
# Climate extremes in the key wheat producing regions of the world

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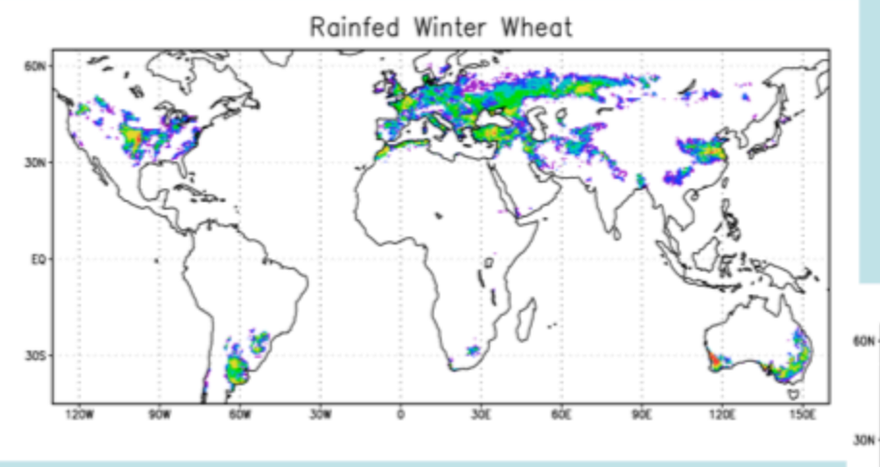
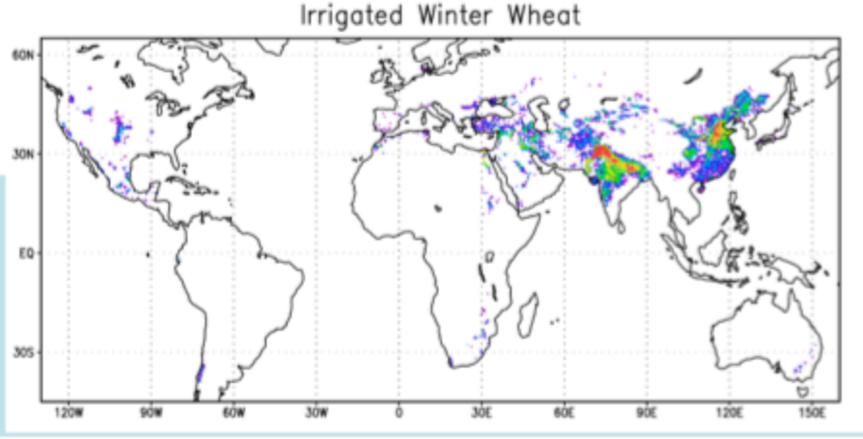
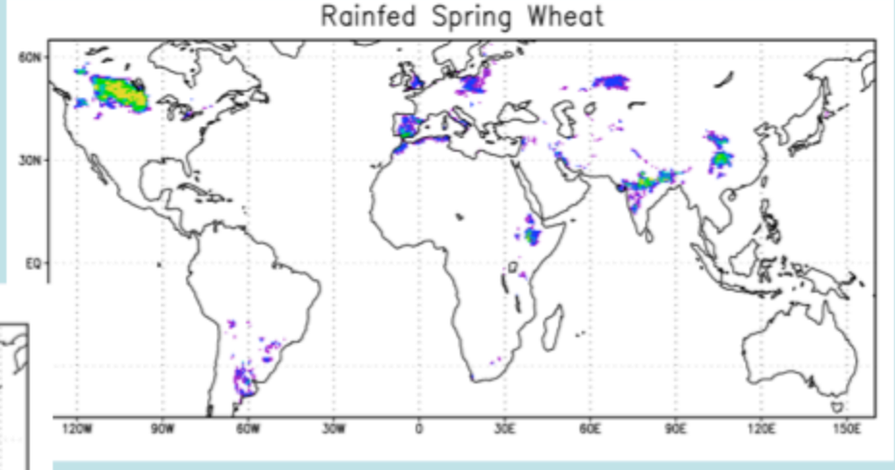
# Why wheat?

Wheat is one of the most important crop of the world with an about 2.2 million km² total harvested area and a production of 750 MTons in 2016




Source: Zampieri et al. 2017

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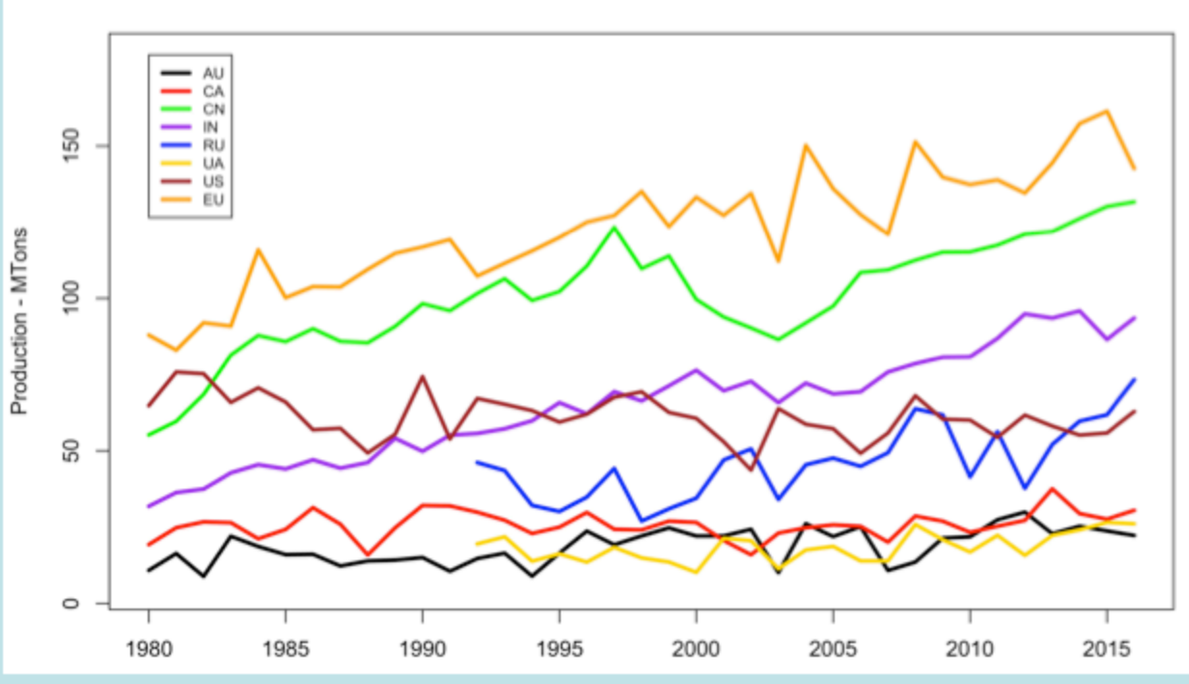
# Wheat yield and climate extremes




Main climate extremes affecting wheat yield when occurring in critical phenological phases

**Heat stress**

**Drought**

**Water excess**

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# Wheat yield and climate extremes


*Few production areas/few exporters*

*Lack of information*

*Trade restrictions*

*Decline in food reserves*

*Increase in price volatility and price spikes*

C²ESAM

Concurrent Climate Extremes and Shocks on global Agricultural Markets

Adapted from von Braun and Tadesse, 2012

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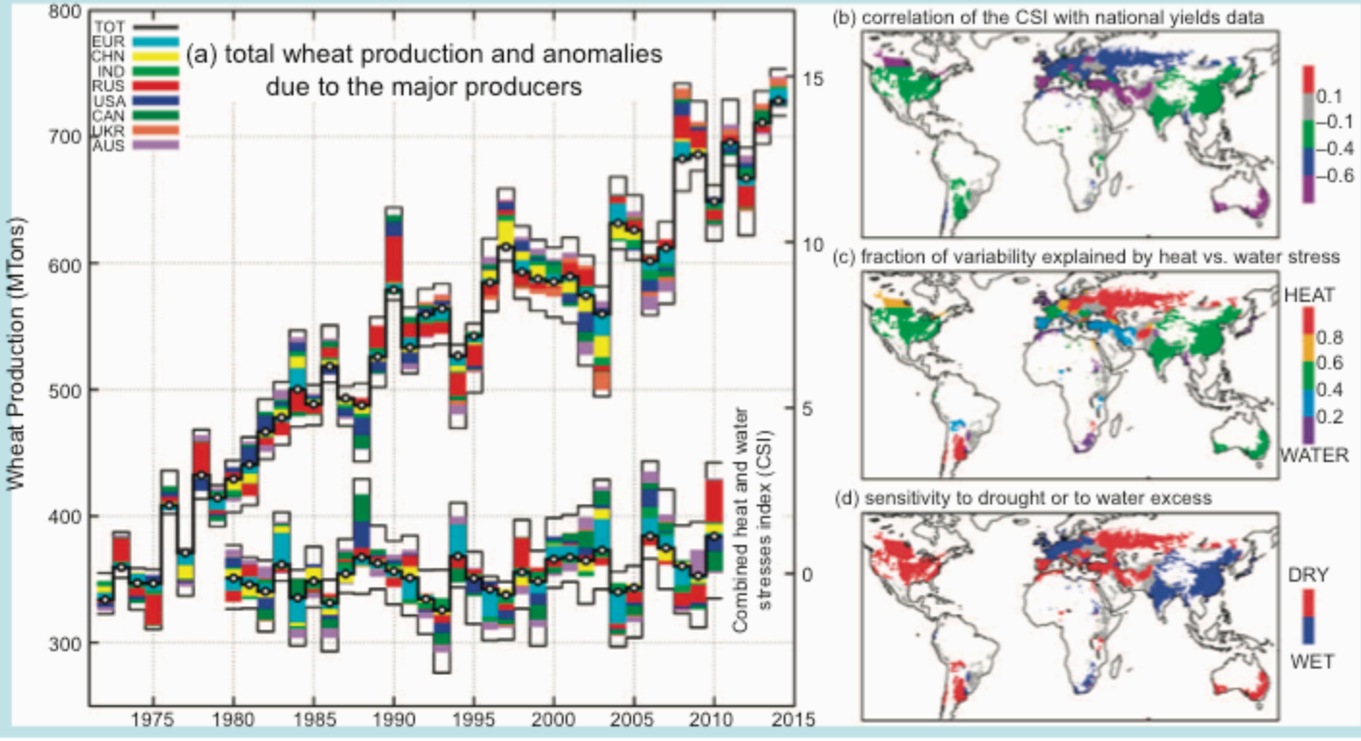
# Combined Stress Index

CSI combines crop/region specific Heat Wave Magnitude Index daily HWMId and the Standardised Precipitation Evapotranspiration Index SPEI




Source: Zampieri et al. 2017

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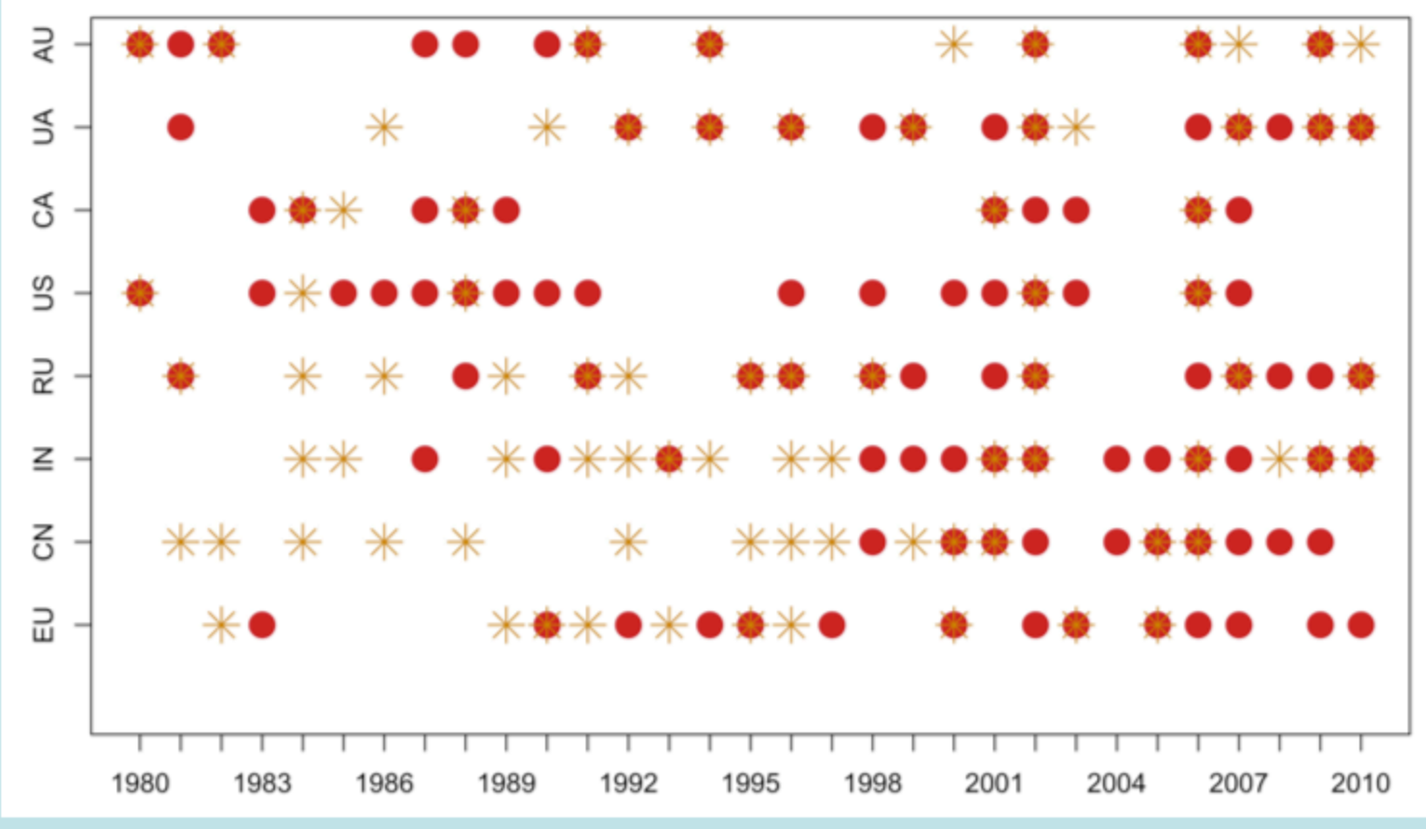
# Extremes - when and where

Severe large-scale extreme events: heat stress and drought affecting at least 20% of the wheat area in key region

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# Intensity and occurrence

We do not usually focus on the occurrence

$$\mathbb{P}(X > u)\mathbb{P}(X > y|X > u)$$

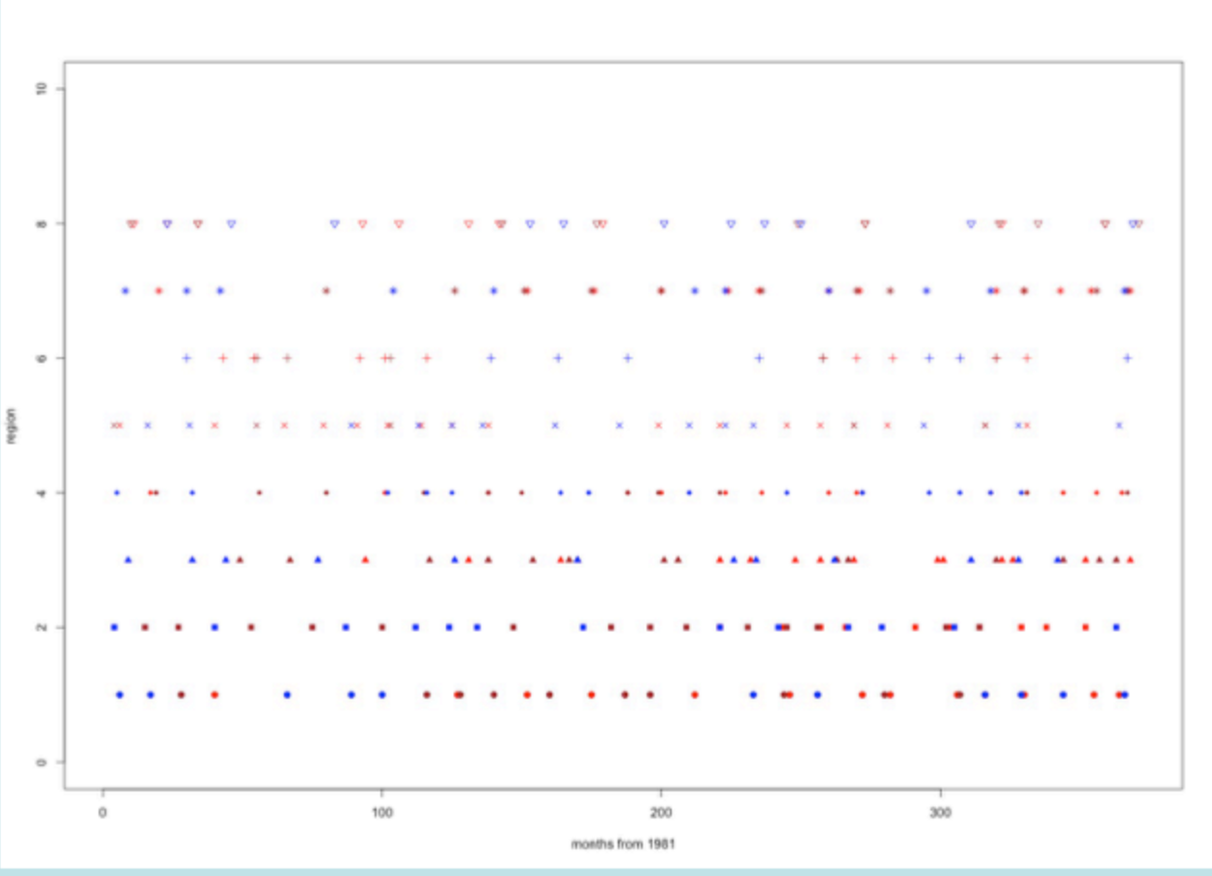
Assumed to be homogeneous-Poisson, i.e. events occur independently with a constant rate

modelled as GPD

**Is the Poisson assumption always valid?**

**No. In many cases we still apply the previous model by de-clustering and still assuming constant rate**

# Multivariate




**Multi-type extremes acting in a spatio-temporal domain**

- Do extremes in different regions occur independently?
- Are different types of extremes occurring in the same region independent?
- Have these extremes a constant rate?

# The proposed approach

Inhomogeneous Marked Temporal Point Process offers the flexibility we need to address these questions

$$Y = \{(T_i, M_i)\}_{i=1}^{N} = \{(T_i, (R_i, C_i))\}_{i=1}^{N} \subset \mathbb{R} \times \mathcal{R} \times \mathcal{C}$$

The process is assumed to be simple, continuous in time and discrete in the marks.

The intensity function is time-dependent

# Intensity

Random number of events occurring in a set A

$$Y(A) = |\{i : (T_i, R_i, C_i) \in Y \cap A, \quad A \subset \mathbb{R} \times \mathcal{R} \times \mathcal{C}\}|$$

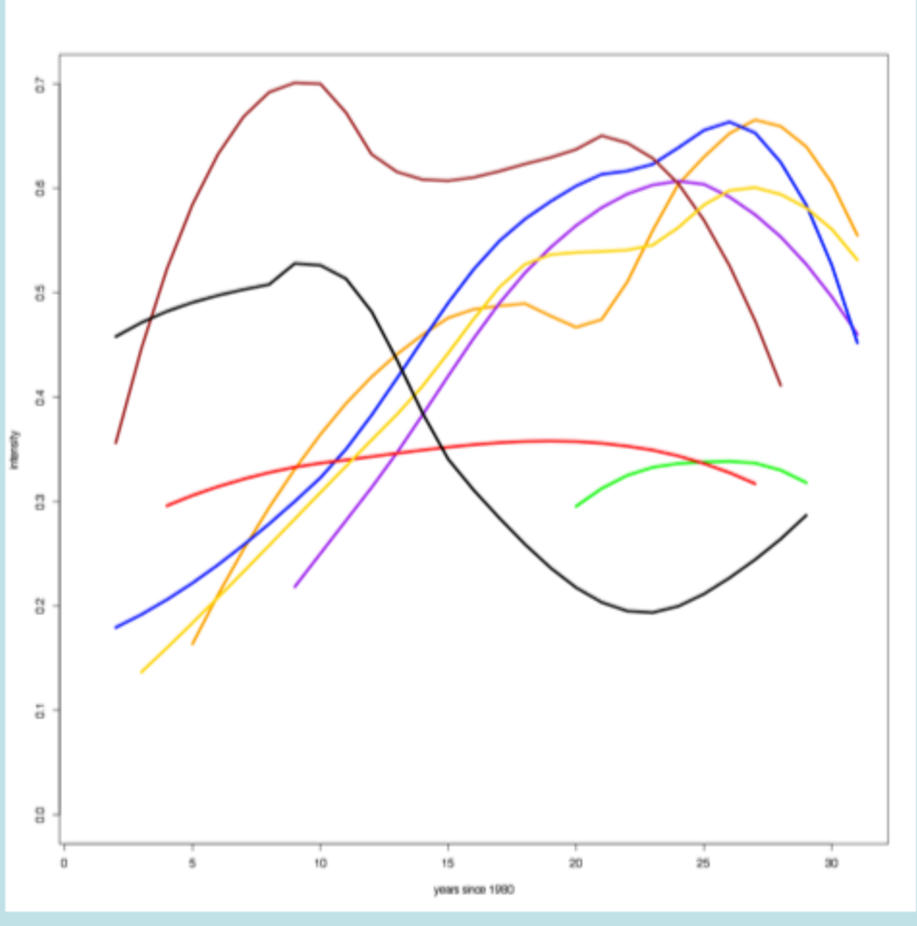
The intensity function is thus given by

$$\mathbb{E}\{Y(A)\} = \sum_{r \in A_2} \sum_{c \in A_3} \int_{A_1} \rho(t, r, c) dt \quad A = A_1 \times A_2 \times A_3$$

that can be estimated with the Kernel-based approach of Cronie and Van Lieshout 2016

# Heat stress

Estimated intensity function for the heat stress events

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# How to measure the interaction

## Marked inhomogeneous J function

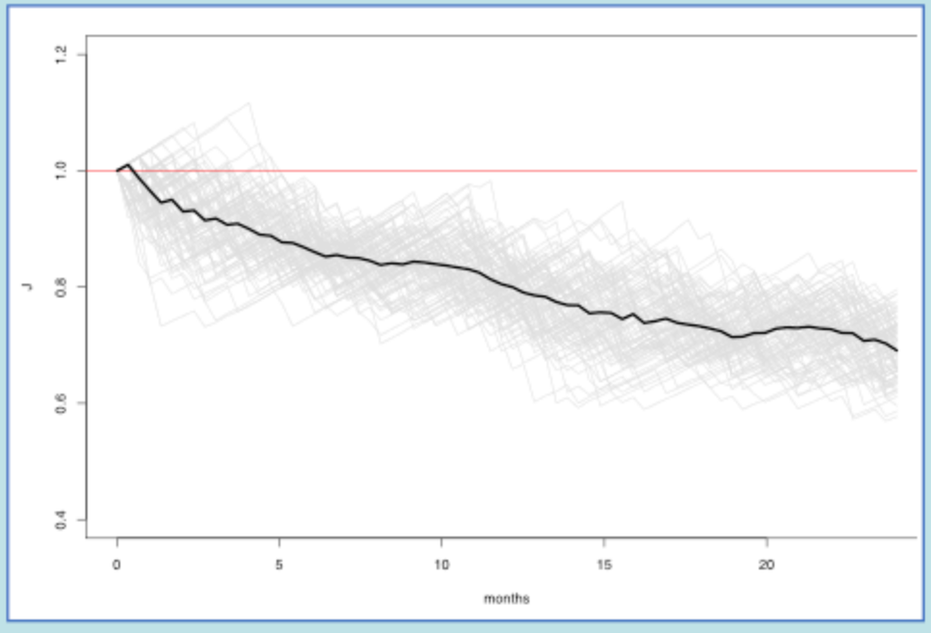
$$J_{B_2,D_2}(d|B_1,D_1) = \frac{1 - G_{B_2,D_2}(d|B_1,D_1)}{1 - F_{B_2,D_2}(d)}$$

$$F_{B_2D_2}(d) = 1 - \mathbb{E}\left[\prod_{(T_i,R_i,C_i)\in Y\cap[s-d,s+d]\times B_2\times D_2}\left(1 - \frac{\bar{\rho}_{B_2,D_2}}{\rho_{R_i,C_i}(T_i)}\right)\right]$$

$$1 - G_{B_2}^{D_2}(d|B_1,D_1) = \frac{1}{\#B_1\#D_1}\sum_{r\in B_1}\sum_{c\in D_1}\mathbb{E}\left\{\prod_{(T_i,R_i,C_i)\in Y\setminus\{(s,r,c)\}\cap[s-d,s+d]\times B_2\times D_2}\left(1 - \frac{\bar{\rho}_{B_2,D_2}}{\rho_{R_i,C_i}(T_i)}\right)\right\}$$

J = 1 Poisson, J > 1 inhibition, J < 1 clustering

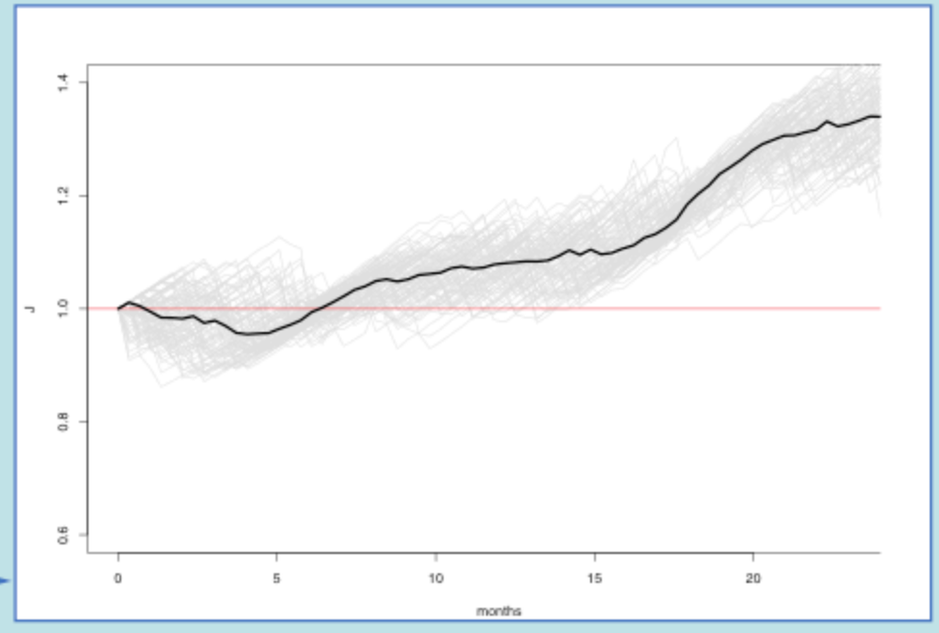
# An example




Estimated J-function for heat stress events occurred in India and China. The bold line denotes the median of the ensemble.

clustering

inhibition




Estimated J-function for heat stress events occurred in India and the EU. The bold line denotes the median of the ensemble.

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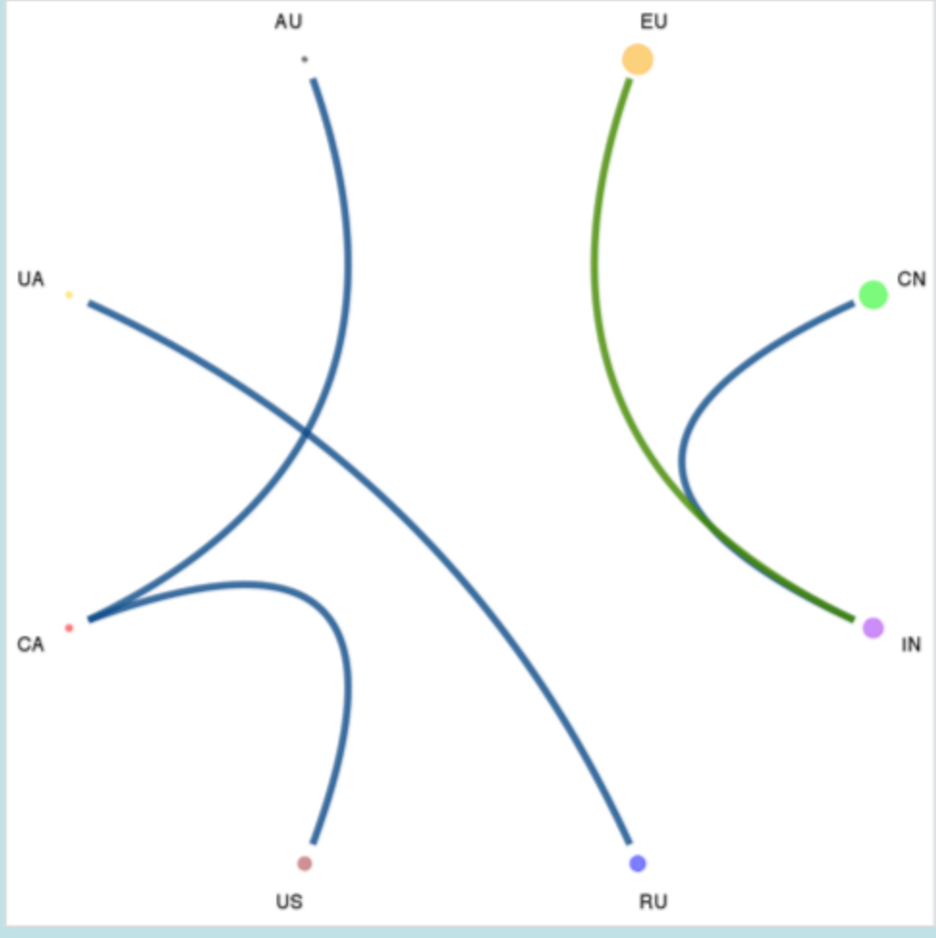
# Global heat stress events

Summary of the analysed interaction of heat stress events in the key regions

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# Conclusions

- Independence is not always a valid assumption
- Neither homogeneity
- Taking into account the interaction of large scale extremes is essential in impact and risk assessment
- Different spatial thresholds should be tested
- Higher-temporal resolution extremes
- The analysis of the J-function has a certain degree of subjectiveness

# Thanks

## Questions?

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