Forward-looking Building Codes

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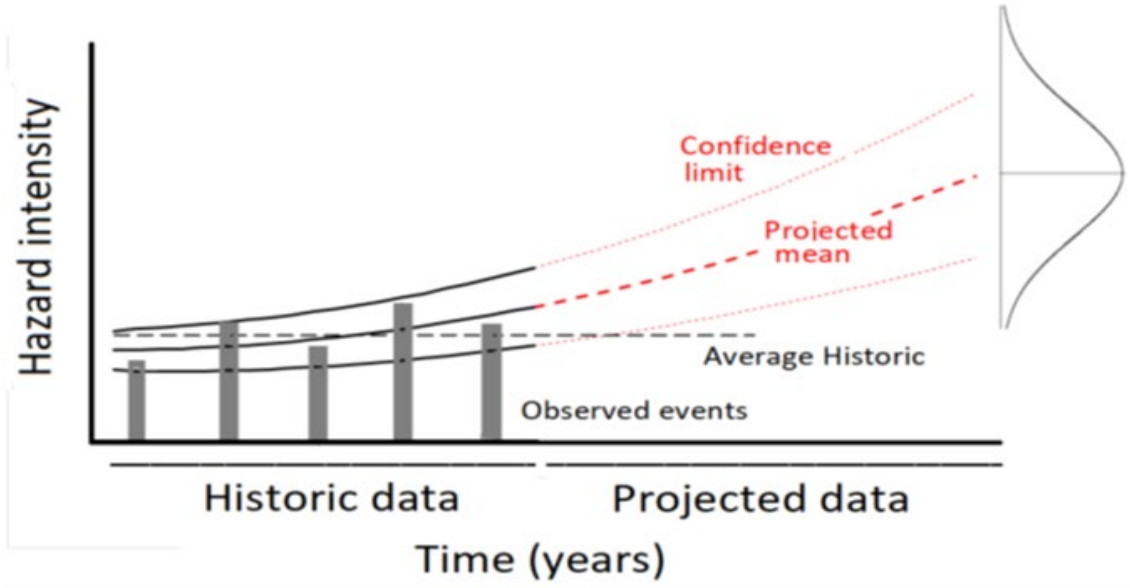
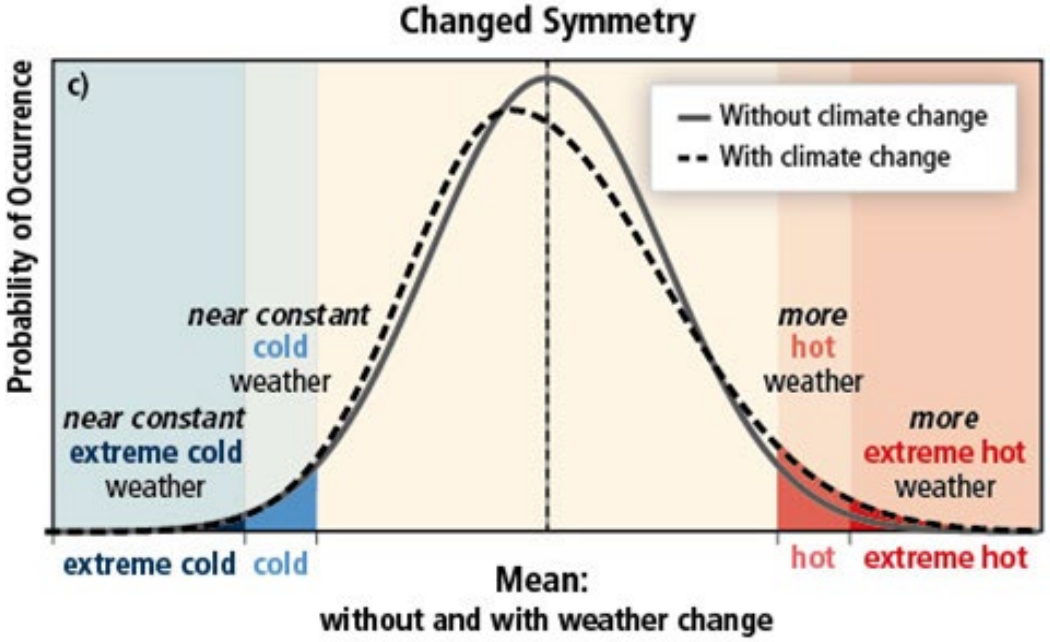
Resilience and Climate

Resilience is the ability to prepare for threats and hazards, adapt to changing conditions, and withstand and recover rapidly from adverse conditions and disruptions.

The definition of hazards is changing from past models to include future climate change.



Source: Ghosn & Ellingwood, 2023



Source: IPCC 2012

Climate to Codes Challenges

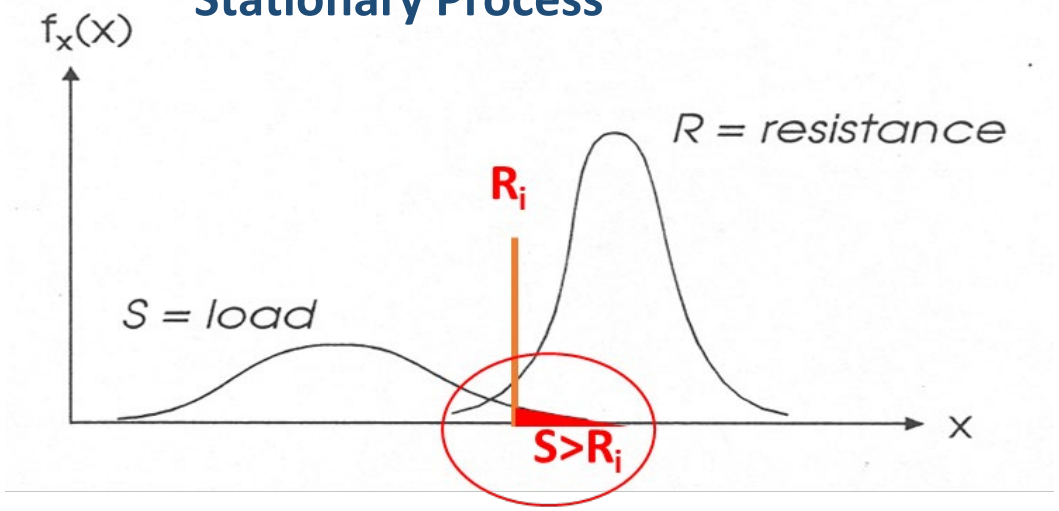
Climate Science

- Global climate models based on mean values and confidence intervals
- Regional and Local models downscaled from the global models

Codes

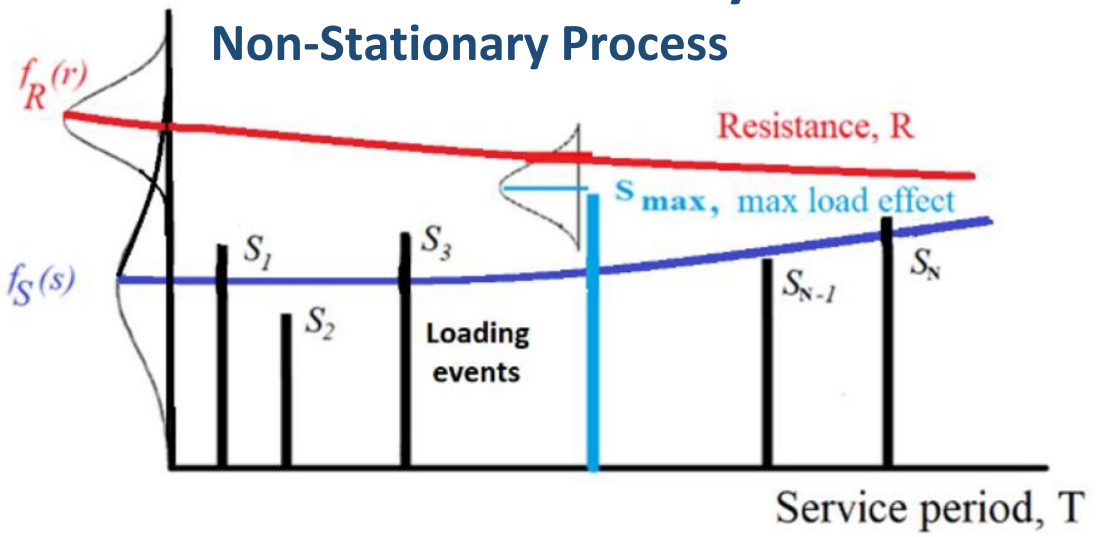
- Current engineering standards are based on the tails of stationary distributions
- Future hazards require new reliability models to account for non-stationary processes

Structural Reliability
Stationary Process



Source: Ghosn, 2024

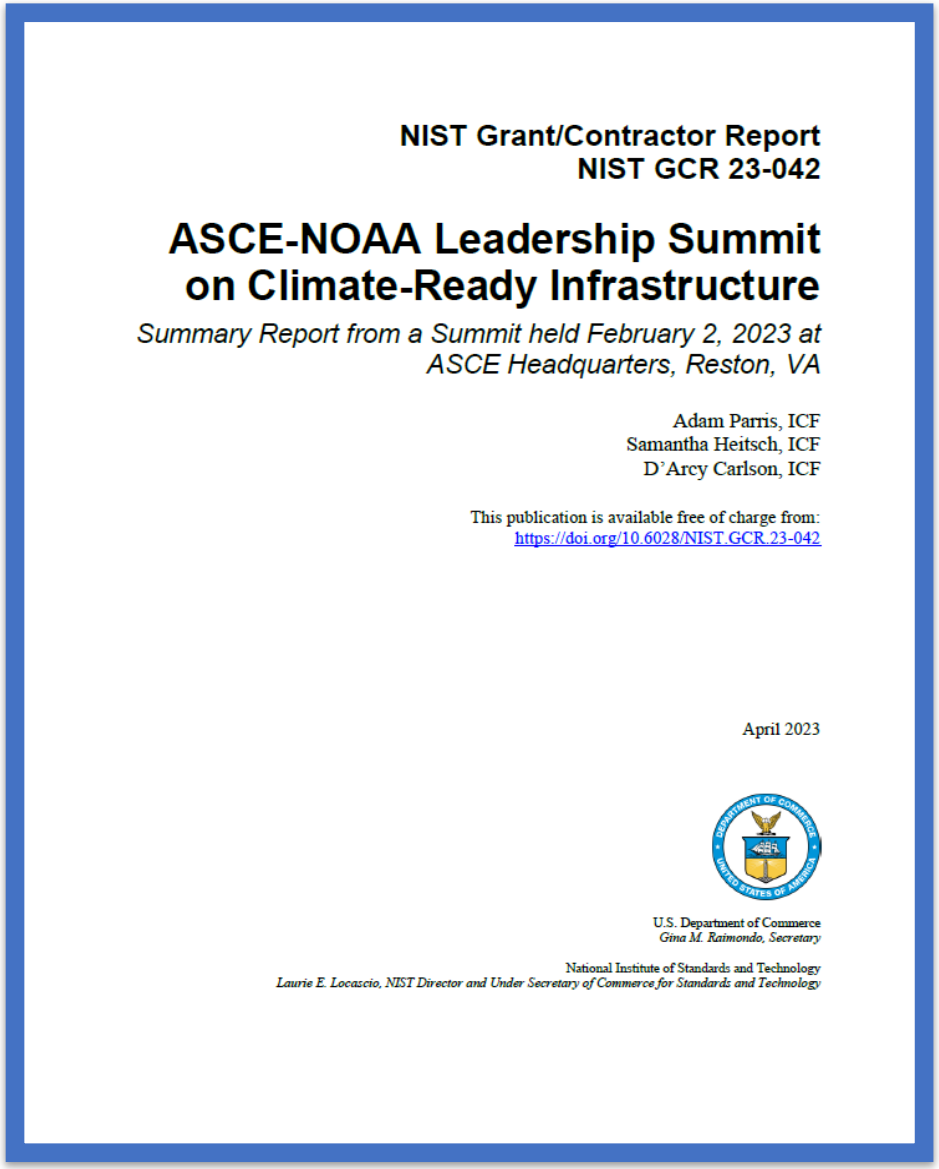
Structural Reliability
Non-Stationary Process



Source: Ghosn & Ellingwood, 2023

Collaboration with NOAA & ASCE

- ASCE-NOAA Partnership began in late 2021, with support from the University of Maryland. Key scope:
  - The needs of the civil engineering community, especially regarding weather and climate information in support of codes and standards
- Federal participants include NIST, FEMA
- Key publications to-date:
  - Feb 2023 Leadership Summit Summary Report
  - ASCE-NOAA 2023 Workshops Report



NIST Grant/Contractor Report
NIST GCR 23-042

ASCE-NOAA Leadership Summit on Climate-Ready Infrastructure

Summary Report from a Summit held February 2, 2023 at ASCE Headquarters, Reston, VA

Adam Parris, ICF
Samantha Heitsch, ICF
D'Arcy Carlson, ICF

This publication is available free of charge from:
https://doi.org/10.6028/NIST.GCR.23-042

April 2023

U.S. Department of Commerce
Gina M. Raimondo, Secretary

National Institute of Standards and Technology
Laurie E. Locascio, NIST Director and Under Secretary of Commerce for Standards and Technology

Community Resilience Collaboration

2023-2024: NIST, NOAA, and ASCE hosted 3 workshops to support the use of climate projections for community resilience planning

Sea Level Rise & Storm Surge
- New York City, NY
- South Florida
- San Francisco Bay, CA

Rain & Inland Urban Floods
- Philadelphia, PA
- Michigan
- Boulder, CO

Wildfire & Urban Planning
- Austin, TX
- Ashland, OR
- CALFIRE, CA


Credit: Jerry Coli, Pixabay


Credit:12019, Pixabay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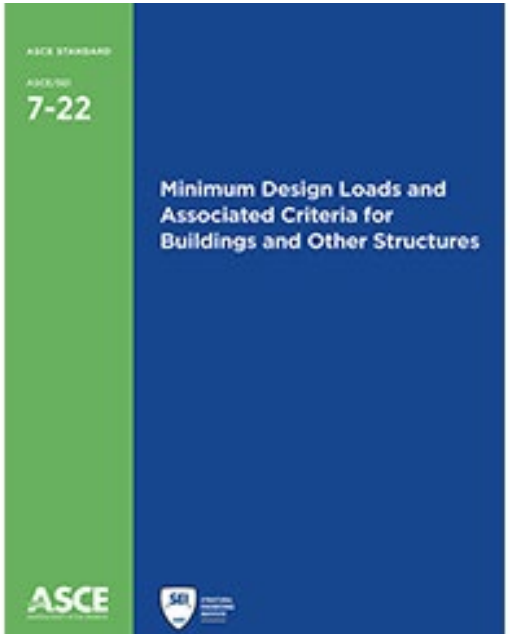
Workshop outcomes:

- Climate use cases
- Range of practices adopted by communities
- Informs basis for guidance, including appropriate use of climate science and decision making considerations

ASCE 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*

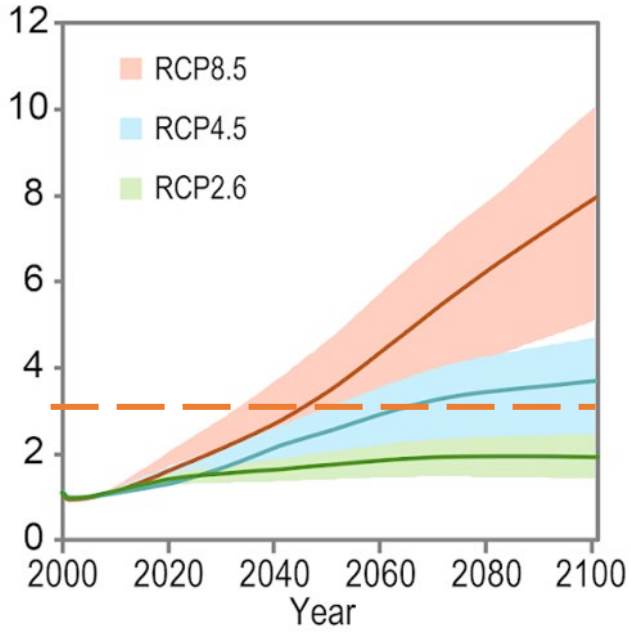


- Multiple environmental hazards.
- Currently includes (stationary) rainfall intensity from NOAA Atlas 14.
- ASCE 7-28 will include a “future conditions” chapter.
- Based on a 3-degree Celsius (in 2100) Global Warming Levels.
- Research NOW will likely inform the 2034 update – establish a reliable research-to-standards process

Over 45 ASCE standards have been identified as climate -sensitive.

Other engineering disciplines develop other standards:

- **IEEE (e.g. electrical transmission lines -- /temperature/icing)**
- **ASHRAE (e.g. heating/cooling of buildings -- enthalpy)**
- **Many, many others**



Global Mean Temperature Change, NCA4

(Joe Barsugli, NOAA Affiliate)

ASCE 7-22 Hazards and Reliability

Risk-Informed/Reliability

- Dead and Live (1982)
- Wind (updated 2016)
- Snow (updated 2022)
- Tornado (new 2022)
- Flood, Supplement #2 (2022)

Conditional Reliability

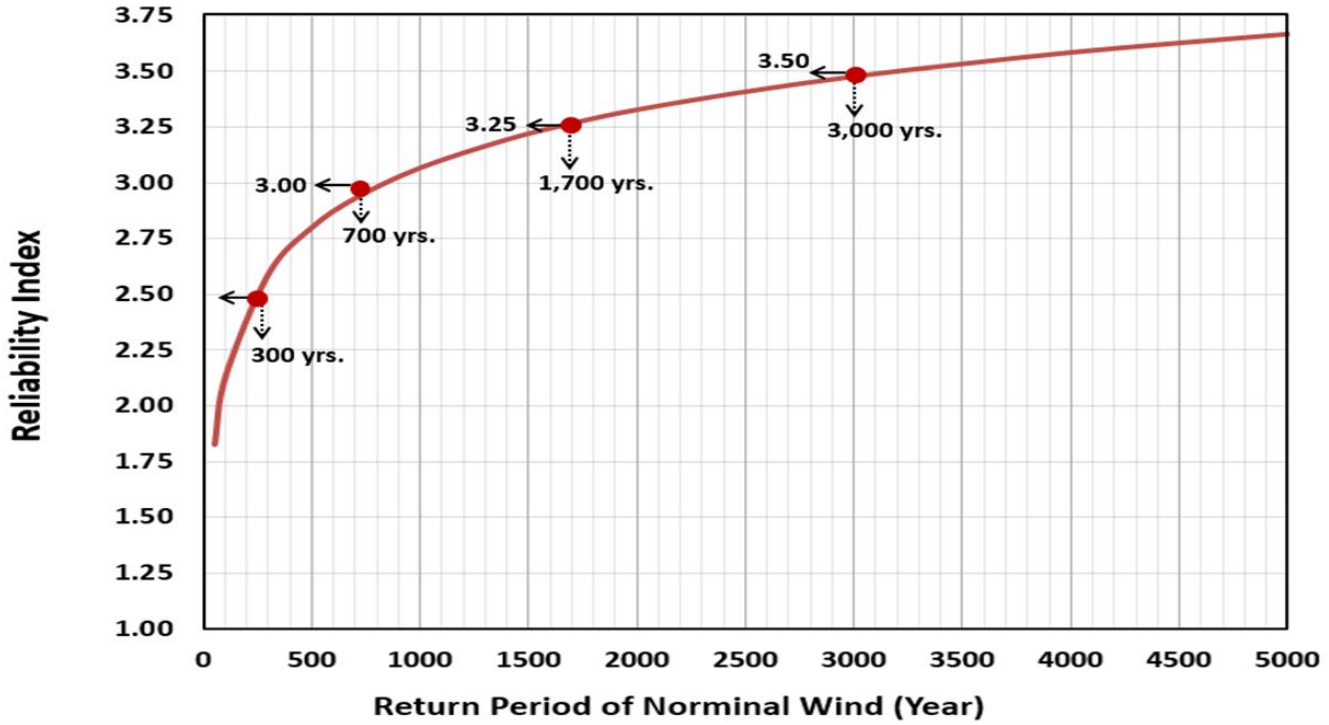
- Seismic (MCE_R) – (updated 2010)
- Extraordinary Events – fire, blast (updated 2010)
- Tsunami (new 2016)

Hazard Basis

- Flood, Ch 5 (2022)
- Ice (500 yr MRI) - (updated 2016)

Other Basis

- Rain – Roof drainage and stability (1982)

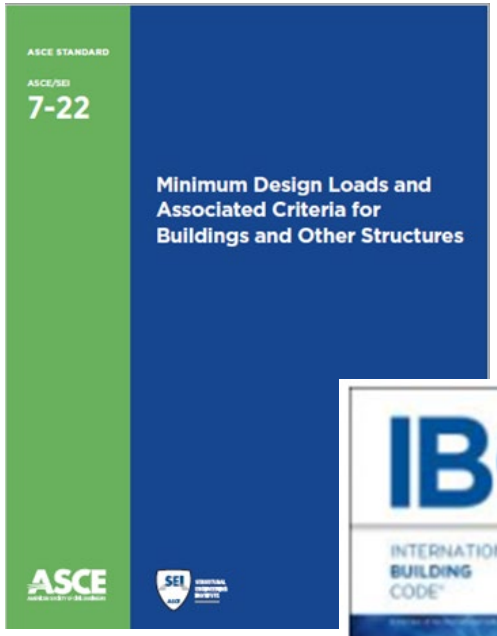


Wind MRI vs Reliability Index
(McAllister, Wang, and Ellingwood 2018)

Standard Development Organizations

ASCE 7-28: Standard for Minimum Design Loads for Buildings and Other Structures

- Published every 6 years
- The 2028 version will have a new section on Future Conditions



Other SDOs

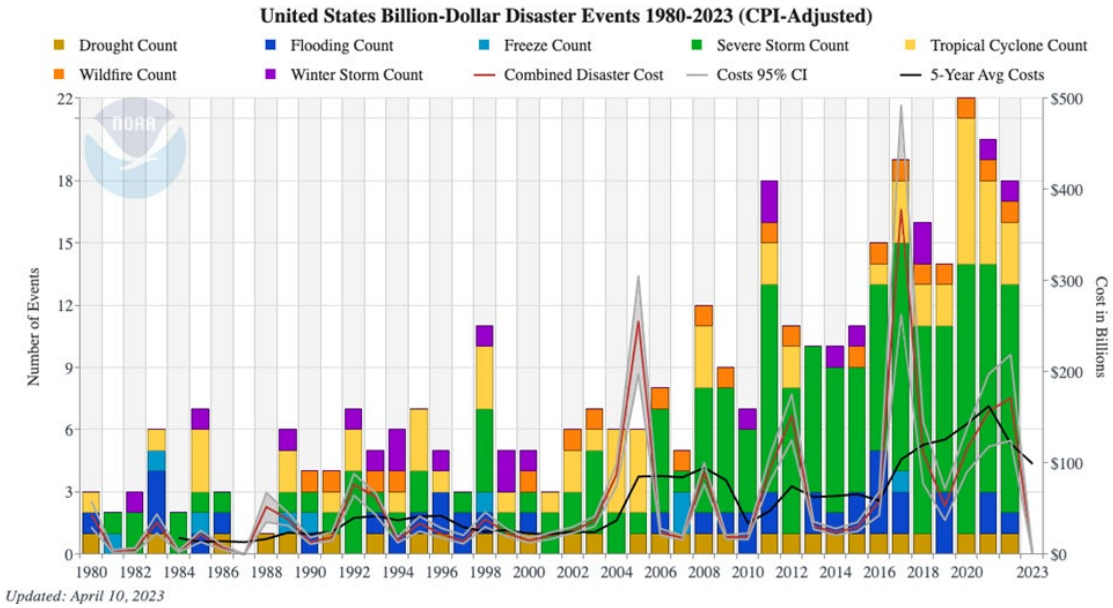
- ASTM, American Concrete Institute

NIST Grants to support ASCE 7-28 (Begins Oct 2024)

- Nonstationary reliability methods
- Wind maps
- Atmospheric icing criteria
- Consequences of climate change in structural loads
- Corrosion in reinforced concrete
- Ground failure and impacts on structures
- Adaptive design and assessment of reinforced concrete structures

NIST Gap Assessment for Standards Development

- **Climate Science:** Temperature, Precipitation (Rain, Snow, Ice), Sea Level Rise, Flood, Wind, Drought, Wildfire
- **Building and Infrastructure Design:** Acute and Chronic Hazard Design Loads, Structural Reliability, Geotechnical Impacts, Materials Degradation, Adaptation Planning
- **Social Impacts:** Equity, Economies, Business and Supply Chain, Indirect Impacts (e.g., health)
- **FY25 Publication:** *State-of-the Art Assessment of Climate Science Projections and Their Application in Codes and Standards*



Consumer Price Index Adjusted historical frequency of billion-dollar weather and climate disasters in the United States.

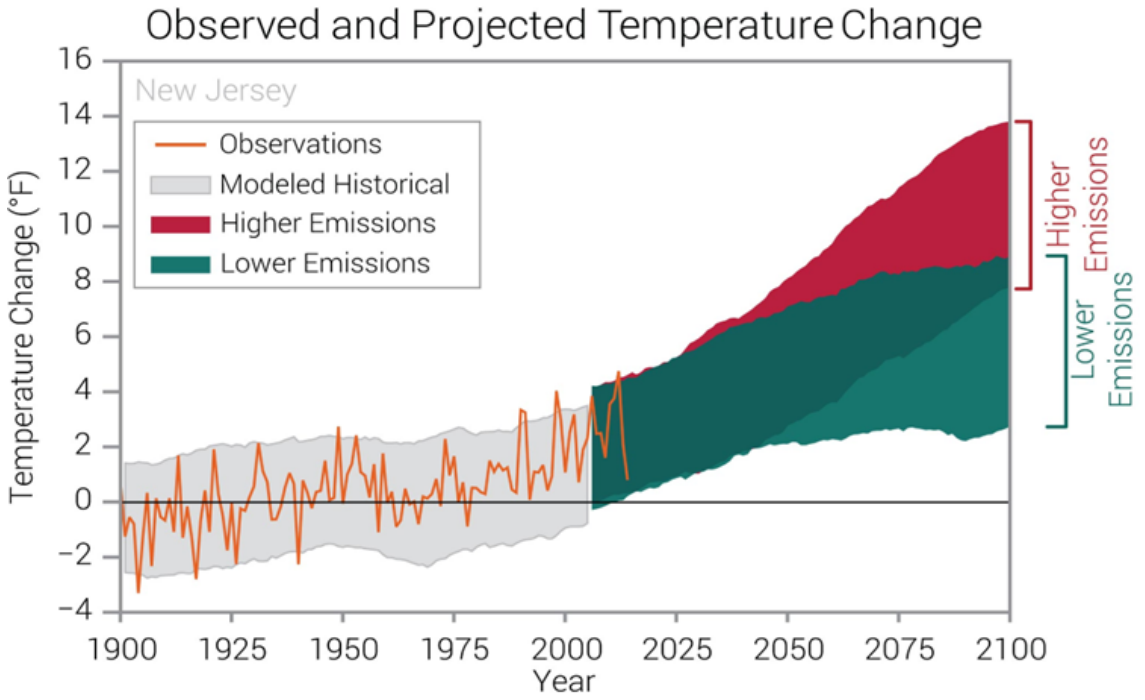
Depicted by event category with annual combined disaster cost, adjusted to 2023 CPI, (red line) and 5-yr running mean (black line).

Source: NCEI 2024

NIST Workshops for Future Codes

NIST will host 4 workshops in 2025 for advancing building and infrastructure codes. These cross-cutting topics will include climate-affected hazards (e.g., sea level rise, temperature, rain, snow, ice, wind, flood) and social impacts/consequences:

- **Climate projections for design** - confidence/uncertainty in climate projections, downscaling of climate models, converting climate hazard projections to engineering design criteria
- **Climate effects on the built environment** - changes in hazard demand relative to historical basis, changes in structural capacity due to changes in material properties and geotechnical conditions
- **Engineering design guidance and criteria** - non-stationary reliability, service life, design scenarios
- **Adaptation and resilience** - buildings and infrastructure systems, material durability, carbon mitigation of building materials



Source : NCA4, Vol II, 2018

NIST Climate Roadmap Summary

- Characterize climate impacts for design:
  - Atmospheric temperatures
  - Precipitation (rain, snow, hail)
  - Flood (sea level rise; coastal/inland flooding)
  - Wind (convective storms, hurricanes)
  - Wildland-urban interface (WUI) fires
  - Earthquake (landslides, liquefaction, drought)
  - Materials degradation (corrosion)

https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts

- Identify gaps and research needs for implementing climate change in future codes and standards.
- Inform strategic planning for future requirements in the built environment, and potential changes to design scenarios (e.g., nonstationary probability characterization, service life, climate scenarios).

Thank you!