Investigating Changes in Historical and Future Rainfall Patterns Using Climate Model Simulations

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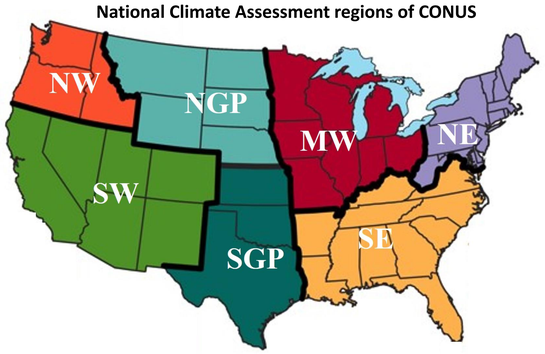
Introduction

- Precipitation changes evident over mid-latitudinal regions, including CONUS, as anthropogenic climate signals intensify
- Evaluation of individual climate models and their ensemble members builds confidence in future climate model projections
- Prediction of changes in future climate with respect to historical patterns using climate model scenarios with large ensemble members

Datasets & Methods

- National Oceanic and Atmospheric Administration Climate Prediction Center Unified CONUS dataset (CPC, 28km/daily)
- Community Earth System Model Version 2 (CESM2, 100km/daily), Large ensemble, 70 members, medium-to-high emission scenario (SSP3-7.0)
- **Period:** 1948-2022 (Historical) & 2023-2100 (Future)

National Climate Assessment regions of CONUS

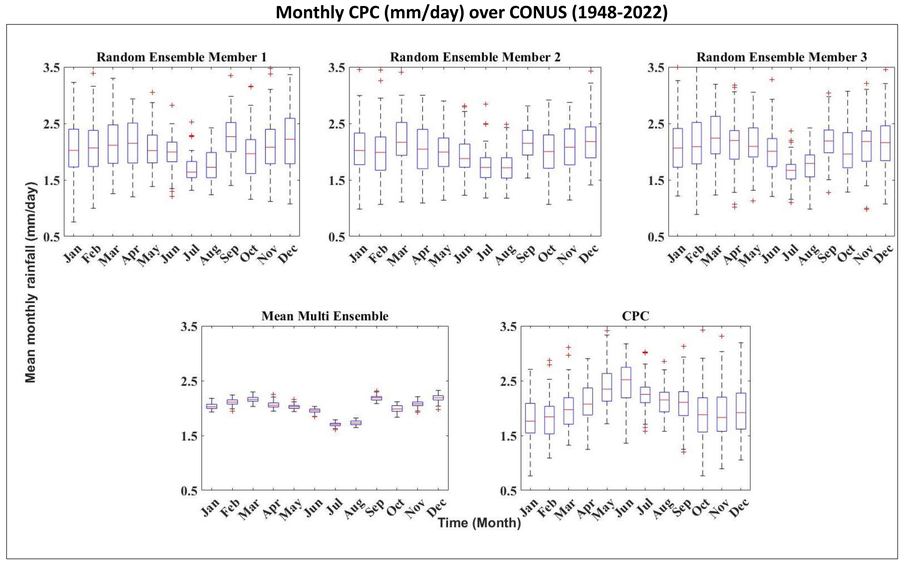


(Source: https://www.c2es.org/content/national-climate-assessment/)

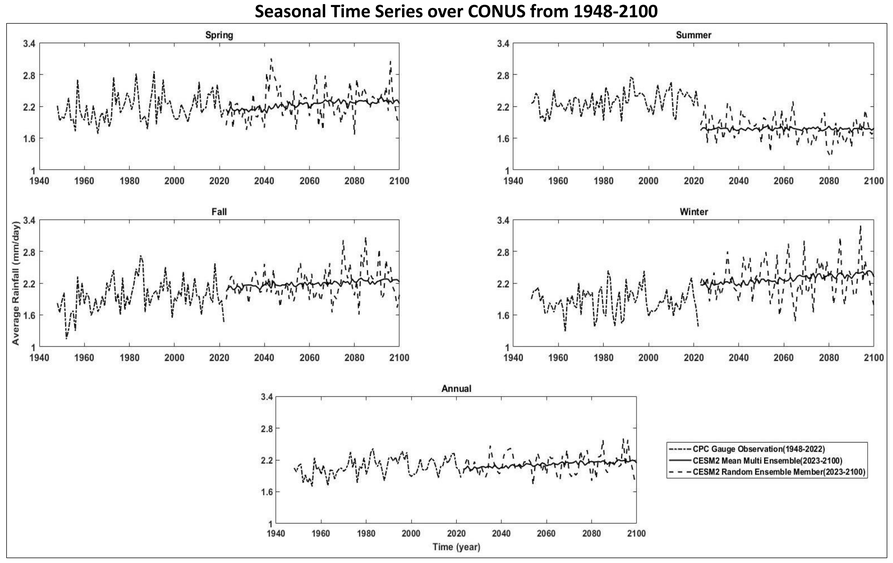
- 70 members of CESM2
- Evaluation of different random ensemble members and mean of the 70 CESM2 ensemble members against CPC observations
- Spatio-temporal analysis of annual and seasonal rainfall for both historical time series and future projections over CONUS

Results

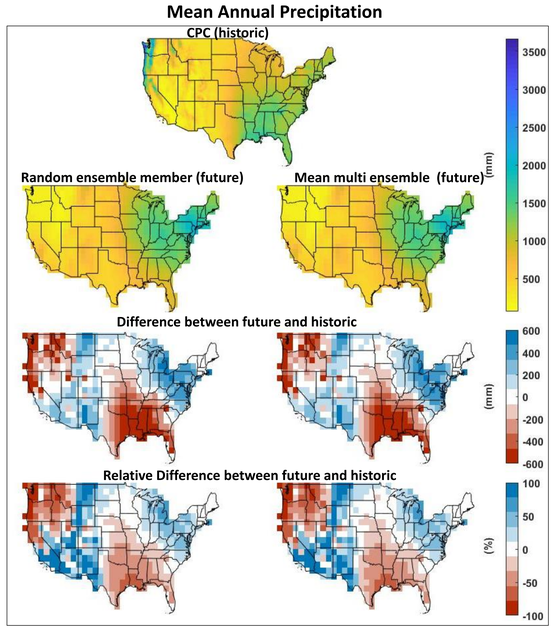
Monthly CPC (mm/day) over CONUS (1948-2022)



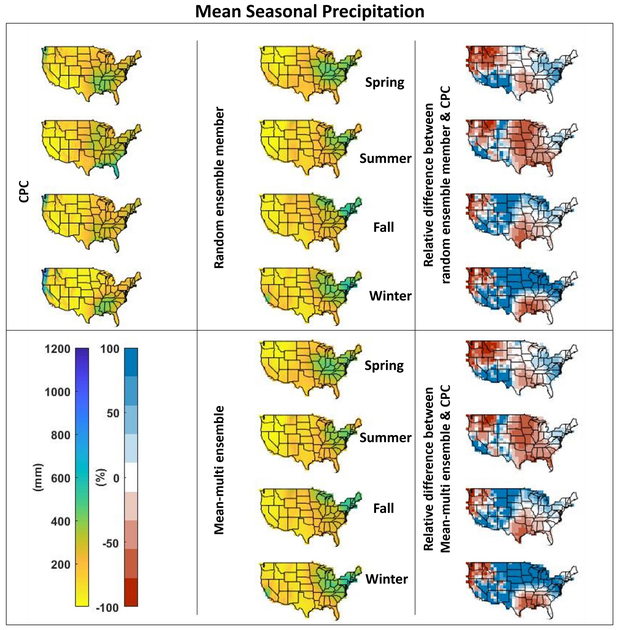
Seasonal Time Series over CONUS from 1948-2100



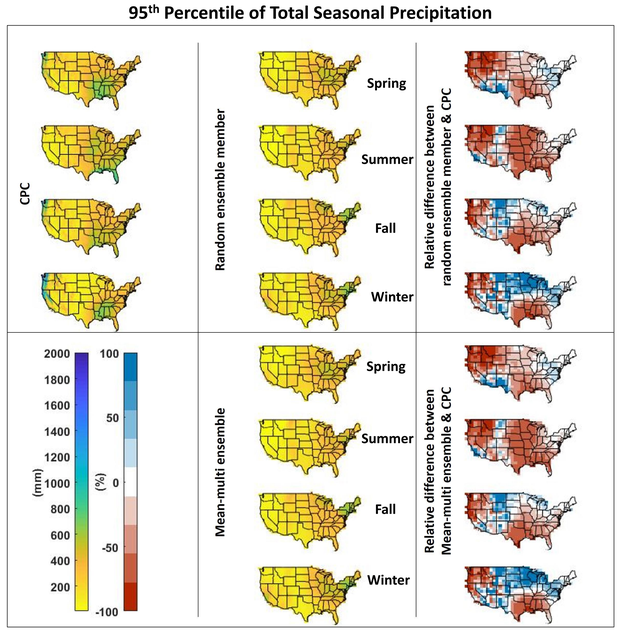
Mean Annual Precipitation



Mean Seasonal Precipitation



95th Percentile of Total Seasonal Precipitation



Discussion of Results

- Rainfall variability/uncertainty is reduced in mean-multi ensemble members.
- Considering CPC as reference, CESM2 underestimates summer precipitation and overestimates winter precipitation
- Historical observations show slightly upward trends in annual, spring, fall, and winter averages, which will continue in the future.
- Climate model simulations do not capture the high magnitude rainfall in the western NW, indicated by historical observations.
- Future annual rainfall will increase in Eastern CONUS (~56%), certain regions of NGP, and SW (~100%), while decreasing in the Western (~100%) and Mid-south regions (~78%).
- NW and Northern California will become drier in the future, particularly in the Spring. MW and SE are expected to become drier over the summer. The NGP and some areas of the SW will see more rain in the Fall. Winter brings more rain to NGP, MW, and some areas of NE and SW.
- The 95th percentiles of the climatological distributions will decrease in summers and springs in NW and NGP (~100%), as well as SGP and SE (~78%). Such extreme percentiles will decrease in the Fall in NW and mid-south US, and increase in NGP and MW in winters.

Conclusions

- Spatial rainfall patterns of a single random ensemble member and average of 70 ensemble members are similar.
- However, averaging all ensemble members together drastically decreases precipitation variability.
- Overall results indicate drier summers and wetter winters in the next century with respect to the past.
- The inability to predict rainy characteristics in NW CONUS in the future might be attributed to inaccurate simulations due to problematic convective parameterizations in models (Srivastava et al., 2020)

References:

Srivastava, Abhishekh, Richard Grotjahn, and Paul A Ullrich. 2020. "Evaluation of Historical CMIP6 Model Simulations of Extreme Precipitation over Contiguous US Regions." Weather and Climate Extremes 29 (December 2019): 100268. https://doi.org/10.1016/j.wace.2020.100268.