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International
Journal
Of Modern Engineering Research (IJMER)

An Attempt To Use Interpolation to Predict Rainfall Intensities tor Crash Analysis

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ABSTRACT: *This study uses different interpolation techniques to predict rainfall intensity at locationsthat are not directly located near a rainfall gauges. The goal of being able to interpolate the rainfall intensity is to study its impact on traffic crashes. To perform the study, a collection of rainfall gauges in Alabama were used as subject locations where rainfall intensity was predicted from surrounding gauges, while also providing validation data to compare the predictions. Essentially, the actual rainfall intensities at existing gauges were interpolated using nearby gauges and the results were analyzed.The interpolation techniques used in the study included proximal, averaging and a distance weighted average. The results of the study indicated that none of the interpolation methodologies were sufficient to accurately predict the rainfall intensity values any significant distance from the actual gauges.*

Keywords: *Rainfall intensity, crash analysis*

I. INTRODUCTION

There have been a number of studies performed recently that seek to understand the relationship between traffic crashes and rainfall intensity and situation where the pavement is wet. Jaroszweski and McNamara in 2014 investigated on the influence of rainfall on road accidents in urban areas (1). They were using an innovative city-wide weather radar approach to rainfall quantification and matched-pairs analysis, road accidents in the UK cities of Manchester and Greater London are examined over a 3-year baseline period (2008–2011) (1).Yannis and Karlafits in 2010 focused on weather effects on daily traffic accidents (2). An Integer Autoregressive Model (INAR) is used to estimate the effects of weather conditions on four traffic safety categories: vehicle accidents, vehicle fatalities, pedestrian accidents and pedestrian fatalities, using 21 years of daily count data for Athens, Greece (2). Blake and Villarini worked on effects of rainfall on vehicle crashes in six US states, a matched pair analysis is used to pair rainfall days with dry days to determine the relative risk of crash, injury, and fatality (3).The difficulty is derived when there is not clear evidence that rainfall is occurring at the time of the crash. To correct this issue, this paper attempts to determine if interpolation techniques can be used to estimate rainfall at locations where rainfall is not being directly measured.

The analysis of the impact of rain and wet pavement on crashes is, obviously, very dependent on the amount of rainfall that was occurring at the time of the crash. The hypothesis behind most studies is that driving on wet pavement, or during rainfall events, leads to a greater number of crashes. In Alabama, the crash statistics from the Critical Analysis Reporting Environment (CARE) database and rainfall databased indicate that while roughly 18 percent of crashes occur during rainfall events, that in actual time, it only rain 5 percent of the total hours in a year.

While the CARE database for Alabama contains an officer's record of whether or not the pavement was wet at the time of the crash, there is no indication of the intensity of rainfall. It is also hypothesized that the intensity of the rainfall will have an impact on the number of crashes, and the severity of the crash. Unfortunately, the ability to get rainfall intensity data in all locations where a crash occurred is difficult, as rainfall records are usually only available in discrete locations. This paper examines the issue by utilizing several interpolation methods to ascertain the ability to accurately predict rainfall intensity at locations that are not adjacent to a rainfall gauge. The results of this paper indicate that it is very difficult to get rainfall intensity data at any significant distance from the actual gauge.

Data

In this study, 5-minute, hourly, daily and monthly data were collected from National Oceans and Atmospheric Administration (NOAA) for 2010-2015 at different rain gage station across Alabama, see figure 1. After reviewing the data, the hourly data was selected for 2012. The analysis was performed on an hourly basis due to the time dependent nature of the analysis that limited the use of daily and monthly data and the quickness of rainfall events and distance between gauge locations limited the use of 5-minute data.Data from the 59 stations were sorted so that every hour of data for the five years of the study were aligned with intensity data to establish a basis to proceed. The data were controlled to establish that all the sites that could be used for the analysis had all of the data necessary to complete the study.

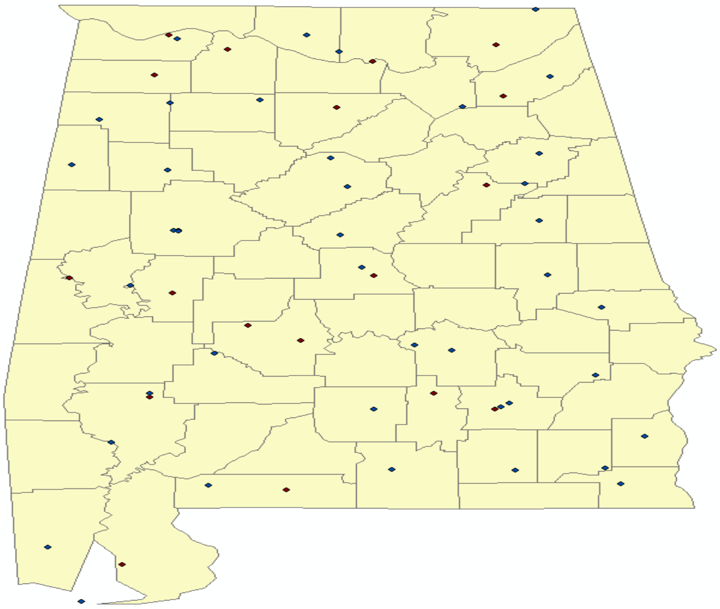

Figure 1. Rain gauge locations in Alabama.

II. METHODOLOGY

After collecting the data to predict rainfall, five regions of the state of Alabama were selected to be included in the study. The locations selected were chosen to provide an area where three or more stations surrounded a central station that was to be used as the prediction location, see Figure 2 and Table 1. Additionally, Table 1 shows the distance from the surrounding stations to the validation station. The analysis is focused on using the area stations to predict the rainfall intensity at the central location. Then the actual rainfall at the central location was used to validate the prediction.

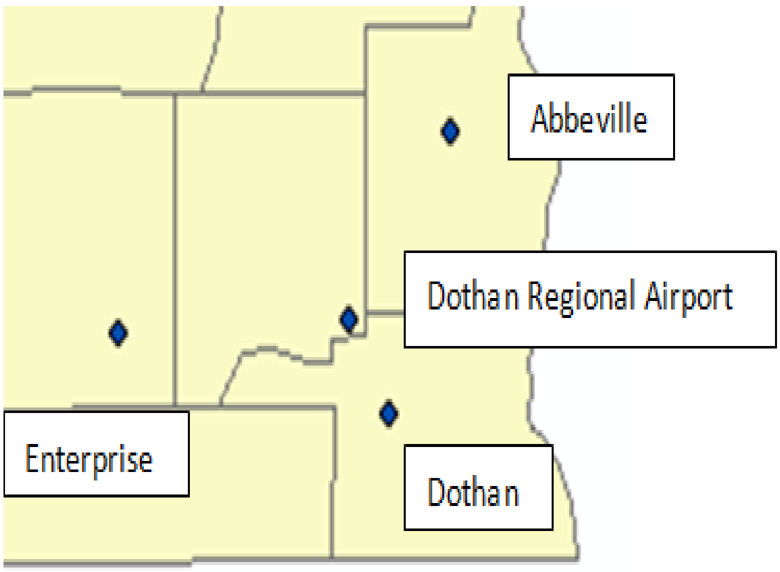

Figure 2. Sample of station locations for analysis.

Table 1. Locations of the five study areas.

Region #	Origin station				Validation station
1	Abbeville	Dothan	Enterprise		Dothan Regional Airport
	21.7 miles	16.1 miles	25.9 miles		
2	Troy	Montgomery	Greenville	Montgomery Airport	Highland Home
	21.1 miles	24.2 miles	18.5 miles	26.9 miles	
3	Alberta	Selma (station 1)	Greensboro		Selma (station 2)
	31.1 miles	17.7 miles	45.7 miles		
4	Hamilton	Addison	Russellville		Haleyville
	36.3 miles	41.3 miles	26.0 miles		
5	Jacksonville	Ashland	Talladega		Anniston Airport
	27.1 miles	33.7 miles	19.1 miles		

There are three methodologies used to predict the intensity of rainfall at the target station: proximal, average and distance weighted average. The proximal method simply states that the value of rainfall will be the same as the value of the station closest to it (4,5,6). While this may sound simple, this is often the methodology used in watershed and rain discharge analysis models. The average methodology uses the average of the three closest values:

$$Average = \frac{P_1+P_2+\cdots+P_n}{n} \quad \text{(eq. 1)}$$

Where:
P_i=Precipitation of origin station i (mm), and
n=number of stations being used.

The use of the average is intended to supplement the values when there is rainfall in the area, but not recorded at the proximal station. The distance weighted average methodology takes into account the distance of the stations with respect to the amount of rainfall, thus combining the proximal and average methodologies:

$$Distance\ weighted\ average = \frac{\frac{P_1}{D_1^2}+\frac{P_2}{D_2^2}+\cdots+\frac{P_n}{D_n^2}}{\frac{1}{D_1^2}+\frac{1}{D_1^2}+\cdots+\frac{1}{D_n^2}} \quad \text{(eq. 2)}$$

Where,
P_i=Precipitation of origin station i (mm), and
D_i=Distance of origin station i to the validation station (miles).

Analysis of data

After developing the predictions, a statistical validation test was performed to test the three interpolation techniques. Nash-Sutcliffe was calculated as a metric using equation 3 (7). Numerically, the value of the N-S coefficient ranges from 1 to negative infinity where a value of 1 indicates that the forecast and actual value are the same, a value of zero indicates that the average value of all the current year data is as good as the forecast methodology and a negative value indicates that the forecast is worse than taking the average of the values and using them.

Where:

$$E = 1 - \frac{\sum_{t=1}^{T}(Q_o^t - Q_m^t)^2}{\sum_{t=1}^{T}(Q_o^t - \overline{Q_o})^2} \quad \text{(eq. 3)}$$

E= Test Statistic
Qo= model value 1
Qm= model value 2
$\overline{(Qo)}$= mean of model 1

The values for the **different analysis are shown in Table 2.**

Table 2. Values for different statistical analysis for different regions

Region	NS		
	Average	Distance average	Inverse distance average
1	-131.24	-165.296	-204.9172251
2	-216.38	-207.28	-200.4309206
3	-12.797	-12.0491	-12.69453438
4	-10.871	-12.1754	-14.49516209
5	-9.6633	-12.8021	-17.3976526

III. CONCLUSIONS

The results of this paper were intended to develop a methodology to interpolate rainfall intensity values for crash analysis. The process was intended to create rainfall intensities in locations where crashes occurred and no direct rainfall data was available. The data collected and analyzed for Alabama demonstrated that the rainfall varied greatly in intensity, even a short distance from the rainfall gauges. Future analysis into rainfall estimation will focus on using radar station data to reduce the distance between crash locations and actual rainfall intensity measurements.

ACKNOWLEDGEMENTS

This work was funded by a grant from the Alabama Department of Transportation.

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