Argonne National Laboratory

Climate Change Adaptation Planning in the Casco Bay Region of Maine

Climate Prediction Applications Science Workshop, Burlington, Vermont

March 24, 2016

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U.S. DEPARTMENT OF ENERGY

Regional Resiliency Assessment Program

- The Regional Resiliency Assessment Program (RRAP) began in 2009 as a pilot program out of efforts to assess the security of individual critical assets
- The goal is to identify opportunities for regional homeland security officials and critical infrastructure partners to strengthen resilience to all hazards
- The RRAP process identifies critical infrastructure security and resilience gaps; dependencies; interdependencies; cascading effects; and State, local, tribal, and territorial government capability gaps

Climate Change Adaptation and the RRAP

- As a part of the DHS efforts to address climate issues, the Assistant Secretary for Infrastructure Protection chose climate change adaptation in the Casco Bay Region of Maine as the focus for one of the ten Fiscal Year 2014 RRAP projects
  - The Casco Bay Region Climate Change Adaptation Planning RRAP is the first RRAP to focus on climate change adaptation
- The goal is to assess the climate change adaptation planning and coordination already underway in Maine's Casco Bay region and to identify opportunities for State and local officials to strengthen those efforts, specifically as they relate to critical infrastructure and its dependencies and interdependencies

Casco Bay Region RRAP Objectives

- Identify gaps in our understanding of regional or sector specific issues related to climate change impacts on critical infrastructure resilience
- Provide data, including climate change impact projections, and develop methodologies to help regional stakeholders better understand and manage the risks associated with extreme weather and other impacts of climate change
- Conduct data-collection activities, such as open-source research, interagency coordination, subject matter expert interviews, and facilitated discussion workshops to fill identified data requirements
- Provide technical assistance for the development of climate change adaptation plans and strategies

Workshop Focus Questions

- Are there critical nodes in the lifeline functions that could be impacted by climate change?
- Are there critical dependencies or interdependencies that could be affected by the projected impacts?
- Does your organization have existing adaptation plans or strategies?
- What are the barriers that prevent active and effective adaptation planning?
- What does your organization need to move forward with its adaptation planning efforts?

Climate Change Adaptation Challenge

- The vast majority of infrastructure is still being designed for a static climate
  - Design standards and tools use historical records (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
- Barriers to climate change adaptation
  - Lack of local-level modeling of temperature and precipitation changes
  - Lack of high-resolution climate scenario data to justify starting adaptation projects
  - Lack of a local framework for adaptation planning

"Two issues are lack of routinely available data that's useful at the local scale and experts who can translate science-based findings into policy objectives. We simply don't have that cadre built yet of knowledgeable people who can consult and offer the advice."

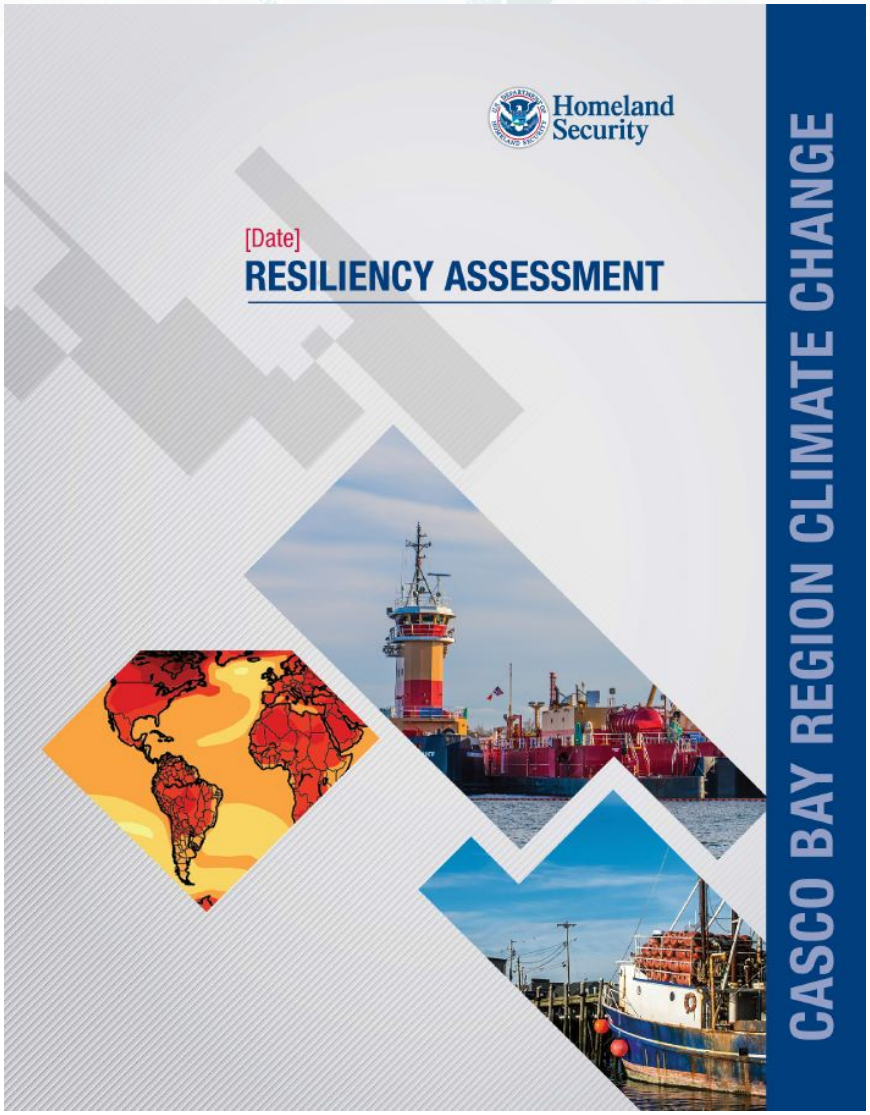
—Alice Hill, National Security Council, White House, June 2015 speech on mainstreaming climate risks into U.S. Government Planning

Gap between Climate Science and Critical Infrastructure Adaptation

- Available climate data are often developed by and for the atmospheric and oceanic science communities
- Projections of future climate conditions are not easily translated into local climate impacts, yet these impacts are more directly actionable through engineering design, infrastructure management, and urban planning practices
- Most urban planning and engineering design practices are currently not adequate to bridge the gap between climate model outputs and the climate impact information necessary for adaptation

Resiliency Assessment

- Presents results of the assessment phase of the RRAP in the form of Key Findings and Resilience Enhancement Options
- Sets the stage for follow-on Implementation Activities

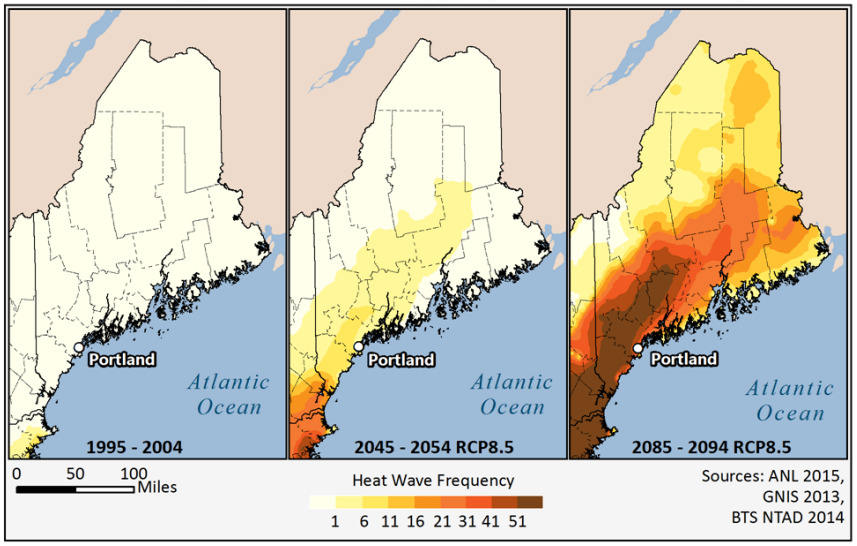


Implementation Activities

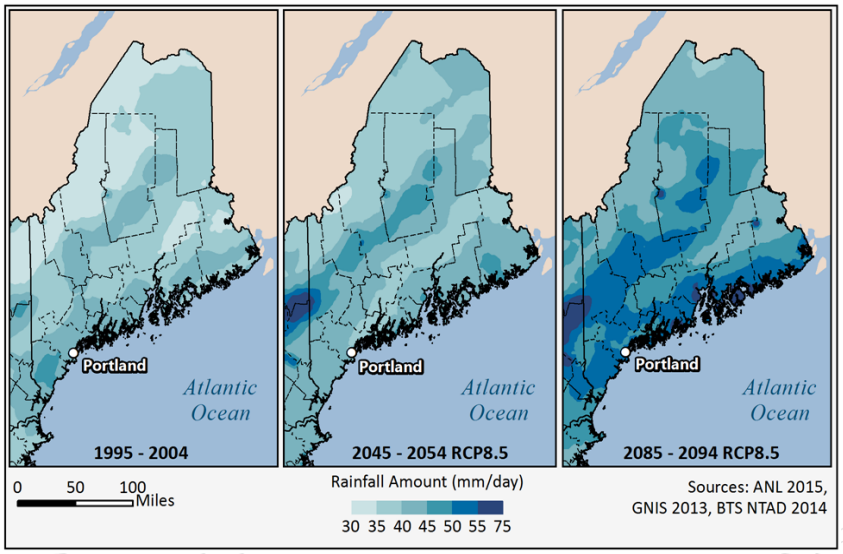
1. Regional Climate Modeling (RCM)
2. Radar-Based Rainfall Data
3. Intensity Duration Frequency Curve Development
4. Storm Surge Modeling

Regional Climate Modeling

- Increases spatial resolution of climate model output: 1- to 2-degree grids (global scale) to 1/8-degree grids (regional scale)
- Downscaling involves using Argonne's supercomputing facility to perform multiple runs of a regional climate model
- Produces projections of the following:
  - Average and maximum annual precipitation
  - Average and maximum annual temperature
  - Other climate stressors identified by stakeholders
  - Multiple time slices: mid-century, end of century



Projected Trends in the Average Annual Number of Heatwaves



Projected Average Annual Maximum Precipitation (Greater than 99%)
Source: Argonne National Laboratory EVS Division (2015)

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Dissemination of Model Results (Data Portal) Using a Globus-based Data Distribution Model

Using Climate Information for Decisionmaking and Impacts Research

State of Our Understanding (User Manual Forthcoming)

- A climate data user manual is being prepared for the Department of Defense (DoD) Strategic Environmental Research and Development Program
- The manual will provide planners and decision makers with:
  1. A critical overview of relevant downscaling models, methodologies, and data
  2. The advantages and disadvantages associated with 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

In collaboration with Texas Tech, the National Center for Atmospheric Research, Arizona State University, and the University of Illinois–Urbana-Champaign, Argonne is developing a users manual detailing how to use downscaled climate data.

Using Downscaled Climate Data to Drive Infrastructure Impact Models

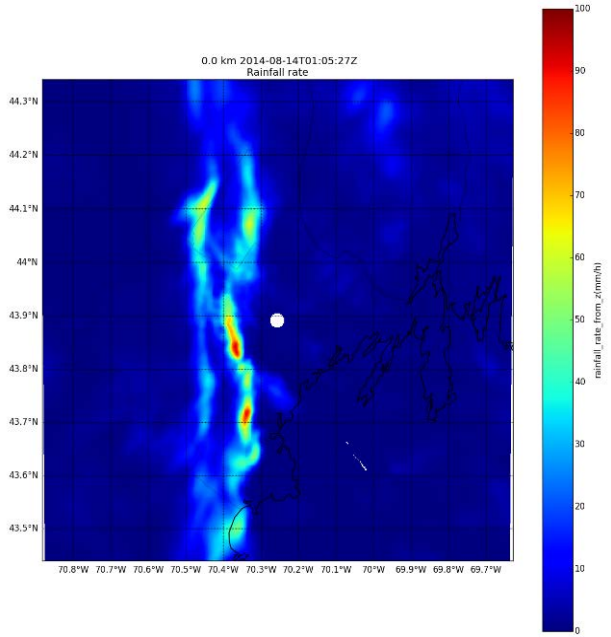
- Infrastructure models (e.g., electric, natural gas, petroleum, water, transportation systems) can be coupled to climate models to assess climate hazards
- For example, Argonne is using the EPfast (electric) model as part of an analysis of the impacts of mid-century increased temperature on Maine's electric grid to
  - Determine impacts on the capacity of power plants, transmission lines, and transformers, as well as growth in demand
  - Identify implications on overall grid performance via load flow simulation
- Results show that increasing temperatures affect seasonal electricity demands (e.g., increased cooling demand in the summer), power plant output, and transmission line capacity, which could cause rolling brown-outs if electric infrastructure does not adapt

Regional climate models, coupled with infrastructure modeling and analysis, can inform planning decisions that will result in design and construction of more resilient infrastructure in the future.

Radar Climatology of Rainfall over Portland, Maine

- Key science question: Is the RCM output (12-km resolution) refined enough to resolve high-intensity localized precipitation events?
- To answer this question, we used National Oceanic and Atmospheric Administration (NOAA) Weather Surveillance Radars to create high-resolution

  (200-m) rain maps to feed into hydrological models to analyze the impact on stream and culvert flow
- More than 10 years of 10-minute-resolution retrievals were performed, generating a 1-Tb database of rainfall maps and a “look-up table” to identify extreme events
- Provides full spatial coverage of an area, as opposed to extrapolating area rainfall information from point-measurements (e.g., rain gauge stations)
- Work coupling output to hydrological model is ongoing

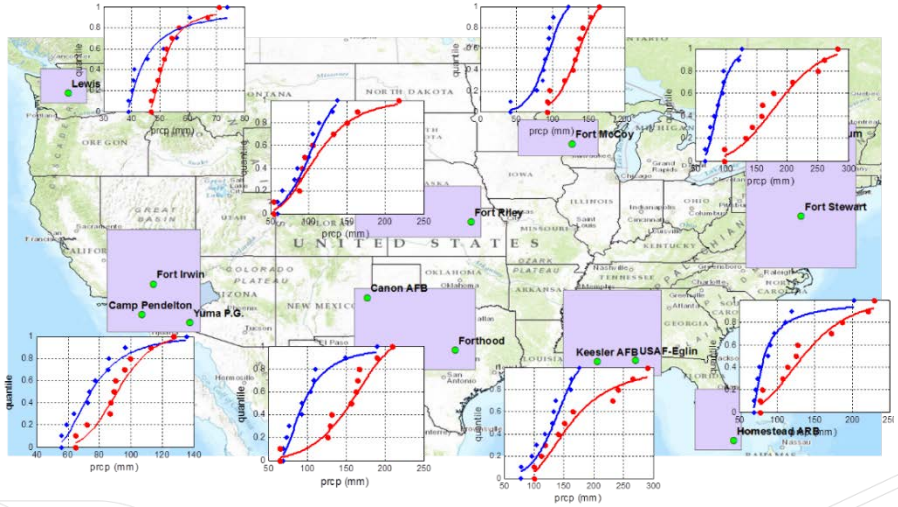


Source: Argonne National Laboratory EVS Division (2016)

Intensity-Duration-Frequency Curves

- Next-generation intensity-duration-frequency (IDF) curves are one approach to incorporating climate data into hydrological modeling and design practices
  - IDF curves are widely used to develop the design basis for precipitation-affected infrastructure systems, engineering standards, and building codes and maintenance standards
- Argonne has provided hydrologic analyses in support of multiple projects for the Nuclear Regulatory Commission and DoD, including:
  - Safety analyses for proposed facilities
  - Flooding re-evaluations in response to the Fukushima disaster
  - Hydrologic analyses for military bases

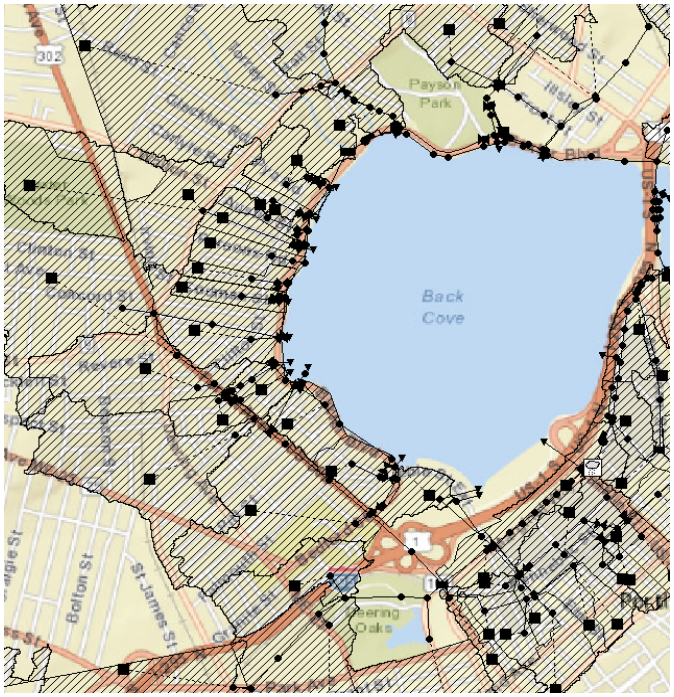

NRC file photo



Source: Argonne National Laboratory EVS Division (2015)

IDF Curves for Portland, Maine, Project Update

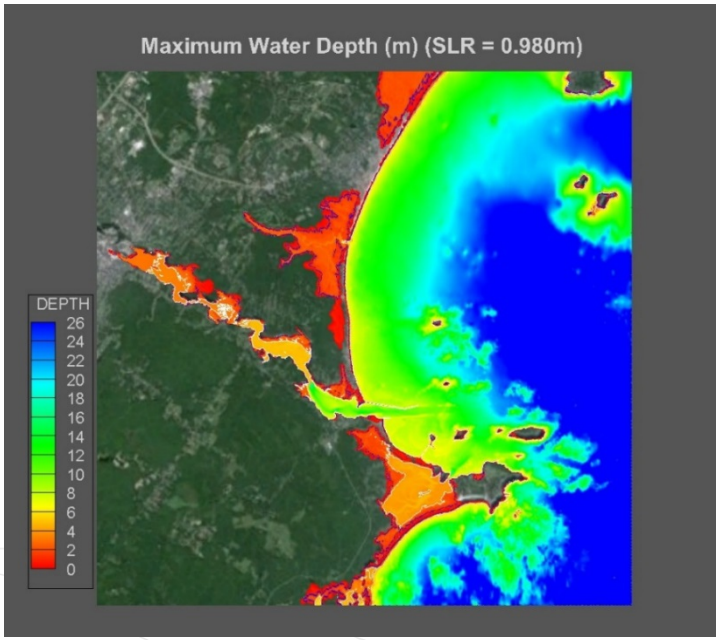
- The City of Portland recommended the Back Cove area as a test site and provided storm water management model (SWMM) drainage data
- A two-dimensional (2-D) hydraulic model was constructed to simulate flow on streets, roof top, and subsurface drainage system
- Work is ongoing to incorporate outputs from radar analysis
- Radar data at 250-m resolution captured spatial variation that cannot be identified based on very limited hourly rain gage stations
- Using the radar data for input to the 2-D hydrological/hydraulic model will improve the model projections
- Task will be completed by December 2016

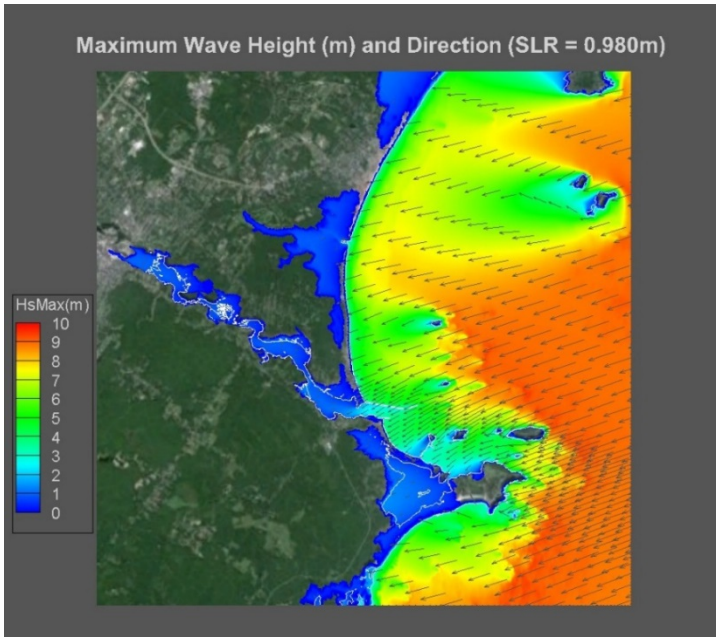


SWMM data showing drainage network
Source: City of Portland, Maine

Storm Surge Modeling

- Projected sea level rise in the region will amplify the effects of storm surge
  - Increasing storm inundation areas
  - Increasing wave action impacts
- Coastal infrastructure that is vulnerable to inundation and marine infrastructure will experience increased loading associated with storm surge waves



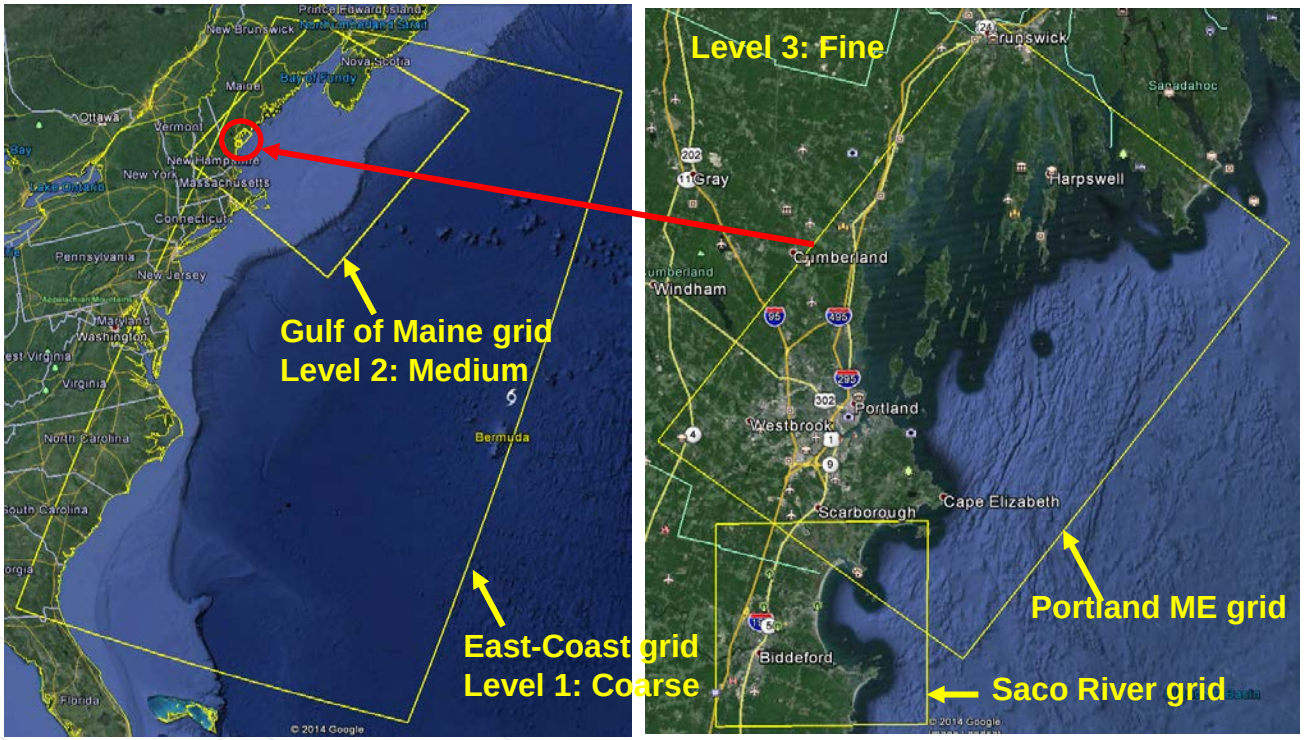


Source: National Center for Computational Hydroscience and Engineering

Storm Surge Modeling (Cont.)

Work to Date

- The National Center for Computational Hydroscience and Engineering (NCCHE) developed three nested model resolutions for preliminary storm surge analysis of an extreme, Sandy-like hurricane
- These models produced data on hydrodynamics (e.g., wave height and direction), sediment transport (e.g., erosion), and wind field (e.g., speed and direction)



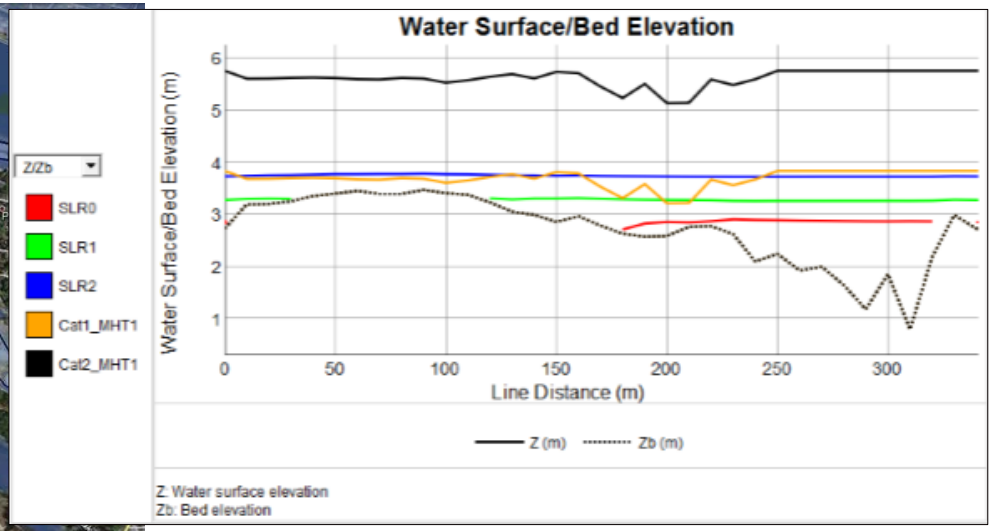
Source: National Center for Computational Hydroscience and Engineering

Storm Surge Modeling (Cont.)

OngoingTasks

- Develop risk analysis for selected critical infrastructure utilizing simulation results
  - Risk-based prioritization of assets based on the probability and consequence of flooding
  - Provide data on water surface elevation and flow depth at critical locations to inform future resilience and adaptation design activities

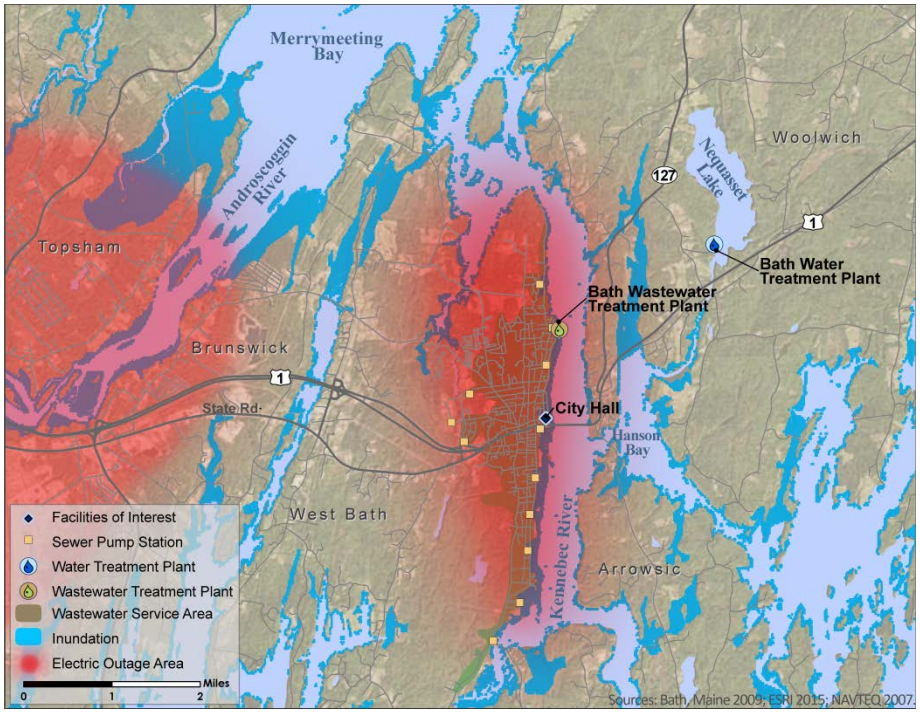
Source: National Center for Computational Hydroscience and Engineering



Source: National Center for Computational Hydroscience and Engineering

Building on Results from Maine within the 2016 Region 1 RRAP

- Assess climate impacts on electric infrastructure throughout New England
- Consider flood risk due to sea level rise combined with more intense overland precipitation events
- Identify high-consequence failure points and potential cascading failure scenarios within the region's electric infrastructure



Regional Climate System Assessment Framework

EXPERTISE

ENVIRONMENTAL SCIENCES
- Atmospheric and Climate Sciences
- Earth Sciences
- Oceanography
- Space Sciences

ENGINEERING & SYSTEMS
- GIS
- Modeling of Complex Systems
- Infrastructure System Analysis
- Operations Research
- Vulnerability Assessment
- Resilience Assessment
- Emergency Management
- Energy Sciences

SOCIOECONOMICS & POLICY
- Land Use/ Development
- Human and Social Sciences
- Economic Sciences
- Political Sciences
- Policy Analysis
- Risk Communication
- Information Sharing

SECURITY
- National Security
- Homeland Security
- Intelligence

Source: Argonne National Laboratory

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