

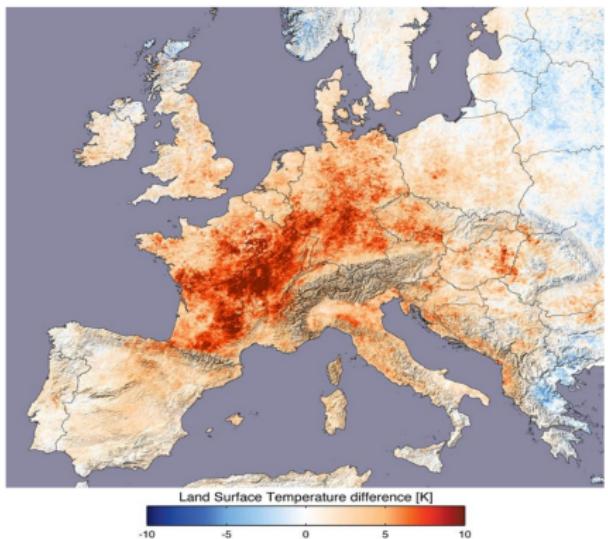
# Extreme Value Analysis for Climate Research

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# Climate extremes

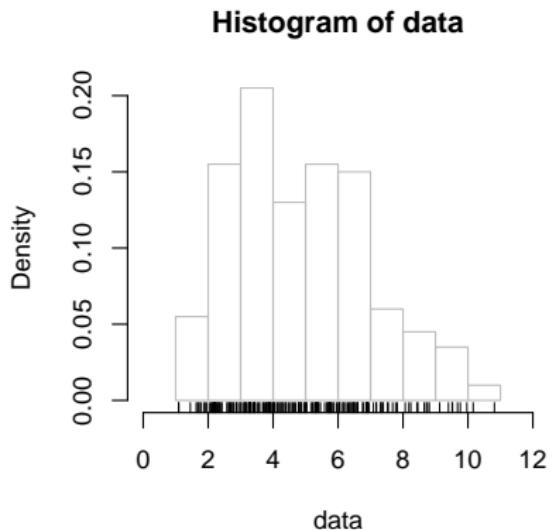
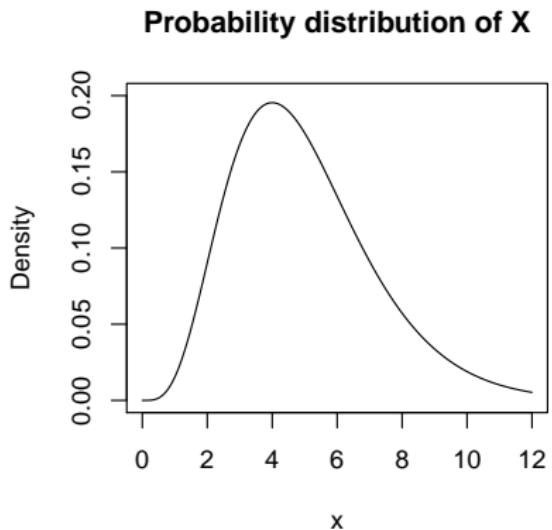


**Figure:** Source: Stöckli, Simmon and Herring, NASA Earth Observatory (**Left**).  
<http://abcnews.go.com/US/tropical-storm-harvey-expect-historic-storm/story?id=49435050> (**Right**).

## Scientific questions

- ▶ How large is the magnitude of extreme events (e.g. 100-year rainfall)?
- ▶ How extremes vary in space and time?
- ▶ How extremes may change in future climate conditions?

# Probability distribution and statistical modeling



How can we infer the underlying probability distribution from data?

# Normal distribution for sample means

# Which distribution to use for sample maxima?

## Some theorems

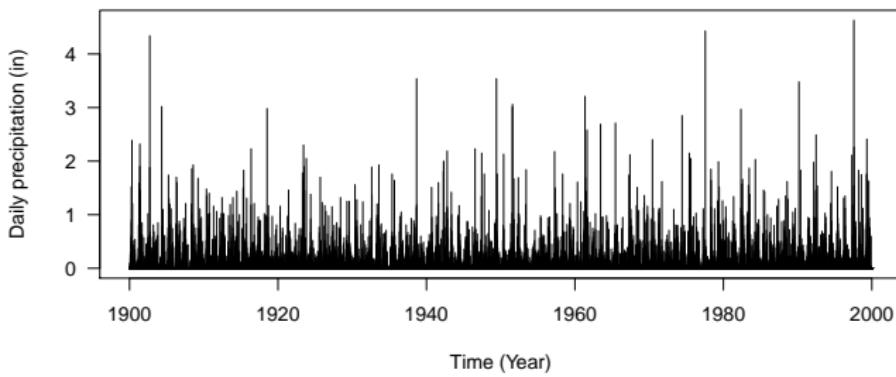
- ▶ Central limit theorem:

Normal for sample means

- ▶ Extremal types theorem:

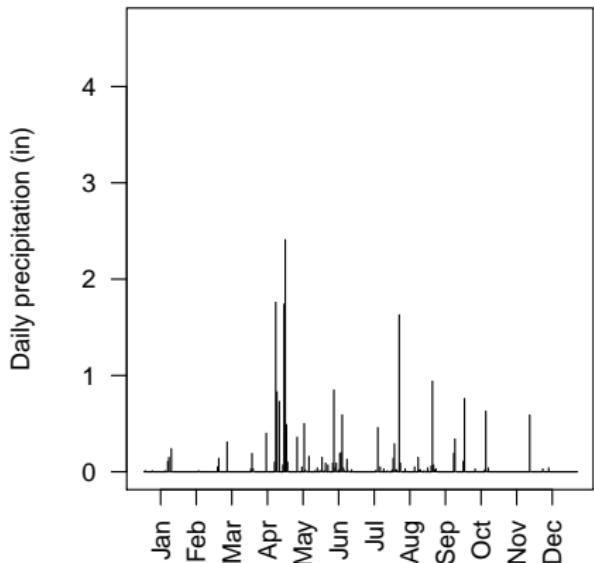
Generalized extreme value distribution for sample maxima

# Fort Collins daily precipitation, 1900 ~ 1999

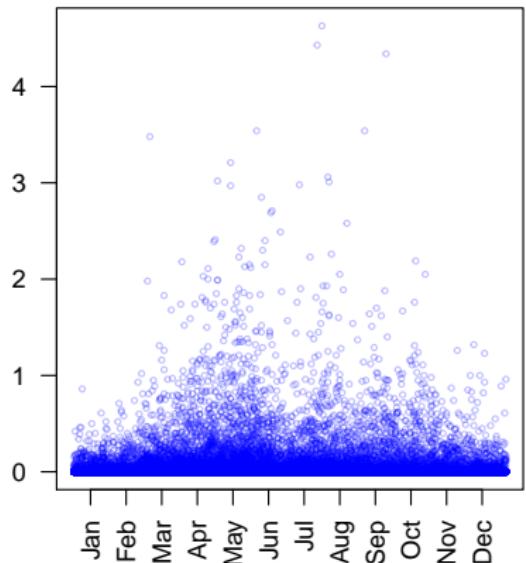


# Seasonal variation for daily precipitation

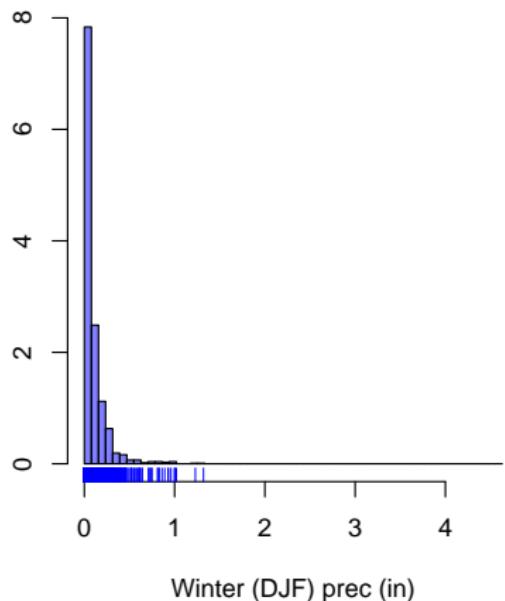
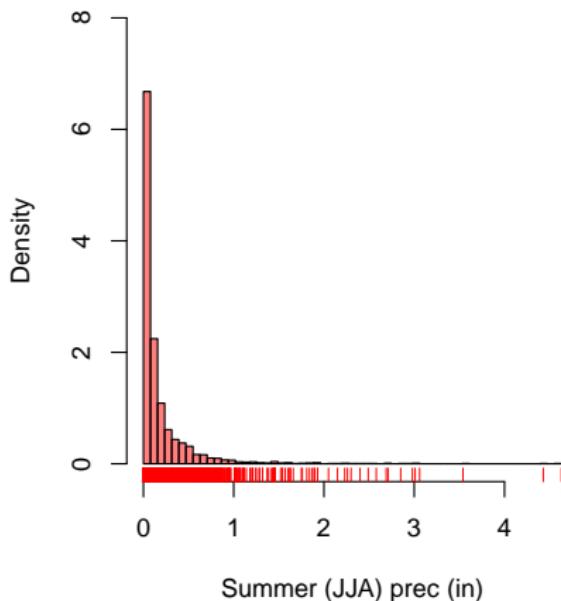
1999



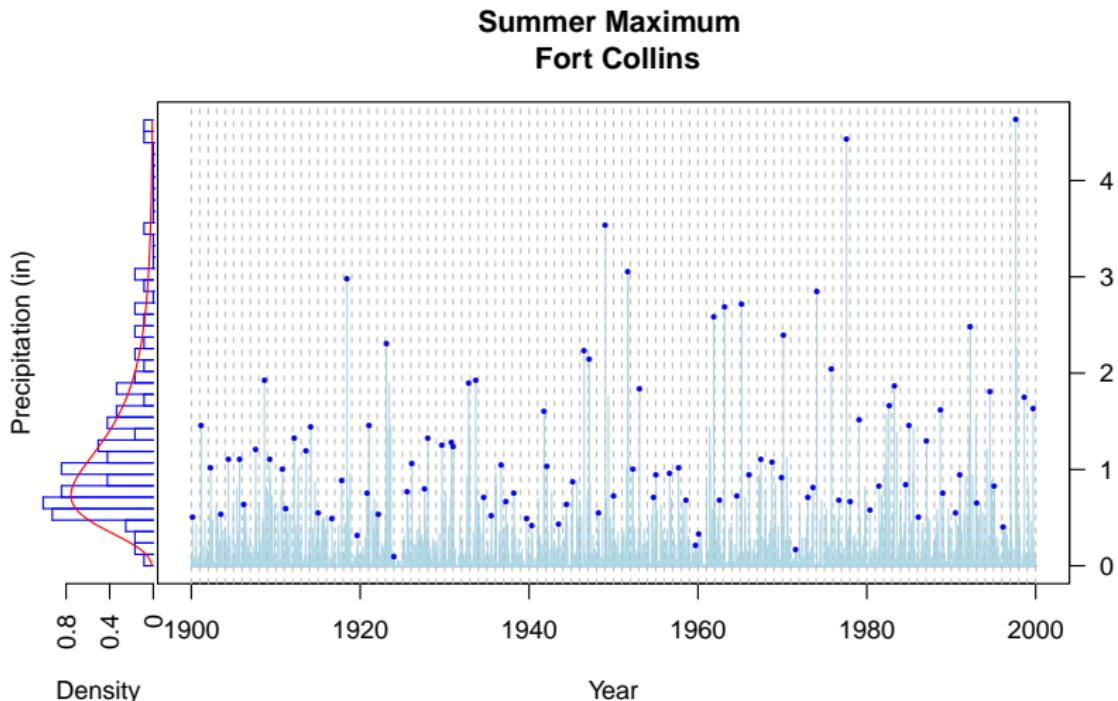
1900 ~ 1999



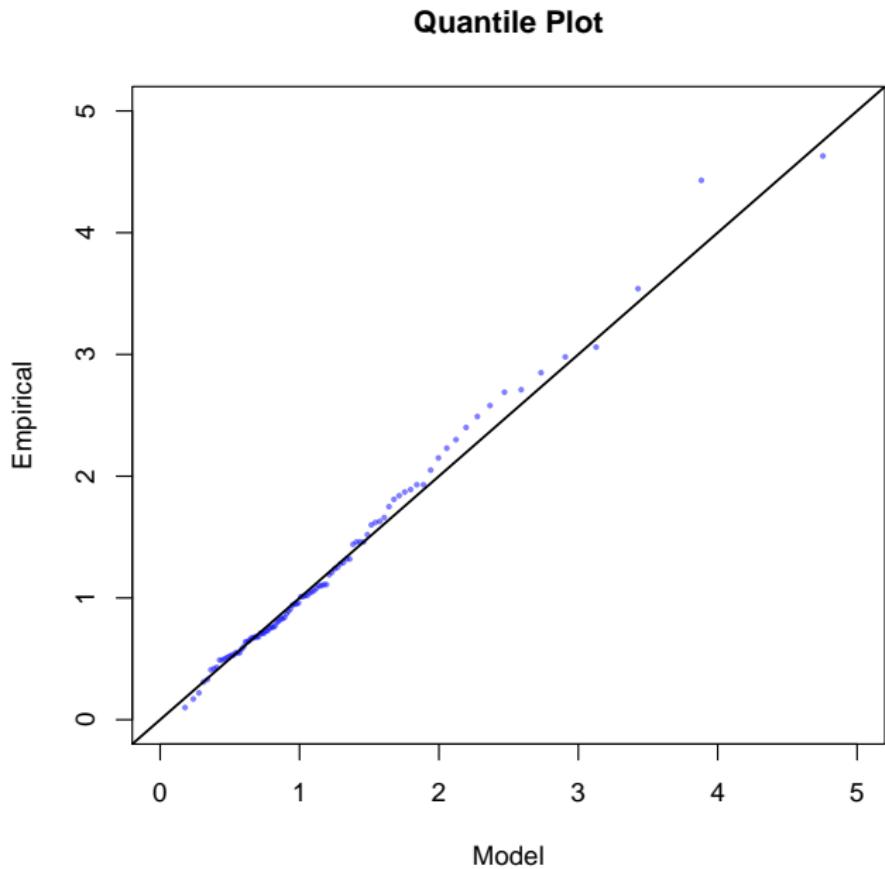
# Summer vs. winter daily precipitation



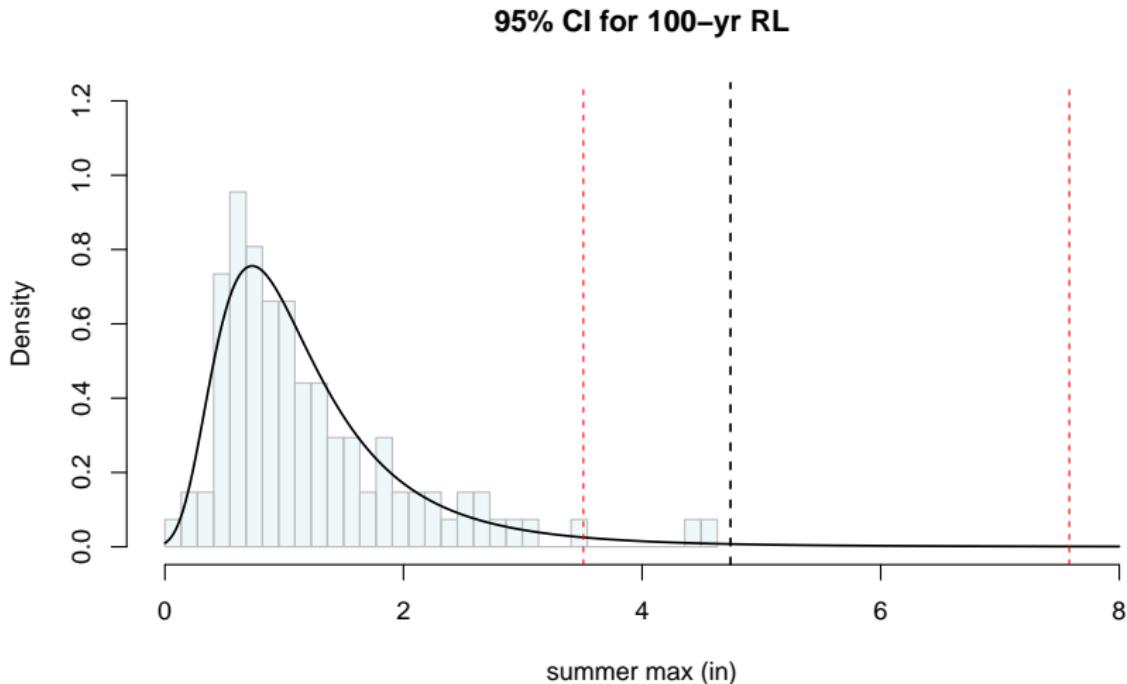
# Block maxima method



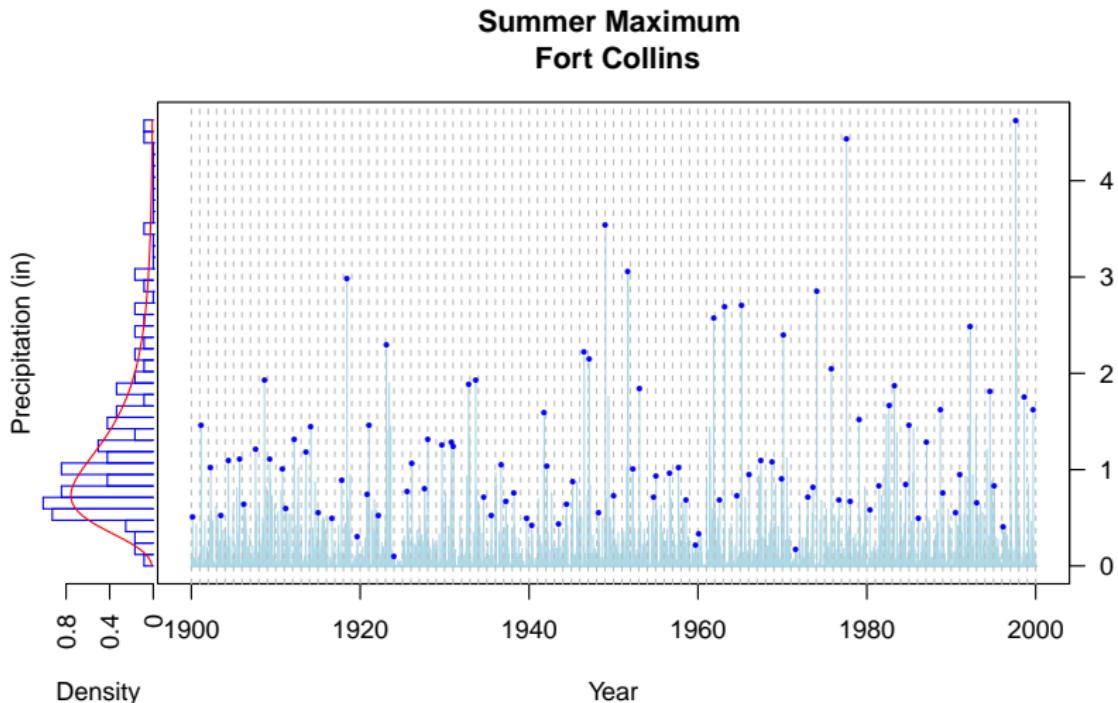
# GEV fit diagnostics



# Inference for 100-year event



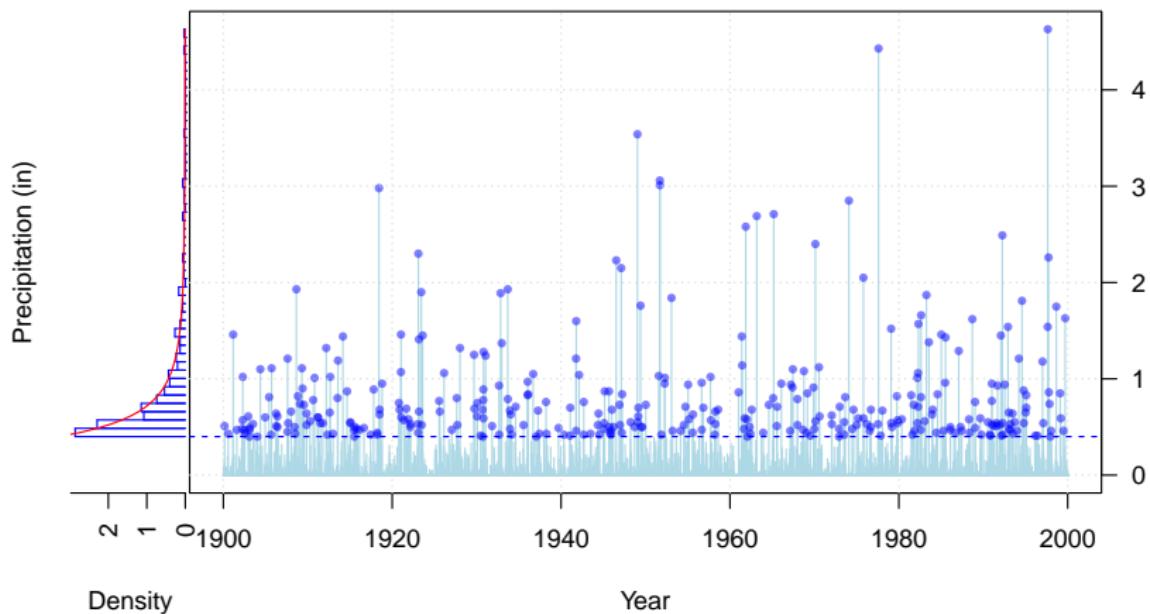
# Recall the block maxima method



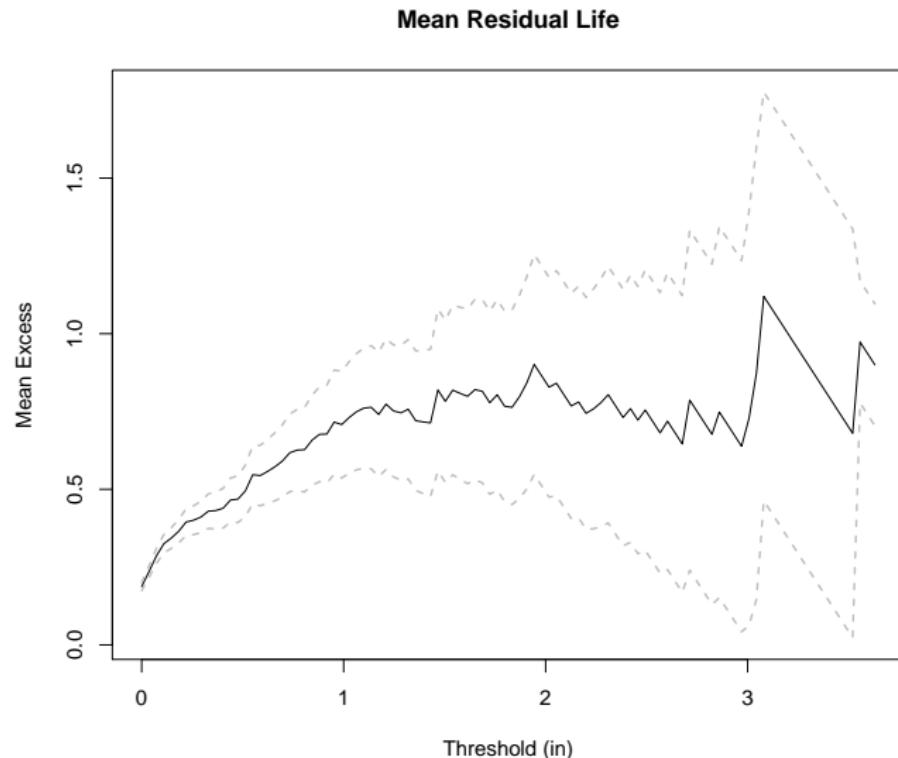
Can we use data more efficiently?

# Threshold exceedances method

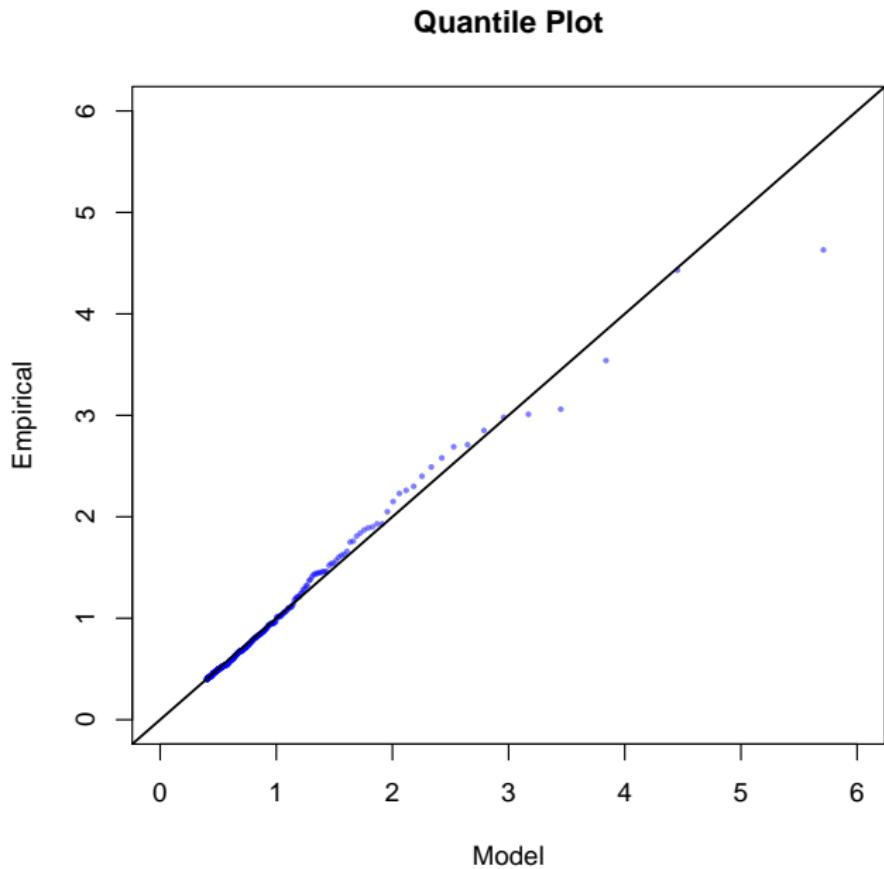
**Theorem:** GEV for block maxima  $\Rightarrow$  GPD for excesses over high threshold



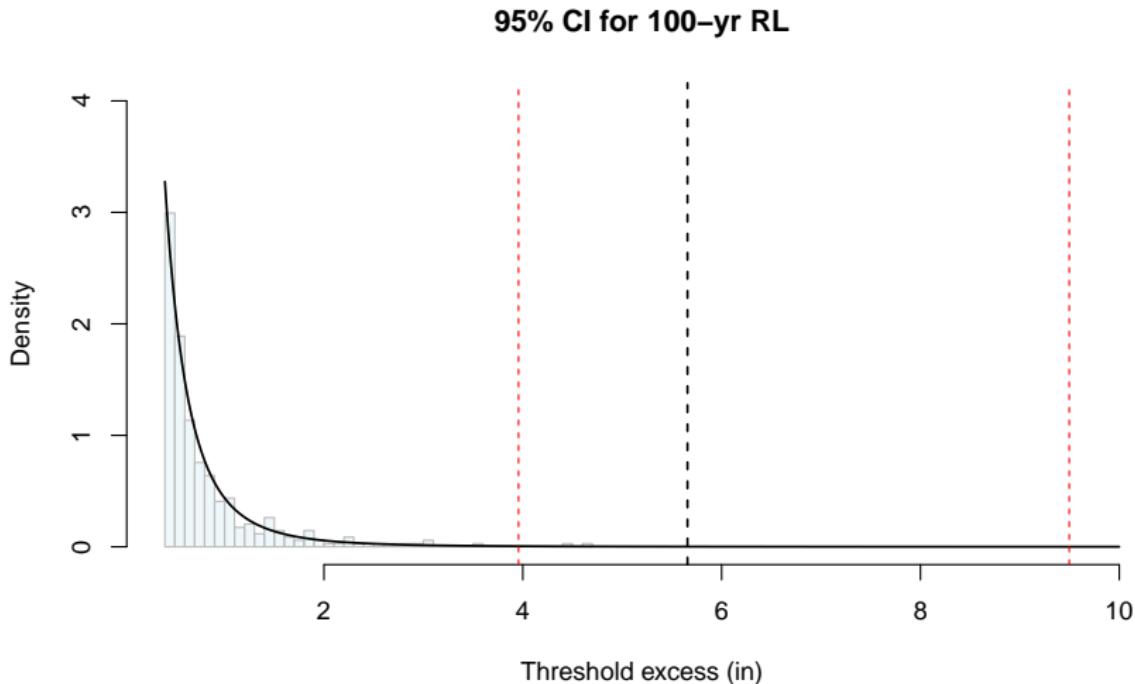
# How to choose the threshold?



# GPD fit diagnostics



# Inference for 100-year event



# Summary

- ▶ Climate extremes can have large impacts on both human society and environmental systems
- ▶ Extreme value theory provides a framework to model extreme values
  - ▶ GEV for fitting block maxima
  - ▶ GPD for fitting threshold exceedances
  - ▶ Return level for communicating risk