# Bridging the Gap Between Climate Science and Civil Engineering Practice

## Committee on Adaptation to a Changing Climate

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Dan Walker, Ph.D., ClimateMonkeys LLC

Rolf Olsen, Ph.D., P.E., U.S. Army Corps of Engineers

Richard N. Wright, Ph.D., P.E., Dist.M.ASCE, NAE, Professor Emeritus, U. of Illinois

Ted Vinson, Ph.D., P.E., Professor Emeritus, Oregon State U.

# Overview

1. Introduction
2. Growing Acknowledgement of Climate Change
3. Recognition of Impacts on Engineering Sectors
4. Incorporating Climate Science into Engineering Practice
5. Potential Actions

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# Acknowledgements

This presentation is:

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# The Gap…from the Engineers Point of View

Climate science observations and models strongly indicate that our engineered facilities and systems should adapt to changing climate, weather and extreme events . . . but climate science does not yet provide an adequate basis for the needed practices.

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# Committee on Adaptation to a Changing Climate

- Primary body within ASCE working to promote understanding and response to climate change
- ASCE has 147,000 members and is the world's largest civil engineering society
- ASCE licenses engineers, provides continuing education opportunities, and promotes standards of practice
- CACC is actively involved with more than a dozen ASCE Institutes, Councils, and Committees:

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# CACC Ties within ASCE (cont.)

Technical Council on Cold Regions*
Council on Disaster Risk Management*
Energy Division
Geomatics (data for sustainability and resilience)
Pipeline Division
Technical Council on Wind Engineering*
Codes and Standards Committee (oversees ASCE standards activities)†
Committee on Critical Infrastructure
Architectural Engineering Institute
Coastal, Oceans, Ports and Rivers Institute
Environmental and Water Resources Institute*
The Geo-Institute
The Structural Engineering Institute*
Multihazard Mitigation
Committee on Sustainability and Environment
The Transportation and Development Institute
Committee on Advancing the Profession
ASCE Resilience Activities

# CACC Goals

1. Foster understanding and transparency of analytical methods necessary to update and describe climate, weather and extreme events for engineered systems. **(CLIMATE CHANGE)**
2. Identify and evaluate methods to assess impacts and vulnerabilities of engineered systems caused by changing climate conditions. **(IMPACTS)**
3. Promote development and communication of best practices for addressing uncertainties associated with changing conditions, including climate, weather, extreme events and the nature and extent of engineered systems. **(POTENTIAL ACTIONS)**

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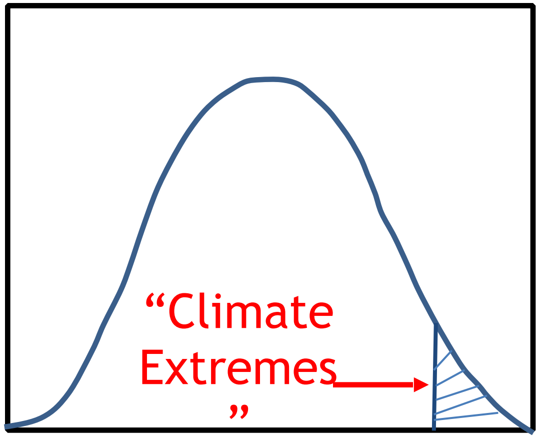
# Engineering Design & Extreme Events

- Engineering Design for Extremes
  - Usually concerned with more extreme "extremes"
  - Generate new distributions based on the "tail" of the observed distribution ~ extrapolations made beyond observed data (dotted line)
- Commonalities:
  - Typically probability and/or threshold based
  - Most commonly described by "return period"

Observed Probability Distribution





USGS

# Impacts on Engineering Sectors

- Selected engineering sectors
  - Buildings and other structures
  - Coastal infrastructure
  - Cold region systems
  - Energy systems
  - Transportation systems
  - Water urban systems
  - Water resources

- Considerations
  - Climate change effects
  - Impacts on functions
  - Impacts on integrity

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# Standards

- Voluntary consensus standards are developed or adopted by voluntary consensus standards bodies such as ASCE and ASME. Their procedures are open and provide a balance of interests, due process and an appeals process.
- They are a primary mechanism linking scientific knowledge with engineering practice. They represent the "state of the art." Compliance helps protect engineers and other users from findings of negligence.
- <u>Adaptation to climate change generally will require more than meeting the minimum requirements of current standards and regulations</u>.

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# Stationarity

- Most of our engineering standards and regulations for extreme events use "stationarity" as their basis for risk assessment.
- Stationarity implies that the statistics for past occurances define the statistics for the future.
- Climate change means that history is an unreliable measure of future risk. **"Stationarity is dead"**

Remember that mean recurrence interval is the inverse of the annual probability of exceedance. Design for a 100 year flood does not mean you are safe for 100 years. It means that you have a 1% chance every year of one or more **greater** floods.

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# Uncertainties in Future Climate Projections

- Sources of uncertainty in Global Climate Models (GCMs):
  - the natural variability of climate;
  - uncertainties in climate model parameters and structure; and
  - projections of future emissions.
- Downscaling - used to obtain higher resolution regional projections from large-scale GCM projections, but uncertainties increase due to local variability

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# Probabilities of future climate states

- Ensemble of climate projections from different models provides a distribution of model outputs
  - Climate models are not independent - use similar assumptions and parameterizations
  - Uncertainties related to the underlying science may lead to similar biases across different models
- Large perturbed physics ensemble (PPE)- single climate model running different values for uncertain model parameters
  - Uncertainty in the distribution increases at the tails

# Building a New Civil Engineering Paradigm

- Promote cooperative research involving climate/ weather/social/life scientists and engineers to gain an adequate, probabilistic understanding of the magnitudes and consequences of future extremes.
- Development of appropriate engineering practices and standards based on the above research.
- Guide engineering decisions now and until improved practices and standards are available (perhaps 5-20 years).

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# Contributors

Bilal M. Ayyub
Ana Barros
Brian Beucler
Ben Harding
Miriam Heller
Nir Y. Krakauer
Arthur Lee
Wayne Lei
Franklin Lombardo
Jay R. Lund
J. Rolf Olsen
Miguel Medina
Joel Smith
Orson P. Smith
Eugene Z. Stakhiv
Jonathan Tan
Ted S. Vinson
Dan Walker
Richard N. Wright

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