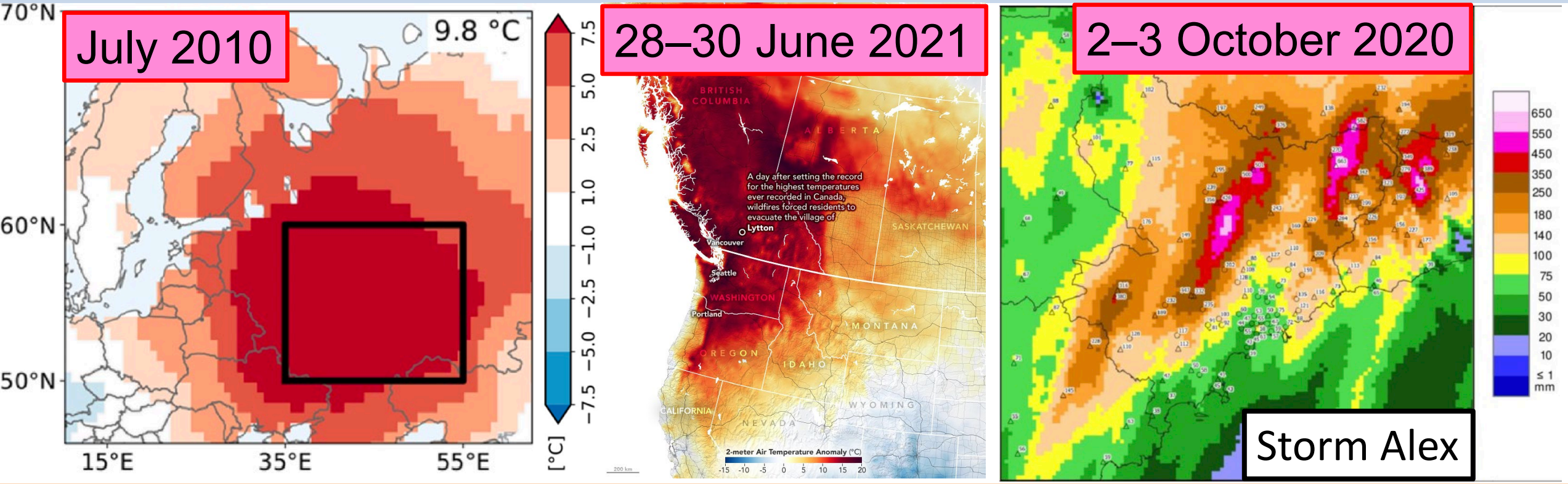
Dynamical adjustment: a simple approach to quantify the contribution of extreme event drivers



Laurent Terray, Cerfacs/CNRS

NASEM Panel Meeting, March 3rd, 2025

References: *Terray WCD 2021, Terray GRL 2023, Terray and Bador Env.Res:Clim 2025*

Dynamical adjustment based on constructed analogues

- A storyline or “singular/conditional” approach

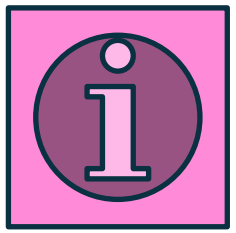
Q1: What were the relevant causal factors that led to the event?

Q2: How might climate change and/or internal variability have contributed to those causal factors?

Q3: “What if “ questions: impact of the same event in a warmer/colder world ?

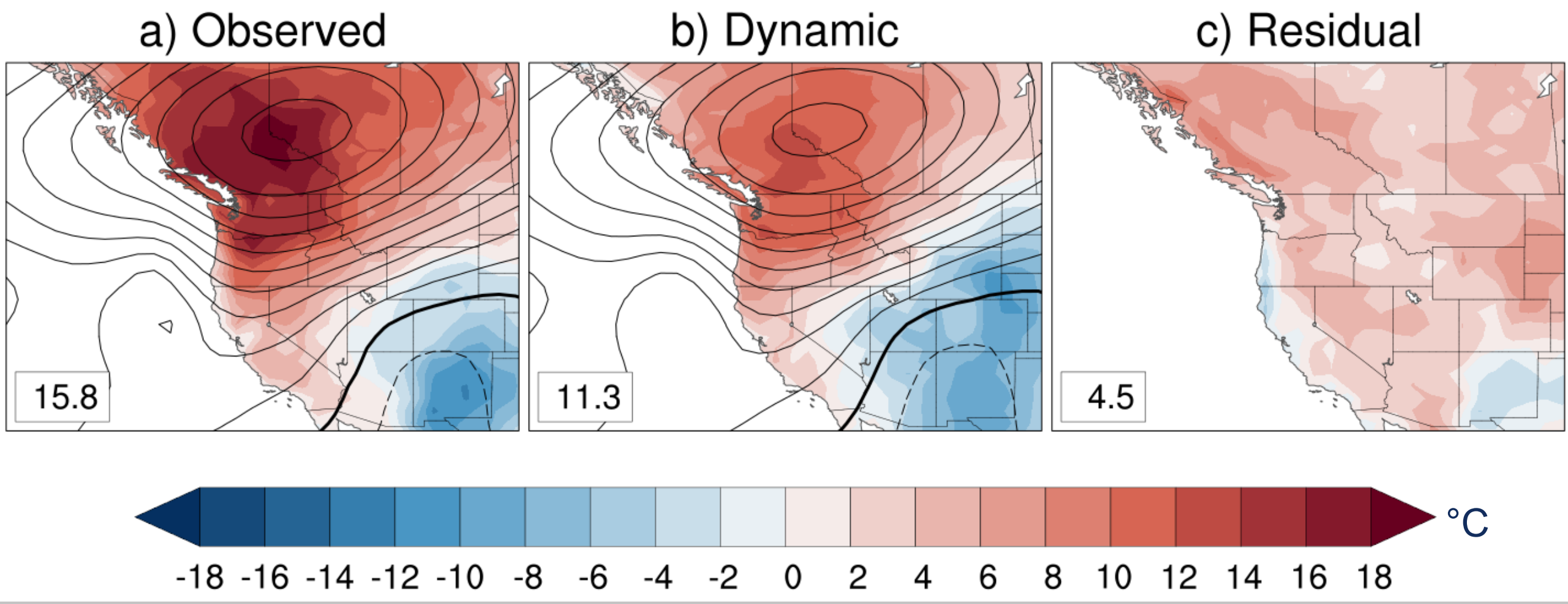
1st Step: Estimate the *mean* contribution of atmospheric circulation (SLP, Z500, …) to the extreme event

$$X = X_{DYN} + X_{RES}$$



X_{DYN} is often estimated in the counterfactual world

June 2021 North America heatwave



TX anomalies relative to the 1991-2020 climatology

Terray, L., 2023: A storyline approach to the June 2021 Northwestern North American heatwave. GRL

Additional steps

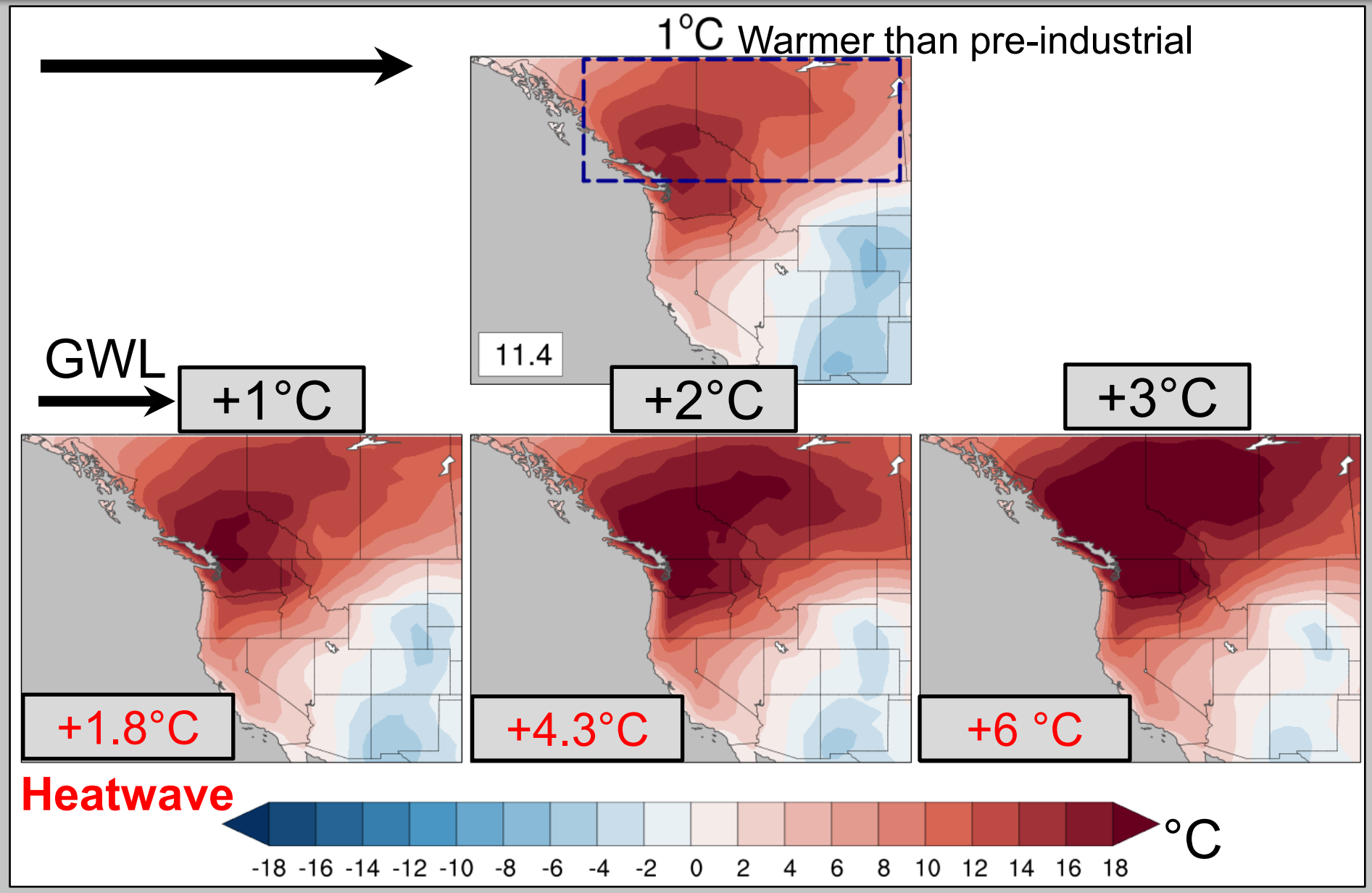
- Estimate the forced contribution for both X_{DYN} and X_{RES}
- How to define the counterfactual ?
  - ➢ Detrending
  - ➢ Contrasting 2 periods (1940–1979 versus 1980–2020)

- Contribution of internal variability drivers: additional dynamical adjustments with analogues drawn from periods with contrasted surface conditions : SST, sea ice, soil moisture, snow cover

→ **June 2021**: internal residual related to soil moisture deficit

- Impact of the June 2021 omega block in a warmer climate (using the CESM2 large ensemble)

Heatwave dynamic component in a warmer climate



Summary

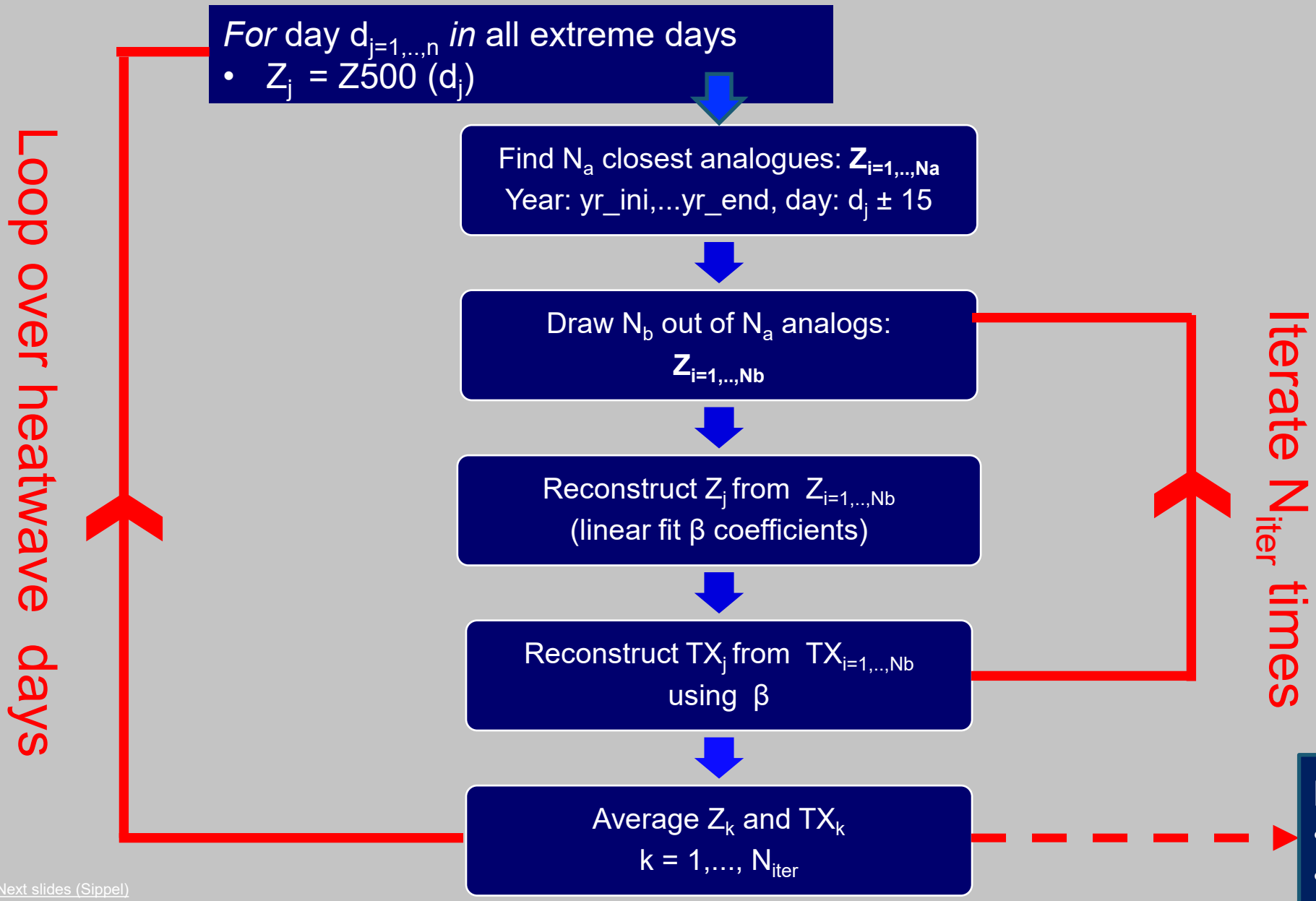
Strengths:

- Conditional on the exact synoptic circulation (differs from the class of event approach used in standard analogue methods)
- Based on observations/reanalyses (no model runs needed)
- Can be applied in quasi-real time
- Provide uncertainty range (analogue bootstrap)
- Can be directly compared with other model-based approaches (nudged model runs – Wehrli et al., Van Garderen et al.–, Nicholas's approach)

Caveats/Issues:

- Sensitivity to the counterfactual definition (but it can be estimated)
- Sensitivity to the spatial and time domains (as with other methods)
- Assess changes in intensity, not in occurrence frequency
- Conservative estimate of the atmospheric circulation contribution
- Current datasets not always fit-for-purpose (reanalyses homogeneity and resolution → Europe: CERRA, ARRA …)

Dynamical Adjustment: constructed analogues



Next slides (Sippel)