

Heatwaves and Droughts in Europe: A multi-year analysis using MODIS Land Surface Temperature Anomalies

Motivation

The European region is highly vulnerable, experiencing frequent and severe heatwaves, expected to increase in occurrence, intensity and duration over the coming decades [1]. Heatwaves frequently coincide with droughts, further exacerbating their impacts [2].

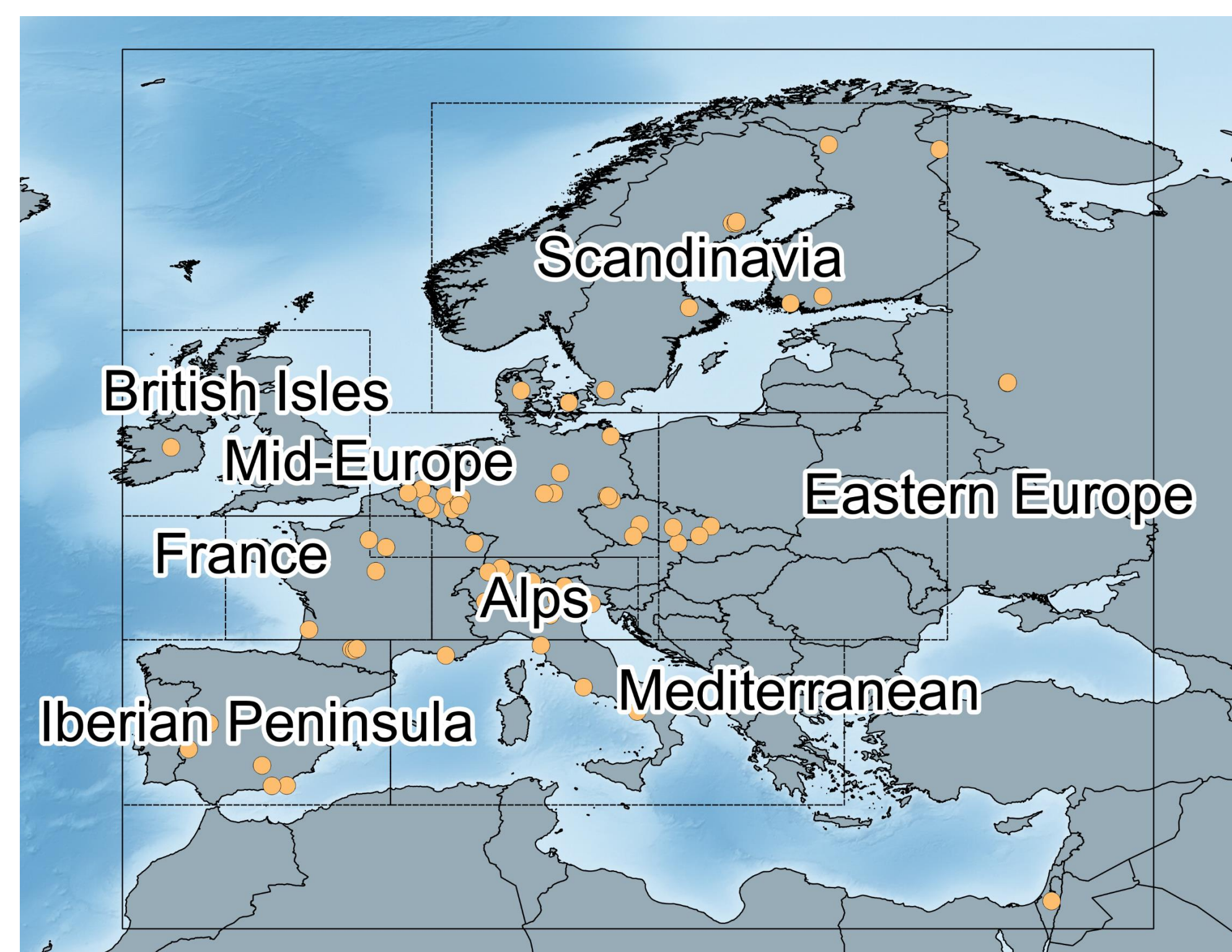
- Can Land Surface Temperature (LST) serve as a prognostic indicator of heatwaves?
- How does the energy balance vary across different land covers during hot and dry periods?

Data & Methodology

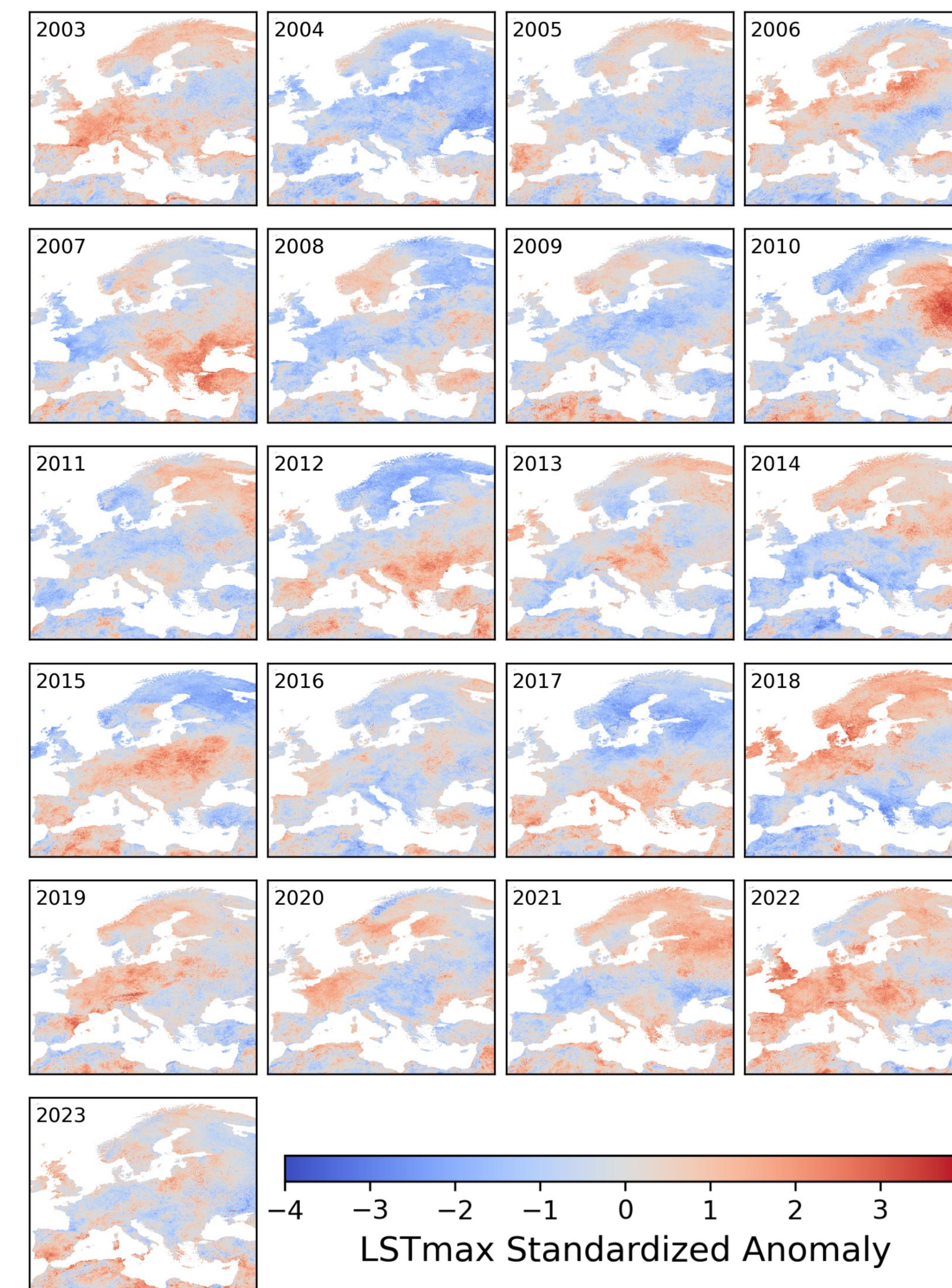
- MODIS/Aqua LST Daily 1 km (MYD11A1 product).
- SPEI global dataset [3] (5 km spatial resolution, monthly time scale), GLEAM surface moisture data [4] (25 km).
- ERA5-Land daily maximum of 2m air temperature (9 km spatial resolution).

$$LSTmaxStandardAnomaly_{annual} = (LSTmax_{current_year} - LSTmax_{mean})/std \text{ [5]}$$

- We detect heatwaves using the CTX90pct index [6] for air temperature, and multiple percentile-based indices [7] for LST data.
- We use flux tower data from the ICOS network to calculate anomalies in latent and sensible heat fluxes during heatwaves compared to typical summer days.

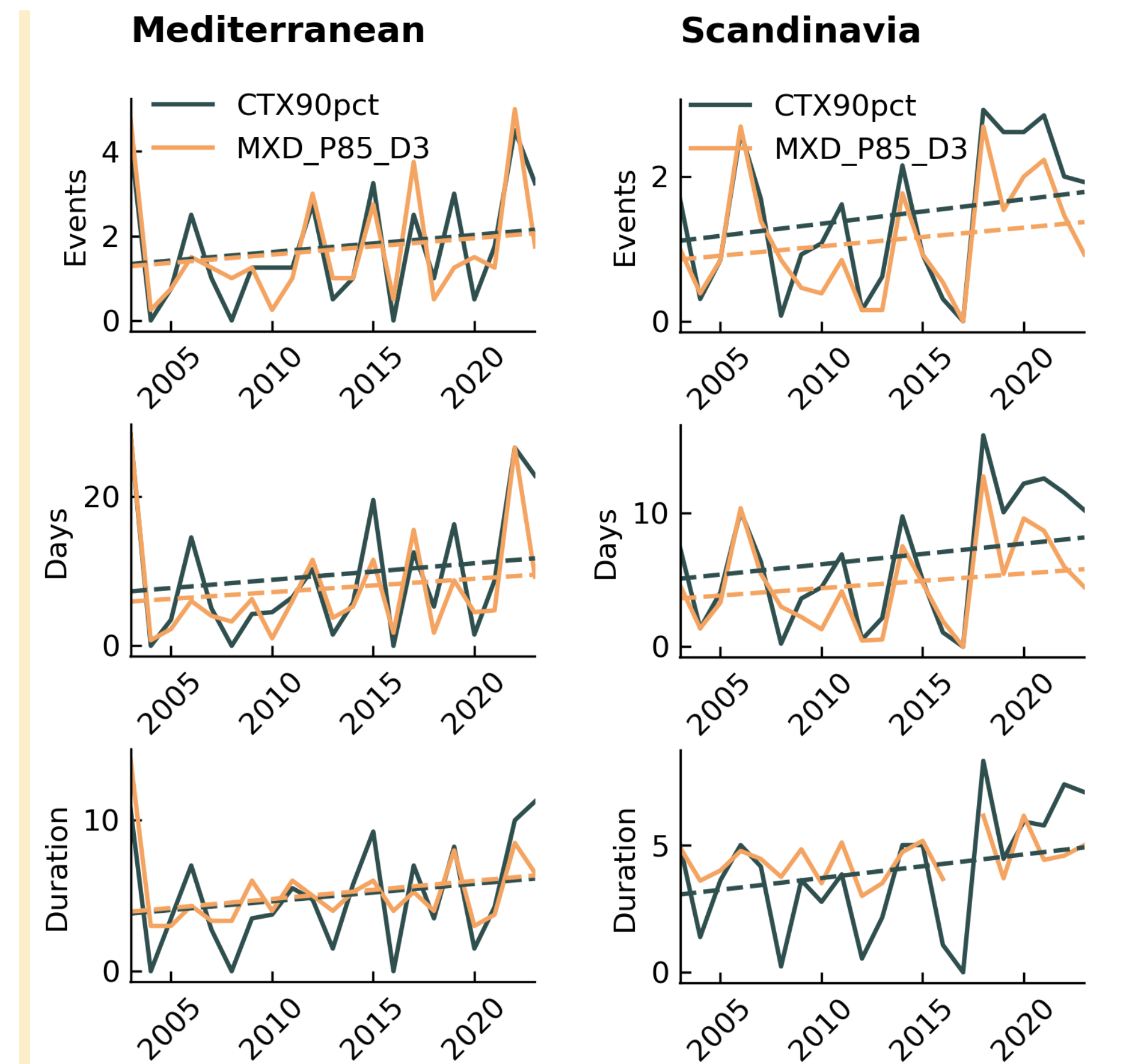
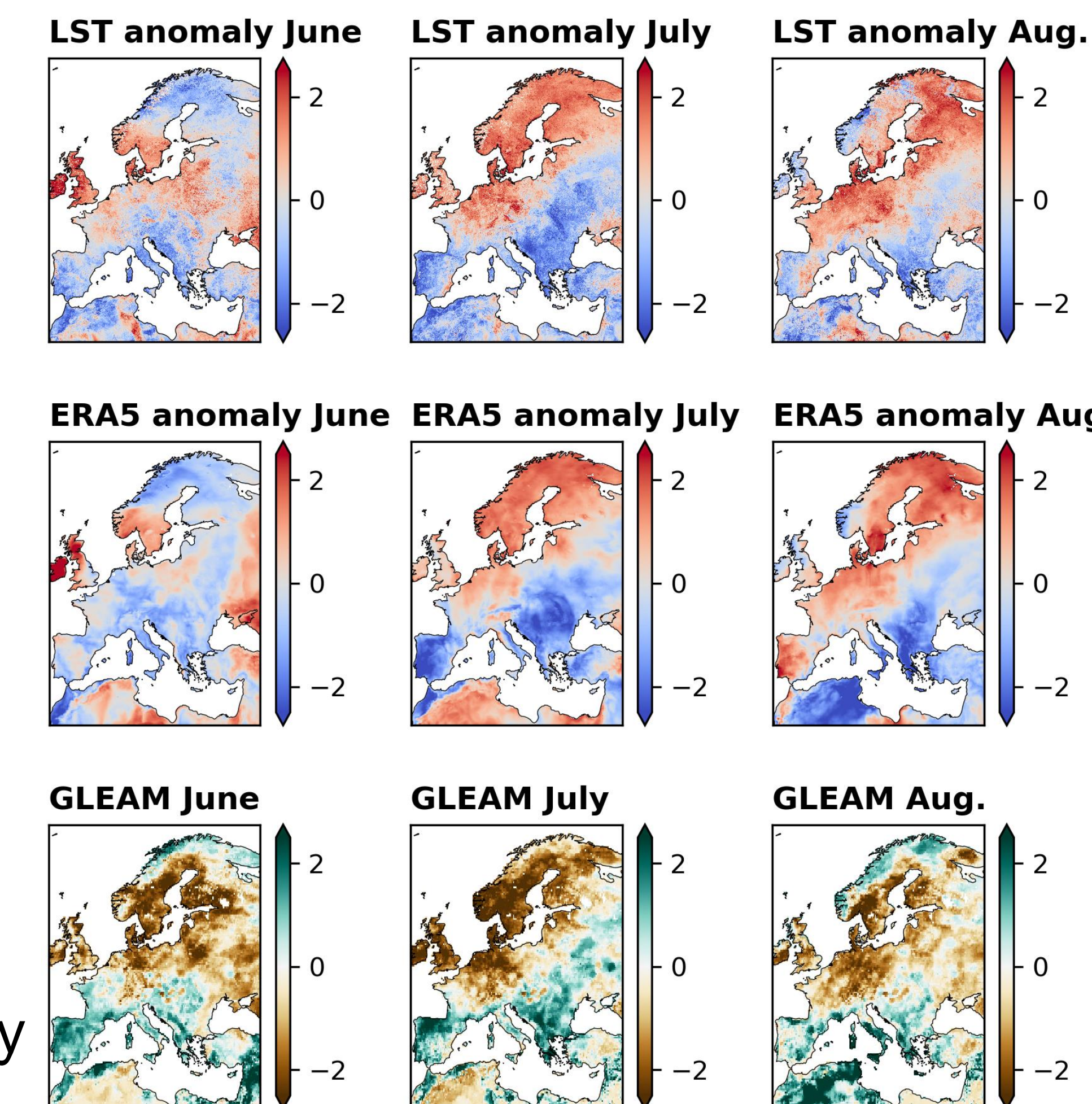


Results



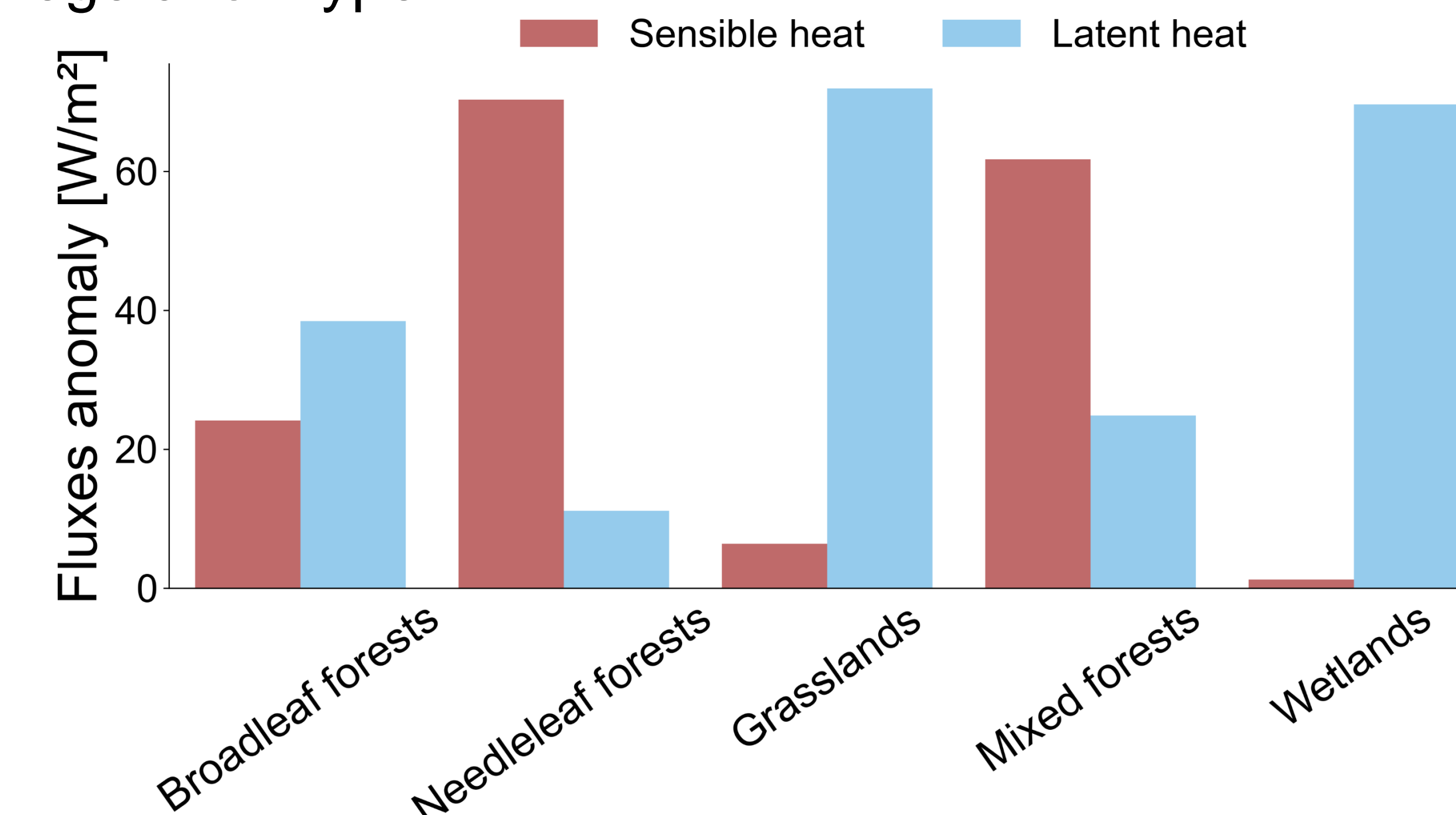
Strong similarity observed between summer season LSTmax anomalies and major heat events in Europe.

- The severe heatwave that impacted Great Britain and Northern Europe in 2018 was clearly evident from satellite-based LST.
- In Scandinavia, exceptionally low surface moisture contributed to a prolonged, severe heatwave in July.



- Depending on the percentile-based index, LST anomalies detected up to 90% of heatwave events.
- The identified LST anomalies closely align with the mean climatology of air temperature-based heatwaves showing consistent agreement in terms of the number of events, days, and duration.

Fluxes anomalies during heatwaves varied significantly vegetation type.



Conclusions

- LST effectively captures the spatial patterns associated with heatwaves and droughts across Europe. An increasing trend in warm anomalies of maximum annual LST was observed across the entire European region.
- Drought conditions can both precede, coincide with, or result from heatwaves.
- Future steps involve expanding the current analysis to other climate zones, with a focus on urban areas, and exploring the influence of synoptic conditions on local surface processes.