Changes to Extreme Precipitation Events: What the Historical Record Shows and What It Means for Engineers

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Session IVa: Design Breakout

Topics

- Brief introduction to NOAA Atlas 14
  - How it is used by engineers
  - Ongoing efforts to update the Atlas
  - Improvements that these updates contain
- Potential Impact of Climate Change on Precip Frequency
  - The semantic problem
  - Exceedances
- Climate Change and PMP

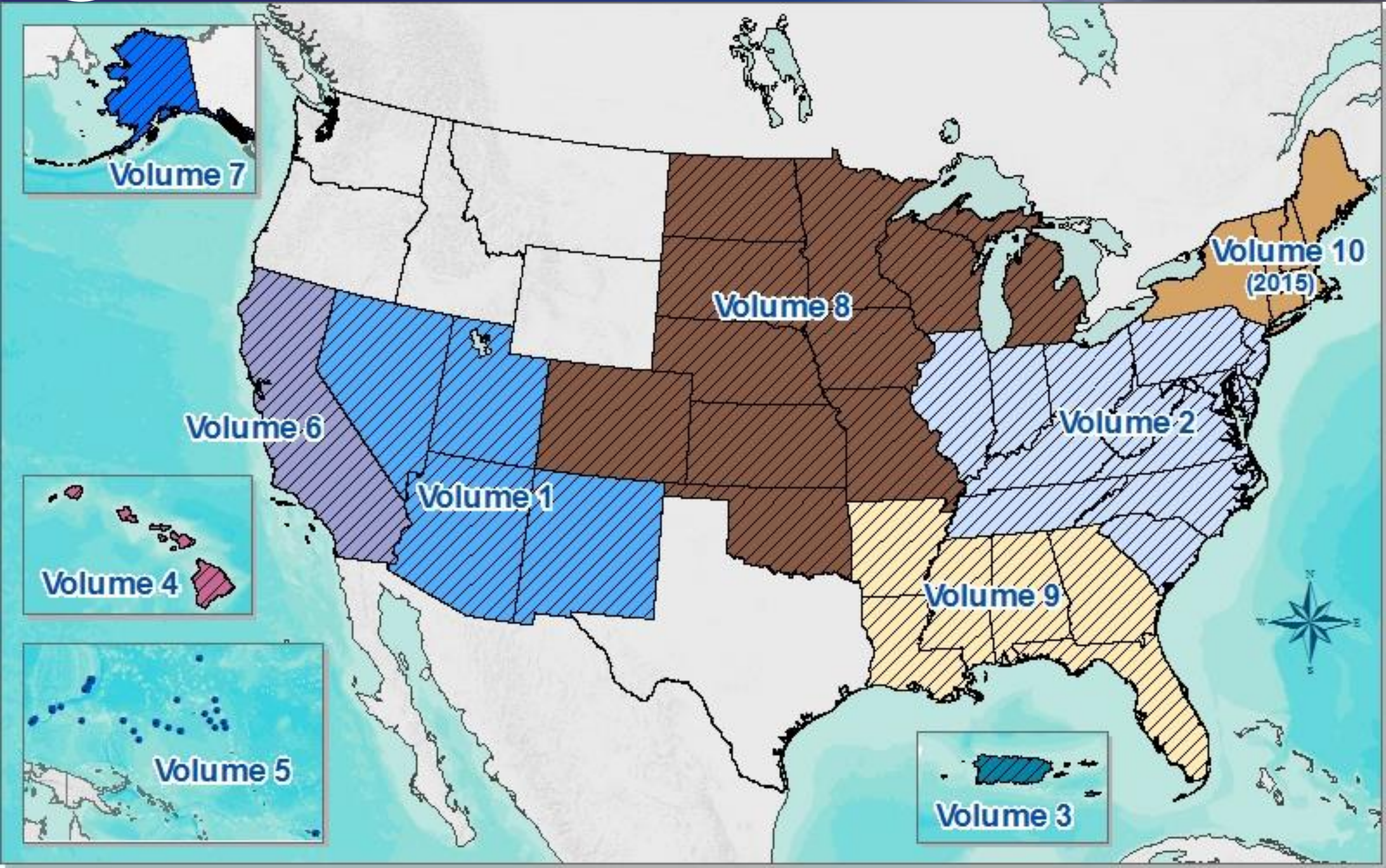
NOAA Atlas 14: Precipitation Frequency Atlas of the United States

- National design standard for infrastructure built to cope with rainfall and runoff
  - *Construction:*
    - storm water drainage systems, roads, bridges, culverts, small dams, detention basins, airport runways
  - *Ecosystems:*
    - in-stream ecosystems including fish habitat, stream erosion control, pollution control systems, soil conservation
  - *Other:*
    - flood insurance rate maps, flood plain management
- Ensure objective assessment of the probability of heavy rainfall in planning and design

NOAA Atlas 14 Summary

- Begun in 2000
- Published as volumes by project area
  - *as funds become available*
- Annual Exceedance Probability: 1/2 – 1/1,000
- Durations: 5 minutes – 60 days
- Error Estimates: 90% confidence intervals
- Locally Relevant: 30 arc-sec resolution
- User Friendly: web based, interactive

NOAA Atlas 14 Status



Sources of Change

- **Much more data** (examples from Volumes 8 & 9)
  - *1,850 daily stations*
    - 360 stations in TP49 (1964) for all CONUS
  - *Average Record Length 70 Years*
    - Rejected daily stations with <~50 years
    - TP49 average record length ~20 years
- **New Statistical Techniques**
  - *L-Moments replaces conventional moments*
  - *Regional approach vs at site*
    - Trading space for time increases effective record length
- **Objective methods of Spatial Interpolation**
  - *Observations in mountains*
    - interpolation vs extrapolation

Potential Impact of Climate Change

"Management and mission-oriented agencies with public-sector responsibilities have been provided with marginally useful scientific information about the likely manifestations of future climate change."

"There are insufficient interactions and knowledge exchange between climate scientists, water scientists, and engineers and practitioners to solve these challenges."

"Global Change and Extreme Hydrology: Testing Conventional Wisdom"
National Research Council, Water Science and Technology Board, 2011

Climatology Semantics

- "It is likely that the frequency of heavy precipitation events … has increased over most areas."
  - *IPCC AR4, Climate Change 2007: Synthesis Report*
- "Groisman et al. (2005) found significant increases in the frequency of heavy and very heavy (between the 95th and 99.7th percentile of daily precipitation events)"
  - *IPCC AR4 Working Group I*
- These and similar statements in the literature define terms such as
  - *"heavy", "very heavy", or "extreme" precipitation*
  - *Sometimes differently!*

For Example

- Groismain et al 2005
  - *"… we define a daily precipitation event as **heavy** when it falls into the upper 10% and/or 5% of all precipitation events;*

    *as **very heavy** when it falls into the upper 1% and/or 0.3% of precipitation events;*

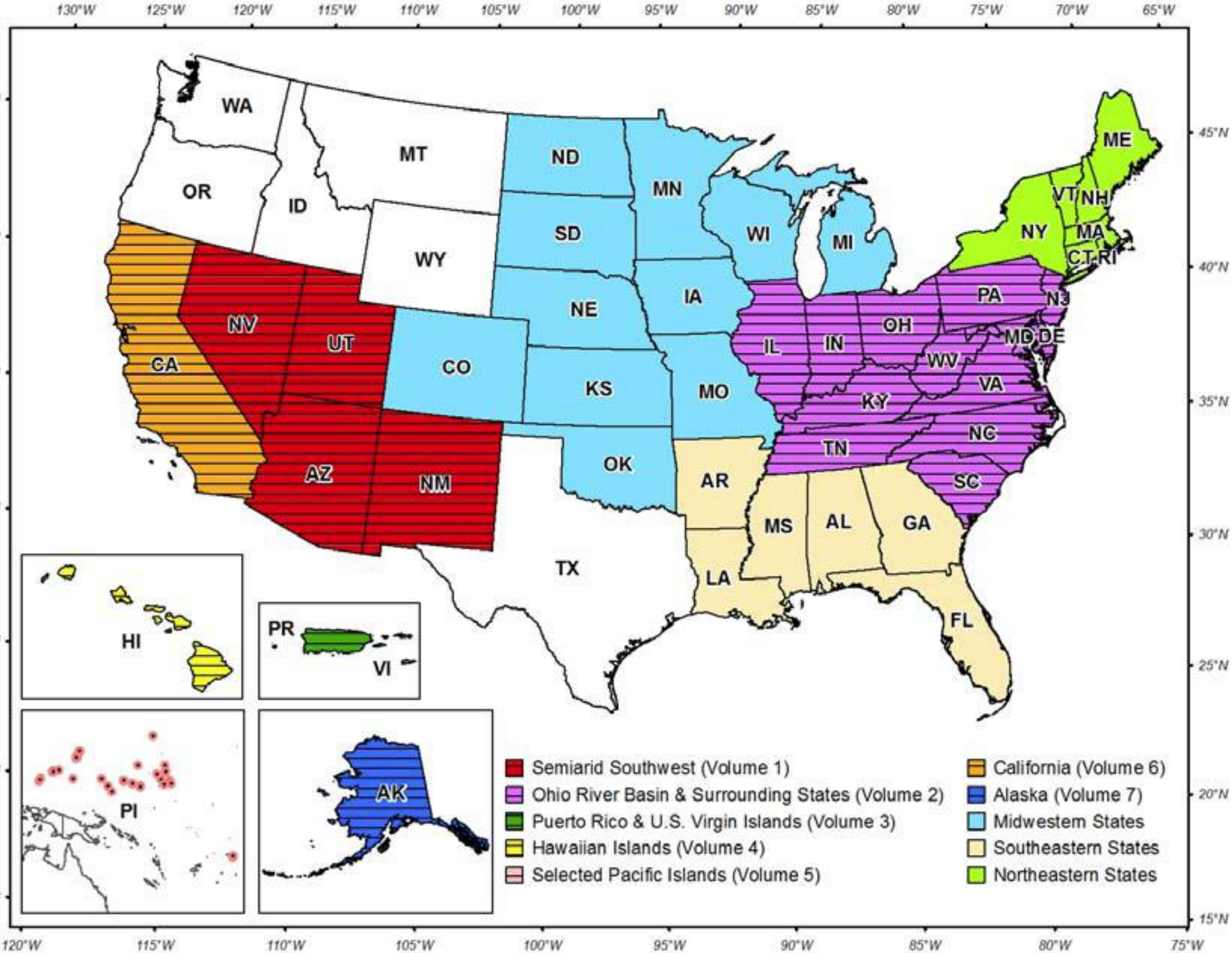
    *and **extreme** when it falls into the upper 0.1% of all precipitation events."*
  - *"The return period for such events … varies, for example, from 3 to 5 yr for … **very heavy** precipitation events."*
- Generally consider just daily durations

Civil Engineering Semantics

- Use precipitation frequency estimates
  - *average annual exceedance probabilities (AEP) or*
  - *average recurrence intervals (ARI)*
- Heavy, very heavy, and extreme rainfall:
  - *generally subjective terms*
- Use many durations; not just daily
  - *NOAA Atlas 14 provides 5 min through 60 days*

Let's Count Exceedances

- Thresholds
  - *Use actual NOAA Atlas 14 thresholds*
    - Not a fixed value or a percentile of a time series
  - *For:*
    - 1 year – 1,000 year ARI
    - Durations: 6 hours – 45 days
- Use Partial Duration Series
  - *Complies with ARI definition*
- Count Number of Exceedances
  - *For each station*
    - Sum for each year over the all stations in the domain
  - *Normalize for varying number of stations each year*
- Linear regression for all ARI/durations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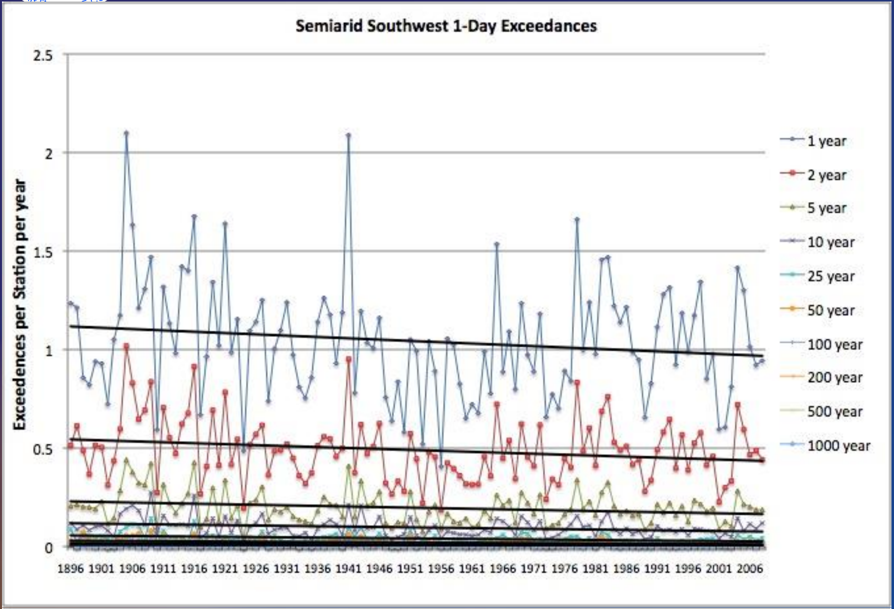
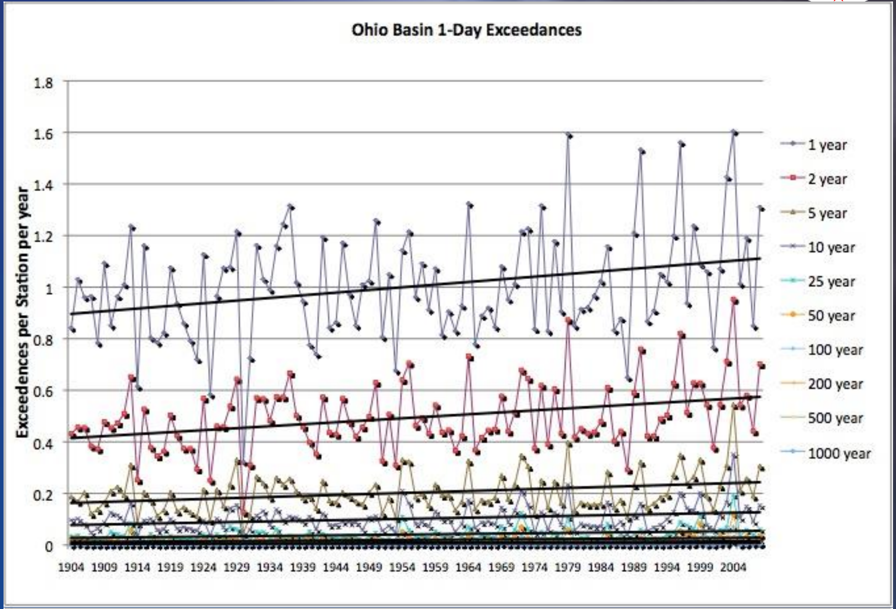
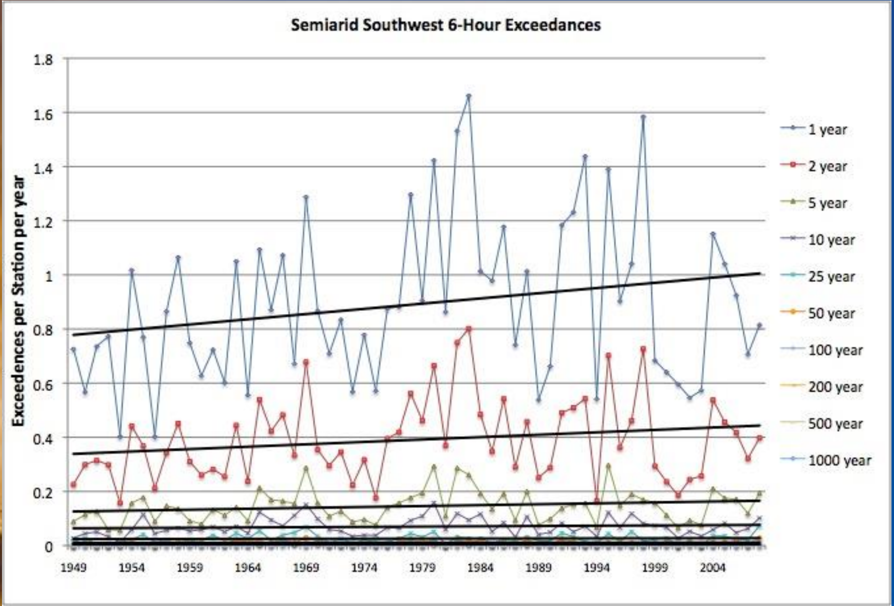
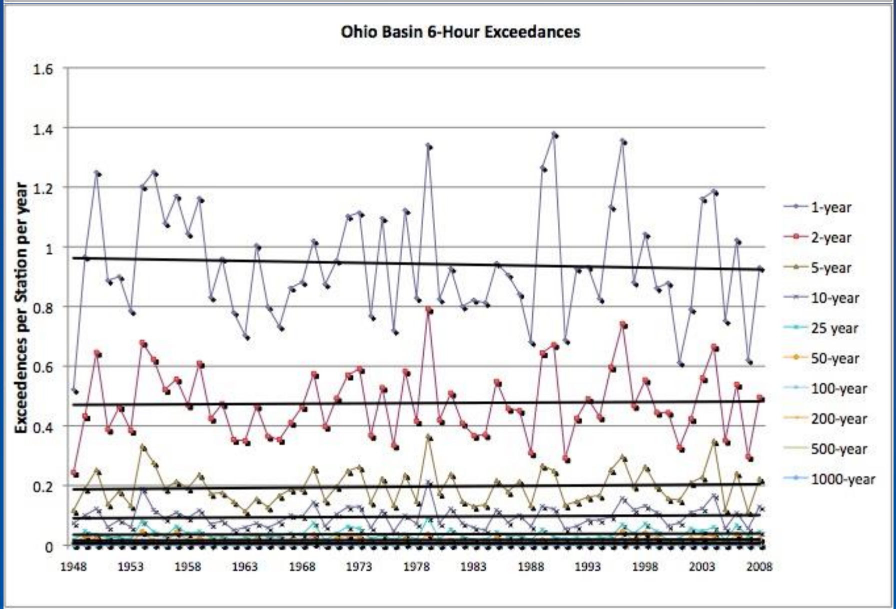
Semiarid Southwest (Volume 1)
Ohio River Basin & Surrounding States (Volume 2)
Puerto Rico & U.S. Virgin Islands (Volume 3)
Hawaiian Islands (Volume 4)
Selected Pacific Islands (Volume 5)
California (Volume 6)
Alaska (Volume 7)
Midwestern States
Southeastern States
Northeastern States

Example Trends in Exceedances









Trends in Exceedances

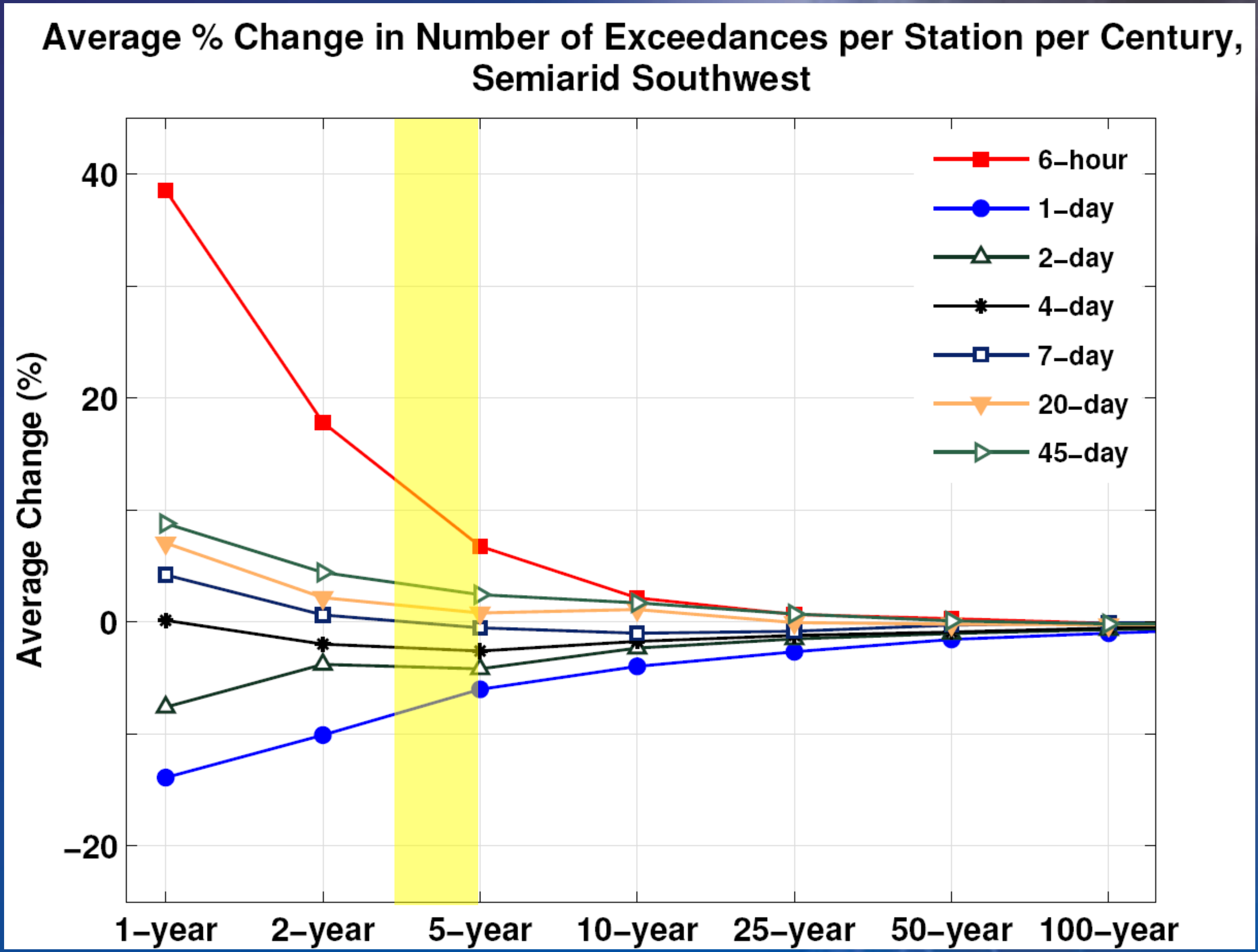
NA14, 90% confidence intervals

+/- 30%

- sparsely instrumented, shorter record; to

+/- 10%

- more densely instrumented, longer record



- Generally statistically significant except for 6 hour durations
  - *.05 level, T-test & Mann Kendall*

Trends in Exceedances (continued)

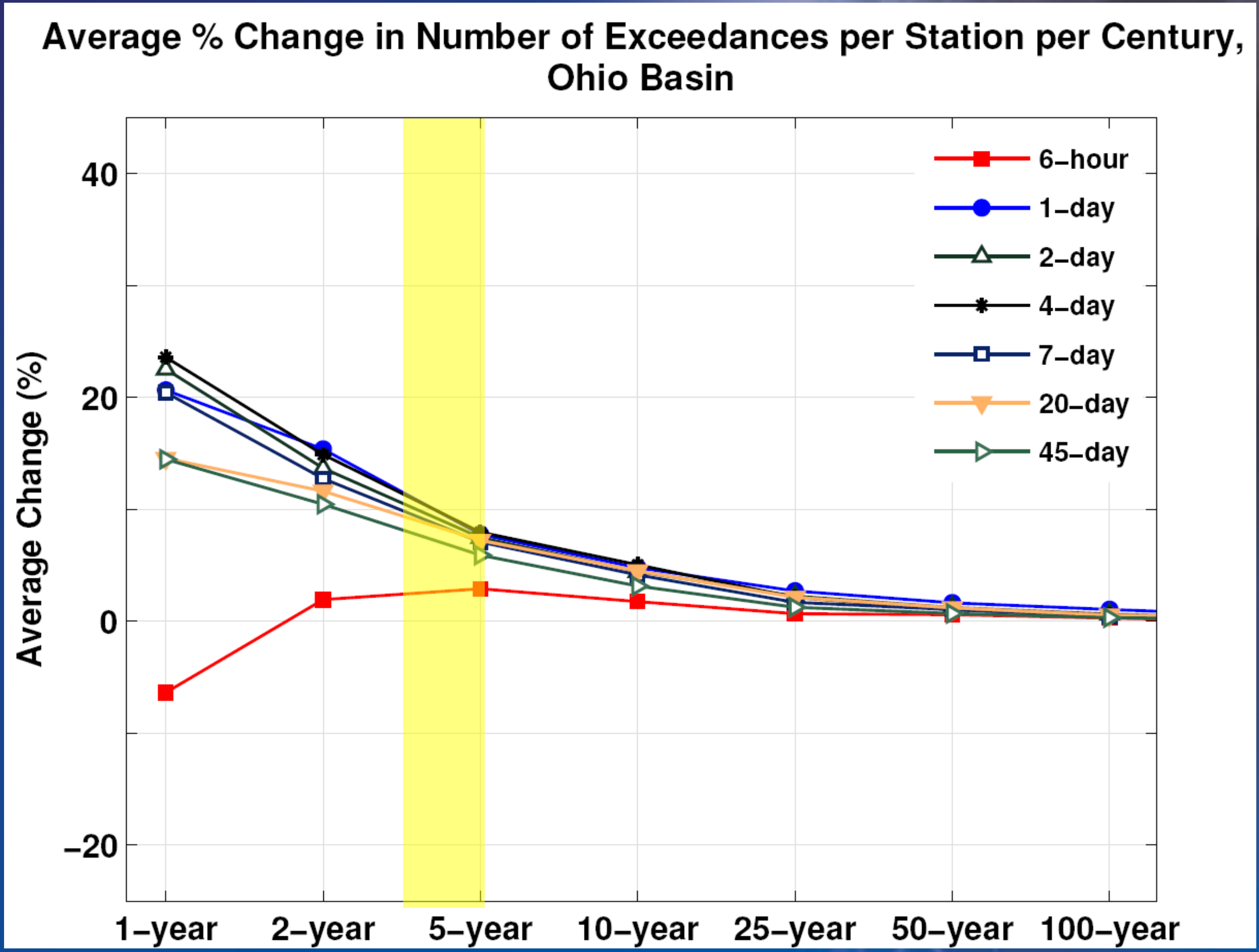
NA14, 90% confidence intervals

+/- 30%

- sparsely instrumented, shorter record; to

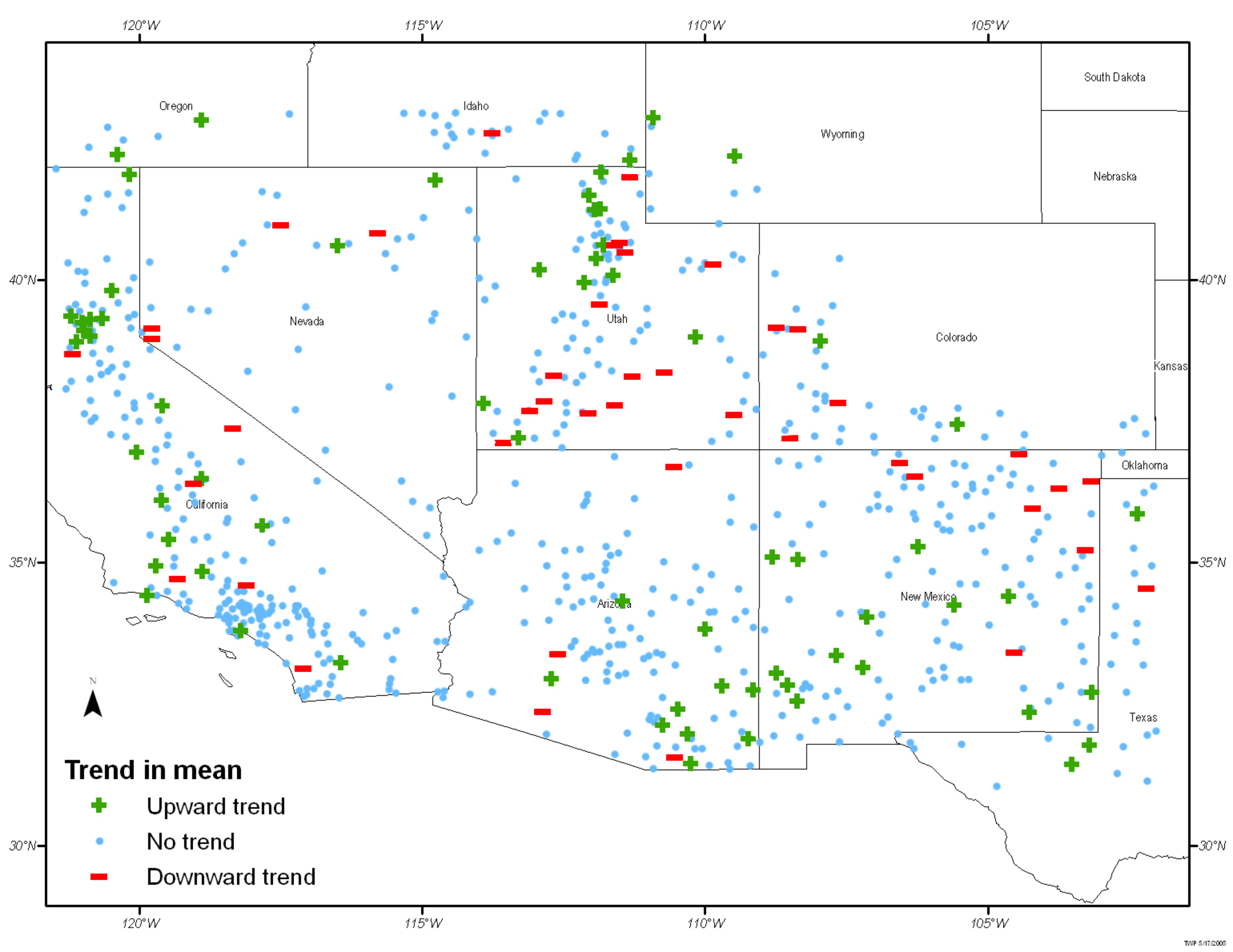
+/- 10%

- more densely instrumented, longer record



- Generally not statistically significant except for daily durations above 2 yr ARI
  - *.05 level, T-test & Mann Kendall*

Spatial Coherence of AMS Means



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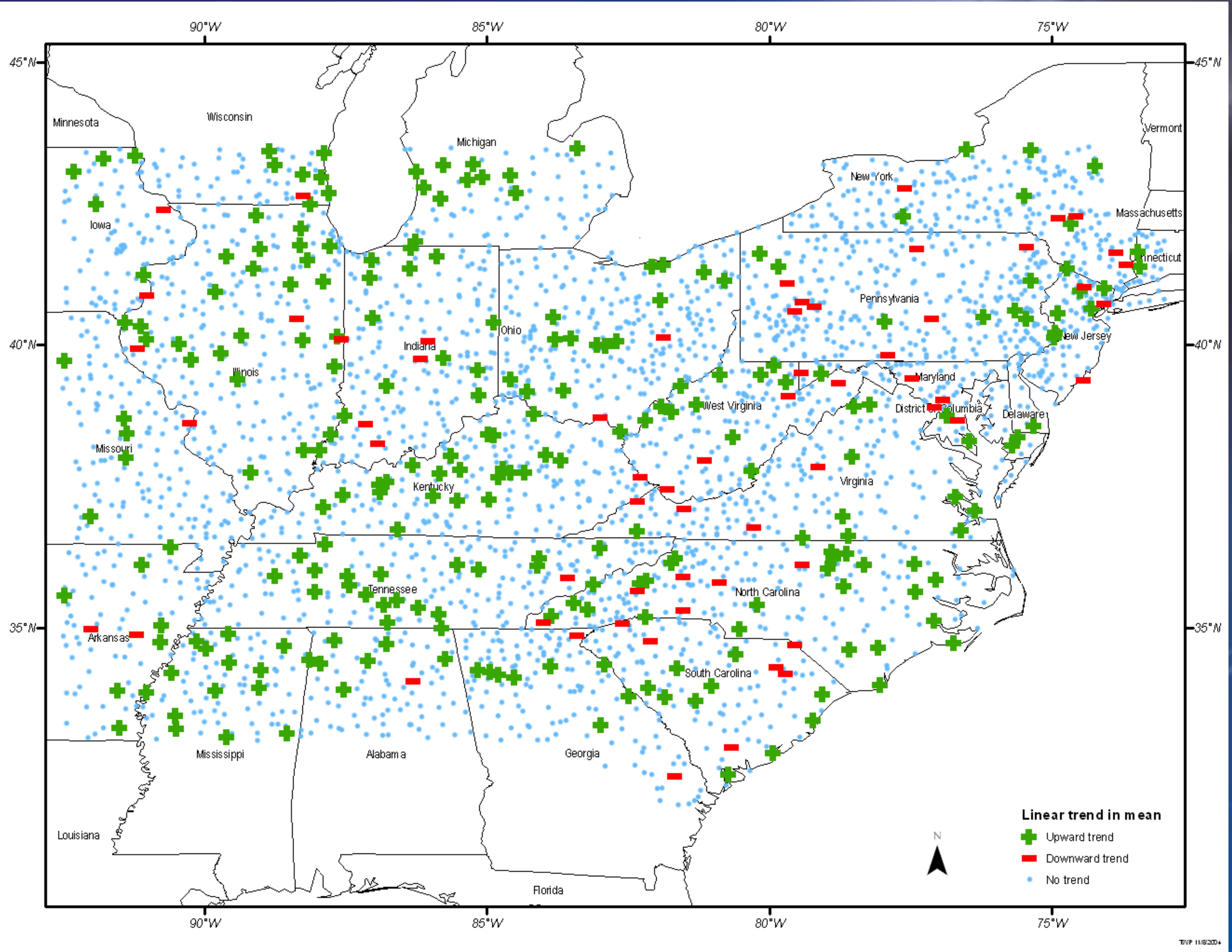

Precip Frequency Conclusions

- Climate community statements on trends in rainfall exceedances
  - *Do not address frequencies and durations required for civil infrastructure*
- Climate community statements are being misinterpreted
  - *by Civil Engineers and probably the public*
- Historical trends in number of events
  - *Are small compared to uncertainty of IFD values*
- Need better guidance on potential impact of climate change on IFD curves
  - *In range relevant to civil infrastructure*

Discussion

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