A Multi-Faceted, Long-Term Analysis of Mediterranean Heatwaves Using In-Situ Temperature Observations, Remote Sensing Imagery and Large-Scale Circulation Types

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Heatwaves in the Mediterranean region

– An exceptional number of record-shattering temperature extremes has been observed recently worldwide.

– The Mediterranean region is a particularly thermally vulnerable area, frequently suffering from severe heatwaves, projected to increase in recurrence, intensity and persistence in coming decades.

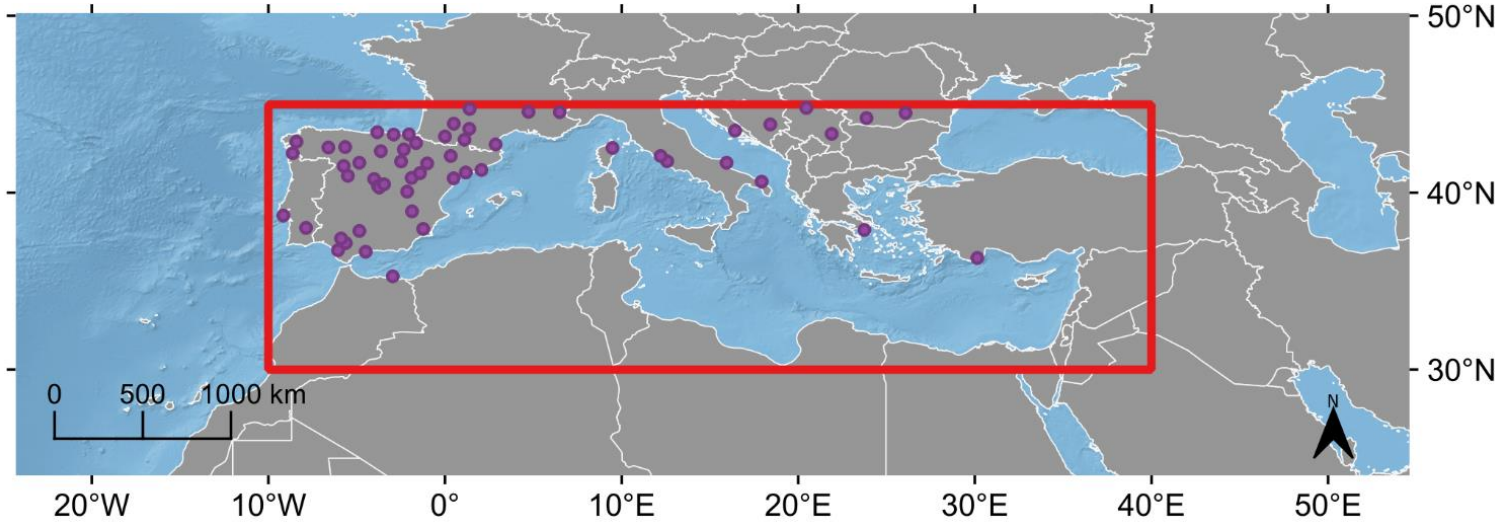
Project *CLIMPACT-National Network for Climate Change* (collaboration of 11 Greek scientific entities with coordinator the National Observatory of Athens)

⟶ Can **satellite-based thermal anomalies** be indicative of heatwaves?

⟶ Which is the spatial and temporal relationship between heatwaves with **atmospheric circulation** in Greece?

Station-based heatwaves

- Daily temperature observations from Global Historical Climatology Network dataset (NOAA)
- 59 weather stations in the Mediterranean area were selected based on:
  - At least 50 years of observations since 1961
  - At least 95% of coverage for summer season days
  - No major land cover changes during the study period



Station-based heatwaves

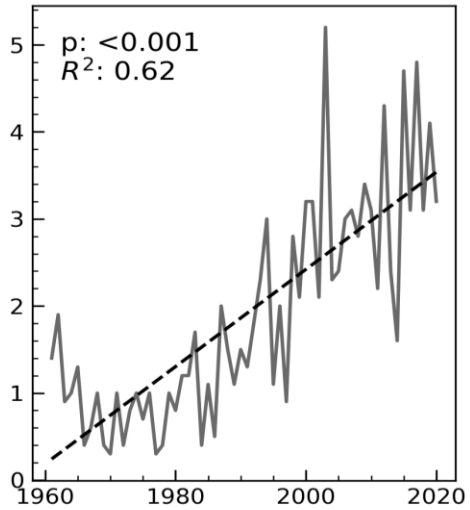
CTX90pct and CTN90pct heatwave definitions (*Perkins & Alexander, 2013*):

(1) 3 or more consecutive days are above the climatologic 90th percentile of Tmax or Tmin respectively (base period: 1961-1990).

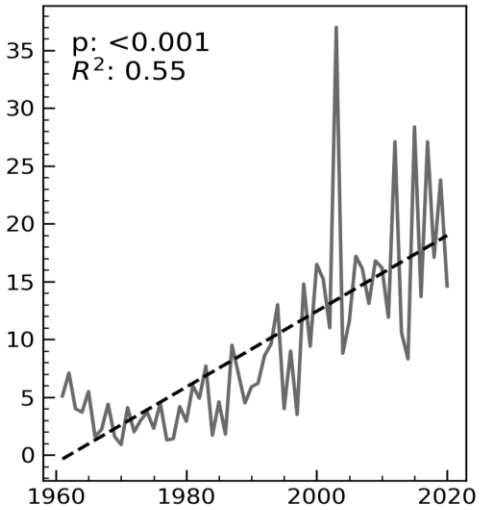
(2) percentile-based thresholds are defined independently for each calendar day based on a 15-day moving window (centered on the specific day).

Statistical significant increasing trends for all heatwave metrics

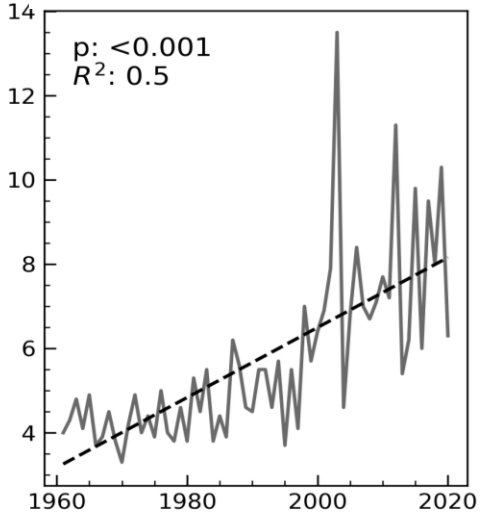
Number of events



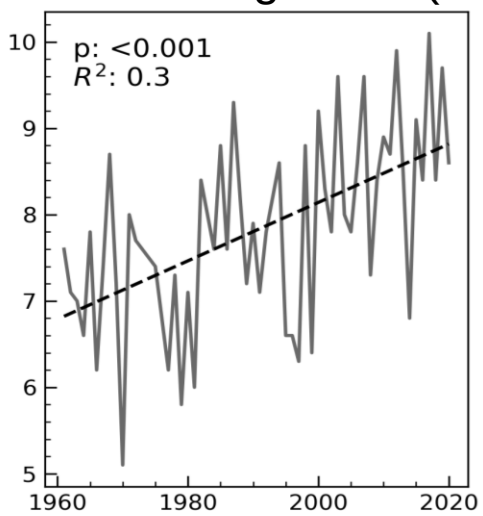
Number of days



Maximum duration



Norm. magnitude (ºC)



Land surface temperature & heatwaves

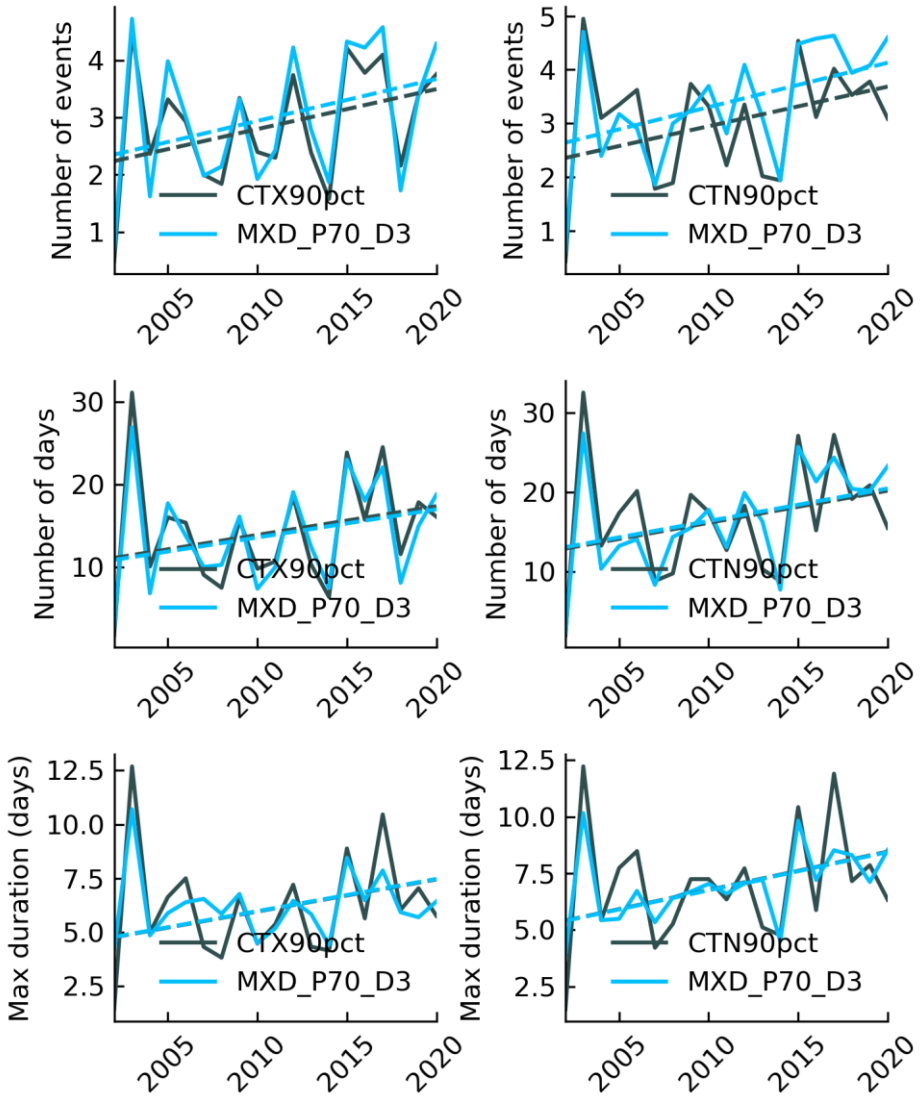
Motivation: LST has been widely used to describe heatwave episodes. Do anomalously high LSTs and heatwaves co-occur spatially and temporally?

- MODIS Terra/Aqua Land Surface Temperature (2002-2020) (MxD11A1 Version 6.1)
- Daily LST anomalies were computed by subtracting the 19-year (2002-2020) mean monthly value and compared against the climatological monthly percentile-based threshold (various percentiles and minimum durations were tested).
- Best performing LST anomaly index: MXD_P70_D3 (joint Terra/Aqua approach, 70th percentile, 3 days minimum duration)

Land surface temperature & heatwaves

– Derived LST anomalies follow the aggregate heatwave climatology of the region with a strong agreement on a year-to-year basis.
(**number of events, number of days, duration**)

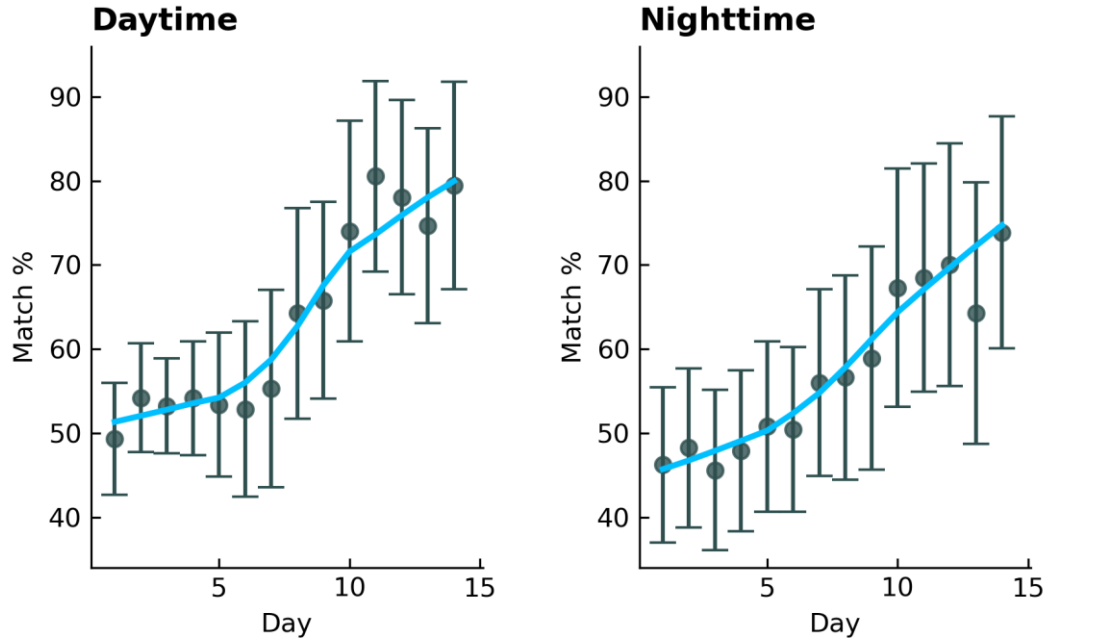
– For both heatwaves and LST anomalies statistically significant ($p < 0.05$) rising heatwave metric trends were observed during the last 20 years.



Land surface temperature & heatwaves

- On average 55% of heatwave days matched LST anomaly days during daytime and 50% during nighttime
- 62% of heatwave events overlapped with an LST anomaly event for at least a day.
- Focusing on the more extreme episodes the match percentage presented a notable increase by 10 to 20 percentage points, up to 75% for daytime a 67% for nighttime.

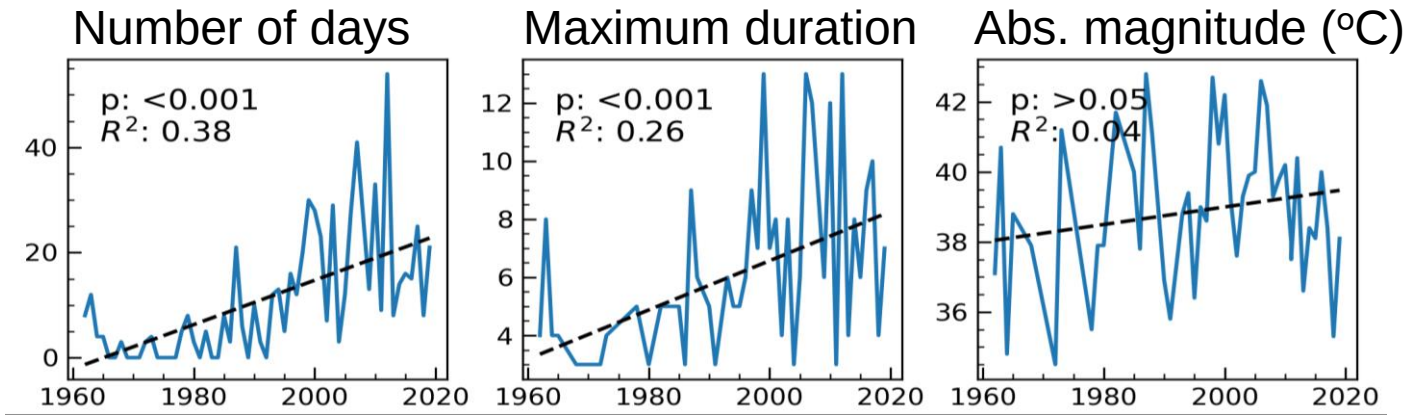
The relation was assessed as a function of the number of days since the start of an episode. As the heatwave progresses the match percentage tends to increase, over 80% for daytime and 75% for nighttime.



Circulation types & heatwaves

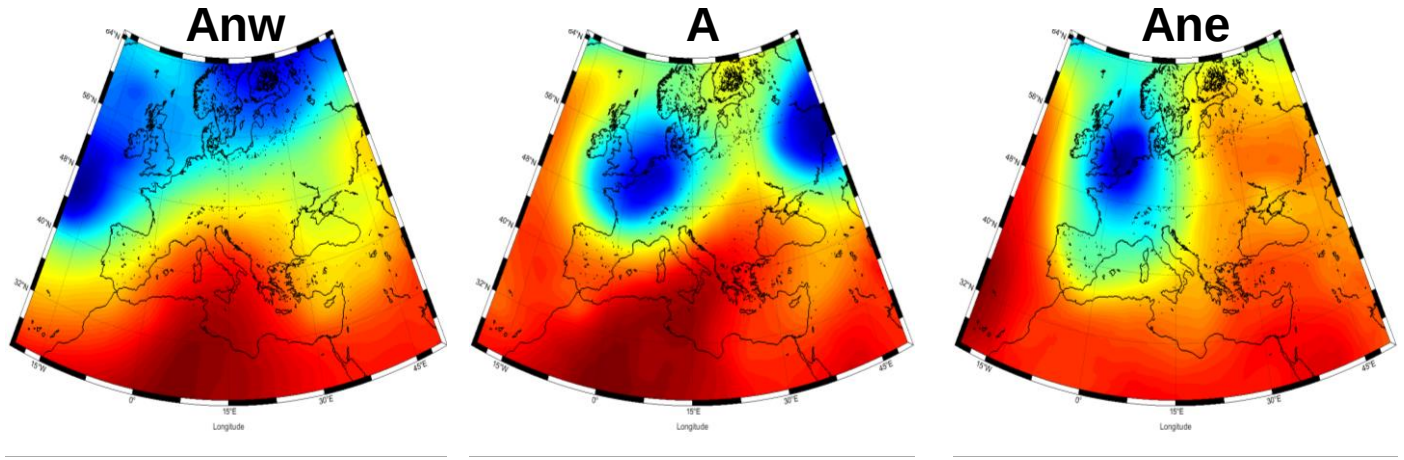
Motivation: Statistical significant increase in frequency and duration but not for magnitude (**Athens**)

Thiseio station: https://data.climpact.gr/dataset/

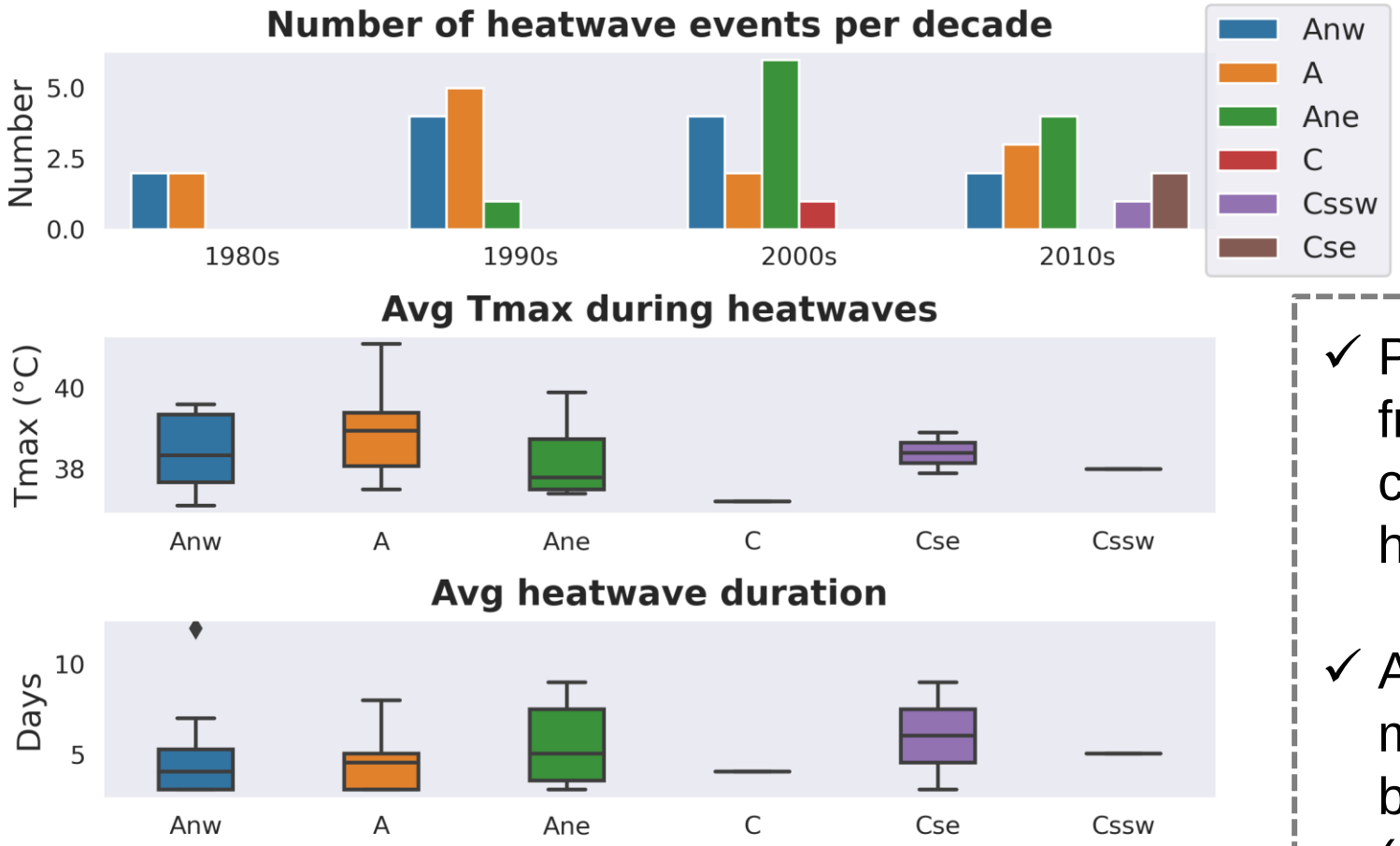


Modified an automated classification scheme for circulation types (*Anagnostopoulou et al., 2009*) that uses daily geopotential anomalies (500 hPa) (ERA5 1979-2020).

Circulation types are determined based on the relative position of the anomaly (upper-level ridge)



Circulation types & heatwaves



- ✓ Progressive change of the frequencies of observed circulation types during heatwaves.
- ✓ After 2000, longer and relatively moderate heatwaves are becoming more common (Ane type).

Future work

- How well do CMIP6 GCM models reproduce the observed circulation types and heatwaves events?
- Do circulation types have effect on the LST-heatwaves relationship?

QUESTIONS?

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