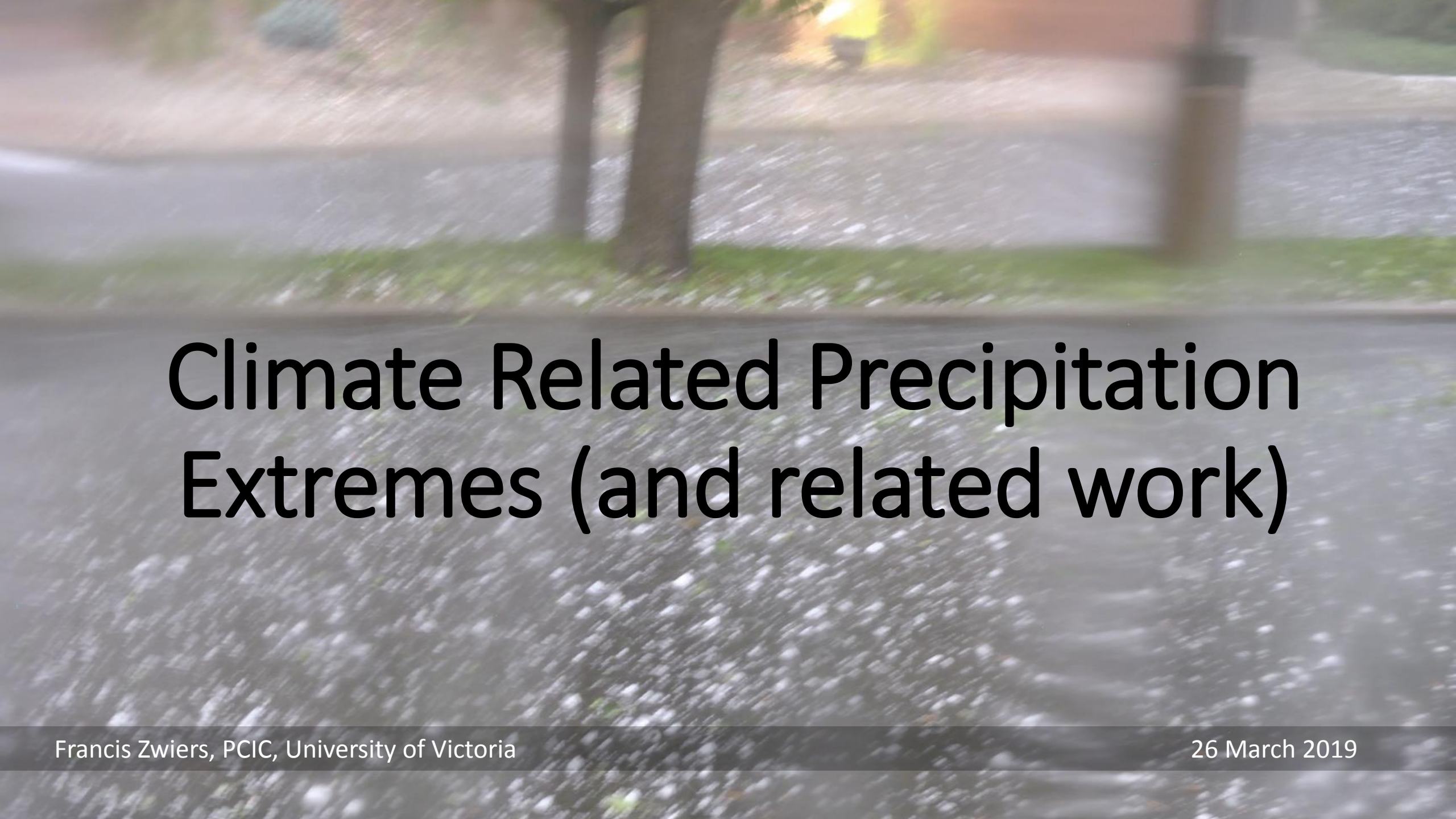

Climate Related Precipitation Extremes (and related work)

Francis Zwiers, PCIC, University of Victoria

26 March 2019

University of Victoria

PACIFIC CLIMATE IMPACTS CONSORTIUM

Motivation

- User motivated questions
- Dominantly engineering related
  - Extreme precip, snow load, wind load, wind/precip combinations
  - Uniform hazard → uniform risk → very long period return levels
- Flood risk (riverine, not flash flooding)
  - Engineering and adaptation question
- Early growing season frost risk changes
  - Agricultural impacts and adaptation question

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Topics

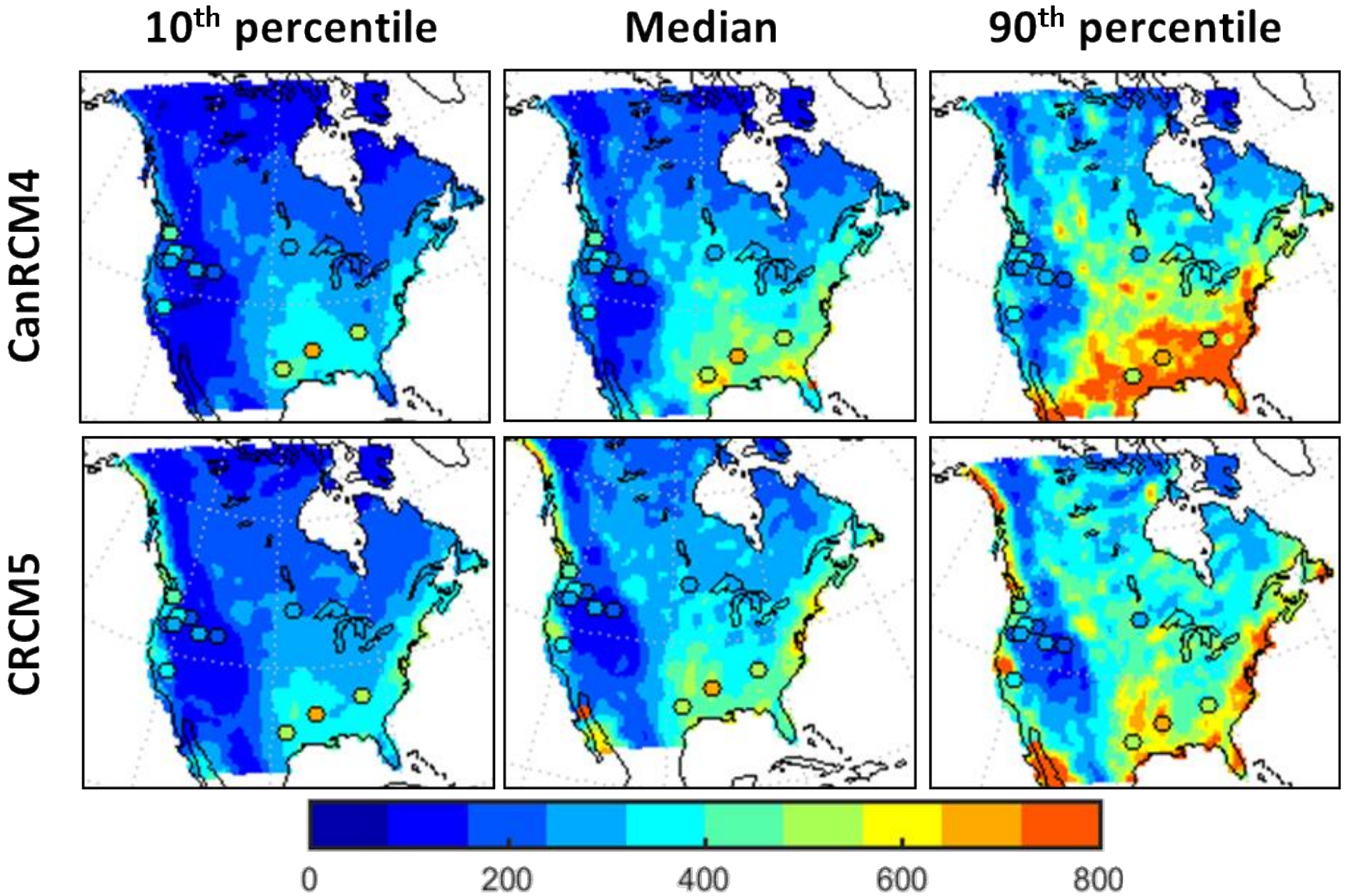
- Probable maximum precipitation (Ben Alaya)
  - Methodology
  - CanRCM4 and CRCM5 assessment
  - Projected changes under RCP8.5
- Temperature scaling of extreme precipitation (Chao Li, Qiaohong Sun)
  - Methodology
  - Assessment of binning scaling in CanRCM4 and other models
  - Update of Westra et al, 2013
  - How much data is required
  - Role of circulation change
- Atmospheric Rivers (Yaheng Tan)
- EVA methodology for extreme precip (Ben Alaya, Dhouha, Whitney)
  - Direct application of asymptotic theory
  - A compound events approach
  - An empirical approach
  - Application to compound precip/wind events
- Early growing season temperature variability (Xuebin, Budong)
- Fraser River flooding regimes (Stephen Dery, Siraj Ul Islam, Charles Curry)

Probable Maximum Precipitation

PMP

- Probable maximum precipitation (Ben Alaya)
  - Methodology
    - Based on bi-variate extreme value theory applied to the moisture maximization approach
    - Ben Alaya et al, 2018, doi:10.1175/JHM-D-17-0110.1
  - CanRCM4 and CRCM5 assessment
    - Ben Alaya et al., 2019a, submitted, *J. Hydrometeorology*
  - Projected changes under RCP8.5
    - Ben Alaya et al., 2019b, submitted, *Climatic Change*

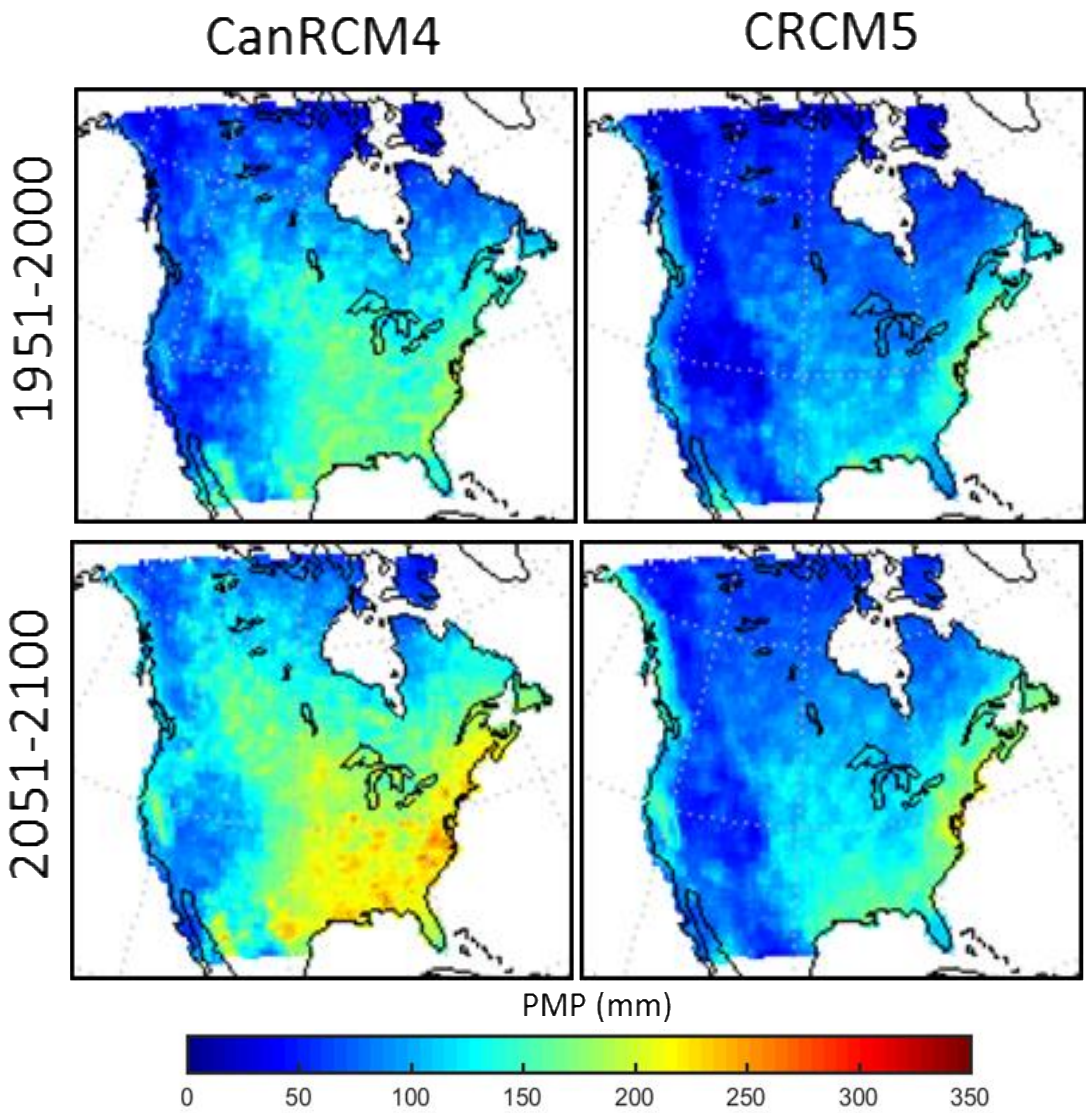
24-hour PMP estimates from CanRCM4 and selected NOAA HMR reports (circles)

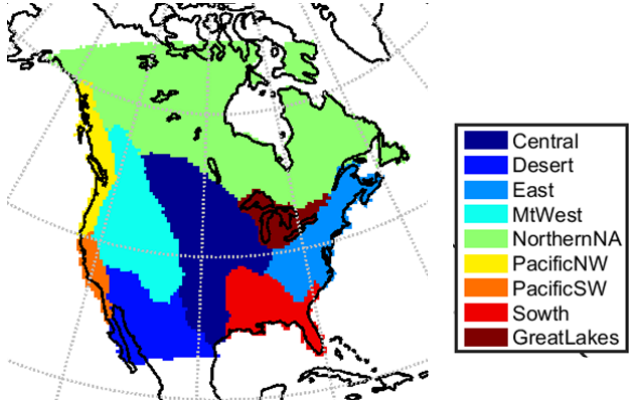


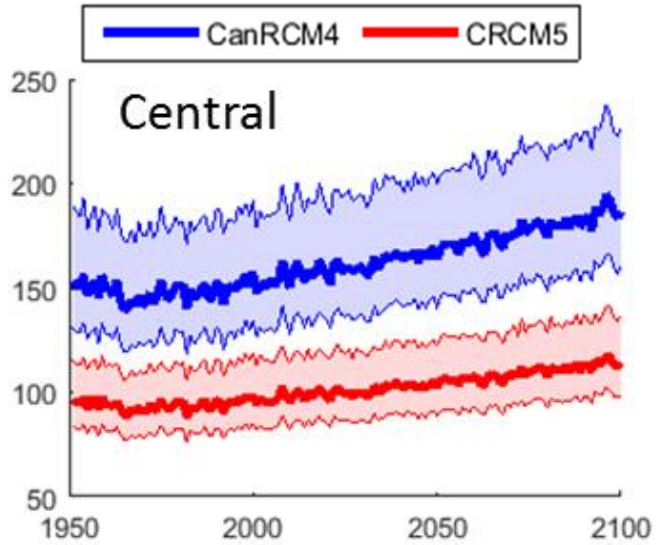
Ben Alaya et al., 2019a, submitted

Evolution of 6-hour PMP estimates from CanRCM4

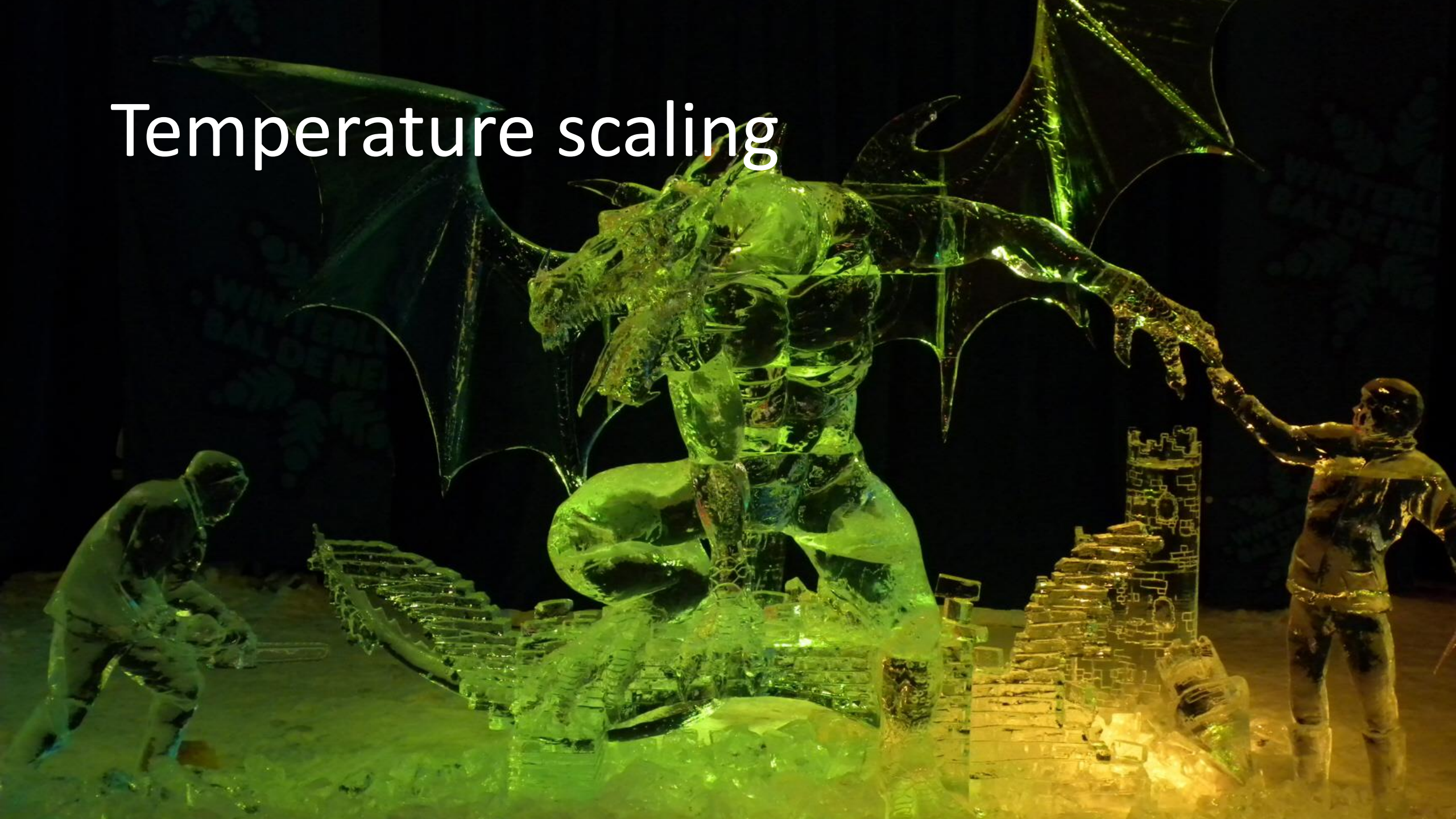
Ben Alaya et al., 2019b, submitted







Temperature scaling



Temperature scaling

- Temperature scaling of extreme precipitation (Chao Li, Qiaohong Sun)
  - Methodology
    - Can “binning scaling” be used?
    - Zhang et al., 2017, doi:10.1038/NGEO2911
  - Assessment of binning scaling in CanRCM4 and other models
    - In progress, Qiaohong Sun (Pillar 1 project lead by Yanping Li)
  - How much data is required?
    - Li et al., 2019, doi:10.1029/2018EF001001
  - Role of circulation change
    - Li et al, 2019, submitted, *GRL*
  - Update of Westra et al, 2013
    - In progress, Qiaohong Sun (Pillar 1 project lead by Yanping Li)

Response of extreme 24-hour precipitation accumulations to warming

- Adapt a method proposed by Emori and Brown (2005) for decomposing changes in mean precipitation into thermodynamic and dynamic components
- Let ω represent vertical velocity, and define

$$\psi(\omega) = \mathrm{E}[P|\omega]$$

- Also, let
  - P_τ be the τ^{th} quantile of 24-hour precipitation,
  - ω_τ be the vertical velocity that corresponds to P_τ
  - δ indicate the differential with respect to temperature
- Then

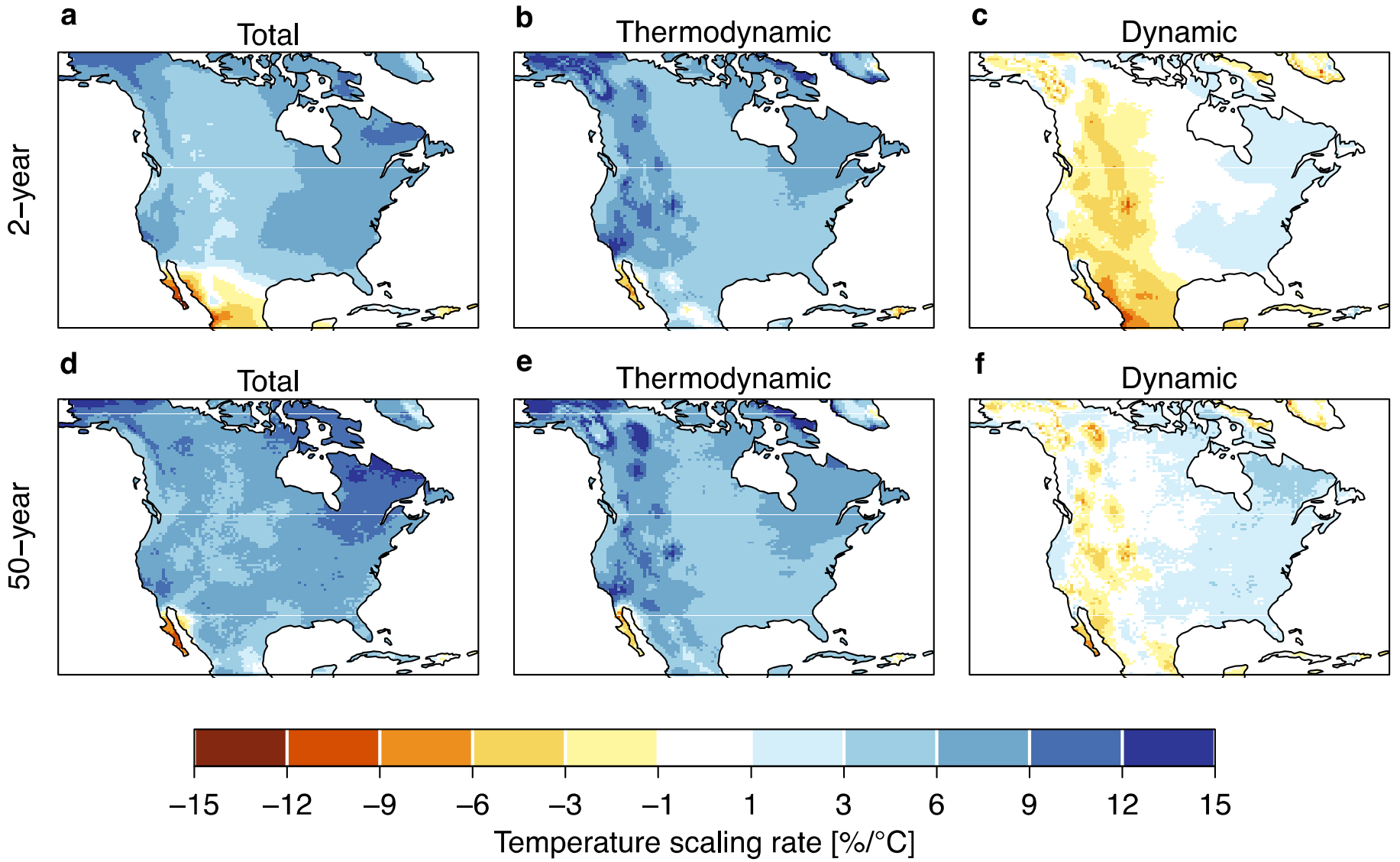
$$\delta P_\tau = \delta\psi(\omega_\tau) + \frac{\partial\psi(\omega)}{\partial\omega}\delta\omega_\tau + \delta\frac{\partial\psi(\omega)}{\partial\omega}\delta\omega_\tau$$

Change wrt temperature

= Thermodynamic + dynamic + cross term (small)

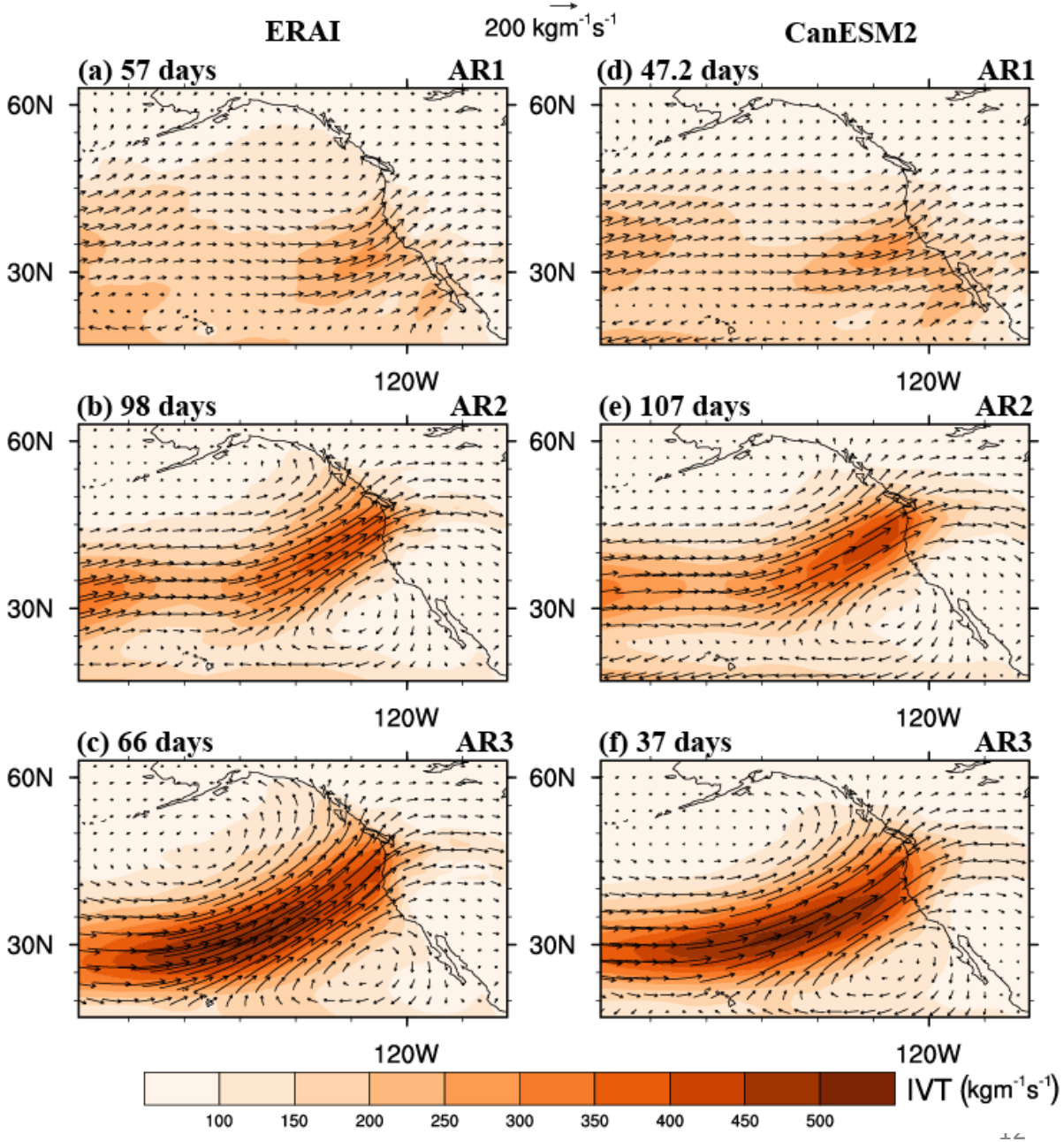
Response of extreme 24-hour precipitation accumulations to warming

Li et al., 2019, submitted

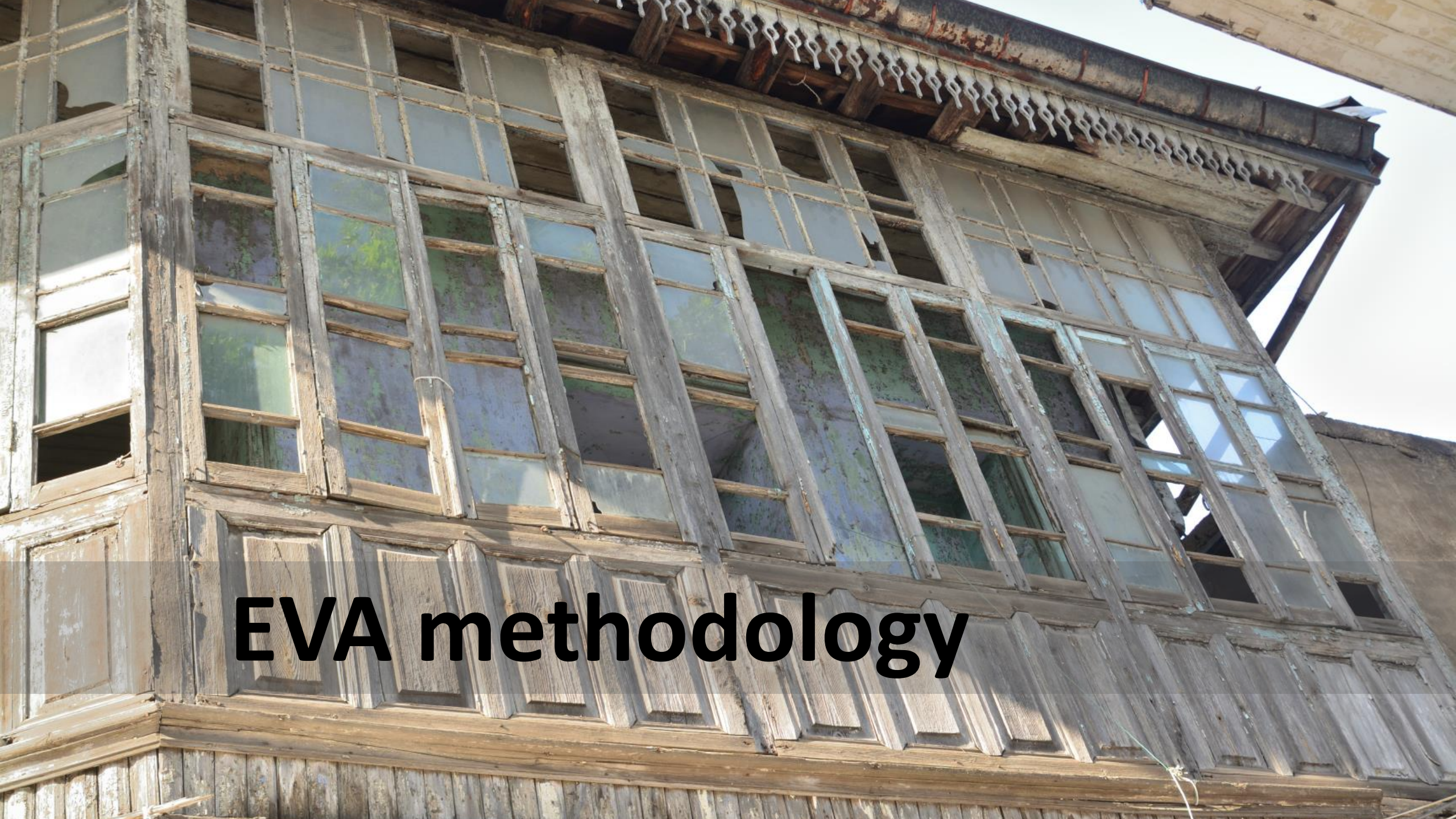


Atmospheric rivers

- Identify 3 kinds of ARs
- Diagnose the dynamical processes involved in each kind
- Diagnose role of dynamical versus thermodynamic influences
- Intercompare several well-performing models
- CanESM2 excels in simulating ARs
- Evaluate projections



Tan et al., 2019, submitted

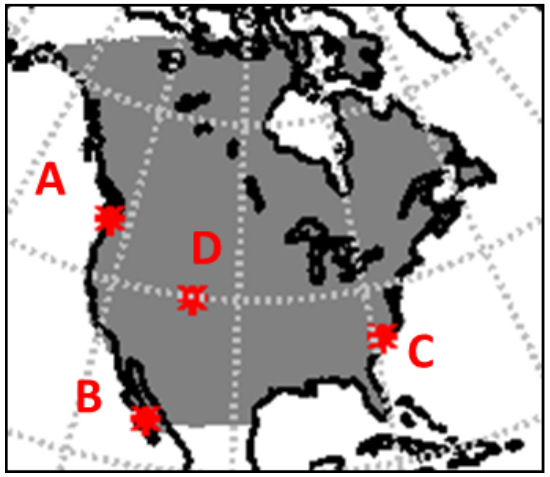


EVA methodology

EVA methodology

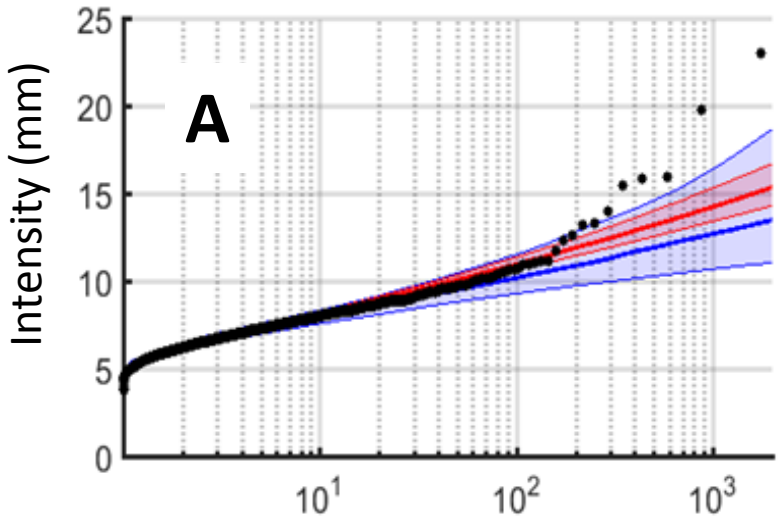
- Should we expect extreme value theory to produce reliable estimates of long return period climate extremes?
  - Ben Alaya et al, 2019c, submitted, *J. Climate*
- Can we solve the problem using a more physically based, compound events approach?
  - Ben Alaya et al., 2019d, in prep
- Alternatively, should we chose a distribution other than the GEV distribution?
  - Ouali, Ben Alaya, et al., in prep.
- Can we usefully apply a compound events approach to joint extreme precip and wind events?
  - Huang, et al, in progress

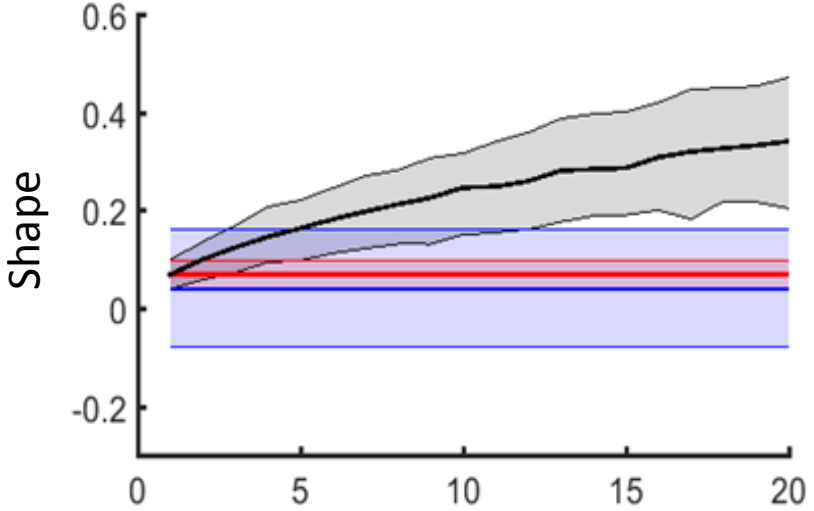
Annual max 1-hour precipitation, CanRCM4 large ensemble, 1951-2000

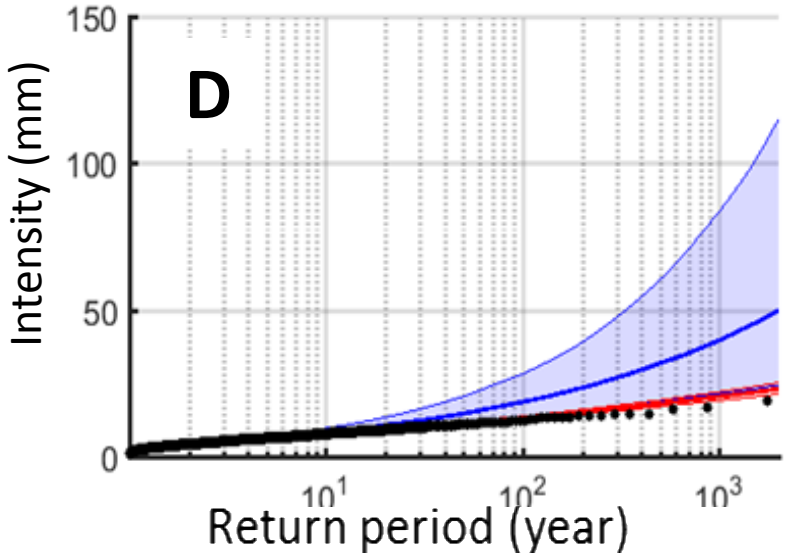


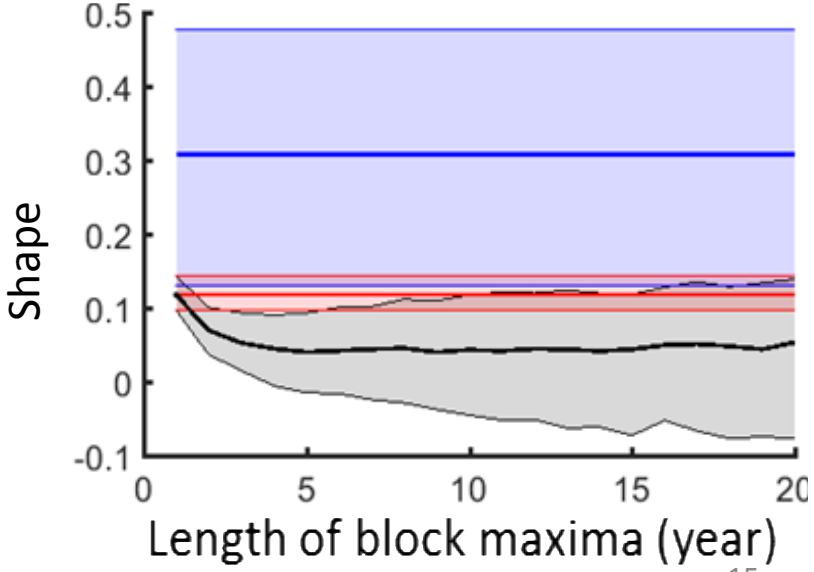
50-year sample
1750-year sample
longer block lengths

Shading - 80% conf. intervals



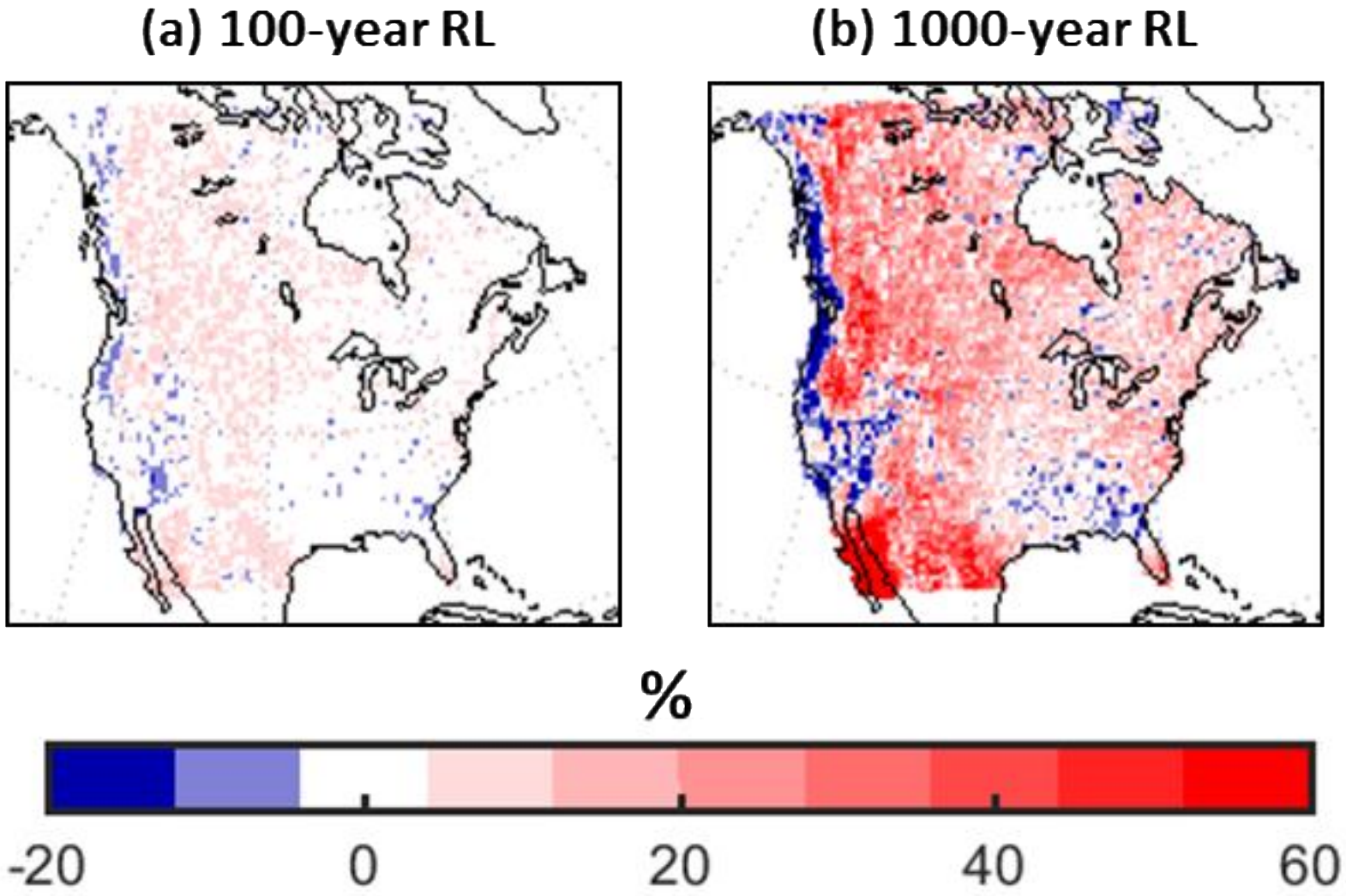






Ben Alaya et al., 2019c, submitted

Relative bias in estimating long period return levels based on GEV fit to 1750 annual maxima of 1-hour precipitation accumulations



Ben Alaya et al., 2019c, submitted

Growing season temperature variability

Photo: F. Zwiers

Early growing season temperature variability

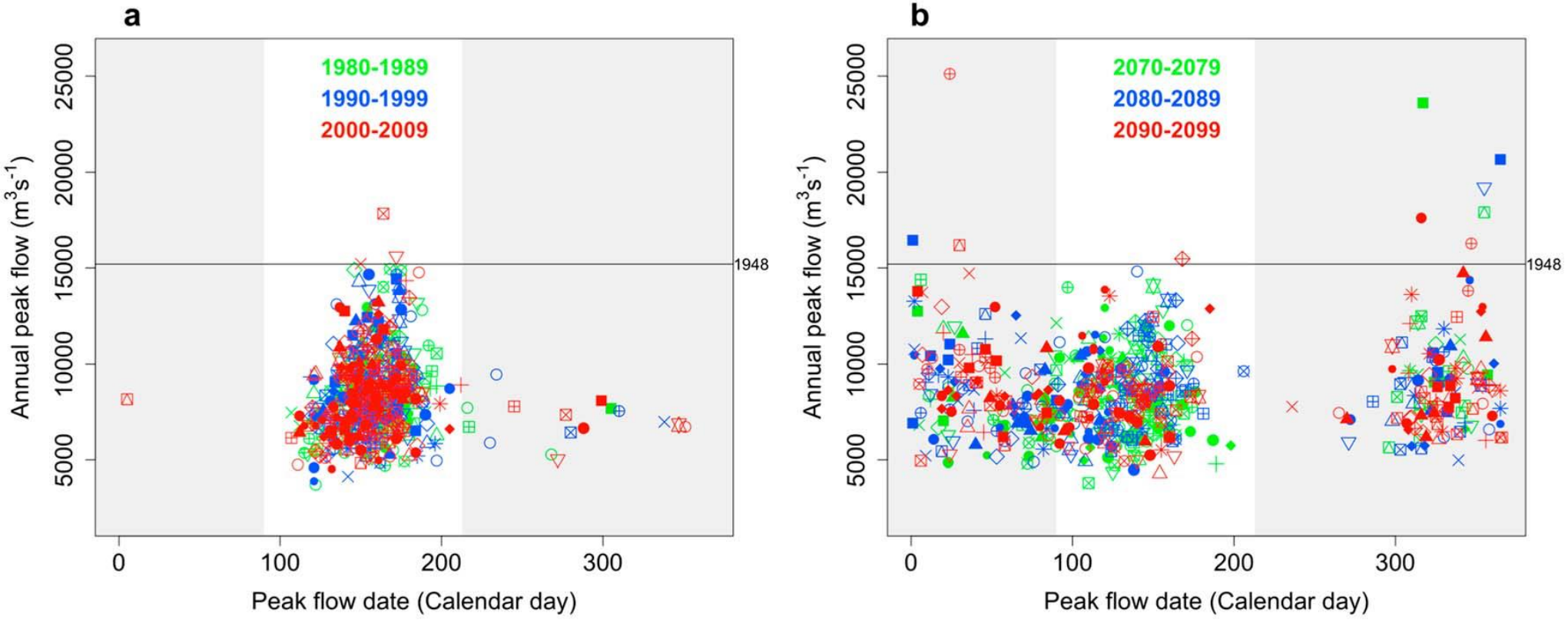
- Early growing season temperature variability (Zhang, et al, in prep)
- CESM and CanESM2 large ensembles
- Basic finding is that as the start of the growing season advances to earlier dates, temperature variability during the early part of the growing season increases, leading to increased frost risk
- The explanation is that with warming, there is increased overlap between the early part of the growing season and the period when extreme cold surges are likely to occur (which advances more slowly).

Fraser River flow regimes

Fraser River flow regimes and flooding

- Islam et al, 2019, doi:10.5194/hess-23-811-2019
- Curry et al, 2019, doi: 10.1029/2018GL080720

Simulated annual peak flow at Hope



Plans

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PACIFIC CLIMATE IMPACTS CONSORTIUM

Plans

- Complete PMP work
- Complete temperature scaling work
- Continue to probe the core EVA methodology
  - The CanRCM4 large ensemble provides an unprecedented opportunity to gain deep insights
  - A critical question is the ”reliable” estimation of very long period return levels
- Compound wind/precip events
- Focus the new GWF/CANSSI postdoc on drought
- Surface wind extremes in CanRCM4


Questions?
https://www.pacificclimate.org/
Photo: F. Zwiers