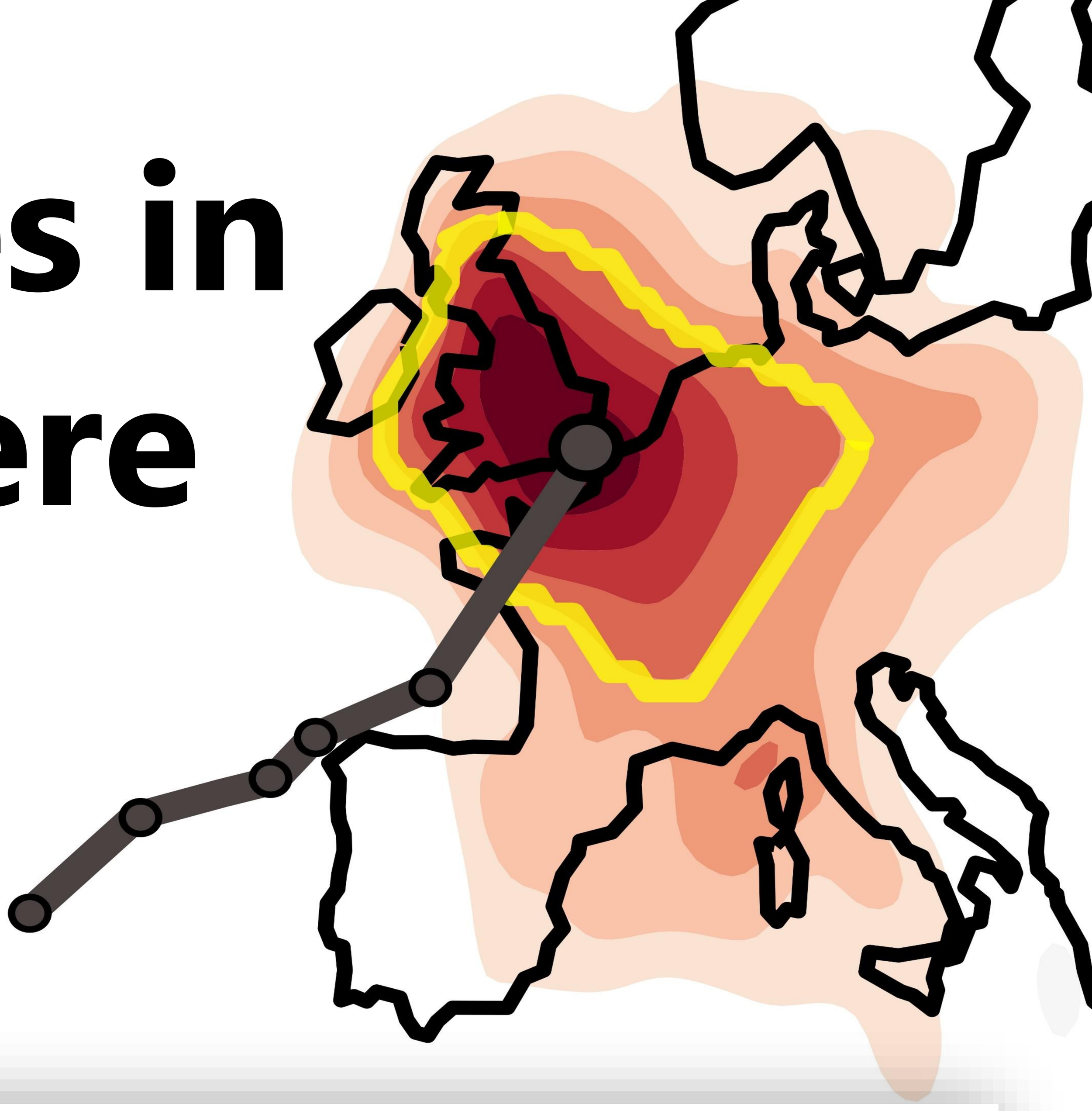
Characterizing heatwaves in the Northern Hemisphere



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Background

Heat waves, as one of the deadliest climate hazards, pose a significant threat to human[1] and natural systems[2], exacerbated by the persistence of hot surface weather conditions. Hence, it is essential to comprehend their characteristics. To do so, we used a Lagrangian feature-tracking algorithm[3] to identify and track temperature anomalies over time. It allows us to analyze spatial extent and tracks of detected heatwaves. From that, we can characterize heatwaves attributes (size, duration) at each location in the Northern Hemisphere.

Results

Where are the regions experiencing the most heatwaves?

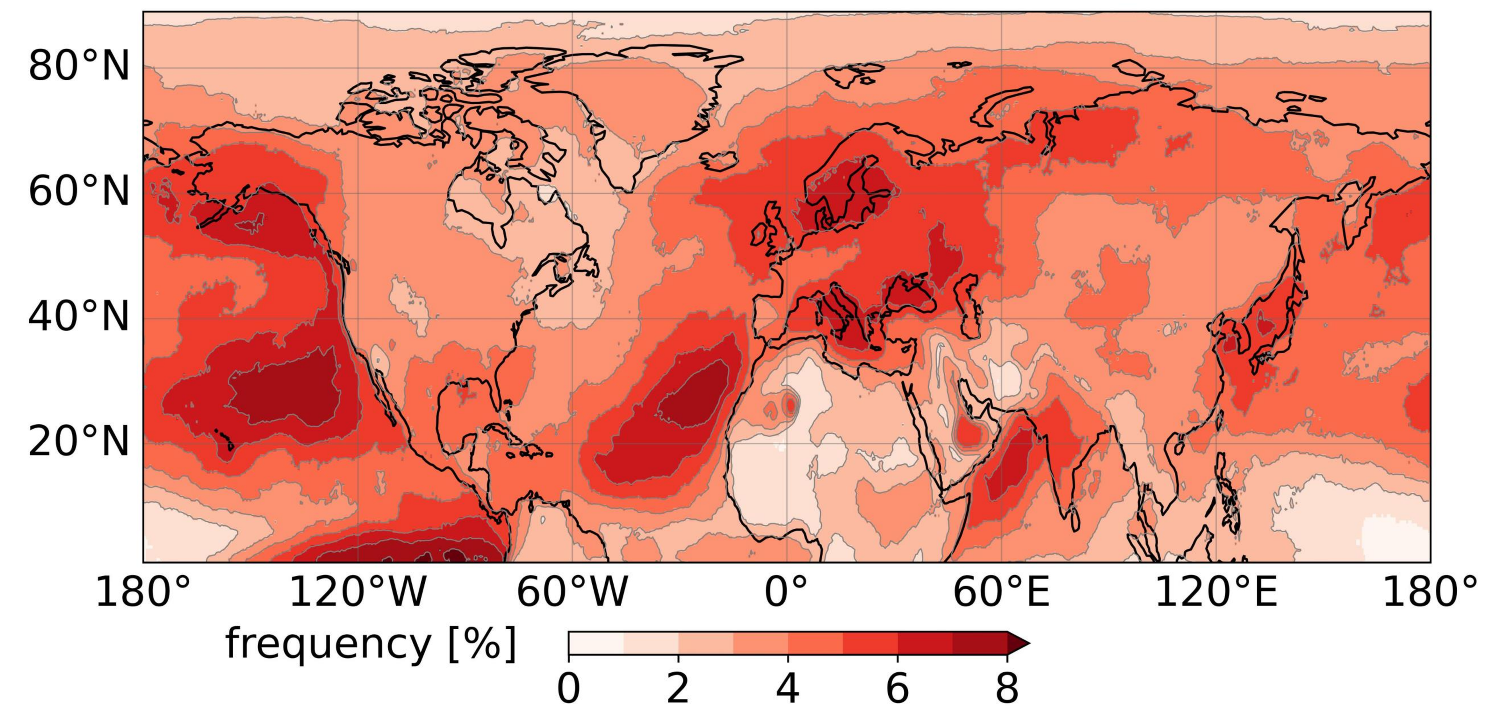


Figure 1: Frequency of heatwaves in percent detected in the Northern Hemisphere (1959-2023).

Most heatwaves detected are in the **Pacific**, and **Atlantic ocean**, **Arabian** and **Mediterranean sea**, and in **Scandinavia**. Conversely, the **central Pacific** and **West of Africa** has the **lowest occurrence**. These high-frequency areas are primarily induced by adiabatic and diabatic processes, except for the North Pacific, where it is mainly due to the advection of warmer air[4].
Heatwaves in the Sahara mainly occur at one location and are short-lived.
When only considering heatwaves **over land**, **Europe** and **India** frequently experience them.

... and the longest ?

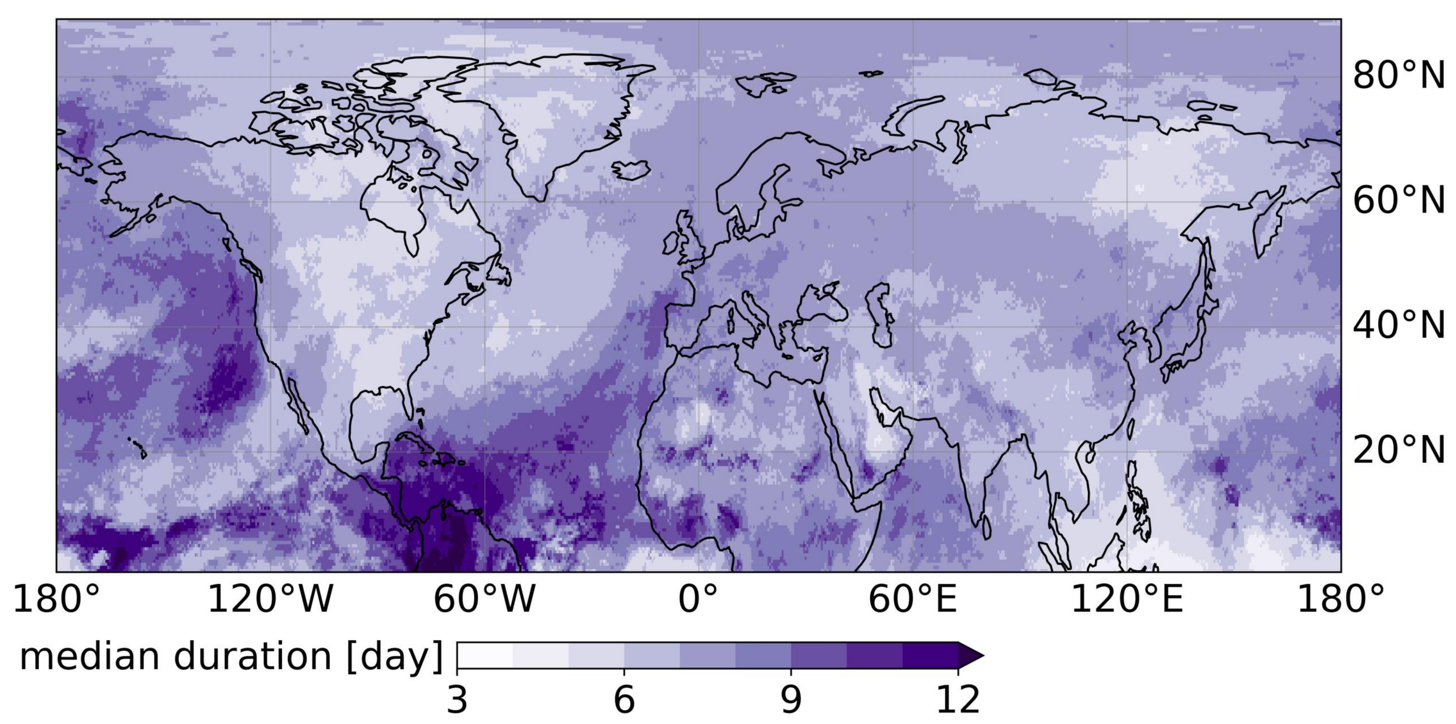


Figure 2: Median duration in days of heatwaves detected in the Northern Hemisphere (1959-2023).

The results suggest that the **longest heatwaves** take place in the **Caribbean sea** and in the **Pacific Ocean**. On the other hand, the **shortest** are located over **North America**, **Siberia**, the **Arabian Peninsula** and **West of Pacific** ocean. Heatwaves are common along the US west coast and frequently last long.

Does El Niño affect the size of heatwaves?

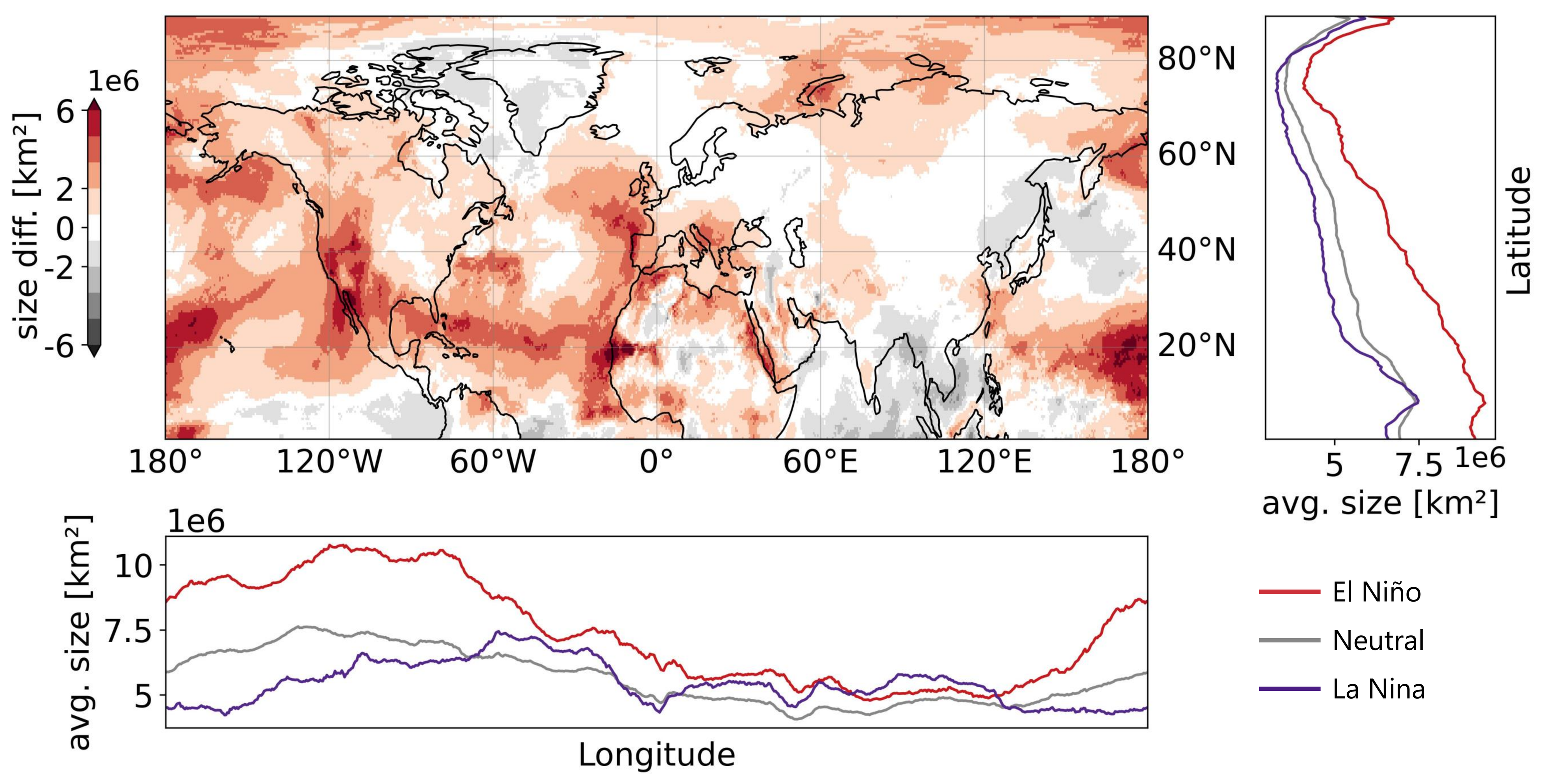


Figure 3: Composite analysis of heatwaves sizes during El Niño years and the total period (1959-2023). Profiles shows the average size along latitudes and longitudes during El Niño years (in red), La Niña years (in purple), and neutral years (in grey).

The greatest differences appear in the Pacific Ocean where El Niño has direct impacts. Interestingly, **Scandinavia** shows no differences. This can be explained by two reasons, either El Niño has no impacts on size over this regions or most heatwaves detected over this region **coincide with El Niño** years. The latter is supported by our observation of a high frequency of heatwaves in Scandinavia during those periods. In addition, during El Niño events, the ocean releases heat to the atmosphere, mainly due to increased air-sea heat fluxes driven by the higher sea surface temperatures[5] (SST). We can observe the **largest size difference** between El Niño and La Niña years **over the Pacific** on the Longitude profile.

Methods

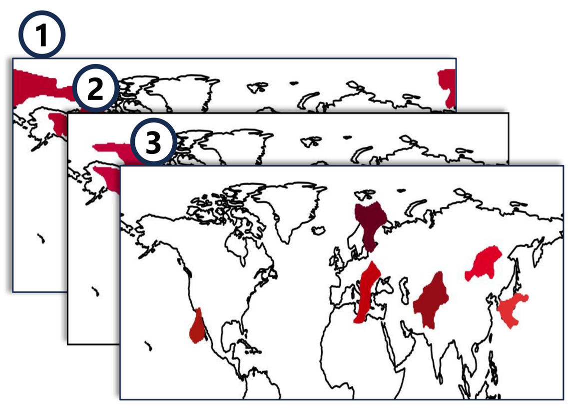
surface temperature (daily mean) ERA5 reanalysis 1959-2023

Heatwave definition

Heatwaves are defined as **regions exceeding the 90th percentile** for at least **3 days** consecutively with at least 50% of there spatial extent overlapping.
The surface temperature **anomaly** was calculated considering a centered 31 days × 9 year moving average.
Only **summer** months (JJA) including heatwaves beginning in May/August and finishing in June/September were analyzed.

Contour analysis

We **associated** each heatwave **contour with its characteristic** (size, duration) previously calculated. Then, we computed the **median** (or average) **value over time** for each grid point.



Composite analysis

We used composite analysis to identify **commonalities** and **differences** between years experiencing **El Niño/La Niña conditions** and those without.
El Niño/La Niña years were defined using the monthly El Niño 3.4 index (ERSSTv5), where SST anomaly was >0.5°C/ <-0.5C° for at least 2 months between May and September.

Conclusion

- Many heatwaves are detected over the ocean, while Europe and India are favored locations for heatwaves over land.
- The longest heatwaves occur in Central America and the shortest in West Pacific.
- North of Europe heatwaves coincide with El Niño years.
- El Niño years reveal larger heatwaves in the Pacific due to Increased air-sea heat fluxes during SST anomalies.

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References
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Questions?
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