Motivation

- Long term changes in extreme daily and sub-daily precipitation simulated by climate models are often compared with corresponding temperature changes to estimate the sensitivity of extreme precipitation to warming.
- Such "trend scaling" rates are difficult to estimate from observations, however, due to limited data availability and high background variability.
- Seasonal temperature scaling (binning scaling), which relates extreme precipitation to temperature at or near the time of occurrence, has been suggested as a possible trend scaling substitute.
- While previous studies have discussed the difference between binning scaling and trend scaling from a statistical perspective, they did not have sufficient data to produce statistically robust trend scaling estimates.
- The availability of large ensemble simulations provides an opportunity to answer the question: whether intra-annual scaling is reliable to predict future changes in precipitation extremes?

Data

A large ensemble of 35 regional climate simulations for North America using the Canadian Regional Climate Model (CanRCM4):
- Hourly precipitation, daily mean near surface air temperature, and daily mean dewpoint temperature from these simulations.
- Hourly precipitation for each grid cell is aggregated into 3-hour and 24-hour accumulations.

Binning scaling curves and binning scaling estimation

- Let $P_{d}\text{max}(\text{hh}=01, 03 \text{ and } 24 \text{ respectively})$ be the daily maxima of precipitation for different durations.
- $P_{d}\text{max}$ values are binned according to daily mean air temperature or dewpoint temperature for each duration separately, using a bin width of 2.0°C and allowing a 1°C overlap between bins.
- Find the 99th percentile of wet (>0.1 mm) $P_{d}\text{max}$ values ($P_{99}$), which are estimated only for bins with sample sizes larger than 100 (50 for summer and winter) and are smoothed across bins using a 3-bin moving-window average, producing a binning curve.
- Exponential scaling rates for 1°C temperature increments $T_{a}$ to $T_{a}+1°C$ are calculated for temperatures $T_{a}$ beginning with first bin with positive scaling and continuing until $T_{a} = T_{\text{peak}} - 1°C$; the average of these scaling rates is taken as the binning rate.

Trend scaling estimation

- Trend scaling rates are estimated for each accumulation period are given by
  
  $Y = \left( \frac{\text{ln} \text{ of } T_{a} + 1°C }{\text{ln} \text{ of } T_{a}} - 1 \right) \times 100\%$ 

where $T_{a}$ and $P_{a}$ are the median of annual, winter, summer maximum precipitation amounts for the period 1951–2000 and the period 2051-2100 respectively. $T_{a}$ and $T_{a}$ are the average of annual, summer, and winter mean temperatures or dewpoint temperatures for the two periods, separately.

Comparison of binning and trend scaling rate

Fig. 2. Binning and trend scaling rates for extreme 3-hour precipitation accumulations based on hourly precipitation from a 35-member ensemble of CanRCM4 simulations. Binning scaling rates are based on the variation of $P_{d}\text{max}$ with daily near surface air temperature during the 1951–2000 and 2051–2100 periods. Trend scaling rates are based on changes in the median of annual/seasonal maximum 3-hour precipitation during the two periods. (a)–(c) for the whole year; (d)–(f) for summer; (g)–(i) for winter.

Conclusion

- Binning curves reflect seasonal changes in the relationship between temperature and extreme precipitation.
- The magnitude and spatial pattern of binning and trend scaling rates are quantitatively different, regardless of precipitation duration or choice of temperature variable.
- Binning scaling with temperature is not a reliable predictor for future changes in precipitation extremes in the climate simulated by CanRCM4.