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Three challenges for extreme event attribution

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Three Challenges in statistical methods for EEA

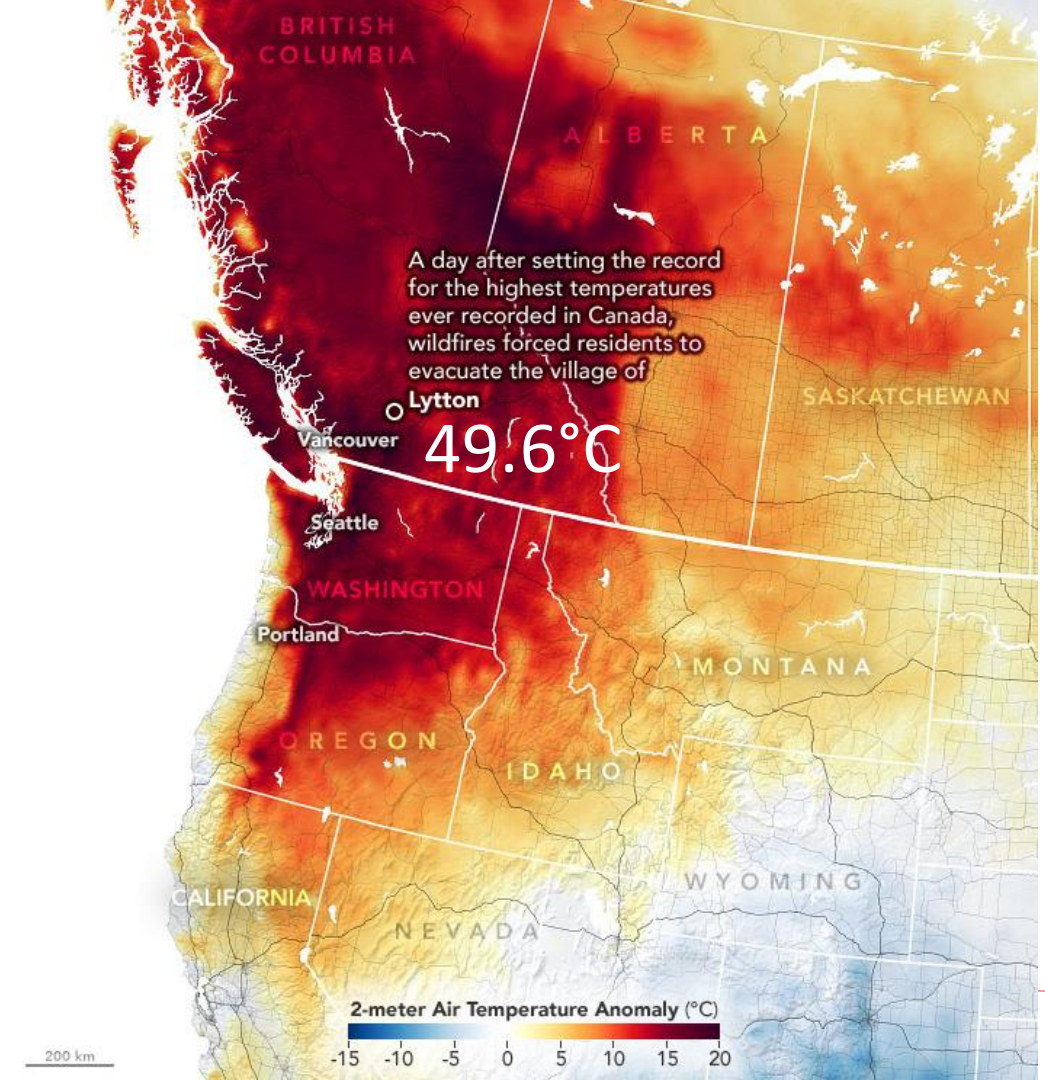
Challenge 1: Statistics of record(-shattering) events

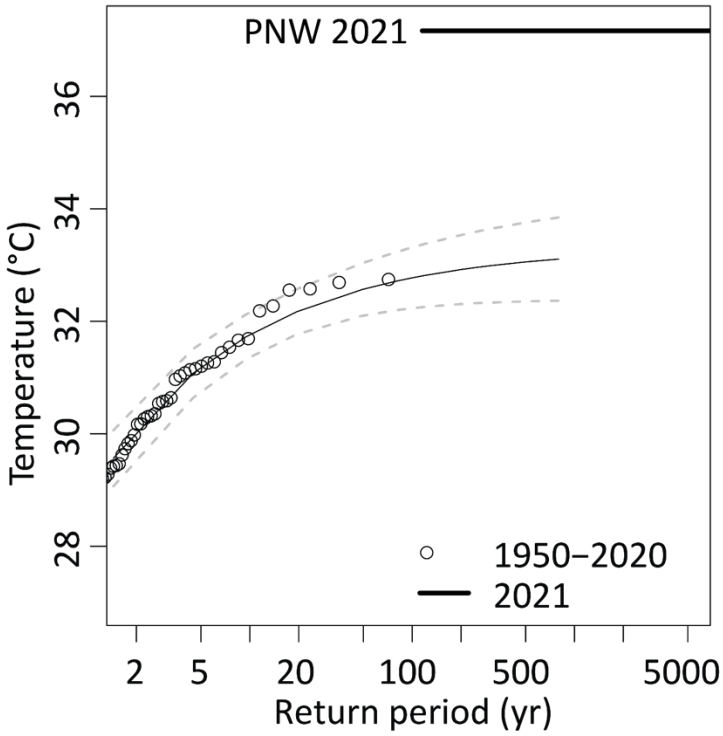
Challenge 2: Aerosols vs. GHGs in statistical EEA

Challenge 3: Dynamical vs. thermodynamical trends

HEATWAVE IN WESTERN NORTH AMERICA

ZERO PROBABILITY – YET REALITY?





Thanks to E. Fischer

Challenge 1: Statistics of record(-shattering) events

Statistical model:

$$z \sim G(z; \mu(x_{\mathrm{GMST}}), \sigma, \xi)$$

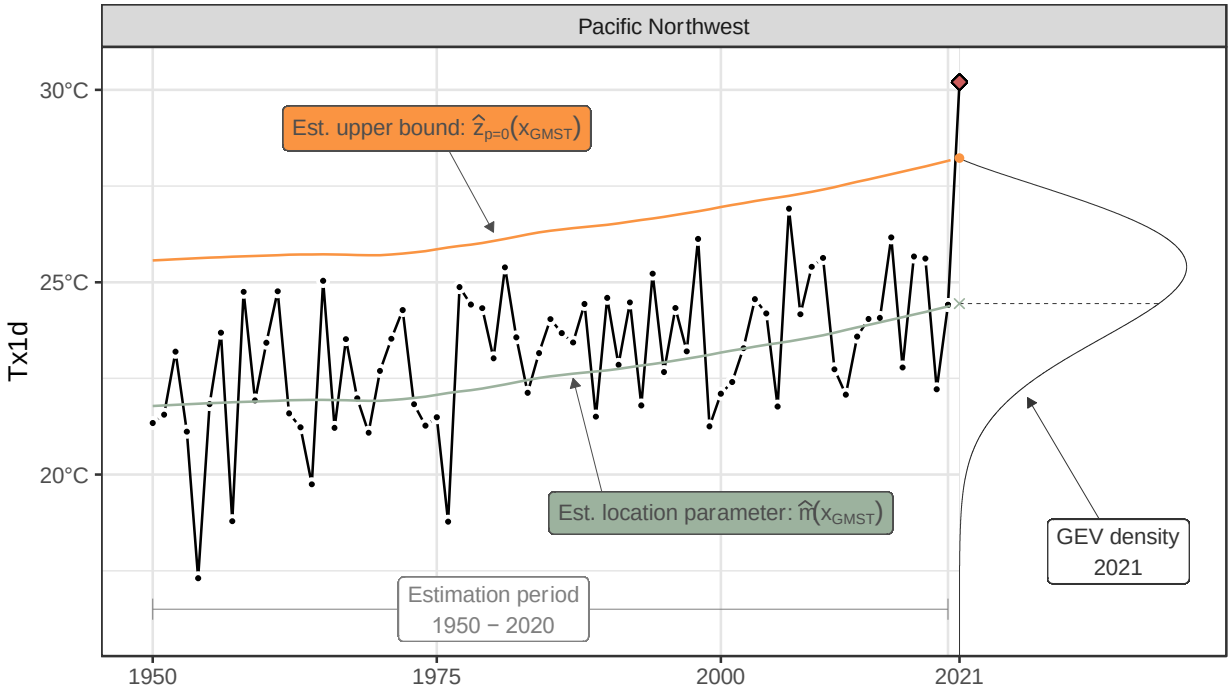
Annual maximum temperature
Tx1d (block maxima)

GEV distribution: $G(z)$

Parametrisation:

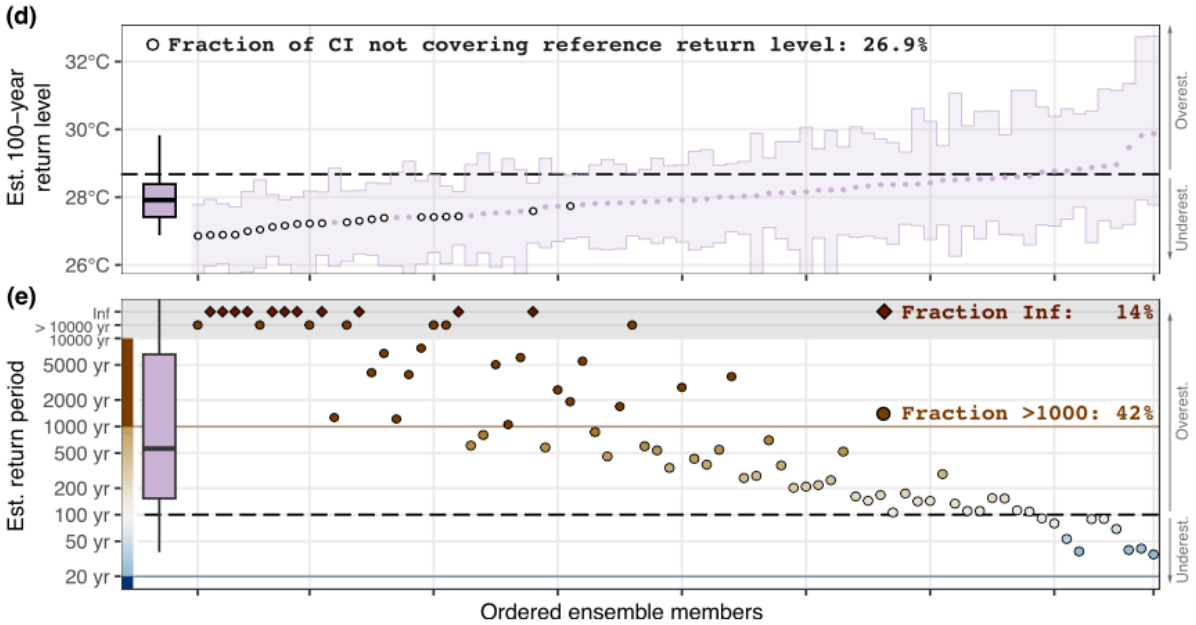
$$\mu = \mu_0 + \mu_{\mathrm{GMST}} x_{\mathrm{GMST}}$$

Global mean surface temperature
covariate: x_{GMST}



Zeder, **Sippel**, et al., 2023,
Geophysical Research Letters

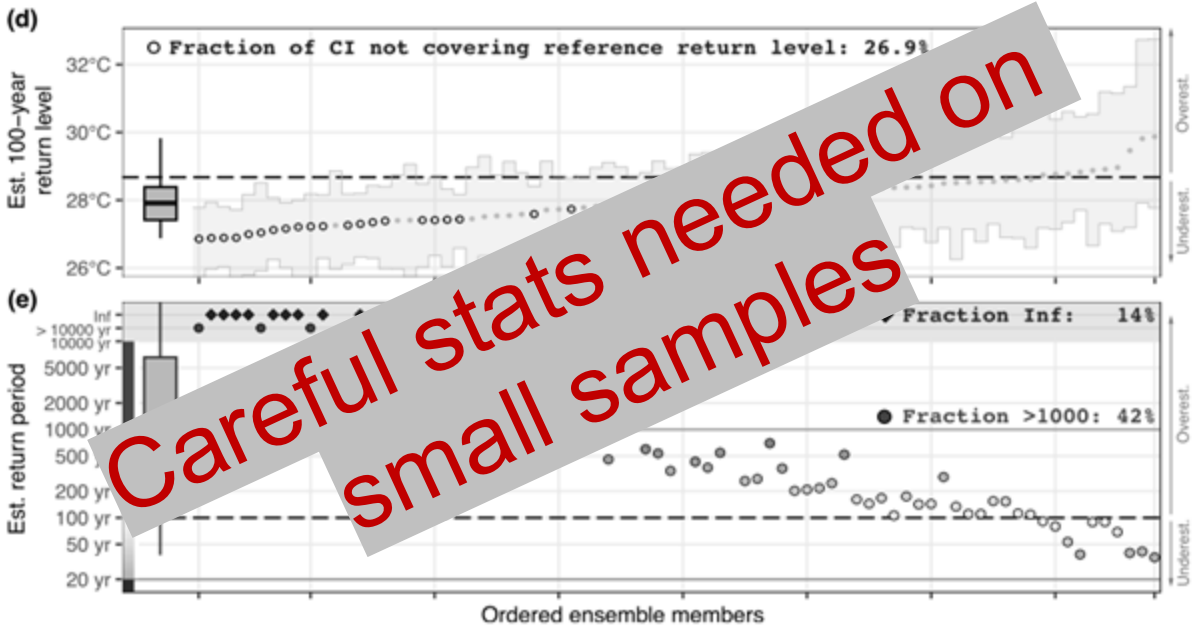
Challenge 1: Statistics of record(-shattering) events



- GEV parameter estimation is biased in practical situations (=finite sample)
- Large number of members show infinite return period even for a “true” 100-year return level

Zeder, **Sippel**, et al., 2023,
Geophysical Research Letters

Challenge 1: Statistics of record(-shattering) events

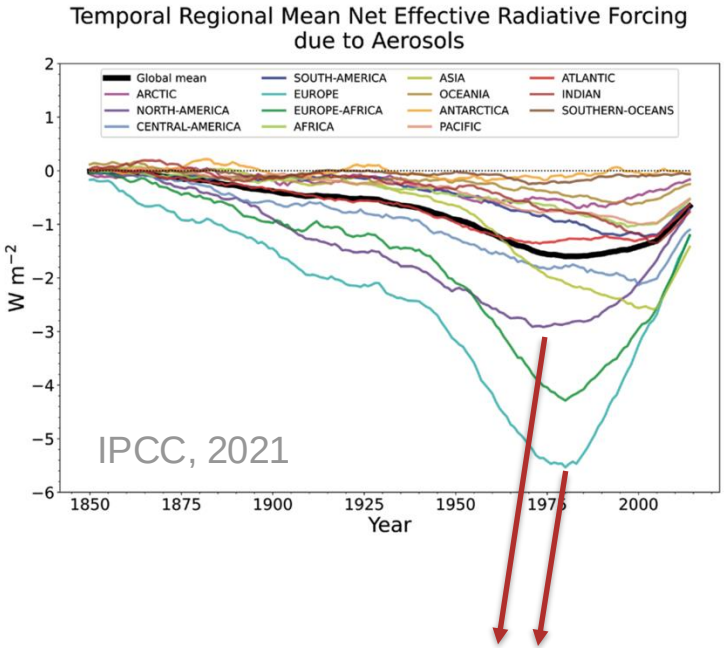


Careful stats needed on small samples

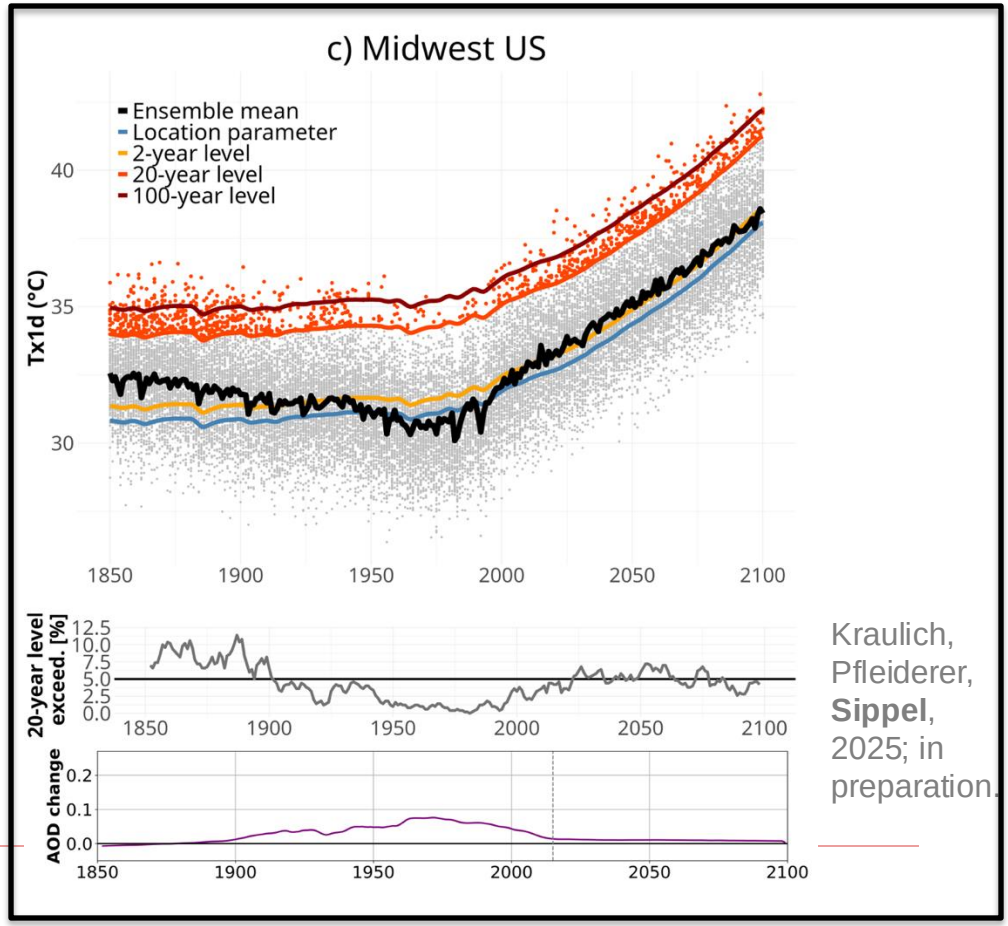
- GEV parameter estimation is biased in practical situations (=finite sample)
- Large number of members show infinite return period even for a “true” 100-year return level

Zeder, **Sippel**, et al., 2023,
Geophysical Research Letters

Challenge 2: Aerosols vs. GHGs in statistical EEA

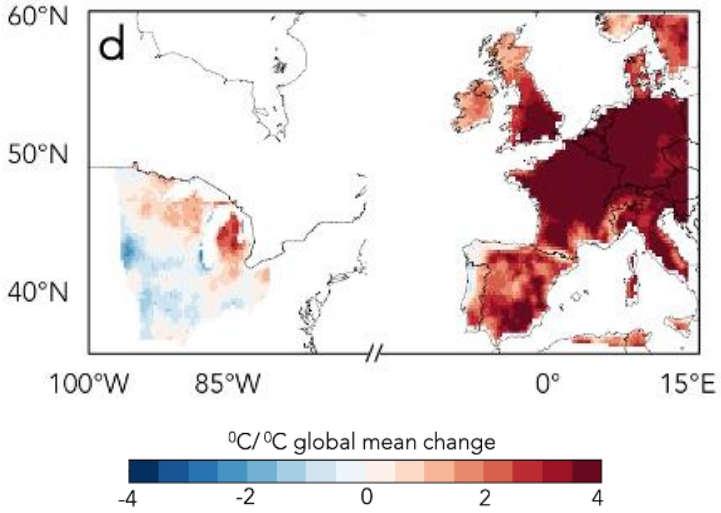


Fast recovery from strong negative aerosol forcing in Europe and North America

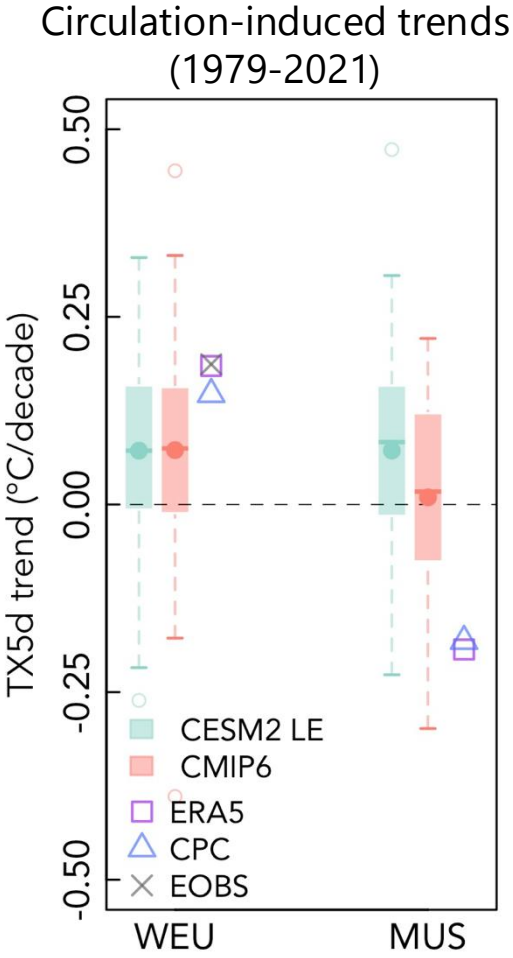


Kraulich, Pfleiderer, **Sippel**, 2025; in preparation.

Challenge 3: Dynamical vs. thermodynamical trends in heat extremes



Singh, **Sippel**, Fischer, 2023,
Communications Earth and Environment



- Circulation causes **0.2°C/decade warming in WEU** (accounting ~1/3 of observed trends) and **cooling trend of ~0.2°C/decade in the MUS**
- Interpretation depends strongly on **whether historical circulation trends are forced or unforced**
- Currently **not fully accounted for in statistical EEA frameworks**, but methods emerging to do so (e.g., Terray et al. 2021 WCD)

Three Challenges in statistical methods for EEA

Statistics of record(-shattering) events

Aerosols vs. GHGs in statistical EEA

Dynamical vs. thermodynamical trends

… methods are emerging of how to solve them!

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Thank you for the attention!

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