Statistical-Dynamical Analysis of Climate Projections for Flood Infrastructure Design

Sustainable Development Conference

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Plan of Attack

Today: an overview of ongoing work; time for discussion is limited but I'd love to follow up!

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River Floods

River floods have different mechanisms, impacts, mitigation strategies from flash floods. *How can we use what we know about climate to inform adaptation to river floods?*

Figure 1: Asunción, Paraguay 2015-16; Cincinatti, OH 1937. [Google Images]

Problem Statement

- Goal: inform risk-based design
- What is the probability of a flood exceeding some design value over the next n years?
- Non-stationarity (including natural variability!): this is not constant in time

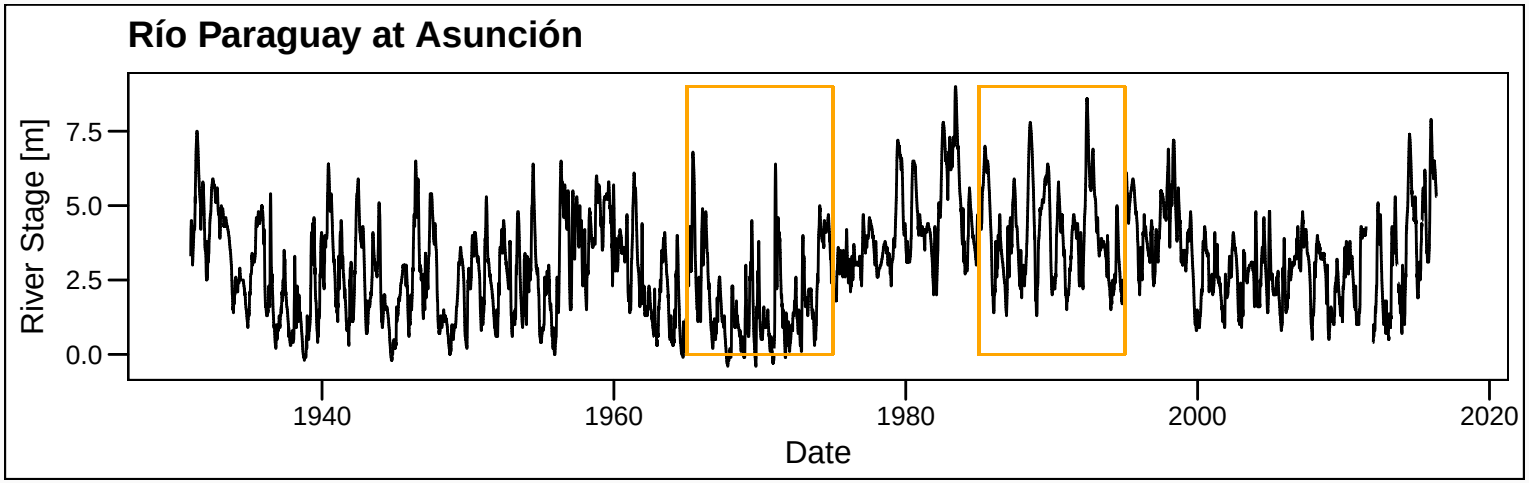

Figure 2: Río Paraguay at Aunción (data courtesy of DINAC Paraguay) exhibits substantial variability at many time scales

Does the past represent the future?

Using the past n years to predict the next n leads to high surprise

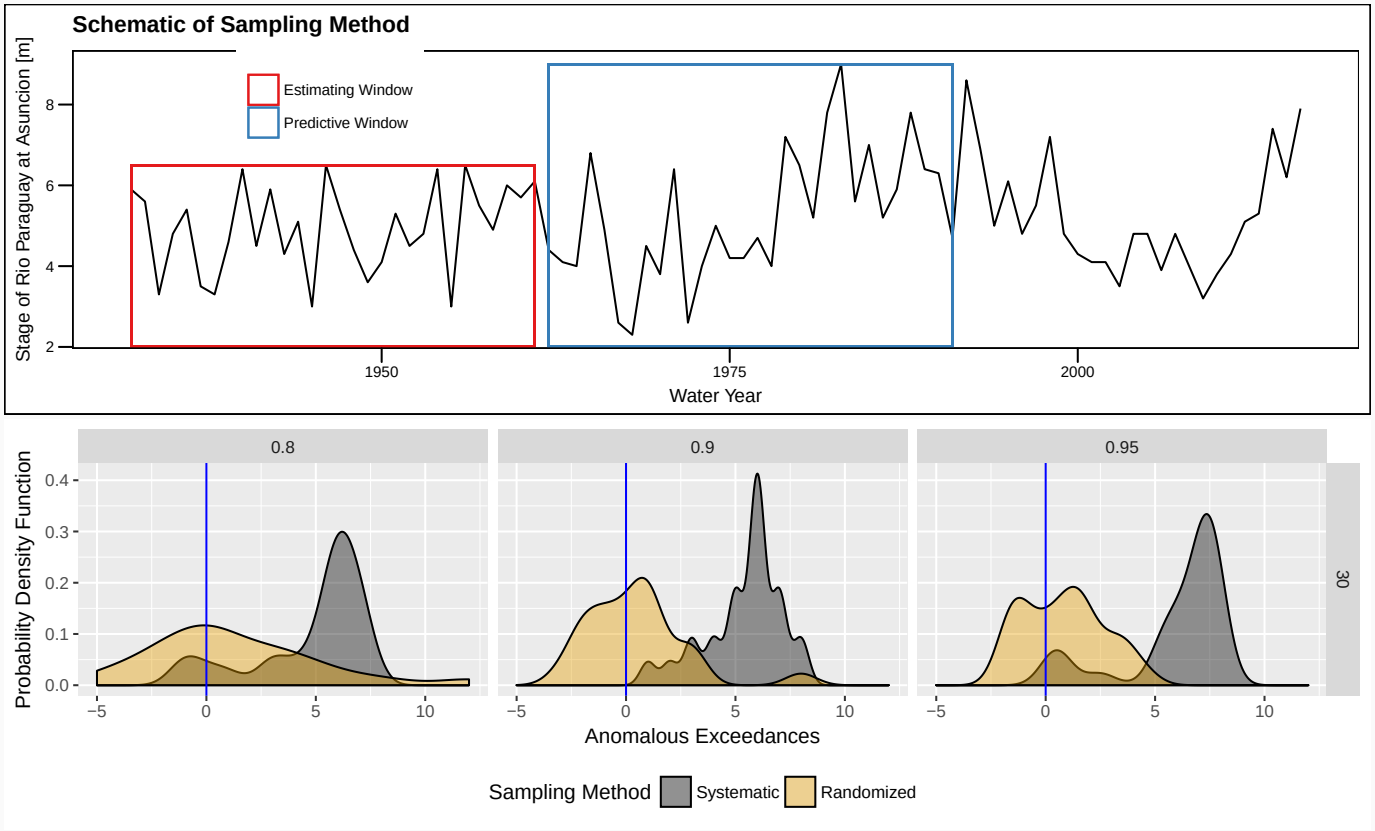

Figure 3: Black: PDF of the anomalous exceedances of certain quantiles (columns) estimated by looking at the previous $n = 30$ years. Orange: bootstrap using random years. See Jain, (2001).

Regional riverine floods: persistent, intense rainfall

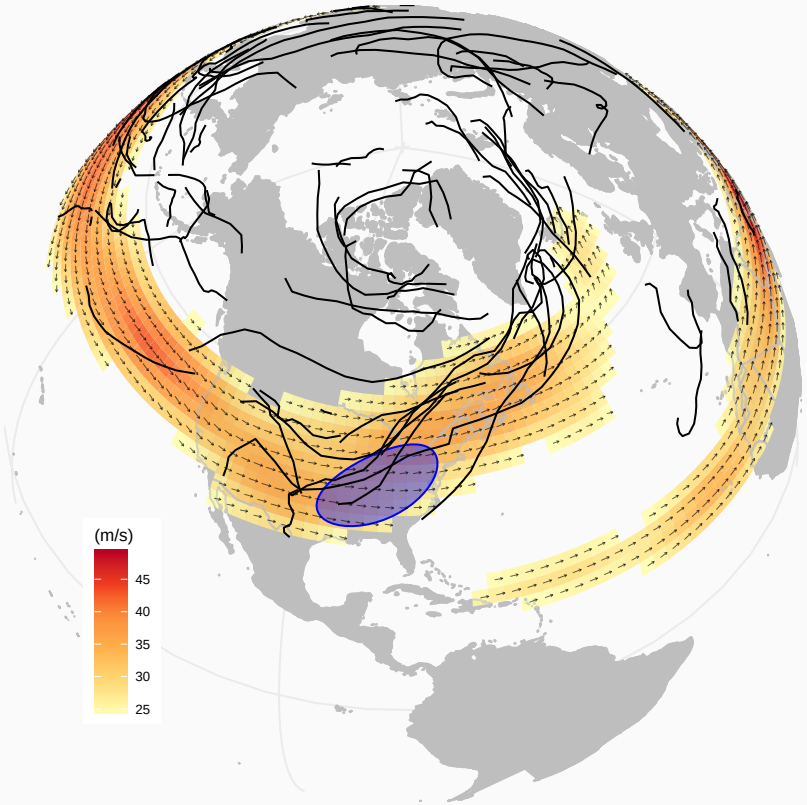

Figure 4: April 2011: 200 hPa monthly-mean wind anomalies(colors, arrows) and cyclone tracks (courtesy of Donna Lee; see Booth et al., 2015).

Ohio River Basin and Intense rainfall

Floods ← persistent, intense rainfall ← intense rainfall. Define Regional Intense Precipitation (RIP) event: $> 10\%$ of stations above 99th percentile for a particular day.

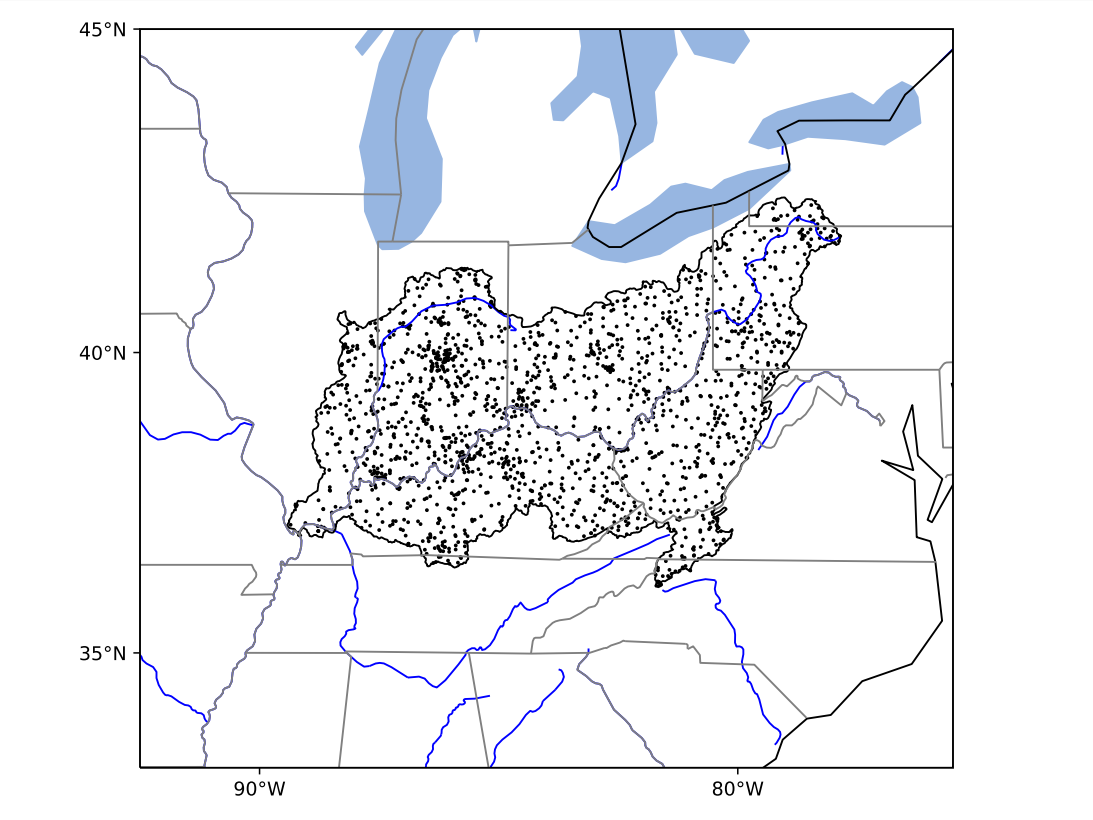

Figure 5: The Ohio River Basin. Dots: GHCN rainfall gauges.

Persistent, intense rainfall: similar circulation patterns

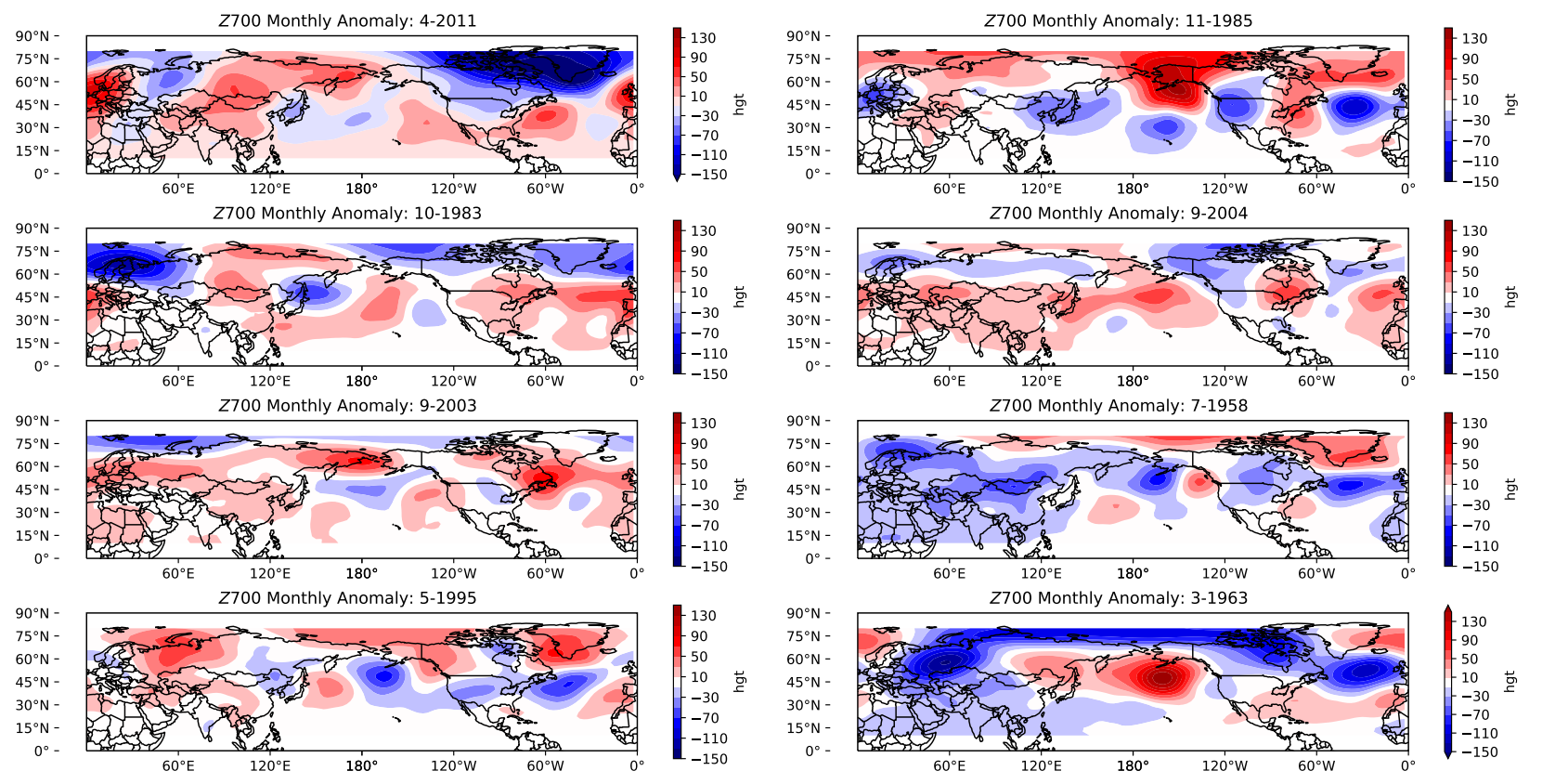

Figure 6: 700 hPa height for months with most RIP events

Potential predictability: known climate patterns

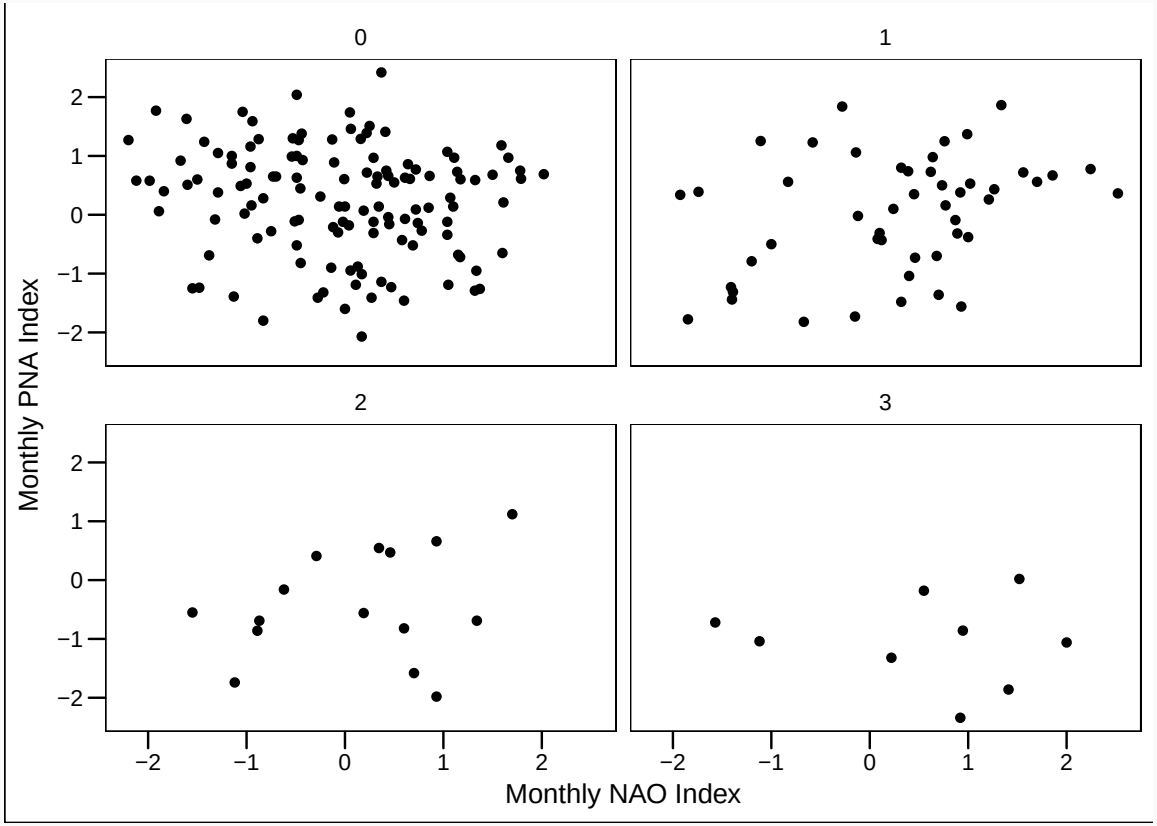

Figure 7: All DJF months 1950-2015. x axis is monthly NAO index, y index monthly PNA index. Months are separated by the number of RIP events observed.

Summary & Next Steps

We've seen:

- Flood hazard is highly non-stationary
- Prediction: need to understand *cross-timescale* dynamics

Ongoing work:

- Predictive statistical model
- Use forecast (not observed) weather regimes (PNA, NAO, etc.)

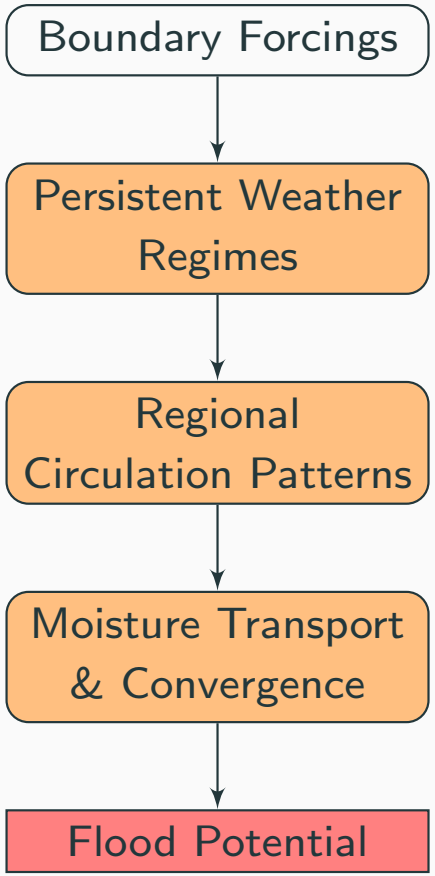

Figure 8: Conceptual framework of flood causal structure

Thanks!

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References I

Booth, James F et al. (2015). "The Paths of Extratropical Cyclones Associated with Wintertime High-Wind Events in the Northeastern United States*". *dx.doi.org* 54.9.

Jain, Shaleen (2001). "Multiscale Low-Frequency Hydroclimatic Variability: Implications for Changes in Seasonality and Extremes". PhD thesis. Utah State University.