Argonne National Laboratory

Climate Change and Infrastructure Adaptation:

Potential Pathways to Address Data, Modeling, and Uncertainty Challenges

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Argonne NATIONAL LABORATORY

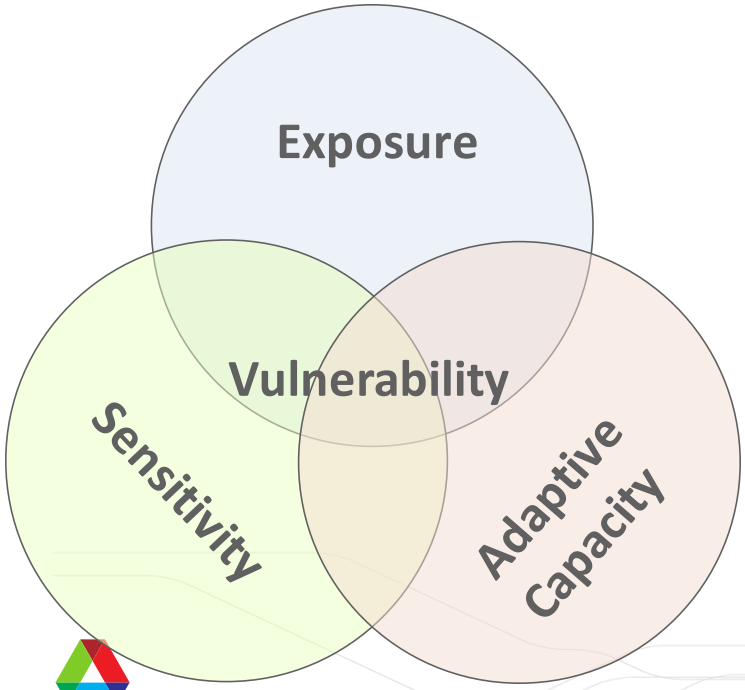
U.S. DEPARTMENT OF ENERGY

Responding to Climate Change: Adaptation

Adaptation:

- "Actions taken to reduce the vulnerability of natural and human systems or increase system resiliency in light of expected climate change." (NCHRP)

- "Actions by individuals or systems to avoid, withstand, or take advantage of current and projected climate changes and impacts. Adaptation decreases a system's vulnerability, reduces risk and/or increases its resilience to impacts." (Pew Center)



Top: US Forest Service / Bottom: Office of Federal Lands Highway, USDOT

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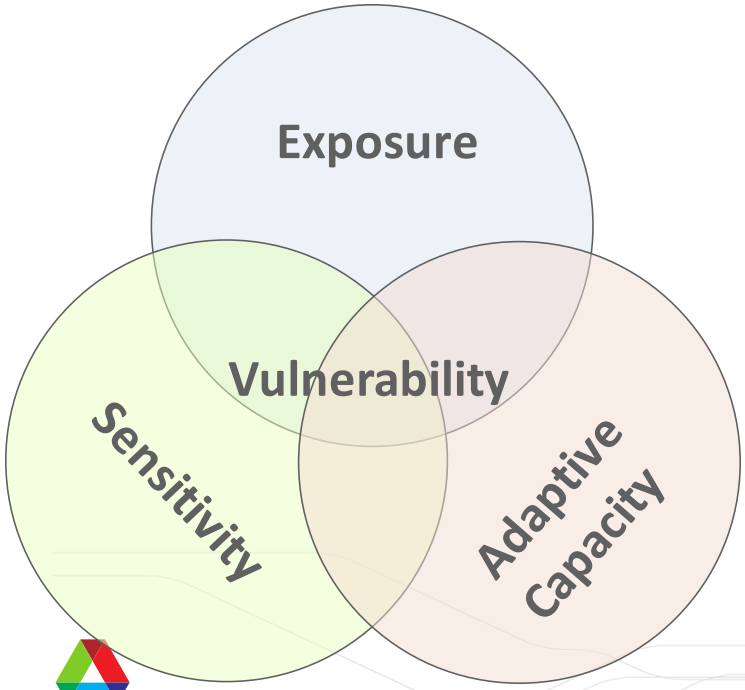

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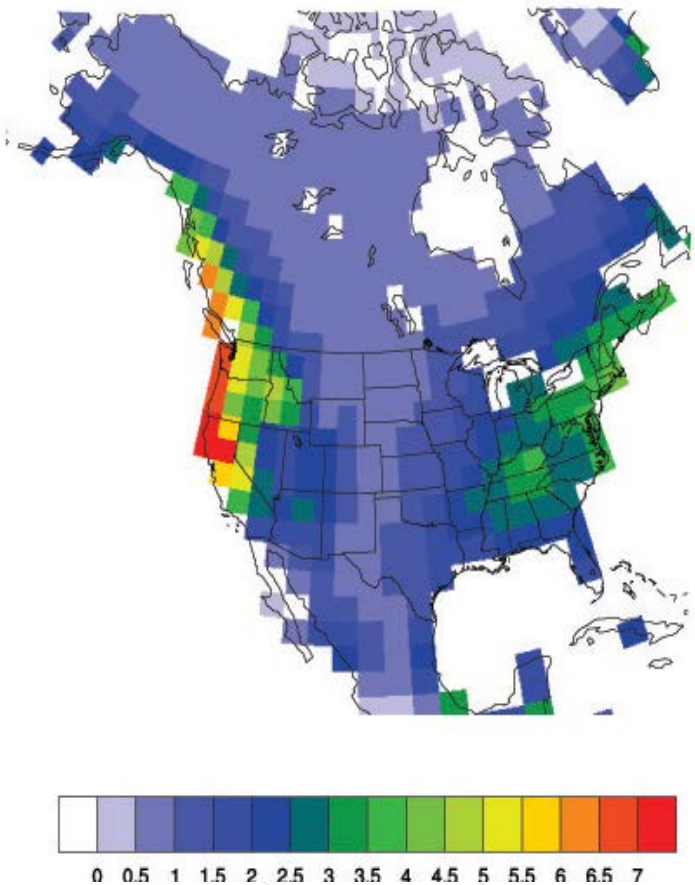
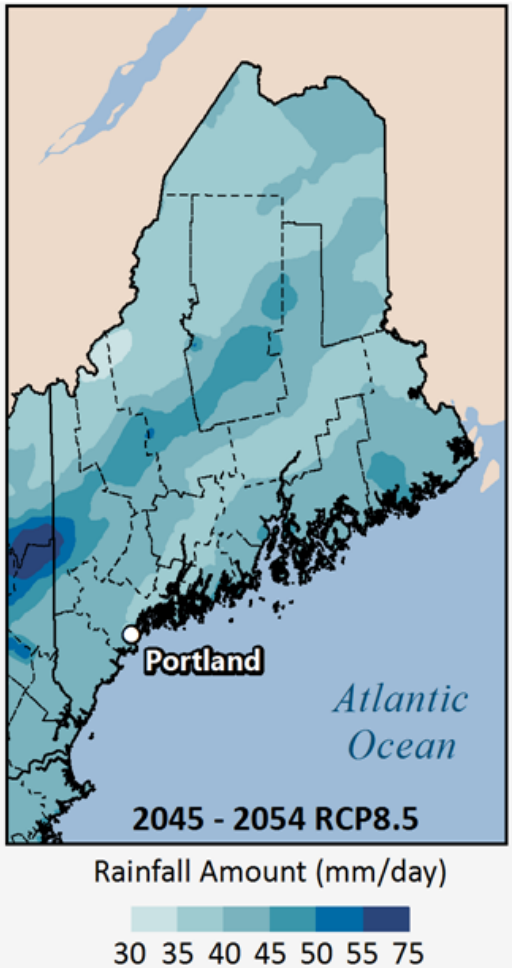
Challenges to Climate Change Adaptation (1)

EXPOSURE: Lack of **high-resolution climate scenario data** needed to justify starting adaptation projects



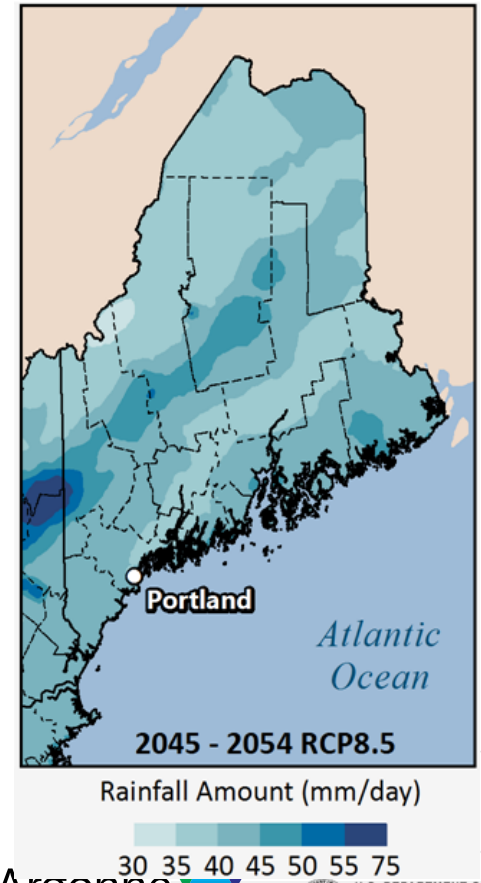


All Images: Argonne National Laboratory

Challenges to Climate Change Adaptation (2)

EXPOSURE: Lack of **local-level modeling** of temperature and precipitation changes, and effects to environmental and design factors

SENSITIVITY: Integrating climate impacts into **infrastructure models**



Left: Argonne National Laboratory
Right: Colorado DOT, "CO SH 7 Flood 2013." 16 Sept 2013. Online image. Flickr. 17 Aug 2016

Challenges to Climate Change Adaptation (3)

SENSITIVITY: The majority of infrastructure is still being designed for a static climate

- Design standards and tools use historical record (e.g., rainfall, temperature)
- Standards drive design to avoid liability in the event of failure
- Unless design reflects a changing climate, failure is more likely

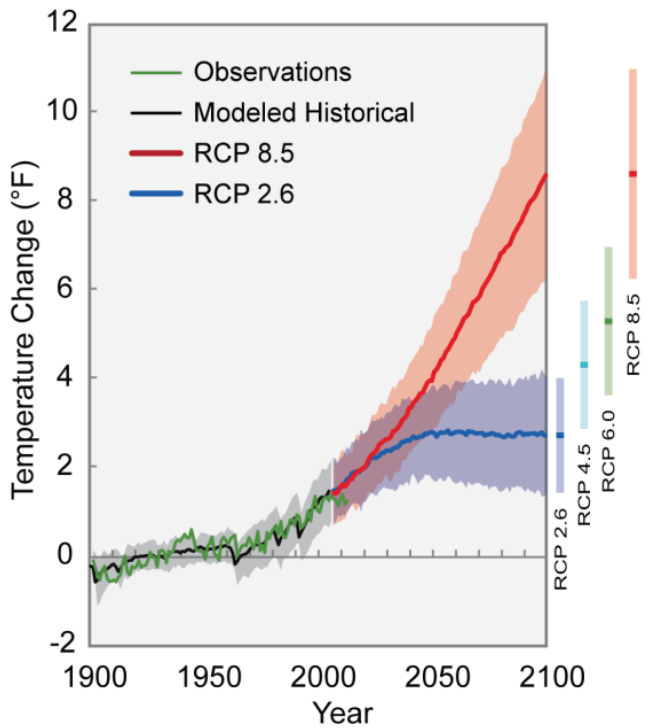
July 2006, Ontario, Canada "…. track structure that was unable to restrain the thermal expansion forces." ~Transportation Safety Board of Canada, Report R06T0153

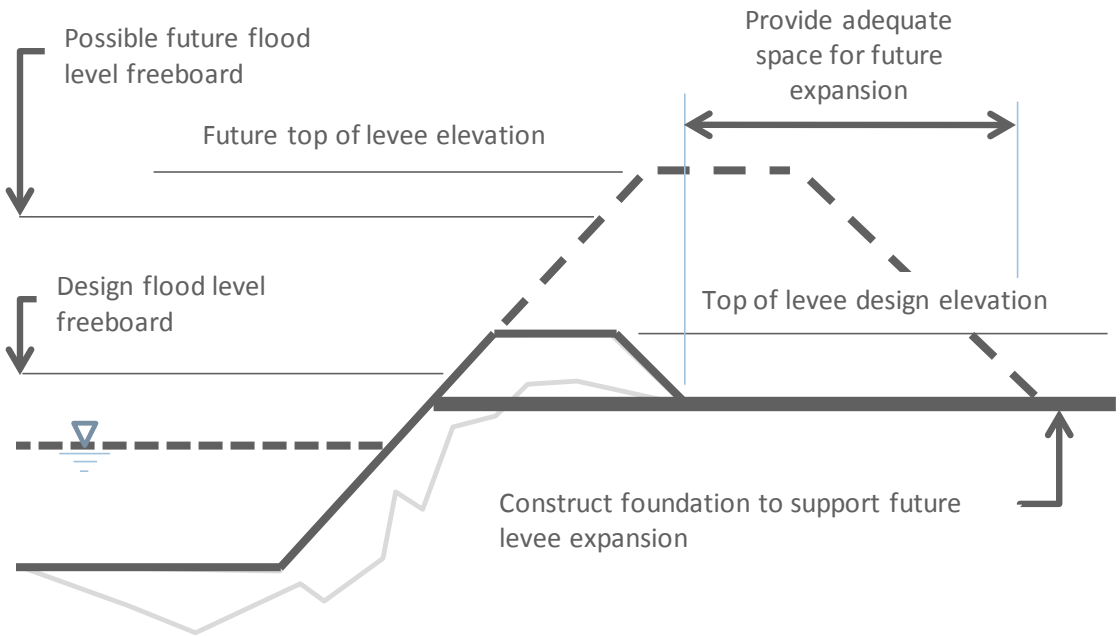
Both Images: Transportation Safety Board of Canada

Challenges to Climate Change Adaptation (4)

ADAPTIVE CAPACITY:

Uncertainty: "Any departure from the unachievable ideal of complete determinism." Walker et. al (2003)

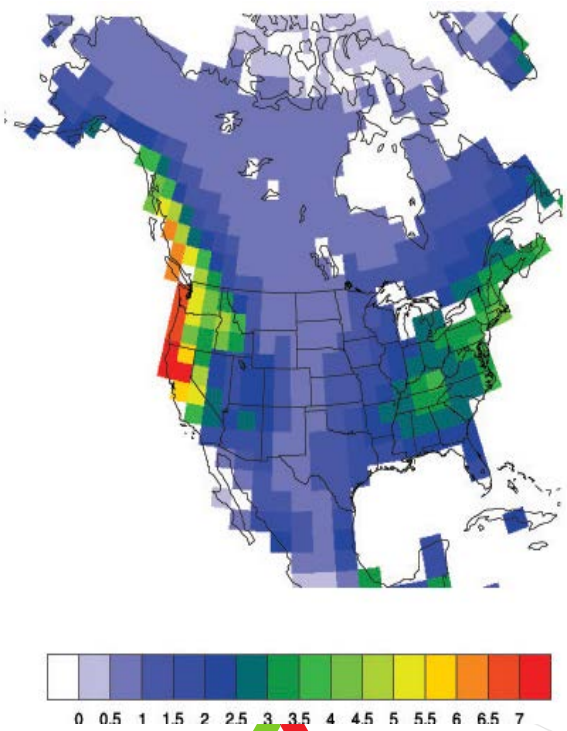


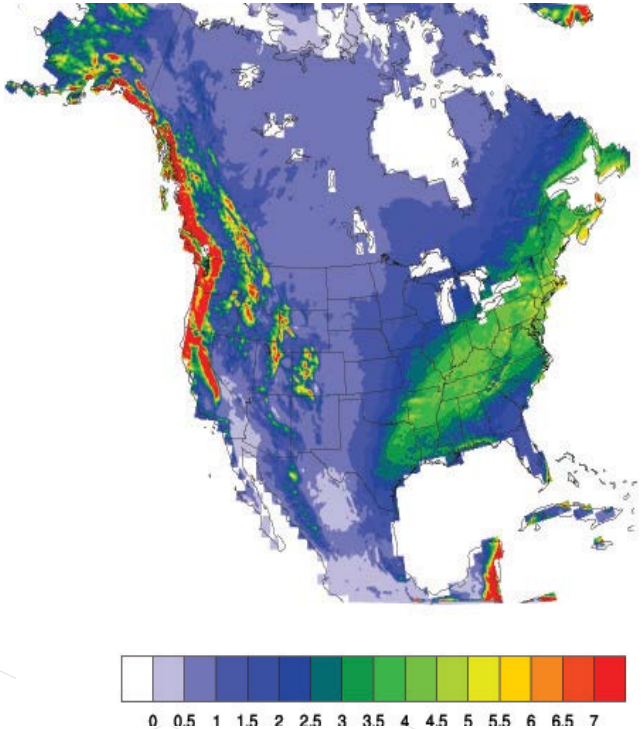


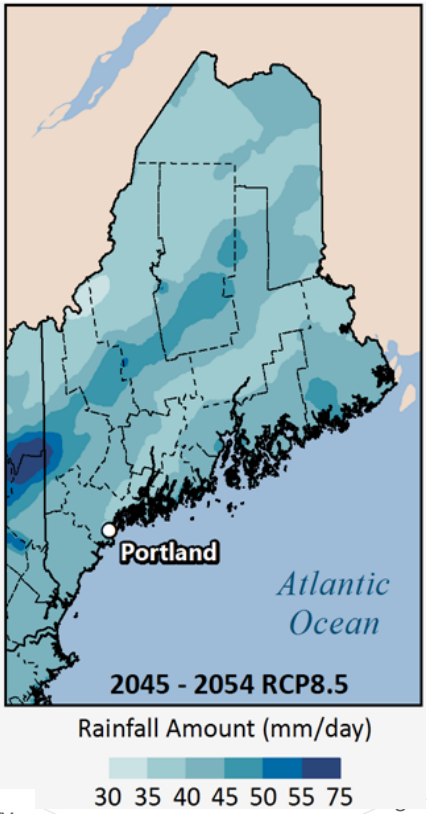
Left Image: National Climate Assessment

1) Need for Higher Resolution Data: Exposure

- Regional climate models (RCMs)
  - Improved ability to simulate surface variables such as air temperature, precipitation, and wind.
  - Better account for topographic details - improved modeling of climate over mountainous regions or other variable terrain
  - Finer temporal resolution than global models: >100km → 12km → 4km grid (?)







All Images: Argonne National Laboratory

2) Need More Directly Relevant Model Outputs: Exposure

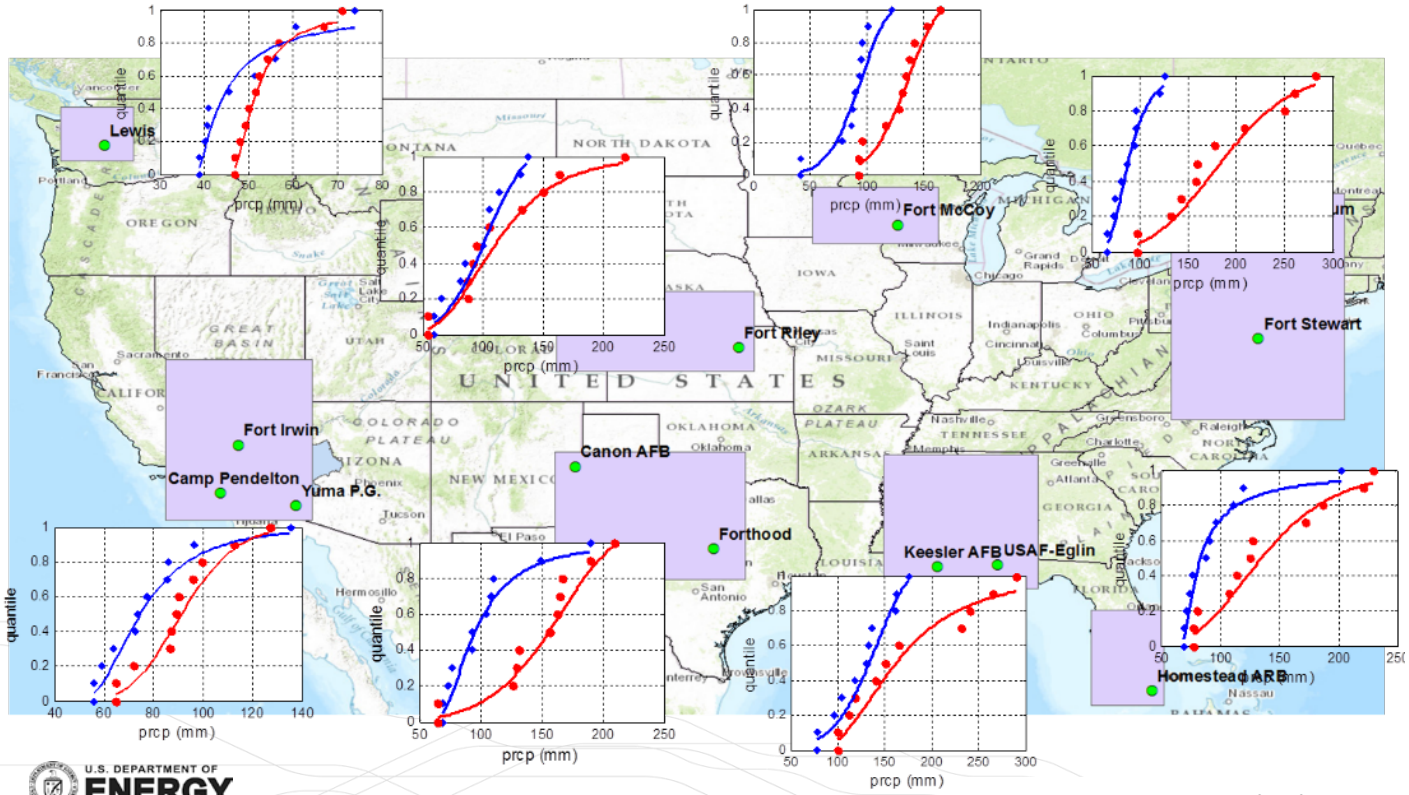
- Some variables can be derived from climate models….
  - Average annual precipitation and average annual temperature are infrequently (if at all?) used in engineering planning and design standards
- Some variables are not widely published / made available…
  - Evapotranspiration
  - Dew point
  - Solar radiation
- Some variables require further modeling….
  - Design/extreme events, e.g., 100-year storm
  - Cooling Degree Days

Source: National Climate Assessment (2014)

3) Generating Actionable Climate Data for Current Design Practices: Sensitivity

Intensity-Duration-Frequency (IDF) Curves

- How will future precipitation translate into surface-water runoff and flooding ?
- Uses current design tools (IDF curves)
- "Next Generation" IDF curves adjusted to reflect projected future extreme precipitation



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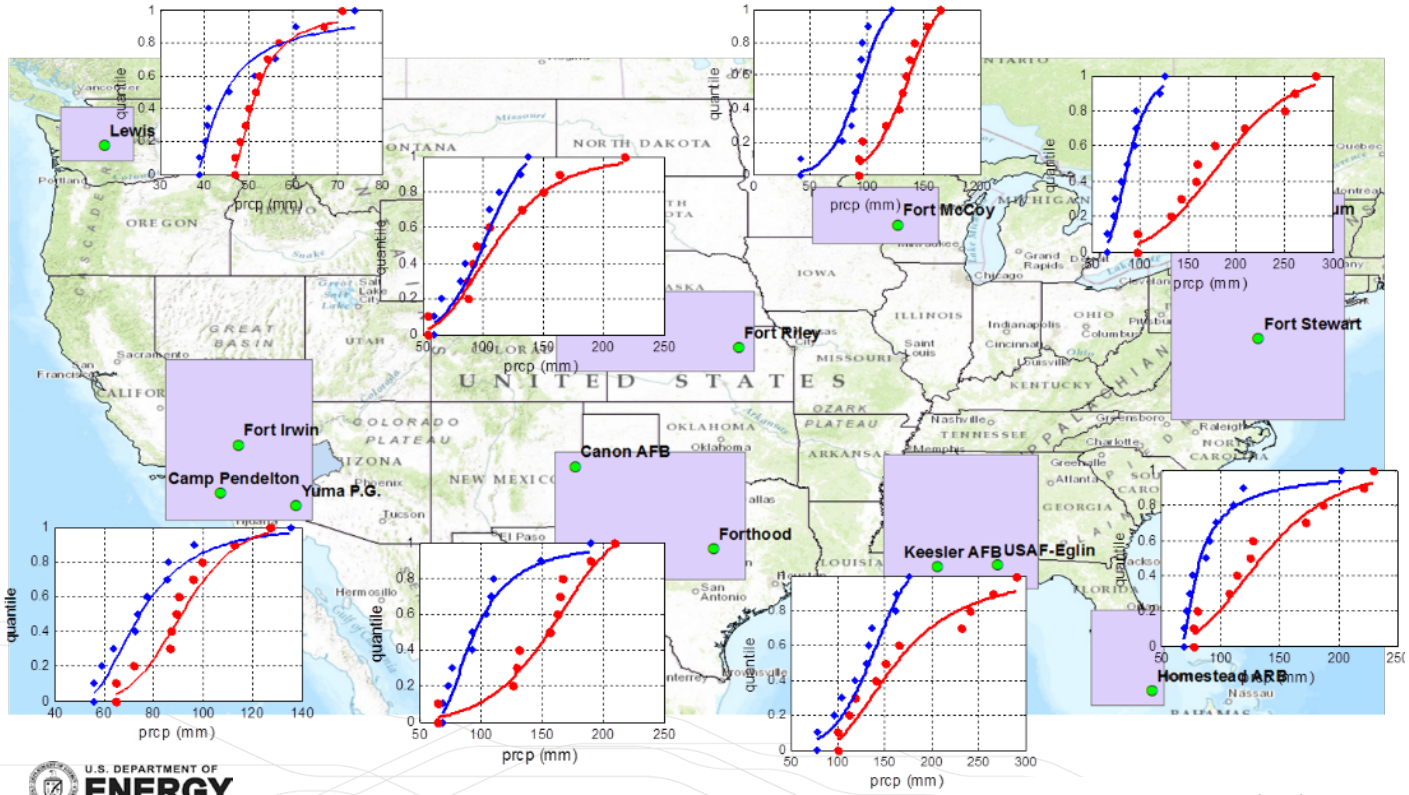

Image: Argonne National Laboratory

4) Using Downscaled Climate Data to Drive Infrastructure Impact Models: Sensitivity

- Infrastructure models (e.g., electric, natural gas, petroleum, water, transportation systems) can be coupled to climate models to assess climate hazards

- Argonne is using the EPfast (electric) model as part of an analysis of the impacts of mid-century increased temperature on Maine's electric grid
  - Impacts to the capacity of power plants, transmission lines, and transformers, as well as growth in demand
  - Overall grid performance via load flow simulation

Results:

- Increasing temperatures affect seasonal electricity demands
- Reduced power plant output capacity
- Reduced transmission line capacity
- Could cause rolling brown-outs if electric infrastructure does not adapt

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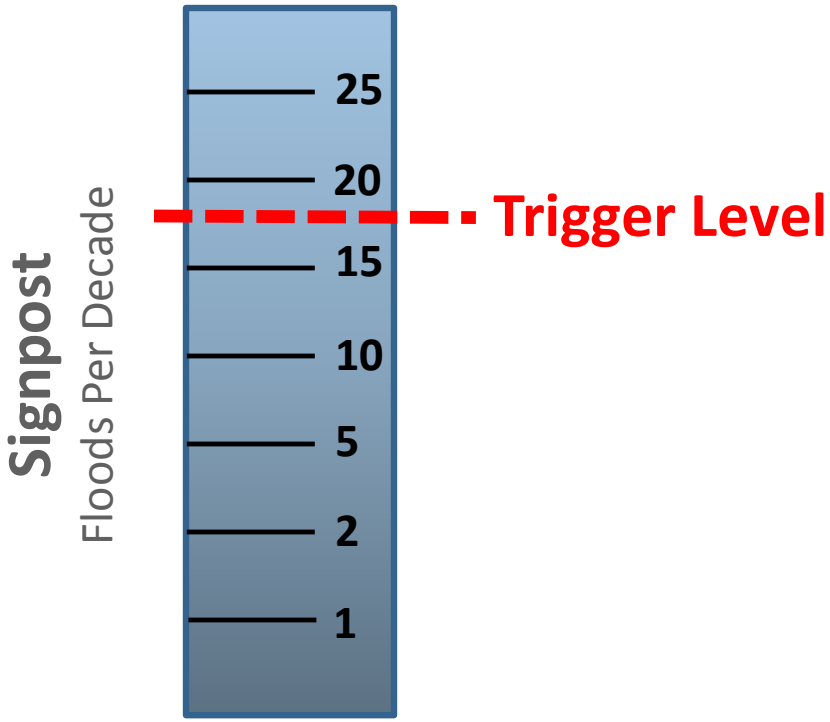
5) Adaptive Planning and Decision-Support: Adaptive Capacity & Uncertainty

Adaptive Planning and Decision Making

- Dynamic Adaptive Planning
- Adaptive Management



SERDP Climate Data User Manual

- Prepared for the DoD's Strategic Environmental Research and Development Program, provides planners and decision makers with:
  1. A critical overview of relevant downscaling models, methodologies, and data;
  2. The advantages and disadvantages of each method;
  3. Geographical dependence of bias for each method (e.g., systematic under- or over-prediction of climate impacts);
  4. Uncertainties associated with the downscaling process and climate data in general (SERDP 2014)

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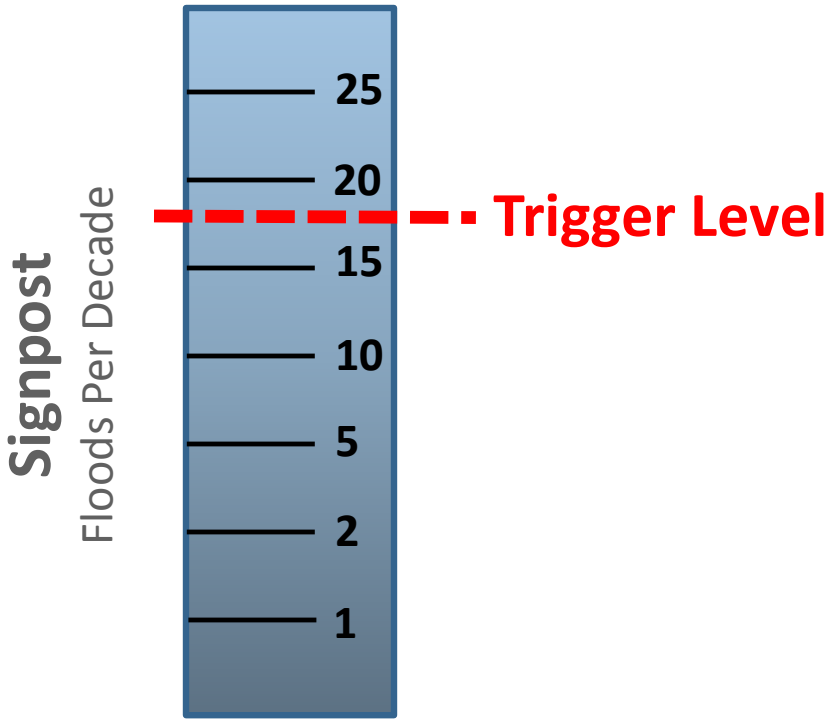

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THANK YOU.

QUESTIONS?

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