Climate Data Needs for Transportation Agencies

Observational and Analytical Climate Modeling for Engineering Applications

November 17, 2011

Rob Hyman
FHWA, Office of Natural Environment

U.S. Department of Transportation
Federal Highway Administration

What Climate Changes Will Impact Transportation?

- **Sea level rise and storm surge**
- **Precipitation changes**
  - **More intense precipitation events**
  - **Flooding**
  - **Snowpack changes**
- **Increase in hurricane intensity**
- **Increase in very hot days**
- **Permafrost thawing**

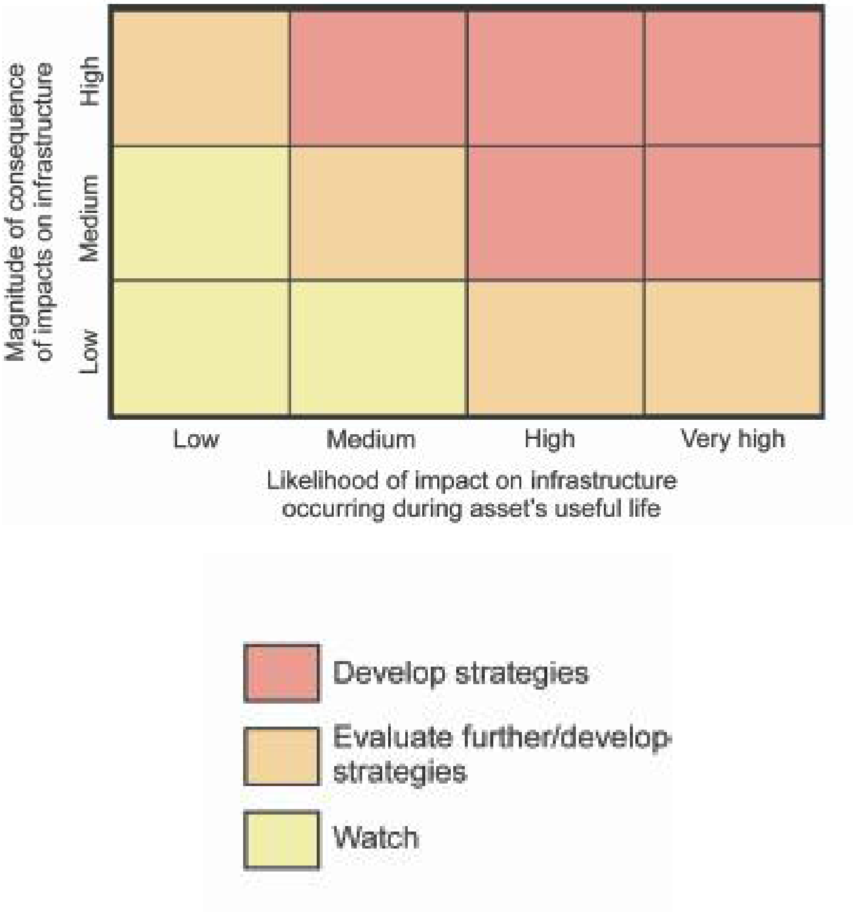
Sources: WSDOT and Caltrans

Why Does FHWA Care About Climate Change Adaptation?

- **Need to protect integrity of transportation investments, safety**
  - Infrastructure has long design life (decades)
  - Infrastructure needs to handle new conditions as climate changes
  - Adaptation is ensuring that we plan our infrastructure for the future
- **FHWA Goal: Systematic consideration of climate change vulnerability and risk in transportation decision making, at system and project level**

FHWA Adaptation Initiatives

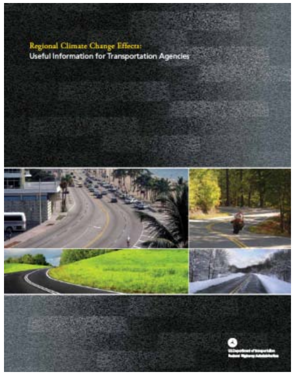
- **FHWA is developing and sharing information on tools and methodologies that states and MPOs can use to assess risk and prioritize actions:**
  - **Climate projections**
  - **Critical asset identification**
  - **Vulnerability assessment methodologies**



Source: City of New York

Regional Climate Change Effects (2010)

- **Report synthesizes information on climate change projections for transportation decision makers**
  - **Snapshot: Summarizes recent science**
- **Projected *changes* by region**
  - **Annual, Seasonal Temperature (change in ºF)**
  - **Seasonal Precipitation (% change)**
  - **Where information exists:**
    - Sea level rise, Storm activity



- **Also includes information at local, state scales**
- **Received assistance from climate experts at NOAA, USGS, DOE, etc.**

http://www.fhwa.dot.gov/hep/climate/climate_effects/

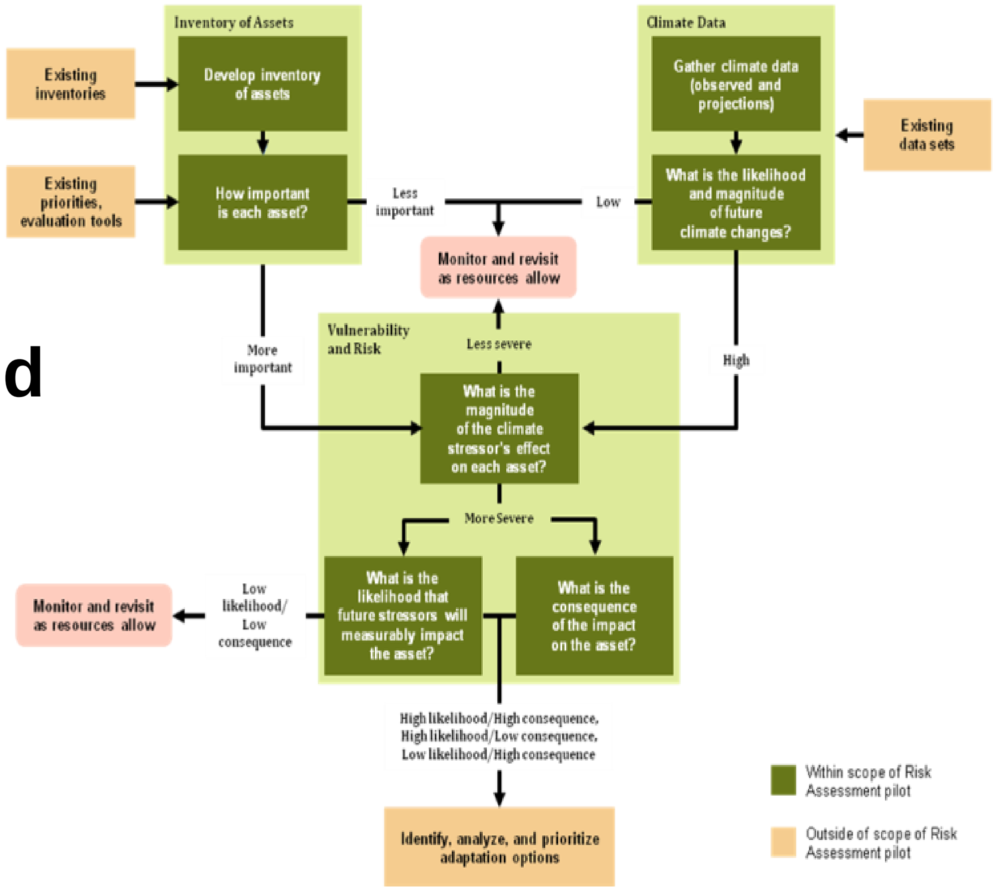
How Can This Information Be Applied?

- **Inform planning efforts with a <u>consistent</u> set of projections**
- **Inform consideration of vulnerability of key assets**
- **Not detailed/certain enough for definitive decisions on specific projects**

Projected Increases in Annual Temperature

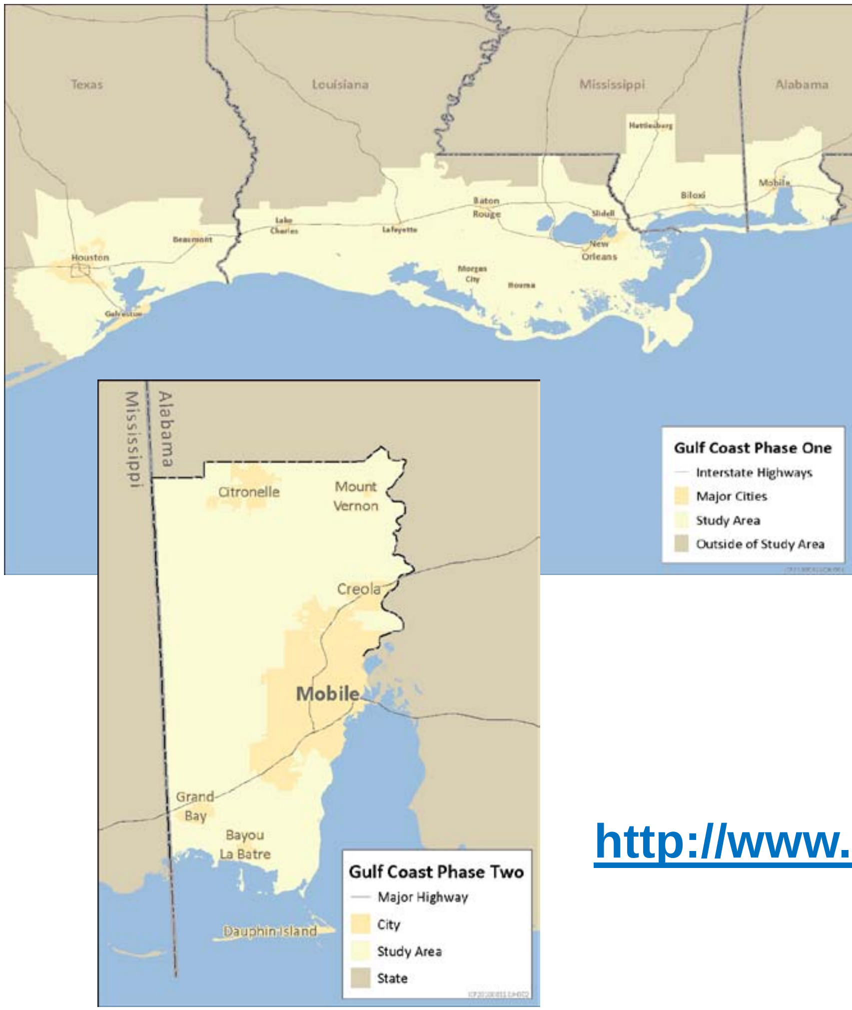
Vulnerability/Risk Assessment Conceptual Model

- Develop inventory of infrastructure assets
- Gather climate data
- Assess vulnerability and risk of assets to projected climate change
- Analyze, prioritize adaptation options
- Monitor and revisit



Climate Change Vulnerability and Risk Assessment Pilot Locations

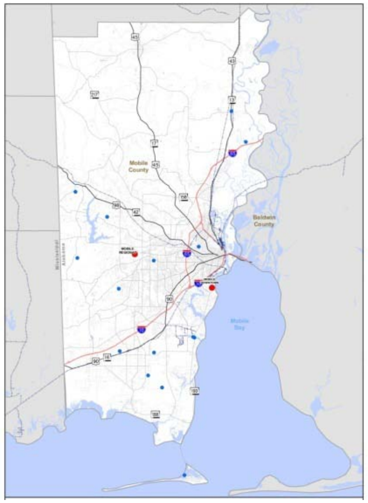
Gulf Coast Project Examines Issues at Metropolitan Scale



- **Phase 1**
  - Overview of climate change impacts on transportation infrastructure in central Gulf Coast (completed 2008)
- **Phase 2**
  - Focus on one metropolitan area – Mobile, AL
  - Development of adaptation tools and strategies that will be transferable to other areas
  - Timeframe: 2010-2013

http://www.fhwa.dot.gov/hep/climate/gulf_coast_study

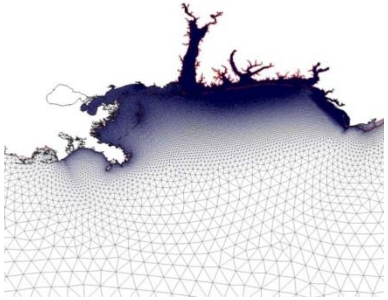
Gulf Coast 2 Study: Task Objectives



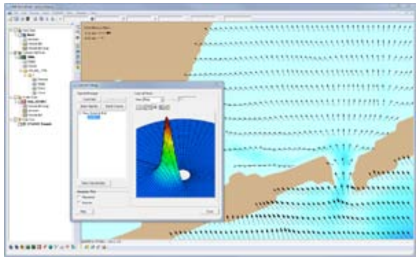
- **Task 1: Identify critical assets in Mobile**
- **Task 2: Climate impacts**
  - Develop climate information
  - Assess sensitivity of assets to climate stressors
- **Task 3: Determine vulnerability of critical assets**
  - Broad assessment of vulnerability
  - In-depth vulnerability assessment of some of the most critical assets
- **Task 4: Develop risk management tool(s)**
- **Task 5: Coordination with Planning Authorities and the Public**
  - Ongoing
- **Task 6: Information dissemination and publication**

Developing Projected Climate Data

- **USGS providing statistically downscaled projections for T and P**
  - 4 to 7 Climate models (PCM, Hadley, …)
  - 3 emission scenarios (A1fi, A2, B1); 3 time horizons out to 2100
  - Secondary variables calculated from daily T and P, e.g., 24-hr precip with 5%/yr prob
- **Sea level rise analysis**
  - Range of recent global SLR scenarios used
  - Accounts for local subsidence



- **Storm Surge Modeling – ADCIRC**
  - Range of storm intensities
  - Output includes surge distribution and dynamics



- **Wave Modeling – STWAVE**
  - Inputs from ADCIRC output and boundary conditions
  - Outputs include key aspects of wave energy
- **Exposure of transportation systems will be assessed using a GIS analysis**

Temperature Variables Developed for Gulf Coast Project

Variable		Analysis
Annual, seasonal, and monthly average min, max, and mean temperature		Runway Design
Daily high temperature: mean, 50 %ile, 95 %ile, and warmest day in the year during each 30-yr period		AREMA Rail design / buildings
Seasonal and annual number of days and maximum consecutive days of high temperatures at or above 95, 100, 105, and 110 °F		Civil/Geotech/ Pavement
Mean, 5%, 25%, 50%, 75%, 95%, and largest occurrences for the average minimum air temperature over 4 consecutive days in winter, and the average maximum temperature over 4 consecutive days in summer		Bridge /Rail
Mean, 50%, 90%, 95%, and 99% occurrence of the coldest day of the year during each 30-yr period		Pavement Design
Max 7-day average air temperature per year with % probability of occurrence for each 30-yr period (mean, 50%, 90%, 95%, 99% occurrence)		Pavement Design (Asphalt)

Precipitation Variables Developed for Gulf Coast Project

Variable	Analysis
Annual, Seasonal and monthly precipitation	Pavement Design
Exceedance probability precipitation for 24-hour period with a 0.2%, 1%, 2%, 5%, 10%, 20%, and 50% exceedance precipitation events (e.g., 500-yr, 100-yr, 50-yr, ..)	Drainage / Liquid Storage
24-hour exceedence probabilities based on today's 0.2%, 1%, 2%, 5%, 10%, 20%, and 50% exceedance precipitation events	Drainage
Exceedance probability precipitation across 4 consecutive days: 0.2%, 1%, 2%, 5%, 10%, 20%, 50%, mean; Exceedance probability of precipitation across 2 consecutive days: 0.2%, 1%, 2%, 5%, 10%, 20%, 50%, mean	Inundation Analysis
Largest 3-day total of precipitation each season	Change in Storm Events

Precipitation Data/Projections Needed

- **Seasonal and monthly precipitation**
- **<u>Extremes/events</u>**
- **Finish updating NOAA Atlas 14 for all regions**
- **Compile data on *projected* changes in precipitation in the same format as NOAA Atlas 14**
- **Snow melt, change in snow cover**
- **Seasonal trends (and projections) in reservoir volumes**

Other Precipitation issues

- **Projection of extreme events provided at 24-hour level, but hydraulic engineers are interested in events of 6-hour or less duration**
- **Small scale events don’t get enough attention - they may be significant in terms of storm water management**
- **Need to develop ways to relate projected model results (for precipitation) to flow/runoff**
    - **Also need to integrate with land use changes and other projected changes that will affect runoff to get a true picture**

Temperature Projections, Coastal Storm Projections

- Temperature
  - Seasonal, monthly
  - Daily extremes (very hot, very cold), frequency/intensity of heat waves
  - Changes to freeze/thaw cycles
- Coastal Storms
  - Projected changes in intensity and frequency
  - Projected storm surge
  - Probability of a given location being hit by hurricane

Sea Level Rise Information Needed

- Range of projected SLR increases
- Projected rates of local change that account for SLR projections and local geologic factors (subsidence, erosion, local variations in sea level)
- LiDAR data for coastal areas
- Baseline DEMs for all coastal areas, with Infrastructure
  - Standardization of DEMs so that they can be meshed
  - DEMs with layers for different scenarios of SLR
  - DEMs for all areas around lakes and rivers (for flooding analyses)

It would be great if the science agencies could facilitate…

- Developing the climate information may be the easy part
- Harder part is making it available, and understanding how to apply it

Provide a Federal agency road map / clearinghouse

- **What agencies (and staff) are doing what?**
  - **“Producers” of climate info (NOAA, NWS, USGS, EPA) and “consumers” (USACE, FEMA, USDOT, etc.) – though the lines are blurred**
  - **General responsibility, available assistance**
  - **Research results**
  - **Relevant regulatory development, guidance, outreach, etc.**
  - **State and local efforts/results**
- **Provide centralized location for information / contacts**
  - **Outreach to track developments, post status updates, contacts, etc.**
  - **Academic and other research results**
  - **NOAA and NWS and State climatologists**

Identify Available Information

- Identify available datasets, now and in the future
  - Historic/observed
  - Projections

- Strengths/weaknesses/recommendations

- Provide enough information for consumers who are not climate scientists to understand what they are using

Provide Guidance on Conducting Analyses

- Recommended approaches for conducting analyses
  - SLR, RSLR, etc. (with USGS?)
  - Tropical storm modeling (with USACE, others?)
  - Temp and precip modeling (with NWS?)

- Recommendations on use of models
  - Full range vs. selected

- Statistical Downscaling approaches, regional modeling

Provide Guidance on Conducting Risk Assessments

- **How can uncertain projections be applied in a planning/engineering context?**
- **Examples of risk assessments done in other fields, and how to apply same type of analysis to climate change adaptation**
- **Development of information to support risk assessments. What do we need?**
  - **Likelihood/certainty information for climate projections**
    - Across models?
    - Across scenarios?

Promote Multi-disciplinary Collaboration

- Engineers and scientists do not speak the same language
- Promote communication among
  - Climate modelers (NOAA, universities)
  - Hydrologists, statisticians, weather experts (NWS, state climatologists)
  - Engineers, planners, environment staff
- Differences in data needs and translating data used by the different fields
- Comfort with applying projections versus following trends in historic data

Thank You

http://www.fhwa.dot.gov/hep/climate

http://www.fhwa.dot.gov/hep/climate/climate_effects

http://www.fhwa.dot.gov/hep/climate/gulf_coast_study

Rob Hyman

Sustainable Transport and Climate Change Team

FHWA Office of Natural Environment

202-366-5843

Robert.Hyman@dot.gov

Lessons Learned: Needed Data Can Be Difficult to Obtain

- Site specific climate projections are difficult to find
  - Downscaling global models is a complex activity
  - Universities are often important players in developing this data – have been partners in many assessments
  - But, downscaled data is becoming more readily available
- Transportation asset inventory data time consuming to assemble
  - Many different sources - even within one agency!
  - Many different formats
  - LIDAR data does not capture all needed details