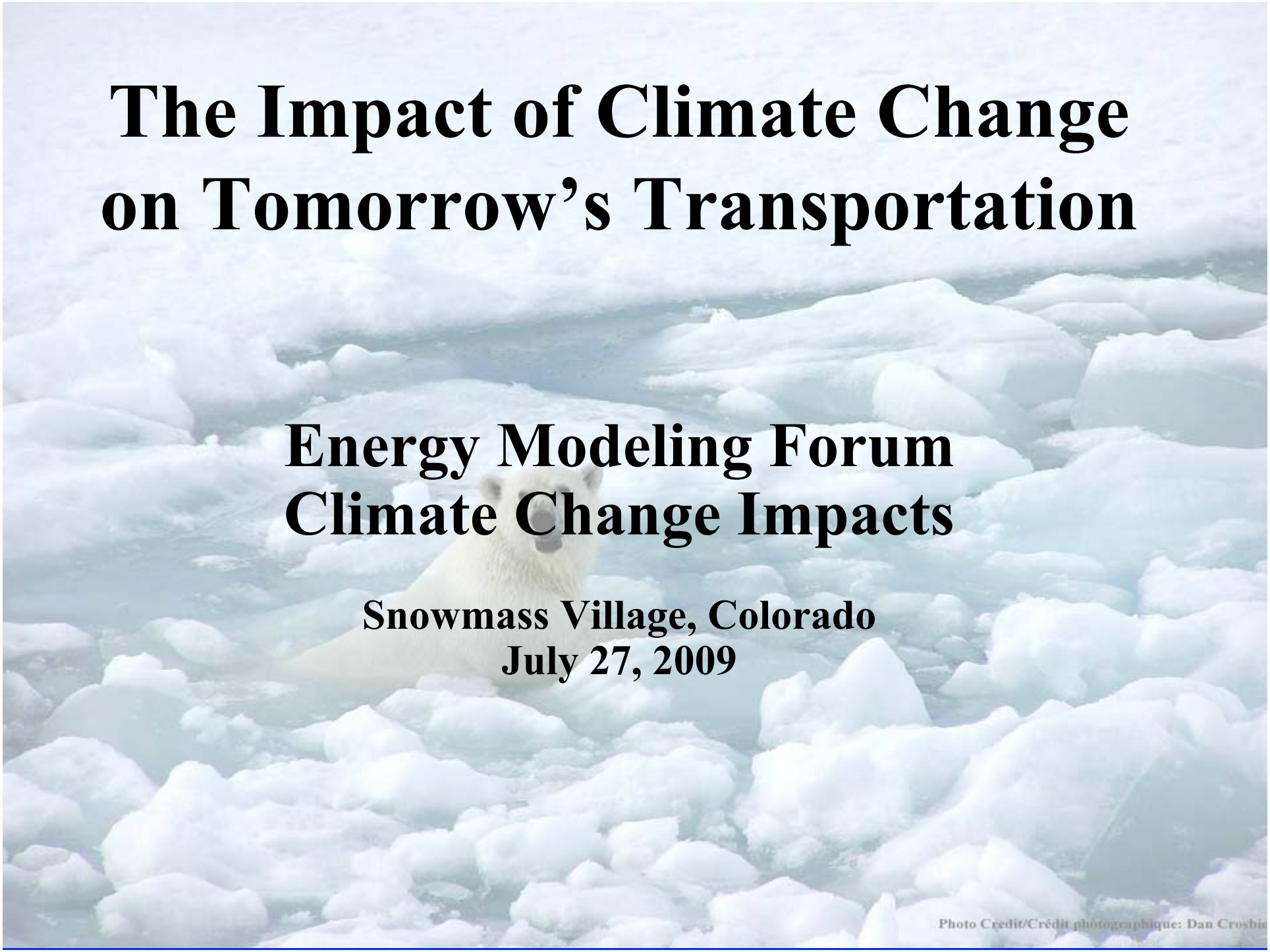
The Impact of Climate Change on Tomorrow's Transportation

Energy Modeling Forum
Climate Change Impacts

Snowmass Village, Colorado
July 27, 2009



BASIC PREMISES

- Global warming is occurring and climate changes are unlikely to unfold gradually.
- Historical weather and climate patterns will no longer be reliable planning guides
- Impacts will affect all U.S. regions and all transportation modes.
- Significant changes necessary in planning, design, operation, and maintenance of the transportation infrastructure.
- Today's investment decisions will affect how well the infrastructure adapts to climate change far into the future.

CLIMATE CHANGES OF RELEVANCE FOR TRANSPORTATION OVER THE NEXT 50-100 YEARS

- Rising sea levels (virtually certain)
- Increases in very hot days and heat waves (very likely)
- Increases in Arctic temperatures (virtually certain)
- Increases in intense precipitation events (very likely)
- Increases in hurricane intensity (likely)

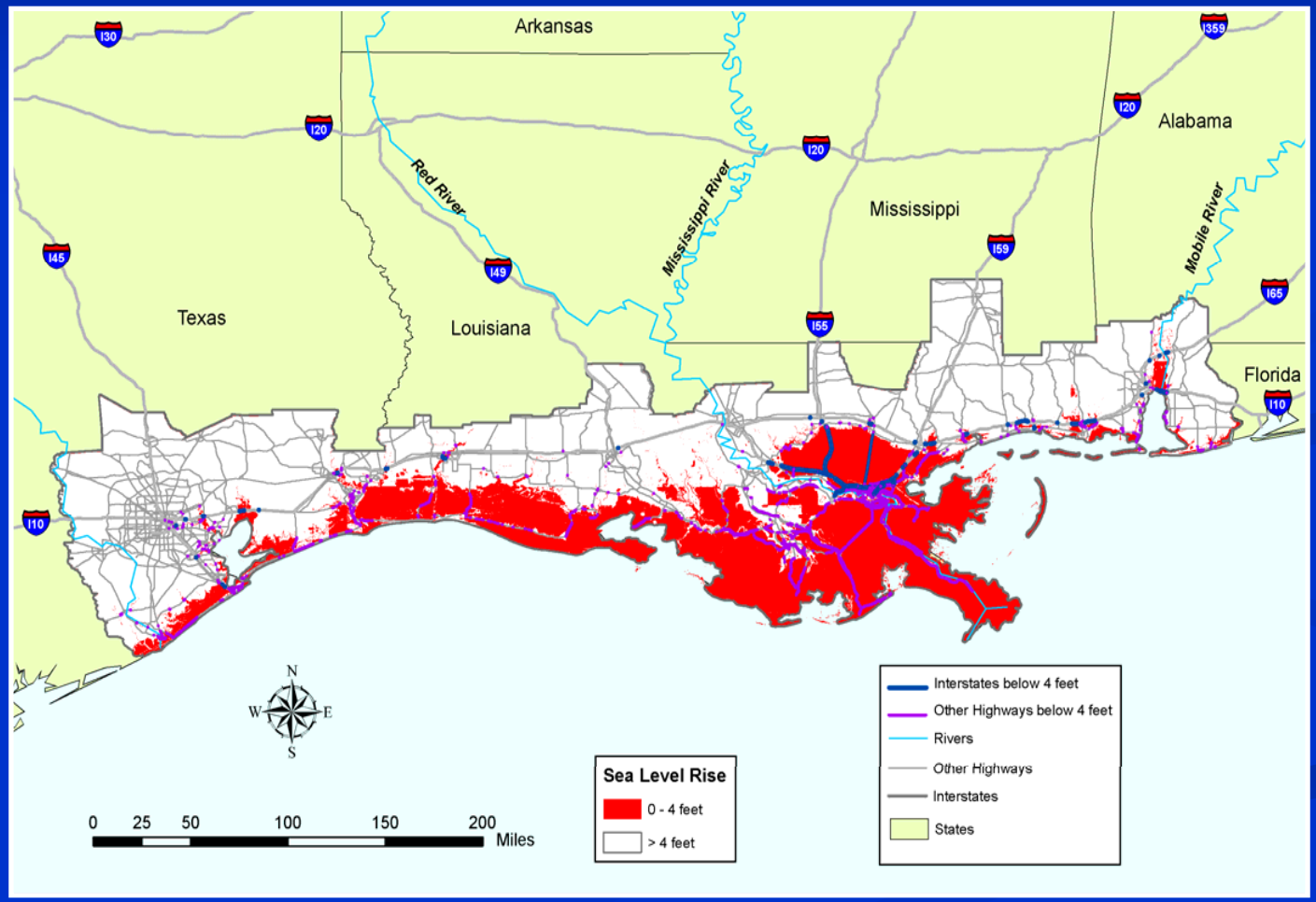
IMPACTS ON TRANSPORTATION

- **Sea level rise** (virtually certain)
  - Inundation of roads, rail lines, and runways in coastal areas
  - Flooding of tunnels and low lying infrastructure
  - Erosion of bridge supports
  - Changes needed in harbors and ports
  - More severe storm surges requiring evacuation
  - 6 of top 10 foreign freight gateways at risk
  - Destruction of barrier islands

Gulf Coast Study

Highways Vulnerable to Relative SLR

4 Feet of Sea Level Rise



Source: Cambridge Systematics analysis of U.S. DOT Data.

Gulf Coast Study

4 foot relative sea level rise

- 24% of the Interstate highway miles
- 28% of the arterials
- 9% of the rail lines
- 72% of the ports
- Three airports

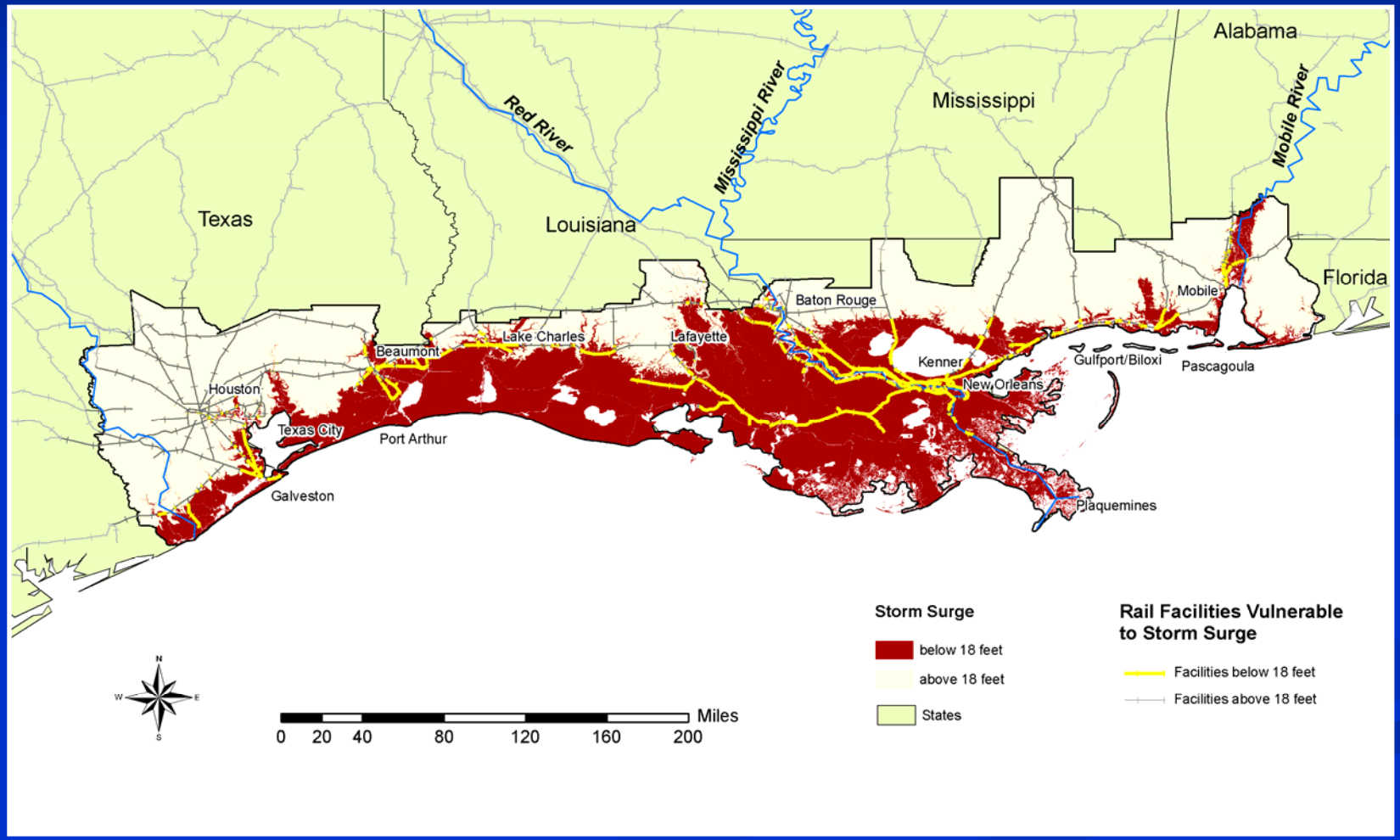
Are flooded!

Hurricane Katrina Damage to Highway 90 at Bay St. Louis, MS

Source: NASA Remote Sensing Tutorial.

Gulf Coast Study

Freight Rail - Storm Surge of 18 Feet

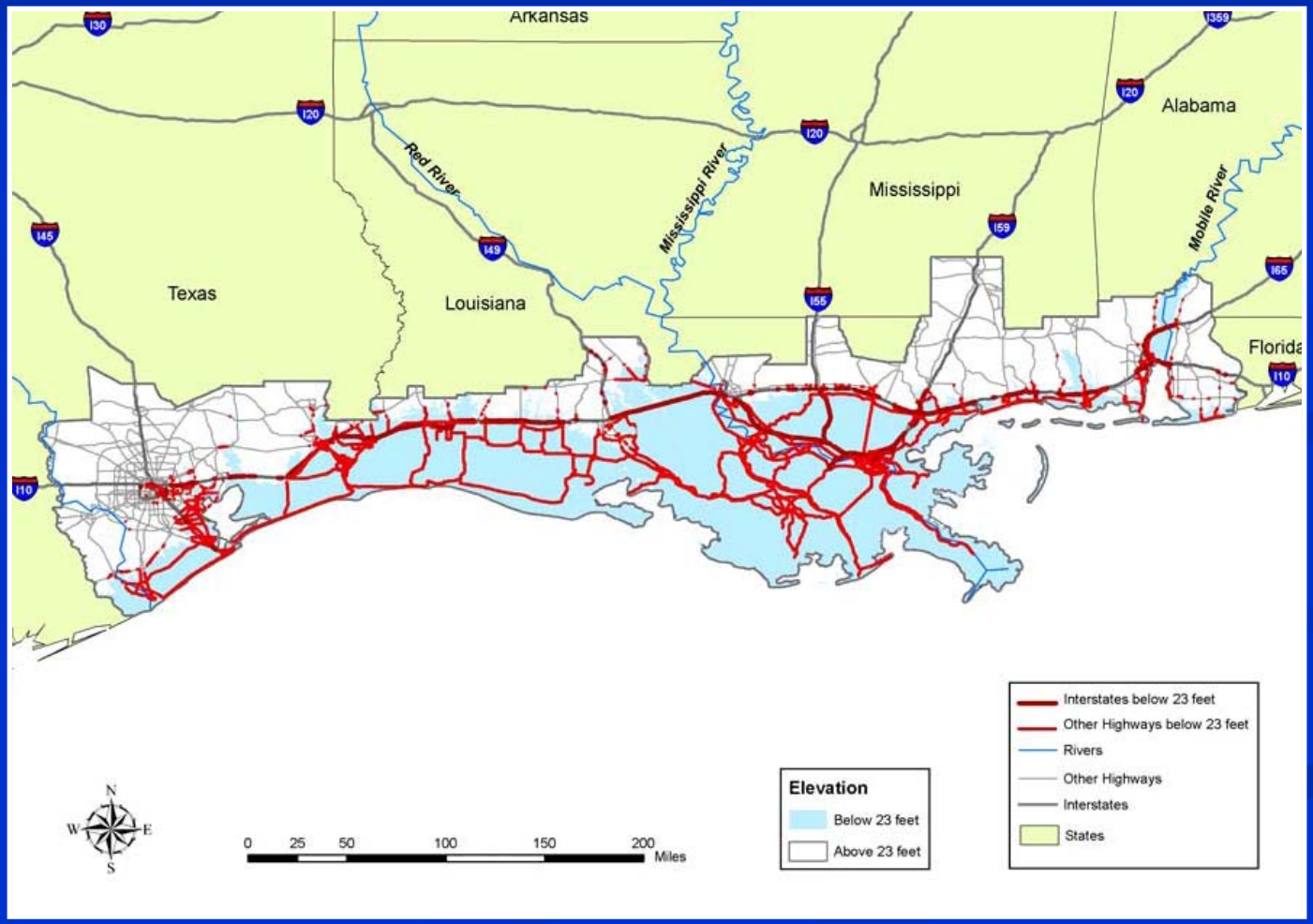


Source: Cambridge Systematics analysis of climate projections and Federal Railroad Administration data.

Gulf Coast Study

Highways Vulnerable to Relative SLR

23 Feet of Sea Level Rise



Source: Cambridge Systematics analysis of U.S. DOT Data.

Gulf Coast Study

At 23 foot storm surge

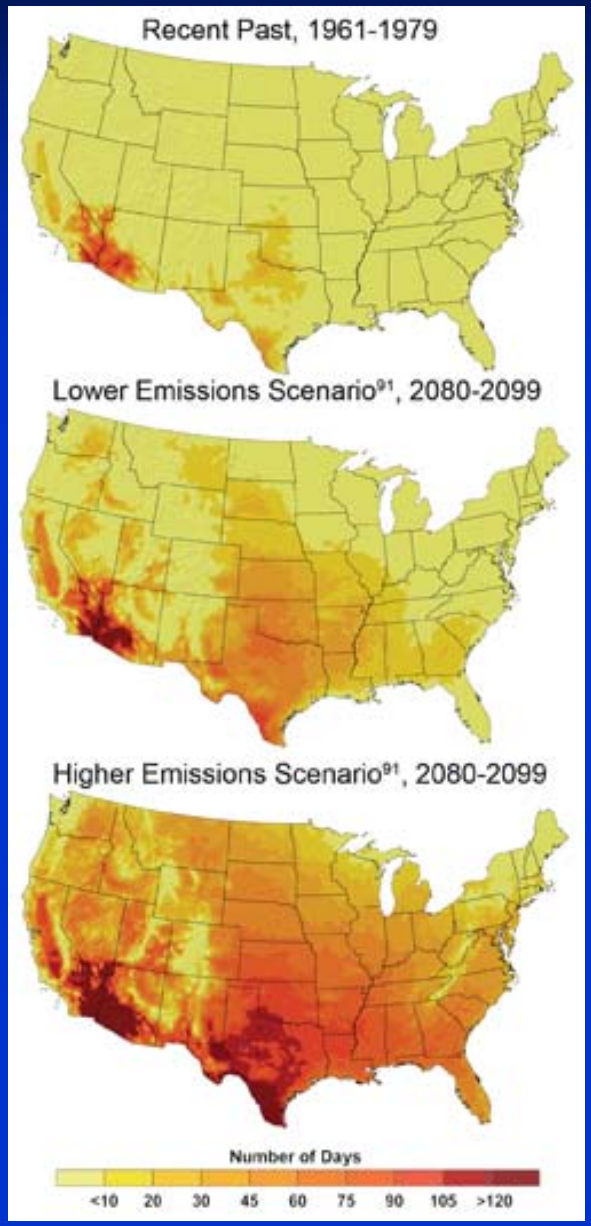
- 64% of Interstate highway miles
- 57% of arterials
- 41% of freight rail lines
- 99% of ports
- 29 airports

Are flooded!

IMPACTS ON TRANSPORTATION

- **Sea level rise**
  - Inundation of roads, rail lines, and runways in coastal areas
  - Flooding of tunnels and low lying infrastructure
  - Erosion of bridge supports
  - Changes needed in harbors and ports
  - More severe storm surges requiring evacuation
  - 6 of top 10 foreign freight gateways at risk
  - Destruction of barrier islands

Number of Days Over 100°F



The number of days in which the temperature exceeds 100°F by late this century, compared to the 1960s and 1970s, is projected to increase strongly across the United States. For example, parts of Texas that recently experienced about 10 to 20 days per year over 100°F are expected to experience more than 100 days per year in which the temperature exceeds 100°F by the end of the century under the higher emissions scenario.[91]

IMPACTS ON TRANSPORTATION

- **Increase in very hot days / heat waves**
  - Thermal expansion – bridges and pavements
  - Pavement integrity
  - Rail track deformations
  - Lift-off limits at hot weather airports
  - Lower water levels in Great Lakes
  - Droughts ⟶ brush and forest fires
  - Limitations on hours of construction

IMPACTS ON TRANSPORTATION

- **Increase in Arctic temperatures**
  - Thawing of permafrost – subsidence of highways, rail beds, pipelines, and runways
  - Shorter season for ice roads
  - Sea ice retreat $\longrightarrow$ erosion
  - 10-20% increase in infrastructure maintenance costs
  - Ice-free Northwest Passage
  - Longer ocean transport season

IMPACTS ON TRANSPORTATION

- **Increase in intense precipitation events**
  - Traffic disruptions
  - Increase in airline delays due to convective weather
  - Localized flooding of roadways, rail lines, runways
  - Major flooding on inland rivers
  - Scouring of pipeline supports and bridge foundations

IMPACTS ON TRANSPORTATION

- **More frequent strong hurricanes**
  - Interruptions to air service
  - More frequent and costly evacuations
  - Greater probability of infrastructure failures
  - Failure of bridge decks
  - Damage to ports and harbors
  - 7 of 10 largest ports are on Gulf Coast
  - Thousands of oil platforms along Gulf Coast

TRANSPORTATION DECISION FRAMEWORK

- Inventory critical infrastructure, particularly in vulnerable locations
- Incorporate climate change in investment plans and decisions
- Adopt strategic, risk-based approaches to decision making
- Improve communication between transportation professionals and climate scientists
- Research on climate science needs to address needs of transportation decision makers

RECOMMENDATIONS (cont'd)
Adaptation Strategies

- **Operations:** integrate emergency response into transportation operations to handle weather and climate extremes
- **Design:**
  - Reevaluate design standards
  - Rebuild infrastructure in vulnerable locations to higher standards
- **Monitoring:** develop new technologies to track conditions and warn of pending failure

RECOMMENDATIONS (cont'd)
Adaptation Strategies

- **Transportation and land use planning:** incorporate climate change in investment and development decisions
- **Flood insurance:** reevaluate National Flood Insurance Program and update flood zone maps
- **New organizational arrangements:** develop regional and multistate structures to address climate change impacts and create a federal interagency working group on adaptation