Understanding the Risk from Correlated Windstorms and Floods in the UK

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A Thought Experiment

References

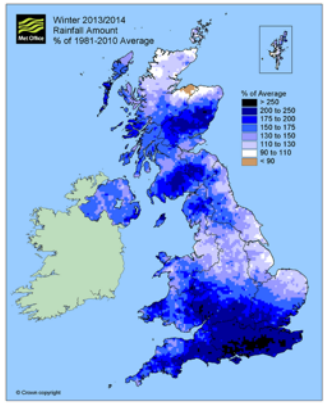
1. The Great Storm of 1987, RMS Special Report.
2. U.K. Environment Agency

Great Storm of 1987

£2bn [1]
(£5.526bn today)

+

Floods of winter 2013/14



£1.3bn [2]

= ?

Could extreme wind and flood events occur in tandem?

Are the two physically linked?

What are the implications for the insurance industry?

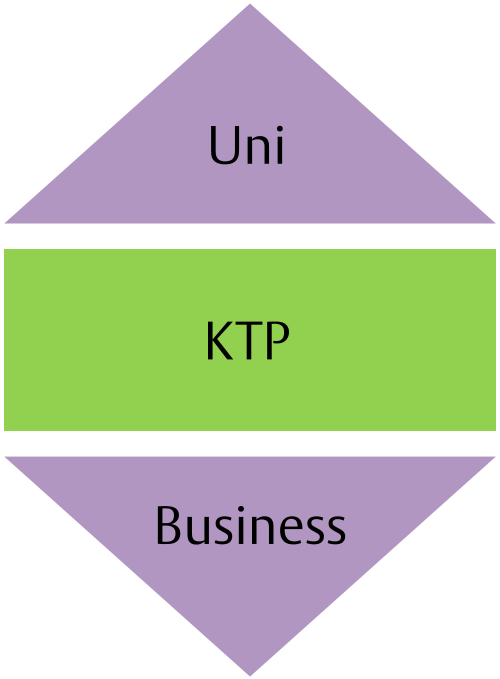
Talk Outline

1. Knowledge Transfer Partnerships (KTP)
2. What is our KTP?
3. Methodology
4. Spatial patterns in correlations between windstorm and high river flow
5. Case studies of some extreme compound events
6. The frequency of compound events
7. Summary

Knowledge Transfer Partnerships (KTP)

Innovate UK

- "UK-wide programme that has been helping businesses for the past 40 years to improve their competitiveness and productivity through the better use of knowledge"
- An extended research problem – usually for **12 to 36 months**
- **Shared funding** between government **(innovate UK)** and a business
- Academic partners who take part in a KTP produce on average more than **3 new research projects** and **2 research papers** for each project.



Our Project

- **Collaborative** 2-year project venture between **Reading University** and insurers at **Lloyds Banking Group**
- Will use a combination of observations/reanalysis/climate simulations to understand the r**isk in correlated flood and windstorms** in order to **prepare** for an **extreme compound event**
- Very little literature on this subject
  (Hillier et al. 2015, De Luca et al. 2017**, and not much else!**)
- Big problem for the Insurance industry, who currently do not know what to do. Any correlation will effect capital requirements.

University of Reading

LLOYDS BANKING GROUP

National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Correlations in River Flow and Wind: Method

Data:

- ERA5 10m wind speed
- NRFA river gauge data
- 1979-2015

Method:

1. Choose a sample of locations
2. Filter river peak over threshold (POT)
3. Choose max wind and max flow during POT.
4. Extra filters (e.g. event proximity)

Example plot

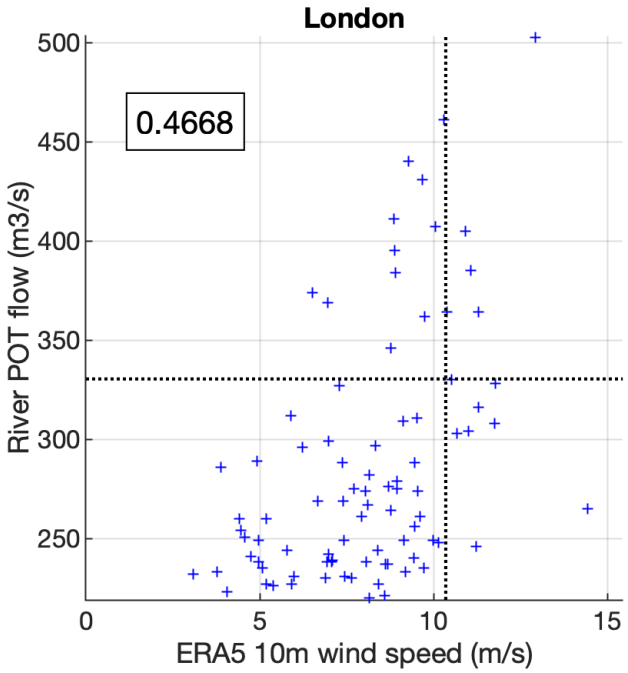
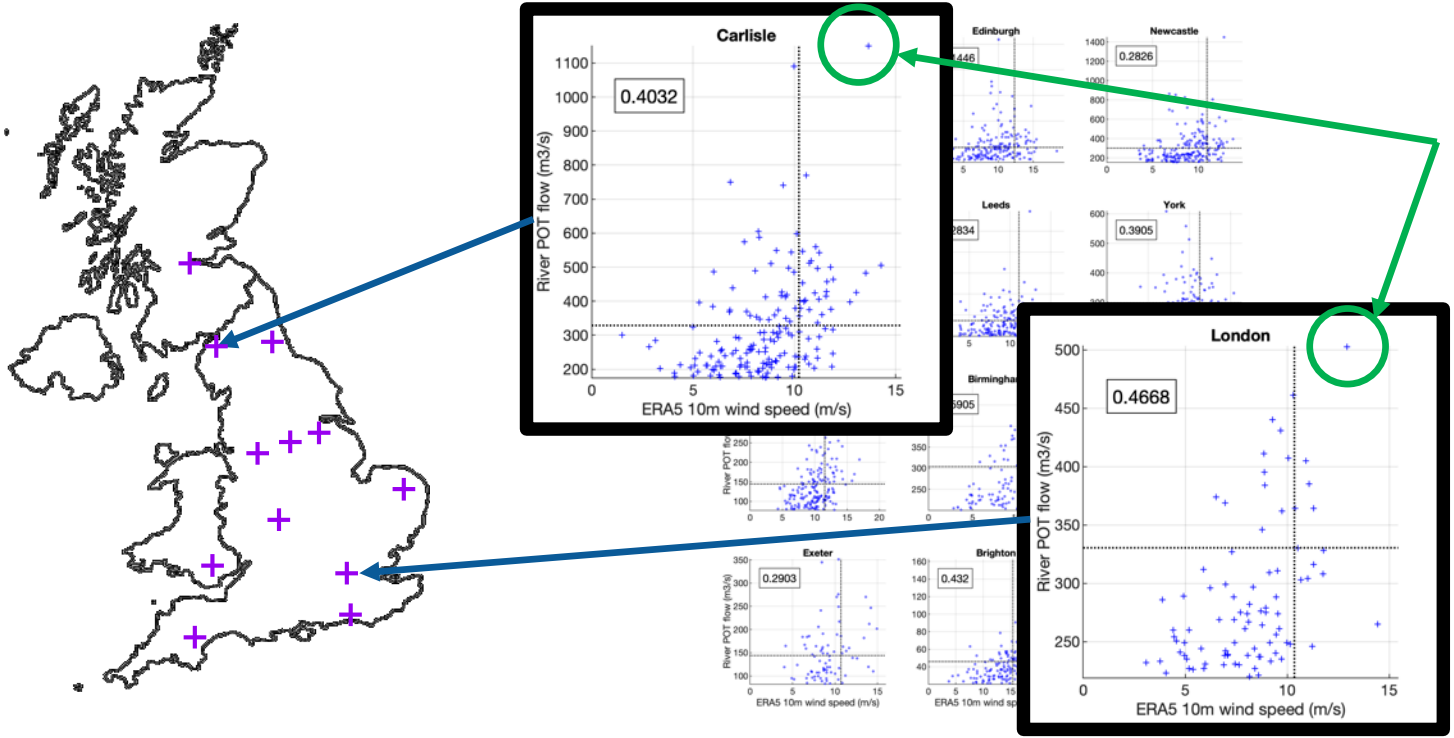


Figure:
Scatter plot of NFRA maximum POT flow and ERA5 **maximum 10m wind speed** for London (Kingston), 1979-2015.
Dashed lines show 99th percentile. Spearman correlation coefficient is printed in the top left.

Correlations in River Flow and Wind



Some large-valued points… what/when are they?

London extreme: Winter 13/14

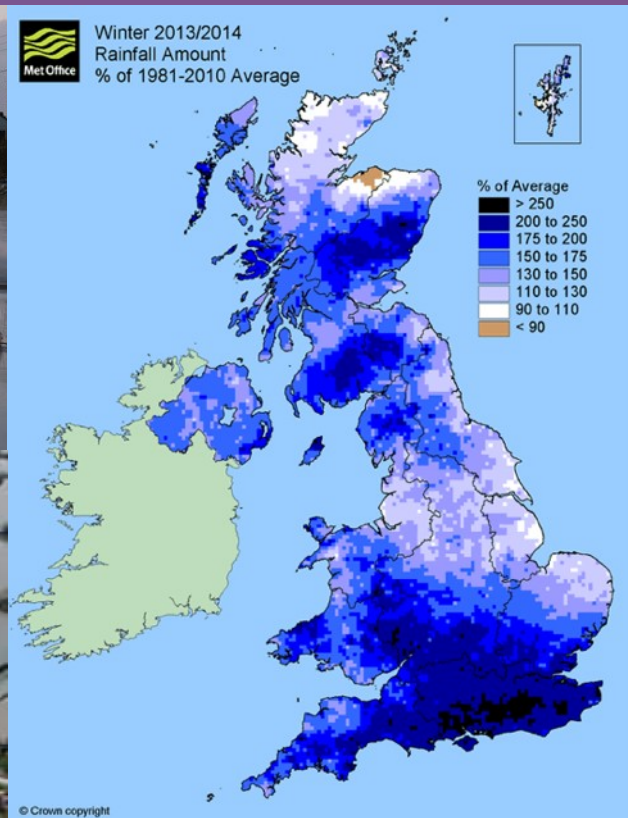
References

1. Environment Agency
2. UK Met Office

- Exceptionally wet period between Dec'13 and Feb'14.
- 8,342 homes were flooded and 4,859 businesses affected (1)
- £1.3bn in economic losses(1)

Meterology

- Relentless "conveyor belt" of low pressure systems hit Southern UK
- At least 12 major storms (Dec-Feb). Many were rapidly deepened by a strong jet stream. (2)
- Extensive flooding + damaging windstorms!



Carlisle Extreme: Storm Desmond

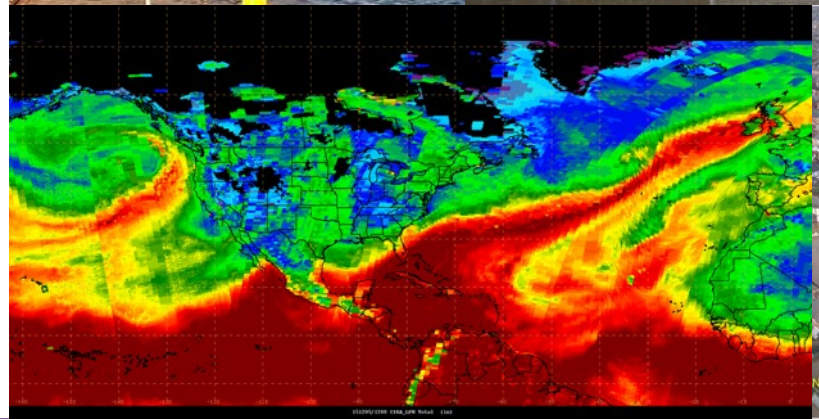
References

1. PricewaterhouseCoopers (2015)
2. McCarthy et al. (2016)

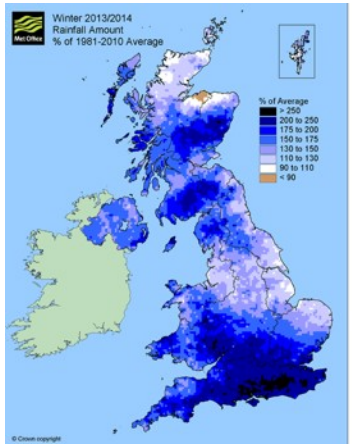
- Winter 15-16
- 5,200 homes flooded, 43,000 without power
- Estimated £500m in damages[1]

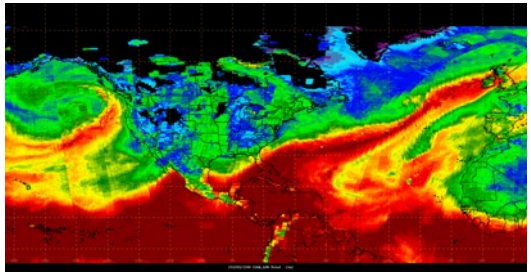
Meterology

- Highest 24-hour total rainfall (341.4 mm) [2]
- Extra-tropical cyclone
- Atmospheric river – advection of mild moist air from Atlantic
- Damaging winds and extreme flood – a compound event! (albeit, flood dominated)



Winter 13/14 vs Desmond





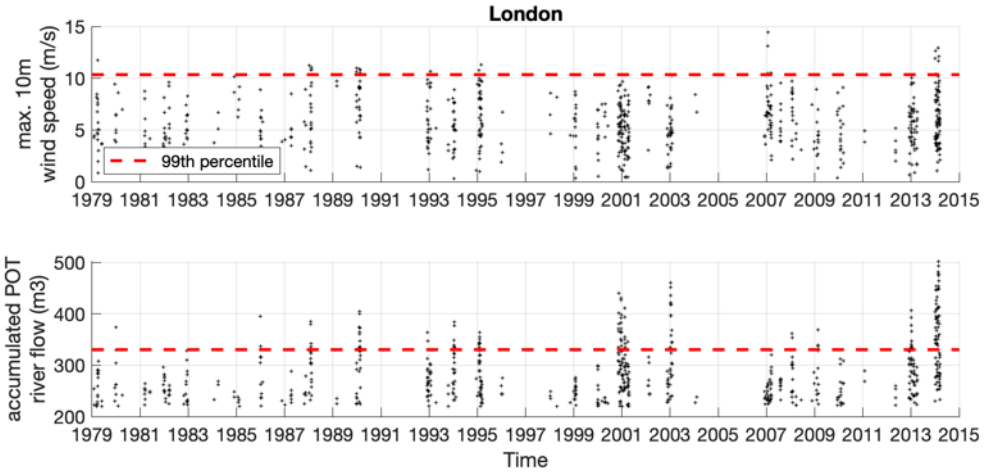
2 different regimes, both led to compound events.

How frequent are compound events?

London History

Wind

River



1979

2015

Black lines = exceeding 99% in both wind and river

Events:
88 - Floods in Maidstone, London.
90 – Storm Daria

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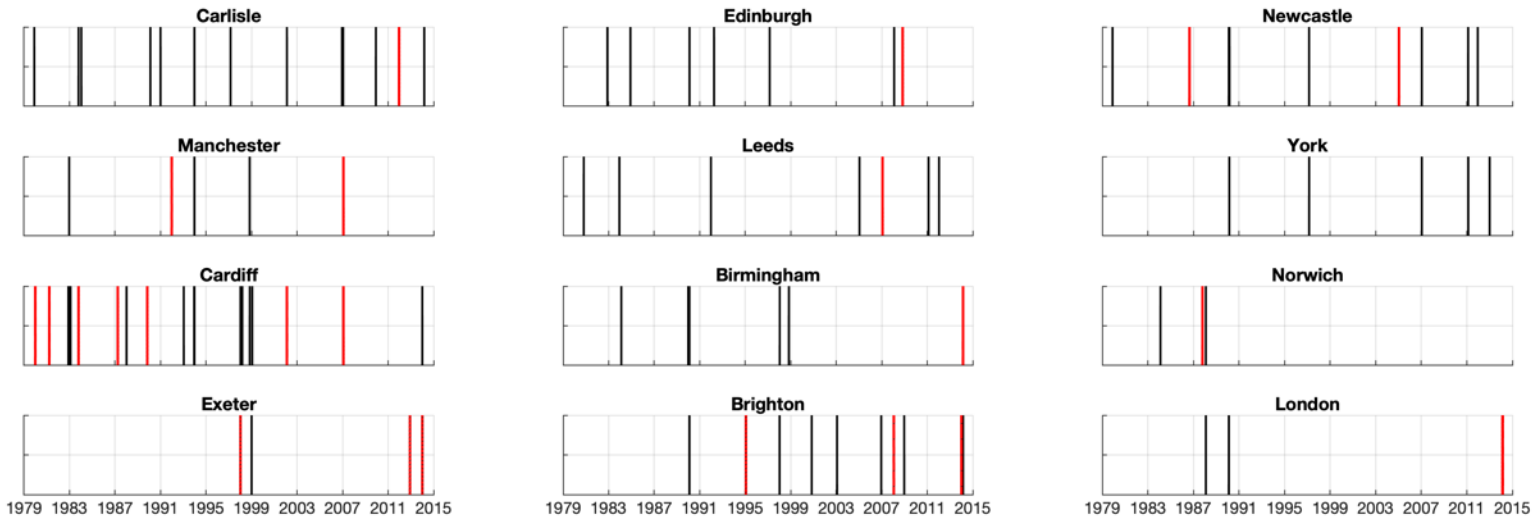
Red lines = exceeding 99% in wind and 99.9% in River

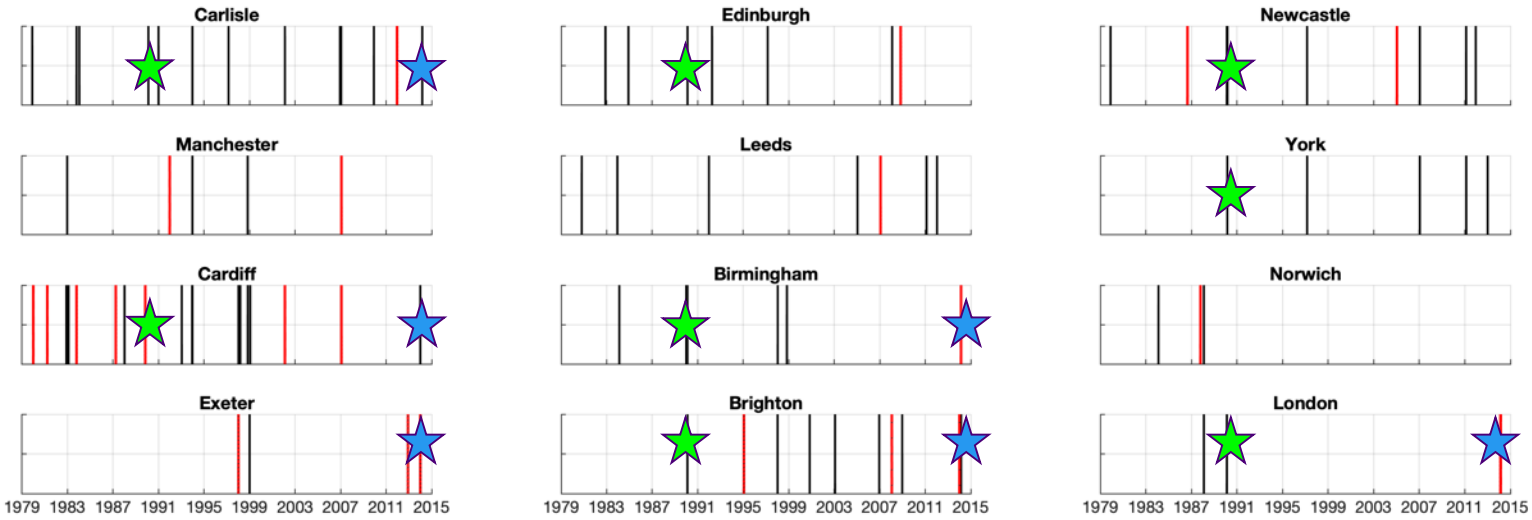
Events: Winter 13/14

The Likelihood of Extreme Compound Events



- More lines than expected! (~10,000 data points, would expect 1 compound point to exceed 99th percentile in both data if uncorrelated).
- Some locations have >10 times as many lines
- Nearly all locations have a very extreme event (red lines).

Wide-ranging Extreme Compound Events



- Winter 13/14 – appears in 6 locations
- Daria (1990) – appears in 8 locations
- Kyrill (2007), Lothar and Martin (1999)…

- Big events can affect large areas of the country
- Winter 13/14 floods estimated return period >100yrs (CEH)
- Daria estimated return period ~25-39yrs (Della-Marta 2009).

Summary

1. We have undertaken a research project with insurers at Lloyds Banking Group to asses the **risk of compound windstorm and flood**.

2. We have investigated **correlations in wind and stationed river flow** and found modest correlations in the South and West UK.

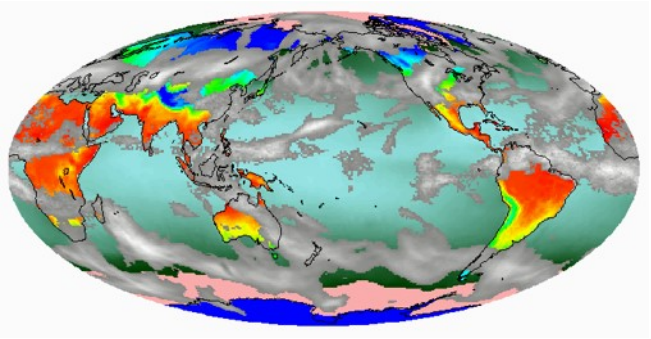
3. We have linked some **extreme compound events** to **named storms**. A number of these events affect multiple areas across the UK.

4. Compound event have occurred at a surprising frequency. In some locations, we find **more extreme compound events** than expected if windstorm and floods were uncorrelated.

Future Work

1. Find the physical mechanism that leads to extreme compound events

2. Use a very long timeseries (~1000 years) of precipitation from a climate model (HiGEM) to examine the correlation in very extreme events.



Thanks!
Questions?

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Reserve Slides

Correlations in Precipitation and Wind

Data:

- ERA5 10m wind speed
- CHESS precipitation

Method:

1. Choose a sample of point locations
2. Designate time "windows"
3. Correlate accumulated rainfall and max wind over time window

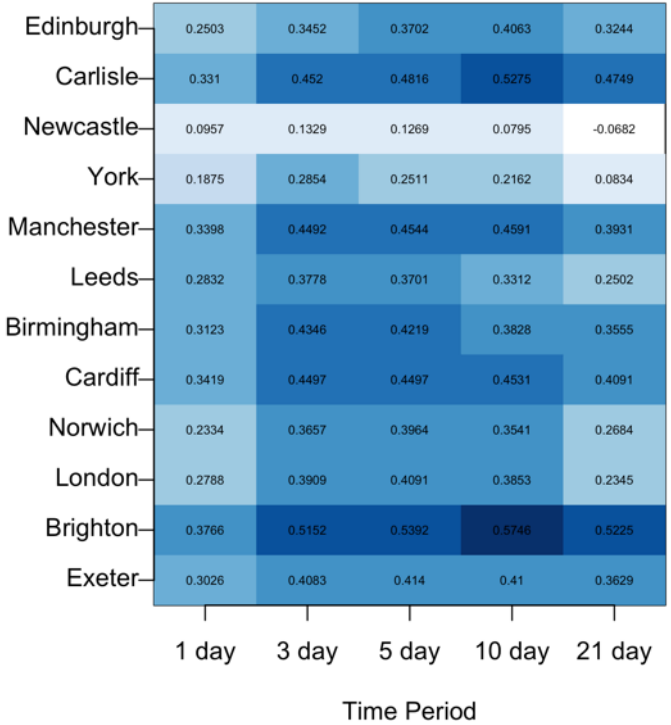
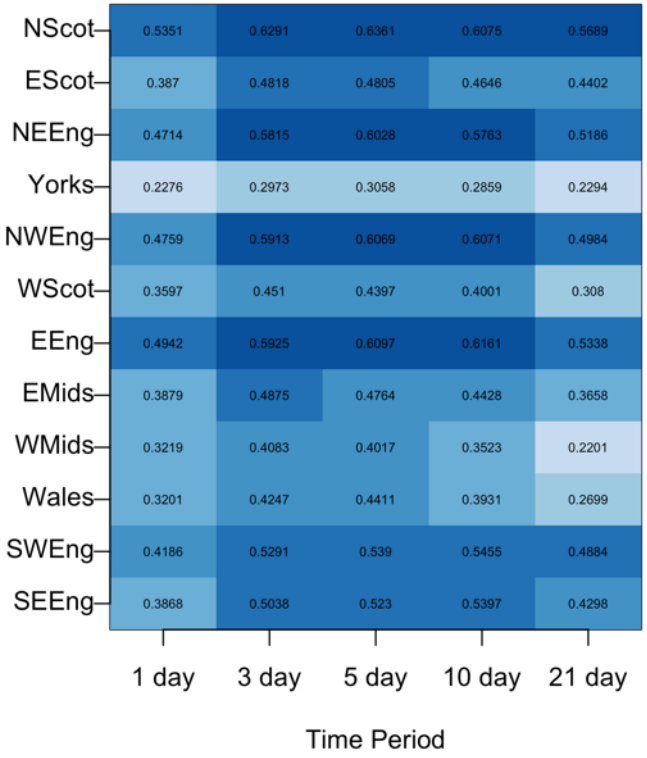


Figure:
Spearman correlation coefficients for the **accumulated** CHESS **rainfall** and ERA5 **maximum 10m wind speed**, for various accumulation periods and locations. Data shown is from an extended winter period only (NDJFM) for the time series 1979-2015.

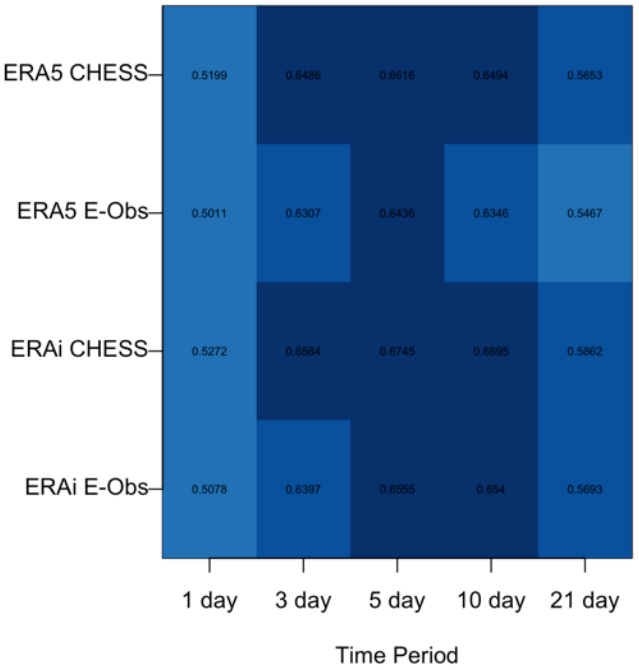
Spatial Aggregations



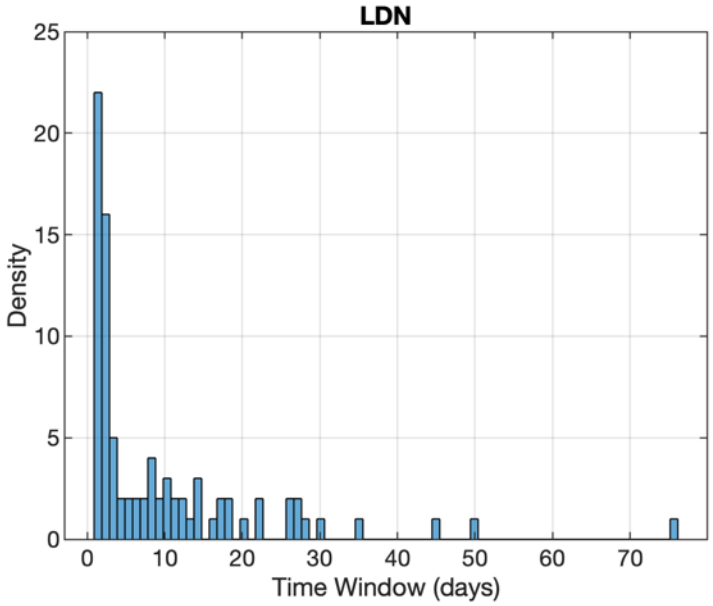
Using gridded products allows us to spatially aggregate.

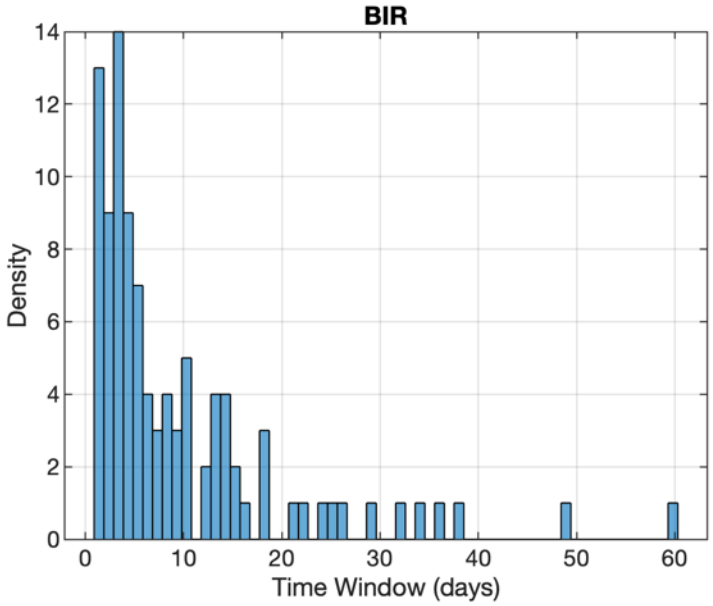
Left: Spatial aggregations do increase correlation slightly, but results broadly consistent with point locations.

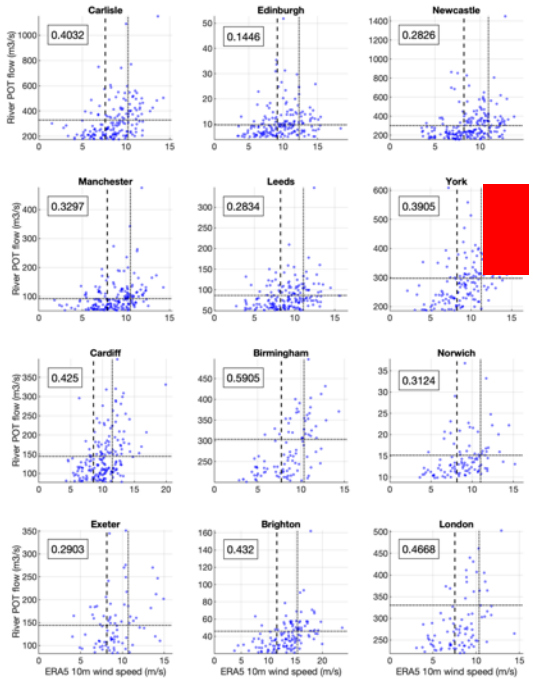
Right: we calculated a number for the whole country from various datasets.



Example Time window histograms







1. 99th percentile in each dataset. Note: due to filtering (POT windows) scatter plots show **sub set** of data. Percentiles calculated from **full timeseries**.

2. Extract compound events from each location (red square)

   - No. of compound points = 228
   - No. of unique compound points = 157

3. Find corresponding storm tracks
   - Search files for any tracks which cross UK and have a matching timestep at any time in storm life time.

   - No. of storm tracks = 167 (i.e. some of compound events are happening at the same time as another storm?)