Building MEPDG Climate Files

- Funded by Mississippi DOT
- Research partners
  - Mississippi State University
  - Auburn University, NCAT
  - Iowa State University, Climate Science Initiative

In this presentation....

- Why is climate input important
- Building historic climate files
- Building future climate files
- Impact on predicted pavement performance

Pavement Design Variables

- Each load application
- Traffic
- CTB Modulus
- PCC Modulus
- HMA Modulus
- Granular Base Modulus
- Subgrade Modulus

Pavement age, months

Predicted Rutting

- 90% Reliability
- Design Limit
- 90% Reliability
- Total Rutting
- Total Rutting

Climate Database for Mississippi

- Only 12 climate files in Mississippi
  - 4 sites with 5-6 years of climate data
  - 8 with 8-10 years of climate data
  - Starting with mid 1990s
- Need to expand time-scale to 20+year
- Need to increase spatial coverage
Limitations of this approach

- Do 12 weather sites adequately cover variations in climate for Mississippi?
- Does the time period of 1996 to present adequately cover expected climate?
- Does this approach to creating a 20-year (or 40 year) climate database generate a reasonable expectation of future pavement performance?

Ames, IA Daily Temperatures

August 21st Temperature Distribution

January 21st Temperature Distribution

Ames Temperature Trends

Iowa Averages and Extremes

<table>
<thead>
<tr>
<th>Decade</th>
<th>Avg High</th>
<th>Avg Low</th>
<th>100°+ events</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970s</td>
<td>58.9</td>
<td>37.4</td>
<td>593</td>
</tr>
<tr>
<td>1980s</td>
<td>59.6</td>
<td>38.1</td>
<td>2073</td>
</tr>
<tr>
<td>1990s</td>
<td>58.4</td>
<td>38.3</td>
<td>235</td>
</tr>
</tbody>
</table>

Development of Climate Data Input Files for the MEPDG

- Build complete 40-year historic climate files
- Build 40-year future climate files

Building better HISTORICAL climate files

**Step 1**
- Data from Climate Archive sources
- Quality control check of data

**Step 2**
- Create a gridded analysis (natural neighbor interpolation)
- Quality control the gridded output

**Step 3**
- Create `__+.hcd` file for each County
- Identify missing data and create values

**Step 4**
- Quality Control the `__.hcd` file

<table>
<thead>
<tr>
<th>ASOS/AWOS</th>
<th>COOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation Interval</td>
<td>Hourly</td>
</tr>
<tr>
<td>Air Temperature</td>
<td>Hourly functional form</td>
</tr>
<tr>
<td>Wind Speed</td>
<td>Verbatim use</td>
</tr>
<tr>
<td>Relative Humidity</td>
<td>Verbatim use</td>
</tr>
<tr>
<td>Percent Sunshine</td>
<td>Verbatim use</td>
</tr>
<tr>
<td>Precipitation</td>
<td>Hourly functional form</td>
</tr>
</tbody>
</table>

ASOS/AWOS COOP
Complete Historic Files

- 40-year files (1970-2010)
- For each county in the State
- Critical for matching climate with pavement data used for calibration
  - MEPDG climate
    1985-2000 pavement and 1995-2000 climate (3x)
- HISTORIC climate

How should future climate files be built?

- **Option - 1**
  - Monthly Climate "DELTAs" (for 50-year period)
    - Temperature DELTA = Future Scenario - Contemporary Scenario
    - Precipitation DELTA = Future Scenario / Contemporary Scenario

- **Option - 2**
  - Global Model
    - 35,000 sq-mi pattern
      - Includes: solar radiation & greenhouse gases changes
      - Frequency: 6 hours over 10 years
  - Regional Model
    - 1200 sq-mi pattern
      - Includes: regional geographic features and climate patterns
      - Frequency: 3 minutes
  - Monthly Climate "DELTAs" (for 50-year period)
    - Temperature DELTA = Future Scenario - Contemporary Scenario
    - Precipitation DELTA = Future Scenario / Contemporary Scenario
Complete Future Files

- 40-year Future Climate Files
- For each climate region in the State
- Critical for predicting pavement performance
  - MEPDG climate
- 2010-2030 pavement design and 1995-2000 climate (4x)
- HISTORIC climate
- 2010-2030 pavement design and 2010-2030 virtual climate

What is the impact of more accurate climate files?

- 9.3-in JPCP
  - 20 ft joint spacing tied PCC shoulder
  - 5.7-in lime stab base
  - A-2-4 subgrade
- 12.5-in HMA
  - AC-30
  - A-6 subgrade
- 4.5-in HMA
  - AC-30
  - 8-in lime stab subgrade
  - A-6 subgrade

9.3-in JPCP

12.5-in HMA

4.5-in HMA
### Pavement Surface Temperature (F)

<table>
<thead>
<tr>
<th>Month</th>
<th>1st</th>
<th>2nd</th>
<th>3rd</th>
<th>4th</th>
<th>5th</th>
<th>Mean</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>29.3</td>
<td>40.5</td>
<td>48.7</td>
<td>58.3</td>
<td>70.9</td>
<td>49.6</td>
<td>14.9</td>
</tr>
<tr>
<td>February</td>
<td>35.0</td>
<td>44.6</td>
<td>52.4</td>
<td>61.0</td>
<td>76.4</td>
<td>63.9</td>
<td>14.9</td>
</tr>
<tr>
<td>March</td>
<td>42.8</td>
<td>53.3</td>
<td>60.5</td>
<td>71.2</td>
<td>92.2</td>
<td>63.6</td>
<td>16.9</td>
</tr>
<tr>
<td>April</td>
<td>52.6</td>
<td>63.7</td>
<td>71.4</td>
<td>85.4</td>
<td>104.6</td>
<td>75.5</td>
<td>18.7</td>
</tr>
<tr>
<td>May</td>
<td>62.4</td>
<td>71.8</td>
<td>81.1</td>
<td>97.3</td>
<td>113.7</td>
<td>85.3</td>
<td>18.9</td>
</tr>
<tr>
<td>June</td>
<td>69.6</td>
<td>76.4</td>
<td>88.7</td>
<td>106.6</td>
<td>132.8</td>
<td>92.6</td>
<td>20.2</td>
</tr>
<tr>
<td>July</td>
<td>73.7</td>
<td>79.8</td>
<td>93.2</td>
<td>112.9</td>
<td>136.5</td>
<td>98.1</td>
<td>21.7</td>
</tr>
<tr>
<td>August</td>
<td>71.8</td>
<td>78.9</td>
<td>90.7</td>
<td>112.8</td>
<td>129.2</td>
<td>96.7</td>
<td>22.0</td>
</tr>
<tr>
<td>September</td>
<td>61.8</td>
<td>71.8</td>
<td>80.6</td>
<td>98.4</td>
<td>117.7</td>
<td>86.0</td>
<td>20.6</td>
</tr>
<tr>
<td>October</td>
<td>52.0</td>
<td>62.9</td>
<td>70.3</td>
<td>82.3</td>
<td>100.7</td>
<td>73.7</td>
<td>17.4</td>
</tr>
<tr>
<td>November</td>
<td>42.6</td>
<td>52.1</td>
<td>58.9</td>
<td>68.6</td>
<td>85.3</td>
<td>61.5</td>
<td>15.3</td>
</tr>
<tr>
<td>December</td>
<td>31.7</td>
<td>40.7</td>
<td>48.3</td>
<td>57.6</td>
<td>70.6</td>
<td>49.8</td>
<td>14.0</td>
</tr>
</tbody>
</table>

### Zone 4 Rutting Thin HMA

- MEPDG
- HIST
- VIRT

### SE Superpave Pooled Fund

Developing MEPDG Climate Files
- 40-yr (1970-2010) Historic files (each county)
- 40-yr (2010-2050) Future “virtual” files (each region)

- 1-2 States in pool ~$44,000 / State
- 3-5 States in pool ~$38,000 / State
- 6+ States in pool ~$34,000 / State