Extreme Weather Events: Trends and Implications for Transportation Emergency Management

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on behalf of the AASHTO Center for Environmental Excellence

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Answer the following questions:

- What does the science say about extreme weather trends, past and future?
- What do these trends mean for transportation security and emergency management?
- What are the research priorities in this area?
Recent Extreme Weather Events

May 2015 Floods in Houston, TX
Maybe You’ve Noticed…

- Flooding in Houston, TX, May 2015
- Flooding in Michigan, August 2014
- Flooding in Colorado, September 2013
- Superstorm Sandy, October 2012
- Tropical Storm Lee, September 2011
- Hurricane Irene, August 2011
- Heat Wave in Midwest, summer 2011
Maybe you’ve noticed…

Texas and Oklahoma, May 2015

Michigan, August 2014

Colorado, September 2013

Vermont, August 2011

Photo sources (clockwise): AP Photo/Brandon Wade, AP Photo/Carlos Osorio, Colorado DOT, VTrans
Not to mention…

- Washington landslide, March 2014
- Texas drought, 2011
- California wildfires, 2014
- Buffalo snow storm, December 2014

Photo sources (clockwise): USGS, City of Austin, Fox News, necn
U.S. Selected Significant Climate Anomalies and Events
May and Spring 2015

AK was record warm for May with a temperature 7.1°F above average. The warmth was widespread with Barrow and Juneau being record warm.

Seven states across the West had a top 10 warm spring. CA had its warmest Jan-May on record, at 5.1°F above average.

The contiguous U.S. drought footprint shrunk to 24.6%, the smallest since Feb 2011. Drought conditions improved across the Great Plains, but remain entrenched in the West.

CO, OK, and TX were record wet for May with widespread flooding. It was also the all-time wettest month for OK and TX. TX was record wet for spring.

HI had a mixed precipitation pattern during May with little change in drought conditions. Over 20% of the state is in drought.

The Northeast was warm and dry with drought developing. CT, MA, NH, and RI were record warm for May.

There were over 400 preliminary tornado reports during May, the most since Apr 2011. There were 7 tornado-related fatalities.

On May 10, Tropical Storm Ana made landfall in SC with sustained winds of 45mph. Ana is the 2nd earliest landfalling tropical cyclone on record for the U.S.

FL had its warmest spring on record with a temperature 4.6°F above average. GA had its 3rd warmest spring.

The average U.S. temperature during May was 60.8°F, 0.6°F above average. The spring U.S. temperature was 53.2°F, 2.2°F above average. May U.S. precipitation was 4.36 inches, 1.45 inches above average and the wettest month of any month on record. The spring precipitation total was 9.33 inches, 1.39 inches above average.

Please Note: Material provided in this map was compiled from NOAA’s State of the Climate Reports. For more information please visit: http://www.ncdc.noaa.gov/sotc
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Loss events in the U.S. 1980 – 2014
Geographical overview

- **Earthquake 1994**
  - Overall losses*: US$ 44bn
  - Insured losses*: US$ 15bn
  - Fatalities: 61

- **Drought 2012**
  - Overall losses*: US$ 20bn
  - Insured losses*: US$ 12bn

- **Hurricane Rita 2005**
  - Overall losses*: US$ 16bn
  - Insured losses*: US$ 12bn
  - Fatalities: 10

- **Hurricane Ike**
  - Overall losses*: US$ 30bn
  - Insured losses*: US$ 19bn
  - Fatalities: 88

- **Hurricane Katrina 2005**
  - Overall losses*: US$ 125bn
  - Insured losses*: US$ 62bn
  - Fatalities: 1,322

- **Floods 1993**
  - Overall losses*: US$ 21bn
  - Insured losses*: US$ 1.3bn
  - Fatalities: 48

- **Hurricane Sandy 2012**
  - Overall losses*: US$ 65bn
  - Insured losses*: US$ 29bn
  - Fatalities: 127

- **Hurricane Ivan 2004**
  - Overall losses*: US$ 18bn
  - Insured losses*: US$ 12bn
  - Fatalities: 53

- **Hurricane Charley 2004**
  - Overall losses*: US$ 18bn
  - Insured losses*: US$ 7.6bn
  - Fatalities: 31

- **Hurricane Andrew 1992**
  - Overall losses*: US$ 27bn
  - Insured losses*: US$ 17bn
  - Fatalities: 62

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Weather is Getting Costlier

Source: NOAA - https://www.ncdc.noaa.gov/billions/time-series
Weather-related loss events in the U.S. 1980 – 2014

Number of events

- **Meteorological events**
  (Tropical storm, extratropical storm, convective storm, local storm)
- **Hydrological events**
  (Flood, mass movement)
- **Climatological events**
  (Extreme temperature, drought, forest fire)

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Observed U.S. Temperature Change

Average temperature from 1991-2012 compared to the 1901-1960 average

Source: National Climate Assessment 2014
Projected Change in Extreme Heat

Projected temperature change of hottest temperature (2081-2100 average compared to 1986-2005)

Hottest Days
Rapid Emissions Reductions (RCP 2.6)  Continued Emissions Increases (RCP 8.5)

Temperature Change (°F)

Source: National Climate Assessment 2014
Projected Change in Extreme Heat

Projected number of days per year above 90°F (2041-2070 average compared to 1971-2000)

1971-2000
Historical Climate

2041-2070
Lower Emissions (B1)
Higher Emissions (A2)

Number of Days

Source: National Climate Assessment 2014
Observed Change in Heavy Precipitation

Change in amount of precipitation falling in heaviest 1% of all daily events, 1901-2012

Source: National Climate Assessment 2014
Flooding Trends

Change in annual flood magnitude, 1920-2008

Source: National Climate Assessment 2014
A New Normal?

- Climate change is widening and shifting weather probability distributions

Trends Projected to Continue, Accelerate

- Increase in average and extreme temperatures, heat wave intensity
- Increasing number of frost-free days
- Increased precipitation variability
- Increased drought intensity in the Southwest
- Increased hurricane intensity and rainfall
Ongoing Research

- NOAA
  - Weather-Ready Nation Program
    - [http://www.nws.noaa.gov/com/weatherreadynation](http://www.nws.noaa.gov/com/weatherreadynation)
  - National Centers for Environmental Information
    - Climate/Extreme Weather Monitoring, State of the Climate, Climate Extremes Index

- National Academies of Science

- Universities
What Does It All Mean?
## Implications for Transportation Systems

<table>
<thead>
<tr>
<th>Extreme Weather</th>
<th>Impacts</th>
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| Flooding / Heavy Downpours| • Road/bridge washouts  
                          • Cut off access to communities or resources  
                          • Risk of hazardous cargo accidents                       |
| Tropical Cyclones        | • Need for evacuation  
                          • Hazardous driving conditions  
                          • Flooding and roadway washouts (especially from storm surge) |
| Wildfires                 | • Need for evacuation                                                 |
| Winter Storms             | • Hazardous driving conditions  
                          • Cut off access to communities or resources                |
| Extreme Heat              | • Pavement deterioration, increased maintenance needs                 |
Whose Job is Resilience?

- Infrastructure Design & Siting
- Emergency Management
- Materials
- Policy
- Maintenance
- Planning
- Operations

Everyone’s!
What Does This Mean for Emergency Management?

- More events (natural hazards), increasing unpredictability
  - How can budget/emergency operations planning be done effectively?

- Added incentive to continue to improve, implement best practices
  - E.g., work with other parts of the organization to reduce impacts, reduce the need for emergency management
  - Can we get ahead of disasters with selective improvements?

- Reviewing and adjusting worst case scenarios, as necessary

- Increased need to coordinate with other departments and agencies (e.g., state agencies, NWS)

- Importance of Road Weather Information System (RWIS) effectiveness
Timelines for Resilience

- Much of the traction in terms of investment has been post-disaster (FEMA reimbursements, rebuilding); this is where $$ is
- Emergency Management plays a role in all phases
Example Best Practices

- Vulnerability assessments of critical infrastructure
- Evacuation planning
- Improved internal and external coordination
- Communications interoperability
- Public communication about real-time weather risks, road conditions
Example Best Practices

- Investment/operations trade-off analysis
- Opportunistic infrastructure hardening
- Post-event debriefs and analysis
- Staff training (and cross-training)
- Drills and tabletop exercises
Example Strategies

- Arizona DOT
  Preliminary Study of Climate Adaptation for the Statewide Transportation System in Arizona (2013)
  - Conduct emergency contingency planning
  - Integrate emergency evacuation procedures into operations
  - Separate budgets for maintenance versus emergency response

- Caltrans
  2009 California Climate Adaptation Strategy (2009)
  - Assess type of extreme weather-related information necessary to respond to district emergencies and incorporate into existing operations management plans
  - Identify how climate impact information can be integrated into existing ITS and Transportation Management Center Operations
Example Strategies

- Maryland SHA

*Climate Change Adaptation Policy (2012)*

- Review equipment needs related to extreme weather response
- Coordinate plowing and road closure decisions with neighboring states
- Update contra-flow plans
- Create checklist for on-scene incident response managers
- Enhance cross-training in emergency management tasks
- Install systems to automatically adjust signal timing to traffic conditions, especially on key detour routes
- Implement an automated system for detecting stoplights affected by power outages
- Develop integrated tracking of major incidents between Statewide Operations Centers and Traffic Operation Centers
Where Do We Go from Here?

- **Continue to understand the problem**
  - Improve monitoring and tracking of weather trends, vulnerabilities, and response options

- **Continue to integrate toward All-Hazards emergency preparedness**

- **Engage other transportation disciplines to create multi-dimensional approaches**
  - E.g., National Operations Center of Excellence

- **Learn from each other**
  - Peer learning from states whose “normal” climate is your “new normal”?

- **Identify information needs and new approaches**
  - What information do emergency managers need to make decisions (near- and long-term)?
Q&A
Thank you!

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