# Extreme Event Detection and Prediction: Method and Applications

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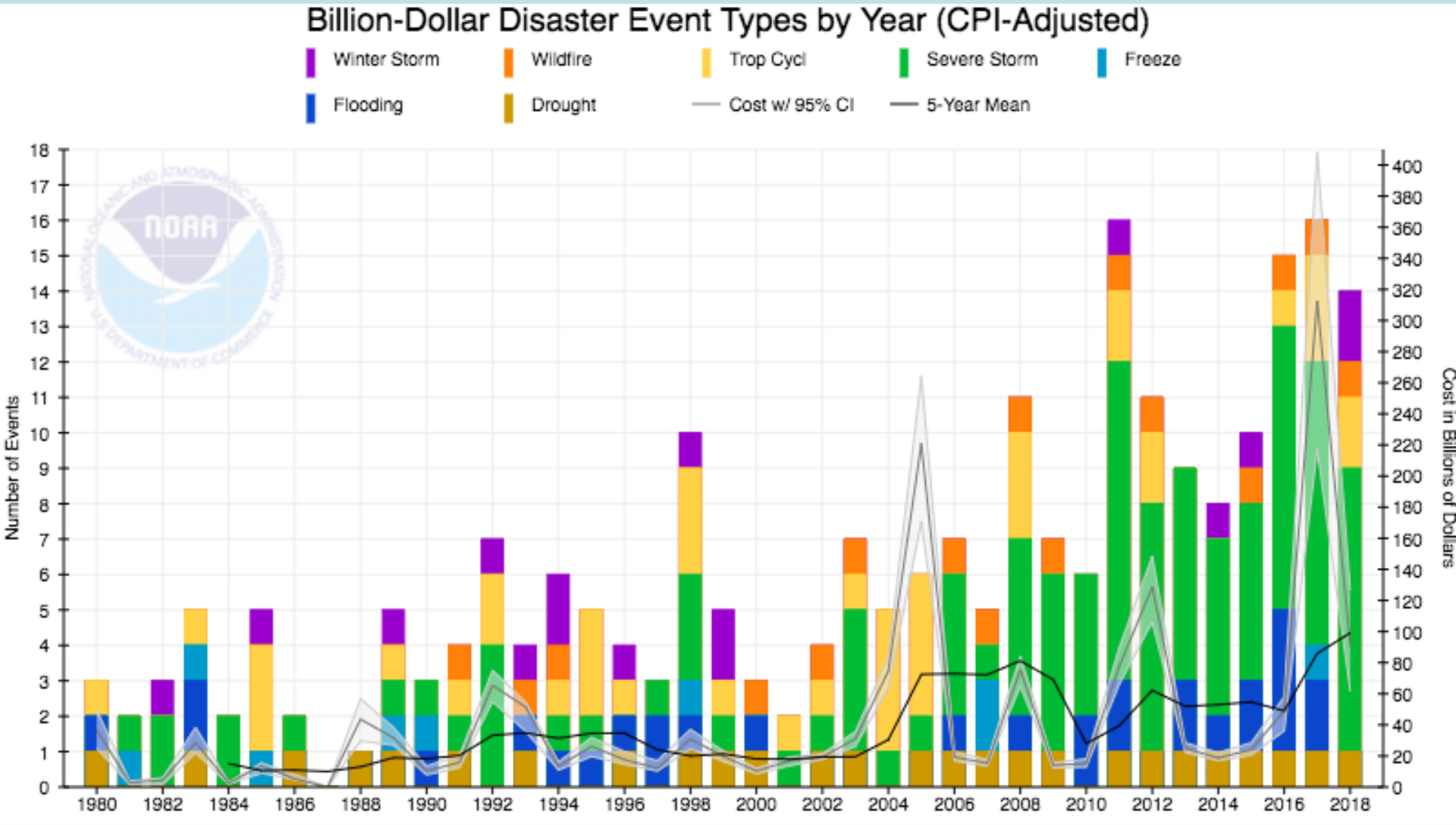
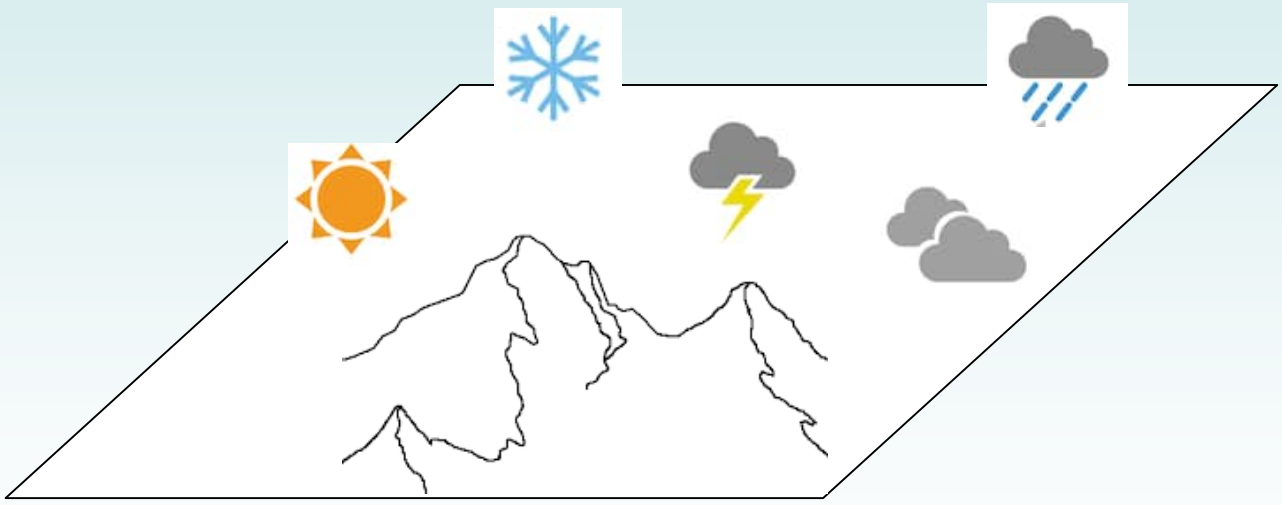
# USA Billion-Dollar Weather Disasters



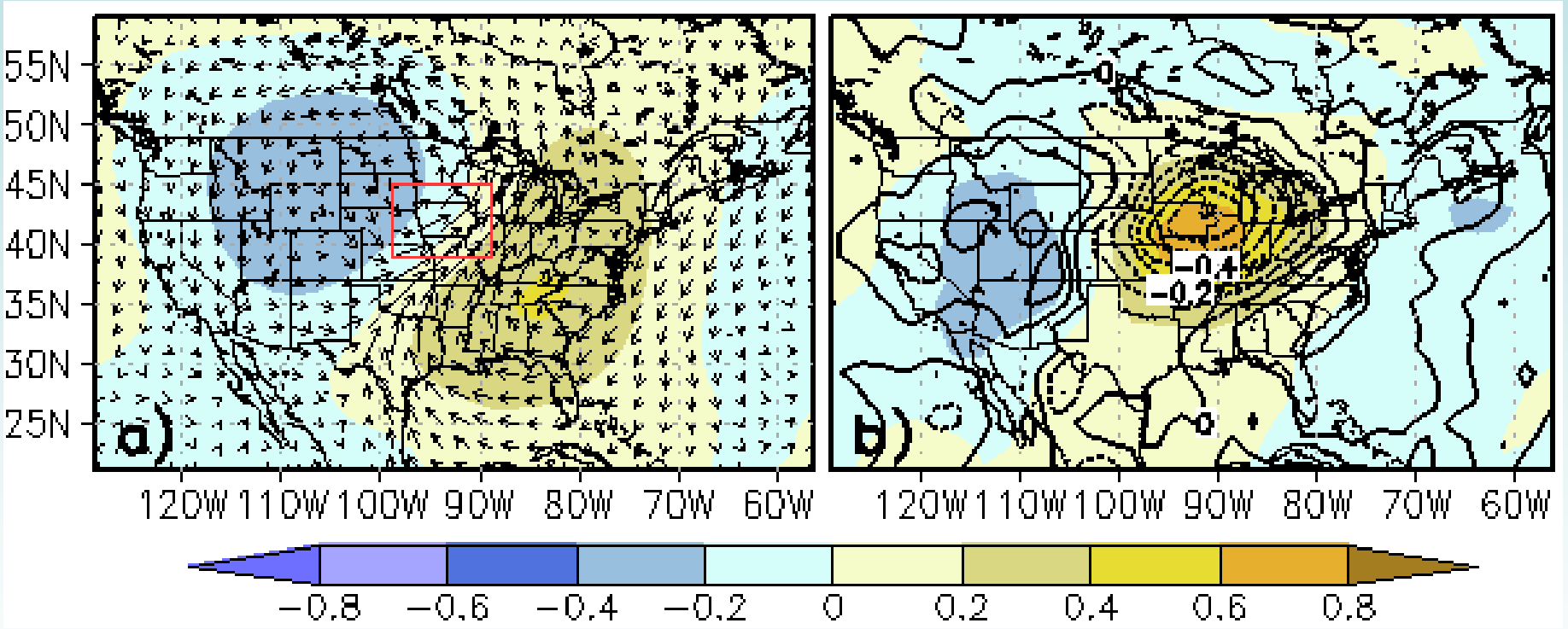
# Challenge

Climate models exhibit regional biases and uncertain processes, attributed to the representation of unresolved features and processes in the atmosphere, ocean, and land surface through semi-empirical parameterizations.



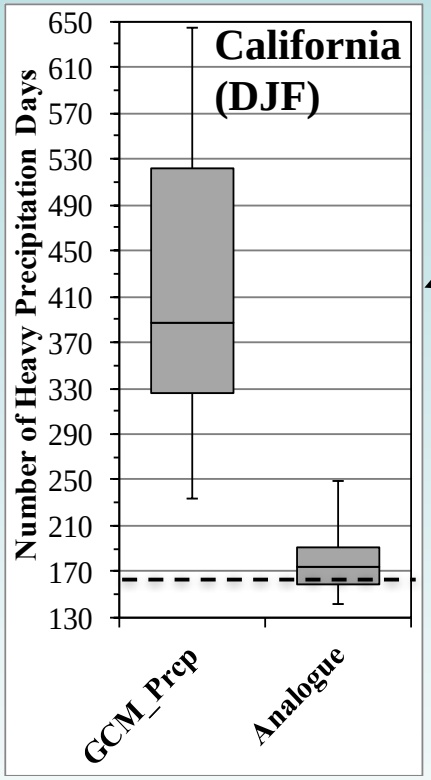
**100 ~ 300 km**

# Analogue: Large-scale Composites

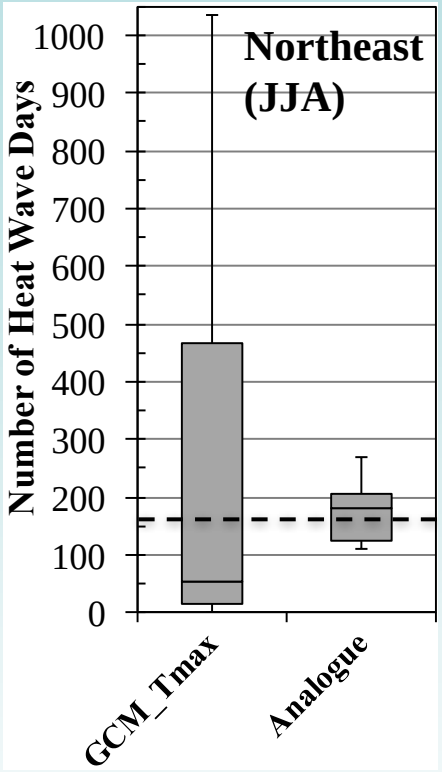


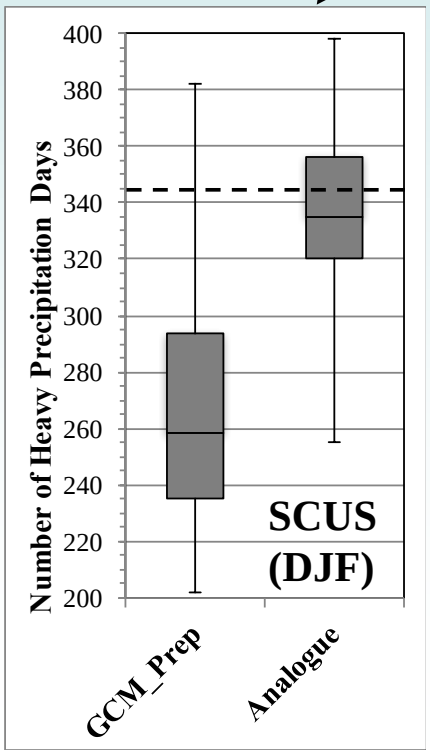

- 500-hPa Geopotential height (shaded)
- vertical integrated water vapor flux vector up to 500-hPa (arrow)
- 500-hPa vertical velocity (contour, $\omega_{500}$)
- Total precipitable water (shaded, tpw)

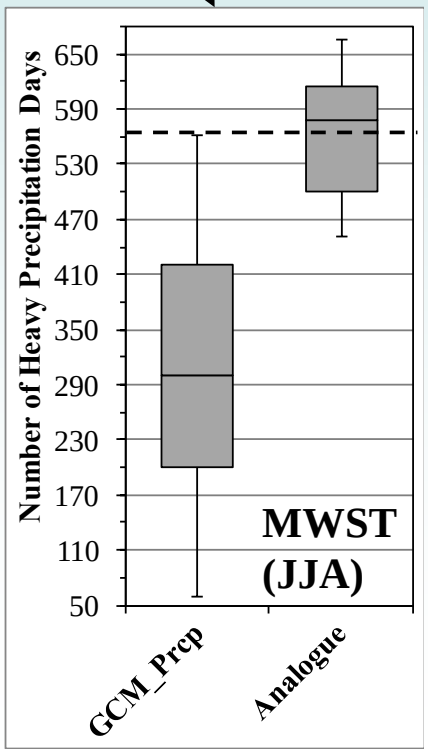
# Analogue vs. Climate Model Simulations



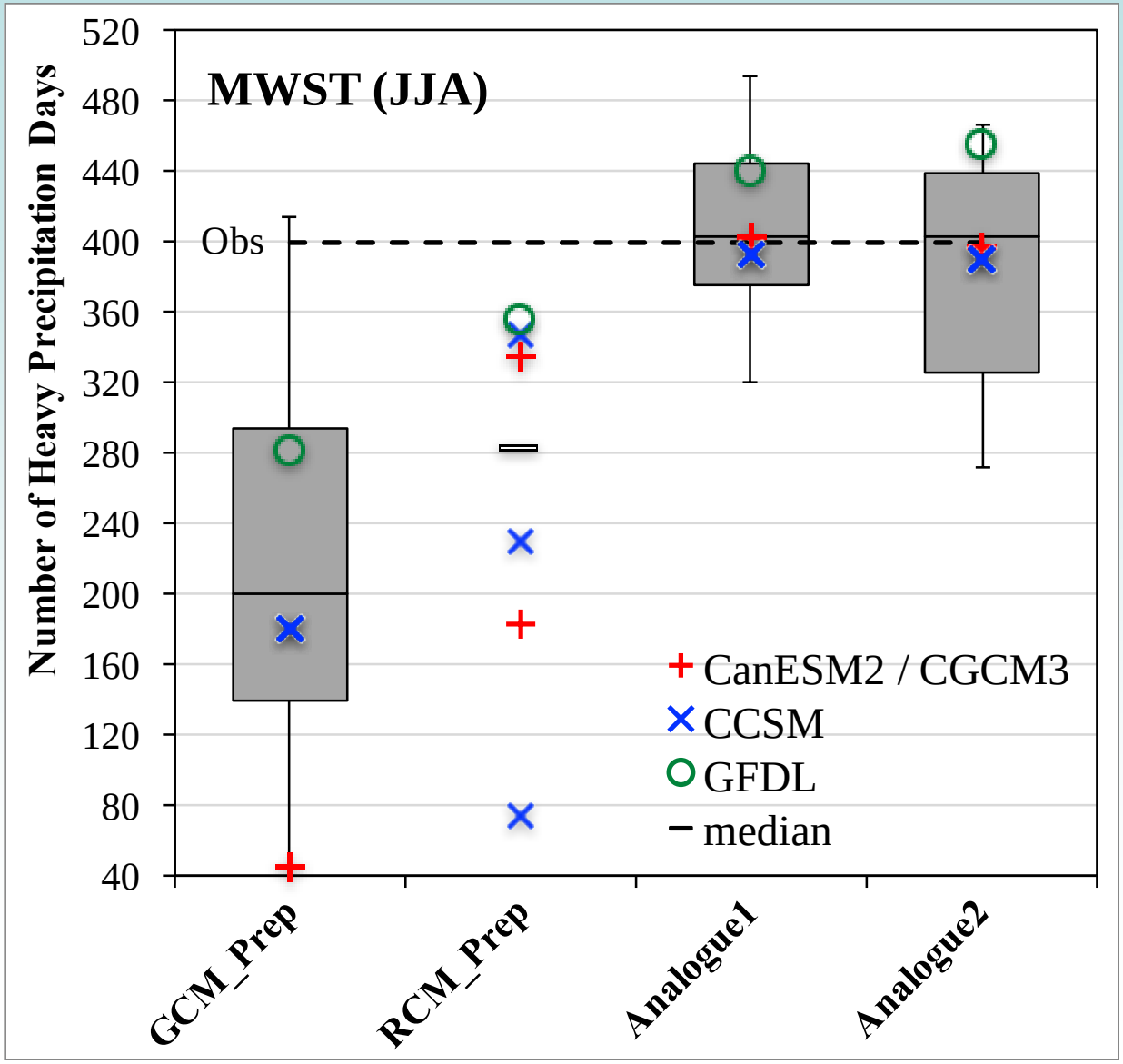




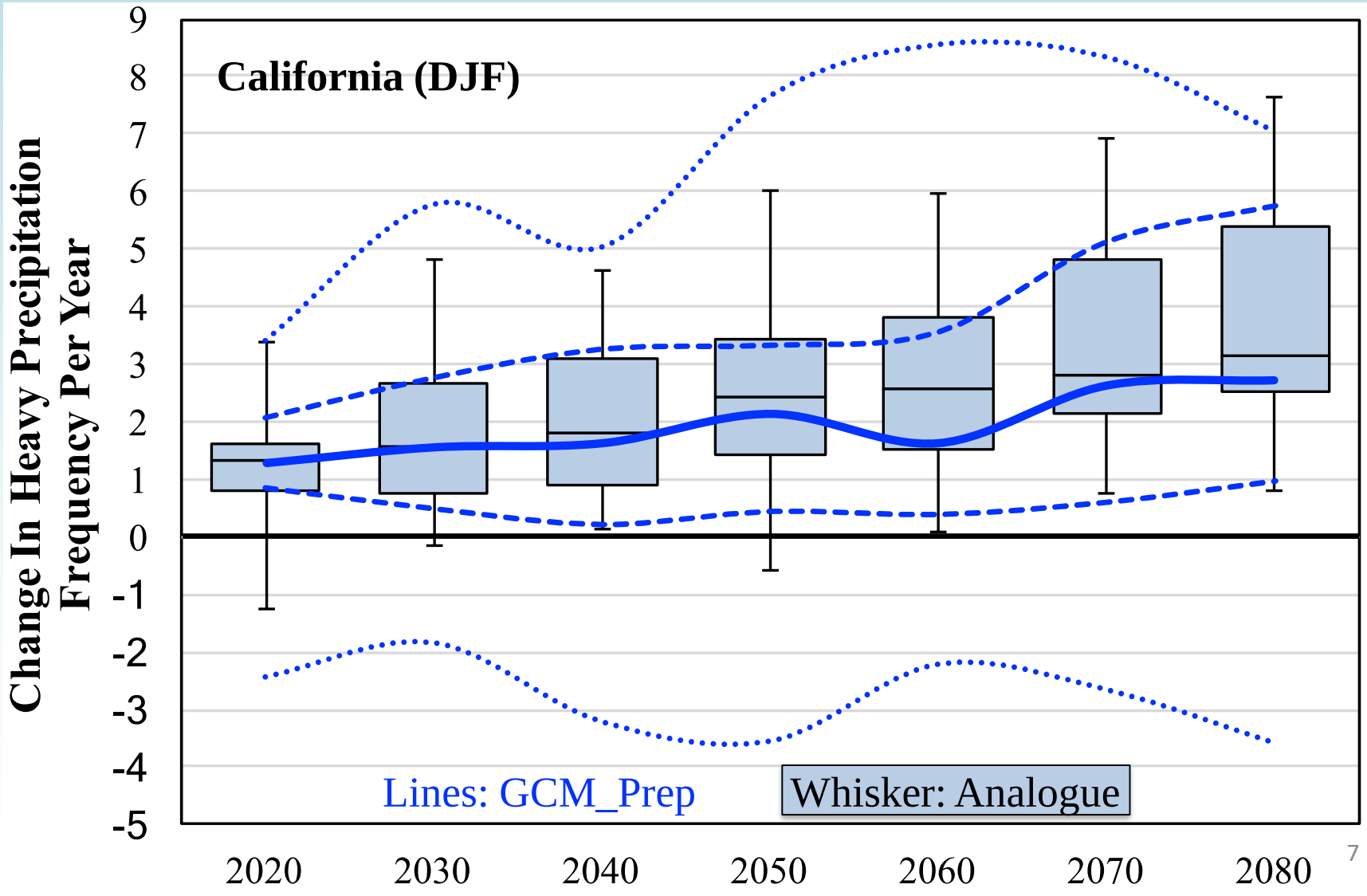



# Analogue vs. Regional Climate Model (RCM)

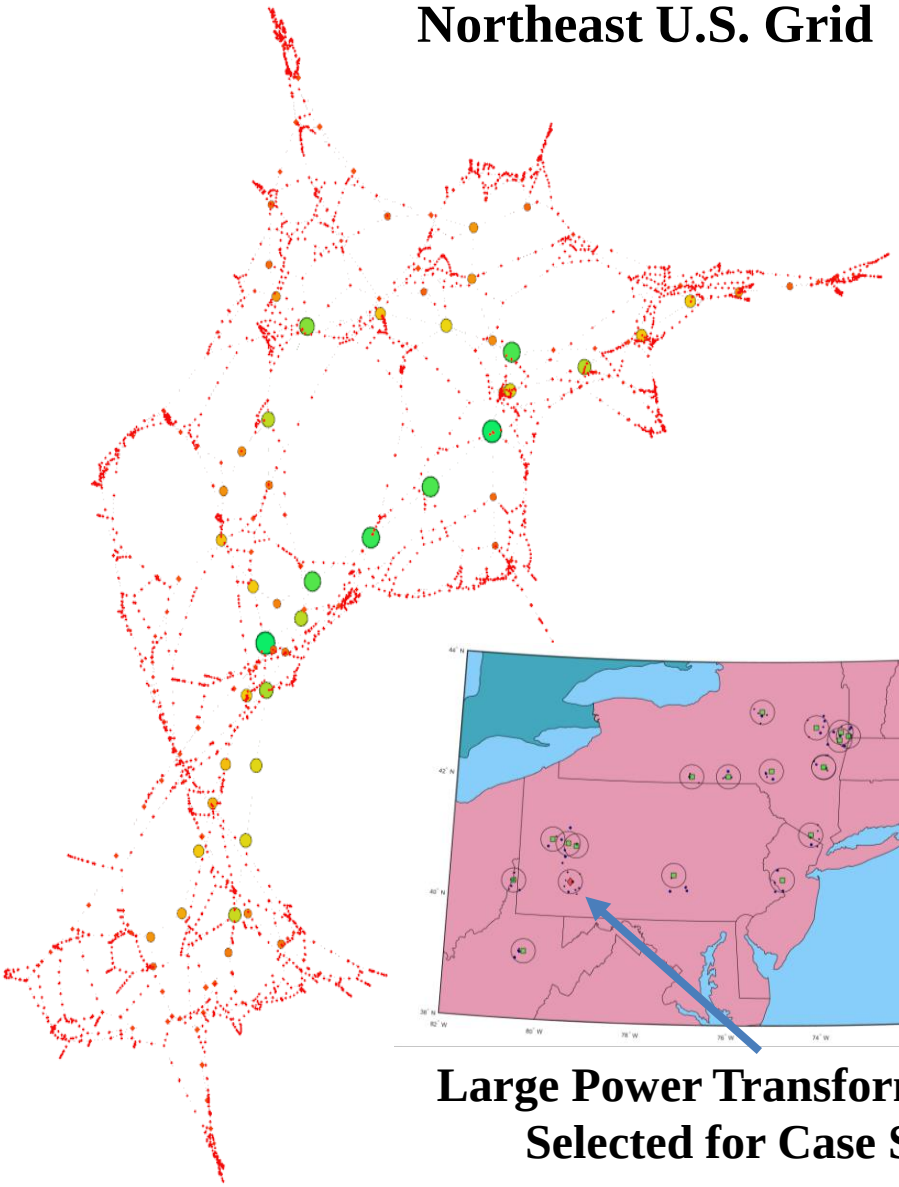


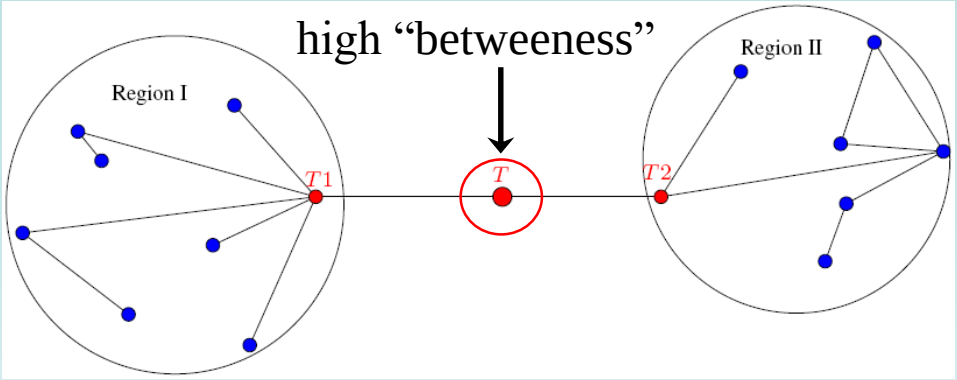
# Heavy Precipitation Prediction



# Overheat Risks to Power-Grid Resiliency

**Northeast U.S. Grid**







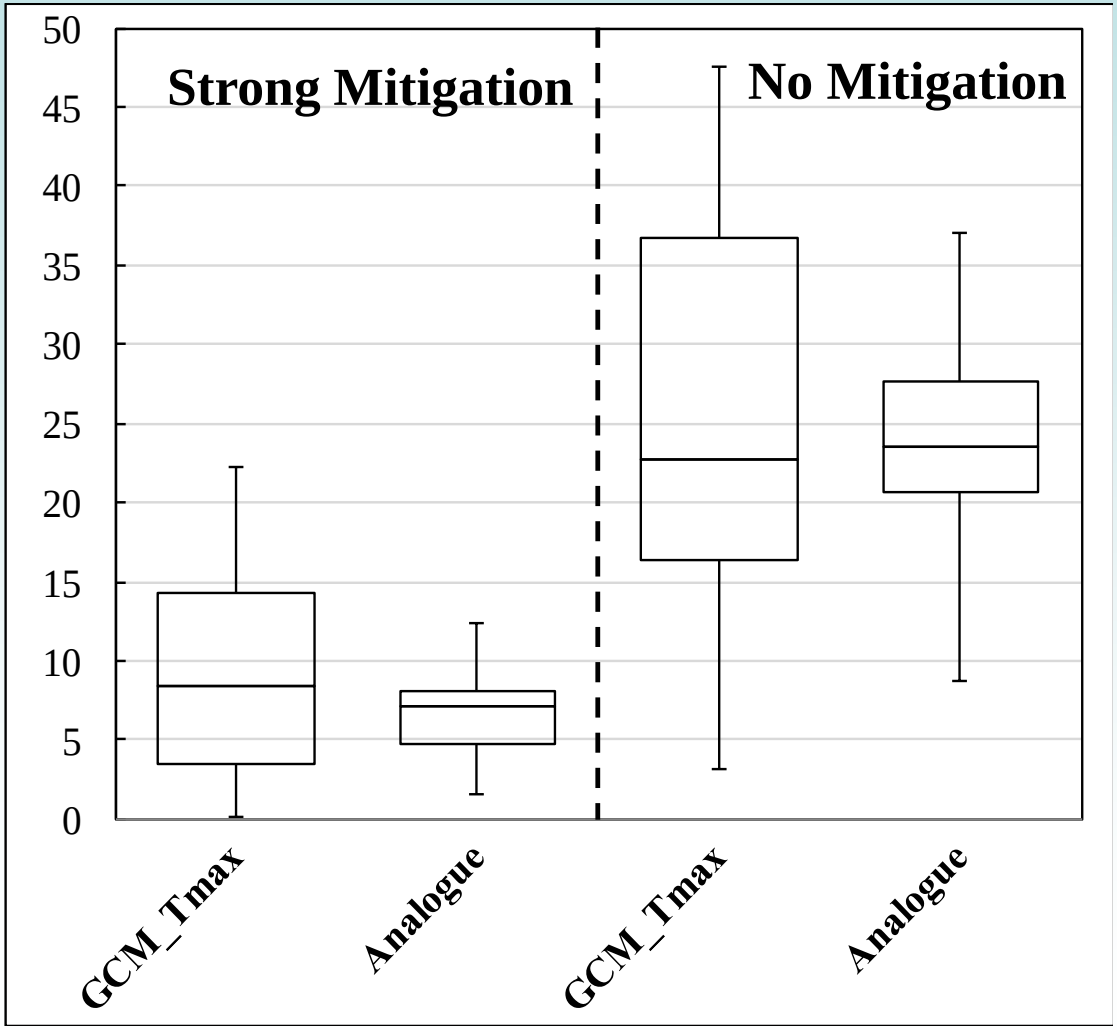


**Large Power Transformer in PA Selected for Case Study**

**Select Transformer Locations With High Degree of "Betweeness" Based on Transformer and Transmission Lines.**

**Focus On Occurrence Of Days With 90+ °F Maximum Temperature.**

# Change in "Damaging" Heat Wave Frequency Per Year in Late 21st Century




- 1°C rise in T, the lifetime of the transformer decreases by 4 years (10%)
- Expected transformer lifetime would decrease to a range of 20 - 40%.

**Mitigation** – Underlying risk is likely to be doubled.

**No Actions** – Underlying risk could be quadrupled.

Analogue improves prediction consensus and skill.

# Summary & Future Direction

- Analogue method improves upon explicit climate model prediction of extreme events – particularly in model consensus.
- Analogue method offers a promising path to provide actionable information for regional hydrological services and more stable/reliable infrastructure.
- **Future Direction:**
  - Machine-learning to enhance detection algorithms
  - Climate risks from compound events
  - Link to uncertainty decision capability
  - Target a collection of high-impact locations within the transformer and transmission-line networks.

# Publications


- Gao, X., C.A. Schlosser, P. Xie, E. Monier, and D. Entekhabi, 2014: An Analogue Approach to Identify Heavy Precipitation Events: Evaluation and Application to CMIP5 Climate Models in the United States. *J. Climate*, 27, 5941–5963.
- Gao, X., C.A. Schlosser, P.A. O'Gorman, E. Monier, and D. Entekhabi, 2017: Twenty-First-Century Changes in U.S. Regional Heavy Precipitation Frequency Based on Resolved Atmospheric Patterns. *J. Climate*, 30, 2501–2521.
- Gao, X., Schlosser, C.A. & Morgan, E.R., 2018: Potential impacts of climate warming and increased summer heat stress on the electric grid: a case study for a large power transformer (LPT) in the Northeast United States, Climatic Change, 147: 107-118.
- Gao, X. and Schlosser, C.A., 2019: Mid-Western US heavy summer-precipitation in regional and global climate models: the impact on model skill and consensus through an analogue lens. Clim. Dyn. 52: 1569-1582.