CLIMATOLOGICAL CHARACTERISTICS AND ATMOSPHERIC CIRCULATION ASSOCIATED WITH 3D HEAT WAVE TYPES IN EUROPEAN REGIONS

ABSTRACT

We evaluate climatological characteristics (temperature anomalies, mean precipitation, and the Climatic Water balance index defined as the difference between potential evapotranspiration and precipitation) and links to atmospheric circulation for threedimensional (3D) heat wave types in several European regions. Heat waves (HWs) are classified according to their 3D structure of positive temperature anomalies in ERA5 over 1979–2022 (the satellite period) into near-surface, lower-tropospheric, highertropospheric, and omnipresent types (Lhotka & Kyselý 2024). The Jenkinson–Collison classification of daily mean sea level pressure patterns is used to identify circulation types with increased frequency during the individual HW types compared to the June-September climatology. We show large differences in surface temperature anomalies and dryness among the HW types, as well as different links to circulation patterns. The differences are most pronounced between near-surface and higher-tropospheric HWs and point to processes important for their onset and development. The analysis contributes to better understanding the interrelationships between HWs, atmospheric circulation, and other driving mechanisms.

METHODOLOGY

ERA5, 1979–2022

- **3D HWs classification** (Lhotka & Kyselý, Commun. Earth Environ. 2024)
- **3D HWs** based on location of temperature anomalies in tropospheric vertical layers: near-surface (HWG), lower-tropospheric (HWL), higher-tropospheric (HWH), and omnipresent (HWO)
- Jenkinson & Collison classification of circulation types summarized into 11 supertypes
- the same procedure as in **poster no. 163**, but for 3 study regions the **British Isles**, France, and Middle Europe



SUMMARY

- Before the onset of heat waves, a similar increase occurs in all regions for the anticyclonic type.
- Anticyclonic vorticity plays a dominant role in higher-tropospheric heat waves (HWH) in all studied regions.
- > For near-surface heat waves (HWG), circulation patterns are weakly expressed and follow a period of prior surface drying in Middle Europe and France regions. In contrast, anticyclonic vorticity remains **dominant in the British Isles region**.
- > The influence of warm advection from the **south** increases in **Middle Europe** for the other two types of heat waves: lower-tropospheric (HWL) and omnipresent (HWO). In **France**, warm advection comes primarily from the **east**, while in **British Isles**, anticyclonic vorticity remains the key driver.
- > The smallest changes in surface dryness before, during, and after heat waves are observed in the British Isles region, while the largest changes occur in the France region.

REFERENCES: Lhotka O. & Kyselý J. (2024) Three-dimensional structures of European HWs (2024). Comm. Earth & Environment 5, 1–8.



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RESULTS → before, during & after HWs





RESULTS → land-atmosphere coupling



RESULTS ➡ during HWs

Middle Europe (ME)



France (FR) anticyclonic southerly indeterminate other

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Figure 3: Frequencies of 11 supertypes on three days before (A), during (B), and three days after (C) each heat wave type, in Middle Europe (ME), France (FR) and the British Isles (BI). The mean June–September frequency over 1979–2022 is shown for comparison (grey bars). Crosses represent no occurrence for the particular case.

Figure 4: Boxplots of differences between potential evapotranspiration (PET) and precipitation (P) for individual heat wave types on three days before, during, and three days after heat waves, in Middle Europe (ME), France (FR) and the British Isles (BI). The black line in the boxplots is the median, and the whiskers denote the 10% and 90% quantiles. The seasonal climatology is shown on the right for comparison.

British Isles (BI)



Figure 5: Frequencies (in %) of the anticyclonic type (A), types with southerly advection (SE, S and SW supertypes), indeterminate flow (IF), and all other circulation types during the individual heat wave types, in Middle Europe (ME), France (FR) and the British Isles (BI).