Bias correction of SMILEs: A bulk approach to preserve internal variability

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Introduction

- Single Model Initial-Condition Large Ensembles (SMILE) contain multiple realizations of dynamical climate simulations.
- They offer a robust estimation of internal climate variability.
- Climate model outputs exhibit biases that need correcting before assessing climate impacts.
- Can we correct the biases, yet preserve internal climate variability?

Tools and datasets

- Bias correction (BC) algorithm: ISIMIP3basd
- SMILE: CESM2-LENS over the CONUS domain (100 members)
- Precipitation reanalysis data: MSWEP (coarsened)

References

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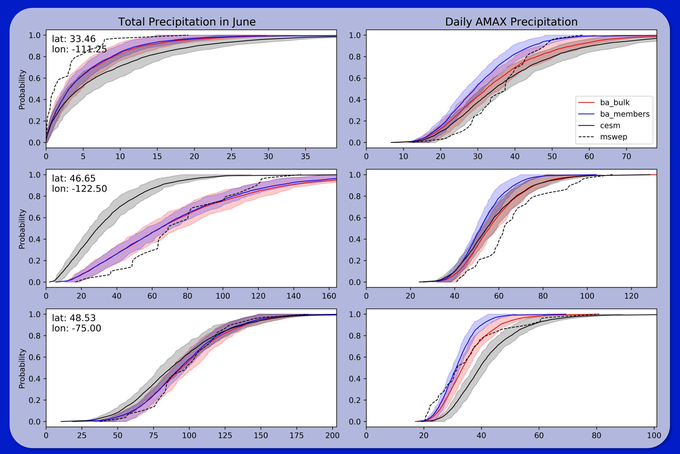
Abstract and full poster

Methods

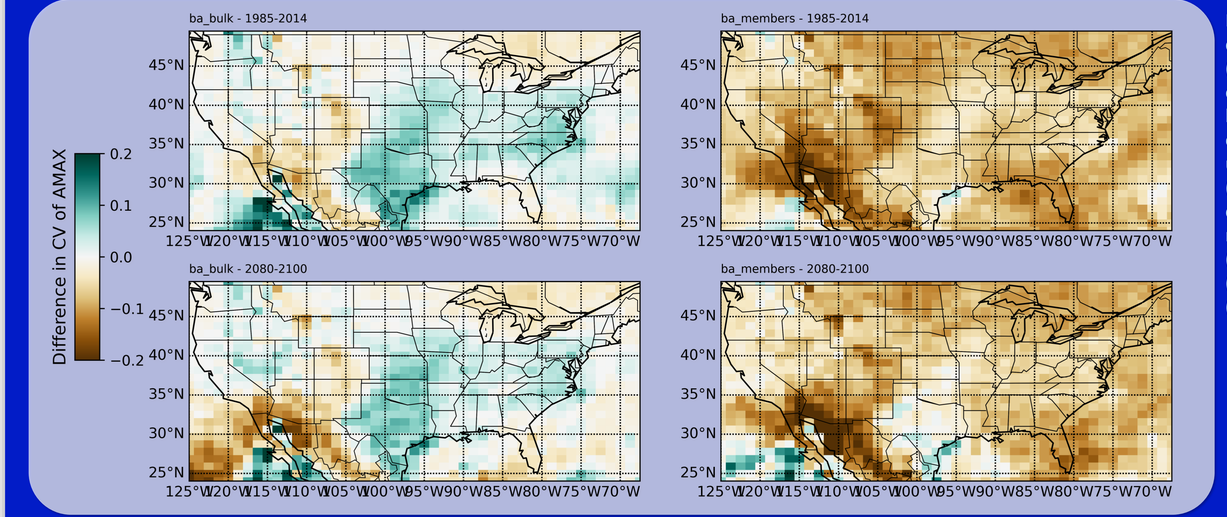
- Two bias correction approaches:
  - Member by member: correct each of the **100 members independently**
  - Bulk: Merge the entire ensemble and correct it **all at once**
- Computed the annual maximum precipitation (AMAX) and dispersion statistics: Coefficient of variation (CV) and variance of the anomalies
- Compared the statistics to those of the original CESM2-LENS

Example of the effect of bias correction on total precipitation in June, and on the extreme daily annual maximum for three selected grid cells.

Both approaches do a good job with average statistics, but **extremes are hard to correct**



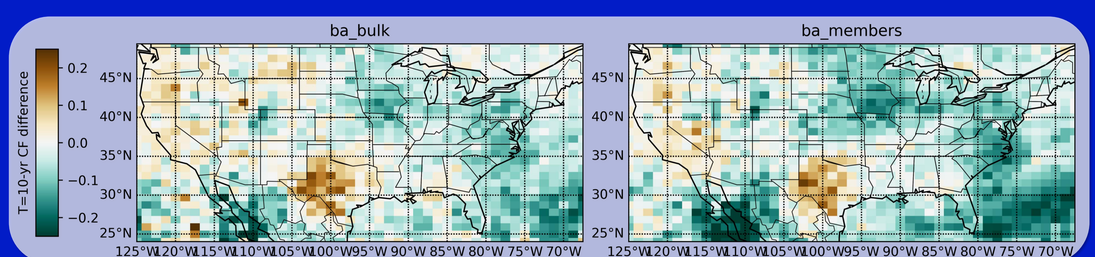
A **bulk bias correction of large ensembles preserves the variability of extremes,** while a member-by-member correction artificially decreases it



Difference in the coefficient of variation (CV) between the original SMILE and the bias-corrected ensembles is smaller using the bulk approach (left column) than correcting each member individually (right), for both present (top row) and future (bottom) climate.

… and both approaches **affect the Change Factors** (CFs) of extreme precipitation

Difference in the 10-year return period change factor (CF) between the 2080—2010 and 1984—2014 periods. The CFs difference was computed from the datasets corrected using the bulk (left) and member-by-member (right) approaches relative to that of the original CESM2 ensemble.



Results

- ISIMIP3basd does a good job with mean statistics, but struggles to correct extremes, regardless of the approach used
- The variability of extreme precipitation statistics, as measured by the CV of AMAX, is affected by the bias correction approach. Analysis of the variance of anomalies lead to the same conclusion
- Estimated **extremes are larger using the bulk approach**: a ~10% difference for T=2yr, up to ~35% for T=200yr
- Change factors are 3.0% and 5.6% lower using the bulk and member-by-member approaches, relative to the original ensemble, but with evident spatial heterogeneity

Discussion

- The BC approach has a large influence on extremes, but we have always used a member-by-member approach (before SMILEs)
- Are these results linked to this specific bias correction algorithm?
- We know climate models have biases—why do we trust their variability?

Outlook

- Behaviour of other variables (e.g., temperature, relative humidity)
- A new ISIMIP3basd code to facilitate bulk correction
- Replicate with a different SMILE and BC algorithm