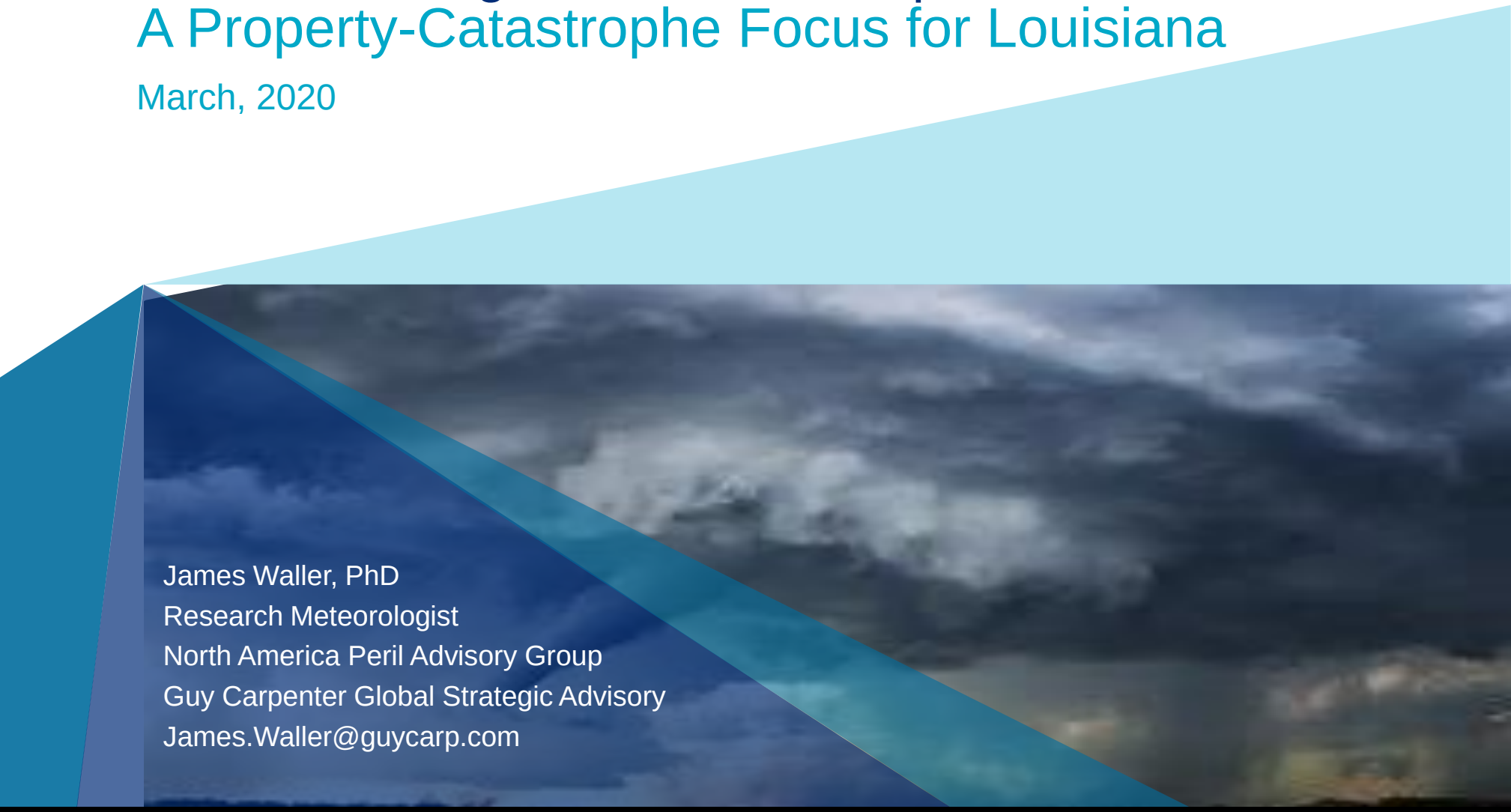
Climate Change Trends and Impacts
A Property-Catastrophe Focus for Louisiana

March, 2020



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GUY CARPENTER

OVERVIEW

1 | BACKGROUND

2 | PROJECTED TRENDS

3 | RESILIENCE MEASURES

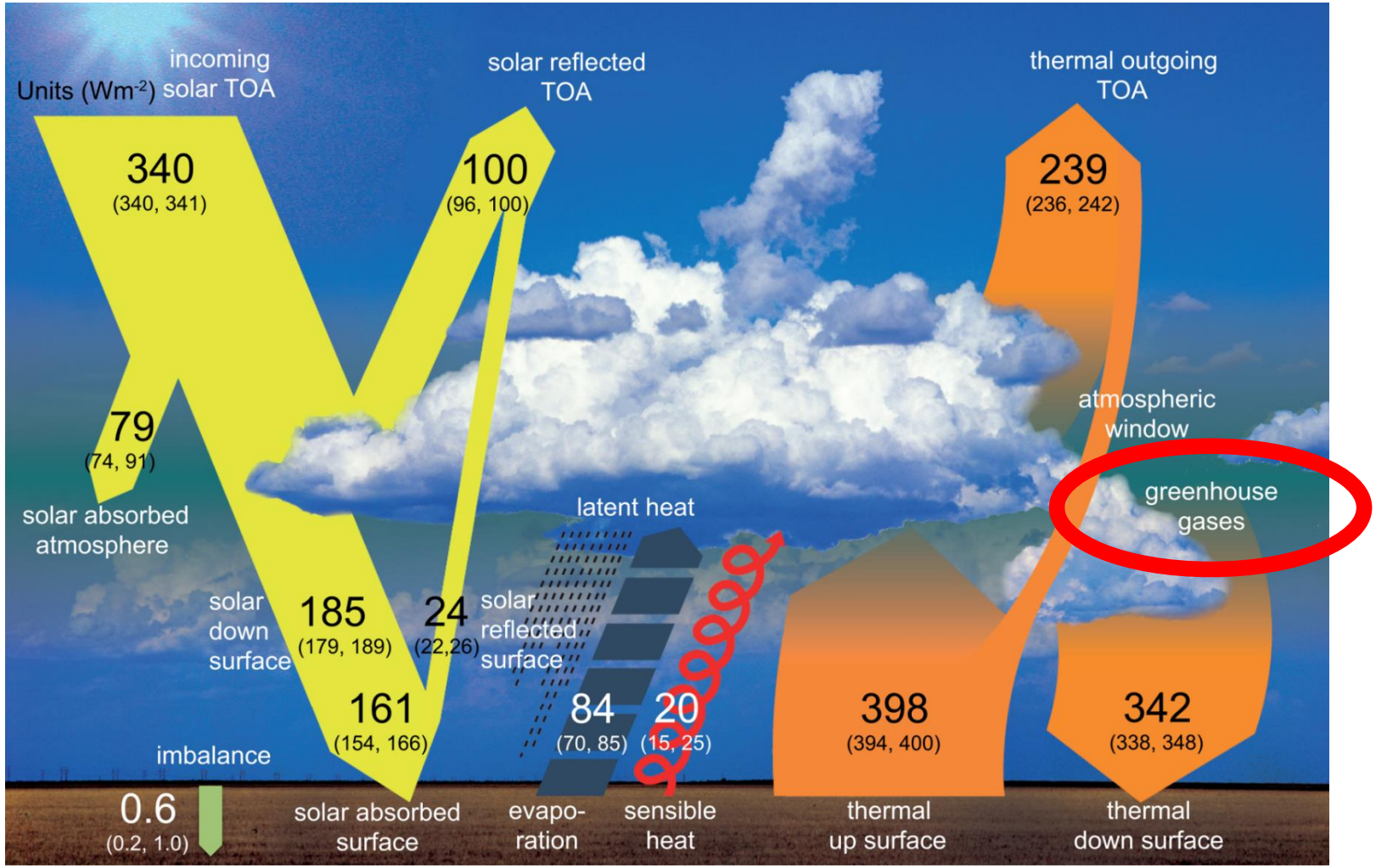
4 | CLOSURE

Section 1

BACKGROUND…

Radiation Balance

Greenhouse gases maintain Earth energy balance, but have increased…

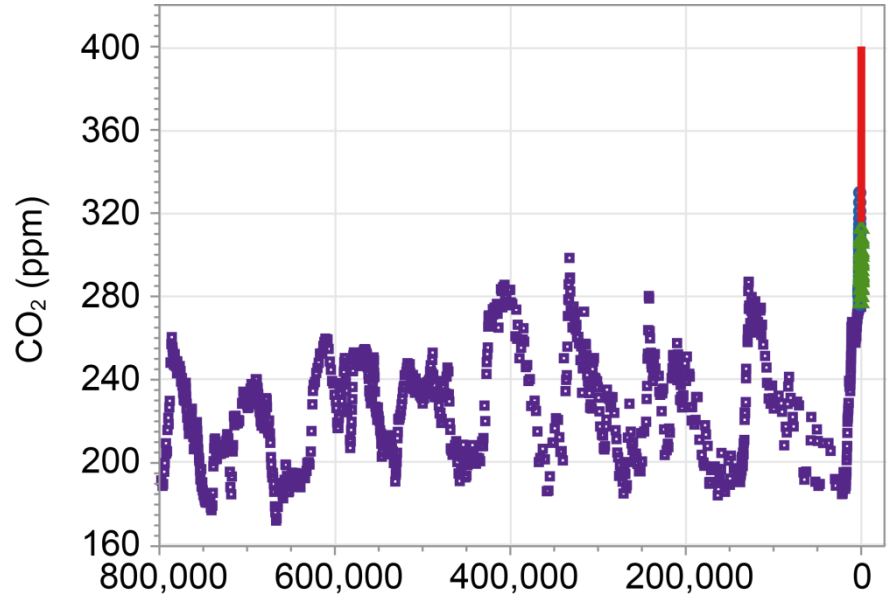


Carbon Dioxide
A greenhouse gas. Considerable observed increase in recent decades.

- Ice core samples show CO_2 in post-industrial era is highest on record. Why do we care?
- Carbon Dioxide is a greenhouse gas, it absorbs radiation from the Earth and emits some of it back to the Earth. Recent warm temperatures have also allowed an increase in atmospheric water vapor (also a greenhouse gas).
- Increased CO_2 and water vapor affects global radiation balance
  - *Forcing a tendency for warming climate.*

SOURCES: IPCC. NCA

Atmospheric CO2 Concentrations Past 800,000 Years

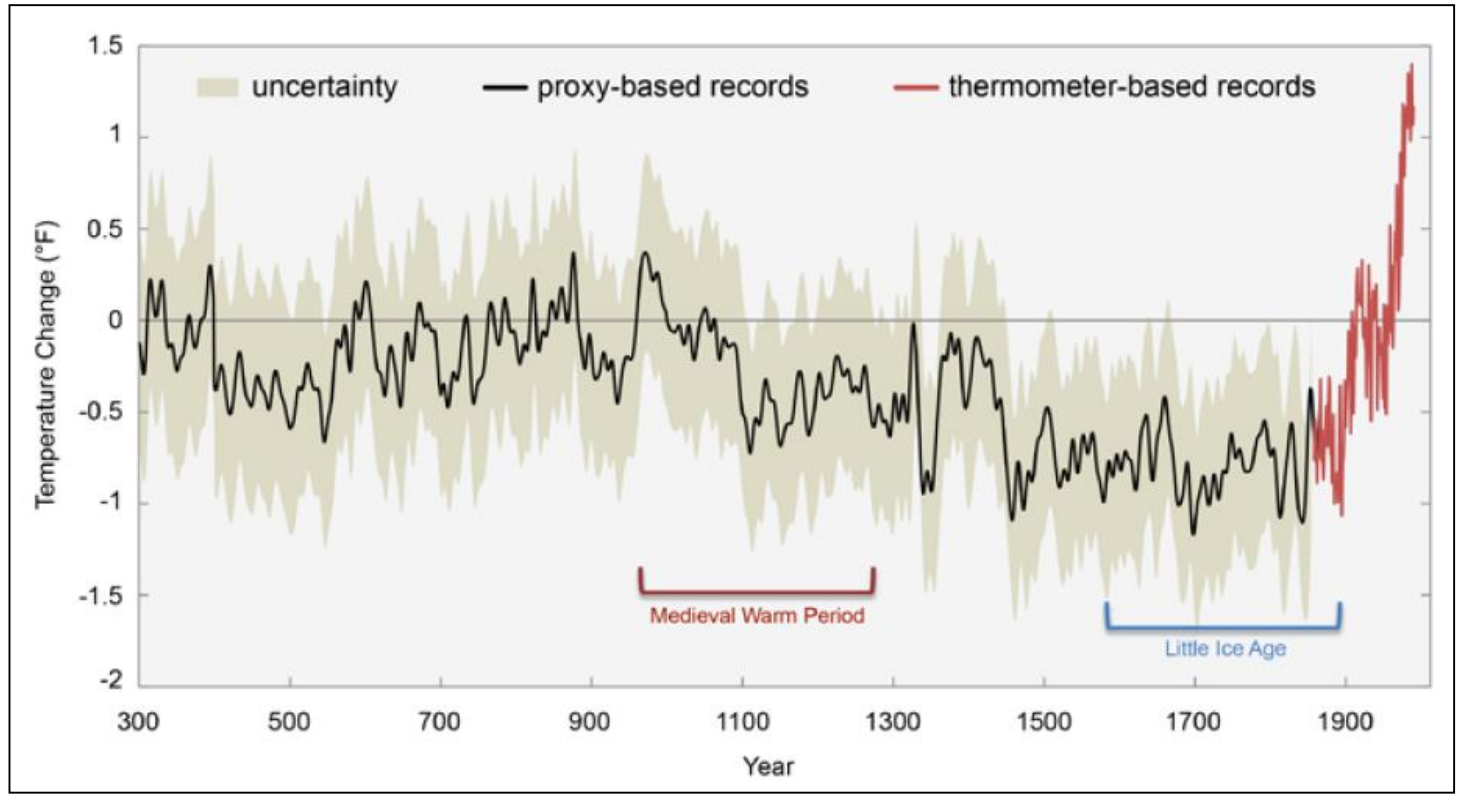


SOURCE: IPCC

Global Warming Context – The Long View

- There is indeed evidence of climate change on a millennial basis
- Can be inferred from ice core chemistry, tree rings, fossilized pollen content, and direct observation over the recent century or so …
- The *rate* of warming experienced in the post-industrial era is unprecedented
- Consistent also with increasing ocean temperatures, retreating ice caps, sea-level rise

SOURCES: IPCC. NCA

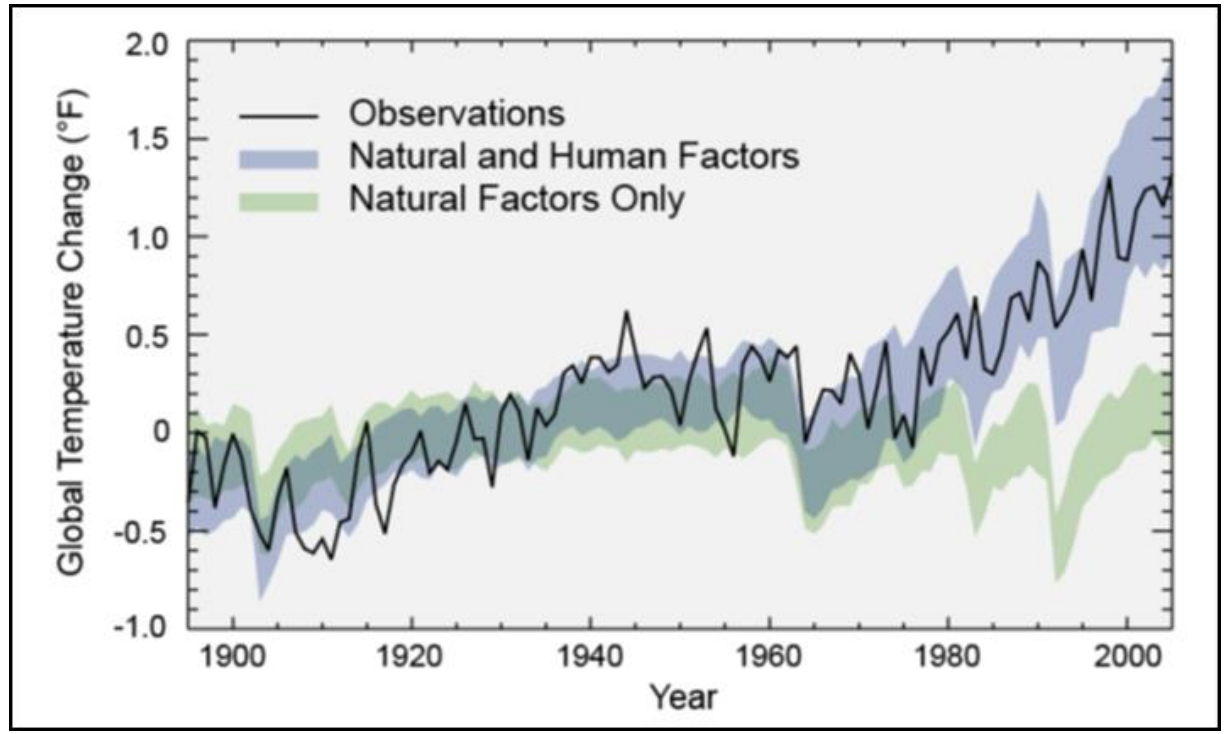


SOURCE: IPCC

Climate Change Context

- The human CO_2 connection cannot be ruled out as statistical noise (IPCC, Zwiers et al 2011).
- Global climate models also lend credibility to this finding (bottom panel).
  - Global climate models generally reproduce observed temperature trends (blue shades).
  - Same models show a cooler Earth (green) when model carbon dioxide is restricted to pre-industrial levels.
  - *Same models predict general temperature increase through 2100s.*

SOURCES: IPCC. NCA



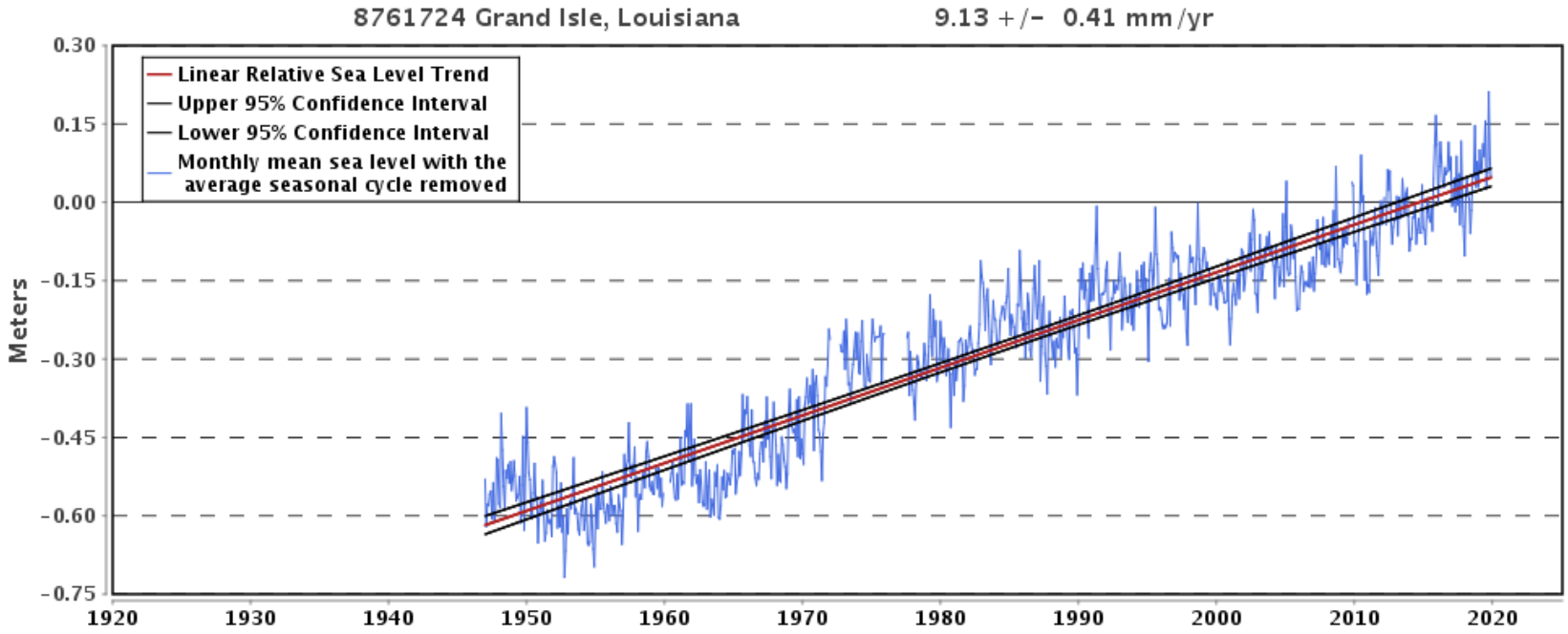
SOURCE: NCA

Section 2

PROJECTED TRENDS…

Sea-Level Rise

- Observed sea-level trend of about 2 feet over 70 years at Grand Isle, Louisiana.
- Projected increase of 4-6 feet by 2100 (Northern Gulf).
- Ice sheet instability may increase these numbers.
- Compacts return periods of coastal flood threats, especially hurricane.
- Coastal urban and agricultural areas face increasing risk.
- Significant threat from a property and infrastructure perspective.

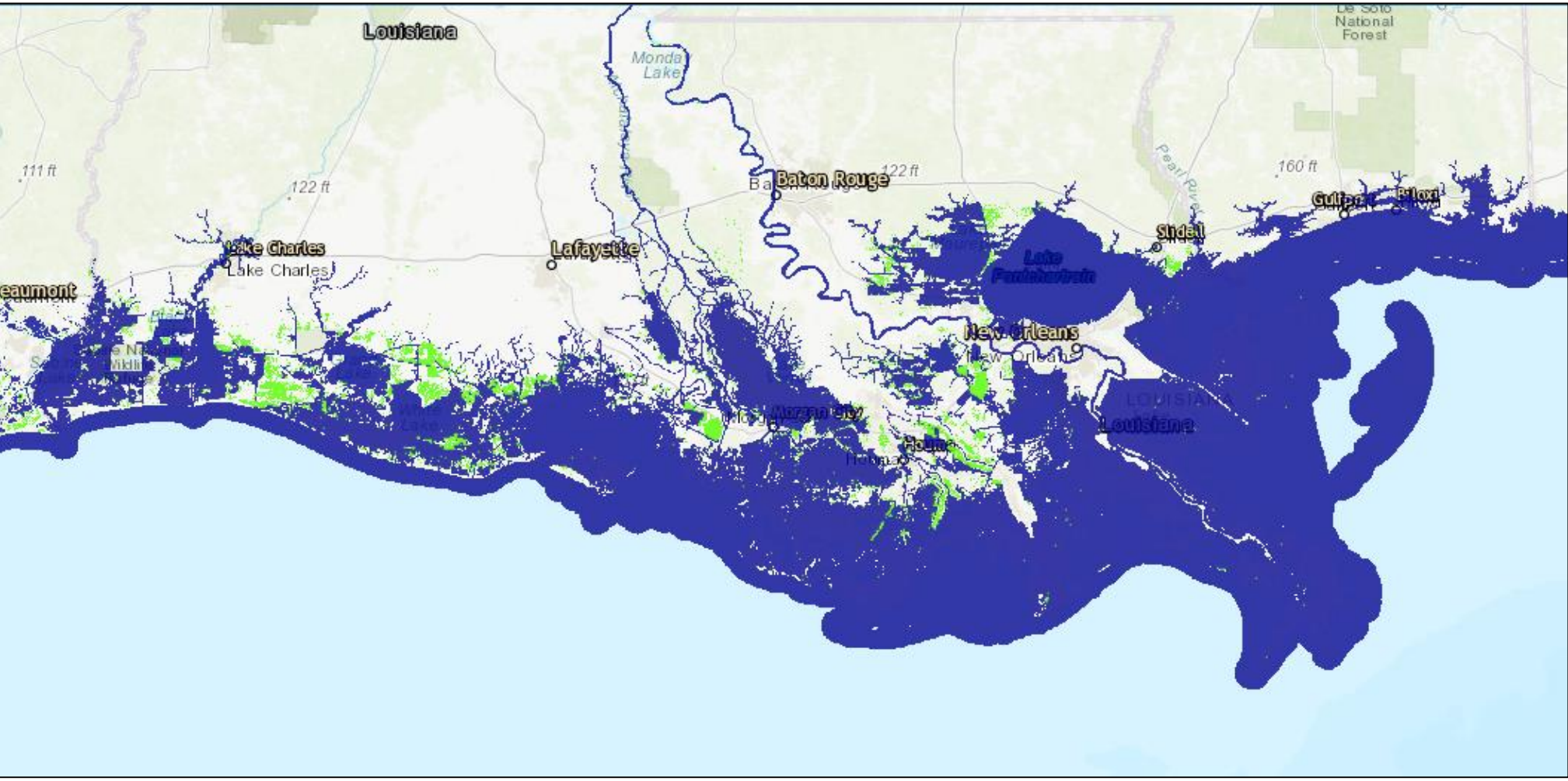


Observed Mean Sea Level and Trend

Grand Isle, Louisiana

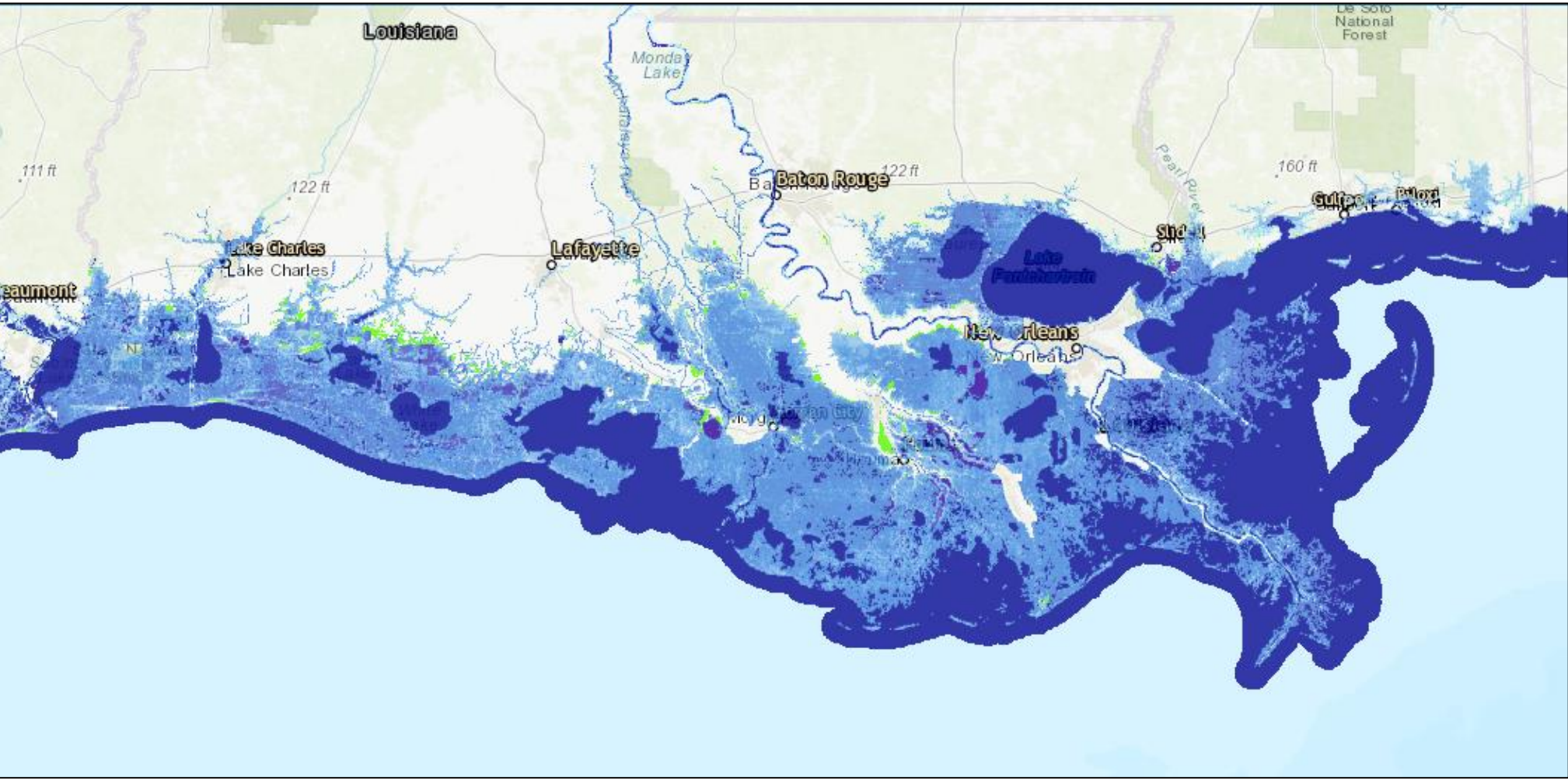
SOURCES: NOAA, NCA, IPCC

Sea-Level Rise Scenarios
Areas prone to seawater flooding at 0 ft Above MHHW



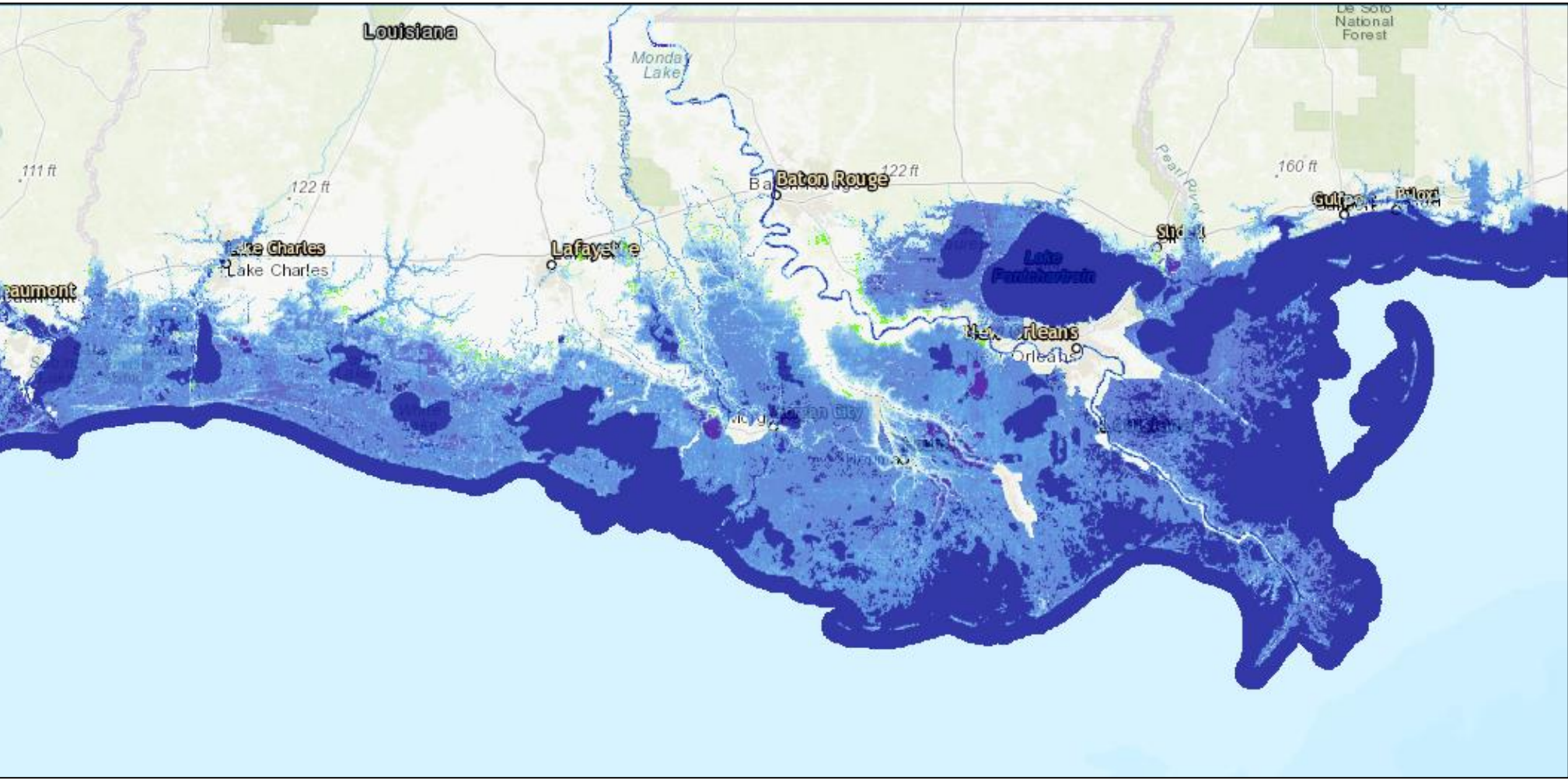
SOURCE: NOAA
https://tidesandcurrents.noaa.gov/inundationdb/

Sea-Level Rise Scenarios
Areas prone to seawater flooding at 2 ft Above MHHW



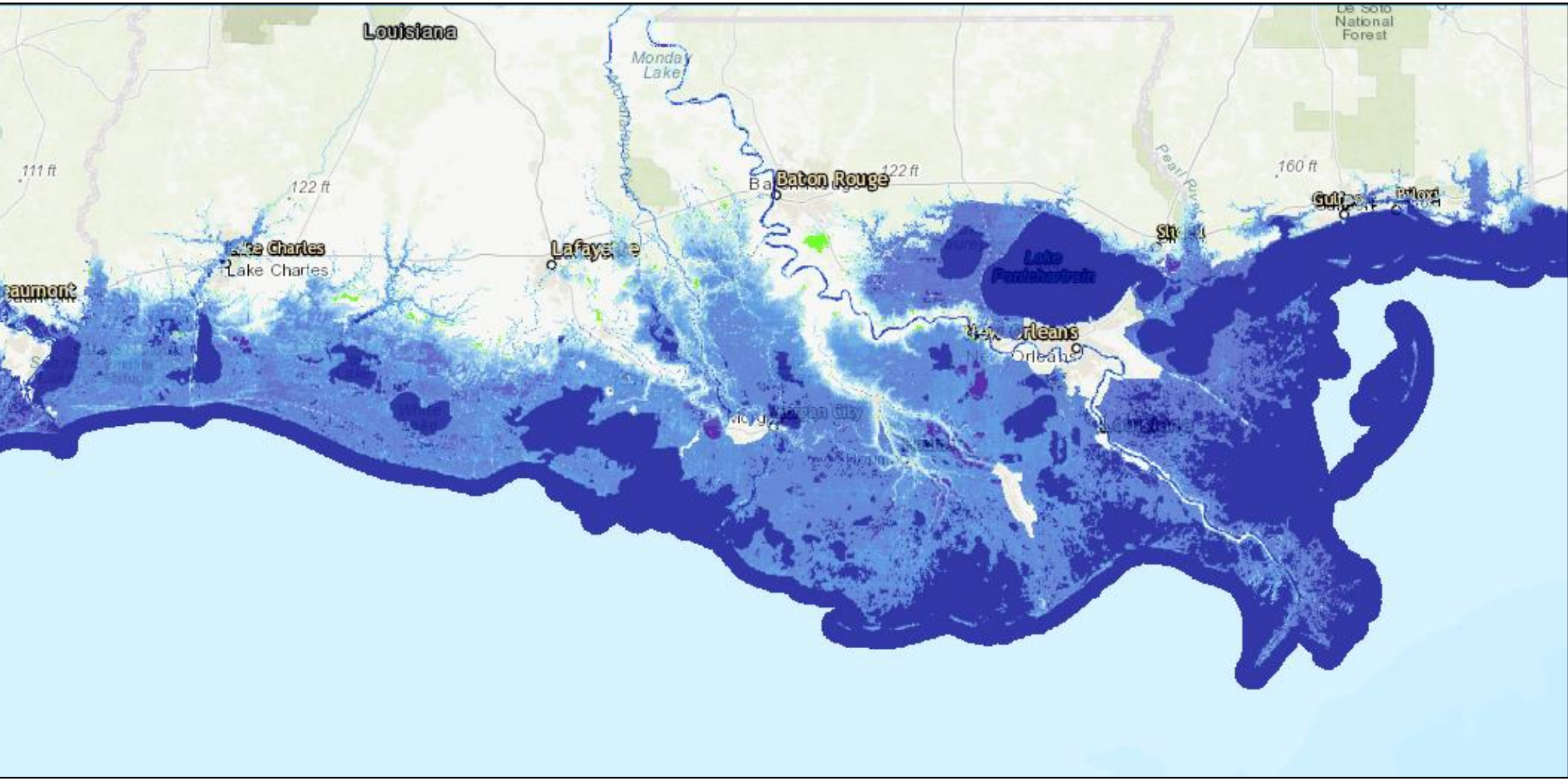
SOURCE: NOAA
https://tidesandcurrents.noaa.gov/inundationdb/

Sea-Level Rise Scenarios
Areas prone to seawater flooding at 4 ft Above MHHW



SOURCE: NOAA
https://tidesandcurrents.noaa.gov/inundationdb/

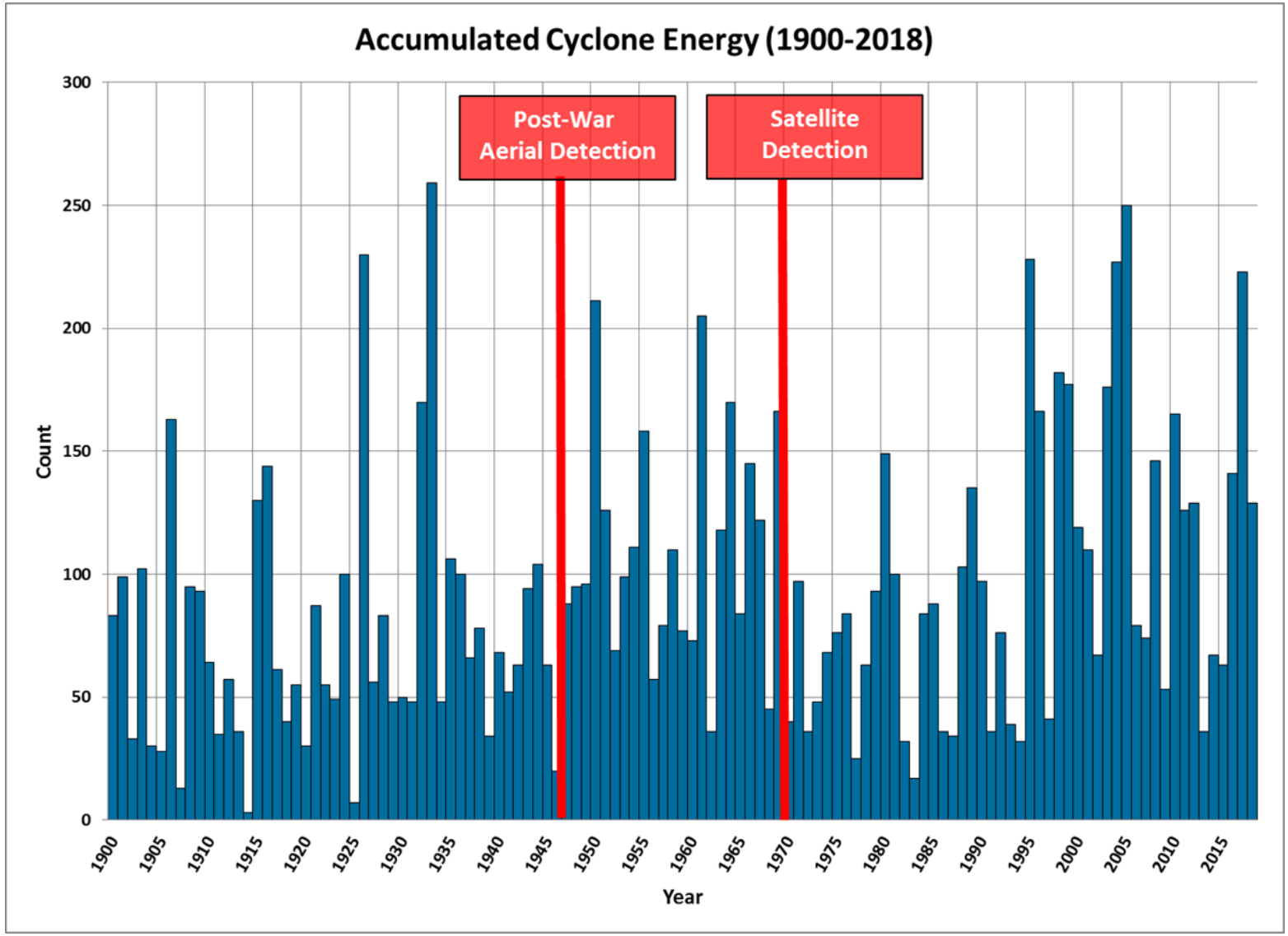
Sea-Level Rise Scenarios
Areas prone to seawater flooding at 6 ft Above MHHW



SOURCE: NOAA
https://tidesandcurrents.noaa.gov/inundationdb/

Hurricane Frequency/Severity – Annual Accumulated Cyclone Energy

No observed long-term trends, significant variability, active since 1995

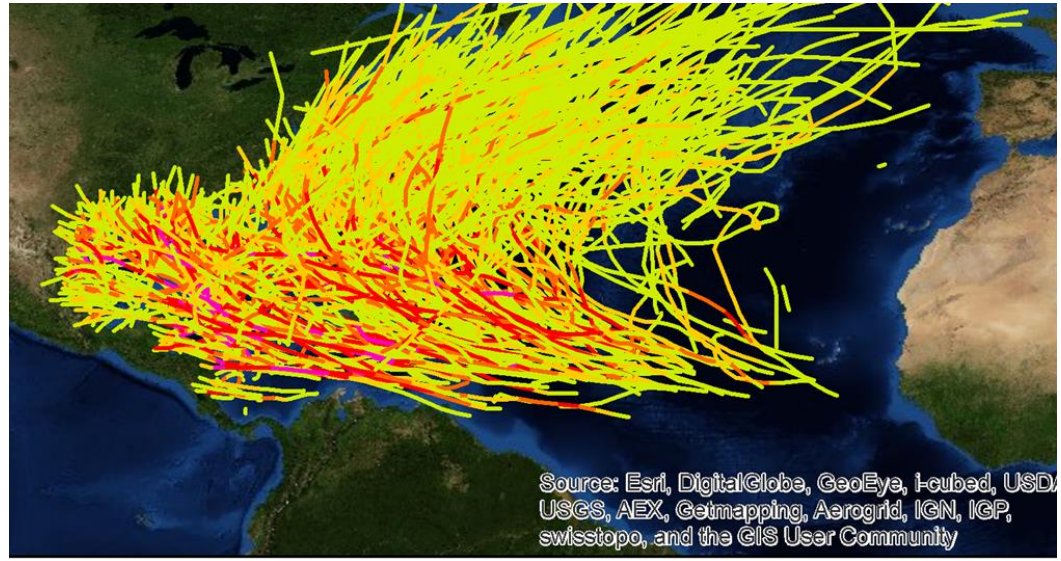


SOURCE: Guy Carpenter, NOAA/HRD

Projected Hurricane Frequency/Severity
Uncertain frequency, but projected intensity increase

- No observed physical changes to date
  - Difficult to detect due to variability, detection improvements with time
- Uncertain change in *frequency* through 2100s
  - Warmer SSTs in Atlantic and Pacific have competing effects in Atlantic HU frequency
  - Modeling approaches (moisture, resolution) produce conflicting results in projections
- Some increase in *intensity* expected
  - Warmer SSTs in Atlantic Basin increase maximum potential intensity
  - Higher proportion of severe hurricanes
- Possible increase in hurricane rainfall intensity, inland flood effects

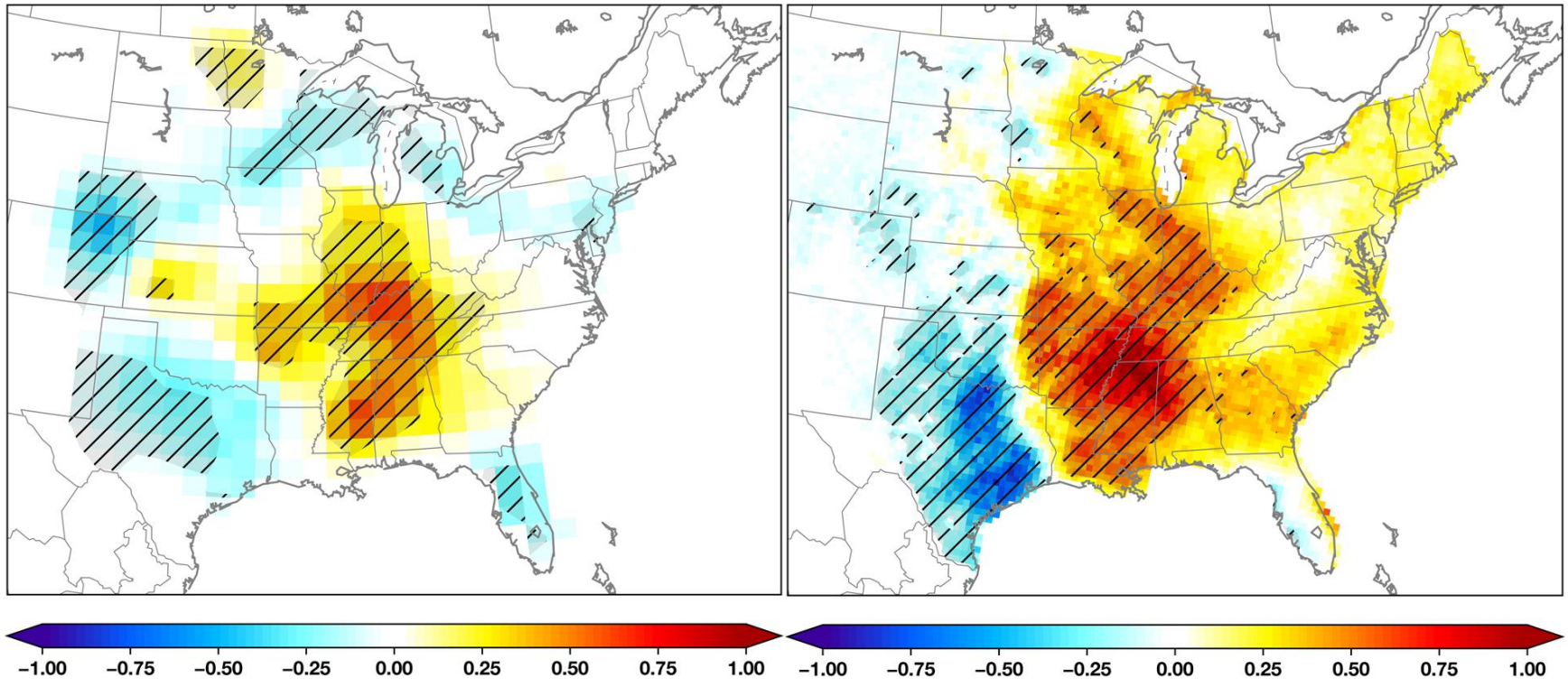
SOURCES: IPCC/NCA



SOURCE: Guy Carpenter, NOAA/HRD

Spatial Trends in Tornado Frequency
Decrease Central & Southern Plains. Increase Southeast & Midwest

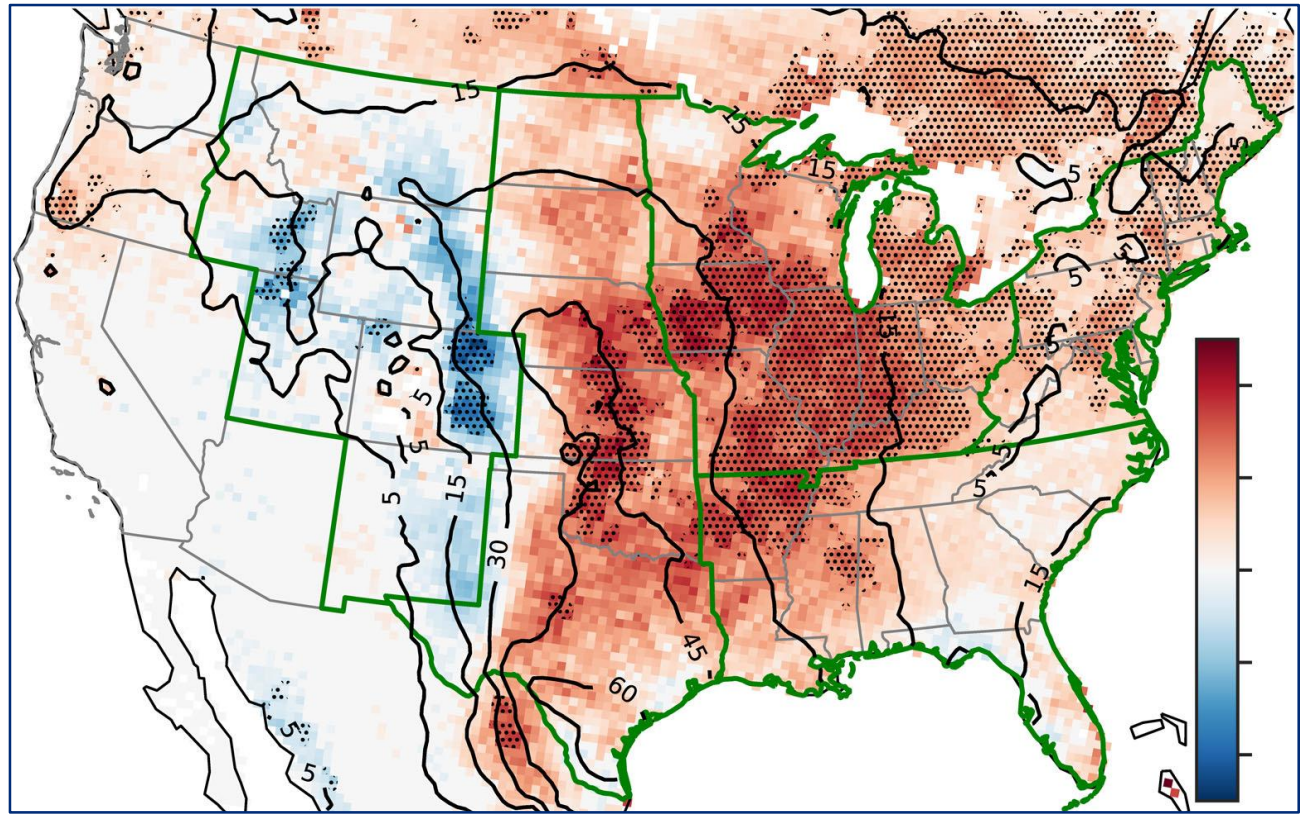
- Analyzed shift in gridded tornado reports (left) and significant tornado environments (right) as analyzed from 1979-2017 (slope units are reports or daily max per year)
- Hatched regions indicate statistical significance.
- Not all days with significant tornado environments produce significant tornadoes (local effects very important and affect initiation)



SOURCE: Gensini & Brooks 2018

Spatial Trends in Hail Frequency
Increasing Trend from Central Plains to Northeast

- Trends in annual large hail environment days (shaded) with observed annual mean number of large-hail-parameter days (contoured) 1979-2017
- Statistically significant increase in days that could produce large hail from Southern Plains and Lower Mississippi Valley through Midwest and Northeast (red-speckled regions)



SOURCE: Tang, Gensini et al., 2019

Severe Thunderstorms under Climate Change
Overall, Slight Change to Means. Greater Variability.

- Observed *decline* in tornado days
- Observed increased *"productivity"* of tornado days
- Observed spatial shift
- Projected tornado environments - unclear

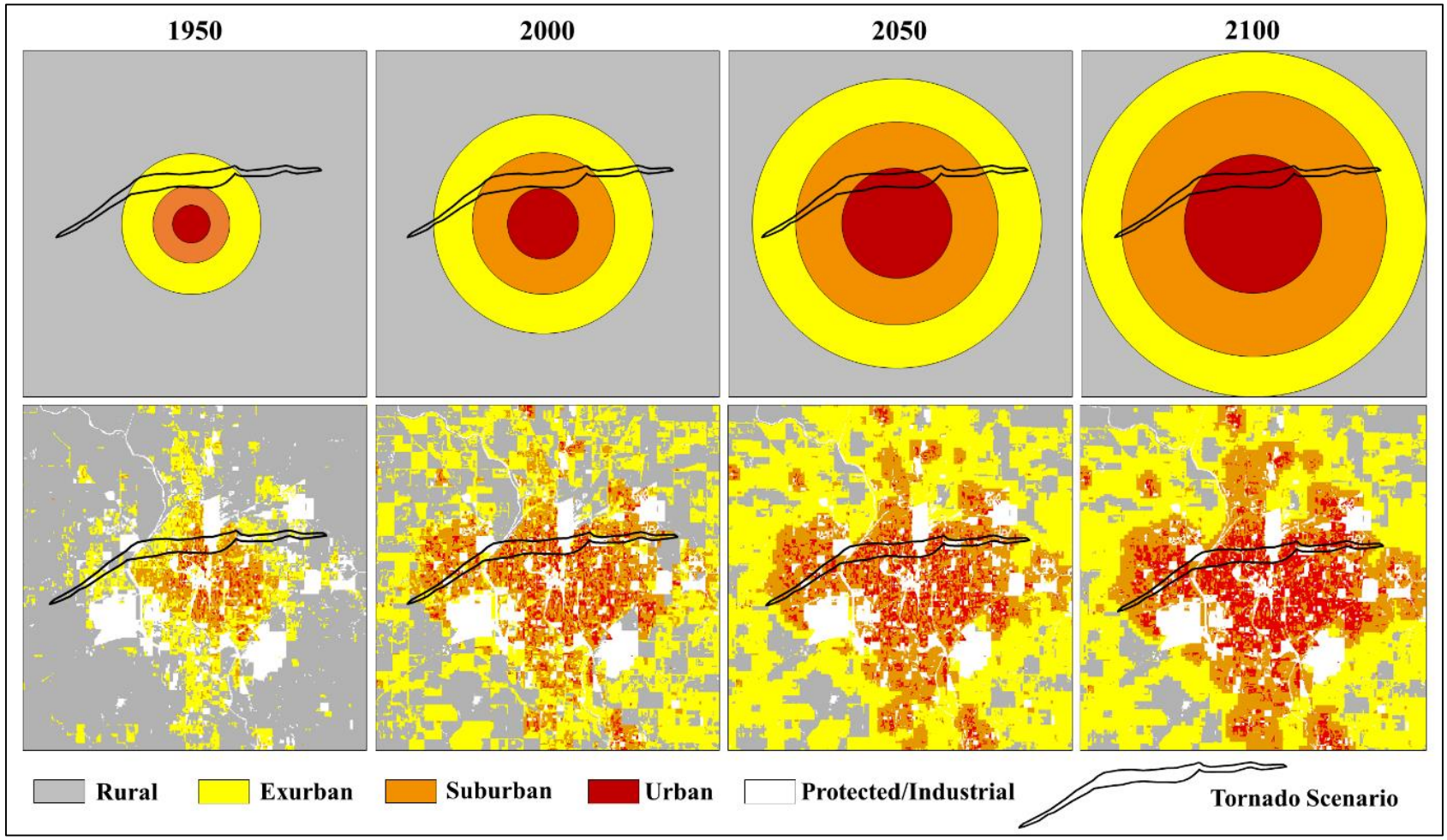
- Observed possible upward drift in 2"+ hail
- Observed spatial shift
- Observed hail environments appear to be occurring more frequently
- Projected net annual increase in severe hail days by late century
- Projected increase in seasonal variability

- Projected changes 2070-2100
  - Increased instability (increases thunderstorm intensity)
  - Decreased wind shear (offsets thunderstorm intensity)
  - What wins??? Clarity is difficult for straight line winds
- *Longer* SCS season, earlier start, increased variability
- Busier spring, quieter summer

SOURCES: Diffenbaugh Scherer Trapp 2013, Trapp et al 2018

Population Trends Can Also Increase Risk

Population increase can bring upward loss trend regardless of hazard

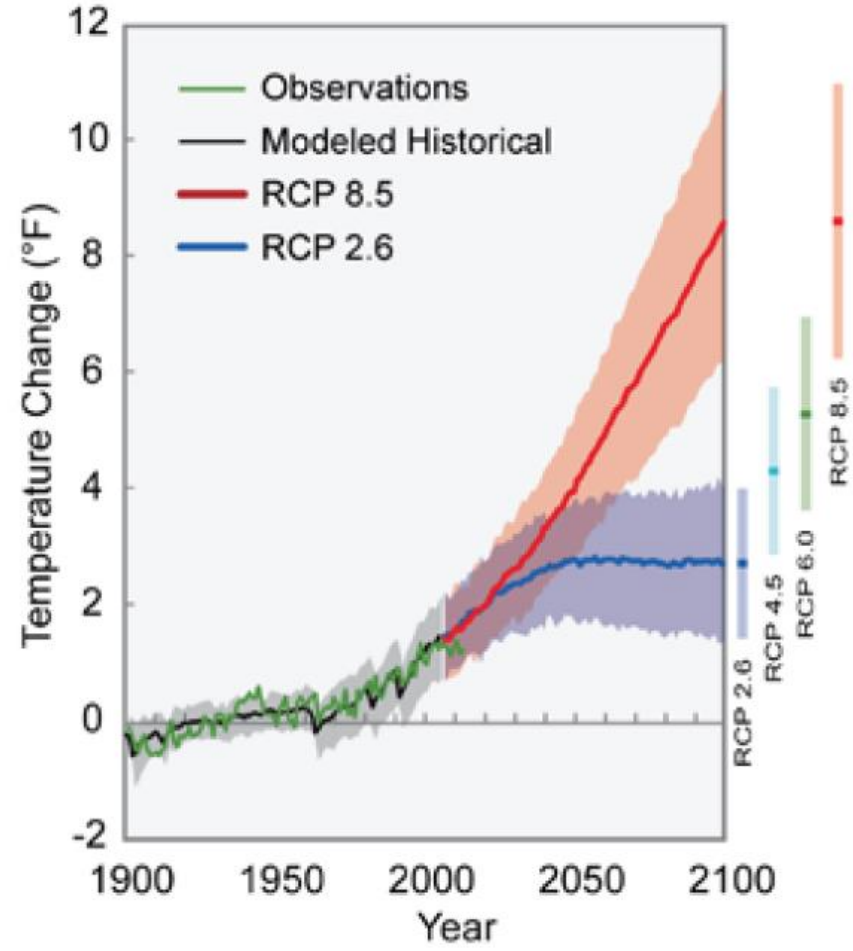


Ashley, W. S., S. Strader, T. Rosencrants, and A. J. Krmenec, 2014: Spatiotemporal changes in tornado hazard exposure: The case of the expanding bull's eye effect in Chicago, IL. Weather, Climate, and Society, 6, 175-193.

Observed and Expected Impacts – Temperature
Possible effects to energy, health

- Observed increase in U.S. mean temperature since late 1800s
  - Significant increase since 1970
  - Last decade was warmest on record
- Observed increase in heat wave frequency and severity, projected to continue
- Observed decrease in cold wave frequency and severity, projected to continue
- Projected to continue through 2100s+
- Persistent warm/cool periods because of storm track behavior
- Implications for energy use, agriculture, heat-related illness, disease, wildfire

SOURCES: NCA, IPCC



Observed and Projected Global Mean Temperature

RCP 8.5 - High Emissions Scenario

RCP 2.6 - Aggressive Reduced Emissions Scenario

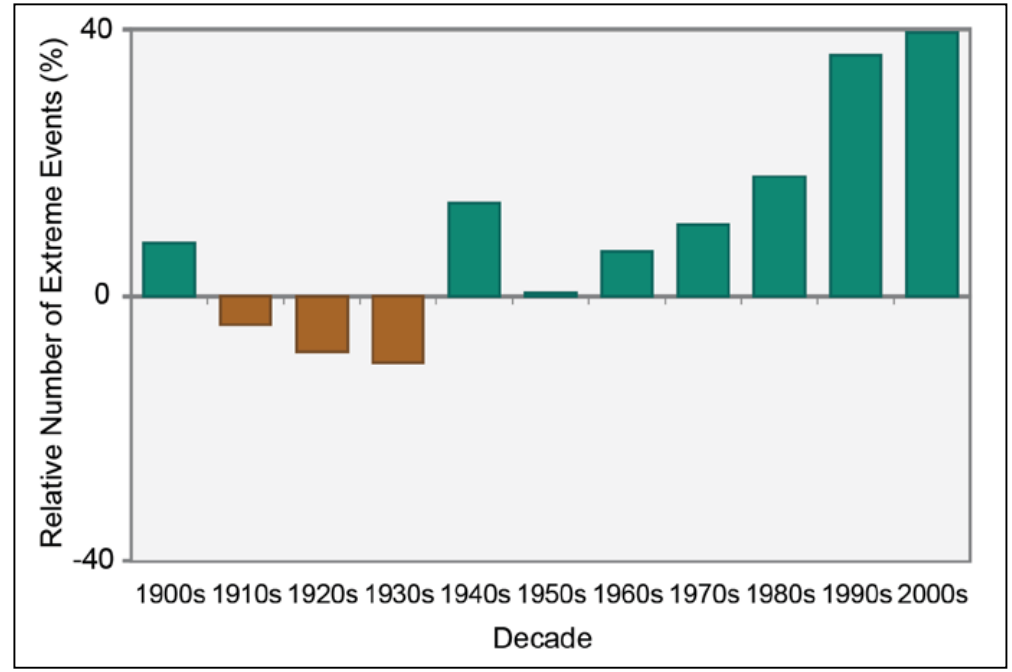
SOURCE: NCA

Observed and Expected Impacts – Precipitation

Minimal change to mean. Greater variability. Increased heavy rainfall.

- Minimal projected change in annual rainfall for Northern Gulf region
- Warm season *heavy rainfall* events
  - Heavy rainfall events have already seen an observed increase in U.S.
  - Projected to continue through 2100s
  - Increased inland flood threat
  - Resilience measures include stormwater management and retention strategies, land use strategy

SOURCES: NCA, IPCC



U.S. Heavy Precipitation Events

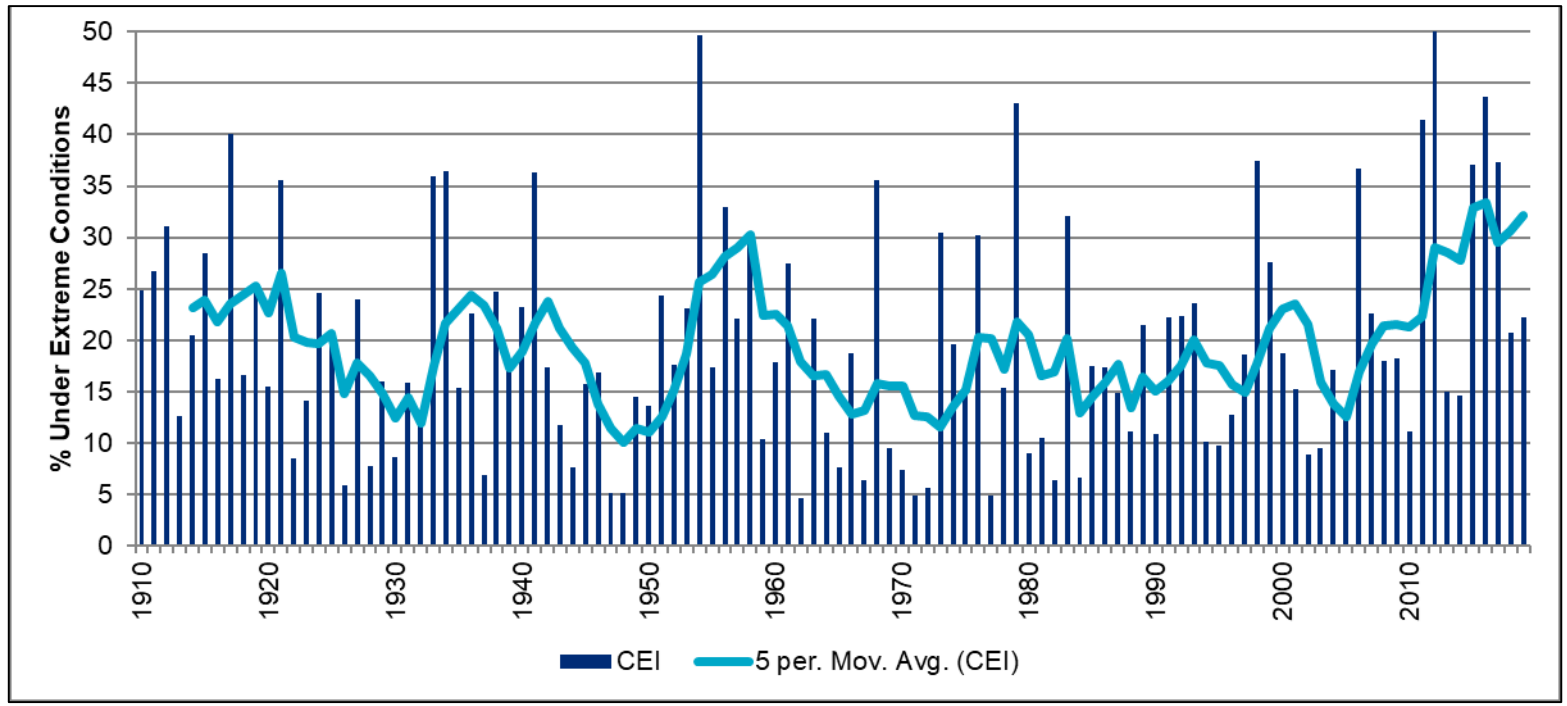
Occurrence of 2-day precipitation totals exceeded, on average, only once every five years (relative to 1901-1960)

SOURCE: NCA

Cold Season Storms
Minimal change to mean. Greater variability.

- Observed trends to date indeterminate, however extremes appear to be increasing
- Storm tracks projected to “bend” more, slowed progression
- Extends duration cold/warm, dry/wet periods
- Expect slight change to temperature and precip *means*, but increased annual *variability*

SOURCE: IPCC, NCA



Southern U.S. Annual Climate Extremes Index

SOURCE: NOAA/NCEI

Section 3

RESILIENCE MEASURES

Coastal Flood Impacts
Mantoloking, New Jersey (January, 2013)

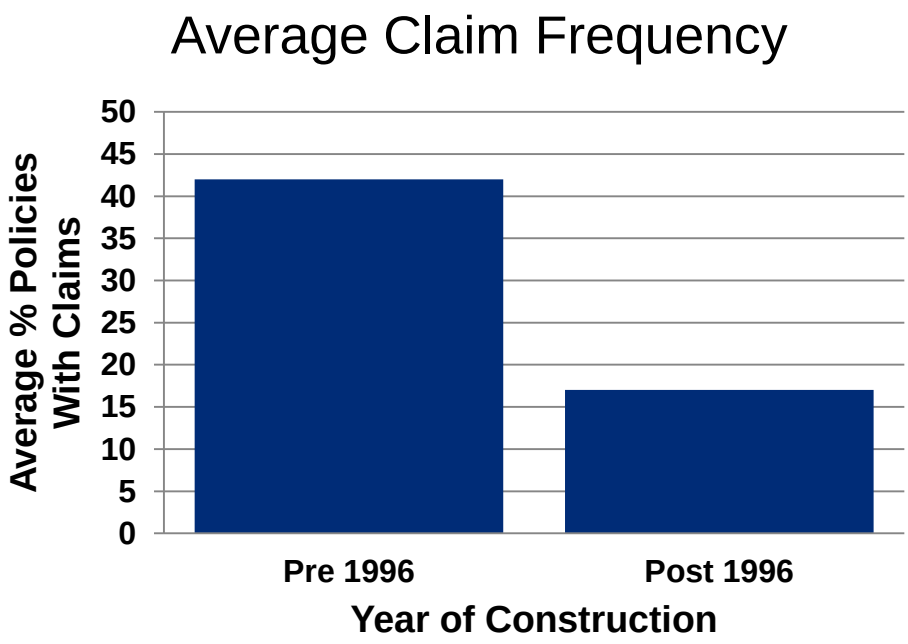
Resilience Measures

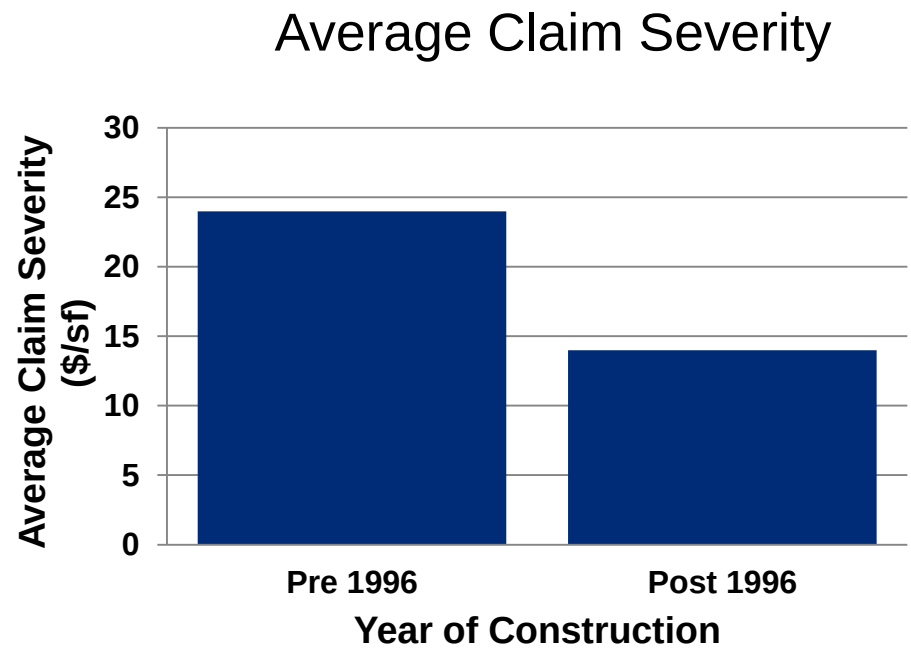
- Coastal flood – elevated foundations, coastal flood defenses, near-shore wetlands
- Inland flood – stormwater management and retention systems, land use
- Wind – structural resilience measures, roof properly attached & sealed, continuous load path from roof through walls to foundation (IBHS).

SOURCES: IPCC. NCA, IBHS

SOURCE: NOAA

Average Claim Frequency, Severity by Building Code Category
Hurricane Charley (2004), Charlotte County (IBHS Report)





Post-Andrew Building codes clearly have a positive influence on claims frequency and severity

SOURCE: Insurance Institute for Business and Home Safety

Section 4

CLOSURE

Climate Change
Observed/Projected Trends

	Sea level rise	Tropical cyclone	Severe thunderstorm	Heatwave	Heavy Rainfall
Observed	Yes	No	Some	Yes	Yes
Projected	Yes	Yes	Yes	Yes	Yes
Peak Peril	Storm surge	Storm Severity	Tornado Clustering Severe Hail	Heatwave	Inland Flood

Increase in curvature and “slowing” of storm tracks projected to increase, to increase duration of warm/cold, wet/dry events. Placement of storm tracks will vary. Implications for extreme cold/warm, winter storm, drought/flood, wildfire…

Increasing population and property value, especially in coastal areas, to produce probable upward trend in losses due to economic factors alone, irrespective of change to hazards…

Three key risks of climate change
Beyond The Physical Risks

Regulatory Influences Starting to Grow
Why now?

Accelerating warming and high-profile disasters have brought the topic forward in terms of insurance pricing, the protection gap, financial markets and the US economy.

ACTUARIES CLIMATE INDEX
INDICE ACTUARIEL CLIMATIQUE

NAIC National Association of Insurance Commissioners

EPA

HOUSE SELECT COMMITTEE ON THE CLIMATE CRISIS

Founded in January 2019

"Deliver recommendations on policy, strategy and innovations to achieve substantial and permanent reduction in pollution and other activities contributing to the climate crisis by March 2020."

COMMODITY FUTURES TRADING COMMISSION 1975

Climate Related Market Subcommittee founded in November 2019

"Identifying appropriate methods by which market participants' data and analyses can enhance and contribute to the assessment of climate-related financial and market risks and their potential impacts on agricultural production, energy, food, insurance, real estate, and other financial stability indicators."

Major Corporations Leading the Charge
Climate Risk is Deemed Financial Risk

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