45 WS ELECTRIC FIELD MILL LIGHTNING PREDICTION THRESHOLD ANALYSIS

THESIS

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AFIT-ENS-MS-20-M-171

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

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Wright-Patterson Air Force Base, Ohio

AFIT-ENS-MS-20-M-171

AN ANALYSIS OF A LIGHTING PREDICTION THRESHOLD FOR 45TH WEATHER SQUADRON ELECTRIC FIELD MILL DATA

THESIS

Presented to the Faculty

Department of Operational Sciences

Graduate School of Engineering and Management

Air Force Institute of Technology

Air University

Air Education and Training Command

In Partial Fulfillment of the Requirements for the

Degree of Master of Science in Operations Research

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March 2020

AFIT-ENS-MS-20-M-171

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Abstract

The mission of the 45th Weather Squadron (45 WS) is to "exploit the weather to assure safe access to air and space" for Patrick Air Force Base, Cape Canaveral Air Force Station (CCAFS), and Kennedy Space Center (KSC) in support of various operations (United States Air Force, n.d.). To support that mission the 45 WS hosts a suite of weather detection instruments that include a lightning warning system that consists of an array of 31 electric field mills (EFM) and a lightning detection and ranging system (Department of the Air Force, 1976).

Electric field mills at Cape Canaveral continuously record data from 31 separate EFM sites 24 hours a day at a rate of 50 Hz. This produces 4,320,000 lines of recorded data daily for each EFM site, a total of more than 16 billion data points annually for the active thunderstorm season. This study seeks to determine a single electric field mill reading threshold for lightning onset and a separate single EFM reading threshold for lightning cessation. Statistical analysis of the EFM and Lightning Detection and Ranging (LDAR) parameters show there is no measurable correlation between EFM readings and lightning activity. Further, attempts to build models using threshold analysis, standard least squares regression fitting, nominal logistic regression fitting, and negative binomial regression fitting are unable to accurately predict any meaningful amount of lightning activity. The best of these models only account for 16% of the variance in the dataset. Overall results show EFM readings do not correlate well with lightning activity and any attempts to predict lightning proved ineffective.

Acknowledgments

I would like to thank Lt Col Andrew Geyer for the guidance and mentorship he provided as my advisor, Dr. Raymond Hill for his guidance and support as the reader of this thesis, and Col McQuade, Lt Col Anderson, and Lt Col Tseng for their personal support and leadership during my time at AFIT.

Finally, I would like to thank my wife and children for their love, understanding, patience, and support given throughout this entire process.

Charles A. Skrovan

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I. Introduction

1.1 General Issue

The mission of the 45th Weather Squadron (45 WS) is to “exploit the weather to assure safe access to air and space” for Patrick Air Force Base, Cape Canaveral Air Force Station (CCAFS), and Kennedy Space Center (KSC) in support of various operations (United States Air Force, n.d.). To support this mission the 45 WS hosts a suite of weather detection instruments that include a lightning warning system that consists of an array of 31 electric field mills (EFM) and a lightning detection and ranging system (LDAR) (Department of the Air Force, 1976). To ensure safe operations, the threat of lightning within 5 nautical miles (NM) of each supported location determines which operations personnel may perform. These delays can lead to monetary losses, loss of production, or cancellation and postponement of launch activities. Launch commit criteria violations lead to delayed launches and increases in launch costs (Merceret *et al*., 2010).

Currently, launch activities cannot take place when EFM sensor values exceed a threshold of 1000 V/m (Merceret *et al*., 2010). At this threshold, the threat of rocket induced lightning is very high. The 45 WS desires a similar threshold value that can predict a lightning strike within 30 minutes.

1.2 Problem Statement

The 45 WS is interested in determining an EFM threshold reading value that can predict lightning onset and a separate EFM threshold value that accurately predicts lightning cessation.

1.3 Research Objectives/Questions/Hypotheses

The hypothesis of this research is that there exists some threshold value above the mean clear-sky sensor reading of an EFM that indicates a strong potential for lightning activity to occur. The objectives of this research are to establish correlation among parameters of interest and build predictive models using threshold analysis and generalized linear regression techniques for time series data to accurately predict when a storm will begin and end.

1.4 Research Focus

This research focuses on establishing correlation between EFM sensor readings and lightning activity in order to conduct threshold analysis and construct regression models for time series analysis.

1.5 Investigative Questions

The questions answered in this analysis are: what factors from the available EFM and LDAR dataset best correlate to each other and to the occurrence of lightning storms? Does a threshold value for EFM readings that accurately predicts storm onset (30 minutes prior to first lightning strike) exist? Does a separate threshold value that accurately predicts storm cessation (15 minutes after last lightning strike) exist? If the threshold analysis does not produce a useful result can a standardized linear regression model accurately predict storm onset or cessation? Is a nominal logistic model useful in predicting if a storm will be present or not? If EFMs seem to be more responsive than predictive, then can a negative binomial model accurately predict when a storm is ending? Should the study use the variance of the EFM readings over 1-minute period instead of the mean EFM reading?

1.6 Methodology

The methodology used in this research includes data preparation, statistical analysis, and model building. The datasets are cleaned, reduced, combined, and augmented with specific parameters of interest. Various statistical processes used in the analysis include basic methods of statistical analysis, threshold analysis, standardized linear regression, nominal logistic regression, and negative binomial regression model building techniques to predict storm onset and cessation.

1.7 Assumptions/Limitations

A fundamental assumption is changes in the electric field of the air cause lightning. Another assumption is it is acceptable to reduce 50 Hz EFM data to 1-minute averages. That is how the range user receives the data in real-time for analysis, so the sponsor requested using the 1-minute EFM mean readings. The choice of response parameters is a potential limitation that determines how well models built on the dataset perform. Therefore, the research considers and explores several lightning response formats for correlation and modeling.

1.8 Implications

Current lightning warning practices at KSC are conservative. Establishing an EFM threshold value for lightning onset and/or lightning cessation has the potential of reducing range downtime and saving costs for range users.

1.9 Preview

The next chapter presents a literature review on various reports, instructions, manuals and texts related to the Eastern Range, lightning detection and measurement techniques, regression model time series analysis techniques, and prior research completed in these areas. Chapter 3 overviews the methodology used including: the equipment used, data preparation steps taken, the types of statistical analysis performed, and creation of the various threshold and regression models. Chapter 4 explains the results of the output from the statistical analysis and discusses how well each of the regression techniques applied perform comparatively. Finally, chapter 5 concludes the report with a summary of the research performed and recommendations for next steps.

II. Literature Review

2.1 Chapter Overview

This chapter provides a brief overview of the literature related to the Eastern Range, lightning detection and measurement techniques, regression model analysis techniques, and prior research completed in these areas.

2.2 Eastern Range

2.2.1 Overview

The Eastern Range, 45th Space Wing (45 SW), is a Major Range and Test Facility Base (MRTFB) Activity situated on Florida's east coast (OUDSR, 2007). The Eastern Range includes Cape Canaveral Air Force Station (CCAFS), National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC), and a corridor extending out over the Atlantic Ocean. As an MRTFB, the Eastern Range infrastructure and associated workforce must be preserved as a national asset to provide test and evaluation capabilities to support the Department of Defense (DoD) acquisition system (OUDSR, 2007). To ensure availability of this capability, range safety requirements safeguard personnel and assets on the range. CCAFS and KSC are situated in an area that receives the highest lightning activity in the United States, known as "Lightning Alley (Flinn *et al*., 2010; Roeder & Saul, 2016)." The 45 WS provides operational support for activities conducted in and around the Eastern Range, which include observation services, meteorological forecasting, meteorological watch, supporting organizations' thresholds and requirements, and launch and landing weather support, all spelled out in detail in the 45th Space Wing Instruction (45 SWI) 15-101 (45 WS/DO, 2018).

2.2.2 Instrumentation

The Eastern Range offers multiple meteorological services as described in the 45 SWI 15-101 and ETR Meteorological Handbook (45 WS/DO, 2018; Department of the Air Force, 1976). Surface instrumentation include: Mecurial Barometer, Barograph, Psychrometer, Hygrothermograph, Wind Measuring Set, Cloud Height Se, Ceiling Light Projector, Weather Radar, Launch Pad Lightning Warning System (LWS), and Weather Information Network Display System (Department of the Air Force, 1976). The Eastern Range has received various updates to its instrumentation to better detect lightning (Flinn *et al*., 2010). The 45 WS implemented an update to its Lightning Detection and Ranging (LDAR) system in 2008 when the Four-Dimensional Lightning Surveillance System (4DLSS) went operational. The 45 WS also upgraded the Cloud to Ground Lighting Surveillance System (CGLSS) and integrated the system into the 4DLSS. In addition, the 45 WS uses the Launch Pad Lightning Warning System, which is a network of 31 surface electric field mills (Flinn *et al*., 2010).

2.2.3 Range Safety Requirements

AFSPC MANUAL 91-701 establishes range safety requirements for lightning on the Eastern Range for all activities performed at CCAFS. Volume 1 tasks range users to perform and document preliminary hazard analysis, to include lightning hazards (Air Force Space Command, 2016). Lightning protections and detection systems are required to keep employees, rockets, launch pads, payloads and processing facilities safe from harm (National Aeronatics and Space Administration, 2005). AFSPC MANUAL 91-701 Volume 3 establishes the requirements for lightning protection systems on buildings and equipment that complies with NFPA 780: *Standard for the Installation of Lighting Protection Systems* (Air Force Space Command, 2019). AFSPC MANUAL 91-701 Volume 5 has more specific requirements for launch vehicles, payloads and ground support equipment for protection against lightning, typically by bonding grounding systems (Air Force Space Command, 2018). Finally, AFSPC MANUAL 91-701 Volume 6 provides operating restrictions for personnel due to lightning and establishes criteria for lightning hazard watches and warnings. Operations Safety Plans (OSP) detail procedures for reaction to lightning including what actions are to be taken during lightning watches and lightning warnings (Air Force Space Command, 2014, p. 21). Lightning watches are established when lightning is forecast to occur within 5 nautical miles of a specific lightning alert area (Air Force Space Command, 2014, p. 31). A lightning warning is established when lightning is imminent or occurring within a 5 nautical mile boundary of a specific lightning alert area (Air Force Space Command, 2014, p. 31).

2.2.4 Launch Commitment Criteria

An important resource detailing the history of Lightning Launch Commitment Criteria (LLCC) is a report produced by NASA, "A History of Lightning Launch Commit Criteria and the Lightning Advisory Panel for America's Space Program," which gives a detailed background and chronology of studies and criteria related to the formation of LLCC. Range users consider two types of lightning when establishing range safety and launch commit criteria. The first is natural lightning, which is the focus of this research, and the second is triggered lightning that is caused when a vehicle flies into a high electric field (Merceret *et al*., 2010, p. 34). Studies from triggered lightning incidents that occurred with the Apollo XII mission and the loss of Atlas-Centaur 67 rocket due to triggered lightning establish a trigger lightning warning for EFM readings in excess of 1000 volts per meter (V/m) (Merceret *et al*., 2010, p. 41). There is currently no established threshold for EFM readings for naturally occurring lightning. Instead, a series of criteria are established based on the detection of lightning, existence of storm clouds, and the temperature of cloud tops (Merceret *et al*., 2010, pp. 128–132).

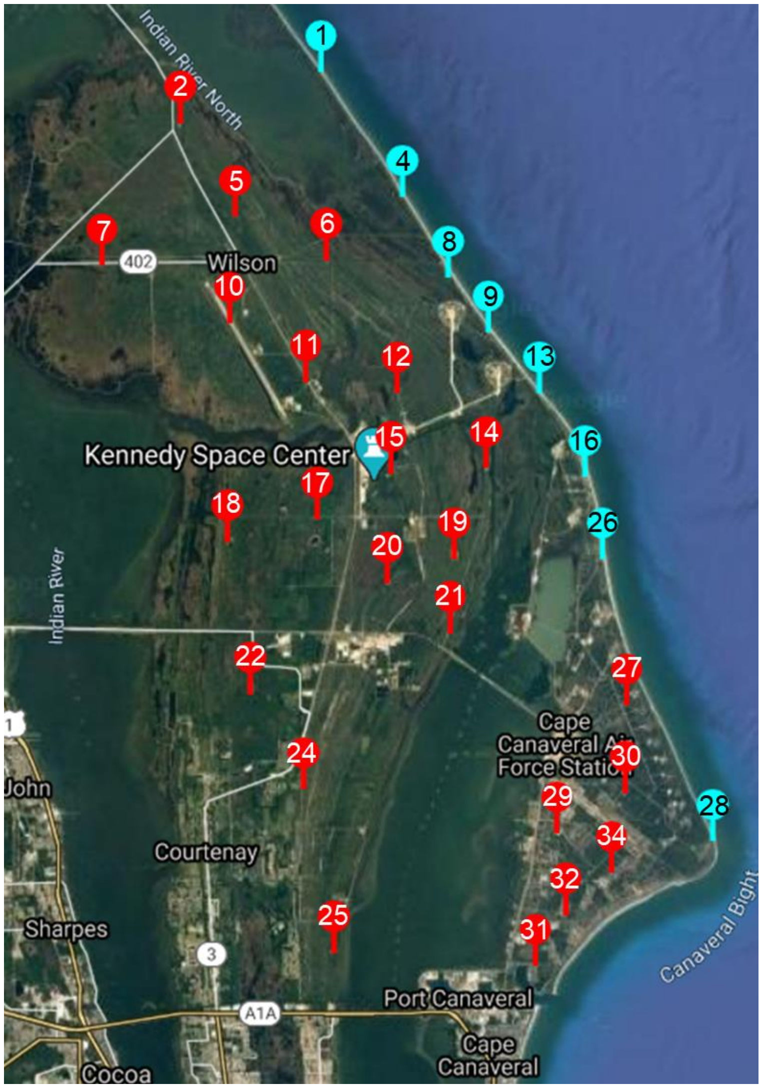
2.3 Lightning Measurement Methods

2.3.1 Overview

The 45 WS on the Eastern Range employs several sensors to detect and report the presence of lightning in and around the Eastern Range. These sensor systems include the 4DLSS, LDAR, CGLSS, and the LPLWS as described in Section 2.2.2. The data made available and used for this study only include the 31 LPLWS EFM sensor data and LDAR sensor data. The following sections discuss these systems in further detail.

2.3.2 Electric Field Mill (EFM)

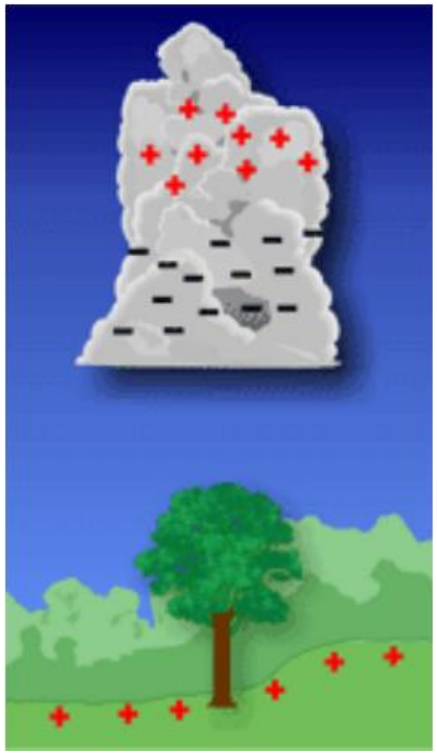
The 45 WS employs an array of 31 electric field mills (EFM) to detect the static atmospheric electric field within 5 nautical miles of the sensor (Flinn *et al*., 2010). The field mills are numbered from 1 to 34, but exclude sensor numbers 3, 23, and 33, which have either been moved to new locations or decommissioned. Figure 1 shows the locations of all 31 sensors. The sensors depicted by a blue marker are considered coastal sensors while the red markers depict inland sensors.



(Snazzy Maps, 2019)

Figure 1: EFM Locations

An EFM "works by alternately exposing a sensor element to the electric field and an uncharged reference (Bloemink, 2013)." The electric field generated during a thunderstorm is caused by the shearing of electrons as particles in a storm ascend and collect on the descending particles (Bloemink, 2013). Figure 2 depicts the charge state conditions of the ground and cloud during storm generation.

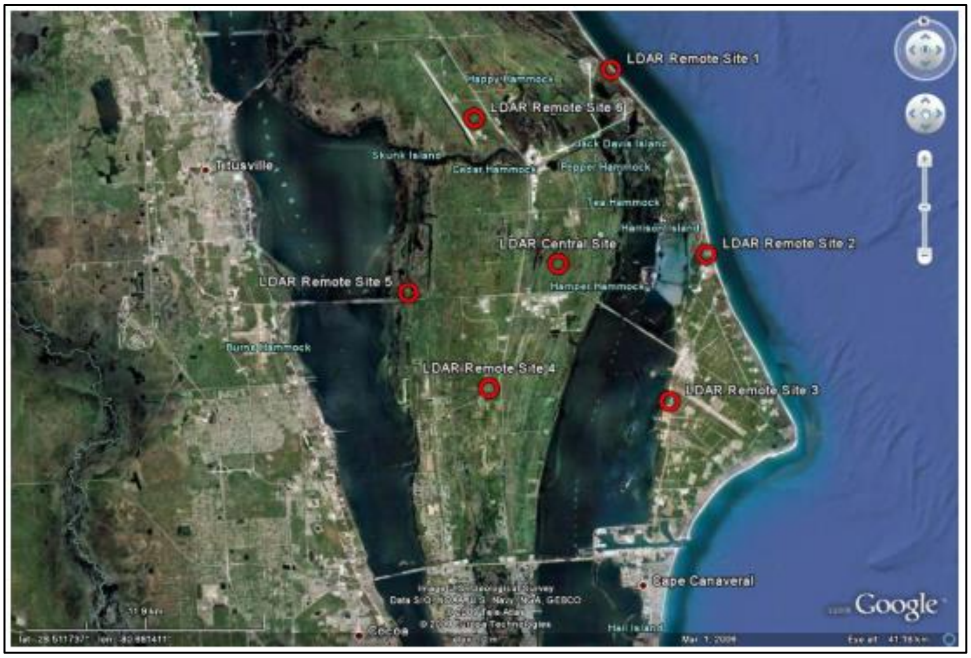


(Bloemink, 2013)
Figure 2: Lightning Storm Electric Field Generation

The electric field charges the exposed sensor element. The sensor element discharges back to its ground state when covered. This induces a charge to the sensor element that is then converted to a voltage proportional to the external electric field (Bloemink, 2013). The EFMs in use by the 45 WS collect and record the atmospheric electric field in units of volts per meter (V/m) at a rate of 50 Hz. Real time display of EFM data at the weather station show a 1-minute running average of the EFM V/m reading for each sensor.

2.3.3 Lightning Detection and Ranging

The function of the lightning detection and ranging (LDAR) system is to detect and determine the X, Y, and Z position of electrical discharge associated with thunderstorm activity and display that activity to the weather office to track the position and movement of thunderstorms (Poehler & Lennon, 1979). The X position represents the latitudinal distance in meters of a lightning strike from the LDAR central station, the Y position is the longitudinal distance in meters of a strike from the station, and Z is the height at which the lightning occurs. Depending on height, these could be depicted as cloud-to-cloud or cloud-to-ground lightning, all of which encompass total lightning. The LDAR system consists of six sensors stationed around a central station and sensor as shown in Figure 3 (Merceret *et al*., 2010, p. 28). Only three of the six sensors are required to obtain lightning strike data, while the other three sensors constitute an independent system used to validate the accuracy of the data (Poehler & Lennon, 1979). The sensors can detect the pulsed 60-80 MHz portion of the RF signal emitted by each lightning event more than 2 milliseconds apart. By using the location of each of the sensors and the time it takes for the lightning event RF signal to reach each sensor, they can triangulate the location of a lightning event (Poehler & Lennon, 1979). The LDAR data displays locally at the 45 WS weather office and Patrick AFB weather station at a limited rate. However, it is recorded at a much higher rate in digital format for processing and analysis. The latter data source is used for the analysis in this study (Poehler & Lennon, 1979).



(Merceret *et al*., 2010)

Figure 3: LDAR Sensor Locations

2.4 Relevant Research

2.4.1 NASA Reports

There have been numerous research studies carried out by National Aeronautics and Space Administration, the United States Air Force, and other agencies near Cape Canaveral Air Force Station, Florida. These studies are detailed in the NASA report, “A History of the Lightning Launch Commit Criteria and the Lightning Advisory Panel for America's Space Program (Merceret *et al*., 2010).” Some of these studies date back to the early 1940s with the Thunderstorm Project and the Thunderstorm II project in the 1970s (Braham Jr., 1996; Poehler & Lennon, 1979). These studies primarily focus on understanding the inner workings of mesoscale disturbances of the atmosphere in an effort to make air travel safer (Braham Jr., 1996).

The first study primarily focuses on turbulence within a storm system. The Thunderstorm II project focuses on the study of and improvements to the LDAR system in place at KSC and CCAFS, ground based electric field mills, and an airborne electric field mill sensor (Poehler, 1977). This study shows that the LDAR system, with the addition of electric field mill sensors, can determine the position, waveshape, rate of rise, and peak current of ground strikes. It also shows that the system is reliable, accurate, and has redundancy (Poehler & Lennon, 1979). An important result of the Thunderstorm II study is that the electric field intensity required to initiate lightning discharge is as low as 200 kV/m in the presence of water drops (Poehler, 1977). It also suggests correlation between LDAR and airborne EFM readings. This study does not explain how the EFM readings reported by an airborne sensor differ from a ground-based sensor or how the readings compare since the airborne readings recorded far exceed the values provided in the current study's available EFM data.

The loss of the Atlas-Centaur 67 rocket due to triggered lightning in 1987 led to the formation of the Lightning Advisory Panel along with additional research activities into atmospheric electricity, lightning and triggered lightning. One of the major studies during this period is the Airborne Field Mill Program (ABFM I) which is similar to the Thunderstorm II project. In this study an aircraft fitted with five electric field mills takes direct measurements of the electric field vector in thunderstorm-related clouds (Merceret *et al*., 2010, p. 53). The summer studies conducted through ABFM I show that fields at the ground were never below 1 kV/m while fields aloft were below 5 kV/m when cumulous clouds were present within 5-6 nautical miles of the LPLWS network (Merceret *et al*., 2010, p. 55). This gives a good indication of the range of EFM values to consider for the lightning prediction threshold for this research.

2.4.3 AFIT EFM Studies

There are several studies from AFIT, requested by the 45 WS, that use various statistical analysis methods conducted on the same KSC EFM dataset. These studies include the use of artificial neural network analysis, ellipse fitting methods, and recurrent neural network modeling of the EFM data with varying results. Hill (2018) proposes using artificial neural networks and EFM data to predict lightning strike potential. Using a 15 minute prediction Hill's best neural network model is able to achieve a reported accuracy of 90.3% with a true positive rate of 77.6% and a probability of false detection rate of 8.3 %, and an overall operational utility index of 53.9% (Hill, 2018).

Speranza (2019) also attempts to predict lightning strikes around KSC and CCAFS using optimal Long Short-term Memory Neural Network models. Speranza makes several deviations from the study conducted by Hill (2018). Speranza uses a different methodology and different subset of the EFM data. While Hill uses 1-minute means on EFM data, Speranza reduces his dataset to 1-hour increments. Ultimately, Speranza's model, based on hourly look backs of 48 hours is able to predict lightning with a maximum accuracy of 84%, but is not very useful due to the low resolution (Speranza, 2019).

Sanderson (2019) focuses on using LDAR data in an effort to reestablish a new lightning storm warning radius from 5 nautical miles to 4 nautical miles using an ellipse fitting method. This change in effect is able to reduce range user's downtime and increase productivity. Sanderson's proposal saves approximately 22.5 8-hour man days annually for the months of May through September (Sanderson, 2019).

2.4.2 EFM Research by Other Institution

Lucas *et al*. (2017) study 18 years of KSC EFM data. They also include readings from meteorological sensors in and around the area to determine meteorological impacts to the EFM readings. Their study primarily focuses on EFM response during fair-weather conditions and suggest there are different responses and signatures between coastal and inland electric field mills (Lucas *et al*., 2017). They are also able to show noticeable variations in the ambient electric field mill readings are affected by wind direction, varying levels of cloud cover, and diurnal variation effects (Lucas *et al*., 2017).

Antonio da Silva Ferro *et al*. (2018) show an EFM response to lightning within 20 km of the sensor. In this study, the researchers consider 1-minute averages of the EFM measurements, showing this to be a satisfactory smoothing technique to filter high frequency oscillations. This study concludes that, using a 45 minute warning window, the EFM sensor is able to provide a 60% probability of detection at a threshold of 900 V/m at a radius of 10 km (Antonio da Silva Ferro *et al*., 2018).

2.5 Statistical Analysis

2.5.1 Overview

Many techniques are available to analyze time series data. This study uses basic statistical analysis, like calculating mean, variance, and correlation, to more involved processes, such as least squares regression, nominal logistic regression (NLR) and negative binomial regression to determine how different variables relate to a response variable of interest. This section summarizes several studies that use these different techniques and demonstrates how to apply them to the time series dataset involved in this research.

2.5.2 Statistical Relationships

This study uses statistical analysis of variables to determine if a relationship exists between provided EFM sensor reading data and the occurrence of lightning. While there are studies specific to the particular dataset used in this research, finding similar studies to suggest a different approach is more challenging. Several studies into research and analysis of noisy time series data typically apply varying techniques to denoise the data prior to processing, such as the use of wavelets (Lucas *et al*., 2017). Masselot *et al*. (2018) show that aggregating the response prior to applying regression model fitting offers good performance. In this technique the aggregation of $\tilde{y}_t$ is:

$$\tilde{y}_t = \sum_{i \in I} w_i y_{t+1} \quad (1)$$

where w_i are the weights attributed to each observation and I is the aggregation window (Masselot *et al*., 2018).

Zhu *et al*. (2013) search for linear correlations in sparse and noisy data sets. They acknowledge the importance of finding correlations to show the dependencies among the varying features in a dataset. The techniques they reference primarily concern themselves with discriminant analysis approaches from classification literature. Their technique of research builds upon those principles to the concept of global linear correlation (Zhu *et al*., 2013). This research focuses on the former, discriminant analysis approach.

2.5.3 Threshold Analysis

Antonio da Silva Ferro *et al*. (2018) give a good example to follow for performing threshold analysis on EFM reading data. It is possible to use prebuilt software tools to study thresholds within time series data. One such package is T-Time, a Java based visual data mining tool that allows for interactive data exploration. T-Time is described as being able to assist users in identifying potentially interesting threshold values (Aßfalg, Kriegel, Kunath, Pryakhin, & Renz, 2008). The techniques behind the software include interval generation, applying distance functions on intervals, and using distance functions on interval sequences. Unfortunately, this particular software does not appear to be available. Another package, available in R, is “threg.” This packages uses an estimation procedure with a threshold regression model (Xiao, Whitmore, He, & Ting Lee, 2015). The approach suggested by da Silva Ferro *et al*. (2018) is the preferred method for this study since the scripts are simple to create and understand how they are working.

2.5.4 Regression Models

This study makes use of various regression analysis techniques for time series analysis to generate descriptive models that may predict detection of a potential lightning strike. Kedem and Fokianos (2002) describe several regression methods for differing types of time series data, including general, binary/categorical, and count time series. Dynamic modeling could prove useful, as suggested by Laine, as these models offer a very generic framework to analyze time series data (Laine, 2019). However, due to the nature of the EFM dataset having a consistent mean value throughout the day, this work's primary focus is on standard least squares regression, nominal logistic regression, and negative binomial regression models.

Standard least squares regression is used "to relate the mean response of a variable of interest to a set of explanatory variables by means of a linear equation" (Kedem & Fokianos, 2002). This type of regression is only useful, however, if the observations in the data are normal and independent, or one can at least assume the observations to be so. The general form for the regression model is:

$$X(t) = a(t, \theta) + \varepsilon(t), t \geq 0, \tag{2}$$

where $a(t, \tau), (\mathrm{t}, \tau) \epsilon \mathbb{R}_{+} \times \Theta^{c}$, is a continuous function, and random noise $\varepsilon = \{\varepsilon(t), t \epsilon \mathbb{R}$ (Ivanov & Orlovskyi, 2018).

Kedem and Fokianos (2002) describe regression models for dealing with binary responses, which is a subset of categorical time series regression models. Logistic regression is considered one of the simplest models for binary classification that can directly estimate posterior probabilities (Kurita *et al.*, 2009). Logistic regression models model events that occur as either a success or a failure. The following expresses the dichotomy as:

$$Y_t \equiv I_{[X_t \epsilon C]} = \begin{cases} 1, & if\ \ X_t \epsilon C \\ 0, & if\ X_t \epsilon \bar{C} \end{cases} \qquad (3)$$

where $\bar{C}$ is the complement of the set C (Kedem & Fokianos, 2002). Additionally, the cumulative density function (CDF) and probability functions are (Kedem & Fokianos, 2002):

$$F_l(x) = \frac{e^x}{1 + e^x} = \frac{1}{1 + e^{-x}}, -\infty < x < \infty \qquad (4)$$

and

$$P(Y_2 = y_2 | Y_1 = y_1) = P_{00} \left(\frac{P_{01}}{P_{00}} \right)^{y_1} \left(\frac{P_{10}}{P_{00}} \right)^{y_2} \left(\frac{P_{11} P_{00}}{P_{01} P_{10}} \right)^{y_2 y_1} \qquad (5)$$

Reforming the equation gives:

$$\log \left\{ \frac{P(Y_2 = 1 | Y_1 = y_1)}{P(Y_2 = 0 | Y_1 = y_1)} \right\} = \theta_2 + \theta_{12} y_1 \qquad (6)$$

where

$$\theta_2 = \log \left(\frac{P_{10}}{P_{00}} \right), \theta_{12} = \log \left(\frac{P_{11} P_{00}}{P_{01} P_{10}} \right). \qquad (7)$$

Pang *et al*. (2019) use a binary logistic regression model to establish a linear or nonlinear relationship between independent and dependent variables. Using the binary logistic regression technique they show low missed forecasting, but high false alarm rates when predicting severe weather (Pang *et al*., 2019).

Count time series are generally modeled using a Poisson distribution model (Kedem & Fokianos, 2002). A subset of the Poisson model is the negative binomial regression model. Negative binomial models are useful when there is a possibility of over-dispersion or extreme observations in the variables (Chen *et al*., 2016). The negative binomial cumulative distribution function is:

$$y_t|\mathcal{F}_{t-1} \sim \mathcal{NB}\left((\gamma_t - 1)^{-1}\mu_t, \frac{\gamma_t - 1}{\gamma_t} \right), (\gamma_t - 1)^{-1}\mu_t, \gamma_t - 1 \geq 0,$$

$$P(y_t = k|\mathcal{F}_{t-1}) = \frac{\Gamma((\gamma_t - 1)^{-1}\mu_t + k)}{\Gamma((\gamma_t - 1)^{-1}\mu_t)\Gamma(k+1)} \left(\frac{1}{\gamma_t}\right)^{(\gamma_t-1)^{-1}\mu_t} \left(1 - \frac{1}{\gamma_t}\right)^k . \tag{8}$$

2.6 Summary

This chapter discussed literature relating to activities at the Eastern Range, the techniques and technologies used for measuring and studying lightning phenomenon, studies related to lightning research and EFM and LDAR analysis, and research covering various statistical methods. This section included a summary of the importance of the Eastern Range as an MRTFB and the protection of personnel and assets as described in various instructions, manuals and reports. It detailed the types of equipment used by the 45 WS and researchers in support of range activities. This chapter presented a summary of the works relevant to this research. Finally, this section reported on and summarized reports related to different statistical analysis. The next chapter explains the research methodology.

III. Methodology

3.1 Chapter Overview

This chapter describes the methodologies used in the analysis of predictive qualities of EFM data. First, this chapter describes the materials used in analysis to include the software, hardware, and sensors. Next, this section details the steps used to create, clean, reduce, and augment the data. Finally, this section finishes by describing various statistical processes used in the analysis including the methods of statistical analysis, threshold analysis, standardized linear regression and NLR model building methods to predict storm onset and cessation, and a negative binomial method to predict lightning storm cessation.

3.2 Materials and Equipment

3.2.1 Computer Hardware and Software

Due to the large size of the dataset, in terms of number of both number of files to process and the amount of data points recorded, the research greatly benefits from the capability to use a programming language, especially one already tailored toward data analysis and statistics. There are several programming languages to choose from. However, being open source and having a large amount of support available make the R programming language version 3.6.1 with the RStudio GUI interface version 1.1.143 an ideal choice for processing the dataset (R Core Team, 2019). The machines available to run the software include two mobile laptops running 64-bit Windows 10 Home Edition, with an Intel Quad-Core i7 CPU and 16 GB of RAM in each. These machines are useful for processing data when away from the desk. However, due to the large number of files, the large size of those files, and the desire to use parallel processing they quickly showed inability to process the dataset in a reasonable amount of time. To help reduce the processing time, an HP Z620 workstation with two Xeon E5-2687W 8-core processors and 192

GB of RAM running both Linux and Windows 10 Professional performed the majority of the data processing tasks.

After the data was cleaned, processed, aggregated, and augmented in R, it was converted into a CSV file for use in JMP 13.0 for statistical analysis of the dataset (SAS Institute Inc., 2019). The JMP data analysis software offers an easy to use interface to interact with the dataset, choose the desired parameters to analyze and compare, and perform the various types of analysis to include multivariate analysis and model fitting. JMP also proved useful in its ability to produce graphical output in addition to analysis in text format. Microsoft Excel provided capability for further processing of JMP output to summarize the JMP results and better represent findings.

3.2.2 Datasets

The dataset used for this research and analysis include EFM sensor readings and LDAR data recordings. They are available on a portable hard disk drive and also available from NASA's Spaceport Weather Archive (Smith, 2019). The EFM data is composed of daily sensor files for each EFM sensor located at KSC and CCAFS. This study makes use of four years of LDAR data grouped into monthly files. The entirety of the dataset takes up nearly 3 terabytes of hard disk space prior to processing.

3.3 Data Preparation

3.3.1 EFM Data

The data available for processing includes four years of "lightning season" data EFM and LDAR readings for the months between May and September. The 50 Hz EFM data is broken up into 34 distinct sensor ".RAW" files for each day, of those 34 ".RAW" files, only up to 31 files contain data since EFM sensors 3, 23, and 33 are deactivated. Daily folders group the ".RAW" files for all sensors for each day of data. Those daily folders combine into 6 groups of 5 days for each month of data and 5 months of data group into years from 2013 to 2016.

The first step in data preparation involved using the R programming language to read in the ".RAW" files for each sensor for a single day. These sensor files have three columns: date in Julian format, time in microseconds, and sensor reading in V/m. Figure 4 shows an example of how R displays the ".RAW" file format. A single daily data frame combines individual sensor files by column for each day; it contains the date, time, and the sensor readings across 31 columns.

2013121	00:00:00.000	368.00
2013121	00:00:00.020	364.00
2013121	00:00:00.040	364.00
2013121	00:00:00.060	364.00
2013121	00:00:00.080	364.00
2013121	00:00:00.100	364.00
2013121	00:00:00.120	364.00
2013121	00:00:00.140	364.00
2013121	00:00:00.160	364.00
2013121	00:00:00.180	360.00
2013121	00:00:00.200	364.00

Figure 4: Example Raw ".RAW" EFM Data Format

Reducing 50 Hz sensor readings to 1-minute averages helps reduce time needed for processing and the size of the dataset by 1/300 of its original length. Real-time displays of the EFM data show EFM readings for each sensor as a 1-minute running average of the electric field in V/m. In addition to columns that represent the 1-minute mean sensor reading for each EFM, the variances for 1-minute of sensor data are stored in columns representing each sensor. The completed dataset combines 1-minute mean sensor readings and 1-minute variances by row into a single dataset and 1-minute variance for every day of the 4 years of available EFM data.

3.3.2 LDAR Data

The LDAR data are processed and cleaned before they are combined with the EFM dataset. The first step involves reading in the LDAR ".txt" files which are provided for every month over the 4-year period included in this study. Each ".txt" file of LDAR data contain one month of comma delimited files with 5 columns. The first column includes the date and time, the second column is latitudinal distance in meters from the center of the LDAR sensor network, the third column is longitudinal distance in meters from the center of the LDAR sensor network, the fourth column represents the height at which the lightning is detected (this height column is ignored since there is only interest if lightning occurs in the area, not if it is a cloud-to-cloud or cloud-to-ground strike), and the fifth column is the Unix epoch time with a base time starting at 00:00:00 on 1 January 1970. Figure 5 shows an example of the formatting of a raw ".txt" file.

```
01/07/2013 00:58:08:442365,-23634,-126106,10450,1357538288.442365

01/07/2013 01:02:40:561306,-20468,-58349,6492,1357538560.561306
01/07/2013 01:02:40:56143,-20846,-57710,6262,1357538560.56143
01/07/2013 01:02:40:563187,-20955,-57658,6968,1357538560.563187
01/07/2013 01:02:40:563633,-18778,-58969,7399,1357538560.563633
01/07/2013 01:02:40:564347,-19129,-61794,10385,1357538560.564347
01/07/2013 01:02:40:564678,-19100,-59666,6212,1357538560.564678
01/07/2013 01:02:40:565384,-19065,-56984,7530,1357538560.565384
01/07/2013 01:02:40:565833,-18570,-57859,7201,1357538560.565833
01/07/2013 01:02:40:568385,-18826,-55372,8458,1357538560.568385
01/07/2013 01:02:40:569221,-18177,-56798,7685,1357538560.569221
01/07/2013 01:02:40:569344,-17871,-55716,7164,1357538560.569344
01/07/2013 01:02:40:569954,-18403,-56330,7539,1357538560.569954
01/07/2013 01:02:40:573603,-19857,-55328,7232,1357538560.573603
```

Figure 5: Example Raw ".txt" LDAR Data Format

The first step for processing the LDAR data was to read it into an R data frame, then separate the combined date and time column into separate columns with the same formatting as the date and time of the EFM data. The latitude and longitude data must go through several transformations prior to analysis. Using equation (9), where λ_{LDAR} is the latitudinal location of the center of the LDAR sensor in degrees, x_{strike} is the latitudinal distance in meters of a lightning flash from the LDAR sensor, and r_{Earth} is the radius of the Earth in kilometers, transforms the raw latitudinal distance into a coordinate in degrees latitude.

$$\lambda_{strike} = \lambda_{LDAR} + \frac{(\frac{x_{strike}}{1000})}{r_{Earth}} * \frac{180}{\pi} \tag{9}$$

Similarly, the calculation shown in equation (10) transforms raw longitudinal distance to degrees longitude, where φ_{LDAR} is the longitudinal location of the center of the LDAR sensor in degrees, y_{strike} is the longitudinal distance in meters of a lightning flash from the LDAR sensor, and r_{Earth} is the radius of the Earth in kilometers.

$$\varphi_{strike} = \varphi_{LDAR} + \frac{\left(\frac{\left(\frac{y_{strike}}{1000}\right)}{r_{Earth}} * \frac{180}{\pi}\right)}{\cos\left(\lambda_{LDAR} * \frac{\pi}{180}\right)} \tag{10}$$

The following steps calculated the distance in nautical miles between each lightning strike and each EFM sensor in the sensor array using the latitudinal and longitudinal coordinates of the lightning strikes and the coordinates of each EFM sensor. The spherical law of cosines transformation in equation (11), where λ_{EFM_i} is the latitudinal coordinate of an EFM sensor in radians, i is the sensor number from 1-34, λ_{strike} is the latitudinal coordinate of a lightning strike in radians, φ_{EFM_i} is the longitudinal coordinate of an EFM sensor in radians, φ_{strike} is the longitudinal coordinate of a lightning strike in radians, and r_{Earth} is the radius of the Earth in nautical miles, calculated the distance between two geographic coordinates (Veness, 2019).

$$Dist = abs\left[\operatorname{acos}\left(sin\left(\lambda_{EFM_i}\right) * \sin(\lambda_{\text{strike}}) + \cos\left(\lambda_{\text{EFM}_\text{i}}\right) * \cos(\lambda_{\text{strike}}) * \cos\left(\varphi_{\text{EFM}_\text{i}} - \varphi_{\text{strike}}\right)\right) * r_{\text{Earth}}\right] \tag{11}$$

Next, the LDAR dataset was reduced by all lightning strikes into a single reading for each EFM for each minute of the day. To do this, the minimum lightning strike distance observed over each 1-minute period for each EFM sensor is calculated and stored in a separate column representing each EFM sensor. The data are displayed as a binary of 1000 if a minimum lightning strike distance is within 5 nautical miles of the sensor, otherwise the value is set to 0 for no lightning detected within that distance. A binary value of 1000 was chosen over using 1 so that lightning strikes could hold more leverage in model building in case the binary columns are treated as continuous variables rather than nominal or binary categories. Additionally, it makes it easier to differentiate when graphed with other variables.

3.3.3 Combined EFM/LDAR Dataset

After processing the EFM and LDAR data, a left-join command combined the two datasets into one where the EFM dataset serves as the base dataset. There are many rows of data representing minutes with no lightning; "NA" values fill the LDAR columns in these empty segments for the lightning strike distance columns and 0s for the binary lightning strike columns. The binary strike columns are referenced to create an additional 31 columns that represent lightning storm periods. A lightning storm period is the time 30 minutes before the first lightning strike occurs to 15 minutes after the last lightning strike. Lightning within 5 nautical miles of a sensor and within 45 minutes of each other are part of the same storm. A no storm period is any time period where there is more than 45 minutes without any lightning strikes. Subsets of the dataset representing storm only and no-storm only data were appended into additional datasets for use in different analysis methods.

In addition to the mean sensor readings and variance calculations, the dataset included calculated 1-minute mean absolute value of each sensor's readings and 1-minute centered mean absolute value for use in threshold evaluation. Appendix A provides a sample of the completed dataset.

3.4.1 Statistical Relationships

Basic statistical analysis on the dataset checked for any relationships between the variables within the dataset against the lightning response. Analysis included plotting the data, exploring the distribution of the EFM sensor readings, and checking for correlations among the EFM readings treated as independent variables. Additionally, analysis investigated correlations between the EFM readings as the input variable and lightning distance as the response variable. This study primarily used JMP 13.0 throughout to analyze the interaction between the EFM dataset and the lightning and storm response (SAS Institute Inc., 2019).

The first step in the statistical analysis checked the EFM sensor data for correlation with each other, with lightning strike distance, and the presence of storms as a binary response. This analysis provided an idea of how EFM sensors react in response to lightning activity. For EFMs to be useful in the prediction of lightning storms there should be high correlation of EFM sensor readings and lightning distances and storm activity. This type of analysis does propose the question: which variable is the independent variable and which is the response? This research, however, considered the EFM sensor readings to be the independent variables predicting lightning activity as a response.

It was prudent to first plot the available data to gain insights into its behavior. The first plots were a scatter plot of an EFM's sensor readings by time-of-day. This plot provided insight into if and how the time-of-day affects EFM readings for each of the 31 individual EFM sensors. Appendix B contains each of these plots for each sensor. Further analysis checked each EFM sensor output for normality using normal quantile plots. Appendix C shows these distribution plots for each EFM sensor. Scatter plots comparing EFM sensor readings with minimum lightning distances for each 1-minute mean time interval were also plotted and are shown in Appendix D.

Centering the EFM data for each sensor was also a parameter desired for analysis. R scripts calculated the mean sensor reading for each EFM sensor during periods when no-storms occur. This was expressed as the mean, μ_j of the sensor, j, conditioned on the binary response of the storm, Y_j, occurring within 5 nautical miles of the sensor, and storm defined as the time period encompassing 30 minutes prior to the first lightning strike and 15 minutes after the last lightning strike.

$$\mu_j\left(x_j \middle| Y_j = 0\right);\ \mathrm{j} = [1,2,4\!:22,24\!:32,34] \tag{12}$$

This calculated mean centered the EFM reading by taking the absolute distance of the sensor reading from the mean and stored the values in a new column in the working dataset using:

$$\mu_{C(i,j)} = \left|x_{i,j} - \mu_j\right|\ \forall i\,;\ \mathrm{j} = [1,2,4\!:22,24\!:32,34]. \tag{13}$$

The centered mean columns were then aggregated into a single column representing the overall EFM response for the entire EFM network covering KSC. Equation (14) expresses the function as:

$$\mathrm{\mu_i} = \frac{\sum_{j=1}^{n} x_{i,j}}{n}\ ;1 \leq i \leq 31. \tag{14}$$

Additionally, the calculation for the geometric mean from the centered mean is the following:

$$\tilde{\mathrm{\mu}}_{\mathrm{i}} = \left(\prod_{j=1}^{n} x_{i,j}\right)^{\frac{1}{n}}\ ;1 \leq i \leq 31. \tag{15}$$

Figure 10 shows the overall centered mean of all EFMs and the geometric mean of all sensors as a function of the time-of-day. Appendix E shows the full set of plots for 2013-2016.

Finally, a multivariate correlation analysis checked the 1-minute mean EFM sensor data for correlations among each other. Correlation analysis also checked for correlation among EFM sensor readings and the minimum distances lightning occurs from each of the EFM sensors. The correlation is calculated using Equation 16:

$$\rho = \frac{\sigma_{XY}}{\sigma_X \sigma_Y} = \frac{Cov(X,Y)}{\sigma_X \sigma_Y} = \frac{E[(X - \mu_X)(Y - \mu_Y)]}{\sigma_X \sigma_Y}. \tag{16}$$

Table 1 and Table 2 show the results for correlation.

3.4.2 Threshold Analysis

R performed threshold analysis. The processing involved:

a. If storm is occurring and EFM reading is above a threshold value, then response was counted as a true positive (TP).

b. If storm is occurring and EFM reading is below a threshold value, then response was counted as a false negative (FN).

c. If storm is not occurring and EFM reading is above a threshold value, then response was counted as a false positive (FP).

d. If storm is not occurring and EFM reading is below a threshold value, then response was counted as a true negative (TN).

The analysis considered threshold values from 100 V/m to 4000 V/m in 100 V/m increments. The analysis also considered and evaluated response times of 30 minutes to 1 minute prior to the first lightning strike in 1-minute decrements and a time period 15 minutes after the last lightning strike in a storm. The analysis evaluated each individual EFM sensor by location and to the overall mean and geometric mean of all EFM sensor readings.

3.4.3 Standard Least Squares Regression

With all the parameters readily available in the working dataset, it was a relatively quick process to also consider and check other models for response and goodness-of-fit. The three models were storm response as a function of the overall mean EFM sensor readings, the geometric mean EFM sensor readings, and as a function of all of the EFM sensors, simultaneously. JMPs Fit Model analysis tool performed the model fitting (SAS Institute Inc., 2019). One output from the JMP provided analysis to consider is the R^2 value as it represents the goodness-of-fit of the model. R^2 showed how well the model explains the variance in parameters. Analysts consider the model to be a good fit for the dataset for high values of R^2.

3.4.4 Nominal Logistic Regression

Storm activity was modeled as a binary event. Either a storm exists (timeframe encompassing 30 minutes prior to the first lightning strike to 15 minutes after the last lightning strike) or it does not exist. The binary storm response considered the 5 nautical mile radial area encompassing each of the EFM sensors. Additionally, a binary response considered a storm occurring over any part of the KSC detection zone. Generalized regression analysis produced a nominal logistic regression (NLR) model for each sensor location. Outputs from this analysis included an R^2 value for the model and the parameter effects. The R^2 value indicates how well the model describes the data. Finally, the NLR analysis output provided a confusion matrix that showed how well the model predicts the TP, FN, FP, and TN response. These accuracies of the prediction rates reported in the confusion matrices are plotted, along with the R^2 values, on a graph for each EFM sensor location along with the prediction rate using the overall centered mean EFM sensor reading with storm response over any area of KSC. Figure 24, Figure 25 and Appendix F show the output from the NLR model generation.

3.4.5 Negative Binomial Regression

A set of lightning response columns contained values that count down the time from 30 minutes prior to a lightning strike until 15 minutes after for each individual storm for each sensor location. A subset of the dataset represented active storms for each sensor. A new database combined these individual sensor subsets for active storms for evaluation. The input variables included all EFM sensor readings while the response was the ending time for each storm for each sensor. The negative binomial regression analysis function created a NBR model for each sensor. Items of interest in the output were the R^2 value for the model to check for goodness of fit and the parameter estimates as this shows which parameters are relevant to the model. Figure 27 displays the calculated R^2 values for each model as bar chart.

3.4.6 Variance Calculations

Analysis considered the 1-minute variance for each EFM sensor in an effort to establish other potential dependences within the dataset. calculates the variance during the EFM data processing step, as (Yau, 2020):

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2 \qquad (17)$$

Multivariate correlations between the variance for each sensor were considered. Additionally, correlations between the variance and the minimum distance of lightning strikes from each sensor location were considered. Table 5 and Table 6 show these correlations values for the variance.

3.5 Summary

This chapter described the equipment, software, and raw data and systematic methodology used to prepare and analyze the dataset in this research. The next section discusses results of statistical analysis and regression model performance.

IV. Analysis and Results

4.1 Chapter Overview

This chapter discusses the analysis on the research dataset and results of the statistical analysis techniques used and performance characteristics of different regression models. Preliminary analysis visualized the dataset and performed some basic statistical analysis. Next, the study explores and reports on correlations between parameters. Once statistical analysis is complete, JMP creates models for the various regression analysis techniques given: threshold analysis, standard least squares regression, nominal logistic regression, and negative binomial regression. Summaries of each section report on the results of model performance.

4.2 Preliminary Analysis

To better understand the structure and behavior of the supplied dataset it is convenient and useful to first visualize the parameters graphically. Starting with the initial 1-minute mean EFM sensor data, an EFM sensor reading vs. the time-of-day is plotted, shown in Figure 6 and Appendix B, to determine if there may be any time effect on the EFM sensor readings. It appears there is a diurnal effect where the EFM readings stay close to their mean value during daylight hours, but show more variation during the night. However, further analysis in correlation indicates that time-of-day is not a statistically significant factor affecting EFM readings in general.

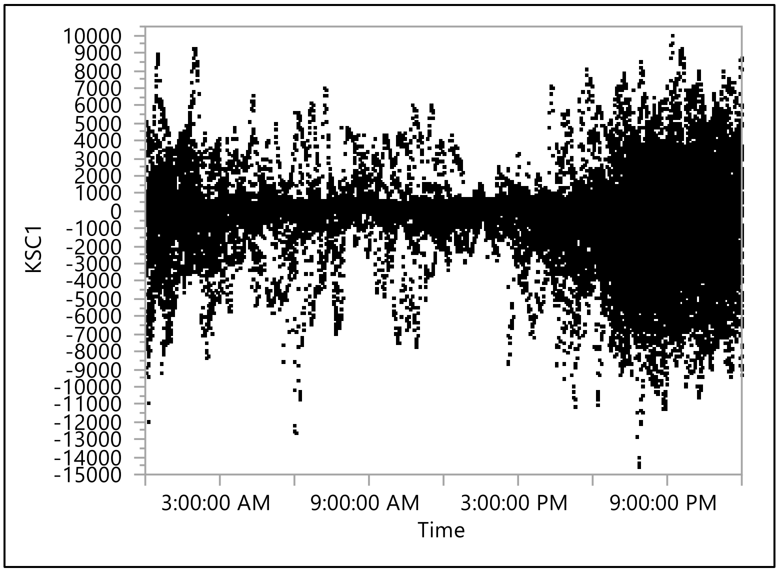


Figure 6: EFM 1 Sensor Readings by Time

Normal distribution quantile plots were generated for each of the EFM sensor readings. Figure 7 and Appendix C shows an example EFM sensor normal quantile plot. The normal quantile plots for each of the EFMs shows a bell-shaped curve. However, readings near the sensor mean heavily dominate the EFM dataset. The normal quantile plot also shows the distributions have very heavy tails. This may suggest that looking for EFM and lightning response might lay somewhere in the fringes.

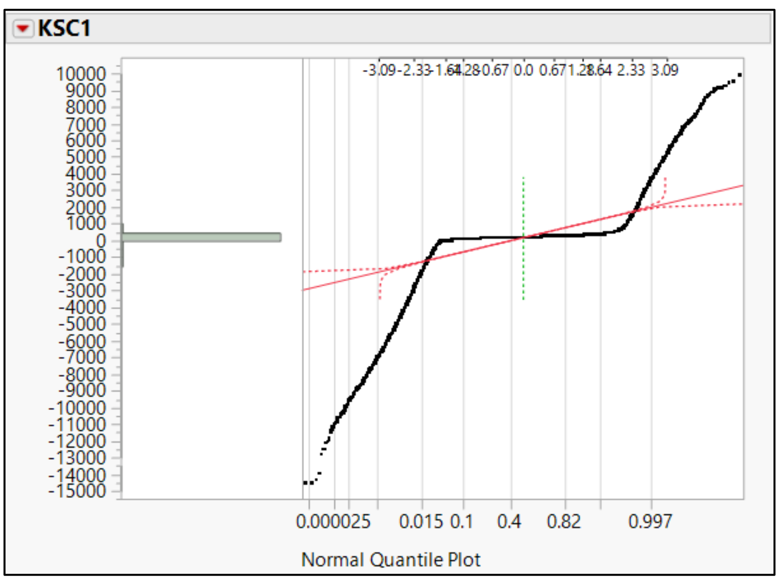


Figure 7: EFM 1 Sensor Normal Quantile Plot

Another plot of interest was sensor readings as a function of the minimum distance of a lightning strike to a sensor location. Figure 8 and Appendix D show the EFM sensor reading versus distance plots. These cases treated EFM readings as a response to lightning rather than lightning responding to EFMs as in the majority of this research. However, it makes sense to look at lightning and EFMs in this way since the storm formation processes are causing the changes in the electric fields of storm clouds. These plots suggest that as storms get closer to an EFM, the range of recorded electric field readings increases.

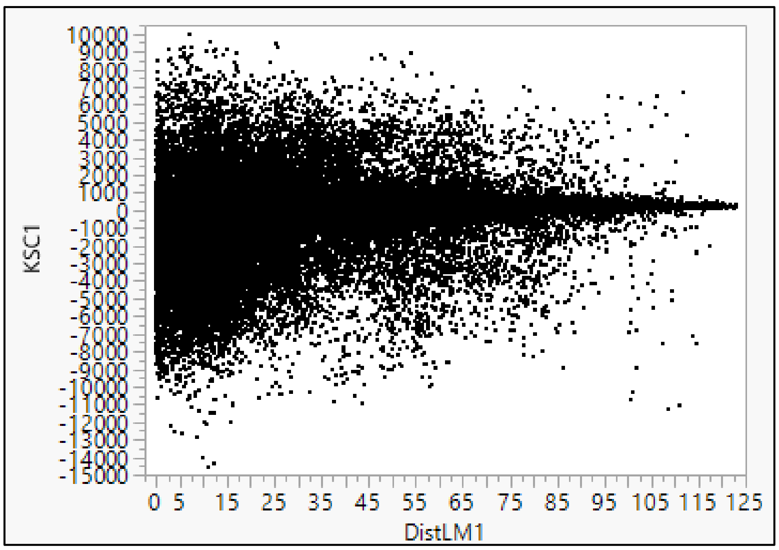


Figure 8: EFM1 Sensor Readings by Minimum Lightning Distance

The mean sensor reading for each EFM during periods where no storms are occurring within 5 nautical miles of the sensor were calculated and displayed in Figure 9. This bar chart for the mean EFM sensor readings show that sensor means are between 100 and 200 V/m. There is an interesting phenomenon with these averages. Sensors 1, 4, 8, 9, 13, 16, 26, 27, and 28 are all in close proximity to the ocean compared to the other sensors as seen in Figure 1. This may suggest that there is an environmental factor caused by the ocean that has an effect on the EFM sensors. These observations coincide with observations made by Lucas *et al.* (2017). The mean sensor readings are also important in centering the data in an effort to get a more consistent response from each sensor reading regardless of its local ambient effects.

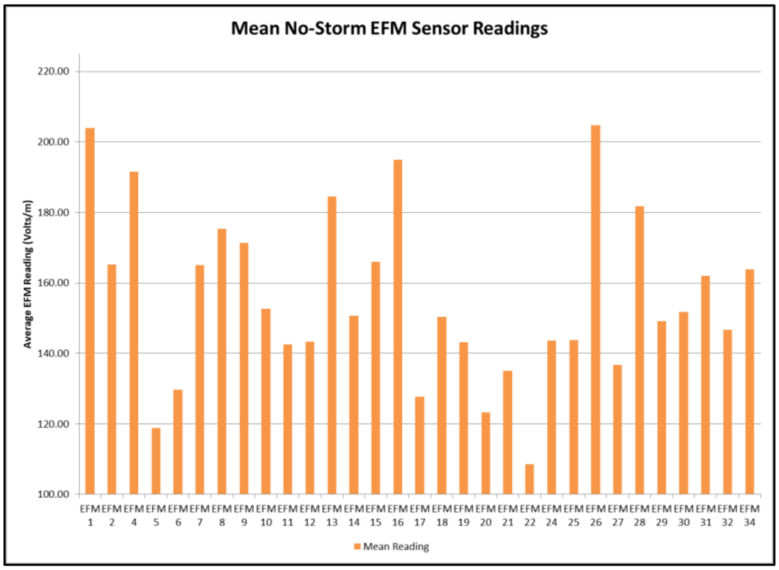


Figure 9: No-Storm EFM Sensor Average Readings

Figure 10 shows the plots for the centered mean and centered geometric mean as a function of time-of-day. As with the individual EFM sensor vs. time-of-day plots, these plots show a potential diurnal effect for periods of daylight and night.

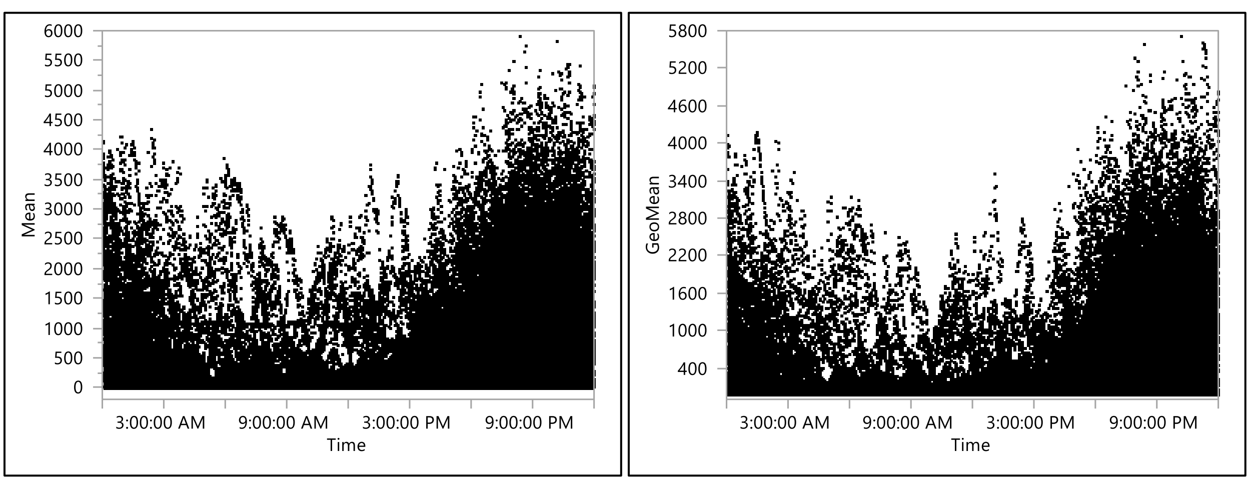


Figure 10: Centered Mean and Geometric Mean EFM Readings vs Time

The final part of the preliminary analysis converted the working dataset to a time-extension format in R and plotted the result (Dan Vanderkam *et al.*, 2018). Appendix E shows the annual plots for each 5-month period of the lightning season using the centered mean sensor reading. Scrutinizing these plots show some areas of interest that suggest the EFM readings may not be a good predictor of lightning activity. Figure 11 shows relatively flat EFM response during periods of high lightning activity.

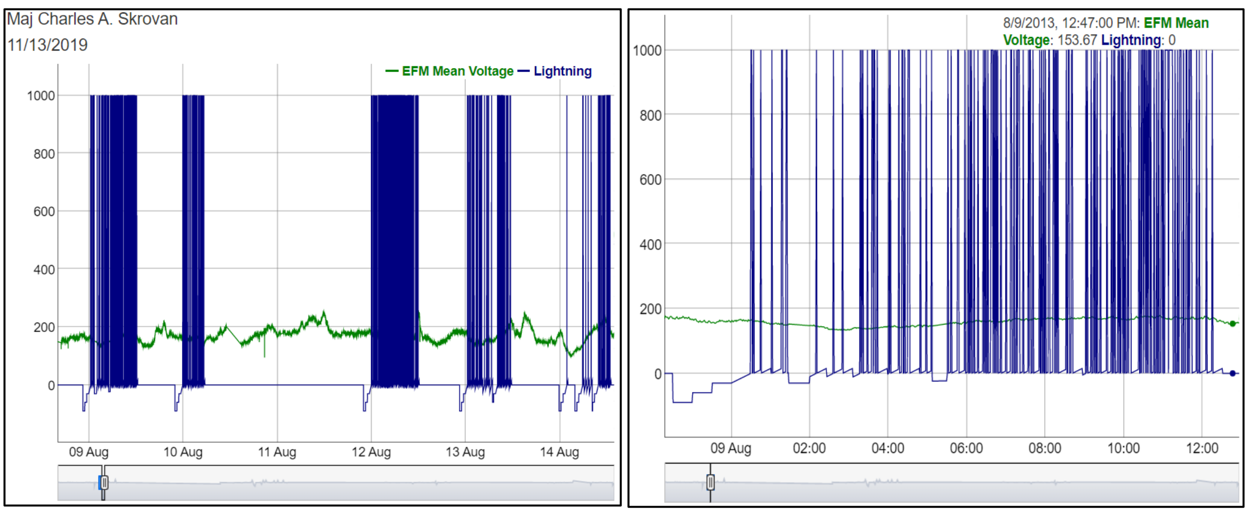


Figure 11: Issue, Flat EFM Response during Storms

In Figure 12, the EFM sensor readings show changes only after a lightning strike occurs. This suggests that the EFM sensors are responding to lightning activity rather than lightning activity responding to the electric field, or perhaps the sensitivity of the EFM sensor does not extend out to 5 nautical miles.

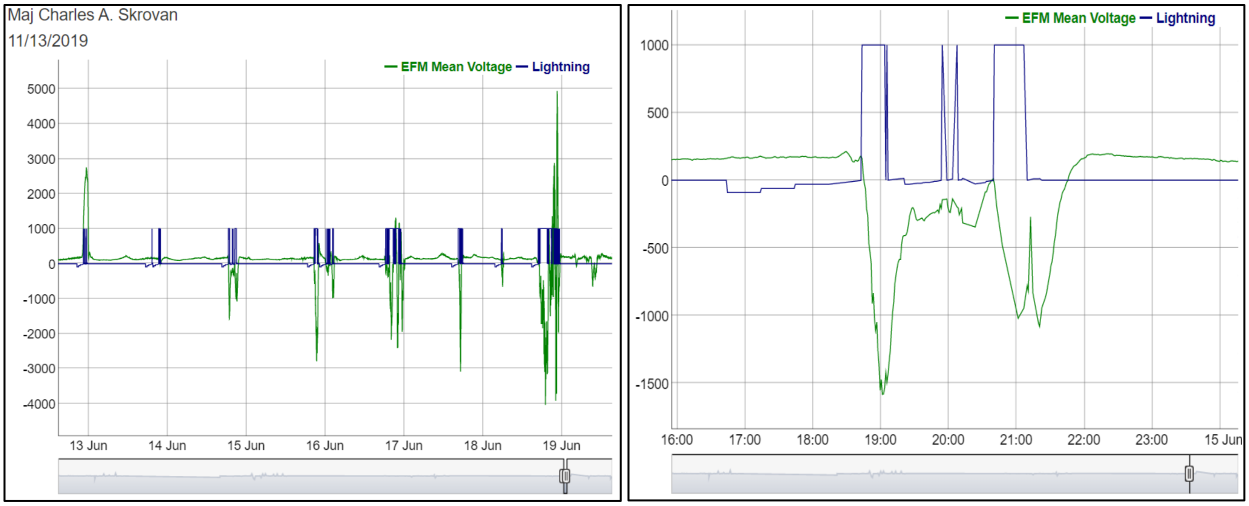


Figure 12: Issue, EFM Response after First Lightning

Finally, Figure 13 shows an example of situations where the EFM sensor reading spike away from their average sensor reading, but there is no reported lightning activity within a 5 nautical mile radius of the sensor area.

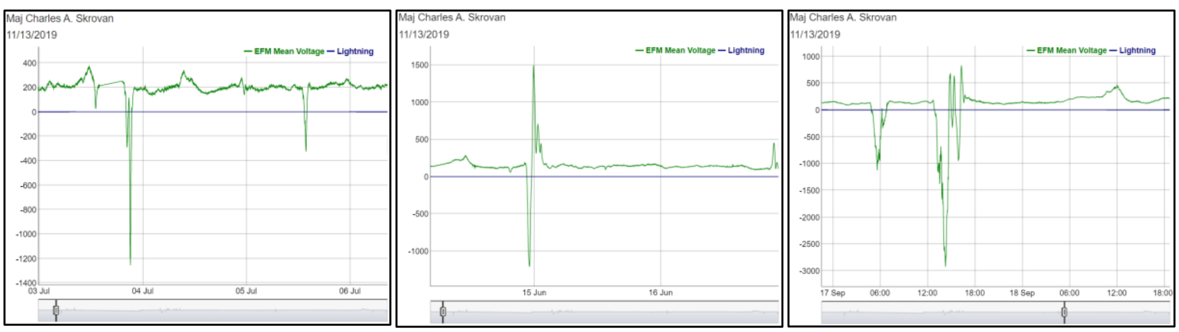


Figure 13: Issue, EFM Spikes with No Storms Present

These issues bring into question whether EFM readings are a good measure or predictor of lightning activity. Further analysis helps in narrowing down a solution.

4.3 Investigative Questions Answered

The questions answered in this analysis are: what factors from the available EFM and LDAR dataset best correlate to each other and to the occurrence of lightning storms? Does a threshold value for EFM readings that accurately predicts storm onset (30 minutes prior to first lightning strike) exist? Does a separate threshold value that accurately predicts storm cessation

(15 minutes after last lightning strike) exist? If the threshold analysis does not produce a useful result can a standardized linear regression model accurately predict storm onset or cessation? Is a nominal logistic model useful in predicting if a storm will be present or not present? If EFMs seem to be more responsive than predictive, then can a negative binomial model accurately predict when a storm is ending? Should the study use the variance of the EFM readings over 1-minute period instead of the mean EFM reading?

4.3.1 Correlation Comparisons

A multivariate correlation analysis helped determine how well different parameters predict or interact with other parameters. Table 1 compares the 1-minute mean EFM sensor readings for each sensor. The blue shading on the table show a relationship where the parameters are more highly correlated, whereas the red shading show little to no correlation among the parameters of interest. As expected, sensors within close proximity to each other have high correlations with one another. The table shows low correlation between time and any of the EFM sensor readings, which is contrary to what the scatter plots in Section 4.2 suggested. This is likely because most EFM sensor readings remain relatively close to the mean, overwhelming any excursions from the mean sensor value.

Table 2 displays the 1-minute mean EFM sensor readings as compared to lightning distance. The analysis assumed that if EFM readings can predict lightning, then there should be a strong correlation between EFM readings and lighting distance. The red shading and low values depicted in this table show otherwise. Since there is not a high correlation between EFM readings and lightning strikes or the existence of lightning storms it suggests there are potentially other external factors affecting EFM readings not captured by LDAR data alone or that EFM readings are not a good indicator of lightning activity.

Table 1: 1-Minute Mean, Sensor to Sensor/Time Multivariate Correlation

	Time	Mean KSC1	Mean KSC2	Mean KSC4	Mean KSC5	Mean KSC6	Mean KSC7	Mean KSC8	Mean KSC9	Mean KSC10	Mean KSC11	Mean KSC12	Mean KSC13	Mean KSC14	Mean KSC15	Mean KSC16	Mean KSC17	Mean KSC18	Mean KSC19	Mean KSC20	Mean KSC21	Mean KSC22	Mean KSC24	Mean KSC25	Mean KSC26	Mean KSC27	Mean KSC28	Mean KSC29	Mean KSC30	Mean KSC31	Mean KSC32	Mean KSC34
Time	1.000	-0.040	-0.053	-0.032	-0.057	-0.069	-0.075	-0.046	-0.040	-0.070	-0.070	-0.053	-0.033	-0.051	-0.023	-0.034	-0.065	-0.072	-0.056	-0.058	-0.044	-0.059	-0.064	-0.058	-0.032	-0.029	-0.025	-0.045	-0.038	-0.030	-0.029	-0.037
Mean KSC1	-0.040	1.000	0.621	0.666	0.601	0.573	0.426	0.539	0.452	0.458	0.424	0.399	0.350	0.340	0.090	0.282	0.316	0.288	0.284	0.288	0.242	0.221	0.178	0.121	0.238	0.165	0.124	0.146	0.140	0.120	0.132	0.126
Mean KSC2	-0.053	0.621	1.000	0.509	0.769	0.587	0.684	0.444	0.378	0.607	0.483	0.404	0.298	0.332	0.108	0.250	0.356	0.378	0.289	0.295	0.236	0.252	0.191	0.155	0.204	0.167	0.119	0.145	0.149	0.125	0.135	0.134
Mean KSC4	-0.032	0.666	0.509	1.000	0.618	0.746	0.424	0.806	0.673	0.545	0.557	0.582	0.531	0.504	0.139	0.440	0.435	0.378	0.412	0.400	0.340	0.292	0.249	0.177	0.363	0.243	0.162	0.196	0.198	0.148	0.172	0.176
Mean KSC5	-0.057	0.601	0.769	0.618	1.000	0.772	0.680	0.548	0.462	0.773	0.633	0.523	0.367	0.408	0.133	0.303	0.451	0.453	0.360	0.375	0.292	0.319	0.257	0.177	0.255	0.201	0.149	0.175	0.181	0.139	0.157	0.163
Mean KSC6	-0.069	0.573	0.587	0.746	0.772	1.000	0.556	0.715	0.606	0.756	0.742	0.673	0.484	0.523	0.161	0.399	0.520	0.492	0.441	0.446	0.361	0.356	0.292	0.212	0.332	0.237	0.167	0.210	0.207	0.152	0.179	0.186
Mean KSC7	-0.075	0.426	0.684	0.424	0.680	0.556	1.000	0.395	0.342	0.695	0.539	0.411	0.287	0.349	0.115	0.263	0.426	0.480	0.338	0.354	0.303	0.327	0.263	0.193	0.235	0.181	0.122	0.174	0.162	0.143	0.149	0.153
Mean KSC8	-0.046	0.539	0.444	0.806	0.548	0.715	0.395	1.000	0.841	0.539	0.616	0.721	0.659	0.627	0.175	0.547	0.490	0.419	0.506	0.475	0.421	0.335	0.289	0.236	0.446	0.313	0.213	0.250	0.254	0.192	0.216	0.226
Mean KSC9	-0.040	0.452	0.378	0.673	0.462	0.606	0.342	0.841	1.000	0.486	0.587	0.741	0.806	0.718	0.182	0.649	0.505	0.423	0.570	0.517	0.483	0.355	0.308	0.250	0.531	0.368	0.257	0.298	0.309	0.219	0.248	0.263
Mean KSC10	-0.070	0.458	0.607	0.545	0.773	0.756	0.695	0.539	0.486	1.000	0.786	0.610	0.404	0.475	0.164	0.359	0.578	0.584	0.442	0.463	0.385	0.406	0.321	0.229	0.317	0.238	0.160	0.225	0.208	0.170	0.185	0.189
Mean KSC11	-0.070	0.424	0.483	0.557	0.633	0.742	0.539	0.616	0.587	0.786	1.000	0.790	0.508	0.594	0.204	0.447	0.687	0.643	0.547	0.567	0.474	0.466	0.366	0.277	0.402	0.304	0.203	0.272	0.255	0.200	0.223	0.235
Mean KSC12	-0.053	0.399	0.404	0.582	0.523	0.673	0.411	0.721	0.741	0.610	0.790	1.000	0.644	0.758	0.220	0.557	0.657	0.551	0.630	0.606	0.523	0.428	0.345	0.274	0.474	0.336	0.222	0.282	0.275	0.206	0.232	0.247
Mean KSC13	-0.033	0.350	0.298	0.531	0.367	0.484	0.287	0.659	0.806	0.404	0.508	0.644	1.000	0.775	0.279	0.783	0.476	0.398	0.603	0.522	0.528	0.354	0.322	0.256	0.641	0.443	0.308	0.345	0.371	0.249	0.282	0.305
Mean KSC14	-0.051	0.340	0.332	0.504	0.408	0.523	0.349	0.627	0.718	0.475	0.594	0.758	0.775	1.000	0.219	0.779	0.632	0.518	0.803	0.696	0.663	0.464	0.416	0.328	0.679	0.478	0.311	0.401	0.397	0.280	0.322	0.342
Mean KSC15	-0.023	0.090	0.108	0.139	0.133	0.161	0.115	0.175	0.182	0.164	0.204	0.220	0.279	0.219	1.000	0.162	0.232	0.178	0.210	0.206	0.192	0.147	0.124	0.088	0.482	0.107	0.067	0.095	0.088	0.068	0.079	0.078
Mean KSC16	-0.034	0.282	0.250	0.440	0.303	0.399	0.263	0.547	0.649	0.359	0.447	0.557	0.783	0.779	0.162	1.000	0.464	0.388	0.680	0.559	0.607	0.367	0.352	0.302	0.841	0.556	0.388	0.428	0.451	0.300	0.343	0.374
Mean KSC17	-0.065	0.316	0.356	0.435	0.451	0.520	0.426	0.490	0.505	0.578	0.687	0.657	0.476	0.632	0.232	0.464	1.000	0.791	0.671	0.760	0.605	0.624	0.489	0.349	0.436	0.350	0.237	0.337	0.303	0.248	0.284	0.277
Mean KSC18	-0.072	0.288	0.378	0.378	0.453	0.492	0.480	0.419	0.423	0.584	0.643	0.551	0.398	0.518	0.178	0.388	0.791	1.000	0.561	0.658	0.532	0.696	0.533	0.374	0.369	0.308	0.223	0.327	0.285	0.257	0.274	0.268
Mean KSC19	-0.056	0.284	0.289	0.412	0.360	0.441	0.338	0.506	0.570	0.442	0.547	0.630	0.603	0.803	0.210	0.680	0.671	0.561	1.000	0.840	0.836	0.554	0.519	0.407	0.677	0.546	0.348	0.476	0.459	0.343	0.386	0.396
Mean KSC20	-0.058	0.288	0.295	0.400	0.375	0.446	0.354	0.475	0.517	0.463	0.567	0.606	0.522	0.696	0.206	0.559	0.760	0.658	0.840	1.000	0.802	0.654	0.584	0.429	0.560	0.479	0.322	0.455	0.420	0.337	0.371	0.374
Mean KSC21	-0.044	0.242	0.236	0.340	0.292	0.361	0.303	0.421	0.483	0.385	0.474	0.523	0.528	0.663	0.192	0.607	0.605	0.532	0.836	0.802	1.000	0.584	0.592	0.465	0.657	0.597	0.400	0.551	0.517	0.403	0.451	0.452
Mean KSC22	-0.059	0.221	0.252	0.292	0.319	0.356	0.327	0.335	0.355	0.406	0.466	0.428	0.354	0.464	0.147	0.367	0.624	0.696	0.554	0.654	0.584	1.000	0.775	0.519	0.387	0.373	0.263	0.405	0.349	0.336	0.345	0.329
Mean KSC24	-0.064	0.178	0.191	0.249	0.257	0.292	0.263	0.289	0.308	0.321	0.366	0.345	0.322	0.416	0.124	0.352	0.489	0.533	0.519	0.584	0.592	0.775	1.000	0.661	0.389	0.417	0.324	0.496	0.416	0.433	0.443	0.417
Mean KSC25	-0.058	0.121	0.155	0.177	0.177	0.212	0.193	0.236	0.250	0.229	0.277	0.274	0.256	0.328	0.088	0.302	0.349	0.374	0.407	0.429	0.465	0.519	0.661	1.000	0.346	0.400	0.370	0.531	0.442	0.569	0.532	0.470
Mean KSC26	-0.032	0.238	0.204	0.363	0.255	0.332	0.235	0.446	0.531	0.317	0.402	0.474	0.641	0.679	0.482	0.841	0.436	0.369	0.677	0.560	0.657	0.387	0.389	0.346	1.000	0.686	0.474	0.525	0.553	0.366	0.427	0.464
Mean KSC27	-0.029	0.165	0.167	0.243	0.201	0.237	0.181	0.313	0.368	0.238	0.304	0.336	0.443	0.478	0.107	0.556	0.350	0.308	0.546	0.479	0.597	0.373	0.417	0.400	0.686	1.000	0.633	0.700	0.796	0.496	0.578	0.643
Mean KSC28	-0.025	0.124	0.119	0.162	0.149	0.167	0.122	0.213	0.257	0.160	0.203	0.222	0.308	0.311	0.067	0.388	0.237	0.223	0.348	0.322	0.400	0.263	0.324	0.370	0.474	0.633	1.000	0.627	0.747	0.544	0.626	0.719
Mean KSC29	-0.045	0.146	0.145	0.196	0.175	0.210	0.174	0.250	0.298	0.225	0.272	0.282	0.345	0.401	0.095	0.428	0.337	0.327	0.476	0.455	0.551	0.405	0.496	0.531	0.525	0.700	0.627	1.000	0.820	0.709	0.814	0.824
Mean KSC30	-0.038	0.140	0.149	0.198	0.181	0.207	0.162	0.254	0.309	0.208	0.255	0.275	0.371	0.397	0.088	0.451	0.303	0.285	0.459	0.420	0.517	0.349	0.416	0.442	0.553	0.796	0.747	0.820	1.000	0.604	0.716	0.806
Mean KSC31	-0.030	0.120	0.125	0.148	0.139	0.152	0.143	0.192	0.219	0.170	0.200	0.206	0.249	0.280	0.068	0.300	0.248	0.257	0.343	0.337	0.403	0.336	0.433	0.569	0.366	0.496	0.544	0.709	0.604	1.000	0.835	0.720
Mean KSC32	-0.029	0.132	0.135	0.172	0.157	0.179	0.149	0.216	0.248	0.185	0.223	0.232	0.282	0.322	0.079	0.343	0.284	0.274	0.386	0.371	0.451	0.345	0.443	0.532	0.427	0.578	0.626	0.814	0.716	0.835	1.000	0.830
Mean KSC34	-0.037	0.126	0.134	0.176	0.163	0.186	0.153	0.226	0.263	0.189	0.235	0.247	0.305	0.342	0.078	0.374	0.277	0.268	0.396	0.374	0.452	0.329	0.417	0.470	0.464	0.643	0.719	0.824	0.806	0.720	0.830	1.000

Table 2: 1-Minute Mean, Sensor to Lightning Distance Multivariate Correlation

	Dist LM1	Dist LM2	Dist LM4	Dist LM5	Dist LM6	Dist LM7	Dist LM8	Dist LM9	Dist LM10	Dist LM11	Dist LM12	Dist LM13	Dist LM14	Dist LM15	Dist LM16	Dist LM17	Dist LM18	Dist LM19	Dist LM20	Dist LM21	Dist LM22	Dist LM24	Dist LM25	Dist LM26	Dist LM27	Dist LM28	Dist LM29	Dist LM30	Dist LM31	Dist LM32	Dist LM34
Mean KSC1	0.155	0.159	0.152	0.158	0.155	0.161	0.151	0.149	0.158	0.155	0.152	0.147	0.148	0.151	0.144	0.153	0.155	0.147	0.149	0.146	0.151	0.146	0.139	0.142	0.138	0.131	0.136	0.135	0.133	0.133	0.133
Mean KSC2	0.155	0.159	0.156	0.160	0.159	0.164	0.156	0.156	0.162	0.161	0.159	0.155	0.157	0.160	0.155	0.162	0.165	0.159	0.161	0.159	0.164	0.162	0.159	0.154	0.153	0.149	0.154	0.153	0.153	0.153	0.152
Mean KSC4	0.162	0.166	0.160	0.164	0.162	0.167	0.158	0.156	0.164	0.161	0.158	0.153	0.154	0.157	0.150	0.158	0.160	0.153	0.154	0.151	0.154	0.149	0.142	0.148	0.143	0.136	0.141	0.140	0.136	0.137	0.138
Mean KSC5	0.162	0.167	0.163	0.167	0.166	0.171	0.163	0.162	0.169	0.168	0.166	0.161	0.163	0.166	0.160	0.168	0.170	0.164	0.166	0.164	0.169	0.166	0.162	0.159	0.158	0.153	0.158	0.156	0.156	0.156	0.155
Mean KSC6	0.174	0.178	0.175	0.179	0.178	0.182	0.175	0.175	0.181	0.180	0.178	0.174	0.176	0.178	0.173	0.180	0.182	0.177	0.178	0.176	0.180	0.177	0.172	0.172	0.169	0.164	0.169	0.168	0.167	0.167	0.167
Mean KSC7	0.169	0.173	0.172	0.176	0.176	0.180	0.173	0.173	0.179	0.179	0.177	0.173	0.176	0.179	0.174	0.182	0.185	0.179	0.181	0.180	0.186	0.185	0.184	0.174	0.175	0.172	0.177	0.175	0.177	0.177	0.175
Mean KSC8	0.170	0.174	0.170	0.173	0.172	0.175	0.169	0.167	0.173	0.172	0.169	0.165	0.166	0.168	0.163	0.169	0.170	0.165	0.166	0.163	0.166	0.161	0.154	0.161	0.157	0.150	0.154	0.154	0.150	0.151	0.152
Mean KSC9	0.166	0.168	0.165	0.168	0.167	0.169	0.164	0.163	0.168	0.166	0.164	0.161	0.161	0.163	0.159	0.164	0.164	0.160	0.161	0.158	0.159	0.155	0.148	0.157	0.152	0.146	0.149	0.149	0.144	0.146	0.147
Mean KSC10	0.176	0.179	0.177	0.181	0.180	0.183	0.177	0.177	0.183	0.182	0.180	0.176	0.178	0.181	0.175	0.182	0.184	0.179	0.181	0.179	0.183	0.181	0.176	0.175	0.173	0.169	0.174	0.172	0.171	0.172	0.171
Mean KSC11	0.181	0.184	0.182	0.185	0.185	0.187	0.183	0.182	0.187	0.186	0.185	0.182	0.183	0.185	0.181	0.186	0.187	0.183	0.184	0.183	0.185	0.182	0.177	0.180	0.177	0.173	0.176	0.176	0.173	0.174	0.174
Mean KSC12	0.148	0.150	0.149	0.151	0.151	0.152	0.149	0.148	0.152	0.151	0.150	0.147	0.148	0.150	0.146	0.150	0.151	0.148	0.148	0.147	0.147	0.145	0.139	0.145	0.142	0.138	0.140	0.140	0.137	0.138	0.138
Mean KSC13	0.176	0.177	0.174	0.176	0.175	0.177	0.173	0.171	0.175	0.174	0.172	0.169	0.168	0.170	0.166	0.170	0.170	0.166	0.167	0.164	0.164	0.159	0.150	0.163	0.158	0.150	0.154	0.154	0.148	0.150	0.151
Mean KSC14	0.171	0.173	0.172	0.173	0.173	0.174	0.171	0.170	0.174	0.173	0.171	0.169	0.169	0.171	0.167	0.171	0.171	0.168	0.168	0.166	0.167	0.163	0.156	0.165	0.161	0.155	0.158	0.158	0.153	0.155	0.156
Mean KSC15	0.058	0.061	0.060	0.063	0.063	0.066	0.061	0.062	0.066	0.066	0.065	0.063	0.065	0.067	0.064	0.069	0.071	0.068	0.069	0.069	0.073	0.073	0.074	0.065	0.067	0.068	0.070	0.068	0.072	0.071	0.070
Mean KSC16	0.162	0.162	0.161	0.162	0.161	0.161	0.159	0.158	0.160	0.159	0.158	0.155	0.155	0.156	0.152	0.155	0.155	0.152	0.152	0.149	0.148	0.144	0.136	0.150	0.144	0.137	0.140	0.140	0.133	0.136	0.137
Mean KSC17	0.184	0.185	0.186	0.187	0.187	0.188	0.186	0.186	0.189	0.189	0.188	0.186	0.187	0.188	0.185	0.188	0.189	0.187	0.187	0.186	0.186	0.184	0.178	0.184	0.181	0.177	0.180	0.180	0.176	0.177	0.178
Mean KSC18	0.186	0.188	0.189	0.190	0.191	0.191	0.190	0.190	0.193	0.193	0.193	0.190	0.192	0.193	0.190	0.194	0.194	0.193	0.194	0.193	0.194	0.192	0.189	0.190	0.189	0.186	0.189	0.188	0.186	0.187	0.187
Mean KSC19	0.174	0.175	0.175	0.176	0.176	0.176	0.175	0.174	0.176	0.176	0.175	0.173	0.173	0.174	0.171	0.174	0.173	0.172	0.172	0.170	0.169	0.166	0.159	0.170	0.166	0.160	0.162	0.163	0.157	0.159	0.160
Mean KSC20	0.185	0.186	0.187	0.188	0.188	0.187	0.187	0.187	0.189	0.188	0.188	0.186	0.187	0.187	0.185	0.187	0.186	0.186	0.186	0.184	0.183	0.180	0.173	0.183	0.180	0.174	0.177	0.177	0.172	0.173	0.174
Mean KSC21	0.165	0.165	0.166	0.166	0.166	0.165	0.166	0.166	0.166	0.166	0.166	0.165	0.165	0.165	0.164	0.164	0.164	0.164	0.163	0.162	0.160	0.157	0.152	0.162	0.159	0.154	0.155	0.156	0.151	0.152	0.154
Mean KSC22	0.173	0.173	0.175	0.175	0.176	0.175	0.176	0.177	0.177	0.178	0.178	0.177	0.178	0.178	0.177	0.178	0.177	0.178	0.178	0.177	0.176	0.174	0.170	0.177	0.175	0.172	0.173	0.174	0.170	0.171	0.172
Mean KSC24	0.176	0.176	0.179	0.178	0.180	0.177	0.181	0.181	0.179	0.180	0.181	0.181	0.182	0.181	0.181	0.180	0.179	0.181	0.180	0.180	0.177	0.175	0.170	0.181	0.179	0.175	0.176	0.177	0.171	0.173	0.175
Mean KSC25	0.177	0.175	0.180	0.177	0.179	0.174	0.182	0.183	0.177	0.179	0.181	0.183	0.182	0.180	0.184	0.178	0.175	0.181	0.179	0.179	0.173	0.172	0.167	0.183	0.181	0.178	0.176	0.179	0.171	0.174	0.176
Mean KSC26	0.163	0.162	0.161	0.162	0.161	0.160	0.160	0.158	0.160	0.159	0.158	0.156	0.155	0.155	0.153	0.154	0.153	0.152	0.151	0.149	0.147	0.142	0.134	0.150	0.144	0.137	0.139	0.140	0.133	0.135	0.137
Mean KSC27	0.164	0.163	0.164	0.163	0.163	0.160	0.163	0.162	0.161	0.160	0.161	0.160	0.158	0.158	0.158	0.156	0.154	0.155	0.154	0.152	0.148	0.144	0.137	0.155	0.149	0.142	0.143	0.145	0.136	0.139	0.141
Mean KSC28	0.152	0.148	0.151	0.148	0.149	0.144	0.150	0.149	0.145	0.145	0.146	0.147	0.144	0.143	0.145	0.140	0.138	0.140	0.139	0.137	0.132	0.128	0.121	0.141	0.135	0.129	0.129	0.131	0.122	0.125	0.127
Mean KSC29	0.167	0.164	0.168	0.165	0.166	0.162	0.168	0.168	0.164	0.164	0.166	0.167	0.165	0.164	0.165	0.161	0.159	0.162	0.160	0.159	0.154	0.151	0.144	0.163	0.158	0.152	0.152	0.154	0.146	0.148	0.151
Mean KSC30	0.161	0.158	0.161	0.158	0.159	0.155	0.160	0.159	0.157	0.156	0.157	0.158	0.156	0.155	0.156	0.152	0.150	0.153	0.151	0.150	0.145	0.141	0.134	0.153	0.147	0.141	0.141	0.144	0.135	0.138	0.140
Mean KSC31	0.152	0.149	0.153	0.149	0.151	0.145	0.153	0.153	0.148	0.149	0.150	0.153	0.150	0.148	0.151	0.145	0.142	0.147	0.145	0.144	0.138	0.135	0.129	0.149	0.144	0.140	0.138	0.141	0.132	0.135	0.137
Mean KSC32	0.162	0.159	0.163	0.160	0.161	0.155	0.163	0.163	0.158	0.159	0.160	0.162	0.160	0.158	0.161	0.155	0.152	0.156	0.154	0.153	0.147	0.144	0.136	0.158	0.152	0.146	0.145	0.148	0.138	0.141	0.144
Mean KSC34	0.158	0.155	0.158	0.155	0.156	0.152	0.157	0.156	0.153	0.153	0.153	0.155	0.152	0.151	0.152	0.148	0.146	0.149	0.147	0.145	0.140	0.137	0.130	0.149	0.143	0.137	0.137	0.139	0.130	0.133	0.135

4.3.2 Threshold Analysis to Predict Storms Onset and Cessation

A primary objective of this research was to determine if there exists a threshold value for EFM sensor readings that accurately predicts storm onset, 30 minutes prior to the first lightning strike, and a separate threshold for storm cessation, 15 minutes after the last lightning strike of the storm. As the next few figures show, the ability to predict storms using threshold analysis is inversely proportional to the ability to predict periods of no storms. As the threshold value increases from 100, more 1-minute mean EFM reading time-segments fall below the threshold value. Figure 14 shows a knee in the curve between 300 and 400 V/m. This is the first point of interest for further analysis. At 1300 V/m the true negative (TN) prediction reaches 99.5% accuracy. However, the desire is to predict lightning. The best lightning prediction occurs at a threshold of only 100 V/m with a true positive (TP) accuracy of 74%, while the TN rate is just under 18%. This serves little to no utility to a user. False negative (FN) rates were also considered. Since false negative reporting poses a dangerous scenario for range users it is of great interest to minimize. However, the FN rate gets worse as the threshold value increases, so there is no utility in this value, either. The 15-minute cessation threshold follows suit showing best prediction rate at 100 V/m, which serves no useful utility. Figure 15 shows prediction accuracy in response to prediction time; the assumption that prediction accuracy would be better with times closer to a lightning strike. However, Figure 15 shows only a slight increase in prediction accuracy for a TP result from the desired 30-minute prediction interval.

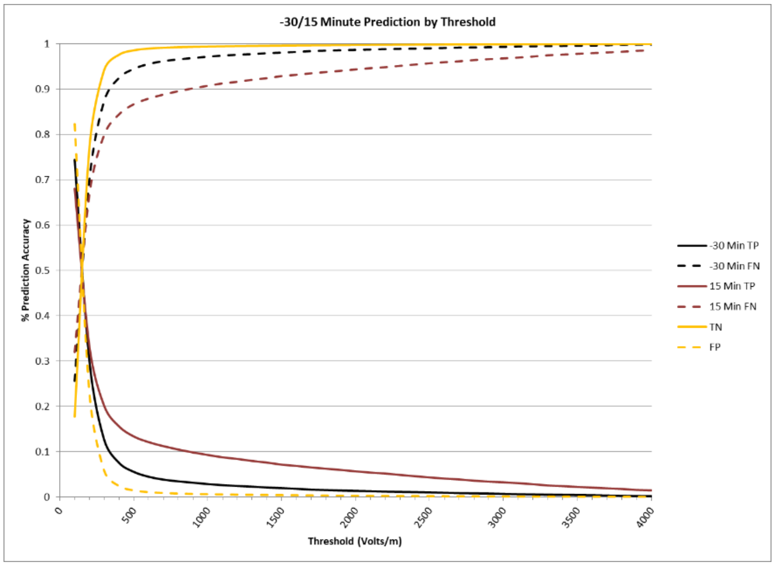


Figure 14: Storm Onset & Cessation Threshold Accuracy

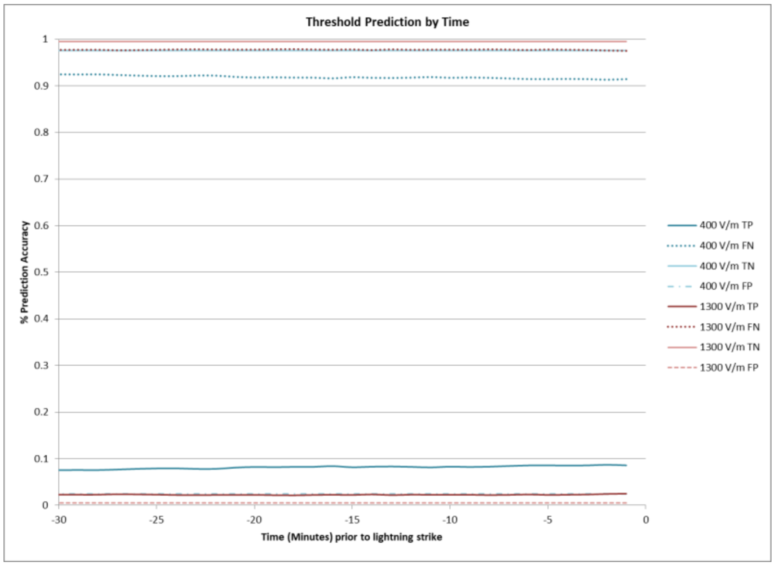


Figure 15: Threshold Prediction Accuracy by Time

Figure 16 shows using the centered mean sensor readings gave less accurate results than the individual sensor counts. The knee now occurs at 300 V/m. The TP storm onset prediction accuracy at 100 V/m is 20% and decreased with increasing threshold. The TN rate reaches 99.5% accuracy at 1400 V/m. There is a more pronounced difference in varying time interval of the prediction as shown in Figure 17, however the accuracy for TP predictions are still poor.

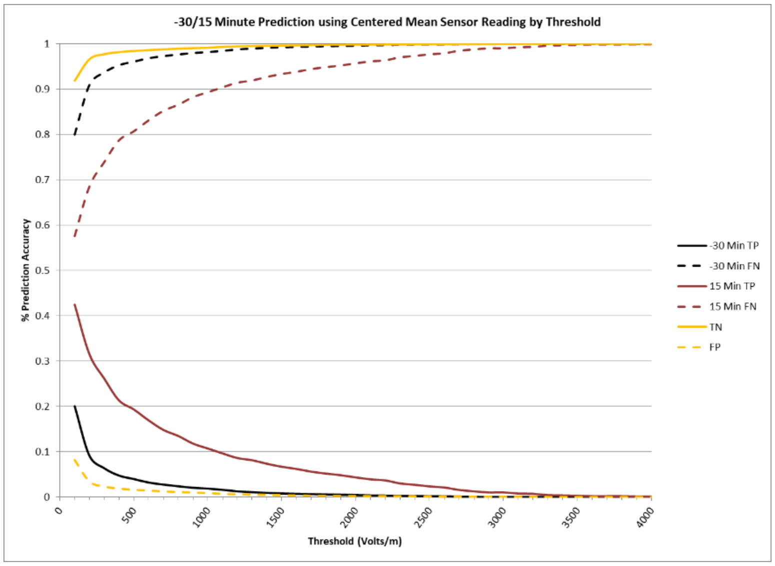


Figure 16: Storm Onset & Cessation Threshold Accuracy using Centered Mean Sensor Readings

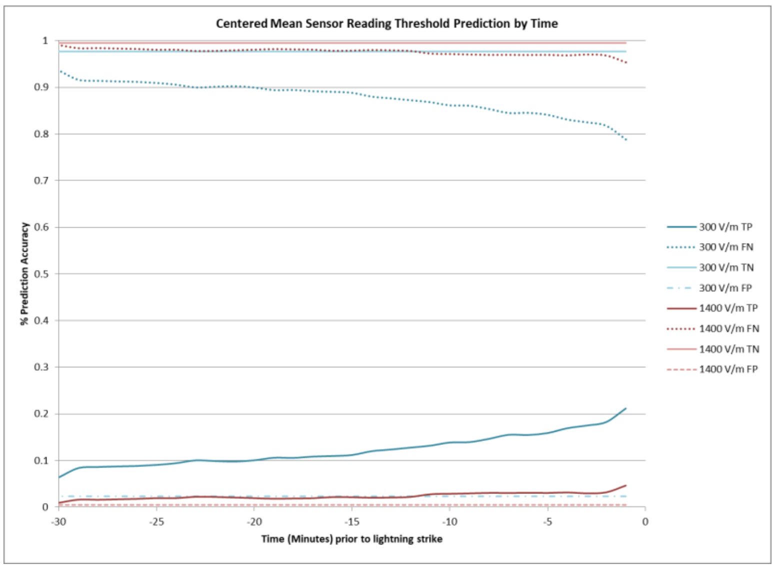


Figure 17: Centered Mean Sensor Threshold Prediction Accuracy by Time

Using the centered geometric mean sensor readings gave less accurate results than previous two threshold models, Figure 18. The knee occurs at 300 V/m. The TP storm onset prediction accuracy at 100 V/m is 11% and decreases as threshold increases. The TN rate reaches 99.5% accuracy at 900 V/m. There is a more pronounced difference in varying time interval of the prediction as shown in Figure 19, however the accuracy for TP predictions are not useful.

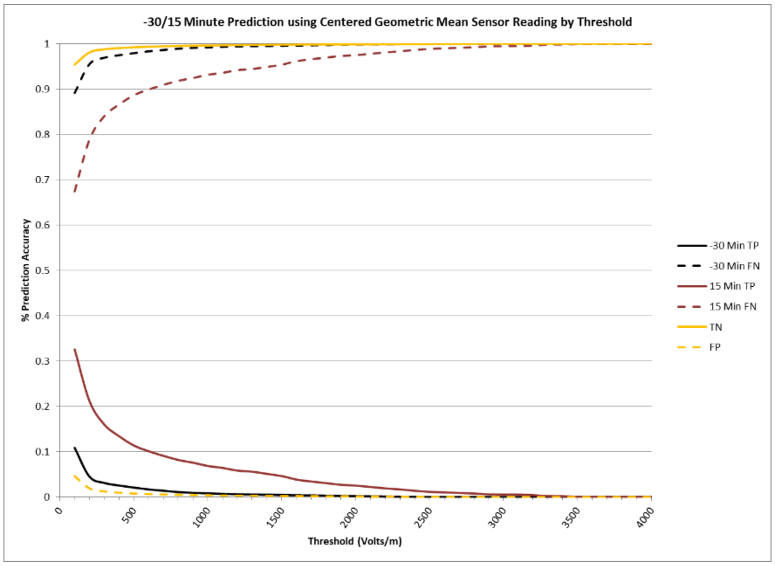


Figure 18: Storm Onset & Cessation Threshold Accuracy using Centered Geometric Mean Sensor Readings

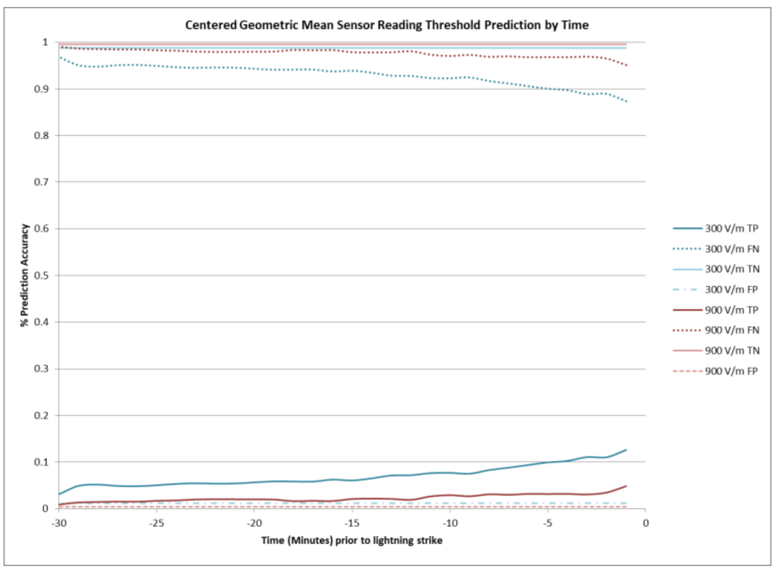


Figure 19: Centered Geometric Mean Sensor Threshold Prediction Accuracy by Time

Performing the same threshold analysis by a binary storm response rather than time response provided slightly better utility in predicting no-storm TN. Figure 20 shows the threshold for 95% (note: this differs from previous TN threshold accuracy of 99.5%) occurs at 2100 V/m, while the best TP accuracy occurs at 100 V/m with an accuracy of 55%.

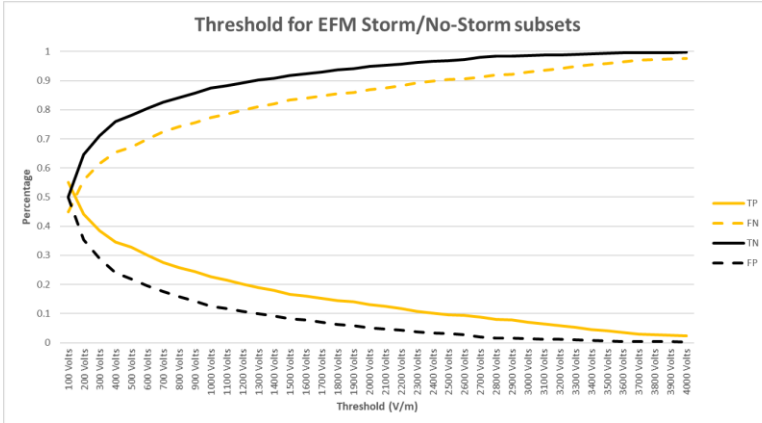


Figure 20: Storm Onset & Cessation Threshold Accuracy by Binary Storm Response

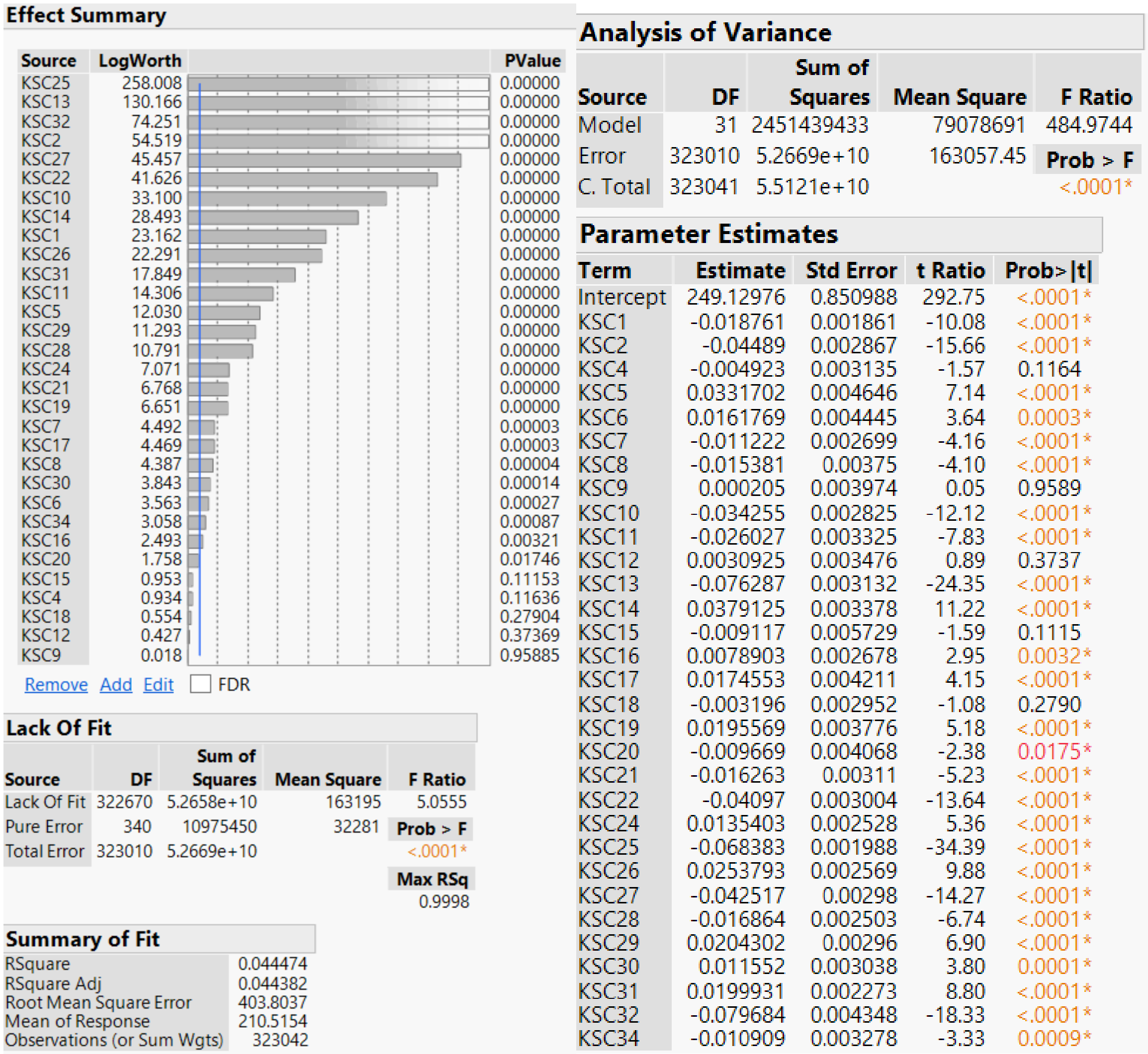
The threshold analysis did not provide a useful result through any of the four methods provided for either storm prediction or storm cessation. The TP accuracy for storm onset for the All Sensors model is 74.39%, while the storm cessation accuracy is 68.02% at 100 V/m thresholds for both.

Table 3: Threshold Analysis Utility

	TP "Best" Threshold (V/m)	TP Accuracy	TN 99.5% Threshold (V/m)
All Sensors	100	0.74	1300
Mean	100	0.20	1400
Geo Mean	100	0.11	900
Binary Storm	100	0.55	2100 (95%)

4.3.3 Standard Least Squares Regression Models to Predict Storms

This section of analysis used least squares regression to predict lightning activity given EFM sensor readings. Three models were built, the first using all EFM sensor readings to predict a single lightning end time response variable, followed by the centered mean EFM readings and the centered geometric mean EFM readings to predict the same single lightning end time response variable. The first model produced does not perform well (see Figure 21). The R^2 and R^2_{adj} are quite low with a value of around 0.0444. This is not a good model. Other insights gleaned from the output in Figure 21 were that sensors 4, 9, 12, 15 and 18 are not significant to the model.



Effect Summary

Source	LogWorth	PValue
KSC25	258.008	0.00000
KSC13	130.166	0.00000
KSC32	74.251	0.00000
KSC2	54.519	0.00000
KSC27	45.457	0.00000
KSC22	41.626	0.00000
KSC10	33.100	0.00000
KSC14	28.493	0.00000
KSC1	23.162	0.00000
KSC26	22.291	0.00000
KSC31	17.849	0.00000
KSC11	14.306	0.00000
KSC5	12.030	0.00000
KSC29	11.293	0.00000
KSC28	10.791	0.00000
KSC24	7.071	0.00000
KSC21	6.768	0.00000
KSC19	6.651	0.00000
KSC7	4.492	0.00003
KSC17	4.469	0.00003
KSC8	4.387	0.00004
KSC30	3.843	0.00014
KSC6	3.563	0.00027
KSC34	3.058	0.00087
KSC16	2.493	0.00321
KSC20	1.758	0.01746
KSC15	0.953	0.11153
KSC4	0.934	0.11636
KSC18	0.554	0.27904
KSC12	0.427	0.37369
KSC9	0.018	0.95885

Remove Add Edit FDR

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	322670	5.2658e+10	163195	5.0555
Pure Error	340	10975450	32281	Prob > F
Total Error	323010	5.2669e+10		<.0001*
				Max RSq
				0.9998

Summary of Fit

RSquare	0.044474
RSquare Adj	0.044382
Root Mean Square Error	403.8037
Mean of Response	210.5154
Observations (or Sum Wgts)	323042

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	31	2451439433	79078691	484.9744
Error	323010	5.2669e+10	163057.45	Prob > F
C. Total	323041	5.5121e+10		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	249.12976	0.850988	292.75	<.0001*
KSC1	-0.018761	0.001861	-10.08	<.0001*
KSC2	-0.04489	0.002867	-15.66	<.0001*
KSC4	-0.004923	0.003135	-1.57	0.1164
KSC5	0.0331702	0.004646	7.14	<.0001*
KSC6	0.0161769	0.004445	3.64	0.0003*
KSC7	-0.011222	0.002699	-4.16	<.0001*
KSC8	-0.015381	0.00375	-4.10	<.0001*
KSC9	0.000205	0.003974	0.05	0.9589
KSC10	-0.034255	0.002825	-12.12	<.0001*
KSC11	-0.026027	0.003325	-7.83	<.0001*
KSC12	0.0030925	0.003476	0.89	0.3737
KSC13	-0.076287	0.003132	-24.35	<.0001*
KSC14	0.0379125	0.003378	11.22	<.0001*
KSC15	-0.009117	0.005729	-1.59	0.1115
KSC16	0.0078903	0.002678	2.95	0.0032*
KSC17	0.0174553	0.004211	4.15	<.0001*
KSC18	-0.003196	0.002952	-1.08	0.2790
KSC19	0.0195569	0.003776	5.18	<.0001*
KSC20	-0.009669	0.004068	-2.38	0.0175*
KSC21	-0.016263	0.00311	-5.23	<.0001*
KSC22	-0.04097	0.003004	-13.64	<.0001*
KSC24	0.0135403	0.002528	5.36	<.0001*
KSC25	-0.068383	0.001988	-34.39	<.0001*
KSC26	0.0253793	0.002569	9.88	<.0001*
KSC27	-0.042517	0.00298	-14.27	<.0001*
KSC28	-0.016864	0.002503	-6.74	<.0001*
KSC29	0.0204302	0.00296	6.90	<.0001*
KSC30	0.011552	0.003038	3.80	0.0001*
KSC31	0.0199931	0.002273	8.80	<.0001*
KSC32	-0.079684	0.004348	-18.33	<.0001*
KSC34	-0.010909	0.003278	-3.33	0.0009*

Figure 21: Least Squares Regression Model for All Sensor Readings by Storm Response

The next least squares regression model used the centered mean EFM readings as the independent variable with lightning end time as the response, Figure 22. This model performed much better than the previous, however an R^2 and R_{adj}^2 of 0.167 was still too low. There were no insignificant parameters within the model.

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	730228	1.0834e+11	148367	3.1716
Pure Error	707	33073000	46779	Prob > F
Total Error	730935	1.0837e+11		<.0001*
				Max RSq
				0.9997

Summary of Fit

RSquare	0.167218
RSquare Adj	0.167217
Root Mean Square Error	385.0568
Mean of Response	217.1515
Observations (or Sum Wgts)	730937

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	2.1761e+10	2.176e+10	146767.5
Error	730935	1.0837e+11	148268.74	Prob > F
C. Total	730936	1.3014e+11		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	154.47284	0.479182	322.37	<.0001*
Mean	0.4094504	0.001069	383.10	<.0001*

Effect Tests

Prediction Expression

154.47283854 + 0.4094504449 • Centered Mean

Figure 22: Least Squares Regression Model for Centered Mean by Storm Response

The final least squares regression model produced used the centered geometric mean EFM readings as the independent variable with lightning end time as the response, Figure 23. This model performed much better than the first model, but not quite as well as the model based on centered mean. The R^2 and R^2_{adj} for this model were 0.139. As in the previous model, this was too low for the model to be of any utility. There were no insignificant parameters within the model.

Lack Of Fit

Source	DF	Sum of Squares	Mean Square	F Ratio
Lack Of Fit	730295	1.1201e+11	153377	3.4300
Pure Error	640	28618900	44717	Prob > F
Total Error	730935	1.1204e+11		<.0001*
				Max RSq
				0.9998

Summary of Fit

RSquare	0.13906
RSquare Adj	0.139058
Root Mean Square Error	391.5125
Mean of Response	217.1515
Observations (or Sum Wgts)	730937

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	1.8097e+10	1.81e+10	118061.0
Error	730935	1.1204e+11	153282.05	Prob > F
C. Total	730936	1.3014e+11		<.0001*

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	167.57065	0.480134	349.01	<.0001*
Centered GeoMean	0.4624556	0.001346	343.60	<.0001*

Effect Tests

Prediction Expression

167.57064734 + 0.4624555694 • Centered GeoMean

Figure 23: Least Squares Regression for Centered Geometric Mean by Storm Response

The method of least square regression model fitting did not produce a viable model that could account for a majority of the variability in the dataset. Table 4 gives a summary of the measured R^2 for each of the three models produced. The best performing model was the one that used a single centered mean EFM reading as the independent variable.

Table 4: Least Squares Regression Model Fit Value

	R^2	R^2_{adj}
All Sensors	0.0445	0.0444
Mean	0.1672	0.1672
Geo Mean	0.1391	0.1391

Since the storm times were not modeled through the techniques attempted so far, NLR models were considered to predict a binary response corresponding to storm and no-storm events in the next section.

4.3.4 Nominal Logistic Regression Model to Predict Storms

Nominal logistic regression (NLR) models, a subset of categorical regression models, are useful for binary response variables. For these cases a storm, binary (1000), was the interval 30 minutes prior to the first lightning strike and 15 minutes after the last lightning strike. No-storm, binary (0), was the interval 15 minutes after the last lightning strike of a storm and 30 minutes before the first lightning strike of the next storm. Figure 24, shows an example output of the nominal logistic fit analysis provided by JMP using the centered mean EFM sensor readings for the independent variable and the binary storm response for a storm occurring anywhere on KSC. Items of interest from this output were the R^2 value and the prediction test offered by the confusion matrix. The NLR model ran with all EFM sensor readings as the independent variables and a binary storm response for each sensor location. Appendix F provides the JMP output for each of the 31 models.

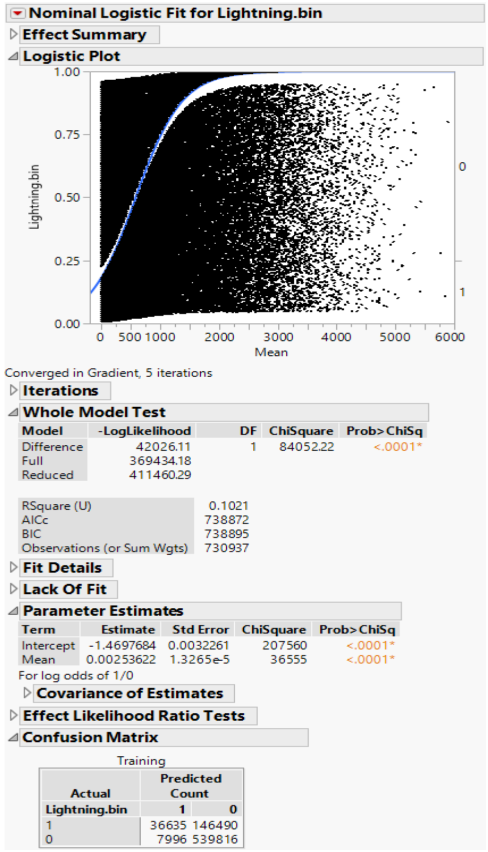


Figure 24: Logistic Regression Analysis EFM Centered Mean by Binary Storm Response

The prediction accuracy for TP, FN, TN, and FP, along with the R^2 for the NLR model produced for each sensor location are reported in Figure 25 where the numbers 1:34 along the bottom of the graph represent sensor numbers; 35 is a recording of the NLR shown in Figure 25. The nominal regression model did well in predicting a TN response for when there are no storms at a rate of 99.7%, but performed poorly in predicting TP for when storms occur at an average rate of around 9.4%. The R^2 values for the models range from around 0.04 to 0.16 for the individual sensor locations and 0.10 for the centered mean model.

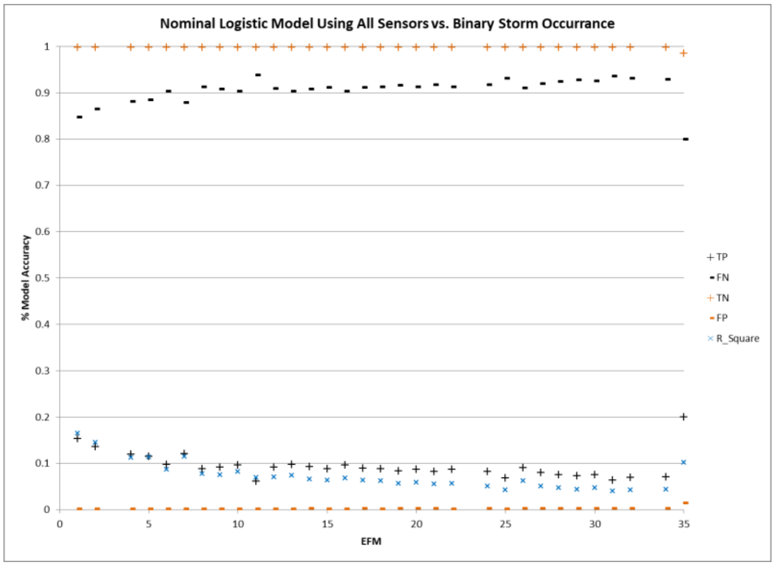


Figure 25: Logistic Regression Analysis EFM Sensor by Binary Storm Response

The nominal logistic regression models were good predictors of no-storm events, and minimized reporting storms when no storms are present (FP rate). However, they were not useful in predicting storms and only accounted for up to 16% of the variance in the dataset. The next section explores a set of models using a count time series regression technique.

4.3.5 Negative Binomial Regression to Predict End of Storms

In negative binomial regression the dependent variable is a count of a certain number of events. In setting up the models to predict the end of a lightning storm the time remaining until the end of the storm, in minutes, for each sensor location was the count parameter. The independent variables were the 1-minute mean EFM sensor readings. The working data was subset to only include storm data for each sensor. JMP generated the negative binomial regression model for each sensor (SAS Institute Inc., 2019). Appendix G displays the models. Figure 26 shows an example of the JMP output for a negative binomial regression model for storms occurring over the 5 nautical mile radial area around EFM sensor 1. These models and in

Figure 26 and Appendix G show there are several parameters that are not significant in the models.

Generalized Regression for lightning.end.1 BySensor=1

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	27652
Sum of Frequencies	9704
-LogLikelihood	50155.066
Number of Parameters	33
BIC	100613.08
AICc	100376.36
Generalized RSquare	0.04599

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-6.096e-6	6.6515e-6	0.8398706	0.3594	-1.913e-5	6.941e-6
KSC2	-4.934e-5	1.0542e-5	21.906621	<.0001*	-0.00007	-2.868e-5
KSC4	-0.000013	1.0378e-5	1.5739139	0.2096	-3.336e-5	7.3209e-6
KSC5	-0.000058	1.5614e-5	13.777185	0.0002*	-8.856e-5	-2.735e-5
KSC6	4.7168e-5	1.4971e-5	9.9265675	0.0016*	1.7826e-5	7.651e-5
KSC7	-5.402e-6	1.0413e-5	0.2691357	0.6039	-2.581e-5	0.000015
KSC8	-9.521e-6	1.2181e-5	0.6109303	0.4344	-3.34e-5	1.4354e-5
KSC9	-1.847e-5	1.2639e-5	2.135389	0.1439	-4.324e-5	6.3029e-6
KSC10	1.8383e-5	1.0236e-5	3.2254041	0.0725	-1.679e-6	3.8445e-5
KSC11	-5.654e-5	1.1253e-5	25.245355	<.0001*	-7.86e-5	-3.448e-5
KSC12	6.5581e-5	1.1469e-5	32.697204	<.0001*	0.0000431	8.806e-5
KSC13	-2.284e-5	1.0211e-5	5.0013879	0.0253*	-4.285e-5	-2.822e-6
KSC14	0.000027	1.184e-5	5.2034433	0.0225*	3.8023e-6	5.0215e-5
KSC15	-5.562e-5	2.035e-5	7.4702088	0.0063*	-9.55e-5	-1.573e-5
KSC16	0.0000267	9.1966e-6	8.4329064	0.0037*	8.6814e-6	4.4731e-5
KSC17	-2.67e-5	1.563e-5	2.9170244	0.0876	-5.733e-5	3.9393e-6
KSC18	7.1899e-6	1.0959e-5	0.4304276	0.5118	-1.429e-5	2.8669e-5
KSC19	-2.073e-5	1.2854e-5	2.6012773	0.1068	-0.000046	4.462e-6
KSC20	-2.486e-5	1.4531e-5	2.9276345	0.0871	-5.334e-5	3.6173e-6
KSC21	7.3707e-6	1.1414e-5	0.4170292	0.5184	-0.000015	2.9741e-5
KSC22	1.0883e-5	1.1322e-5	0.9238568	0.3365	-1.131e-5	3.3074e-5
KSC24	-0.000017	1.0456e-5	2.674267	0.1020	-3.759e-5	3.3945e-6
KSC25	-2.382e-5	8.0806e-6	8.6879984	0.0032*	-3.966e-5	-7.98e-6
KSC26	-3.269e-5	9.131e-6	12.816003	0.0003*	-5.059e-5	-1.479e-5
KSC27	5.397e-5	1.1028e-5	23.951853	<.0001*	3.2356e-5	7.5584e-5
KSC28	2.4326e-5	9.2022e-6	6.987813	0.0082*	6.2896e-6	4.2362e-5
KSC29	5.0743e-5	1.0638e-5	22.751952	<.0001*	0.0000299	0.0000716
KSC30	-3.719e-5	1.0737e-5	11.999964	0.0005*	-5.824e-5	-1.615e-5
KSC31	-5.086e-6	8.142e-6	0.3901806	0.5322	-0.000021	1.0872e-5
KSC32	1.8849e-5	1.5315e-5	1.5147934	0.2184	-1.117e-5	4.8865e-5
KSC34	-3.115e-5	1.1386e-5	7.4843253	0.0062*	-5.347e-5	-8.833e-6

Figure 26: NB Regression to Predict Lightning Cessation by Sensor Location

The R^2 values for these models range from 0.008 to a maximum 0.046. Figure 27 shows these values plotted as a bar graph.

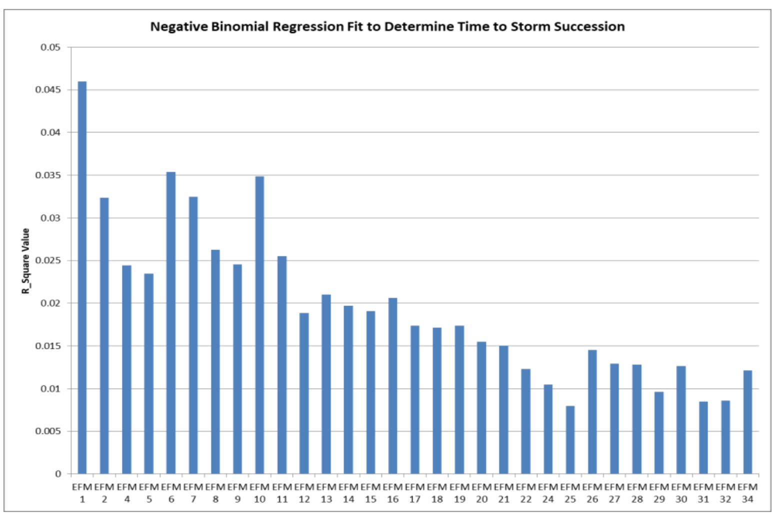


Figure 27: Negative Binomial Regression Fit to Predict Storm Cessation

The negative binomial regression model did not prove to have any utility in predicting the end of a storm based given the EFM sensor reading input. The negative binomial regression model was by far the worst performing of the different regression techniques applied for this time series dataset. The next section explores the EFM variance and its correlation properties to determine if they would be a better parameter to use in estimating lightning response.

4.3.6 Consideration for EFM Variance Instead of Mean

Analysis considered the 1-minute variance for each of the 31 EFM sensors using the multivariate correlation technique previously applied to the 1-minute mean EFM sensor readings. Table 5 shows that the EFM sensors within close proximity to others have higher correlation than those further away, however the correlations did not extend as far away as they did for the 1-minute mean EFM sensor comparisons. Table 6 compares the 1-minute variance for each EFM sensor with the minimum distance of lightning from a sensor location. As with the 1-minute mean sensor comparisons, there is little to no correlation between the EFM variance readings and lightning activity.

Table 5: 1-Minute Mean, Sensor to Sensor Multivariate Correlation

	var KSC1	var KSC2	var KSC4	var KSC5	var KSC6	var KSC7	var KSC8	var KSC9	var KSC10	var KSC11	var KSC12	var KSC13	var KSC14	var KSC15	var KSC16	var KSC17	var KSC18	var KSC19	var KSC20	var KSC21	var KSC22	var KSC24	var KSC25	var KSC26	var KSC27	var KSC28	var KSC29	var KSC30	var KSC31	var KSC32	var KSC34
var KSC1	1.000	0.734	0.718	0.648	0.687	0.507	0.549	0.415	0.531	0.494	0.429	0.304	0.343	0.051	0.238	0.346	0.313	0.273	0.287	0.213	0.217	0.191	0.152	0.202	0.149	0.095	0.141	0.125	0.123	0.117	0.022
var KSC2	0.734	1.000	0.547	0.776	0.655	0.748	0.449	0.336	0.644	0.494	0.382	0.250	0.274	0.045	0.186	0.303	0.343	0.228	0.249	0.189	0.218	0.185	0.137	0.159	0.123	0.082	0.118	0.107	0.109	0.103	0.021
var KSC4	0.718	0.547	1.000	0.629	0.831	0.432	0.839	0.678	0.563	0.588	0.582	0.474	0.472	0.064	0.371	0.391	0.348	0.340	0.345	0.253	0.262	0.223	0.152	0.272	0.170	0.113	0.151	0.142	0.123	0.122	0.029
var KSC5	0.648	0.776	0.629	1.000	0.793	0.711	0.550	0.429	0.778	0.646	0.499	0.315	0.339	0.059	0.227	0.375	0.416	0.278	0.309	0.226	0.260	0.207	0.130	0.183	0.130	0.084	0.124	0.115	0.109	0.103	0.023
var KSC6	0.687	0.655	0.831	0.793	1.000	0.617	0.798	0.650	0.818	0.793	0.683	0.490	0.480	0.074	0.337	0.445	0.469	0.380	0.393	0.303	0.302	0.260	0.168	0.266	0.180	0.120	0.169	0.157	0.138	0.137	0.032
var KSC7	0.507	0.748	0.432	0.711	0.617	1.000	0.404	0.325	0.756	0.578	0.416	0.255	0.289	0.054	0.203	0.391	0.478	0.256	0.306	0.221	0.301	0.235	0.170	0.170	0.131	0.096	0.128	0.120	0.133	0.118	0.023
var KSC8	0.549	0.449	0.839	0.550	0.798	0.404	1.000	0.893	0.570	0.653	0.724	0.668	0.626	0.084	0.506	0.413	0.394	0.459	0.432	0.358	0.294	0.266	0.191	0.384	0.257	0.174	0.215	0.212	0.178	0.177	0.051
var KSC9	0.415	0.336	0.678	0.429	0.650	0.325	0.893	1.000	0.478	0.589	0.743	0.809	0.726	0.087	0.630	0.402	0.373	0.516	0.459	0.407	0.289	0.268	0.193	0.476	0.315	0.205	0.247	0.252	0.201	0.202	0.059
var KSC10	0.531	0.644	0.563	0.778	0.818	0.756	0.570	0.478	1.000	0.853	0.635	0.370	0.426	0.081	0.285	0.542	0.602	0.372	0.430	0.316	0.366	0.296	0.201	0.238	0.183	0.120	0.177	0.165	0.162	0.151	0.032
var KSC11	0.494	0.494	0.588	0.646	0.793	0.578	0.653	0.589	0.853	1.000	0.831	0.478	0.567	0.108	0.363	0.669	0.665	0.492	0.550	0.404	0.428	0.355	0.246	0.303	0.229	0.152	0.221	0.205	0.200	0.189	0.045
var KSC12	0.429	0.382	0.582	0.499	0.683	0.416	0.724	0.743	0.635	0.831	1.000	0.634	0.747	0.122	0.506	0.631	0.559	0.602	0.608	0.475	0.400	0.353	0.255	0.409	0.298	0.196	0.266	0.253	0.220	0.223	0.062
var KSC13	0.304	0.250	0.474	0.315	0.490	0.255	0.668	0.809	0.370	0.478	0.634	1.000	0.800	0.175	0.784	0.372	0.331	0.604	0.497	0.485	0.279	0.280	0.204	0.627	0.415	0.276	0.301	0.323	0.234	0.244	0.078
var KSC14	0.343	0.274	0.472	0.339	0.480	0.289	0.626	0.726	0.426	0.567	0.747	0.800	1.000	0.116	0.829	0.546	0.457	0.830	0.714	0.679	0.409	0.395	0.283	0.719	0.501	0.323	0.398	0.405	0.301	0.321	0.089
var KSC15	0.051	0.045	0.064	0.059	0.074	0.054	0.084	0.087	0.081	0.108	0.122	0.175	0.116	1.000	0.081	0.112	0.091	0.112	0.112	0.094	0.074	0.065	0.045	0.073	0.055	0.034	0.049	0.047	0.039	0.041	0.010
var KSC16	0.238	0.186	0.371	0.227	0.337	0.203	0.506	0.630	0.285	0.363	0.506	0.784	0.829	0.081	1.000	0.347	0.303	0.702	0.546	0.599	0.306	0.323	0.235	0.863	0.590	0.384	0.409	0.462	0.295	0.321	0.100
var KSC17	0.346	0.303	0.391	0.375	0.445	0.391	0.413	0.402	0.542	0.669	0.631	0.372	0.546	0.112	0.347	1.000	0.768	0.601	0.706	0.539	0.586	0.446	0.294	0.336	0.282	0.185	0.277	0.249	0.242	0.238	0.058
var KSC18	0.313	0.343	0.348	0.416	0.469	0.478	0.394	0.373	0.602	0.665	0.559	0.331	0.457	0.091	0.303	0.768	1.000	0.503	0.648	0.473	0.710	0.501	0.319	0.289	0.251	0.175	0.274	0.234	0.244	0.239	0.049
var KSC19	0.273	0.228	0.340	0.278	0.380	0.256	0.459	0.516	0.372	0.492	0.602	0.604	0.830	0.112	0.702	0.601	0.503	1.000	0.890	0.893	0.526	0.524	0.364	0.735	0.599	0.378	0.509	0.509	0.380	0.405	0.109
var KSC20	0.287	0.249	0.345	0.309	0.393	0.306	0.432	0.459	0.430	0.550	0.608	0.497	0.714	0.112	0.546	0.706	0.648	0.890	1.000	0.869	0.666	0.606	0.402	0.579	0.504	0.325	0.479	0.449	0.380	0.394	0.098
var KSC21	0.213	0.189	0.253	0.226	0.303	0.221	0.358	0.407	0.316	0.404	0.475	0.485	0.679	0.094	0.599	0.539	0.473	0.893	0.869	1.000	0.574	0.613	0.445	0.695	0.659	0.439	0.612	0.593	0.452	0.488	0.124
var KSC22	0.217	0.218	0.262	0.260	0.302	0.301	0.294	0.289	0.366	0.428	0.400	0.279	0.409	0.074	0.306	0.586	0.710	0.526	0.666	0.574	1.000	0.802	0.497	0.326	0.330	0.249	0.391	0.325	0.352	0.348	0.068
var KSC24	0.191	0.185	0.223	0.207	0.260	0.235	0.266	0.268	0.296	0.355	0.353	0.280	0.395	0.065	0.323	0.446	0.501	0.524	0.606	0.613	0.802	1.000	0.725	0.371	0.414	0.335	0.537	0.443	0.481	0.475	0.093
var KSC25	0.152	0.137	0.152	0.130	0.168	0.170	0.191	0.193	0.201	0.246	0.255	0.204	0.283	0.045	0.235	0.294	0.319	0.364	0.402	0.445	0.497	0.725	1.000	0.284	0.370	0.348	0.565	0.451	0.644	0.585	0.103
var KSC26	0.202	0.159	0.272	0.183	0.266	0.170	0.384	0.476	0.238	0.303	0.409	0.627	0.719	0.073	0.863	0.336	0.289	0.735	0.579	0.695	0.326	0.371	0.284	1.000	0.757	0.467	0.533	0.604	0.358	0.408	0.115
var KSC27	0.149	0.123	0.170	0.130	0.180	0.131	0.257	0.315	0.183	0.229	0.298	0.415	0.501	0.055	0.590	0.282	0.251	0.599	0.504	0.659	0.330	0.414	0.370	0.757	1.000	0.676	0.713	0.845	0.510	0.598	0.161
var KSC28	0.095	0.082	0.113	0.084	0.120	0.096	0.174	0.205	0.120	0.152	0.196	0.276	0.323	0.034	0.384	0.185	0.175	0.378	0.325	0.439	0.249	0.335	0.348	0.467	0.676	1.000	0.696	0.836	0.592	0.704	0.177
var KSC29	0.141	0.118	0.151	0.124	0.169	0.128	0.215	0.247	0.177	0.221	0.266	0.301	0.398	0.049	0.409	0.277	0.274	0.509	0.479	0.612	0.391	0.537	0.565	0.533	0.713	0.696	1.000	0.870	0.742	0.851	0.179
var KSC30	0.125	0.107	0.142	0.115	0.157	0.120	0.212	0.252	0.165	0.205	0.253	0.323	0.405	0.047	0.462	0.249	0.234	0.509	0.449	0.593	0.325	0.443	0.451	0.604	0.845	0.836	0.870	1.000	0.656	0.779	0.186
var KSC31	0.123	0.109	0.123	0.109	0.138	0.133	0.178	0.201	0.162	0.200	0.220	0.234	0.301	0.039	0.295	0.242	0.244	0.380	0.380	0.452	0.352	0.481	0.644	0.358	0.510	0.592	0.742	0.656	1.000	0.873	0.169
var KSC32	0.117	0.103	0.122	0.103	0.137	0.118	0.177	0.202	0.151	0.189	0.223	0.244	0.321	0.041	0.321	0.238	0.239	0.405	0.394	0.488	0.348	0.475	0.585	0.408	0.598	0.704	0.851	0.779	0.873	1.000	0.184
var KSC34	0.022	0.021	0.029	0.023	0.032	0.023	0.051	0.059	0.032	0.045	0.062	0.078	0.089	0.010	0.100	0.058	0.049	0.109	0.098	0.124	0.068	0.093	0.103	0.115	0.161	0.177	0.179	0.186	0.169	0.184	1.000

Table 6: 1-Minute Variance, Sensor to Lightning Distance Multivariate Correlation

	Dist LM1	Dist LM2	Dist LM4	Dist LM5	Dist LM6	Dist LM7	Dist LM8	Dist LM9	Dist LM10	Dist LM11	Dist LM12	Dist LM13	Dist LM14	Dist LM15	Dist LM16	Dist LM17	Dist LM18	Dist LM19	Dist LM20	Dist LM21	Dist LM22	Dist LM24	Dist LM25	Dist LM26	Dist LM27	Dist LM28	Dist LM29	Dist LM30	Dist LM31	Dist LM32	Dist LM34
var KSC1	-0.136	-0.140	-0.135	-0.139	-0.137	-0.142	-0.134	-0.133	-0.139	-0.138	-0.135	-0.132	-0.133	-0.135	-0.130	-0.136	-0.138	-0.132	-0.134	-0.131	-0.135	-0.132	-0.127	-0.129	-0.126	-0.121	-0.125	-0.124	-0.122	-0.123	-0.123
var KSC2	-0.157	-0.162	-0.157	-0.162	-0.160	-0.165	-0.157	-0.156	-0.163	-0.162	-0.159	-0.155	-0.157	-0.159	-0.153	-0.161	-0.164	-0.157	-0.159	-0.157	-0.162	-0.159	-0.154	-0.153	-0.151	-0.146	-0.151	-0.150	-0.149	-0.149	-0.149
var KSC4	-0.140	-0.144	-0.139	-0.143	-0.141	-0.145	-0.138	-0.137	-0.143	-0.141	-0.139	-0.135	-0.136	-0.138	-0.133	-0.139	-0.140	-0.135	-0.136	-0.134	-0.136	-0.132	-0.127	-0.132	-0.128	-0.124	-0.127	-0.126	-0.123	-0.124	-0.125
var KSC5	-0.141	-0.144	-0.140	-0.144	-0.143	-0.147	-0.140	-0.139	-0.145	-0.144	-0.142	-0.138	-0.139	-0.142	-0.137	-0.143	-0.145	-0.140	-0.141	-0.139	-0.143	-0.140	-0.135	-0.136	-0.134	-0.130	-0.133	-0.132	-0.131	-0.132	-0.131
var KSC6	-0.158	-0.161	-0.158	-0.161	-0.160	-0.164	-0.157	-0.156	-0.162	-0.161	-0.158	-0.154	-0.155	-0.158	-0.152	-0.159	-0.161	-0.155	-0.157	-0.154	-0.157	-0.154	-0.148	-0.151	-0.148	-0.143	-0.147	-0.146	-0.144	-0.144	-0.144
var KSC7	-0.165	-0.169	-0.166	-0.170	-0.169	-0.173	-0.166	-0.166	-0.171	-0.170	-0.168	-0.165	-0.167	-0.169	-0.164	-0.171	-0.173	-0.167	-0.169	-0.167	-0.171	-0.169	-0.165	-0.163	-0.162	-0.158	-0.162	-0.161	-0.160	-0.160	-0.160
var KSC8	-0.151	-0.154	-0.150	-0.153	-0.151	-0.155	-0.148	-0.147	-0.153	-0.151	-0.149	-0.145	-0.145	-0.147	-0.143	-0.148	-0.149	-0.144	-0.145	-0.142	-0.144	-0.140	-0.134	-0.141	-0.137	-0.131	-0.134	-0.134	-0.130	-0.132	-0.132
var KSC9	-0.143	-0.145	-0.142	-0.145	-0.143	-0.146	-0.140	-0.139	-0.144	-0.142	-0.140	-0.137	-0.137	-0.139	-0.135	-0.139	-0.140	-0.136	-0.136	-0.134	-0.135	-0.131	-0.125	-0.133	-0.128	-0.123	-0.126	-0.126	-0.122	-0.123	-0.124
var KSC10	-0.151	-0.154	-0.151	-0.154	-0.153	-0.156	-0.151	-0.150	-0.155	-0.154	-0.153	-0.149	-0.151	-0.153	-0.148	-0.154	-0.156	-0.151	-0.152	-0.150	-0.153	-0.150	-0.146	-0.148	-0.145	-0.141	-0.145	-0.144	-0.142	-0.143	-0.143
var KSC11	-0.149	-0.152	-0.150	-0.152	-0.152	-0.154	-0.149	-0.149	-0.153	-0.152	-0.151	-0.148	-0.149	-0.150	-0.146	-0.151	-0.152	-0.148	-0.149	-0.147	-0.149	-0.146	-0.141	-0.145	-0.142	-0.138	-0.141	-0.140	-0.137	-0.138	-0.139
var KSC12	-0.151	-0.153	-0.151	-0.153	-0.152	-0.154	-0.150	-0.149	-0.154	-0.152	-0.151	-0.148	-0.148	-0.150	-0.146	-0.151	-0.151	-0.147	-0.148	-0.146	-0.147	-0.143	-0.137	-0.144	-0.140	-0.135	-0.138	-0.138	-0.134	-0.135	-0.136
var KSC13	-0.145	-0.146	-0.144	-0.146	-0.144	-0.146	-0.142	-0.140	-0.145	-0.143	-0.141	-0.138	-0.138	-0.139	-0.136	-0.139	-0.139	-0.136	-0.136	-0.133	-0.133	-0.129	-0.123	-0.133	-0.128	-0.122	-0.125	-0.125	-0.120	-0.122	-0.123
var KSC14	-0.156	-0.157	-0.156	-0.157	-0.156	-0.157	-0.154	-0.153	-0.156	-0.155	-0.154	-0.151	-0.150	-0.152	-0.148	-0.151	-0.151	-0.149	-0.149	-0.146	-0.145	-0.141	-0.134	-0.146	-0.141	-0.135	-0.137	-0.138	-0.132	-0.134	-0.135
var KSC15	-0.027	-0.027	-0.025	-0.026	-0.025	-0.027	-0.024	-0.023	-0.025	-0.024	-0.024	-0.022	-0.022	-0.023	-0.021	-0.023	-0.023	-0.021	-0.021	-0.020	-0.021	-0.019	-0.016	-0.020	-0.018	-0.015	-0.017	-0.017	-0.015	-0.015	-0.016
var KSC16	-0.141	-0.142	-0.140	-0.141	-0.140	-0.140	-0.138	-0.137	-0.139	-0.138	-0.137	-0.134	-0.133	-0.134	-0.131	-0.134	-0.133	-0.131	-0.131	-0.128	-0.127	-0.123	-0.117	-0.129	-0.124	-0.118	-0.120	-0.121	-0.115	-0.117	-0.118
var KSC17	-0.145	-0.147	-0.146	-0.148	-0.148	-0.148	-0.147	-0.146	-0.149	-0.148	-0.148	-0.146	-0.146	-0.147	-0.145	-0.148	-0.147	-0.146	-0.146	-0.144	-0.144	-0.142	-0.136	-0.143	-0.140	-0.136	-0.138	-0.138	-0.134	-0.136	-0.136
var KSC18	-0.161	-0.163	-0.163	-0.164	-0.164	-0.165	-0.163	-0.163	-0.165	-0.165	-0.164	-0.162	-0.163	-0.165	-0.162	-0.165	-0.165	-0.163	-0.164	-0.162	-0.163	-0.161	-0.155	-0.161	-0.158	-0.154	-0.157	-0.157	-0.153	-0.155	-0.155
var KSC19	-0.150	-0.150	-0.150	-0.151	-0.151	-0.150	-0.150	-0.149	-0.150	-0.150	-0.149	-0.147	-0.147	-0.148	-0.145	-0.147	-0.146	-0.145	-0.145	-0.143	-0.141	-0.137	-0.131	-0.143	-0.138	-0.133	-0.135	-0.136	-0.130	-0.132	-0.133
var KSC20	-0.155	-0.155	-0.156	-0.156	-0.157	-0.155	-0.156	-0.155	-0.156	-0.156	-0.156	-0.154	-0.154	-0.155	-0.152	-0.154	-0.153	-0.153	-0.152	-0.151	-0.149	-0.146	-0.139	-0.150	-0.146	-0.141	-0.143	-0.144	-0.138	-0.140	-0.141
var KSC21	-0.147	-0.147	-0.148	-0.147	-0.148	-0.145	-0.147	-0.147	-0.147	-0.146	-0.146	-0.145	-0.145	-0.145	-0.143	-0.144	-0.142	-0.143	-0.142	-0.140	-0.138	-0.134	-0.128	-0.141	-0.137	-0.132	-0.133	-0.134	-0.128	-0.130	-0.131
var KSC22	-0.155	-0.155	-0.156	-0.156	-0.157	-0.155	-0.157	-0.157	-0.156	-0.157	-0.157	-0.157	-0.157	-0.157	-0.156	-0.156	-0.155	-0.156	-0.155	-0.155	-0.152	-0.150	-0.145	-0.155	-0.152	-0.148	-0.150	-0.150	-0.145	-0.147	-0.148
var KSC24	-0.159	-0.158	-0.161	-0.159	-0.161	-0.157	-0.161	-0.162	-0.159	-0.160	-0.161	-0.161	-0.161	-0.160	-0.161	-0.159	-0.157	-0.159	-0.158	-0.158	-0.153	-0.151	-0.146	-0.160	-0.156	-0.152	-0.152	-0.154	-0.147	-0.149	-0.151
var KSC25	-0.149	-0.147	-0.151	-0.148	-0.150	-0.145	-0.151	-0.152	-0.148	-0.149	-0.150	-0.152	-0.150	-0.149	-0.152	-0.147	-0.144	-0.148	-0.147	-0.147	-0.141	-0.139	-0.134	-0.150	-0.147	-0.143	-0.142	-0.144	-0.137	-0.139	-0.141
var KSC26	-0.141	-0.140	-0.140	-0.140	-0.139	-0.138	-0.138	-0.137	-0.138	-0.137	-0.136	-0.135	-0.133	-0.134	-0.132	-0.132	-0.131	-0.130	-0.130	-0.128	-0.125	-0.122	-0.115	-0.129	-0.123	-0.118	-0.119	-0.120	-0.114	-0.116	-0.117
var KSC27	-0.133	-0.131	-0.132	-0.131	-0.131	-0.128	-0.131	-0.130	-0.129	-0.128	-0.129	-0.129	-0.127	-0.126	-0.126	-0.124	-0.123	-0.123	-0.122	-0.121	-0.117	-0.114	-0.108	-0.123	-0.118	-0.113	-0.113	-0.115	-0.108	-0.110	-0.112
var KSC28	-0.129	-0.126	-0.128	-0.126	-0.126	-0.122	-0.127	-0.126	-0.123	-0.123	-0.123	-0.124	-0.122	-0.121	-0.122	-0.118	-0.117	-0.118	-0.117	-0.115	-0.112	-0.109	-0.103	-0.119	-0.113	-0.108	-0.108	-0.110	-0.104	-0.105	-0.107
var KSC29	-0.135	-0.132	-0.135	-0.133	-0.133	-0.130	-0.134	-0.134	-0.131	-0.131	-0.132	-0.133	-0.131	-0.130	-0.131	-0.128	-0.126	-0.128	-0.127	-0.125	-0.121	-0.119	-0.113	-0.129	-0.124	-0.119	-0.119	-0.121	-0.114	-0.116	-0.118
var KSC30	-0.128	-0.126	-0.128	-0.126	-0.127	-0.123	-0.127	-0.127	-0.124	-0.124	-0.125	-0.125	-0.123	-0.122	-0.123	-0.120	-0.119	-0.120	-0.119	-0.117	-0.114	-0.111	-0.105	-0.120	-0.115	-0.110	-0.111	-0.112	-0.106	-0.108	-0.109
var KSC31	-0.133	-0.131	-0.134	-0.131	-0.132	-0.128	-0.134	-0.133	-0.129	-0.130	-0.131	-0.133	-0.131	-0.129	-0.131	-0.127	-0.125	-0.128	-0.126	-0.125	-0.121	-0.119	-0.113	-0.129	-0.125	-0.120	-0.120	-0.122	-0.115	-0.117	-0.119
var KSC32	-0.134	-0.132	-0.135	-0.132	-0.133	-0.129	-0.135	-0.134	-0.131	-0.131	-0.132	-0.133	-0.131	-0.130	-0.132	-0.127	-0.125	-0.128	-0.126	-0.125	-0.121	-0.118	-0.113	-0.129	-0.124	-0.120	-0.119	-0.121	-0.114	-0.116	-0.118
var KSC34	-0.051	-0.052	-0.047	-0.049	-0.046	-0.049	-0.044	-0.042	-0.046	-0.043	-0.041	-0.039	-0.038	-0.039	-0.036	-0.039	-0.039	-0.036	-0.036	-0.033	-0.034	-0.030	-0.025	-0.033	-0.028	-0.022	-0.025	-0.025	-0.021	-0.022	-0.023

4.4 Summary

The analysis showed there was little correlation between 1-minute mean EFM sensor readings and lightning/storm activity. The poor correlation between EFM readings and lightning activity also led to poor regression model generation. For the threshold model technique requested by the sponsor, lightning prediction based on a threshold value has no utility. While storm prediction rate can be as high as 74% at a threshold value of just 100 V/m, the false positive reporting rate shoots up to over 82%. Ideally one would want to, at a minimum, reduce the amount of false negative reporting, but this value only gets worse as the threshold increased.

Table 7 shows how the four different types of models compare in performance. Overall the best performing models used the standard least squares regression technique and the nominal logistic regression model techniques, which each were able to account for around 16% of the variance in the dataset, however these models do not explain enough of the variance to be of much utility.

Table 7: Regression Model Comparison

Method	Best R^2	TP rate (max)	TN rate | TP rate (max)
Threshold		0.7439	0.1772
SLSR	0.1672		
NLR	0.1644	0.2001	0.985
NBR	0.046		

V. Conclusions and Recommendations

5.1 Conclusions of Research

Lightning activity is an important natural phenomenon that occurs at a high rate on the Eastern Range. It affects processing operations as it relates to ensuring the safety of personnel and equipment on the range. Weather delays due to lightning can lead to monetary losses, loss of production, or cancellation and postponement of launch activities. Launch commit criteria violations lead to delayed launches and increases in launch costs (Merceret *et al*., 2010). Therefore, it is important to identify other techniques that can assist in accurately predicting the occurrence of severe weather.

This research analyzed EFM sensor readings from 31 sensor sites at KSC to determine their ability to predict lightning activity. It analyzed the correlations between EFM sensor readings and lightning/storm activity. Regression models using a threshold analysis technique, standard least squares regression technique, nominal logistic regression technique, and negative binomial regression technique were all examined for each of the 31 sensor sites and as a centered mean value of all the sensor sites for lightning activity that might be occurring anywhere on station.

The attempts to establish correlation between the EFM sensor readings and lightning activity proved futile as pairwise correlations had values of less than 0.2 between the parameters. Table 7 shows that standard least squares regression model and nominal logistic regression model offered the best performance of the techniques applied. However, all modeling techniques failed to offer a good fit for the dataset.

Table 7: Regression Model Comparison

Method	Best R^2	TP rate (max)	TN rate | TP rate (max)
Threshold		0.7439	0.1772
SLSR	0.1672		
NLR	0.1644	0.2001	0.985
NBR	0.046		

The study could not establish an EFM threshold reading value to predict lightning onset that maximized positive identification of storm onset, cessation, or clear weather while simultaneously reducing false reporting of clear weather at a rate better than what a trained meteorologist could report based on prior day activity.

5.2 Significance of Research

This has been a thorough and exhaustive examination of the EFM and LDAR data. The techniques used were unable to establish a correlation between EFM sensor readings and lighting activity. This analysis leads to the conclusion that EFMs are not very useful in the prediction of or even indication of already occurring lightning activity.

5.3 Recommendations for Action

After exhaustive studies, all with varying levels of success, most being unsuccessful, predicting lightning storm onset or cessation should not consider only the use of EFM sensor readings as a predictor variable for lightning activity.

5.4 Recommendations for Future Research

It may be beneficial to revisit creating a new negative binomial regression model that uses counts of the number of total lightning strikes occurring within each 1-minute time interval as an independent variable with a response variable of time ending. Other weather data may also help prove useful in predicting storm movements to give better prediction accuracy than EFM data alone.

5.5 Summary

The primary goal of this research was to establish an EFM threshold value to predict the occurrence of lightning within a specified area proved unsuccessful. The multivariate techniques for correlation eluded to an inability to make predictions using EFM sensor readings due to low correlation values. A thorough analysis of the dataset showed there were no other relations recognized through threshold analysis and regression model building, with the best performing models only providing a goodness-of-fit R^2 of approximately 0.16. The multitude of studies on this dataset should be enough to establish the case to stop looking at EFM sensors to make predictions on natural lightning events.

Appendix A: Sample Working Dataset

Column #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Column Label	Date	Time	KSC1	KSC2	KSC4	KSC5	KSC6	KSC7	KSC8	KSC9	KSC10	KSC11	KSC12	KSC13	KSC14	KSC15
1	2013121	0:00:00	357.6893333	485.5706667	378.7093333	339.1666667	237.76	493.1653333	228.6213333	380.6413333	624.448	645.7586667	757.9973333	500.728	NA	734.7613333
2	2013121	0:01:00	373.8986667	479.9813333	324.9346667	336.1786667	224.0786667	455.8253333	271.984	353.592	575.4786667	591.084	664.2626667	475.42	NA	647.2453333
3	2013121	0:02:00	370.8666667	440.7186667	364.3693333	306.5	228.2946667	424.8986667	308.9	330.9813333	522.664	559.576	NA	479.3026667	NA	550.3386667
4	2013121	0:03:00	331.5973333	422.728	329.0733333	277.6213333	207.1306667	402.9293333	344.5173333	320.2626667	487.88	532.1866667	NA	476.652	NA	493.6613333
5	2013121	0:04:00	380.5453333	414.8826667	324.0706667	272.244	193.348	408.0253333	344.536	306.552	457.9333333	504.5093333	NA	463.0053333	NA	457.6866667
6	2013121	0:05:00	350.7773333	402.268	388.3173333	253.156	200.188	418.656	319.936	302.676	427.7546667	500.8666667	442.5586667	403.8946667	NA	419.4506667
7	2013121	0:06:00	395.2893333	381.6066667	354.216	246.2133333	190.2293333	424.032	310.3653333	292.5426667	402.344	463.8373333	416.5986667	358.9786667	NA	384.4506667
8	2013121	0:07:00	418.1266667	392.6813333	344.728	237.8986667	201.512	434.9226667	318.6213333	278.16	387.1866667	425.6693333	369.428	386.0306667	NA	372
9	2013121	0:08:00	393.364	388	299.1786667	233.128	195.9893333	429.94	314.236	280.1453333	373.372	403.5746667	346.428	388.6426667	NA	352.3226667
10	2013121	0:09:00	389.3186667	403.9573333	290.8066667	222.1866667	200.7066667	435.2773333	293.6546667	258.896	355.8866667	371.796	317.9813333	400.1106667	NA	339.8586667
Column #	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Column Label	KSC16	KSC17	KSC18	KSC19	KSC20	KSC21	KSC22	KSC24	KSC25	KSC26	KSC27	KSC28	KSC29	KSC30	KSC31	KSC32
1	602.7986667	825.848	484.1013333	1025.161333	677.1773333	988.8066667	399.0346667	573.8826667	1520.721333	NA	710.316	534.7586667	774.292	673.0986667	904.3506667	682.916
2	632.1186667	759.24	445.464	950.288	566.8413333	947.9053333	369.6986667	492.7133333	1425.712	NA	792.0146667	512.1573333	709.844	650.856	866.5466667	632.368
3	618.236	725.684	413.476	867.728	495.5213333	812.0466667	339.4266667	509.524	1351.976	NA	751.2813333	583.7986667	642.316	609.4706667	907.3386667	659.708
4	571.152	674.4306667	404.7946667	807.2413333	475.652	779.5346667	308.9533333	501.1493333	1237.78	NA	714.1693333	499.6546667	571.728	564.1506667	870.42	642.4493333
5	533.1253333	632.5306667	385.728	721.552	472.476	775.5346667	275.968	491.9133333	1102.585333	NA	678.236	366.228	540.2706667	539.8613333	825.612	553.5053333
6	456.904	577.5213333	372.2573333	686.9466667	461.076	723.1346667	250.1653333	451.2453333	934.528	NA	645.5213333	384.124	496.664	505.656	780.828	546.8093333
7	438.4693333	523.576	373.644	646.872	433.3466667	746.3386667	232.8493333	381.2786667	874.8413333	NA	647.4133333	431.8266667	428.616	449.1693333	713.556	493.0106667
8	464.38	498.0733333	374.34	629.8866667	451.6226667	679.3493333	225.6933333	366.932	720.8733333	NA	640.0426667	327.0373333	379.72	409.584	697.7773333	442.0653333
9	431.7293333	475.4746667	374.4973333	571.2493333	449.576	557.4866667	208.4026667	355.7373333	647.0386667	NA	568.86	366.92	344.5293333	352.0933333	NA	462.9253333
10	347.8706667	460.4413333	351.5586667	518.5586667	411.8826667	493.124	205.7853333	342.7066667	632.6693333	NA	516.1053333	326.6613333	309.936	333.7013333	557.9666667	403.324
Column #	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
Column Label	KSC34	abs.KSC1	abs.KSC2	abs.KSC4	abs.KSC5	abs.KSC6	abs.KSC7	abs.KSC8	abs.KSC9	abs.KSC10	abs.KSC11	abs.KSC12	abs.KSC13	abs.KSC14	abs.KSC15	abs.KSC16
1	785.5906667	357.6893333	485.5706667	378.7093333	339.1666667	237.76	493.1653333	228.6213333	380.6413333	624.448	645.7586667	757.9973333	500.728	NA	734.7613333	602.7986667
2	661.1026667	373.8986667	479.9813333	324.9346667	336.1786667	224.0786667	455.8253333	271.984	353.592	575.4786667	591.084	664.2626667	475.42	NA	647.2453333	632.1186667
3	628.184	370.8666667	440.7186667	364.3693333	306.5	228.2946667	424.8986667	308.9	330.9813333	522.664	559.576	NA	479.3026667	NA	550.3386667	618.236
4	590.4813333	331.5973333	422.728	329.0733333	277.6213333	207.1306667	402.9293333	344.5173333	320.2626667	487.88	532.1866667	NA	476.652	NA	493.6613333	571.152
5	576.7413333	380.5453333	414.8826667	324.0706667	272.244	193.348	408.0253333	344.536	306.552	457.9333333	504.5093333	NA	463.0053333	NA	457.6866667	533.1253333
6	530.1746667	350.7773333	402.268	388.3173333	253.156	200.188	418.656	319.936	302.676	427.7546667	500.8666667	442.5586667	403.8946667	NA	419.4506667	456.904
7	498.3853333	395.2893333	381.6066667	354.216	246.2133333	190.2293333	424.032	310.3653333	292.5426667	402.344	463.8373333	416.5986667	358.9786667	NA	384.4506667	438.4693333
8	521.1653333	418.1266667	392.6813333	344.728	237.8986667	201.512	434.9226667	318.6213333	278.16	387.1866667	425.6693333	369.428	386.0306667	NA	372	464.38
9	523.1973333	393.364	388	299.1786667	233.128	195.9893333	429.94	314.236	280.1453333	373.372	403.5746667	346.428	388.6426667	NA	352.3226667	431.7293333
10	435.748	389.3186667	403.9573333	290.8066667	222.1866667	200.7066667	435.2773333	293.6546667	258.896	355.8866667	371.796	317.9813333	400.1106667	NA	339.8586667	347.8706667
Column #	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64
Column Label	abs.KSC17	abs.KSC18	abs.KSC19	abs.KSC20	abs.KSC21	abs.KSC22	abs.KSC24	abs.KSC25	abs.KSC26	abs.KSC27	abs.KSC28	abs.KSC29	abs.KSC30	abs.KSC31	abs.KSC32	abs.KSC34
1	825.848	484.1013333	1025.161333	677.1773333	988.8066667	399.0346667	573.8826667	1520.721333	NA	710.316	534.7586667	774.292	673.0986667	904.3506667	682.916	785.5906667
2	759.24	445.464	950.288	566.8413333	947.9053333	369.6986667	492.7133333	1425.712	NA	792.0146667	512.1573333	709.844	650.856	866.5466667	632.368	661.1026667
3	725.684	413.476	867.728	495.5213333	812.0466667	339.4266667	509.524	1351.976	NA	751.2813333	583.7986667	642.316	609.4706667	907.3386667	659.708	628.184
4	674.4306667	404.7946667	807.2413333	475.652	779.5346667	308.9533333	501.1493333	1237.78	NA	714.1693333	499.6546667	571.728	564.1506667	870.42	642.4493333	590.4813333
5	632.5306667	385.728	721.552	472.476	775.5346667	275.968	491.9133333	1102.585333	NA	678.236	366.228	540.2706667	539.8613333	825.612	553.5053333	576.7413333
6	577.5213333	372.2573333	686.9466667	461.076	723.1346667	250.1653333	451.2453333	934.528	NA	645.5213333	384.124	496.664	505.656	780.828	546.8093333	530.1746667
7	523.576	373.644	646.872	433.3466667	746.3386667	232.8493333	381.2786667	874.8413333	NA	647.4133333	431.8266667	428.616	449.1693333	713.556	493.0106667	498.3853333
8	498.0733333	374.34	629.8866667	451.6226667	679.3493333	225.6933333	366.932	720.8733333	NA	640.0426667	327.0373333	379.72	409.584	697.7773333	442.0653333	521.1653333
9	475.4746667	374.4973333	571.2493333	449.576	557.4866667	208.4026667	355.7373333	647.0386667	NA	568.86	366.92	344.5293333	352.0933333	NA	462.9253333	523.1973333
10	460.4413333	351.5586667	518.5586667	411.8826667	493.124	205.7853333	342.7066667	632.6693333	NA	516.1053333	326.6613333	309.936	333.7013333	557.9666667	403.324	435.748

Appendix A: Sample Working Dataset (cont.)

Column #	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80
Column Label	fold.KSC1	fold.KSC2	fold.KSC4	fold.KSC5	fold.KSC6	fold.KSC7	fold.KSC8	fold.KSC9	fold.KSC10	fold.KSC11	fold.KSC12	fold.KSC13	fold.KSC14	fold.KSC15	fold.KSC16	fold.KSC17
1	153.8579771	320.4731117	187.1351864	220.3982556	108.0814227	328.3616088	53.45718876	209.3796575	471.8391704	503.376908	614.8455272	316.2635345	0	569.2300851	408.0242746	698.3314699
2	170.0673104	314.8837783	133.3605197	217.4102556	94.40008941	291.0216088	96.81985543	182.3303241	422.8698371	448.7022413	521.1108606	290.9555345	0	481.7140851	437.3442746	631.7234699
3	167.0353104	275.6211117	172.7951864	187.7315889	98.61608941	260.0949421	133.7358554	159.7196575	370.0551704	417.1942413	0	294.8382012	0	384.8074184	423.4616079	598.1674699
4	127.7659771	257.630445	137.4991864	158.8529223	77.45208941	238.1256088	169.3531888	149.0009908	335.2711704	389.804908	0	292.1875345	0	328.1300851	376.3776079	546.9141365
5	176.7139771	249.7851117	132.4965197	153.4755889	63.66942274	243.2216088	169.3718554	135.2903241	305.3245037	362.1275747	0	278.5408679	0	292.1554184	338.3509412	505.0141365
6	146.9459771	237.170445	196.7431864	134.3875889	70.50942274	253.8522754	144.7718554	131.4143241	275.1458371	358.484908	299.4068606	219.4302012	0	253.9194184	262.1296079	450.0048032
7	191.4579771	216.5091117	162.6418531	127.4449223	60.55075607	259.2282754	135.2011888	121.2809908	249.7351704	321.4555747	273.4468606	174.5142012	0	218.9194184	243.6949412	396.0594699
8	214.2953104	227.5837783	153.1538531	119.1302556	71.83342274	270.1189421	143.4571888	106.8983241	234.5778371	283.2875747	226.2761939	201.5662012	0	206.4687518	269.6056079	370.5568032
9	189.5326437	222.902445	107.6045197	114.3595889	66.31075607	265.1362754	139.0718554	108.8836575	220.7631704	261.192908	203.2761939	204.1782012	0	186.7914184	236.9549412	347.9581365
10	185.4873104	238.8597783	99.23251972	103.4182556	71.02808941	270.4736088	118.4905221	87.63432414	203.2778371	229.4142413	174.8295272	215.6462012	0	174.3274184	153.0962746	332.9248032
Column #	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
Column Label	fold.KSC18	fold.KSC19	fold.KSC20	fold.KSC21	fold.KSC22	fold.KSC24	fold.KSC25	fold.KSC26	fold.KSC27	fold.KSC28	fold.KSC29	fold.KSC30	fold.KSC31	fold.KSC32	fold.KSC34	Mean
1	334.0294523	882.1893547	554.1714463	853.9442266	290.5905194	430.4142912	1377.153179	0	573.6310803	353.2724897	625.2908222	521.4734086	742.4407853	536.333784	621.9017388	447.0932889
2	295.392119	807.3160214	443.8354463	813.0428932	261.2545194	349.2449579	1282.143846	0	655.329747	330.6711564	560.8428222	499.2307419	704.6367853	485.785784	497.4137388	410.3501491
3	263.404119	724.7560214	372.5154463	677.1842266	230.9825194	366.0556245	1208.407846	0	614.5964136	402.3124897	493.3148222	457.8454086	745.4287853	513.125784	464.4950721	370.2676913
4	254.7227856	664.2693547	352.646113	644.6722266	200.5091861	357.6809579	1094.211846	0	577.4844136	318.1684897	422.7268222	412.5254086	708.5101186	495.8671173	426.7924054	339.198487
5	235.656119	578.5800214	349.470113	640.6722266	167.5238528	348.4449579	959.0171789	0	541.5510803	184.7418231	391.2694889	388.2360753	663.7021186	406.9231173	413.0524054	312.0767235
6	222.1854523	543.974688	338.070113	588.2722266	141.7211861	307.7769579	790.9598455	0	508.8364136	202.6378231	347.6628222	354.0307419	618.9181186	400.2271173	366.4857388	295.6798696
7	223.572119	503.9000214	310.3407797	611.4762266	124.4051861	237.8102912	731.2731789	0	510.7284136	250.3404897	279.6148222	297.5440753	551.6461186	346.4284507	334.6964054	273.0941061
8	224.268119	486.914688	328.6167797	544.4868932	117.2491861	223.4636245	577.3051789	0	503.357747	145.5511564	230.7188222	257.9587419	535.867452	295.4831173	357.4764054	255.7267083
9	224.4254523	428.2773547	326.570113	422.6242266	99.95851944	212.2689579	503.4705122	0	432.1750803	185.4338231	195.5281556	200.4680753	0	316.3431173	359.5084054	218.7731776
10	201.4867856	375.586688	288.8767797	358.2615599	97.34118611	199.2382912	489.1011789	0	379.4204136	145.1751564	160.9348222	182.0760753	396.0567853	256.741784	272.0590721	208.4031384
Column #	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112
Column Label	GeoMean	LM1	LM2	LM4	LM5	LM6	LM7	LM8	LM9	LM10	LM11	LM12	LM13	LM14	LM15	LM16
1	397.3588304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	369.9719779	0	0	0	0	0	0	0	-30	0	0	-30	-30	-30	-30	-30
3	350.4219773	0	0	0	0	0	0	0	-29	0	0	-29	-29	-29	-29	-29
4	318.772959	0	0	0	0	0	0	0	-28	0	0	-28	-28	-28	-28	-28
5	294.924695	0	0	0	0	0	0	0	-27	0	0	-27	-27	-27	-27	-27
6	275.5290133	0	0	0	0	0	0	0	-26	0	0	-26	-26	-26	-26	-26
7	254.213552	0	0	0	0	0	0	0	-25	0	0	-25	-25	-25	-25	-25
8	241.0646191	0	0	0	0	0	0	0	-24	0	0	-24	-24	-24	-24	-24
9	216.8429686	0	0	0	0	0	0	0	-23	0	0	-23	-23	-23	-23	-23
10	199.0852854	0	0	0	0	0	0	0	-22	0	0	-22	-22	-22	-22	-22
Column #	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128
Column Label	LM17	LM18	LM19	LM20	LM21	LM22	LM24	LM25	LM26	LM27	LM28	LM29	LM30	LM31	LM32	LM34
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	-30	0	-30	-30	-30	0	0	0	-30	-30	0	0	-30	0	0	0
3	-29	0	-29	-29	-29	0	0	0	-29	-29	0	0	-29	0	0	0
4	-28	0	-28	-28	-28	0	0	0	-28	-28	0	0	-28	0	0	0
5	-27	0	-27	-27	-27	0	0	0	-27	-27	0	0	-27	0	0	0
6	-26	0	-26	-26	-26	0	0	0	-26	-26	0	0	-26	0	0	0
7	-25	0	-25	-25	-25	0	0	0	-25	-25	0	0	-25	0	0	0
8	-24	0	-24	-24	-24	0	0	0	-24	-24	0	0	-24	0	0	0
9	-23	-30	-23	-23	-23	-30	-30	0	-23	-23	0	-30	-23	-30	-30	-30
10	-22	-29	-22	-22	-22	-29	-29	0	-22	-22	0	-29	-22	-29	-29	-29

Appendix A: Sample Working Dataset (cont.)

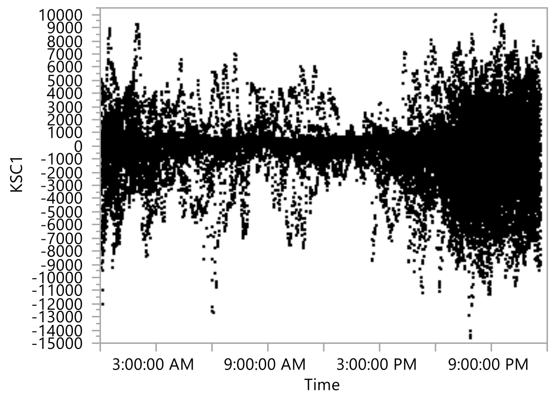
Column #	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
Column Label	bin.LM1	bin.LM2	bin.LM4	bin.LM5	bin.LM6	bin.LM7	bin.LM8	bin.LM9	bin.LM10	bin.LM11	bin.LM12	bin.LM13	bin.LM14	bin.LM15	bin.LM16	bin.LM17
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
3	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
4	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
5	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
6	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
7	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
8	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
9	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
10	0	0	0	0	0	0	0	1000	0	0	1000	1000	1000	1000	1000	1000
Column #	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160
Column Label	bin.LM18	bin.LM19	bin.LM20	bin.LM21	bin.LM22	bin.LM24	bin.LM25	bin.LM26	bin.LM27	bin.LM28	bin.LM29	bin.LM30	bin.LM31	bin.LM32	bin.LM34	Lightning1
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-25
3	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-24
4	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-23
5	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-22
6	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-21
7	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-20
8	0	1000	1000	1000	0	0	0	1000	1000	0	0	1000	0	0	0	-19
9	1000	1000	1000	1000	1000	1000	0	1000	1000	0	1000	1000	1000	1000	1000	-18
10	1000	1000	1000	1000	1000	1000	0	1000	1000	0	1000	1000	1000	1000	1000	-17
Column #	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176
Column Label	Lightning2	Lightning.bin	Lightning3	lightning.end.1	lightning.end.2	lightning.end.4	lightning.end.5	lightning.end.6	lightning.end.7	lightning.end.8	lightning.end.9	lightning.end.10	lightning.end.11	lightning.end.12	lightning.end.13	lightning.end.14
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	950	1	0	0	0	0	0	0	0	0	40	0	0	52	52	52
3	960	1	0	0	0	0	0	0	0	0	39	0	0	51	51	51
4	970	1	0	0	0	0	0	0	0	0	38	0	0	50	50	50
5	980	1	0	0	0	0	0	0	0	0	37	0	0	49	49	49
6	990	1	0	0	0	0	0	0	0	0	36	0	0	48	48	48
7	1000	1	0	0	0	0	0	0	0	0	35	0	0	47	47	47
8	1010	1	0	0	0	0	0	0	0	0	34	0	0	46	46	46
9	1020	1	0	0	0	0	0	0	0	0	33	0	0	45	45	45
10	1030	1	0	0	0	0	0	0	0	0	32	0	0	44	44	44
Column #	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
Column Label	**lightning.end.15**	**lightning.end.16**	**lightning.end.17**	**lightning.end.18**	**lightning.end.19**	**lightning.end.20**	**lightning.end.21**	**lightning.end.22**	**lightning.end.24**	**lightning.end.25**	**lightning.end.26**	**lightning.end.27**	**lightning.end.28**	**lightning.end.29**	**lightning.end.30**	**lightning.end.31**
1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2	**52**	**52**	**52**	**0**	**52**	**52**	**52**	**0**	**0**	**0**	**52**	**66**	**0**	**0**	**66**	**0**
3	**51**	**51**	**51**	**0**	**51**	**51**	**51**	**0**	**0**	**0**	**51**	**65**	**0**	**0**	**65**	**0**
4	**50**	**50**	**50**	**0**	**50**	**50**	**50**	**0**	**0**	**0**	**50**	**64**	**0**	**0**	**64**	**0**
5	**49**	**49**	**49**	**0**	**49**	**49**	**49**	**0**	**0**	**0**	**49**	**63**	**0**	**0**	**63**	**0**
6	**48**	**48**	**48**	**0**	**48**	**48**	**48**	**0**	**0**	**0**	**48**	**62**	**0**	**0**	**62**	**0**
7	**47**	**47**	**47**	**0**	**47**	**47**	**47**	**0**	**0**	**0**	**47**	**61**	**0**	**0**	**61**	**0**
8	**46**	**46**	**46**	**0**	**46**	**46**	**46**	**0**	**0**	**0**	**46**	**60**	**0**	**0**	**60**	**0**
9	**45**	**45**	**45**	**45**	**45**	**45**	**45**	**59**	**59**	**0**	**45**	**59**	**0**	**59**	**59**	**45**
10	**44**	**44**	**44**	**44**	**44**	**44**	**44**	**58**	**58**	**0**	**44**	**58**	**0**	**58**	**58**	**44**

Appendix A: Sample Working Dataset (cont.)

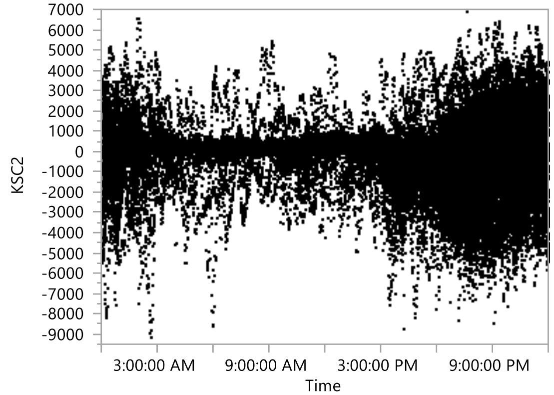
Column #	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	
Column Label	**lightning.end.32**	**lightning.end.34**	**lightning.end.all**	**DistLM1**	**DistLM2**	**DistLM4**	**DistLM5**	**DistLM6**	**DistLM7**	**DistLM8**	**DistLM9**	**DistLM10**	**DistLM11**	**DistLM12**	**DistLM13**	**DistLM14**	
1	**0**	**0**	**0**	**41.85093529**	**40.22532045**	**40.0906007**	**38.78059831**	**38.46752501**	**37.25463443**	**38.96923615**	**38.29438851**	**36.78168244**	**36.16681115**	**36.56830884**	**37.63814729**	**35.93019198**	
2	**0**	**0**	**66**	**42.90021227**	**41.33760344**	**41.07853724**	**39.85329467**	**39.48465413**	**38.39102629**	**39.91670691**	**39.20706578**	**37.84217008**	**37.17402796**	**37.51997416**	**38.34933516**	**36.72010657**	
3	**0**	**0**	**65**	**40.64563207**	**39.16935748**	**38.75403358**	**37.63222521**	**37.19487354**	**36.26256548**	**37.55096449**	**36.80844852**	**35.60774857**	**34.87552689**	**35.16094945**	**36.06851318**	**34.38396929**	
4	**0**	**0**	**64**	**43.31327675**	**41.64979576**	**41.58483267**	**40.230519**	**39.94807635**	**38.66381209**	**40.46151752**	**39.77871367**	**38.23950949**	**37.6531273**	**38.06120276**	**39.03585514**	**37.35268158**	
5	**0**	**0**	**63**	**39.53858051**	**37.99520619**	**37.70965592**	**36.49765326**	**36.11811686**	**35.06020262**	**36.54823981**	**35.8419987**	**34.48361692**	**33.80656585**	**34.15122627**	**35.14922603**	**33.45029801**	
6	**0**	**0**	**62**	**40.62007595**	**39.13002951**	**38.74050284**	**37.60094968**	**37.17501864**	**36.21706204**	**37.54512622**	**36.80915752**	**35.57842573**	**34.85698539**	**35.15361141**	**36.07753141**	**34.39029354**	
7	**0**	**0**	**61**	**54.20211109**	**53.10433032**	**51.94775372**	**51.4190917**	**50.63085959**	**50.3280146**	**50.50521782**	**49.5474531**	**49.37227812**	**48.31913636**	**48.22612747**	**48.5212409**	**46.98715128**	
8	**0**	**0**	**60**	**37.02708782**	**35.68549377**	**35.03501257**	**34.07168325**	**33.5310342**	**32.84960404**	**33.77335173**	**32.98416344**	**32.03248491**	**31.2041859**	**31.39781299**	**32.18954729**	**30.52413479**	
9	**59**	**59**	**59**	**40.55070063**	**39.00318858**	**38.72227429**	**37.50862016**	**37.13087323**	**36.06528273**	**37.55957191**	**36.85127002**	**35.49516044**	**34.81935848**	**35.16280112**	**36.1546192**	**34.45691075**	
10	**58**	**58**	**58**	**42.8921223**	**41.2393671**	**41.15455906**	**39.81281792**	**39.52166206**	**38.25762048**	**40.04610864**	**39.38109614**	**37.81950459**	**37.22501912**	**37.64441047**	**38.73595096**	**37.02555493**	
Column #	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	
Column Label	**DistLM15**	**DistLM16**	**DistLM17**	**DistLM18**	**DistLM19**	**DistLM20**	**DistLM21**	**DistLM22**	**DistLM24**	**DistLM25**	**DistLM26**	**DistLM27**	**DistLM28**	**DistLM29**	**DistLM30**	**DistLM31**	
1	**35.10476868**	**36.58540896**	**33.76397862**	**32.81464153**	**34.08703245**	**33.13845476**	**32.76335057**	**30.22884578**	**28.92307961**	**26.35743627**	**35.37196627**	**33.22530218**	**32.04600375**	**30.45235646**	**31.81139813**	**28.1210745**	
2	**36.0415659**	**37.05908331**	**34.73645694**	**33.83881764**	**34.87558259**	**34.04943728**	**33.4750273**	**31.20377233**	**29.83383331**	**27.05223353**	**35.683761**	**33.23530194**	**31.52824372**	**30.48305102**	**31.67095129**	**27.97372113**	
3	**33.66934198**	**34.92575088**	**32.40260081**	**31.56503542**	**32.53329899**	**31.65482089**	**31.17549681**	**28.87802376**	**27.44512949**	**24.728876**	**33.65066122**	**31.39234877**	**30.03885121**	**28.61374462**	**29.922651**	**26.21130153**	
4	**36.59460699**	**37.88572052**	**35.26040811**	**34.29386947**	**35.5018713**	**34.62254681**	**34.14242571**	**31.72535043**	**30.40653384**	**27.69449045**	**36.60301942**	**34.32499625**	**32.92113844**	**31.54683648**	**32.84259203**	**29.128642**	
5	**32.67370228**	**34.05996947**	**31.36728572**	**30.47365716**	**31.60294502**	**30.68423592**	**30.26430914**	**27.83467455**	**26.46827579**	**23.83739813**	**32.8232008**	**30.6386858**	**29.41422665**	**27.86272462**	**29.20805183**	**25.51038357**	
6	**33.66445183**	**34.94388493**	**32.39021761**	**31.54182427**	**32.54000735**	**31.65426223**	**31.18539559**	**28.86370781**	**27.44286835**	**24.74114163**	**33.6750999**	**31.42855341**	**30.09489968**	**28.64996139**	**29.96484262**	**26.25499598**	
7	**46.69064831**	**47.06487732**	**45.70888839**	**45.23280451**	**45.18158216**	**44.5877847**	**43.75583756**	**42.34806213**	**40.58228942**	**37.50450005**	**45.5862057**	**42.94337286**	**40.80017616**	**40.30134309**	**41.29550703**	**37.73516129**	
8	**29.88970737**	**30.99328613**	**28.68399215**	**27.94182994**	**28.67308442**	**27.84621027**	**27.2962141**	**25.18312706**	**23.65693729**	**20.84471815**	**29.68534687**	**27.37396214**	**25.95609192**	**24.59699946**	**25.88168223**	**22.16686877**	
9	**33.68458991**	**35.0594177**	**32.37964604**	**31.48627932**	**32.60915064**	**31.6935634**	**31.2685779**	**28.84715771**	**27.47777956**	**24.83882043**	**33.8174141**	**31.62076012**	**30.36965169**	**28.84387694**	**30.18260871**	**26.48145437**	
10	**36.18549994**	**37.69389972**	**34.83435497**	**33.8676754**	**35.18391831**	**34.22662978**	**33.86479596**	**31.29945918**	**30.01240004**	**27.46588681**	**36.48701191**	**34.20882487**	**32.78359161**	**31.43117577**	**32.72012402**	**29.00541353**	
Column #	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	
Column Label	DistLM32	DistLM34	varKSC1	varKSC2	varKSC4	varKSC5	varKSC6	varKSC7	varKSC8	varKSC9	varKSC10	varKSC11	varKSC12	varKSC13	varKSC14	varKSC15	
1	29.27021218	30.4090462	143.7380656	19.42748205	621.9121503	34.02089585	55.24614872	208.1087011	507.2817055	140.4408385	81.70386395	412.7833527	1655.474484	69.06103635	NA	732.016377	
2	29.11314112	30.16686762	1548.399198	182.0870139	78.46455307	76.1961436	152.2098815	69.69405624	269.614949	66.21294031	280.5310552	407.55813	170.094371	199.788863	NA	970.687374	
3	27.36363606	28.48082062	424.4783817	28.20225231	376.7198328	136.6808936	41.43631699	142.8986978	9.331777259	52.66520662	160.1671597	20.8084935	827.7517049	95.51889919	NA	389.0069739	
4	30.28080047	31.39083351	408.1765851	36.5381954	102.2900522	22.63749072	167.9935908	28.34045304	73.39949939	34.08103323	75.15731911	99.65704124	16.23766388	210.2743208	NA	259.3637595	
5	26.66093178	27.79473334	613.416417	70.90320062	295.9176454	22.84407869	7.972220073	40.1567438	267.930014	111.6471784	101.1599422	12.17130332	314.6567094	192.7922356	NA	151.4936534	
6	27.40726906	28.52723153	1157.285515	26.56102968	186.7348778	40.34644615	9.231733244	84.64321174	122.5434185	71.35347516	25.93245571	47.25397355	18.58475314	1078.070929	NA	144.973224	
7	38.81914705	39.75458208	1262.886582	27.150339	423.0596972	19.88645104	34.22014627	44.33375392	72.92550672	71.60671513	58.97332177	129.467362	96.20166544	186.7311219	NA	58.74981616	
8	23.31876324	24.42586073	323.6865177	134.359238	129.3584688	12.95404957	6.569379126	46.6202263	27.24969479	50.22047349	15.63169946	224.8082623	273.876108	158.7826538	NA	46.34078026	
9	27.63262829	28.7632802	321.451988	47.32244081	215.2691679	29.64949917	45.00688852	86.82000667	118.6718613	23.61875114	35.76687162	95.34420629	408.1875452	390.7038808	NA	22.55940602	
10	30.15734171	31.26409104	545.1361636	132.7250879	68.4921196	20.35594087	10.21336001	133.7409999	471.1524624	187.505019	32.10985884	45.60025075	13.44413293	240.5746111	NA	54.03537001	
Column #	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257
Column Label	varKSC16	varKSC17	varKSC18	varKSC19	varKSC20	varKSC21	varKSC22	varKSC24	varKSC25	varKSC26	varKSC27	varKSC28	varKSC29	varKSC30	varKSC31	varKSC32	varKSC34
1	408.5116354	298.134941	643.5962636	766.8695948	1931.711123	268.8415694	7.966787151	96.61577148	733.532189	702.5693929	2172.667033	2858.478584	257.7819967	5.749514727	44.25978615	88.35306169	486.5546311
2	234.3627058	208.6332778	139.930014	344.5865849	798.5023257	400.2364504	196.9028325	942.1785484	139.5369016	169.6186942	40.70135201	716.1713033	376.1223715	227.3323748	123.6677115	255.4804028	1292.863081
3	104.9606242	162.6743688	109.9594105	734.2614365	440.4030126	1588.564677	134.1800156	55.0451057	1692.01943	321.3772752	1335.77411	864.2635527	427.8294205	103.850423	730.1313487	244.1294458	435.5780033
4	898.0229036	108.5547111	32.43531666	221.6689812	4.909865955	1192.122172	15.14420362	65.6342443	1455.604802	696.4561519	31.78992286	3178.726987	576.5875452	178.9756248	1031.730177	555.5032673	215.4881476
5	417.9662803	231.6676154	35.09504768	368.8395759	14.03410203	215.6366771	231.8736005	82.52132933	2052.128094	386.8466163	574.5784968	494.1820767	53.51791219	9.808040903	70.45427409	782.9069405	359.9437395
6	622.7610377	248.9205184	132.4846078	183.922463	159.5940887	403.6470806	12.8836261	264.8200849	857.6711064	277.5328048	31.69611026	1461.927933	243.9924348	409.5755225	374.1431304	240.9613	51.72006491
7	432.030403	156.4590437	35.06361854	104.2557012	17.14687118	33.81657708	38.56081983	555.2380909	3378.018164	2112.546552	60.2092253	2958.374747	330.4186836	108.2420736	177.9635185	39.36500789	120.6170572
8	248.2956986	66.29938869	34.89336445	14.10385684	48.99928598	2403.876592	7.609825497	66.34282361	1145.99262	371.6941662	269.4319902	42.159326	136.7138379	185.0726349	78.50458775	199.4115354	114.349448
9	119.0544244	49.45784417	61.70389419	943.7350779	113.9061927	1616.200556	30.1092293	311.7095761	170.4446531	329.6892787	424.1324441	60.98726242	191.5329839	200.7835501	1454.080929	70.66598022	245.976385
10	254.6868352	65.14427298	24.84283917	232.8001583	35.92354074	66.24137112	9.855870179	105.6371679	298.894291	66.31733868	156.0249132	509.4284477	71.85985729	23.25721729	53.27531399	588.2564428	983.5123334

Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time

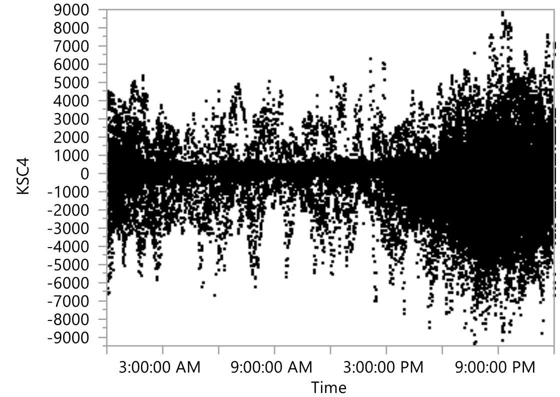
Bivariate Fit of KSC1 By Time



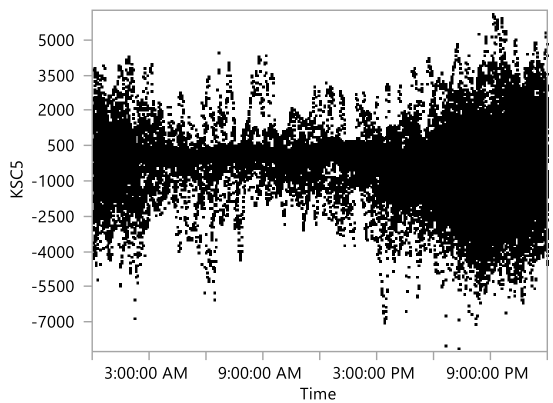
Bivariate Fit of KSC2 By Time



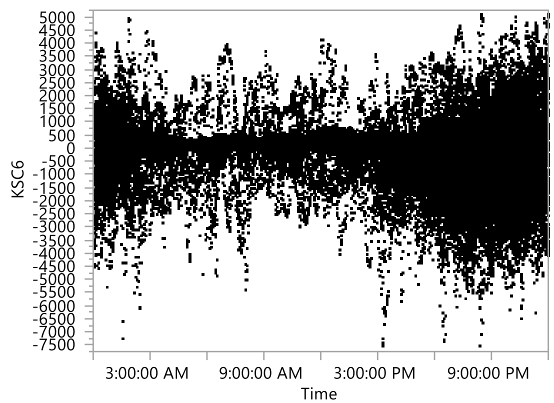
Bivariate Fit of KSC4 By Time



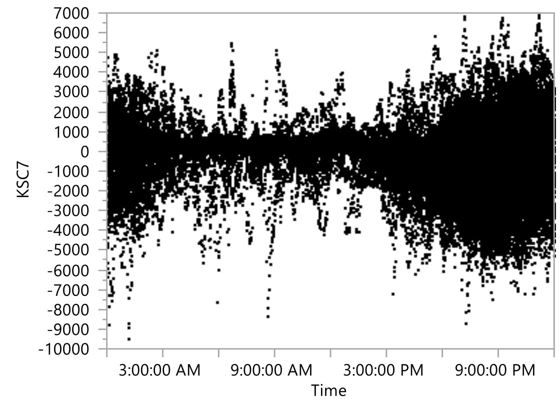
Bivariate Fit of KSC5 By Time



Bivariate Fit of KSC6 By Time

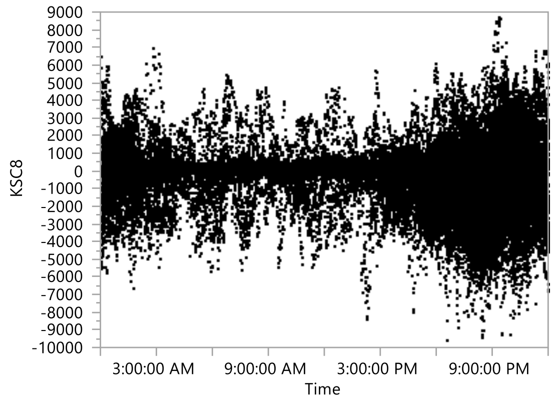


Bivariate Fit of KSC7 By Time

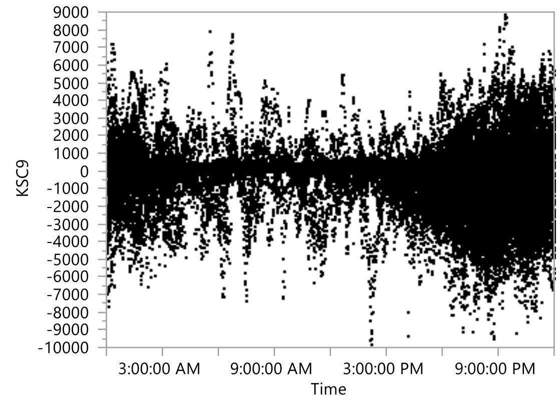


Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time (cont.)

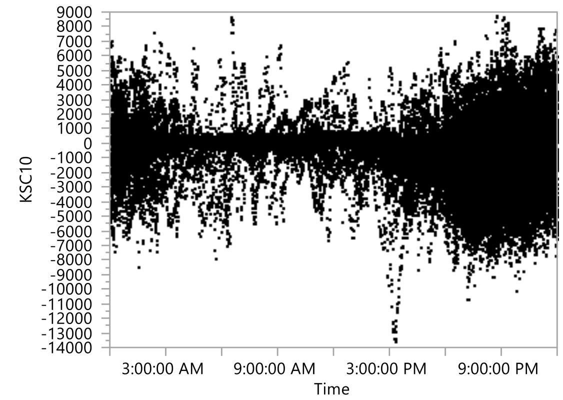
Bivariate Fit of KSC8 By Time



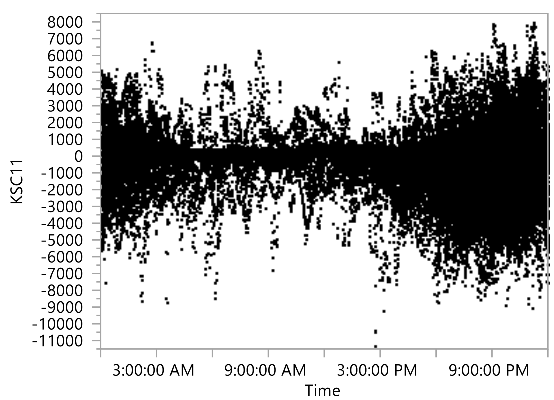
Bivariate Fit of KSC9 By Time



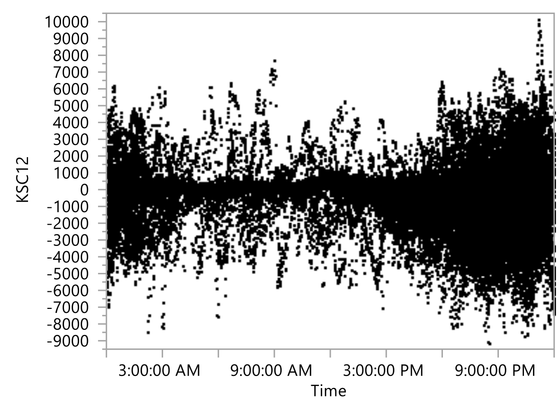
Bivariate Fit of KSC10 By Time



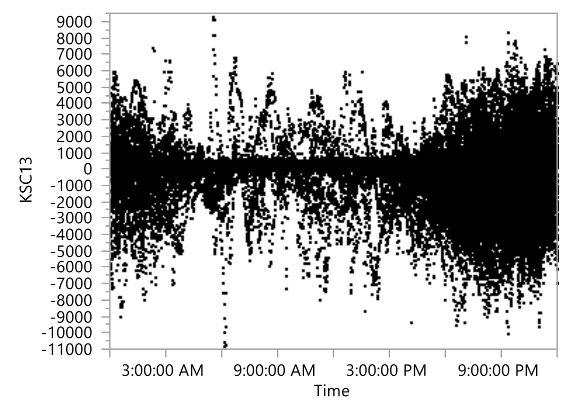
Bivariate Fit of KSC11 By Time



Bivariate Fit of KSC12 By Time

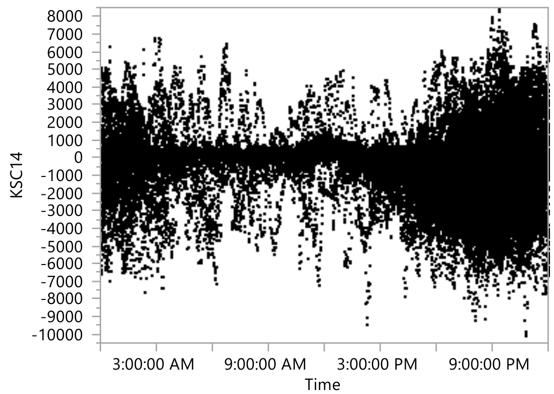


Bivariate Fit of KSC13 By Time

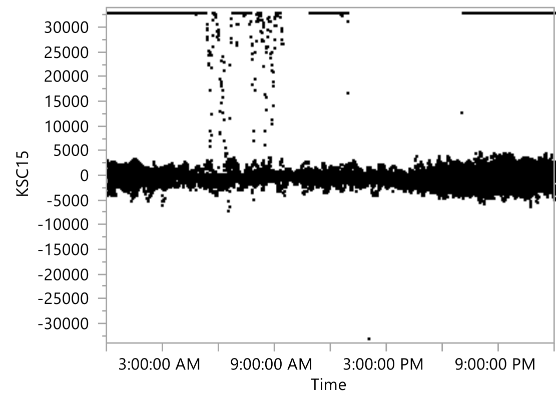


Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time (cont.)

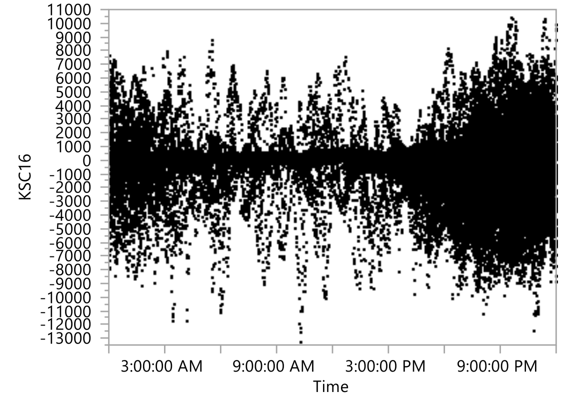
Bivariate Fit of KSC14 By Time



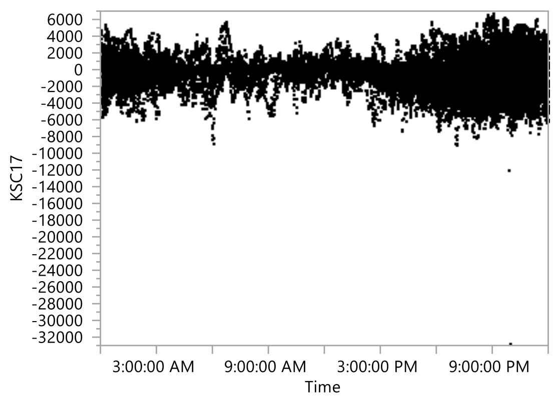
Bivariate Fit of KSC15 By Time



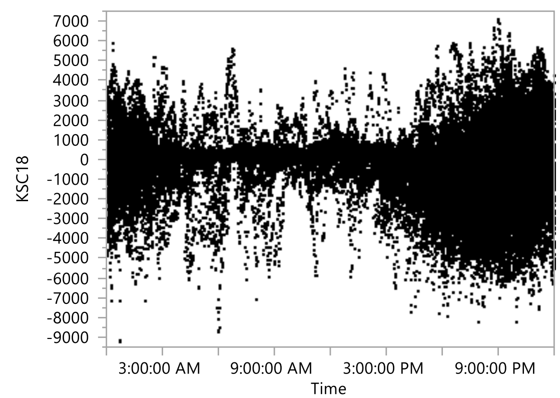
Bivariate Fit of KSC16 By Time



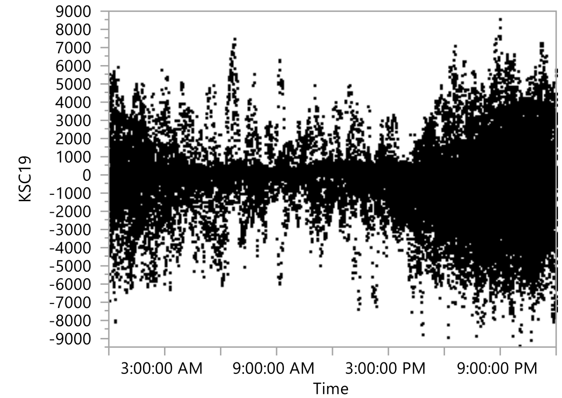
Bivariate Fit of KSC17 By Time



Bivariate Fit of KSC18 By Time

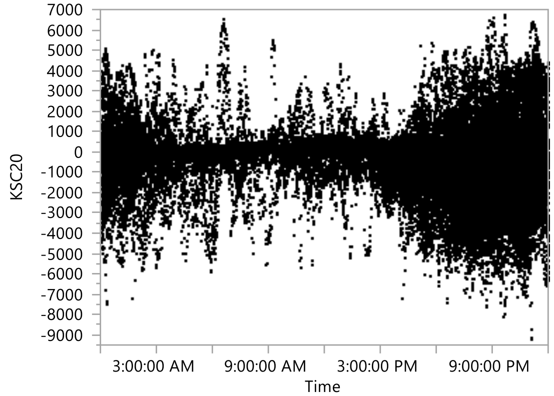


Bivariate Fit of KSC19 By Time

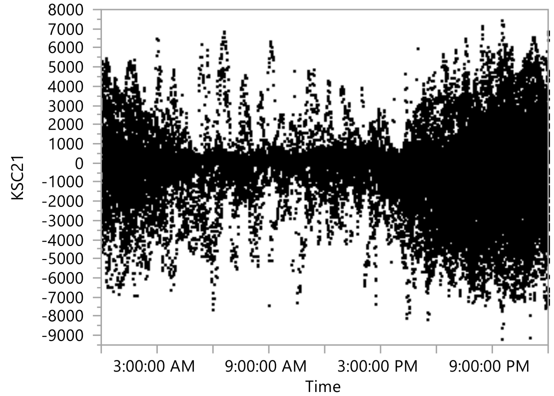


Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time (cont.)

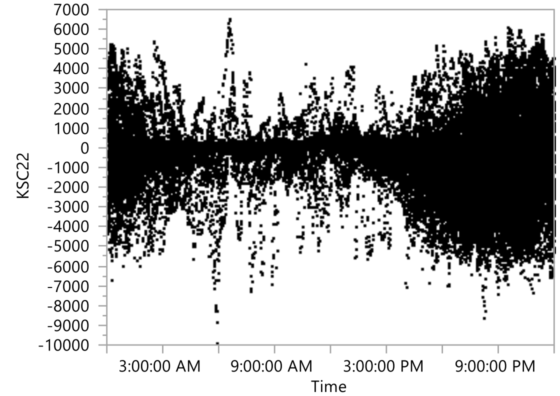
Bivariate Fit of KSC20 By Time



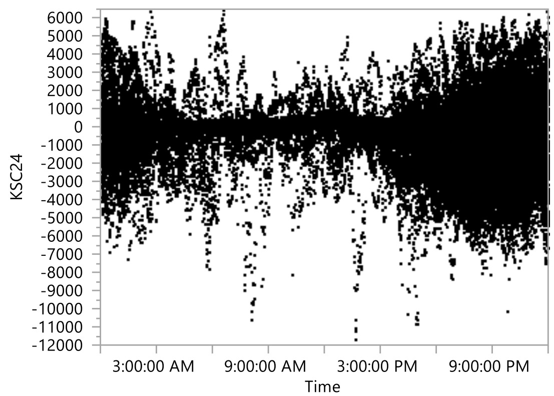
Bivariate Fit of KSC21 By Time



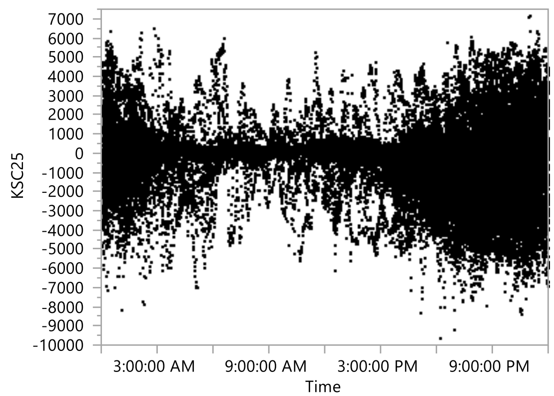
Bivariate Fit of KSC22 By Time



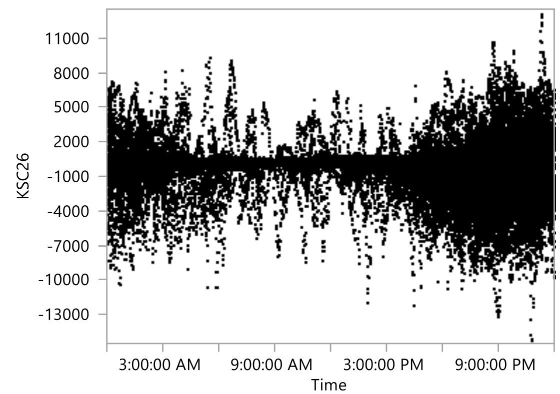
Bivariate Fit of KSC24 By Time



Bivariate Fit of KSC25 By Time

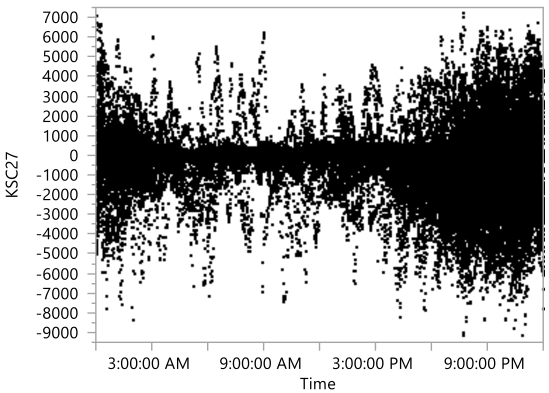


Bivariate Fit of KSC26 By Time

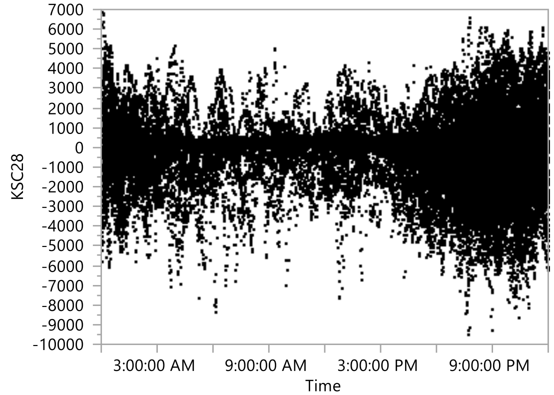


Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time (cont.)

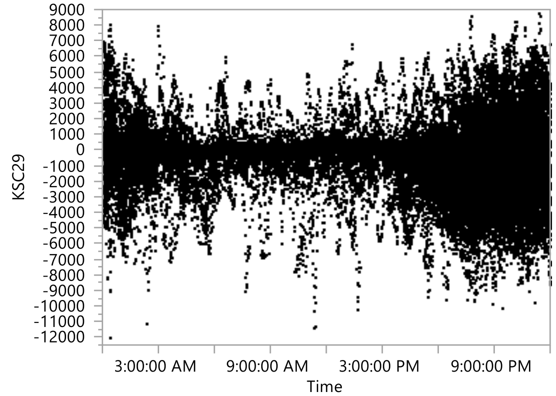
Bivariate Fit of KSC27 By Time



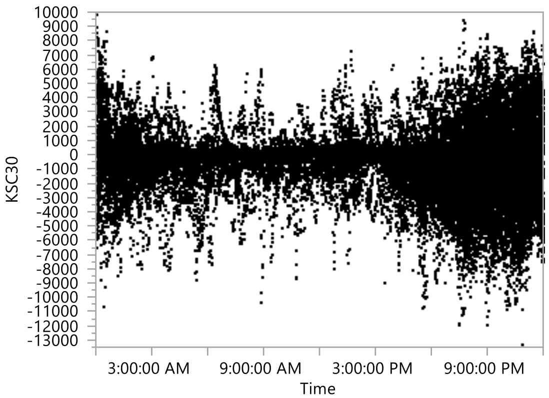
Bivariate Fit of KSC28 By Time



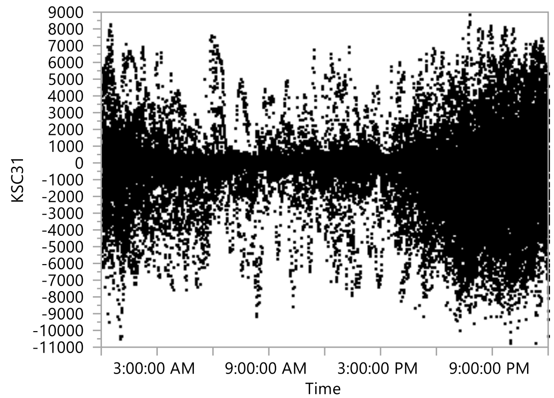
Bivariate Fit of KSC29 By Time



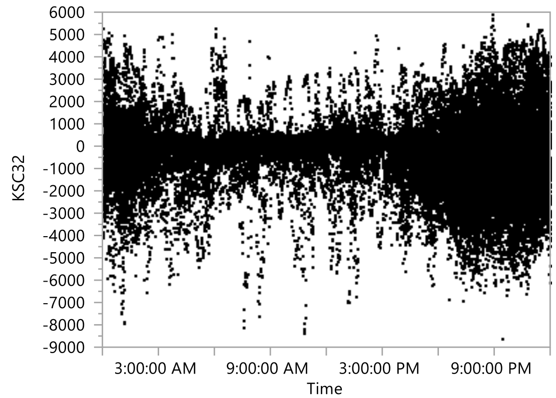
Bivariate Fit of KSC30 By Time



Bivariate Fit of KSC31 By Time

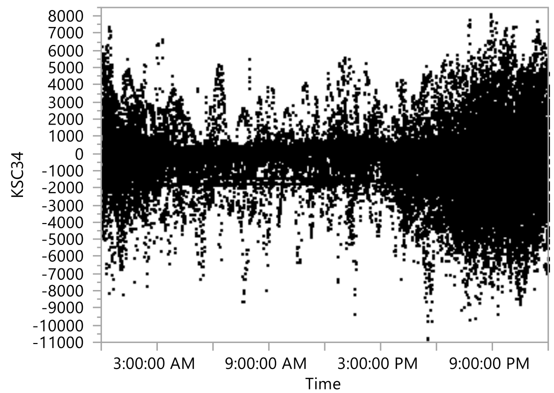


Bivariate Fit of KSC32 By Time



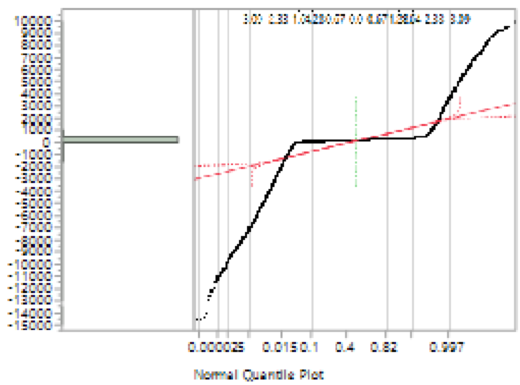
Appendix B: Scatter Plots 1-Minute Mean Sensor Values by Time (cont.)

Bivariate Fit of KSC34 By Time

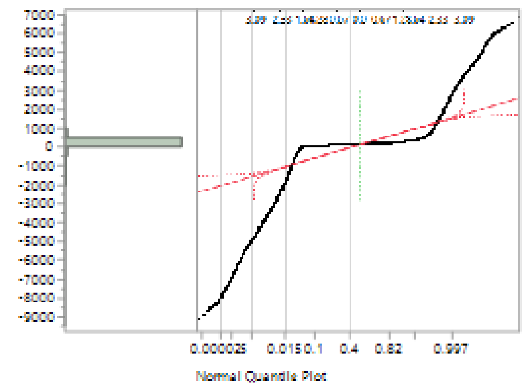


Appendix C: Normal Quantile Plots for EFM Sensor Readings

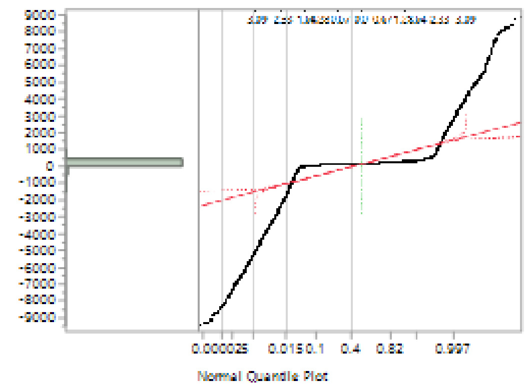
KSC1



KSC2



KSC4



Quantiles (KSC1)

100.0%	maximum	9940.0173333
99.5%		2688.9498667
97.5%		513.928
90.0%		321.90266667
75.0%	quartile	253.11466667
50.0%	median	201.93866667
25.0%	quartile	151.93333333
10.0%		102.216
2.5%		-812.8453333
0.5%		-4293.0664
0.0%	minimum	-14503.552

Quantiles (KSC2)

100.0%	maximum	6872.1826667
99.5%		2285.5680933
97.5%		562.2332
90.0%		277.8404
75.0%	quartile	200.80933333
50.0%	median	153.31066667
25.0%	quartile	119.116
10.0%		87.113333333
2.5%		-939.6155333
0.5%		-3269.12184
0.0%	minimum	-9083.388

Quantiles (KSC4)

100.0%	maximum	8819.7013333
99.5%		2286.9184667
97.5%		488.48316667
90.0%		307.59
75.0%	quartile	242.68233333
50.0%	median	189.224
25.0%	quartile	135.935
10.0%		88.659333333
2.5%		-747.6763333
0.5%		-3208.8287
0.0%	minimum	-9382.976

Summary Statistics (KSC1)

Mean	159.59655
Std Dev	662.95604
Std Err Mean	0.8188768
Upper 95% Mean	161.20152
Lower 95% Mean	157.99158
N	655439

Summary Statistics (KSC2)

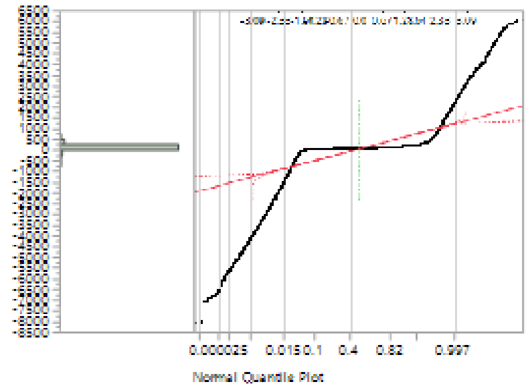
Mean	128.49252
Std Dev	528.22254
Std Err Mean	0.6193042
Upper 95% Mean	129.70634
Lower 95% Mean	127.27871
N	727488

Summary Statistics (KSC4)

Mean	156.7688
Std Dev	528.61296
Std Err Mean	0.6521098
Upper 95% Mean	158.04691
Lower 95% Mean	155.49068
N	657104

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC5



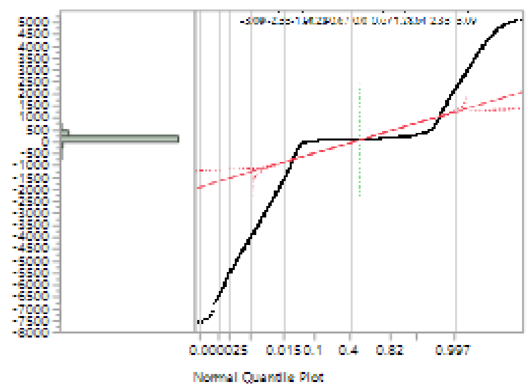
Quantiles

100.0%	maximum	6052.1946667
99.5%		1768.2720267
97.5%		409.0908
90.0%		197.22693333
75.0%	quartile	146.612
50.0%	median	113.5
25.0%	quartile	87.497333333
10.0%		62.1424
2.5%		-793.6312
0.5%		-2640.349733
0.0%	minimum	-8041.912

Summary Statistics

Mean	88.743996
Std Dev	424.18331
Std Err Mean	0.500996
Upper 95% Mean	89.725932
Lower 95% Mean	87.76206
N	716867

KSC6



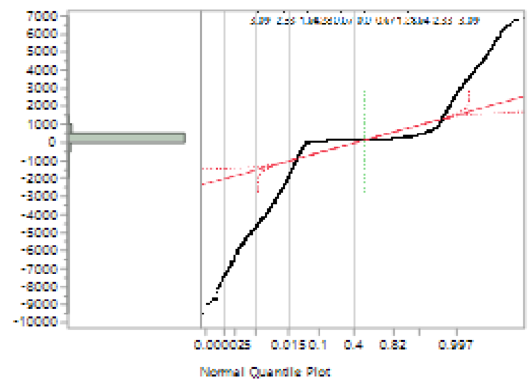
Quantiles

100.0%	maximum	5103.9133333
99.5%		1808.22998
97.5%		433.67076667
90.0%		227.04813333
75.0%	quartile	165.71866667
50.0%	median	124.31733333
25.0%	quartile	91.361333333
10.0%		52.908
2.5%		-878.0410333
0.5%		-2554.126293
0.0%	minimum	-7493.770667

Summary Statistics

Mean	97.772414
Std Dev	426.18521
Std Err Mean	0.5084172
Upper 95% Mean	98.768895
Lower 95% Mean	96.775933
N	702678

KSC7



Quantiles

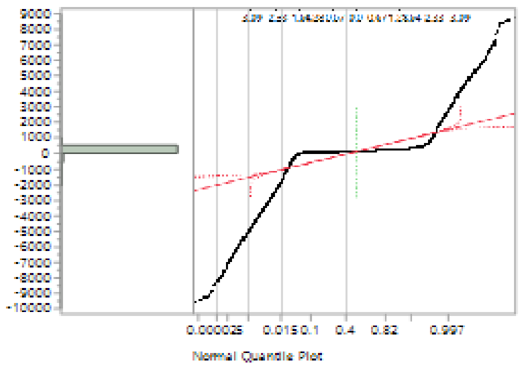
100.0%	maximum	6870.964
99.5%		2208.4002133
97.5%		644.983
90.0%		302.49493333
75.0%	quartile	198.38666667
50.0%	median	143.852
25.0%	quartile	108.54666667
10.0%		76.989333333
2.5%		-1007.8594
0.5%		-3217.406187
0.0%	minimum	-9436.321333

Summary Statistics

Mean	125.17482
Std Dev	520.21805
Std Err Mean	0.6149025
Upper 95% Mean	126.38001
Lower 95% Mean	123.96963
N	715745

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC8



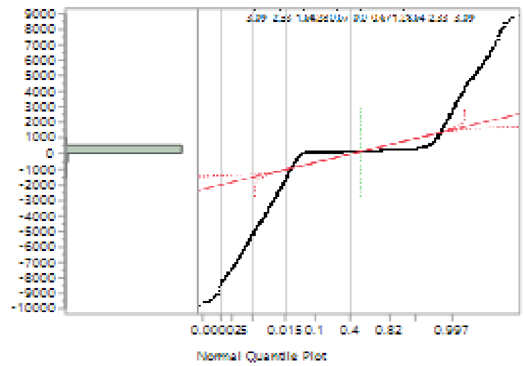
Quantiles

100.0%	maximum	8685.7466667
99.5%		2210.0898333
97.5%		500.3712
90.0%		285.95866667
75.0%	quartile	216.45733333
50.0%	median	168.75466667
25.0%	quartile	129.06166667
10.0%		93.271066667
2.5%		-934.6845667
0.5%		-3189.762573
0.0%	minimum	-9513.589333

Summary Statistics

Mean	138.09477
Std Dev	526.63742
Std Err Mean	0.6205223
Upper 95% Mean	139.31098
Lower 95% Mean	136.87857
N	720292

KSC9



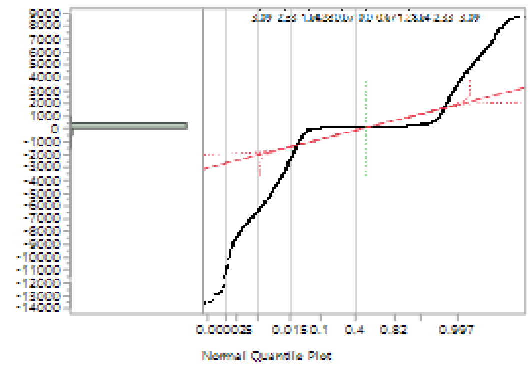
Quantiles

100.0%	maximum	8822.728
99.5%		2094.3318867
97.5%		461.79833333
90.0%		274.5944
75.0%	quartile	213.291
50.0%	median	168.05733333
25.0%	quartile	128.92933333
10.0%		94.1868
2.5%		-803.5041333
0.5%		-3233.97888
0.0%	minimum	-9744.029333

Summary Statistics

Mean	136.86967
Std Dev	521.13513
Std Err Mean	0.6149628
Upper 95% Mean	138.07498
Lower 95% Mean	135.66436
N	718130

KSC10



Quantiles

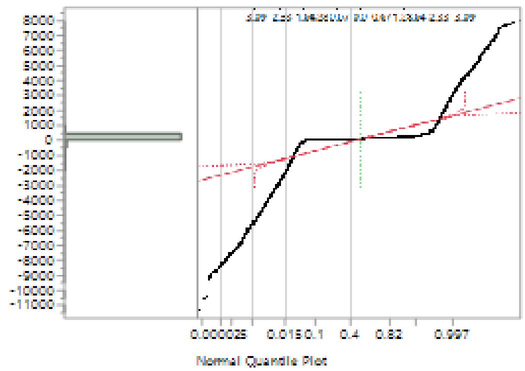
100.0%	maximum	8734.6786667
99.5%		2811.5056667
97.5%		493.83903333
90.0%		257.2588
75.0%	quartile	190.09066667
50.0%	median	146.13133333
25.0%	quartile	112.56266667
10.0%		80.408
2.5%		-1248.334867
0.5%		-4357.483993
0.0%	minimum	-13500.284

Summary Statistics

Mean	100.50526
Std Dev	670.16676
Std Err Mean	0.7951076
Upper 95% Mean	102.06364
Lower 95% Mean	98.946872
N	710418

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC11



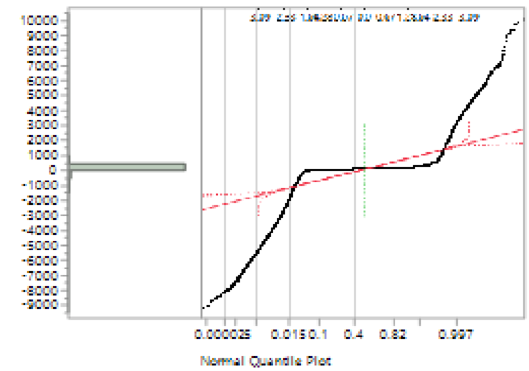
Quantiles

100.0%	maximum	7949.3066667
99.5%		2442.4183467
97.5%		457.352
90.0%		237.3016
75.0%	quartile	178.22666667
50.0%	median	139.44666667
25.0%	quartile	109.832
10.0%		79.5464
2.5%		-1178.8464
0.5%		-3628.420747
0.0%	minimum	-11271.05733

Summary Statistics

Mean	98.422934
Std Dev	583.74111
Std Err Mean	0.6830643
Upper 95% Mean	99.761718
Lower 95% Mean	97.08415
N	730327

KSC12



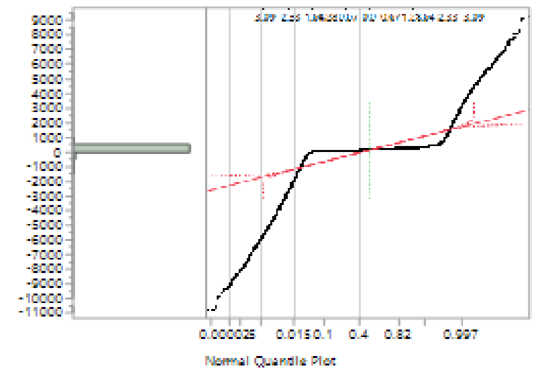
Quantiles

100.0%	maximum	10054.16
99.5%		2508.59752
97.5%		459.73066667
90.0%		239.45866667
75.0%	quartile	177.49066667
50.0%	median	138.86133333
25.0%	quartile	109.288
10.0%		82.647466667
2.5%		-831.2830667
0.5%		-3623.645493
0.0%	minimum	-9101.418667

Summary Statistics

Mean	109.14169
Std Dev	566.32465
Std Err Mean	0.6898631
Upper 95% Mean	110.4938
Lower 95% Mean	107.78958
N	673915

KSC13



Quantiles

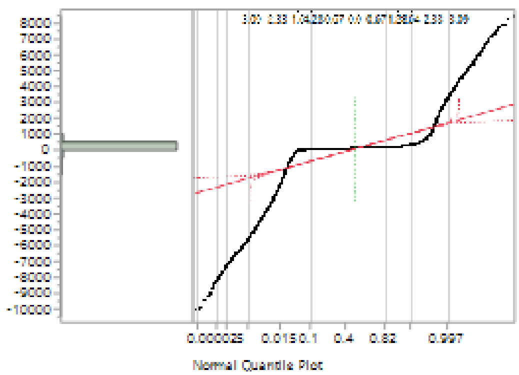
100.0%	maximum	9284.0973333
99.5%		2476.25238
97.5%		479.64073333
90.0%		298.232
75.0%	quartile	234.60533333
50.0%	median	185.54666667
25.0%	quartile	135.935
10.0%		81.674666667
2.5%		-915.3963667
0.5%		-3724.703433
0.0%	minimum	-10718.72267

Summary Statistics

Mean	143.08029
Std Dev	590.15922
Std Err Mean	0.697615
Upper 95% Mean	144.4476
Lower 95% Mean	141.71299
N	715660

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC14



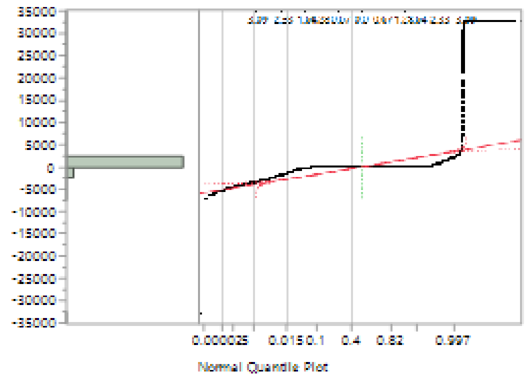
Quantiles

100.0%	maximum	8386.5573333
99.5%		2640.64696
97.5%		561.50546667
90.0%		249.6312
75.0%	quartile	183.09333333
50.0%	median	143.44133333
25.0%	quartile	113.388
10.0%		82.840266667
2.5%		-989.3358667
0.5%		-3803.71984
0.0%	minimum	-10023.944

Summary Statistics

Mean	110.78012
Std Dev	594.04368
Std Err Mean	0.7073728
Upper 95% Mean	112.16654
Lower 95% Mean	109.39369
N	705245

KSC15



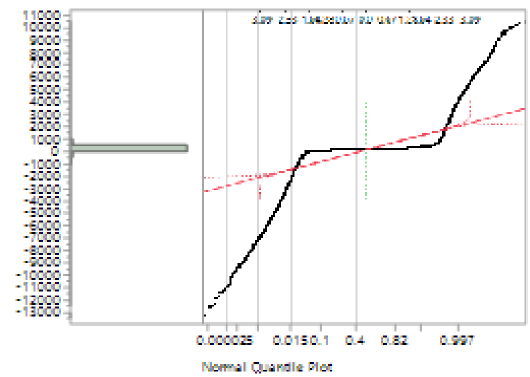
Quantiles

100.0%	maximum	32764
99.5%		1874.9395
97.5%		347.87916667
90.0%		205.254
75.0%	quartile	151.89033333
50.0%	median	111.89133333
25.0%	quartile	82.284
10.0%		44.944666667
2.5%		-727.1078333
0.5%		-2264.2665
0.0%	minimum	-32768

Summary Statistics

Mean	133.82366
Std Dev	1270.5871
Std Err Mean	1.5665692
Upper 95% Mean	136.89409
Lower 95% Mean	130.75324
N	657824

KSC16



Quantiles

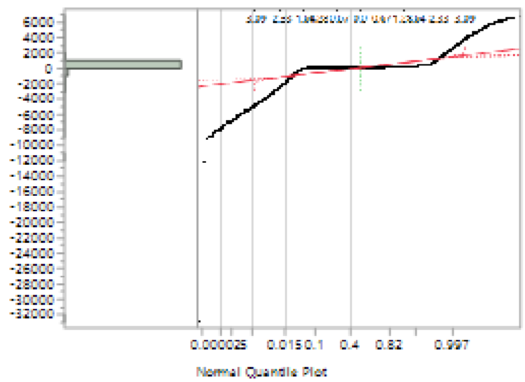
100.0%	maximum	10388.962667
99.5%		3220.79544
97.5%		532.13706667
90.0%		314.58133333
75.0%	quartile	241.43333333
50.0%	median	189.89733333
25.0%	quartile	147.01066667
10.0%		104.44293333
2.5%		-983.9785333
0.5%		-4564.484613
0.0%	minimum	-13234.68667

Summary Statistics

Mean	150.06505
Std Dev	714.69309
Std Err Mean	0.8413425
Upper 95% Mean	151.71405
Lower 95% Mean	148.41604
N	721595

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC17



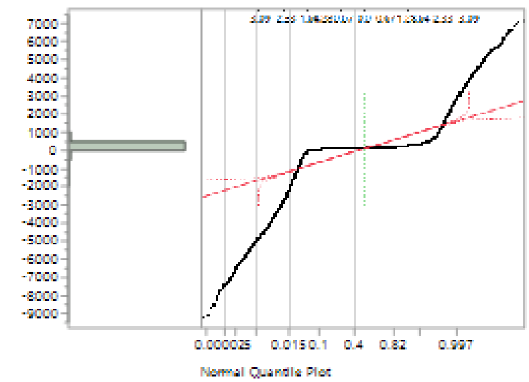
Quantiles

100.0%	maximum	6674.9026667
99.5%		2126.1738
97.5%		447.54666667
90.0%		226.43066667
75.0%	quartile	165.22133333
50.0%	median	123.624
25.0%	quartile	88.257333333
10.0%		51.647333333
2.5%		-1053.531833
0.5%		-3327.869567
0.0%	minimum	-32746.156

Summary Statistics

Mean	86.991835
Std Dev	527.67706
Std Err Mean	0.6234539
Upper 95% Mean	88.213785
Lower 95% Mean	85.769886
N	716354

KSC18



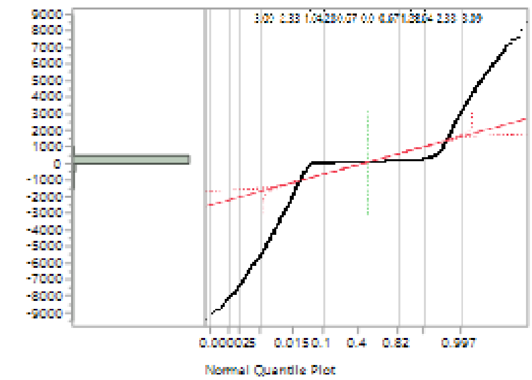
Quantiles

100.0%	maximum	7087.7333333
99.5%		2376.2472
97.5%		576.567
90.0%		264.63066667
75.0%	quartile	182.91466667
50.0%	median	138.028
25.0%	quartile	105.75333333
10.0%		76.428
2.5%		-1194.975333
0.5%		-3557.311267
0.0%	minimum	-9161.84

Summary Statistics

Mean	104.76302
Std Dev	564.17398
Std Err Mean	0.6628041
Upper 95% Mean	106.06209
Lower 95% Mean	103.46394
N	724529

KSC19



Quantiles

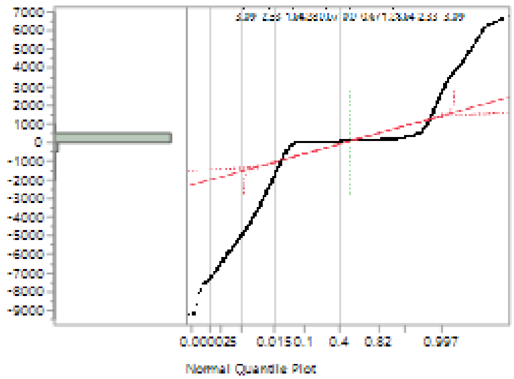
100.0%	maximum	8520.9253333
99.5%		2441.1515733
97.5%		468.49046667
90.0%		237.2024
75.0%	quartile	175.536
50.0%	median	137.08266667
25.0%	quartile	108.08933333
10.0%		78.716266667
2.5%		-947.2637333
0.5%		-3529.617373
0.0%	minimum	-9333.362667

Summary Statistics

Mean	104.74397
Std Dev	559.89816
Std Err Mean	0.6616679
Upper 95% Mean	106.04081
Lower 95% Mean	103.44712
N	716041

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC20



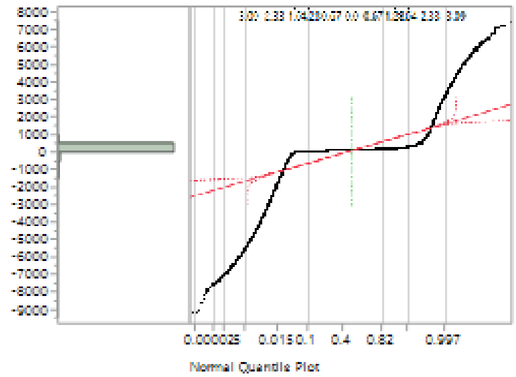
Quantiles

100.0%	maximum	6744.132
99.5%		2104.7092933
97.5%		435.34513333
90.0%		207.44613333
75.0%	quartile	151.28466667
50.0%	median	116.69066667
25.0%	quartile	90.232
10.0%		62.784
2.5%		-916.4475333
0.5%		-3229.81916
0.0%	minimum	-9167.577333

Summary Statistics

Mean	85.077838
Std Dev	506.40082
Std Err Mean	0.6061777
Upper 95% Mean	86.265927
Lower 95% Mean	83.88975
N	697893

KSC21



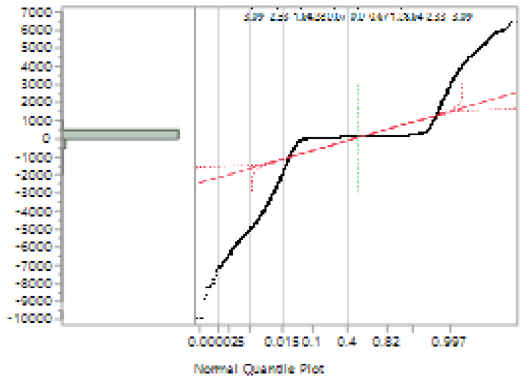
Quantiles

100.0%	maximum	7441.3213333
99.5%		2464.5833067
97.5%		443.92693333
90.0%		220.45226667
75.0%	quartile	164.58133333
50.0%	median	129.33066667
25.0%	quartile	102.46133333
10.0%		74.87354386
2.5%		-835.6248
0.5%		-3641.91792
0.0%	minimum	-9166.645333

Summary Statistics

Mean	99.599516
Std Dev	558.17217
Std Err Mean	0.6694064
Upper 95% Mean	100.91153
Lower 95% Mean	98.287502
N	695275

KSC22



Quantiles

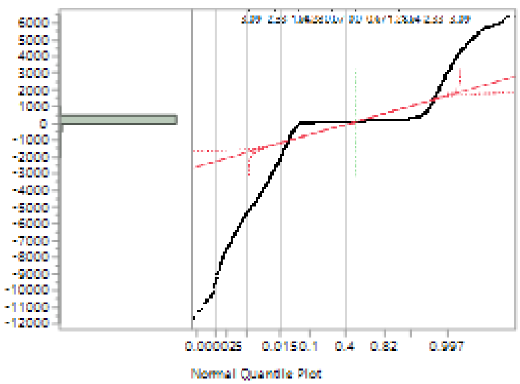
100.0%	maximum	6507.92
99.5%		2322.6969267
97.5%		356.8588
90.0%		182.91546667
75.0%	quartile	138.975
50.0%	median	107.348
25.0%	quartile	81.682666667
10.0%		52.329333333
2.5%		-1009.794567
0.5%		-3479.946693
0.0%	minimum	-9881.764

Summary Statistics

Mean	68.294278
Std Dev	537.01856
Std Err Mean	0.6296818
Upper 95% Mean	69.528434
Lower 95% Mean	67.060122
N	727338

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC24



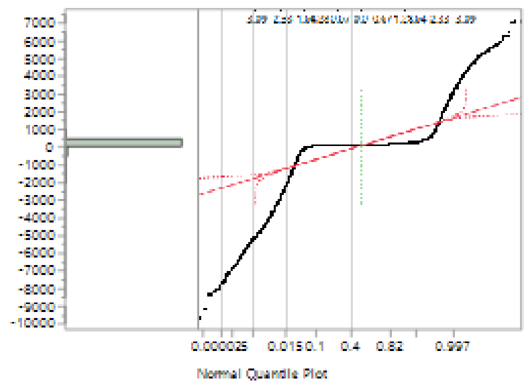
Quantiles

100.0%	maximum	6400.2613333
99.5%		2463.96086
97.5%		473.7758
90.0%		235.0756
75.0%	quartile	178.039
50.0%	median	139.49733333
25.0%	quartile	109.98
10.0%		80.346666667
2.5%		-1149.695767
0.5%		-3634.30722
0.0%	minimum	-11581.43733

Summary Statistics

Mean	100.08246
Std Dev	578.08724
Std Err Mean	0.67646
Upper 95% Mean	101.4083
Lower 95% Mean	98.756617
N	730302

KSC25



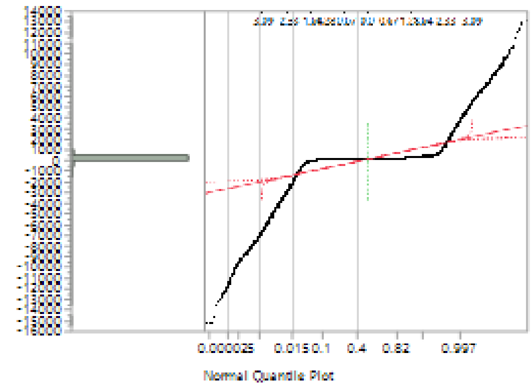
Quantiles

100.0%	maximum	7104.5333333
99.5%		2571.7459533
97.5%		485.98916667
90.0%		235.57346667
75.0%	quartile	175.85033333
50.0%	median	136.47133333
25.0%	quartile	106.97333333
10.0%		74.892933333
2.5%		-1204.6263
0.5%		-3700.703467
0.0%	minimum	-9597.394667

Summary Statistics

Mean	97.26789
Std Dev	585.27668
Std Err Mean	0.7280282
Upper 95% Mean	98.694801
Lower 95% Mean	95.840978
N	646288

KSC26



Quantiles

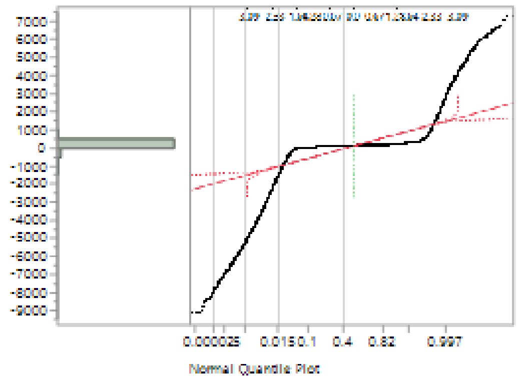
100.0%	maximum	13023.558667
99.5%		2995.1208333
97.5%		540.10166667
90.0%		327.39533333
75.0%	quartile	253.00666667
50.0%	median	200.10533333
25.0%	quartile	154.85733333
10.0%		105.16266667
2.5%		-894.0998333
0.5%		-4156.673433
0.0%	minimum	-15167.00933

Summary Statistics

Mean	164.09545
Std Dev	674.82001
Std Err Mean	0.8019978
Upper 95% Mean	165.66734
Lower 95% Mean	162.52356
N	707994

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC27



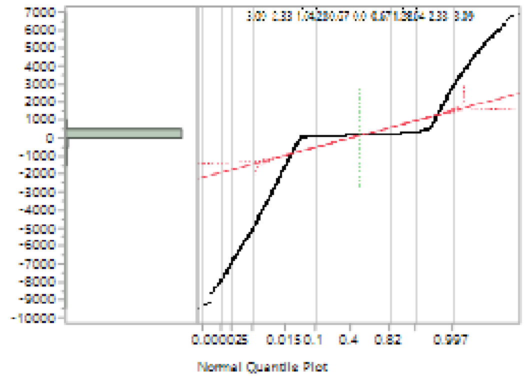
Quantiles

100.0%	maximum	7223.8253333
99.5%		2156.3088954
97.5%		391.1928
90.0%		228.70226667
75.0%	quartile	175.184
50.0%	median	136.53466667
25.0%	quartile	102.76266667
10.0%		61.180266667
2.5%		-736.7429333
0.5%		-3209.351147
0.0%	minimum	-9072.258667

Summary Statistics

Mean	105.13906
Std Dev	509.45323
Std Err Mean	0.5968134
Upper 95% Mean	106.3088
Lower 95% Mean	103.96933
N	728671

KSC28



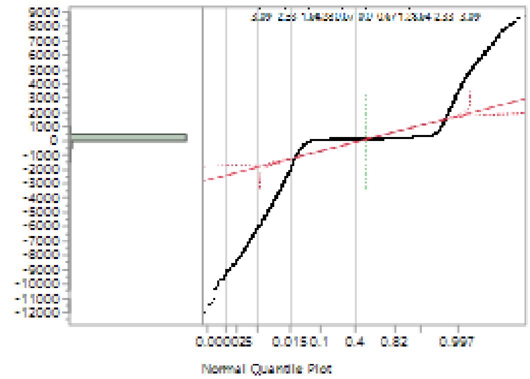
Quantiles

100.0%	maximum	6877.1106667
99.5%		2255.36132
97.5%		489.86226667
90.0%		286.944
75.0%	quartile	220.93533333
50.0%	median	174.74666667
25.0%	quartile	140.24133333
10.0%		108.19733333
2.5%		-743.1706
0.5%		-3091.012853
0.0%	minimum	-9424.146667

Summary Statistics

Mean	152.18766
Std Dev	502.20954
Std Err Mean	0.5897497
Upper 95% Mean	153.34355
Lower 95% Mean	151.03177
N	725161

KSC29



Quantiles

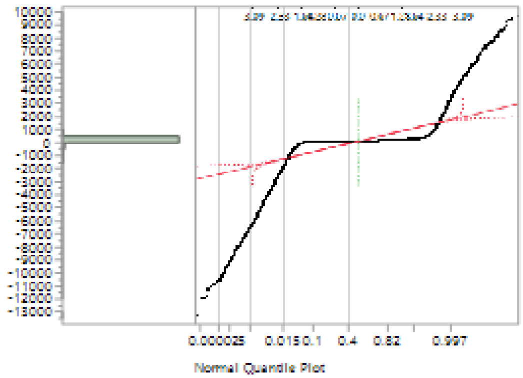
100.0%	maximum	8687.3026667
99.5%		2611.3265
97.5%		423.48116667
90.0%		243.06266667
75.0%	quartile	186.94133333
50.0%	median	146.71333333
25.0%	quartile	114.928
10.0%		80.192
2.5%		-921.5293333
0.5%		-3872.133833
0.0%	minimum	-11933.85467

Summary Statistics

Mean	108.76132
Std Dev	609.14577
Std Err Mean	0.7138691
Upper 95% Mean	110.16048
Lower 95% Mean	107.36216
N	728124

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC30



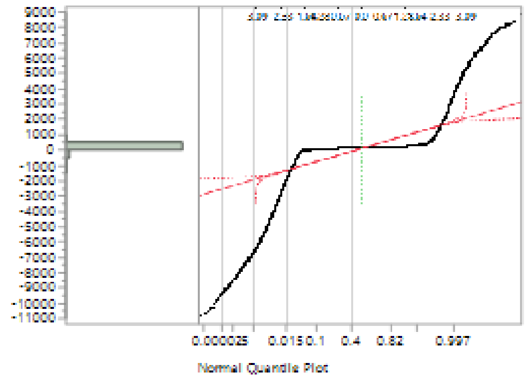
Quantiles

100.0%	maximum	9763.112
99.5%		2574.8303333
97.5%		433.597
90.0%		243.752
75.0%	quartile	189.78
50.0%	median	150.89866667
25.0%	quartile	116.87733333
10.0%		79.453333333
2.5%		-896.5
0.5%		-3782.664
0.0%	minimum	-13251.68933

Summary Statistics

Mean	113.00599
Std Dev	612.08364
Std Err Mean	0.7166111
Upper 95% Mean	114.41053
Lower 95% Mean	111.60146
N	729549

KSC31



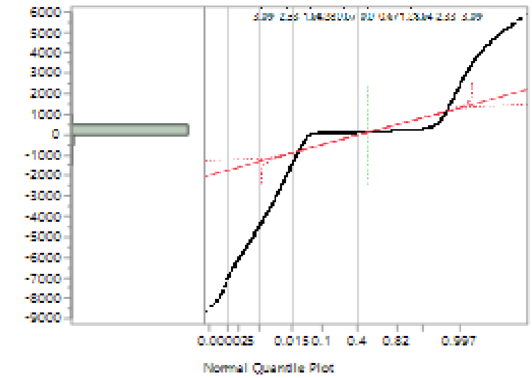
Quantiles

100.0%	maximum	8853.9693333
99.5%		2769.389
97.5%		480.19866667
90.0%		260.344
75.0%	quartile	199.948
50.0%	median	156.79
25.0%	quartile	121.672
10.0%		83.504666667
2.5%		-913.4956667
0.5%		-4178.3745
0.0%	minimum	-10681.85467

Summary Statistics

Mean	120.71366
Std Dev	646.15639
Std Err Mean	0.763454
Upper 95% Mean	122.21
Lower 95% Mean	119.21731
N	716324

KSC32



Quantiles

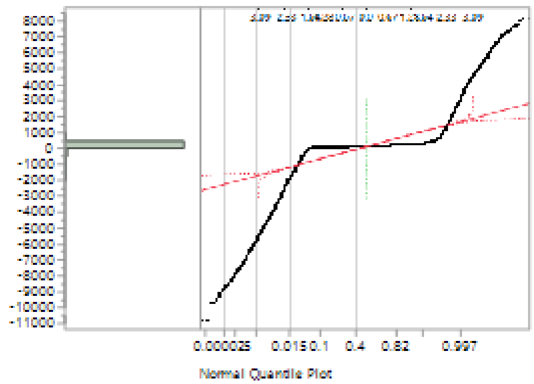
100.0%	maximum	5866.9746667
99.5%		1922.3985667
97.5%		418.447
90.0%		233.744
75.0%	quartile	178.876
50.0%	median	141.58333333
25.0%	quartile	111.91366667
10.0%		81.989333333
2.5%		-722.862
0.5%		-2805.843733
0.0%	minimum	-8573.265333

Summary Statistics

Mean	116.34205
Std Dev	448.63088
Std Err Mean	0.5260044
Upper 95% Mean	117.373
Lower 95% Mean	115.3111
N	727444

Appendix C: Normal Quantile Plots for EFM Sensor Readings (cont.)

KSC34



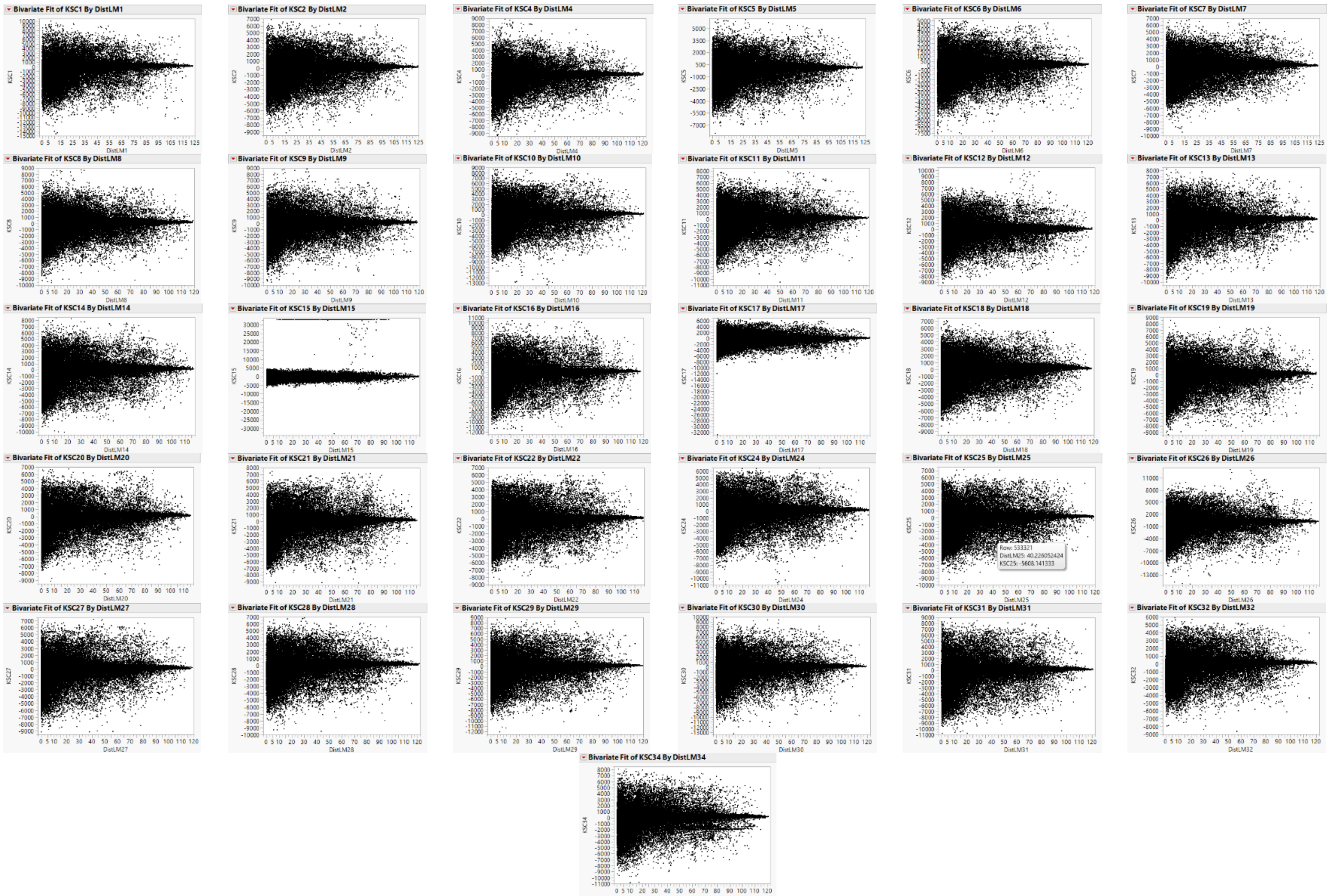
Quantiles

100.0%	maximum	8108.74
99.5%		2479.61252
97.5%		482.88676667
90.0%		270.916
75.0%	quartile	205.60266667
50.0%	median	161.51866667
25.0%	quartile	127.464
10.0%		93.882666667
2.5%		-1106.097233
0.5%		-3590.04974
0.0%	minimum	-10795.02533

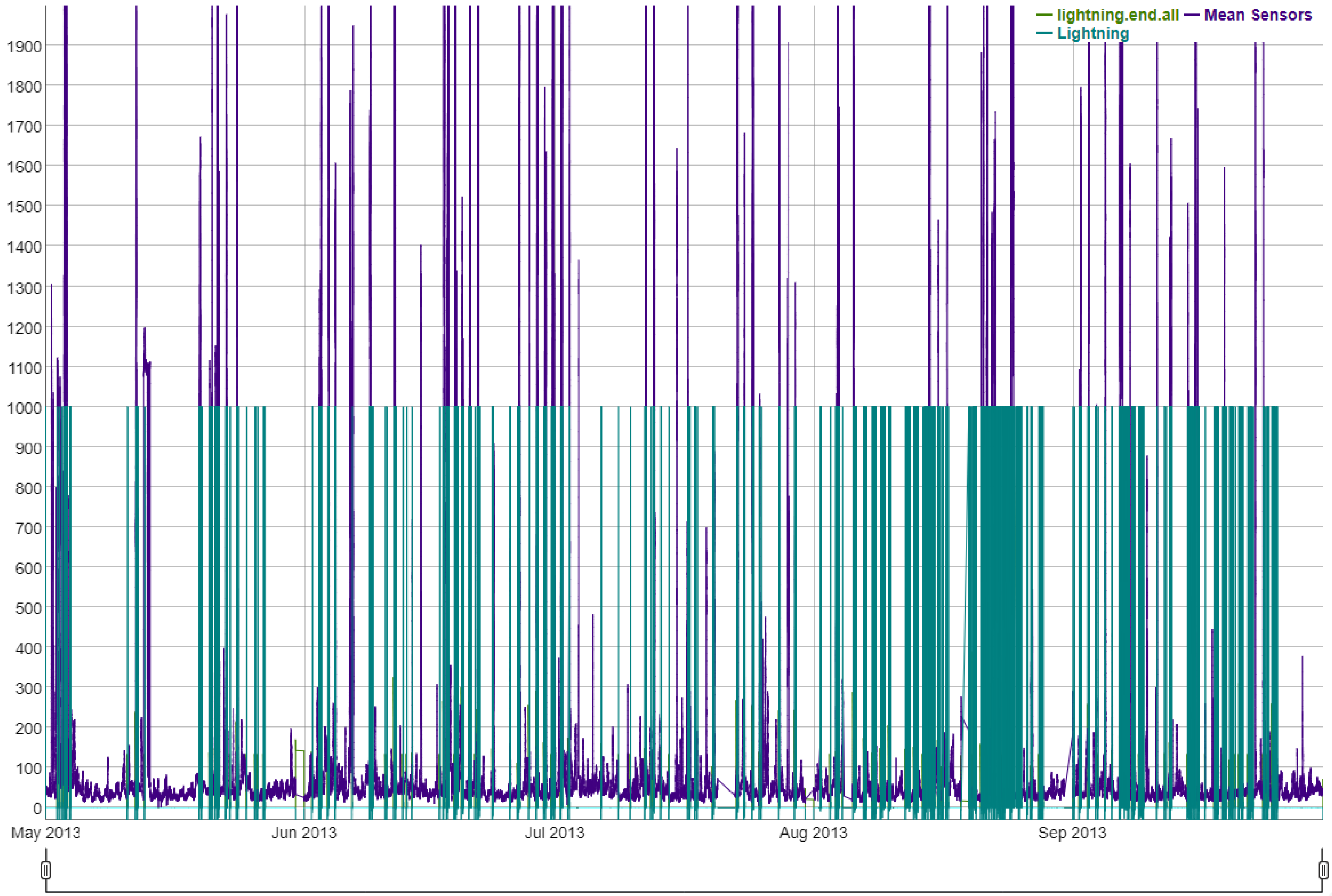
Summary Statistics

Mean	125.46772
Std Dev	580.67973
Std Err Mean	0.709481
Upper 95% Mean	126.85828
Lower 95% Mean	124.07716
N	669872

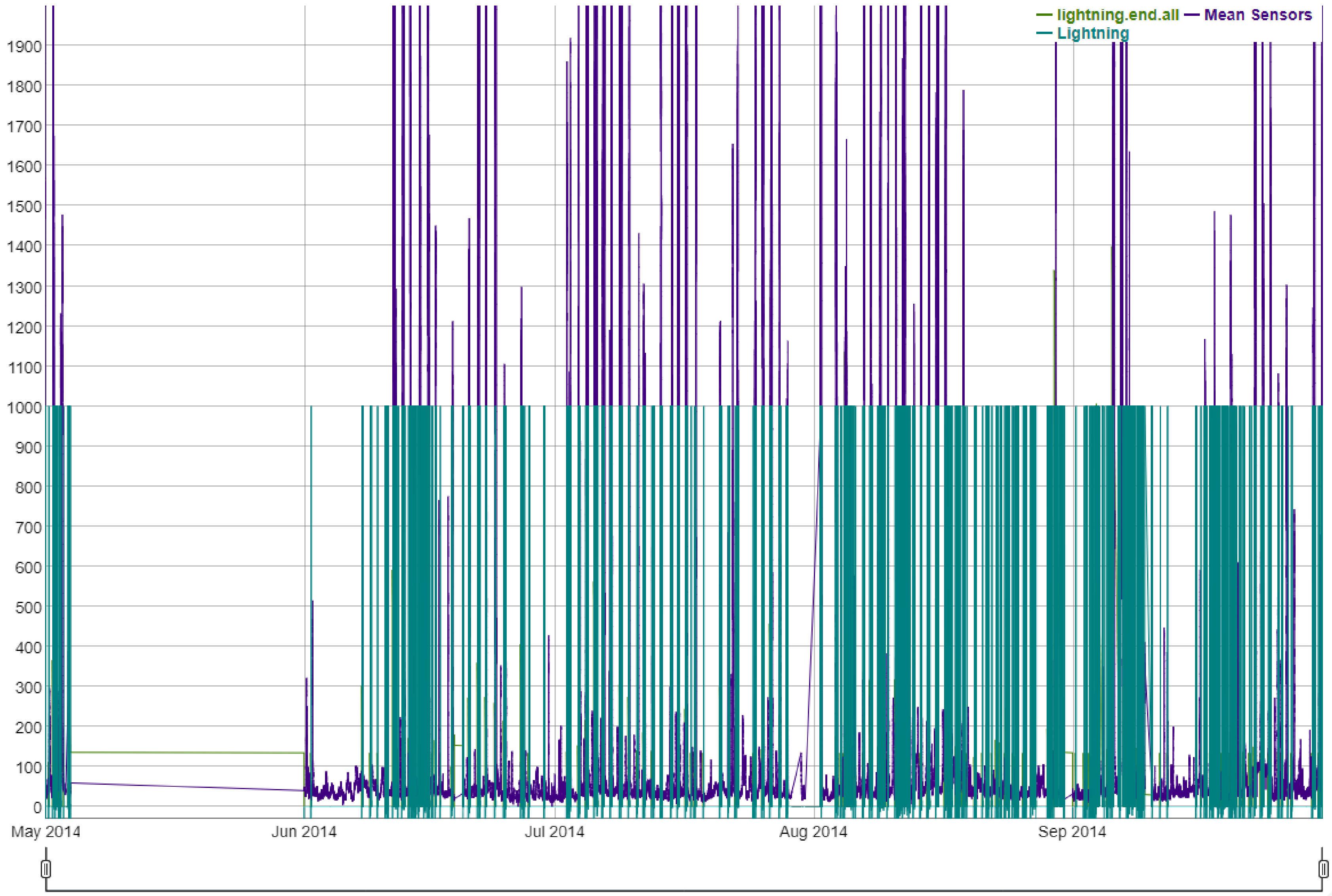
Appendix D: Scatter Plot 1-Minute Mean Sensor to Minimum Lightning Distance



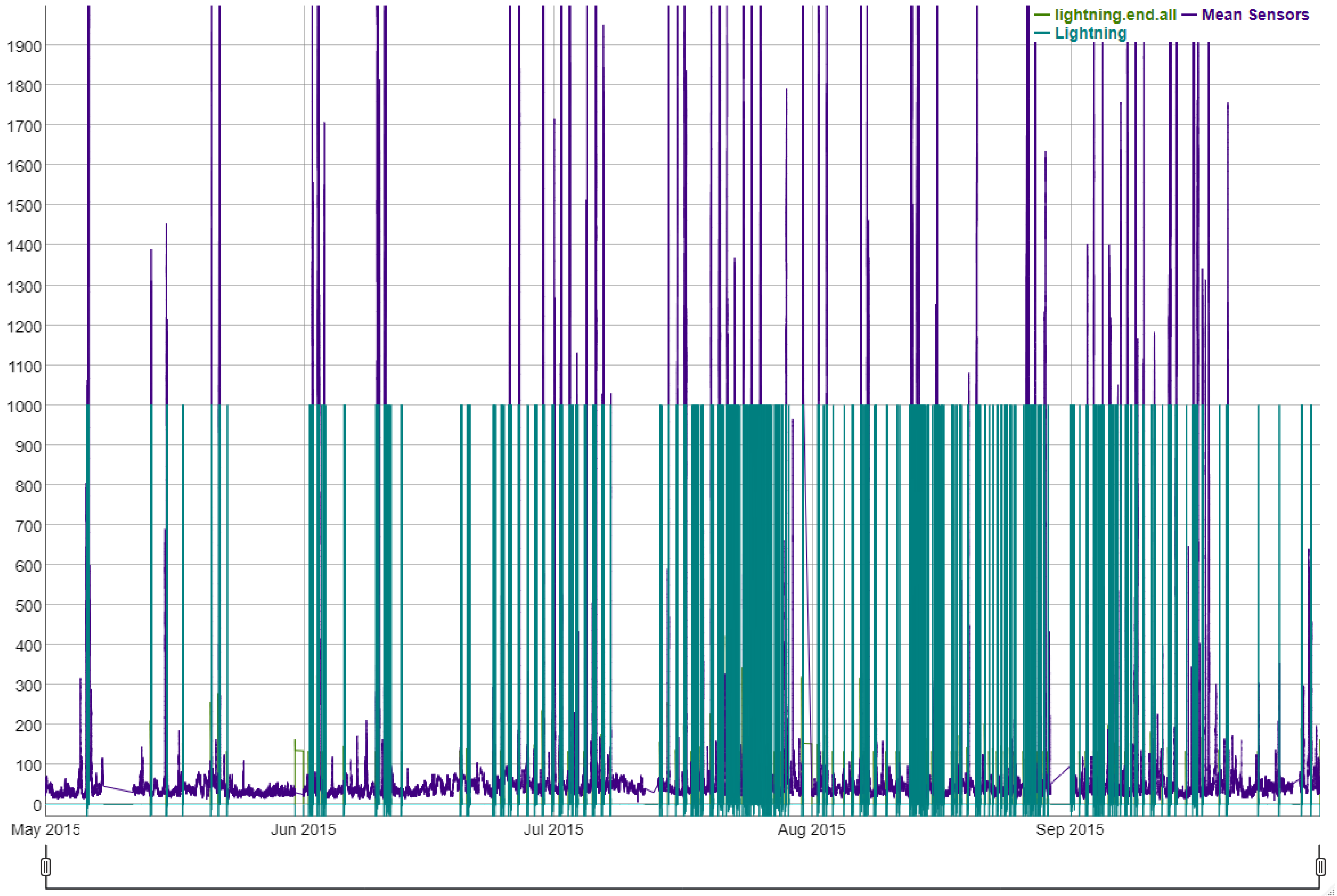
Appendix E: Annual Centered Mean Sensor and Lightning Response Plots



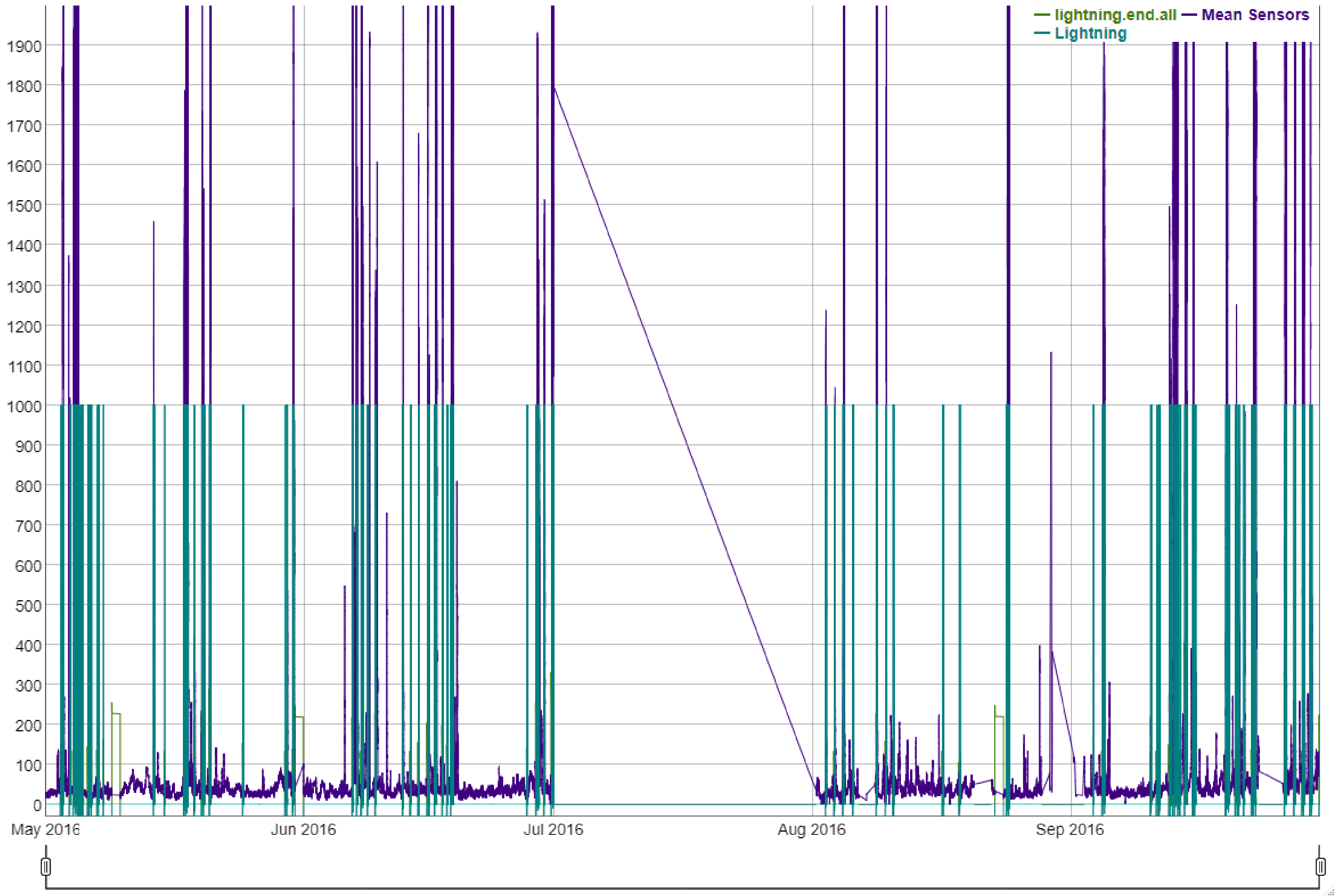
Appendix E: Annual Centered Mean Sensor and Lightning Response Plots (cont.)



Appendix E: Annual Centered Mean Sensor and Lightning Response Plots (cont.)



Appendix E: Annual Centered Mean Sensor and Lightning Response Plots (cont.)



Appendix F: Nominal Logistic Regression Model to Predict Storms

Nominal Logistic Fit for bin.LM1

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	7162.549	31	14325.1	<.0001*
Full	36409.108			
Reduced	43571.656			

RSquare (U)	0.1644
AICc	72882.2
BIC	73224.2
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	36409.108	72818.22
Saturated	322701	0.000	Prob>ChiSq
Fitted	31	36409.108	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-3.4345366	0.0116424	87027	<.0001*
KSC1	-0.0001996	1.6274e-5	150.48	<.0001*
KSC2	-0.0002264	2.5038e-5	81.79	<.0001*
KSC4	-0.0002041	2.5883e-5	62.19	<.0001*
KSC5	0.00010289	3.8419e-5	7.17	0.0074*
KSC6	0.00025726	3.8958e-5	43.61	<.0001*
KSC7	-0.0001569	0.0000238	43.47	<.0001*
KSC8	-0.0001233	3.1413e-5	15.41	<.0001*
KSC9	0.00008507	3.442e-5	6.11	0.0135*
KSC10	-1.6375e-5	2.3776e-5	0.47	0.4910
KSC11	-0.0002889	2.8715e-5	101.22	<.0001*
KSC12	9.93856e-5	3.0639e-5	10.52	0.0012*
KSC13	-0.0005791	2.8684e-5	407.61	<.0001*
KSC14	0.00016264	2.9271e-5	30.87	<.0001*
KSC15	0.00010959	4.9057e-5	4.99	0.0255*
KSC16	3.02851e-5	2.294e-5	1.74	0.1868
KSC17	8.88827e-5	3.6363e-5	5.97	0.0145*
KSC18	0.00005272	2.6083e-5	4.09	0.0433*
KSC19	0.0003126	3.1918e-5	95.92	<.0001*
KSC20	-7.6856e-5	0.0000329	5.45	0.0195*
KSC21	-0.0002529	2.5412e-5	99.01	<.0001*
KSC22	-0.0002827	2.6229e-5	116.15	<.0001*
KSC24	-3.7309e-6	2.2154e-5	0.03	0.8663
KSC25	-0.0001287	0.0000178	52.27	<.0001*
KSC26	-7.6761e-5	0.0000214	12.86	0.0003*
KSC27	-0.0004033	2.5319e-5	253.69	<.0001*
KSC28	-0.0004608	2.1489e-5	459.91	<.0001*
KSC29	-0.0001099	2.4918e-5	19.44	<.0001*
KSC30	0.00031141	2.5715e-5	146.65	<.0001*
KSC31	-0.0001078	1.9331e-5	31.08	<.0001*
KSC32	-3.0517e-5	3.7259e-5	0.67	0.4128
KSC34	-0.0001313	2.7833e-5	22.27	<.0001*

Nominal Logistic Fit for bin.LM2

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6759.861	31	13519.72	<.0001*
Full	39711.048			
Reduced	46470.908			

RSquare (U)	0.1455
AICc	79486.1
BIC	79828
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	39711.048	79422.1
Saturated	322701	0.000	Prob>ChiSq
Fitted	31	39711.048	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-3.3256531	0.0110481	90610	<.0001*
KSC1	-0.0001942	1.5811e-5	150.88	<.0001*
KSC2	-0.000215	2.4254e-5	78.56	<.0001*
KSC4	-0.0001949	2.5231e-5	59.65	<.0001*
KSC5	0.0001916	3.7215e-5	26.51	<.0001*
KSC6	0.00020268	3.7682e-5	28.93	<.0001*
KSC7	-0.0002362	2.3212e-5	103.56	<.0001*
KSC8	-0.0001462	3.0421e-5	23.09	<.0001*
KSC9	4.12926e-5	3.3834e-5	1.49	0.2223
KSC10	-2.0877e-5	2.3069e-5	0.82	0.3655
KSC11	-0.0003217	2.7751e-5	134.36	<.0001*
KSC12	5.32543e-5	2.9623e-5	3.23	0.0722
KSC13	-0.0005918	2.7922e-5	449.25	<.0001*
KSC14	0.00019668	2.8731e-5	46.86	<.0001*
KSC15	0.00017843	4.7853e-5	13.90	0.0002*
KSC16	-0.0000108	2.2353e-5	0.23	0.6291
KSC17	0.00006902	3.5681e-5	3.74	0.0531
KSC18	9.42189e-5	2.5665e-5	13.48	0.0002*
KSC19	0.000319	0.0000313	103.83	<.0001*
KSC20	-0.0001351	3.2542e-5	17.24	<.0001*
KSC21	-0.0001507	2.515e-5	35.88	<.0001*
KSC22	-0.0002589	2.5983e-5	99.27	<.0001*
KSC24	-4.2689e-6	0.0000218	0.04	0.8448
KSC25	-0.000191	0.0000174	120.62	<.0001*
KSC26	-6.9438e-5	0.0000212	10.73	0.0011*
KSC27	-0.000319	2.5062e-5	162.01	<.0001*
KSC28	-0.0003991	2.1273e-5	352.04	<.0001*
KSC29	-0.0001197	2.4855e-5	23.18	<.0001*
KSC30	0.00025033	0.0000254	97.11	<.0001*
KSC31	-0.0001213	1.9056e-5	40.51	<.0001*
KSC32	-2.4894e-7	3.6969e-5	0.00	0.9946
KSC34	-9.9828e-6	2.7846e-5	0.13	0.7200

Nominal Logistic Fit for bin.LM4

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6627.662	31	13255.32	<.0001*
Full	52042.184			
Reduced	58669.846			

RSquare (U)	0.1130
AICc	104148
BIC	104490
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	52038.026	104076.1
Saturated	322701	4.159	Prob>ChiSq
Fitted	31	52042.184	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.9689607	0.0094462	98787	<.0001*
KSC1	-0.0001927	1.5176e-5	161.24	<.0001*
KSC2	-0.0002157	2.3256e-5	86.01	<.0001*
KSC4	-0.0001604	0.0000243	43.57	<.0001*
KSC5	0.00028315	3.6362e-5	60.64	<.0001*
KSC6	0.00019477	3.6312e-5	28.77	<.0001*
KSC7	-0.0001176	2.2049e-5	28.44	<.0001*
KSC8	-2.4949e-5	3.0079e-5	0.69	0.4069
KSC9	-4.3648e-5	3.2863e-5	1.76	0.1841
KSC10	-0.0001138	2.2148e-5	26.40	<.0001*
KSC11	-0.0002248	2.6556e-5	71.66	<.0001*
KSC12	-1.4318e-6	2.8531e-5	0.00	0.9600
KSC13	-0.0004984	2.686e-5	344.32	<.0001*
KSC14	0.00029097	0.0000279	108.74	<.0001*
KSC15	8.16321e-5	4.5779e-5	3.18	0.0746
KSC16	-1.1887e-5	2.1416e-5	0.31	0.5789
KSC17	-3.4426e-5	0.0000334	1.06	0.3026
KSC18	0.00012167	2.4216e-5	25.24	<.0001*
KSC19	0.00019297	3.0263e-5	40.66	<.0001*
KSC20	-3.4731e-5	3.1621e-5	1.21	0.2720
KSC21	-0.0001986	2.3964e-5	68.65	<.0001*
KSC22	-0.0002619	0.0000243	116.09	<.0001*
KSC24	-1.4838e-5	2.0382e-5	0.53	0.4666
KSC25	-0.000201	1.5984e-5	158.06	<.0001*
KSC26	-6.6714e-6	0.0000205	0.11	0.7447
KSC27	-0.0003273	2.4117e-5	184.19	<.0001*
KSC28	-0.0003627	2.0116e-5	325.13	<.0001*
KSC29	-9.2446e-5	2.3743e-5	15.16	<.0001*
KSC30	0.0002456	2.4681e-5	99.02	<.0001*
KSC31	-0.0000443	1.804e-5	6.03	0.0140*
KSC32	-0.0002708	3.4724e-5	60.84	<.0001*
KSC34	0.00001445	2.6615e-5	0.29	0.5872

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM5

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6516.904	31	13033.81	<.0001*
Full	50860.306			
Reduced	57377.210			

RSquare (U)	0.1136
AICc	101785
BIC	102127
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	50860.306	101720.6
Saturated	322701	0.000	Prob>ChiSq
Fitted	31	50860.306	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.9991989	0.0095642	98337	<.0001*
KSC1	-0.0001168	1.5279e-5	58.46	<.0001*
KSC2	-0.0003478	2.3184e-5	225.07	<.0001*
KSC4	-0.0001685	0.0000242	48.48	<.0001*
KSC5	0.00028422	3.6087e-5	62.03	<.0001*
KSC6	0.00010966	3.6132e-5	9.21	0.0024*
KSC7	-6.0729e-5	0.0000219	7.68	0.0056*
KSC8	-7.6727e-5	2.937e-5	6.82	0.0090*
KSC9	2.4867e-5	3.2258e-5	0.59	0.4408
KSC10	-8.0683e-5	2.1771e-5	13.73	0.0002*
KSC11	-0.0003105	2.6351e-5	138.86	<.0001*
KSC12	9.60937e-5	2.8216e-5	11.60	0.0007*
KSC13	-0.0005831	2.688e-5	470.60	<.0001*
KSC14	0.00010212	2.7325e-5	13.97	0.0002*
KSC15	0.00010977	4.5025e-5	5.94	0.0148*
KSC16	5.41256e-5	2.1839e-5	6.14	0.0132*
KSC17	-0.0001063	3.2782e-5	10.52	0.0012*
KSC18	8.82471e-5	2.3918e-5	13.61	0.0002*
KSC19	0.00026604	3.0269e-5	77.25	<.0001*
KSC20	-3.8258e-5	3.1374e-5	1.49	0.2227
KSC21	-8.2562e-5	0.0000242	11.64	0.0006*
KSC22	-0.0001963	0.0000246	63.65	<.0001*
KSC24	-6.4069e-5	0.0000208	9.49	0.0021*
KSC25	-0.0001064	1.6555e-5	41.32	<.0001*
KSC26	-2.8182e-5	2.0632e-5	1.87	0.1720
KSC27	-0.0003326	2.4136e-5	189.84	<.0001*
KSC28	-0.000267	2.0234e-5	174.12	<.0001*
KSC29	-7.6387e-5	0.0000236	10.48	0.0012*
KSC30	0.00016505	2.4215e-5	46.46	<.0001*
KSC31	-6.3072e-5	1.8261e-5	11.93	0.0006*
KSC32	-0.000224	3.4964e-5	41.05	<.0001*
KSC34	-9.9292e-6	2.6413e-5	0.14	0.7070

Nominal Logistic Fit for bin.LM6

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5908.604	31	11817.21	<.0001*
Full	62254.183			
Reduced	68162.786			

RSquare (U)	0.0867
AICc	124572
BIC	124914
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	62250.024	124500
Saturated	322701	4.159	Prob>ChiSq
Fitted	31	62254.183	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.727159	0.0085178	102511	<.0001*
KSC1	-0.0001517	1.4453e-5	110.10	<.0001*
KSC2	-0.0003081	2.1956e-5	196.96	<.0001*
KSC4	-0.0001569	2.3048e-5	46.37	<.0001*
KSC5	0.00025086	0.0000344	53.17	<.0001*
KSC6	0.00020603	3.4457e-5	35.75	<.0001*
KSC7	-0.0000563	2.0835e-5	7.30	0.0069*
KSC8	-0.0000916	2.8352e-5	10.44	0.0012*
KSC9	-3.7678e-6	3.1313e-5	0.01	0.9042
KSC10	-0.0001378	2.102e-5	42.99	<.0001*
KSC11	-0.0001905	2.5189e-5	57.19	<.0001*
KSC12	3.72778e-5	0.0000273	1.86	0.1722
KSC13	-0.0005078	2.5817e-5	386.85	<.0001*
KSC14	0.00026612	0.0000269	97.87	<.0001*
KSC15	-3.8663e-5	4.3534e-5	0.79	0.3745
KSC16	3.89163e-5	2.0966e-5	3.45	0.0634
KSC17	-4.8113e-5	3.1861e-5	2.28	0.1310
KSC18	0.00012871	0.000023	31.31	<.0001*
KSC19	0.00013781	2.9183e-5	22.30	<.0001*
KSC20	-1.2368e-5	3.0471e-5	0.16	0.6848
KSC21	-0.0001583	2.2963e-5	47.54	<.0001*
KSC22	-0.0001597	2.3424e-5	46.46	<.0001*
KSC24	-7.1726e-5	0.0000197	13.26	0.0003*
KSC25	-0.0001196	1.5744e-5	57.73	<.0001*
KSC26	-5.2478e-5	0.0000197	7.10	0.0077*
KSC27	-0.0003058	2.3267e-5	172.73	<.0001*
KSC28	-0.0002722	1.9484e-5	195.15	<.0001*
KSC29	-5.1664e-5	0.0000229	5.09	0.0240*
KSC30	0.00015545	0.0000235	43.79	<.0001*
KSC31	-2.8332e-5	1.7517e-5	2.62	0.1058
KSC32	-0.0002545	3.3774e-5	56.77	<.0001*
KSC34	0.00006649	2.5767e-5	6.66	0.0099*

Nominal Logistic Fit for bin.LM7

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6597.245	31	13194.49	<.0001*
Full	50742.752			
Reduced	57339.997			

RSquare (U)	0.1151
AICc	101550
BIC	101891
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	50742.752	101485.5
Saturated	322701	0.000	Prob>ChiSq
Fitted	31	50742.752	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.9866465	0.0095463	97882	<.0001*
KSC1	-0.000147	1.517e-5	93.93	<.0001*
KSC2	-0.0003116	0.0000229	185.26	<.0001*
KSC4	-0.0002417	2.4039e-5	101.11	<.0001*
KSC5	0.0002988	3.5725e-5	69.96	<.0001*
KSC6	3.84524e-5	0.0000361	1.13	0.2867
KSC7	-0.0001014	0.0000218	21.61	<.0001*
KSC8	-0.0001596	0.0000289	30.50	<.0001*
KSC9	0.00008874	3.2164e-5	7.61	0.0058*
KSC10	-7.2285e-5	2.1842e-5	10.95	0.0009*
KSC11	-0.0002665	2.6627e-5	100.20	<.0001*
KSC12	0.00015614	2.8449e-5	30.12	<.0001*
KSC13	-0.0006701	0.0000269	620.21	<.0001*
KSC14	0.00017441	2.777e-5	39.44	<.0001*
KSC15	7.28334e-5	0.0000453	2.59	0.1078
KSC16	2.68076e-5	2.1944e-5	1.49	0.2219
KSC17	-0.0001176	3.3231e-5	12.52	0.0004*
KSC18	7.87168e-5	2.4168e-5	10.61	0.0011*
KSC19	0.00022167	3.0389e-5	53.21	<.0001*
KSC20	-1.3715e-5	3.1632e-5	0.19	0.6646
KSC21	-0.000127	2.4524e-5	26.80	<.0001*
KSC22	-0.0001884	2.5069e-5	56.46	<.0001*
KSC24	-0.0000247	2.1315e-5	1.34	0.2467
KSC25	-0.0001229	0.0000169	52.91	<.0001*
KSC26	-2.8389e-5	0.0000206	1.90	0.1680
KSC27	-0.0001887	2.372e-5	63.26	<.0001*
KSC28	-0.00036	2.0222e-5	316.88	<.0001*
KSC29	-4.7819e-5	2.3924e-5	4.00	0.0456*
KSC30	0.00014254	2.4242e-5	34.58	<.0001*
KSC31	-1.8632e-5	1.8478e-5	1.02	0.3133
KSC32	-0.0001514	3.5564e-5	18.11	<.0001*
KSC34	1.87561e-7	0.0000268	0.00	0.9944

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM8

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5677.196	31	11354.39	<.0001*
Full	67569.856			
Reduced	73247.052			

RSquare (U)	0.0775
AICc	135204
BIC	135546
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	67565.697	135131.4
Saturated	322701	4.159	Prob>ChiSq
Fitted	31	67569.856	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.6230063	0.0081487	103614	<.0001*
KSC1	-9.5253e-5	1.444e-5	43.51	<.0001*
KSC2	-0.0002794	2.2031e-5	160.87	<.0001*
KSC4	-0.0000895	2.2977e-5	15.17	<.0001*
KSC5	0.00023312	3.4442e-5	45.81	<.0001*
KSC6	0.00014114	0.000034	17.23	<.0001*
KSC7	1.68337e-5	2.0828e-5	0.65	0.4190
KSC8	-0.000104	2.8224e-5	13.59	0.0002*
KSC9	-4.8073e-5	3.1058e-5	2.40	0.1217
KSC10	-0.0001268	0.0000208	37.16	<.0001*
KSC11	-0.0001874	2.495e-5	56.40	<.0001*
KSC12	7.37633e-5	2.7155e-5	7.38	0.0066*
KSC13	-0.0005166	2.5568e-5	408.25	<.0001*
KSC14	0.00034055	0.0000269	160.17	<.0001*
KSC15	-0.0001253	0.0000431	8.45	0.0036*
KSC16	9.27886e-7	2.083e-5	0.00	0.9645
KSC17	-6.6912e-5	0.0000312	4.60	0.0320*
KSC18	0.00016967	2.2749e-5	55.63	<.0001*
KSC19	0.00011211	2.8968e-5	14.98	0.0001*
KSC20	-8.508e-5	3.012e-5	7.98	0.0047*
KSC21	-0.000197	0.0000229	74.00	<.0001*
KSC22	-0.0001712	2.3186e-5	54.53	<.0001*
KSC24	2.00143e-5	1.9368e-5	1.07	0.3014
KSC25	-0.0002203	1.5162e-5	211.09	<.0001*
KSC26	3.3571e-5	1.9665e-5	2.91	0.0878
KSC27	-0.0002868	2.3013e-5	155.35	<.0001*
KSC28	-0.0003155	1.8948e-5	277.34	<.0001*
KSC29	-6.026e-6	2.2637e-5	0.07	0.7901
KSC30	0.00021346	2.3328e-5	83.73	<.0001*
KSC31	-1.1238e-5	1.7134e-5	0.43	0.5119
KSC32	-0.0003093	3.2835e-5	88.75	<.0001*
KSC34	1.26555e-5	2.5212e-5	0.25	0.6157

Nominal Logistic Fit for bin.LM9

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6108.918	31	12217.84	<.0001*
Full	74848.692			
Reduced	80957.610			

RSquare (U)	0.0755
AICc	149761
BIC	150103
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	74837.602	149675.2
Saturated	322701	11.090	Prob>ChiSq
Fitted	31	74848.692	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.4615109	0.0077027	102121	<.0001*
KSC1	-0.0001538	1.402e-5	120.26	<.0001*
KSC2	-0.0003125	0.0000214	213.15	<.0001*
KSC4	-5.7177e-5	2.2676e-5	6.36	0.0117*
KSC5	0.00031374	3.3961e-5	85.34	<.0001*
KSC6	0.00009081	3.3273e-5	7.45	0.0063*
KSC7	2.05524e-5	2.013e-5	1.04	0.3073
KSC8	-7.2321e-5	2.7848e-5	6.74	0.0094*
KSC9	-0.0001103	0.0000307	12.91	0.0003*
KSC10	-0.0001598	0.0000205	60.84	<.0001*
KSC11	-0.0001737	0.0000247	49.41	<.0001*
KSC12	0.00014664	2.6822e-5	29.89	<.0001*
KSC13	-0.0005026	2.514e-5	399.67	<.0001*
KSC14	0.0003175	2.6486e-5	143.70	<.0001*
KSC15	-4.577e-5	4.2518e-5	1.16	0.2817
KSC16	0.00002032	2.0658e-5	0.97	0.3253
KSC17	-0.0001673	3.0489e-5	30.12	<.0001*
KSC18	0.00014613	2.2165e-5	43.47	<.0001*
KSC19	0.0001056	2.8835e-5	13.41	0.0002*
KSC20	-7.675e-5	2.9781e-5	6.64	0.0100*
KSC21	-0.0001943	2.2751e-5	72.96	<.0001*
KSC22	-0.0001407	2.2566e-5	38.89	<.0001*
KSC24	-0.0000349	1.8786e-5	3.45	0.0632
KSC25	-0.0002426	1.4646e-5	274.31	<.0001*
KSC26	6.42261e-5	1.9634e-5	10.70	0.0011*
KSC27	-0.0003151	2.2931e-5	188.83	<.0001*
KSC28	-0.0002616	1.8617e-5	197.40	<.0001*
KSC29	5.93973e-5	2.2189e-5	7.17	0.0074*
KSC30	0.00018455	2.3082e-5	63.93	<.0001*
KSC31	-2.2924e-6	1.6774e-5	0.02	0.8913
KSC32	-0.0003846	3.2259e-5	142.18	<.0001*
KSC34	1.86111e-5	2.4825e-5	0.56	0.4534

Nominal Logistic Fit for bin.LM10

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6091.618	31	12183.24	<.0001*
Full	68233.143			
Reduced	74324.761			

RSquare (U)	0.0820
AICc	136530
BIC	136872
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	68228.984	136458
Saturated	322701	4.159	Prob>ChiSq
Fitted	31	68233.143	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.5943307	0.0081063	102426	<.0001*
KSC1	-0.0001134	1.4366e-5	62.28	<.0001*
KSC2	-0.0002686	2.1678e-5	153.48	<.0001*
KSC4	-0.0001998	2.2843e-5	76.49	<.0001*
KSC5	0.00027095	3.4157e-5	62.92	<.0001*
KSC6	6.47319e-5	3.3943e-5	3.64	0.0565
KSC7	-2.9141e-5	2.0585e-5	2.00	0.1569
KSC8	-0.0001418	2.7724e-5	26.15	<.0001*
KSC9	5.92131e-5	3.0844e-5	3.69	0.0549
KSC10	-0.0001296	0.0000208	38.87	<.0001*
KSC11	-0.0001803	2.5139e-5	51.45	<.0001*
KSC12	0.00013407	2.7072e-5	24.53	<.0001*
KSC13	-0.0005878	2.5538e-5	529.69	<.0001*
KSC14	0.000182	2.6368e-5	47.64	<.0001*
KSC15	-1.7891e-6	4.274e-5	0.00	0.9666
KSC16	4.68079e-5	2.104e-5	4.95	0.0261*
KSC17	-0.0001304	3.1053e-5	17.63	<.0001*
KSC18	0.00011287	2.2619e-5	24.90	<.0001*
KSC19	0.00014282	2.8869e-5	24.48	<.0001*
KSC20	-1.2838e-5	3.0079e-5	0.18	0.6695
KSC21	-0.000124	2.2984e-5	29.11	<.0001*
KSC22	-0.0002464	2.3147e-5	113.34	<.0001*
KSC24	-1.3787e-5	1.9578e-5	0.50	0.4813
KSC25	-0.0001012	1.5457e-5	42.87	<.0001*
KSC26	-1.1213e-7	1.9862e-5	0.00	0.9955
KSC27	-0.000245	2.2889e-5	114.58	<.0001*
KSC28	-0.0001886	1.9334e-5	95.17	<.0001*
KSC29	-0.0000746	2.2578e-5	10.92	0.0010*
KSC30	0.00011173	2.3144e-5	23.30	<.0001*
KSC31	-0.0000282	1.7356e-5	2.64	0.1042
KSC32	-0.0002517	3.3247e-5	57.31	<.0001*
KSC34	3.68164e-5	2.5524e-5	2.08	0.1492

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM11

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5829.910	31	11659.82	<.0001*
Full	77434.722			
Reduced	83264.632			

RSquare (U)	0.0700
AICc	154933
BIC	155275
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	77430.563	154861.1
Saturated	322701	4.159	Prob>ChiSq
Fitted	31	77434.722	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.4143315	0.0075562	102091	<.0001*
KSC1	-0.0001027	1.3939e-5	54.23	<.0001*
KSC2	-0.0003131	2.0965e-5	222.98	<.0001*
KSC4	-0.000122	2.2344e-5	29.79	<.0001*
KSC5	0.00033428	3.3452e-5	99.86	<.0001*
KSC6	3.00975e-5	3.2825e-5	0.84	0.3592
KSC7	-1.202e-5	1.975e-5	0.37	0.5428
KSC8	-0.00016	0.000027	35.10	<.0001*
KSC9	3.3706e-5	2.9784e-5	1.28	0.2578
KSC10	-0.0001837	2.0226e-5	82.51	<.0001*
KSC11	-0.0001364	2.4415e-5	31.20	<.0001*
KSC12	0.00013183	2.6478e-5	24.79	<.0001*
KSC13	-0.0005047	2.4767e-5	415.32	<.0001*
KSC14	0.00023914	0.000026	84.61	<.0001*
KSC15	-4.183e-5	4.1775e-5	1.00	0.3167
KSC16	4.32088e-5	0.0000204	4.49	0.0342*
KSC17	-0.0001135	3.0078e-5	14.24	0.0002*
KSC18	9.56941e-5	2.1785e-5	19.29	<.0001*
KSC19	0.00016696	0.0000284	34.55	<.0001*
KSC20	-3.8622e-5	2.9148e-5	1.76	0.1852
KSC21	-0.0002195	2.2377e-5	96.23	<.0001*
KSC22	-0.0001844	2.2227e-5	68.83	<.0001*
KSC24	-5.7275e-5	1.8731e-5	9.35	0.0022*
KSC25	-0.0000927	1.494e-5	38.50	<.0001*
KSC26	7.52896e-6	1.9244e-5	0.15	0.6956
KSC27	-0.0003037	2.243e-5	183.28	<.0001*
KSC28	-0.0002152	1.8553e-5	134.55	<.0001*
KSC29	0.0000579	2.1589e-5	7.19	0.0073*
KSC30	0.00010007	0.0000224	19.96	<.0001*
KSC31	-5.7112e-6	0.0000168	0.12	0.7338
KSC32	-0.0002879	3.2112e-5	80.36	<.0001*
KSC34	2.72754e-6	2.4331e-5	0.01	0.9107

Nominal Logistic Fit for bin.LM12

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6141.499	31	12283	<.0001*
Full	81276.611			
Reduced	87418.110			

RSquare (U)	0.0703
AICc	162617
BIC	162959
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	81264.134	162528.3
Saturated	322701	12.477	Prob>ChiSq
Fitted	31	81276.611	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.3308424	0.0073567	100383	<.0001*
KSC1	-0.0001094	1.3775e-5	63.13	<.0001*
KSC2	-0.0003197	2.0812e-5	235.93	<.0001*
KSC4	-3.2779e-5	2.2185e-5	2.18	0.1395
KSC5	0.00030932	3.3287e-5	86.35	<.0001*
KSC6	0.00006973	3.2356e-5	4.64	0.0312*
KSC7	-3.0778e-5	1.952e-5	2.49	0.1148
KSC8	-0.000171	2.6935e-5	40.31	<.0001*
KSC9	-5.502e-5	2.9852e-5	3.40	0.0653
KSC10	-0.0001675	2.0015e-5	70.04	<.0001*
KSC11	-0.0001577	0.0000241	42.87	<.0001*
KSC12	0.00012113	2.6163e-5	21.44	<.0001*
KSC13	-0.0004474	2.4288e-5	339.31	<.0001*
KSC14	0.00029027	0.0000258	126.65	<.0001*
KSC15	-3.0828e-5	4.1485e-5	0.55	0.4574
KSC16	-2.0569e-5	1.9928e-5	1.07	0.3020
KSC17	-9.8055e-5	2.9821e-5	10.81	0.0010*
KSC18	7.14943e-5	2.1541e-5	11.02	0.0009*
KSC19	0.00012287	2.8063e-5	19.17	<.0001*
KSC20	-9.0017e-5	2.8739e-5	9.81	0.0017*
KSC21	-0.0001532	2.2137e-5	47.92	<.0001*
KSC22	-0.000157	2.1947e-5	51.16	<.0001*
KSC24	-0.0000215	0.0000184	1.37	0.2422
KSC25	-0.0002272	1.4422e-5	248.06	<.0001*
KSC26	9.75532e-6	0.0000191	0.26	0.6095
KSC27	-0.0003156	2.2368e-5	199.06	<.0001*
KSC28	-0.0002391	1.8353e-5	169.79	<.0001*
KSC29	0.00008039	2.1447e-5	14.05	0.0002*
KSC30	0.00014178	2.238e-5	40.13	<.0001*
KSC31	1.51452e-5	1.657e-5	0.84	0.3607
KSC32	-0.00033	3.186e-5	107.28	<.0001*
KSC34	0.00002148	2.4165e-5	0.79	0.3740

Nominal Logistic Fit for bin.LM13

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6483.357	31	12966.71	<.0001*
Full	81175.902			
Reduced	87659.259			

RSquare (U)	0.0740
AICc	162416
BIC	162758
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	81164.812	162329.6
Saturated	322701	11.090	Prob>ChiSq
Fitted	31	81175.902	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.3328393	0.0073834	99829	<.0001*
KSC1	-0.0001167	1.3889e-5	70.54	<.0001*
KSC2	-0.0003708	2.1172e-5	306.76	<.0001*
KSC4	-1.1725e-5	0.0000224	0.27	0.6007
KSC5	0.00036217	3.3919e-5	114.01	<.0001*
KSC6	0.00003317	3.2871e-5	1.02	0.3129
KSC7	8.21419e-5	1.9922e-5	17.00	<.0001*
KSC8	-9.8362e-5	2.748e-5	12.81	0.0003*
KSC9	-0.00013	3.0337e-5	18.37	<.0001*
KSC10	-0.000153	2.0318e-5	56.73	<.0001*
KSC11	-0.0001675	2.4465e-5	46.90	<.0001*
KSC12	0.00015242	2.6358e-5	33.44	<.0001*
KSC13	-0.0004177	2.4523e-5	290.12	<.0001*
KSC14	0.0002725	0.0000258	111.53	<.0001*
KSC15	-3.7965e-5	0.000042	0.82	0.3661
KSC16	-4.4345e-5	2.0017e-5	4.91	0.0267*
KSC17	-0.0001375	3.0022e-5	20.99	<.0001*
KSC18	0.00011185	2.1827e-5	26.26	<.0001*
KSC19	0.00010498	0.0000283	13.76	0.0002*
KSC20	-0.0001001	2.9111e-5	11.82	0.0006*
KSC21	-0.0001562	2.242e-5	48.54	<.0001*
KSC22	-0.0001458	2.2087e-5	43.59	<.0001*
KSC24	-3.4732e-5	1.8363e-5	3.58	0.0586
KSC25	-0.0003069	1.4262e-5	463.13	<.0001*
KSC26	5.49449e-5	1.9351e-5	8.06	0.0045*
KSC27	-0.0002276	2.2315e-5	103.99	<.0001*
KSC28	-0.0002762	1.8288e-5	228.02	<.0001*
KSC29	8.42035e-5	2.1789e-5	14.93	0.0001*
KSC30	0.000103	2.2553e-5	20.86	<.0001*
KSC31	0.00002579	1.6536e-5	2.43	0.1188
KSC32	-0.0005031	3.2059e-5	246.27	<.0001*
KSC34	0.00010182	2.4915e-5	16.70	<.0001*

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM14

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6383.375	31	12766.75	<.0001*
Full	90367.497			
Reduced	96750.872			

RSquare (U)	0.0660
AICc	180799
BIC	181141
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	90356.407	180712.8
Saturated	322701	11.090	Prob>ChiSq
Fitted	31	90367.497	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.1744633	0.006979	97078	<.0001*
KSC1	-0.00006	1.3629e-5	19.38	<.0001*
KSC2	-0.0003504	2.0547e-5	290.83	<.0001*
KSC4	1.39075e-5	2.1984e-5	0.40	0.5270
KSC5	0.00033041	3.3146e-5	99.37	<.0001*
KSC6	-0.0000521	3.1984e-5	2.65	0.1034
KSC7	0.00011554	1.9455e-5	35.27	<.0001*
KSC8	-0.0001649	2.6719e-5	38.07	<.0001*
KSC9	-5.423e-5	0.0000294	3.40	0.0650
KSC10	-0.0001977	1.9813e-5	99.61	<.0001*
KSC11	-0.0001493	2.394e-5	38.91	<.0001*
KSC12	0.00015287	2.5834e-5	35.02	<.0001*
KSC13	-0.0003994	0.0000237	283.90	<.0001*
KSC14	0.00025164	0.0000251	100.49	<.0001*
KSC15	2.13085e-5	4.0934e-5	0.27	0.6027
KSC16	-4.8817e-5	1.9378e-5	6.35	0.0118*
KSC17	-0.0001377	2.9371e-5	21.98	<.0001*
KSC18	0.00011835	2.1273e-5	30.95	<.0001*
KSC19	0.00008145	0.0000274	8.84	0.0029*
KSC20	-0.0001016	2.8236e-5	12.95	0.0003*
KSC21	-0.0001096	2.1878e-5	25.07	<.0001*
KSC22	-0.0001553	2.145e-5	52.40	<.0001*
KSC24	-4.6828e-5	1.7855e-5	6.88	0.0087*
KSC25	-0.000323	1.3928e-5	537.85	<.0001*
KSC26	3.38151e-5	1.8783e-5	3.24	0.0718
KSC27	-0.0002378	2.1729e-5	119.77	<.0001*
KSC28	-0.0002734	0.0000178	235.69	<.0001*
KSC29	0.0001179	2.1088e-5	31.26	<.0001*
KSC30	7.25245e-5	0.0000219	10.97	0.0009*
KSC31	1.53689e-5	1.6188e-5	0.90	0.3424
KSC32	-0.0004165	3.1234e-5	177.84	<.0001*
KSC34	0.00007163	2.3919e-5	8.97	0.0027*

Nominal Logistic Fit for bin.LM15

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6244.115	31	12488.23	<.0001*
Full	91648.368			
Reduced	97892.483			

RSquare (U)	0.0638
AICc	183361
BIC	183703
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	91635.891	183271.8
Saturated	322701	12.477	Prob>ChiSq
Fitted	31	91648.368	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.1505567	0.0069155	96707	<.0001*
KSC1	-7.7777e-5	1.3528e-5	33.06	<.0001*
KSC2	-0.0003495	2.0376e-5	294.28	<.0001*
KSC4	-4.0964e-6	2.1882e-5	0.04	0.8515
KSC5	0.00030387	3.2773e-5	85.97	<.0001*
KSC6	2.89216e-5	0.0000317	0.83	0.3614
KSC7	7.7512e-5	1.9178e-5	16.33	<.0001*
KSC8	-0.0001918	2.6514e-5	52.33	<.0001*
KSC9	-1.4136e-6	2.9051e-5	0.00	0.9612
KSC10	-0.0001815	1.9629e-5	85.48	<.0001*
KSC11	-0.0001926	0.0000237	66.08	<.0001*
KSC12	0.00013649	2.5652e-5	28.31	<.0001*
KSC13	-0.0004089	0.0000235	302.94	<.0001*
KSC14	0.00023891	2.4966e-5	91.57	<.0001*
KSC15	-3.673e-5	4.0426e-5	0.83	0.3636
KSC16	-3.2633e-5	0.0000193	2.86	0.0910
KSC17	-6.7265e-5	2.8934e-5	5.40	0.0201*
KSC18	3.56358e-8	2.0755e-5	0.00	0.9986
KSC19	9.69637e-5	2.734e-5	12.58	0.0004*
KSC20	-0.0000722	2.807e-5	6.62	0.0101*
KSC21	-0.0001017	0.0000217	21.97	<.0001*
KSC22	-0.0001663	0.0000212	61.60	<.0001*
KSC24	-0.0000343	1.786e-5	3.69	0.0548
KSC25	-0.0002454	1.3944e-5	309.81	<.0001*
KSC26	3.76385e-5	0.0000187	4.06	0.0440*
KSC27	-0.0003174	2.1845e-5	211.09	<.0001*
KSC28	-0.0002114	0.0000178	140.94	<.0001*
KSC29	0.00010581	2.083e-5	25.80	<.0001*
KSC30	0.00012834	2.1866e-5	34.45	<.0001*
KSC31	2.99252e-5	1.6163e-5	3.43	0.0641
KSC32	-0.0003957	0.000031	163.00	<.0001*
KSC34	9.45567e-6	2.3449e-5	0.16	0.6868

Nominal Logistic Fit for bin.LM16

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6593.500	31	13187	<.0001*
Full	89372.416			
Reduced	95965.916			

RSquare (U)	0.0687
AICc	178809
BIC	179151
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	89361.326	178722.7
Saturated	322701	11.090	Prob>ChiSq
Fitted	31	89372.416	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.1815749	0.0070177	96638	<.0001*
KSC1	-0.000084	1.3675e-5	37.73	<.0001*
KSC2	-0.0003113	2.0744e-5	225.14	<.0001*
KSC4	1.78149e-5	2.211e-5	0.65	0.4204
KSC5	0.00027587	3.3262e-5	68.79	<.0001*
KSC6	8.49516e-7	3.2186e-5	0.00	0.9789
KSC7	5.77884e-5	1.953e-5	8.76	0.0031*
KSC8	-0.0001272	2.6977e-5	22.25	<.0001*
KSC9	-0.0001137	0.0000296	14.76	0.0001*
KSC10	-0.0001297	0.0000199	42.51	<.0001*
KSC11	-0.0001756	0.0000241	53.04	<.0001*
KSC12	0.00014664	0.0000259	32.08	<.0001*
KSC13	-0.0003901	0.0000239	266.52	<.0001*
KSC14	0.00026367	2.5251e-5	109.03	<.0001*
KSC15	-8.2636e-5	0.000041	4.06	0.0439*
KSC16	-6.3618e-5	0.0000195	10.64	0.0011*
KSC17	-0.0001233	2.9426e-5	17.56	<.0001*
KSC18	0.00010687	2.1317e-5	25.13	<.0001*
KSC19	0.00008226	2.769e-5	8.83	0.0030*
KSC20	-4.432e-5	2.8635e-5	2.40	0.1217
KSC21	-0.0001355	2.2116e-5	37.53	<.0001*
KSC22	-0.0001899	2.1644e-5	76.98	<.0001*
KSC24	1.01835e-5	1.8081e-5	0.32	0.5733
KSC25	-0.0003581	0.000014	654.30	<.0001*
KSC26	6.51367e-5	0.000019	11.75	0.0006*
KSC27	-0.0002113	2.1913e-5	92.94	<.0001*
KSC28	-0.0002695	0.0000179	226.45	<.0001*
KSC29	0.00011056	0.0000213	26.96	<.0001*
KSC30	0.00010496	2.2135e-5	22.48	<.0001*
KSC31	0.00004575	0.0000163	7.87	0.0050*
KSC32	-0.0004867	3.1373e-5	240.62	<.0001*
KSC34	1.83589e-5	2.4062e-5	0.58	0.4455

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM17

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6387.90	31	12775.81	<.0001*
Full	94500.08			
Reduced	100887.99			

RSquare (U)	0.0633
AICc	189064
BIC	189406
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	94484.832	188969.7
Saturated	322701	15.249	Prob>ChiSq
Fitted	31	94500.082	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.0955363	0.0068176	94478	<.0001*
KSC1	-0.0001032	0.0000135	58.44	<.0001*
KSC2	-0.0003458	2.017e-5	293.90	<.0001*
KSC4	-1.3767e-5	2.1863e-5	0.40	0.5289
KSC5	0.00031937	0.0000326	96.01	<.0001*
KSC6	-1.0178e-5	3.156e-5	0.10	0.7471
KSC7	0.00006996	0.000019	13.55	0.0002*
KSC8	-0.0001972	2.6423e-5	55.72	<.0001*
KSC9	0.00005527	0.000029	3.63	0.0566
KSC10	-0.0002187	1.9631e-5	124.15	<.0001*
KSC11	-0.0001405	0.0000237	35.14	<.0001*
KSC12	0.00014707	2.5782e-5	32.54	<.0001*
KSC13	-0.0005335	2.3737e-5	505.16	<.0001*
KSC14	0.00023469	2.4951e-5	88.48	<.0001*
KSC15	-0.0001053	4.0179e-5	6.86	0.0088*
KSC16	1.84856e-5	1.9627e-5	0.89	0.3463
KSC17	-9.5354e-5	2.8881e-5	10.90	0.0010*
KSC18	7.54802e-7	0.0000207	0.00	0.9709
KSC19	0.00013567	2.7648e-5	24.08	<.0001*
KSC20	-3.1339e-5	2.8356e-5	1.22	0.2691
KSC21	-0.0001227	2.1955e-5	31.22	<.0001*
KSC22	-0.0001667	2.1144e-5	62.16	<.0001*
KSC24	-2.0416e-5	1.7864e-5	1.31	0.2531
KSC25	-0.0002426	1.3937e-5	303.03	<.0001*
KSC26	3.79422e-5	1.8845e-5	4.05	0.0441*
KSC27	-0.0002802	2.1727e-5	166.26	<.0001*
KSC28	-0.0001614	1.7832e-5	81.95	<.0001*
KSC29	0.00010395	2.0669e-5	25.29	<.0001*
KSC30	6.78343e-5	2.1766e-5	9.71	0.0018*
KSC31	4.82132e-5	1.6163e-5	8.90	0.0029*
KSC32	-0.0003714	3.0876e-5	144.72	<.0001*
KSC34	-2.1165e-6	0.0000234	0.01	0.9279

Nominal Logistic Fit for bin.LM18

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6185.453	31	12370.91	<.0001*
Full	92669.756			
Reduced	98855.209			

RSquare (U)	0.0626
AICc	185404
BIC	185745
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	92654.507	185309
Saturated	322701	15.249	Prob>ChiSq
Fitted	31	92669.756	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.1338963	0.0068842	96082	<.0001*
KSC1	-0.000095	1.3533e-5	49.28	<.0001*
KSC2	-0.0003449	0.0000202	291.53	<.0001*
KSC4	-3.616e-5	2.1881e-5	2.73	0.0984
KSC5	0.00031784	3.2546e-5	95.37	<.0001*
KSC6	1.09423e-5	3.164e-5	0.12	0.7295
KSC7	1.06486e-5	1.8961e-5	0.32	0.5744
KSC8	-0.0001904	2.6417e-5	51.95	<.0001*
KSC9	7.86233e-5	2.9066e-5	7.32	0.0068*
KSC10	-0.0002274	1.9652e-5	133.92	<.0001*
KSC11	-0.0001054	0.0000237	19.77	<.0001*
KSC12	8.57259e-5	2.5731e-5	11.10	0.0009*
KSC13	-0.0005447	2.3943e-5	517.64	<.0001*
KSC14	0.00024404	2.5117e-5	94.40	<.0001*
KSC15	-0.0001072	4.0183e-5	7.12	0.0076*
KSC16	5.33845e-5	1.9883e-5	7.21	0.0073*
KSC17	-0.0001053	2.8987e-5	13.20	0.0003*
KSC18	1.42716e-5	0.0000207	0.48	0.4904
KSC19	0.00010704	2.7671e-5	14.96	0.0001*
KSC20	-1.9073e-5	2.8546e-5	0.45	0.5040
KSC21	-0.0001418	2.1943e-5	41.76	<.0001*
KSC22	-0.0001605	2.1181e-5	57.39	<.0001*
KSC24	-4.2272e-5	1.7966e-5	5.54	0.0186*
KSC25	-0.000179	1.4132e-5	160.46	<.0001*
KSC26	2.25543e-5	1.8951e-5	1.42	0.2340
KSC27	-0.0002568	2.1881e-5	137.77	<.0001*
KSC28	-9.6762e-5	1.8128e-5	28.49	<.0001*
KSC29	0.00011907	2.0936e-5	32.34	<.0001*
KSC30	0.00004164	2.1922e-5	3.61	0.0575
KSC31	3.22975e-5	1.6284e-5	3.93	0.0473*
KSC32	-0.0003673	3.1035e-5	140.05	<.0001*
KSC34	-2.808e-6	2.3629e-5	0.01	0.9054

Nominal Logistic Fit for bin.LM19

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6058.44	31	12116.89	<.0001*
Full	100140.26			
Reduced	106198.71			

RSquare (U)	0.0570
AICc	200345
BIC	200686
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	100129.17	200258.3
Saturated	322701	11.09	Prob>ChiSq
Fitted	31	100140.26	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.0202094	0.0066028	93614	<.0001*
KSC1	-2.3847e-5	0.0000133	3.22	0.0729
KSC2	-0.0003477	1.9979e-5	302.91	<.0001*
KSC4	5.47974e-5	2.168e-5	6.39	0.0115*
KSC5	0.00028947	3.2238e-5	80.63	<.0001*
KSC6	-0.0000377	0.0000311	1.47	0.2255
KSC7	0.00003499	0.0000187	3.50	0.0614
KSC8	-0.0001816	2.632e-5	47.62	<.0001*
KSC9	-1.5024e-5	2.8338e-5	0.28	0.5960
KSC10	-0.0002168	1.9445e-5	124.33	<.0001*
KSC11	-0.0001459	2.3413e-5	38.83	<.0001*
KSC12	0.0001212	2.5283e-5	22.98	<.0001*
KSC13	-0.0003937	2.2913e-5	295.20	<.0001*
KSC14	0.00024655	2.4526e-5	101.05	<.0001*
KSC15	-4.1511e-5	3.9675e-5	1.09	0.2954
KSC16	-2.5154e-5	1.904e-5	1.75	0.1865
KSC17	-1.1276e-5	2.8737e-5	0.15	0.6948
KSC18	-3.3424e-5	2.0382e-5	2.69	0.1010
KSC19	0.00009047	2.6689e-5	11.49	0.0007*
KSC20	-7.9281e-5	2.7545e-5	8.28	0.0040*
KSC21	-0.0001085	2.1411e-5	25.69	<.0001*
KSC22	-0.0001988	2.0588e-5	93.23	<.0001*
KSC24	-2.5154e-5	1.7376e-5	2.10	0.1477
KSC25	-0.0002888	1.3635e-5	448.67	<.0001*
KSC26	5.15743e-5	1.8423e-5	7.84	0.0051*
KSC27	-0.0002138	2.1288e-5	100.91	<.0001*
KSC28	-0.0001929	1.7418e-5	122.65	<.0001*
KSC29	0.00016615	2.0464e-5	65.92	<.0001*
KSC30	3.28772e-5	2.1244e-5	2.40	0.1217
KSC31	8.89163e-5	1.596e-5	31.04	<.0001*
KSC32	-0.0004734	0.0000306	239.27	<.0001*
KSC34	2.55862e-5	2.3081e-5	1.23	0.2676

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM20

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6420.83	31	12841.66	<.0001*
Full	102010.62			
Reduced	108431.45			

RSquare (U)	0.0592
AICc	204085
BIC	204427
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	101996.76	203993.5
Saturated	322701	13.86	Prob>ChiSq
Fitted	31	102010.62	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.9807585	0.0065604	91160	<.0001*
KSC1	-4.7188e-5	1.3324e-5	12.54	0.0004*
KSC2	-0.0003353	1.9965e-5	282.01	<.0001*
KSC4	0.0000527	0.0000218	5.84	0.0156*
KSC5	0.00032087	0.0000325	97.53	<.0001*
KSC6	-3.1822e-5	3.127e-5	1.04	0.3088
KSC7	3.53763e-5	1.874e-5	3.56	0.0591
KSC8	-0.0001911	0.0000265	51.97	<.0001*
KSC9	1.68983e-5	2.8463e-5	0.35	0.5527
KSC10	-0.000241	1.9546e-5	152.04	<.0001*
KSC11	-0.0001621	0.0000235	47.55	<.0001*
KSC12	0.00013208	2.5566e-5	26.69	<.0001*
KSC13	-0.0004693	0.0000231	412.50	<.0001*
KSC14	0.00027982	0.0000248	127.36	<.0001*
KSC15	-0.0001091	3.9767e-5	7.53	0.0061*
KSC16	3.53782e-6	1.9285e-5	0.03	0.8544
KSC17	4.0224e-6	2.8758e-5	0.02	0.8888
KSC18	-0.0000705	2.0324e-5	12.03	0.0005*
KSC19	9.45567e-5	2.7131e-5	12.15	0.0005*
KSC20	-7.6921e-5	2.7921e-5	7.59	0.0059*
KSC21	-0.0001062	2.1546e-5	24.28	<.0001*
KSC22	-0.0001593	0.0000206	59.76	<.0001*
KSC24	-3.0781e-5	1.7373e-5	3.14	0.0764
KSC25	-0.0003013	1.3645e-5	487.52	<.0001*
KSC26	0.00006497	1.864e-5	12.15	0.0005*
KSC27	-0.0002698	0.0000215	157.39	<.0001*
KSC28	-0.0001361	1.7543e-5	60.21	<.0001*
KSC29	0.00015437	2.0417e-5	57.17	<.0001*
KSC30	-8.4438e-6	2.1415e-5	0.16	0.6934
KSC31	6.75851e-5	1.5933e-5	17.99	<.0001*
KSC32	-0.0004397	3.0581e-5	206.78	<.0001*
KSC34	5.4101e-5	2.318e-5	5.45	0.0196*

Nominal Logistic Fit for bin.LM21

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6133.65	31	12267.3	<.0001*
Full	105316.05			
Reduced	111449.70			

RSquare (U)	0.0550
AICc	210696
BIC	211038
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	105300.80	210601.6
Saturated	322701	15.25	Prob>ChiSq
Fitted	31	105316.05	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.9392872	0.0064463	90502	<.0001*
KSC1	-3.6234e-5	1.3225e-5	7.51	0.0061*
KSC2	-0.0002982	0.0000198	226.83	<.0001*
KSC4	0.00006052	0.0000216	7.85	0.0051*
KSC5	0.00032681	3.2283e-5	102.48	<.0001*
KSC6	-6.4934e-5	3.0963e-5	4.40	0.0360*
KSC7	0.00005169	1.8649e-5	7.68	0.0056*
KSC8	-0.0001969	2.6179e-5	56.58	<.0001*
KSC9	3.63116e-5	2.8017e-5	1.68	0.1950
KSC10	-0.0002673	0.0000195	187.91	<.0001*
KSC11	-0.0001512	2.337e-5	41.87	<.0001*
KSC12	0.00016299	2.537e-5	41.28	<.0001*
KSC13	-0.0004441	2.2761e-5	380.72	<.0001*
KSC14	0.00022585	2.4213e-5	87.01	<.0001*
KSC15	-7.9961e-5	3.9369e-5	4.13	0.0422*
KSC16	4.43512e-6	0.000019	0.05	0.8153
KSC17	4.51921e-5	2.8553e-5	2.51	0.1135
KSC18	-8.1629e-5	2.017e-5	16.38	<.0001*
KSC19	9.29151e-5	2.6534e-5	12.26	0.0005*
KSC20	-0.0001095	0.0000274	15.97	<.0001*
KSC21	-8.2379e-5	2.1336e-5	14.91	0.0001*
KSC22	-0.000187	2.035e-5	84.44	<.0001*
KSC24	-0.0000209	1.7164e-5	1.48	0.2234
KSC25	-0.0003133	0.0000135	538.67	<.0001*
KSC26	5.81233e-5	1.8363e-5	10.02	0.0015*
KSC27	-0.0002012	2.1052e-5	91.32	<.0001*
KSC28	-0.0001624	1.7271e-5	88.44	<.0001*
KSC29	0.00016197	2.0234e-5	64.08	<.0001*
KSC30	-2.2962e-5	2.1065e-5	1.19	0.2757
KSC31	0.0001028	1.5852e-5	42.05	<.0001*
KSC32	-0.0004971	3.0417e-5	267.05	<.0001*
KSC34	0.00006432	0.000023	7.82	0.0052*

Nominal Logistic Fit for bin.LM22

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6259.20	31	12518.39	<.0001*
Full	105406.45			
Reduced	111665.64			

RSquare (U)	0.0561
AICc	210877
BIC	211219
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	105389.81	210779.6
Saturated	322701	16.64	Prob>ChiSq
Fitted	31	105406.45	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.9218817	0.0064537	88682	<.0001*
KSC1	-0.0000592	1.3223e-5	20.05	<.0001*
KSC2	-0.0003318	0.0000196	286.41	<.0001*
KSC4	-4.4943e-5	2.1489e-5	4.37	0.0365*
KSC5	0.00029608	3.1868e-5	86.32	<.0001*
KSC6	-3.0965e-6	3.0862e-5	0.01	0.9201
KSC7	-6.1361e-5	1.836e-5	11.17	0.0008*
KSC8	-0.0002113	2.5979e-5	66.14	<.0001*
KSC9	6.26887e-5	0.0000282	4.94	0.0262*
KSC10	-0.0002389	1.9368e-5	152.11	<.0001*
KSC11	-9.1373e-5	0.0000232	15.52	<.0001*
KSC12	0.00010416	2.5274e-5	16.99	<.0001*
KSC13	-0.0004546	2.2987e-5	391.10	<.0001*
KSC14	0.00017133	2.424e-5	49.96	<.0001*
KSC15	-0.0001032	0.0000393	6.89	0.0086*
KSC16	6.56858e-5	1.9411e-5	11.45	0.0007*
KSC17	-4.2154e-5	2.8514e-5	2.19	0.1393
KSC18	-6.4946e-5	0.0000201	10.44	0.0012*
KSC19	0.00013004	2.6983e-5	23.23	<.0001*
KSC20	-5.9739e-6	2.7923e-5	0.05	0.8306
KSC21	-0.0001512	2.1419e-5	49.83	<.0001*
KSC22	-0.0001623	2.0448e-5	63.02	<.0001*
KSC24	-2.5842e-5	0.0000174	2.21	0.1375
KSC25	-0.0002099	1.3653e-5	236.43	<.0001*
KSC26	5.97911e-5	1.8526e-5	10.42	0.0012*
KSC27	-0.0002369	0.0000213	123.71	<.0001*
KSC28	-0.0001017	1.7513e-5	33.73	<.0001*
KSC29	0.00011645	2.024e-5	33.10	<.0001*
KSC30	-4.5759e-6	0.0000212	0.05	0.8290
KSC31	6.77978e-5	1.5841e-5	18.32	<.0001*
KSC32	-0.0003911	3.0351e-5	166.07	<.0001*
KSC34	2.07122e-5	2.2953e-5	0.81	0.3669

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM24

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5906.01	31	11812.02	<.0001*
Full	110483.35			
Reduced	116389.36			

RSquare (U)	0.0507
AICc	221031
BIC	221373
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	110468.10	220936.2
Saturated	322701	15.25	Prob>ChiSq
Fitted	31	110483.35	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8642177	0.006292	87784	<.0001*
KSC1	-4.1217e-5	0.000013	10.06	0.0015*
KSC2	-0.0002873	0.0000194	219.16	<.0001*
KSC4	3.55783e-5	2.1368e-5	2.77	0.0959
KSC5	0.00026892	3.1582e-5	72.51	<.0001*
KSC6	-0.0000524	0.0000304	2.97	0.0848
KSC7	-0.0001177	1.8152e-5	42.02	<.0001*
KSC8	-0.0001905	0.0000258	54.52	<.0001*
KSC9	2.96937e-5	2.763e-5	1.15	0.2825
KSC10	-0.0002607	1.9288e-5	182.70	<.0001*
KSC11	-6.4118e-5	0.0000229	7.83	0.0051*
KSC12	8.09487e-5	2.4921e-5	10.55	0.0012*
KSC13	-0.0003872	2.2427e-5	298.11	<.0001*
KSC14	0.00017778	2.3864e-5	55.50	<.0001*
KSC15	-3.7327e-5	3.8985e-5	0.92	0.3383
KSC16	4.62771e-5	1.9015e-5	5.92	0.0149*
KSC17	2.71267e-5	2.8425e-5	0.91	0.3399
KSC18	-0.0001175	1.9869e-5	34.95	<.0001*
KSC19	0.00013654	2.6316e-5	26.92	<.0001*
KSC20	-0.0000436	2.7284e-5	2.55	0.1101
KSC21	-0.0001816	2.1079e-5	74.22	<.0001*
KSC22	-0.0001832	2.0016e-5	83.78	<.0001*
KSC24	0.00001296	1.7013e-5	0.58	0.4462
KSC25	-0.0002608	1.3439e-5	376.73	<.0001*
KSC26	6.24621e-5	1.826e-5	11.70	0.0006*
KSC27	-0.0002135	2.1121e-5	102.18	<.0001*
KSC28	-6.0277e-5	1.7311e-5	12.13	0.0005*
KSC29	0.00013768	2.0013e-5	47.33	<.0001*
KSC30	-0.0000285	0.000021	1.84	0.1747
KSC31	0.00012595	1.5778e-5	63.73	<.0001*
KSC32	-0.0004406	0.0000302	212.81	<.0001*
KSC34	2.8139e-5	2.274e-5	1.53	0.2159

Nominal Logistic Fit for bin.LM25

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5042.32	31	10084.65	<.0001*
Full	113836.02			
Reduced	118878.34			

RSquare (U)	0.0424
AICc	227736
BIC	228078
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	113827.70	227655.4
Saturated	322701	8.32	Prob>ChiSq
Fitted	31	113836.02	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8491339	0.0061878	89302	<.0001*
KSC1	-1.7235e-5	0.0000128	1.82	0.1779
KSC2	-0.0002873	1.9155e-5	225.04	<.0001*
KSC4	3.46429e-5	0.0000211	2.70	0.1006
KSC5	0.00027011	3.1128e-5	75.30	<.0001*
KSC6	4.42073e-5	0.00003	2.17	0.1406
KSC7	-0.0001732	0.0000179	93.67	<.0001*
KSC8	-0.0001855	2.5588e-5	52.53	<.0001*
KSC9	8.12231e-5	2.7316e-5	8.84	0.0029*
KSC10	-0.0002417	1.8961e-5	162.52	<.0001*
KSC11	-0.0000819	2.253e-5	13.21	0.0003*
KSC12	-6.7132e-6	2.4288e-5	0.08	0.7822
KSC13	-0.0003977	0.0000224	314.87	<.0001*
KSC14	0.00013871	0.0000236	34.55	<.0001*
KSC15	4.63957e-5	3.8572e-5	1.45	0.2290
KSC16	0.00016832	1.9271e-5	76.30	<.0001*
KSC17	3.89769e-5	2.8239e-5	1.91	0.1675
KSC18	-0.0001556	1.954e-5	63.40	<.0001*
KSC19	3.33431e-5	2.5876e-5	1.66	0.1976
KSC20	4.28691e-6	2.7222e-5	0.02	0.8749
KSC21	-0.0001323	2.077e-5	40.54	<.0001*
KSC22	-0.0001516	1.9651e-5	59.48	<.0001*
KSC24	4.83367e-6	1.6784e-5	0.08	0.7734
KSC25	-0.0002672	0.0000134	397.67	<.0001*
KSC26	4.92422e-6	1.8064e-5	0.07	0.7852
KSC27	-0.0001825	0.000021	75.55	<.0001*
KSC28	-5.6719e-5	1.7213e-5	10.86	0.0010*
KSC29	0.0000802	1.9856e-5	16.31	<.0001*
KSC30	2.62062e-5	2.0885e-5	1.57	0.2096
KSC31	0.00017922	1.5737e-5	129.71	<.0001*
KSC32	-0.0003705	2.9982e-5	152.68	<.0001*
KSC34	2.81251e-5	2.2475e-5	1.57	0.2108

Nominal Logistic Fit for bin.LM26

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	6431.20	31	12862.41	<.0001*
Full	97217.10			
Reduced	103648.30			

RSquare (U)	0.0620
AICc	194498
BIC	194840
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	97206.007	194412
Saturated	322701	11.090	Prob>ChiSq
Fitted	31	97217.097	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-2.0529662	0.0067149	93474	<.0001*
KSC1	-5.2028e-5	1.333e-5	15.23	<.0001*
KSC2	-0.0003056	2.0235e-5	228.03	<.0001*
KSC4	4.72479e-5	2.1823e-5	4.69	0.0304*
KSC5	0.00017147	3.2249e-5	28.27	<.0001*
KSC6	3.23657e-5	3.1489e-5	1.06	0.3040
KSC7	4.65548e-6	1.8955e-5	0.06	0.8060
KSC8	-0.0001818	0.0000267	46.37	<.0001*
KSC9	-0.0000958	2.8941e-5	10.96	0.0009*
KSC10	-0.0001004	1.9573e-5	26.31	<.0001*
KSC11	-0.0001526	2.3789e-5	41.15	<.0001*
KSC12	0.00016353	2.5572e-5	40.89	<.0001*
KSC13	-0.0004216	2.3419e-5	324.14	<.0001*
KSC14	0.00027243	2.4886e-5	119.84	<.0001*
KSC15	-0.0001057	4.0346e-5	6.86	0.0088*
KSC16	-4.4851e-5	0.0000195	5.29	0.0214*
KSC17	-6.2624e-5	2.9181e-5	4.61	0.0319*
KSC18	4.25664e-5	2.0877e-5	4.16	0.0415*
KSC19	0.00007702	2.7085e-5	8.09	0.0045*
KSC20	-0.0000252	0.0000282	0.80	0.3717
KSC21	-0.0001366	2.182e-5	39.21	<.0001*
KSC22	-0.0002705	2.1064e-5	164.87	<.0001*
KSC24	0.00003223	0.0000177	3.31	0.0687
KSC25	-0.0003864	1.3819e-5	782.10	<.0001*
KSC26	9.73566e-5	1.8915e-5	26.49	<.0001*
KSC27	-0.0001832	2.1686e-5	71.33	<.0001*
KSC28	-0.0002447	1.7641e-5	192.44	<.0001*
KSC29	0.00015783	2.0959e-5	56.71	<.0001*
KSC30	7.67661e-5	2.1653e-5	12.57	0.0004*
KSC31	9.54666e-5	1.6141e-5	34.98	<.0001*
KSC32	-0.0005094	0.0000311	268.33	<.0001*
KSC34	1.30087e-5	2.3651e-5	0.30	0.5823

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM27

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5846.66	31	11693.32	<.0001*
Full	109626.77			
Reduced	115473.43			

RSquare (U)	0.0506
AICc	219318
BIC	219659
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	109614.29	219228.6
Saturated	322701	12.48	Prob>ChiSq
Fitted	31	109626.77	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8929146	0.0063157	89830	<.0001*
KSC1	-3.1183e-5	1.2961e-5	5.79	0.0161*
KSC2	-0.0002816	1.9638e-5	205.60	<.0001*
KSC4	0.0000462	2.1245e-5	4.73	0.0297*
KSC5	0.00020392	3.1572e-5	41.72	<.0001*
KSC6	0.00014859	3.0745e-5	23.36	<.0001*
KSC7	2.75879e-5	0.0000185	2.22	0.1358
KSC8	-0.0001853	2.6086e-5	50.48	<.0001*
KSC9	-0.0000265	2.7985e-5	0.90	0.3438
KSC10	-0.0001669	1.9077e-5	76.52	<.0001*
KSC11	-0.0002318	0.0000232	99.83	<.0001*
KSC12	7.16552e-5	0.0000246	8.49	0.0036*
KSC13	-0.000388	2.2627e-5	294.09	<.0001*
KSC14	0.0001963	2.3747e-5	68.33	<.0001*
KSC15	-4.1954e-5	3.9132e-5	1.15	0.2837
KSC16	-2.8304e-6	0.0000189	0.02	0.8809
KSC17	1.96769e-5	0.0000285	0.48	0.4898
KSC18	1.92186e-5	2.0141e-5	0.91	0.3400
KSC19	0.00012644	2.6148e-5	23.38	<.0001*
KSC20	-4.6334e-5	2.7687e-5	2.80	0.0942
KSC21	-0.0001066	2.1133e-5	25.46	<.0001*
KSC22	-0.000283	2.0264e-5	195.02	<.0001*
KSC24	2.66867e-5	0.000017	2.46	0.1164
KSC25	-0.0004152	1.3435e-5	954.85	<.0001*
KSC26	0.00010135	1.8359e-5	30.48	<.0001*
KSC27	-0.0001413	2.088e-5	45.77	<.0001*
KSC28	-0.0001621	1.7154e-5	89.27	<.0001*
KSC29	0.00012916	2.0113e-5	41.24	<.0001*
KSC30	-1.6492e-6	2.0823e-5	0.01	0.9369
KSC31	9.65467e-5	1.5617e-5	38.22	<.0001*
KSC32	-0.0004485	3.0017e-5	223.25	<.0001*
KSC34	4.30948e-5	2.2876e-5	3.55	0.0596

Nominal Logistic Fit for bin.LM28

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5599.46	31	11198.91	<.0001*
Full	111830.35			
Reduced	117429.81			

RSquare (U)	0.0477
AICc	223725
BIC	224067
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	111816.49	223633
Saturated	322701	13.86	Prob>ChiSq
Fitted	31	111830.35	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8759819	0.0062558	89926	<.0001*
KSC1	-1.1466e-5	1.2887e-5	0.79	0.3736
KSC2	-0.0002619	0.0000195	180.48	<.0001*
KSC4	3.74516e-5	2.1077e-5	3.16	0.0756
KSC5	9.59519e-5	3.1238e-5	9.44	0.0021*
KSC6	0.00016248	3.0555e-5	28.28	<.0001*
KSC7	7.02778e-5	1.8457e-5	14.50	0.0001*
KSC8	-0.0001386	2.5914e-5	28.62	<.0001*
KSC9	1.80881e-5	2.7617e-5	0.43	0.5125
KSC10	-0.0001751	1.8923e-5	85.58	<.0001*
KSC11	-0.0001985	2.288e-5	75.29	<.0001*
KSC12	4.86955e-5	2.4331e-5	4.01	0.0454*
KSC13	-0.0004333	2.2573e-5	368.45	<.0001*
KSC14	0.00018936	2.3566e-5	64.56	<.0001*
KSC15	-0.0001509	0.0000388	15.13	0.0001*
KSC16	4.37334e-5	1.9033e-5	5.28	0.0216*
KSC17	7.72462e-5	2.8465e-5	7.36	0.0067*
KSC18	-9.0458e-6	1.9959e-5	0.21	0.6504
KSC19	0.00016416	2.6135e-5	39.45	<.0001*
KSC20	-7.1575e-5	2.765e-5	6.70	0.0096*
KSC21	-0.0001298	2.1047e-5	38.05	<.0001*
KSC22	-0.0002285	2.0027e-5	130.23	<.0001*
KSC24	3.00362e-5	1.6823e-5	3.19	0.0742
KSC25	-0.0004697	1.3449e-5	1220.0	<.0001*
KSC26	8.0525e-5	1.8282e-5	19.40	<.0001*
KSC27	-0.0001179	2.0873e-5	31.91	<.0001*
KSC28	-6.4055e-5	1.7219e-5	13.84	0.0002*
KSC29	0.00014429	2.014e-5	51.33	<.0001*
KSC30	-5.1441e-5	0.0000208	6.12	0.0134*
KSC31	0.00008854	1.556e-5	32.38	<.0001*
KSC32	-0.000489	3.0047e-5	264.83	<.0001*
KSC34	9.61777e-5	2.317e-5	17.23	<.0001*

Nominal Logistic Fit for bin.LM29

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5327.88	31	10655.77	<.0001*
Full	115160.50			
Reduced	120488.39			

RSquare (U)	0.0442
AICc	230385
BIC	230727
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	115150.80	230301.6
Saturated	322701	9.70	Prob>ChiSq
Fitted	31	115160.50	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8279646	0.0061514	88306	<.0001*
KSC1	-0.0000294	1.2783e-5	5.29	0.0214*
KSC2	-0.0002503	1.9318e-5	167.87	<.0001*
KSC4	5.37442e-5	2.0927e-5	6.60	0.0102*
KSC5	0.0001873	3.1188e-5	36.07	<.0001*
KSC6	0.00011343	3.023e-5	14.08	0.0002*
KSC7	-2.6721e-5	1.8112e-5	2.18	0.1401
KSC8	-0.0001152	2.5611e-5	20.22	<.0001*
KSC9	3.87549e-5	2.7261e-5	2.02	0.1551
KSC10	-0.0001969	1.8917e-5	108.32	<.0001*
KSC11	-0.0001876	2.287e-5	67.32	<.0001*
KSC12	7.59862e-5	0.0000243	9.77	0.0018*
KSC13	-0.0004572	2.2316e-5	419.83	<.0001*
KSC14	0.00018683	2.3455e-5	63.45	<.0001*
KSC15	-4.9534e-5	0.0000385	1.65	0.1983
KSC16	3.29031e-5	0.0000188	3.06	0.0801
KSC17	8.90361e-5	0.0000283	9.90	0.0017*
KSC18	-0.0000724	1.9741e-5	13.45	0.0002*
KSC19	0.00011043	2.5717e-5	18.44	<.0001*
KSC20	-8.0314e-5	2.7147e-5	8.75	0.0031*
KSC21	-8.2481e-5	2.0878e-5	15.61	<.0001*
KSC22	-0.0002217	1.971e-5	126.56	<.0001*
KSC24	-3.2773e-6	0.0000166	0.04	0.8435
KSC25	-0.0004082	1.3259e-5	947.79	<.0001*
KSC26	0.00007754	0.0000181	18.35	<.0001*
KSC27	-0.0001238	2.0645e-5	35.96	<.0001*
KSC28	-6.0577e-5	1.7021e-5	12.67	0.0004*
KSC29	0.00014989	0.0000197	57.95	<.0001*
KSC30	-3.9941e-5	2.0542e-5	3.78	0.0519
KSC31	0.00012715	1.5483e-5	67.45	<.0001*
KSC32	-0.0004072	2.9555e-5	189.80	<.0001*
KSC34	2.42228e-6	2.2387e-5	0.01	0.9138

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM30

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5544.91	31	11089.83	<.0001*
Full	112167.82			
Reduced	117712.74			

RSquare (U)	0.0471
AICc	224400
BIC	224742
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	112153.96	224307.9
Saturated	322701	13.86	Prob>ChiSq
Fitted	31	112167.82	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8700627	0.0062419	89758	<.0001*
KSC1	0.00000479	1.2926e-5	0.14	0.7110
KSC2	-0.0002848	1.9485e-5	213.60	<.0001*
KSC4	-4.4206e-7	0.000021	0.00	0.9832
KSC5	0.00014191	3.1323e-5	20.53	<.0001*
KSC6	0.00015234	3.0444e-5	25.04	<.0001*
KSC7	7.22986e-5	1.8378e-5	15.48	<.0001*
KSC8	-0.0001102	2.5744e-5	18.31	<.0001*
KSC9	9.96434e-6	2.7536e-5	0.13	0.7175
KSC10	-0.0002038	1.8964e-5	115.45	<.0001*
KSC11	-0.0002043	2.2938e-5	79.31	<.0001*
KSC12	7.63314e-5	2.4372e-5	9.81	0.0017*
KSC13	-0.0003941	2.2314e-5	311.92	<.0001*
KSC14	0.0001404	2.3385e-5	36.04	<.0001*
KSC15	-6.8449e-5	3.8623e-5	3.14	0.0764
KSC16	6.86187e-6	1.8749e-5	0.13	0.7144
KSC17	4.77772e-5	0.0000283	2.85	0.0914
KSC18	-1.6543e-5	1.9872e-5	0.69	0.4051
KSC19	0.00014805	2.5853e-5	32.79	<.0001*
KSC20	-7.2879e-5	0.0000274	7.07	0.0078*
KSC21	-0.0001037	2.0889e-5	24.66	<.0001*
KSC22	-0.0002462	1.9923e-5	152.77	<.0001*
KSC24	0.00001245	1.676e-5	0.55	0.4576
KSC25	-0.000417	1.334e-5	977.30	<.0001*
KSC26	0.00007633	1.8158e-5	17.67	<.0001*
KSC27	-0.0001127	2.0723e-5	29.57	<.0001*
KSC28	-8.7564e-5	1.712e-5	26.16	<.0001*
KSC29	0.00009983	0.0000199	25.17	<.0001*
KSC30	-5.1658e-5	2.0687e-5	6.24	0.0125*
KSC31	0.00009498	1.5518e-5	37.46	<.0001*
KSC32	-0.0004402	2.9882e-5	217.04	<.0001*
KSC34	0.00010604	0.000023	21.25	<.0001*

Nominal Logistic Fit for bin.LM31

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	4868.53	31	9737.062	<.0001*
Full	117536.46			
Reduced	122404.99			

RSquare (U)	0.0398
AICc	235137
BIC	235479
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	117523.99	235048
Saturated	322701	12.48	Prob>ChiSq
Fitted	31	117536.46	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8074748	0.0060889	88118	<.0001*
KSC1	-4.606e-5	1.2563e-5	13.44	0.0002*
KSC2	-0.0002375	0.000019	156.14	<.0001*
KSC4	3.63715e-5	2.0667e-5	3.10	0.0784
KSC5	0.00016229	0.0000306	28.12	<.0001*
KSC6	0.00017375	2.9829e-5	33.93	<.0001*
KSC7	-4.8177e-5	0.0000178	7.32	0.0068*
KSC8	-0.0001179	2.5364e-5	21.61	<.0001*
KSC9	1.96486e-5	0.0000271	0.53	0.4683
KSC10	-0.000226	1.8754e-5	145.22	<.0001*
KSC11	-0.0001409	0.0000224	39.54	<.0001*
KSC12	4.68874e-5	2.393e-5	3.84	0.0501
KSC13	-0.0004268	2.2178e-5	370.35	<.0001*
KSC14	0.00012815	2.3252e-5	30.38	<.0001*
KSC15	-4.7864e-5	3.8041e-5	1.58	0.2083
KSC16	0.0001293	0.000019	46.30	<.0001*
KSC17	6.32066e-5	2.7959e-5	5.11	0.0238*
KSC18	-9.8773e-5	1.9382e-5	25.97	<.0001*
KSC19	8.74849e-5	0.0000255	11.76	0.0006*
KSC20	-4.0453e-5	2.7033e-5	2.24	0.1345
KSC21	-8.1456e-5	2.0623e-5	15.60	<.0001*
KSC22	-0.0001977	1.9478e-5	102.99	<.0001*
KSC24	0.00002113	1.656e-5	1.63	0.2020
KSC25	-0.0004043	1.3221e-5	934.94	<.0001*
KSC26	1.90085e-6	1.797e-5	0.01	0.9158
KSC27	-0.0001469	2.0742e-5	50.14	<.0001*
KSC28	-0.0000025	0.0000171	0.02	0.8837
KSC29	0.00011859	1.9723e-5	36.15	<.0001*
KSC30	-2.9421e-5	2.0773e-5	2.01	0.1567
KSC31	0.00013363	1.541e-5	75.20	<.0001*
KSC32	-0.0003779	2.9653e-5	162.38	<.0001*
KSC34	8.85964e-5	2.2644e-5	15.31	<.0001*

Nominal Logistic Fit for bin.LM32

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5155.64	31	10311.27	<.0001*
Full	117195.14			
Reduced	122350.78			

RSquare (U)	0.0421
AICc	234454
BIC	234796
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	117185.44	234370.9
Saturated	322701	9.70	Prob>ChiSq
Fitted	31	117195.14	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.8064553	0.0061049	87557	<.0001*
KSC1	-2.4626e-5	1.266e-5	3.78	0.0518
KSC2	-0.0002397	0.0000191	157.50	<.0001*
KSC4	0.00003922	2.0754e-5	3.57	0.0588
KSC5	0.00014968	3.0775e-5	23.65	<.0001*
KSC6	0.00015537	2.9962e-5	26.89	<.0001*
KSC7	-3.736e-5	1.7925e-5	4.34	0.0371*
KSC8	-0.0001193	2.5464e-5	21.96	<.0001*
KSC9	5.12848e-6	2.7211e-5	0.04	0.8505
KSC10	-0.0002279	1.8825e-5	146.56	<.0001*
KSC11	-0.0001514	2.2514e-5	45.20	<.0001*
KSC12	5.00037e-5	2.4047e-5	4.32	0.0376*
KSC13	-0.0004387	2.2259e-5	388.37	<.0001*
KSC14	0.00012867	2.3288e-5	30.53	<.0001*
KSC15	-5.7346e-5	3.8213e-5	2.25	0.1334
KSC16	0.000115	1.9058e-5	36.41	<.0001*
KSC17	5.69773e-5	0.0000281	4.11	0.0427*
KSC18	-0.0000433	1.9572e-5	4.89	0.0270*
KSC19	0.00011453	2.5734e-5	19.81	<.0001*
KSC20	-6.0072e-5	2.7225e-5	4.87	0.0273*
KSC21	-0.0001034	2.0724e-5	24.91	<.0001*
KSC22	-0.0002104	0.0000196	115.27	<.0001*
KSC24	1.71252e-5	1.6544e-5	1.07	0.3006
KSC25	-0.0004179	1.3243e-5	995.97	<.0001*
KSC26	2.59274e-5	1.8116e-5	2.05	0.1524
KSC27	-9.0452e-5	2.0679e-5	19.13	<.0001*
KSC28	-2.4231e-5	0.0000171	2.01	0.1564
KSC29	6.94515e-5	1.9754e-5	12.36	0.0004*
KSC30	-5.2854e-5	2.0717e-5	6.51	0.0107*
KSC31	0.00011631	1.5417e-5	56.92	<.0001*
KSC32	-0.0003694	2.9665e-5	155.09	<.0001*
KSC34	0.00010776	2.2842e-5	22.25	<.0001*

Appendix F: Nominal Logistic Regression Model to Predict Storms (cont.)

Nominal Logistic Fit for bin.LM34

Whole Model Test

Model	-LogLikelihood	DF	ChiSquare	Prob>ChiSq
Difference	5293.63	31	10587.26	<.0001*
Full	115355.69			
Reduced	120649.32			

RSquare (U)	0.0439
AICc	230775
BIC	231117
Observations (or Sum Wgts)	323042

Fit Details

Lack Of Fit

Source	DF	-LogLikelihood	ChiSquare
Lack Of Fit	322670	115343.21	230686.4
Saturated	322701	12.48	**Prob>ChiSq**
Fitted	31	115355.69	1.0000

Parameter Estimates

Term	Estimate	Std Error	ChiSquare	Prob>ChiSq
Intercept	-1.829035	0.0061531	88359	<.0001*
KSC1	-0.0000264	1.2718e-5	4.31	0.0379*
KSC2	-0.0002728	1.9238e-5	201.02	<.0001*
KSC4	3.19979e-5	0.0000208	2.37	0.1240
KSC5	0.00017698	0.000031	32.58	<.0001*
KSC6	0.0001323	3.0145e-5	19.26	<.0001*
KSC7	1.89539e-5	1.8119e-5	1.09	0.2955
KSC8	-0.0000999	2.5542e-5	15.30	<.0001*
KSC9	3.87059e-6	2.7326e-5	0.02	0.8874
KSC10	-0.0001896	0.0000188	101.74	<.0001*
KSC11	-0.0002034	2.2683e-5	80.40	<.0001*
KSC12	0.0000642	2.4166e-5	7.06	0.0079*
KSC13	-0.0004462	2.2369e-5	397.83	<.0001*
KSC14	0.00015311	2.3347e-5	43.01	<.0001*
KSC15	-5.5273e-5	0.0000384	2.07	0.1501
KSC16	6.67245e-5	1.8931e-5	12.42	0.0004*
KSC17	7.98888e-5	0.0000282	8.03	0.0046*
KSC18	-1.205e-5	1.9769e-5	0.37	0.5422
KSC19	0.00015403	2.5846e-5	35.52	<.0001*
KSC20	-9.4563e-5	2.7257e-5	12.04	0.0005*
KSC21	-0.0001373	2.0774e-5	43.68	<.0001*
KSC22	-0.0002166	1.9775e-5	119.99	<.0001*
KSC24	2.35509e-6	0.0000166	0.02	0.8872
KSC25	-0.0004005	1.3236e-5	915.38	<.0001*
KSC26	6.39317e-5	1.814e-5	12.42	0.0004*
KSC27	-0.0001088	2.065e-5	27.78	<.0001*
KSC28	-0.0000437	1.7064e-5	6.56	0.0105*
KSC29	9.44113e-5	1.9837e-5	22.65	<.0001*
KSC30	-6.3972e-5	2.0671e-5	9.58	0.0020*
KSC31	9.00843e-5	0.0000154	34.19	<.0001*
KSC32	-0.000424	2.9651e-5	204.51	<.0001*
KSC34	0.00010816	0.0000229	22.31	<.0001*

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation

Generalized Regression for lightning.end.1 BySensor=1

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	27652
Sum of Frequencies	9704
-LogLikelihood	50155.066
Number of Parameters	33
BIC	100613.08
AICc	100376.36
Generalized RSquare	0.04599

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-6.096e-6	6.6515e-6	0.8398706	0.3594	-1.913e-5	6.941e-6
KSC2	-4.934e-5	1.0542e-5	21.906621	<.0001*	-0.00007	-2.868e-5
KSC4	-0.000013	1.0378e-5	1.5739139	0.2096	-3.336e-5	7.3209e-6
KSC5	-0.000058	1.5614e-5	13.777185	0.0002*	-8.856e-5	-2.735e-5
KSC6	4.7168e-5	1.4971e-5	9.9265675	0.0016*	1.7826e-5	7.651e-5
KSC7	-5.402e-6	1.0413e-5	0.2691357	0.6039	-2.581e-5	0.000015
KSC8	-9.521e-6	1.2181e-5	0.6109303	0.4344	-3.34e-5	1.4354e-5
KSC9	-1.847e-5	1.2639e-5	2.135389	0.1439	-4.324e-5	6.3029e-6
KSC10	1.8383e-5	1.0236e-5	3.2254041	0.0725	-1.679e-6	3.8445e-5
KSC11	-5.654e-5	1.1253e-5	25.245355	<.0001*	-7.86e-5	-3.448e-5
KSC12	6.5581e-5	1.1469e-5	32.697204	<.0001*	0.0000431	8.806e-5
KSC13	-2.284e-5	1.0211e-5	5.0013879	0.0253*	-4.285e-5	-2.822e-6
KSC14	0.000027	1.184e-5	5.2034433	0.0225*	3.8023e-6	5.0215e-5
KSC15	-5.562e-5	2.035e-5	7.4702088	0.0063*	-9.55e-5	-1.573e-5
KSC16	0.0000267	9.1966e-6	8.4329064	0.0037*	8.6814e-6	4.4731e-5
KSC17	-2.67e-5	1.563e-5	2.9170244	0.0876	-5.733e-5	3.9393e-6
KSC18	7.1899e-6	1.0959e-5	0.4304276	0.5118	-1.429e-5	2.8669e-5
KSC19	-2.073e-5	1.2854e-5	2.6012773	0.1068	-0.000046	4.462e-6
KSC20	-2.486e-5	1.4531e-5	2.9276345	0.0871	-5.334e-5	3.6173e-6
KSC21	7.3707e-6	1.1414e-5	0.4170292	0.5184	-0.000015	2.9741e-5
KSC22	1.0883e-5	1.1322e-5	0.9238568	0.3365	-1.131e-5	3.3074e-5
KSC24	-0.000017	1.0456e-5	2.674267	0.1020	-3.759e-5	3.3945e-6
KSC25	-2.382e-5	8.0806e-6	8.6879984	0.0032*	-3.966e-5	-7.98e-6
KSC26	-3.269e-5	9.131e-6	12.816003	0.0003*	-5.059e-5	-1.479e-5
KSC27	5.397e-5	1.1028e-5	23.951853	<.0001*	3.2356e-5	7.5584e-5
KSC28	2.4326e-5	9.2022e-6	6.987813	0.0082*	6.2896e-6	4.2362e-5
KSC29	5.0743e-5	1.0638e-5	22.751952	<.0001*	0.0000299	0.0000716
KSC30	-3.719e-5	1.0737e-5	11.999964	0.0005*	-5.824e-5	-1.615e-5
KSC31	-5.086e-6	8.142e-6	0.3901806	0.5322	-0.000021	1.0872e-5
KSC32	1.8849e-5	1.5315e-5	1.5147934	0.2184	-1.117e-5	4.8865e-5
KSC34	-3.115e-5	1.1386e-5	7.4843253	0.0062*	-5.347e-5	-8.833e-6

Generalized Regression for lightning.end.1 BySensor=2

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	32797
Sum of Frequencies	10549
-LogLikelihood	55222.887
Number of Parameters	33
BIC	110751.48
AICc	110511.99
Generalized RSquare	0.0323624

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-1.059e-5	0.0000066	2.5772446	0.1084	-2.353e-5	2.34e-6
KSC2	-4.96e-5	1.0581e-5	21.970557	<.0001*	-7.034e-5	-2.886e-5
KSC4	-7.249e-6	1.0332e-5	0.4922178	0.4829	-2.75e-5	0.000013
KSC5	-5.189e-5	1.5372e-5	11.393972	0.0007*	-0.000082	-2.176e-5
KSC6	3.224e-5	1.5058e-5	4.5841182	0.0323*	2.7269e-6	6.1753e-5
KSC7	5.9163e-6	1.0511e-5	0.3167906	0.5735	-1.469e-5	2.6518e-5
KSC8	-2.625e-5	0.0000123	4.5497524	0.0329*	-5.036e-5	-2.129e-6
KSC9	1.9956e-6	1.2762e-5	0.0244516	0.8757	-0.000023	0.000027
KSC10	2.0575e-5	1.0339e-5	3.9604027	0.0466*	3.1133e-7	4.0839e-5
KSC11	-3.233e-5	1.1325e-5	8.1470898	0.0043*	-5.452e-5	-1.013e-5
KSC12	6.5026e-5	0.0000114	32.48361	<.0001*	4.2665e-5	8.7388e-5
KSC13	-1.839e-5	1.0442e-5	3.1029982	0.0781	-3.886e-5	2.0721e-6
KSC14	1.9658e-5	1.197e-5	2.6971472	0.1005	-3.802e-6	4.3119e-5
KSC15	-5.168e-5	2.0428e-5	6.4006812	0.0114*	-9.172e-5	-1.164e-5
KSC16	1.5465e-5	9.5447e-6	2.6253396	0.1052	-3.242e-6	3.4173e-5
KSC17	-1.587e-5	1.5656e-5	1.0273823	0.3108	-4.655e-5	1.4816e-5
KSC18	-5.476e-6	0.0000109	0.2526307	0.6152	-2.683e-5	1.5879e-5
KSC19	-0.000034	1.2734e-5	7.1170579	0.0076*	-0.000059	-9.013e-6
KSC20	-2.266e-5	1.4531e-5	2.430986	0.1190	-5.114e-5	5.8241e-6
KSC21	1.4926e-5	1.1445e-5	1.7008579	0.1922	-7.506e-6	3.7359e-5
KSC22	-4.034e-6	1.1259e-5	0.1283948	0.7201	-2.61e-5	1.8033e-5
KSC24	0.0000086	1.0427e-5	0.6803621	0.4095	-1.184e-5	2.9038e-5
KSC25	-3.157e-5	8.3102e-6	14.432711	0.0001*	-4.786e-5	-1.528e-5
KSC26	-1.246e-5	9.2689e-6	1.8068801	0.1789	-3.063e-5	5.7074e-6
KSC27	5.1726e-5	1.1387e-5	20.634568	<.0001*	0.0000294	7.4044e-5
KSC28	2.5461e-5	9.59e-6	7.0485032	0.0079*	6.6645e-6	4.4257e-5
KSC29	3.0411e-5	1.124e-5	7.3205669	0.0068*	8.3813e-6	5.244e-5
KSC30	-0.000038	1.1346e-5	11.238278	0.0008*	-6.027e-5	-1.58e-5
KSC31	-3.279e-6	8.349e-6	0.154249	0.6945	-1.964e-5	1.3085e-5
KSC32	0.0000215	0.0000162	1.7609207	0.1845	-1.025e-5	5.3243e-5
KSC34	-2.63e-5	1.2019e-5	4.788447	0.0287*	-4.986e-5	-2.744e-6

Generalized Regression for lightning.end.1 BySensor=4

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	37176
Sum of Frequencies	14276
-LogLikelihood	76699.012
Number of Parameters	33
BIC	153713.71
AICc	153464.18
Generalized RSquare	0.024431

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-0.00001	7.3145e-6	1.8595049	0.1727	-2.431e-5	4.3618e-6
KSC2	-0.000039	0.0000115	11.541376	0.0007*	-6.166e-5	-1.654e-5
KSC4	-2.186e-5	1.125e-5	3.7747197	0.0520	-0.000044	1.9237e-7
KSC5	-2.631e-5	1.6452e-5	2.5579023	0.1097	-5.856e-5	5.9328e-6
KSC6	5.2173e-5	1.6356e-5	10.175108	0.0014*	2.0116e-5	8.423e-5
KSC7	-1.189e-5	1.0716e-5	1.2301768	0.2674	-3.289e-5	9.1172e-6
KSC8	-1.264e-5	1.3443e-5	0.8843567	0.3470	-0.000039	0.0000137
KSC9	4.5972e-6	0.000014	0.1077417	0.7427	-2.285e-5	3.2048e-5
KSC10	0.0000201	1.0855e-5	3.4300791	0.0640	-1.171e-6	4.138e-5
KSC11	-3.619e-5	1.2443e-5	8.4581905	0.0036*	-6.058e-5	-1.18e-5
KSC12	0.0000621	1.2524e-5	24.59277	<.0001*	3.7562e-5	8.6657e-5
KSC13	-0.000033	1.1231e-5	8.5862394	0.0034*	-0.000055	-1.09e-5
KSC14	5.0144e-7	1.3027e-5	0.0014817	0.9693	-0.000025	2.6034e-5
KSC15	-5.913e-5	2.2052e-5	7.1890479	0.0073*	-0.000102	-0.000016
KSC16	0.0000293	1.0334e-5	8.0380738	0.0046*	9.0441e-6	4.9552e-5
KSC17	0.0000184	0.0000166	1.229747	0.2675	-1.413e-5	5.0944e-5
KSC18	-3.638e-5	1.1587e-5	9.8604122	0.0017*	-0.000059	-1.367e-5
KSC19	-0.000012	1.3718e-5	0.7669914	0.3811	-0.000039	1.4873e-5
KSC20	-2.442e-5	1.5819e-5	2.384069	0.1226	-5.543e-5	6.5793e-6
KSC21	1.5469e-6	1.1775e-5	0.017258	0.8955	-2.153e-5	2.4625e-5
KSC22	0.0000103	0.0000114	0.8164287	0.3662	-0.000012	3.2635e-5
KSC24	-4.078e-5	1.0564e-5	14.903106	0.0001*	-6.149e-5	-0.00002
KSC25	-1.49e-5	8.2955e-6	3.2258206	0.0725	-3.116e-5	1.3597e-6
KSC26	-1.461e-5	9.5019e-6	2.3651447	0.1241	-3.324e-5	4.0104e-6
KSC27	0.0000389	1.1447e-5	11.551741	0.0007*	1.647e-5	6.1341e-5
KSC28	0.0000365	1.0151e-5	12.937132	0.0003*	1.6615e-5	0.0000564
KSC29	4.1477e-5	1.1612e-5	12.757517	0.0004*	1.8717e-5	6.4237e-5
KSC30	-3.08e-5	1.1842e-5	6.7664361	0.0093*	-0.000054	-7.594e-6
KSC31	7.2256e-6	8.359e-6	0.7472154	0.3874	-9.158e-6	0.0000236
KSC32	2.5847e-5	1.6943e-5	2.3274012	0.1271	-7.36e-6	5.9054e-5
KSC34	-2.363e-5	0.0000128	3.4076117	0.0649	-4.871e-5	1.459e-6

Generalized Regression for lightning.end.1 BySensor=5

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	40495
Sum of Frequencies	13917
-LogLikelihood	74734.181
Number of Parameters	33
BIC	149783.21
AICc	149534.52
Generalized RSquare	0.0234465

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-9.381e-6	7.5039e-6	1.5628146	0.2113	-0.000024	5.3266e-6
KSC2	-1.855e-5	1.1767e-5	2.4838884	0.1150	-4.161e-5	4.5176e-6
KSC4	-2.037e-5	0.0000116	3.0781561	0.0794	-4.312e-5	2.3856e-6
KSC5	-5.329e-5	0.0000168	10.055279	0.0015*	-8.623e-5	-2.035e-5
KSC6	0.0000607	1.7041e-5	12.688609	0.0004*	0.0000273	0.0000941
KSC7	-2.585e-5	1.1318e-5	5.2153874	0.0224*	-0.000048	-3.664e-6
KSC8	-2.368e-5	1.3861e-5	2.9184781	0.0876	-5.085e-5	3.4876e-6
KSC9	-2.834e-6	1.4322e-5	0.0391557	0.8431	-0.000031	2.5236e-5
KSC10	2.2957e-5	1.1172e-5	4.2227695	0.0399*	1.061e-6	4.4853e-5
KSC11	-0.000019	1.275e-5	2.2376006	0.1347	-0.000044	5.9173e-6
KSC12	5.5872e-5	1.2763e-5	19.163124	<.0001*	3.0856e-5	8.0887e-5
KSC13	-1.848e-5	1.1665e-5	2.5101358	0.1131	-4.134e-5	4.3817e-6
KSC14	1.8927e-5	1.3266e-5	2.0355361	0.1537	-7.074e-6	4.4927e-5
KSC15	-5.588e-5	2.2544e-5	6.1438334	0.0132*	-0.0001	-1.169e-5
KSC16	2.4283e-5	1.0568e-5	5.2797084	0.0216*	3.5699e-6	0.000045
KSC17	0.0000135	1.6911e-5	0.6379697	0.4244	-1.964e-5	4.6653e-5
KSC18	-2.958e-5	1.1941e-5	6.1378088	0.0132*	-0.000053	-6.179e-6
KSC19	-2.561e-5	1.3945e-5	3.3722892	0.0663	-0.000053	1.7234e-6
KSC20	-1.96e-5	1.6047e-5	1.4926722	0.2218	-0.000051	1.1846e-5
KSC21	-6.898e-6	1.2279e-5	0.3155311	0.5743	-0.000031	1.717e-5
KSC22	-1.549e-6	1.1962e-5	0.0167619	0.8970	-0.000025	0.0000219
KSC24	-2.667e-5	0.0000112	5.6742562	0.0172*	-4.861e-5	-4.726e-6
KSC25	-0.000023	8.9362e-6	6.5823647	0.0103*	-4.044e-5	-5.412e-6
KSC26	-2.547e-5	9.7455e-6	6.8309284	0.0090*	-4.457e-5	-6.37e-6
KSC27	4.4221e-5	1.2224e-5	13.08651	0.0003*	2.0262e-5	6.818e-5
KSC28	2.6327e-5	1.0956e-5	5.7745166	0.0163*	4.854e-6	0.0000478
KSC29	2.5784e-5	1.2661e-5	4.1470403	0.0417*	9.6815e-7	0.0000506
KSC30	-2.765e-5	1.2625e-5	4.7980076	0.0285*	-5.24e-5	-2.91e-6
KSC31	-5.422e-7	8.9443e-6	0.0036753	0.9517	-0.000018	1.6988e-5
KSC32	4.7357e-5	1.7934e-5	6.9728664	0.0083*	0.0000122	0.0000825
KSC34	-7.442e-6	1.3676e-5	0.2961485	0.5863	-3.425e-5	1.9362e-5

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=6

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	44959
Sum of Frequencies	17319
-LogLikelihood	95842.252
Number of Parameters	33
BIC	192006.57
AICc	191750.63
Generalized RSquare	0.0353912

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-2.243e-5	7.9948e-6	7.8730483	0.0050*	-3.81e-5	-6.763e-6
KSC2	-5.389e-5	1.1976e-5	20.249069	<.0001*	-7.736e-5	-3.042e-5
KSC4	-1.683e-5	1.2428e-5	1.8340629	0.1756	-4.119e-5	7.5275e-6
KSC5	0.0000589	1.6555e-5	12.655515	0.0004*	2.6446e-5	9.134e-5
KSC6	5.6071e-5	1.7943e-5	9.7649006	0.0018*	0.0000209	9.124e-5
KSC7	-1.63e-6	1.093e-5	0.0222296	0.8815	-0.000023	0.0000198
KSC8	-2.226e-7	0.0000152	0.0002144	0.9883	-0.00003	2.9573e-5
KSC9	-3.469e-5	1.5576e-5	4.9600518	0.0259*	-6.522e-5	-4.161e-6
KSC10	1.7959e-5	1.0984e-5	2.6735518	0.1020	-3.568e-6	3.9487e-5
KSC11	-1.443e-5	1.3835e-5	1.0881262	0.2969	-4.155e-5	1.2684e-5
KSC12	4.4215e-5	1.4166e-5	9.7418437	0.0018*	1.645e-5	7.198e-5
KSC13	-0.000045	1.2789e-5	12.4008	0.0004*	-7.01e-5	-0.00002
KSC14	1.6316e-5	0.0000148	1.2136888	0.2706	-1.271e-5	4.5342e-5
KSC15	-3.149e-5	2.5179e-5	1.5641716	0.2111	-8.084e-5	1.7859e-5
KSC16	0.0000436	1.1558e-5	14.225364	0.0002*	2.094e-5	6.6247e-5
KSC17	-5.289e-5	1.7916e-5	8.714046	0.0032*	-0.000088	-1.777e-5
KSC18	-4.253e-5	0.0000129	10.860034	0.0010*	-6.783e-5	-1.724e-5
KSC19	-5.448e-7	1.5579e-5	0.001223	0.9721	-0.000031	2.9989e-5
KSC20	-1.475e-5	1.7826e-5	0.6846939	0.4080	-4.969e-5	2.0188e-5
KSC21	1.375e-5	1.3289e-5	1.0705769	0.3008	-1.23e-5	0.0000398
KSC22	-0.00003	1.2264e-5	5.9515017	0.0147*	-0.000054	-5.882e-6
KSC24	-2.513e-5	1.1446e-5	4.8195228	0.0281*	-4.756e-5	-2.694e-6
KSC25	-0.000044	9.2453e-6	22.590538	<.0001*	-0.000062	-2.582e-5
KSC26	-1.68e-5	1.0057e-5	2.789763	0.0949	-3.651e-5	2.9135e-6
KSC27	5.1589e-5	1.2289e-5	17.624296	<.0001*	0.0000275	7.5674e-5
KSC28	9.283e-5	1.1184e-5	68.892054	<.0001*	0.0000709	0.0001148
KSC29	6.9747e-6	0.0000132	0.2790771	0.5973	-0.000019	3.2851e-5
KSC30	-5.969e-5	1.3332e-5	20.04678	<.0001*	-8.582e-5	-3.356e-5
KSC31	1.2431e-5	9.352e-6	1.7668027	0.1838	-5.899e-6	3.076e-5
KSC32	3.955e-5	0.000019	4.3318302	0.0374*	2.3058e-6	0.0000768
KSC34	-6.405e-6	1.4633e-5	0.191603	0.6616	-0.000035	2.2275e-5

Generalized Regression for lightning.end.1 BySensor=7

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	40322
Sum of Frequencies	13905
-LogLikelihood	75210.937
Number of Parameters	33
BIC	150736.69
AICc	150488.04
Generalized RSquare	0.0324546

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-0.00001	7.4489e-6	1.776259	0.1826	-2.453e-5	4.6719e-6
KSC2	-3.454e-5	1.1972e-5	8.3231469	0.0039*	-0.000058	-0.000011
KSC4	-9.749e-6	1.1565e-5	0.7105509	0.3993	-3.242e-5	1.2919e-5
KSC5	-0.000061	1.6824e-5	13.141979	0.0003*	-0.000094	-0.000028
KSC6	7.5566e-5	1.7125e-5	19.47186	<.0001*	0.000042	0.0001091
KSC7	-3.82e-5	0.0000111	11.855666	0.0006*	-0.00006	-1.645e-5
KSC8	-1.645e-5	1.3943e-5	1.3915767	0.2381	-4.378e-5	1.088e-5
KSC9	2.5817e-6	1.4543e-5	0.0315141	0.8591	-0.000026	3.1086e-5
KSC10	2.8822e-5	0.0000111	6.7316452	0.0095*	7.0494e-6	0.0000506
KSC11	-0.000017	1.3065e-5	1.7077159	0.1913	-4.268e-5	8.5339e-6
KSC12	3.9076e-5	1.3128e-5	8.8599134	0.0029*	1.3346e-5	0.0000648
KSC13	-8.538e-6	0.000012	0.5055332	0.4771	-0.000032	0.000015
KSC14	1.0812e-5	1.3588e-5	0.6332024	0.4262	-1.582e-5	3.7444e-5
KSC15	-1.625e-5	2.2871e-5	0.5048085	0.4774	-0.000061	2.8576e-5
KSC16	1.8683e-5	1.0953e-5	2.909839	0.0880	-2.784e-6	4.015e-5
KSC17	-3.112e-5	1.6981e-5	3.3592962	0.0668	-6.441e-5	2.1587e-6
KSC18	-1.562e-5	0.000012	1.6952425	0.1929	-3.915e-5	7.8958e-6
KSC19	-2.536e-6	1.4286e-5	0.0315025	0.8591	-3.054e-5	2.5465e-5
KSC20	-1.523e-5	0.0000166	0.8418535	0.3589	-4.778e-5	0.0000173
KSC21	5.3615e-6	1.263e-5	0.1802105	0.6712	-1.939e-5	3.0116e-5
KSC22	-6.938e-6	1.1653e-5	0.3544686	0.5516	-2.978e-5	0.0000159
KSC24	-3.433e-5	1.0881e-5	9.9570142	0.0016*	-5.566e-5	-0.000013
KSC25	-5.141e-5	9.0502e-6	32.262122	<.0001*	-6.914e-5	-3.367e-5
KSC26	2.8492e-6	1.0187e-5	0.0782272	0.7797	-1.712e-5	2.2815e-5
KSC27	4.0152e-5	1.2458e-5	10.387418	0.0013*	1.5734e-5	6.4569e-5
KSC28	4.5476e-5	1.1149e-5	16.6371	<.0001*	2.3624e-5	6.7329e-5
KSC29	-9.19e-6	1.3317e-5	0.4762744	0.4901	-3.529e-5	1.691e-5
KSC30	-0.000023	1.3165e-5	3.0322309	0.0816	-4.873e-5	2.8783e-6
KSC31	-9.852e-6	9.4094e-6	1.0963898	0.2951	-2.829e-5	8.5896e-6
KSC32	2.9042e-5	1.8668e-5	2.4203729	0.1198	-7.546e-6	6.563e-5
KSC34	6.9215e-6	0.0000142	0.2376063	0.6259	-0.000021	3.4752e-5

Generalized Regression for lightning.end.1 BySensor=8

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	49836
Sum of Frequencies	19123
-LogLikelihood	103078.25
Number of Parameters	33
BIC	206481.83
AICc	206222.61
Generalized RSquare	0.0262853

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-1.773e-5	7.0466e-6	6.3332923	0.0118*	-3.154e-5	-3.922e-6
KSC2	-3.965e-5	0.000011	13.007675	0.0003*	-6.12e-5	-1.81e-5
KSC4	-4.814e-5	1.0728e-5	20.137022	<.0001*	-6.917e-5	-2.712e-5
KSC5	1.2443e-5	1.5589e-5	0.6370516	0.4248	-1.811e-5	0.000043
KSC6	0.0000663	1.582e-5	17.56561	<.0001*	0.0000353	0.0000973
KSC7	-4.558e-6	1.0039e-5	0.2061057	0.6498	-2.423e-5	1.5119e-5
KSC8	2.7738e-5	1.2948e-5	4.5892221	0.0322*	2.3602e-6	5.3116e-5
KSC9	-1.687e-5	1.3663e-5	1.5246805	0.2169	-4.365e-5	9.9084e-6
KSC10	-4.588e-6	1.0162e-5	0.2038085	0.6517	-2.451e-5	1.533e-5
KSC11	-1.955e-5	1.212e-5	2.6018831	0.1067	-4.331e-5	4.2048e-6
KSC12	4.8433e-5	1.2161e-5	15.861479	<.0001*	0.0000246	7.2268e-5
KSC13	-5.066e-5	1.1025e-5	21.112259	<.0001*	-7.227e-5	-0.000029
KSC14	8.3957e-6	1.2674e-5	0.4388397	0.5077	-1.644e-5	3.3236e-5
KSC15	-2.587e-5	2.1577e-5	1.4374951	0.2305	-6.816e-5	1.642e-5
KSC16	2.6725e-5	0.00001	7.1429595	0.0075*	7.1264e-6	4.6324e-5
KSC17	1.4688e-6	1.5846e-5	0.0085918	0.9261	-2.959e-5	3.2526e-5
KSC18	-0.000053	1.1127e-5	22.626078	<.0001*	-7.474e-5	-3.112e-5
KSC19	-1.344e-5	1.3354e-5	1.0131765	0.3141	-3.961e-5	1.2732e-5
KSC20	-7.947e-7	1.5388e-5	0.0026666	0.9588	-0.000031	2.9366e-5
KSC21	-5.411e-6	1.1445e-5	0.2235176	0.6364	-2.784e-5	1.7021e-5
KSC22	-9.814e-6	0.0000108	0.8254029	0.3636	-0.000031	1.1358e-5
KSC24	-4.519e-5	9.839e-6	21.092125	<.0001*	-6.447e-5	-0.000026
KSC25	-1.02e-5	7.8418e-6	1.6920726	0.1933	-2.557e-5	5.169e-6
KSC26	-0.000016	9.1235e-6	3.0752668	0.0795	-3.388e-5	1.8824e-6
KSC27	0.0000283	1.1075e-5	6.5341265	0.0106*	6.603e-6	5.0014e-5
KSC28	4.8927e-5	9.7303e-6	25.284057	<.0001*	2.9856e-5	0.000068
KSC29	3.9455e-5	1.1374e-5	12.033064	0.0005*	1.7162e-5	6.1748e-5
KSC30	-3.128e-5	0.0000117	7.142471	0.0075*	-5.422e-5	-8.34e-6
KSC31	2.1511e-5	7.8734e-6	7.4645749	0.0063*	6.0797e-6	3.6943e-5
KSC32	7.307e-6	1.6015e-5	0.2081686	0.6482	-0.000024	0.0000387
KSC34	-1.971e-5	1.2385e-5	2.5325568	0.1115	-0.000044	4.5646e-6

Generalized Regression for lightning.end.1 BySensor=9

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	54777
Sum of Frequencies	21577
-LogLikelihood	122850.38
Number of Parameters	33
BIC	246030.07
AICc	245766.86
Generalized RSquare	0.0245443

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC2	-4.487e-5	1.2674e-5	12.534856	0.0004*	-6.971e-5	-0.00002
KSC4	-0.000017	0.0000124	1.8912775	0.1691	-4.135e-5	7.2503e-6
KSC5	7.278e-5	1.7484e-5	17.327165	<.0001*	3.8511e-5	0.000107
KSC6	3.8639e-5	1.8736e-5	4.2528885	0.0392*	1.9165e-6	7.5362e-5
KSC7	1.6687e-5	1.1345e-5	2.163703	0.1413	-5.548e-6	3.8922e-5
KSC8	4.5569e-5	1.5528e-5	8.6117595	0.0033*	1.5134e-5	0.000076
KSC9	-4.651e-5	0.0000163	8.1337602	0.0043*	-7.847e-5	-1.455e-5
KSC10	2.599e-6	1.1485e-5	0.0512047	0.8210	-0.00002	0.0000251
KSC11	-1.632e-5	1.4535e-5	1.2601198	0.2616	-4.48e-5	1.2172e-5
KSC12	2.577e-5	1.4566e-5	3.1302637	0.0769	-2.778e-6	5.4318e-5
KSC13	-3.648e-5	1.3371e-5	7.4432531	0.0064*	-6.269e-5	-1.027e-5
KSC14	4.4412e-6	0.0000149	0.0887997	0.7657	-2.477e-5	3.3652e-5
KSC15	-1.911e-5	0.000026	0.5404991	0.4622	-0.00007	3.184e-5
KSC16	-4.436e-6	1.1872e-5	0.1395948	0.7087	-2.77e-5	1.8833e-5
KSC17	-3.834e-5	1.8366e-5	4.3569976	0.0369*	-7.433e-5	-2.339e-6
KSC18	-6.175e-5	1.3235e-5	21.768335	<.0001*	-8.769e-5	-3.581e-5
KSC19	5.7783e-6	1.5811e-5	0.133559	0.7148	-2.521e-5	3.6767e-5
KSC20	-4.021e-5	1.8242e-5	4.8588905	0.0275*	-0.000076	-4.457e-6
KSC21	5.9259e-5	0.0000135	19.270108	<.0001*	0.0000328	8.5717e-5
KSC22	-1.471e-5	1.2451e-5	1.3954524	0.2375	-3.911e-5	9.6951e-6
KSC24	-0.000032	1.1225e-5	8.1368282	0.0043*	-0.000054	-0.00001
KSC25	-1.857e-5	8.9778e-6	4.2782289	0.0386*	-3.617e-5	-9.734e-7
KSC26	-7.979e-6	9.9527e-6	0.6426587	0.4227	-2.749e-5	1.1528e-5
KSC27	0.000055	1.2238e-5	20.193995	<.0001*	0.000031	7.8983e-5
KSC28	9.2657e-5	1.108e-5	69.934924	<.0001*	7.0941e-5	0.0001144
KSC29	2.2305e-7	1.3263e-5	0.0002828	0.9866	-2.577e-5	2.6218e-5
KSC30	-6.25e-5	1.3238e-5	22.291603	<.0001*	-8.845e-5	-3.656e-5
KSC31	3.1269e-5	9.1034e-6	11.798164	0.0006*	1.3427e-5	4.9111e-5
KSC32	3.3449e-5	0.000019	3.1000105	0.0783	-3.786e-6	7.0683e-5
KSC34	-0.000013	1.4669e-5	0.77992	0.3772	-4.171e-5	0.0000158
Dispersion	1.3483919	0.0111164	14713.187	<.0001*	1.3266043	1.3701796

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=10

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	51518
Sum of Frequencies	19505
-LogLikelihood	106810.43
Number of Parameters	33
BIC	213946.86
AICc	213686.98
Generalized RSquare	0.034894

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-2.68e-5	7.4848e-6	12.818122	0.0003*	-4.147e-5	-1.213e-5
KSC2	-6.75e-5	1.153e-5	34.275513	<.0001*	-9.01e-5	-0.000045
KSC4	-2.063e-6	1.1728e-5	0.0309293	0.8604	-0.000025	2.0924e-5
KSC5	0.0000404	1.588e-5	6.4726818	0.0110*	9.2766e-6	7.1524e-5
KSC6	7.7344e-5	1.7053e-5	20.570389	<.0001*	4.3921e-5	0.0001108
KSC7	-1.46e-5	0.0000105	1.9324965	0.1645	-3.52e-5	5.9865e-6
KSC8	3.4126e-6	1.4255e-5	0.057312	0.8108	-2.453e-5	3.1352e-5
KSC9	-3.767e-5	1.4558e-5	6.6957873	0.0097*	-6.62e-5	-9.137e-6
KSC10	1.5112e-5	1.0431e-5	2.0986778	0.1474	-5.333e-6	3.5557e-5
KSC11	-2.349e-5	1.2972e-5	3.2793503	0.0702	-0.000049	1.9337e-6
KSC12	2.8516e-5	1.3172e-5	4.6869894	0.0304*	0.0000027	5.4333e-5
KSC13	-0.000035	1.2081e-5	8.3958787	0.0038*	-5.868e-5	-1.133e-5
KSC14	2.4077e-5	0.0000138	3.0407557	0.0812	-2.985e-6	5.114e-5
KSC15	-2.253e-5	2.3061e-5	0.9545022	0.3286	-6.773e-5	2.2669e-5
KSC16	3.9324e-5	1.0955e-5	12.884422	0.0003*	1.7852e-5	0.0000608
KSC17	-4.463e-5	1.6455e-5	7.3578597	0.0067*	-7.688e-5	-1.238e-5
KSC18	-4.244e-5	0.000012	12.511864	0.0004*	-0.000066	-0.000019
KSC19	-7.226e-6	1.448e-5	0.2490506	0.6177	-3.561e-5	2.1155e-5
KSC20	4.8989e-6	1.6625e-5	0.086833	0.7682	-2.769e-5	3.7483e-5
KSC21	0.0000103	1.251e-5	0.6791321	0.4099	-1.421e-5	3.483e-5
KSC22	-2.076e-5	1.1414e-5	3.3093841	0.0689	-4.313e-5	1.607e-6
KSC24	-2.957e-5	1.0673e-5	7.6739996	0.0056*	-5.049e-5	-8.648e-6
KSC25	-6.13e-5	8.7322e-6	49.283158	<.0001*	-7.842e-5	-4.419e-5
KSC26	-1.559e-5	9.5657e-6	2.6569201	0.1031	-3.434e-5	3.1563e-6
KSC27	4.0322e-5	0.0000118	11.662492	0.0006*	1.718e-5	6.3463e-5
KSC28	6.6052e-5	0.0000108	37.338081	<.0001*	4.4866e-5	8.7239e-5
KSC29	-1.076e-5	1.2819e-5	0.7047075	0.4012	-3.588e-5	1.4363e-5
KSC30	-4.89e-5	1.2882e-5	14.405828	0.0001*	-7.414e-5	-2.365e-5
KSC31	9.787e-6	8.8921e-6	1.2114017	0.2711	-7.641e-6	2.7215e-5
KSC32	3.0158e-5	1.8083e-5	2.7813016	0.0954	-5.285e-6	0.0000656
KSC34	0.0000226	1.4128e-5	2.5604313	0.1096	-5.084e-6	0.0000503
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Generalized Regression for lightning.end.1 BySensor=11

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	59031
Sum of Frequencies	22542
-LogLikelihood	127785.76
Number of Parameters	33
BIC	255902.28
AICc	255637.62
Generalized RSquare	0.0255474

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	-0.000017	8.0641e-6	4.4512522	0.0349*	-3.282e-5	-1.208e-6
KSC2	-3.459e-5	1.2129e-5	8.134748	0.0043*	-5.837e-5	-1.082e-5
KSC4	-5.94e-5	1.2012e-5	24.454836	<.0001*	-0.000083	-3.586e-5
KSC5	0.000022	1.668e-5	1.7401691	0.1871	-1.069e-5	0.0000547
KSC6	8.8625e-5	0.0000178	24.814802	<.0001*	5.3755e-5	0.0001235
KSC7	0.0000012	1.0824e-5	0.0122981	0.9117	-0.00002	2.2414e-5
KSC8	4.766e-5	0.0000145	10.815737	0.0010*	1.9256e-5	7.6064e-5
KSC9	-4.539e-5	1.5281e-5	8.8230401	0.0030*	-7.534e-5	-1.544e-5
KSC10	0.0000159	1.0816e-5	2.1587284	0.1418	-5.307e-6	3.7089e-5
KSC11	-6.82e-6	1.3577e-5	0.2523014	0.6155	-3.343e-5	0.0000198
KSC12	3.7261e-5	1.3682e-5	7.4171702	0.0065*	1.0446e-5	6.4077e-5
KSC13	-0.000048	0.0000125	14.700777	0.0001*	-7.239e-5	-2.342e-5
KSC14	3.9216e-5	0.0000144	7.4138884	0.0065*	1.0987e-5	6.7444e-5
KSC15	-4.586e-5	0.000024	3.651098	0.0560	-0.000093	1.1803e-6
KSC16	2.8568e-5	1.1272e-5	6.4229365	0.0113*	6.4747e-6	5.0662e-5
KSC17	-3.059e-5	0.0000169	3.2735235	0.0704	-6.372e-5	2.5473e-6
KSC18	-5.435e-5	1.2364e-5	19.324461	<.0001*	-7.859e-5	-3.012e-5
KSC19	-2.313e-5	1.5078e-5	2.3534564	0.1250	-5.268e-5	6.4213e-6
KSC20	6.3501e-6	1.7529e-5	0.1312314	0.7172	-0.000028	0.0000407
KSC21	3.143e-5	1.3025e-5	5.8232227	0.0158*	5.9024e-6	5.6959e-5
KSC22	-2.154e-5	1.1836e-5	3.3112741	0.0688	-4.474e-5	1.6603e-6
KSC24	-1.126e-5	1.0889e-5	1.070038	0.3009	-3.261e-5	1.0078e-5
KSC25	-0.000066	8.9357e-6	54.679542	<.0001*	-8.359e-5	-4.856e-5
KSC26	-1.285e-5	9.9418e-6	1.6709572	0.1961	-3.234e-5	6.6343e-6
KSC27	2.4842e-5	1.2061e-5	4.2423898	0.0394*	1.203e-6	4.8481e-5
KSC28	9.8244e-5	1.1074e-5	78.707564	<.0001*	7.654e-5	0.0001199
KSC29	-3.738e-6	1.3232e-5	0.0797959	0.7776	-2.967e-5	0.0000222
KSC30	-4.356e-5	1.3446e-5	10.495177	0.0012*	-0.00007	-1.721e-5
KSC31	2.4133e-5	9.0023e-6	7.1864256	0.0073*	6.4887e-6	4.1777e-5
KSC32	2.1283e-6	1.8468e-5	0.0132811	0.9083	-0.000034	3.8324e-5
KSC34	1.8925e-5	0.0000142	1.7768154	0.1825	-8.902e-6	4.6751e-5
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Generalized Regression for lightning.end.1 BySensor=12

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	51949
Sum of Frequencies	24181
-LogLikelihood	139226.86
Number of Parameters	33
BIC	278786.8
AICc	278519.82
Generalized RSquare	0.0188456

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC2	-3.524e-5	1.2444e-5	8.0179189	0.0046*	-5.962e-5	-1.085e-5
KSC4	-3.281e-5	1.1865e-5	7.6445615	0.0057*	-0.000056	-9.55e-6
KSC5	3.6363e-5	1.7312e-5	4.411888	0.0357*	2.4321e-6	0.0000703
KSC6	0.0000256	1.8461e-5	1.9218605	0.1657	-1.059e-5	6.1777e-5
KSC7	1.9524e-5	1.1231e-5	3.022256	0.0821	-2.488e-6	4.1536e-5
KSC8	8.3273e-5	1.5149e-5	30.216104	<.0001*	5.3582e-5	0.000113
KSC9	-6.119e-5	1.6073e-5	14.493934	0.0001*	-9.269e-5	-2.969e-5
KSC10	4.6818e-6	1.1429e-5	0.1677985	0.6821	-1.772e-5	2.7083e-5
KSC11	-6.945e-6	1.4323e-5	0.2350841	0.6278	-0.000035	2.1128e-5
KSC12	0.0000404	0.0000143	7.9680153	0.0048*	1.2346e-5	6.8438e-5
KSC13	-4.122e-5	1.3346e-5	9.5368906	0.0020*	-6.737e-5	-0.000015
KSC14	0.0000358	1.4828e-5	5.8285745	0.0158*	6.736e-6	6.4861e-5
KSC15	-3.631e-5	2.5427e-5	2.03912	0.1533	-8.615e-5	1.3527e-5
KSC16	-2.395e-7	1.1746e-5	0.0004158	0.9837	-2.326e-5	2.2783e-5
KSC17	-4.755e-5	1.7719e-5	7.2023909	0.0073*	-8.228e-5	-1.282e-5
KSC18	-3.644e-5	1.3029e-5	7.8210528	0.0052*	-0.000062	-0.000011
KSC19	-1.532e-5	1.5482e-5	0.9789956	0.3224	-4.566e-5	1.5026e-5
KSC20	-0.000036	0.0000179	4.0448385	0.0443*	-0.000071	-9.167e-7
KSC21	5.7114e-5	1.3471e-5	17.97525	<.0001*	3.0711e-5	8.3517e-5
KSC22	3.7958e-7	1.2421e-5	0.0009338	0.9756	-0.000024	2.4725e-5
KSC24	-3.09e-5	1.1213e-5	7.5927286	0.0059*	-5.288e-5	-8.92e-6
KSC25	-4.356e-5	9.0948e-6	22.937687	<.0001*	-6.138e-5	-2.573e-5
KSC26	1.8698e-6	1.001e-5	0.0348893	0.8518	-1.775e-5	2.1489e-5
KSC27	4.8889e-5	0.0000122	16.080333	<.0001*	0.000025	7.2785e-5
KSC28	9.1645e-5	0.0000113	65.820565	<.0001*	0.0000695	0.0001138
KSC29	-0.000028	1.3257e-5	4.4465663	0.0350*	-0.000054	-1.972e-6
KSC30	-3.189e-5	1.3421e-5	5.6472963	0.0175*	-5.82e-5	-5.589e-6
KSC31	3.0767e-5	9.0295e-6	11.610506	0.0007*	1.307e-5	4.8465e-5
KSC32	2.5673e-5	1.897e-5	1.831595	0.1759	-1.151e-5	6.2853e-5
KSC34	-1.269e-5	1.4512e-5	0.7648094	0.3818	-4.113e-5	1.5751e-5
Dispersion	1.3087998	0.0103329	16043.691	<.0001*	1.2885478	1.3290519

Generalized Regression for lightning.end.1 BySensor=13

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	59899
Sum of Frequencies	24080
-LogLikelihood	138109.6
Number of Parameters	33
BIC	276552.15
AICc	276285.3
Generalized RSquare	0.0210318

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	1.4245e-5	7.9922e-6	3.1768131	0.0747	-1.419e-6	0.0000299
KSC2	-8.115e-5	1.1986e-5	45.841651	<.0001*	-0.000105	-5.766e-5
KSC4	-4.155e-5	0.0000119	12.190022	0.0005*	-6.487e-5	-1.822e-5
KSC5	5.9188e-5	1.6871e-5	12.307798	0.0005*	2.6121e-5	9.2255e-5
KSC6	6.6824e-5	1.8137e-5	13.574016	0.0002*	3.1275e-5	0.0001024
KSC7	-2.442e-5	0.0000107	5.2155036	0.0224*	-4.539e-5	-3.463e-6
KSC8	5.1482e-5	1.5031e-5	11.730915	0.0006*	2.2022e-5	8.0942e-5
KSC9	-6.341e-5	1.5783e-5	16.139521	<.0001*	-9.434e-5	-3.247e-5
KSC10	6.0383e-6	1.0982e-5	0.3023108	0.5824	-1.549e-5	2.7563e-5
KSC11	-0.000019	1.3721e-5	1.9091905	0.1671	-4.585e-5	7.9339e-6
KSC12	4.0376e-5	1.4246e-5	8.0324502	0.0046*	1.2454e-5	0.0000683
KSC13	-7.76e-5	1.3063e-5	35.288816	<.0001*	-0.000103	-0.000052
KSC14	3.5978e-5	1.4227e-5	6.3951681	0.0114*	8.0938e-6	6.3863e-5
KSC15	-1.067e-5	2.4881e-5	0.1839453	0.6680	-5.944e-5	0.0000381
KSC16	1.7817e-6	1.1238e-5	0.0251338	0.8740	-2.024e-5	0.0000238
KSC17	-2.535e-5	1.7412e-5	2.1199329	0.1454	-5.948e-5	8.7748e-6
KSC18	-4.843e-5	1.2268e-5	15.58003	<.0001*	-7.247e-5	-2.438e-5
KSC19	3.2875e-5	1.4934e-5	4.8461161	0.0277*	3.6054e-6	6.2145e-5
KSC20	-1.784e-5	0.000017	1.1020795	0.2938	-5.114e-5	1.5464e-5
KSC21	-1.955e-6	1.267e-5	0.0238182	0.8773	-2.679e-5	2.2877e-5
KSC22	-1.433e-5	1.2164e-5	1.387305	0.2389	-3.817e-5	9.5141e-6
KSC24	-2.115e-5	1.0631e-5	3.9589596	0.0466*	-0.000042	-3.163e-7
KSC25	-5.477e-6	8.6226e-6	0.4034366	0.5253	-2.238e-5	1.1423e-5
KSC26	8.1041e-6	9.7803e-6	0.6866048	0.4073	-0.000011	2.7273e-5
KSC27	3.7073e-5	1.1829e-5	9.8225762	0.0017*	1.3889e-5	6.0258e-5
KSC28	8.7262e-5	1.058e-5	68.0312	<.0001*	6.6526e-5	0.000108
KSC29	-9.162e-6	1.2488e-5	0.5383071	0.4631	-3.364e-5	1.5313e-5
KSC30	-3.89e-5	0.0000123	9.994878	0.0016*	-0.000063	-1.478e-5
KSC31	3.118e-5	8.7498e-6	12.69897	0.0004*	1.4031e-5	4.8329e-5
KSC32	4.3182e-5	1.8222e-5	5.6157281	0.0178*	7.4672e-6	0.0000789
KSC34	-3.964e-5	1.3865e-5	8.1754698	0.0042*	-6.682e-5	-1.247e-5
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=14

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	68532
Sum of Frequencies	27774
-LogLikelihood	162946.53
Number of Parameters	33
BIC	326230.72
AICc	325959.15
Generalized RSquare	0.0196912

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	8.1433e-6	8.3922e-6	0.9415801	0.3319	-8.305e-6	0.0000246
KSC2	-3.977e-5	1.2648e-5	9.8859036	0.0017*	-6.456e-5	-0.000015
KSC4	-4.353e-5	1.2149e-5	12.839705	0.0003*	-6.734e-5	-1.972e-5
KSC5	-1.054e-5	1.7313e-5	0.3704755	0.5427	-4.447e-5	0.0000234
KSC6	9.8936e-5	1.8848e-5	27.553017	<.0001*	0.000062	0.0001359
KSC7	-5.561e-5	1.1124e-5	24.99021	<.0001*	-7.741e-5	-3.381e-5
KSC8	6.9628e-5	1.5487e-5	20.21285	<.0001*	3.9274e-5	0.0001
KSC9	-6.732e-5	1.6423e-5	16.802978	<.0001*	-0.0001	-3.513e-5
KSC10	4.6846e-6	1.1426e-5	0.1680941	0.6818	-1.771e-5	2.7079e-5
KSC11	-2.168e-6	1.4253e-5	0.0231318	0.8791	-3.01e-5	2.5767e-5
KSC12	3.3347e-5	1.4749e-5	5.1123163	0.0238*	4.4405e-6	6.2254e-5
KSC13	-7.127e-5	1.3577e-5	27.559391	<.0001*	-9.788e-5	-4.466e-5
KSC14	4.1737e-5	1.4911e-5	7.8344473	0.0051*	1.2511e-5	7.0963e-5
KSC15	-8.101e-6	0.0000254	0.1017745	0.7497	-5.787e-5	4.1669e-5
KSC16	9.7066e-7	1.1727e-5	0.0068511	0.9340	-0.000022	2.3955e-5
KSC17	-3.449e-5	1.749e-5	3.8887995	0.0486*	-6.877e-5	-2.106e-7
KSC18	-5.22e-5	1.2832e-5	16.547634	<.0001*	-7.735e-5	-0.000027
KSC19	6.6365e-6	1.568e-5	0.1791287	0.6721	-0.000024	3.737e-5
KSC20	-2.636e-5	0.0000177	2.2181909	0.1364	-0.000061	8.329e-6
KSC21	4.0225e-5	0.0000136	8.752355	0.0031*	1.3576e-5	6.6875e-5
KSC22	-8.102e-6	1.2258e-5	0.4369206	0.5086	-3.213e-5	1.5922e-5
KSC24	-0.000016	1.1023e-5	2.1155896	0.1458	-3.764e-5	5.5717e-6
KSC25	-4.351e-6	8.9241e-6	0.2376834	0.6259	-2.184e-5	1.314e-5
KSC26	2.8961e-6	1.0154e-5	0.0813447	0.7755	-0.000017	0.0000228
KSC27	3.6247e-5	1.2267e-5	8.7315321	0.0031*	0.0000122	0.0000603
KSC28	9.8421e-5	1.124e-5	76.666339	<.0001*	7.639e-5	0.0001205
KSC29	-0.000024	1.3263e-5	3.2980318	0.0694	-0.00005	1.9087e-6
KSC30	-0.000034	1.3437e-5	6.3672684	0.0116*	-6.024e-5	-7.57e-6
KSC31	0.0000331	9.0578e-6	13.354951	0.0003*	1.5348e-5	5.0854e-5
KSC32	0.0000519	1.9023e-5	7.4425501	0.0064*	1.4612e-5	8.9181e-5
KSC34	-2.33e-5	1.4731e-5	2.501848	0.1137	-5.217e-5	5.572e-6

Generalized Regression for lightning.end.1 BySensor=15

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	65583
Sum of Frequencies	27989
-LogLikelihood	165859.08
Number of Parameters	33
BIC	332056.06
AICc	331784.23
Generalized RSquare	0.0191094

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.2087e-5	8.6922e-6	6.4567383	0.0111*	5.0506e-6	3.9123e-5
KSC2	-0.000024	1.298e-5	3.3984882	0.0653	-4.937e-5	1.5117e-6
KSC4	-6.669e-5	1.2086e-5	30.445742	<.0001*	-9.038e-5	-0.000043
KSC5	-3.578e-5	0.0000178	4.0415106	0.0444*	-7.066e-5	-8.967e-7
KSC6	0.0001125	1.938e-5	33.718683	<.0001*	7.4551e-5	0.0001505
KSC7	-3.19e-5	1.156e-5	7.6146649	0.0058*	-5.455e-5	-9.242e-6
KSC8	7.2155e-5	1.5776e-5	20.918561	<.0001*	4.1235e-5	0.0001031
KSC9	-9.341e-5	1.6685e-5	31.343986	<.0001*	-0.000126	-6.071e-5
KSC10	-3.968e-6	1.1821e-5	0.1126987	0.7371	-2.714e-5	0.0000192
KSC11	2.5988e-5	0.0000147	3.1271556	0.0770	-2.816e-6	0.0000548
KSC12	4.7916e-5	1.5115e-5	10.049328	0.0015*	0.0000183	7.7541e-5
KSC13	-0.000082	1.4074e-5	34.028933	<.0001*	-0.00011	-5.451e-5
KSC14	5.7652e-5	1.5242e-5	14.307202	0.0002*	2.7779e-5	8.7526e-5
KSC15	-1.344e-5	0.0000263	0.2610803	0.6094	-0.000065	0.0000381
KSC16	-6.593e-6	1.2029e-5	0.3004077	0.5836	-3.017e-5	1.6983e-5
KSC17	-0.000045	0.0000182	6.0844412	0.0136*	-8.061e-5	-9.227e-6
KSC18	-3.958e-5	1.3464e-5	8.6433719	0.0033*	-0.000066	-1.319e-5
KSC19	-2.738e-8	1.6241e-5	2.8417e-6	0.9987	-3.186e-5	0.0000318
KSC20	-1.172e-5	1.8153e-5	0.4167671	0.5186	-4.73e-5	2.386e-5
KSC21	4.9943e-5	1.3735e-5	13.222998	0.0003*	2.3024e-5	7.6863e-5
KSC22	-5.884e-6	1.2835e-5	0.2101753	0.6466	-0.000031	1.9272e-5
KSC24	-1.744e-5	1.1449e-5	2.3213599	0.1276	-3.988e-5	4.996e-6
KSC25	-0.000021	9.3163e-6	5.0997859	0.0239*	-3.93e-5	-2.779e-6
KSC26	-1.235e-5	1.0528e-5	1.3769332	0.2406	-0.000033	8.281e-6
KSC27	4.4436e-5	1.2884e-5	11.894078	0.0006*	1.9183e-5	6.9689e-5
KSC28	0.0001016	1.1936e-5	72.447991	<.0001*	0.0000782	0.000125
KSC29	-4.056e-5	0.000014	8.3892494	0.0038*	-0.000068	-1.311e-5
KSC30	-1.543e-5	0.0000143	1.1632191	0.2808	-4.347e-5	0.0000126
KSC31	0.0000233	9.5384e-6	5.9654772	0.0146*	4.602e-6	0.000042
KSC32	0.0000688	1.9888e-5	11.964657	0.0005*	2.9813e-5	0.0001078
KSC34	-2.436e-5	1.5156e-5	2.5832666	0.1080	-0.000054	5.3458e-6

Generalized Regression for lightning.end.1 BySensor=16

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	66459
Sum of Frequencies	27362
-LogLikelihood	159653.56
Number of Parameters	33
BIC	319644.27
AICc	319373.2
Generalized RSquare	0.0206331

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.5674e-5	8.3112e-6	9.5421484	0.0020*	9.384e-6	4.1963e-5
KSC2	-7.645e-5	1.2354e-5	38.299729	<.0001*	-0.000101	-5.224e-5
KSC4	-8.109e-6	1.1756e-5	0.4757487	0.4904	-3.115e-5	1.4933e-5
KSC5	3.6168e-5	0.0000172	4.4249651	0.0354*	2.469e-6	6.9867e-5
KSC6	5.1255e-5	1.8661e-5	7.5436343	0.0060*	1.4679e-5	8.783e-5
KSC7	-0.000051	1.115e-5	20.868329	<.0001*	-7.279e-5	-0.000029
KSC8	3.7365e-5	1.5182e-5	6.0569451	0.0139*	7.6082e-6	6.7122e-5
KSC9	-8.14e-5	0.0000163	24.956002	<.0001*	-0.000113	-4.947e-5
KSC10	-1.078e-5	1.1448e-5	0.8859758	0.3466	-3.321e-5	1.1662e-5
KSC11	1.9629e-5	0.0000144	1.8596342	0.1727	-8.583e-6	4.7842e-5
KSC12	0.0000419	1.4779e-5	8.037146	0.0046*	1.2932e-5	7.0866e-5
KSC13	-0.000086	0.0000136	39.995118	<.0001*	-0.000113	-5.94e-5
KSC14	3.4455e-5	1.4883e-5	5.3591363	0.0206*	5.2839e-6	6.3626e-5
KSC15	1.7476e-6	2.6127e-5	0.0044739	0.9467	-4.946e-5	5.2956e-5
KSC16	8.751e-6	1.1742e-5	0.5554571	0.4561	-1.426e-5	3.1764e-5
KSC17	-3.679e-5	0.000018	4.1828359	0.0408*	-0.000072	-1.533e-6
KSC18	-5.689e-5	1.2924e-5	19.377452	<.0001*	-8.222e-5	-3.156e-5
KSC19	1.5782e-5	1.5437e-5	1.0451819	0.3066	-1.447e-5	4.6039e-5
KSC20	-0.000013	1.767e-5	0.5467044	0.4597	-4.77e-5	2.1568e-5
KSC21	2.886e-5	0.0000131	4.8520345	0.0276*	3.1808e-6	5.454e-5
KSC22	-5.169e-6	1.2335e-5	0.1755641	0.6752	-2.935e-5	0.000019
KSC24	-0.000016	1.0921e-5	2.1708657	0.1406	-3.75e-5	5.3139e-6
KSC25	-1.247e-5	0.0000088	2.0090959	0.1564	-2.972e-5	4.7739e-6
KSC26	4.3233e-6	1.034e-5	0.174805	0.6759	-0.000016	0.0000246
KSC27	3.1836e-5	1.2285e-5	6.715425	0.0096*	7.7574e-6	5.5914e-5
KSC28	0.0000924	1.1238e-5	67.604912	<.0001*	7.0373e-5	0.0001144
KSC29	-2.427e-5	1.3155e-5	3.4043119	0.0650	-0.00005	1.5113e-6
KSC30	-0.000039	1.2839e-5	9.1844368	0.0024*	-0.000064	-1.375e-5
KSC31	1.7877e-5	9.0802e-6	3.8759992	0.0490*	7.9831e-8	3.5674e-5
KSC32	0.0000693	0.0000187	13.738389	0.0002*	3.2655e-5	0.0001059
KSC34	-1.163e-5	1.4531e-5	0.6409197	0.4234	-4.011e-5	1.6847e-5

Generalized Regression for lightning.end.1 BySensor=17

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	72801
Sum of Frequencies	29363
-LogLikelihood	174077.48
Number of Parameters	33
BIC	348494.45
AICc	348221.04
Generalized RSquare	0.0173619

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.7482e-5	8.4344e-6	10.617042	0.0011*	1.0951e-5	4.4013e-5
KSC2	-3.168e-5	1.2534e-5	6.3879586	0.0115*	-5.624e-5	-7.113e-6
KSC4	-5.934e-5	1.1772e-5	25.414999	<.0001*	-8.242e-5	-3.627e-5
KSC5	-3.381e-5	0.0000173	3.8216446	0.0506	-6.77e-5	8.7528e-8
KSC6	0.0001284	1.873e-5	47.020407	<.0001*	9.1725e-5	0.0001651
KSC7	-4.077e-5	1.1287e-5	13.048531	0.0003*	-6.289e-5	-1.865e-5
KSC8	0.0000641	1.5123e-5	17.964216	<.0001*	3.4456e-5	9.3735e-5
KSC9	-9.676e-5	1.5862e-5	37.214972	<.0001*	-0.000128	-6.568e-5
KSC10	5.4156e-6	1.146e-5	0.2233023	0.6365	-0.000017	2.7878e-5
KSC11	8.4372e-6	1.406e-5	0.3601036	0.5484	-1.912e-5	0.000036
KSC12	4.0719e-5	1.4471e-5	7.9178148	0.0049*	1.2357e-5	6.9081e-5
KSC13	-5.948e-5	1.3277e-5	20.07287	<.0001*	-8.55e-5	-3.346e-5
KSC14	5.0854e-5	1.4867e-5	11.700061	0.0006*	2.1715e-5	0.00008
KSC15	-2.129e-6	2.5364e-5	0.0070469	0.9331	-5.184e-5	4.7584e-5
KSC16	-2.164e-5	1.1753e-5	3.3900813	0.0656	-4.468e-5	1.3956e-6
KSC17	-2.649e-5	1.7362e-5	2.3275445	0.1271	-6.052e-5	7.5407e-6
KSC18	-5.129e-5	0.000013	15.54606	<.0001*	-7.679e-5	-2.58e-5
KSC19	1.6385e-5	1.5443e-5	1.1256608	0.2887	-1.388e-5	4.6652e-5
KSC20	-2.328e-5	0.0000174	1.7923024	0.1806	-5.737e-5	0.0000108
KSC21	4.9237e-5	0.0000131	14.120764	0.0002*	2.3556e-5	7.4917e-5
KSC22	1.1627e-6	1.2468e-5	0.008696	0.9257	-2.327e-5	0.0000256
KSC24	-2.476e-5	0.0000112	4.8933704	0.0270*	-4.671e-5	-2.823e-6
KSC25	-2.422e-5	9.2149e-6	6.9062407	0.0086*	-4.228e-5	-6.156e-6
KSC26	-1.535e-6	1.0282e-5	0.0222825	0.8813	-2.169e-5	1.8617e-5
KSC27	0.0000213	1.2565e-5	2.8711877	0.0902	-3.336e-6	4.5917e-5
KSC28	9.5564e-5	0.0000118	65.672471	<.0001*	7.2452e-5	0.0001187
KSC29	-3.249e-5	1.3711e-5	5.6148255	0.0178*	-5.936e-5	-5.616e-6
KSC30	-1.157e-5	1.3876e-5	0.6954682	0.4043	-3.877e-5	1.5625e-5
KSC31	1.5787e-5	9.4098e-6	2.8146978	0.0934	-2.656e-6	3.423e-5
KSC32	0.000069	1.9824e-5	12.114663	0.0005*	3.0145e-5	0.0001079
KSC34	-0.000024	0.000015	2.5471149	0.1105	-5.331e-5	5.4566e-6

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=18

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	72137
Sum of Frequencies	28661
-LogLikelihood	170616.98
Number of Parameters	33
BIC	341572.66
AICc	341300.05
Generalized RSquare	0.0171414

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	3.0431e-5	8.4442e-6	12.987032	0.0003*	1.388e-5	4.6981e-5
KSC2	-2.589e-5	1.2568e-5	4.2432937	0.0394*	-5.052e-5	-1.256e-6
KSC4	-0.000053	1.1864e-5	19.953122	<.0001*	-7.625e-5	-2.974e-5
KSC5	-5.126e-5	1.7353e-5	8.7248484	0.0031*	-8.527e-5	-1.725e-5
KSC6	0.0001141	0.0000188	36.812342	<.0001*	7.7253e-5	0.000151
KSC7	-3.471e-5	0.0000113	9.4456344	0.0021*	-5.685e-5	-1.258e-5
KSC8	7.0689e-5	1.5241e-5	21.511793	<.0001*	4.0817e-5	0.0001006
KSC9	-0.000107	1.5821e-5	45.647587	<.0001*	-0.000138	-7.589e-5
KSC10	1.4317e-5	1.1531e-5	1.5415191	0.2144	-8.284e-6	3.6917e-5
KSC11	-5.148e-7	1.417e-5	0.00132	0.9710	-2.829e-5	2.7258e-5
KSC12	4.4873e-5	1.4479e-5	9.604905	0.0019*	0.0000165	7.3251e-5
KSC13	-0.000045	1.3286e-5	11.47796	0.0007*	-0.000071	-0.000019
KSC14	4.1371e-5	1.473e-5	7.8884311	0.0050*	0.0000125	7.0241e-5
KSC15	8.267e-7	2.5471e-5	0.0010534	0.9741	-0.000049	5.0748e-5
KSC16	-2.686e-5	1.1715e-5	5.2571043	0.0219*	-4.982e-5	-3.9e-6
KSC17	-0.000021	1.7462e-5	1.4557508	0.2276	-5.529e-5	1.3156e-5
KSC18	-5.245e-5	1.2987e-5	16.309078	<.0001*	-0.000078	-0.000027
KSC19	2.2476e-5	1.5357e-5	2.1419464	0.1433	-7.624e-6	5.2576e-5
KSC20	-0.000025	1.7432e-5	2.0431538	0.1529	-0.000059	9.2491e-6
KSC21	4.882e-5	1.3183e-5	13.713689	0.0002*	2.2981e-5	7.4659e-5
KSC22	2.5544e-6	1.259e-5	0.0411661	0.8392	-2.212e-5	2.723e-5
KSC24	-2.148e-5	0.0000114	3.5566756	0.0593	-4.381e-5	8.4354e-7
KSC25	-3.219e-5	9.4399e-6	11.630877	0.0006*	-5.07e-5	-1.369e-5
KSC26	7.6374e-6	1.0251e-5	0.555084	0.4562	-1.245e-5	2.7729e-5
KSC27	0.000028	1.2665e-5	4.8908918	0.0270*	3.1861e-6	5.2831e-5
KSC28	8.4382e-5	1.2078e-5	48.806055	<.0001*	0.0000607	0.0001081
KSC29	-4.925e-5	1.3933e-5	12.493423	0.0004*	-7.656e-5	-0.000022
KSC30	-3.037e-6	0.0000141	0.046414	0.8294	-3.067e-5	0.0000246
KSC31	1.5488e-5	9.5781e-6	2.6148568	0.1059	-3.284e-6	3.4261e-5
KSC32	8.4925e-5	2.0235e-5	17.615175	<.0001*	4.5266e-5	0.0001246
KSC34	-2.263e-5	1.5328e-5	2.1789709	0.1399	-5.267e-5	7.4161e-6
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Generalized Regression for lightning.end.1 BySensor=19

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	77164
Sum of Frequencies	31552
-LogLikelihood	187680.45
Number of Parameters	33
BIC	375702.76
AICc	375426.97
Generalized RSquare	0.017359

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	1.9751e-5	8.5537e-6	5.3316707	0.0209*	2.9859e-6	3.6516e-5
KSC2	-2.843e-5	1.2626e-5	5.0696091	0.0243*	-5.318e-5	-3.682e-6
KSC4	-7.652e-5	1.1926e-5	41.167147	<.0001*	-0.0001	-5.314e-5
KSC5	-3.719e-5	1.7535e-5	4.4990978	0.0339*	-7.156e-5	-2.826e-6
KSC6	0.0001199	0.000019	39.840179	<.0001*	8.2656e-5	0.0001571
KSC7	-1.743e-5	0.0000112	2.4227205	0.1196	-3.938e-5	4.5183e-6
KSC8	0.0000734	1.5686e-5	21.896429	<.0001*	4.2658e-5	0.0001041
KSC9	-9.662e-5	0.0000167	33.439521	<.0001*	-0.000129	-6.387e-5
KSC10	5.5204e-6	1.1544e-5	0.228688	0.6325	-1.71e-5	2.8146e-5
KSC11	1.2069e-5	1.4423e-5	0.7002398	0.4027	-1.62e-5	4.0337e-5
KSC12	5.0424e-5	1.5138e-5	11.095114	0.0009*	2.0754e-5	0.0000801
KSC13	-8.533e-5	0.000014	37.157839	<.0001*	-0.000113	-5.79e-5
KSC14	6.5761e-5	1.5256e-5	18.579429	<.0001*	3.5859e-5	9.5663e-5
KSC15	-2.384e-5	2.5755e-5	0.856733	0.3547	-7.432e-5	2.664e-5
KSC16	-9.357e-6	1.2085e-5	0.5994394	0.4388	-0.000033	1.433e-5
KSC17	-4.37e-5	0.0000173	6.3780029	0.0116*	-7.762e-5	-9.786e-6
KSC18	-0.000031	1.2934e-5	5.7795568	0.0162*	-5.645e-5	-5.744e-6
KSC19	6.8863e-6	1.6164e-5	0.1815061	0.6701	-2.479e-5	3.8567e-5
KSC20	-8.386e-6	1.7822e-5	0.2214278	0.6380	-4.332e-5	2.6543e-5
KSC21	4.3461e-5	1.3515e-5	10.340735	0.0013*	1.6972e-5	6.9951e-5
KSC22	-4.028e-6	1.2486e-5	0.1040487	0.7470	-2.85e-5	2.0445e-5
KSC24	-9.348e-6	1.1173e-5	0.7000242	0.4028	-3.125e-5	1.255e-5
KSC25	-1.967e-5	9.0147e-6	4.7602313	0.0291*	-3.734e-5	-0.000002
KSC26	-1.156e-5	1.054e-5	1.2028461	0.2728	-3.222e-5	9.0982e-6
KSC27	1.2727e-5	1.2778e-5	0.9919384	0.3193	-1.232e-5	3.7771e-5
KSC28	0.0001067	0.0000117	82.960586	<.0001*	0.0000837	0.0001296
KSC29	-5.182e-5	1.3727e-5	14.251289	0.0002*	-7.873e-5	-0.000025
KSC30	6.8351e-7	1.3969e-5	0.0023942	0.9610	-2.67e-5	2.8062e-5
KSC31	1.5259e-5	9.2685e-6	2.7102623	0.0997	-2.907e-6	3.3425e-5
KSC32	7.3425e-5	1.9377e-5	14.358808	0.0002*	3.5447e-5	0.0001114
KSC34	-1.727e-5	0.0000148	1.3637708	0.2429	-4.626e-5	1.1716e-5
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Generalized Regression for lightning.end.1 BySensor=20

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	71361
Sum of Frequencies	32532
-LogLikelihood	193896.69
Number of Parameters	33
BIC	388136.25
AICc	387859.45
Generalized RSquare	0.0154748

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.5439e-5	8.4535e-6	9.0558529	0.0026*	8.8705e-6	0.000042
KSC2	-3.071e-5	1.2414e-5	6.1191661	0.0134*	-0.000055	-6.378e-6
KSC4	-0.000062	1.1859e-5	27.330092	<.0001*	-8.524e-5	-3.875e-5
KSC5	-4.279e-5	1.7219e-5	6.175748	0.0130*	-7.654e-5	-9.042e-6
KSC6	0.0001184	1.848e-5	41.03511	<.0001*	8.2161e-5	0.0001546
KSC7	-1.781e-5	1.1029e-5	2.6084724	0.1063	-3.943e-5	3.8037e-6
KSC8	6.0671e-5	1.5233e-5	15.86324	<.0001*	3.0815e-5	9.0528e-5
KSC9	-0.000091	1.6153e-5	31.725227	<.0001*	-0.000123	-5.932e-5
KSC10	0.0000144	1.1287e-5	1.6295363	0.2018	-7.714e-6	3.6531e-5
KSC11	9.3063e-6	1.384e-5	0.4521746	0.5013	-1.782e-5	3.6431e-5
KSC12	3.9482e-5	0.0000146	7.3200406	0.0068*	1.088e-5	6.8084e-5
KSC13	-6.835e-5	1.3327e-5	26.306514	<.0001*	-9.447e-5	-4.223e-5
KSC14	5.4389e-5	1.4827e-5	13.455769	0.0002*	2.5328e-5	8.3449e-5
KSC15	-1.34e-5	2.5156e-5	0.2839442	0.5941	-6.271e-5	0.0000359
KSC16	-0.000019	1.1772e-5	2.6062233	0.1064	-0.000042	4.0683e-6
KSC17	-3.833e-5	0.0000168	5.203848	0.0225*	-7.126e-5	-5.397e-6
KSC18	-0.000026	1.2643e-5	4.2438414	0.0394*	-5.083e-5	-1.266e-6
KSC19	1.1817e-5	1.5572e-5	0.5758414	0.4479	-1.87e-5	4.2338e-5
KSC20	-0.000019	1.7486e-5	1.170911	0.2792	-5.319e-5	1.5351e-5
KSC21	4.971e-5	0.0000133	13.975754	0.0002*	2.3648e-5	7.5772e-5
KSC22	-4.207e-6	1.2288e-5	0.117196	0.7321	-2.829e-5	1.9878e-5
KSC24	-1.253e-5	1.1089e-5	1.2775518	0.2584	-3.427e-5	0.0000092
KSC25	-0.000015	9.0262e-6	2.7390109	0.0979	-3.263e-5	2.7527e-6
KSC26	-7.151e-6	1.0274e-5	0.4843911	0.4864	-2.729e-5	1.2987e-5
KSC27	1.8934e-5	1.2574e-5	2.2674535	0.1321	-5.711e-6	4.3579e-5
KSC28	0.0001033	1.1734e-5	77.477273	<.0001*	8.0283e-5	0.0001263
KSC29	-3.676e-5	1.352e-5	7.3916134	0.0066*	-6.325e-5	-1.026e-5
KSC30	1.3931e-6	0.0000138	0.0101814	0.9196	-2.567e-5	2.8454e-5
KSC31	1.9829e-5	9.3213e-6	4.5254948	0.0334*	1.56e-6	0.0000381
KSC32	7.1679e-5	1.9513e-5	13.494369	0.0002*	3.3435e-5	0.0001099
KSC34	-3.525e-5	1.4847e-5	5.6365313	0.0176*	-6.435e-5	-6.149e-6
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Generalized Regression for lightning.end.1 BySensor=21

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	76117
Sum of Frequencies	33722
-LogLikelihood	202062.86
Number of Parameters	33
BIC	404469.78
AICc	404191.79
Generalized RSquare	0.0150384

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.787e-5	8.3459e-6	11.151055	0.0008*	1.1512e-5	4.4227e-5
KSC2	-4.555e-5	1.2368e-5	13.562328	0.0002*	-6.979e-5	-2.131e-5
KSC4	-7.021e-5	1.1421e-5	37.78618	<.0001*	-9.259e-5	-4.782e-5
KSC5	-3.828e-5	0.0000172	4.9505145	0.0261*	-0.000072	-4.56e-6
KSC6	0.0001309	1.7877e-5	53.623787	<.0001*	9.587e-5	0.0001659
KSC7	-1.523e-5	1.1085e-5	1.8876562	0.1695	-0.000037	6.496e-6
KSC8	7.2043e-5	0.0000148	23.698399	<.0001*	4.3038e-5	0.000101
KSC9	-0.000124	1.5736e-5	62.516659	<.0001*	-0.000155	-9.358e-5
KSC10	1.0111e-5	0.000011	0.8437767	0.3583	-1.146e-5	3.1685e-5
KSC11	1.9977e-6	1.3465e-5	0.0220106	0.8821	-2.439e-5	2.8389e-5
KSC12	4.0018e-5	1.4265e-5	7.8704776	0.0050*	1.206e-5	6.7976e-5
KSC13	-4.33e-5	1.3039e-5	11.029095	0.0009*	-6.886e-5	-1.775e-5
KSC14	6.1527e-5	1.4364e-5	18.347111	<.0001*	3.3374e-5	8.9681e-5
KSC15	2.4222e-6	2.4718e-5	0.0096026	0.9219	-0.000046	5.0868e-5
KSC16	-3.172e-6	1.142e-5	0.0771483	0.7812	-2.555e-5	1.921e-5
KSC17	-5.668e-5	1.6488e-5	11.817438	0.0006*	-0.000089	-2.436e-5
KSC18	-0.000016	1.2453e-5	1.6654097	0.1969	-4.048e-5	8.3368e-6
KSC19	4.1953e-6	1.5456e-5	0.0736807	0.7861	-0.000026	3.4488e-5
KSC20	-1.175e-5	1.7177e-5	0.4675333	0.4941	-4.541e-5	2.1922e-5
KSC21	3.5159e-5	1.3248e-5	7.0428748	0.0080*	9.1928e-6	6.1126e-5
KSC22	1.3332e-5	1.2211e-5	1.1919512	0.2749	-1.06e-5	3.7266e-5
KSC24	-2.317e-5	1.108e-5	4.372586	0.0365*	-4.488e-5	-1.453e-6
KSC25	-9.19e-6	8.9558e-6	1.0529961	0.3048	-2.674e-5	8.363e-6
KSC26	-2.022e-5	1.0142e-5	3.9759063	0.0462*	-4.01e-5	-3.449e-7
KSC27	-2.831e-7	1.2346e-5	0.0005259	0.9817	-2.448e-5	2.3914e-5
KSC28	0.000103	1.1518e-5	79.898656	<.0001*	8.0383e-5	0.0001255
KSC29	-0.000046	1.3371e-5	11.849859	0.0006*	-7.224e-5	-1.982e-5
KSC30	0.00001	1.3629e-5	0.5376464	0.4634	-1.672e-5	0.0000367
KSC31	0.0000329	8.8108e-6	13.946523	0.0002*	1.5635e-5	5.0173e-5
KSC32	6.005e-5	1.8638e-5	10.381312	0.0013*	2.3521e-5	9.658e-5
KSC34	-3.577e-5	0.0000144	6.1749987	0.0130*	-0.000064	-7.556e-6
Dispersion	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=22

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	82239
Sum of Frequencies	33998
-LogLikelihood	201491.4
Number of Parameters	33
BIC	403327.12
AICc	403048.86
Generalized RSquare	0.0123198

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	1.3025e-5	7.9331e-6	2.6955322	0.1006	-2.524e-6	2.8573e-5
KSC2	-2.424e-5	1.1852e-5	4.1841552	0.0408*	-4.747e-5	-1.014e-6
KSC4	-1.685e-5	1.1938e-5	1.9910319	0.1582	-4.024e-5	6.5531e-6
KSC5	-0.000013	1.6523e-5	0.623599	0.4297	-4.543e-5	1.9337e-5
KSC6	4.4233e-5	1.7686e-5	6.2547133	0.0124*	9.568e-6	0.0000789
KSC7	-0.000047	1.0373e-5	20.567744	<.0001*	-6.738e-5	-2.671e-5
KSC8	6.0414e-5	1.4433e-5	17.522133	<.0001*	3.2127e-5	0.0000887
KSC9	-6.232e-5	1.5383e-5	16.41048	<.0001*	-9.246e-5	-3.217e-5
KSC10	3.4035e-5	1.0664e-5	10.18658	0.0014*	1.3134e-5	5.4935e-5
KSC11	-2.458e-5	1.3259e-5	3.4356054	0.0638	-5.056e-5	1.4111e-6
KSC12	1.4467e-5	1.389e-5	1.0848703	0.2976	-1.276e-5	0.0000417
KSC13	-3.581e-5	1.265e-5	8.015429	0.0046*	-6.061e-5	-0.000011
KSC14	2.2072e-5	0.0000143	2.3820125	0.1227	-5.958e-6	0.0000501
KSC15	5.7835e-5	2.3852e-5	5.8796956	0.0153*	1.1087e-5	0.0001046
KSC16	8.4633e-6	1.1412e-5	0.5500071	0.4583	-0.000014	3.083e-5
KSC17	-0.000024	1.5982e-5	2.2682317	0.1321	-5.539e-5	7.2542e-6
KSC18	-0.000026	1.1838e-5	4.8206103	0.0281*	-4.92e-5	-2.789e-6
KSC19	-0.000011	1.4773e-5	0.5637565	0.4528	-0.00004	1.7862e-5
KSC20	-4.669e-5	1.6746e-5	7.7745844	0.0053*	-7.951e-5	-1.387e-5
KSC21	0.0000254	0.0000128	3.9366303	0.0472*	3.0885e-7	5.048e-5
KSC22	1.8138e-5	0.0000117	2.4004444	0.1213	-4.807e-6	4.1082e-5
KSC24	-7.313e-6	1.0672e-5	0.4695722	0.4932	-2.823e-5	0.0000136
KSC25	-2.511e-5	0.0000089	7.9602766	0.0048*	-4.255e-5	-7.666e-6
KSC26	8.0263e-6	9.8262e-6	0.6672035	0.4140	-1.123e-5	2.7285e-5
KSC27	3.4886e-5	1.185e-5	8.6676549	0.0032*	1.1661e-5	5.8111e-5
KSC28	0.0001164	1.1287e-5	106.36999	<.0001*	9.4288e-5	0.0001385
KSC29	-4.189e-5	0.0000131	10.215917	0.0014*	-6.758e-5	-1.62e-5
KSC30	-0.00004	0.0000134	8.8858702	0.0029*	-6.622e-5	-1.368e-5
KSC31	3.0122e-5	9.0776e-6	11.011064	0.0009*	1.233e-5	4.7914e-5
KSC32	4.2077e-5	0.0000191	4.8580125	0.0275*	4.6604e-6	0.0000795
KSC34	-5.118e-6	1.4482e-5	0.1249005	0.7238	-3.35e-5	2.3266e-5

Generalized Regression for lightning.end.1 BySensor=24

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	88207
Sum of Frequencies	36209
-LogLikelihood	215211.44
Number of Parameters	33
BIC	430769.28
AICc	430488.94
Generalized RSquare	0.0104516

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	1.1625e-5	7.7224e-6	2.266123	0.1322	-3.511e-6	2.6761e-5
KSC2	-3.964e-5	0.0000115	11.872402	0.0006*	-6.218e-5	-0.000017
KSC4	-4.044e-5	1.1469e-5	12.434586	0.0004*	-0.000063	-0.000018
KSC5	-2.503e-6	1.6211e-5	0.02385	0.8773	-3.428e-5	2.9269e-5
KSC6	6.8925e-5	1.7241e-5	15.982614	<.0001*	3.5134e-5	0.0001027
KSC7	-2.948e-5	1.0127e-5	8.4729497	0.0036*	-4.932e-5	-9.629e-6
KSC8	6.3718e-5	1.3831e-5	21.223884	<.0001*	0.0000366	9.0826e-5
KSC9	-6.826e-5	1.4946e-5	20.862649	<.0001*	-9.756e-5	-0.000039
KSC10	0.0000281	1.0388e-5	7.3167154	0.0068*	7.739e-6	4.846e-5
KSC11	-2.581e-5	1.2748e-5	4.0979539	0.0429*	-5.079e-5	-8.207e-7
KSC12	1.0338e-5	1.3268e-5	0.6071726	0.4359	-1.567e-5	3.6342e-5
KSC13	-3.413e-5	1.2146e-5	7.8973217	0.0050*	-0.000058	-1.033e-5
KSC14	2.3221e-5	1.3655e-5	2.8918747	0.0890	-3.542e-6	4.9985e-5
KSC15	0.0000218	2.295e-5	0.9019867	0.3422	-2.318e-5	6.6776e-5
KSC16	0.0000241	1.0865e-5	4.9180614	0.0266*	0.0000028	0.0000454
KSC17	-0.000024	1.554e-5	2.3918861	0.1220	-5.449e-5	6.424e-6
KSC18	-8.663e-6	1.1518e-5	0.5656325	0.4520	-3.124e-5	1.3912e-5
KSC19	-7.883e-6	1.4216e-5	0.3074785	0.5792	-3.575e-5	1.998e-5
KSC20	-4.15e-5	1.627e-5	6.5063674	0.0107*	-7.339e-5	-9.612e-6
KSC21	2.7661e-5	1.2429e-5	4.9530244	0.0260*	0.0000033	5.2022e-5
KSC22	2.5656e-5	1.1242e-5	5.2086899	0.0225*	3.623e-6	4.7689e-5
KSC24	-2.457e-5	1.0079e-5	5.9419125	0.0148*	-4.432e-5	-4.814e-6
KSC25	-1.751e-5	8.574e-6	4.1724643	0.0411*	-3.432e-5	-7.09e-7
KSC26	1.1522e-6	9.512e-6	0.0146729	0.9036	-1.749e-5	0.0000198
KSC27	2.0834e-5	1.1346e-5	3.3715962	0.0663	-1.404e-6	4.3073e-5
KSC28	0.0001159	1.1083e-5	109.41564	<.0001*	0.0000942	0.0001376
KSC29	-3.85e-5	1.2615e-5	9.3127579	0.0023*	-6.322e-5	-1.377e-5
KSC30	-3.787e-5	1.2961e-5	8.5360768	0.0035*	-6.327e-5	-1.246e-5
KSC31	0.0000284	8.549e-6	11.03907	0.0009*	1.1648e-5	4.516e-5
KSC32	4.305e-5	1.8144e-5	5.6297868	0.0177*	7.4888e-6	7.861e-5
KSC34	-1.953e-5	1.3971e-5	1.9542939	0.1621	-0.000047	7.8519e-6

Generalized Regression for lightning.end.1 BySensor=25

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	80471
Sum of Frequencies	37189
-LogLikelihood	221348.15
Number of Parameters	33
BIC	443043.59
AICc	442762.37
Generalized RSquare	0.0079536

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	0.0000139	7.9797e-6	3.0321571	0.0816	-1.745e-6	2.9535e-5
KSC2	-2.563e-5	1.1773e-5	4.7394506	0.0295*	-4.87e-5	-2.555e-6
KSC4	-5.837e-5	1.1971e-5	23.777237	<.0001*	-8.183e-5	-0.000035
KSC5	1.4165e-6	0.0000168	0.0071145	0.9328	-3.15e-5	3.433e-5
KSC6	7.9922e-5	1.8047e-5	19.611087	<.0001*	4.4549e-5	0.0001153
KSC7	-3.19e-5	1.0162e-5	9.8534391	0.0017*	-5.182e-5	-0.000012
KSC8	6.3117e-5	0.0000147	18.434428	<.0001*	0.0000343	9.1929e-5
KSC9	-7.789e-5	1.5932e-5	23.901023	<.0001*	-0.000109	-4.666e-5
KSC10	1.834e-5	1.0715e-5	2.9292444	0.0870	-2.662e-6	3.9341e-5
KSC11	-2.286e-5	1.3188e-5	3.0038732	0.0831	-4.871e-5	2.991e-6
KSC12	4.6679e-6	1.4026e-5	0.110762	0.7393	-2.282e-5	3.2158e-5
KSC13	-1.436e-5	1.3143e-5	1.1930286	0.2747	-4.012e-5	0.0000114
KSC14	0.00003	1.4539e-5	4.2591965	0.0390*	1.5094e-6	0.0000585
KSC15	7.7129e-6	2.4248e-5	0.1011798	0.7504	-3.981e-5	5.5237e-5
KSC16	-8.633e-6	0.0000118	0.5352973	0.4644	-3.176e-5	0.0000145
KSC17	-3.524e-5	1.5922e-5	4.8993943	0.0269*	-6.645e-5	-4.036e-6
KSC18	-3.059e-6	1.1913e-5	0.0659379	0.7973	-2.641e-5	0.0000203
KSC19	2.7872e-5	0.0000152	3.3605244	0.0668	-1.928e-6	5.7672e-5
KSC20	-5.461e-5	1.7054e-5	10.25566	0.0014*	-0.000088	-2.119e-5
KSC21	3.8546e-5	1.3353e-5	8.3332476	0.0039*	1.2375e-5	6.4716e-5
KSC22	0.0000139	1.1734e-5	1.4049683	0.2359	-9.089e-6	0.0000369
KSC24	-6.964e-6	1.0723e-5	0.4217459	0.5161	-0.000028	1.4053e-5
KSC25	-2.51e-5	9.1038e-6	7.6023405	0.0058*	-0.000043	-7.258e-6
KSC26	9.8961e-6	1.0056e-5	0.9685164	0.3251	-9.813e-6	0.0000296
KSC27	2.7749e-5	1.2023e-5	5.3264855	0.0210*	4.1836e-6	5.1315e-5
KSC28	0.000107	1.1662e-5	84.192249	<.0001*	8.415e-5	0.0001299
KSC29	-2.048e-5	1.3278e-5	2.3798525	0.1229	-4.651e-5	5.5409e-6
KSC30	-0.000043	1.3675e-5	9.8917813	0.0017*	-6.981e-5	-1.621e-5
KSC31	1.8177e-5	9.3116e-6	3.8105948	0.0509	-7.346e-8	3.6427e-5
KSC32	4.4267e-5	1.9443e-5	5.1838362	0.0228*	6.1602e-6	8.2374e-5
KSC34	-4.573e-5	1.4664e-5	9.7244759	0.0018*	-7.447e-5	-0.000017

Generalized Regression for lightning.end.1 BySensor=26

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	73276
Sum of Frequencies	30478
-LogLikelihood	179258.44
Number of Parameters	33
BIC	358857.59
AICc	358582.95
Generalized RSquare	0.0145289

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	0.0000209	8.3041e-6	6.3371113	0.0118*	4.6287e-6	3.718e-5
KSC2	-5.124e-5	1.256e-5	16.646685	<.0001*	-7.586e-5	-2.663e-5
KSC4	-2.762e-5	1.1753e-5	5.5221173	0.0188*	-5.065e-5	-4.583e-6
KSC5	2.4979e-5	1.7155e-5	2.1200862	0.1454	-8.645e-6	0.0000586
KSC6	0.0000741	1.8585e-5	15.897373	<.0001*	3.7676e-5	0.0001105
KSC7	-3.773e-5	1.1038e-5	11.685643	0.0006*	-5.937e-5	-0.000016
KSC8	0.0000521	1.5021e-5	12.02649	0.0005*	2.2652e-5	8.1534e-5
KSC9	-7.97e-5	1.6116e-5	24.457862	<.0001*	-0.000111	-4.812e-5
KSC10	-1.548e-5	0.0000113	1.8741146	0.1710	-3.764e-5	6.682e-6
KSC11	0.0000136	1.4419e-5	0.8889145	0.3458	-1.467e-5	4.1854e-5
KSC12	3.0123e-5	0.0000147	4.2000139	0.0404*	1.3145e-6	5.8932e-5
KSC13	-6.117e-5	1.3542e-5	20.408263	<.0001*	-8.772e-5	-3.463e-5
KSC14	5.4665e-5	1.4857e-5	13.537767	0.0002*	2.5546e-5	8.3785e-5
KSC15	-1.203e-6	2.5445e-5	0.0022336	0.9623	-0.000051	4.8669e-5
KSC16	-1.265e-6	1.1613e-5	0.0118723	0.9132	-0.000024	0.0000215
KSC17	-3.352e-5	1.7275e-5	3.7658381	0.0523	-6.738e-5	3.3492e-7
KSC18	-4.674e-5	1.2536e-5	13.902324	0.0002*	-7.131e-5	-2.217e-5
KSC19	2.2537e-6	0.0000156	0.0208472	0.8852	-2.834e-5	3.2847e-5
KSC20	-2.873e-5	1.745e-5	2.7100505	0.0997	-0.000063	5.4748e-6
KSC21	0.0000372	1.3181e-5	7.9639557	0.0048*	1.1363e-5	6.3031e-5
KSC22	1.727e-5	0.0000121	2.034762	0.1537	-6.459e-6	0.000041
KSC24	-2.087e-5	1.0728e-5	3.7857336	0.0517	-4.19e-5	1.5306e-7
KSC25	-6.147e-6	8.556e-6	0.5160839	0.4725	-0.000023	1.0623e-5
KSC26	-8.869e-6	1.0183e-5	0.7585393	0.3838	-2.883e-5	1.109e-5
KSC27	7.445e-6	0.000012	0.3844221	0.5352	-0.000016	3.098e-5
KSC28	0.0001041	1.1222e-5	85.986714	<.0001*	8.2068e-5	0.0001261
KSC29	-4.262e-5	1.3125e-5	10.545403	0.0012*	-6.835e-5	-1.69e-5
KSC30	-2.919e-5	1.3221e-5	4.8732073	0.0273*	-5.51e-5	-3.273e-6
KSC31	0.0000102	8.9461e-6	1.3016118	0.2539	-7.328e-6	2.774e-5
KSC32	6.0153e-5	1.8438e-5	10.643002	0.0011*	2.4014e-5	0.0000963
KSC34	1.0468e-5	1.4554e-5	0.5173075	0.4720	-0.000018	0.000039

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=27

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	86349
Sum of Frequencies	35855
-LogLikelihood	212627.51
Number of Parameters	33
BIC	425601.1
AICc	425321.09
Generalized RSquare	0.0129503

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.944e-5	7.761e-6	14.38899	0.0001*	1.4228e-5	4.4651e-5
KSC2	-6.08e-5	0.000012	25.638779	<.0001*	-8.434e-5	-3.727e-5
KSC4	-5.265e-5	1.113e-5	22.379982	<.0001*	-7.447e-5	-3.084e-5
KSC5	0.0000366	1.6836e-5	4.724447	0.0297*	3.5963e-6	0.0000696
KSC6	7.3353e-5	1.7613e-5	17.344958	<.0001*	3.8832e-5	0.0001079
KSC7	-3.759e-5	1.0558e-5	12.67366	0.0004*	-5.828e-5	-1.689e-5
KSC8	7.5979e-5	0.000014	29.417716	<.0001*	4.8523e-5	0.0001034
KSC9	-0.000114	1.5228e-5	55.953864	<.0001*	-0.000144	-0.000084
KSC10	-8.652e-6	1.0716e-5	0.6519289	0.4194	-2.965e-5	1.235e-5
KSC11	0.0000164	1.2845e-5	1.6285905	0.2019	-8.783e-6	4.1568e-5
KSC12	8.8588e-6	1.3318e-5	0.4424745	0.5059	-1.724e-5	3.4961e-5
KSC13	-2.425e-5	1.235e-5	3.854637	0.0496*	-4.845e-5	-4.148e-8
KSC14	6.2161e-5	1.3761e-5	20.406035	<.0001*	0.0000352	8.9131e-5
KSC15	-5.304e-6	2.3556e-5	0.0506983	0.8219	-5.147e-5	4.0865e-5
KSC16	2.4214e-5	1.0657e-5	5.1627346	0.0231*	3.3271e-6	0.0000451
KSC17	-5.265e-5	1.5777e-5	11.136106	0.0008*	-8.357e-5	-2.173e-5
KSC18	-2.338e-5	1.1613e-5	4.0538337	0.0441*	-4.614e-5	-6.207e-7
KSC19	-1.725e-5	1.4535e-5	1.4081517	0.2354	-4.574e-5	1.124e-5
KSC20	-2.879e-5	0.0000164	3.0800353	0.0793	-0.000061	3.3621e-6
KSC21	2.6919e-5	1.3011e-5	4.2802354	0.0386*	1.4171e-6	5.2421e-5
KSC22	3.8661e-5	1.1374e-5	11.553684	0.0007*	1.6368e-5	6.0954e-5
KSC24	-3.34e-5	1.0351e-5	10.409638	0.0013*	-5.368e-5	-1.311e-5
KSC25	7.937e-6	8.4847e-6	0.8750624	0.3496	-8.693e-6	2.4567e-5
KSC26	-4.331e-6	9.6863e-6	0.1999351	0.6548	-2.332e-5	1.4654e-5
KSC27	-1.638e-5	1.1532e-5	2.0171414	0.1555	-0.000039	6.224e-6
KSC28	0.0001003	1.0759e-5	86.909668	<.0001*	7.9213e-5	0.0001214
KSC29	-3.081e-5	0.0000123	6.2697662	0.0123*	-0.000055	-6.693e-6
KSC30	-1.928e-5	1.2761e-5	2.2833169	0.1308	-4.429e-5	5.7282e-6
KSC31	3.4167e-5	8.1077e-6	17.758457	<.0001*	1.8276e-5	5.0057e-5
KSC32	2.8018e-5	1.704e-5	2.7036727	0.1001	-5.379e-6	6.1416e-5
KSC34	-1.56e-5	0.0000137	1.2966037	0.2548	-4.245e-5	1.1252e-5

Generalized Regression for lightning.end.1 BySensor=28

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	87688
Sum of Frequencies	37095
-LogLikelihood	219400.86
Number of Parameters	33
BIC	439148.92
AICc	438867.77
Generalized RSquare	0.0127942

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	4.9419117	0.0062281	629624.72	<.0001*	4.9297049	4.9541185
KSC1	1.9968e-5	7.6599e-6	6.7953802	0.0091*	4.9547e-6	3.4981e-5
KSC2	-7.381e-5	1.1784e-5	39.226539	<.0001*	-0.000097	-5.071e-5
KSC4	-0.000035	1.1032e-5	10.074559	0.0015*	-5.664e-5	-1.339e-5
KSC5	4.5937e-5	0.0000166	7.6539202	0.0057*	0.0000134	7.8481e-5
KSC6	0.0000775	0.0000175	19.607723	<.0001*	0.0000432	0.0001118
KSC7	-4.158e-5	1.0365e-5	16.095548	<.0001*	-6.19e-5	-2.127e-5
KSC8	6.8245e-5	1.3882e-5	24.166624	<.0001*	4.1036e-5	9.5453e-5
KSC9	-0.000126	1.5162e-5	69.184356	<.0001*	-0.000156	-9.639e-5
KSC10	-1.138e-5	1.0585e-5	1.1553473	0.2824	-3.212e-5	9.3685e-6
KSC11	1.8017e-5	1.2574e-5	2.0530871	0.1519	-6.628e-6	4.2662e-5
KSC12	2.9696e-6	1.3084e-5	0.0515154	0.8204	-2.267e-5	2.8613e-5
KSC13	-7.847e-6	0.0000123	0.4064974	0.5238	-0.000032	1.6275e-5
KSC14	0.000051	1.3317e-5	14.671492	0.0001*	0.0000249	0.0000771
KSC15	1.848e-5	2.3343e-5	0.6267205	0.4286	-2.727e-5	6.4231e-5
KSC16	1.3177e-5	1.0647e-5	1.5317169	0.2159	-7.691e-6	3.4045e-5
KSC17	-7.181e-5	0.0000154	21.736031	<.0001*	-0.000102	-4.162e-5
KSC18	-0.000029	0.0000112	6.662567	0.0098*	-5.086e-5	-6.958e-6
KSC19	-3.686e-6	1.4355e-5	0.0659311	0.7974	-3.182e-5	2.4449e-5
KSC20	-2.72e-5	1.6148e-5	2.8372485	0.0921	-5.885e-5	4.4497e-6
KSC21	0.000027	1.2879e-5	4.3937382	0.0361*	1.7536e-6	5.2237e-5
KSC22	0.0000329	1.0983e-5	8.9765935	0.0027*	1.138e-5	5.4434e-5
KSC24	-1.731e-5	9.8897e-6	3.0629181	0.0801	-3.669e-5	2.0753e-6
KSC25	5.3224e-6	7.9626e-6	0.4467932	0.5039	-1.028e-5	2.0929e-5
KSC26	-9.575e-7	9.4716e-6	0.0102203	0.9195	-1.952e-5	0.0000176
KSC27	-8.552e-6	1.1337e-5	0.5690155	0.4507	-3.077e-5	1.3668e-5
KSC28	9.3271e-5	0.0000107	76.090269	<.0001*	7.2314e-5	0.0001142
KSC29	-3.687e-5	1.1871e-5	9.6472669	0.0019*	-6.014e-5	-1.36e-5
KSC30	-2.876e-5	1.2487e-5	5.3032345	0.0213*	-5.323e-5	-4.282e-6
KSC31	0.0000325	8.0358e-6	16.350307	<.0001*	1.6743e-5	4.8243e-5
KSC32	3.8111e-5	1.6845e-5	5.1184263	0.0237*	5.0945e-6	7.1127e-5

Generalized Regression for lightning.end.1 BySensor=29

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	91601
Sum of Frequencies	38460
-LogLikelihood	230765.52
Number of Parameters	33
BIC	461879.44
AICc	461597.1
Generalized RSquare	0.0096032

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	0.0000178	7.7132e-6	5.3209495	0.0211*	2.6746e-6	0.0000329
KSC2	-5.989e-5	1.174e-5	26.02731	<.0001*	-0.000083	-3.688e-5
KSC4	-4.751e-5	0.0000112	18.013028	<.0001*	-6.945e-5	-2.557e-5
KSC5	2.993e-5	1.6665e-5	3.2253836	0.0725	-2.734e-6	0.0000626
KSC6	9.0588e-5	1.7178e-5	27.808227	<.0001*	5.6919e-5	0.0001243
KSC7	-4.167e-5	1.0412e-5	16.015067	<.0001*	-0.000062	-2.126e-5
KSC8	4.3053e-5	0.0000139	9.5872081	0.0020*	0.0000158	0.0000703
KSC9	-0.000105	0.0000151	48.131175	<.0001*	-0.000134	-7.512e-5
KSC10	1.6077e-5	1.0433e-5	2.3748504	0.1233	-4.37e-6	3.6525e-5
KSC11	-8.507e-6	1.2558e-5	0.4588553	0.4982	-3.312e-5	0.0000161
KSC12	1.6434e-5	1.3274e-5	1.5327673	0.2157	-9.583e-6	4.2452e-5
KSC13	-8.94e-6	1.2142e-5	0.5420792	0.4616	-3.274e-5	1.4858e-5
KSC14	5.6089e-5	1.3422e-5	17.463133	<.0001*	2.9782e-5	0.0000824
KSC15	-1.301e-6	2.2946e-5	0.0032172	0.9548	-4.627e-5	4.3671e-5
KSC16	1.1353e-5	1.0546e-5	1.1590616	0.2817	-9.316e-6	3.2023e-5
KSC17	-0.000066	1.5268e-5	18.743383	<.0001*	-0.000096	-3.618e-5
KSC18	-1.553e-5	1.131e-5	1.8865409	0.1696	-3.77e-5	6.633e-6
KSC19	-4.085e-6	1.4463e-5	0.079779	0.7776	-3.243e-5	2.4263e-5
KSC20	-0.000013	1.6413e-5	0.6364833	0.4250	-4.526e-5	1.9075e-5
KSC21	2.1567e-5	0.000013	2.7553903	0.0969	-3.898e-6	4.7033e-5
KSC22	0.0000277	0.0000112	6.121904	0.0134*	5.7583e-6	4.9648e-5
KSC24	-5.075e-6	1.0174e-5	0.248795	0.6179	-0.000025	1.4865e-5
KSC25	7.0624e-6	8.3776e-6	0.7106704	0.3992	-9.357e-6	2.3482e-5
KSC26	-1.149e-5	9.6027e-6	1.4326372	0.2313	-3.031e-5	7.3272e-6
KSC27	-1.733e-5	1.1619e-5	2.2235911	0.1359	-0.00004	5.4467e-6
KSC28	0.0000884	1.1222e-5	62.058171	<.0001*	0.0000664	0.0001104
KSC29	-3.342e-5	0.0000125	7.1539672	0.0075*	-0.000058	-8.932e-6
KSC30	-0.00002	1.296e-5	2.3731695	0.1234	-4.536e-5	5.4359e-6
KSC31	2.3667e-5	8.3788e-6	7.978541	0.0047*	7.2449e-6	4.0089e-5
KSC32	2.7721e-5	1.7362e-5	2.5490663	0.1104	-6.309e-6	6.175e-5
KSC34	-0.000012	1.4144e-5	0.7246413	0.3946	-3.976e-5	1.5681e-5

Generalized Regression for lightning.end.1 BySensor=30

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	89728
Sum of Frequencies	37103
-LogLikelihood	223750.53
Number of Parameters	33
BIC	447848.28
AICc	447567.13
Generalized RSquare	0.0126544

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	5.0832834	0.0064682	617629.06	<.0001*	5.070606	5.0959607
KSC1	-7.87e-6	8.1207e-6	0.9392586	0.3325	-2.379e-5	8.0461e-6
KSC2	-2.484e-6	0.0000122	0.0414201	0.8387	-2.64e-5	2.1435e-5
KSC4	-1.053e-5	0.0000112	0.8839596	0.3471	-3.247e-5	1.1416e-5
KSC5	5.3064e-5	1.7672e-5	9.016715	0.0027*	1.8428e-5	0.0000877
KSC6	3.4175e-6	1.7951e-5	0.0362454	0.8490	-3.177e-5	0.0000386
KSC7	-4.586e-5	1.1018e-5	17.322295	<.0001*	-6.745e-5	-2.426e-5
KSC8	0.0001008	1.3925e-5	52.354942	<.0001*	7.3464e-5	0.000128
KSC9	-0.000126	1.5522e-5	66.08979	<.0001*	-0.000157	-9.576e-5
KSC10	-5.397e-6	1.1221e-5	0.2313465	0.6305	-2.739e-5	0.0000166
KSC11	2.382e-5	1.3417e-5	3.1519487	0.0758	-2.477e-6	5.0117e-5
KSC12	4.7126e-6	0.0000136	0.1201264	0.7289	-0.000022	3.1362e-5
KSC13	-1.567e-5	1.2825e-5	1.4922314	0.2219	-4.08e-5	9.4702e-6
KSC14	6.9521e-5	1.3772e-5	25.480968	<.0001*	4.2528e-5	9.6515e-5
KSC15	-3.356e-6	0.0000241	0.0193961	0.8892	-5.059e-5	4.3877e-5
KSC16	-2.922e-5	1.0756e-5	7.3821198	0.0066*	-5.031e-5	-8.143e-6
KSC17	-7.686e-5	1.598e-5	23.135225	<.0001*	-0.000108	-4.554e-5
KSC18	3.5113e-6	1.1863e-5	0.0876079	0.7672	-1.974e-5	2.6762e-5
KSC19	1.7643e-5	1.4534e-5	1.4735035	0.2248	-1.084e-5	4.613e-5
KSC20	-7.949e-5	1.6425e-5	23.422389	<.0001*	-0.000112	-4.73e-5
KSC21	0.0000342	1.3145e-5	6.7688251	0.0093*	8.4358e-6	5.9965e-5
KSC22	0.000048	1.1479e-5	17.481061	<.0001*	0.0000255	0.0000705
KSC24	-2.284e-5	1.0351e-5	4.8678206	0.0274*	-4.313e-5	-2.55e-6
KSC25	4.486e-5	8.4374e-6	28.268269	<.0001*	2.8323e-5	0.0000614
KSC26	-2.145e-6	9.5193e-6	0.0507657	0.8217	-2.08e-5	1.6513e-5
KSC27	1.2516e-5	1.1423e-5	1.2004955	0.2732	-9.873e-6	0.0000349
KSC28	7.9569e-5	0.0000111	51.392413	<.0001*	5.7815e-5	0.0001013
KSC29	-0.000034	1.2166e-5	7.8345678	0.0051*	-0.000058	-1.021e-5
KSC30	-2.816e-5	1.248e-5	5.0911981	0.0240*	-5.262e-5	-3.699e-6
KSC31	3.4338e-5	8.053e-6	18.181965	<.0001*	1.8555e-5	5.0122e-5
KSC32	2.6168e-5	0.0000171	2.3440708	0.1258	-7.331e-6	5.9667e-5

Appendix G: Negative Binomial Regression Models to Predict Storm Cessation (cont.)

Generalized Regression for lightning.end.1 BySensor=31

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	93105
Sum of Frequencies	39185
-LogLikelihood	235454.33
Number of Parameters	33
BIC	471257.66
AICc	470974.71
Generalized RSquare	0.0084749

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	5.0433569	0.0061145	680326.29	<.0001*	5.0313727	5.0553411
KSC1	1.2665e-5	7.7915e-6	2.6421861	0.1041	-2.606e-6	2.7936e-5
KSC2	-5.046e-5	1.1816e-5	18.23765	<.0001*	-7.362e-5	-2.73e-5
KSC4	-0.000053	1.1683e-5	20.536507	<.0001*	-7.584e-5	-0.00003
KSC5	-1.449e-5	1.6722e-5	0.7508156	0.3862	-4.726e-5	1.8284e-5
KSC6	9.1229e-5	1.7363e-5	27.605935	<.0001*	0.0000572	0.0001253
KSC7	-2.48e-5	1.0357e-5	5.7310341	0.0167*	-0.000045	-4.495e-6
KSC8	5.6731e-5	1.4188e-5	15.989298	<.0001*	2.8924e-5	8.4539e-5
KSC9	-9.784e-5	1.5266e-5	41.07525	<.0001*	-0.000128	-0.000068
KSC10	3.0825e-5	1.0524e-5	8.5789159	0.0034*	0.0000102	5.1452e-5
KSC11	-2.688e-5	0.0000127	4.4712519	0.0345*	-5.179e-5	-1.965e-6
KSC12	3.1523e-5	0.0000135	5.4538306	0.0195*	5.0669e-6	5.7979e-5
KSC13	-0.000021	1.2439e-5	2.8753609	0.0899	-4.547e-5	3.2874e-6
KSC14	9.0125e-5	1.3538e-5	44.316827	<.0001*	0.0000636	0.0001167
KSC15	-3.632e-5	0.0000231	2.4714438	0.1159	-8.161e-5	8.9625e-6
KSC16	-1.677e-5	1.0745e-5	2.4348577	0.1187	-3.783e-5	4.2934e-6
KSC17	-7.078e-5	1.5472e-5	20.927058	<.0001*	-0.000101	-4.045e-5
KSC18	-1.94e-6	0.0000113	0.0295003	0.8636	-0.000024	0.0000202
KSC19	0.0000209	1.4946e-5	1.953808	0.1622	-8.403e-6	5.0186e-5
KSC20	-1.161e-5	1.6858e-5	0.4739939	0.4912	-4.465e-5	2.1435e-5
KSC21	3.8355e-6	1.3139e-5	0.0852151	0.7704	-0.000022	2.9588e-5
KSC22	2.9546e-5	1.1324e-5	6.8077269	0.0091*	7.3515e-6	5.1741e-5
KSC24	-0.000001	1.0154e-5	0.0095304	0.9222	-2.089e-5	1.891e-5
KSC25	1.0885e-5	8.4283e-6	1.667976	0.1965	-5.634e-6	0.0000274
KSC26	4.7828e-6	9.7051e-6	0.2428711	0.6221	-1.424e-5	0.0000238
KSC27	-0.000024	1.1734e-5	4.1830889	0.0408*	-0.000047	-0.000001
KSC28	7.9837e-5	1.1369e-5	49.315227	<.0001*	5.7555e-5	0.0001021
KSC29	-0.000032	0.0000128	6.2361877	0.0125*	-0.000057	-6.881e-6
KSC30	-1.721e-5	1.3245e-5	1.6886451	0.1938	-4.317e-5	8.7483e-6
KSC31	1.6016e-5	8.5753e-6	3.4880982	0.0618	-7.917e-7	3.2823e-5
KSC32	2.3716e-5	1.7753e-5	1.7845455	0.1816	-0.000011	5.8511e-5

Generalized Regression for lightning.end.1 BySensor=32

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	93380
Sum of Frequencies	39193
-LogLikelihood	235301.99
Number of Parameters	33
BIC	470952.99
AICc	470670.03
Generalized RSquare	0.0086079

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	2.3779e-5	7.7014e-6	9.5332597	0.0020*	8.6844e-6	3.8873e-5
KSC2	-0.000071	0.0000119	35.620841	<.0001*	-9.429e-5	-4.767e-5
KSC4	-5.386e-5	1.143e-5	22.202364	<.0001*	-7.626e-5	-3.145e-5
KSC5	2.9244e-5	1.6973e-5	2.9684194	0.0849	-4.024e-6	6.2511e-5
KSC6	7.8339e-5	1.7764e-5	19.4479	<.0001*	4.3522e-5	0.0001132
KSC7	-0.000041	1.038e-5	15.645277	<.0001*	-6.14e-5	-2.071e-5
KSC8	5.8468e-5	0.000014	17.444028	<.0001*	3.1031e-5	0.0000859
KSC9	-0.000095	1.5059e-5	39.726026	<.0001*	-0.000124	-6.54e-5
KSC10	2.1344e-5	1.0666e-5	4.0048157	0.0454*	4.3985e-7	4.2249e-5
KSC11	-2.767e-6	1.2779e-5	0.0468928	0.8286	-2.781e-5	2.2278e-5
KSC12	0.00001	1.3327e-5	0.5633582	0.4529	-1.612e-5	3.6124e-5
KSC13	-9.575e-6	1.2325e-5	0.603563	0.4372	-3.373e-5	1.4581e-5
KSC14	6.2415e-5	1.3435e-5	21.582115	<.0001*	3.6082e-5	8.8747e-5
KSC15	-2.149e-6	2.3067e-5	0.0086797	0.9258	-4.736e-5	4.3062e-5
KSC16	-4.322e-6	0.0000106	0.1664868	0.6833	-0.000025	1.644e-5
KSC17	-4.819e-5	1.5554e-5	9.5973383	0.0019*	-7.867e-5	-1.77e-5
KSC18	-2.94e-5	1.1182e-5	6.9107486	0.0086*	-5.131e-5	-7.479e-6
KSC19	1.6555e-5	1.4739e-5	1.2617421	0.2613	-1.233e-5	4.5443e-5
KSC20	-0.000024	1.6521e-5	2.1271877	0.1447	-5.648e-5	8.2848e-6
KSC21	0.0000066	1.2928e-5	0.2606356	0.6097	-1.874e-5	3.1939e-5
KSC22	2.825e-5	1.1119e-5	6.4553479	0.0111*	6.4575e-6	5.0042e-5
KSC24	-1.316e-6	0.00001	0.0173125	0.8953	-0.000021	1.8283e-5
KSC25	8.1238e-6	8.1764e-6	0.9871637	0.3204	-7.902e-6	2.4149e-5
KSC26	4.8324e-6	9.652e-6	0.2506599	0.6166	-0.000014	2.375e-5
KSC27	-0.00003	0.0000116	6.6962388	0.0097*	-5.276e-5	-7.283e-6
KSC28	8.8978e-5	1.108e-5	64.48955	<.0001*	6.7262e-5	0.0001107
KSC29	-1.888e-5	1.2447e-5	2.3000081	0.1294	-4.327e-5	5.5187e-6
KSC30	-1.65e-5	0.000013	1.6097662	0.2045	-0.000042	8.9864e-6
KSC31	1.9264e-5	8.2978e-6	5.3898432	0.0203*	0.000003	3.5528e-5
KSC32	6.4011e-6	0.0000173	0.1368615	0.7114	-2.751e-5	4.0314e-5
KSC34	-2.764e-5	1.3986e-5	3.9050854	0.0481*	-0.000055	-2.261e-7

Generalized Regression for lightning.end.1 BySensor=34

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	89304
Sum of Frequencies	38362
-LogLikelihood	232361.84
Number of Parameters	33
BIC	465071.98
AICc	464789.73
Generalized RSquare	0.0121409

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
Intercept	5.1041641	0.006301	656190.2	<.0001*	5.0918143	5.1165138
KSC1	3.1646e-7	7.8641e-6	0.0016193	0.9679	-0.000015	1.573e-5
KSC2	-9.726e-6	1.1978e-5	0.659336	0.4168	-3.32e-5	1.375e-5
KSC4	-0.000023	0.0000111	4.3205976	0.0377*	-4.479e-5	-1.316e-6
KSC5	3.8137e-5	1.743e-5	4.7874215	0.0287*	3.975e-6	0.0000723
KSC6	1.5746e-5	1.7722e-5	0.7894658	0.3743	-0.000019	5.048e-5
KSC7	-4.682e-5	0.0000107	19.132361	<.0001*	-6.781e-5	-2.584e-5
KSC8	9.1281e-5	1.3572e-5	45.236807	<.0001*	6.4681e-5	0.0001179
KSC9	-0.00011	0.0000151	53.046327	<.0001*	-0.00014	-8.036e-5
KSC10	-1.167e-6	1.0941e-5	0.0113817	0.9150	-2.261e-5	2.0276e-5
KSC11	0.0000282	1.3071e-5	4.6551868	0.0310*	2.5832e-6	5.3822e-5
KSC12	-5.724e-7	0.0000133	0.001853	0.9657	-2.663e-5	2.5489e-5
KSC13	-1.763e-5	1.2511e-5	1.9866857	0.1587	-4.216e-5	6.8869e-6
KSC14	0.000064	1.3223e-5	23.429562	<.0001*	3.8087e-5	8.992e-5
KSC15	-7.131e-6	0.0000236	0.0912743	0.7626	-5.34e-5	3.9133e-5
KSC16	-3.758e-5	1.0359e-5	13.158573	0.0003*	-5.788e-5	-1.727e-5
KSC17	-7.428e-5	0.0000158	22.095476	<.0001*	-0.000105	-4.331e-5
KSC18	-1.222e-5	0.0000114	1.1497696	0.2836	-3.456e-5	1.0118e-5
KSC19	0.0000348	1.4376e-5	5.8572504	0.0155*	6.6162e-6	6.2971e-5
KSC20	-7.633e-5	1.6128e-5	22.400797	<.0001*	-0.000108	-4.472e-5
KSC21	3.6344e-5	1.268e-5	8.2150615	0.0042*	0.0000115	0.0000612
KSC22	3.0354e-5	1.1066e-5	7.5248308	0.0061*	8.6663e-6	5.2042e-5
KSC24	3.9275e-6	9.7833e-6	0.1611631	0.6881	-1.525e-5	0.0000231
KSC25	3.6417e-5	8.0071e-6	20.685715	<.0001*	2.0724e-5	5.2111e-5
KSC26	5.5987e-6	9.2323e-6	0.3677543	0.5442	-1.25e-5	0.0000237
KSC27	1.9393e-6	1.1153e-5	0.0302375	0.8620	-0.00002	0.0000238
KSC28	8.4925e-5	1.0731e-5	62.634734	<.0001*	0.0000639	0.000106
KSC29	-3.439e-5	1.1935e-5	8.3044024	0.0040*	-5.779e-5	-0.000011
KSC30	-0.000028	1.2374e-5	5.1483414	0.0233*	-5.233e-5	-3.824e-6
KSC31	2.8787e-5	7.9104e-6	13.24305	0.0003*	1.3283e-5	0.0000443
KSC32	1.1776e-5	1.6628e-5	0.5015577	0.4788	-2.081e-5	4.4366e-5

Generalized Regression for lightning.end.1

Model Launch

Maximum Likelihood

Model Summary

Response	lightning.end.1
Distribution	Negative Binomial
Estimation Method	Maximum Likelihood
Validation Method	None
Mean Model Link	Log
Dispersion Model Link	Identity

Measure	
Number of rows	2075913
Sum of Frequencies	852760
-LogLikelihood	5006746.5
Number of Parameters	33
BIC	10013944
AICc	10013559
Generalized RSquare	0.0116081

Parameter Estimates for Original Predictors

Term	Estimate	Std Error	Wald ChiSquare	Prob > ChiSquare	Lower 95%	Upper 95%
KSC1	1.4765e-5	1.4921e-6	97.918663	<.0001*	1.184e-5	1.7689e-5
KSC2	-3.819e-5	2.2612e-6	285.20735	<.0001*	-4.262e-5	-3.376e-5
KSC4	-0.000033	2.1508e-6	236.6985	<.0001*	-3.731e-5	-2.887e-5
KSC5	2.8604e-6	3.1706e-6	0.8139252	0.3670	-3.354e-6	9.0746e-6
KSC6	7.0529e-5	3.3453e-6	444.48416	<.0001*	6.3972e-5	7.7086e-5
KSC7	-2.833e-5	2.0235e-6	196.02797	<.0001*	-3.23e-5	-2.436e-5
KSC8	5.5946e-5	0.0000027	429.28871	<.0001*	5.0654e-5	6.1238e-5
KSC9	-7.881e-5	2.8752e-6	751.23699	<.0001*	-8.444e-5	-7.317e-5
KSC10	1.0614e-5	2.0578e-6	26.602727	<.0001*	6.5804e-6	1.4647e-5
KSC11	-6.209e-7	2.5103e-6	0.0611691	0.8047	-5.541e-6	0.0000043
KSC12	0.000027	2.583e-6	109.25659	<.0001*	2.1936e-5	3.2061e-5
KSC13	-3.527e-5	2.3788e-6	219.85276	<.0001*	-0.00004	-3.061e-5
KSC14	4.1268e-5	2.6401e-6	244.32945	<.0001*	0.0000361	4.6443e-5
KSC15	-6.604e-6	4.5202e-6	2.1342081	0.1440	-1.546e-5	2.2559e-6
KSC16	9.5708e-7	2.0869e-6	0.2103271	0.6465	-3.133e-6	5.0473e-6
KSC17	-4.649e-5	3.0965e-6	225.40092	<.0001*	-5.256e-5	-4.042e-5
KSC18	-3.118e-5	2.2704e-6	188.6358	<.0001*	-3.563e-5	-2.673e-5
KSC19	4.8991e-7	2.7808e-6	0.0310389	0.8602	-4.96e-6	5.9402e-6
KSC20	-2.456e-5	3.1506e-6	60.776564	<.0001*	-3.074e-5	-1.839e-5
KSC21	3.1237e-5	2.4267e-6	165.68798	<.0001*	2.648e-5	0.000036
KSC22	0.0000133	2.2132e-6	36.064294	<.0001*	8.9534e-6	1.7629e-5
KSC24	-1.641e-5	2.0015e-6	67.185306	<.0001*	-2.033e-5	-1.248e-5
KSC25	-0.000011	1.6306e-6	45.614766	<.0001*	-1.421e-5	-7.817e-6
KSC26	-2.5e-6	1.8413e-6	1.8437197	0.1745	-6.109e-6	1.1087e-6
KSC27	2.2619e-5	2.226e-6	103.25015	<.0001*	1.8256e-5	2.6982e-5
KSC28	9.3823e-5	2.0731e-6	2048.1825	<.0001*	8.976e-5	9.7887e-5
KSC29	-1.965e-5	0.0000024	67.059748	<.0001*	-2.435e-5	-0.000015
KSC30	-2.968e-5	2.4324e-6	148.90238	<.0001*	-3.445e-5	-0.000025
KSC31	0.0000239	1.6388e-6	212.77773	<.0001*	0.0000207	2.7118e-5
KSC32	4.1367e-5	3.4076e-6	147.37019	<.0001*	3.4688e-5	4.8046e-5
KSC34	-1.959e-5	2.6466e-6	54.762224	<.0001*	-2.477e-5	-1.44e-5

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1. REPORT DATE *(DD-MM-YYYY)* 26-03-2020	**2. REPORT TYPE** Master's Thesis		**3. DATES COVERED** *(From – To)* October 2018 – March 2020
TITLE AND SUBTITLE 45 WS Electric Field Mill Lightning Prediction Threshold Analysis			**5a. CONTRACT NUMBER** **5b. GRANT NUMBER** **5c. PROGRAM ELEMENT NUMBER**
6. AUTHOR(S) Skrovan, Charles A., Major, USAF			**5d. PROJECT NUMBER** **5e. TASK NUMBER** **5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(S) Air Force Institute of Technology Graduate School of Operational Sciences (AFIT/ENS) 2950 Hobson Way WPAFB OH 45433-8865			**8. PERFORMING ORGANIZATION REPORT NUMBER** AFIT-ENS-MS-20-M-171
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) 45TH WEATHER SQUADRON MORRELL OPERATIONS CENTER CAPE CANAVERAL, FL. 32920 COMM: (321) 853-8610 EMAIL: william.roeder@us.af.mil ATTN: ROEDER			**10. SPONSOR/MONITOR'S ACRONYM(S)** **45 WS/WXT** **11. SPONSOR/MONITOR'S REPORT NUMBER(S)**
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14. ABSTRACT

Electric field mills at Cape Canaveral continuously record data from 31 separate EFM sites 24 hours a day at a rate of 50 Hz. This produces 4,320,000 lines of recorded data daily for each EFM site, a total of more than 16 billion data points annually for the active thunderstorm season. This study seeks to determine a single electric field mill reading threshold for lightning onset and a separate single EFM reading threshold for lightning cessation. Statistical analysis of the EFM and Lightning Detection and Ranging (LDAR) parameters show there is no measurable correlation between EFM readings and lightning activity. Further, attempts to build models using threshold analysis, standard least squares regression fitting, nominal logistic regression fitting, and negative binomial regression fitting are unable to accurately predict any meaningful amount of lightning activity. The best of these models can only account for 16% of the variance in the dataset. Overall results show EFM readings do not correlate well with lightning activity and any attempts to predict lightning proved ineffective.

15. SUBJECT TERMS

Statistical Analysis, Standard Least Squares Regression, Threshold Analysis, Negative Binomial Regression, Nominal Logistic Regression, Lightning Prediction

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** Lt Col Andrew Geyer, AFIT/ENC
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