A Lagrangian Analysis of upper-level ridges associated with heat waves in Europe

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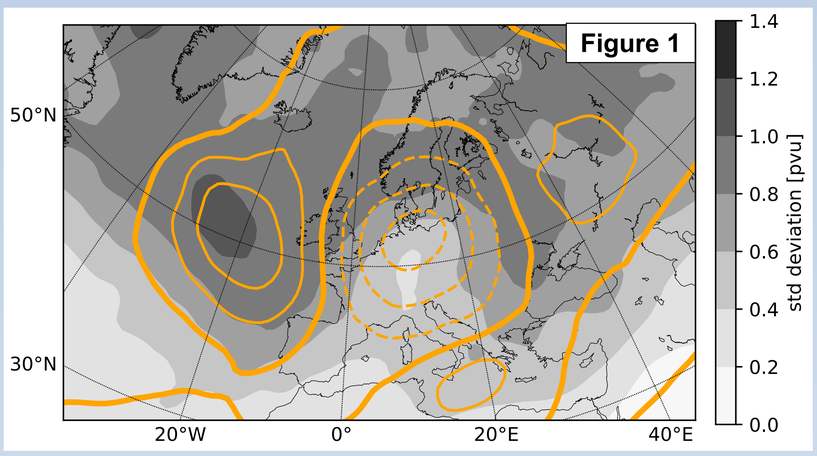
1. Introduction

- Upper-level ridge building strongly influenced by diabatic processes (e.g. Pomroy and Thorpe, 2000)
- **Latent heating** important for atmospheric blocking (Pfahl et al., 2015), but not yet studied for upper-level ridges in association with heat waves in Europe
- **Questions to be addressed:**
  1. What are the typical source regions of air parcels reaching upper-level ridges over Central Europe?
  2. Where does the maximum latent heating occur and under which synoptic conditions?
  3. Do spatio-temporal details of latent heating impact on the maintenance of upper-level ridges?

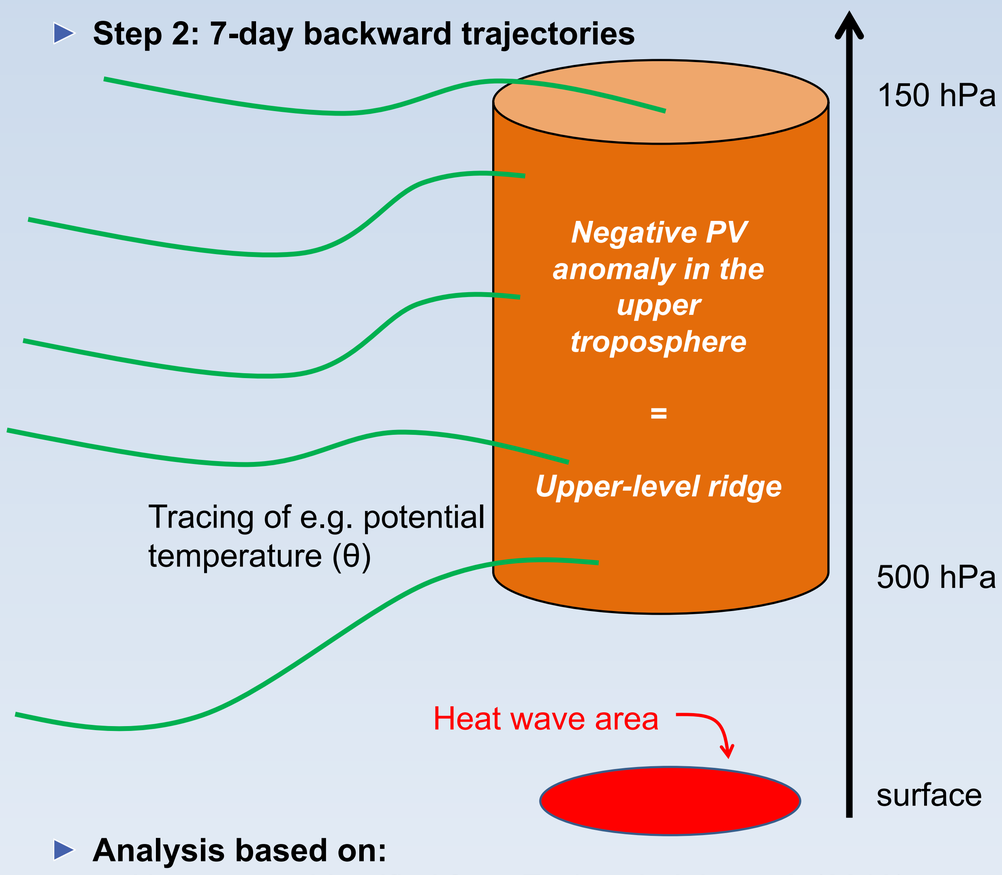
2. Method

- **Step 1: Relate upper-level ridges to heat waves**

Composite of vertically averaged potential vorticity anomalies between 500 and 150 hPa for all heat waves in Central Europe. Lines denote mean values (in 0.25 pvu increments, 0 pvu bold) and grey shading the standard deviation:



- **Step 2: 7-day backward trajectories**



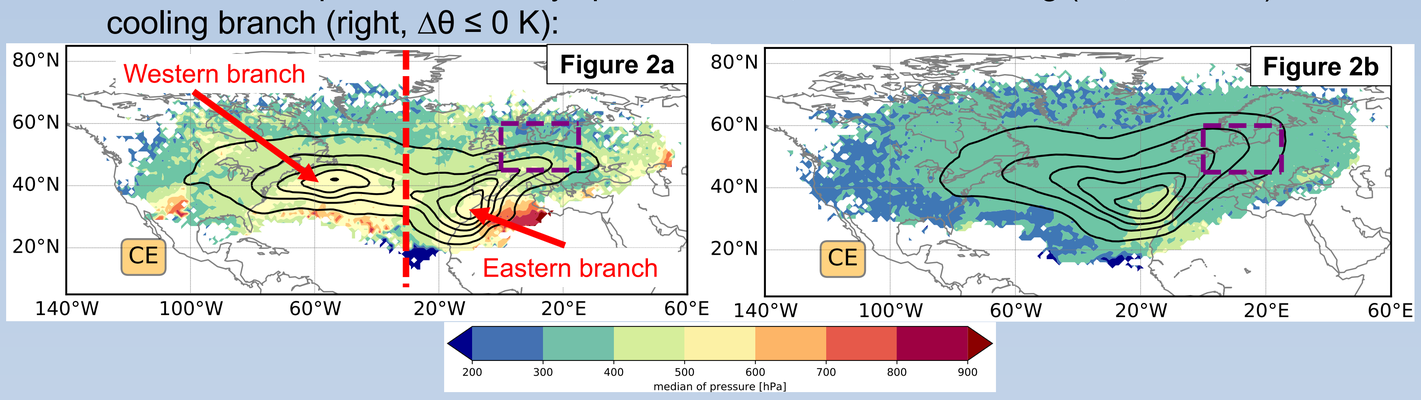
- **Analysis based on:**
  - Heat waves identified from Zschenderlein et al. (2019)
  - ERA - Interim from 1979 to 2016
  - Trajectories calculated with LAGRANTO (Sprenger et al., 2015)
  - separating trajectories in two subsets: diabatically heated ($\Delta\theta > 0$ K) and cooled branch ($\Delta\theta \leq 0$ K)

5. Conclusions

- 29 (42)% of air parcels experience latent heating during the last three (seven) days prior to reaching upper-level ridges
- This heating branch consists of two regions (Fig. 2a) with different synoptic conditions:
  (i) western branch is heated above the North Atlantic (Fig. 3a) within extratropical cyclones (Fig. 4a)
  (ii) eastern branch is heated above western/ central Europe (Fig. 3b) within higher mixed-layer convective available potential energy (Fig. 4b)
- Western branch is relevant for the onset of the ridges, whereas eastern branch is relevant for the maintenance of the ridges (Fig. 5)

3. Source regions

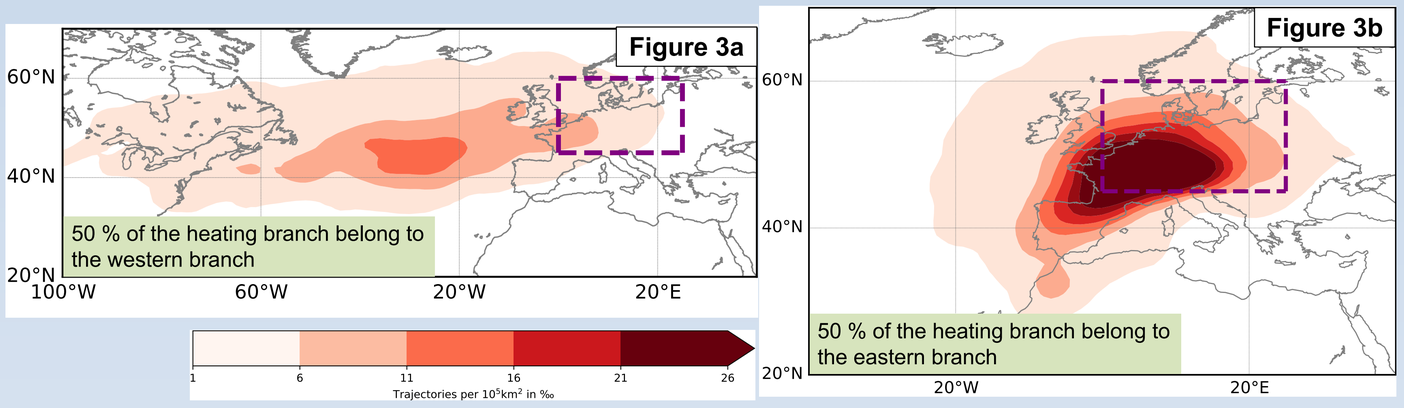
- Location of air parcels three days prior to arrival, divided in heating (left, $\Delta\theta > 0$ K) and cooling branch (right, $\Delta\theta \leq 0$ K):



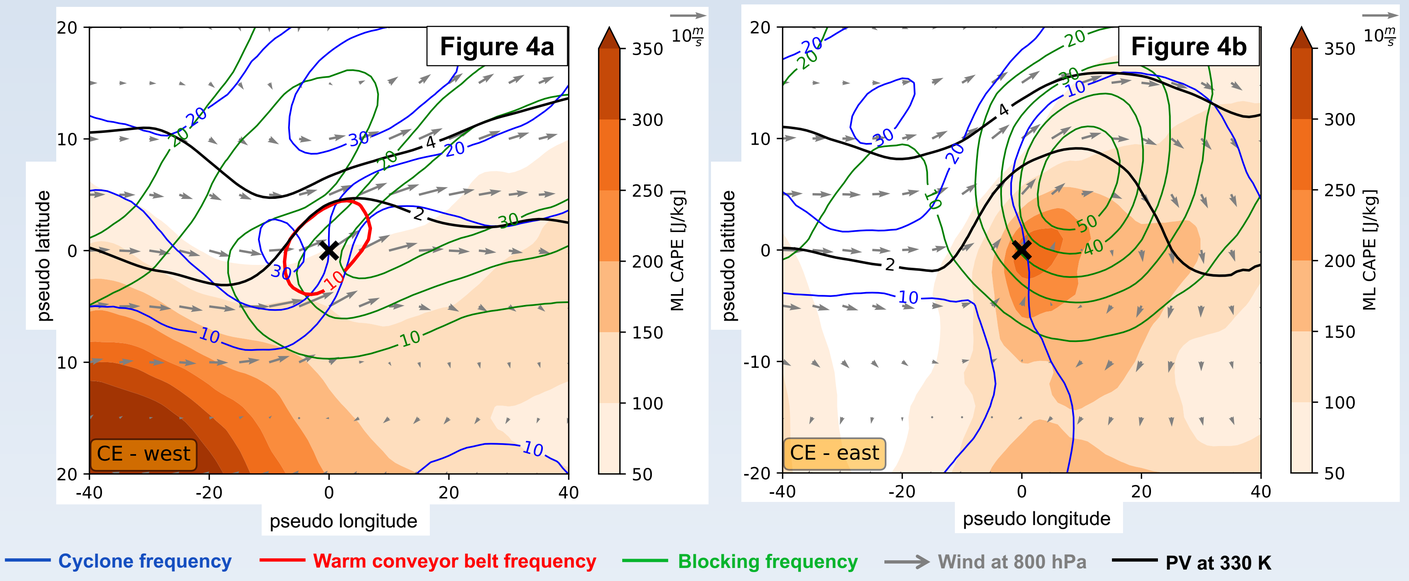
- 29 (42)% of the air parcels reaching upper-tropospheric anticyclones are diabatically heated during the last three (seven) days
- two geographically separate origins of the heating branch (western and eastern branch)

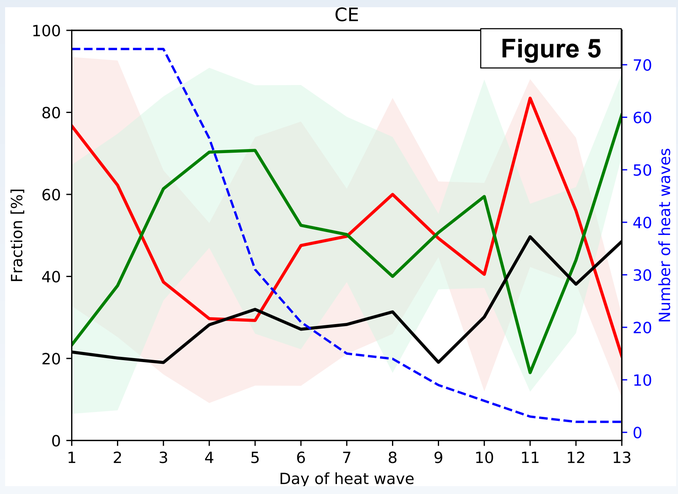
4. Location of maximum diabatic heating, synoptic conditions and life cycle

- Location of maximum diabatic heating for the western (left) and eastern branch (right):



- Composites centred on the location of maximum diabatic heating (black cross) for the western (left) and eastern branch (right):





- The red (green) line shows the median contribution of the western (eastern) branch to the heating branch, shading represents the interquartile range. The median fraction of the heating branch relative to all trajectories is shown by the black line.
- Results robust up to day six (→ because number of heat waves decreases for longer durations)

Literature

- *Pfahl et al. (2015):* Importance of latent heat release in ascending air streams for atmospheric blocking, Nat. Geosc.
- *Pomroy and Thorpe (2000)*: The Evolution and Dynamical Role of Reduced Upper-Tropospheric Potential Vorticity in Intensive Observing Period One of FASTEX, Mon. Wea. Rev.
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