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Abstract

Estimation of extreme climate trends is a crucial, influential, and also controversial step in long-term water resources planning studies. One of the main approaches to capturing the variability of climate trends is to use a diverse set of General Circulation Models (GCMs). As climate change models refine following deepening climate knowledge, utilizing updated models is unavoidable. The California Central Valley (CCV), a key agricultural zone in the western U.S., derives the bulk of its surface water from the Sacramento and San Joaquin rivers. Moreover, this area serves as a water source for several megacities, including Los Angeles, San Francisco, San Diego, and Sacramento. On average, over 80% of the total Sacramento-San Joaquin Delta outflow comes from the north and eastern upgradient regions (called rim watersheds) surrounding the valley. In this study, the effect of climate change on extreme trends in precipitation and temperature is evaluated for 12 CCV rim watersheds using downscaled CMIP6 data. Downscaled data are derived from NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6), which were downscaled using the Bias-Correction Spatial Disaggregation (BCSD) statistical method. Based on the availability of precipitation and temperature data from historical and future time spans, 21 models were selected out of 35 available models. For comparison and consistency with previous studies, 1980–2010 is selected to represent the base period, and 2040–2070 is selected to represent the future period. Average daily temperature and precipitation are calculated for each period under historical and SSP126, SSP245, SSP370, and SSP585 scenarios at each grid point lying inside the rim watershed boundaries. Figure 1 shows the average changes in temperature and precipitation for each GCM and SSP scenario during the historical period. As shown in Figure 1, which is an average across all specified rim watersheds, extreme trends show a maximum of 10.75% decrease to a maximum of 28.25% increase in precipitation and a minimum of 0.7°C increase to a maximum of 5°C increase in temperature. The previous study, conducted using CMIP5 by Schwarz et al. in 2019, revealed that the changes in precipitation and temperature would range approximately from -13% to +25% and +0.6°C to +3.9°C, respectively. These findings show more severe temperature extremes when using CMIP6 compared to CMIP5. On the other hand, extreme precipitation trends were not significantly influenced by changing model generation and scenarios. These findings suggest that using the latest CMIP generation would take a more diverse set of climatological uncertainties into account. Another analysis was conducted by examining each of the 12 rim watersheds separately. The results of this section show that the temperature and precipitation extremes did not change significantly compared to those from the holistic analysis. Thus, it seems that a holistic analysis of all 12 rim watersheds could properly represent precipitation and temperature extreme trends for each of the rim watersheds.

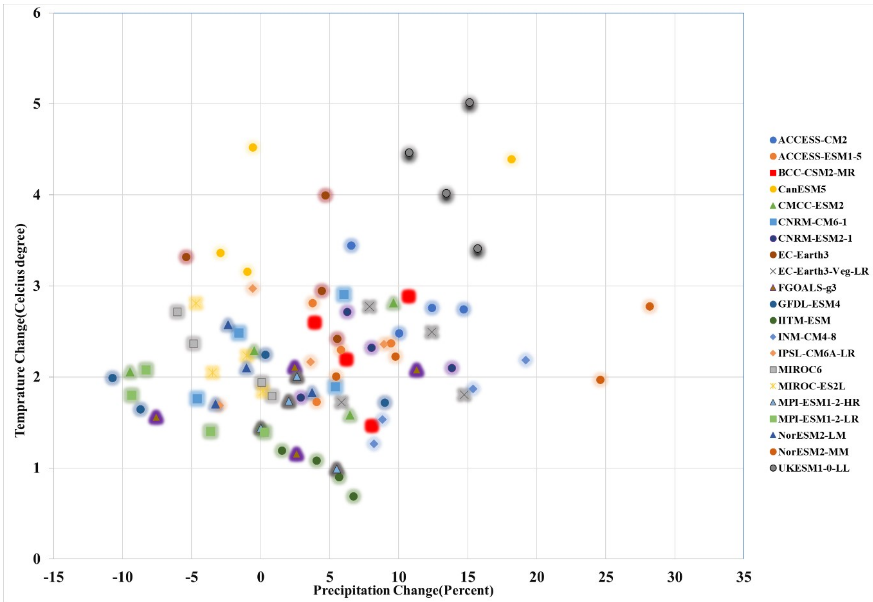

Figure 1: T

References:

Schwarz, A., Ray, P., & Arnold, W. (2019). Decision scaling evaluation of climate change driven hydrologic risk to the state water project. Sacramento, CA.

Hausfather, Z., Marvel, K., Schmidt, G. A., Nielsen-Gammon, J. W., & Zelinka, M. (2022). Climate simulations: Recognize the 'hot model' problem. Nature, 605(7908), 26-29.

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Extreme Climate Trends in California Central Valley: Insights from CMIP6

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Introduction:

As the general circulation models are improved to consider more details and move toward more precision, the uncertainty bound of precipitation and temperature should be checked and clarified. 12 rim (abbreviated from perimeter) watersheds located on the north and east sides of California's Central Valley (shown in Figure 1) are selected to analyze the extreme average trends, using the sixth phase of coupled models intercomparison project (CMIP6) data.

These rim watersheds, on average, supplied approximately 85% of the total outflow to the Sacramento- San Joaquin Delta inflow, this indicates the importance of the fluctuations in precipitation and mean air temperature on the supplied water for the main agricultural center of the western region of the United States of America.

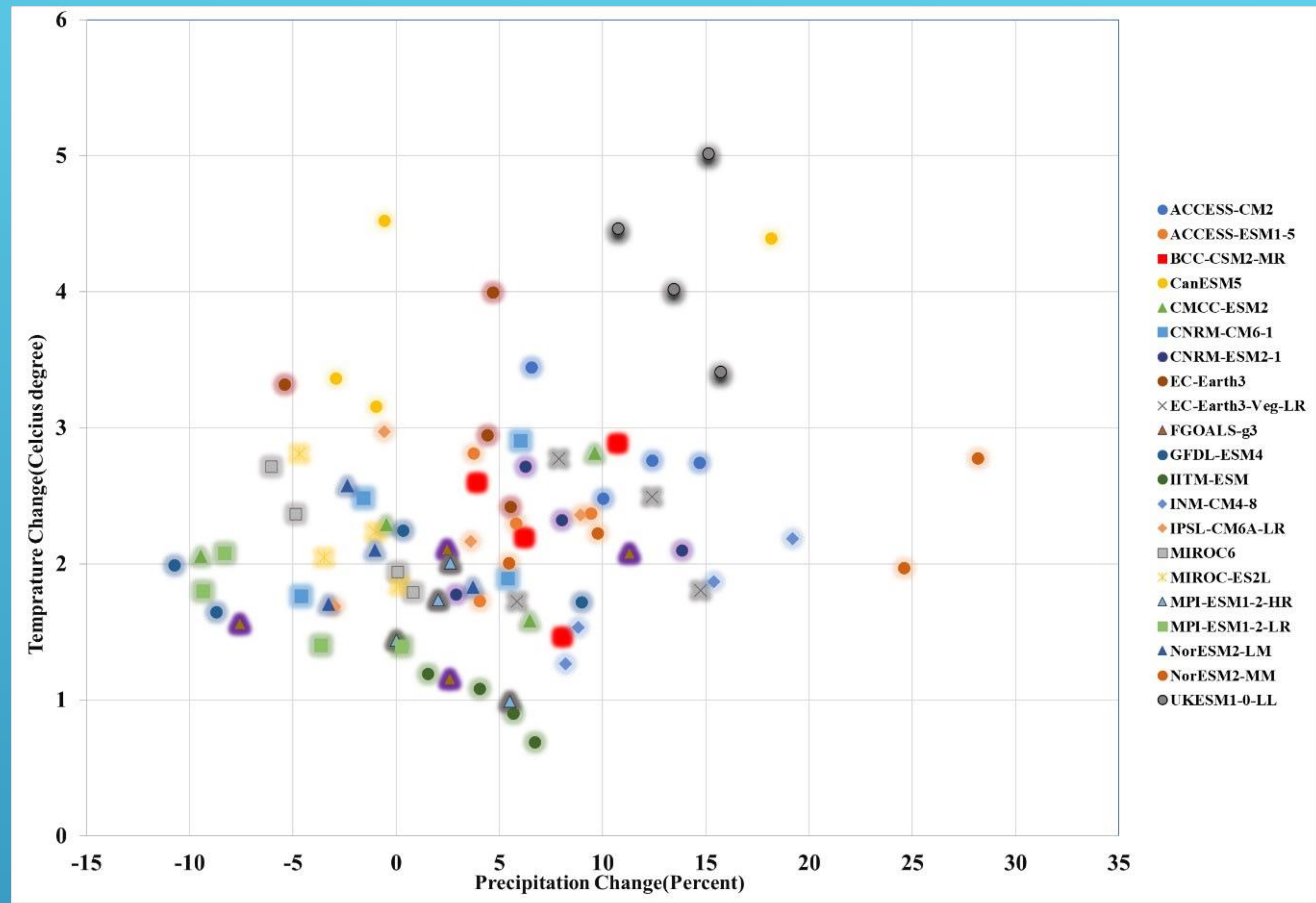

Figure 2- CMIP6 downscaled models average Temperature and Precipitation changes for 2040-2070 relative to 1980-2010

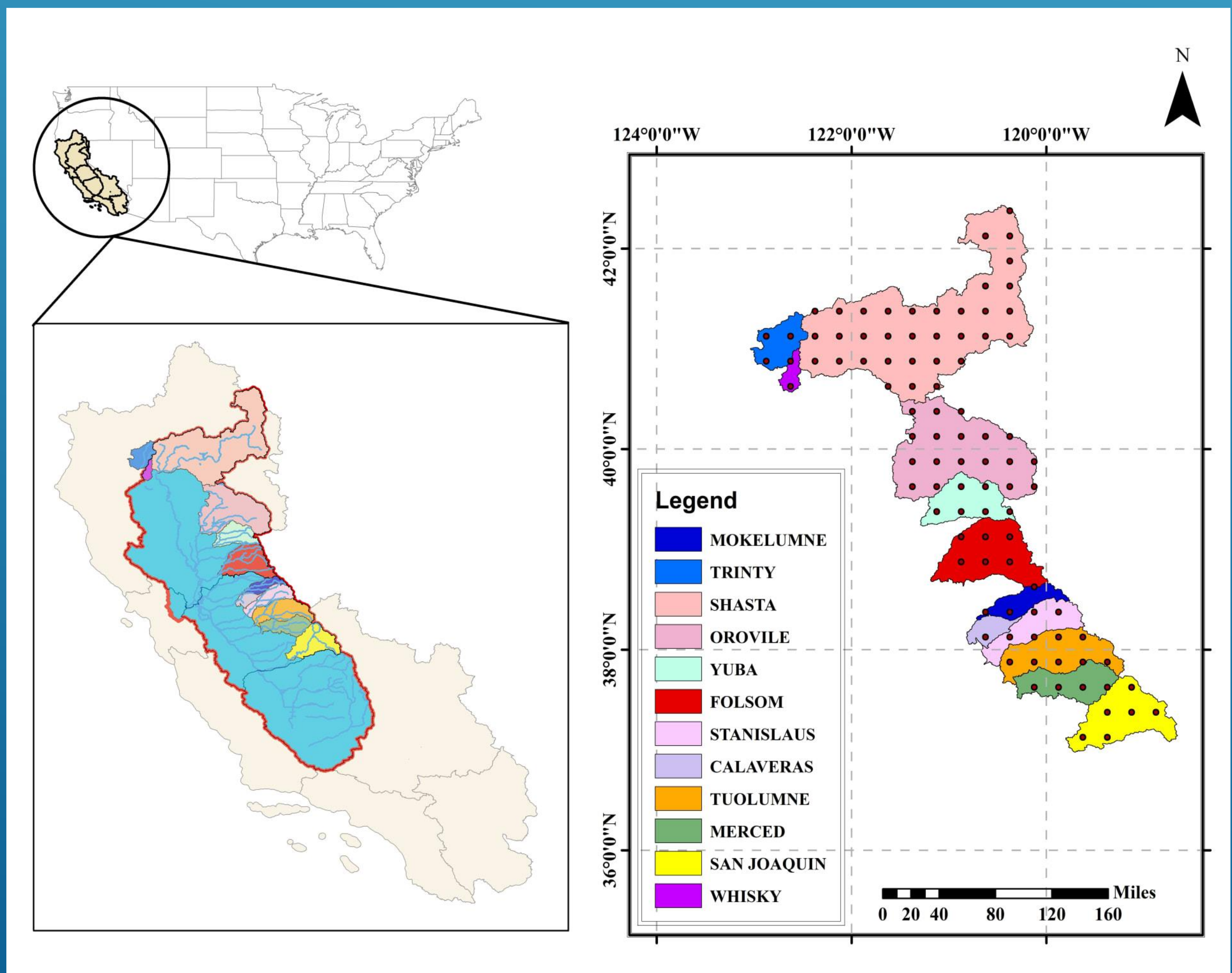

Figure 1 - Rim watersheds of California Central Valley (dots on the right side map, indicate the center of pixels that are extracted to evaluate the mean changes in precipitation and temperature)

Methods: The downscaled data are collected from the NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP-CMIP6) dataset, which underwent downscaling using the Bias-Correction Spatial Disaggregation (BCSD) statistical technique. The downscaled gridded data were presented in 0.25*0.25 degrees resolution. Of the total 35 available models, we select 21 based on the availability of both precipitation and temperature in historical and future periods. The selected models are shown in Figure 2 legend. Average daily temperature and precipitation are calculated for each period under historical and SSP126, SSP245, SSP370, and SSP585 scenarios at each grid point lying inside the 12 rim watersheds boundaries. The changes in temperature and precipitation for each GCM and SSP scenario with respect to to historical period are shown in Figure 2.

Results: As shown in Figure 2 which is averaged through all specified rim watersheds, extreme trends show a maximum of 10.75% decrease to a maximum of 28.25% increase in precipitation and a minimum of 0.7°C increase to a maximum of 5°C increase in temperature. Another analysis was done on the examination of each of the 12 rim watersheds separately. Results of this section show that the temperature and precipitation extremes did not change significantly compared to the holistic analysis. Thus, it seems that a holistic analysis of all 12 rim watersheds could be a proper representation of precipitation and temperature extremes trends for each of the rim watersheds. An earlier study using CMIP5(Schwarz et al. 2019) showed the precipitation and temperature change would be approximately between -13% to +25% and +0.6°C to +3.9°C, respectively. This shows more severe temperature extreme trends and precipitation extreme trends when using CMIP6 compared to CMIP5.

Conclusion: The findings of this research propose that the climate extreme trend uncertainty bound is getting wider in CMIP6 datasets in comparison with CMIP5 datasets. It is worth noting that the findings of this research should be treated with caution. Concerning the methodology and the aim of the study, the outcomes are only preliminary results of the possible extreme trends. The 'hot model' problem should also be considered when interpreting such results (Hausfather et al. 2022).

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Schwarz, A., Ray, P., & Arnold, W. (2019). Decision scaling evaluation of climate change driven hydrologic risk to the state water project. Sacramento, CA.
Hausfather, Z., Marvel, K., Schmidt, G. A., Nielsen-Gammon, J. W., & Zelinka, M. (2022). Climate simulations: Recognize the 'hot model' problem. Nature, 605(7908), 26-29.
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