Extreme Weather Events and Their Impact on Temperature in **Climate Projections** (2006–2080)

EART60702

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Climate change is increasing the frequency and intensity of **extreme weather events.**

Understanding future trends in heatwaves, precipitation, and wind extremes is **crucial for climate adaptation.**

*How do **extreme weather events** (heatwaves, heavy precipitation, strong winds) evolve over time in **climate projections** from 2006 to 2080, and how do they impact **temperature levels**?*

To address this question, we utilized a climate projection dataset from the Community Earth System Model (CESM), encompassing 27,374 records spanning from 2006 to 2080.

Attributes

I. Temporal/Spatial:
Time: Time of observation/measurement
Latitude (lat): Latitude of the location (units to be specified - likely degrees)
Longitude (lon): Longitude of the location (units to be specified - likely degrees)

II. Temperature:
TREFMXAV_U: Urban daily maximum of the average 2-meter air temperature (K)
TREFHT: Reference height temperature (K)

III. Wind:
UBOT: Zonal wind component at the lowest model level (m/s)
VBOT: Meridional wind component at the lowest model level (m/s)

IV. Precipitation:
PRECT: Total precipitation rate (m/s)
PRSN: (Undocumented - Potential snowfall/snow precipitation rate.

V. Flux and Humidity:
FLNS: Net longwave flux at the surface (W/m^2)
FSNS: Net Shortwave Flux at the Surface (W/m^2)
QBOT: Water vapor mixing ratio at the lowest model level (kg/kg)

Location

Based on the latitude and longitude attributes (53.246075, 357.5), we identified a unique location within the dataset, in **Norwich, UK.**

Data Preparation

1. Generated month and decade columns to facilitate temporal analysis.
2. Generated columns with temperature in °C
3. Wind speed was calculated using the L2 norm of the relevant wind vector components.

What is an Extreme Weather Event?

Based on the literature, we have defined a **reference period** for the analysis: **2006 to 2016**, which serves as a reference for analysing extreme events in each decade.

Extreme events are identified based on values that exceed certain percentiles within this base period.

HT95

Warm Days

Days (per year /season/ month) with a site-specific threshold, calculated as the calendar-day 95th percentile of the daily temperature distribution in the baseline period.

LT05

Cold Days

Days (per year/ season/ month) with temperatures below a site-specific threshold, calculated as the calendar-day 5th percentile of the daily temperature distribution in the baseline period.

R95

Precipitation Extremes

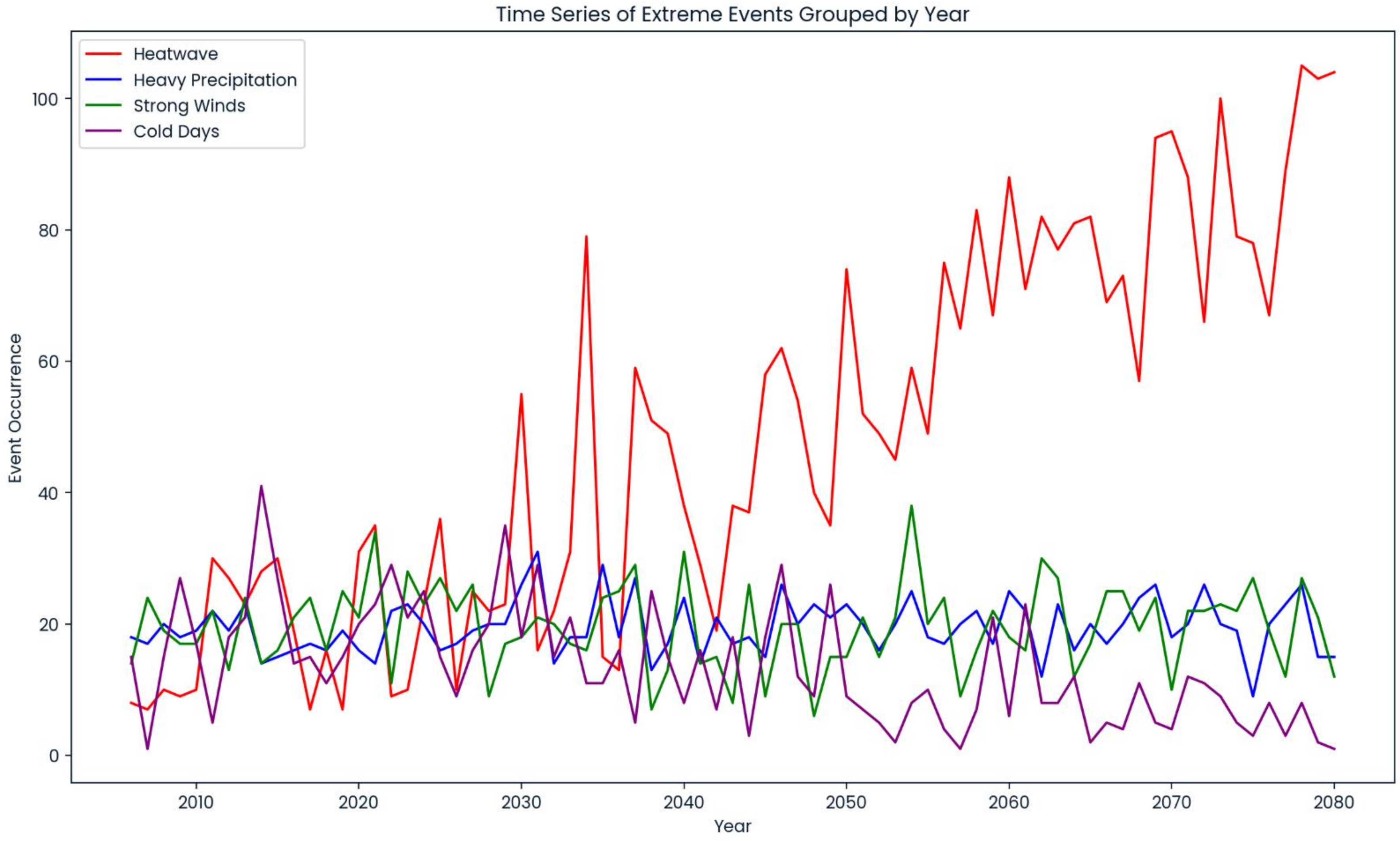
Days (per year/season/month) with precipitation amounts exceeding a site-specific threshold for moderate and very wet days, calculated as the 95th percentile of the daily precipitation distribution in the baseline period.

W95

Wind Extremes

Days (per year /season /month) with wind speeds exceeding a site-specific threshold for moderate and very windy days, calculated as the 95th percentile of the daily wind speed distribution in the baseline period.

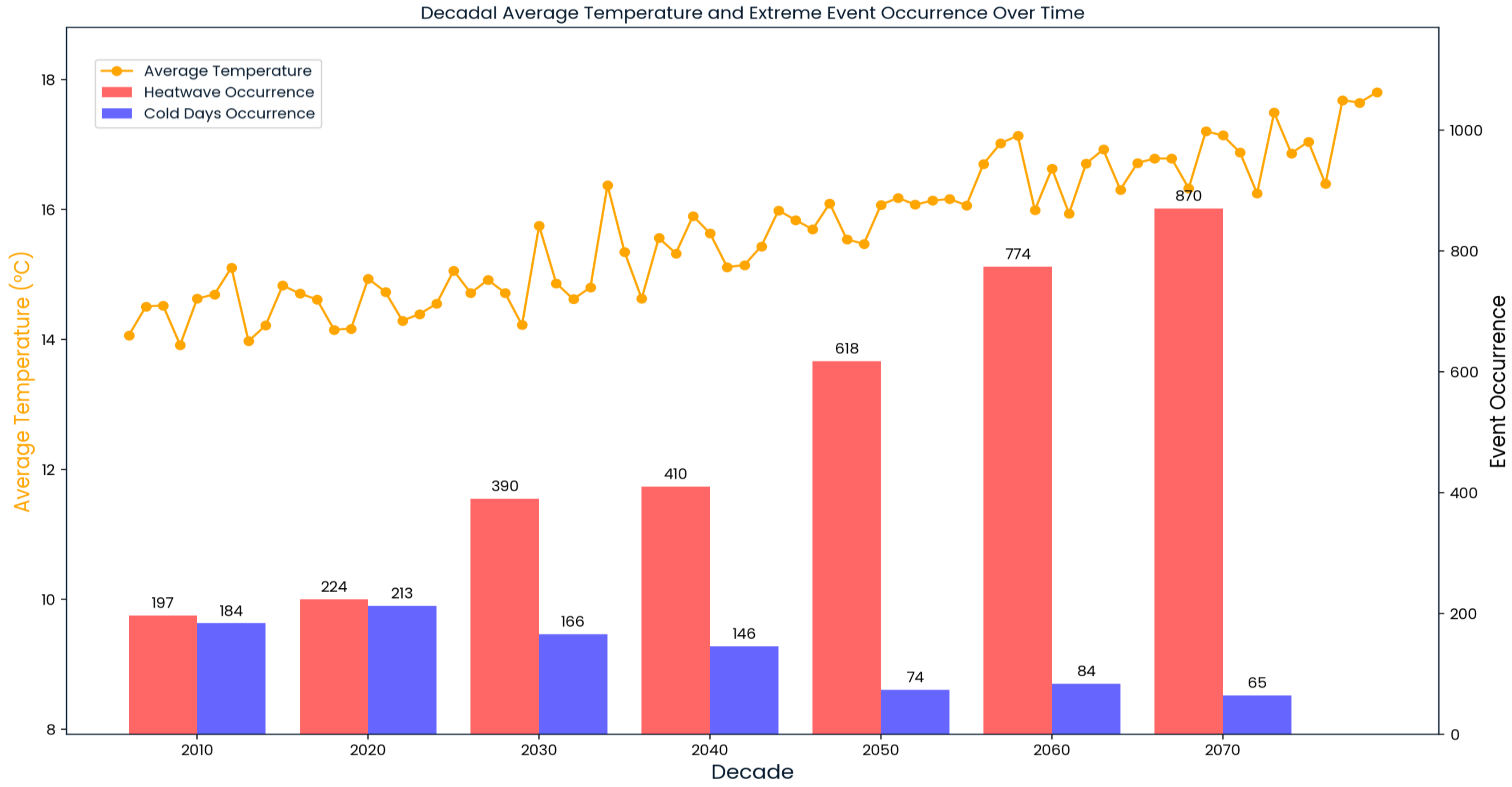
Our analysis of the event time series indicates a projected significant increase in the frequency of heatwaves.



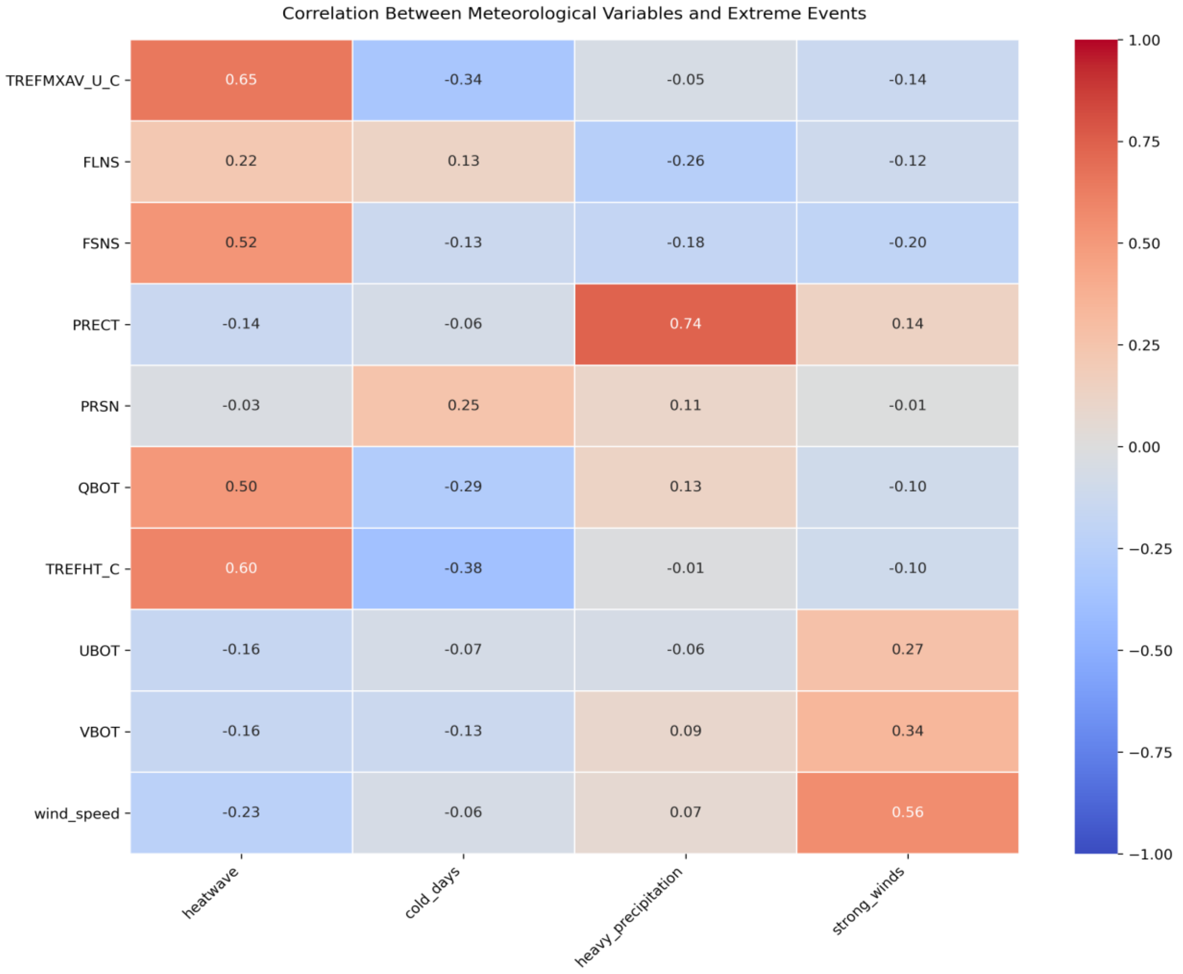
Extreme precipitation and wind events are expected to remain relatively constant over the next few decades, unlike warm and cold events, which tend to vary significantly.

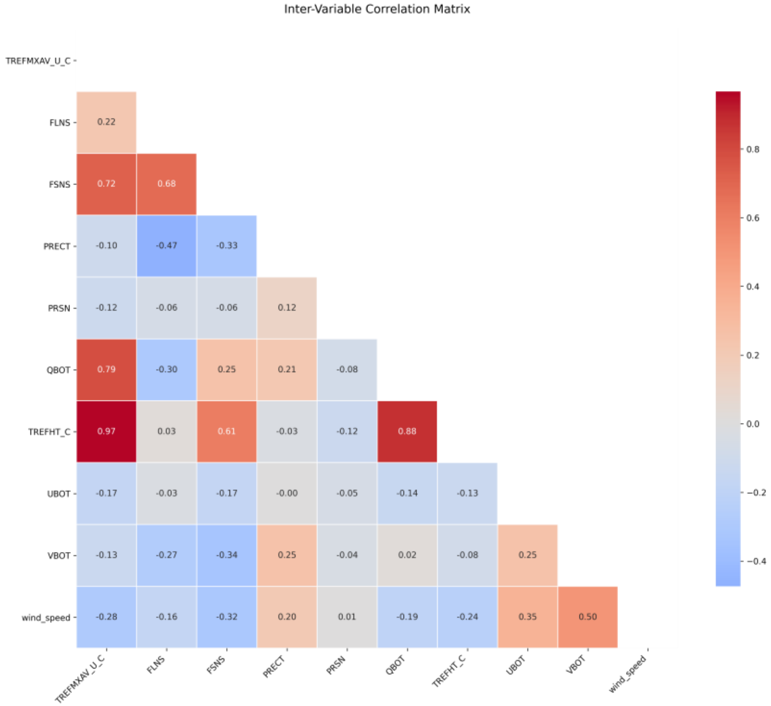
By 2080, extreme heat events are expected to increase by at least 4.4 times compared to the 2010s and average maximum temperatures are expected to increase by at least 25%.

The analysis reveals a projected increase in warm days and a decrease in cold days.



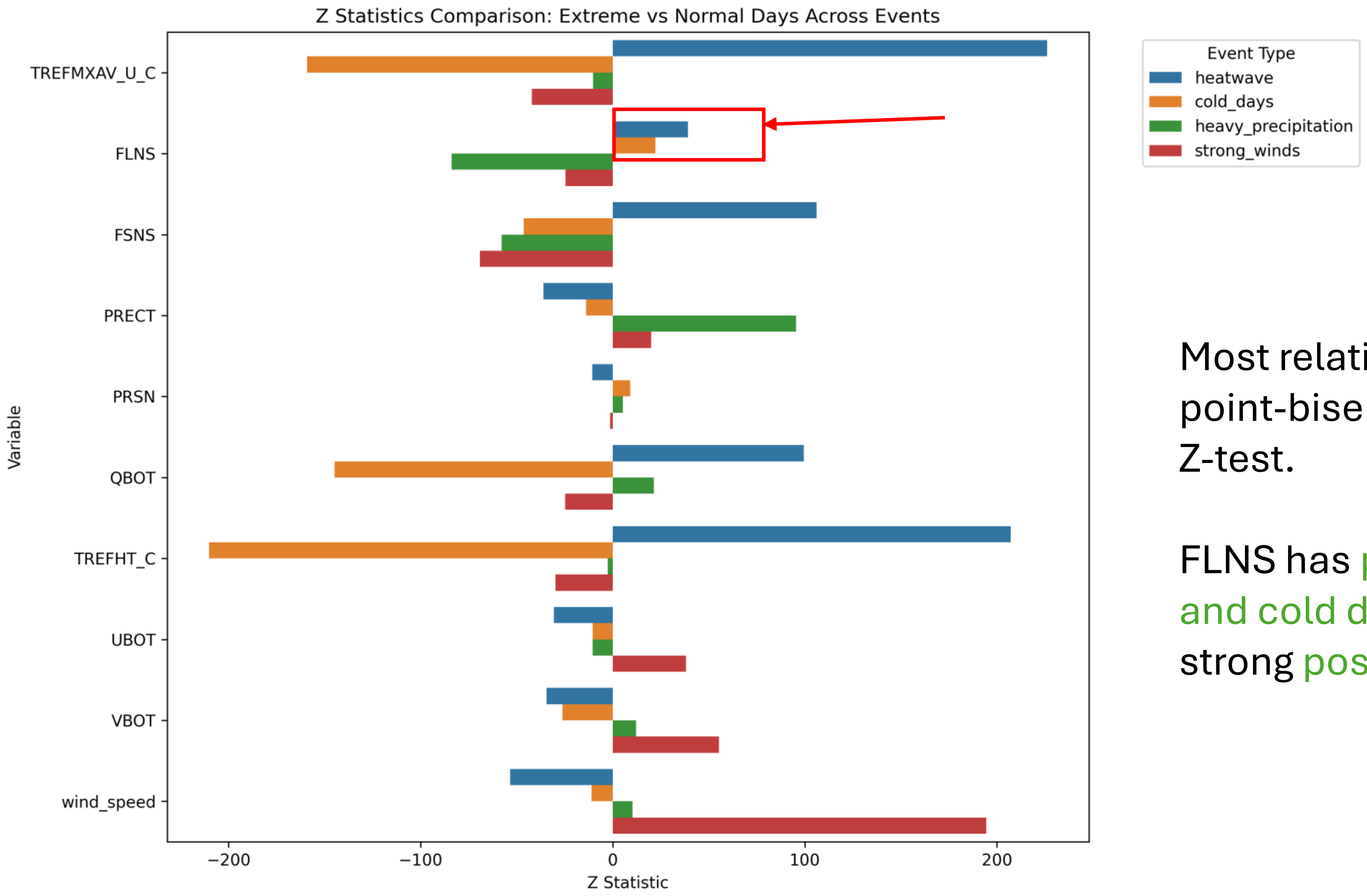
To better understand the relationships between various variables and extreme weather events, we calculate point-biserial correlation coefficients.





Solar flux and humidity strongly influence temperature extremes (heatwaves, cold days), while humidity fuels heavy rain. Wind patterns show complex, often indirect, relationships.

High Z-statistics and near-zero p-values indicate significant differences in variable averages between extreme events and normal days.

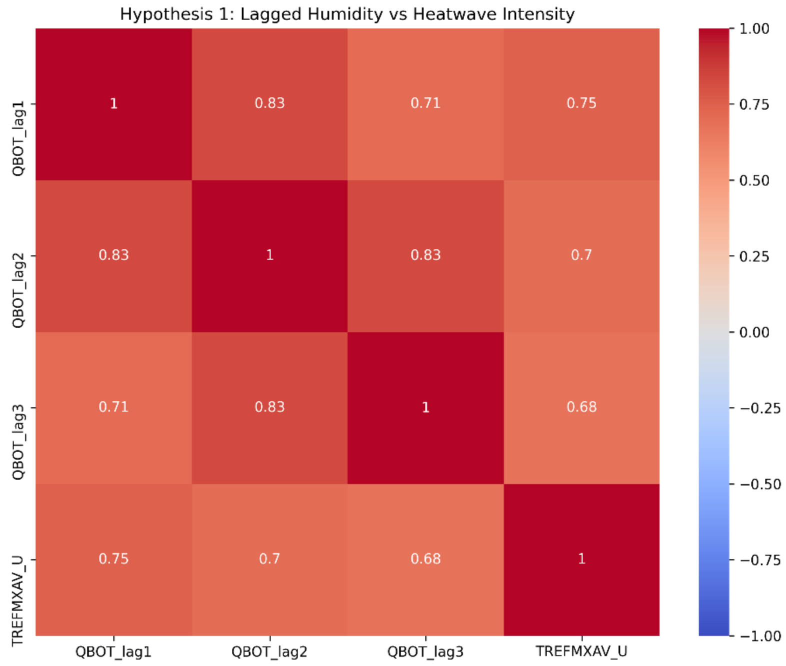


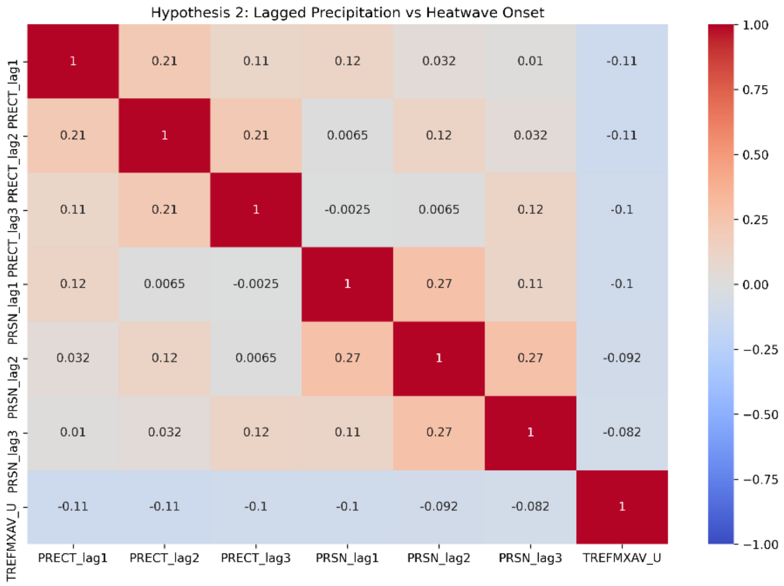
Most relationships in the correlation matrix and point-biserial correlation results are aligned with Z-test.

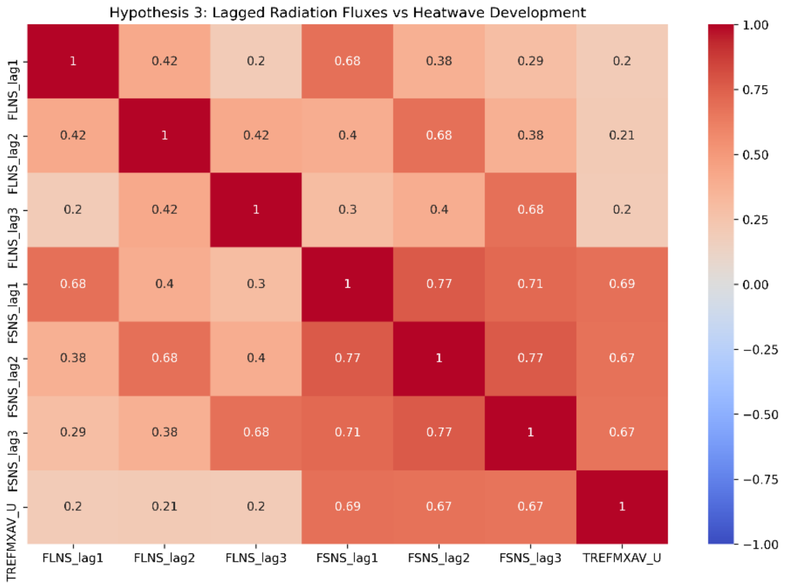
FLNS has positive Z-scores in both heatwaves and cold days
strong positive correlation with temperature.

Lag Effects on Heatwave Development

Key Drivers from Humidity, Precipitation & Radiation







Humidity in past days has a **strong link (0.7–0.8)** to heatwaves.

•**Less rain/snow in past days** shows only a **tiny link (-0.1 to -0.02)** to heatwaves.

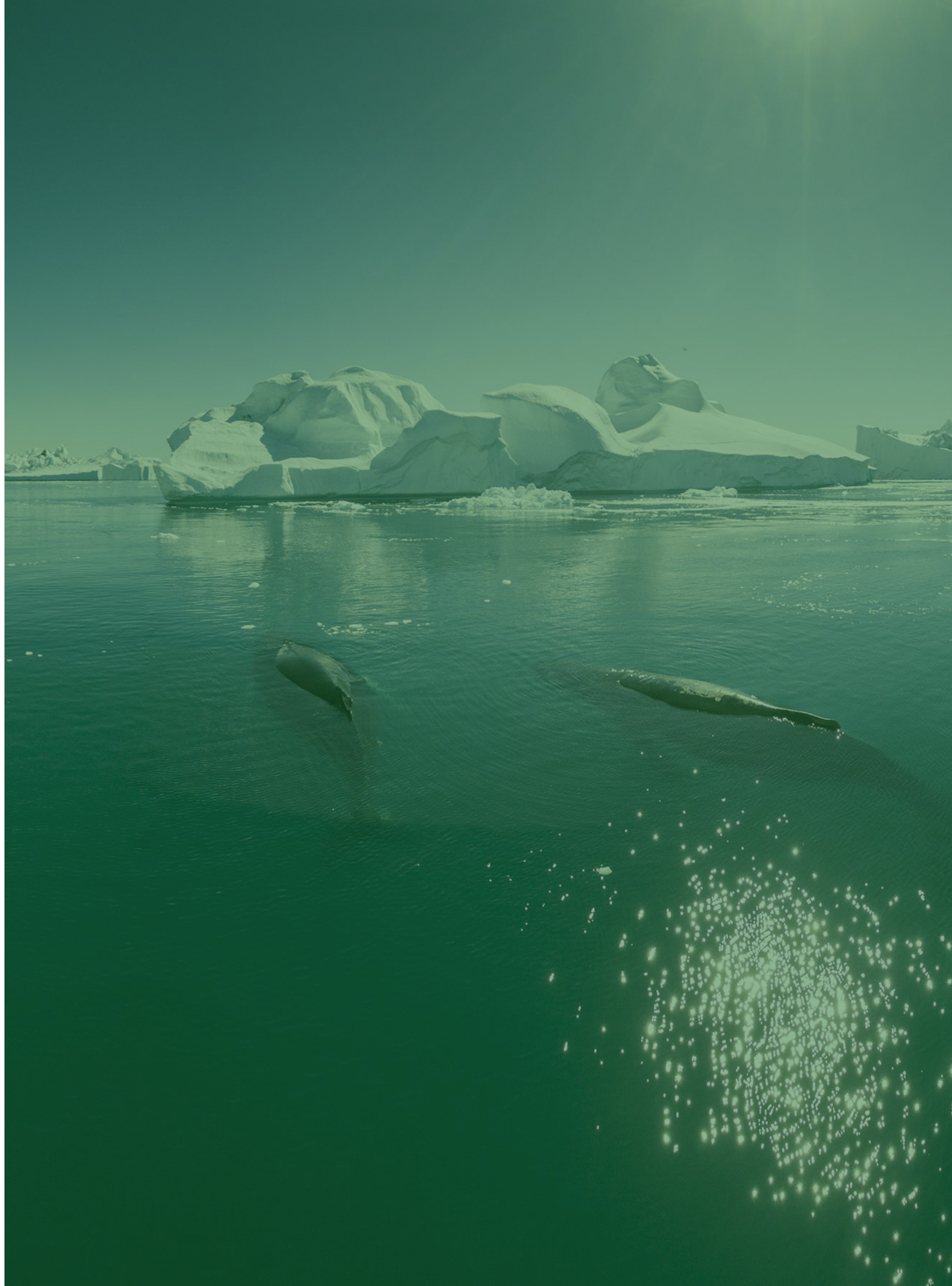
•**Strong sunlight days before → bigger heatwaves** (link: ~0.8).

Conclusions & Implications

1. The frequency and intensity of extreme events are expected to rise, potentially leading to **more frequent and severe heat stress**.

2. **Heatwaves** show dramatic **rising trends**, especially in later decades (2050–2080).

3. High **humidity** and **radiation flux** are strongly correlated with the occurrence of **temperature extremes** and can serve as early warning signals.



Future Work

1. **Validate findings** using historical climate data to compare projected trends with past observations and assess the **reliability of the projections.**
2. **Expand** the analysis to **other regions in the UK** to identify spatial patterns and regional differences in extreme weather events and their temperature impacts.
3. **Develop machine learning models** to predict extreme weather events . Use predictive algorithms to identify early warning signs of extreme heat, storms, or heavy rainfall, improving preparedness and response strategies.

References

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