H41A-1428

# Non-stationary hydropower generation projection over the western United States

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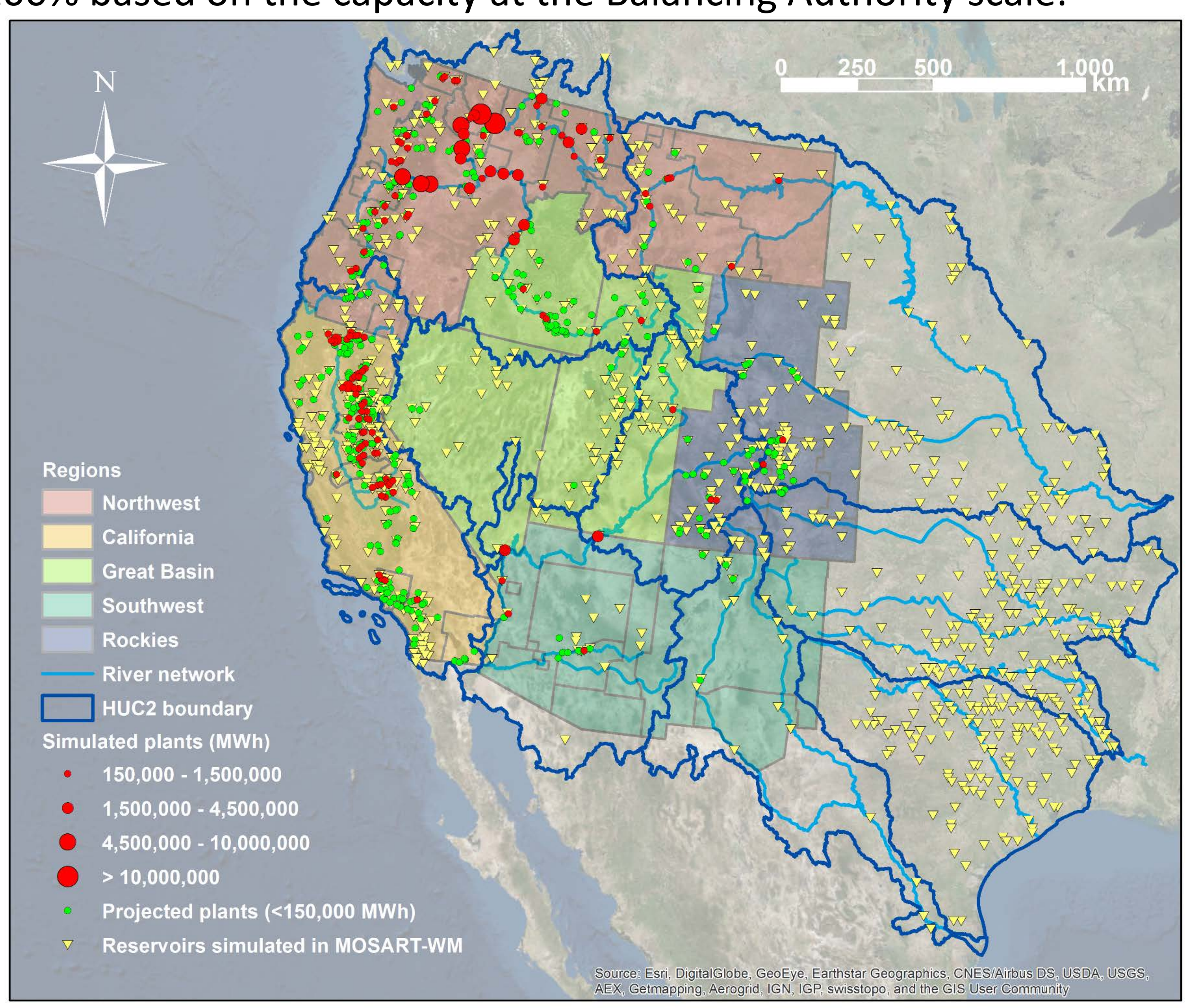
## Introduction

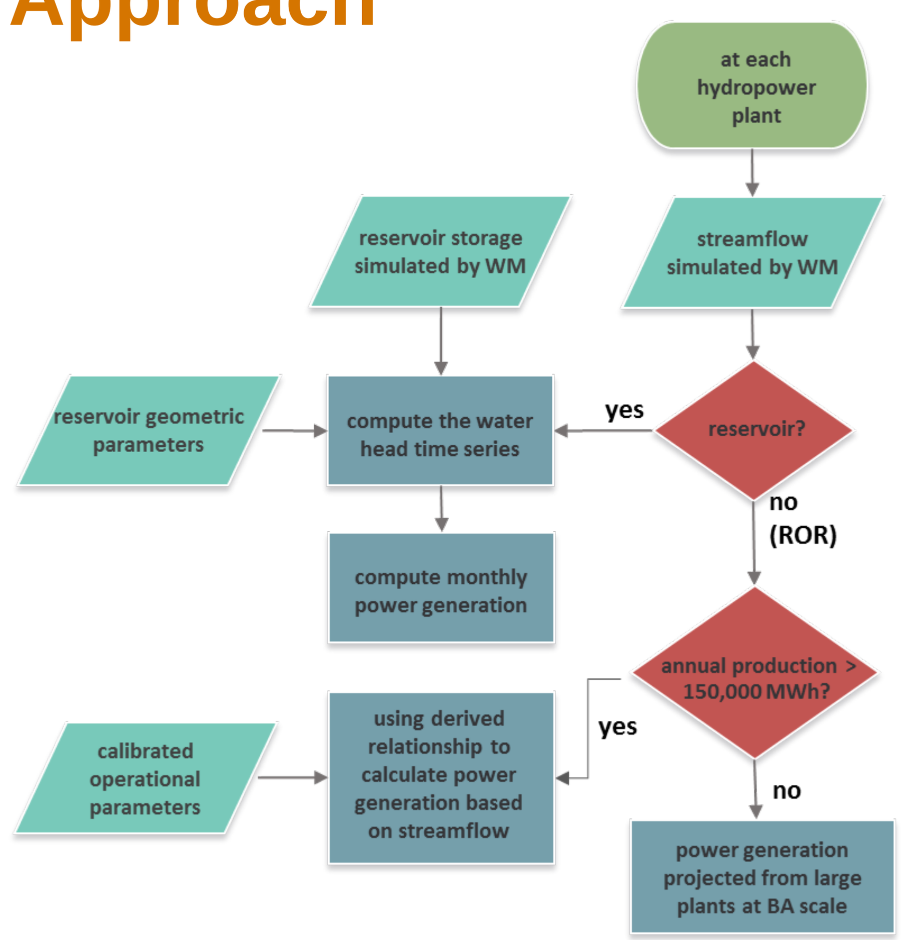
Hydropower fulfills about 27% of the total electricity demands over the western U.S. in an average year. Future projections of hydropower generation which are based on regression relationship between observed streamflow and hydropower generation have the advantage of reflecting the complexity in hydropower operations through simulated flow. However this approach could not represent the shifts in natural flow seasonality and associated changes in reservoir storage which potentially affect the power generation. In this study, we developed and calibrated a process-based hydropower model combining with a river routing – reservoir management model (MOSART-WM) to represent the non-stationarity in future hydropower generations across the Balancing Authorities (BAs) in the Western Electricity Coordinating Council (WECC) region.

## Study domain

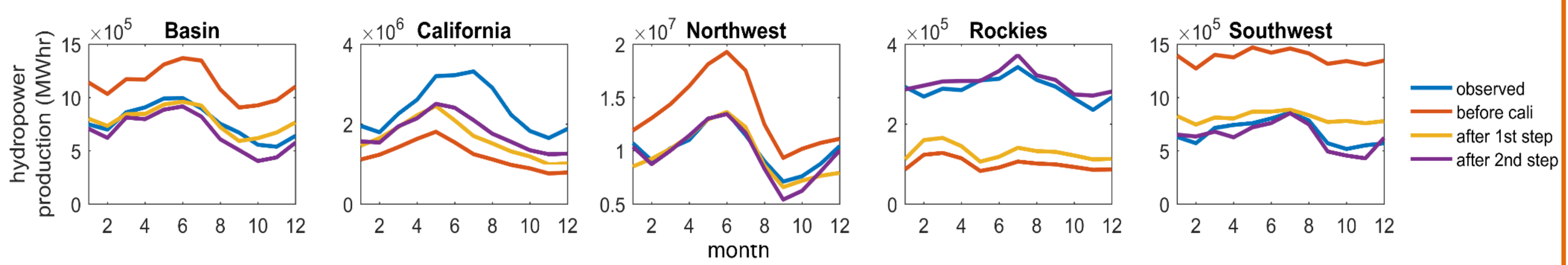
We simulate 149 large hydropower plants, with combined capacity of 50,000 MW or about 92% of the total hydropower capacity over the WECC region. The simulated results were then projected to 100% based on the capacity at the Balancing Authority scale.



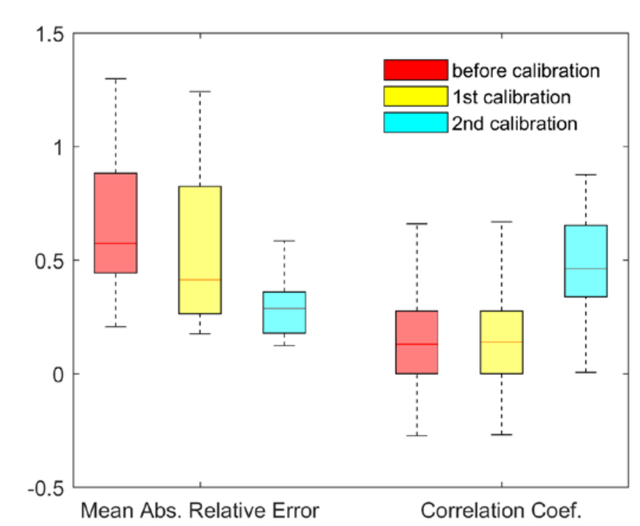

## Approach

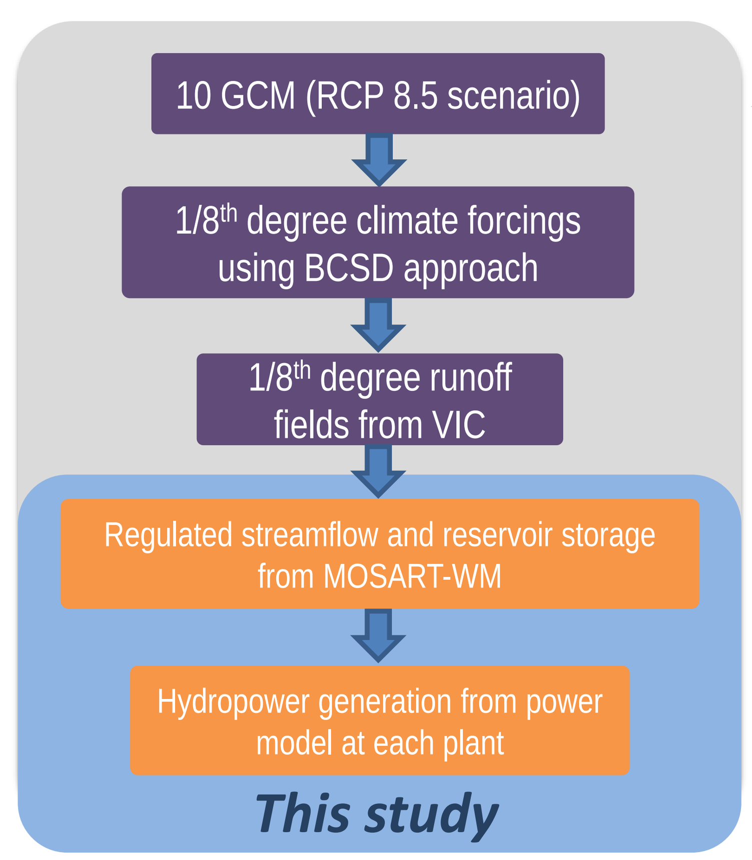


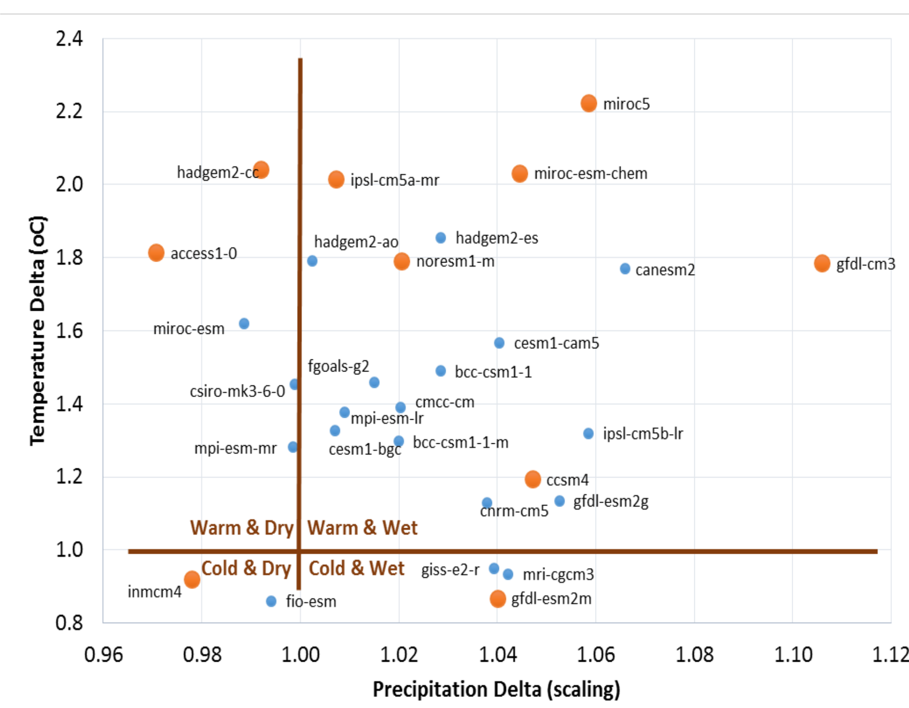

The process-based model represents the hydropower plant operations through a number of parameters, which were calibrated through two steps: 1) generator efficiency and grid reserve for annual power generation at the balancing authority scale; and 2) monthly ecologic and reserve spill factors, and penstock capacity at plant scale. Reservoir geometric parameters were used for dams with significant reservoirs.




By applying Shuffled Complex Evolution (SCE) auto-calibration algorithm, the 1st step calibration reduced the overall bias and the 2nd step calibration improved the seasonal variations in hydropower generation.

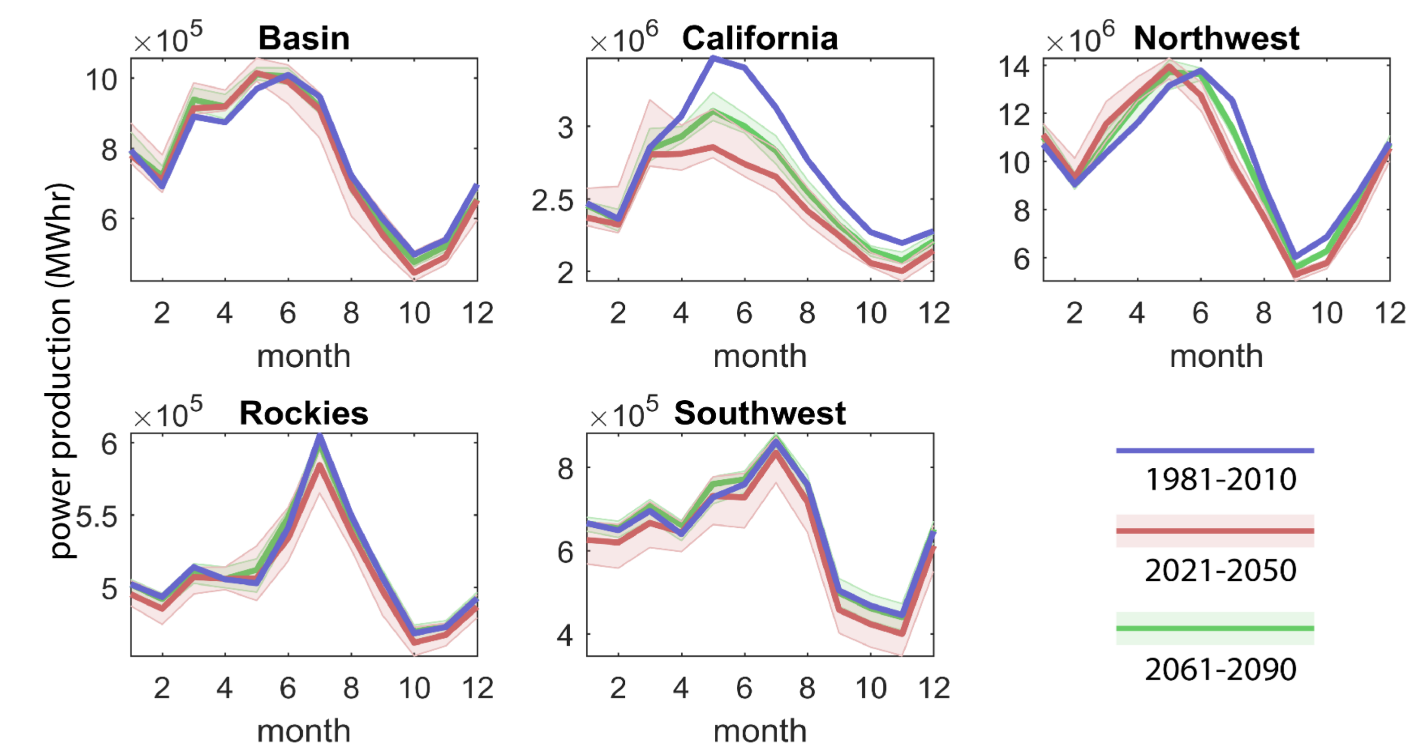


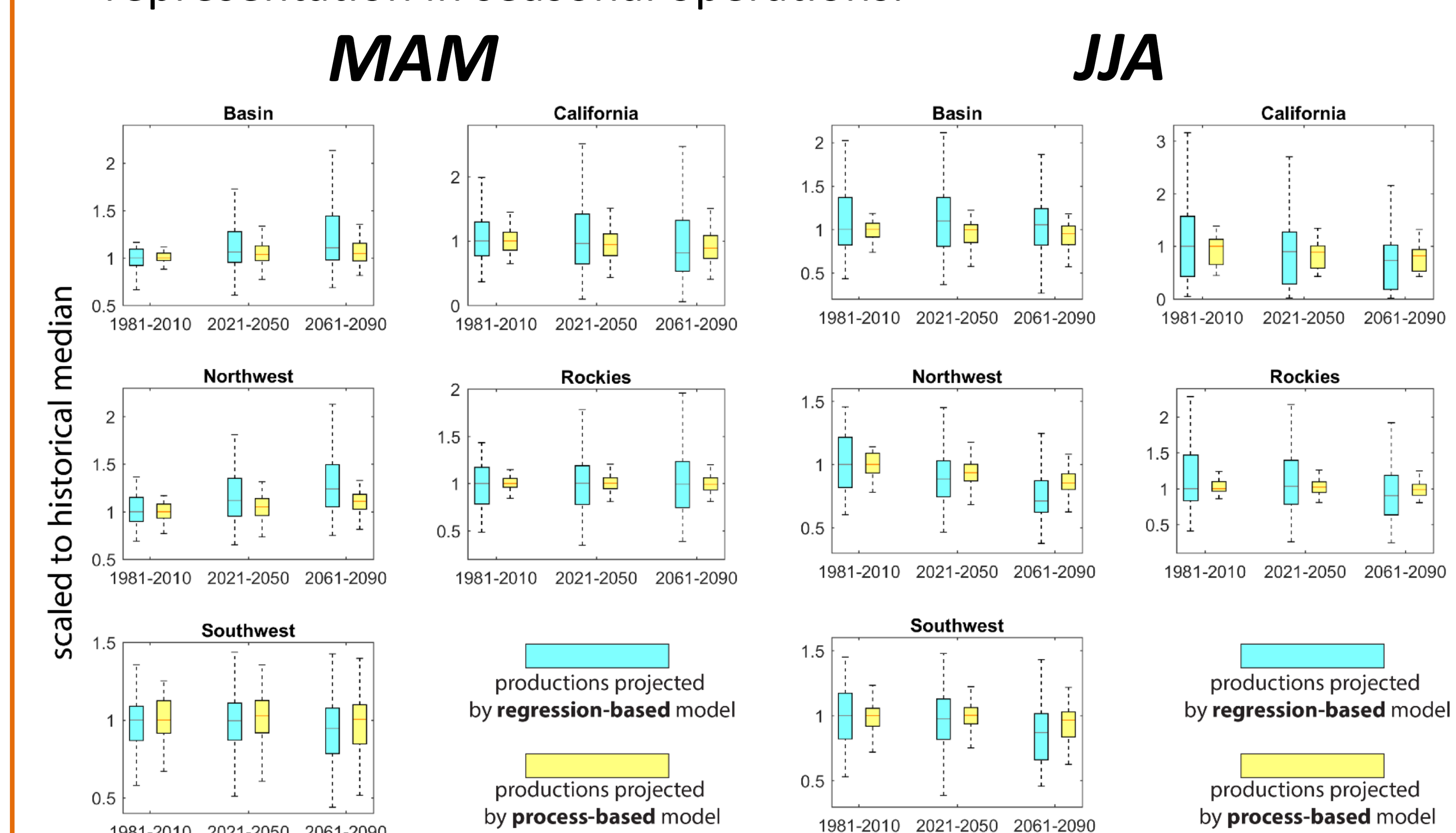




## Findings

- In most of the regions except California, the **annual total production shows little change**.
- Projected **seasonality shifts in snow-dominated regions suggest non-stationarity in potential hydropower generation**.




- Our estimates, which consider ecological spill, electric grid reserve, and penstock capacity suggest **lower opportunities in spring (MAM) hydropower generations** with respect to regression-based estimates .
- Our estimates however suggest **higher opportunities in summer (JJA) hydropower generations** with respect to regression-based estimates due to the non stationarity representation in seasonal operations.

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**Acknowledgements**
This work was supported by the Office of Science of the U.S. Department of Energy, Office of Biological and Environmental Research as part of the Integrated Assessment Research Program

## Conclusions

- Non-stationarity for projecting hydropower opportunities
- Process-based power model projects less (more) hydropower potentials in spring (summer) than regression-based models
- Projections will be used in power system models to assess the impact on grid operations (see H41A-1425 by Voisin et. al.)

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