Partitioning How Natural Variability and Climate Change Influence Hydroclimate Response in Five Major Central Valley Watersheds

AUTHORS

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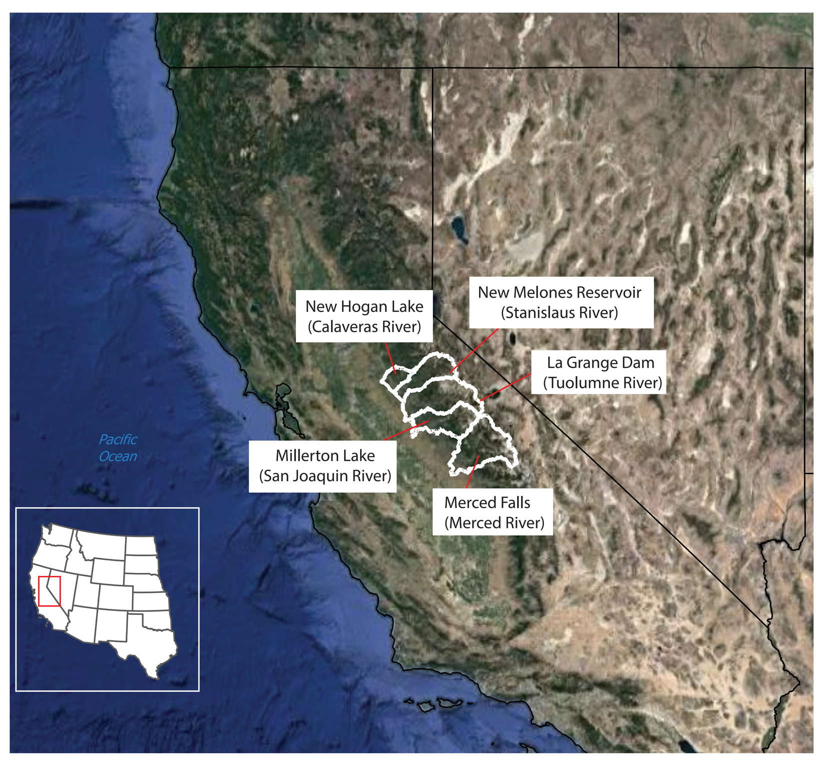
1 Hydroclimate changes in Central California have major implications for water availability in the region.



The current drought enveloping California has led to unprecedented low snowpack and persistent water shortages. This drought is occurring within the context of two decades of extreme climate variability. A better understanding of the region's vulnerabilities requires partitioning how both natural variability in the weather system and mechanisms of climate change are shaping the region's hydrologic response regimes. We develop a framework to characterize the relative importance of these drivers and demonstrate implications for five key basins in the San Joaquin region (**Figure 1**).

2 Weather-regime based stochastic weather generation conditioned on climate changes is used to develop regional weather and streamflow ensembles.

Figure 2. We simulate sequences of weather regimes (WR, patterns of large-scale atmospheric flow) and local precipitation and temperature using a stochastic weather generator. We develop scenarios of thermodynamic climate change (i.e., warming and Clausius-Clapeyron (CC) scaling of precipitation) and dynamic climate variability using 600 years of tree-ring reconstructed WR dynamics.

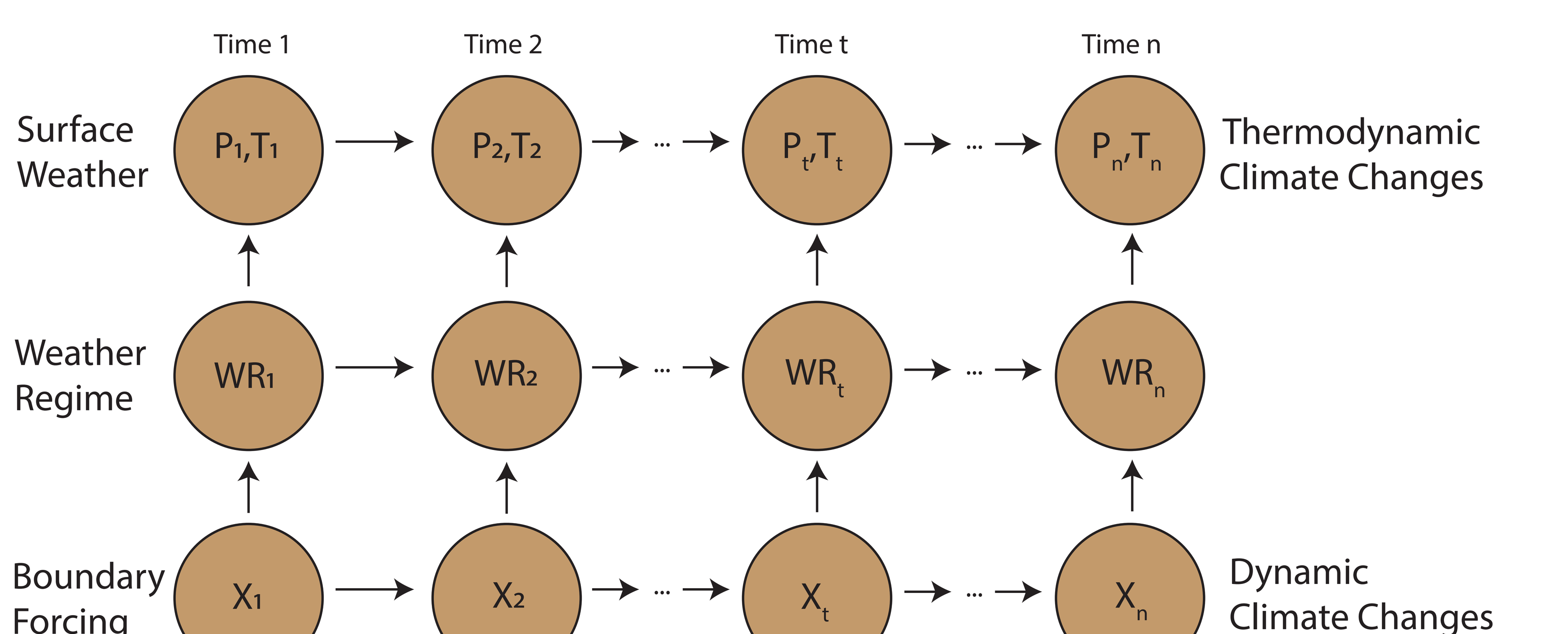
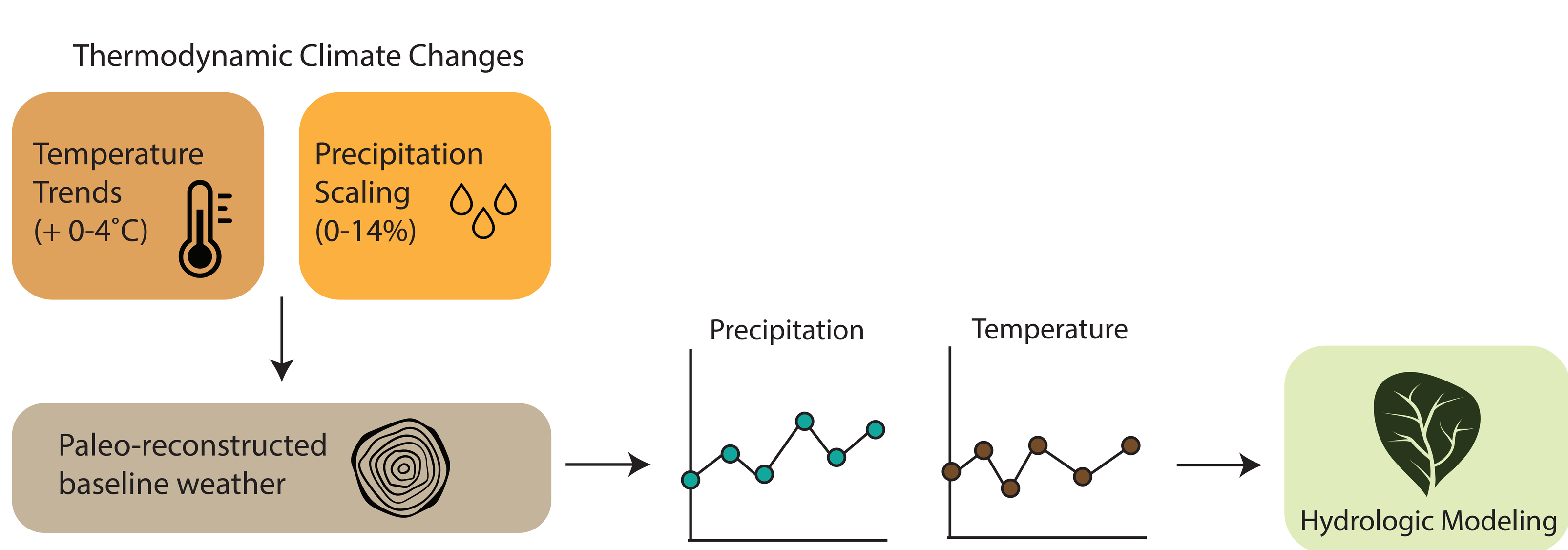
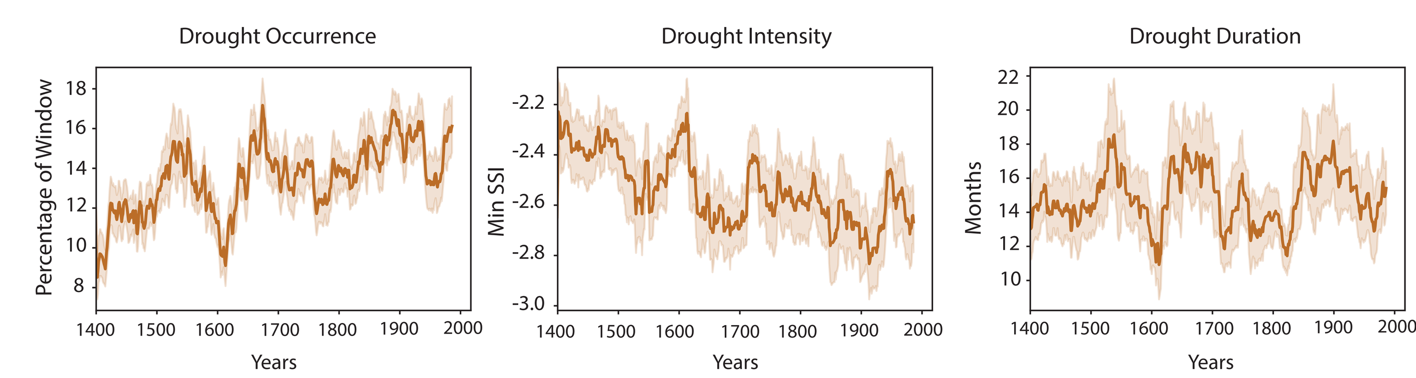


Figure 3. Climate change-informed weather ensembles are generated by layering different combinations of thermodynamic climate changes on baseline paleo-reconstructed temperature and precipitation scenarios for each basin. Each scenario is fed through a hydrologic model, SAC-SMA, to create traces of streamflow for each basin.



3 The most recent 30-year record is characterized by more frequent droughts that are longer and more intense.

Figure 4. SSI-based drought metrics (occurrence, intensity, and duration) are calculated across 50-member ensembles for the baseline and CC scenarios using a 30-year moving window. The metrics align with well-defined consequential paleo-periods, particularly the late 1500s megadrought and the early 1600s wet period. The most recent 30-year window is characterized by high drought occurrence and severity, though the drought duration is not as long as other parts of the paleo-period. The increasing trend in drought occurrence and intensity can be, in part, due to key persistent drought periods that have occurred in the mid to late 1800s, 1900s, and the most recent 20-year period.



4 Natural variability is a strong driver of drought metrics, but climate change effects are significant over longer windows.

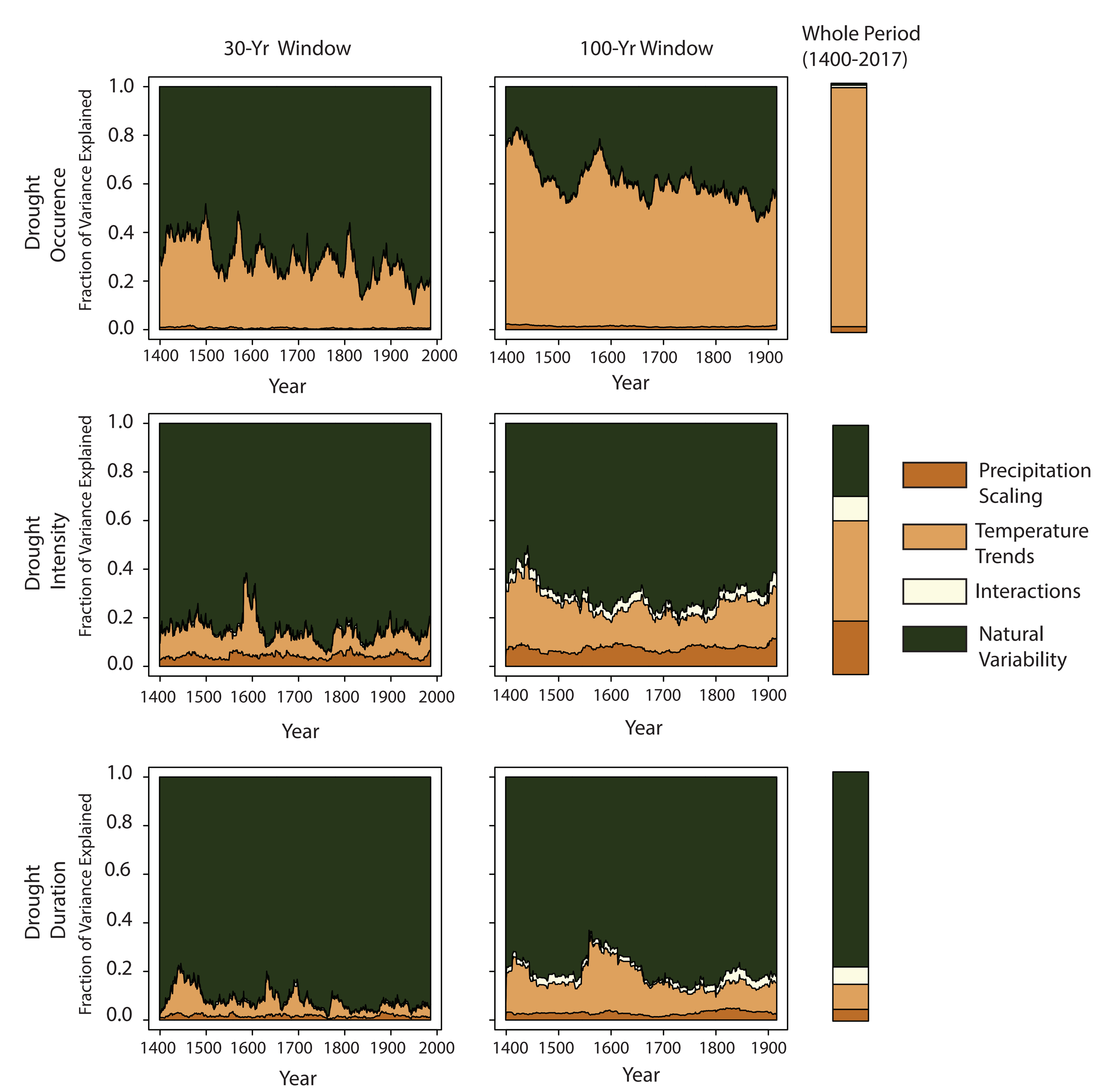


Figure 5. An analysis of variance (ANOVA) was performed to determine main drivers of the variability in drought metrics for the Tuolumne. Natural variability is the strongest driver of all three metrics when the metrics are derived over smaller 30-year windows. Climate change has a much larger presence when metrics are derived across longer windows. Of the thermodynamic changes, temperature trends are the strongest driver of the drought metrics, though precipitation scaling becomes more relevant to determining drought intensity.

5 Extreme flooding events are strongly driven by thermodynamic changes.

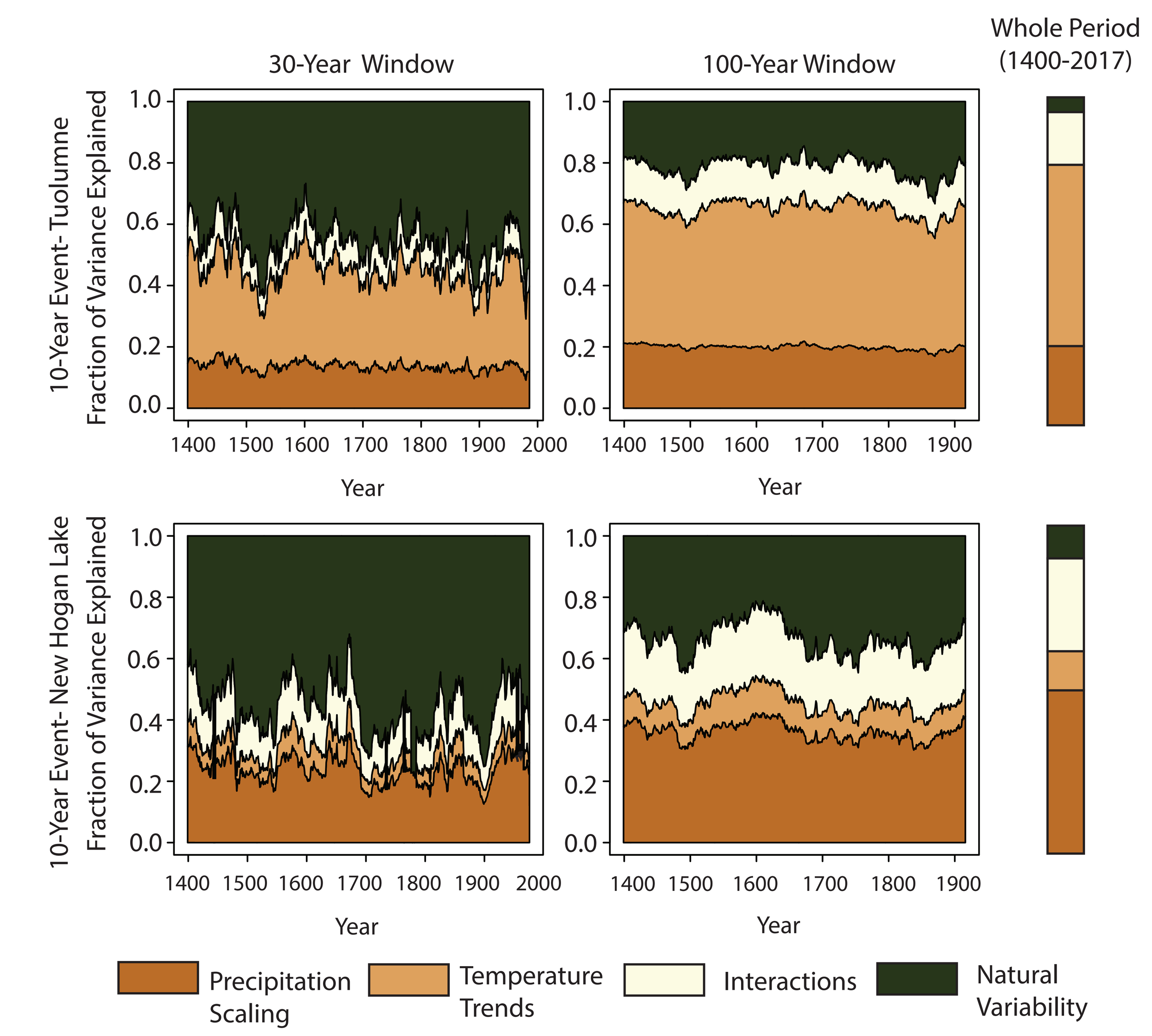


Figure 6. Drivers of variability in flows associated with 10-yr return period events. Natural variability is a more prominent driver when the metric is derived over a smaller window. Climate changes become a more prominent driver over longer windows. Flooding within snow-dominated basins are primarily driven by changes in temperature, while lower-elevation basins (i.e. New Hogan Lake) see a greater influence from precipitation scaling.

6 Joint flooding across basins is highly driven by natural variability.

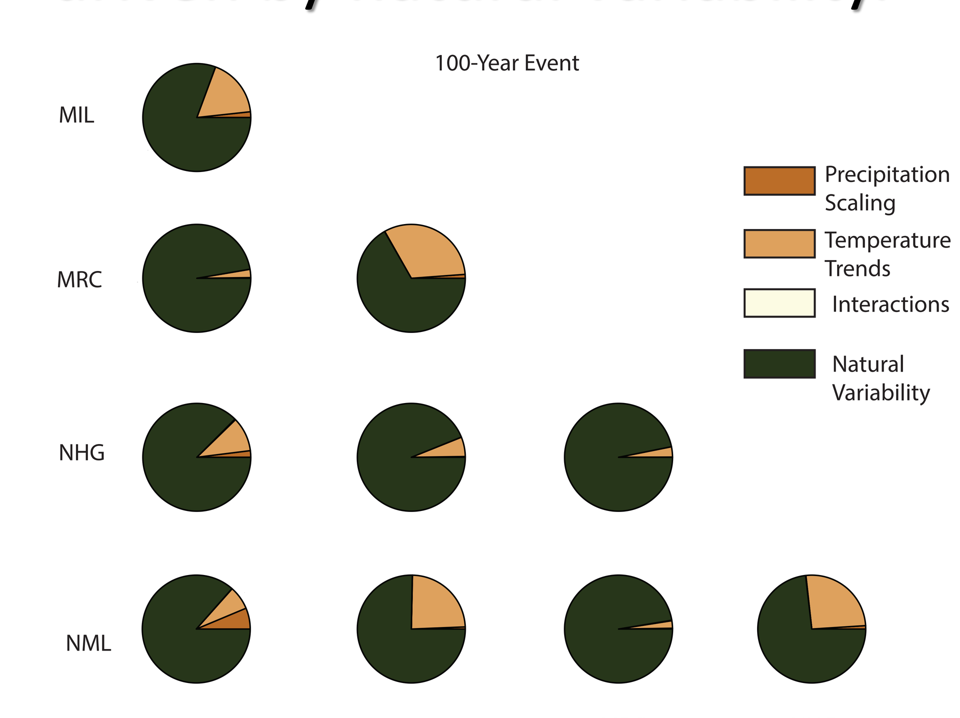


Figure 7. Drivers of variability in a copula-based metric that captures the likelihood of exceeding a 100-yr return period event across multiple basins. Natural variability (i.e. randomness in storm tracks) is a strong driver of joint flooding. Joint flooding that exhibits a larger influence from climate change (which would influence snowmelt or scale up storms) tends to occur across basins that are in close proximity.

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