The challenges of assessing low-likelihood temperature extremes with empirical data of past events

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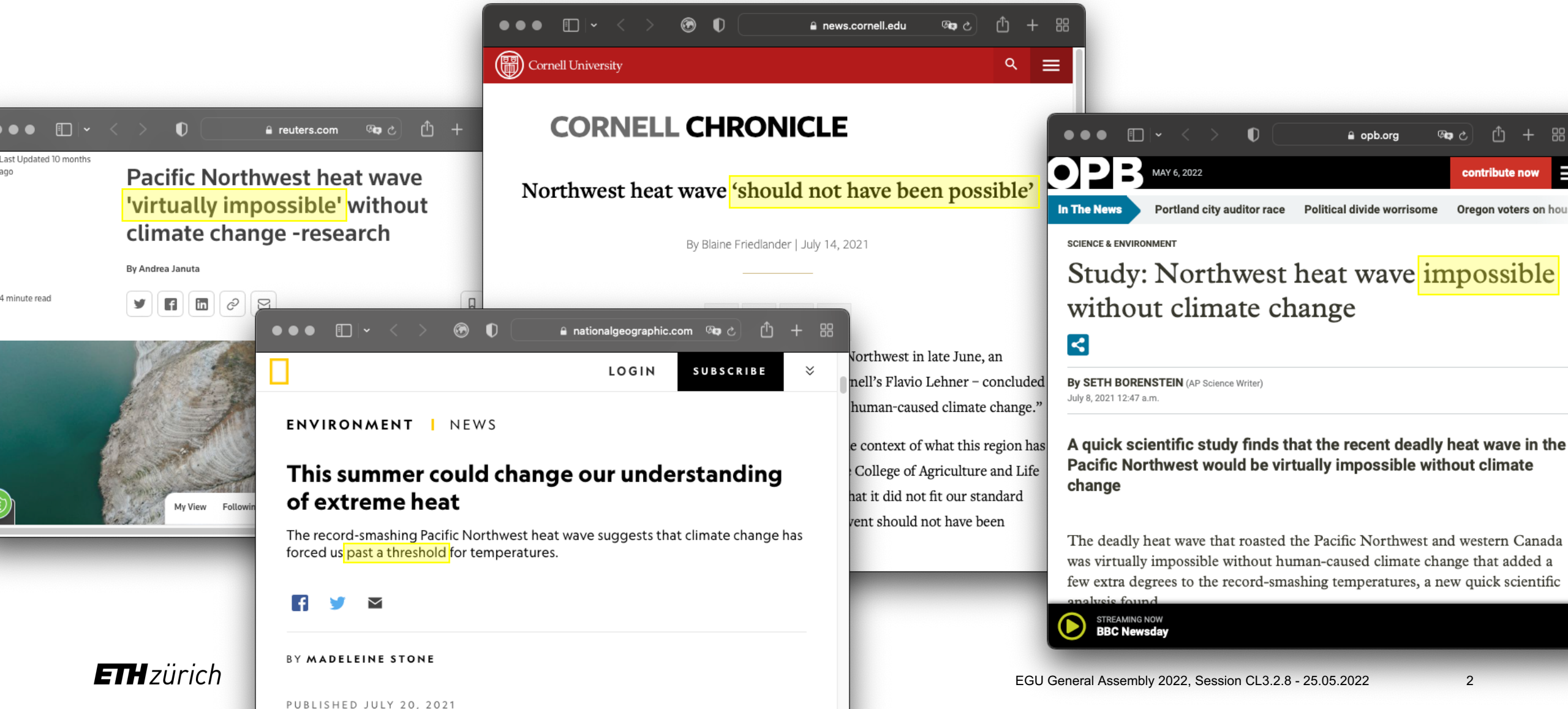
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The Pacific Northwest (PNW) Heat Wave
How extreme events shape our perception of climate change

The Pacific Northwest Heatwave
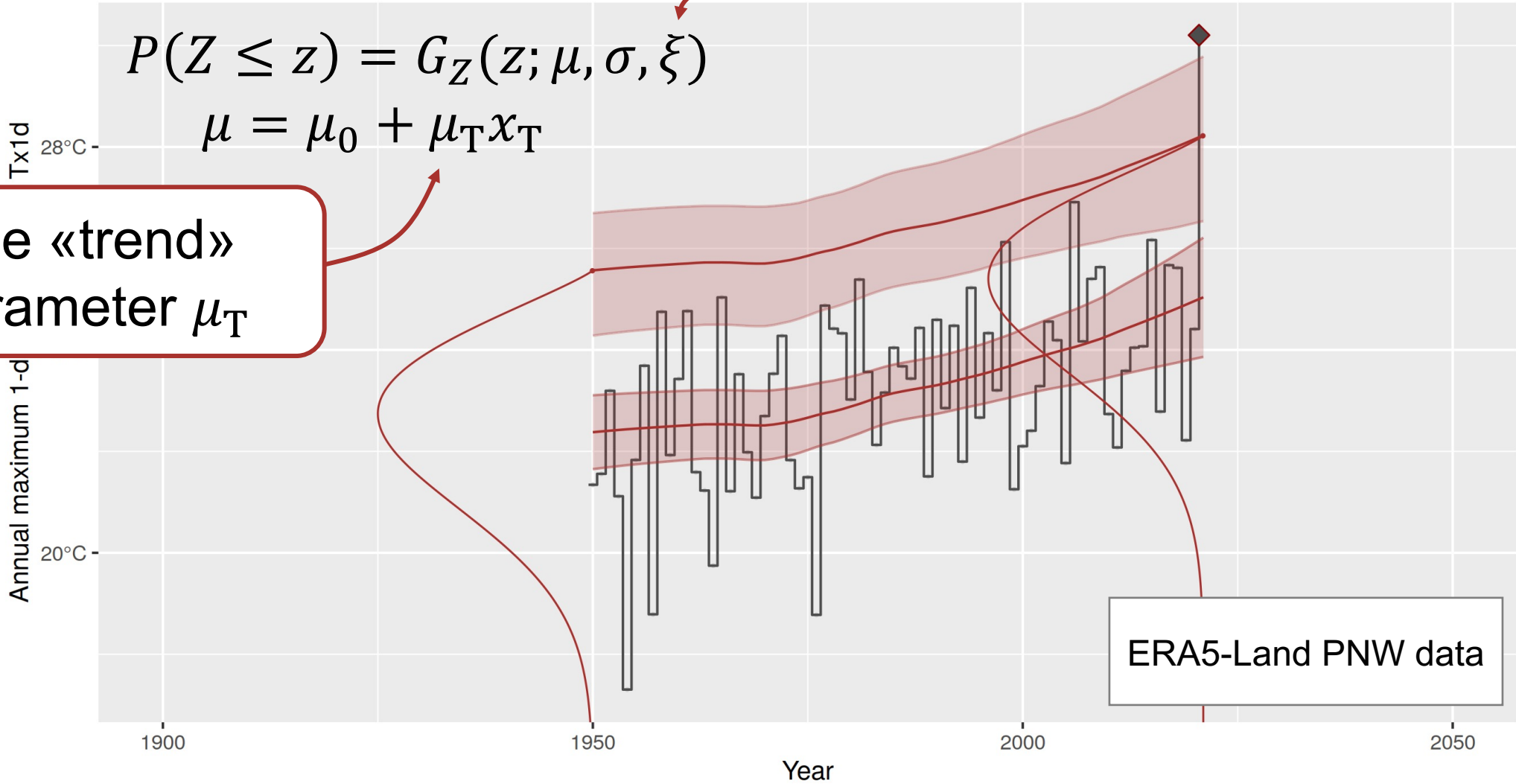## A truly record shattering extreme event

The «shape» parameter ξ

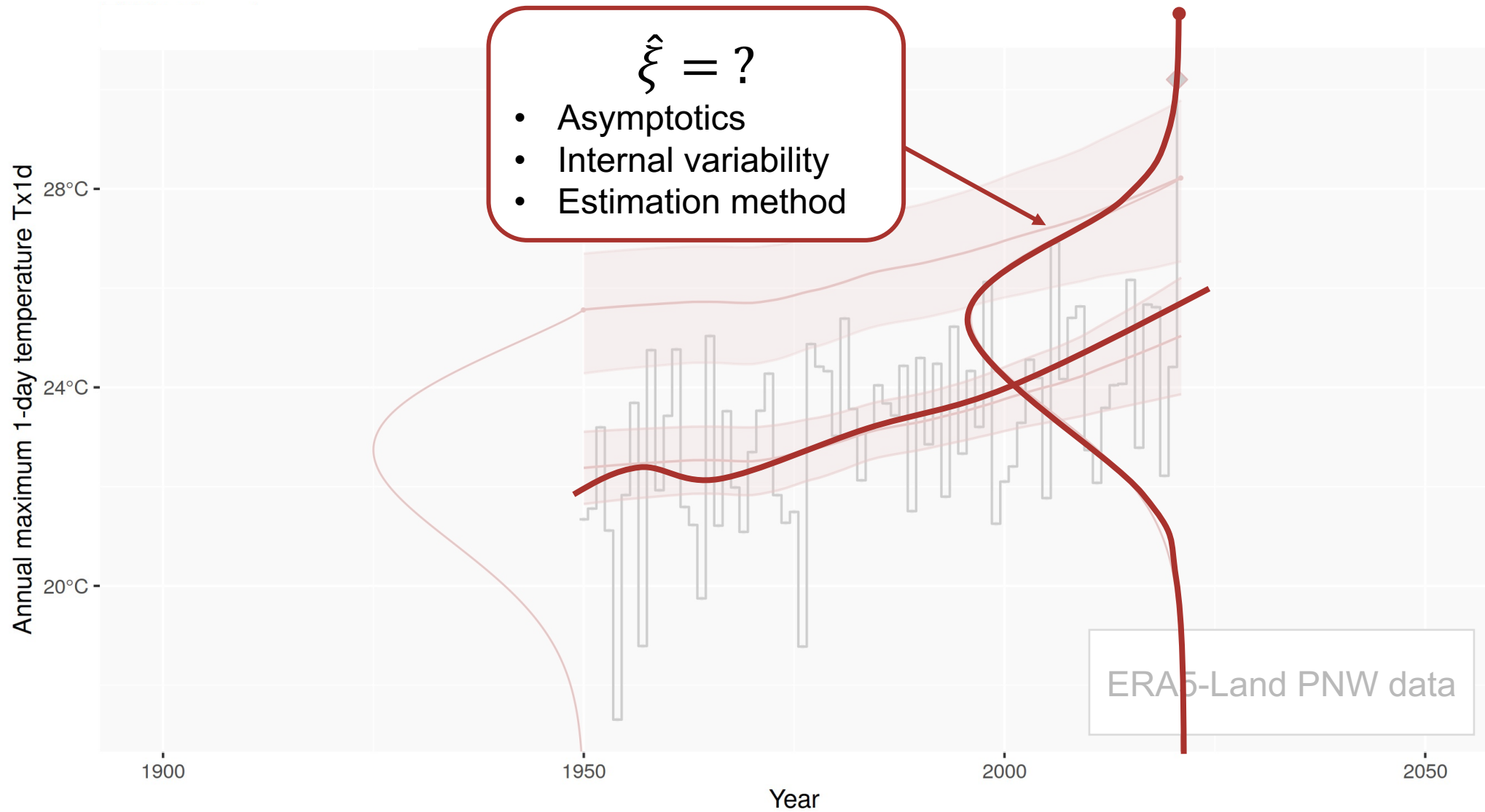$$P(Z \leq z) = G_Z(z; \mu, \sigma, \xi)$$
$$\mu = \mu_0 + \mu_T x_T$$

The «trend» parameter μ_T

ERA5-Land

Annual maximum 1-d — Tx1d
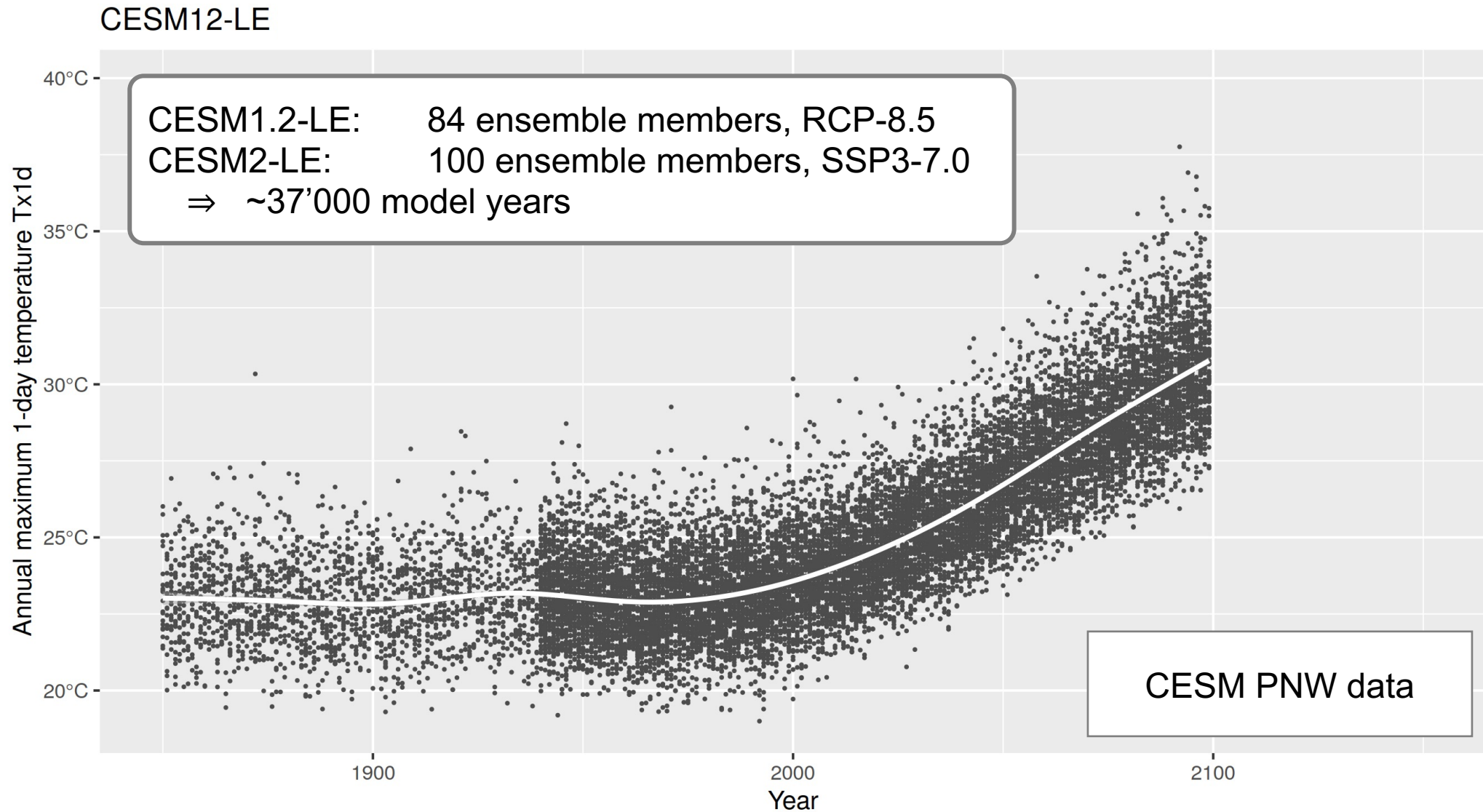
28°C

20°C

ERA5-Land PNW data

1900   1950   2000   2050

Year

Hypotheses
What went wrong in our analysis?

Large Ensemble Testbed
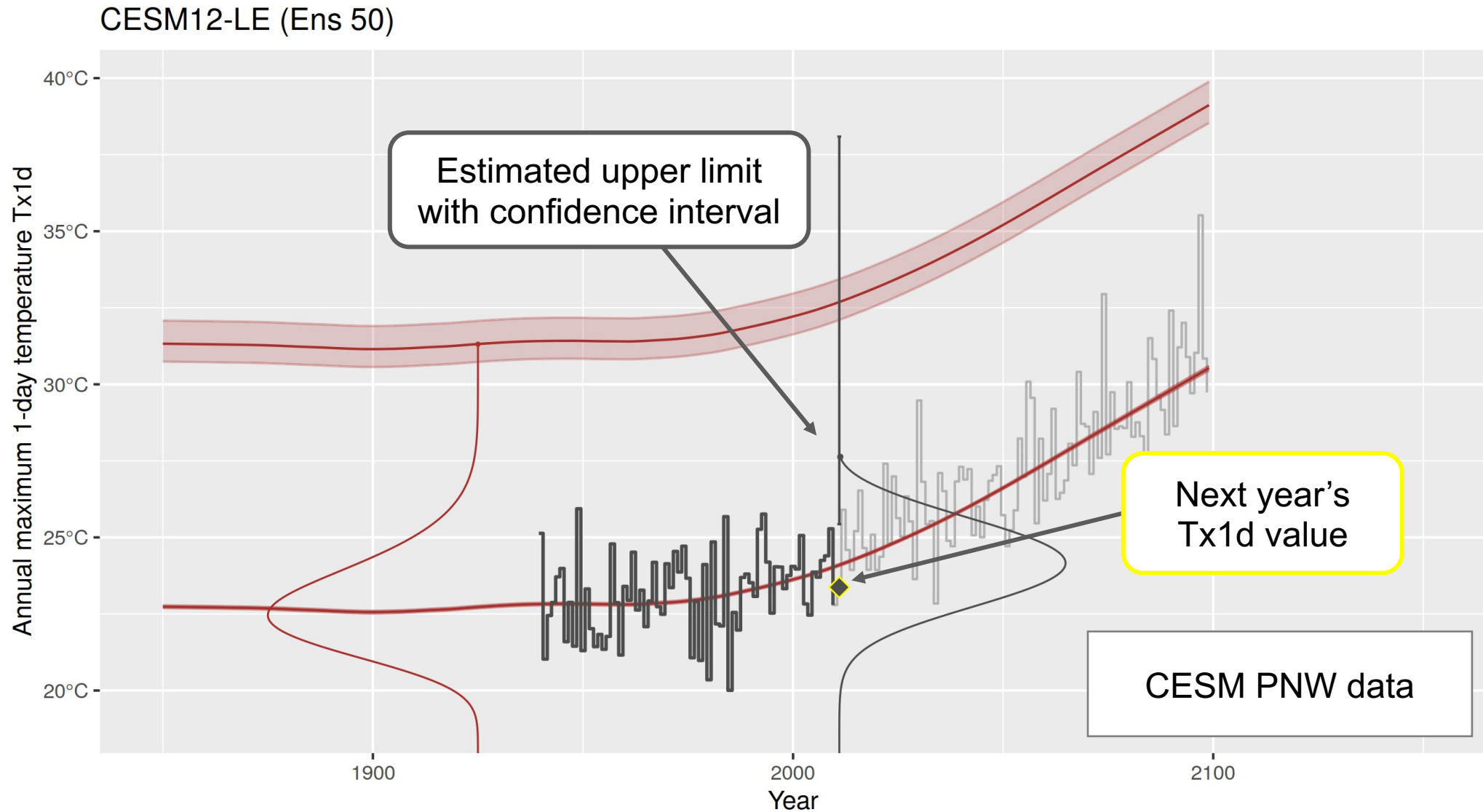## Do we find such violations also in climate models?
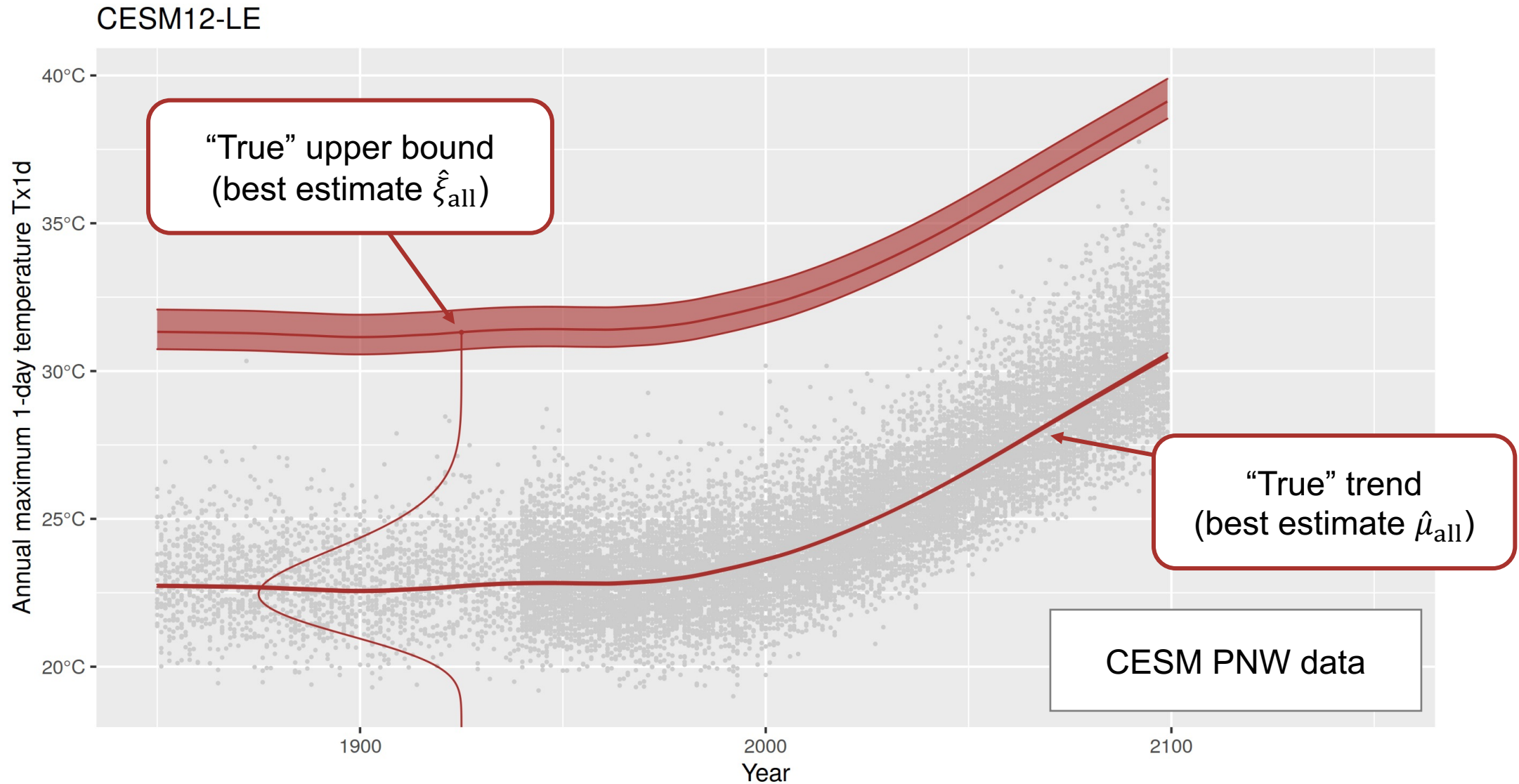
CESM12-LE

CESM1.2-LE: 84 ensemble members, RCP-8.5
CESM2-LE: 100 ensemble members, SSP3-7.0
⇒ ~37'000 model years

CESM PNW data

Large Ensemble Testbed
Do we find such violations also in climate models?

CESM12-LE

"True" upper bound (best estimate $\hat{\hat{\xi}}_{all}$)

"True" trend (best estimate $\hat{\mu}_{all}$)

CESM PNW data

Annual maximum 1-day temperature Tx1d

Year

Large Ensemble Testbed
Do we find such violations also in climate models?

CESM12-LE (Ens 50)

Estimated upper limit with confidence interval

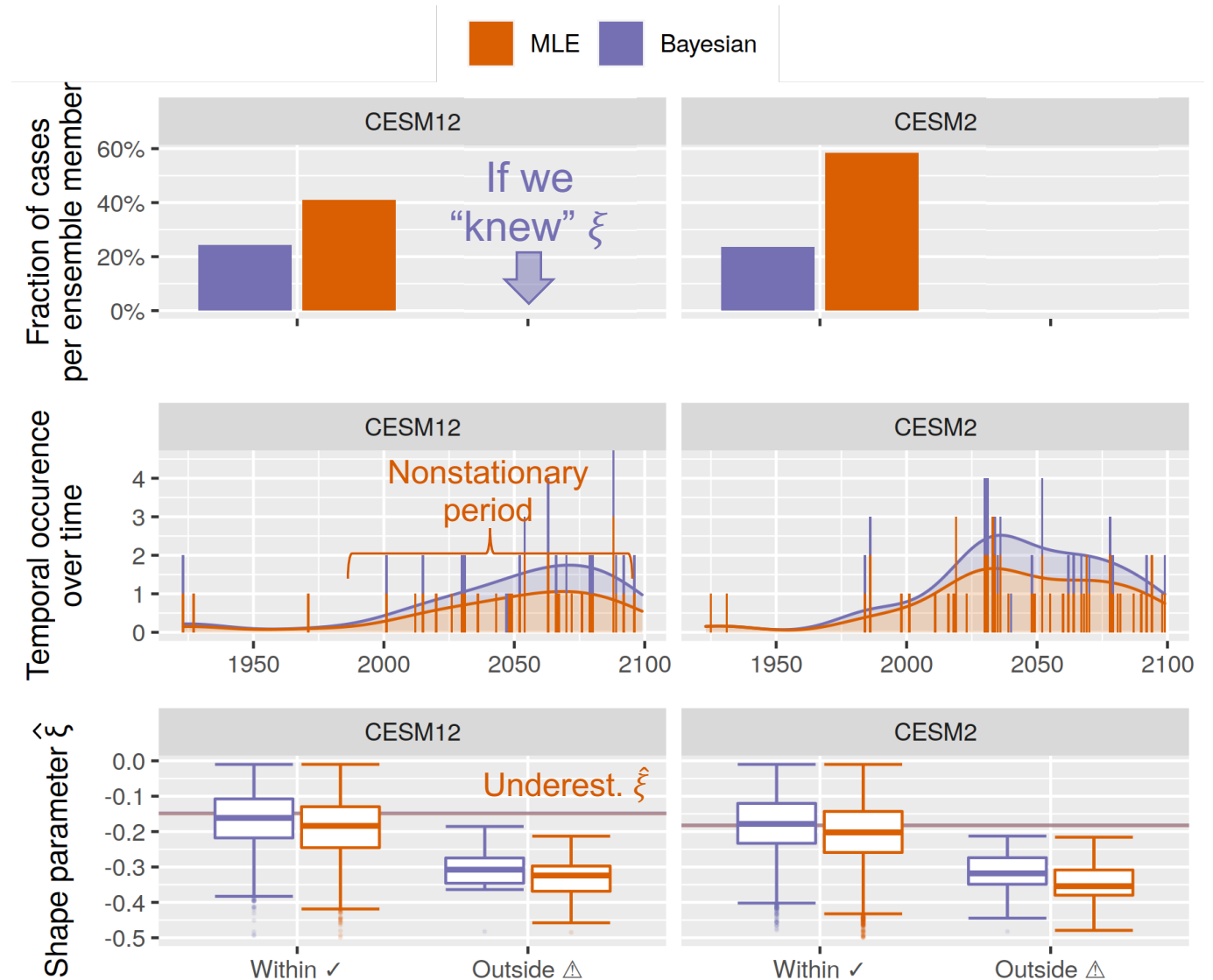Next year's Tx1d value

CESM PNW data

ETH zürich

Large Ensemble Testbed
When is the upper bound underestimated?

Findings

- Large fraction of cases where estimated upper limited is exceeded

- Exceedances occur mostly in non-stationary time period

- Shape parameter consistently under-estimated before exceedance occurs

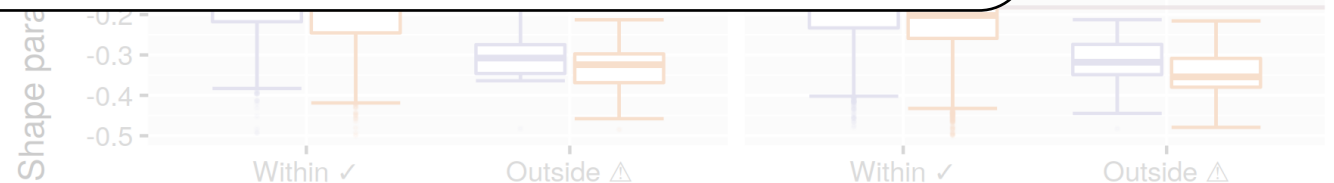- Lower risk when using Bayesian estimation method
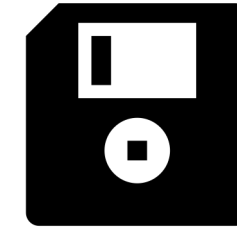
Large Ensemble Testbed
When is the upper bound underestimated?

Take-Home Messages

✓ Modelling extremes is challenging
✓ Tail estimates are *very* sensitive
✓ The estimation method matters

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