EGU General Assembly 2022

NH10.2 Compound weather and climate events

A Methodology for the Spatiotemporal Identification of Compound Hazards (SI-CH)

Wind and Precipitation Extremes in Great Britain (1979–2019)

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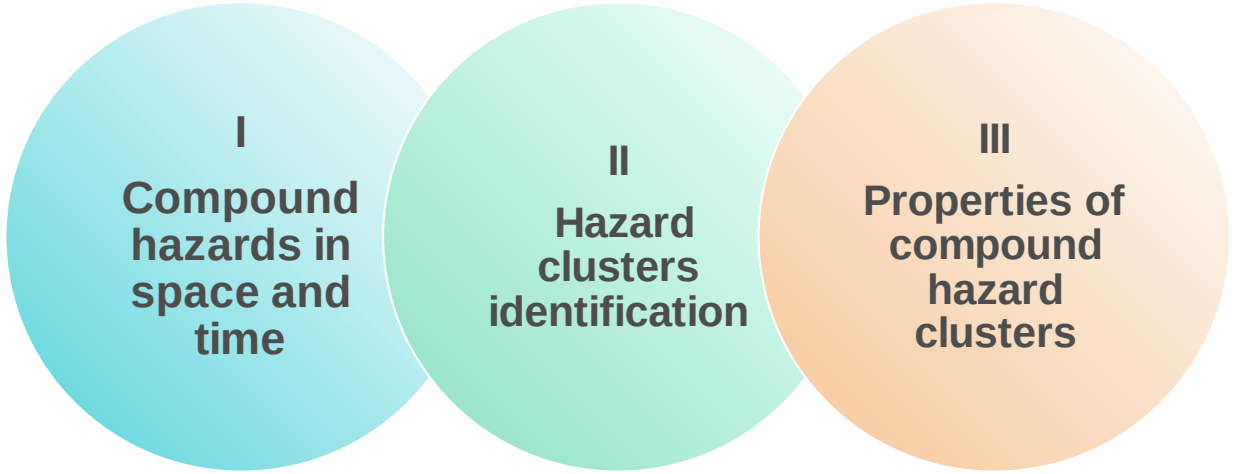
Spatial and temporal scales of compound events

- **Compound natural hazards** can operate on different spatial and temporal scales than their component single hazards.

- Two key **compound hazard** questions:
  - How do we **define** and **characterize** compound hazards in **time** and **space**?
  - What are appropriate methods to **quantify** spatiotemporal attributes of compound hazards?

- Here we illustrate a **methodology** for the **spatial-temporal identification** of **compound hazards (SI–CH)** applied to **wind and precipitation extremes in Great Britain** (1979–2019).

- **Approach aimed to be applicable to different natural hazards interrelations.**

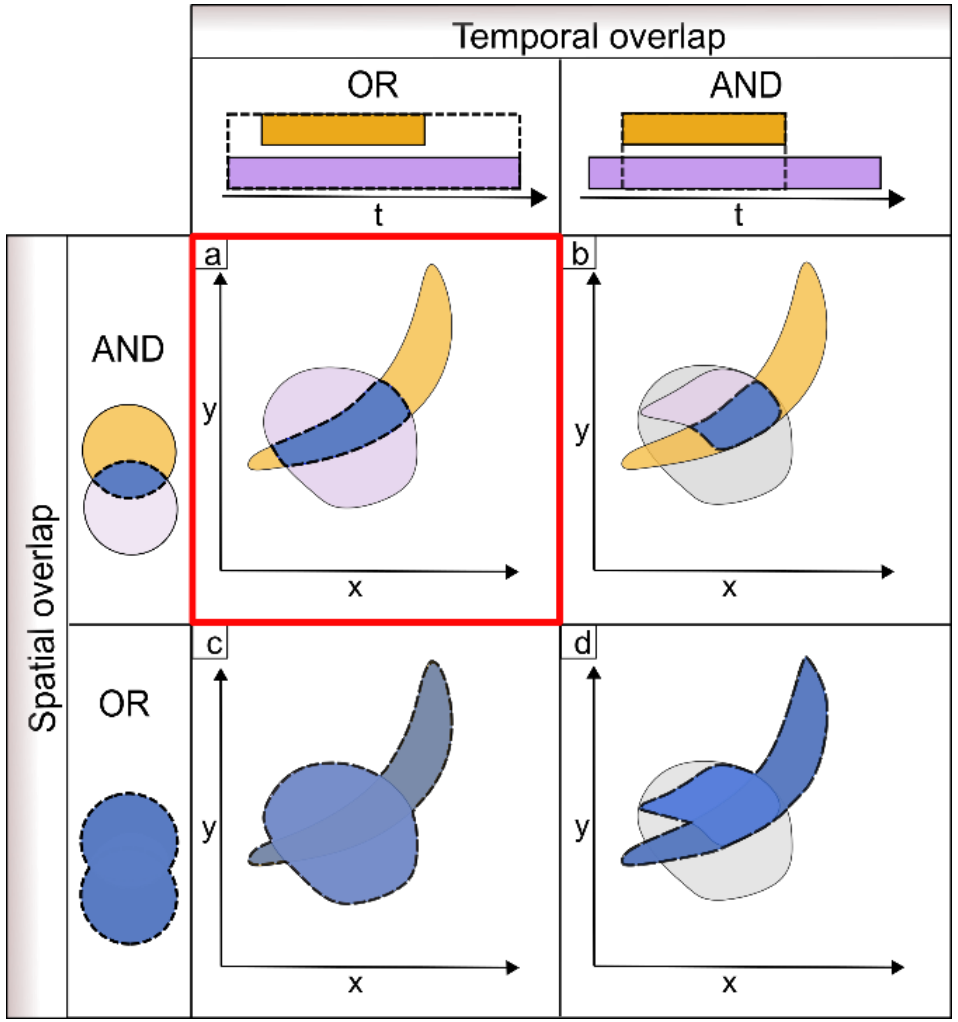


Spatial and temporal scales of compound events

- Hazard clusters: a **cluster** in space and time representing the **footprint** of a **singular phenomenon.**

- **Compound extremes**: two or more associated extreme events **occurring** the **same time and place**.

- **Spatiotemporal footprint** of **compound hazards**: Area impacted by two(or more) hazards during the aggregated duration of a event (AND-OR).

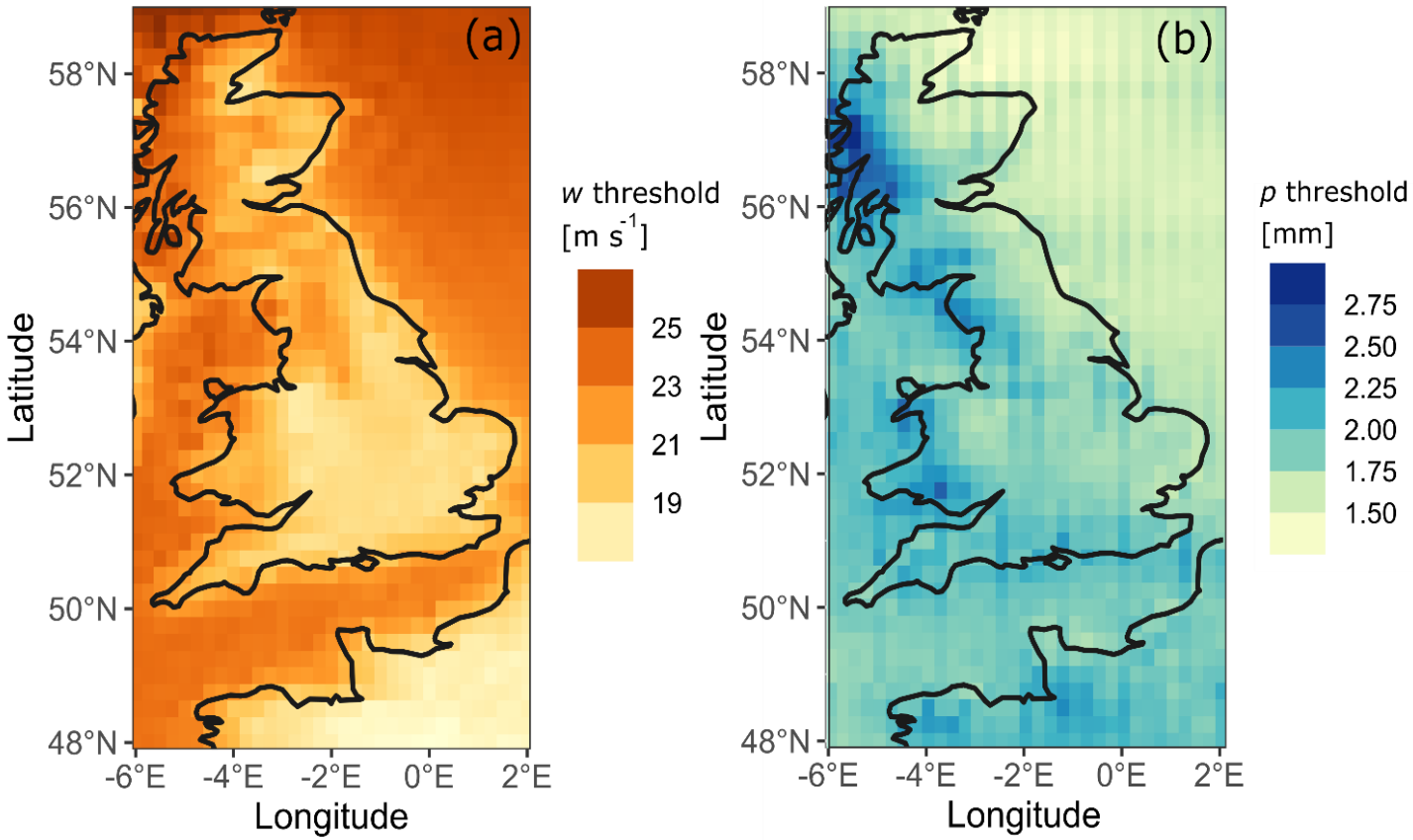


Different spatial and temporal scales considered to define compound hazard events. Each case representing a combination of spatial and temporal overall.

II

Extremes sampling

- Hourly wind and precipitation data from ERA5 (1979–2019).
- We consider for each hour:
  - **Hourly maximum wind gusts** (average 3 s of wind)
  - **Precipitation** (total rainfall and snow).
- For each we take the **99th percentile** computed on each grid cell of the domain (1485 cells).
- **Compound hazard clusters**: **co-occurrences** of **extreme wind** and **extreme rainfall clusters.**



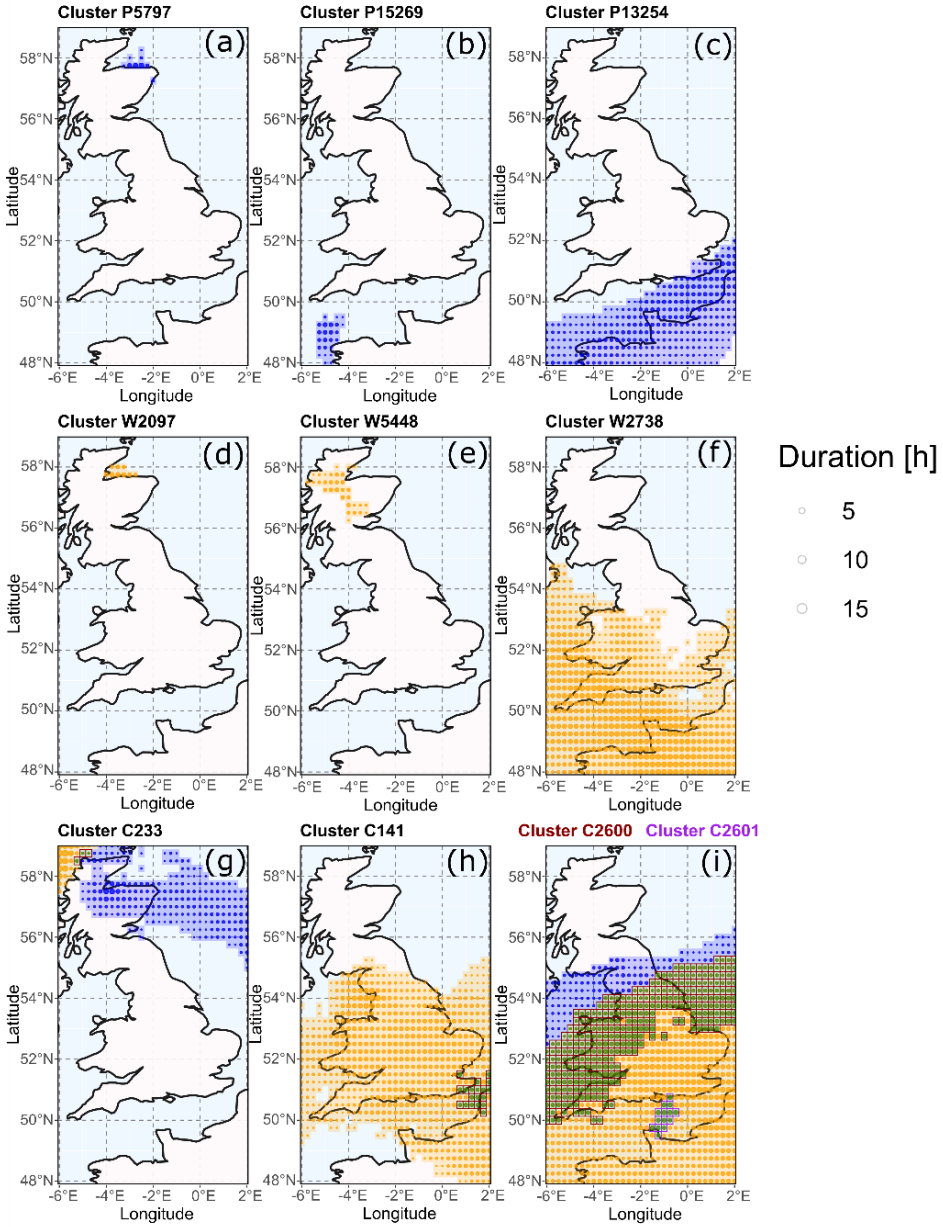
Threshold values corresponding to 99th percentile of each grid cell, 1979-2019, for hourly maximum wind gust (*w*) and hourly rainfall accumulation (*r*).

II

Cluster identification

- **Extremes** are **point objects** with coordinates in space (latitude and longitude) and time (date)
- Clustering algorithm: Density Based Spatial Clustering of Applications with Noise (**DBSCAN**)
- Extremes are clustered in time and space
- Each cluster has attributes

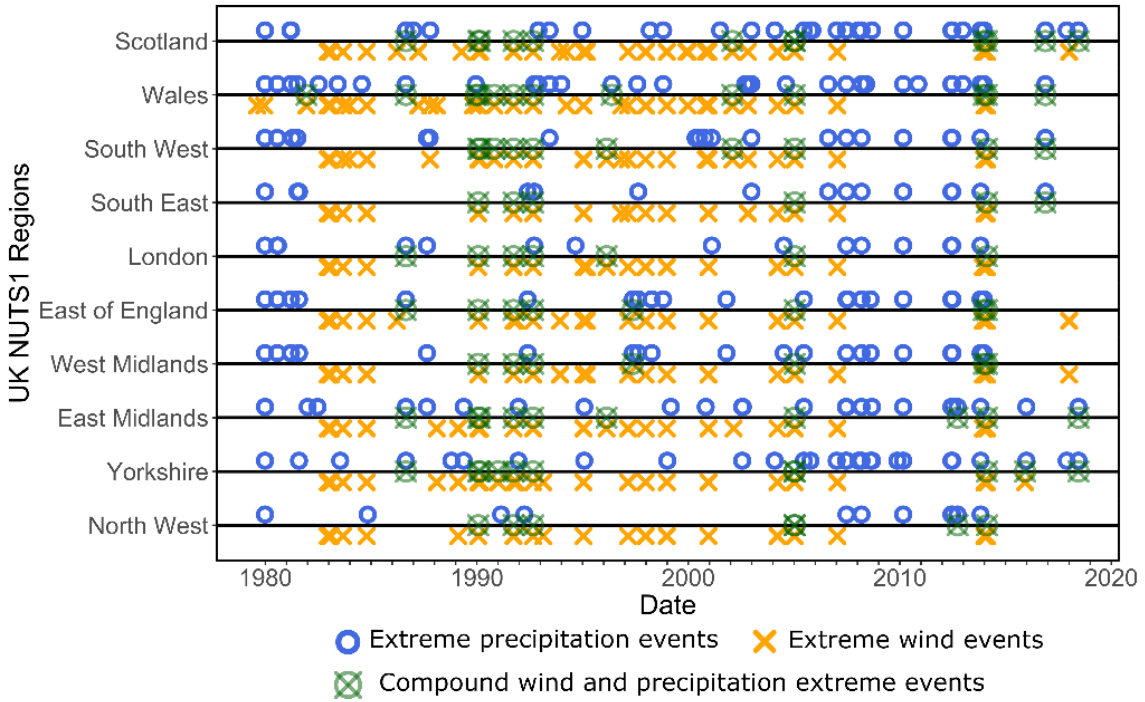
	Attribute	Wind clusters	Precipitation clusters	Compound wind–precipitation clusters
Intensity	p_a (mm)		✓	✓
	w_g (m s^{-1})	✓		✓
Scales	Footprint (%)	✓	✓	✓
	Duration (h)	✓	✓	✓
Historical	Start time (h)	✓	✓	✓
	End time (h)	✓	✓	✓
	Location (cells involved)	✓	✓	✓



Footprints of ten example natural hazard clusters over Great Britain.

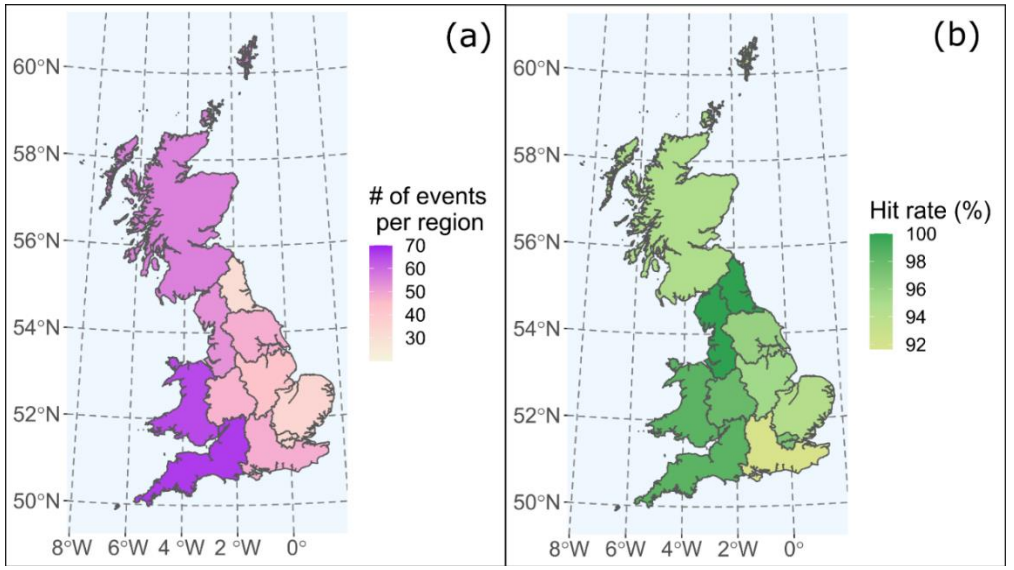
Confrontation with significant events

- We create "Great Britain Significant Weather Events Catalogue 1979–2019" consisting of **157 significant Great Britain weather events** between January 1979 and September 2019.



Timeline of 157 events in the Great Britain Significant Weather Events Catalogue 1979–2019

- Also created "Database of **4555 compound hazard clusters for Great Britain** (1979-2019)".
- **Hit rate** (# of events with corresponding clusters / total # of events) used to assess the capacity of our "Spatiotemporal Identification of Compound Hazards" (SI–CH) methodology.
- Over Great Britain, **hit rate = 93.4%.**



Map of Great Britain divided into 11 NUTS1 regions showing: (a) the number of events per region, (b) for each region, the hit rate

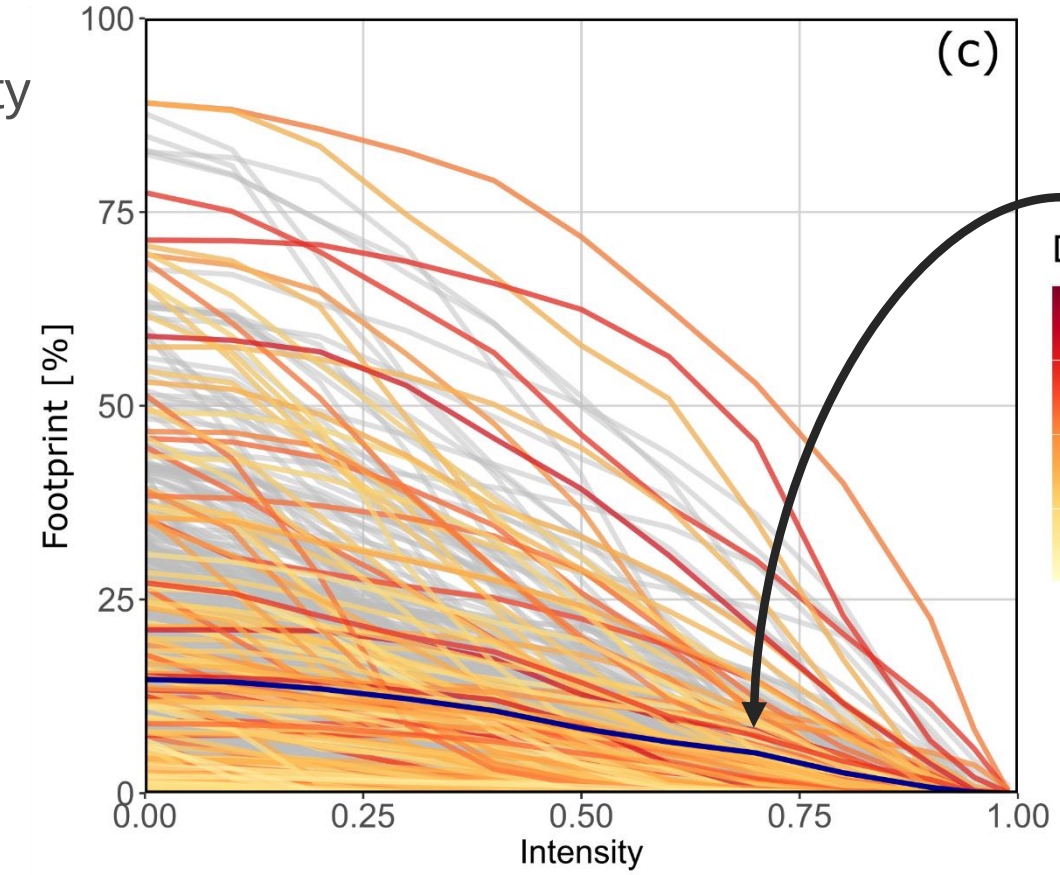
Properties of compound hazard clusters

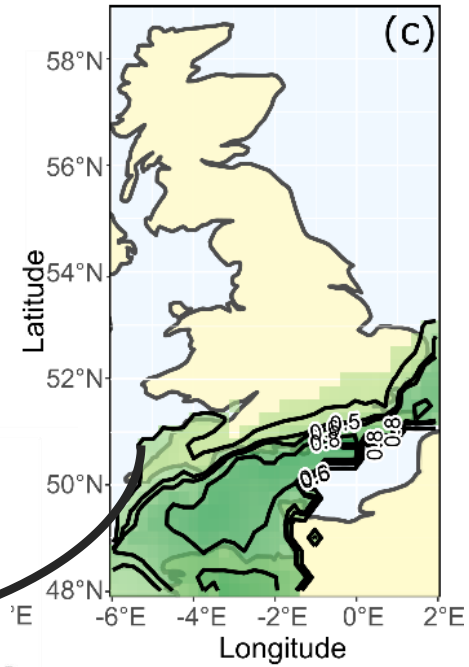
- Combined intensity of compound hazards

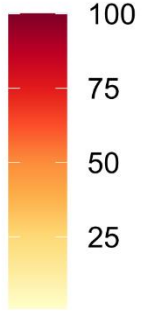
minimum cumulative probability

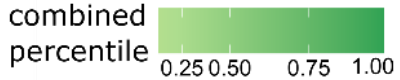
$$P(x_i, y_i) = \min\left(\frac{R_{x,i}}{N_x + 1}, \frac{R_{y,i}}{N_y + 1}\right)$$

- **Spatial scale, temporal scale, intensity**
- Most intense compound hazard clusters linked to a significant weather event
- >1 cluster per event









Footprint and intensity of compound clusters associated with storm Angus (2016)

Spatial-quantile plot for the 4555 compound hazard clusters detected

Thank you

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Uncorrected proofs for manuscript accepted for publication

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Research article

A methodology for the spatiotemporal identification of compound hazards: wind and precipitation extremes in Great Britain (1979–2019)

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Abstract Compound hazards refer to two or more different natural hazards occurring over the same time period and spatial area. Compound hazards can operate on different spatial and temporal scales than their component single hazards. This article proposes a definition of compound hazards in space and time, presents a methodology for the spatio-temporal identification of compound hazards (SI–CH), and compiles two compound-hazard-related open-access databases for extreme precipitation and wind in Great Britain over a 40-year period. The SI–CH methodology is applied to hourly precipitation and wind gust values for 1979–2019 from climate reanalysis (ERA5) within a region including Great Britain and the British Channel. Extreme values (above the 99 % quantile) of precipitation and wind gust are clustered with the Density-Based Spatial Clustering of Appli-cations with Noise (DBSCAN) algorithm, creating clusters for precipitation and wind gusts. Compound hazard clusters that correspond to the spatial overlap of single hazard clusters during the aggregated duration of the two hazards are then identified. We compile these clusters into a detailed and comprehensive ERA5 Hazard Clusters Database 1979–2019 (given in the Supplement), which consists of 18 086 precipitation clusters, 6190 wind clus-ters, and 4555 compound hazard clusters for 1979–2019 in Great Britain. The methodology's ability to identify extreme precipitation and wind events is assessed with a catalogue of 157 significant events (96 extreme precip-itation and 61 extreme wind events) in Great Britain over the period 1979–2019 (also given in the Supplement). We find good agreement between the SI–CH outputs and the catalogue with an overall hit rate (ratio between the number of joint events and the total number of events) of 93.7 %. The spatial variation of hazard intensity within wind, precipitation, and compound hazard clusters is then visualised and analysed. The study finds that the SI–CH approach (given as R code in the Supplement) can accurately identify single and compound hazard events and represent spatial and temporal properties of these events. We find that compound wind and precip-itation extremes, despite occurring on smaller scales than single extremes, can occur on large scales in Great Britain with a decreasing spatial scale when the combined intensity of the hazards increases.

Resources:

Tilloy, A., Malamud, B. D., & Joly-Laugel, A. (2022). A Methodology for the Spatiotemporal Identification of Compound Hazards: Wind and Precipitation Extremes in Great Britain (1979–2019). *Earth System Dynamics* (In Press).

- **ERA5 Hazard Clusters Database for Great Britain 1979–2019** (Wind, Precipitation, Compound hazards).
- **Great Britain Significant Weather Events Catalogue 1979–2019**.