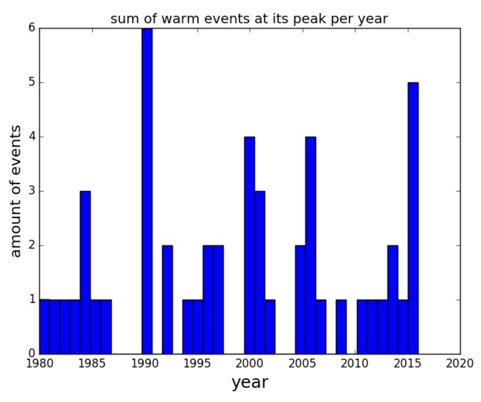
- **Dynamic drivers**:
  - Quasi-adiabatic with no latent heating (advection of low PV air)
  - Diabatic regime: northward transport of extratropical air-masses with low PV air entering the blockings via latent heat release in the ascending air → important in the formation and maintenance of polar anticyclones[1,3]. Arctic sea-ice loss is related with anticyclones[5].

Main questions & outlook:

- Preconditions for warm events to occur?
- Teleconnections between high and low latitude climate, extratropical cyclones and polar anticyclones?
- Origin of the low PV air & importance of diabatic processes as dynamic driver?
- Regional differences or general patterns during these events?
- Persistance of blockings?
- Change of large scale patterns over time & future climate → impact on the occurence of warm events?

Methods & Data

- Investigating the origin of the polar anticyclones identified during 50 warm events of extreme wintertime Arctic surface temperature anomalies[2].



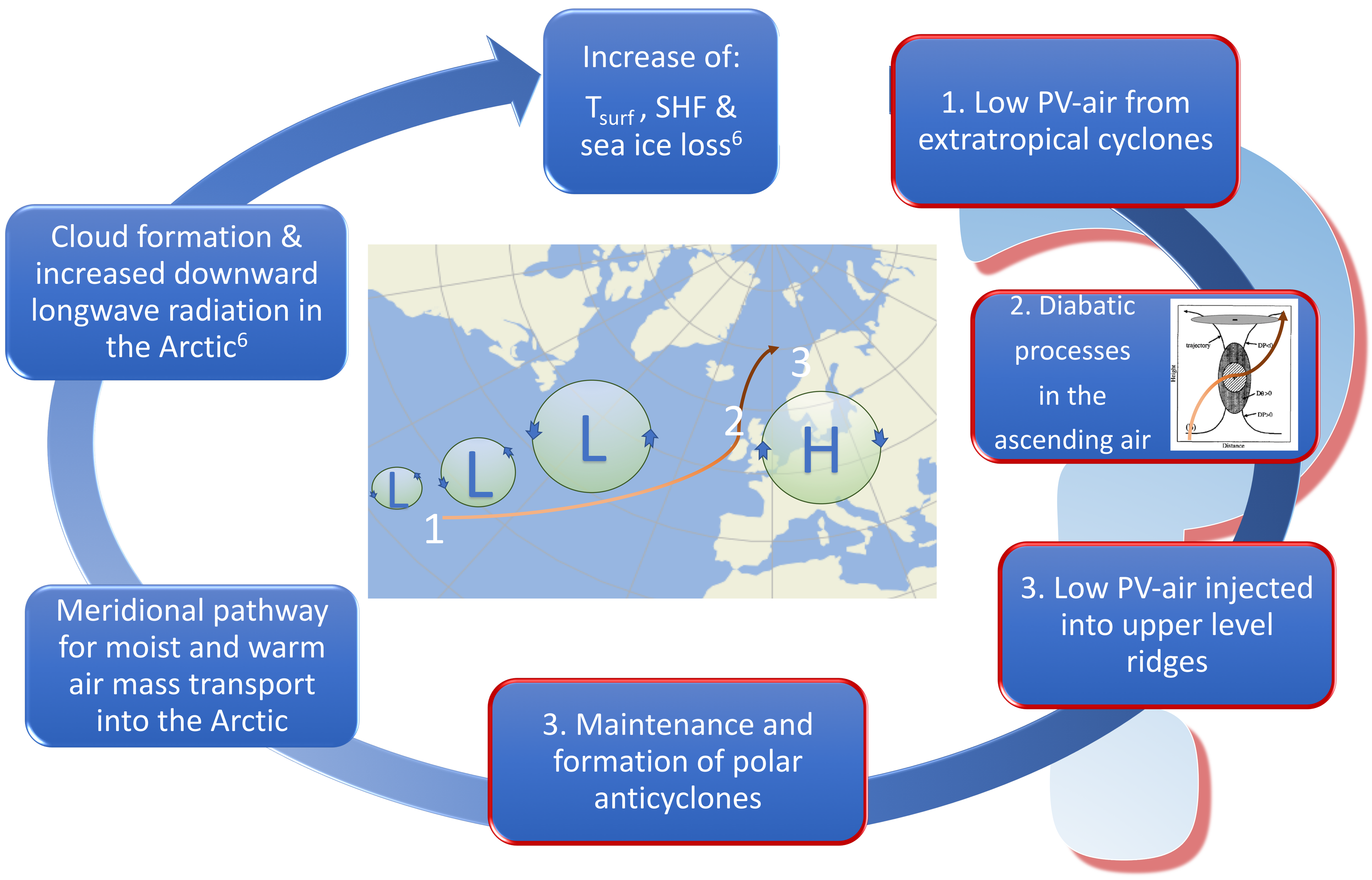
→ track the air originated from these anticyclones at 70°N a few days (lag -1/-2) prior to each warm event

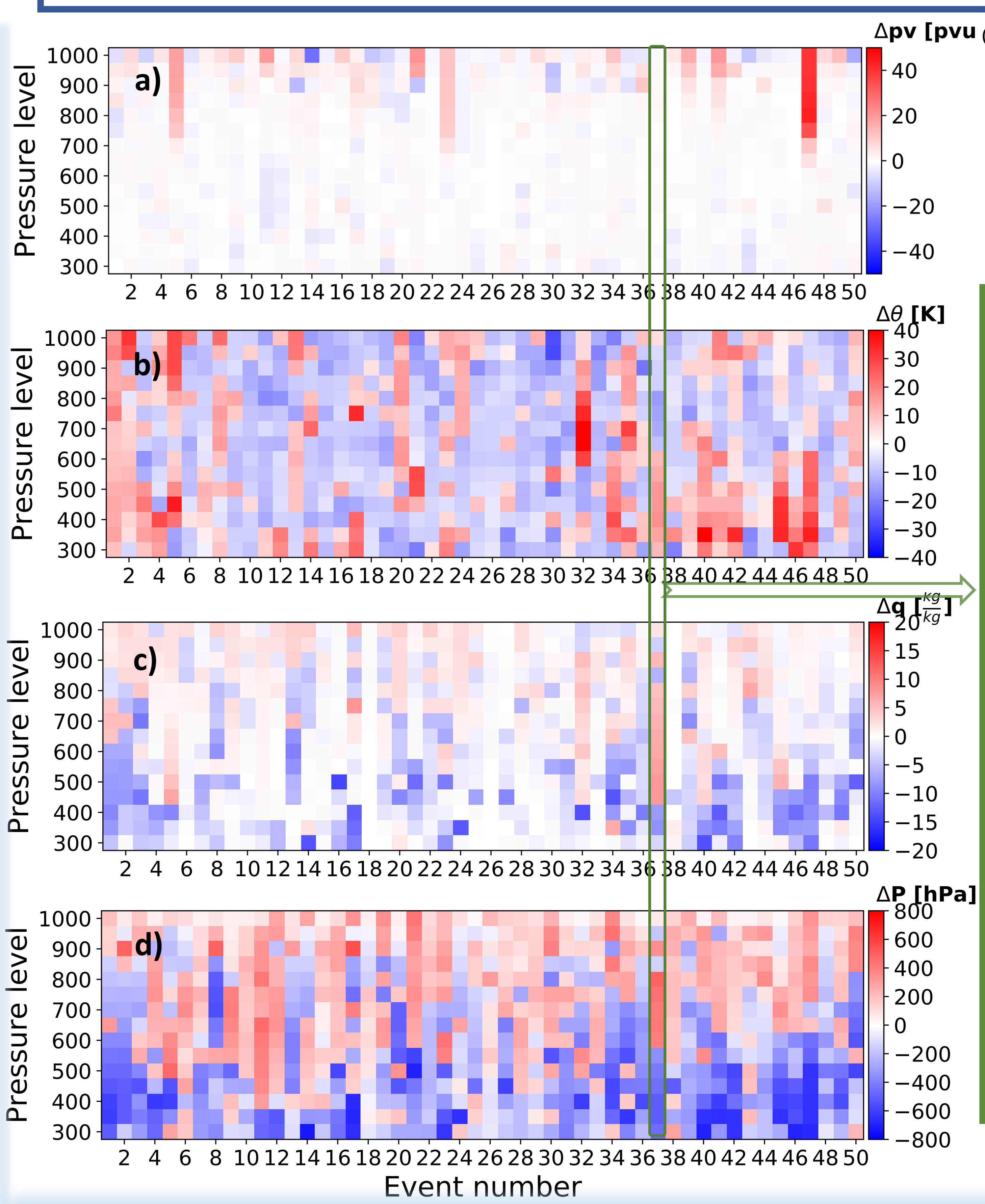
→ Initial position: absolute max in 500 hPa geopotential height / absolute max in the θ_{2pvu} -field

- Lagrangian trajectories: 5-day backward trajectories, initialized at 15 different pressure levels, using velocity fields from ERA-Interim reanalysis dataset + linear interpolation

$$x(t + \Delta t) = x(t) + u(x,t)\ \Delta t$$

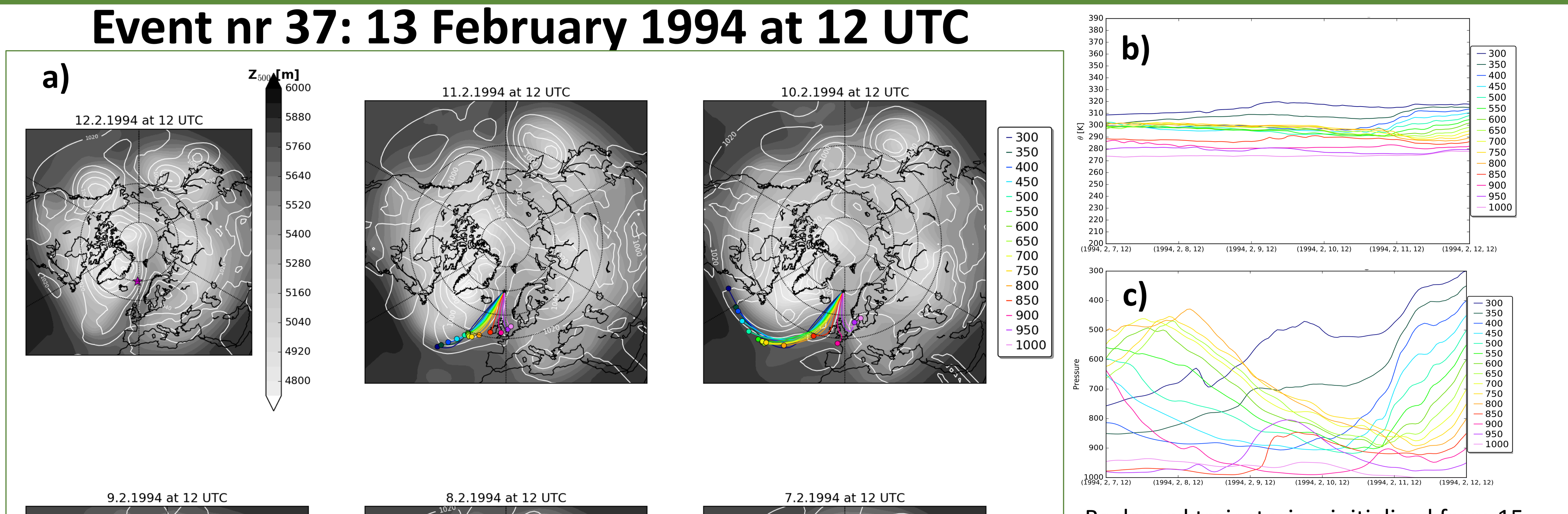
- Quantites (θ, PV, q, P) tracked along the journey of the trajectory for examining the importance of the diabatic processes





Matrixplot showing the largest difference in (**a**) PV, (**b**) potential temperature, (**c**) specific humidity and (**d**) pressure for each event separately (one column) during the journey of the trajectory, shown for each initial pressure level separately (row). The event nr 37 is marked with a green column. Notice the inverse proportionality between ΔP and $\Delta\theta$, as well as between $\Delta\theta$ and Δq. This analysis is made with unfiltered data.

Event nr 37: 13 February 1994 at 12 UTC



Backward trajectories, initialized from 15 different vertical pressure levels (colored lines, in hPa) from the anticyclone using the max θ_{2pvu} -method one day prior to the warm event. (**a**) Horisontal displacement per day during its 5-d journey. The 500 hPa geopotential height (in meters) is in shading and surface level pressure (in hPa) as contours. (**b**) Evolution of the potential temperature (θ) along each trajectory. (**c**) Vertical displacement (in hPa) in time.

References:

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