Multivariate

Sequential

Concurrent

Previous: simple “superposition” simultaneously; joint probability – combined density distribution; spatial clustering of multiple individual extreme events within spatiotemporal distance; event encoding establishing a coding system for CE detection

Propose CE detection method

METHOD:

Preprocessing: ECMWF-ERA5  
Also include CRU\_JRA, and GLDAS (all reanalysis) and  
CMIP6   
Input includes maximum temp, total precip, mean wind speed, mean wind speed at 500 hPa

Use absolute, percentile or combined thresholds to identify individual events

1991-2020 as reference period and 95th, 5th percentiles as thresholds

Detect: hot, dry, wet, windy or stagnation (low surface winds, dry, weak upper-level flow)

Seven combinations:

Hot-dry; hot-dry-stagnation; hot-dry-windy; hot-wet; hot-stagnation; hot-wet-stagnation; wet-windy

Hot-dry, hot-dry-stagnation, hot-dry-windy all known for effects on human health, air pollutants, food security, supply chains  
hot-wet, hot-stagnation, hot-wet-stagnation associated with human perception of ambient temperature, likely heatstroke  
wet-windy associated to flooding events

Characteristics:

Number of events, Number of days, Maximum duration, Minimum duration, Average duration, Average severity, Peak severity, Start date, End date, Extent (proportion of land area)

Limitations: extreme values are not the only events with high impact. E.g. moderate flooding during above-average tides can pose substantial risks

Examples:

Multivariate events during 2022 European Heatwave

0.4C higher than previous summer (hottest season on record) in addition to reduced precipitation and dryness  
- ~ 60000 deaths + reduced river flows and hydrological droughts impacting public water supplies, commercial transport, hydropower  
- based on 95% threshold, >60% of Europe’s land-areas have experienced at least one hot-dry and one hot-dry-stagnation event every summer since 2000  
- in 2022, avg number of hot-dry and hot-dry-stagnation events reached 6 and 4 day resp., twice the average; peak severity also twice the average

Multivariate events during 2019 Australian Wildfires

~462 direct or indirect deaths; 3000 homes destroyed

Maximum duration, number of days, peak severity of hot-dry and hot-dry-stagnation events were observed to be 2-3 times higher than respective avg values

Sequential Events 2022 Pakistan Floods

* Spring 2022 devastating heatwaves -> glacier melting -> excacerbating (both directly and intensification of low-pressure systems):
* Summer 2022 intense rainfall -> severe flooding (~2000 deaths, 1/3 country submerged, 32 million people displaced)

Concurrent Events 2023 Texas Heatwave

* Large spatial distribution of heatwaves