

AASHTO 2015 EXTREME WEATHER SESSIONS

TECHNICAL COMMITTEE ON HYDROLOGY AND HYDRAULICS

WORKSHOP: HYDROLOGIC AND HYDRAULIC ISSUES RELATED TO EXTREME EVENTS AND CLIMATE CHANGE: BRIDGING THE GAP BETWEEN CLIMATE SCIENTISTS AND ENGINEERS

THURSDAY, SEPTEMBER 24
10:15 AM – 12:00 PM
SEATTLE, WA

SESSION SUMMARY

Dr. Guillaume Mauger, a climate scientist with the University of Washington Climate Impacts Group (CIG), attended a workshop with the AASHTO Technical Committee on Hydrology and Hydraulics (TCHH). He presented to the group on best practices for acquiring and applying climate projections, answered TCHH members' questions about climate data, and participated in a dynamic group discussion.

The workshop covered a range of topics regarding the application of climate projections to hydrologic and hydraulic (H&H) engineering. The group identified best practices as well as several key questions and continued needs. This document summarizes i) the topics covered, ii) key questions and considerations raised, and iii) needs identified during the workshop.

Presentation and Discussion Excerpts

The Technical Committee had a lively discussion on topics that were important to the group and included advice and input from Dr. Mauger. Among the topics discussed were the need for and how to select climate models, choosing CO₂ emission scenarios, downscaling, and data resolution.

Selecting Models

The following comments were raised during the discussion:

- Due to resource constraints, it may be necessary to select a subset of available climate models for your analysis. Some climate scientists argue that it is important to always use all available models. The rationale for including all models is that the ability for a model to perform good hindcast simulations is not necessarily predictive of its ability to forecast conditions, especially with a changing climate. Different models have different strengths and weaknesses regarding their ability to model various physical processes, and excluding models could result in excluding key climate sensitivities or processes that haven't occurred in the past but could in the future.
- Dr. Mauger presented several strategies for selecting models (if necessary):
 - Option 1: Rank models by performance for your region¹ based on ability to simulate historical conditions. Select at least 10 models.

¹The correct size of the "region" to use will vary by location because of locally-specific topographical and other climatic considerations. Additional guidance is needed for engineers on how to determine the appropriate region for comparison. See **Needs Identified** section.

- Option 2: Choose models that provide a range of projections. Choose the range of projections based on how sensitive your decisions are to the projections. For example, one may want to select the models that give you the biggest range, or the ones that give the most extreme projections.

Choosing Emissions Scenarios

- If the decision time-scale is earlier than 2050, there is very little difference between the various emission scenarios; choose whichever is most convenient.
- If the decision time-scale is beyond 2050, choose scenarios based on your risk tolerance and other decision criteria. For example, if the state’s approach can be classified as risk tolerant, choose a middle or average scenario. If risk averse, choose the worst case scenario.

Downscaling

- Whether downscaling, obtaining local-scale weather from regional-scale global climate models, is necessary depends on the sensitivity of the decisions to be made. If seasonal changes in regional temperature provide sufficient information, then there may be no need to downscale. Similarly, if a large geographical area (e.g., river basin) is the study area, then there may not be a need to downscale. For transportation H&H engineering, downscaling is generally necessary.
- In general, there are two main approaches to downscaling:
 - Statistical downscaling – Regression or analog-based approach to train the models on a location
 - Dynamical downscaling – Physics-based approach that requires running a regional model but with global model inputs
 - Dynamical downscaling is better at capturing local extreme weather phenomena such as thunderstorms; but
 - it is significantly more resource-intensive than statistical downscaling
- Choosing between statistical and dynamical: It is important to understand the tradeoffs (summarized, at a very high level, in Table 1). The fact that statistically downscaled data are easily and cheaply available is a huge advantage. It’s just important to know that it may mute some extremes in the data.

Table 1 Comparison between Statistical and Dynamical Downscaling

	Statistical	Dynamical
Pros	<ul style="list-style-type: none"> • Readily-available, easy to acquire and use • Projections may be sufficient for most purposes • Many models available for ensemble comparisons 	<ul style="list-style-type: none"> • Better at modeling local extreme weather phenomena (e.g., thunderstorms)
Cons	<ul style="list-style-type: none"> • May mute extreme values • Not great at capturing local extreme phenomena 	<ul style="list-style-type: none"> • Expensive and time-consuming to develop • Limited number of models

Data Resolution

- Climate models are technically capable of producing outputs at a small time resolution (e.g., hourly or even 3-minute precipitation). However, it is much harder to validate the models at smaller intervals, and for this reason time intervals of less than 24 hours are not usually considered reliable. For hourly precipitation, models are not likely to get the timing of events correct, but can provide information on the probability distribution of rainfall.
- Smaller intervals for precipitation are easier to project for areas west of the Cascade Mountains and in other areas that are not subject to severe thunderstorms and supercells that dump large amounts of rainfall over very small geographic areas. Such events are very difficult for climate models to predict. This is a challenge for TCHH members, because severe thunderstorm events are central to H&H design in most parts of the country.

Key Questions and Considerations

Key questions and considerations can be identified from the Technical Committee discussion.

The appropriate ways to incorporate knowledge of climate changes into transportation engineering and planning decisions is an area of active research and discovery. Transportation agencies face difficult decisions as they struggle to ensure their systems are resilient to extreme events with increasingly limited resources. Key questions that departments of transportation (DOTs) are grappling with include:

- How do you consider climate change as a “wild card” (i.e. using analysis that is outside of the normal H&H modelling process)? It may require assessment that is more like those employed in in planning and economics. It’s important to recognize that the solution might not always be an engineering approach. Some advocated that a better approach may be to 1) assess the assets that you have (i.e., gain a better awareness of those that are currently under-designed); 2) get a sense of the trend from climate models for what might be happening in your region; then 3) use an asset management process to incorporate the climate risk into your whole asset management plan. There is only so much money to spend up front on assets, so replacing assets after they are damaged is the more likely way that adaptation will occur.
- At what point does what is known about climate eclipse what is not known? The direction of a climate impact may be known with some precision but in other cases, the uncertainty in the timing, direction and magnitude of climate impacts will be too great to address. Is the order of magnitude of projected changes within my safety margin? Oftentimes the answer is yes. Reviewing order of magnitude projections can be a helpful first screen.
- Climate models will always have uncertainty bands and less-than-perfect resolutions. When should historical statistical methods be abandoned?
- What are the relative impacts of climate change versus economic growth and development on design? Development impacts may be much larger, and uncertainty about development may be much greater. It is important to think about climate change as just one of many uncertain factors in H&H design.
- The engineering decision framework is actually well-suited to dealing with the uncertainty and risks associated with climate change—if engineers treat climate change as just one of many unknown factors affecting hydrology.

- What are the incremental costs of increasing design? It may often be cost-effective to increase design opportunistically, e.g. as capital improvements are being made for other reasons, including damage from storms.
- What is the best way for TCHH members to communicate with the designers in their agencies? What are the best ways to communicate to designers about the uncertainties associated with climate change?
- How do we differentiate between regular variability in weather events and climate change? How do we know when the climate is different? Will trends be gradual enough that if we keep up our data records we can continue to rely on historical data?
- DOTs need to be explicit about what decisions they are trying to make and what level of precision they need to have.

Needs Identified

Also derived from the conversation among TCHH members were a variety of needs that would serve to improve current analysis and decision making.

For the transportation community (AASHTO, FHWA, DOTs)²

- Transportation engineering-specific best practice guidance for developing and applying climate projections, including:
 - A prescribed process for selecting climate models and when should you discard some models?
 - What size geography should you use to decide whether models are “good” for “your area” (city, state, region, country).
 - Explanations of what is known and what is not known by climate scientists, and the limits to current climate information. Engineers don’t need to have the answer to every question, but they need to know which questions have answers and which don’t.
 - Processes for updating climate projections and vulnerability assessments as models evolve.
 - How to proceed if models don’t provide consistent directionality (e.g., 100-year event will either increase by 23% or decrease by 24% – what do you do in that situation?).
- Processes for risk-based engineering that are not based on a single number or design standard, but on situational context, risk (from climate change and other threats), etc. Is there guidance or case studies available where DOTs have done this successfully?
- Cross-fertilization with traffic engineers to improve data or methods that H&H engineers use to estimate costs of detours associated with weather-related damage and resilience projects.
- A common set of definitions between H&H engineers and climate scientists (e.g., What are extreme events? Does “flow” refer to average annual, 100-year instantaneous, or something else?).
- Information on the incremental costs of changing design events or designing for larger events (HEC-17 will include some of this).

² Several of these will require coordination with the climate science community

- Information on how H&H engineers can work with regulators around the challenge to demonstrate that projects will not change the base flood elevation by more than 0.0 feet, when many adaptation projects might need to do that.
- Continued dialogue between the climate science and transportation communities through forums like this workshop, the TRB First Annual Conference on Surface Transportation System Resilience to Climate Change and Extreme Weather Events, the AASHTO 2013 Transportation and Extreme Weather Symposium, the FHWA climate resilience webinars, the Infrastructure Climate Network (ICNet), and others.

For AASHTO

- Coordination across the various AASHTO groups and subcommittees about the topic of climate change adaptation. This includes the Resilient and Sustainable Transportation Systems (RSTS) Technical Assistance Program, the Center for Environmental Excellence, the Subcommittee on Design (SCOD), the Technical Committee on Hydrology and Hydraulics (TCHH), and the Technical Committee on Environmental Design. Specific ideas include:
 - Use RSTS as a platform for coordination
 - Use the RSTS newsletter to disseminate information from AASHTO groups doing relevant work to all relevant groups
 - Continue to facilitate or support workshops and joint meetings around this topic

For climate scientists

- Better documentation of the process climate scientists use to validate their models would be very helpful for engineers. Engineers may not be aware that climate models are painstakingly validated.
- “Plain English” explanations of the differences between different climate models (e.g., Model A is good at modeling the jet stream, while Model B is good at modeling ocean dynamics).
- Better transparency behind climate projections – how many models were used, which ones, etc., so that engineers can judge how much they can trust the numbers.
- Research on empirical comparisons between dynamical and statistical downscaling.
- Improved regional climate modeling capabilities to provide more models covering more geographic areas.