

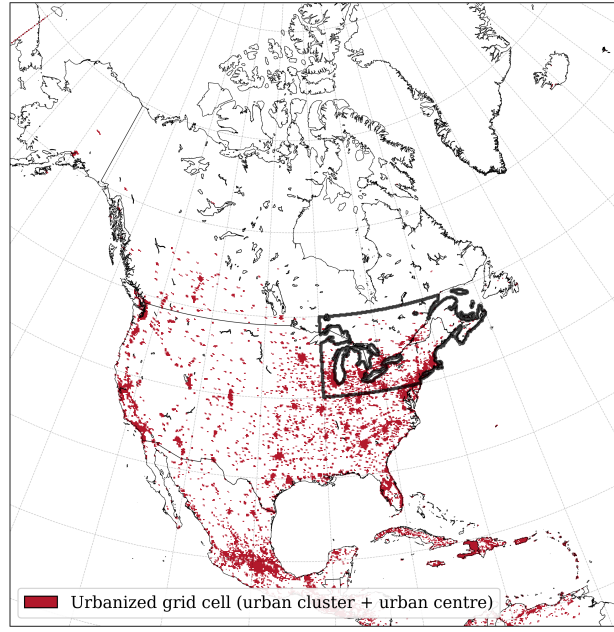


Figure S1. Region of northeastern North America (NNA, black contour) selected for the individual-ETC analysis of Section 3.3, with the urban grid cells over the NA-CORDEX domain shown to convey the degree of urbanisation of the region, one of the criteria guiding its selection. Urban grid cells are identified using the GHS-SMOD epoch 2025 dataset: those with a non-zero combined urban fraction—summing the Urban Centre, Dense Urban Cluster, Semi-dense Urban Cluster, and Suburban or peri-urban classes—are flagged as urban. See Appendix 1 for a full description of the GHS-SMOD product and the construction of the urban mask.

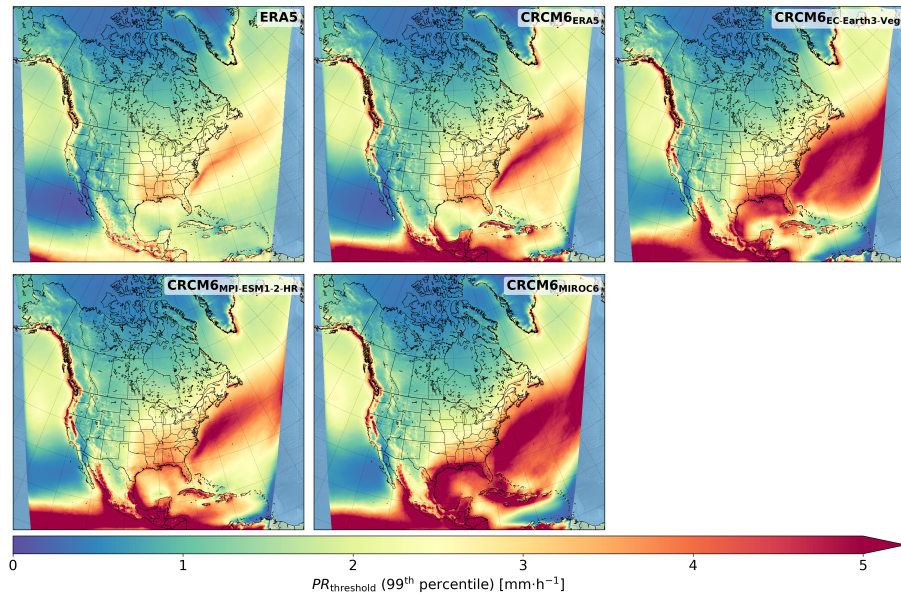


Figure S2. The 99th percentile of hourly precipitation rate computed over all hours of the historical period (1980–2014) for ERA5 (a) and the four CRCM6-GEM5 simulations (b–e).

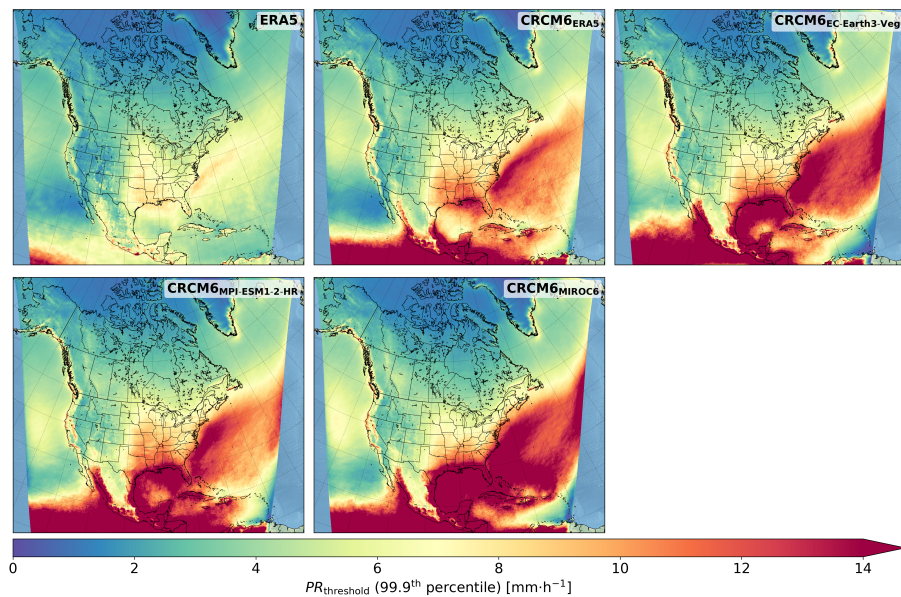


Figure S3. The 99.9th percentile of hourly precipitation rate computed over all hours of the historical period (1980–2014) for ERA5 (a) and the four CRCM6-GEM5 simulations (b–e).

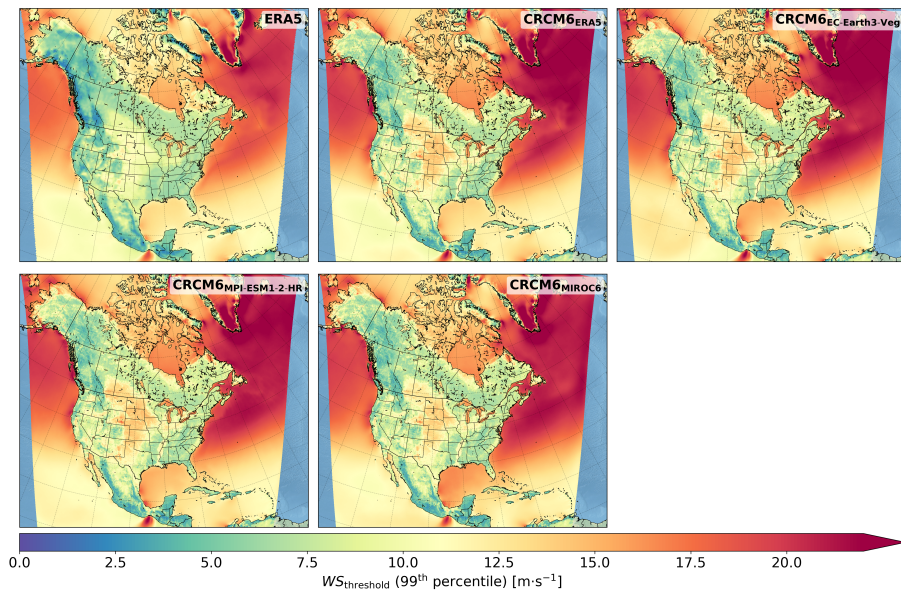


Figure S4. The 99th percentile of hourly near-surface wind speed computed over all hours of the historical period (1980–2014) for ERA5 (a) and the four CRCM6-GEM5 simulations (b–e).

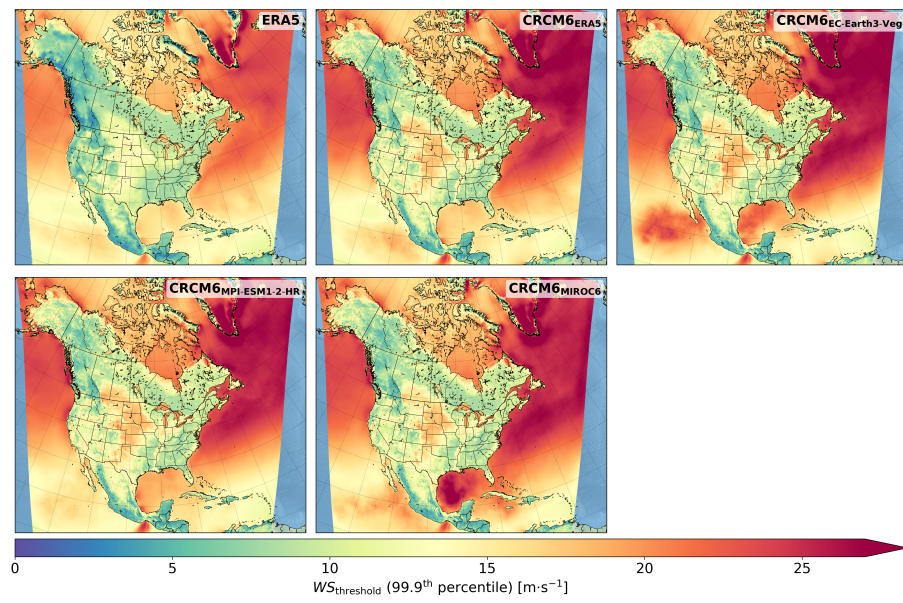


Figure S5. The 99.9th percentile of hourly near-surface wind speed computed over all hours of the historical period (1980–2014) for ERA5 (a) and the four CRCM6-GEM5 simulations (b–e).

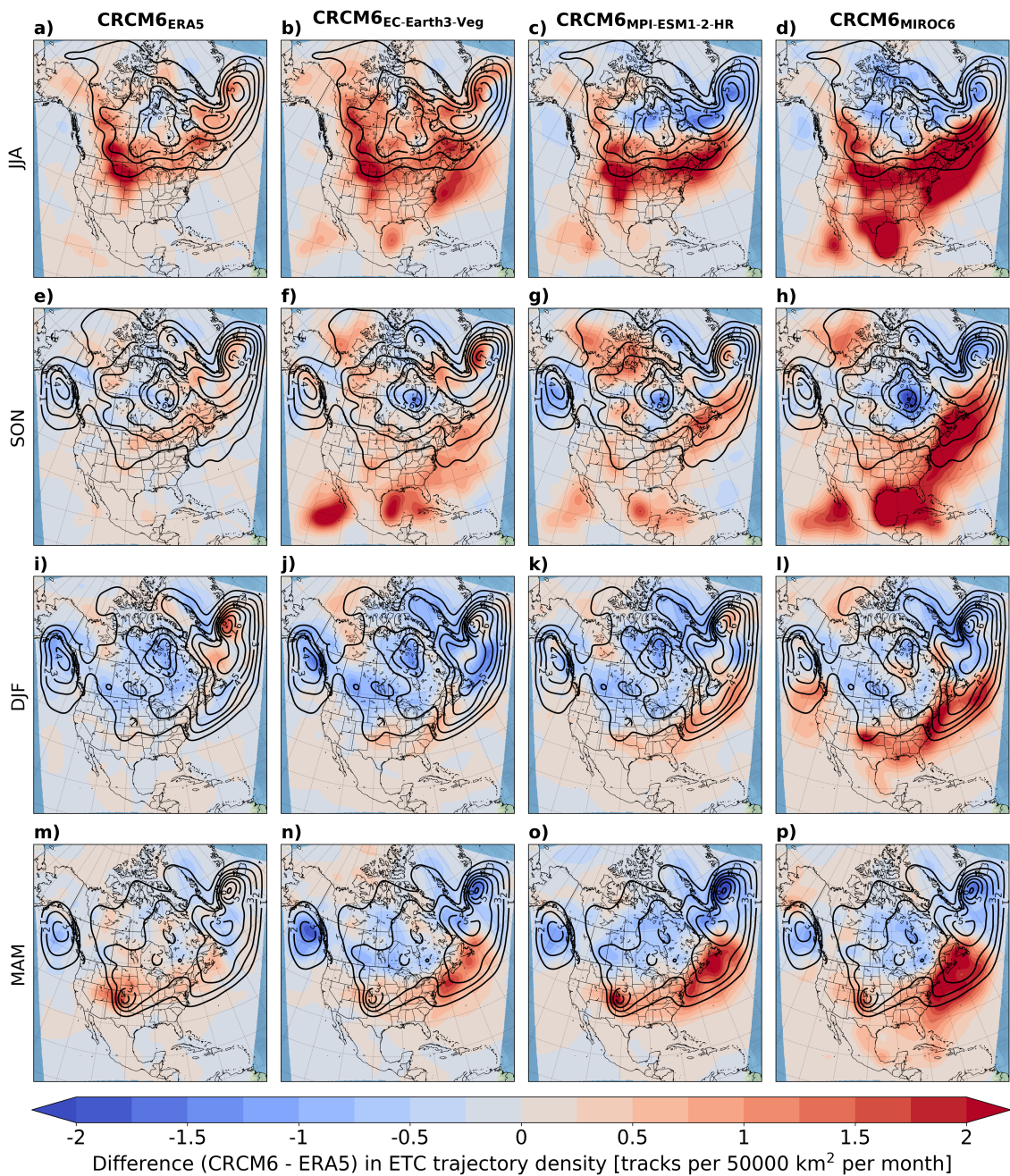


Figure S6. Seasonal differences in ETC trajectory density relative to ERA5 over the historical period (1980—2014), shown by season (rows) and regional simulation (columns), with ERA5 reference climatology indicated by black contours.

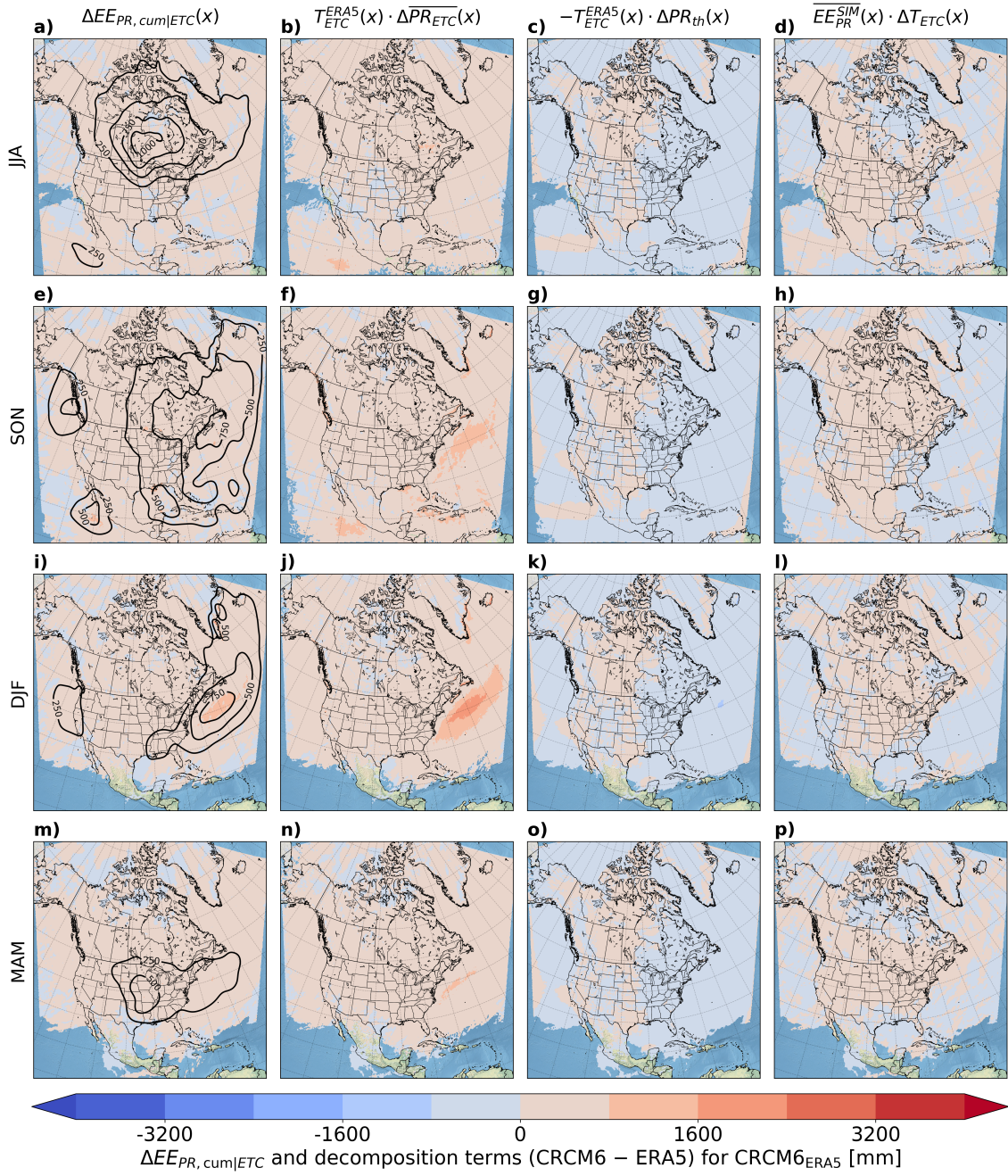


Figure S7. Same as Fig. 3 but for CRCM6_{ERA5} only, with each row representing a different season. ERA5 values are indicated by black contours.

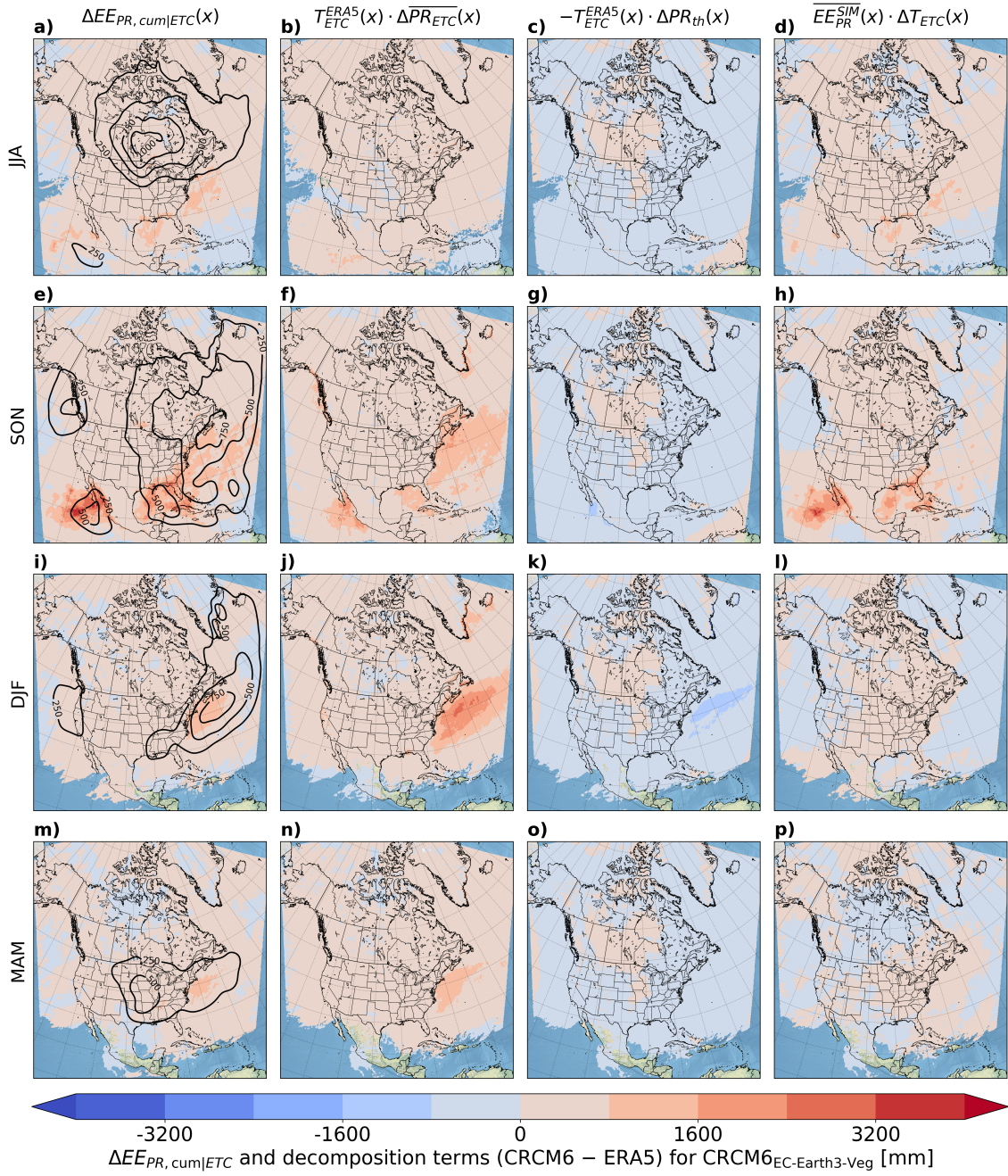


Figure S8. Same as Fig. 3 but for CRCM6_{EC-Earth3-Veg} only, with each row representing a different season. ERA5 values are indicated by black contours.

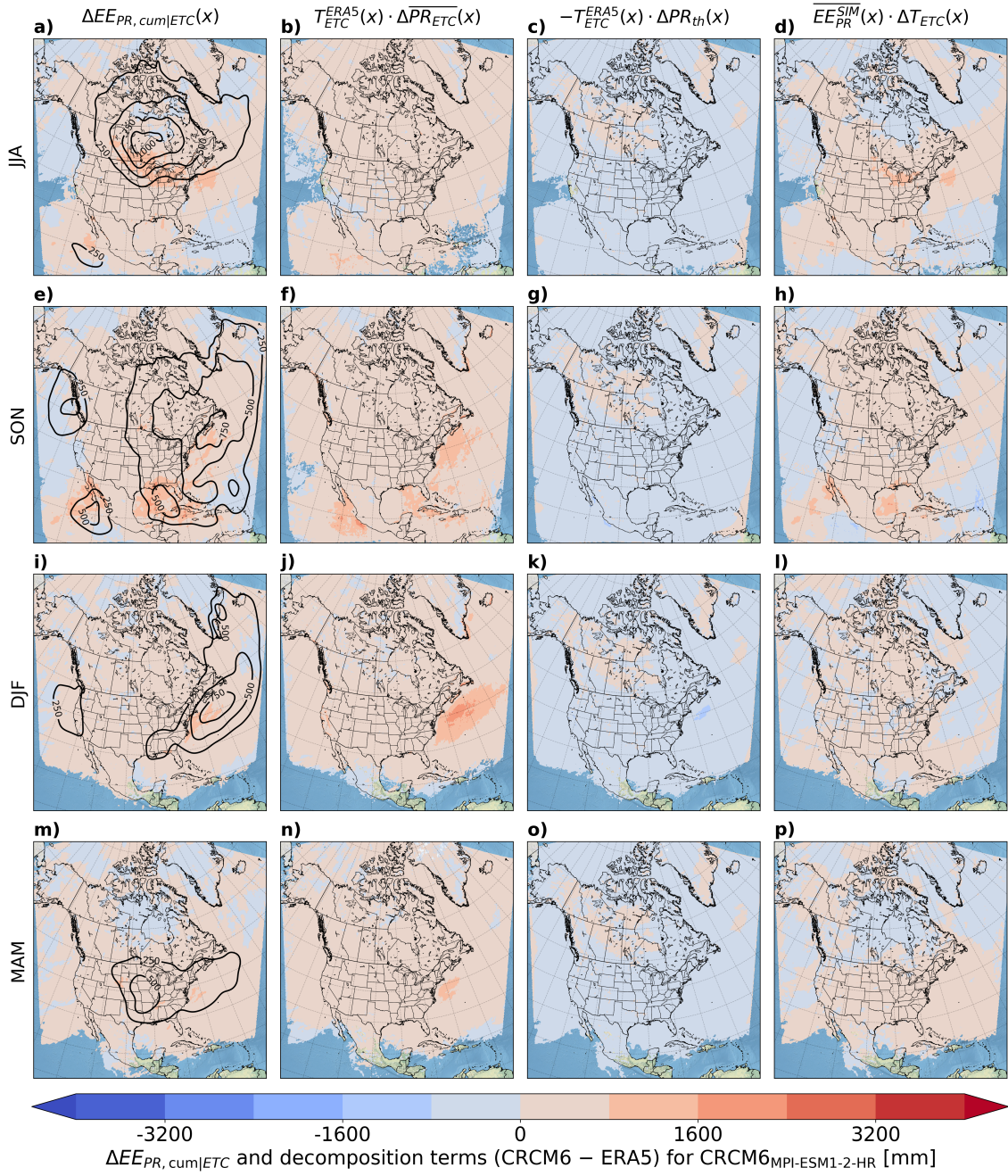


Figure S9. Same as Fig. 3 but for CRCM6_{MPI-ESM1-2-HR} only, with each row representing a different season. ERA5 values are indicated by black contours.

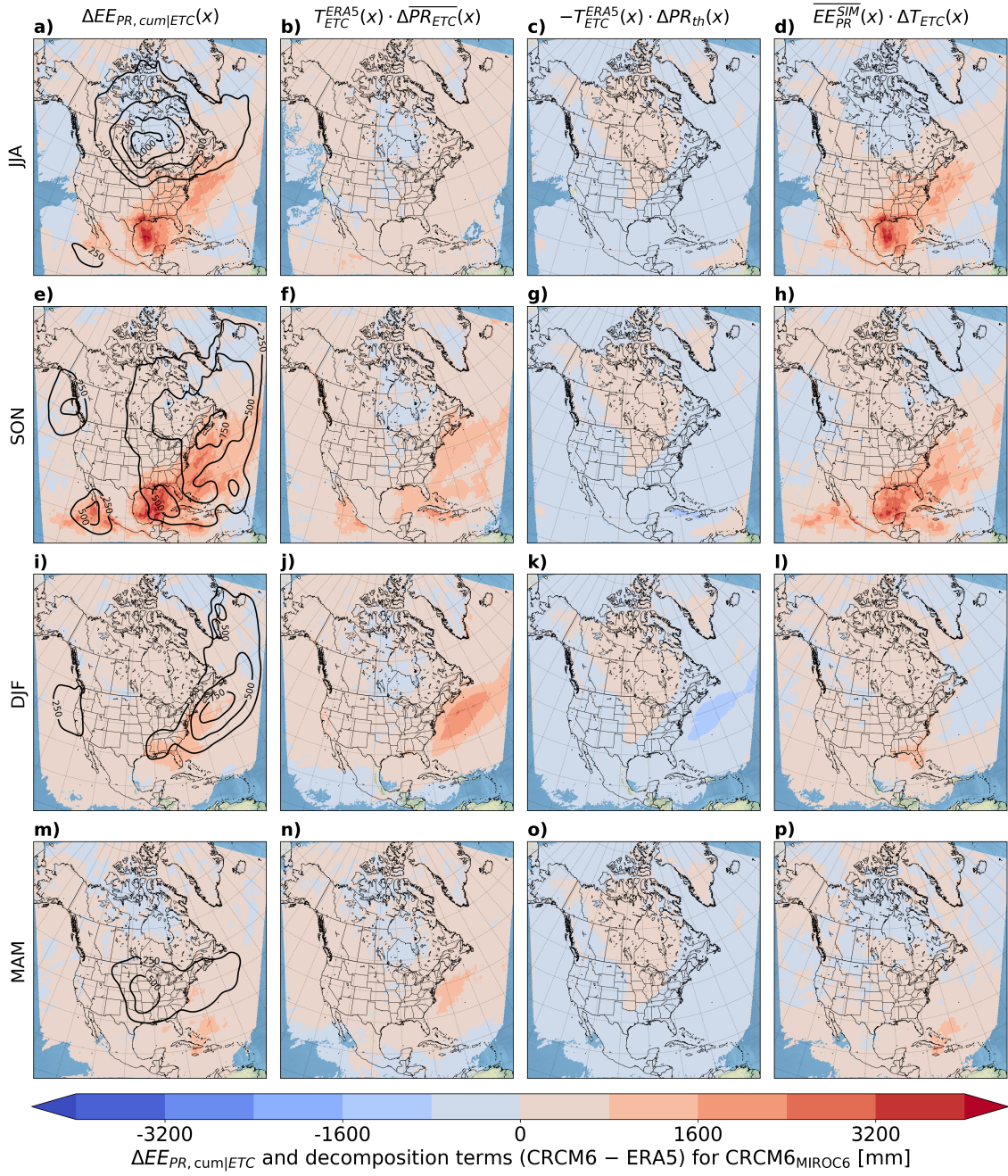


Figure S10. Same as Fig. 3 but for CRCM6_MIROC6 only, with each row representing a different season. ERA5 values are indicated by black contours.

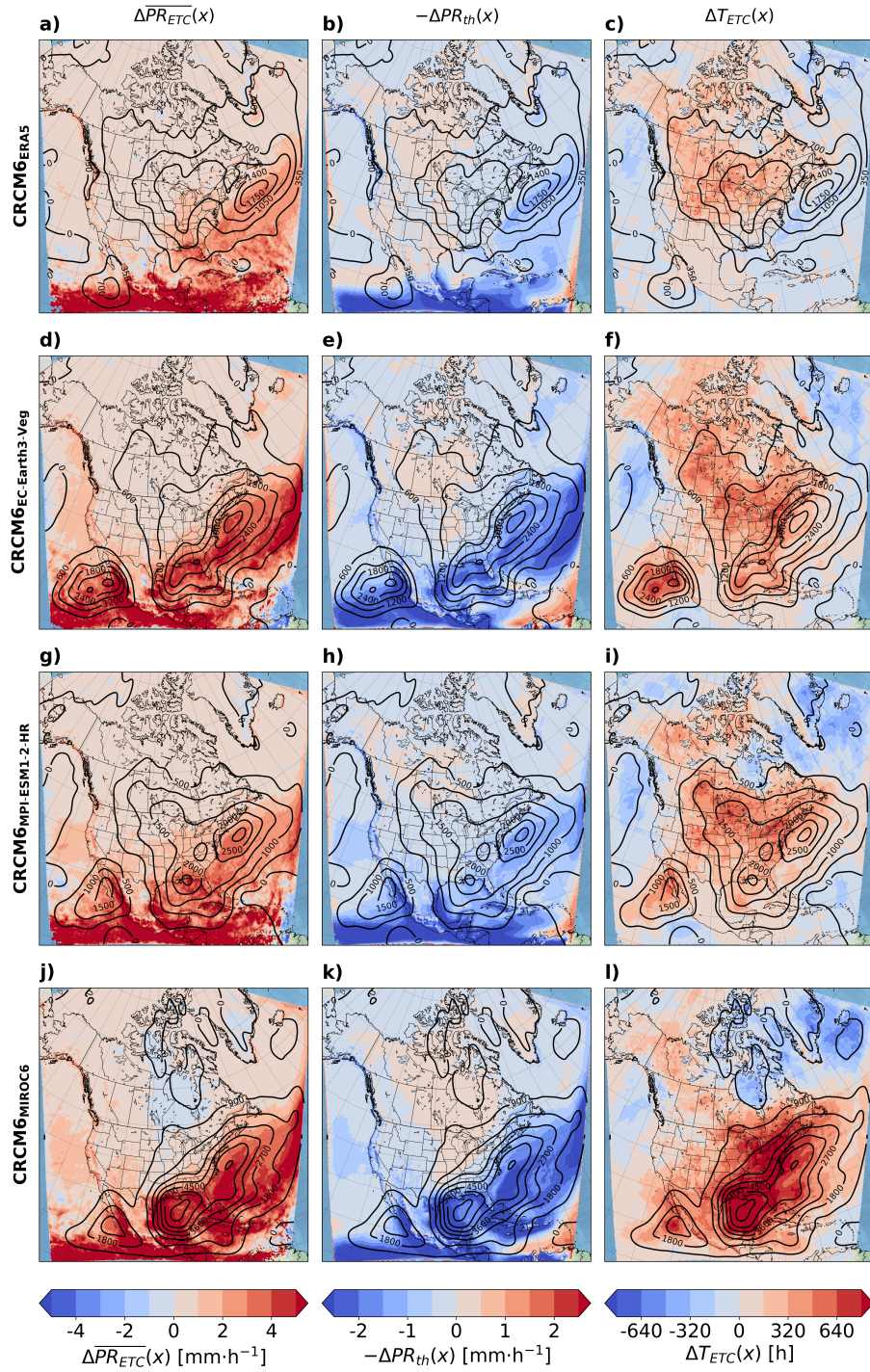


Figure S11. Intrinsic differences in (a, d, g, j) mean ETC-related precipitation extreme intensity ($\Delta \overline{PR}_{ETC}$), (b, e, h, k) extreme threshold (ΔPR_{th}), and (c, f, i, l) number of extreme time steps (ΔT_{ETC}) for precipitation between each historical regional simulation and ERA5, prior to scaling by the exposure factors of Eq. 7.

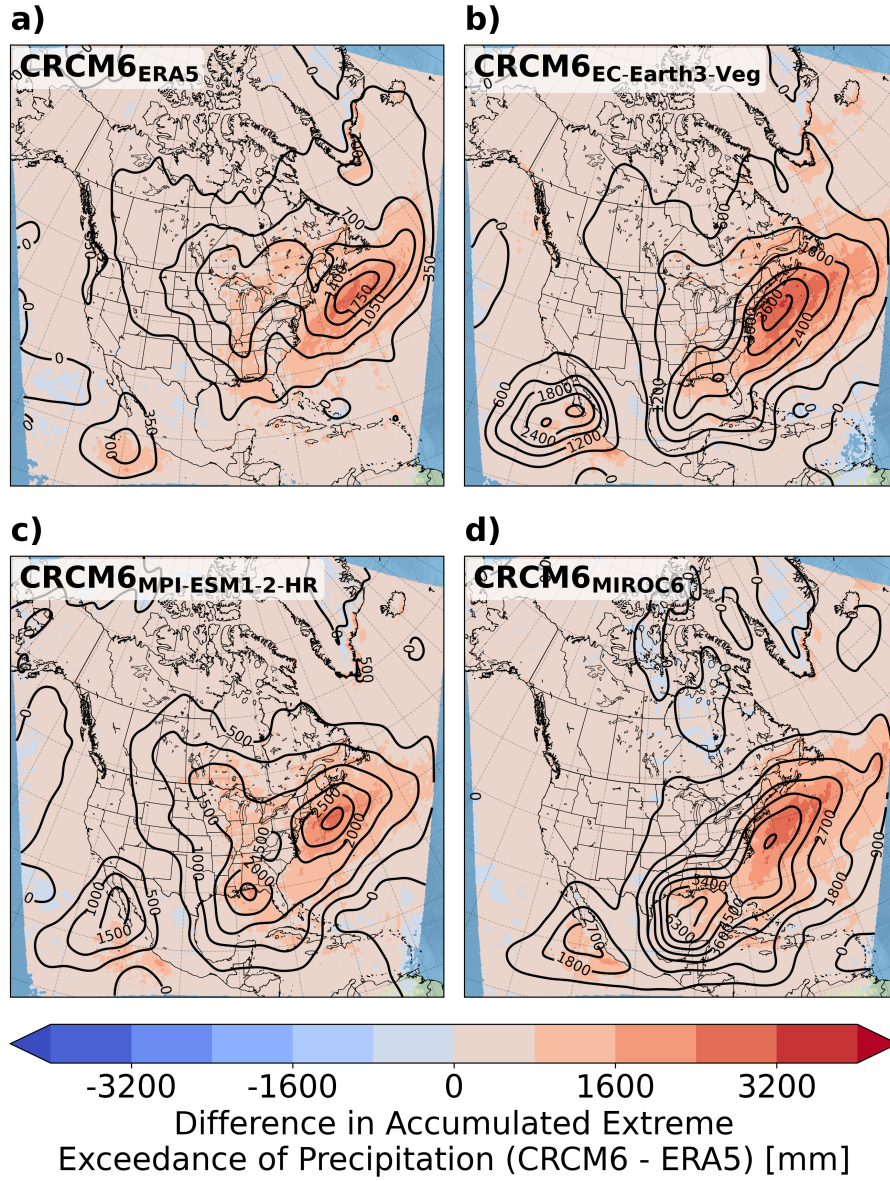


Figure S12. Sum of the intensity and threshold terms (terms 1 and 2) from Fig. 3, equivalent to $T_{ETC}^{ERA5}(x) \cdot \left(\overline{EE_{PR}^{SIM}}(x) - \overline{EE_{PR}^{ERA5}}(x) \right)$.

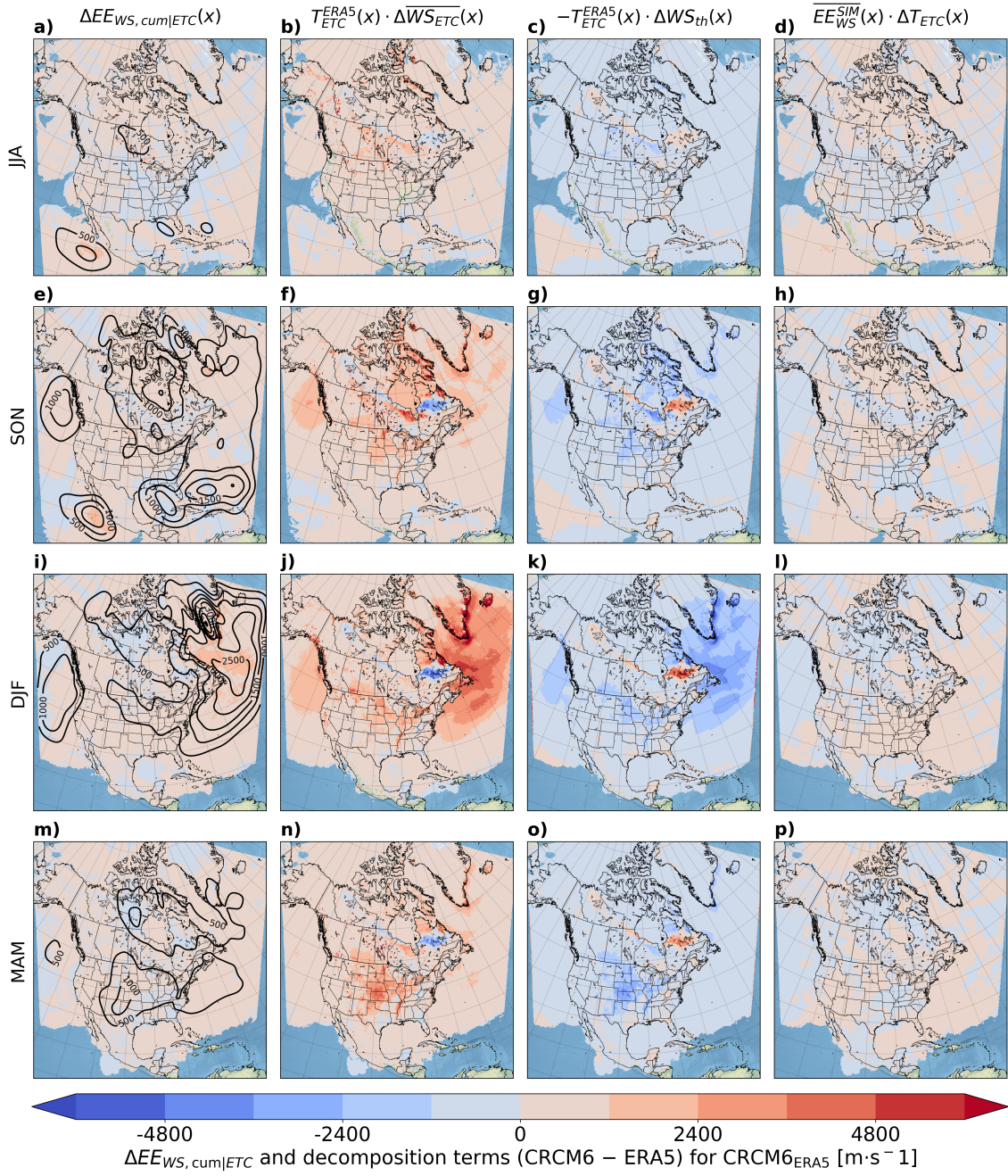


Figure S13. Same as Fig. 5 but for CRCM6_{ERA5} only, with each row representing a different season. ERA5 values are indicated by black contours.

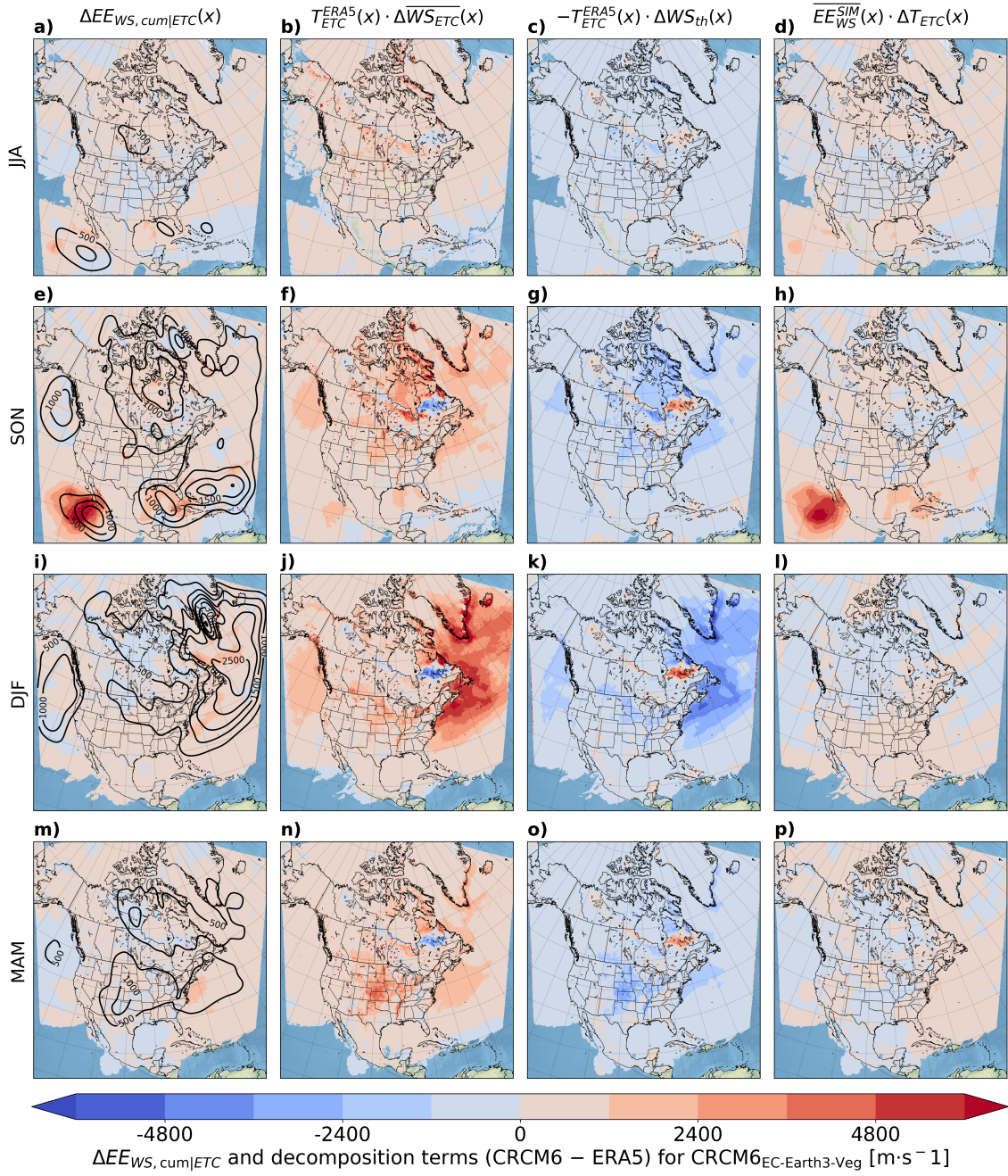


Figure S14. Same as Fig. 5 but for CRCM6_{EC-Earth3-Veg} only, with each row representing a different season. ERA5 values are indicated by black contours.

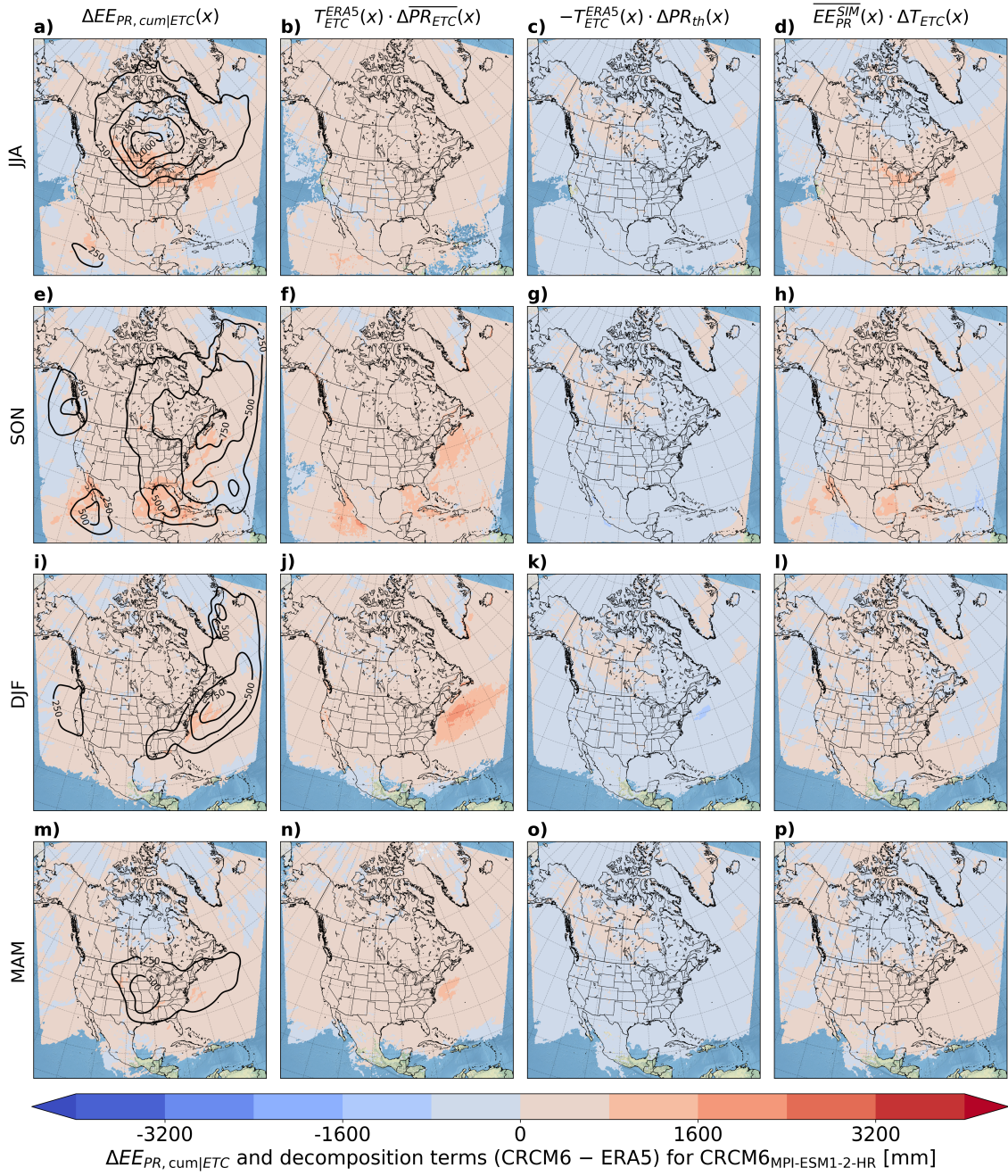


Figure S15. Same as Fig. 5 but for CRCM6_{MPI-ESM1-2-HR} only, with each row representing a different season. ERA5 values are indicated by black contours.

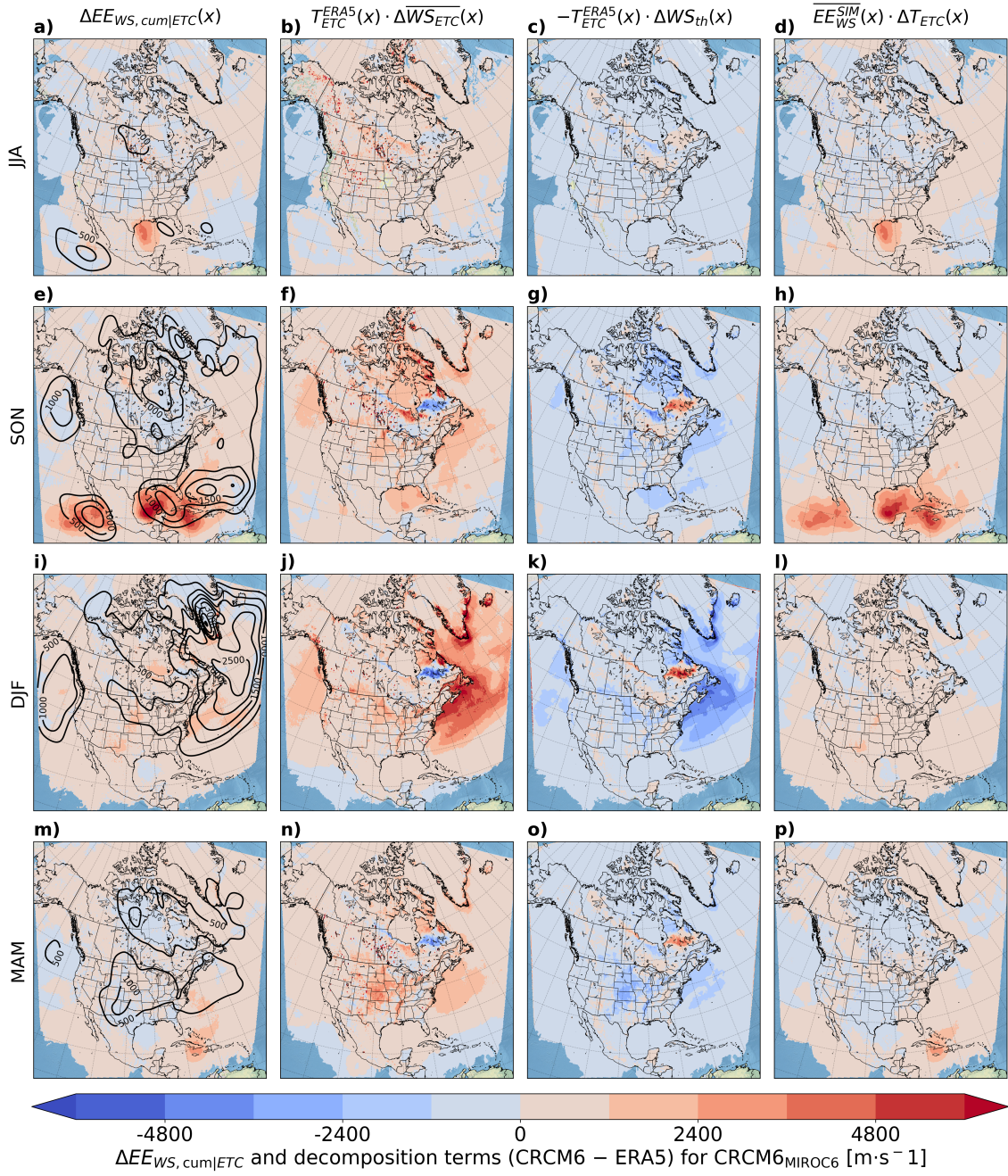


Figure S16. Same as Fig.5 but for CRCM6_{MIROC6} only, with each row representing a different season. ERA5 values are indicated by black contours.

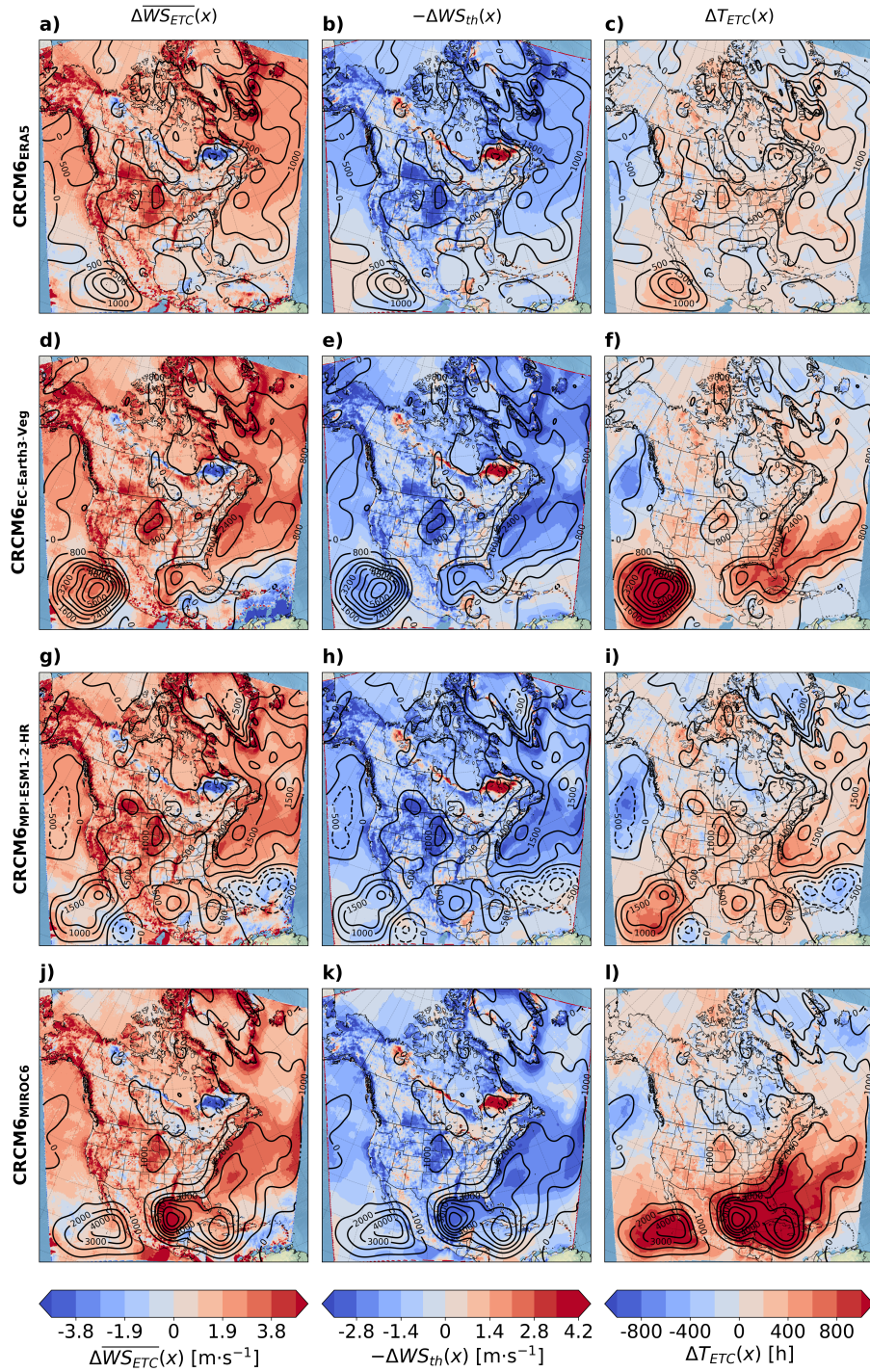


Figure S17. Intrinsic differences in (a, d, g, j) mean ETC-related extreme intensity ($\Delta \overline{WS}_{ETC}(x)$), (b, e, h, k) extreme threshold ($-\Delta WS_{th}(x)$), and (c, f, i, l) number of extreme time steps ($\Delta T_{ETC}(x)$) for surface wind speed between each historical regional simulation and ERA5, prior to scaling by the exposure factors of Eq. 7.

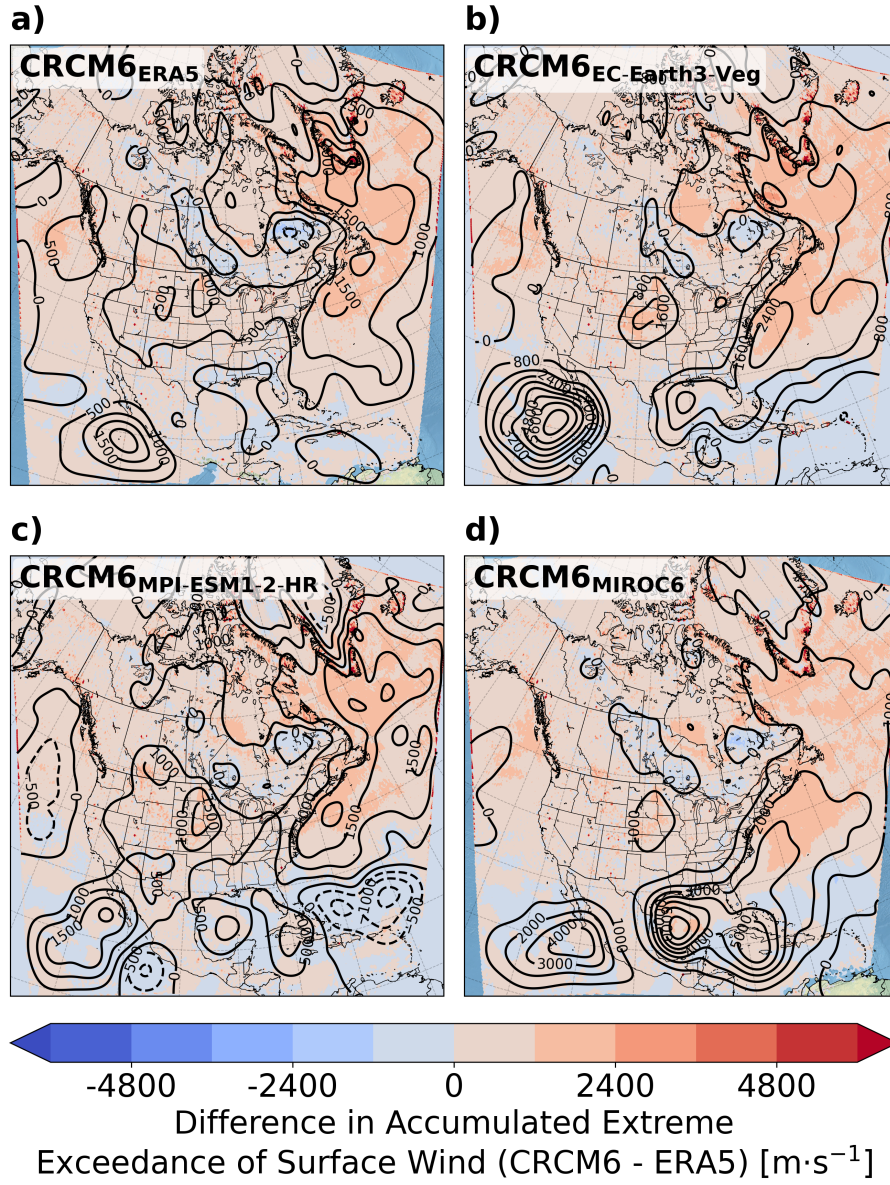


Figure S18. Sum of the intensity and threshold terms (terms 1 and 2) from Fig. 5, equivalent to $T_{ETC}^{ERA5}(x) \cdot \left(\overline{EE_{WS}^{SIM}}(x) - \overline{EE_{WS}^{ERA5}}(x) \right)$.

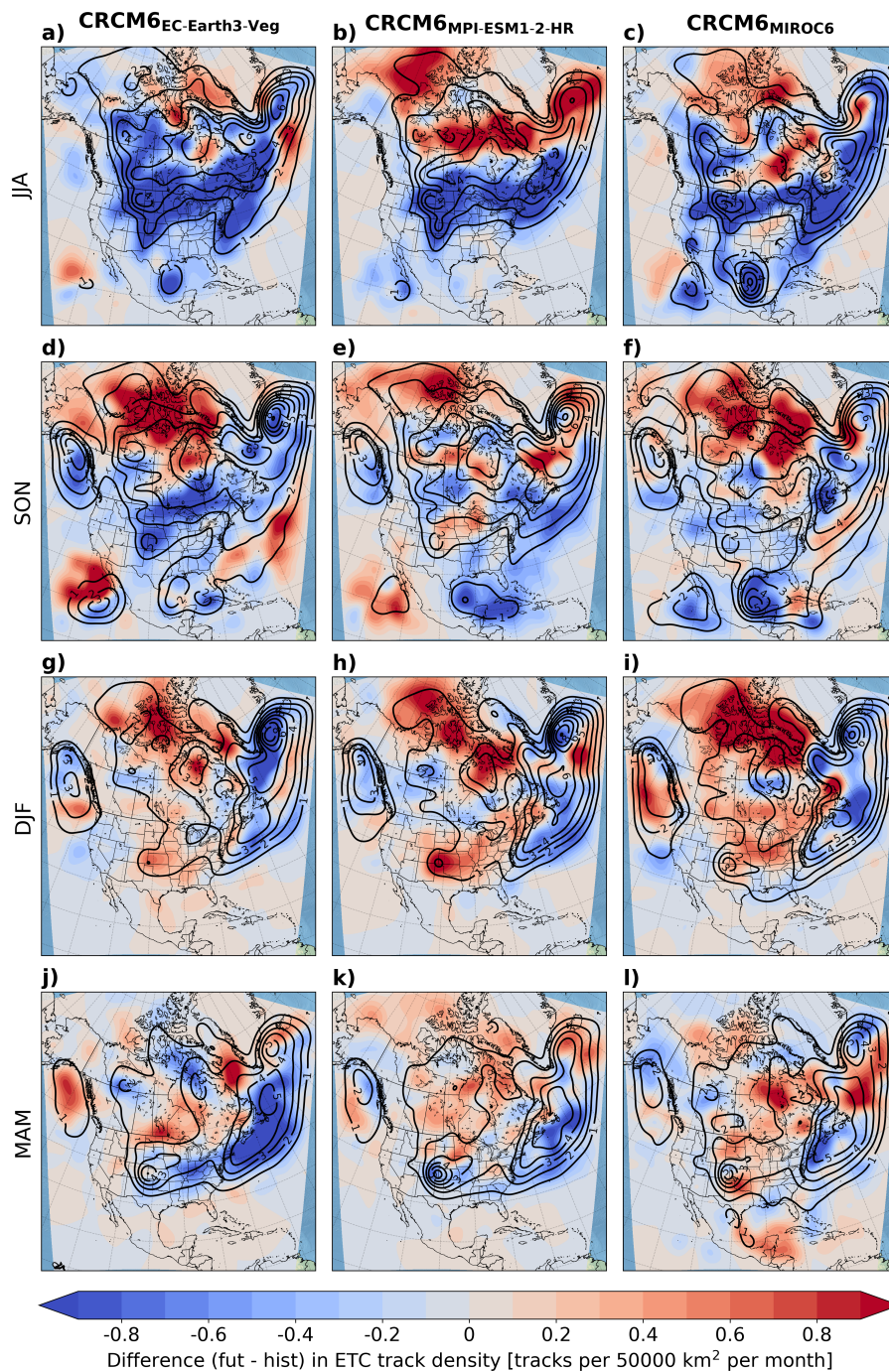


Figure S19. Future changes in ETC trajectory density relative to the historical period (1980—2014), shown by season (rows) and regional simulation (columns), with historical climatology indicated by black contours.

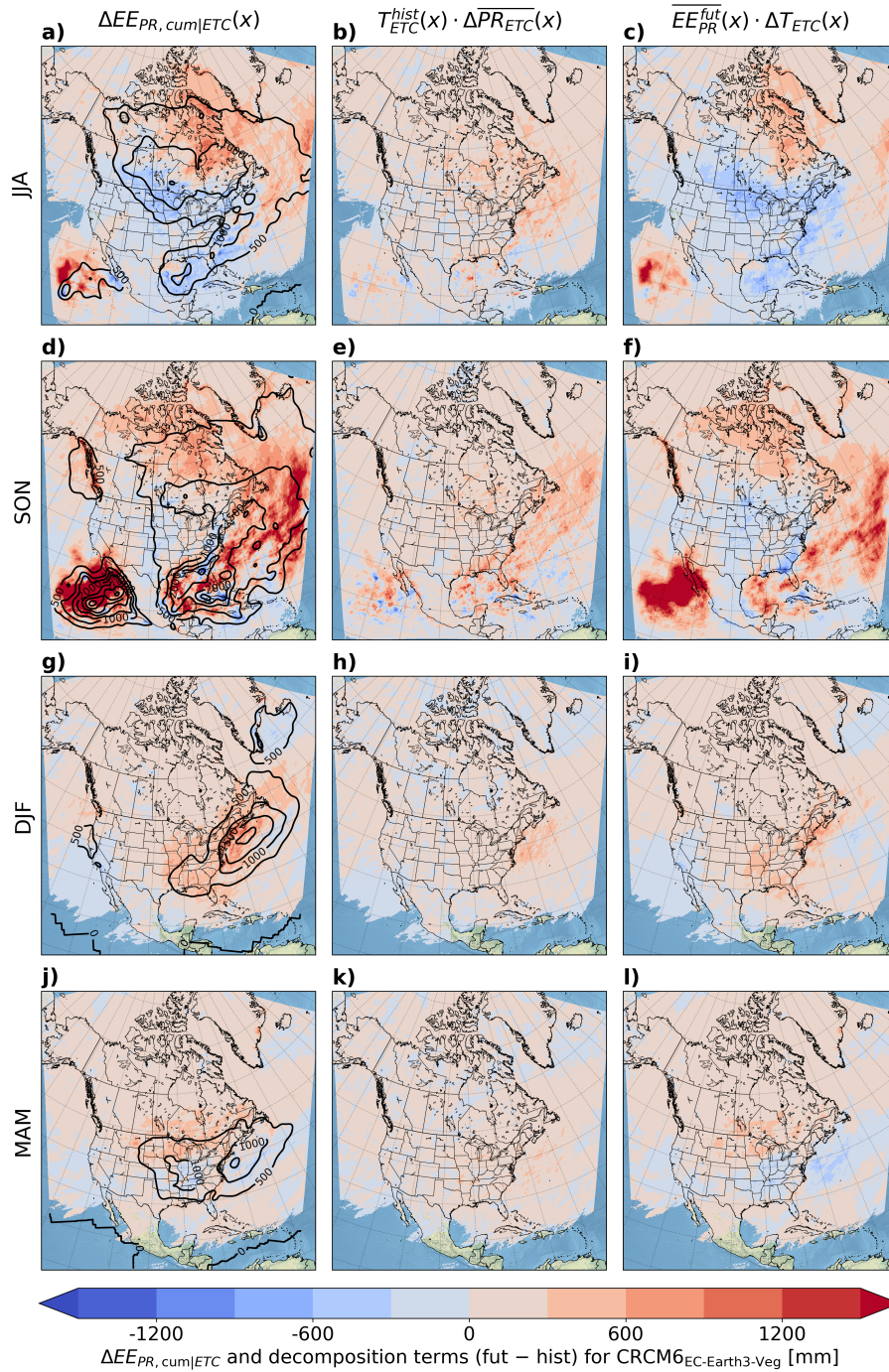


Figure S20. Same as Fig. 7 but for CRCM6_{EC-Earth3-Veg} only, with each row representing a different season. Historical values are indicated by black contours.

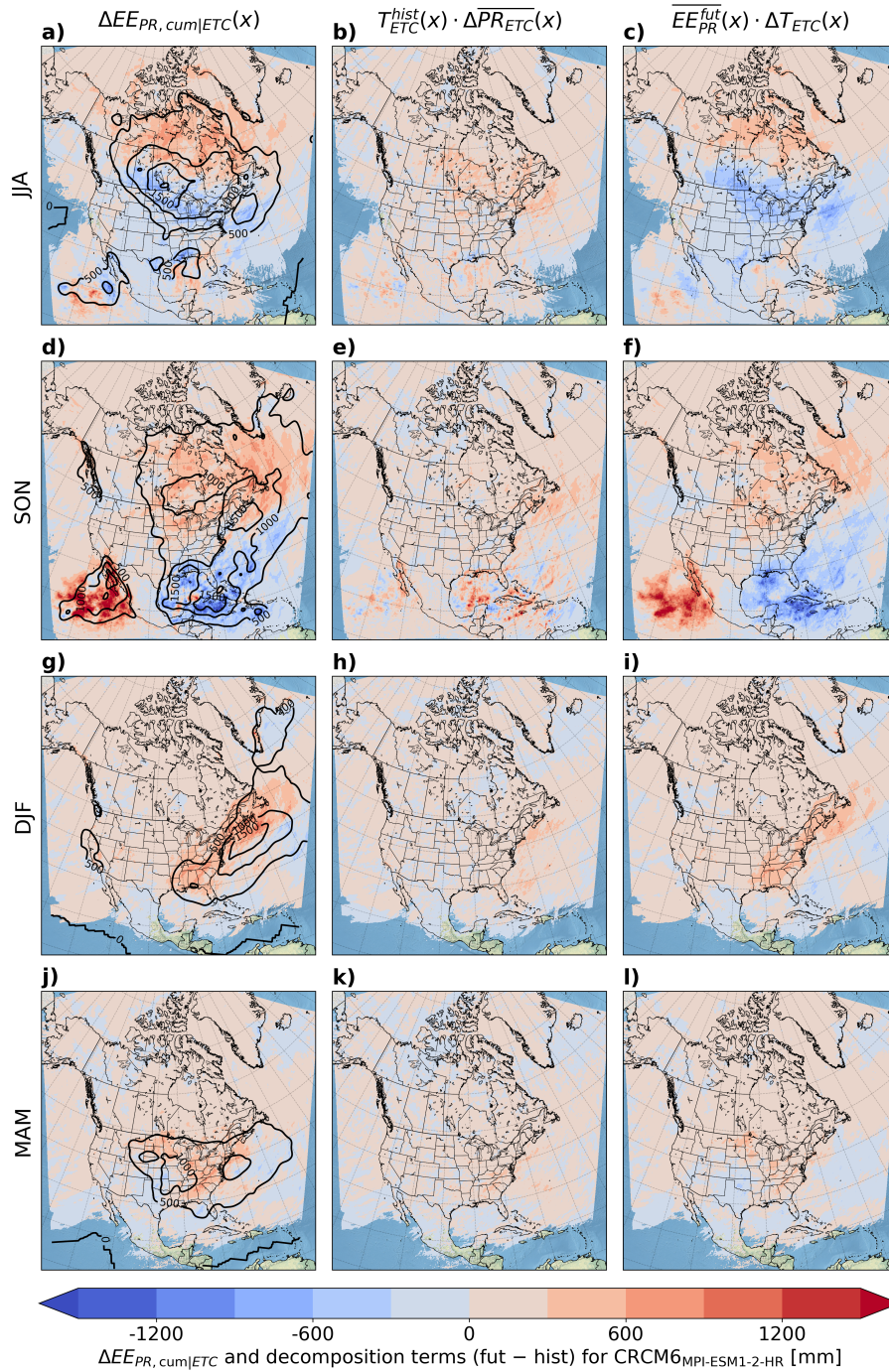


Figure S21. Same as Fig. 7 but for CRCM6_{MPI-ESM1-2-HR} only, with each row representing a different season. Historical values are indicated by black contours.

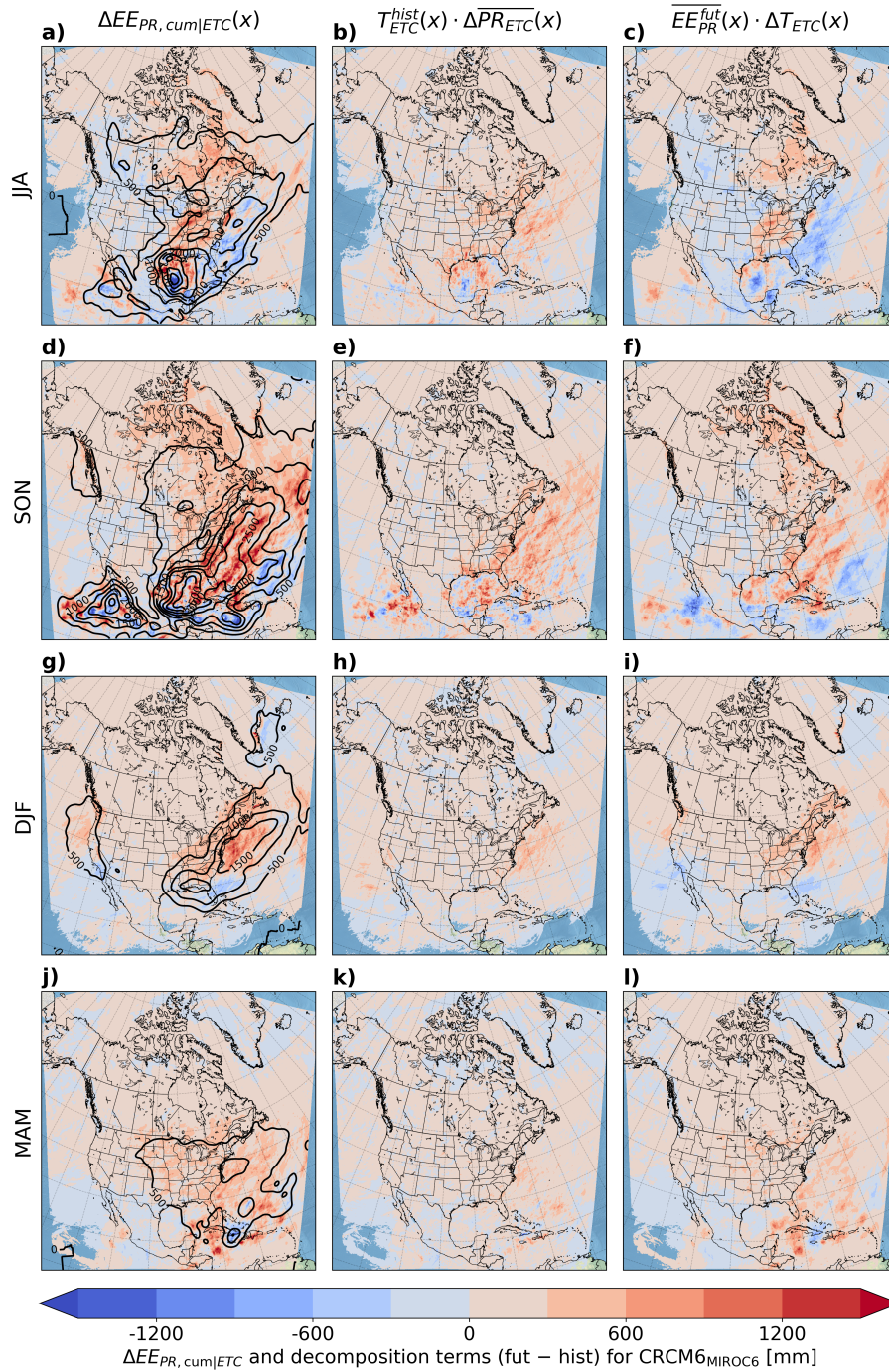


Figure S22. Same as Fig. 7 but for CRCM6_{MIROC6} only, with each row representing a different season. Historical values are indicated by black contours.

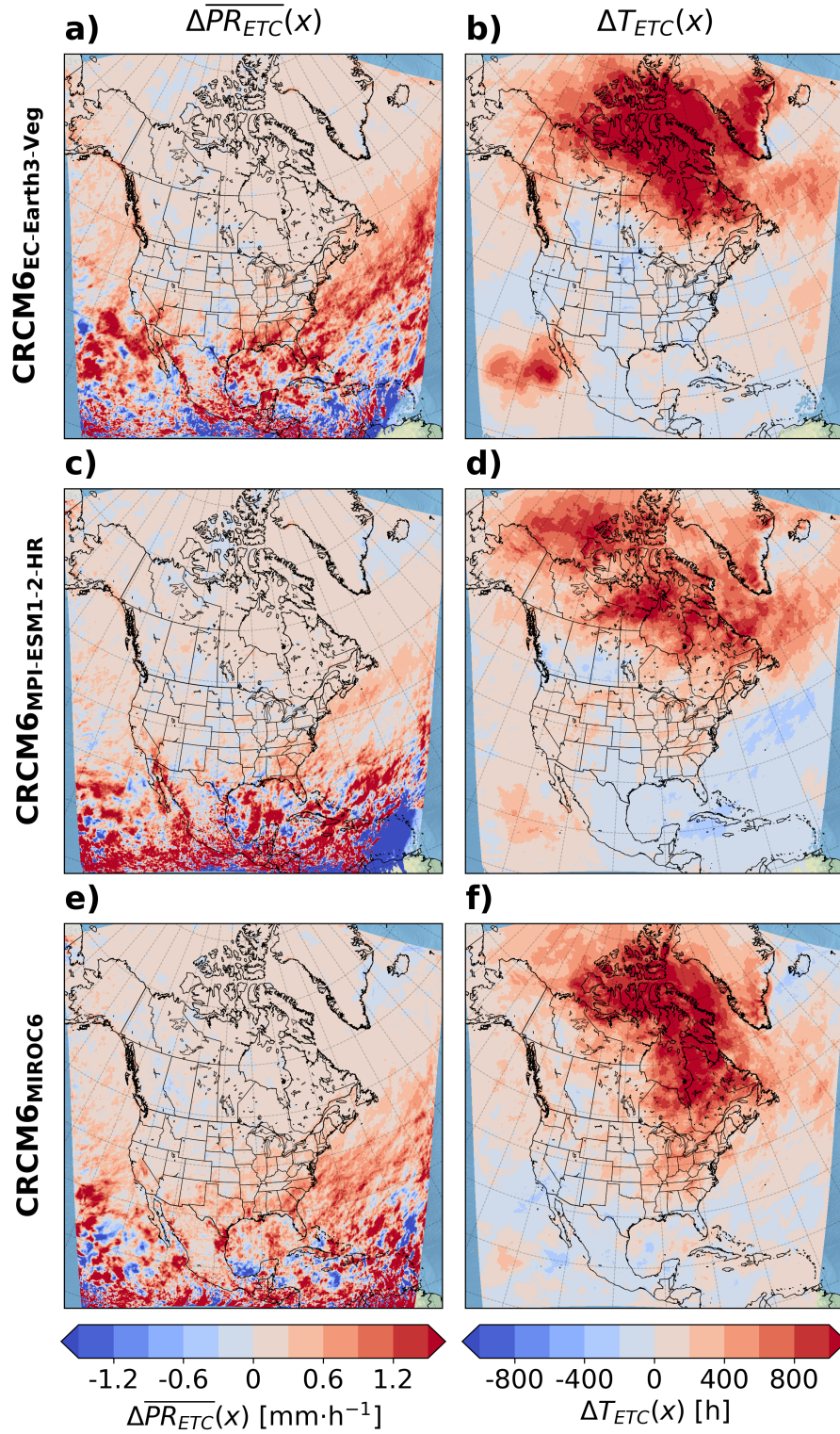


Figure S23. Intrinsic differences in (a, d, g, j) mean ETC-related precipitation extreme intensity ($\Delta \overline{PR}_{ETC}$), (b, e, h, k) extreme threshold (ΔPR_{th}), and (c, f, i, l) number of extreme time steps (ΔT_{ETC}) for precipitation between each historical regional simulation and its future counterpart, prior to scaling by the exposure factors of Eq. 7.

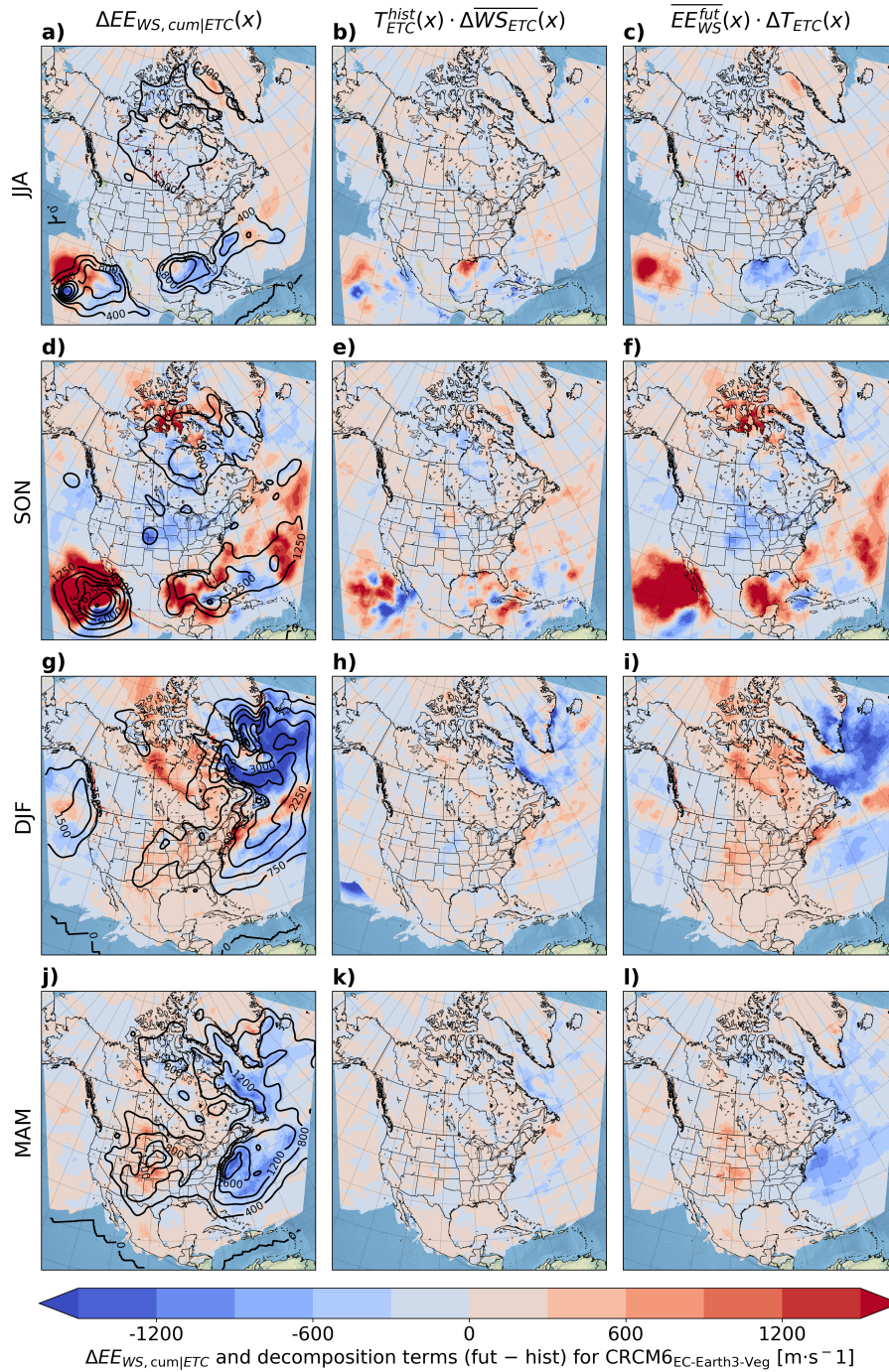


Figure S24. Same as Fig. 8 but for CRCM6_{EC-Earth3-Veg} only, with each row representing a different season. Historical values are indicated by black contours.

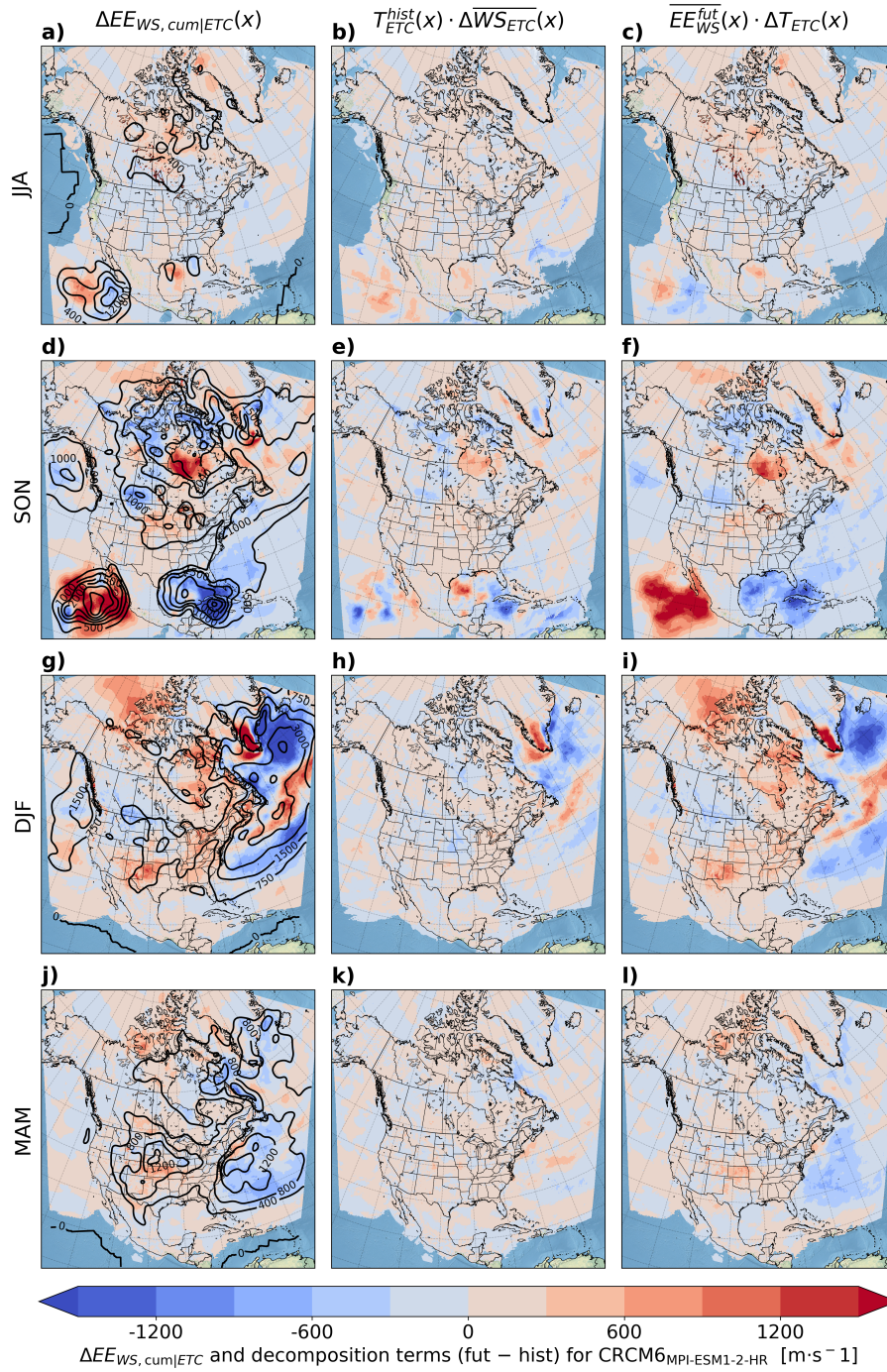


Figure S25. Same as Fig. 8 but for CRCM6_{MPI-ESM1-2-HR} only, with each row representing a different season. Historical values are indicated by black contours.

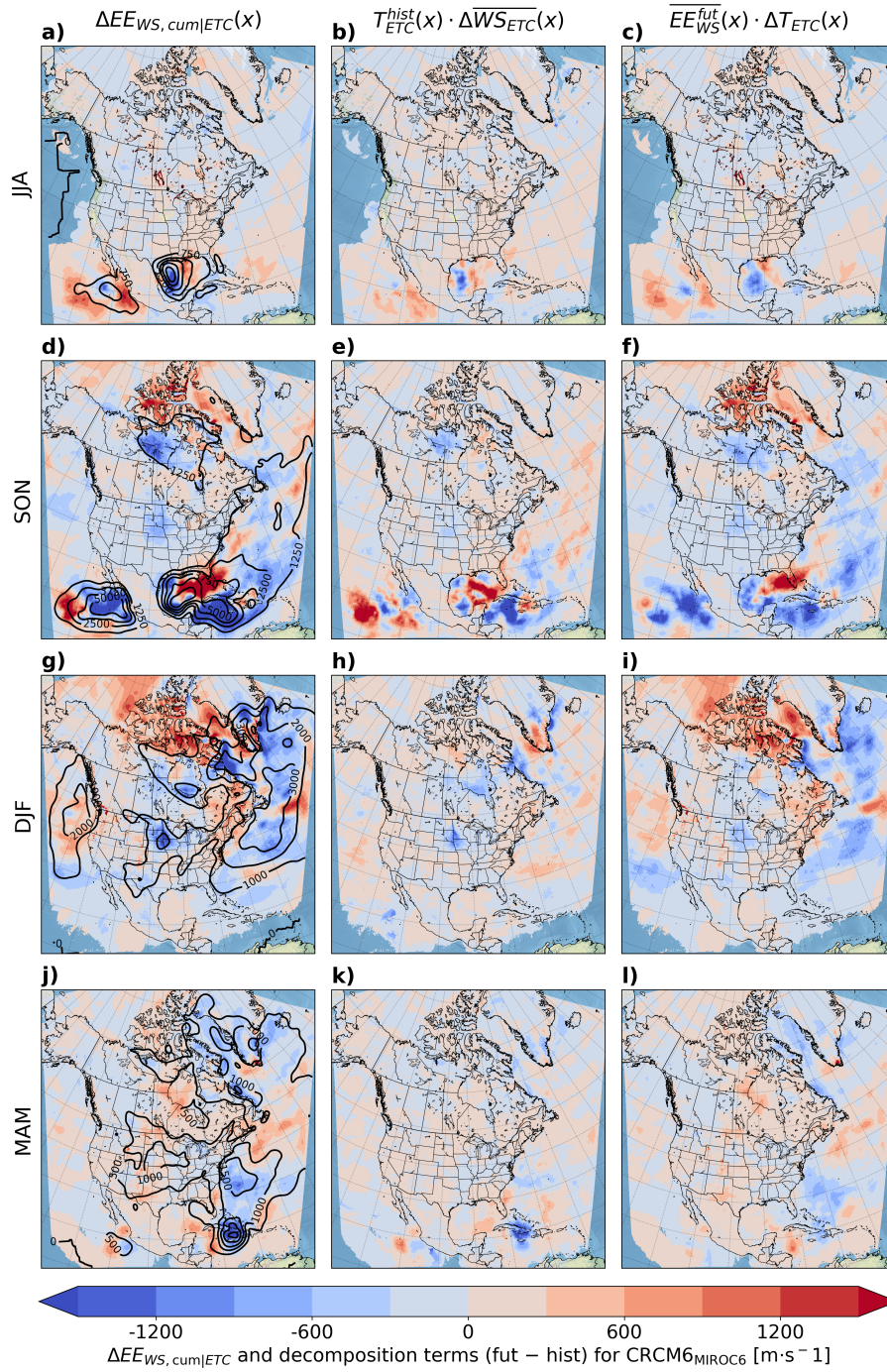


Figure S26. Same as Fig. 8 but for CRCM6_MIROC6 only, with each row representing a different season. Historical values are indicated by black contours.

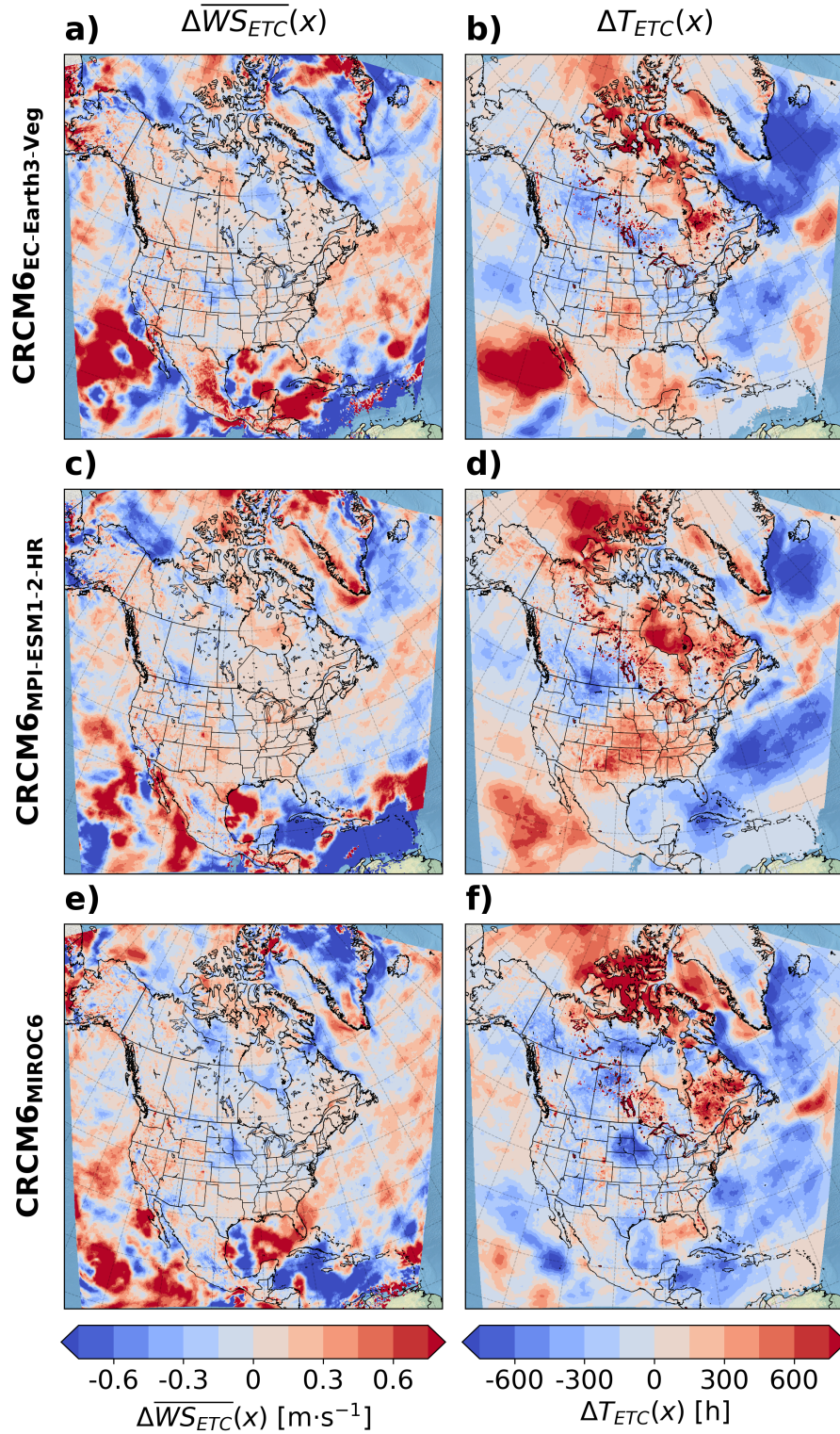


Figure S27. Intrinsic differences in (a, d, g, j) mean ETC-related extreme intensity ($\Delta \overline{WS}_{ETC}(x)$), (b, e, h, k) extreme threshold ($-\Delta WS_{th}$), and (c, f, i, l) number of extreme time steps (ΔT_{ETC}) for surface wind speed between each historical regional simulation and its future counterpart, prior to scaling by the exposure factors of Eq. 7.

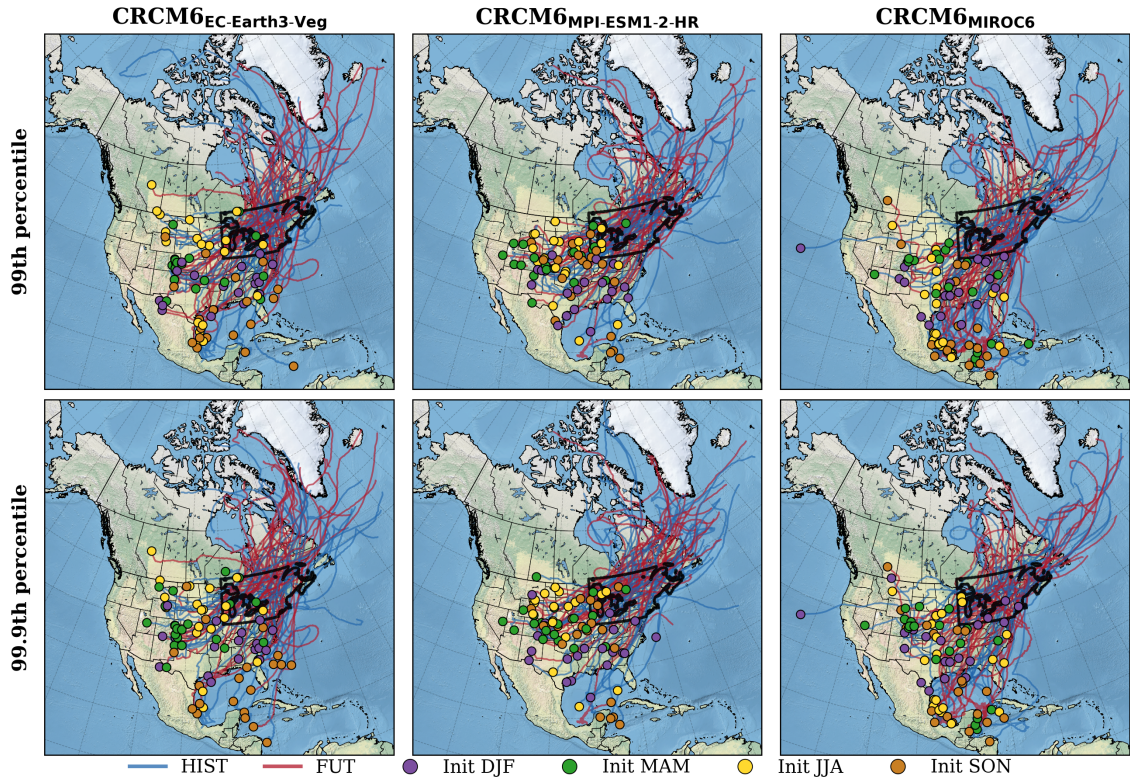


Figure S28. Trajectories of the 10 ETCs with the largest accumulated extreme exceedance $EE_{PR,cum|ETC}$ of each season over the NNA region (black contour), for historical (1980–2014, blue) and future (2063–2097, red) periods. Columns correspond to the three GCM-driven simulations (**CRCM6_{EC-Earth3-Veg}**, **CRCM6_{MPI-ESM1-2-HR}**, **CRCM6_{MIROC6}**); the top row uses the historical 99th percentile as the extreme threshold, the bottom row the historical 99.9th percentile. Marker shape and color indicate the season of ETC initiation (see legend).

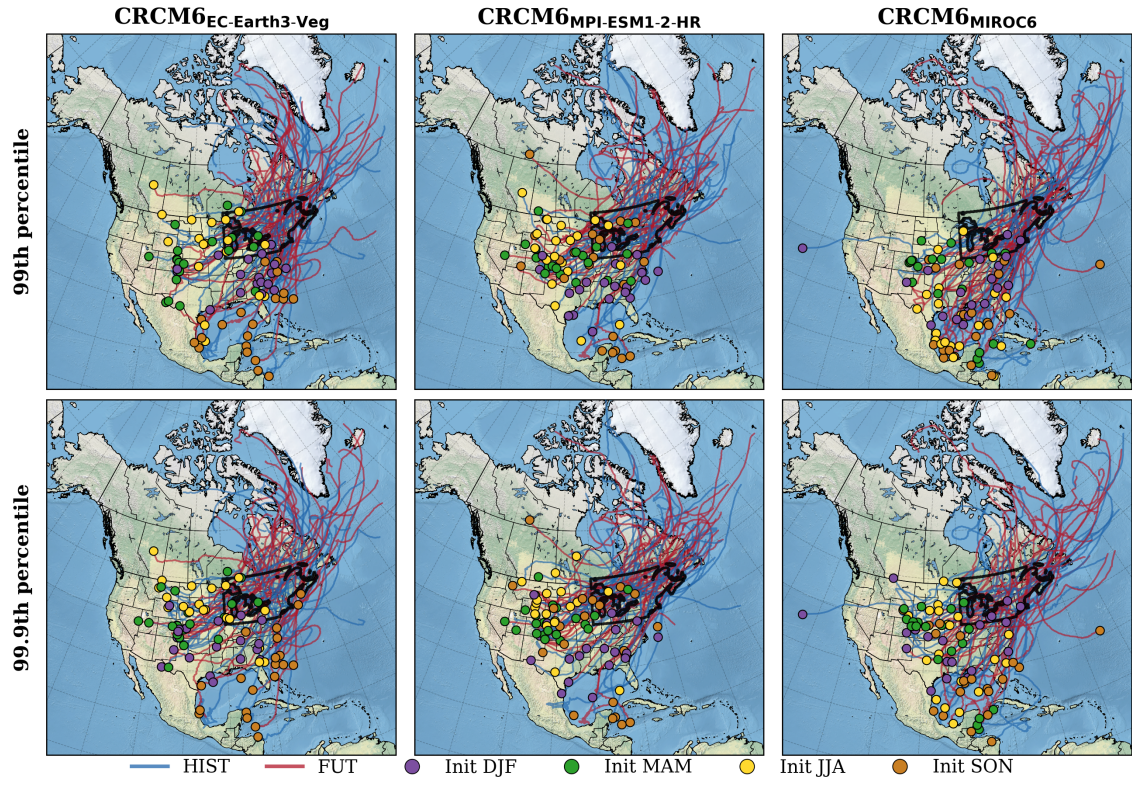


Figure S29. As in Fig. S28, but for the 10 most intense ETCs of each season over the NNA region (black contour) selected on the basis of the regularized intensity $\overline{EE_{PR|ETC}} \cdot T_{ETC} / (T_{ETC} + \lambda)$, with $\lambda = 1000$ for the 99th percentile and $\lambda = 2500$ for the 99.9th percentile.

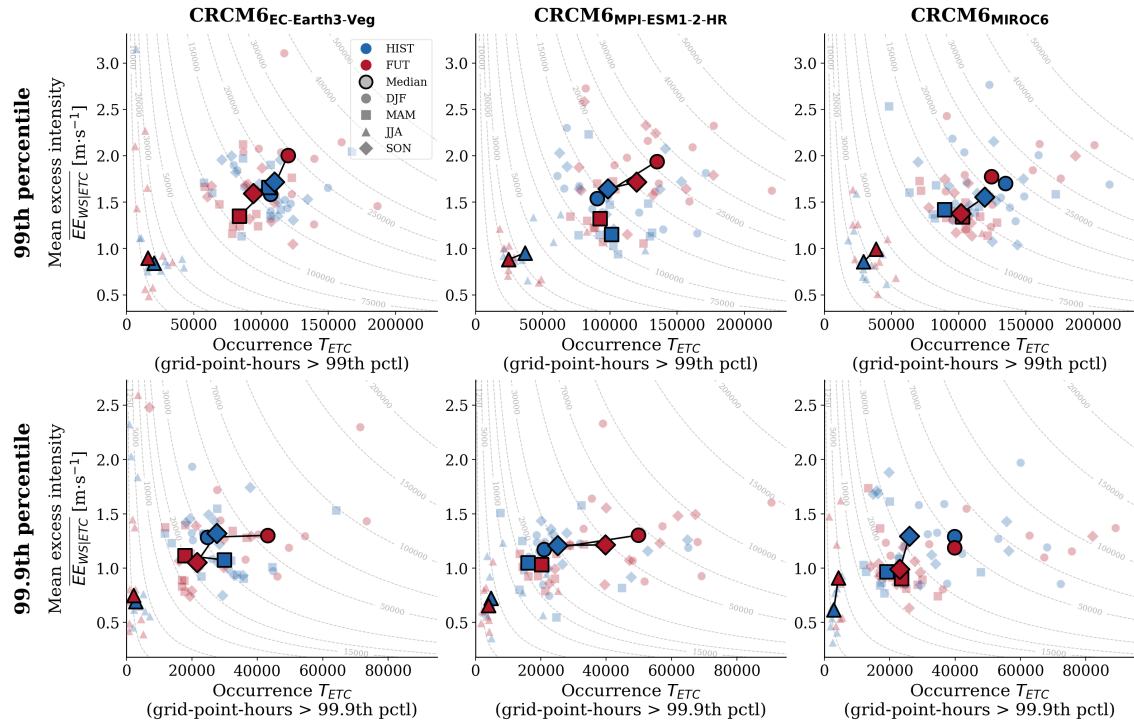


Figure S30. As in Fig. 9, but for surface wind speed.

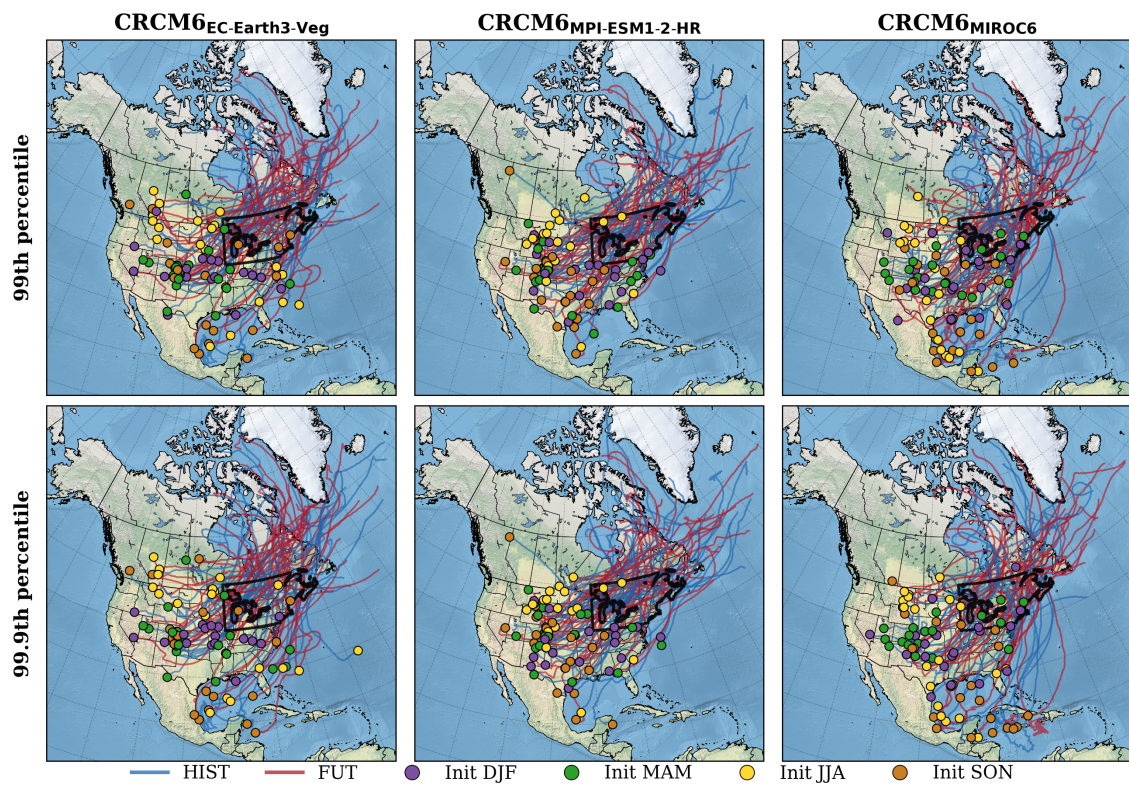


Figure S31. As in Fig. S28, but for surface wind speed.

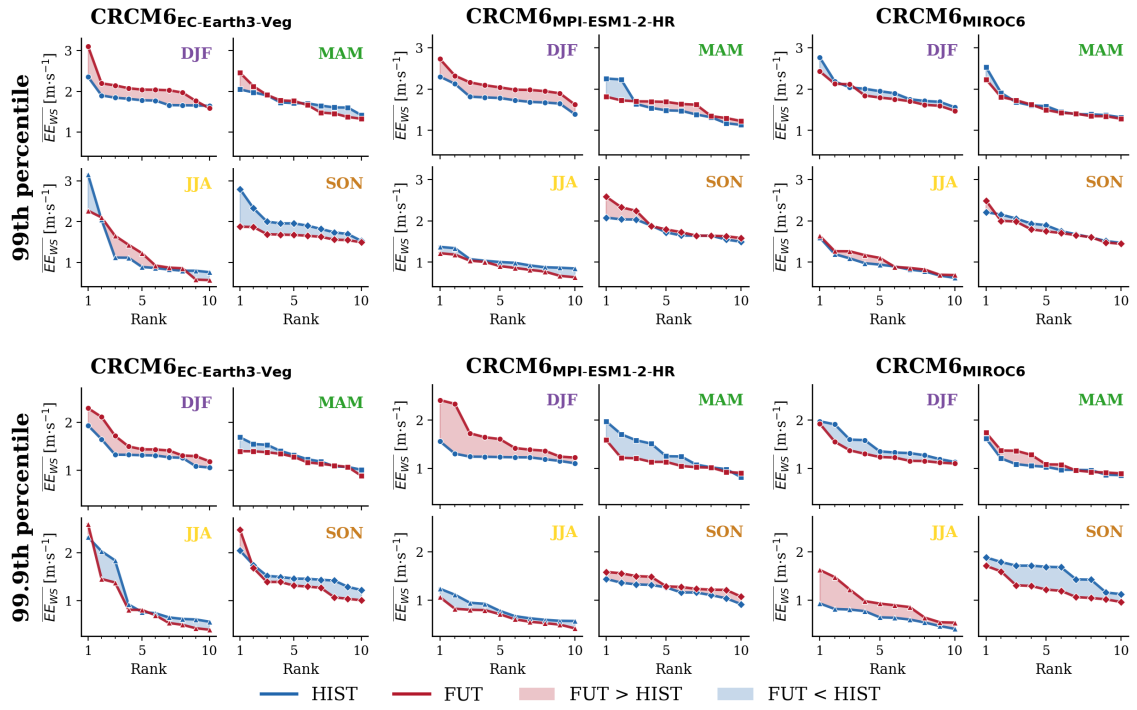


Figure S32. As in Fig. 10, but for surface wind speed and $\lambda = 20000$ for the 99th percentile and $\lambda = 5000$ for the 99.9th percentile.

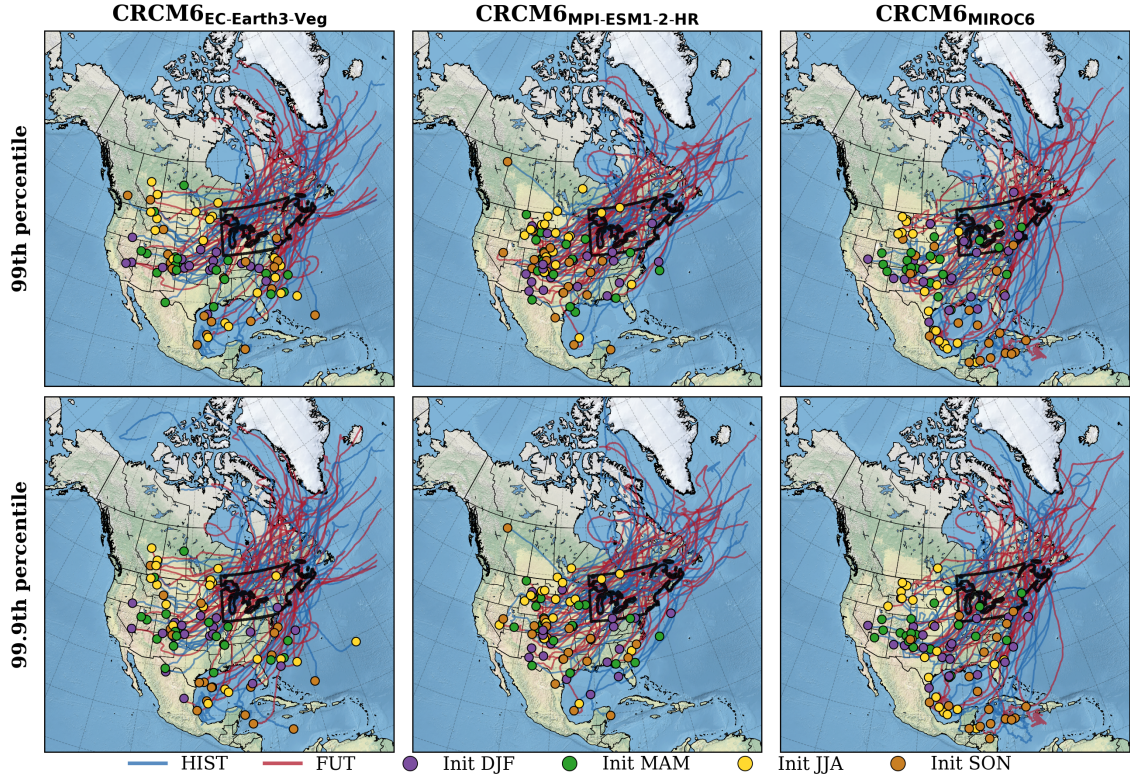


Figure S33. As in Fig. S29, but for surface wind speed and $\lambda = 20000$ for the 99th percentile and $\lambda = 5000$ for the 99.9th percentile.

1 GHS-SMOD urban mask

To identify urban grid cells over North America, we use the Global Human Settlement Layer Settlement Model (GHS-SMOD), produced by the European Commission Joint Research Centre (Schiavina et al., 2023). GHS-SMOD applies the Degree of Urbanisation framework to a global 1 km grid, classifying each cell into seven settlement typologies on the basis of population density, built-up surface, and spatial contiguity criteria, ranging from Urban Centres to Very Low Density Rural cells. The product is derived from satellite-based estimates of built-up surface combined with gridded population estimates obtained by disaggregating national census data. The dataset spans 1975 to 2030 in 5 yr intervals, with epochs after 2018 obtained by spatial-temporal interpolation and projection of built-up surface dynamics. Although end-of-century projections are available in other GHS products such as the GHS-WUP, we prefer to use the GHS-SMOD epoch 2025 to remain closer to the present-day urban extent (note that a 41.3% increase is found between epochs 1995 and 2085 across the NA-CORDEX domain using GHS-WUP). We regrid the native 1 km product onto the CRCM6-GEM5 rotated-pole grid, yielding at each CRCM6-GEM5 grid cell the fraction of its area covered by each class. Grid cells with a non-zero combined urban fraction—summing the Urban Centre, Dense Urban Cluster, Semi-dense Urban Cluster, and Suburban or peri-urban classes—are flagged as urban.

References

- 15 Schiavina, M., Melchiorri, M., and Pesaresi, M.: GHS-SMOD R2023A - GHS settlement layers, application of the Degree of Urbanisation methodology (stage I) to GHS-POP R2023A and GHS-BUILT-S R2023A, multitemporal (1975-2030), <https://doi.org/10.2905/A0DF7A6F-49DE-46EA-9BDE-563437A6E2BA>, [Dataset], 2023.