IN CCIA
Indiana Climate Change Impacts Assessment

Projecting Indiana's Future Climate

"Understanding Climate Change in South Bend"
February 18, 2019

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Indiana Climate Change Impacts Assessment (INCCIA)

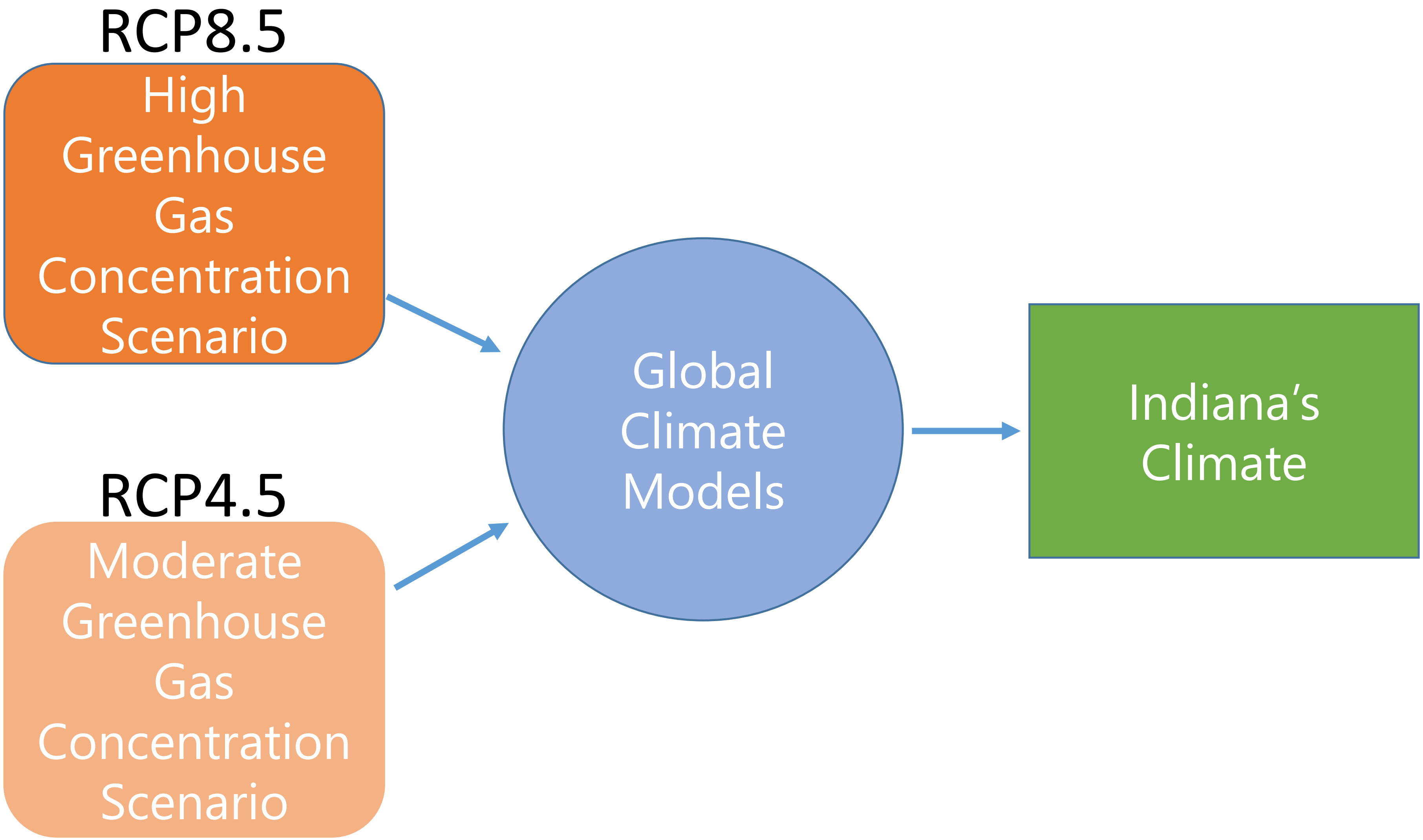
INCCIA Website:

https://ag.purdue.edu/indianaclimate/

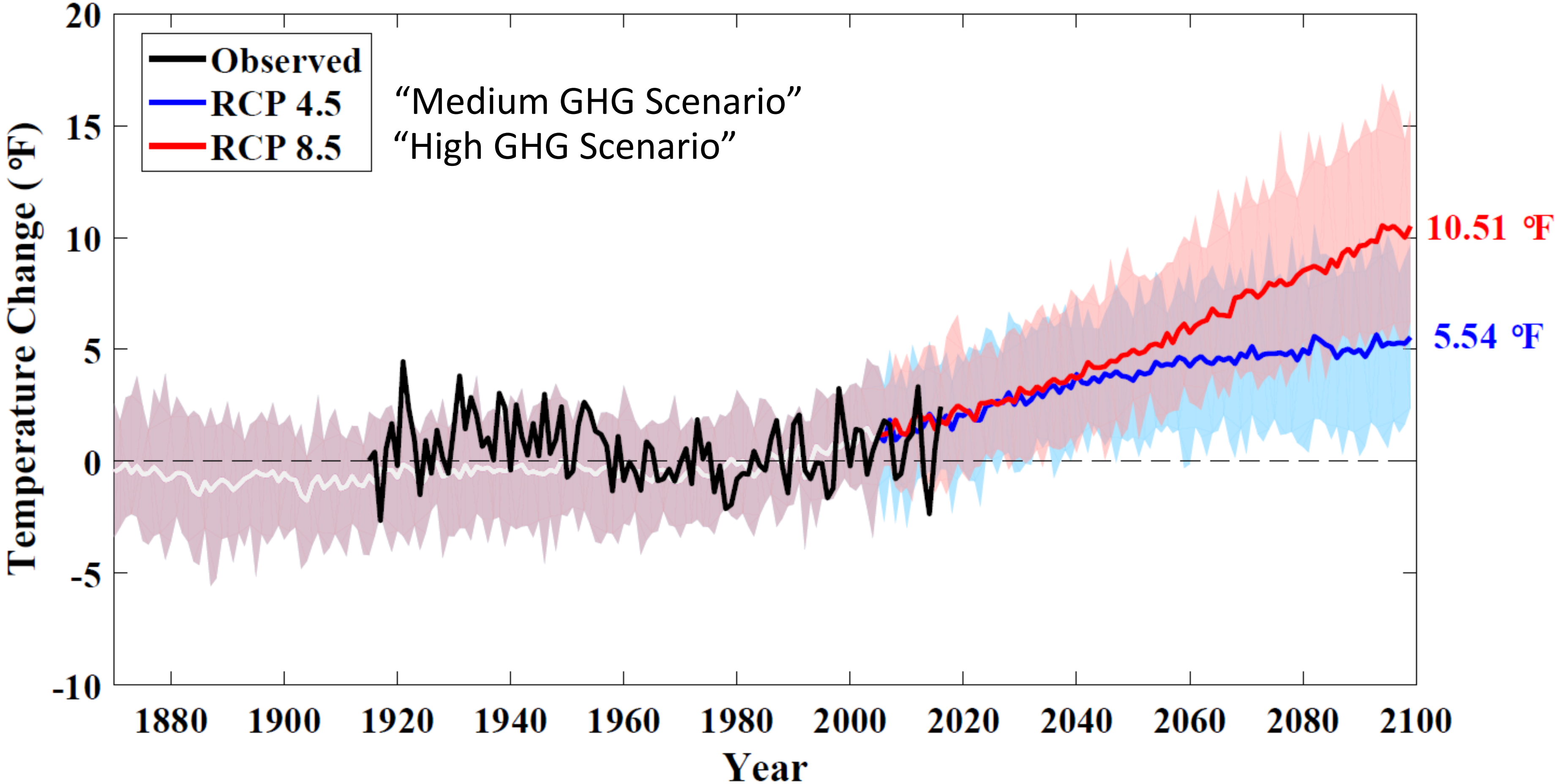
INCCIA Climate Paper:

Hamlet, A. F., K. Byun, S. M. Robeson, M. Widhalm, M. Baldwin, 2019: Impacts of Climate Change on the State of Indiana: Ensemble Future Projections Based on Statistical Downscaling, Climatic Change, DOI: 10.1007/s10584-018-2309-9

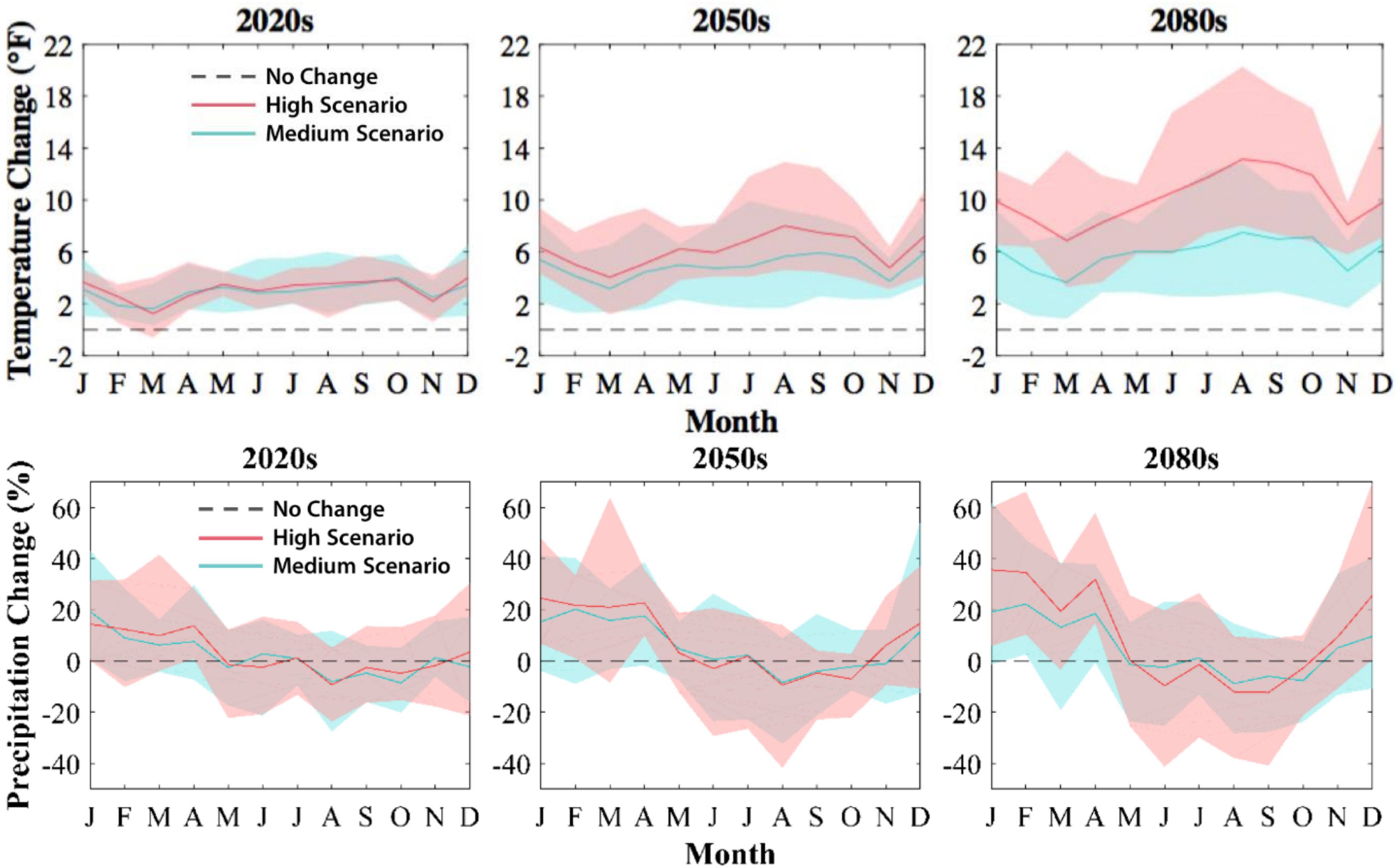
Using Global Climate Models to Simulate the Future



Annual Temperature Projections for Indiana Based on 31 Global Climate Model Simulations

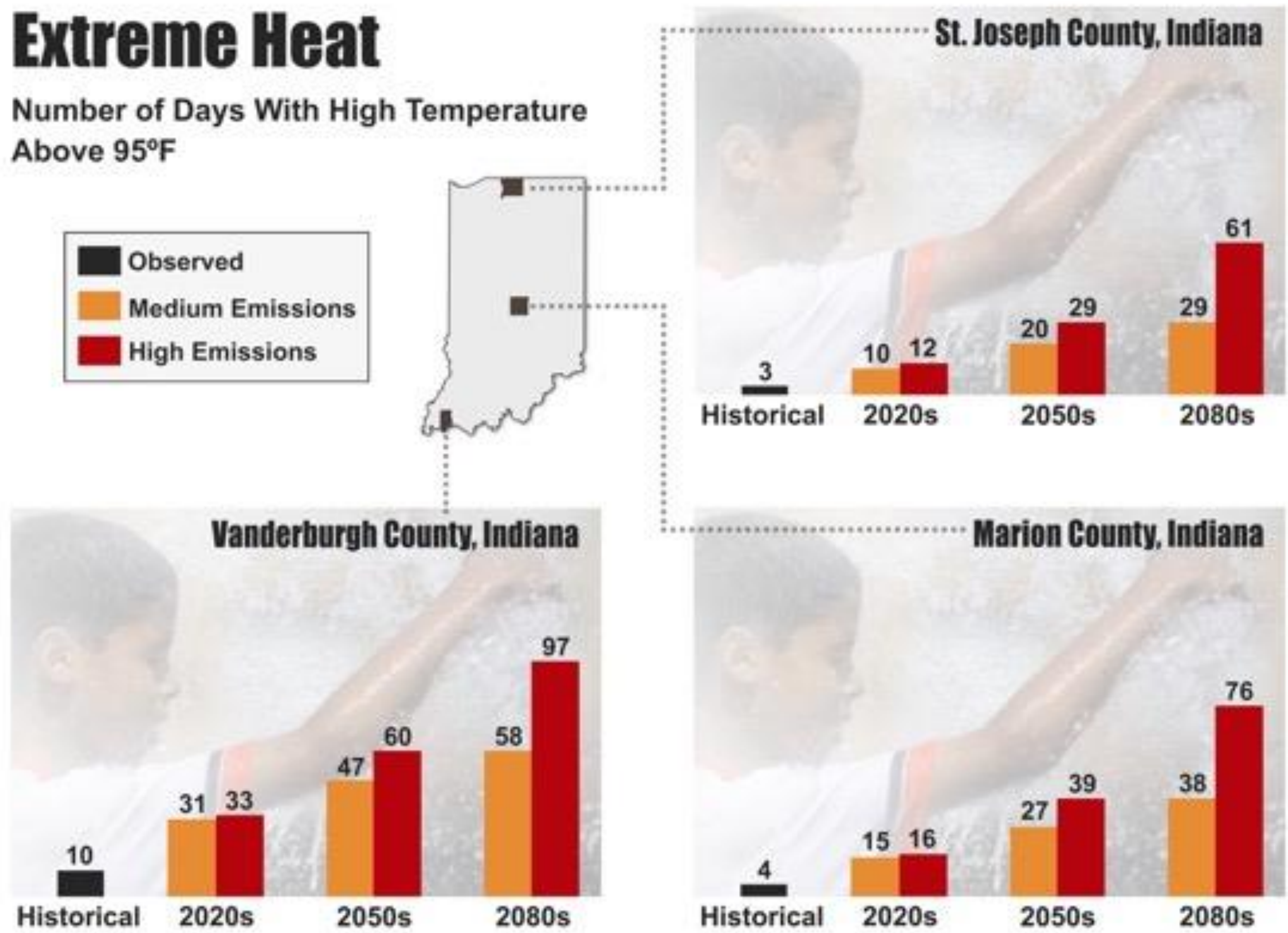


Seasonal Changes in Temperature and Precipitation for IN



Strong agreement between models: Temperature increases in all seasons. Largest increases in temperature in Summer. Precipitation increases in Winter and Spring, Increases in Annual Precipitation.

Weaker agreement between models: Summer and Fall precipitation changes: some models higher, some models lower.



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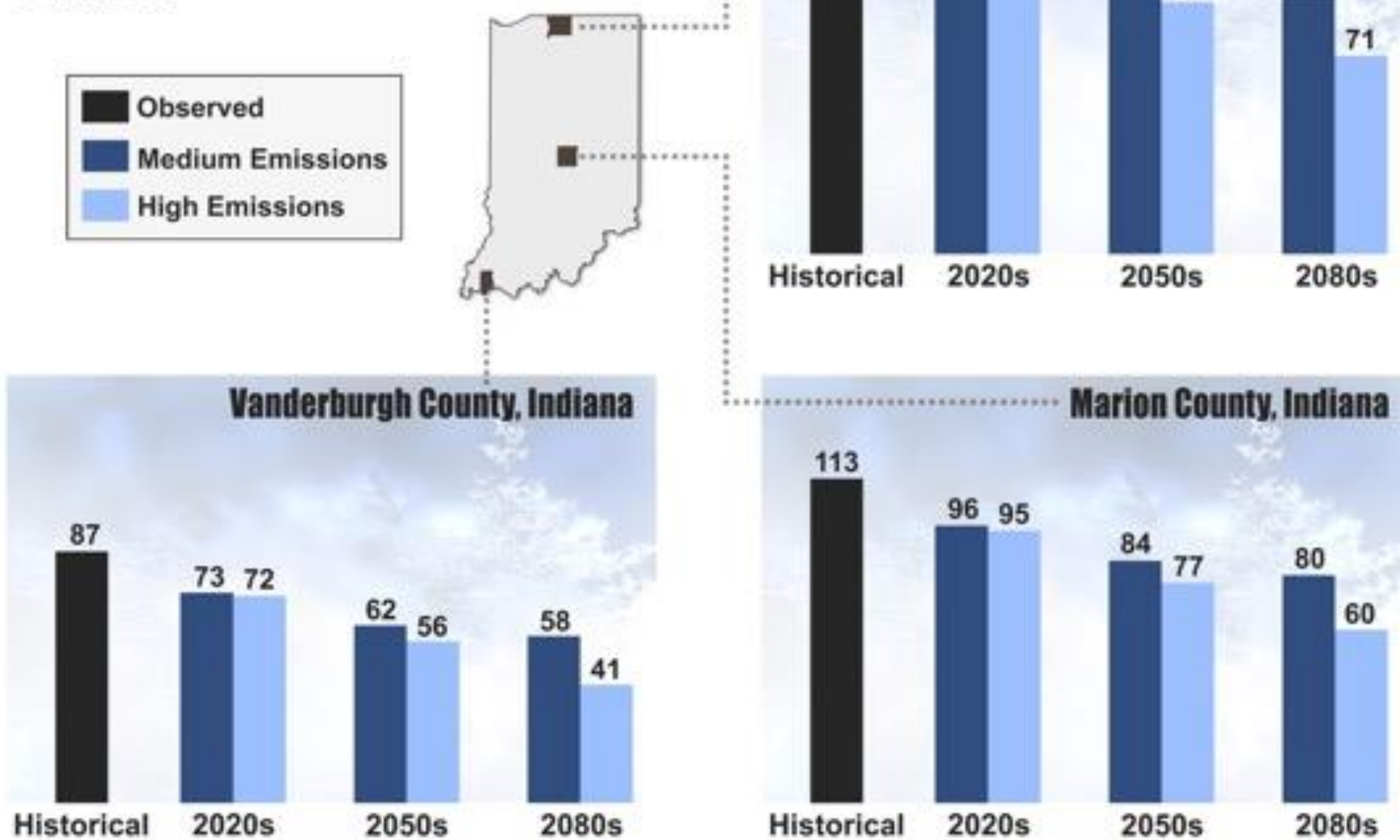
Impact Pathways:

- Human health in cities (heat, humidity, air quality)
- Outdoor recreation
- Agricultural Impacts
- Terrestrial and aquatic Ecosystems (forests, fish, and wildlife)
- Energy supply and demand

Frost Days

Number of Days With Low Temperature Below 32ºF



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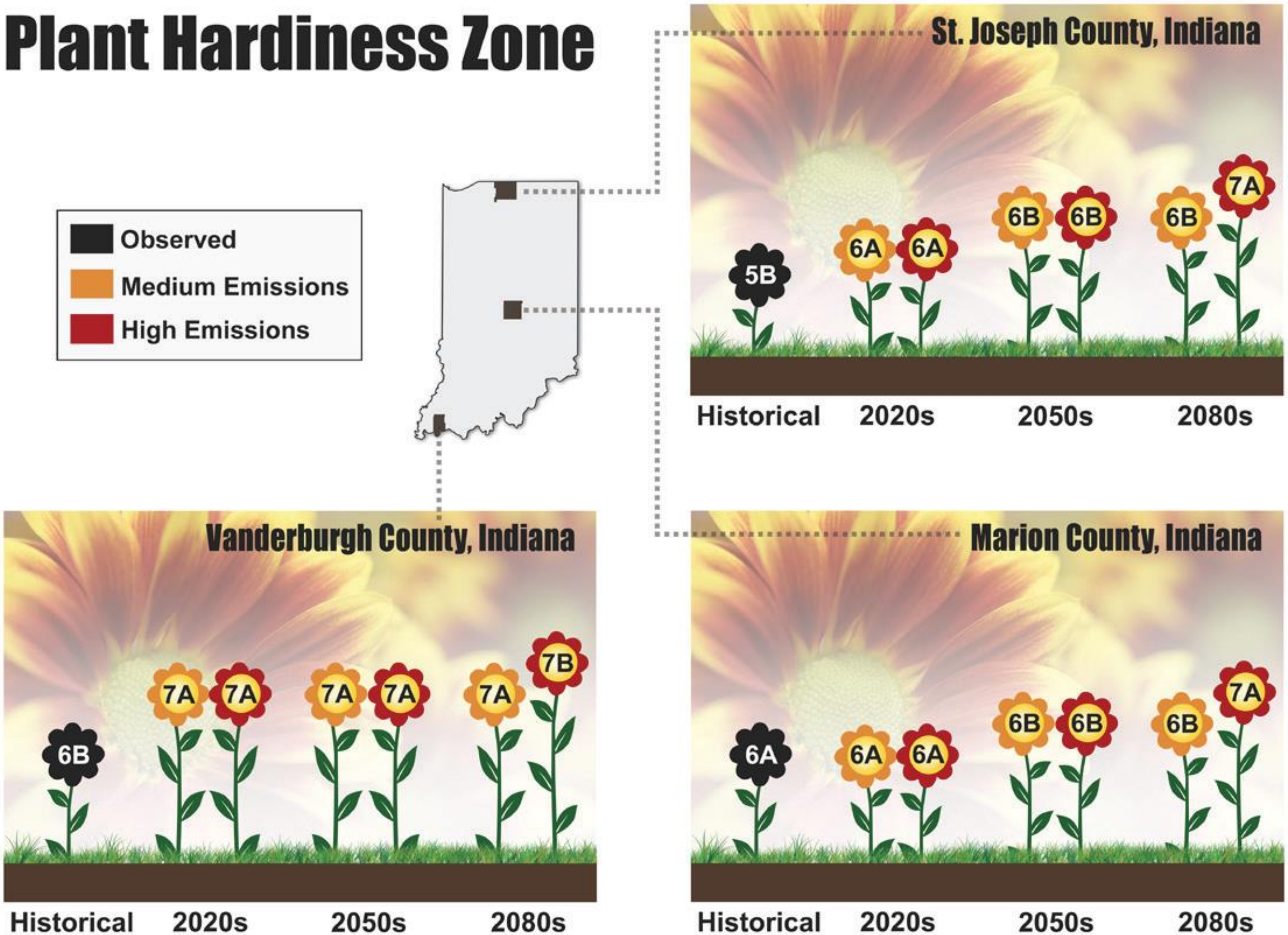
Frost-free season extended 32 days by 2050

Preliminary Data

Future data based on high emissions scenario

Plant Hardiness Zone



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Impact Pathways:

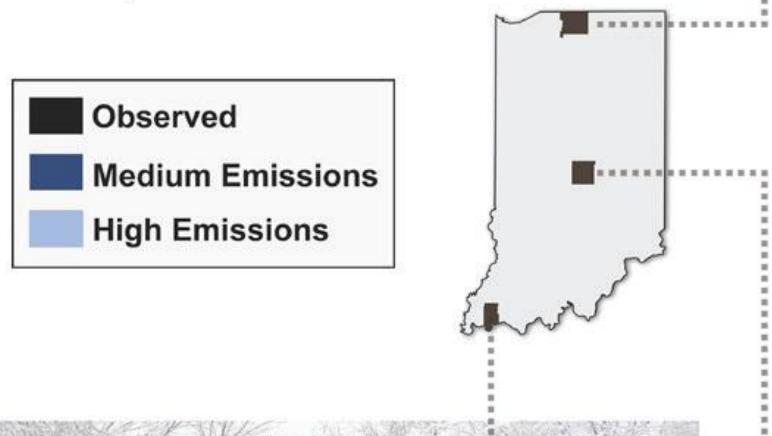
- Agriculture
- Recreational gardening
- Impacts to fish and wildlife (migratory birds)
- Increased exposure to pests and diseases (e.g. ticks and mosquitoes)
- Plant and animal invasive species

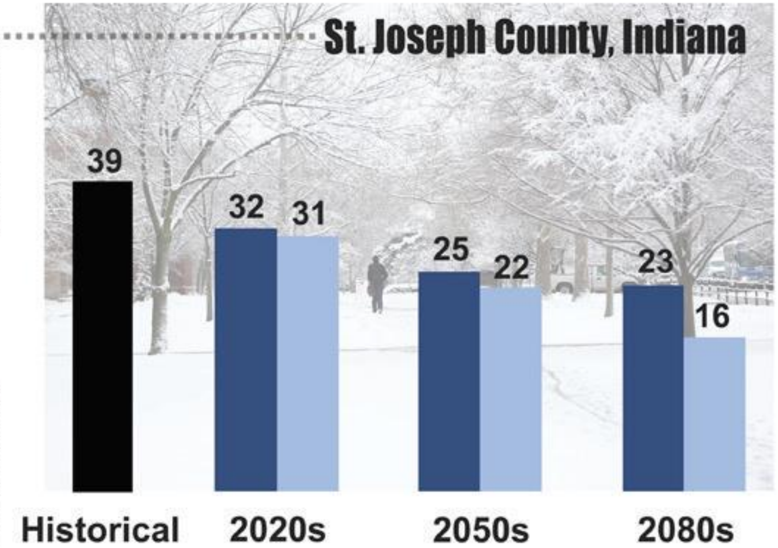
Deer ticks Collected (on my dog) At Potato Creek State Park Jan 5, 2019 (temperature ~50 F)

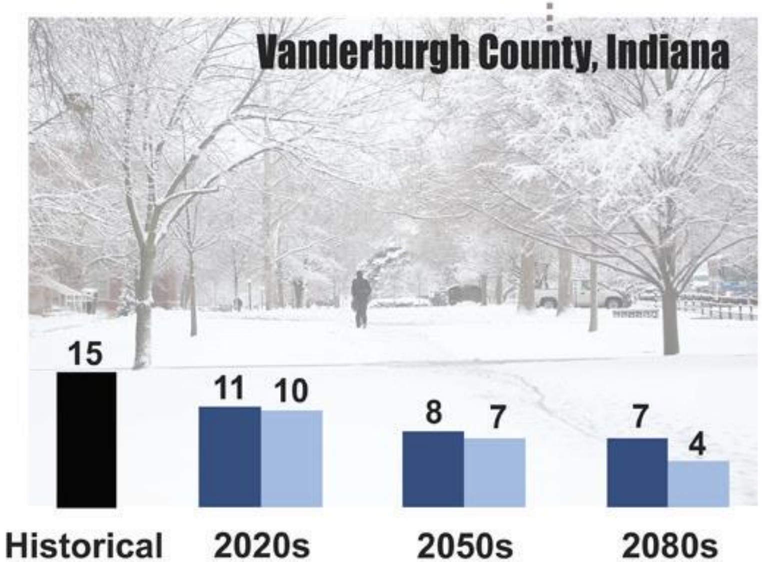
Note that this tick species is a common carrier of Lyme Disease, is not killed by freezing temperatures, and can quickly emerge in relatively warm winter conditions, even after a cold snap. That is, on relatively warm winter days when people will likely be attracted to outside activities, the ticks are also likely to be active!

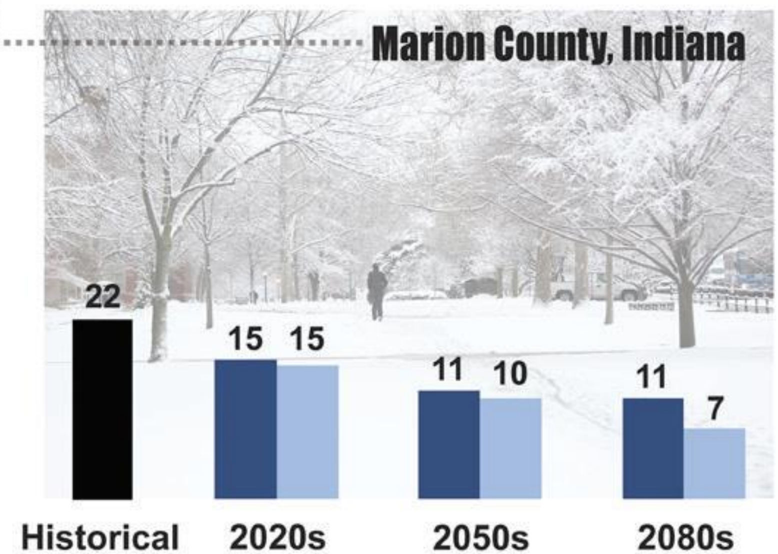
Rain vs Snow

Pecent of precipiation falling as snow (Nov- Mar)









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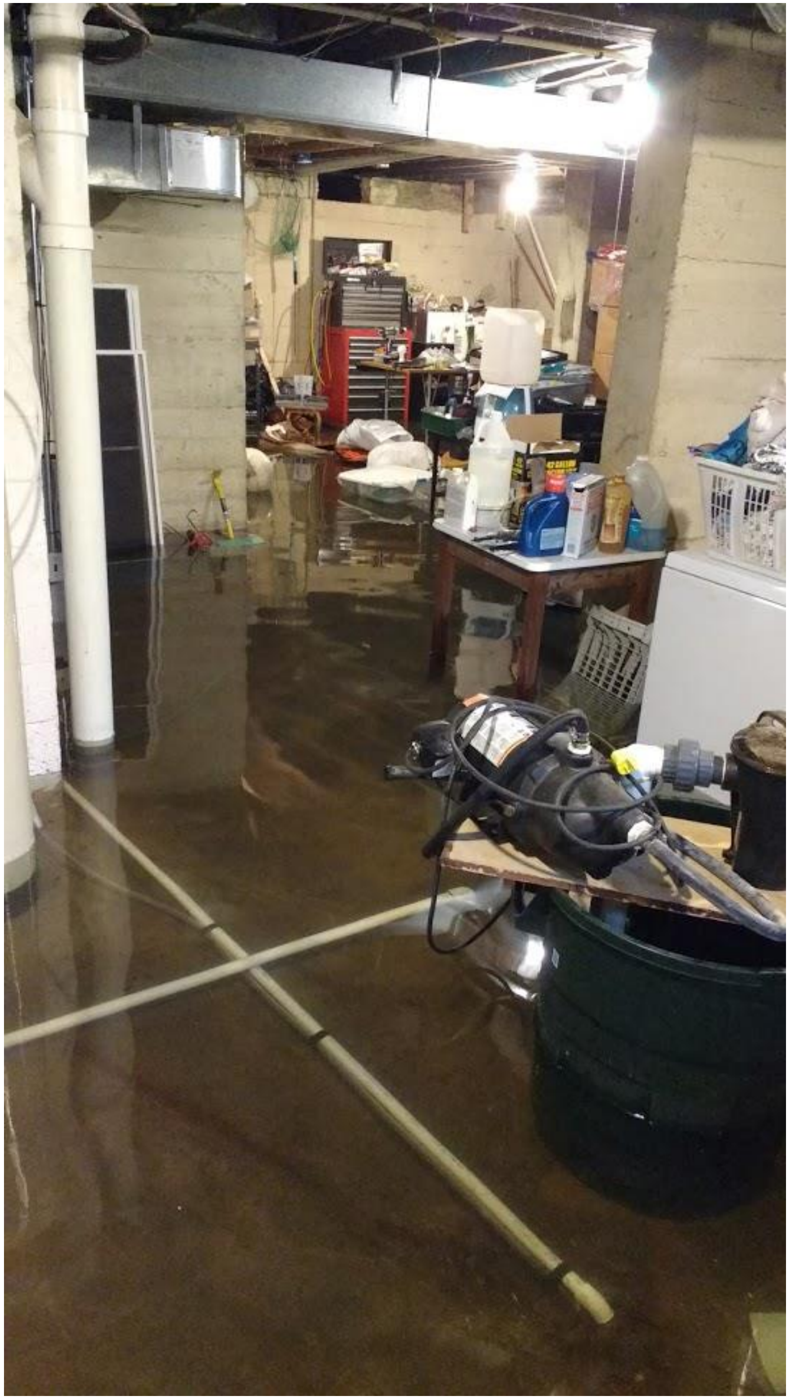
Impact Pathways:

- Winter flooding and stormwater impacts
- Water supply from groundwater
- Higher soil moisture in winter and spring
- Increased erosion and transport of nutrients from farmland
- Water quality in rivers and health of the Great Lakes

Aftermath of record-breaking rainfall on August 15, 2016, (~1000 year event!)

Canoeing on Nokomis Park, August 16, 2016

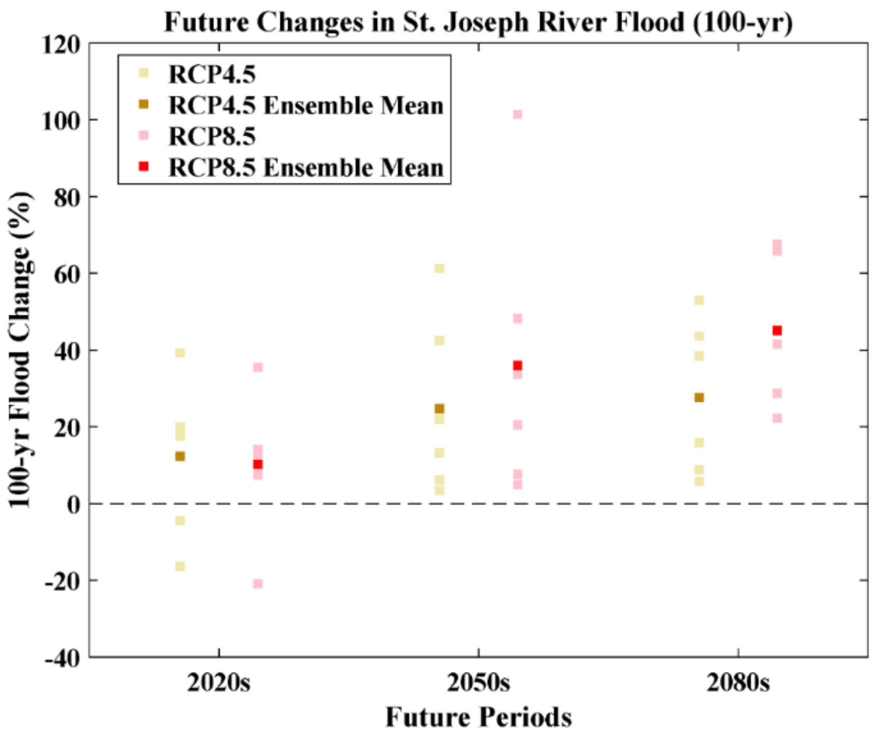
Record-breaking flooding in the St. Joseph River at South Bend, Feb 21, 2018, due to an extreme rain-on-snow event (~2500 year event!)



~8,000 gallons of groundwater in my basement!

St. Joseph River at Niles, MI
Projected Changes in the 100-yr Flood

- **Changes in 100-yr event for future 30-yr window compared to historical one**



- Hydrologic simulation with:
6 GCMs climate data,
2 green house gas scenarios,
RCP4.5 (Medium) and RCP8.5 (Worst)

- Future 30-yr window centered on :
2020s, 2050s and 2080s

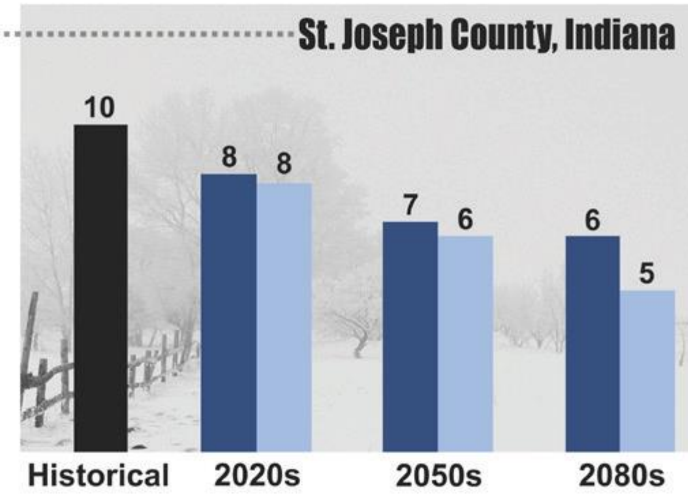
- Significant changes at later periods

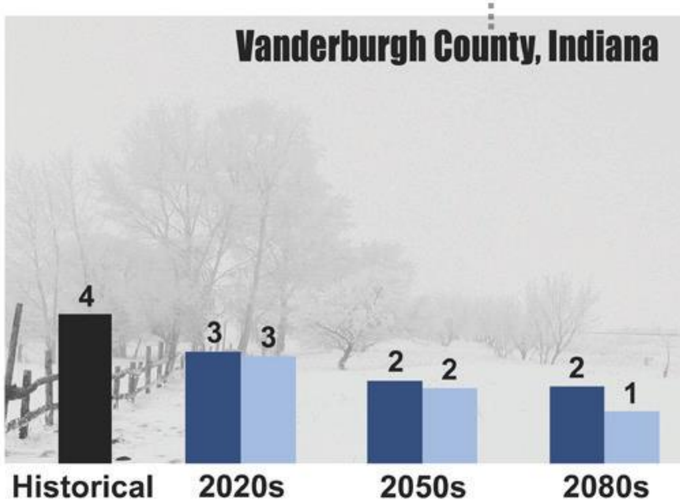
Ensemble mean 100-yr event increases by 45% by the 2080s

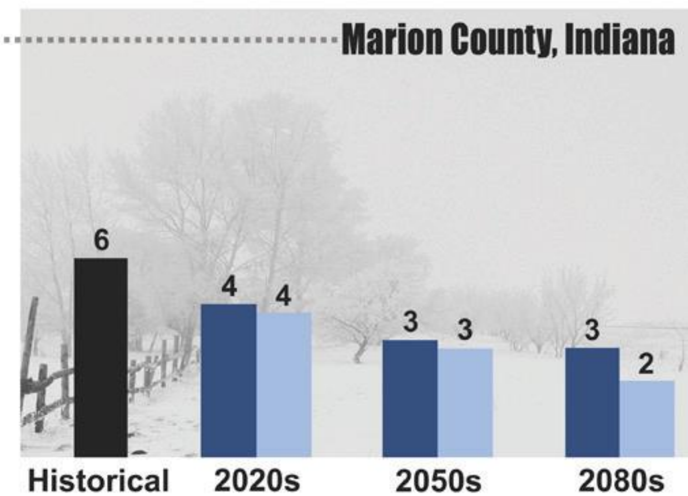
Snow Days

Annual number of days with over snowfall over 2"

Observed
Medium Emissions
High Emissions







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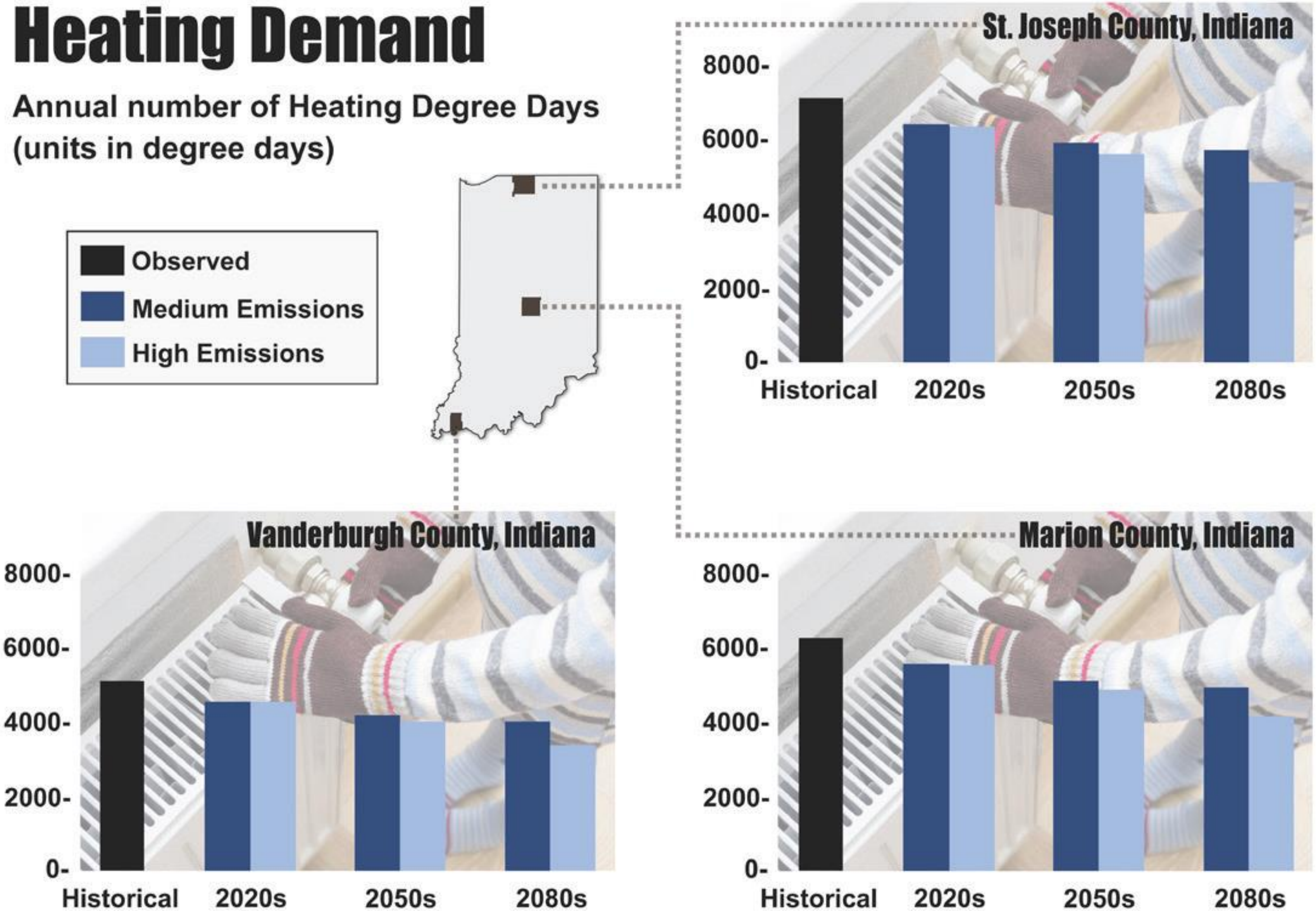
Impact Pathways:

- Reduced effort/costs associated with snow removal
- Fewer school closures
- Fewer transportation impacts from snow (long-term)
- Loss of winter recreation opportunities

Heating Demand

Annual number of Heating Degree Days (units in degree days)



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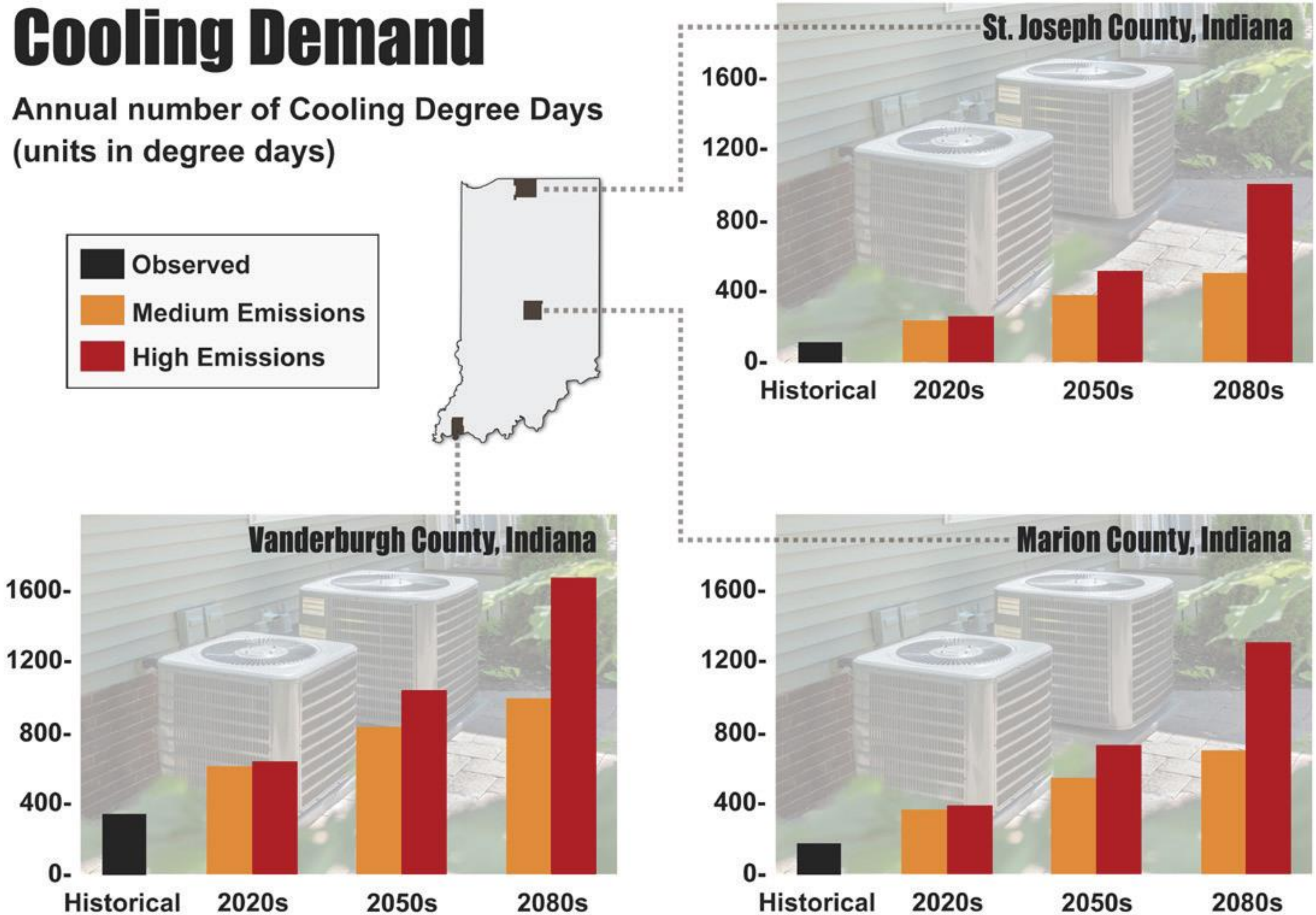
Cooling Demand

Annual number of Cooling Degree Days (units in degree days)



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Impact Pathways:

- Reduced gas and electric bills in winter
- Increased electrical bills in summer
- Increased peak electrical demand in summer (need for more capacity, grid reliability).
- Small (< 5 %) reductions in annual energy costs for consumers and businesses

Summary of Key Conclusions:

- Indiana temperatures are projected to increase dramatically in the coming decades, resulting in substantial increases in the number of extreme hot days, and reductions in extreme cold days.

- The number of days below freezing will substantially decrease in response to warming, but Indiana will still experience cold winters, especially in northern IN. The length of the growing season will increase substantially, and plant hardiness zones will shift by about 2 half zones throughout the state.

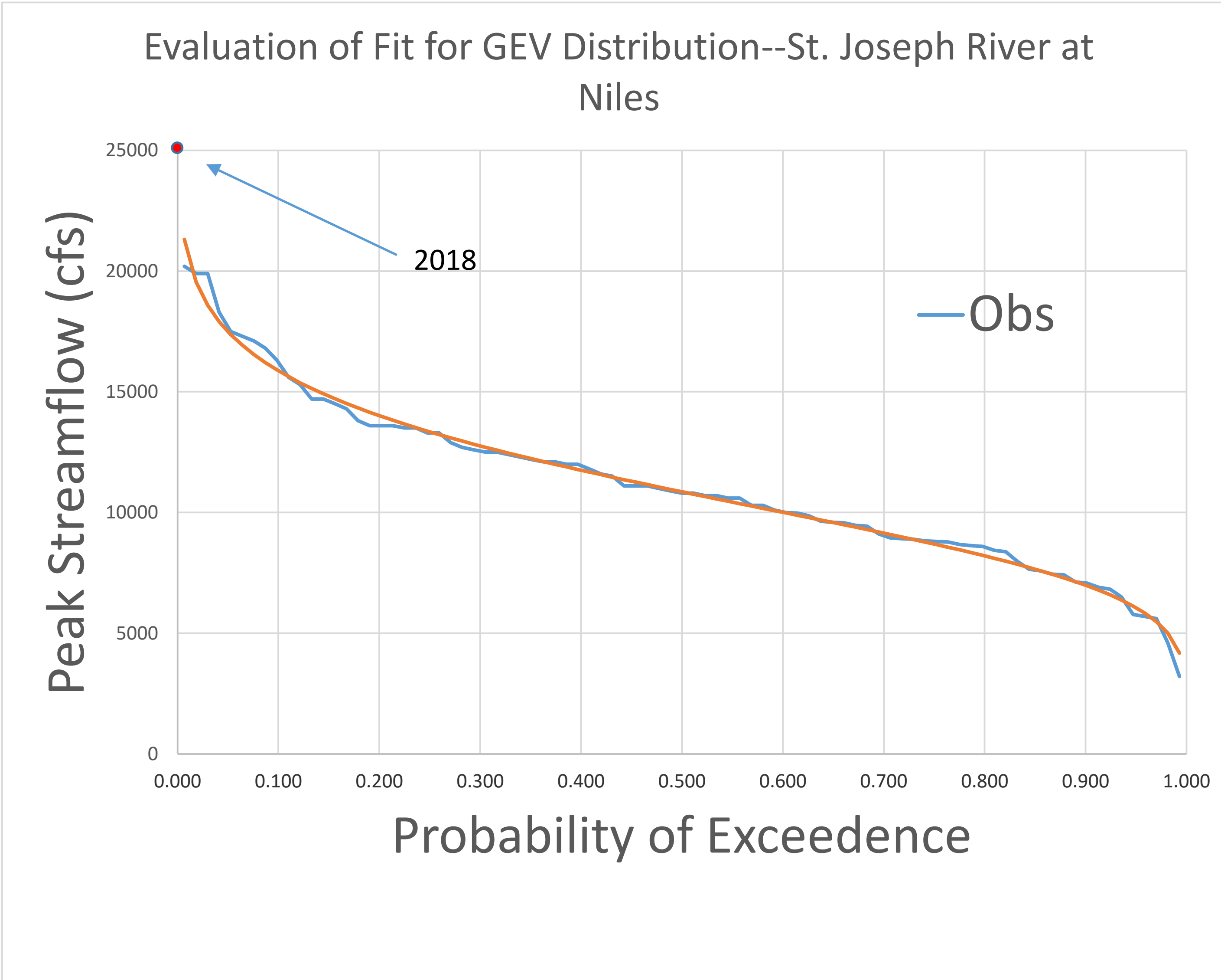
- Precipitation is projected to increase in winter and spring, but more of this cool-season precipitation will fall as rain, with potential increases in winter flooding and stormwater impacts. St. Joseph River flooding is projected to increase substantially.

- The number of days with more than 2 inches of snow is projected to decrease throughout the state. Snow will become infrequent in southern IN by the 2080s, and less frequent in northern IN.

- Precipitation in summer could increase or decrease, and there is not a strong consensus in the model simulations for a systematic change.

- Heating energy demand is projected to decrease, and cooling energy demand is projected to increase, resulting in lower energy bills in winter and higher energy bills in summer, with modest annual reductions (~5 %) in energy demand for space heating and cooling overall.

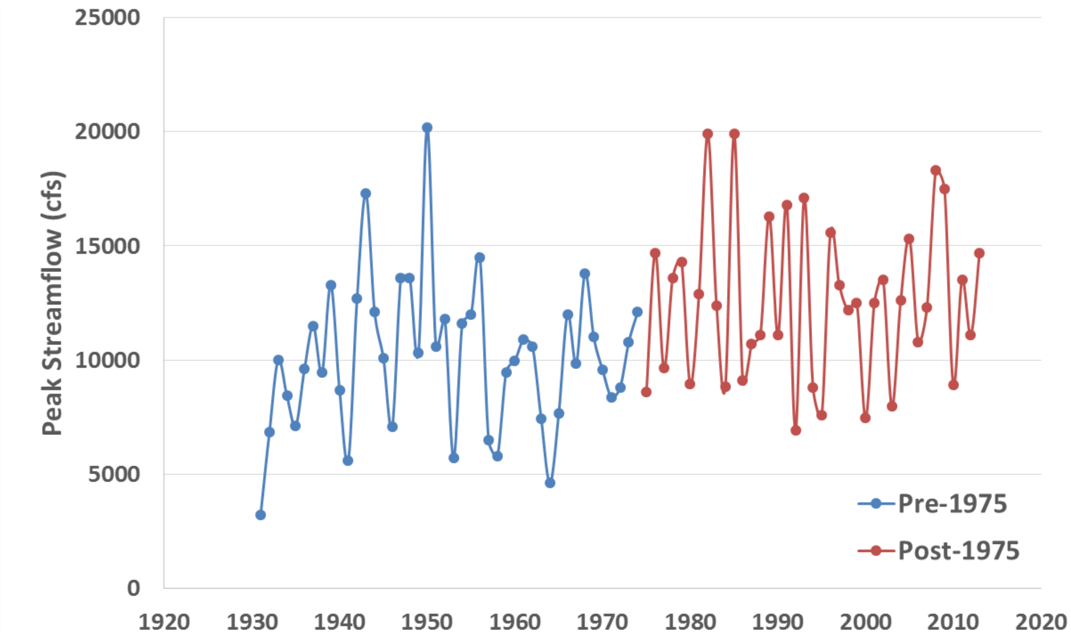
Extras



Evaluation of Fit for GEV Distribution--St. Joseph River at Niles
Peak Streamflow (cfs)
25000
20000
15000
10000
5000
0
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
Probability of Exceedence
2018
Obs

Historical Changes in Peak Annual Discharge

- **Non-stationarity of Extremes (St. Joseph River)**



1. Two-sample Hypothesis Test

$$H_0: \mu_{pre} = \mu_{post}$$

$$z = \frac{(\overline{x_{pre}} - \overline{x_{post}}) - (\mu_{pre} - \mu_{post})}{\sqrt{\frac{\sigma_{pre}^2}{n_{pre}} + \frac{\sigma_{post}^2}{n_{post}}}} = 2.982$$

$$P - value = 0.001432$$
$$(reject\ H_0\ at\ \alpha = 0.01)$$

2. Cumulative Deviation from the Mean

Negative trend in pre-1975

Positive trend in post-1975

- Feb. 2018 St. Joseph Flood

“2500-yr” event