Climate Resilience and Drainage

An Indiana Perspective

@DukesJeff
@PurdueCCRC

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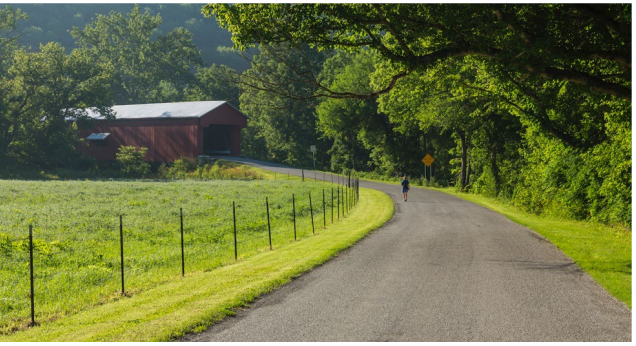
Purdue Climate Change Research Center
DISCOVERY PARK

Dr. Jeffrey Dukes

PCCRC Director



How is the climate changing in INDIANA?

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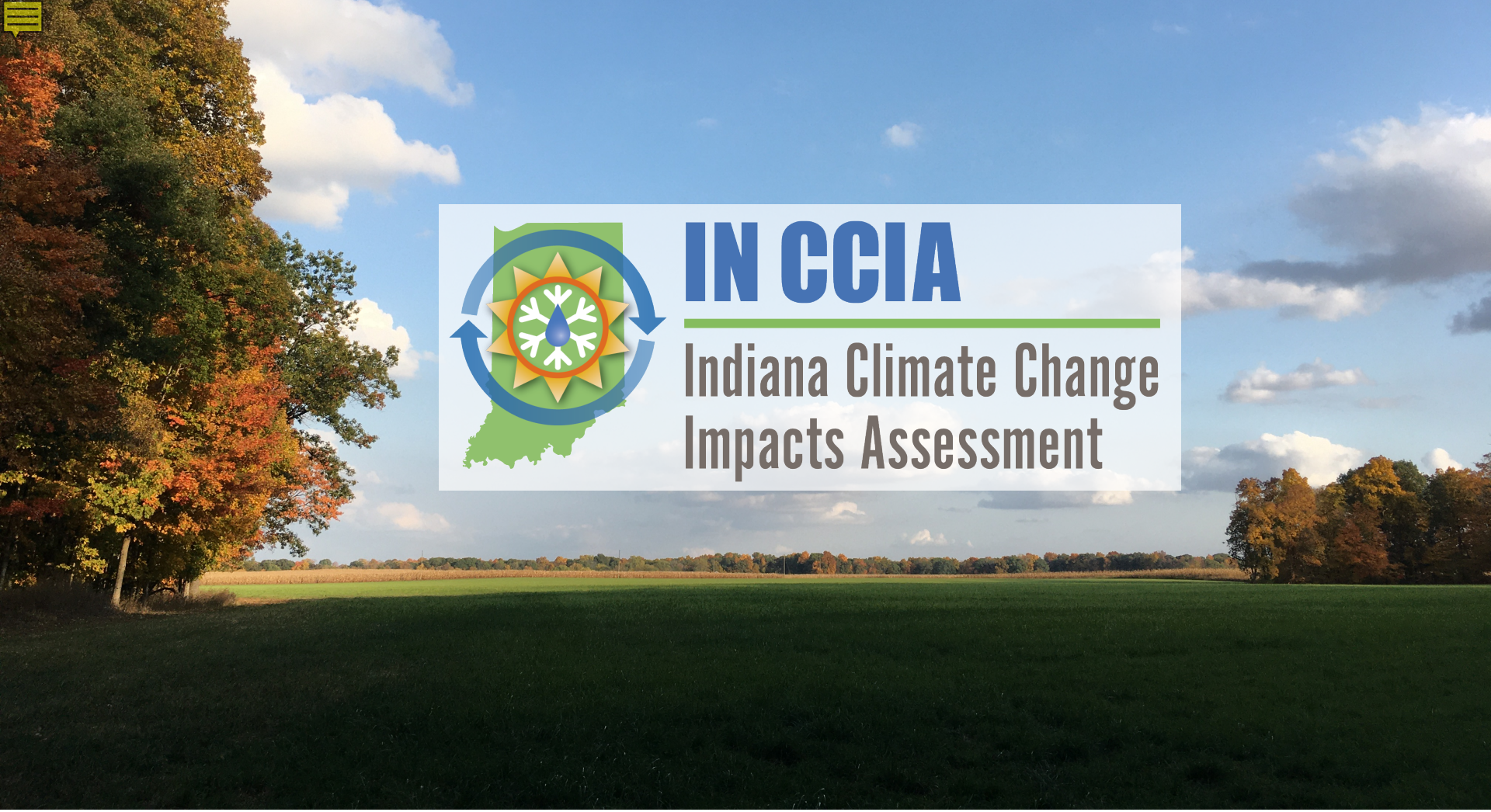

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Indiana Climate Change Impacts Assessment

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Technical contributions from:

Purdue Climate Change Research Center
University of Notre Dame
Illinois-Indiana Sea Grant
IUPUI
Indiana University
Indiana University Northwest
Ball State University
Indiana State University
Purdue University Northwest
Midwest Regional Climate Center
U.S. Forest Service
Northern Institute of Applied Climate Science
Indiana Department of Natural Resources
Marion County Public Health Department
Mesh Coalition
State Utility Forecasting Group
U.S. Geological Survey

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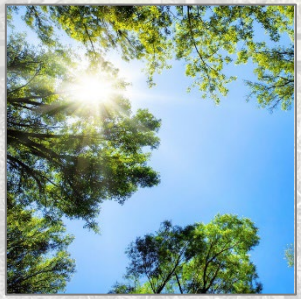
IN CCIA Reports

Putting global change into local perspective

Climate

Health



Forest Ecosystems

Urban Green Infrastructure

Agriculture

Aquatic Ecosystems

Tourism & Recreation

Energy

Water Resources

Infrastructure

www.IndianaClimate.org

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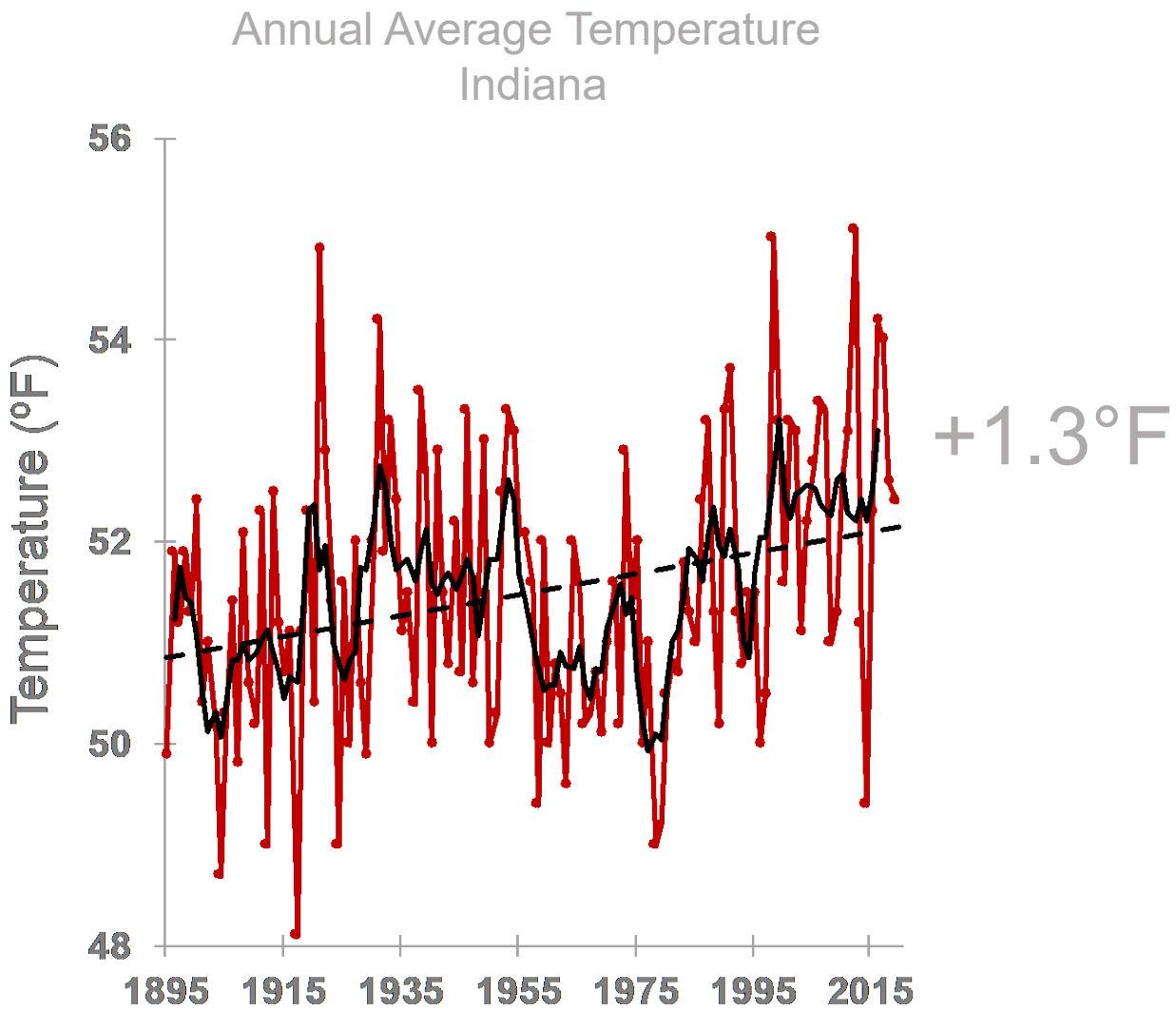
Indiana is getting warmer



Indiana is getting warmer

Annual temperature has increased 1.3°F over the last century.

- Longer frost-free season
- Fewer cold days
- Significantly warmer overnight temperatures

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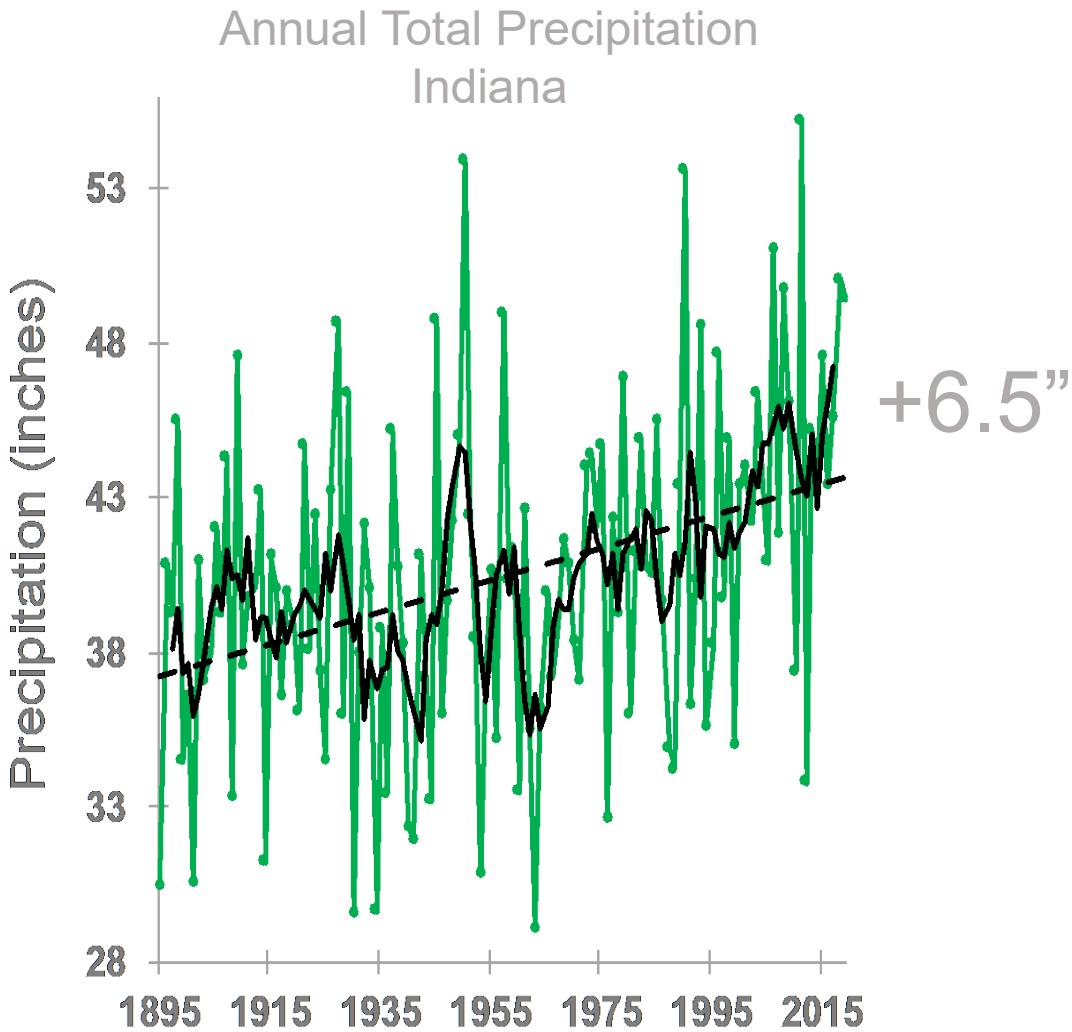
Indiana is getting wetter



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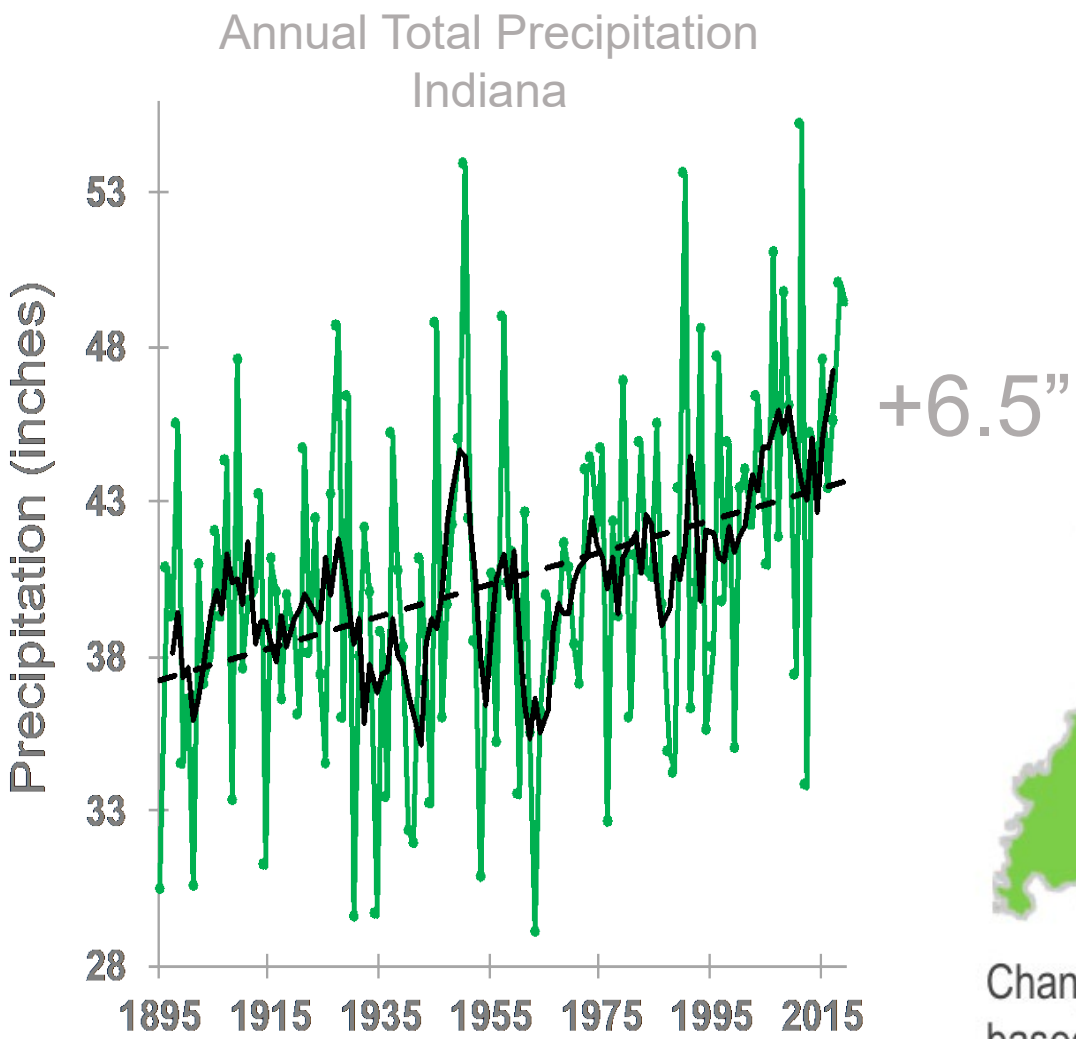
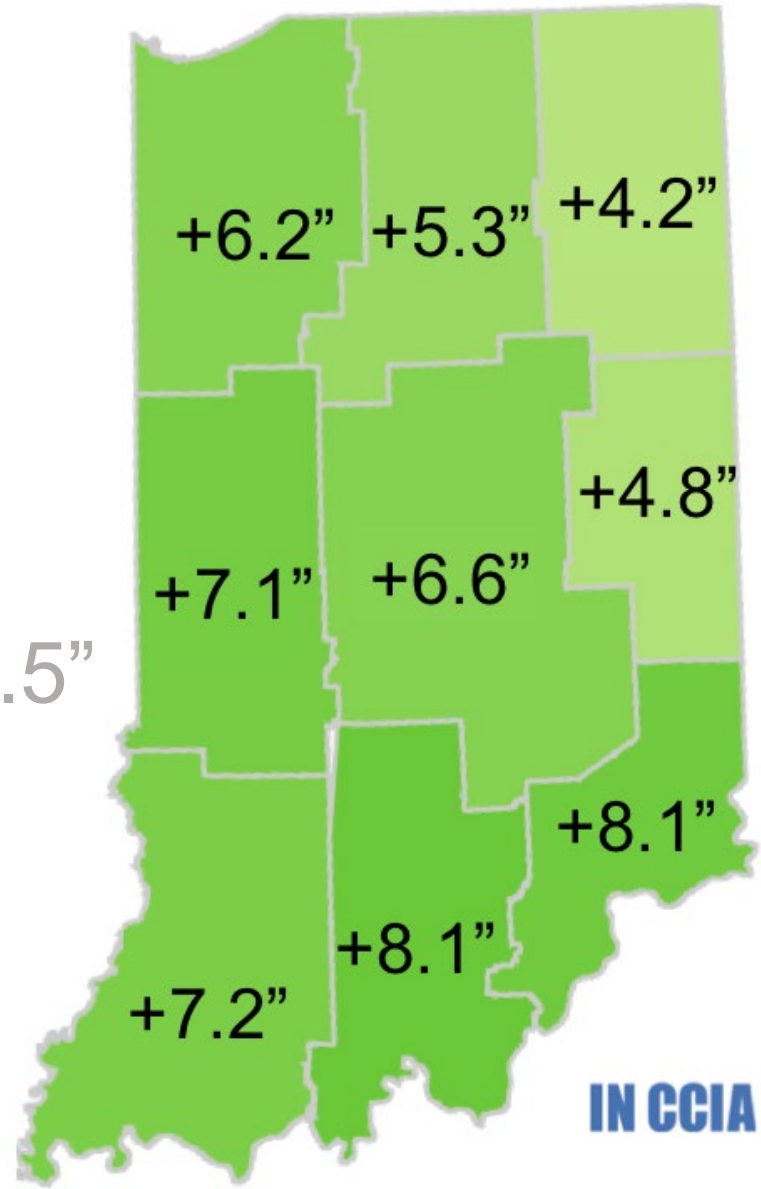
Indiana is getting wetter





Change in annual average precipitation based on linear trend between 1895 to 2019

Heavy rainfall is more intense & happening more often.

42%

In the amount of rain falling in heavy downpours

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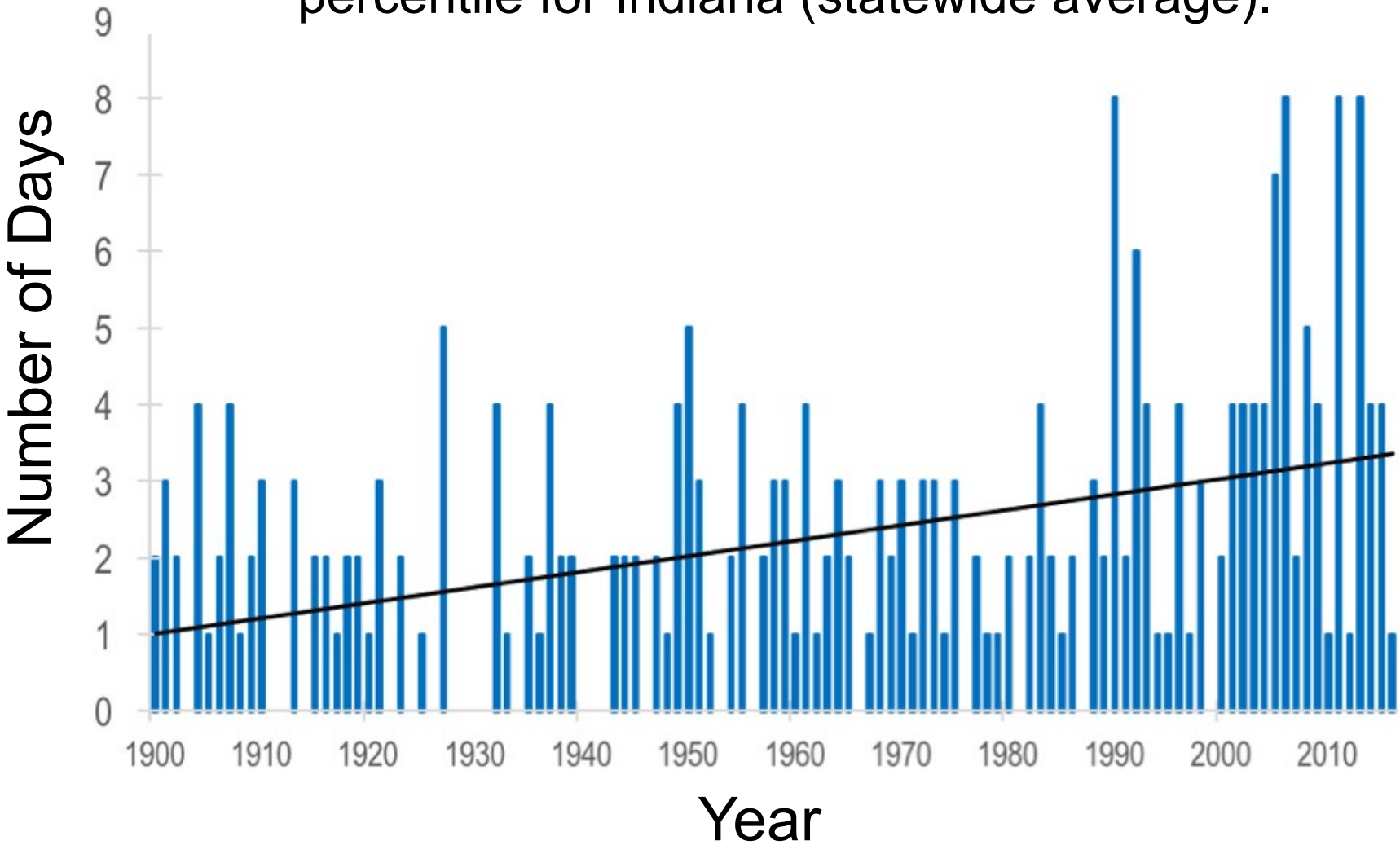
Data for Midwest U.S., 1958 – 2016. Source: NOAA

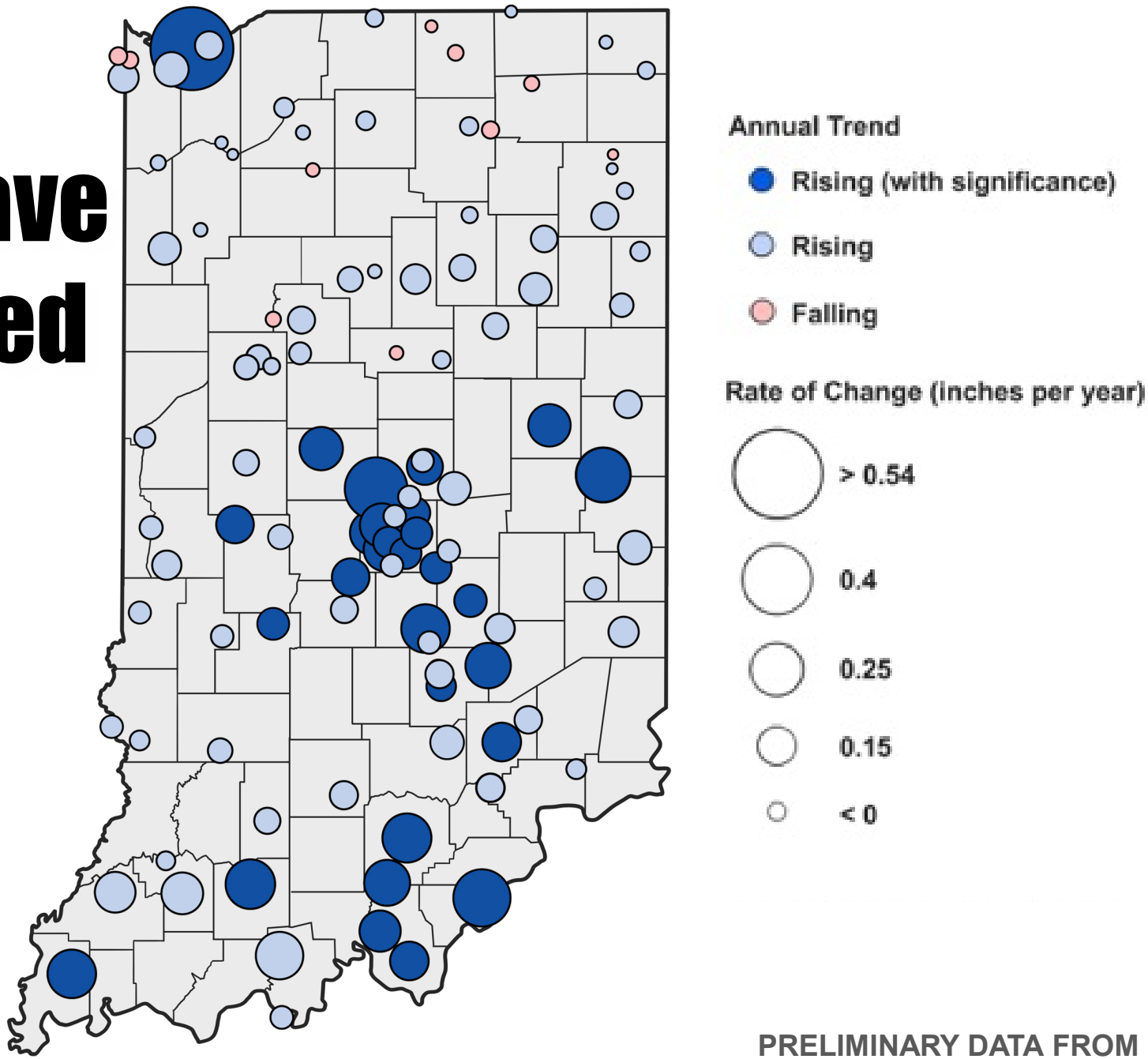
Photo credit: NOAA

More frequent extreme precipitation

Days per year that exceed the 1900-2016 period's 99th percentile for Indiana (statewide average).



Stream flows have increased



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PRELIMINARY DATA FROM
INCCIA WATER REPORT

Should we expect these changes to continue?

Indiana will get warmer

Annual temperature has already increased 1.3°F over the last century.

Warming expected to continue and accelerate

Indiana scientists used 10 climate models to look at future warming.

Range of outcomes based on medium- and high-emissions scenarios

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Indiana's warming will continue and accelerate.

5°F to 6°F of warming expected by mid-century

- Fewer "mild" days
- More hot days
- Longer warm season
- Milder cold season

Future projection for medium & high emissions scenario

Mid-century represents average from 2041-2070, with change relative to the average from 1915 -2013

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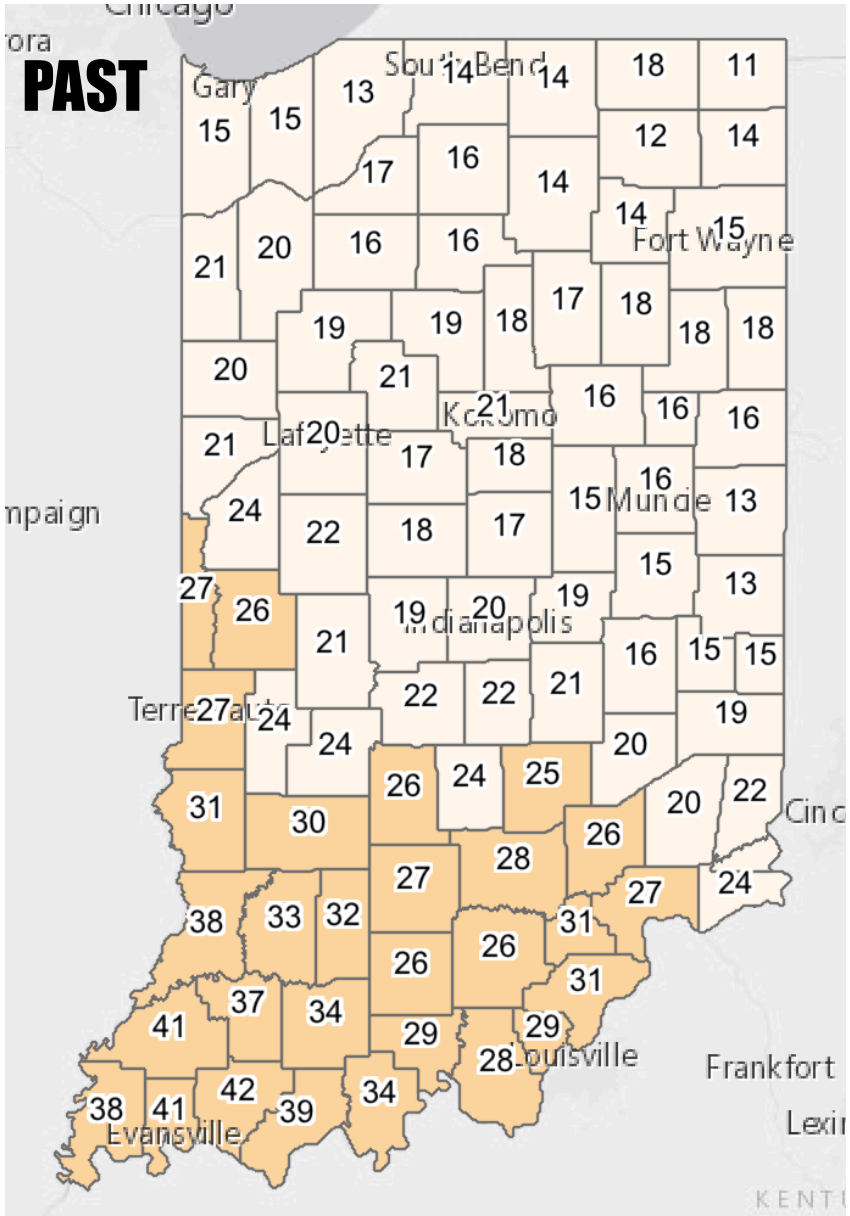
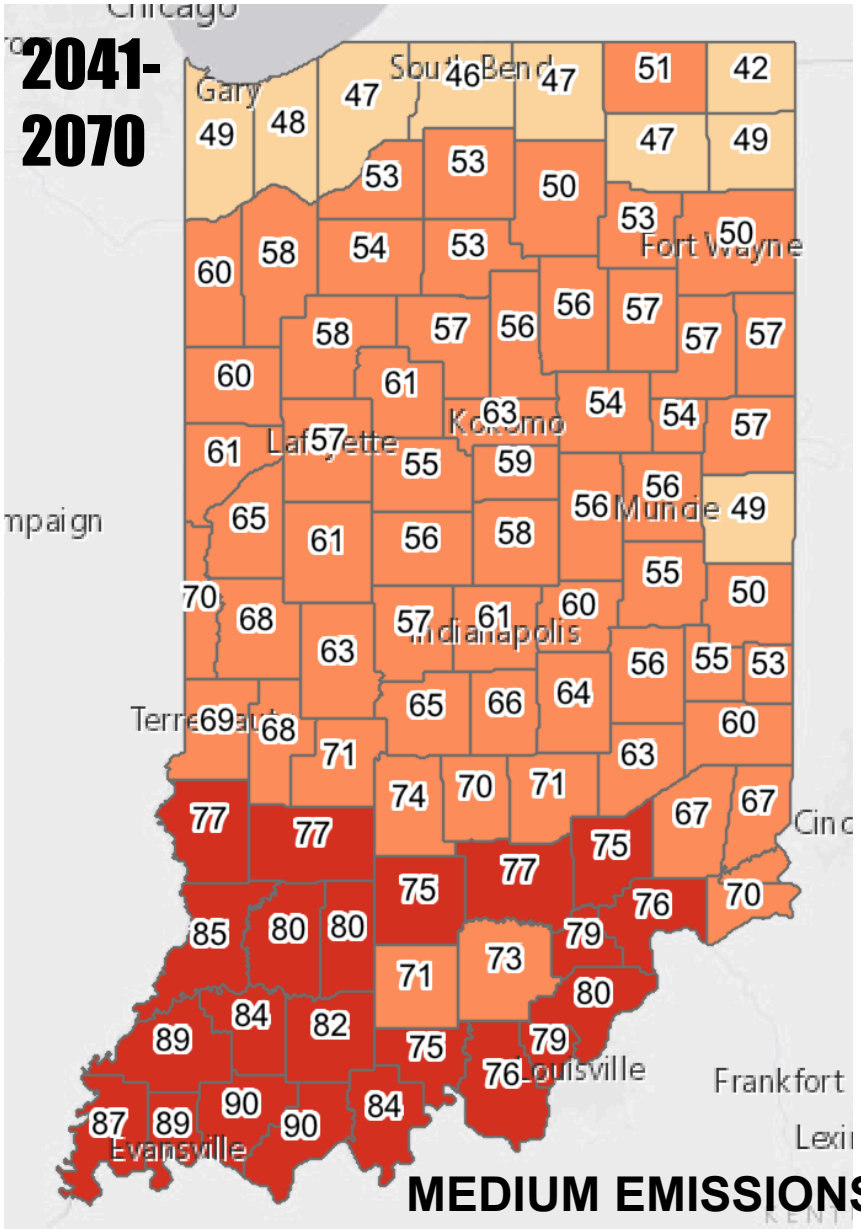
Annual Count

Days Above 90 ºF





Freeze Thaw Cycles

Average Number of Cycles in February

2-6 Events (PAST)

4-7 Events (2041-2070)

Increased variability in winter temperature resulting in more freeze/thaw cycles

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Indiana will get wetter

Annual precipitation has increased 6.5” over the last century.

6% to 8% increase in annual rainfall is projected by mid-century.

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Some seasons will be wetter

WINTER: 16 to 20% increase by mid-century

SPRING: 13 to 16% increase by mid-century

- More falling as rain, not snow
- Increased early-season soil saturation

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Some seasons will be drier

Summer & fall **show slight declines by mid-century, with less certainty in the projections**

- Increased water demand from added heat
- Drier soils

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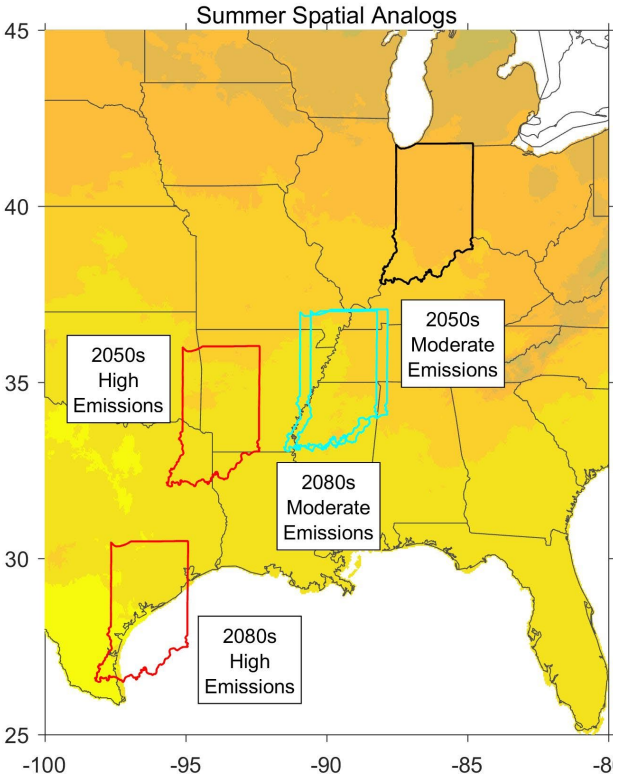
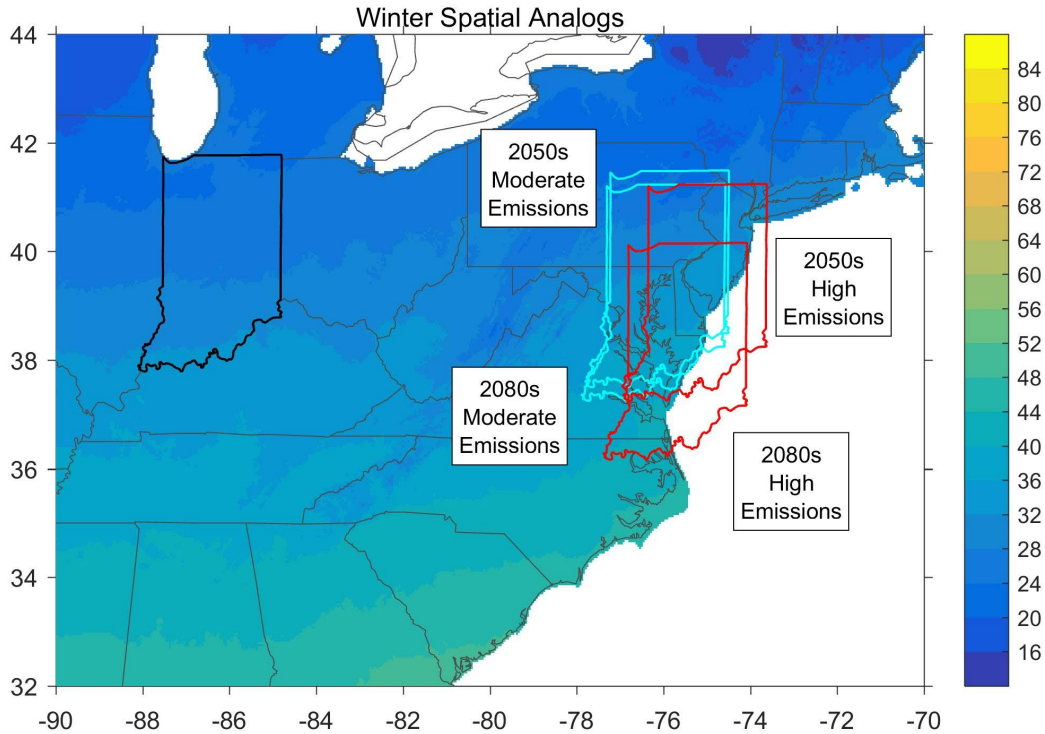
Seasonal Analogs

Based on seasonal average temperature and precipitation





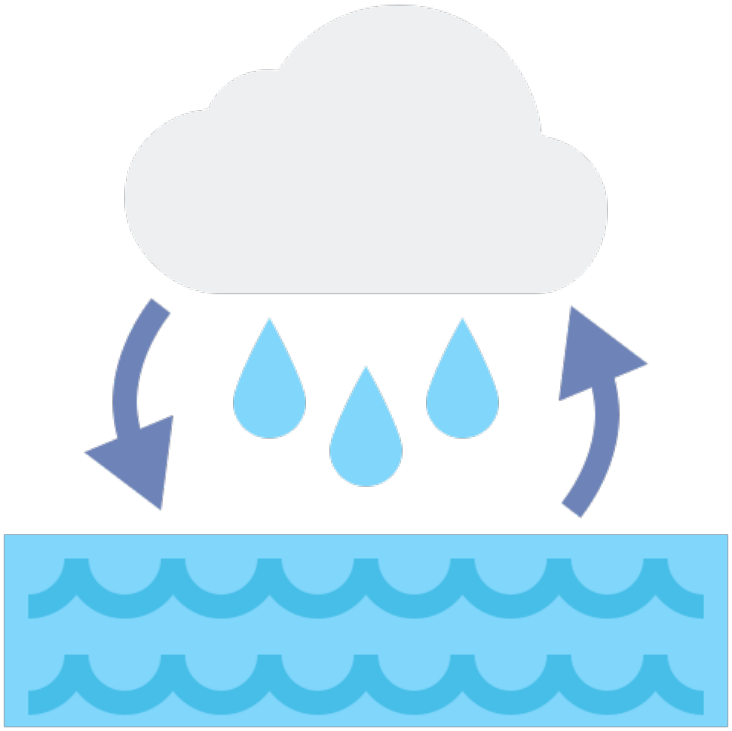
Statewide Average

2050s represents average from 2041 to 2070

2080s represents average from 2071 to 2100

Base map shows 1981 to 2010 average seasonal temperature from PRISM archive

Changes in temperature & precipitation will alter all aspects of the hydrologic cycle



Amount & timing

Snow cover

Runoff

Soil moisture

Evaporation

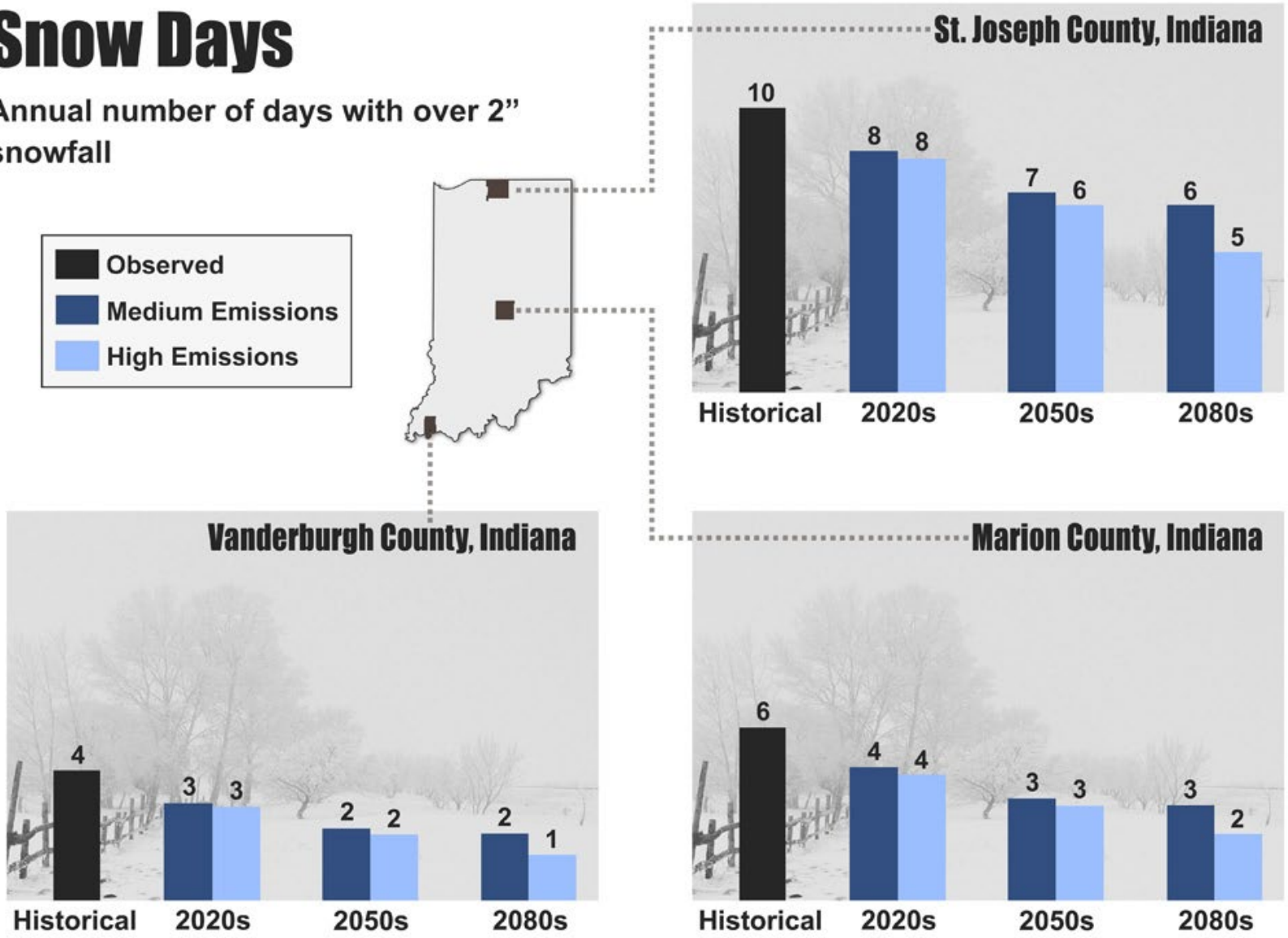
Streamflow

Flooding

Drought

Snow Days

Annual number of days with over 2" snowfall



"Historical" is an average for the period 1915 to 2013. "2020s" represents the average 30-year future period 2011 to 2040. "2050s" represents the average 30-year period 2041 to 2070. "2080s" represents the 30-year period 2071 to 2100.

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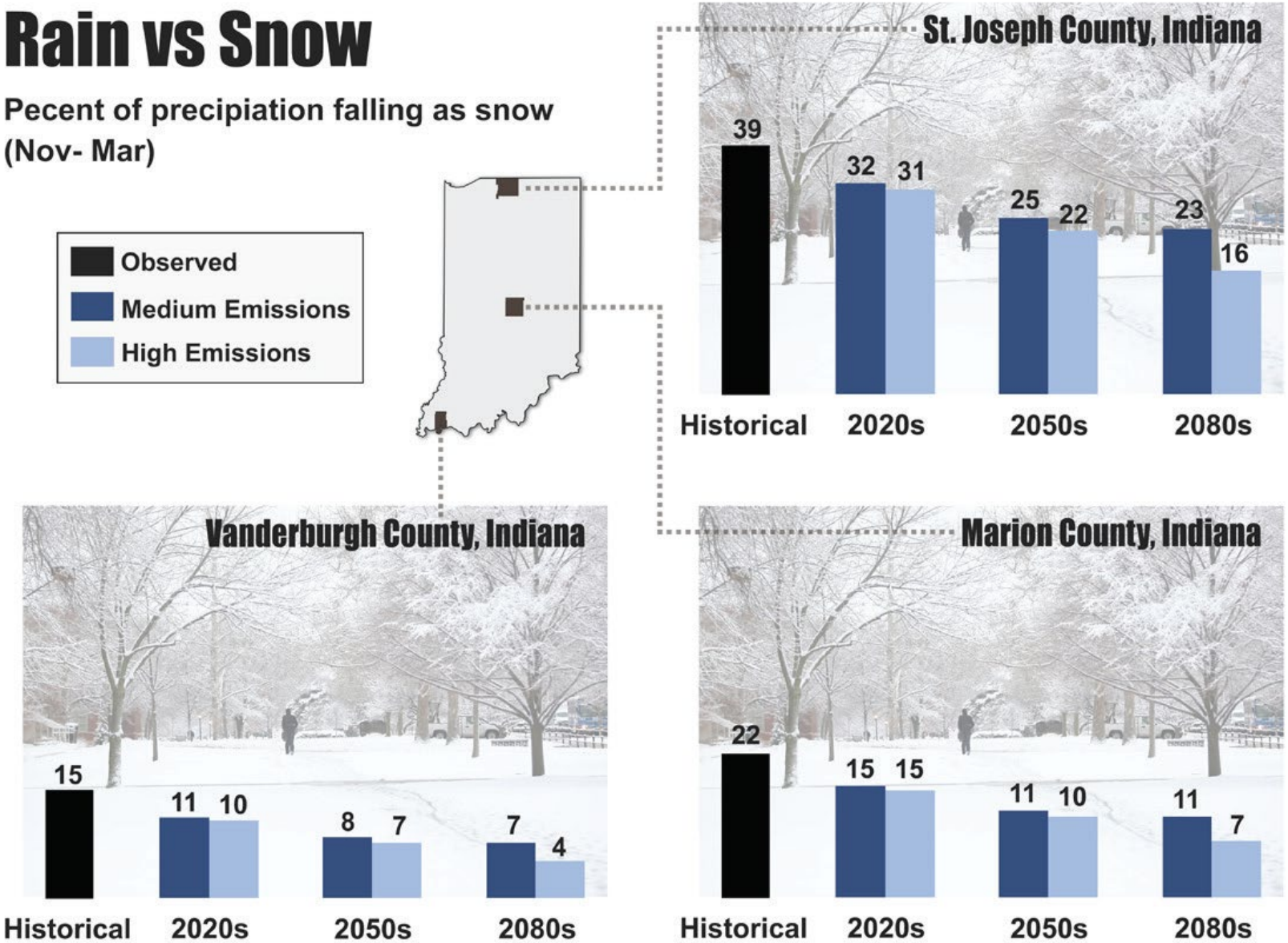
Rain vs Snow

Pecent of precipiation falling as snow (Nov- Mar)



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Infrastructure

Water Quality

Flood Control

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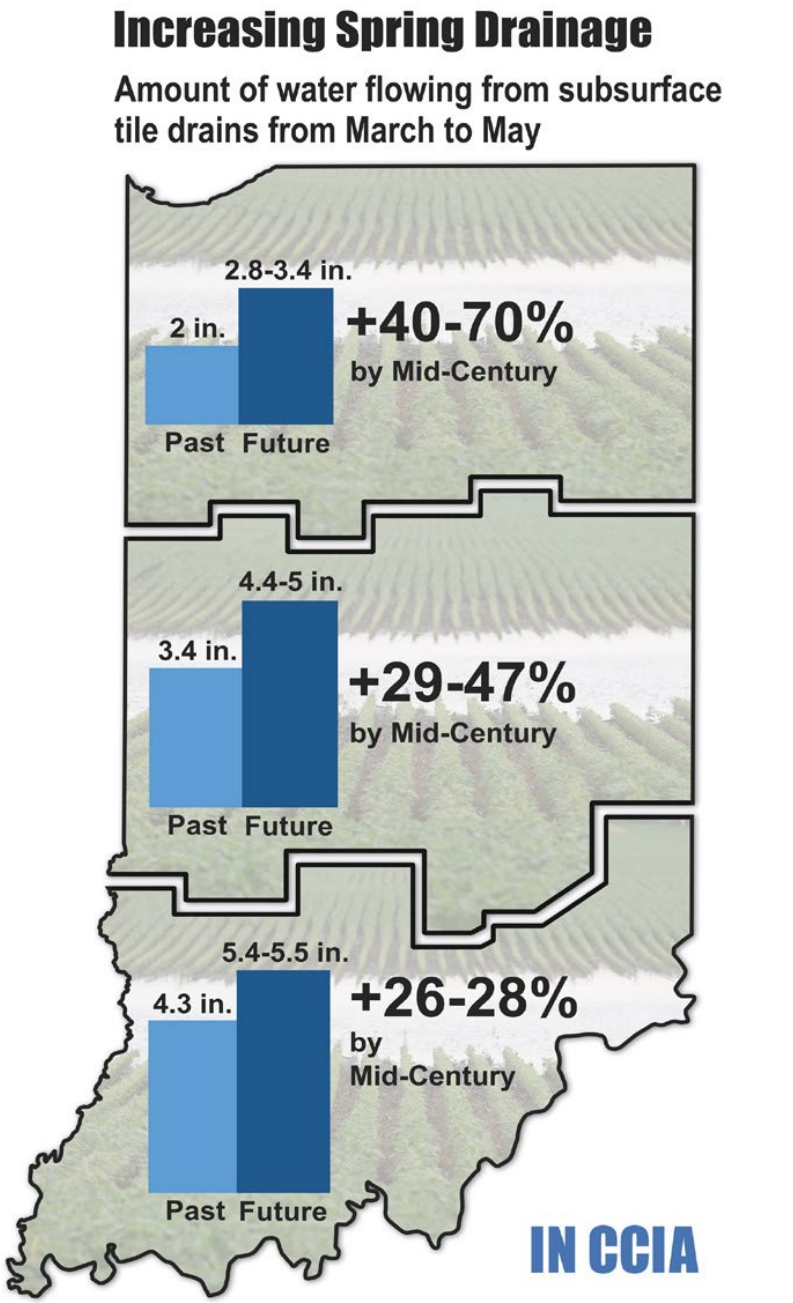
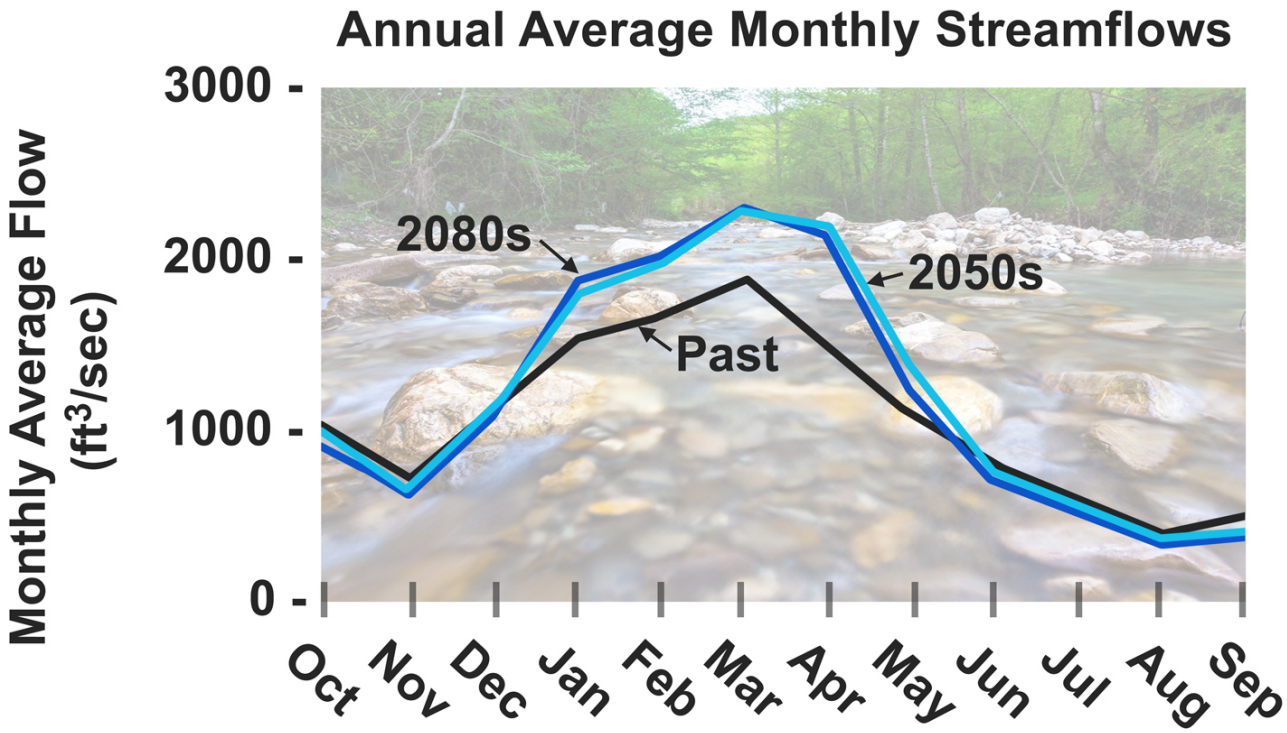


Historical period is from 1981 to 2010. Mid-century represents the period from 2041 to 2070. Range of results based on medium and high emissions scenarios.

Higher Highs, Lower Lows

White River near Indianapolis, IN



SNEAK PEAK

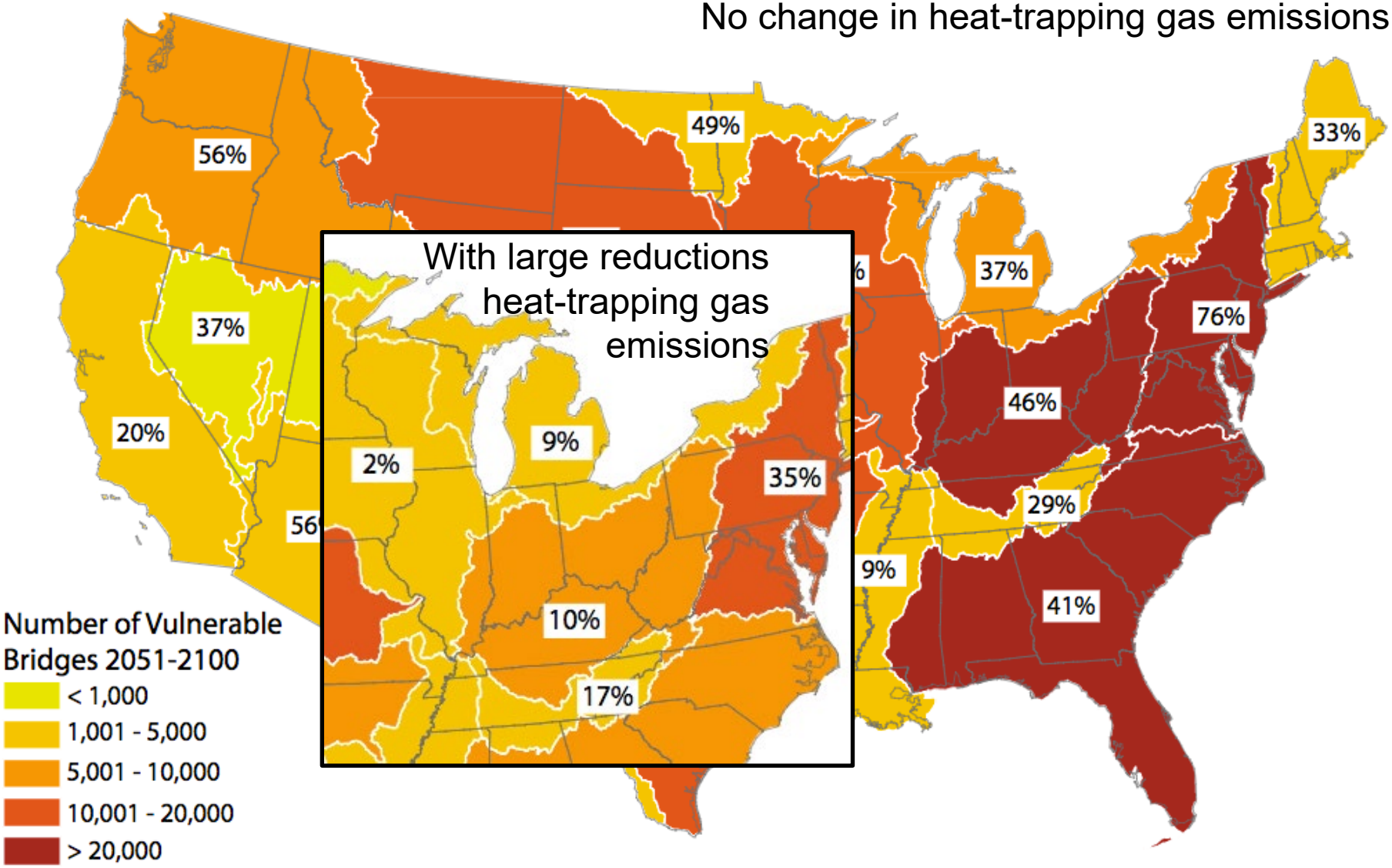
PRELIMINARY DATA FROM INCCIA WATER REPORT

MEDIUM EMISSIONS SCENARIO

All values are simulated discharge for comparison purposes. Past is an average for the period 1984 to 2013. For the future projections, “2050s” represents the 30-year period from 2041 to 2070, and “2080s” represents the 30-year period from 2071 to 2100. Percent change on right panel is relative to the 1984 to 2013 average.

Vulnerable Bridges

No change in heat-trapping gas emissions



CIRA analysis identified bridges that may be vulnerable to increased peak river flows

EPA 2015

Adaptation:
Are we ready for these changes?

Adaptation strategy: rethinking location of structures

"One of the most effective strategies for reducing the risks of climate change is to avoid placing people and infrastructure in vulnerable locations."

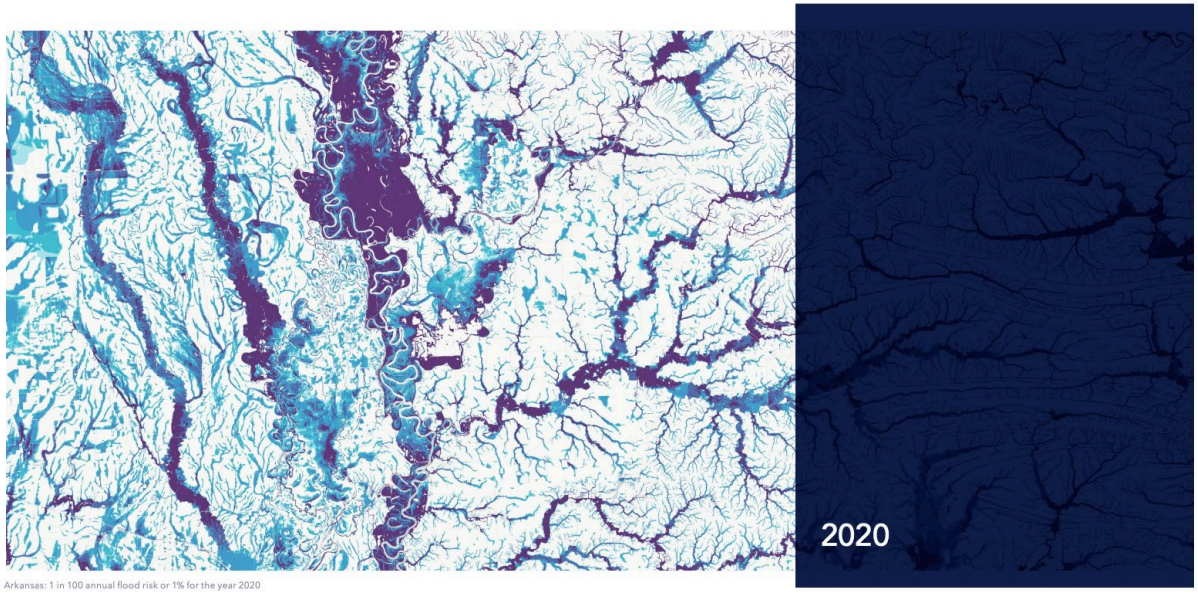
-- Transportation and Climate Change: An Assessment by the National Research Council (2008)

- Need to consider CC impacts on infrastructure investments
- There needs to be integration between land use planning and transportation planning.

Critical infrastructure in the floodplain?

New analysis suggests flood risk is underestimated in many communities

FIRST STREET FOUNDATION



Arkansas: 1 in 100 annual flood risk or 1% for the year 2020

The First National Flood Risk Assessment

Defining America's Growing Risk

Adaptation strategy: update design standards

Are past experiences with extreme events still a reliable indicator for future risk?

Climate and hydrological projections show the frequency and magnitude of extreme rainfall events and streamflows/flooding will shift in Indiana.

Several Indiana communities are already building stormwater systems to accommodate changing rainfall and runoff patterns. What about adjustments in bridge design? Pavement specs?

Adaptation strategy: integrated planning

"Cities can enhance their adaptive capacity to climate change through their urban land management, which includes the legal and political systems, planning departments, zoning regulations, infrastructure and urban services, land markets, and fiscal arrangement."

NCA 2014 Technical Input Paper
"Climate Change and Infrastructure, Urban Systems, and Vulnerabilities"

<u>We must take a systems approach to achieve climate resilience.</u>

Coping with excess rainfall - watershed impacts

- Slow down the runoff
- Rain gardens, bioswales
- Increase pervious pavement
- Nutrient stewardship(4-R's)
- Insurance options
- Relocating infrastructure vs. buffering systems against impacts

Stay informed, stay connected

http://IndianaClimate.org

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Advancing sustainable, electrified transportation

A new research center, co-led by Purdue University, is developing new infrastructure that facilitates widespread adoption of electric vehicles. The center is named ASPIRE – Advancing Sustainability through Powered Infrastructure for Roadway Electrification.

The goal:
Eliminate vehicle range and charging as obstacles for all types of vehicles

Impacts to green drainage systems include floodwater stress, degrading structure & function of riparian buffers

and reducing rain garden benefits