# LET'S ALL CALM DOWN ABOUT CLIMATE CHANGE













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# CLIMATE CHANGE
## MAY 9, 2019
## OHIO STORMWATER CONFERENCE

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# OVERVIEW

- Straight from the Climate Studies
- Period of Record for Precipitation Estimates
- NOAA Atlas 14 Trends
- Uncertainties in Flood Studies
- Impact on Flooding; Climate Change vs. Development
- Recommendations
- Conclusions
- Misleading Reports

# CLIMATE STUDIES

- U.S. Global Change Research Program
  - Climate Science Special Report
  - Fourth National Climate Assessment (2017)
  - NOAA, NASA, USACE, US DOE Office of Science, US EPA, Oak Ridge National Laboratory, Pacific Northwest National Laboratory, >20 Universities

# CLIMATE STUDIES

- “an authoritative assessment of the science of climate change, with a focus on the United States, to serve as the foundation for efforts to assess climate-related risks and inform decision-making about responses”

# CLIMATE SCIENCE SPECIAL REPORT

- Temperature Rise
- Sea Level Rise
- Heavy Rainfall
- Floods
- Hurricanes
- Tornados
- Drought
- Wildfires

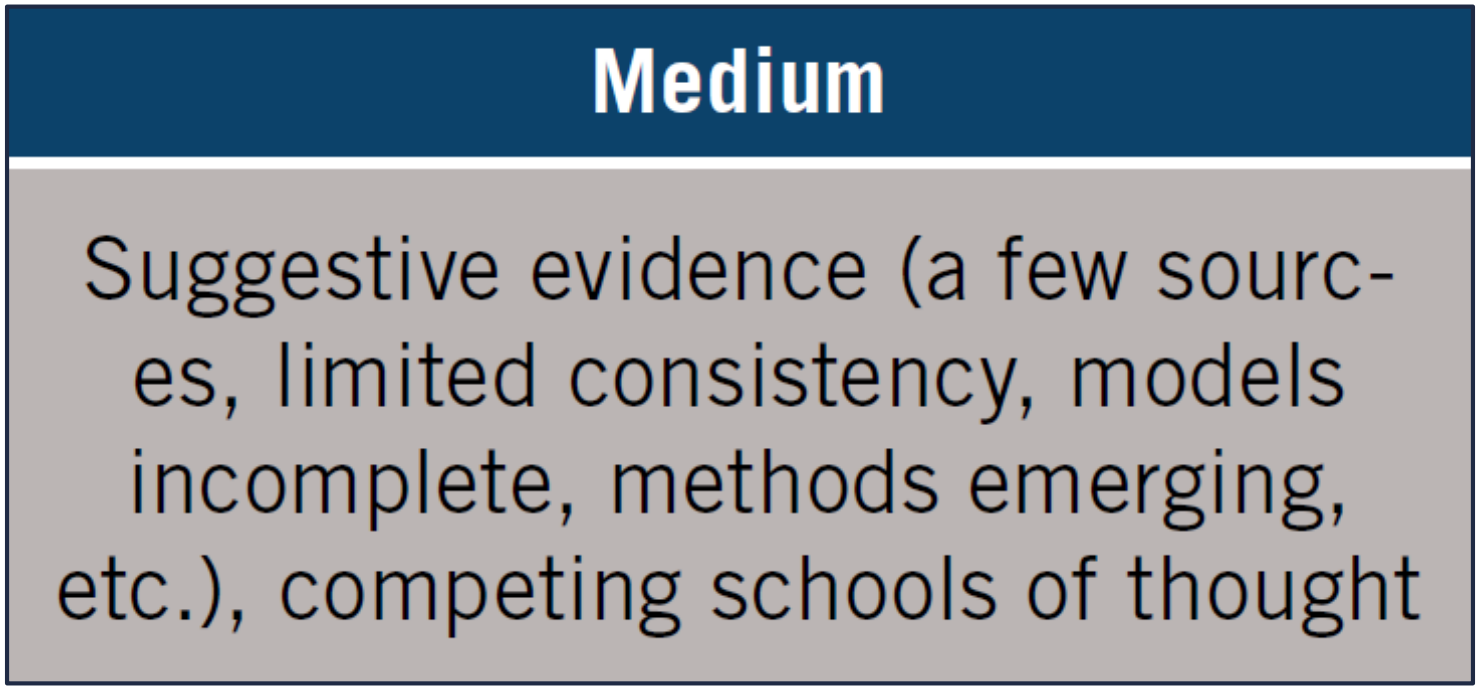
# CLIMATE SCIENCE SPECIAL REPORT

- Low Confidence

| Low |
| --- |
| Inconclusive evidence (limited sources, extrapolations, inconsis-tent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts |

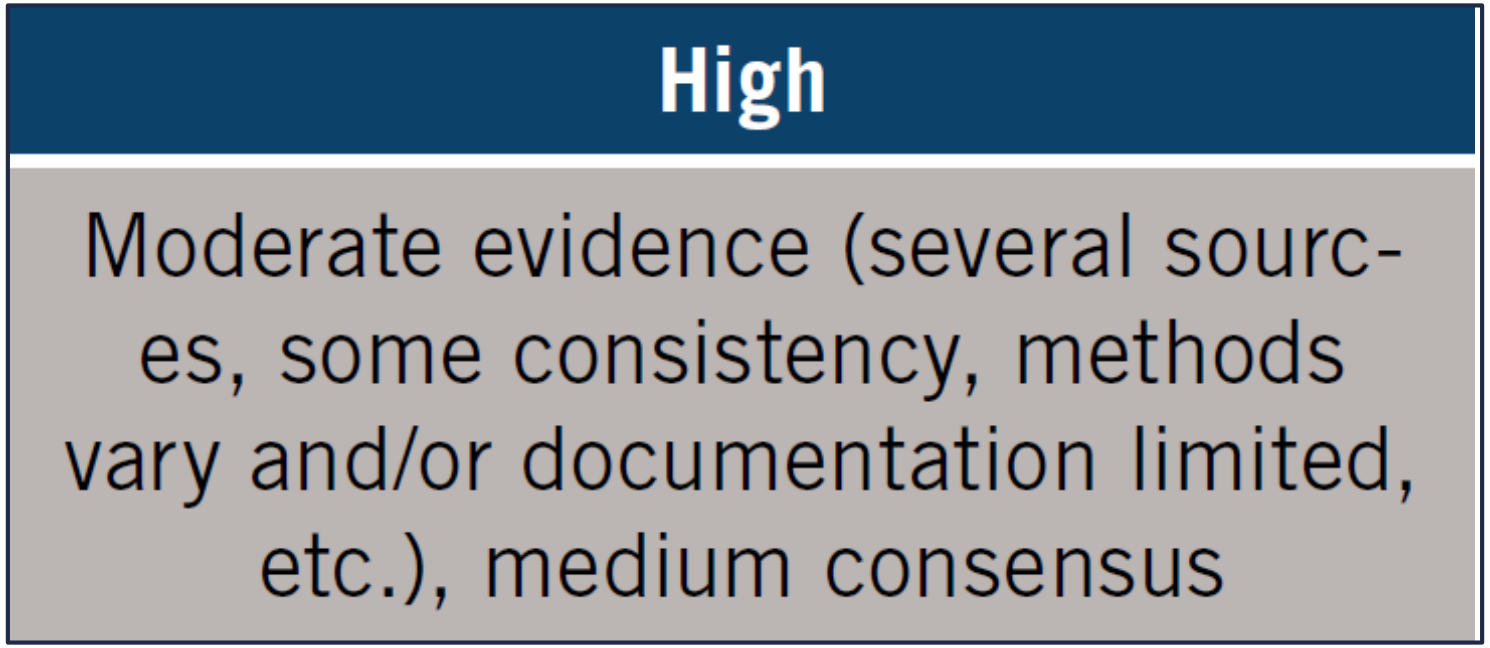
# CLIMATE SCIENCE SPECIAL REPORT

- Medium Confidence



# CLIMATE SCIENCE SPECIAL REPORT

- High Confidence



# CLIMATE SCIENCE SPECIAL REPORT

- Very High Confidence

| Very High |
| --- |
| Strong evidence (established theory, multiple sources, consistent results, well documented and accepted methods, etc.), high consensus |

# MISLEADING TERMS

- Heavy precipitation?
- Very heavy precipitation?
- Extreme precipitation?
- 95$^{th}$ percentile?
- 99$^{th}$ percentile?
- 99.9$^{th}$ percentile?

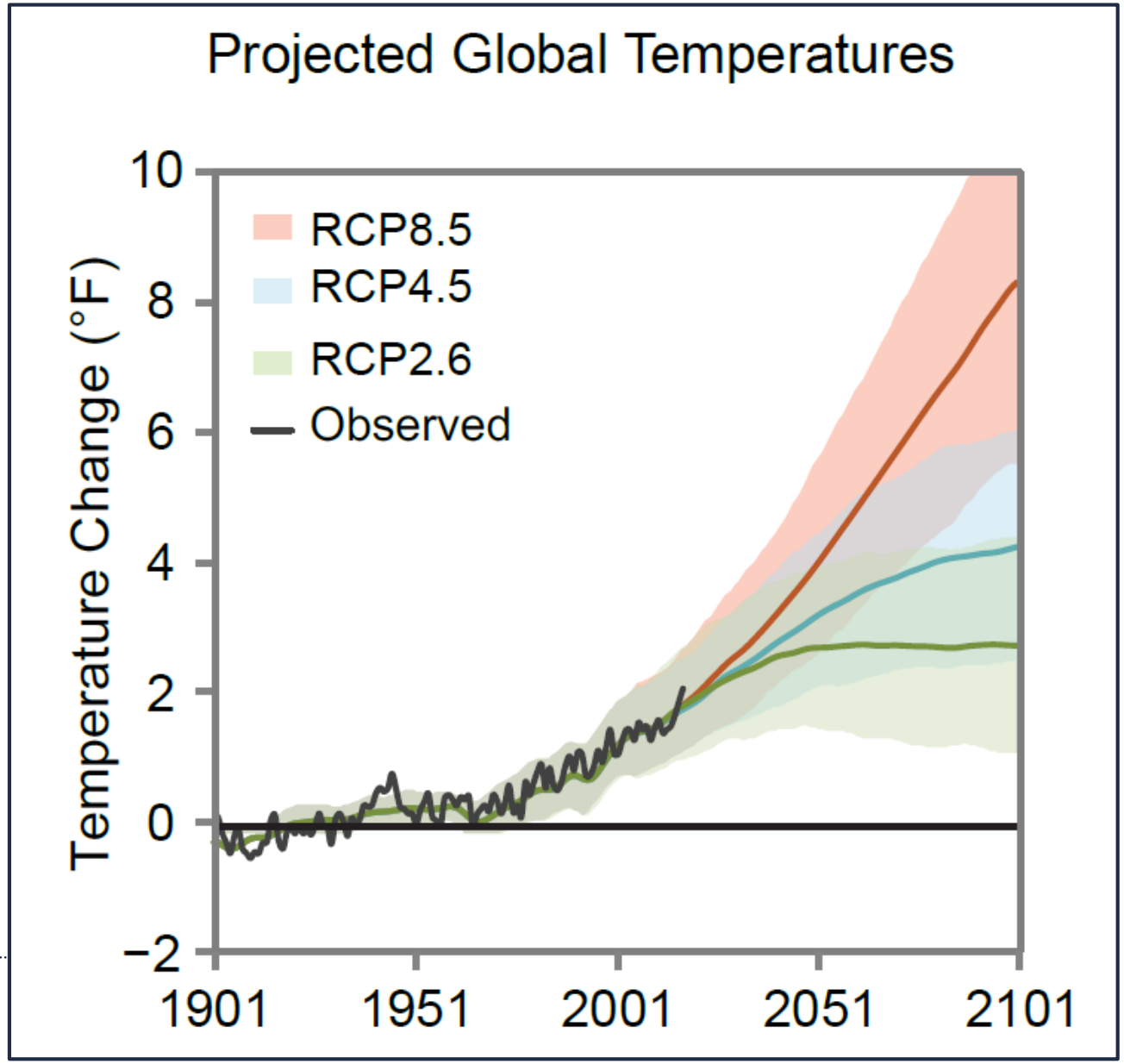
# MISLEADING TERMS

- In Ohio, it rains about 79 days a year
- So it rains about 7,900 days a century
- $95^{th}$ percentile = 3-month storm
- $99^{th}$ percentile = 1-yr storm
- $99.9^{th}$ percentile = 13-yr storm
- $99.99^{th}$ percentile = 100-yr storm

# CLIMATE SCIENCE SPECIAL REPORT

## ***Temperature Rise***

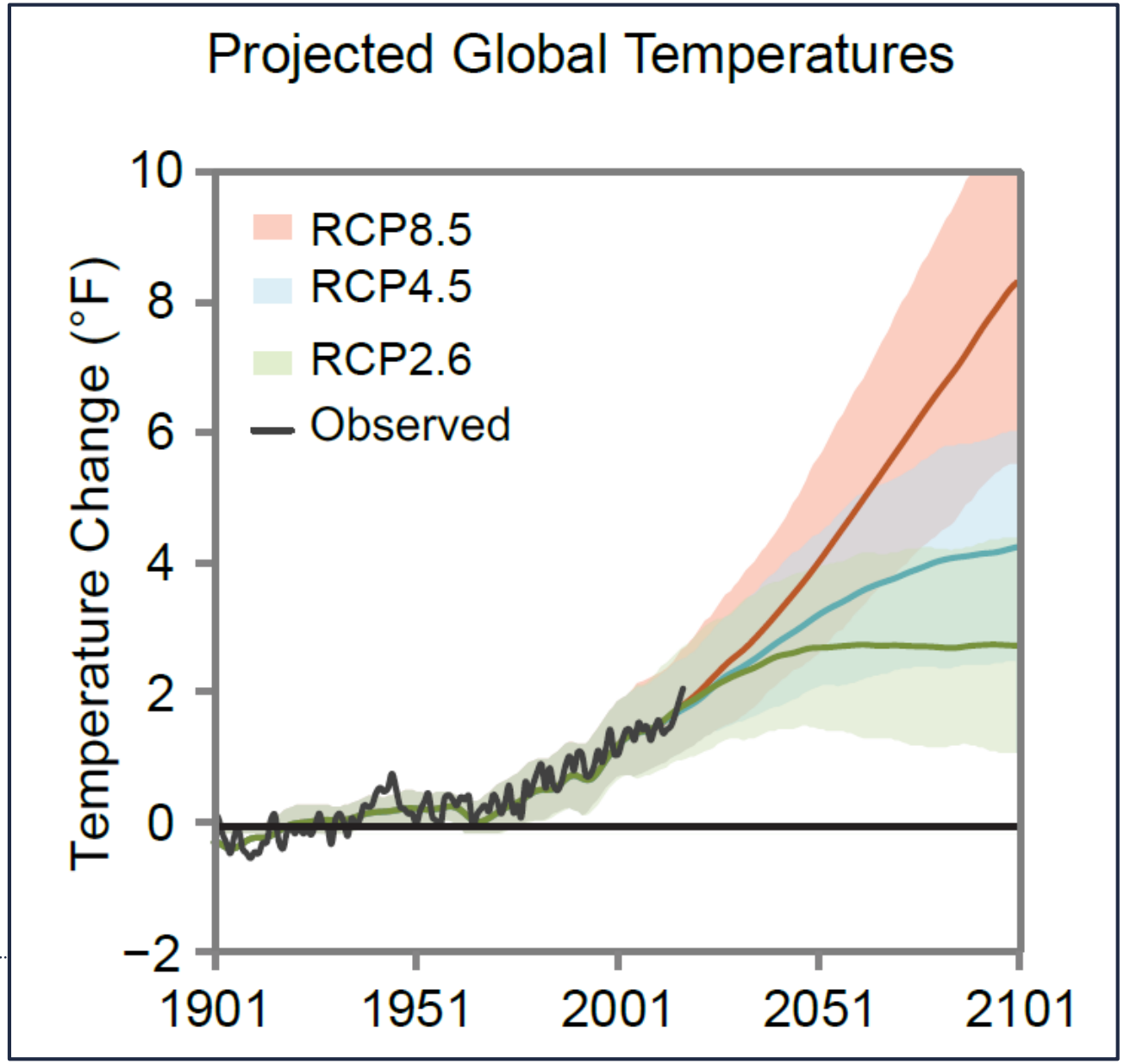
- RCP2.6: substantial reduction in green house gasses soon
- RCP4.5: increase and stabilize around 2100
- RCP8.5: increase green house gasses indefinitely; move nat'l gas back to coal, few tech. improvements



# CLIMATE SCIENCE SPECIAL REPORT

## ***Temperature Rise***

- Temperature has been increasing and is going to keep increasing
- Temperature increased 1.2 - 1.8˚F in the last 115 years
- Temperature will increase 1-6˚F by 2100
- Dust Bowl 1930s still most extreme heat period in US



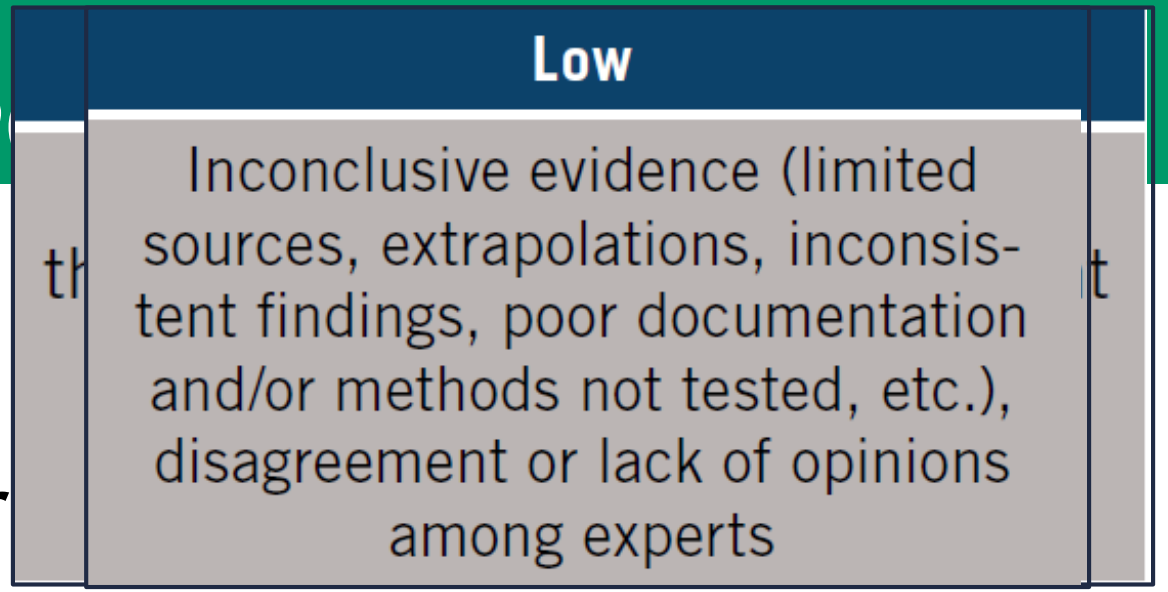
# CLIMATE SCIENCE SPECIAL REPORT

Image: YouTube

## ***Sea Level Rise***

- "Global mean sea level (GMSL) has risen by about 7-8 inches since 1900"
- "Global average sea levels are expected to continue to rise – by at least several inches in the next 15 years and by 1-4 feet by 2100. A rise of as much as 8 feet by 2100 cannot be ruled out."
- "Regardless of pathway, it is *extremely likely* that GMSL rise will continue beyond 2100."

# CLIMATE SCIENCE SPECIAL REP




***Sea Level Rise***

- From 2000, sea level will r
- Very high confidence in lower bound (1.0 ft)
- Low confidence in upper bound (4.3)
- “a GMSL rise exceeding 8 feet (2.4m) by 2100 is physically possible, although the probability of such an extreme outcome cannot be assessed.”



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# CLIMATE SCIENCE SPECIAL REPORT

## ***Sea Level Rise***

- More coastal flooding expected
- Scenarios have little impact

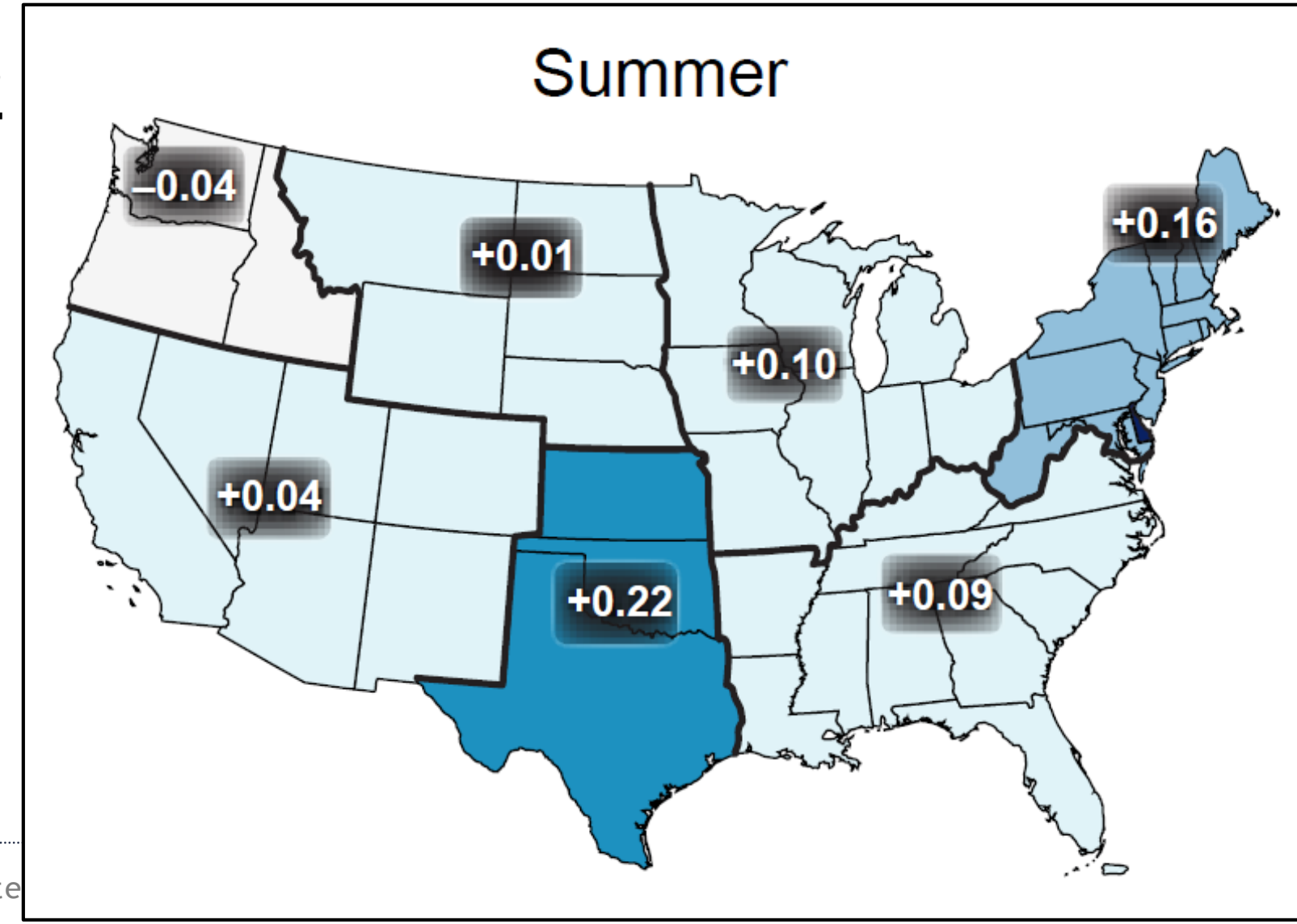
## ***Sea Level Rise - Recap***

- Average sea levels are expected to rise at approximately the same rate as in the past, or they may accelerate, but there is inconclusive evidence and inconsistent findings with poor documentation on which experts disagree about the acceleration part.
- Also, we threw in an 8 foot rise for impact, even though we don't even have confidence in a 4 foot rise and we stated that it's just "physically possible."

# CLIMATE SCIENCE SPECIAL REPORT

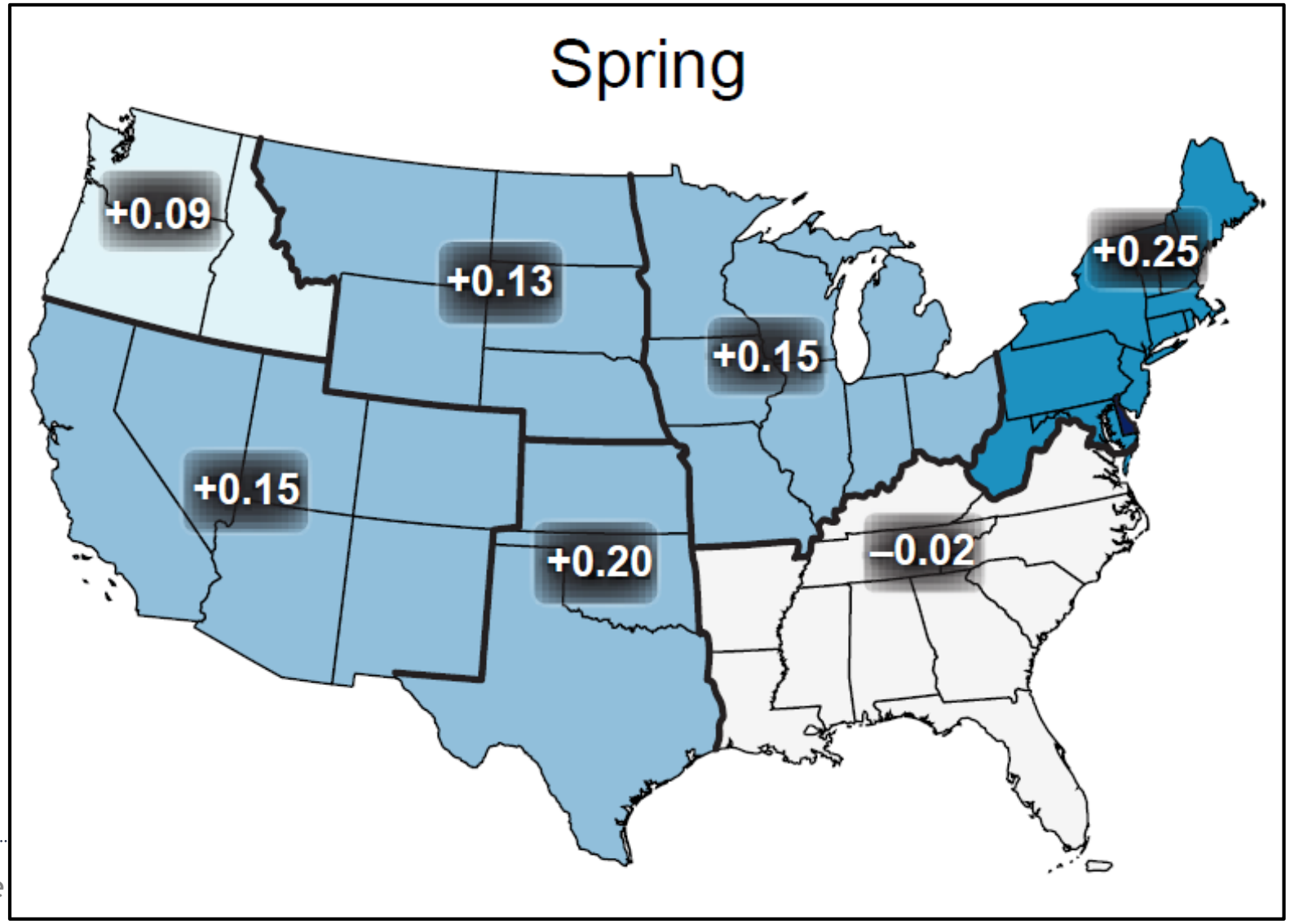
## ***Heavy Precipitation***

- Observed changes from 1948-2015
- 20-yr, 24-hr precip.
- Ohio: + 0.10 in
- Columbus 25-yr, 24-hr event = 4.44 in
- ~2% increase



## ***Heavy Precipitation***

- Observed changes from 1948-2015
- 20-yr, 24-hr precip.
- Ohio: + 0.15 in
- Columbus 25-yr, 24-hr event = 4.44 in
- ~3% increase



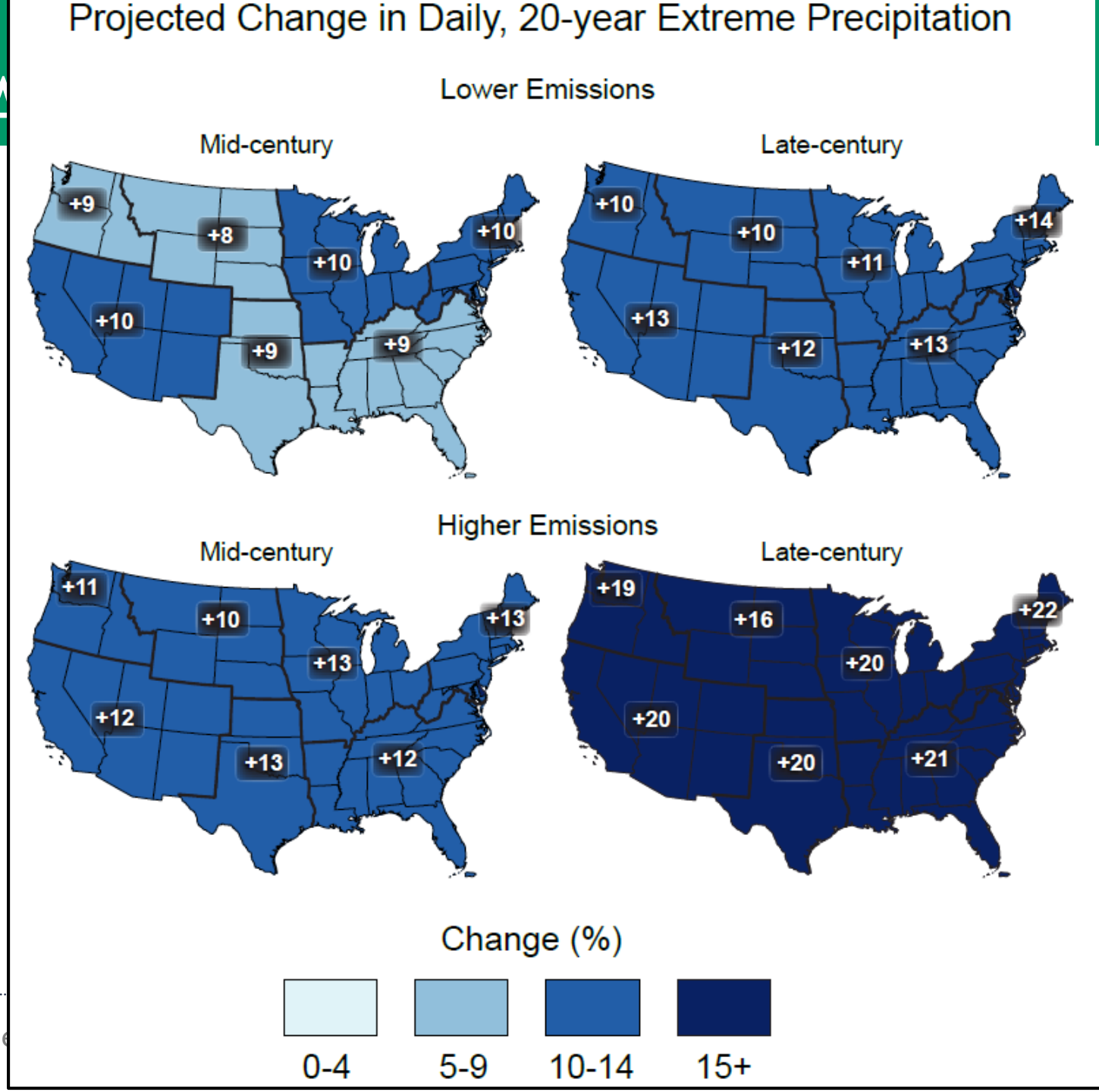
## ***Heavy Precipitation***

- Clausius-Clapeyron Relation
- The water holding capacity of the atmosphere increases 6-7% for every 1°C rise in temperature

# CLIMATE SCIENCE SPECIA

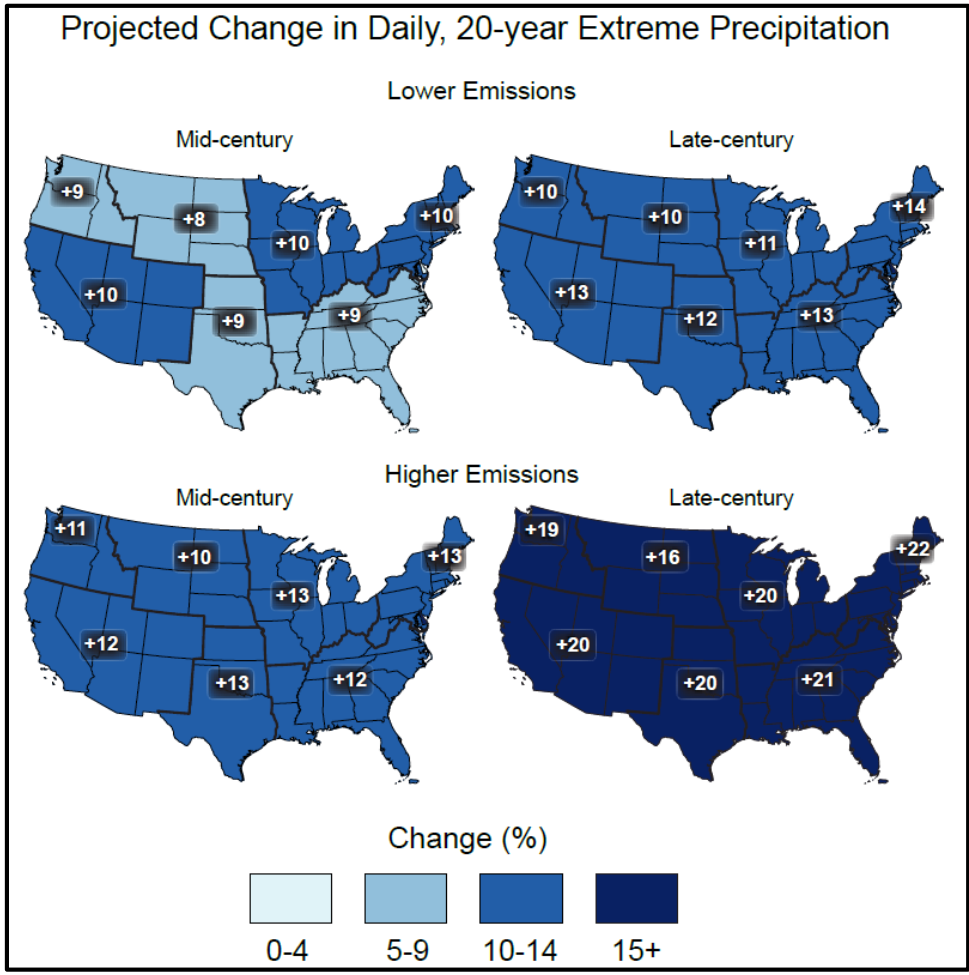
## ***Heavy Precipitation***

- Ohio: 10-20% increase in 20-yr, 24-hr event
- Closely matches water holding relation



## ***Heavy Precipitation***

- Climate modeling historical 20-yr value = 2.37 in
- NOAA Atlas 14 values:
  - 1-yr, 24hr = 2.20 in  2-yr, 24hr = 2.63 in
  - 5-yr, 24hr = 3.24 in  10-yr, 24hr = 3.74 in
  - 25-yr, 24hr = 4.44 in  100-yr, 24hr = 5.64in
- Climate model 20-yr closer to NOAA 1-yr



## ***Heavy Precipitation***

- "trends identified for the U.S. regions have not been clearly attributed to anthropogenic forcing."
- "it is concluded that for the continental United States there is *high confidence* in the detection of extreme precipitation increases, while there is *low confidence* in attributing the extreme precipitation changes purely to anthropogenic forcing"
- "confidence is *low* based on those studies alone due to the short observational period, high natural variability, and model uncertainty."

## ***Heavy Precipitation***

- "Simulation of present and future summer precipitation remains a significant challenge, as current convective parameterizations fail to properly represent the statistics of mesoscale convective systems."
- "Most global climate models lack sufficient resolution to project changes in mesoscale convective systems (MCSs) in a changing climate" (MCSs account for 74% of extreme rain events.)

Image: noaa.gov

## ***Heavy Precipitation – Recap:***

- The climate models are bad at simulating extreme rain and we don't have any confidence that any current changes are affected by human actions, but we're pretty sure it's going to keep getting warmer, so there should be more water vapor in the air.
- Also, we're showing a 10% - 20% increase in the 20-year event by 2100, but the models are not validated for historical precipitation, and values are more consistent with lower frequency storms instead of 20-year events.

# CLIMATE SCIENCE SPECIAL REPORT

## ***Floods***

- No change trends in flooding magnitude, duration, or frequency detected
- Some stream gauges show increasing, some decreasing flood magnitude
- Those changes not attributed to human-caused climate change
- Deforestation, urbanization, dams, floodwater management, and changes in agricultural practices have a big impact

Image: whio.com



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# CLIMATE SCIENCE SPECIAL REPORT

## ***Floods***

- "The IPCC AR5 did not attribute changes in flooding to anthropogenic influence nor report detectable changes in flooding magnitude, duration, or frequency. Trends in extreme high values of streamflow are mixed across the United States."
- "no formal attribution of observed flooding changes to anthropogenic forcing has been claimed."

# CLIMATE SCIENCE SPECIAL REPORT

**Medium**

Suggestive evidence (a few sources, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought

## ***Floods***

- "Given the connection between extreme precipitation and flooding, and the complexities of other relevant factors, we concur with the IPCC Special Report on Extremes (SREX) assessment of medium confidence (based on physical reasoning) that projected increases in heavy rainfall would contribute to increases in local flooding in some catchments or regions."

## ***Floods – Recap:***

- We can't say that humans are having an impact on flooding through climate change, or that flooding is getting worse based on climate change projections, but we're pretty sure it's getting warmer, so there should be more water vapor in the air, so *if* it rains more, *some* local areas *might* see increases to flooding.


Image: gettyimages.com

# CLIMATE SCIENCE SPECIAL REPORT

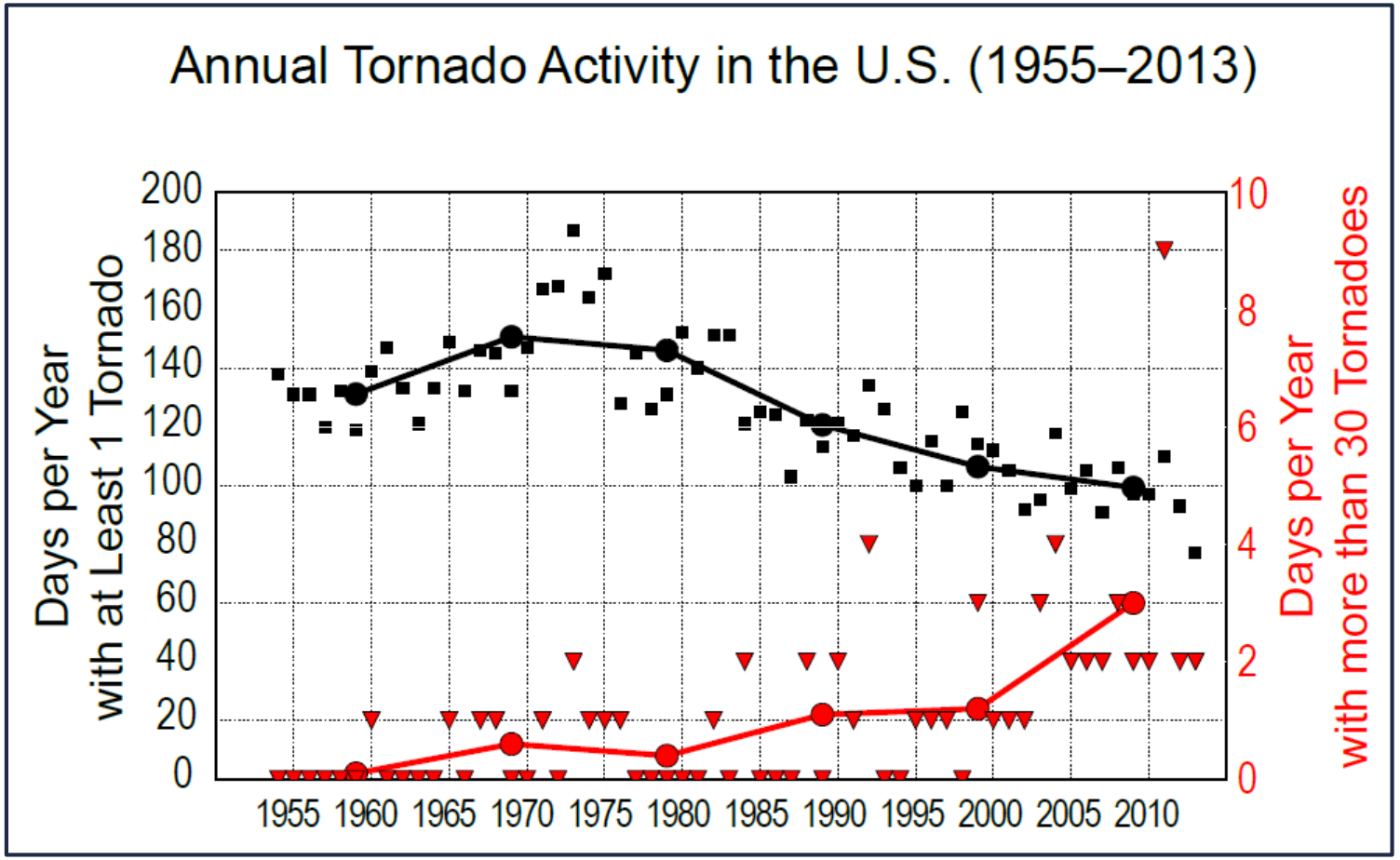
Image: tampabay.com

## ***Hurricanes***

- No observable increasing trends in historical hurricane activity
- It is more likely than not that the global frequency of occurrence of hurricanes will either decrease or remain the same.
- “projections show a reduced occurrence frequency over U.S. land, indicating uncertainty about future outcomes.”
- “it remains likely that global mean tropical cyclone maximum wind speeds and precipitation rates will increase”
- “Confidence in projected increases in the frequency of very intense TCs is generally lower (*medium* in eastern North Pacific and *low* in the Western North Pacific and Atlantic)”

## ***Tornados***

- # of days with tornados decreasing
- # of days with +30 tornadoes increasing
- Low confidence in any future projections of increasing intensity



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# CLIMATE SCIENCE SPECIAL REPORT

Image: time.com

## ***Drought***

- 1930s Dust Bowl era benchmark for extreme heat and drought in US
- Little evidence is found for human influence on precipitation reductions in Southwest US
- “there has not yet been a formal identification of human influence on past changes in United States meteorological drought”
- “While human influence on surface soil moisture trends has been identified with *medium confidence*, its relevance to agriculture may be exaggerated.”

# CLIMATE SCIENCE SPECIAL REPORT

Image: insideclimate news.org

## ***Wildfire***

- "State-level fire data over the 20th century indicates that area burned in the western United States decreased from 1916 to about 1940, was at low levels until the 1970s, then increased into the more recent period."
- "Both anthropogenic climate change and the legacy of land use / management have influence on U.S. wildfires and are subtly and inextricably intertwined. Forest management practices have resulted in higher fuel density in most U.S. forests"

# CLIMATE SCIENCE SPECIAL REPORT

## ***Wildfire***

- There is “low to medium confidence for a detectable human climate change contribution in the western United States based on existing studies.”

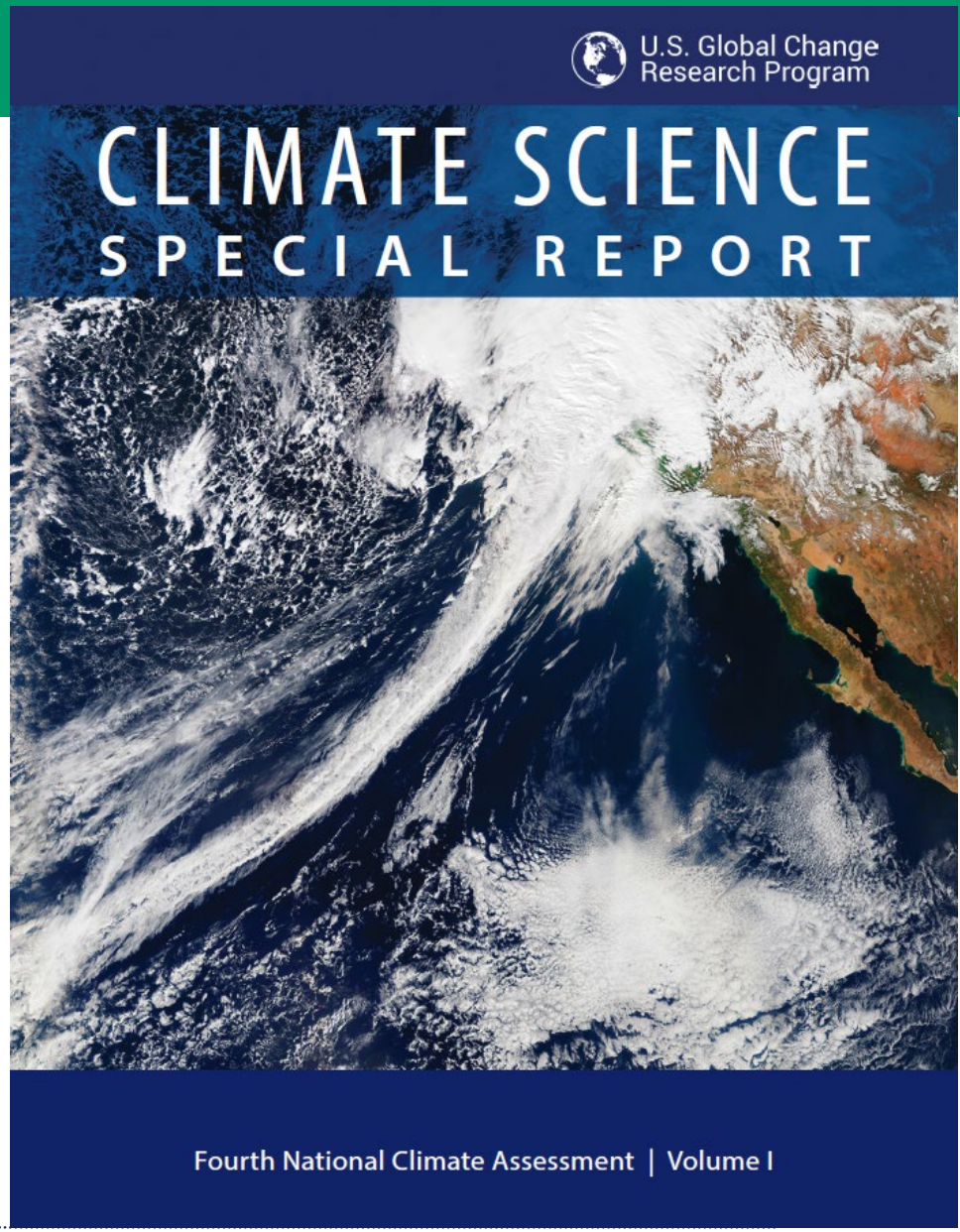
| Low | Medium |
| --- | --- |
| Inconclusive evidence (limited sources, extrapolations, inconsis-tent findings, poor documentation and/or methods not tested, etc.), disagreement or lack of opinions among experts | Suggestive evidence (a few sourc-es, limited consistency, models incomplete, methods emerging, etc.), competing schools of thought |

## ***Wildfire – Recap:***

- We know that wildfires have been getting worse in the U.S since the 1970s and 1980s and that forest management has contributed to that. We know that drought makes wildfires more likely, but the worst droughts in the U.S. were in the 1930s and we don't think rainfall droughts are caused by human-caused climate change. But we're pretty sure it's getting warmer, so that might make wildfires worse. Our confidence that climate change is affecting wildfires is somewhere between zero and incomplete models with competing schools of thought.

# CLIMATE SCIENCE SPECIAL REPORT

- Temperature has been rising, and will probably keep rising
- Sea level has been rising, and will probably keep rising
- Precipitation is increasing, but it's unclear how much, especially for flood-causing events, and not attributed to humans.
- No confident projections in changes to hurricanes, tornados, droughts, floods, or wildfires due to climate change



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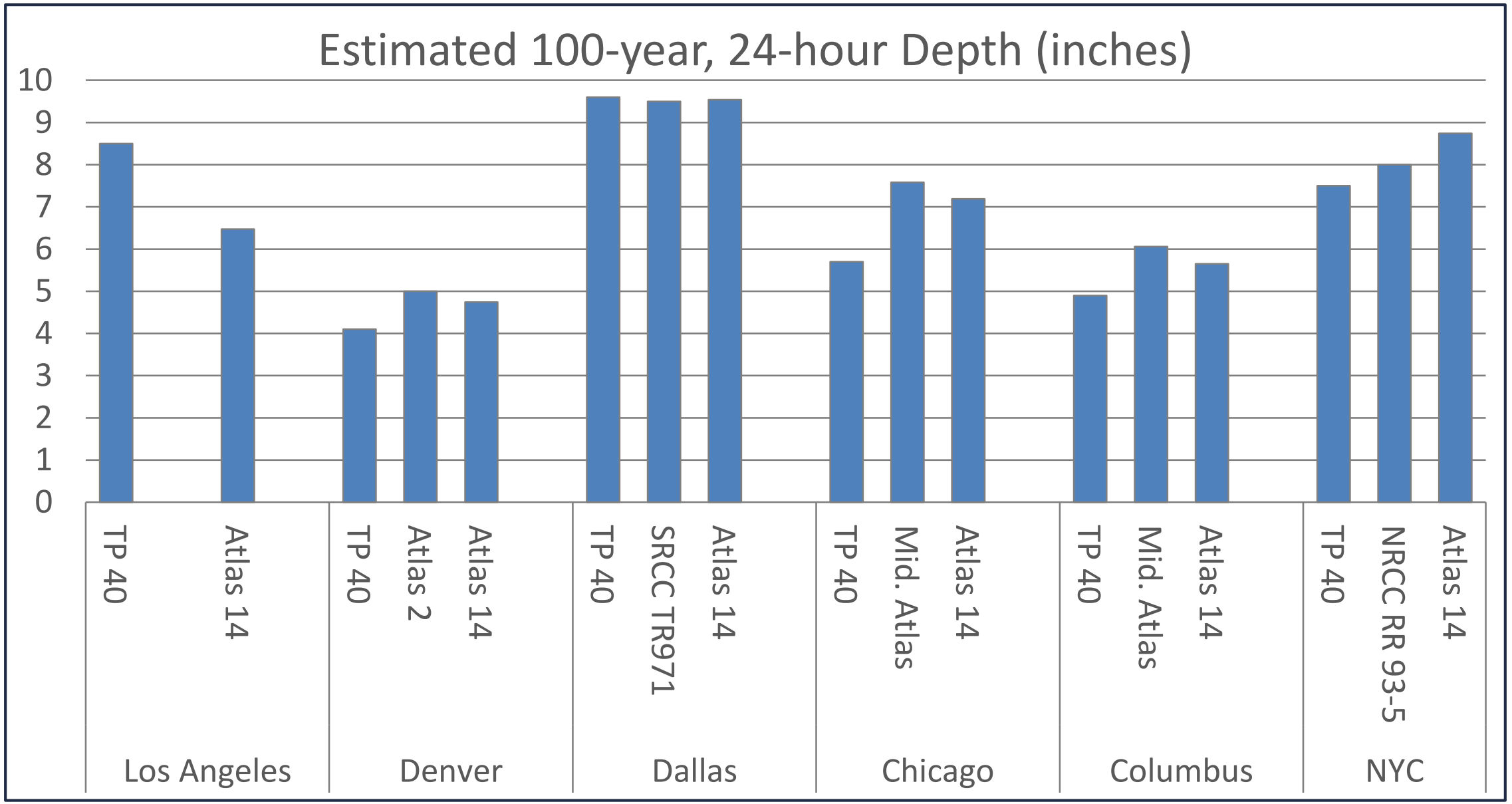
# NATIONAL PRECIPITATION STUDIES


***How much data?***

- 1961 Technical Paper 40 – 14 years
- 1973 NOAA Atlas 2 (West) – 26 years
- 1992 ISWS Bulletin 71 (Midwest) – 45 years
- 1993 NRCC Pub. RR 93-5 (Northeast) – 46 years
- 1997 SRCC Tech. Report 971 (South-Central) – 50 yrs
- 2006-Present NOAA Atlas 14 – 59 – 69 years

# CHANGING DESIGN STORMS OVER TIME



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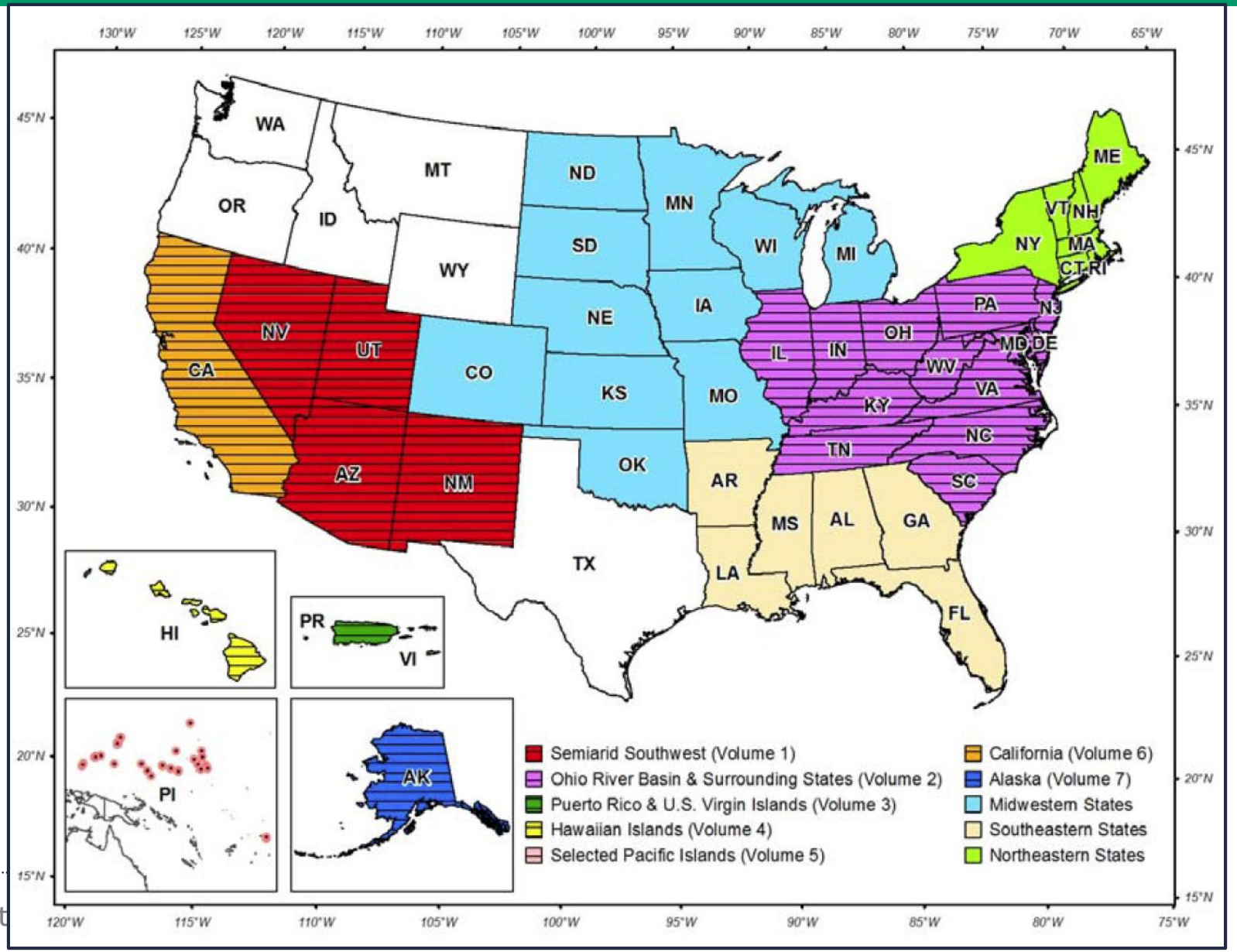
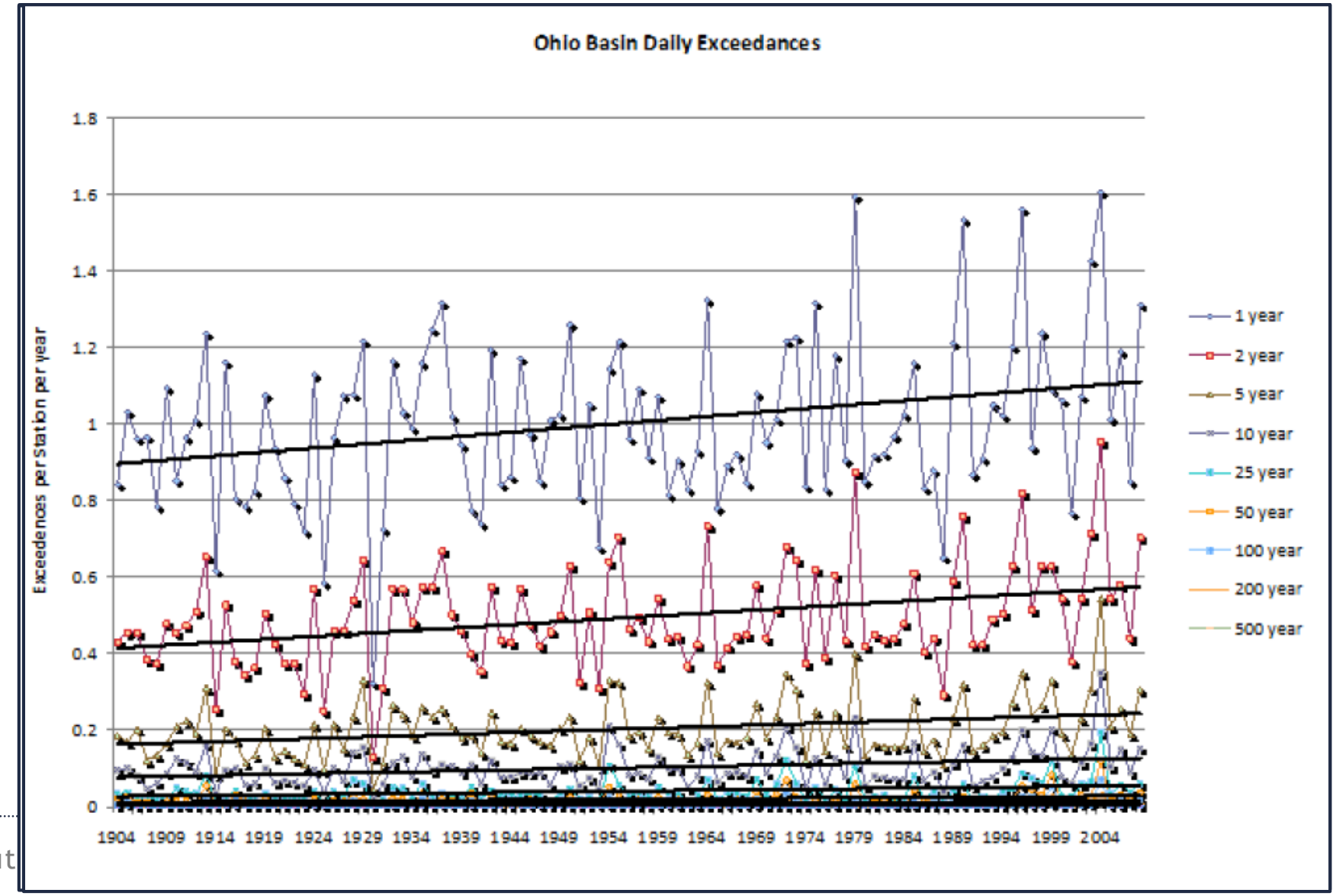
# NOAA ATLAS 14 – TRENDS

- Trends in design storms over 100 years
- Ohio Basin
- Semiarid Southwest



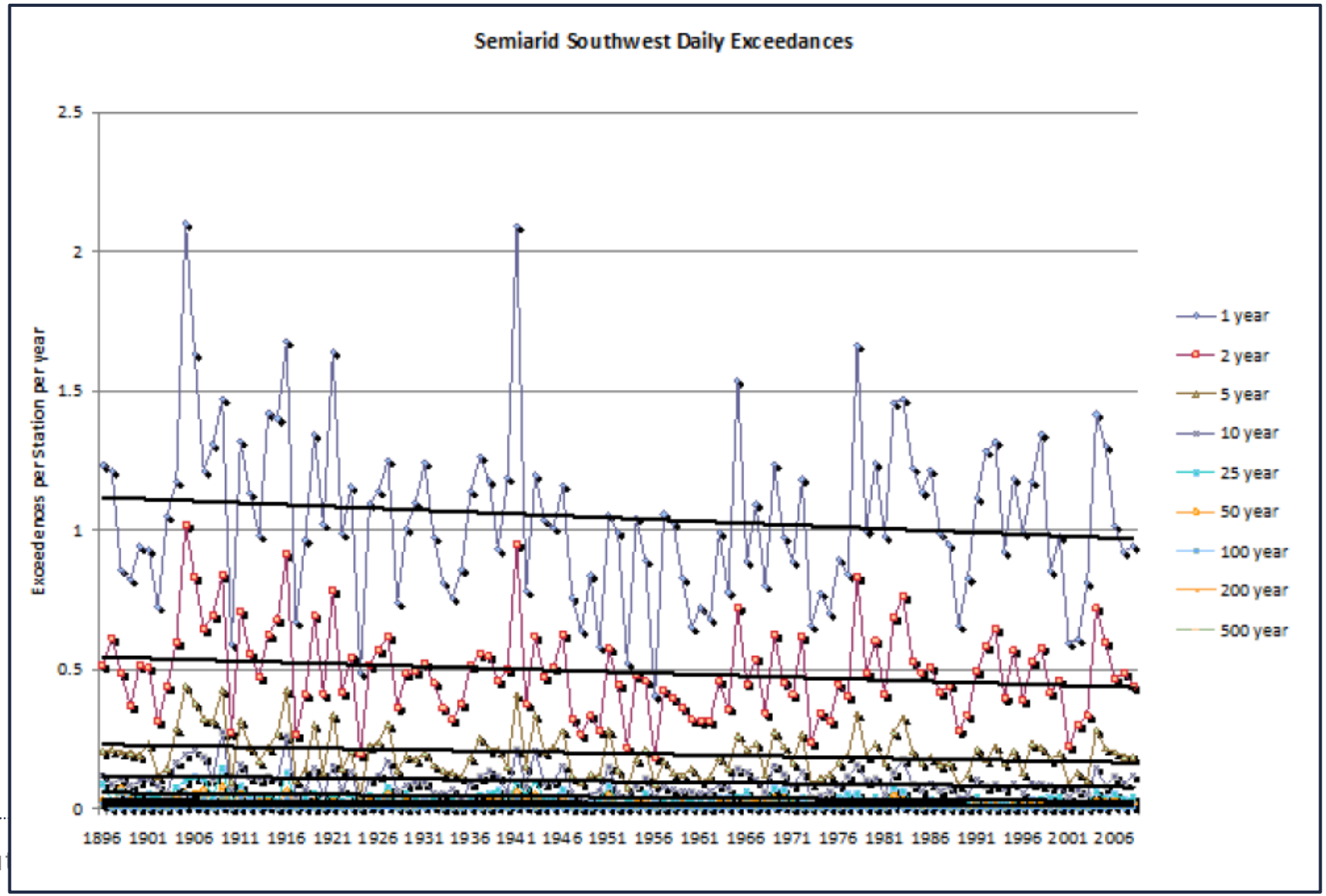
# NOAA ATLAS 14 - TRENDS

- Ohio Basin trends
- Increasing



# NOAA ATLAS 14 - TRENDS

- Southwest trends
- Decreasing



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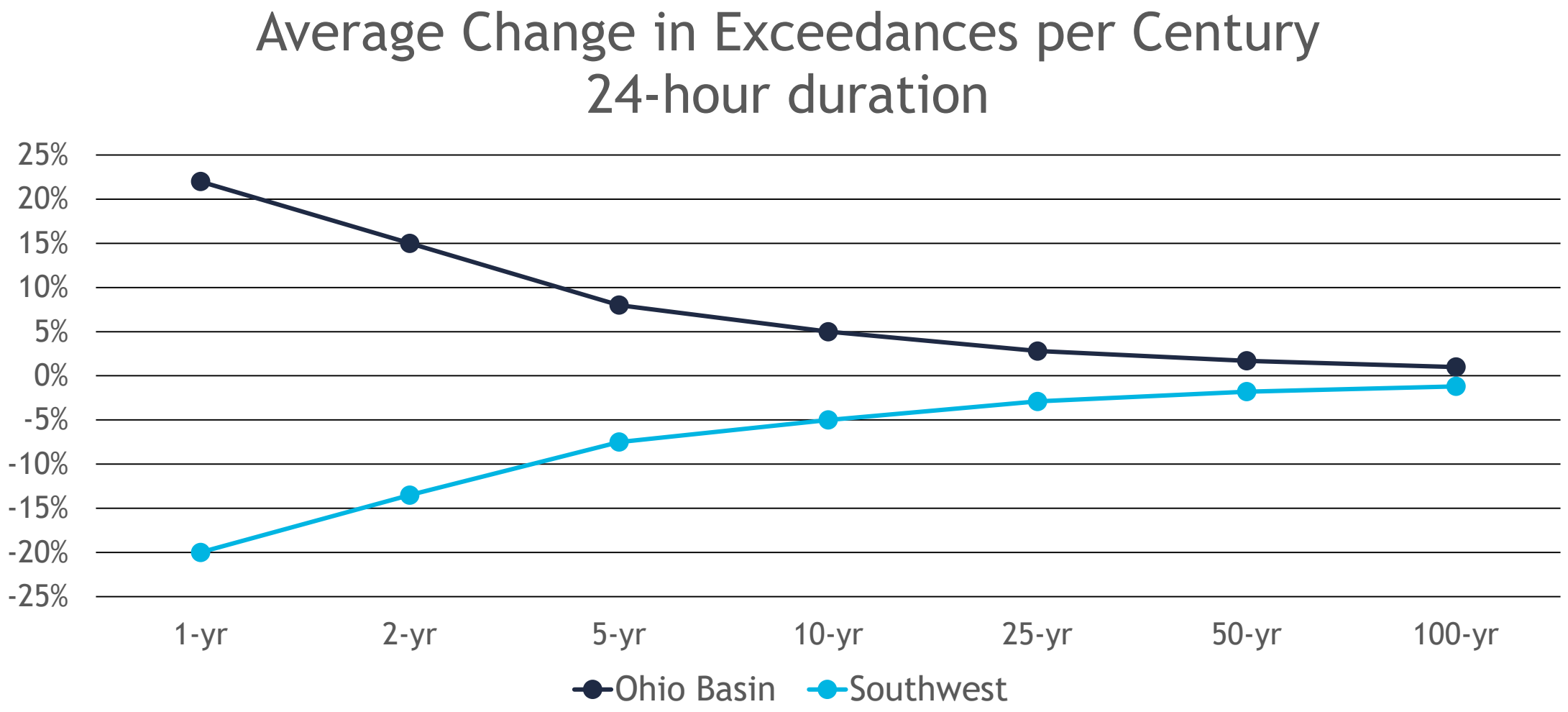
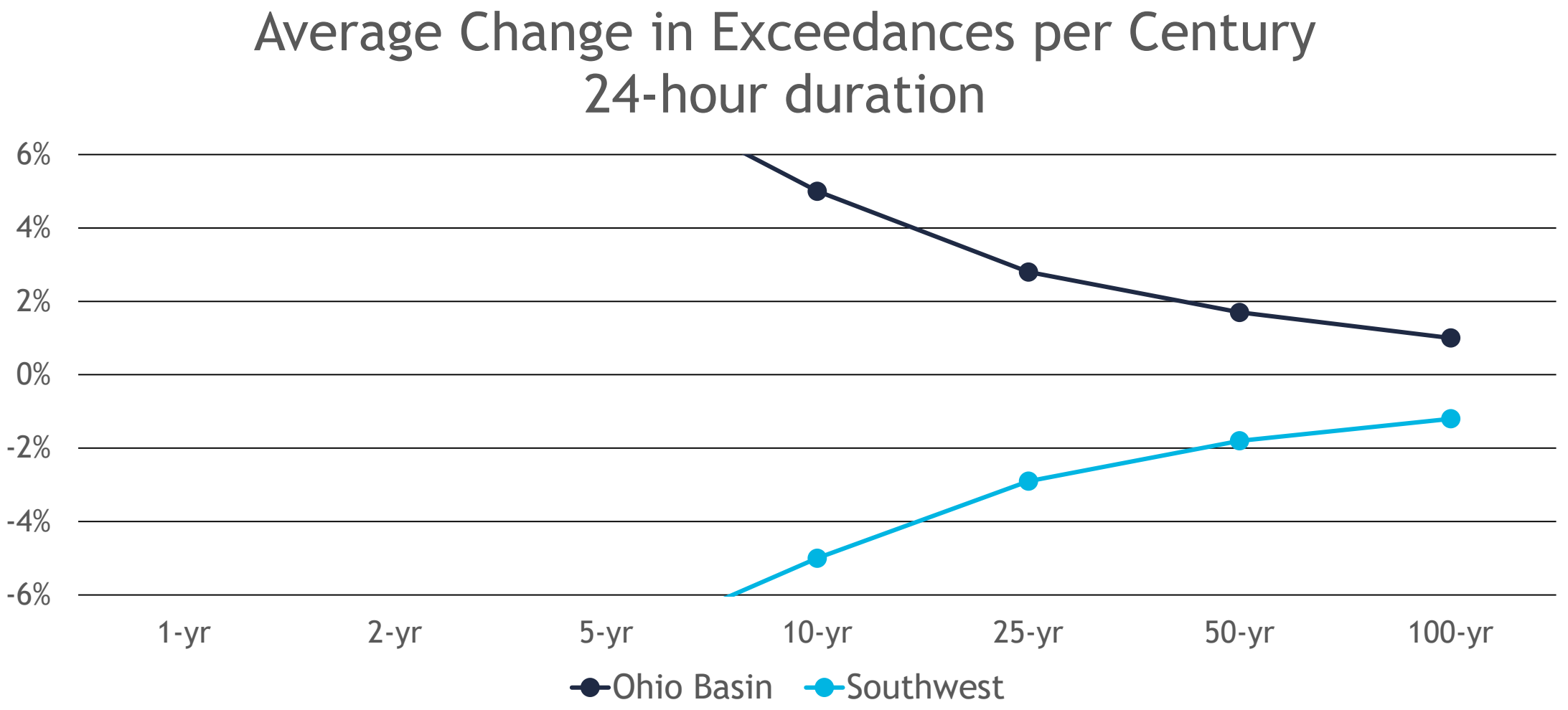


# NOAA ATLAS 14 – TRENDS



# NOAA ATLAS 14 – TRENDS

- Atlas 14, Ohio: 25-yr, 24-hr increase ~ 3%
- Climate Science Special Report, Ohio: 20-yr, 24-hr increase ~ 2-3%
- Both using NOAA data, results consistent
- Atlas 14, Ohio: 100-yr, 24-hr increase 1%
- NOAA assumed stationarity for Atlas 14 (No Climate Change)

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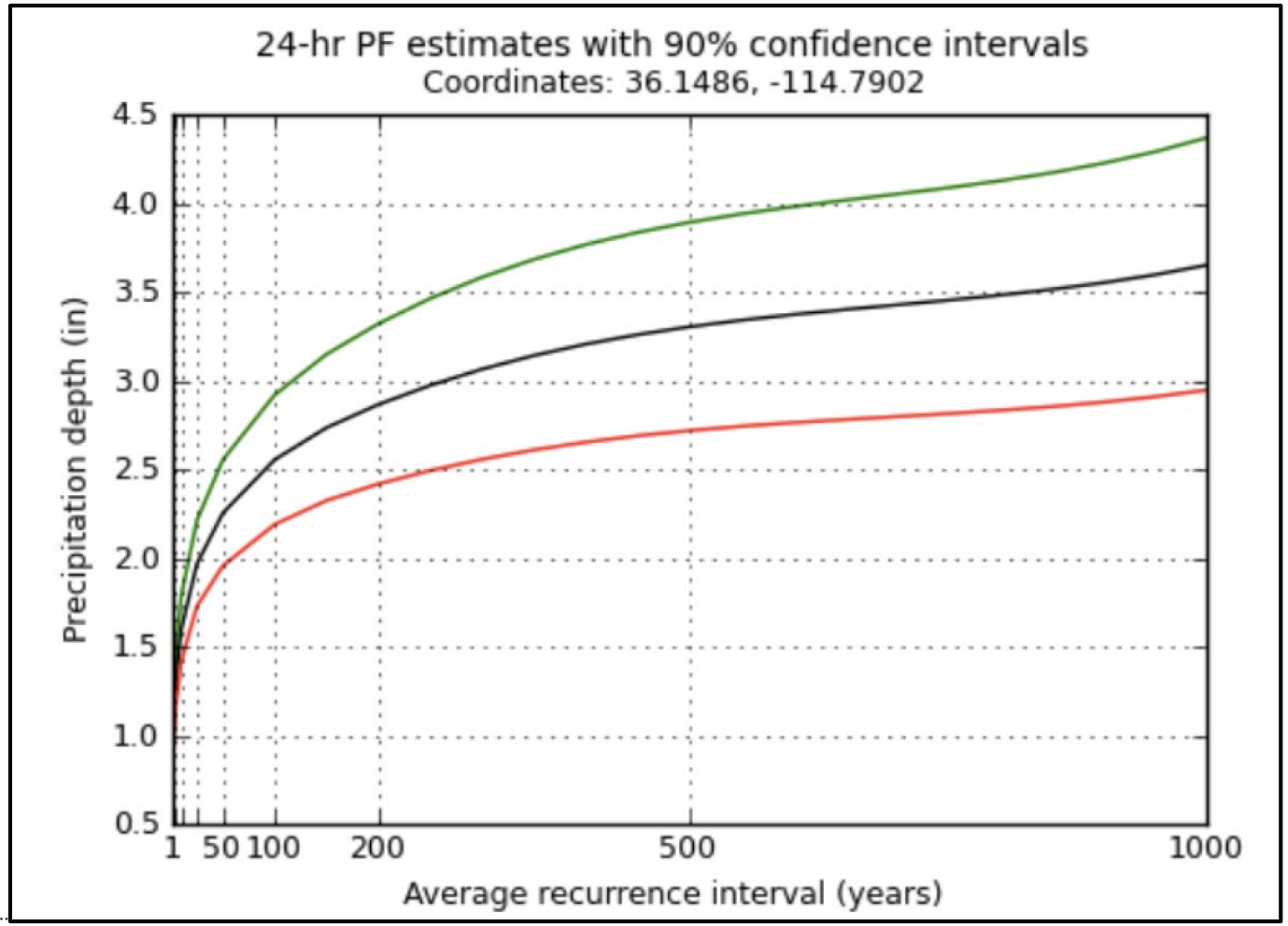
# UNCERTAINTIES IN FLOOD STUDIES

- Precipitation
- Runoff Coefficient
- Manning's Roughness Coefficient
- Time of Concentration

# UNCERTAINTIES IN FLOOD STUDIES

## ***Precipitation***

- NOAA Atlas 14, 90% confidence intervals
- +-30%: sparsely instrumented, shorter record
- +-10%: densely instrumented, longer record



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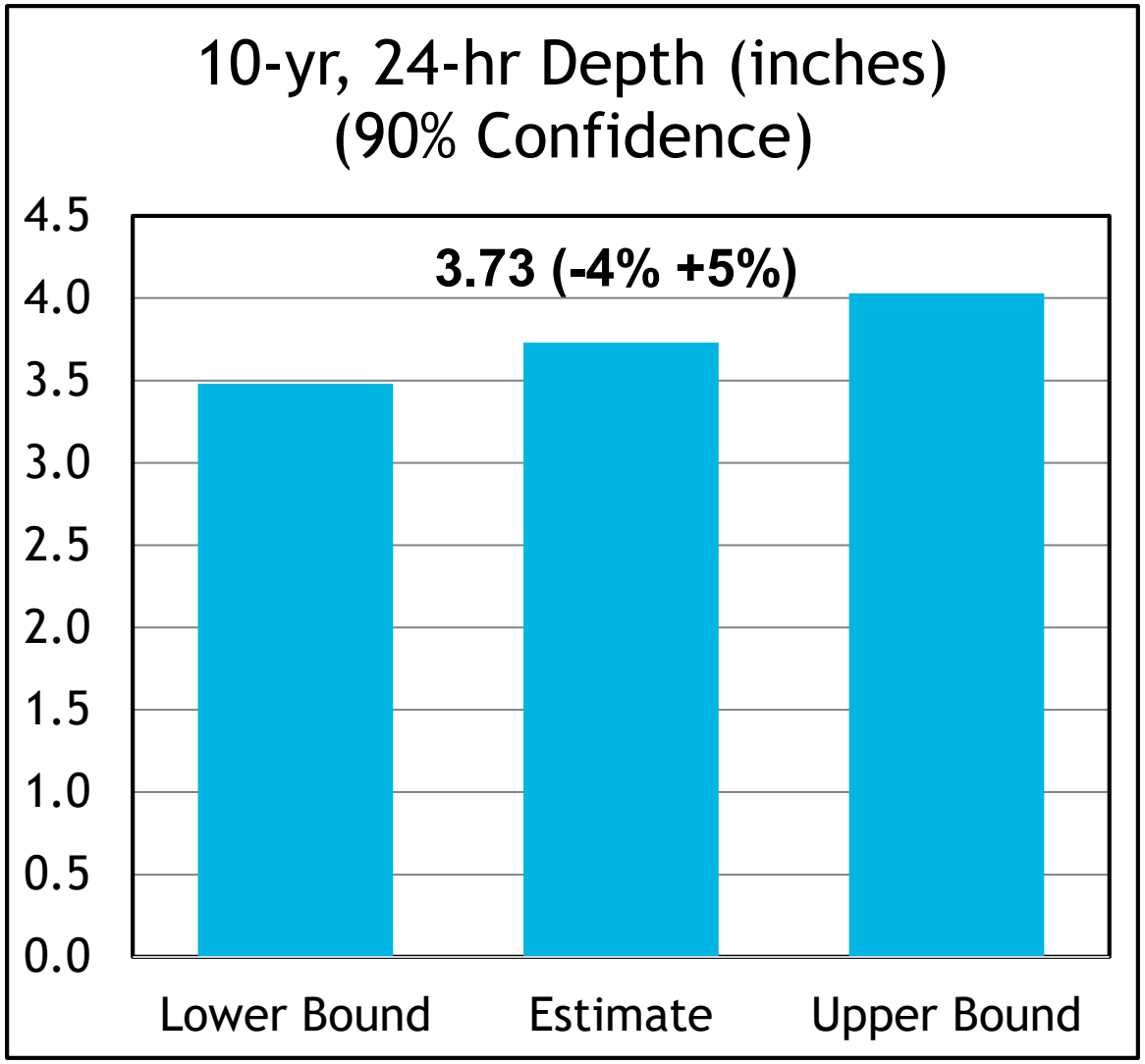
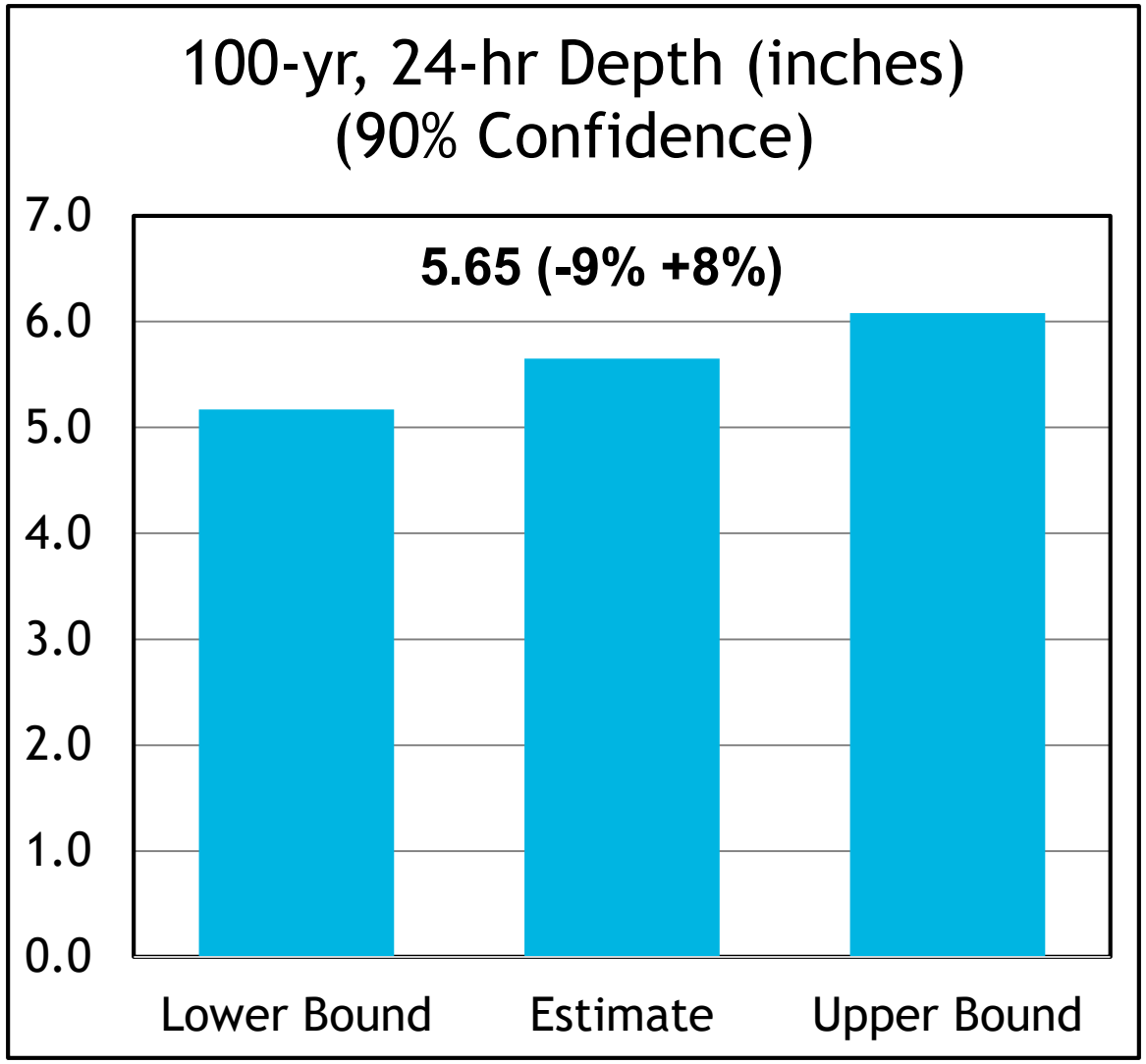
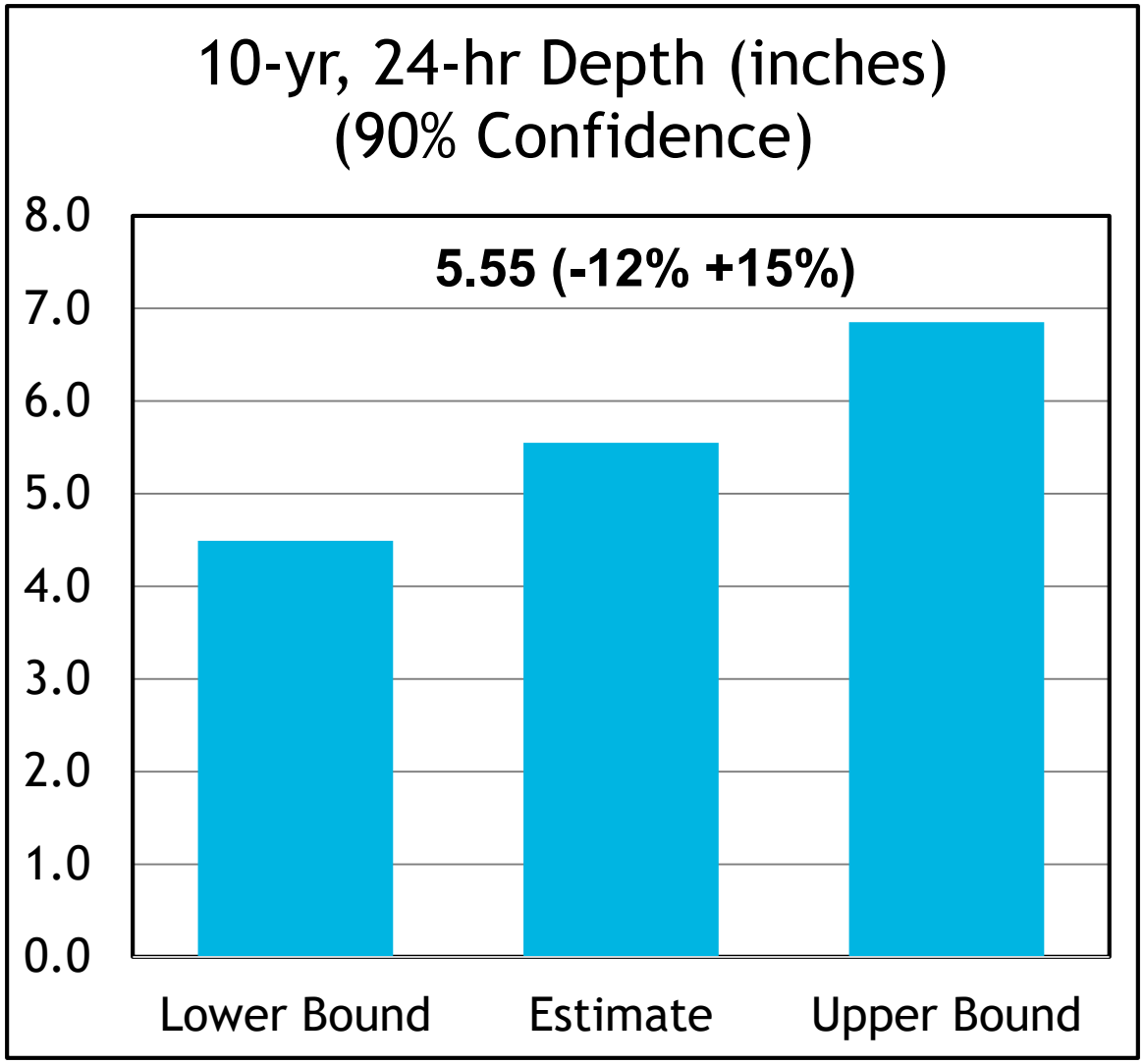
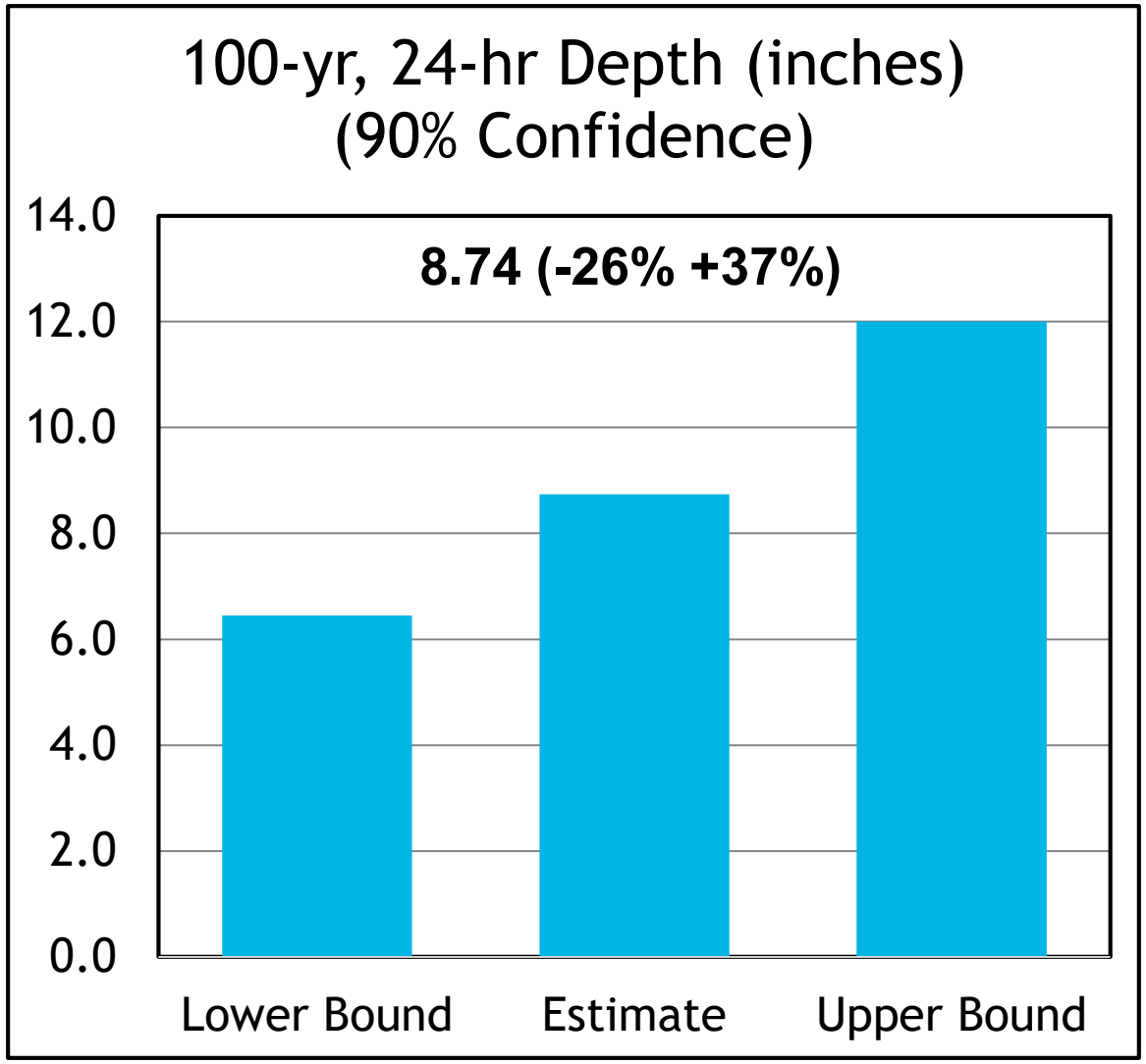
# PRECIPITATION UNCERTAINTY - COLUMBUS



# PRECIPITATION UNCERTAINTY – NEW YORK CITY



# UNCERTAINTIES IN FLOOD STUDIES

- Precipitation: 10% - 30% uncertainty
- Runoff Coefficient:  20% - 50% uncertainty
- Manning's Roughness Coefficient:  40% - 70% uncertainty
- Time of Concentration:  ~33% uncertainty
- Other factors with some uncertainty:
  - Drainage area, land use, stream cross section, floodplain storage, baseflow, tailwater

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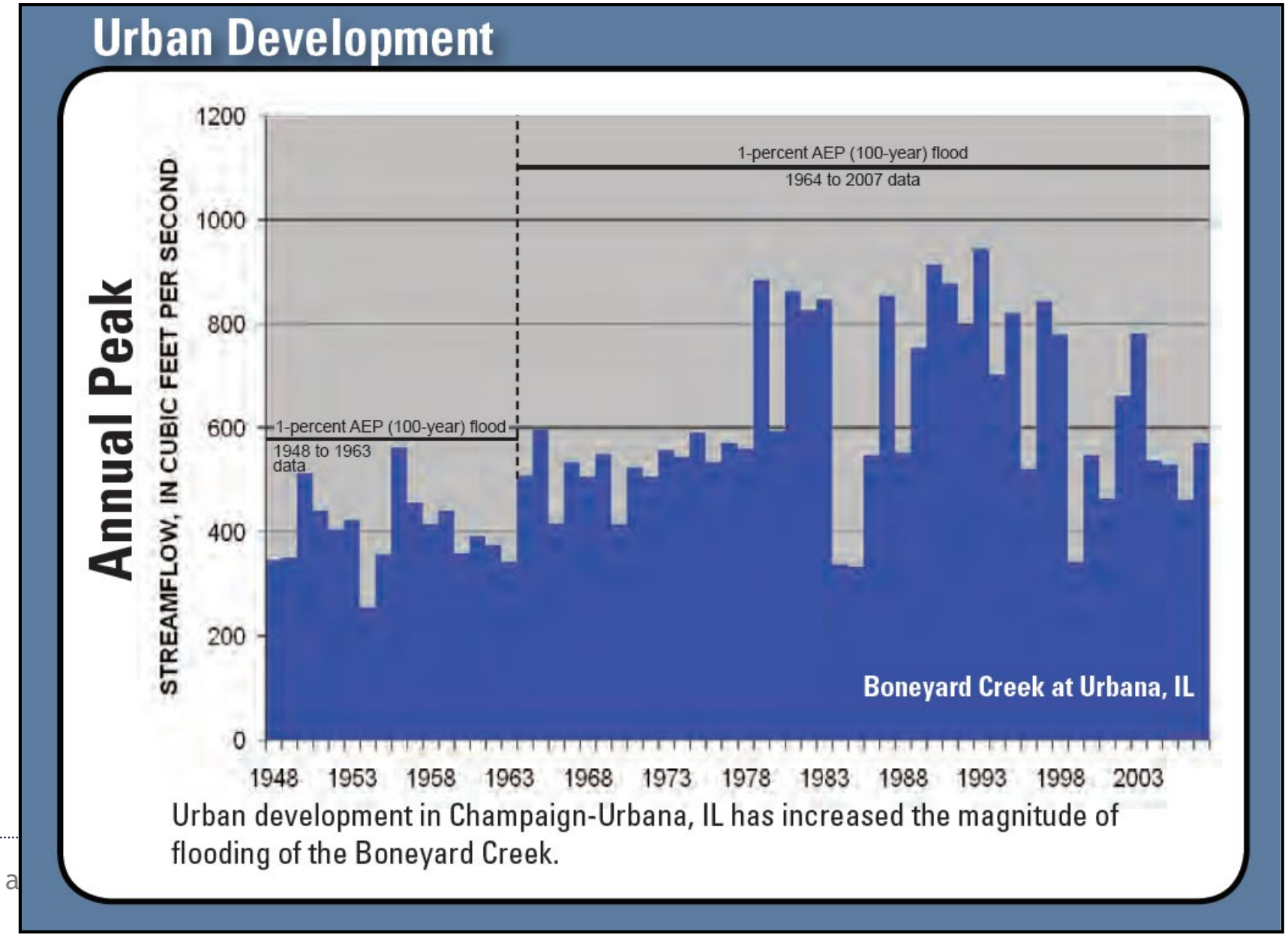
# IMPACTS OF DEVELOPMENT

**90% increase** in 100-year flood based on development (USGS)



# IMPACTS OF DEVELOPMENT

CN = 73

# IMPACTS OF DEVELOPMENT

CN = 89

# IMPACTS OF DEVELOPMENT

- Columbus 10-yr, 24-hr storm = 3.73 in
- Pre  CN = 73:  Runoff = 1.34 inches
- Post CN = 89:  Runoff = 2.57 inches
- 92% increase in runoff

# CLIMATE CHANGE VS. DEVELOPMENT

- Development:
  - Big, known increases to flooding
  - Even with current detention requirements, still a lot more volume into streams
- +-25 to 50% uncertainty
- Climate Change
  - ~10% increase in 100 years
  - Sketchy models, low confidence

Image: whio.com

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# WHAT SHOULD WE DO???

- Keep doing what we've been doing for decades, but make sure it's working:
- Consider allowable risk for infrastructure, and set design requirements based on that.

Table 6.1. Design event selection guidelines.

| Roadway Classification* | Exceedance Probability (percent) | Return Period (years) |
|---|---|---|
| Interstate, Freeways (Urban/Rural) | 2% | 50 |
| Principal Arterial | 2% | 50 |
| Minor Arterial System, ADT>3000 VPD | 2% | 50 |
| Minor Arterial System, ADT=<3000 VPD | 4% | 25 |
| Collector System with ADT>3000 VPD | 4% | 25 |
| Collector System with ADT=<3000 VPD | 10% | 10 |
| Local Road System | 20%-10% | 5-10 |

*Average Daily Traffic (ADT): Vehicles per Day (VPD)

# WHAT SHOULD WE DO???

- Consider the impacts of development on infrastructure flooding.
- Incorporate development standards to address excess runoff.
- Plan for resilient infrastructure (flood protection).
- Why make a small change based on very low confidence?
- If you have specific capacity concerns, address those directly by adjusting the design storm for that situation.

# WHAT SHOULD WE NOT DO???

- Don’t make a poorly justified change just to feel better about doing something.
- Don’t use climate change as a scapegoat for all natural disasters and flooding.
- Climate change is a hard problem to try to solve on a project scale.  Runoff reduction, flood control, and staying out of the floodplain are much more implementable.

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# CONCLUSIONS

- Temperature and Sea Level will probably continue to rise no matter what we do, but there is no confidence that it will be catastrophic.
- No confidence that human-caused climate change is increasing hurricanes, tornadoes, floods, meteorological droughts, or wildfires. More common “heavy” precipitation is getting bigger, but not large flood-causing precipitation, and not attributed to humans.
- Trends in historical design storm precipitation are very small compared to existing uncertainties in flood studies.
- Other factors, like development, have a much greater impact on flooding.
- Let’s focus on things that we can control and that do actually matter, like responsible development practices and flood control.

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# MISLEADING REPORTS – EXTREME EVENTS

## ***Climate Science Special Report***

- "Changes in the characteristics of extreme events are particularly important for human safety, infrastructure, agriculture, water quality and quantity, and natural ecosystems. **Heavy rainfall is increasing in intensity and frequency across the United States and Globally and is expected to continue to increase."**

# MISLEADING REPORTS – EXTREME EVENTS

## ***Climate Science Special Report***

- "Changes" seems bad
- No confidence in "extreme events" getting worse (hurricanes, tornadoes, flooding, drought)
- Decent confidence that "heavy rainfall" (95$^{th}$ percentile) will get more intense and frequent (by at least some amount)
- Grouping all "extreme events" in with "heavy rainfall" seems misleading, especially when "heavy rainfall" probably doesn't have a significant impact on safety, infrastructure, and agriculture.

# MISLEADING REPORTS – EXTINCTION

***U.S. News***

- "Animal Populations Have Declined By 60 Percent Since 1970"
- "Climate change, as well as other human activities, such as agriculture and development, are the main culprits."
- "the main drivers of biodiversity decline continue to be overexploitation of species, agriculture and land conversion"

# MISLEADING REPORTS – BEER AND REVOLUTION

***Forbes***

- "Climate Change Could Lead to Global Beer Crisis"
- Researchers simulated barley harvests with simulated temperatures in 2099.
- "with a temperature rise of 2°C, harvests decrease by 10%."
- Demand will be high, but supply lower, driving up cost
- "A famine in the aftermath of a volcanic winter caused by the Laki eruption of 1783 and the inefficiency of politicians to deal with the problems lead to the French Revolution of 1789."

# MISLEADING REPORTS – ANIMAL BITES

Image: NBC News / Getty

## ***NBC News***

- "Doctors cite climate change for rise in animal bites, U.S. health care costs"
- "Researchers also note that poorer families are at higher risk of animal bites"
- NBC Article based on Dec. 11, 2018 University of Stanford Article
  - Article does not mention climate change in the abstract, results, or conclusions.
  - The article is about the annual effects of animal encounters and healthcare cost.
  - There is one sentence buried in the article that says that insect bites might increase due to climate change (referencing a different study)

# QUESTIONS