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Changing risks of simultaneous global breadbasket failure

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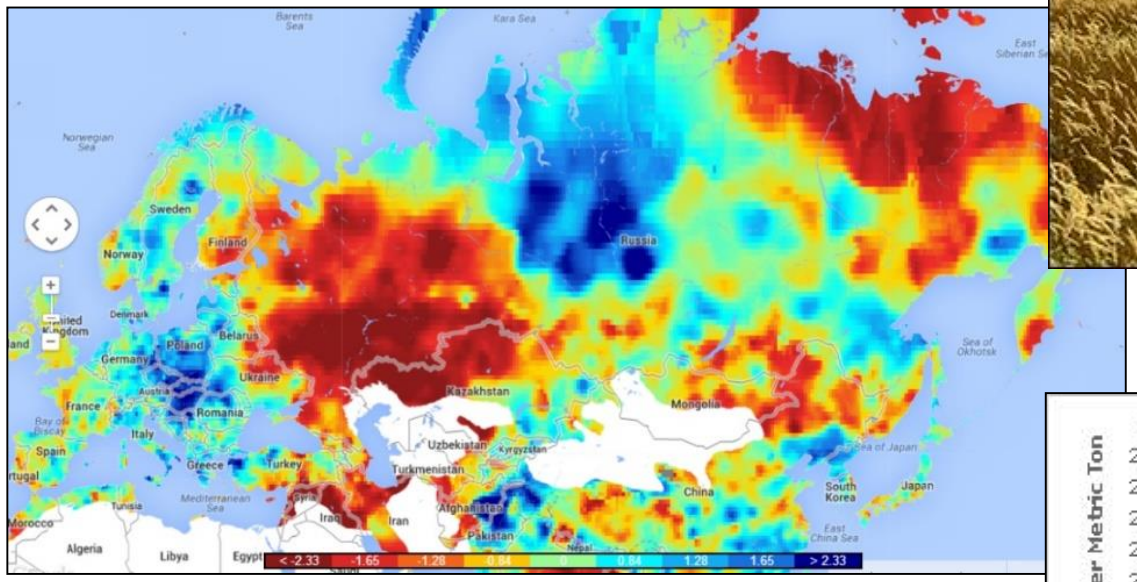
Background

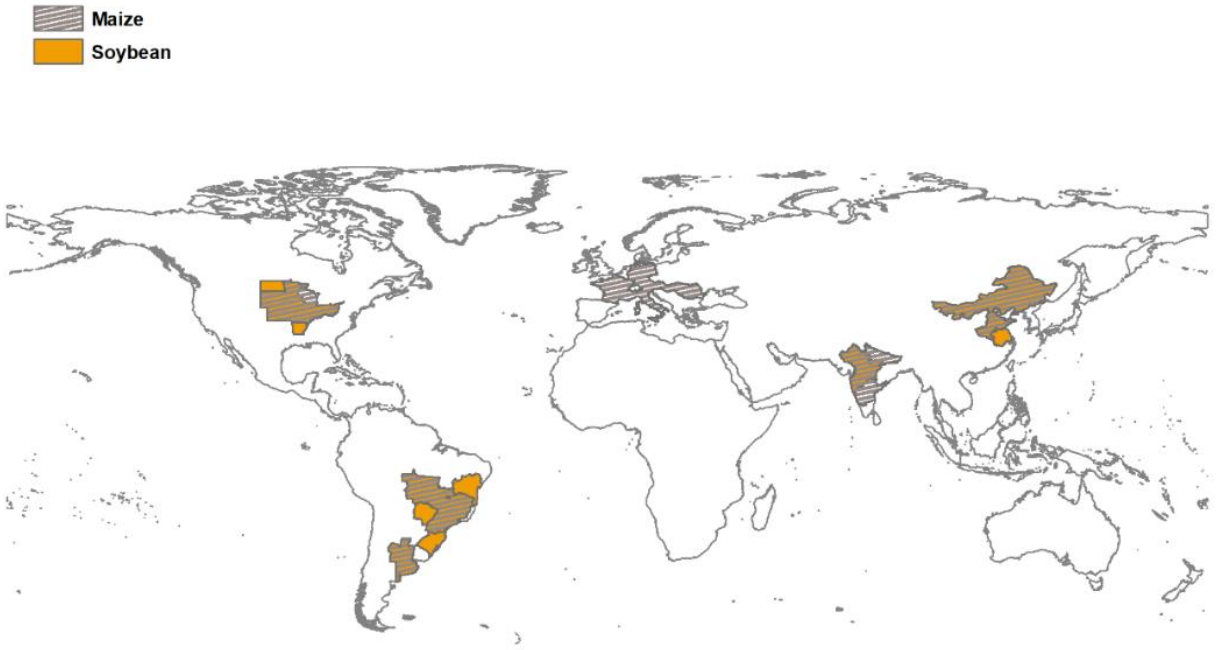
Russia, 2010

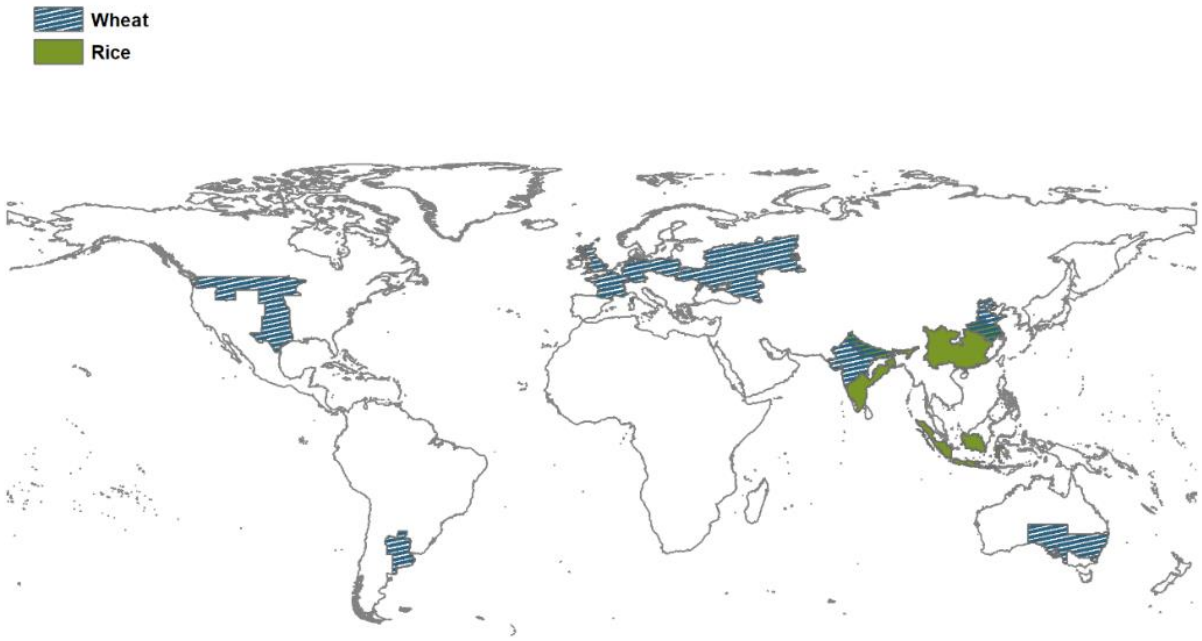
SPEI Global Drought Monitor: October 2010



Wheat prices in US Dollars (Worldbank)

The global breadbaskets





Global wheat, maize, soybean and rice breadbaskets

Simultaneous climate risks in the global breadbaskets

Literature review: crop and region specific climate indicators

Correlation analysis with observed subnational de-trended yields and re-analysis climate indicators

Selection

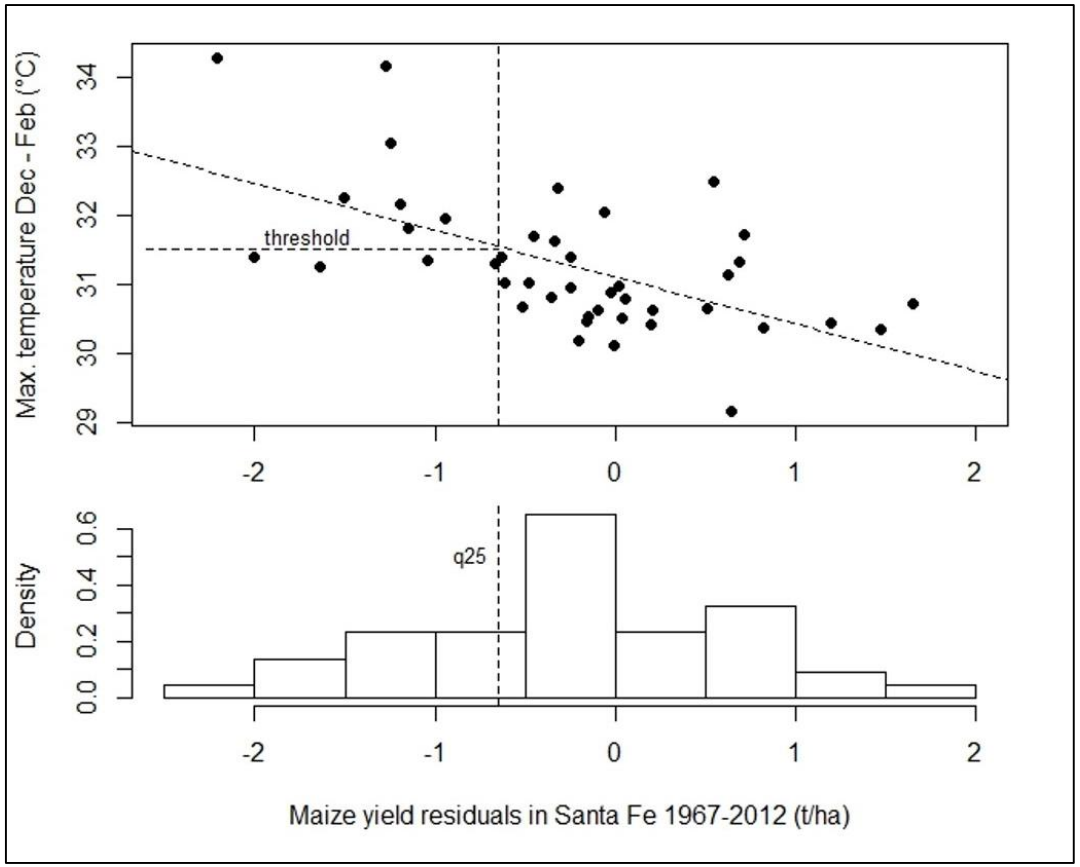
One temperature, precipitation and/or solar radiation based **climate indicator** per crop and region

Definition of **climate indicator threshold** (~25 detrended yield percentile)

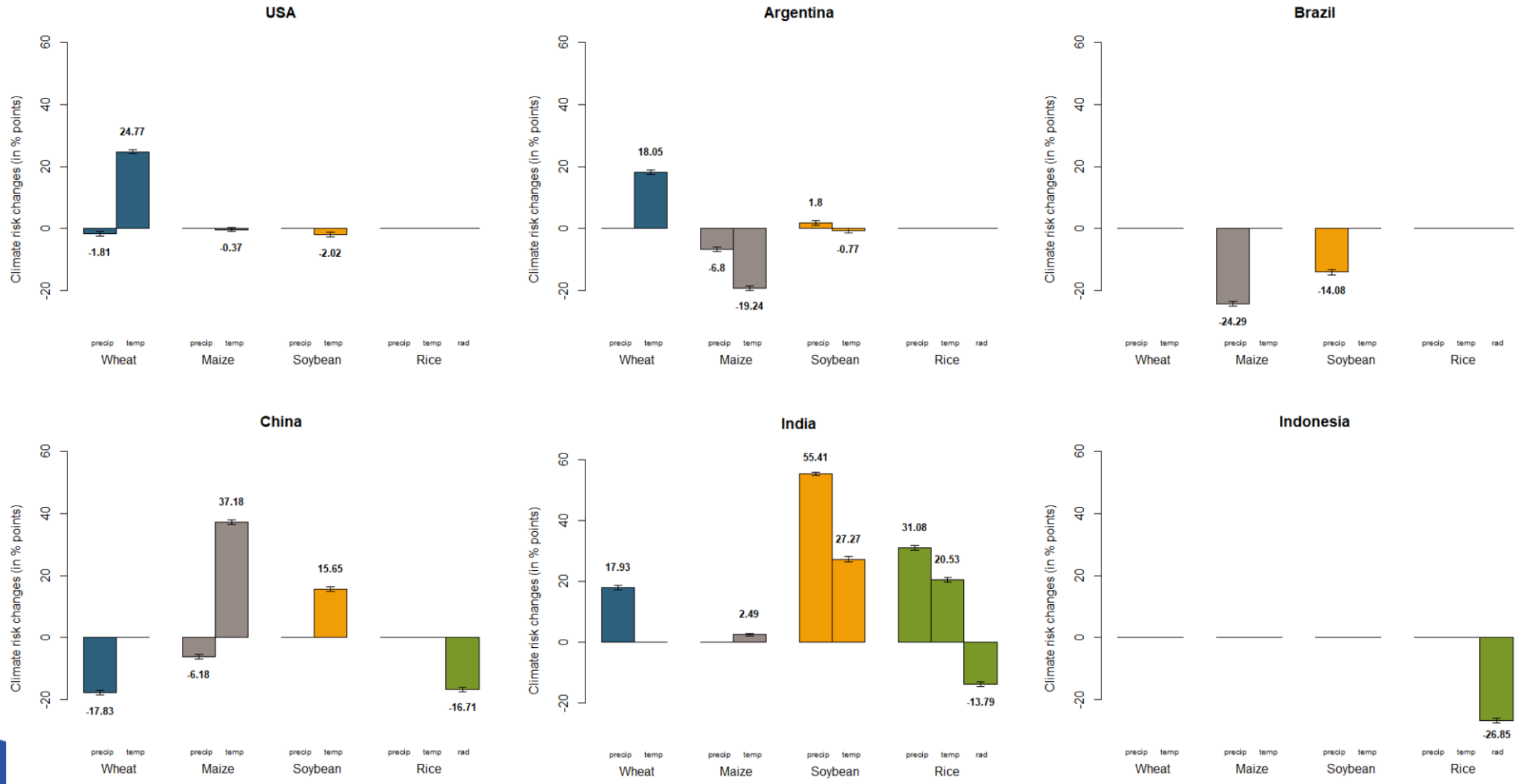
Regional and global **copula analysis**

➡ **Joint climate risks**

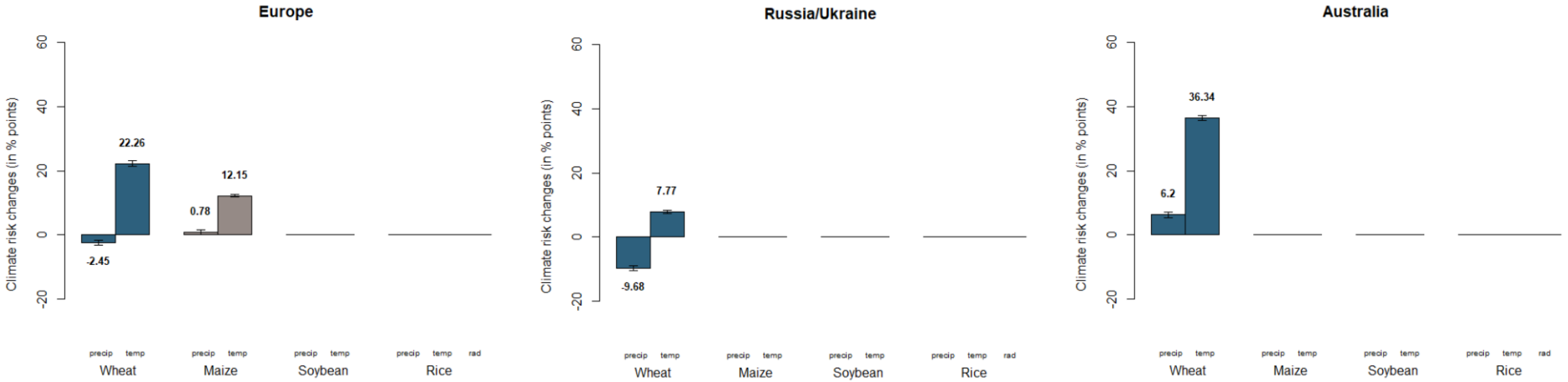
Maize-climate relationship in Santa Fe, Argentina



Changes in climate risks between 1967-1990 and 1991-2012



Changes in climate risks between 1967-1990 and 1991-2012 (cont.)



Copulas

- Combine univariate distribution functions in order to form multivariate, joint distributions

- Flexible tool as it allows marginal distributions from different families to model dependence between random variables

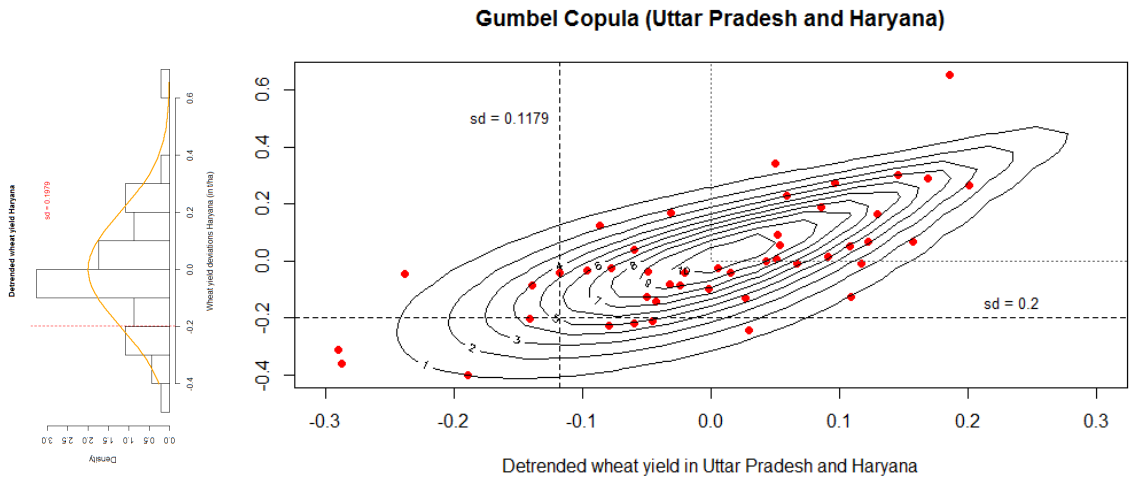
- Sklar's Theorem (1951):

$$H(x,y) = C[F_X(x), F_Y(y)] \quad x,y \in R$$

-> C, F_X and F_Y are uniquely defined if H is

- Two steps: 1. univariate marginal distribution parameters are estimated
  2. the copula dependence parameter is derived

Wheat yields in Uttar Pradesh and Haryana in India



Gumbel copula:

with *u* and *v* as cumulative distribution functions such as $F_{CH}(ch)$and $F_{US/IN}(us/in)$ and α as copula parameter.

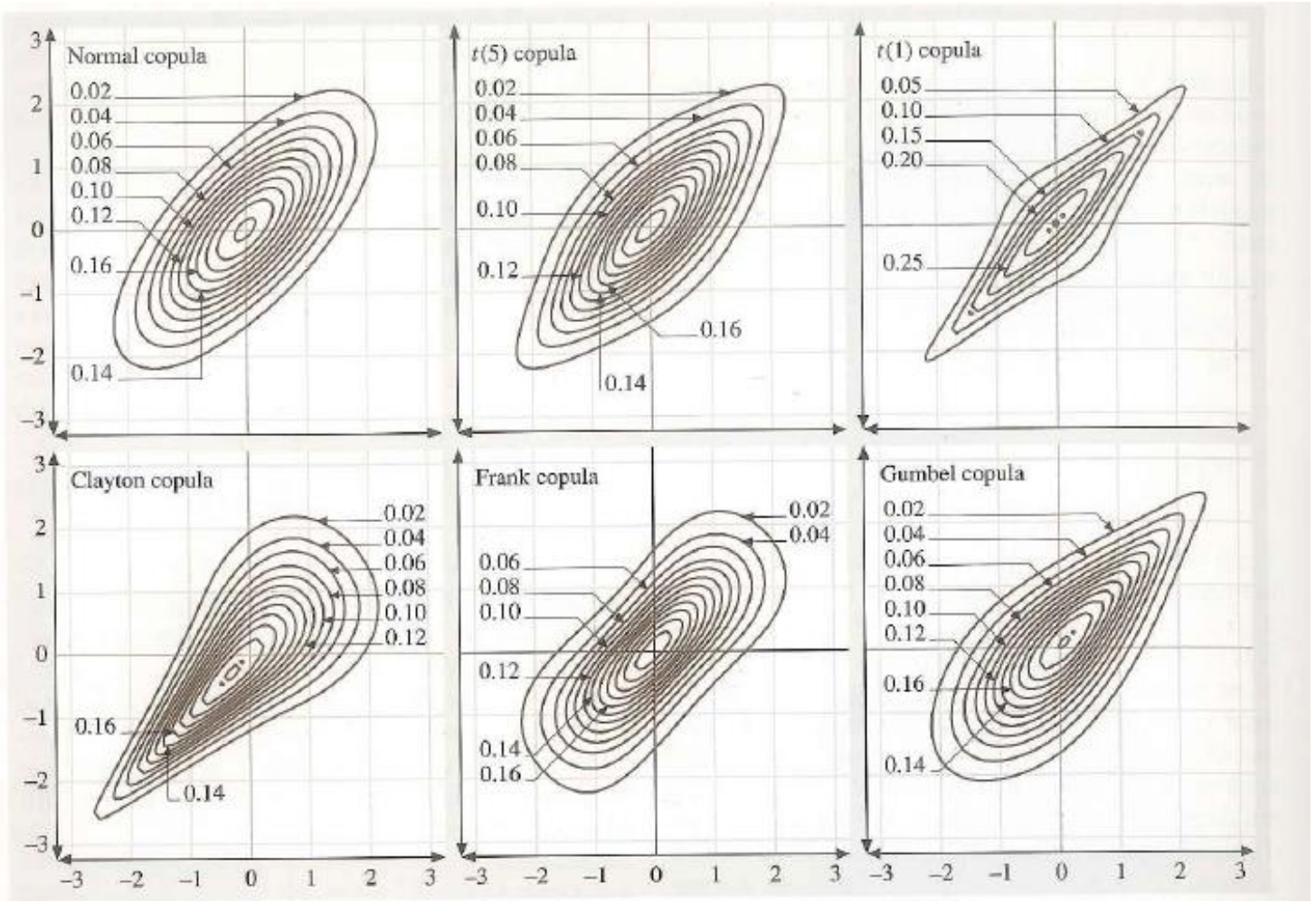
Uttar Pradesh and Haryana yield deviations follow the **normal distribution**.

P(UP ≤ -0.118, H ≤ -0.2)
= **C[**$F_{CH}(-0.118)$, $F_{US/IN}(-0.2)$**]**
= 0.075

Compared to independence:
P(UP ≤ -0.118, H ≤ -0.2)
= $F_{UP}(-0.118) \cdot F_{H}(-0.2)$
= 0.024

-> risks would be underestimated by a factor of three!

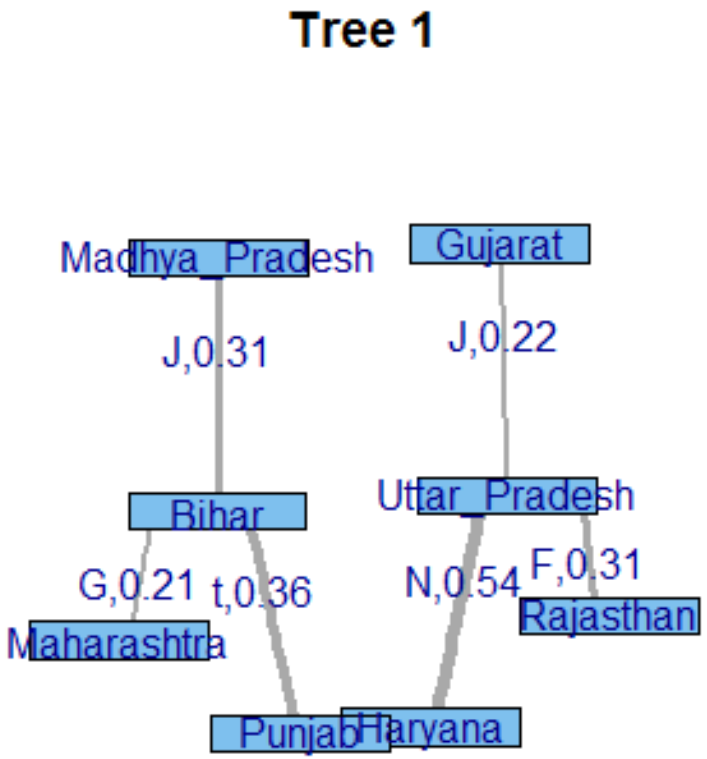
more copula families…



Pham (Ed) (2006).

Multivariate vine copulas

RVine structure of the Indian breadbasket



More information on vine copulas:
Aas (2004), Aas et al. (2009), Czado et al. (2010), Dißmann et al. (2013)

Simultaneous climate risks in the global breadbaskets

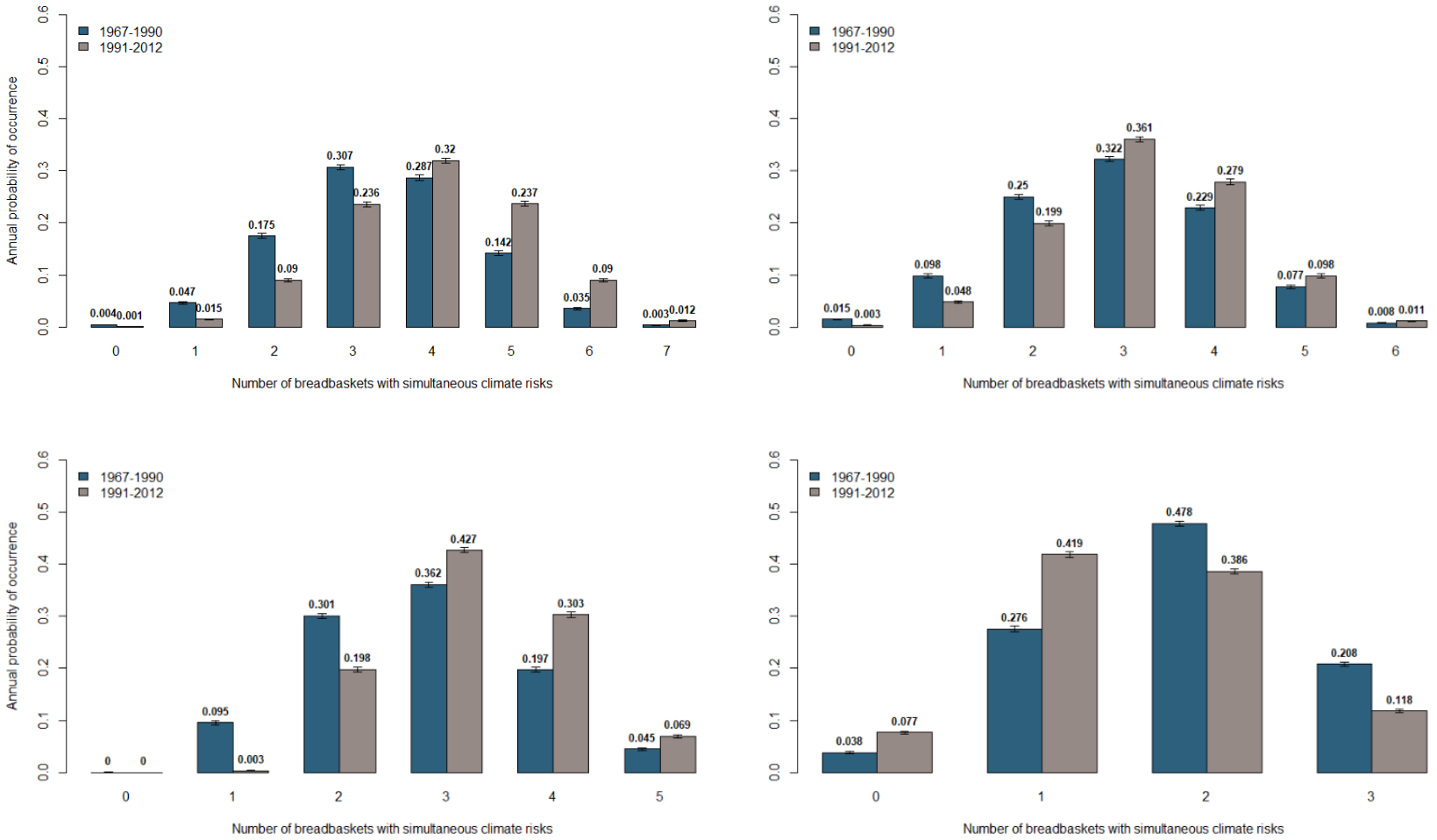


Figure 1: Likelihood of simultaneous climate risks: defined as relevant climate indicators exceeding the value that corresponds to the to the lower 25% yield deviation percentile. Likelihood of climatic conditions simultaneously threatening crop losses in multiple global **(a)** wheat **(b)** maize **(c)** soybean and **(d)** rice breadbaskets

Gaupp et al., *in revision*

Thank you for your attention!

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