Traffic Crashes Under Low Visibility Due to Fog in Florida

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Overview:
Traffic Crashes Under Low Visibility Conditions
Florida is among the top state in the US regarding traffic safety problems resulting from adverse visibility conditions due to fog or smoke.

Fog/smoke related Fatal Crashes (2001-2010)

- Florida: 1,726
- Texas: 2,236
- California: 1,597

National average per state: 363

Source: Fatality Analysis Reporting System
Crashes due to reduced visibility from fog/smoke are more severe compared to those without vision obstructions.
Macro- and Micro-level Fog Crash Hotspot Identification
Hotspot Identification

- **Macroscopic Screening**
  - Area-wide Analysis
  - Kernel Density Estimation

- **Microscopic Screening**
  - Segment-based Analysis
  - Fog crashes per mile
- KDE was applied and found 11 fog crash hotspots at the macro-level.
The 11 hotspots were magnified and then fog crashes were counted based on 1-mile segments.
Detection of Fog on the Roadway Using Airport Weather Data
There are about 70 airports in Florida. Most of the airports have weather stations and provide hourly weather data.
Airport Weather Data Structure

- Sky conditions, visibility, weather, temp, humidity, wind speed, etc.
Combining Airport Weather Data with Fog Crashes

**Non-matched**
Fog crashes within the buffers but airport weather is not foggy at the crash time.

**Matched**
Fog crashes within the buffers and airport weather is foggy at the crash time.
## Matching Airport Weather Data with Fog Crashes

<table>
<thead>
<tr>
<th>Buffer size</th>
<th>2mi</th>
<th>3mi</th>
<th>4mi</th>
<th>5mi</th>
<th>6mi</th>
<th>7mi</th>
<th>8mi</th>
<th>9mi</th>
<th>10mi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog crashes</td>
<td>11</td>
<td>28</td>
<td>51</td>
<td>78</td>
<td>97</td>
<td>113</td>
<td>128</td>
<td>152</td>
<td>169</td>
</tr>
<tr>
<td>Matched case</td>
<td>10</td>
<td>24</td>
<td>42</td>
<td>63</td>
<td>78</td>
<td>92</td>
<td>100</td>
<td>118</td>
<td>131</td>
</tr>
<tr>
<td>Non-matched case</td>
<td>1</td>
<td>4</td>
<td>9</td>
<td>15</td>
<td>19</td>
<td>21</td>
<td>28</td>
<td>34</td>
<td>38</td>
</tr>
<tr>
<td>Matching rate</td>
<td>90.9%</td>
<td>85.7%</td>
<td>82.4%</td>
<td>80.8%</td>
<td>80.4%</td>
<td>81.4%</td>
<td>78.1%</td>
<td>77.6%</td>
<td>77.5%</td>
</tr>
</tbody>
</table>

Bar chart showing matching rates for different buffer sizes.
If fog conditions are predicted using the airport weather data, the authority should

- Reduce the speed limits (VSL)
- Inform drivers of fog conditions (VMS)
- Close entrance ramps onto the highway with dense fog.

Images acquired from
http://safety.fhwa.dot.gov/speedmgt/vslimits/docs/vslexamples.ppt
http://ops.fhwa.dot.gov/weather/best_practices/CaseStudiesFINALv2-RPT.pdf
Fog Crash Modeling with In-land Water Data
FL has more than 7,700 named lakes over 20 acres and countless ponds from 1-20 acres.

The existence of lakes/ponds increases the probability of fog on nearby roads.
The study area
- 9 in-land counties in Central Florida
- not affected by sea-water

Collected data
- Roadway, AADT*, and fog crashes
  (from Florida DOT)

* AADT: Annual Average Daily Traffic
Distance between the roadway and the closest lakes/ponds were calculated and included as a variable in the model.

N = 4,477

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fog crash #</td>
<td>0.0578</td>
<td>0.2889</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>AADT</td>
<td>16361.82</td>
<td>19097.24</td>
<td>150</td>
<td>184000</td>
</tr>
<tr>
<td>Distance (m)</td>
<td>545.699</td>
<td>765.031</td>
<td>0</td>
<td>6275.11</td>
</tr>
<tr>
<td>Length (mi)</td>
<td>3.076</td>
<td>1.989</td>
<td>0.104</td>
<td>9.999</td>
</tr>
</tbody>
</table>
Negative Binomial Model

\[ \text{Predicted Crashes} = \exp[a + \beta_1 \times \ln(AADT) + \beta_2 \times \text{distance} + \ln(\text{Segment Length})] \]

Results

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Coefficient</th>
<th>Estimate</th>
<th>SE</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>a</td>
<td>-16.8245</td>
<td>1.3573</td>
<td>-19.4846, -14.1643</td>
<td>&lt;0001</td>
</tr>
<tr>
<td>ln(AADT)</td>
<td>( \beta_1 )</td>
<td>1.1493</td>
<td>0.1416</td>
<td>0.8719, 1.4268</td>
<td>&lt;0001</td>
</tr>
<tr>
<td>distance</td>
<td>( \beta_2 )</td>
<td>-0.0005</td>
<td>0.0002</td>
<td>-0.0009, -0.0000</td>
<td>0.0352</td>
</tr>
</tbody>
</table>

As the distance between roadway and lake/pond is closer, it is likely to have more fog crashes.
Summary and Conclusion
Fog crashes were analyzed using GIS.
Hotspot Identification was conducted both at the macroscopic and microscopic levels.
Airport weather data can be used for predicting fog conditions nearby roads.
Distance to the closest lakes/ponds for each segment was calculated and it was found to be a negative and significant predictor of fog crashes.
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