Supplemental Material

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A comparison of intra-annual and long-term trend scaling of extreme precipitation with temperature in a large-ensemble regional climate simulation

Journal of Climate

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**Figure S1.** Schematic diagram for the statistical interpretation of binning and trend scaling approaches. Daily temperature and 3-hour duration precipitation in summer (June-July-August, JJA) simulated by CanRCM4 at the location (84.3°W, 35.2°N) are used. The dashed and solid red lines indicate the binning curves derived from data for the whole year for the 99th percentile of wet event precipitation amounts (3-hourly precipitation > 0.1 mm) conditional on daily air temperature for the 1950-2000 and 2051-2100 periods, respectively. The black dots in (a) and (b) indicate daily maxima of 3-hourly amounts above the 98.9th percentile level of all zero and non-zero values (corresponding approximately to the summer maximum of all zero and non-zero values). Panels (c) and (d) are identical, except black dots indicate the summer maxima of 3-hourly amounts with sample of size 50 (years)×35 (simulations). The green and blue triangles and dots indicate the median and mean of black dots during the 1950-2000 and 2051-2100 periods, respectively. Units: mm
**Figure S2.** As Figure S1, except for winter (December-January-February, DJF).
Figure S3. The map of the Bukovsky regions (Bukovsky 2011) used in this study.
Figure S4. Binning curves with daily surface air temperature for the CPLains, PacificSW, and MidAtlantic Bukovsky regions. (a–i) Binning curves for the whole year, DJF, and JJA 1-hour precipitation extremes (P99_{01}) during 1951–2000 (blue) and 2051–2100 (red) together with a version of the curve for 1951-2000 that has been shifted by 7% per °C of projected warming between the two periods (gray). Thick lines, circles, and crosses indicate binning curves based on data for the full year, DJF, and JJA, respectively. Shaded areas show the 5 to 95 percentile spread determined via bootstrapping.
Figure S5. 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 $P_{99.03}$ with daily near surface air temperature during the 1951–2000 and 2051–2100 periods. Trend scaling rates are based on changes in the medians of annual/seasonal maximum 1-hour precipitation during the two periods. (a–c) for the whole year; (d–f) for summer; (g–i) for winter. Units: %/°C.
Figure S6. Binning and trend scaling rates for extreme 1-hour precipitation accumulations based on hourly precipitation from a 35-member ensemble of CanRCM4 simulations. Binning scaling rates are based on the variation of \( P_{99.01} \) with daily dewpoint temperature during the 1951–2000 and 2051–2100 periods. Trend scaling rates are based on changes in the medians of annual/seasonal maximum 1-hour precipitation during the two periods. (a–c) for the whole year; (d–f) for summer; (g–i) for winter. Units: \%/°C.
Figure S7. Binning and trend scaling rates for extreme 24-hour precipitation accumulations based on hourly precipitation from a 35-member ensemble of CanRCM4 simulations. Binning scaling rates are based on the variation of P99$_{24}$ with daily dewpoint temperature during the 1951–2000 and 2051–2100 periods. Trend scaling rates are based on changes in the medians of annual/seasonal maximum 24-hour precipitation during the two periods. (a–c) for the whole year; (d–f) for summer; (g–i) for winter. Units: %/°C.
Figure S8. Zonal averages of the binning scaling rate during the 1951–2000 period (blue lines) and the 2051–2100 period (red lines) together with those of the trend scaling rate (orange lines) for the annual and seasonal maximum 1-hour, 3-hour and 1-day precipitation. Daily near surface air temperature is used as the scaling variable for both the binning scaling and trend scaling. Grid boxes over oceans were removed to calculated the zonal averages. Results from left to right are shown for zonal averages for the whole year, JJA, and DJF maxima respectively. Thick lines for binning scaling show the median scaling rates and shaded areas show the 5 to 95 percentile spread from 200 block bootstrap samples (see Section 2). Units: % /°C.
**Figure S9.** The mean frequency of occurrence of the annual maximum 3-hour precipitation in the CanRCM4 large ensemble in MAM, JJA, SON and DJE during the 1951–2000 and 2051–2100 periods. The white regions in northern North America in DJF indicate locations where there were no instances of the occurrence of the annual maximum of 3-hour precipitation in DJF during the periods indicated.
Figure S10. As Figure S9, except for annual maximum 1-hour precipitation.
Figure S11. As Figure S9, except for annual maximum 1-day precipitation.
Figure S12. Binning curves with daily surface air temperature for the CPLains, PacificSW, and MidAtlantic Bukovsky regions. (a–i) Binning curves for the whole year, DJF, and JJA 3-hour precipitation extremes (P99(03)) during 1951–2000 (blue) and 2051–2100 (red) together with a version of the curve for 1951-2000 that has been shifted by 7% per °C of projected warming between the two periods (gray). Thick lines, circles, and crosses indicate binning curves based on data for the full year, DJF, and JJA, respectively. Shaded areas show the 5 to 95 percentile spread determined via bootstrapping.