CGFI UK Centre for Greening Finance & Investment

University of BRISTOL

How might compound wind and flood risks impact UK Infrastructure?

DR HANNAH BLOOMFIELD

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Background

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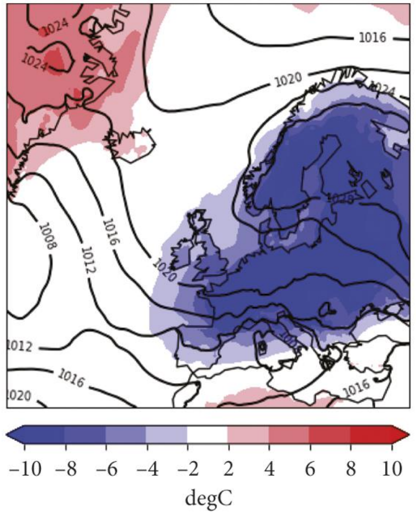
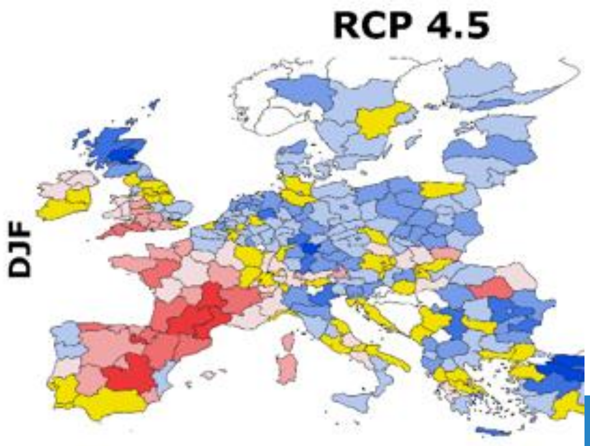
Talk to me about any of these later!

1. Postdoc in climate risk analytics at University of Bristol.
2. Working on how the energy and insurance sectors can use weather and climate data better.
3. Key theme of this work is extreme events, and resilient energy systems

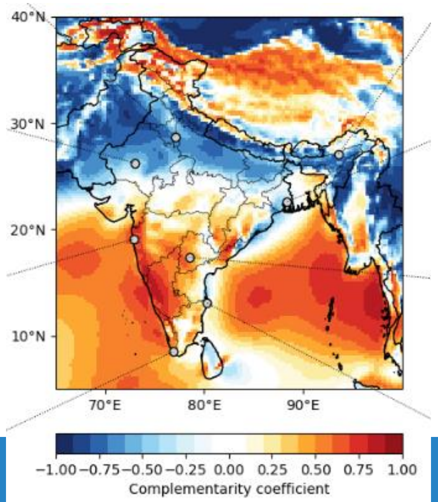
High demand
cold + low wind



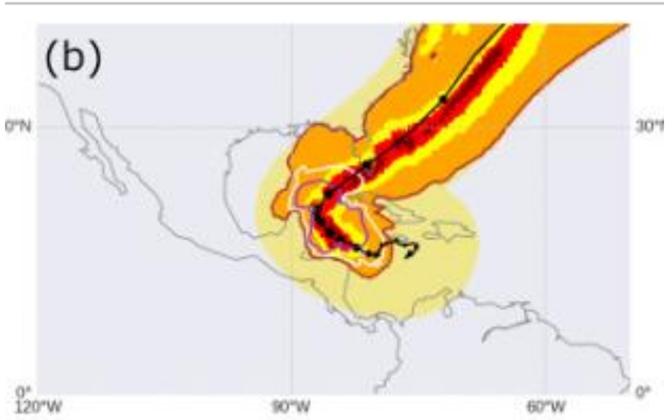
European 'Dunkelflaute'
wind + solar droughts



Renewable
complementarity



Tropical cyclone damage
to wind farms



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Motivation

Strong winds and extremes in precipitation can produce devastating socio-economic impacts.

Wind storms are the main cause: e.g. Storm Kyrill (2007) had estimated insured losses for Europe of £6.3 billion (Fink et al., 2009).

The 2013/14 winter UK floods caused economic damages of £1.3 billion (Environmental Agency, 2016).

More Recently compound events from storms Dudley, Eunice and Franklin.

Storm Eunice wind damage

Storm Franklin floods greater Manchester

Motivation

Strong winds and extremes in precipitation can produce devastating socio-economic impacts.

Thousands of homes can be left without power after wind storms if pylons are damaged and the network requires repair.

Power supplies in the UK face a significant threat from flooding because many electricity substations are located in floodplains.

Is there correlation between extreme wind damage and flooding over Europe?

Strong winds in Houghton-le-Spring

Flooded UK substation

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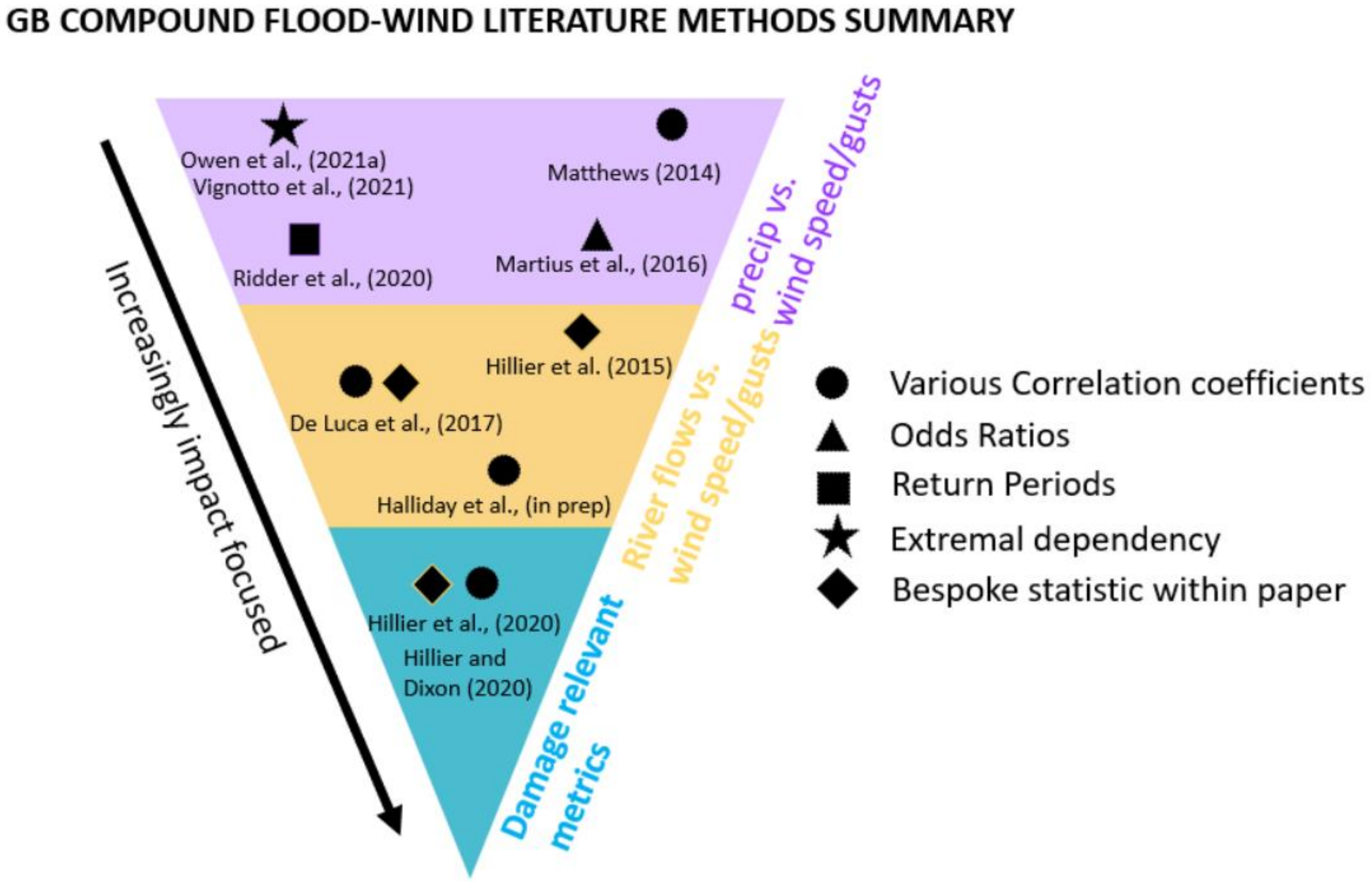
Key literature



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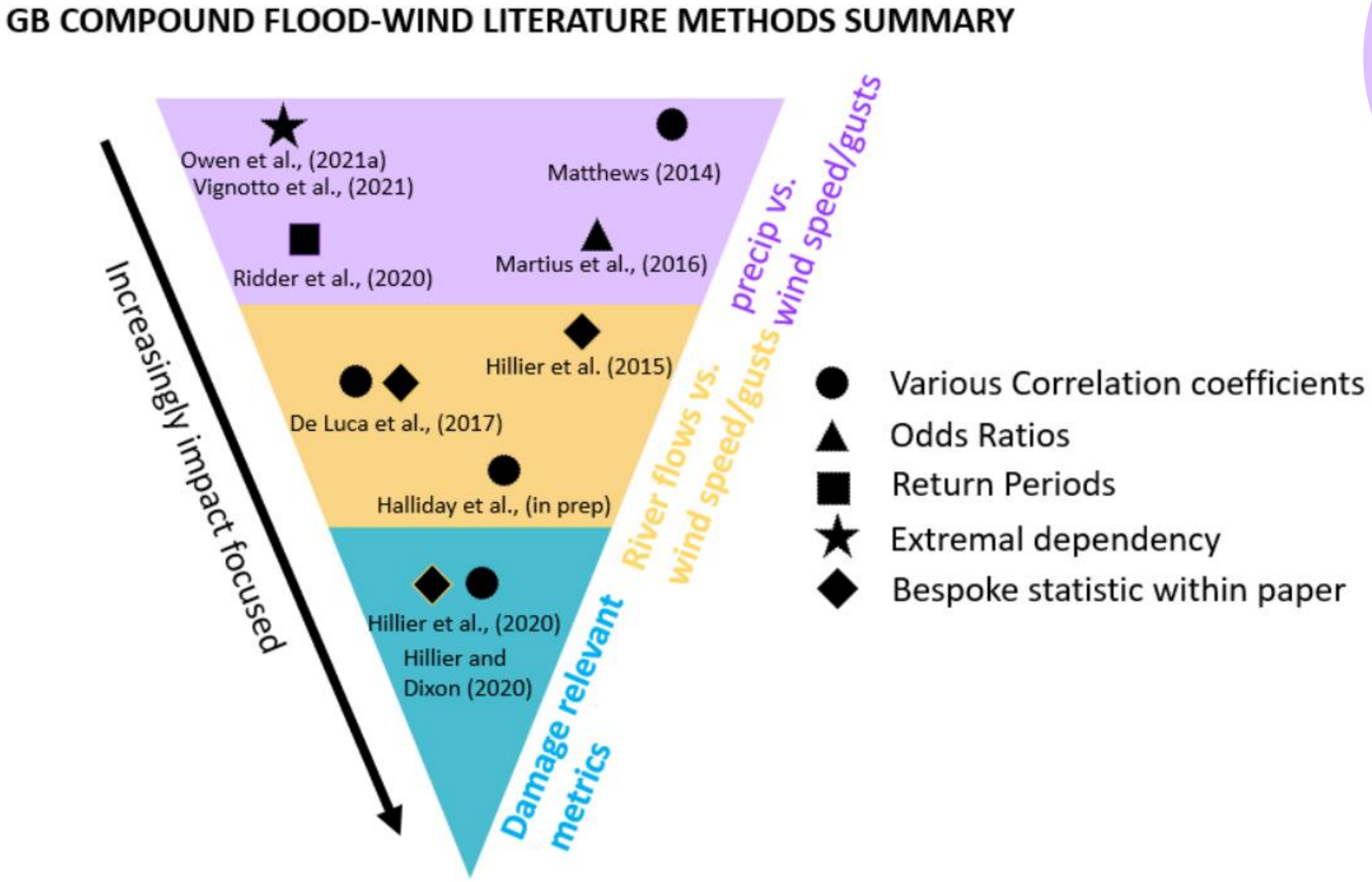
Key Literature Gaps



Focus on precip rather than on riverflow…

Model resolution is generally quite coarse for thinking about catchments

Studies not easily translatable to impact-metrics

Generally, a focus on present day climate

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Data

Wind Data

ERA5 Reanalysis (1980-present)

UK Climate Projections (UKCP) Regional 12km simulations

Precipitation Data

ERA5 Reanalysis (1980-present)

UK Climate Projections (UKCP) Regional 12km simulations

River Flow Data

Glofas historical run (1980-2018)

UKCP 12km run through the CEH Grid2Grid hyrdrological model

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Metrics for wind/flood damage

Wind Damage Metric

Storm Severity Index

Exceedance of P98 max daily wind gust

$$SSI(t) = \sum_{i=1}^{N_i} \sum_{j=1}^{N_j} \left(\frac{v(t)_{i,j}}{v^{98}_{i,j}} - 1\right)^3 \cdot I_{i,j} \cdot L_{i,j} \cdot pop_{i,j}$$

$$I_{i,j} = \begin{cases} 0 & \text{if } v(t)_{i,j} < v^{98}_{i,j} \\ 1 & \text{otherwise} \end{cases}$$

$$L_{i,j} = \begin{cases} 0 & \text{over sea} \\ 1 & \text{over land} \end{cases}$$

Flood Damage

Flood Severity Index

Exceedance of P99.5 total daily river discharge (twice year overtopping of river)

$$FSI(t) = \sum_{i=1}^{N_i} \sum_{j=1}^{N_j} \left(\frac{q(t)_{i,j}}{q^{99.5}_{i,j}} - 1\right) \cdot I_{i,j} \cdot L_{i,j} \cdot pop_{i,j}$$

$$I_{i,j} = \begin{cases} 0 & \text{if } q(t)_{i,j} < q^{99.5}_{i,j} \\ 1 & \text{otherwise} \end{cases}$$

$$L_{i,j} = \begin{cases} 0 & \text{over sea} \\ 1 & \text{over land} \end{cases}$$

Start with a GB focus

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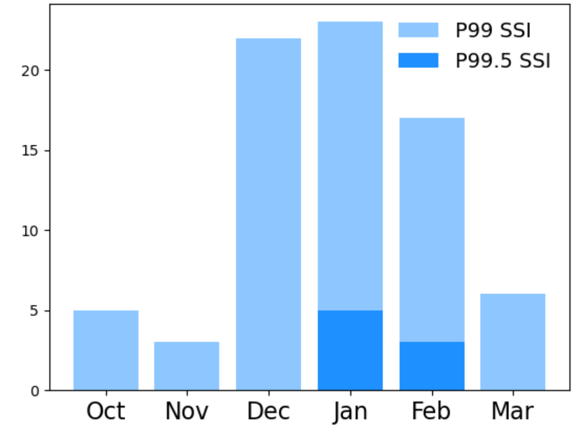
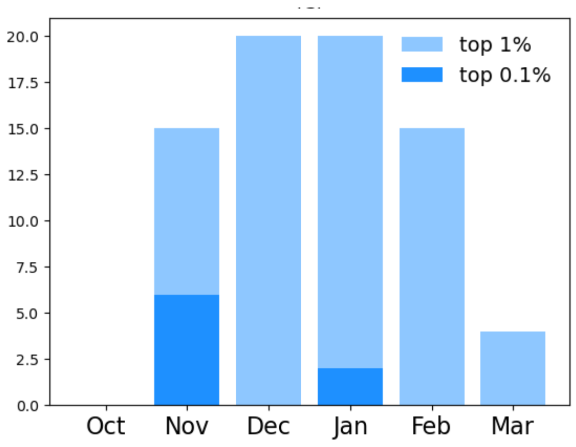
When & Where are big events?

Largest Wind damage events



Largest Flood damage events



This is useful to understand when/where critical infrastructure is most likely to be at risk.

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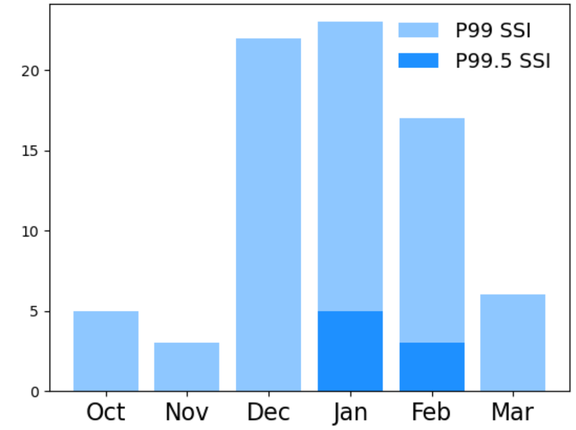
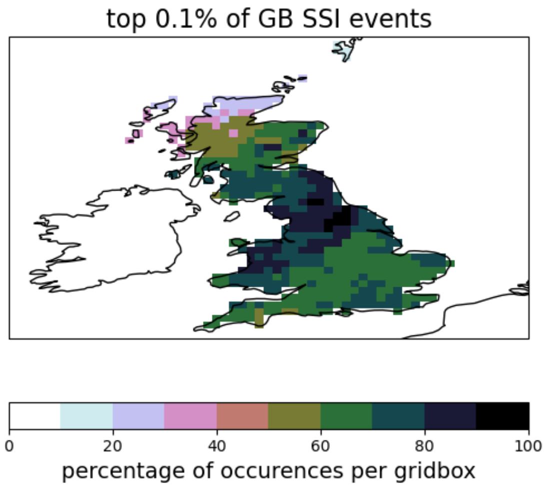
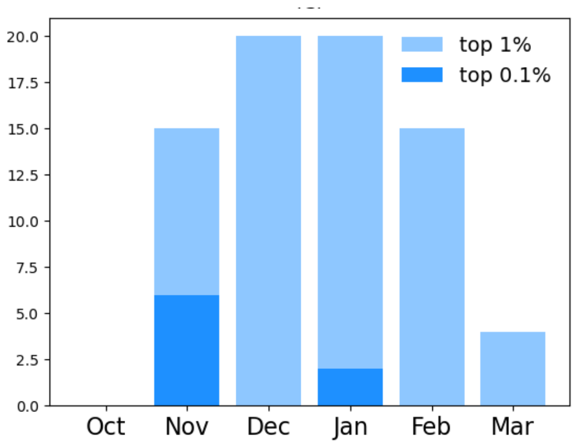
When & Where are big events?

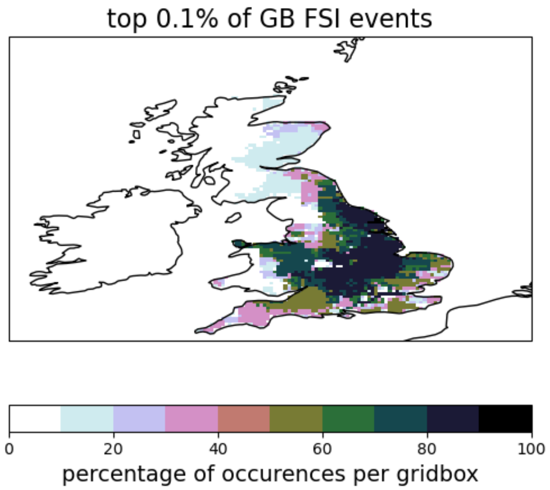
Largest Wind damage events





Largest Flood damage events





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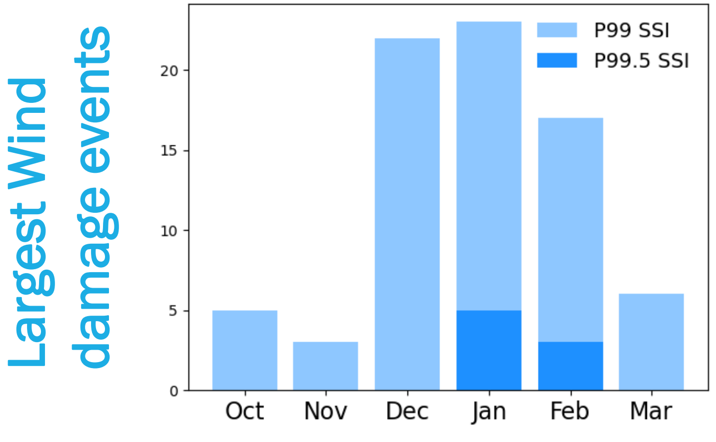
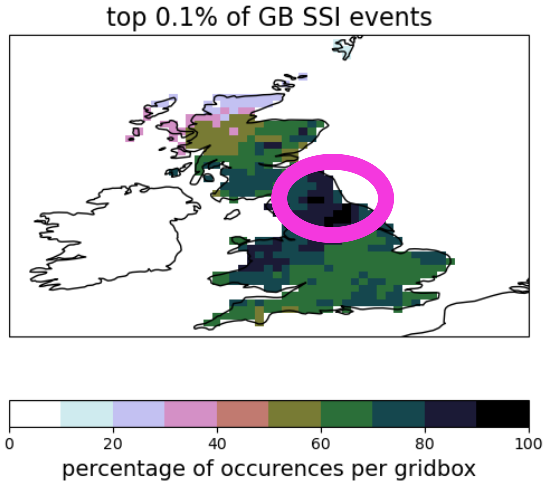
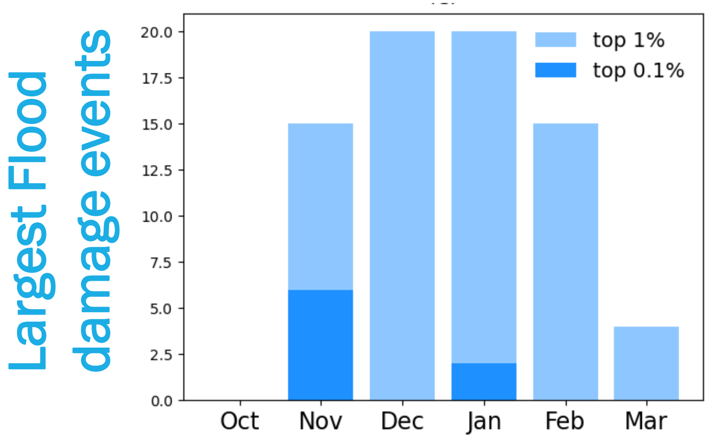
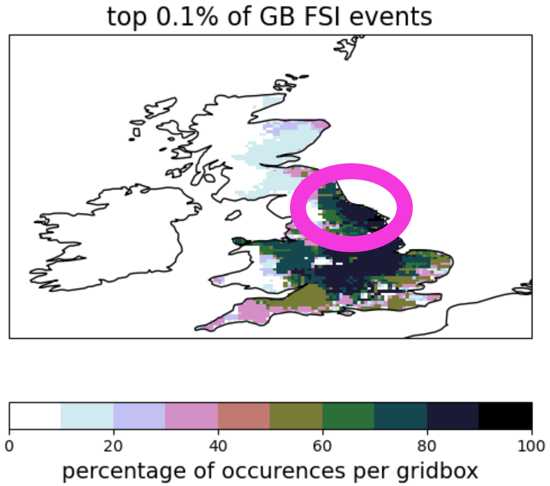
When & Where are big events?









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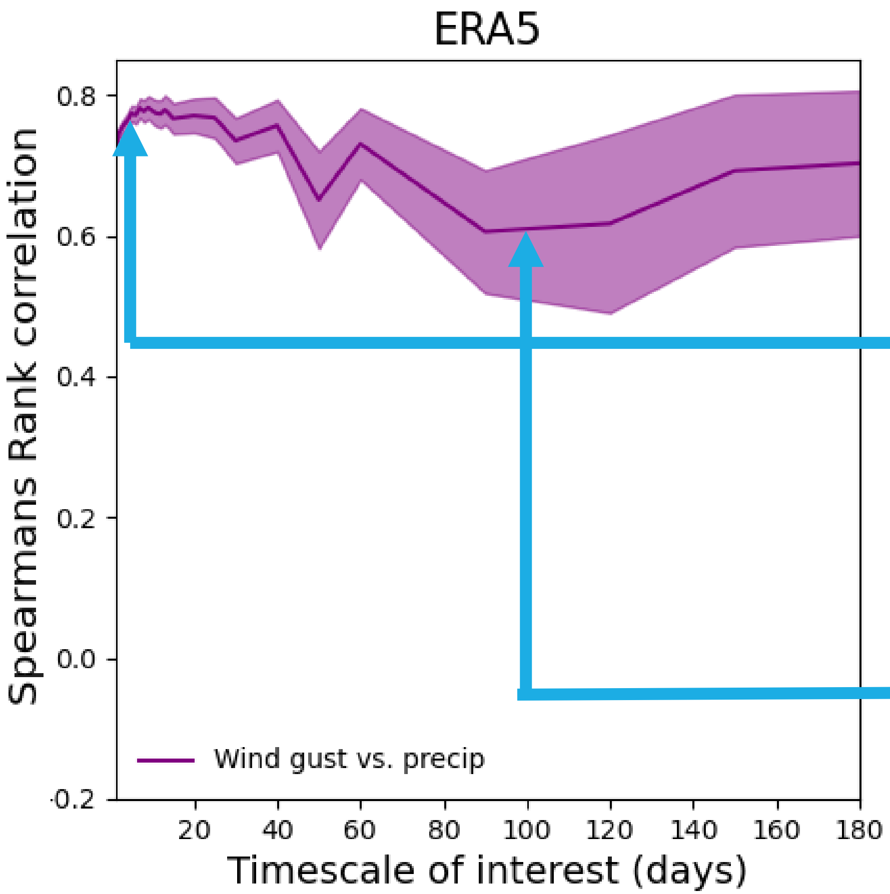
Correlation analysis: observations



GB-aggregate data October-March 1980-2020

Correlation between 3-day mean daily-max gust and 3-day accumulated precipitation.

Correlation between 100-day mean daily-max gust and 100-day Accumulated precipitation.

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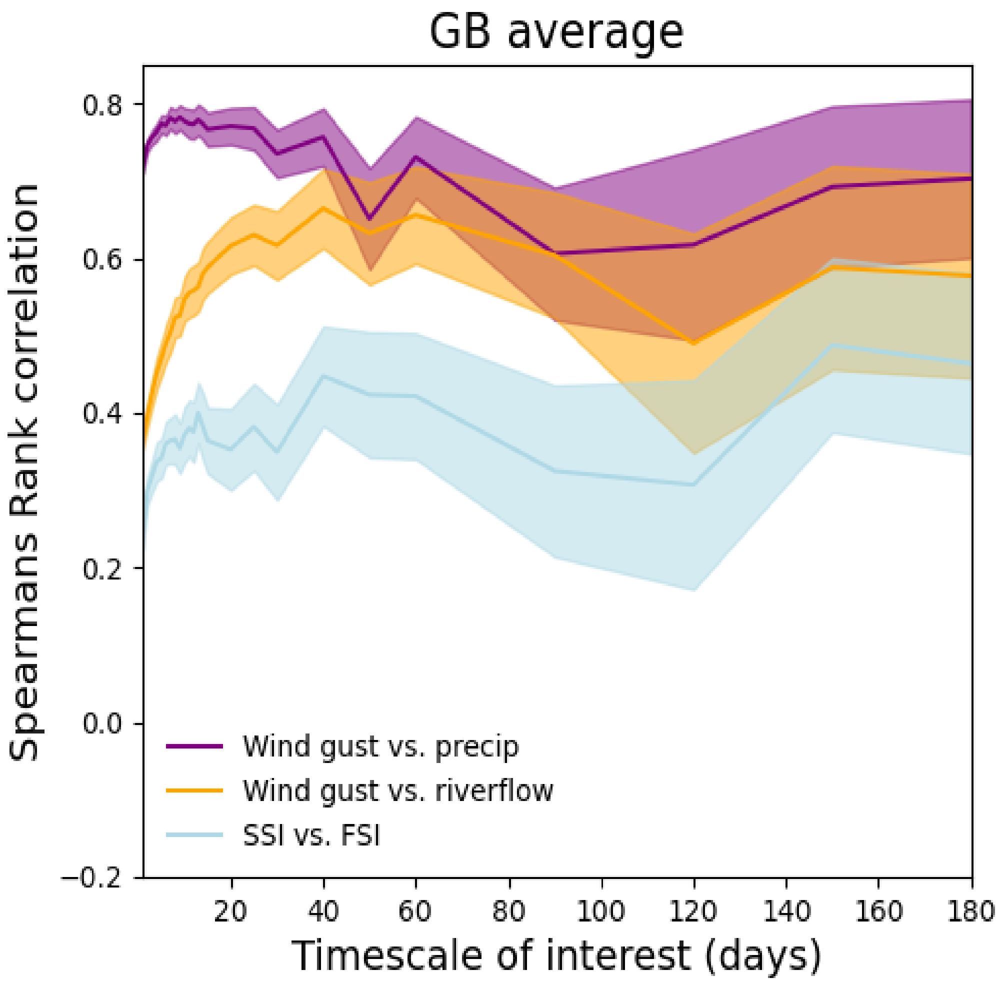
Correlation analysis: wind-flood metrics



1. Wind gusts vs. Precip correlation is relatively constant **~0.7** throughout all time periods
2. Relationship between riverflow and wind gusts behaves very differently.
3. Correlation decays as we get closer to the final impact.
4. **Puts previous studies into context**

Also seen in other GB observational datasets (not shown)

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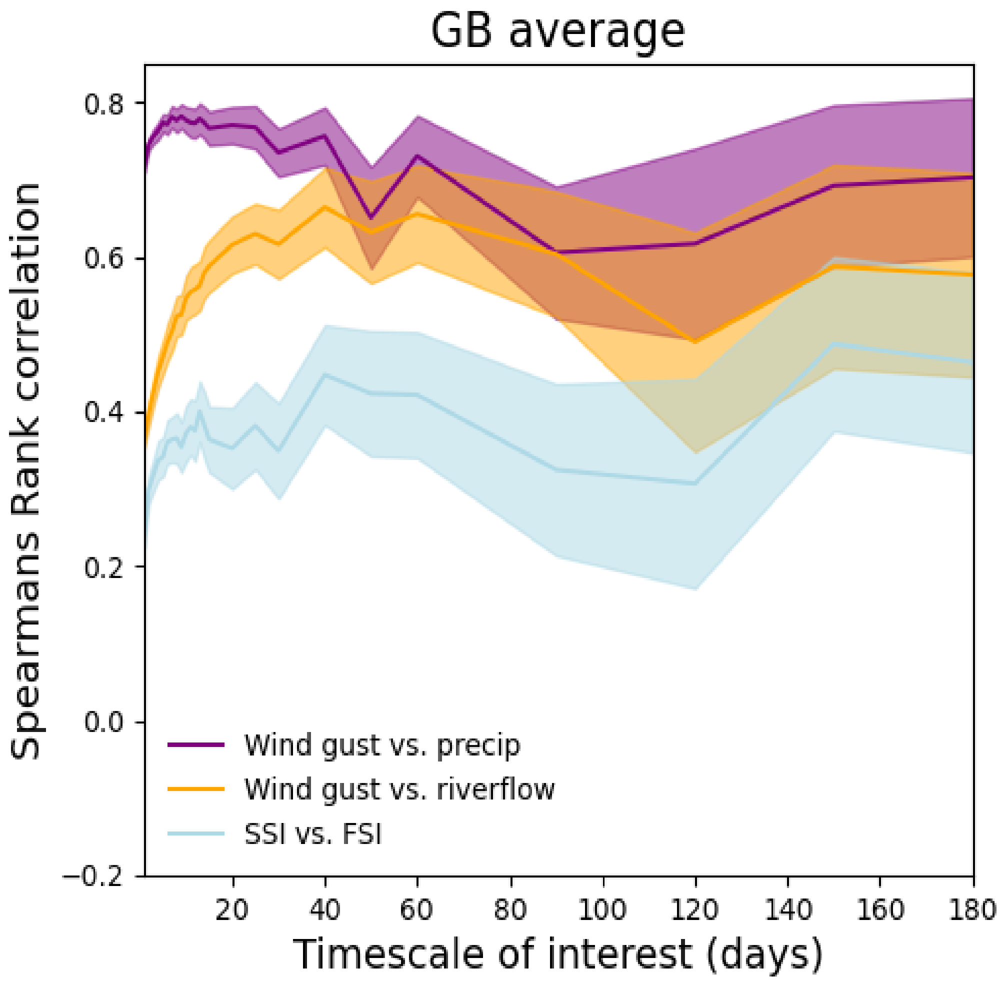
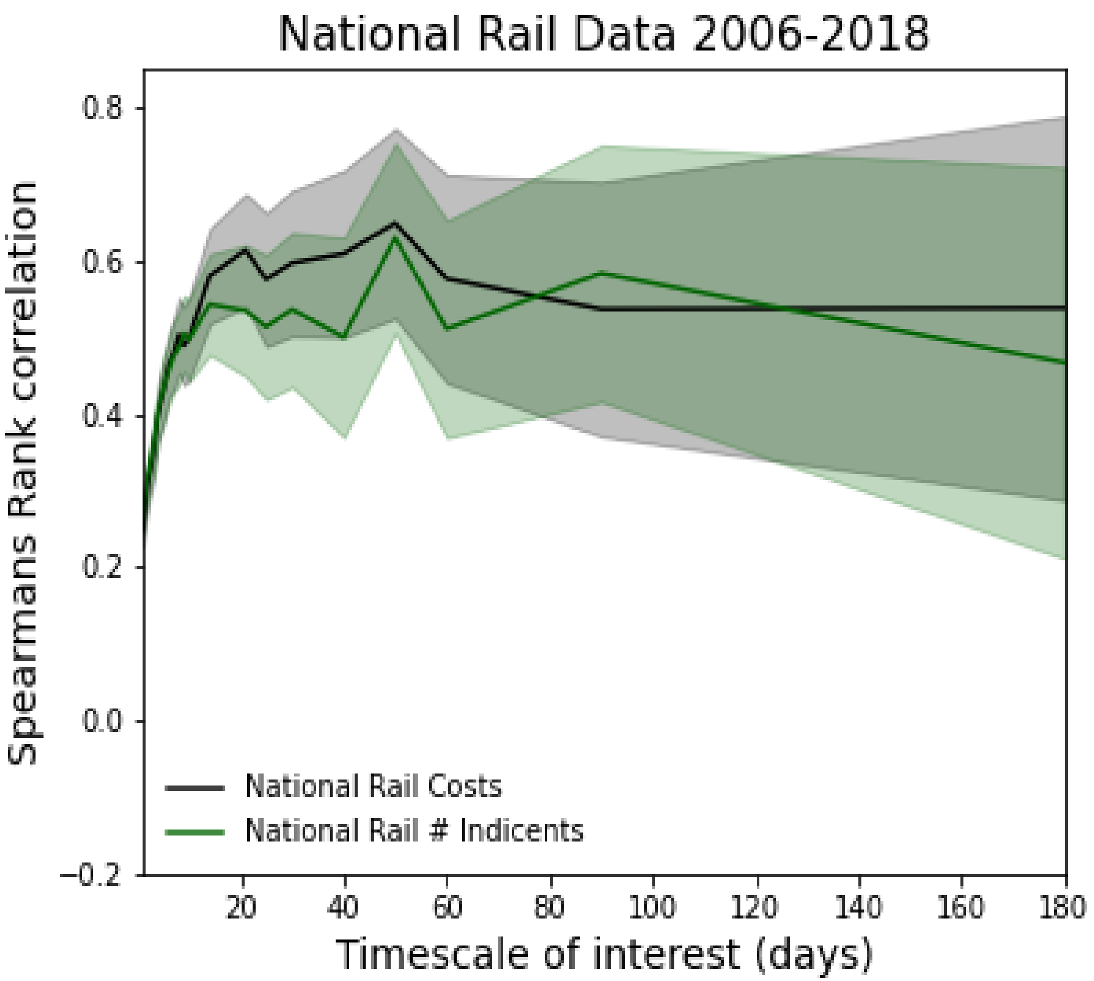
Correlations in impact data





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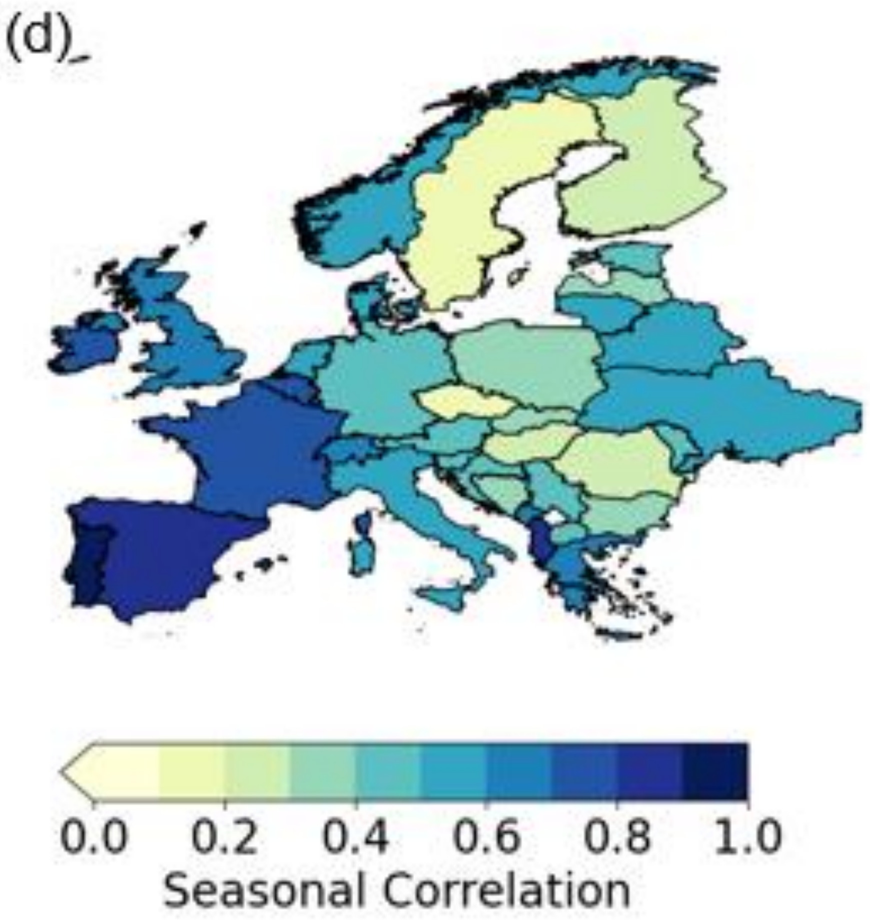
Extending Across Europe

1. Correlation between riverflow and wind gusts is quite variable across Europe. Generally being stronger in North or West Europe.

1. The timescale of maximum correlation appears to depend on the driver of the flooding (extreme precipitation, snowmelt of soil-moisture).

This is useful to understand potential for failure across interconnected energy systems



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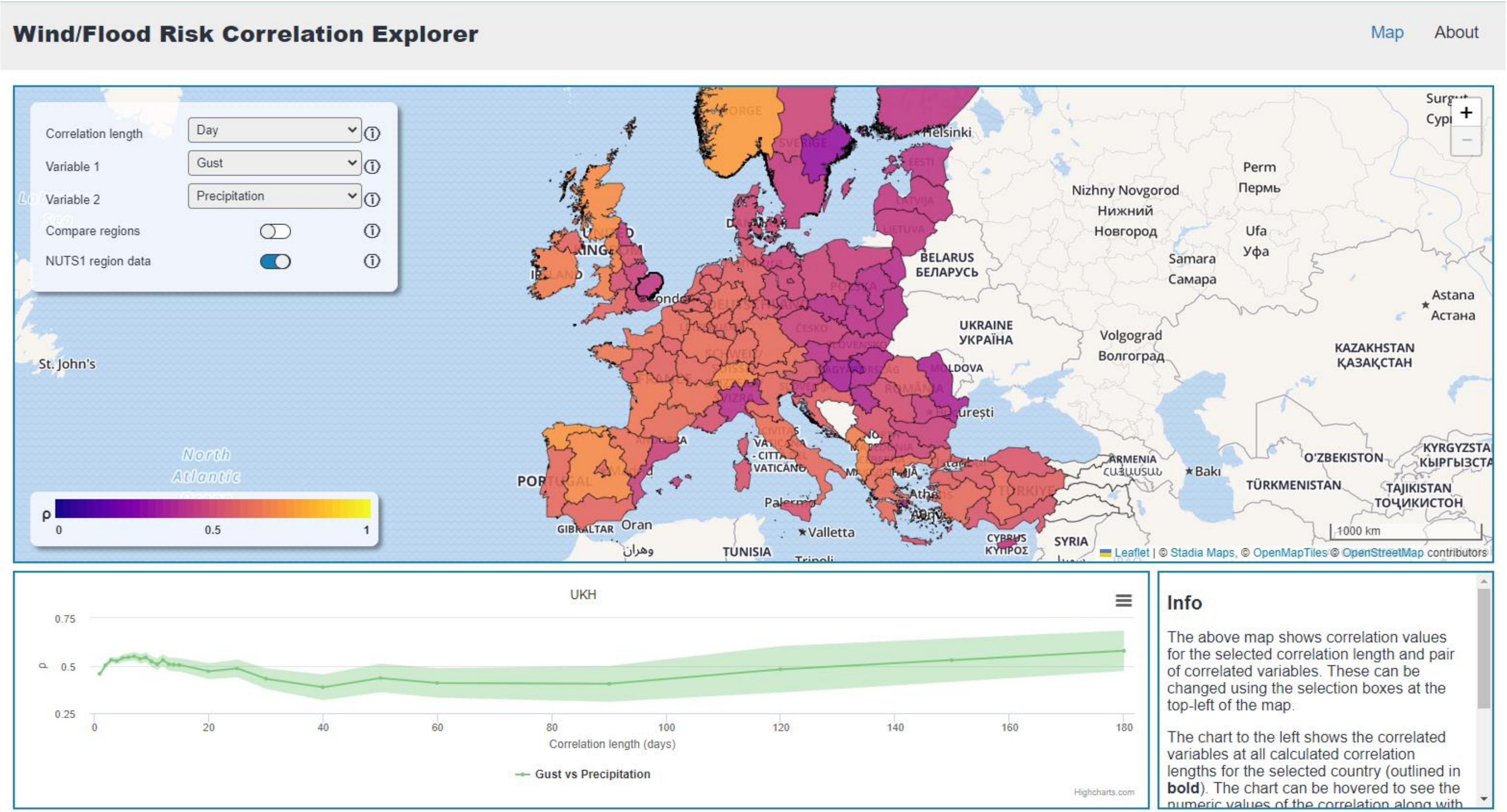
Online Demonstrator



https://the-iea.github.io/cgfi-wind-flood/

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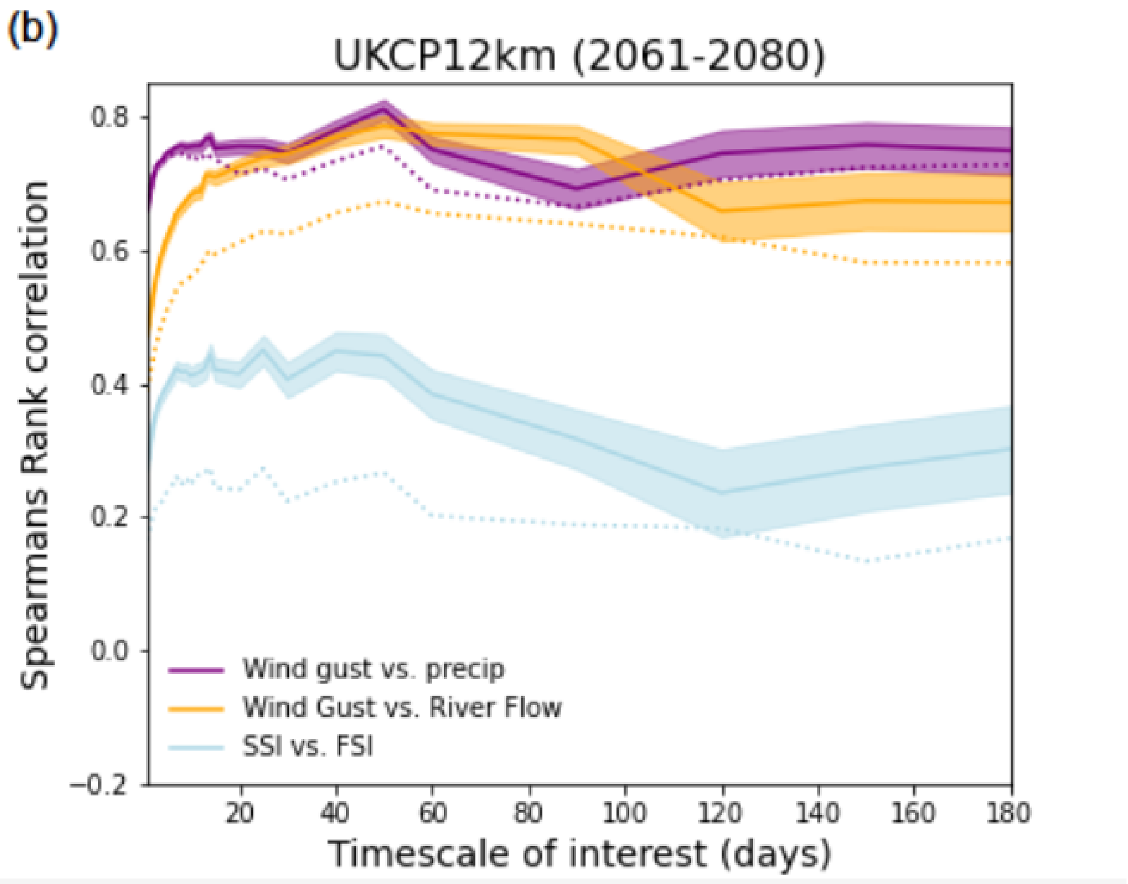
What about climate change?



In a future climate the return period of compound extreme (P99) wind-flood damage events reduces from 1 in 16 years to 1 in 5 years.

Bad news for critical infrastructure…

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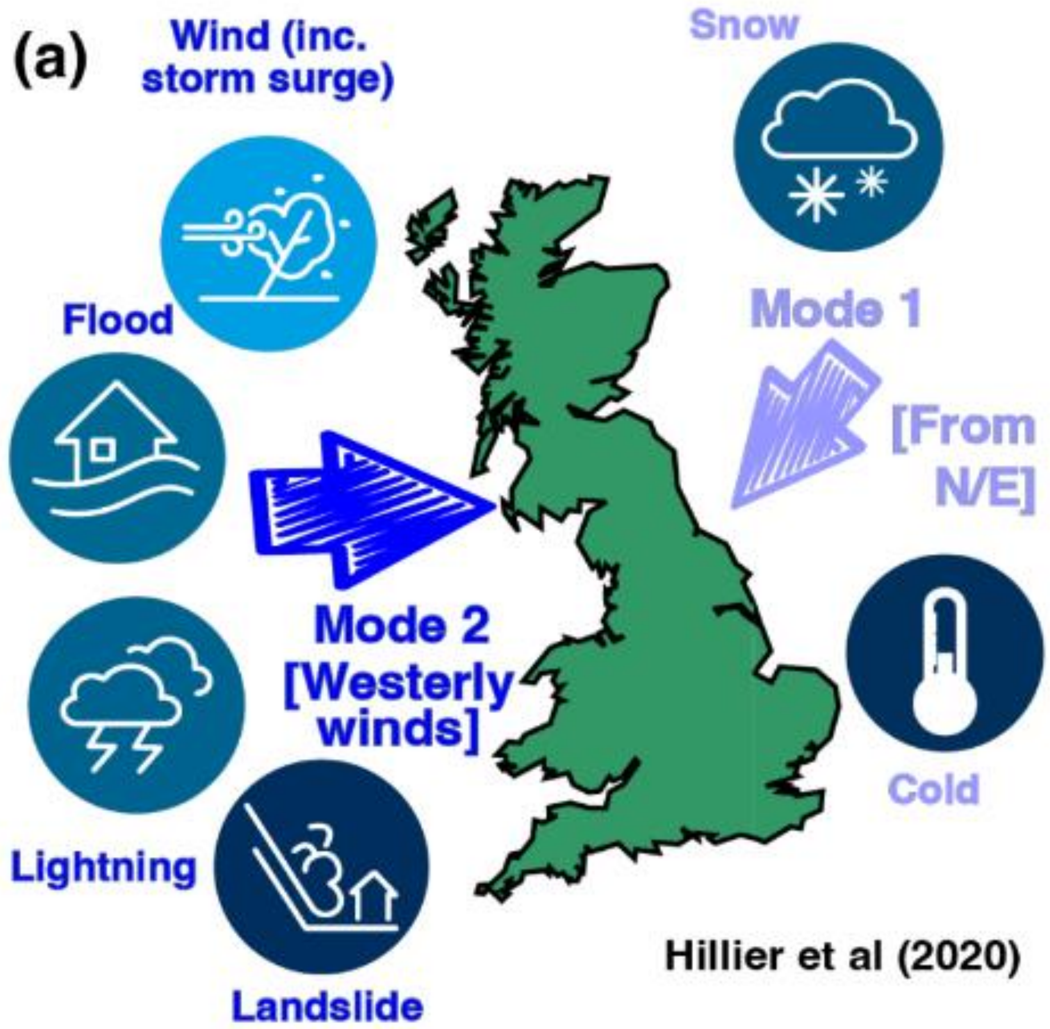
Ongoing Activities

- NERC HYDRA project

- Will quantify correlations between 6 winter UK hazards with a focus on the rail and power sectors

- Understanding which hazard pairs are most likely to cause issues.

- Understanding the meteorlogical drives in a present /future climate.



Hillier et al (2020)

Get in touch with me for more information!

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Summary

- Compound wind-flood events can have a large impacts on critical infrastructure across Europe, but particuarly In the UK.
- Climate change expected to quadruple the return period of extreme compound wind/flood events compared to those seen in the historical period.
- **Understanding impacts of weather and climate on power systems is important!**

Thank you for listening, any questions?

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DOWNLOAD

https://the-iea.github.io/cgfi-wind-flood/

Personal website: hcbloomfield19.github.io

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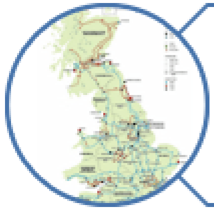
Extra slide

Climate resilient energy systems for the net-zero transition



Create a new risk-based UK power system modelling tool that exploits state-of-the-art weather and climate data and catastrophe modelling techniques.

Quantify how climate change and power system decarbonisation impact the resilience of national infrastructure

Co-develop early warning systems to forecast notable resilience challenges with project partners

Develop a reproducible framework to replicate the analysis over multiple regions, including India, Mexico and East Africa.

Fellowship starting soon…

Please come find me if you're interested in these topics and want to be involved in my user group!

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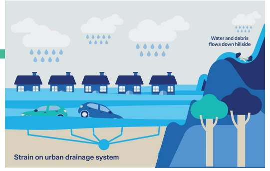
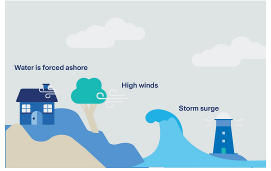
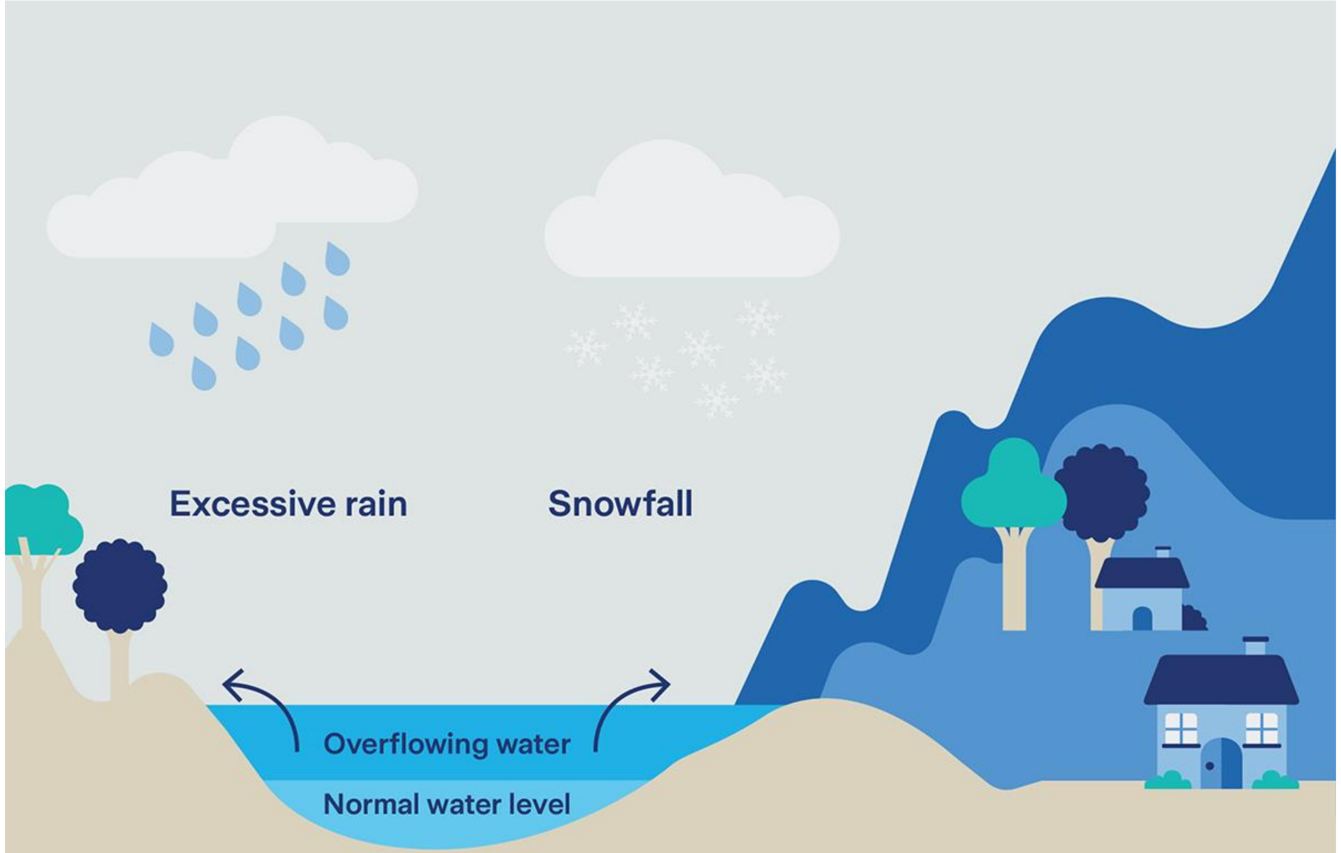
Types of flooding







Fluvial Floods

- Water level in a river, lake or stream rises and overflows onto the neighboring land.
- Could be due to excessive rain or snowmelt.
- Severity is determined by terrain profile, duration and intensity (volume) of rainfall

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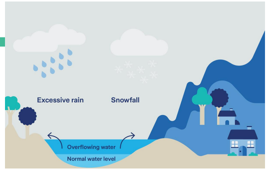
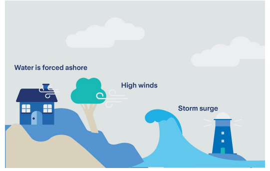
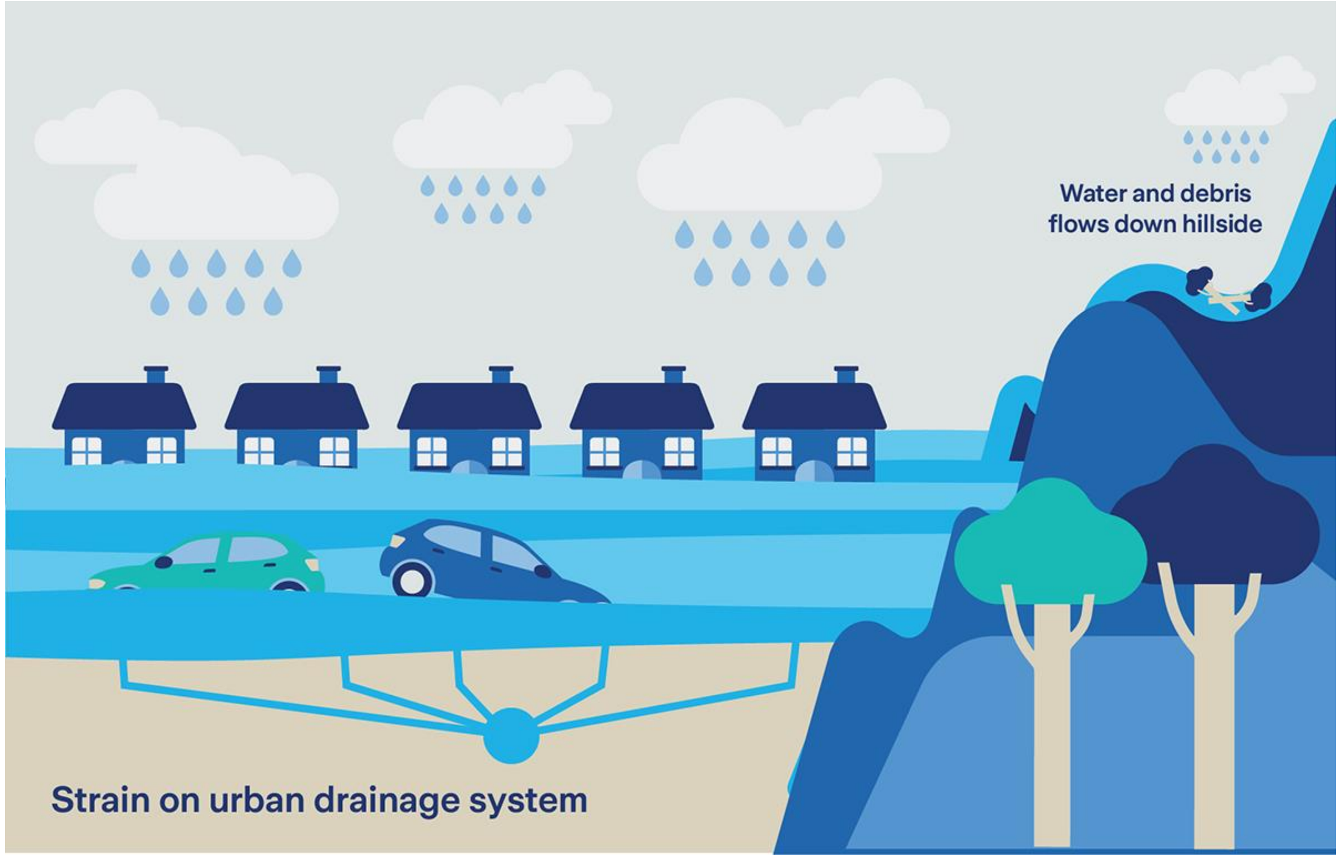
Types of flooding







Pluvial floods

- Extreme rainfall creates a flood independent of an overflowing water body
- Surface water floods: overwhelmed drainage system
- Flash floods: torrential rain in short amount of time.

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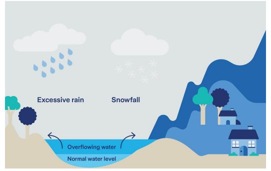
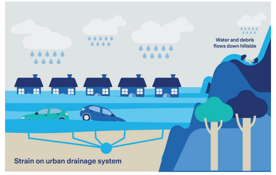
Types of flooding





Coastal Floods

- Common causes of coastal flooding are intense windstorm events occurring at the same time as high tide (Storm surge).
- Greatest threat associated with a hurricane or typhoon (Tsunamis).

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