ADOT Experiences Analyzing and Using Climate Projections: Handling Scientifically-Informed Climate Data Downscaling

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*Building a Climate Resilient Transportation System* Webinar Series
Developing Scenarios of Future Temperature and Precipitation Conditions
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Arizona Asset Universe

Arizona

- 140,000 maintenance lane miles
- 7,800 bridges
- 1 International border

Arizona Department of Transportation

- 30,000 maintenance lane miles connecting those 140,000
- 4,700 bridges
- 10 maintenance and construction districts
- 1,500 facility buildings

Spread over 114,000 square miles

Our agency operates from sea level to 6,000 feet

Temperatures below 0°F to over 120°F
Impacts
Impacts
Impacts
Impacts
Impacts
ADOT’s FHWA sponsored climate resilience pilot project was to assess the vulnerability of critical infrastructure to extreme weather for the major Arizona highway corridor (I-19, I-10, I-17) extending from Nogales to Flagstaff.

Objectives

- Integrate asset data, gain stakeholder input, identify a reasonable defensible long-term climate model (CMIP-5)
- Establish key climate variables, identify and rate vulnerabilities
- Develop risk models for multiple ecoregions/ecosystems
- Contribute to the national adaptation process and enhance the FHWA Vulnerability Assessment Framework
ADOT looked at climate-related stressors - Extreme Heat, Freeze-Thaw, Extreme Precipitation, and Wildfire, considering the potential change in these risk factors as the century progresses.

Stressor considerations hit all business areas – Planning, Design, Construction, Maintenance and Operations, Asset Management
- Shortened pavement life (heat, freeze-thaw, snow plowing)
- Culverts - design capacity, maintenance frequency
- Bridges - design capacity, maintenance frequency
- Roadside erosion
- Road closures - flooding/fire/rockfall/dust/low water crossings
- Shifting periods for paving operations
- Winter storm maintenance costs
ADOT chose a bold large scale resilience assessments

- 322-mile corridor made up study area
- Gather members of Arizona’s climate science community
- Study boundary defined by watersheds adjacent to corridor
- Hydrologic Unit Code 6 (HUC-6) basins as defined by USGS
- Further complicated by elevations and eco-regions
- Extreme weather events (severity and likelihood)
- Average climate (annual and seasonal)
- Landscapes and vegetation (e.g., fire risk, imperviousness, etc.)

Question

- Could ADOT be satisfied working with one best case scenario outcome for now as the climate science develops?
## ADOT Approach - Climate Data Downscaling

<table>
<thead>
<tr>
<th>Climate Data Parameters</th>
<th>Selection for Assessment</th>
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</thead>
<tbody>
<tr>
<td>Projections &amp; Historical Data Source</td>
<td>CMIP5 Bias Corrected – Spatially Disaggregated (BCSD) daily projections and historical data</td>
</tr>
<tr>
<td>Emissions Pathway</td>
<td>Representative Concentration Pathway 8.5</td>
</tr>
<tr>
<td>Downscaled General Circulation Models</td>
<td>NorESM1-M, HadGEM2-ES, CSIRO-MK3.6, CanESM2, MPI ESM-LR, MPI ESM-P, GFDL-ESM2M</td>
</tr>
<tr>
<td>Horizontal Spatial Resolution</td>
<td>1/8° (~7.5 mile or ~12 km)</td>
</tr>
<tr>
<td>Temporal Resolution</td>
<td>Daily for 1950-2000 (backcastings from models in addition to historical data), 2025-2055, and 2065-2095</td>
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</tbody>
</table>
## Climate Data Fields Summary

<table>
<thead>
<tr>
<th>Field Name(s)</th>
<th>Temporal Period(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max 1-Day Precipitation Event (by time period)</td>
<td>1950-1999, 2000-2049, 2050-2099</td>
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<tr>
<td>100-/200-Year Maximum Precipitation Event</td>
<td></td>
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<tr>
<td>Minimum Annual Precipitation</td>
<td>1950-1999, 2025-2055, 2065-2095</td>
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<tr>
<td>Average Annual Precipitation</td>
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<tr>
<td>- Avg Number of Days Per Year in which Precipitation Exceeds Baseline Period’s 99th-Percentile Precipitation Event</td>
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<tr>
<td>- Avg May-June-July-August Precipitation</td>
<td></td>
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<tr>
<td>- Avg Daily Maximum Temperature</td>
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<tr>
<td>- Avg Number of Days Per Year in which Temperature equals or exceeds 100</td>
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<tr>
<td>- Avg Number of Days Per Year in which Temperature equals or exceeds 110</td>
<td></td>
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<tr>
<td>- Avg Number of Days Per Year in which Temperature falls below or equals 32</td>
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<tr>
<td>- Avg Daily Minimum Temperature</td>
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</table>
To retrieve downscaled climate data, the team leveraged the U.S. DOT CMIP Climate Data Processing Tool (2014). In order to automate the downscaling process - a necessity given the approximately 450 CMIP grid cells covering the study area (multiplied by as many as seven (7) climate models, three (3) time periods, and thirteen (13) climate variables) - the team enhanced the Tool to facilitate batch processing and to derive a wider range of variables (such as the projected 100-year 24-hour rainfall magnitude)

Within a given grid cell, projections vary depending on which climate model is referenced (and would vary further if alternative emissions scenarios were considered). Across the study corridor, projections vary spatially depending on factors such as latitude, topography, urbanization, and land cover.

100-/200-Year Maximum Precipitation Event - Estimated by fitting Generalized Extreme Value (GEV) distribution to annual precipitation maxima. 2000 to 2049 and 2050 to 2099 are the future analysis periods for GEV-generated projections.
Lessons Learned

- More confidence in climate temperature projections than in the precipitation projections – need to focus on extrapolating historical precipitation data for now
- Precipitation seasonality modeling difficult – ADWR
- CMIP processing experience had a host of lessons learned
- Determining appropriate Representative Concentration Pathways – ADOT primarily concerned with extreme impacts
- Natural climate variability representation – what metrics to use – currently looking at climatology, atmospheric variability, surface temps, historic precipitation data
- Address bias implications for the precipitation data but also Pacific sea surface temps. (i.e. ENSO)
Lessons Learned

- Gather something more than just 24-hr maximum precipitation event numbers – scale up to address erosion, sediment, scour, run-off, flooding, man-made structures
- Development guidance to allow implementation into construction contracts regarding this material - specifically the higher risk drainage structures and system pinch points
- ADOT effort addresses unique component of ecoregions and biotic communities impacts as our corridor study covers about sea level to 6000’
- Currently looking at 3 ecoregions and 8 biotic communities – 5 of which intersect our corridor study
- Watershed – Complementary USGS/ADOT partnering project under development
How has ADOT Used the Results

Resilience - Structure by Structure
Questions?

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