Update on Precipitation Frequency Estimates and Questions of Stationarity

Geoff Bonnin

301-713-0640 x103 Geoffrey.Bonnin@noaa.gov

Office of Hydrologic Development

NOAA National Weather Service

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Topics

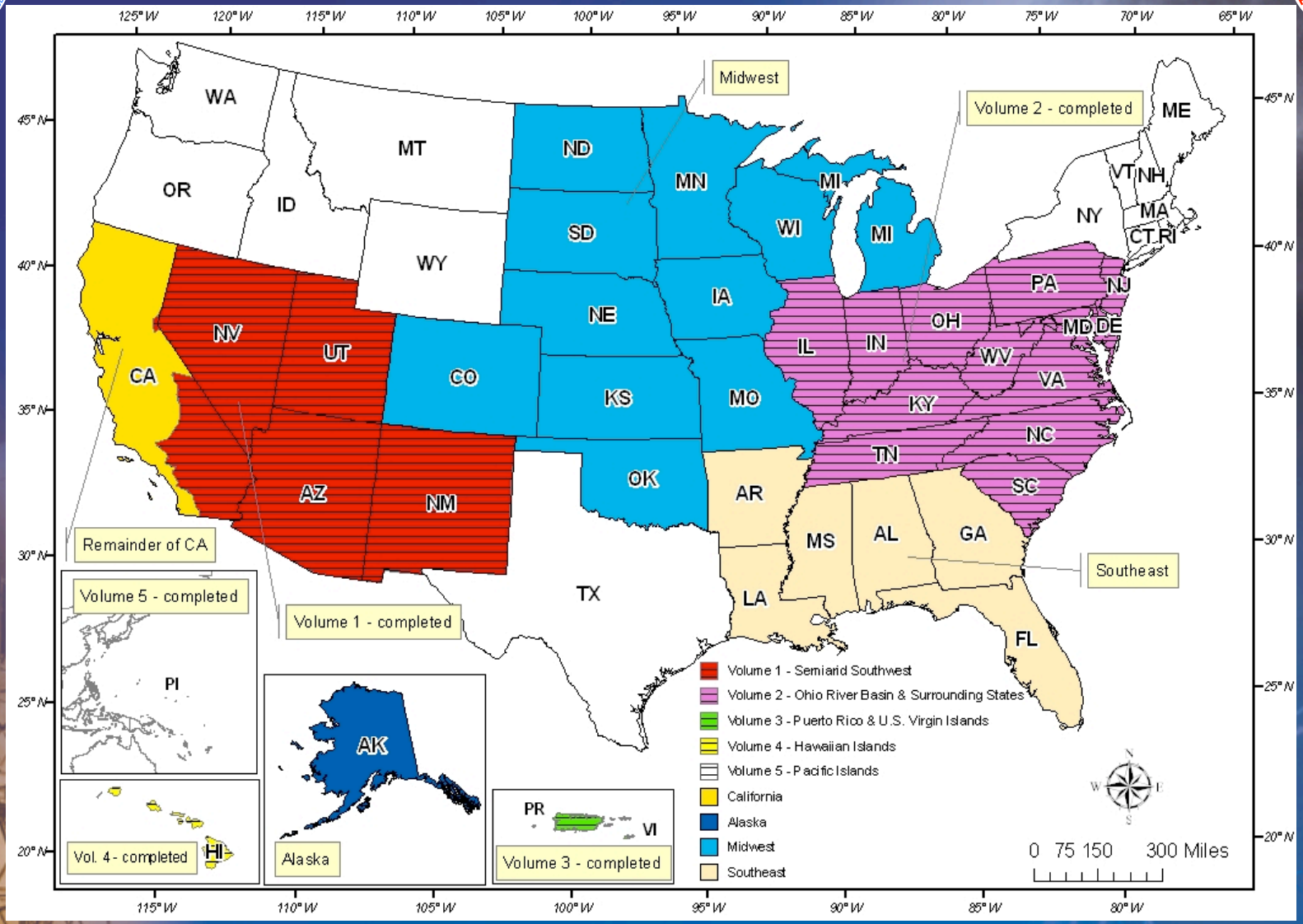
- **Updates to NOAA Atlas 14**
  - ***Performed by:***

    NWS

    Office of Hydrologic Development

    Hydrometeorological Design Studies Center
- **Semantics of Precipitation Frequency**
- **New Analysis of Exceedances**
  - ***With assistance from:***
    - **Michael Yekta**
    - **Sanja Perica**
    - **Kazungu Maitaria**

NOAA Atlas 14 Volumes, Projects



www.nws.noaa.gov/oh/hdsc

California Project Status

- Data collection, formatting, initial QC; Complete
  - *Station numbers:*
    - 1,681 stations; 1-day through 60-day
    - 667 stations; 1-hour through 12-hour
    - 350 stations; 15-minute and 30-minute
  - *Included snow depth data for stations > 3000 feet*
  - *Added semiarid CA to recheck Vol 1*
- Initial regionalization; Complete
- Spatial interpolation; Begin in mid-March
  - *Analysis of means by OSU PRISM Group*

California Project Schedule

- **Complete regionalization and statistics**
  - *Expected end of March*
- **Peer review**
  - *Expected to begin in April 2010*
- **Web publication**
  - *Expected in September 2010*

Alaska Project

- Data collection (U of Alaska, Fairbanks (UAF))
  - *Complete pending three minor data sources*
  - *15 data sources collected*
    - 819 daily stations
    - 684 hourly stations
    - 38 15-minute stations
- Data formatting (UAF); In Progress
  - *11 data sources completed*
  - *Resolving issues in 4 data sources*

Alaska Project (continued)

- **Under-catch bias correction (UAF)**
  - *Requires information on stations with Alter shields*
  - *Researching alternative approach if accurate information is unavailable*
- **Data quality control (UAF)**
  - *NWS will extract AMS and provide QC tools*
- **Data Collection, QC & Bias Correction**
  - *Behind schedule by 3-4 months*
- **Web publication due September 2011**

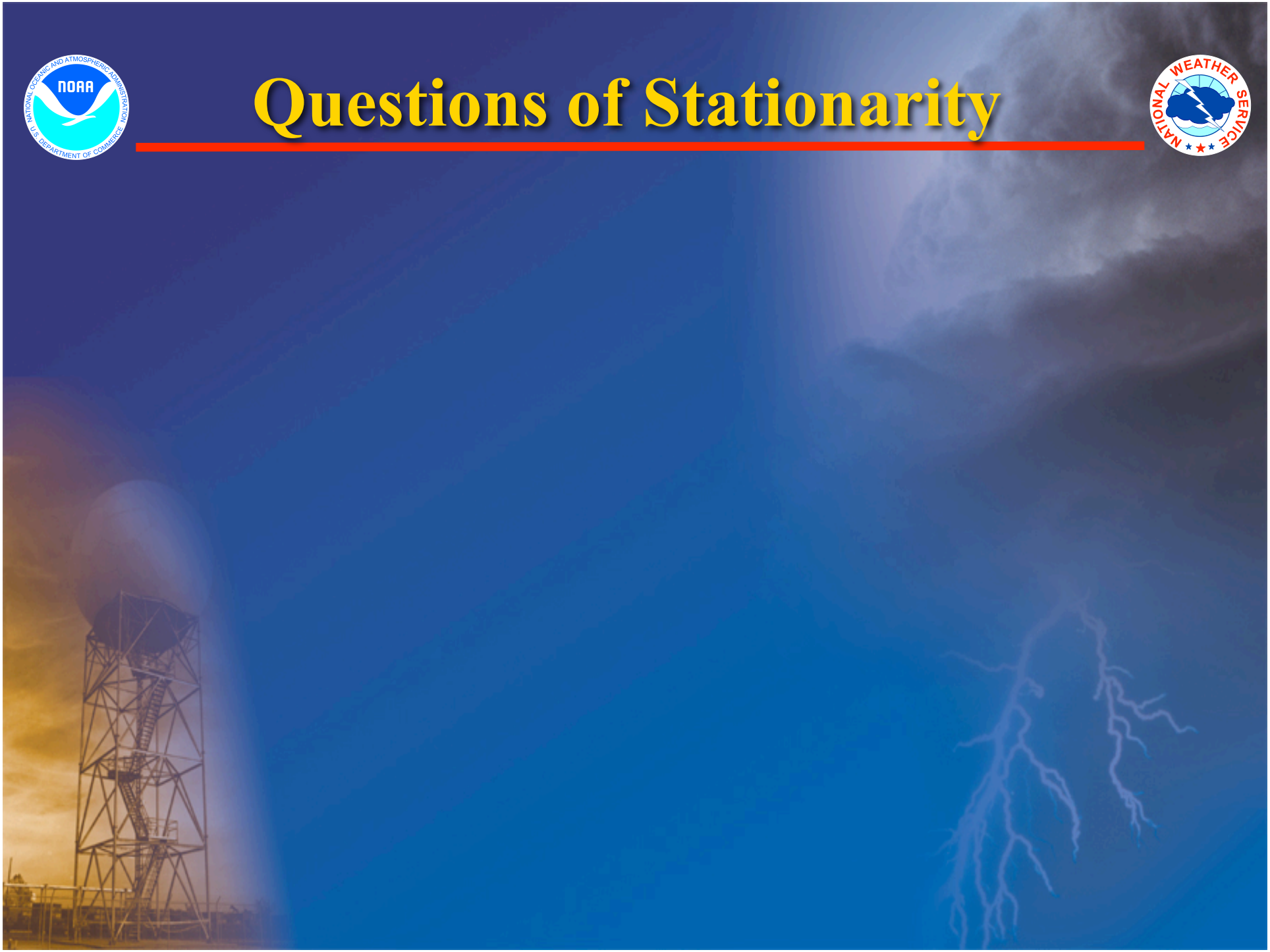
Southeastern States Project

- **Data collection; Complete**
  - *Identified 39 potential data sources*
    - 23 data sources may not be used:
      - *Stations have less than 10 years of data*
      - *Duplicated data from another source*
- **Data formatting; In Progress**
  - *Completed 8 data sources*
- **Data QC; In Progress**
  - *Examined co-located NCDC stations for*
    - Consistency & duplicate records
- **Web publication expected May 2012**

Midwestern States Project

- **Data collection; Complete**
  - *Identified 49 potential datasets*
    - 11 data sources may not be used:
      - *stations have less than 10 years of data*
      - *duplicated data from another data source*
- **Data formatting; In progress**
  - *Completed 17 data sources*
- **Data QC**
  - *Examined co-located NCDC stations for*
    - Consistency & duplicate records
- **Web publication expected May 2012**

Questions of Stationarity



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

- **Groisman 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*
  - *but their meaning can be construed*
- **Use many durations; not just daily**
  - *NOAA Atlas 14 provides 5 min through 60 days*

Example Civil Eng Design Criteria

Type of structure	Return period (years)
Highway culverts	
Low traffic	5–10
Intermediate traffic	10–25
High traffic	50–100
Highway bridges	

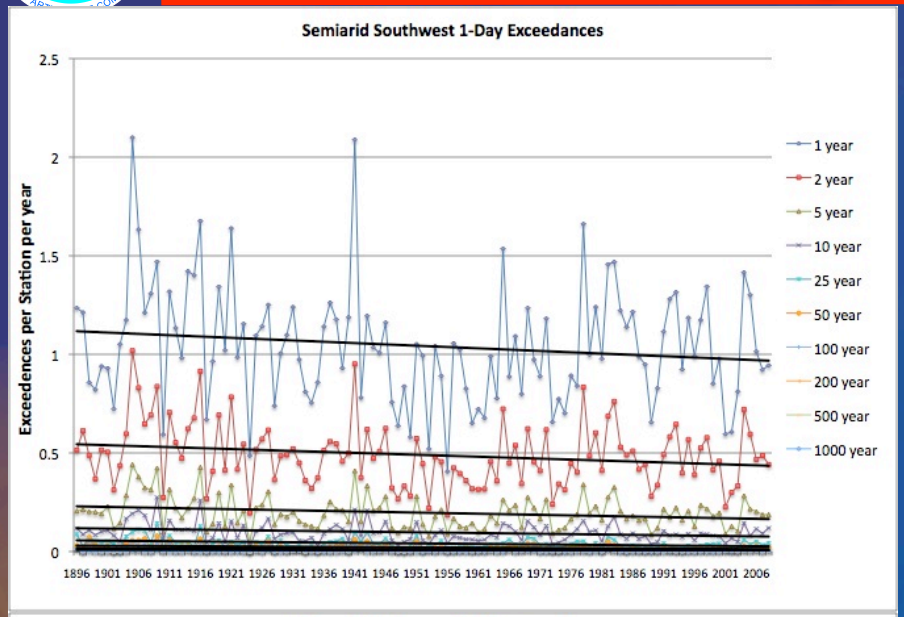
Type of structure	Return period (years)	ELV
Highway culverts		
Low traffic	5–10	–
Intermediate traffic	10–25	–
High traffic	50–100	–
Highway bridges		
Secondary system	10–50	–
Primary system	50–100	–
Farm drainage		
Culverts	5–50	–
Ditches	5–50	–
Urban drainage		
Storm sewers in small cities	2–25	–
Storm sewers in large cities	25–50	–
Airfields		
Low traffic	5–10	–
Intermediate traffic	10–25	–
High traffic	50–100	–
Levees		
On farms	2–50	–
Around cities	50–200	–
Dams with no likelihood of loss of life (low hazard)		
Small dams	50–100	–
Intermediate dams	100+	–
Large dams	–	50–100%
Dams with probable loss of life (significant hazard)		
Small dams	100+	50%
Intermediate dams	–	50–100%
Large dams	–	100%
Dams with high likelihood of considerable loss of life (high hazard)		
Small dams	–	50–100%
Intermediate dams	–	100%
Large dams	–	100%

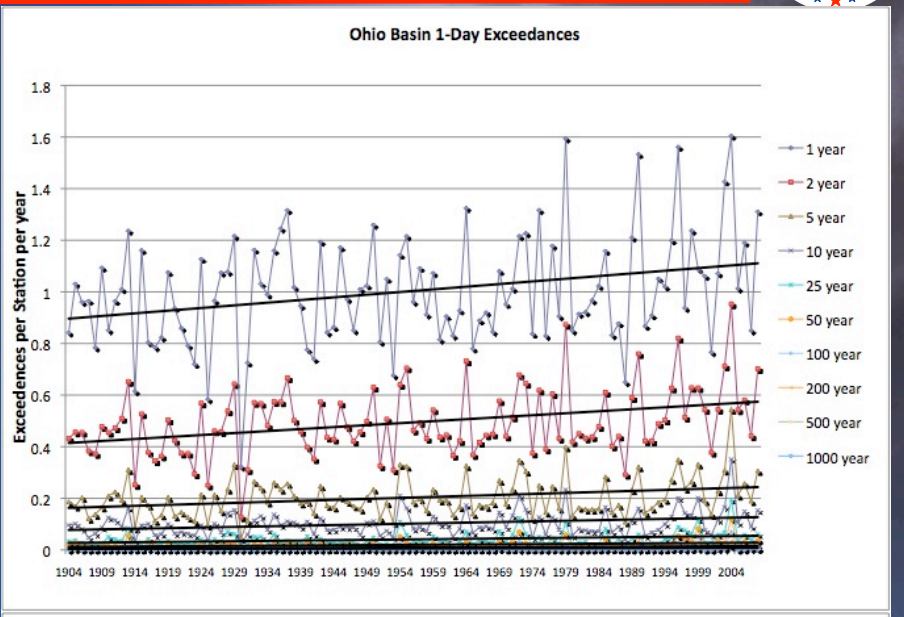
Source: Mays, Water Resources Handbook, McGraw-Hill, 1996.

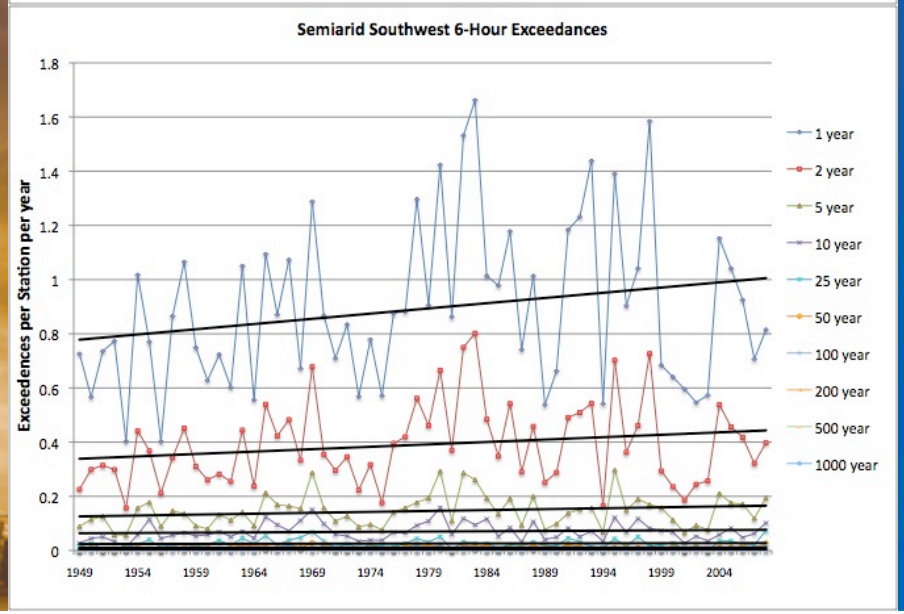
Let's Count Exceedances

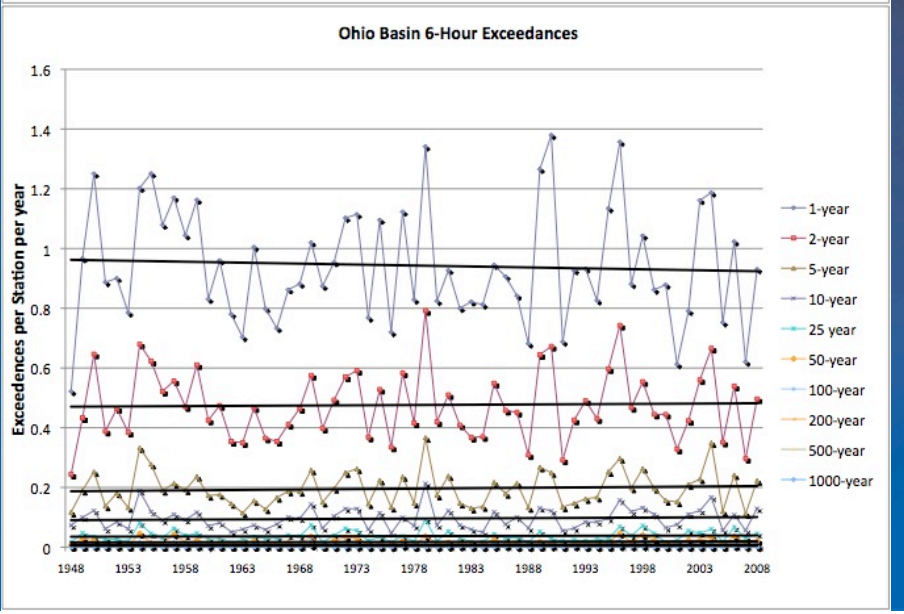
- **Thresholds**
  - *Use actual NOAA Atlas 14 thresholds*
    - Not a fixed value or a percentile of a time series
  - *For:*
    - 1 year – 1,000 year ARI
    - Durations: 6 hours – 45 days
- **Use Partial Duration Series**
  - *Complies with ARI definition*
- **Count Number of Exceedances**
  - *For 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**
- **Show slopes as % of expected mean**

Example Trends

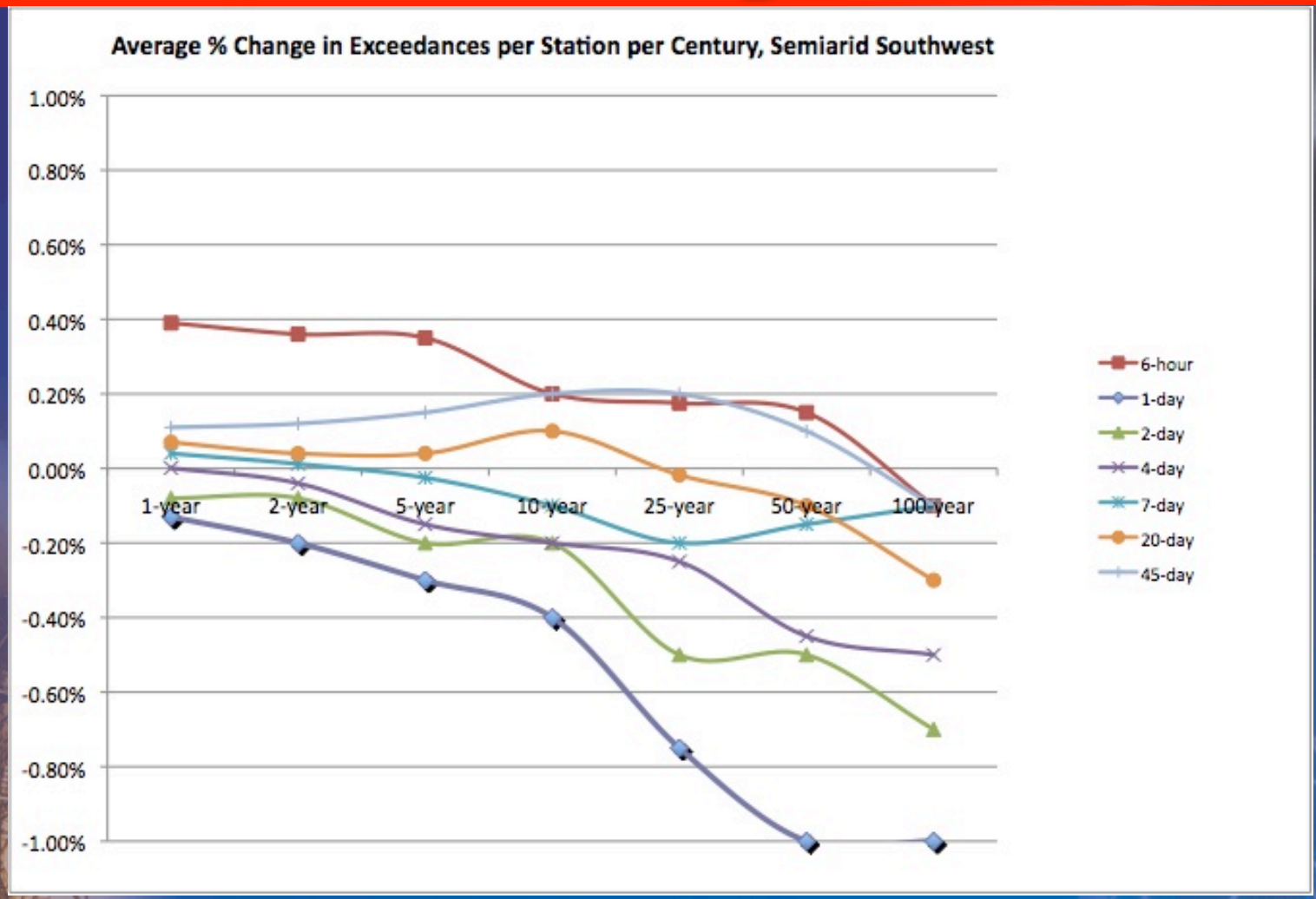






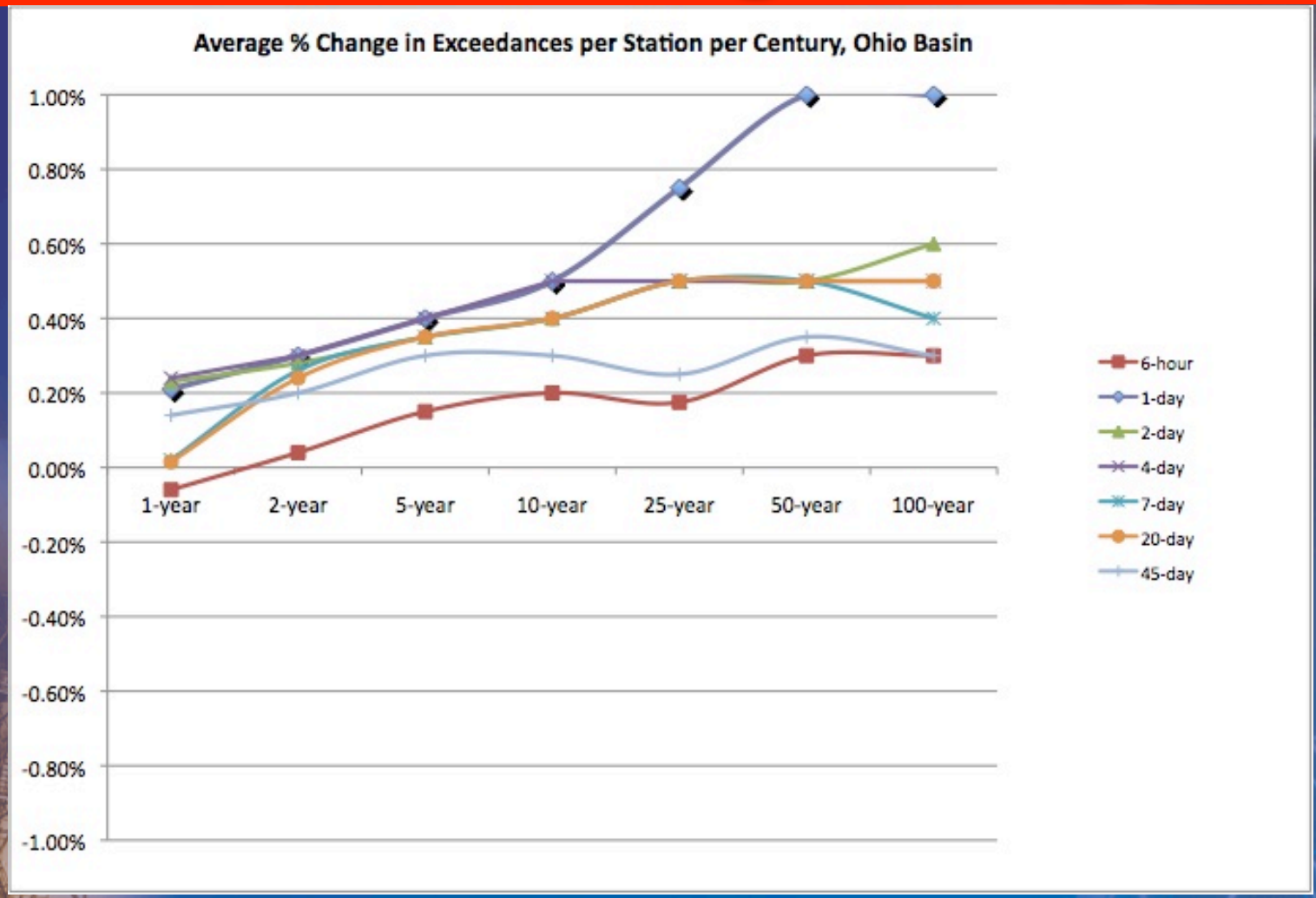


Trends and Significance



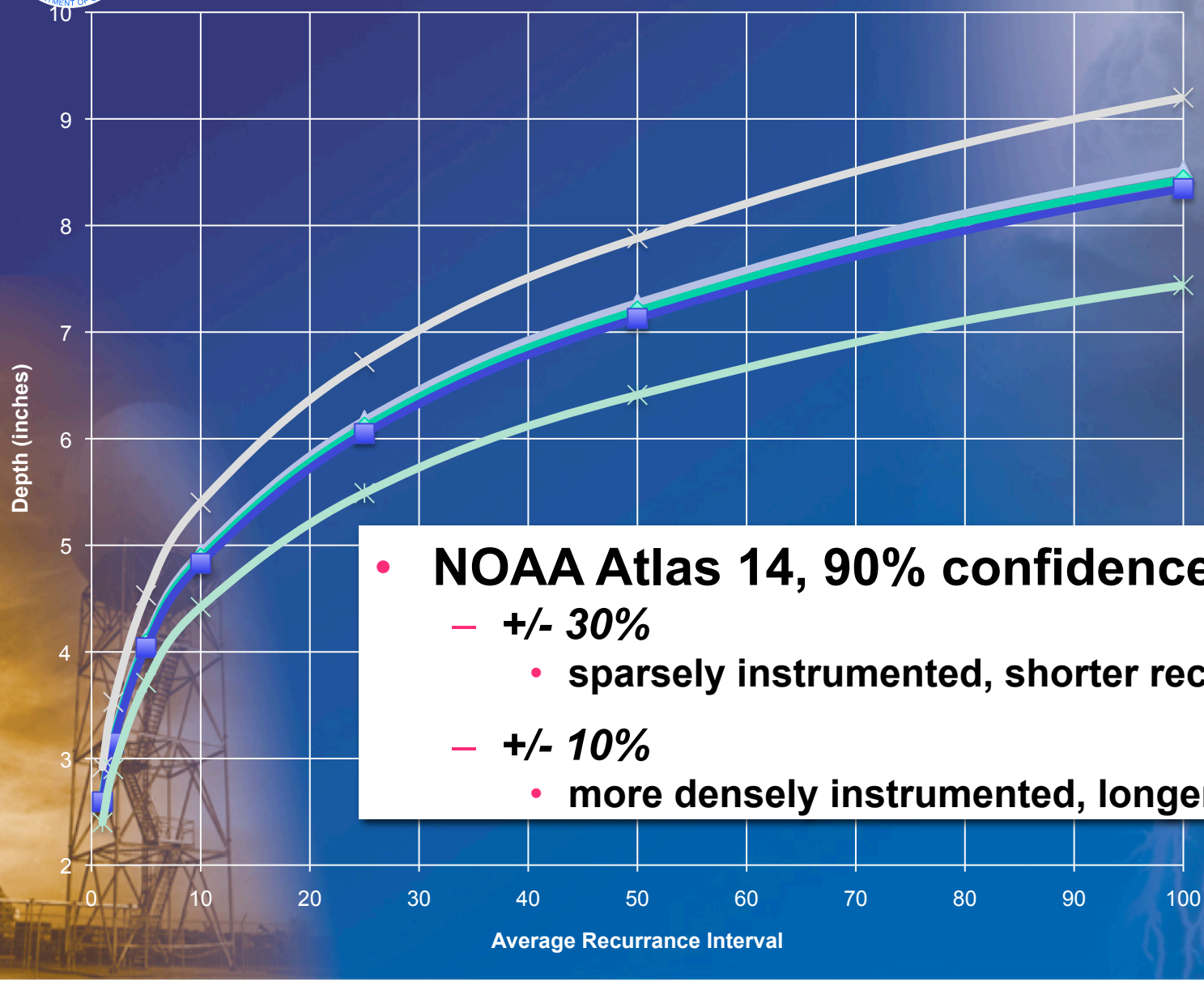
- Generally statistically significant except for 6 hour durations
  - *.05 level, T-test & Mann Kendall*

Trends and Significance

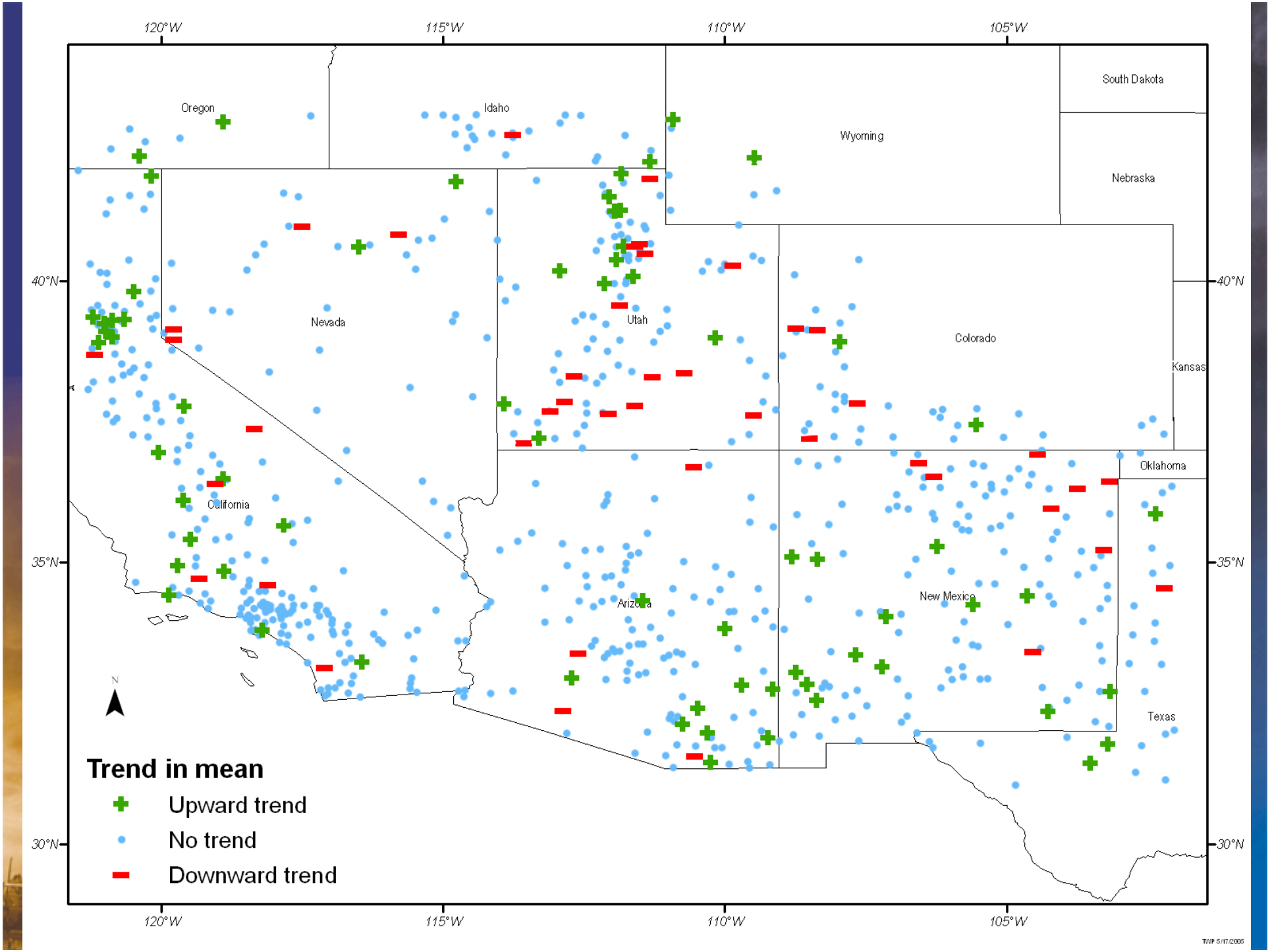


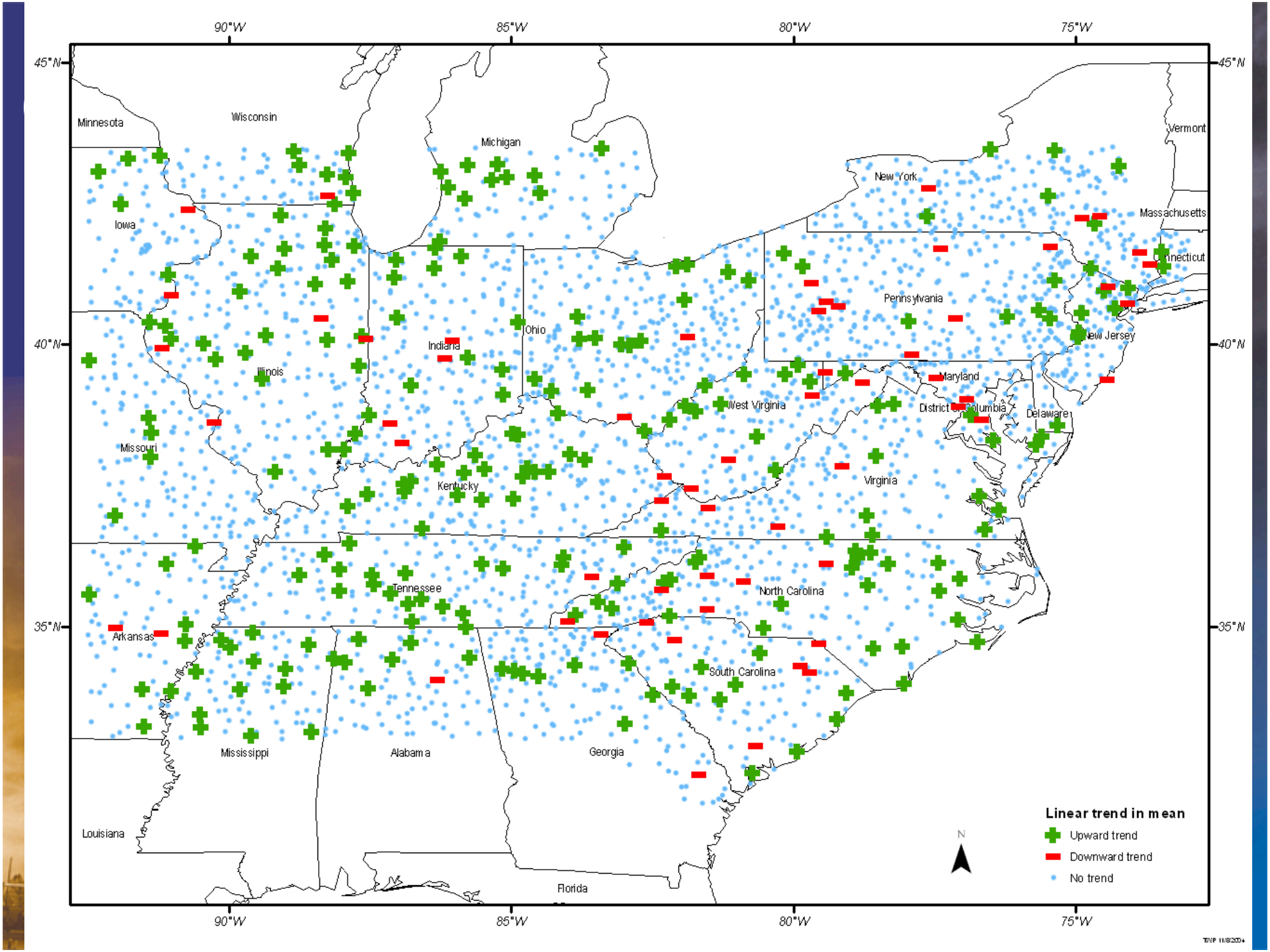
- Generally not statistically significant except for daily durations above 2 yr ARI
  - *.05 level, T-test & Mann Kendall*

Compare with NOAA Atlas 14 Confidence Intervals



- **NOAA Atlas 14, 90% confidence intervals**
  - ***+/- 30%***
    - **sparsely instrumented, shorter record; to**
  - ***+/- 10%***
    - **more densely instrumented, longer record**


120°W
115°W
110°W
105°W
40°N
35°N
30°N
Oregon
Idaho
Wyoming
South Dakota
Nebraska
Nevada
Utah
Colorado
Kansas
Oklahoma
California
Arizona
New Mexico
Texas
N
Trend in mean
Upward trend
No trend
Downward trend
TWP 5/17/2005


90°W
85°W
80°W
75°W
45°N
40°N
35°N
Minnesota
Wisconsin
Michigan
Vermont
New York
Massachusetts
Iowa
Connecticut
Pennsylvania
Ohio
Indiana
New Jersey
Illinois
Maryland
West Virginia
District of Columbia
Delaware
Missouri
Kentucky
Virginia
Tennessee
North Carolina
Arkansas
South Carolina
Mississippi
Alabama
Georgia
Louisiana
Florida
N
Linear trend in mean
Upward trend
Downward trend
No trend

Conclusions

- Climate community statements on trends in rainfall intensity
  - *Do not address frequencies and durations required for civil infrastructure*
- Climate community statements are being misinterpreted
- 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*

Questions