# MATH5805 – A Modern Introduction to Extreme Value Theory

## Week 11 - Diving deeper in the world of extremes

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## Lecture outline

1. What we have NOT talked about
2. Research Topics





# 1. What we have NOT talked about

# Other topics in extremes

If we had more time, we would extend the course to include

**Multivariate Peaks-Over-Threshold methods**

- **Coles (2001, Section 8.3.1)**: small section on bivariate threshold excess models
- No unique way of generalising the conditioning event $Y > u$.
- Main manuscripts: **Rootzén, Segers & Wadsworth (2018)**, **Kiriliouk, Rootzén, Segers & Wadsworth (2019)**.

# Other topics in extremes

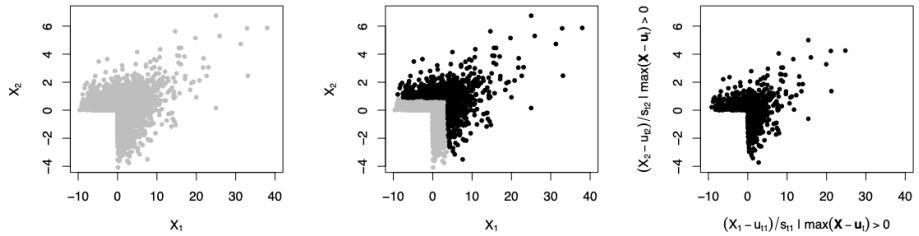
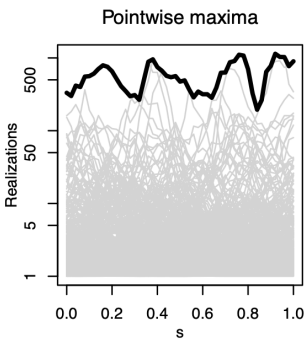


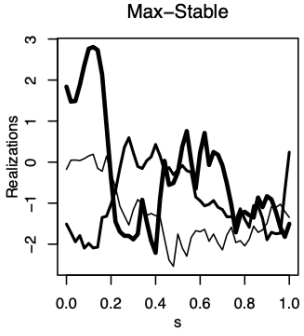

**Fig. 1** Illustration of (T2). Left panel: points from a two-dimensional multivariate GP distribution with parameters $\boldsymbol{\sigma} = (2, 0.5)$ and $\boldsymbol{\gamma} = (0.2, 0.1)$. Centre: black points denote exceedances of the threshold $\boldsymbol{u}_t = \boldsymbol{\sigma}(t^{\boldsymbol{\gamma}} - 1)/\boldsymbol{\gamma}$, for $t = 5$. Right: excesses of $\boldsymbol{u}_t$ rescaled by $\boldsymbol{s}_t = t^{\boldsymbol{\gamma}}$ have the same distribution as points in the left panel, but are five times fewer. In particular extremes in right plot hence are smaller.

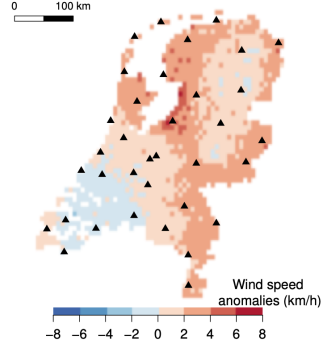
# Other topics in extremes

**Spatial extremes:** max-stable processes

- Extension of multivariate extremes to infinite dimensions
- Component-wise Maxima of stochastic processes
- Parametric modelling and estimation



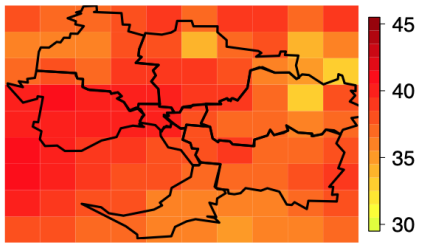



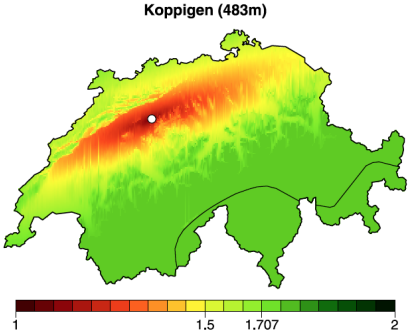



# Other topics in extremes

**Spatial extremes:** max-stable processes

- **Ribatet (2013)**: Introduction and implementation
- `R` package `SpatialExtremes` and its vignette
- **Padoan, Ribatet, Sisson (2010)**: pairwise likelihood

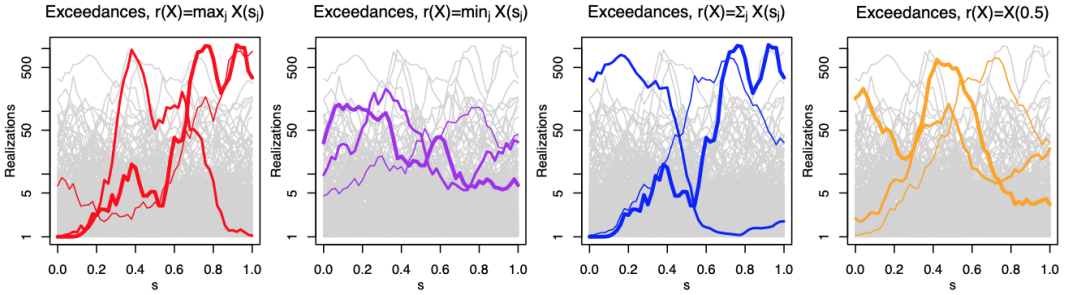


# Other topics in extremes

**Spatial extremes:** Pareto processes

- Generalized Pareto processes: conditioning event over the entire space $\{\sup_{s\in\mathcal{S}} \tilde{Y}(s) > n\}$
- $r$-Pareto processes: conditioning on some risk function



# Other topics in extremes

**Spatial extremes**

**Max-id models, max-mixtures, scale mixtures, conditional extremes etc.**

A good (comprehensive) review: **Huser & Wadsworth (2021)**.

Using neural networks, machine learning techniques, AI (forecasting), ...

**Graphical extremes**: river networks, flight delays, financial markets, ...

## 2. Research Topics



# Research projects

**Collaborations** at UNSW Sydney with Prof Scott Sisson, Dr Peng Zhong but also Prof Andy Pitman (and others in the CoE for Climate Extremes). International collaborations possible too!

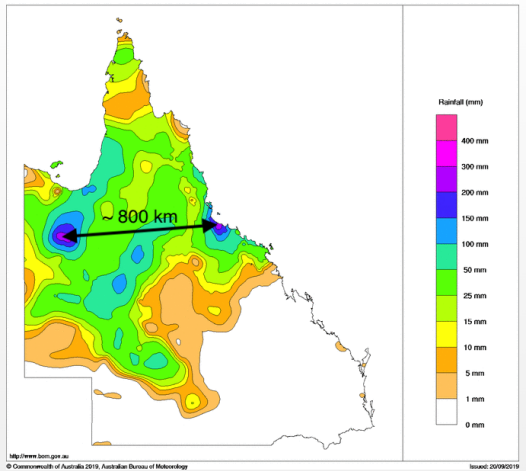
There are **many** possible projects that can be tailored to one's interests

- Improving the `ExtremalDep` package!
- What makes an extreme, extreme: use of $r$-Pareto processes, theoretical improvements, big inferential questions, modelling of floods (locally intense rainfall vs cyclonic rainfall)
- Tailoring $r$-Pareto processes to real-world problem: use of flexible risk functions, reduce computational burden.

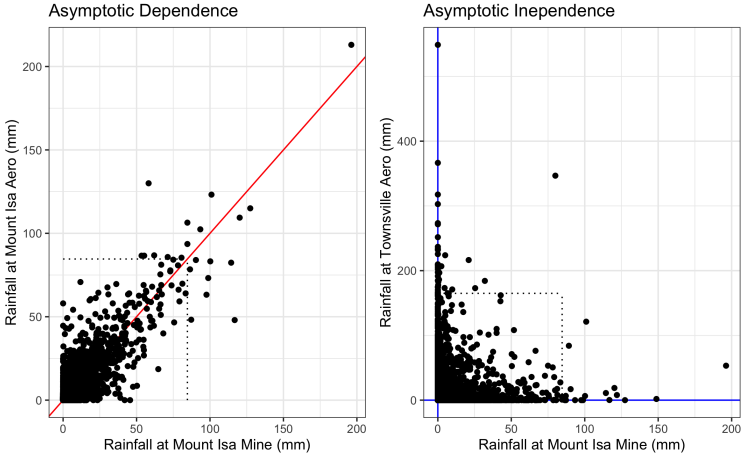
# Research projects

- Moving from asymptotic to sub-asymptotic models. Max-stability $\rightarrow$ asymptotic dependence (non-zero levels of dependence at asymptotic extreme levels).
- Modelling non-stationarity.
- **Applications in Climate, Finance, Defence.**
- **From theoretical to computational and applied projects.**

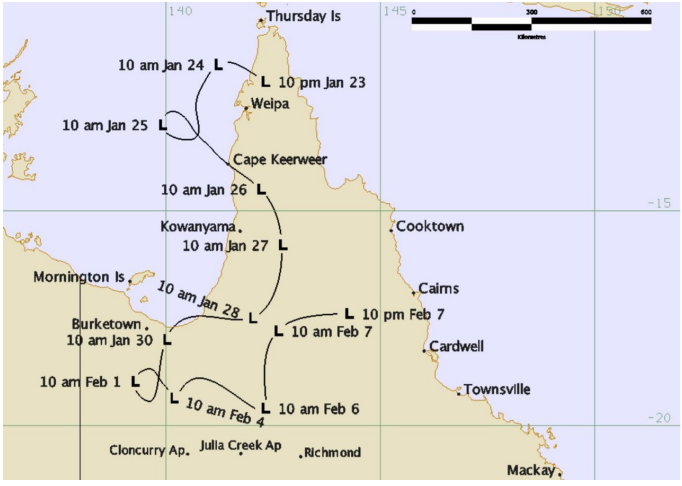
# Real-world problems aren't always easy to model!



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# The End

**Please reach out if you're interested in doing a PhD or a research project!!**



Litterature


1. **[C01]** Coles, S. (2001). An Introduction to Statistical Modeling of Extreme Values. Springer. Chapter 4.
2. **Rootzén, H., Segers, J. & Wadsworth, J. (2018)**. Multivariate peaks over thresholds models, *Extremes*, 21, pp.115–145.
3. **Kiriliouk, A., Rootzén, H., Segers, J. & Wadsworth, J. (2019)**. Peaks over thresholds modelling with multivariate generalized Pareto distributions, *Technometrics*, 61, pp.123–135.
4. **Ribatet, M. (2013)**. Max-stables processes at work, *Journal de la Société Francaise de Statistique*, 145(2), pp.156–177.
5. **Padoan, S., Ribatet, M. & Sisson, S. A. (2010)**. Likelihood-based inference for max-stable processes, *Journal of the American Statistical Association*, 105(489), pp.263–277.
6. **Huser, R.. & Wadsworth, J. (2020)**. Advances in statistical modeling of spatial extremes, *WIREs Computational Statistics*, 5(3), e1537.