

Dependence structures for a reinsurance portfolio exposed to natural catastrophe

**Alain Chiolero* & Hervé Castella,
PartnerRe Zurich Branch**

Current address: Bank Leu, Zürich, Alain.Chiolero@leu.com

Natural catastrophe risk for a reinsurance portfolio

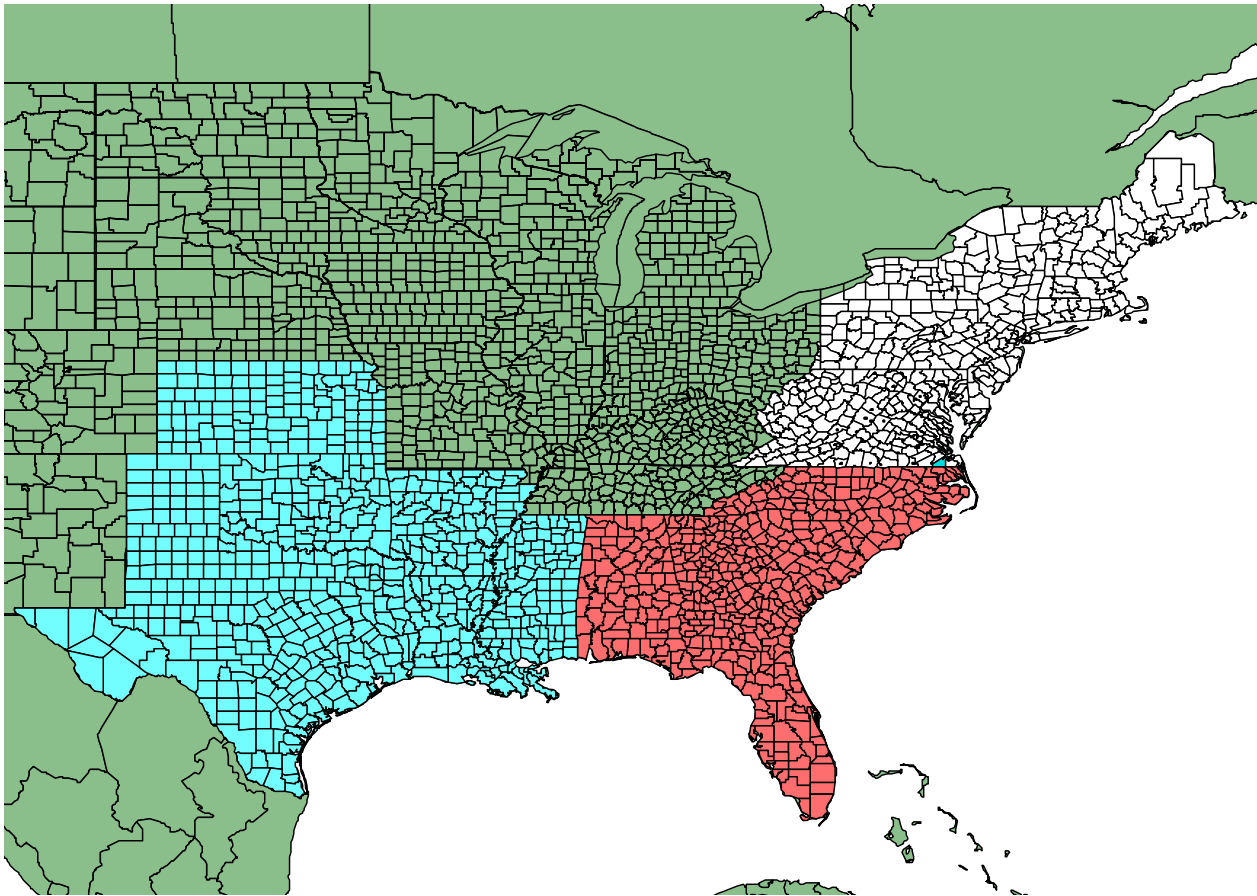
- Natural catastrophes pose a major financial risk for reinsurances
- Modelling their impact on its portfolio is essential to estimate the capital needs of a reinsurance
- Dependencies are Achilles heel of any portfolio model:
 - Different models of dependencies may result in very different capital requirements
- Ideal playground to analyse dependencies:
 - Large body of research on natural catastrophes
 - Well-established catastrophe (CAT) models



Focus of study

- Comparative study of several types of dependencies:
 - Gaussian, t-, and empirical copula
 - Event-induced dependencies
- Dependencies applied to marginal distributions of losses in neighboring regions due to same natural peril:
 - Hurricane risk within 3 zones on the East Coast of the US
 - Windstorm risk across countries in Western Europe
- Study of the impact on the distribution of annual loss aggregate over all regions.

Zones on the East Coast of the US



Marginal distributions within single region

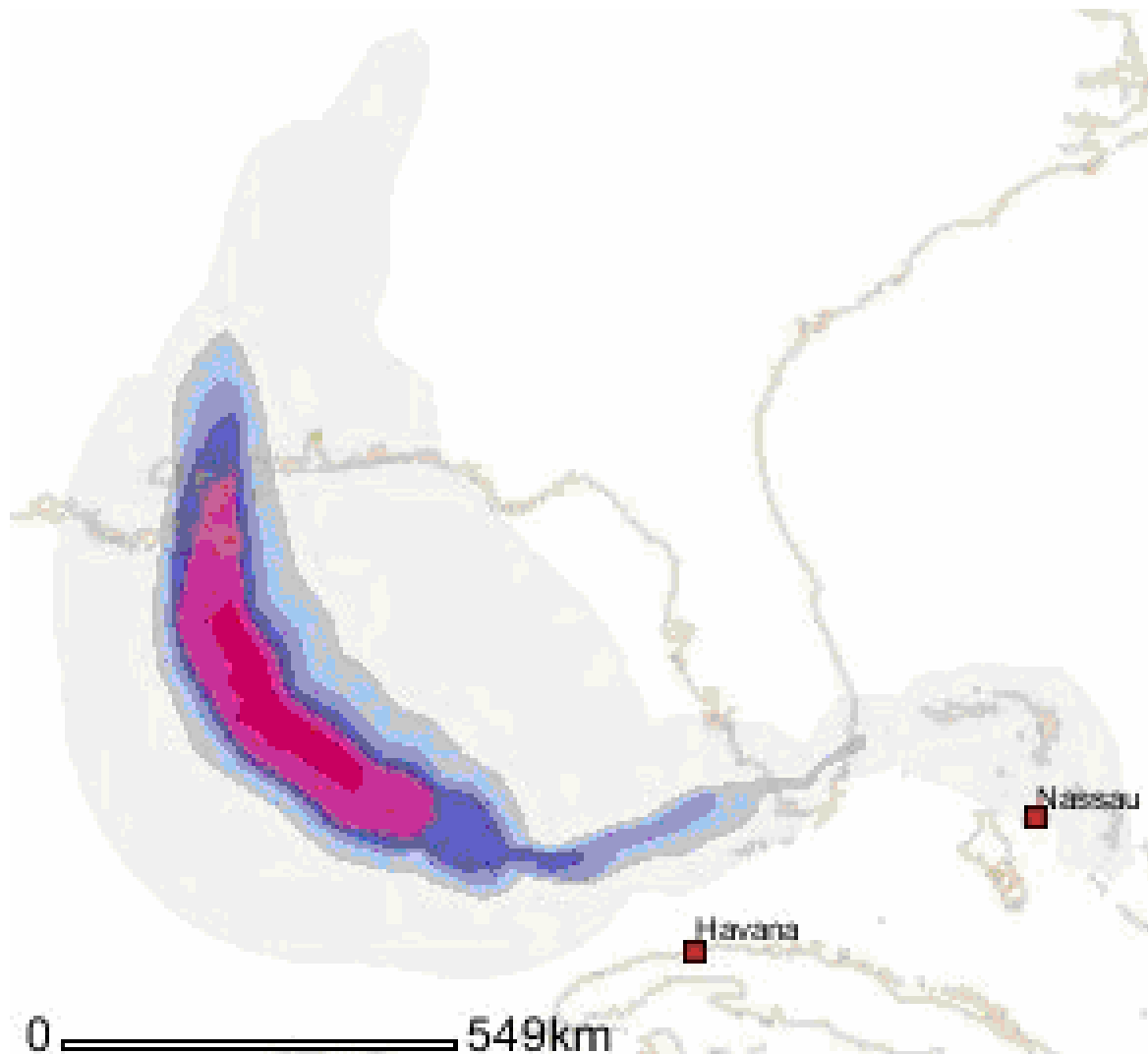
- **Distribution of annual loss for all reinsurance contracts exposed to given peril in region:**
 - Exposure of individual contract based on pricing information.
 - Different contracts exposed within the same region are assumed fully correlated (comonotonic addition)

Study of dependencies between zones/marginal distributions

Dependencies in Cat models

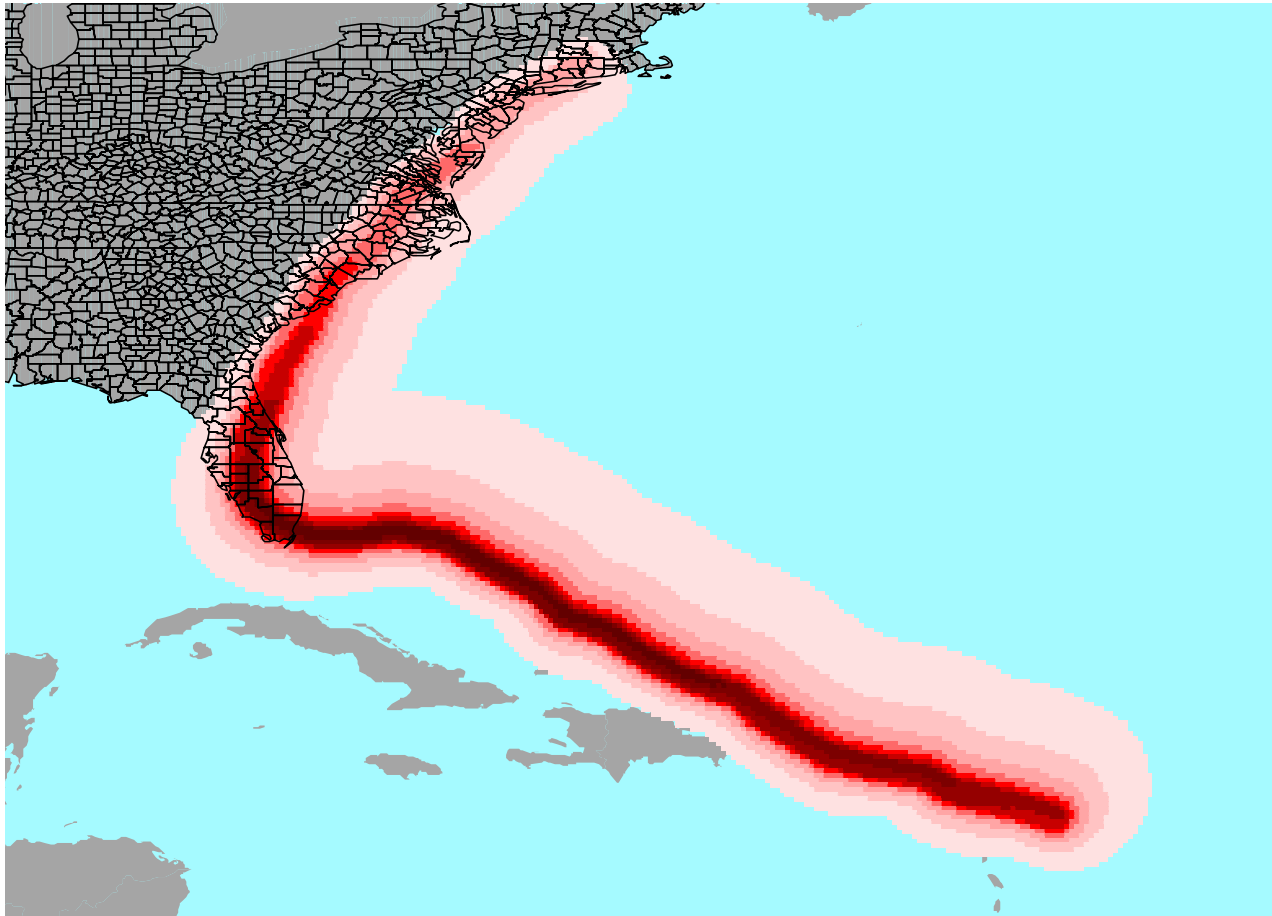
- **Cat models have a natural way to describe dependencies via events:**
 - Catalogue of events that hit several regions
 - For a given event the losses to each region can be simply added up.

Hurricane Katrina



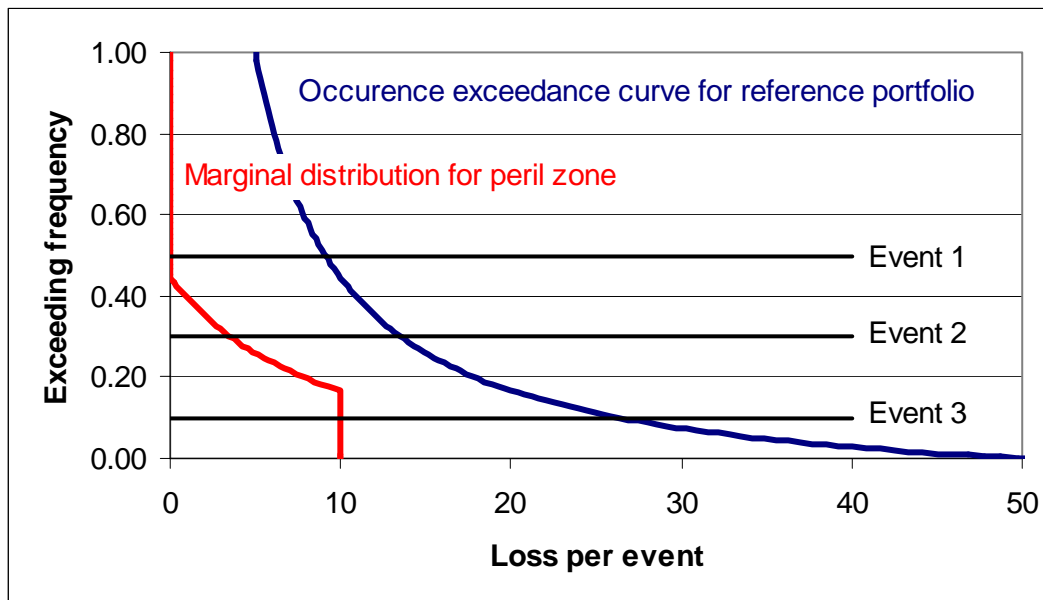
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Hurricanes hitting South East and North East



Event-induced dependencies

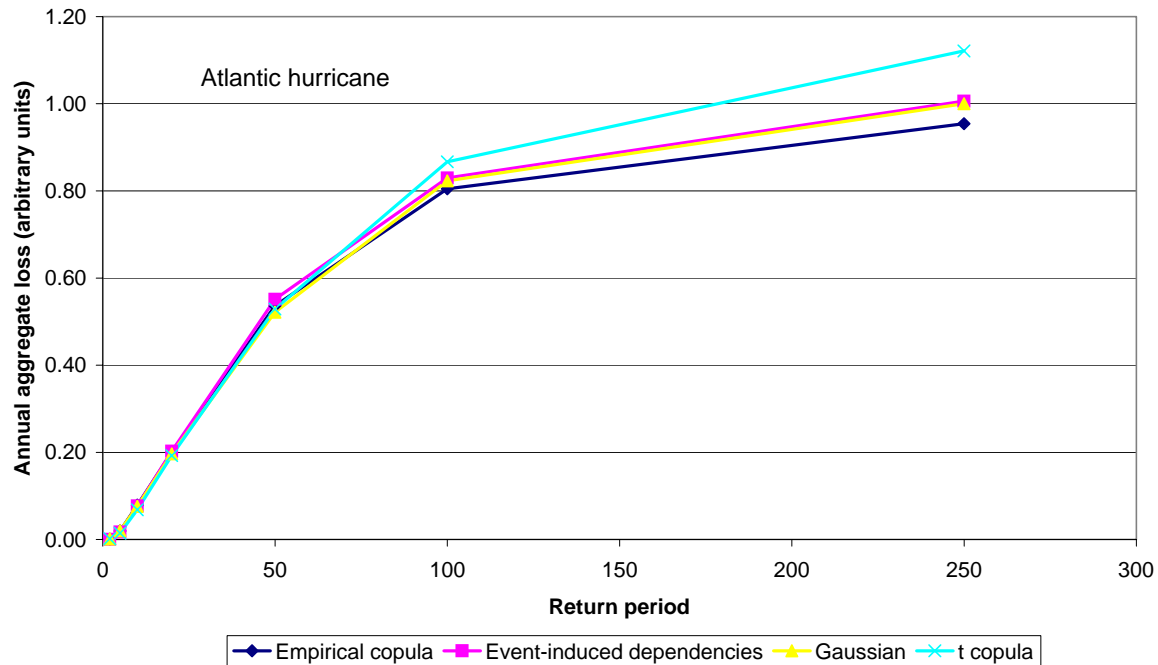
- **Event-induced dependencies as a reference model:**
 - Reproduces the inherent dependencies within events.
 - Maps severity distributions for each region on event losses using the exceedance frequency curve for a reference portfolio produced by the Cat model.



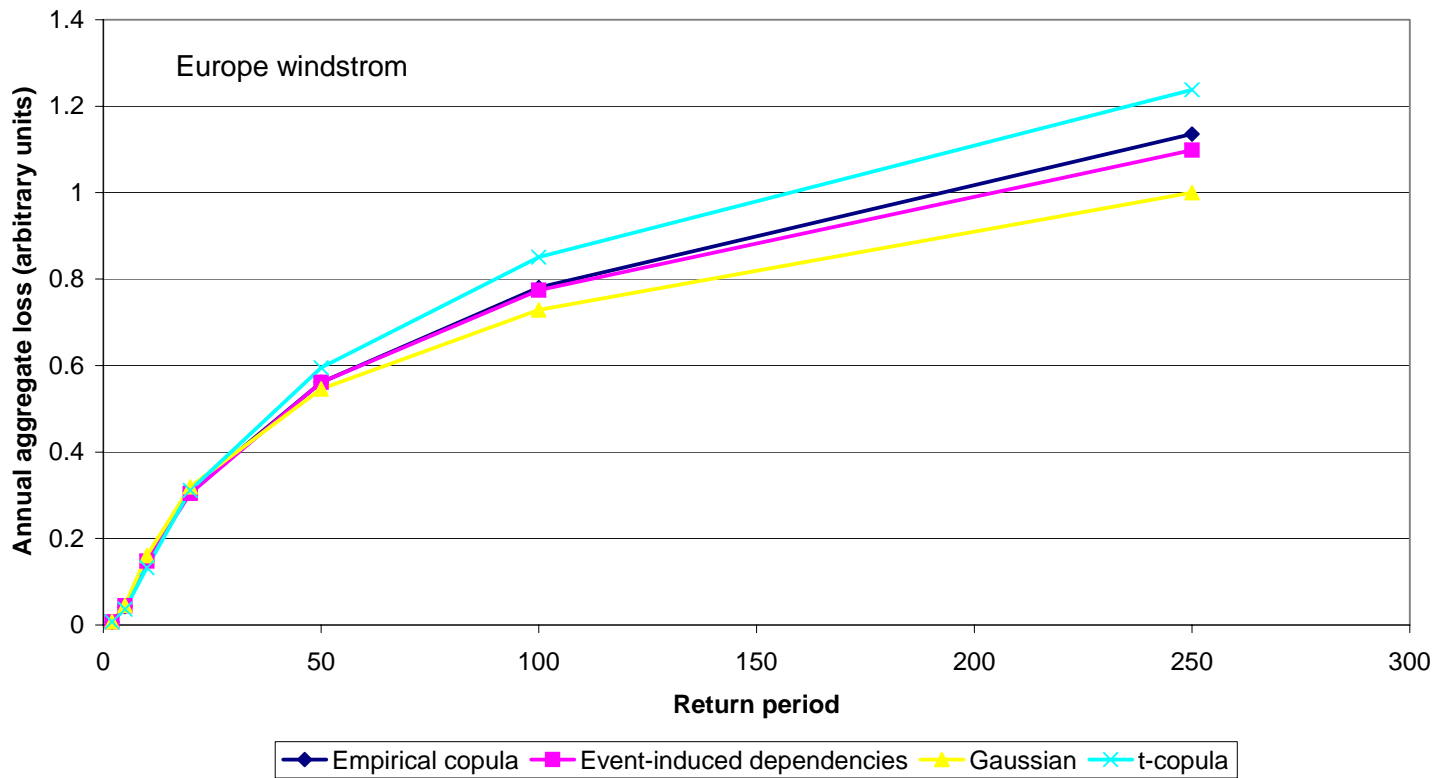
Dependencies via copula

- **Copula are parameterized with runs of Cat models:**
 - Parameters are correlation matrix and degree of freedom (for t copula)
 - Cat models are run on reference exposure concentrated in each region.
 - Result of run is an ensemble of events (hurricanes or windstorms) with the corresponding loss to each region.
 - Ensemble of annual losses generated from event losses using frequency of each event and Poisson distribution.

Impact on annual aggregate loss distribution: Hurricanes

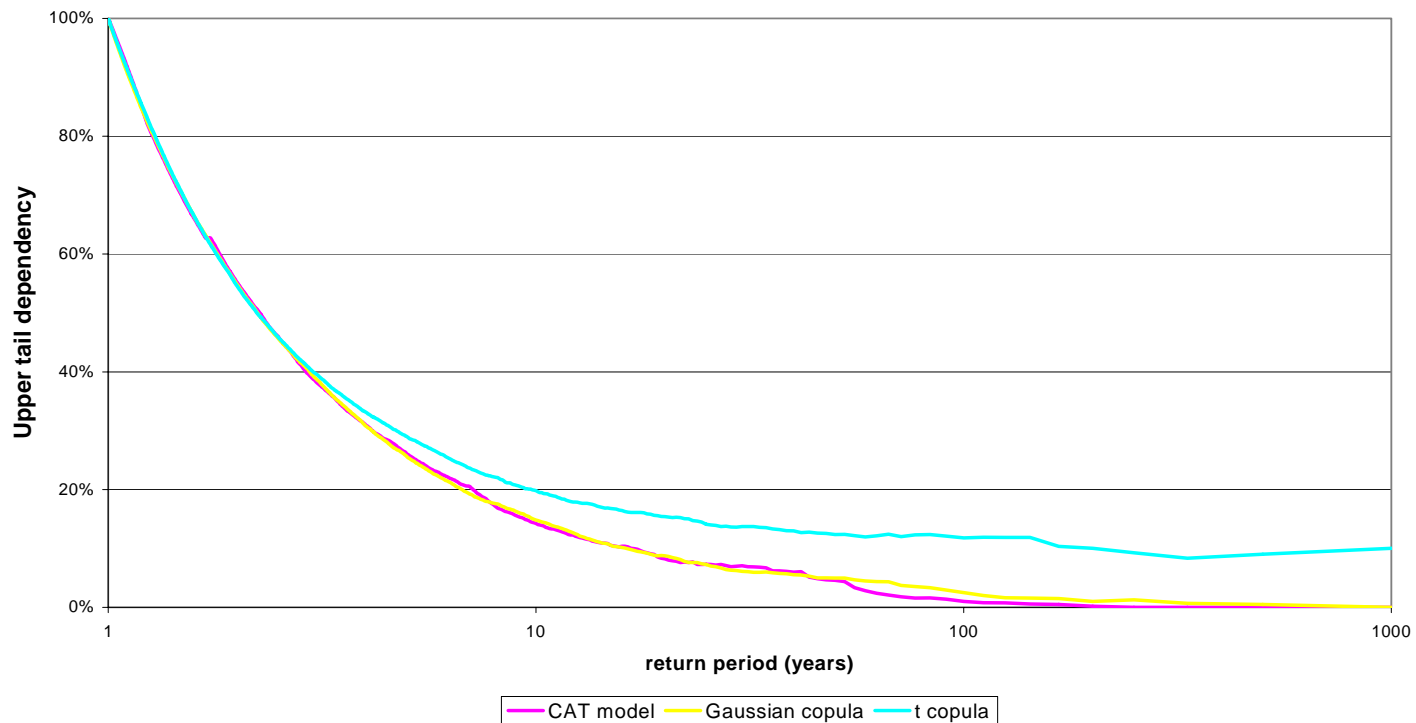


European windstorms



Upper-tail dependency

$$T(q) = P\left[Y > F_1^{-1}(q) \mid X > F_2^{-1}(q)\right]$$



Conclusions

- Gaussian and empirical copula give a good description of dependencies present in CAT models
- t-copula tends to overestimate the dependency in the tail
- No evidence of upper-tail dependency