ETH zürich

Developing Storylines for Unprecedented Extreme Events using Ensemble Boosting

Luna Bloin-Wibe[1], Erich Fischer[1], Reto Knutti[1]
[1]Institute for Atmospheric and Climate Science, ETH Zurich
lbloin@ethz.ch

Sharing is encouraged

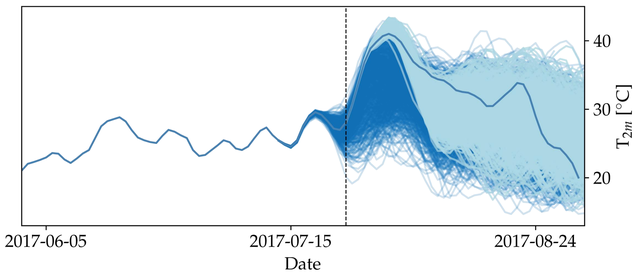
1. How can storylines and boosting help assess extremes?

Storylines?
"A physically self-consistent unfolding of past events, or of plausible future events or pathways"[1]
Likelihood of event → impact of event
Episodic representation of knowledge (not semantic)

Ensemble Boosting?
1. Select a model event (highest temperature)
2. Re-initialize before peak: initial condition perturbation
3. Run until past peak

Re-run leading up to peak

Quantitative analysis of tail events



Models and variables

1) Identify real-life extreme or plausible climate change risk:
   ERA5 for original event (reanalysis)
2) Select analogues from climate model
   CESM2 for model analogues
   - 30-member ensemble
   - 2005-2035 (future years warmed w.r.t. SSP-3.70)\

Selection criteria: $\frac{T_{max}(i) - T_{avg}(i)}{T_{std}(i)}$ $[\sigma]$

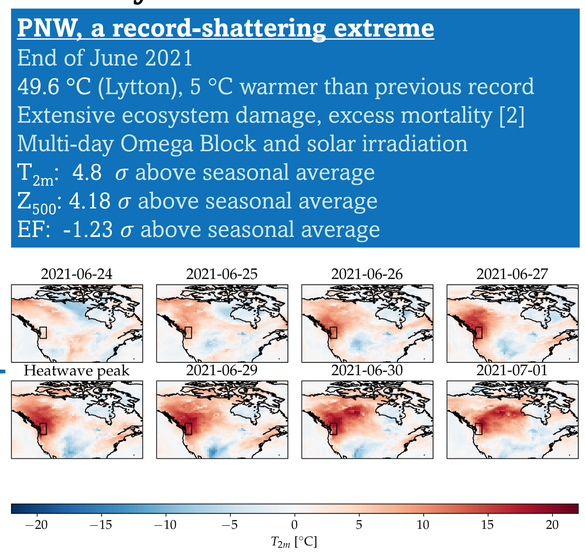
Variables (daily): 45 °N–52 °N, 119 °W–123 °W

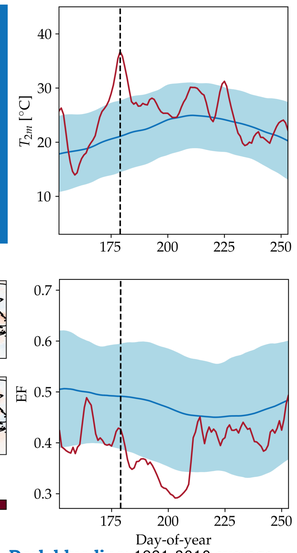
References

[1] Shepherd, T.G., Boyd, E., Calel, R.A. *et al.* (2018) Storylines: an alternative approach to representing uncertainty in physical aspects of climate change. *Climatic Change* 151, 555–571.
[2] Overland, J. E. (2021). Causes of the Record-Breaking Pacific Northwest Heatwave, Late June 2021. *Atmosphere*, 12, 1434.
[3] Sherwood, S. C., Huber, M., (2010), An adaptability limit to climate change due to heat stress, *PNAS*, 107, 21 9552-9555

2. Storyline: the Pacific Northwest Heatwave

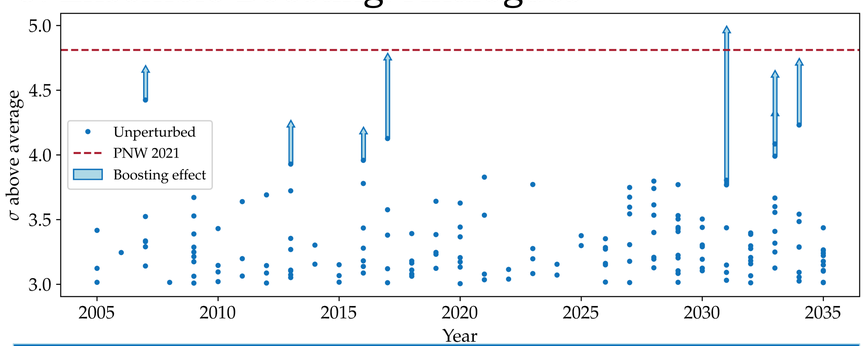
PNW, a record-shattering extreme
End of June 2021
49.6 °C (Lytton), 5 °C warmer than previous record
Extensive ecosystem damage, excess mortality [2]
Multi-day Omega Block and solar irradiation
T_{2m}: 4.8 σ above seasonal average
Z_{500}: 4.18 σ above seasonal average
EF: -1.23 σ above seasonal average





Dark blue line: 1981-2010 average
Light blue shading: ±2 σ

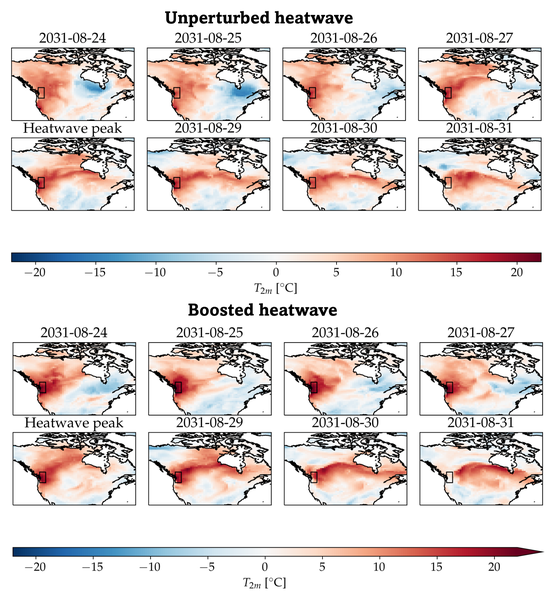
3. Ensemble Boosting: Analogues

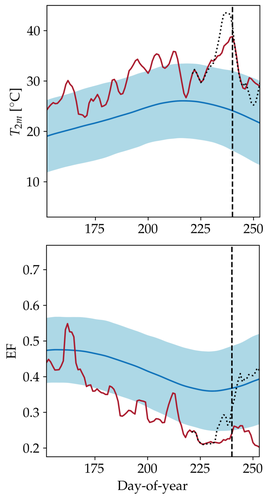


With ensemble boosting, CESM2 simulates heatwaves that **exceed PNW 2021**

4. Extreme boosted analogues

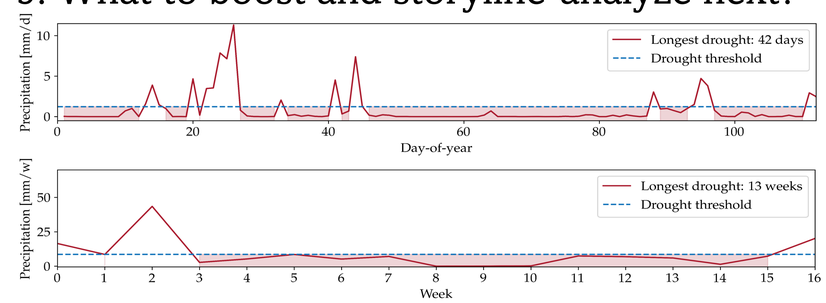
T_{2m}: 3.77 → 4.99 σ above seasonal average
Z_{500}: 3.37 → 4.66 σ above seasonal average
EF: -1.83 → 0.95 σ above seasonal average

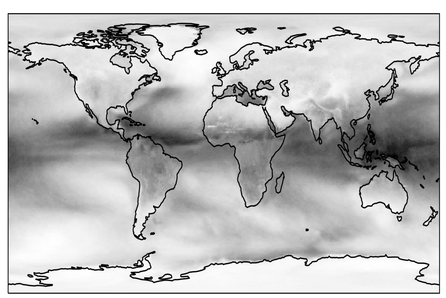




The boosted heatwave shows **similar anomaly patterns** to observations

5. What to boost and storyline-analyze next?





Humid heatwaves
Heat stress indicator: T_w (wet-bulb temperature)
Mortality threshold of 35 °C [3]

Identify unprecedented extremes (jumps) w.r.t model records

Probability of jump (over all years)

Droughts in Switzerland
Megadroughts (1-5 years), impact of heavy rainfall aftermath
Seasonal droughts

Selection Criteria:
$\mu = \frac{BYA(1-WR)}{TP} =$ **1.32 mm/day** *or* **8.65 mm/week** *or* **450 mm/year**
Baseline Yearly Average (BYA) [mm/y], Wanted Reduction (WR), Time Period (TP)