DETERMINATION OF A LIMITED SCOPE NETWORK'S LIGHTNING DETECTION EFFICIENCY

John T. Rompala
University of Wisconsin-Stout
Menomonie, Wisconsin

Richard Blakeslee
NASA, Marshall Space Flight Center
Huntsville, Alabama

Rational:

- **The Detection Efficiency for a Network of Widely Spaced Lightning Detectors Will Vary Significantly Over the Service Area.**
- **Variations in detection efficiency are due primarily to:**
  - range signal attenuation
  - site detection threshold parameters
  - irregular network grid geography
- **Knowledge of the detection efficiency profile is critical in:**
  - meeting operational objectives
  - analyzing local data
  - linking network data with data form neighboring networks
  - linking network data with data from alternate detection systems
  - applying data in scientific lightning research
  - applying data in regional meteorological studies

Assumptions:

- **There exists some portion of the service area in which the detection efficiency is nearly idea.**
- **The distribution of stroke peak currents is uniform over the entire service area.**

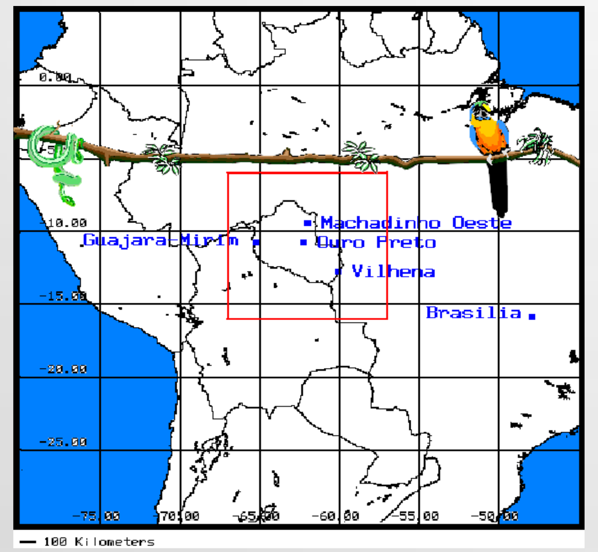
Process:

- **Compare the peak current distribution at a given location to the full distribution.**
- **Interpret the variation between these distributions as a measure of the detection efficiency at that locale.**

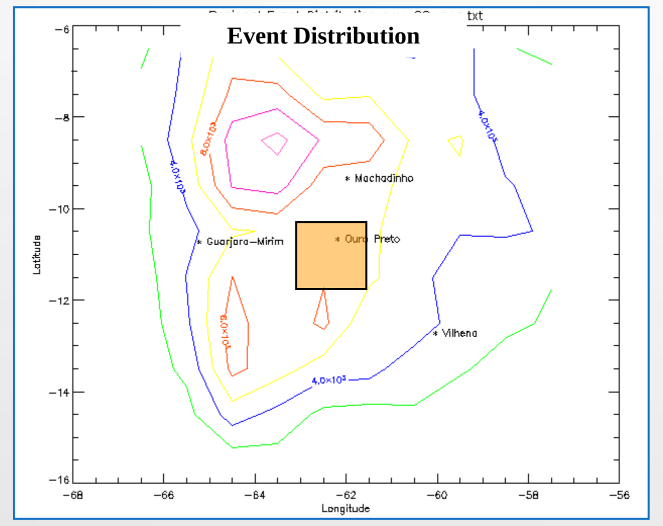
Summary:

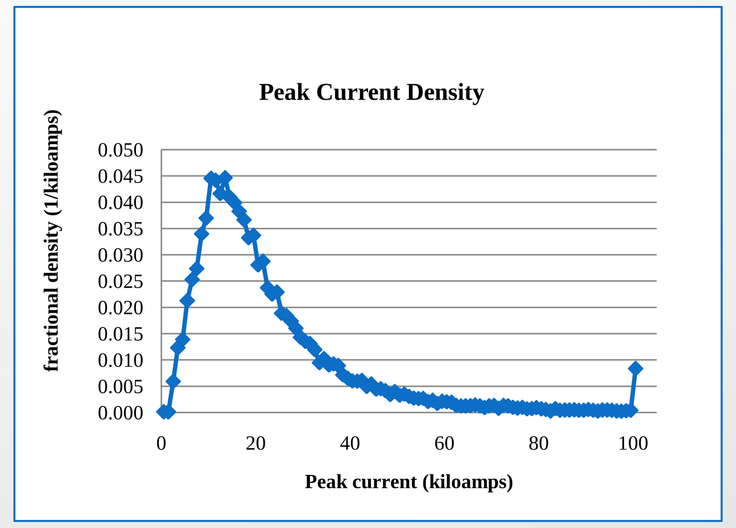
- **The process described here leads to an evaluation of the regional detection efficiency and the formulation of detection efficiency contours. This is achieved by application of a nearly ideal empirical peak current or an analytical probability distribution function.**
- **The process also finds utility as a tool in designing network grids, facilitating meteorological and lightning research, and in determination of the effects of regional anomalies, operational parameters.**

Application of the Process Using Data from the Rodonian Lightning Detection Network

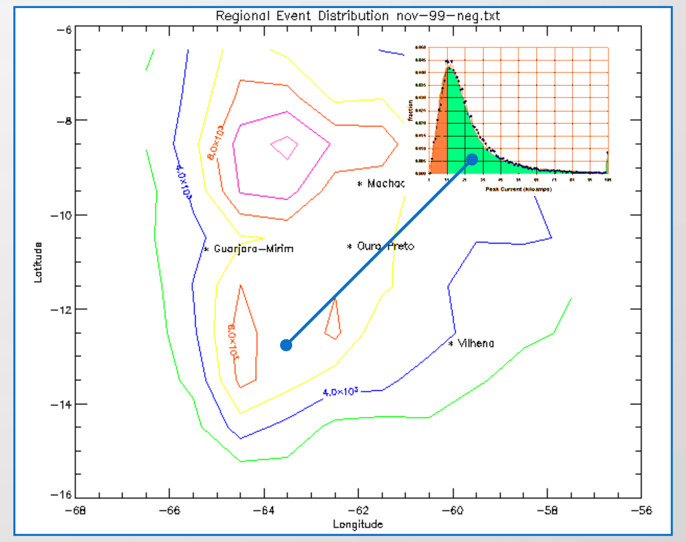


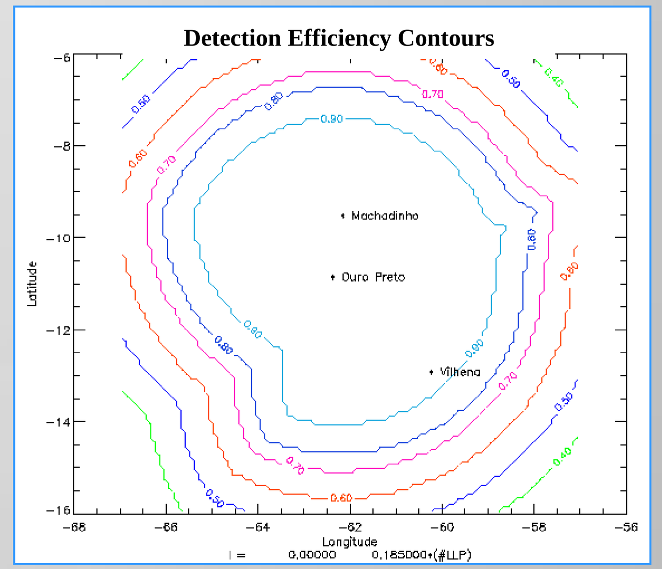
The Rodonian Network
Four Ground Based Detection Sites

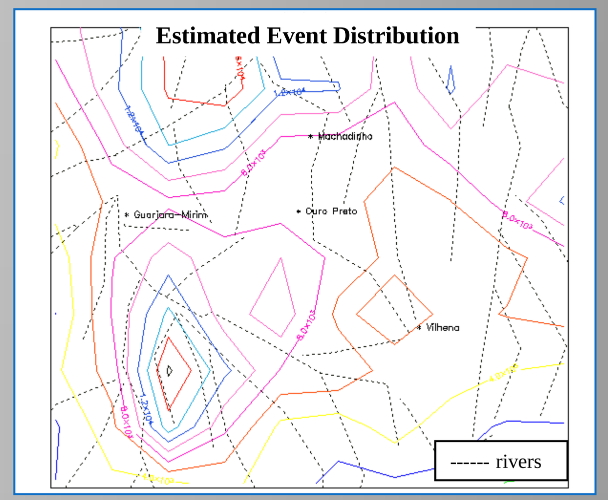




Central Region
Taken as Having a Nearly Ideal Detection Efficiency
Distribution Detected Strokes
Negative Cloud to Ground Events During November , 1999
Peak Current Density Distribution
Events with a peak current > 100 kamps were registered in the last bin.







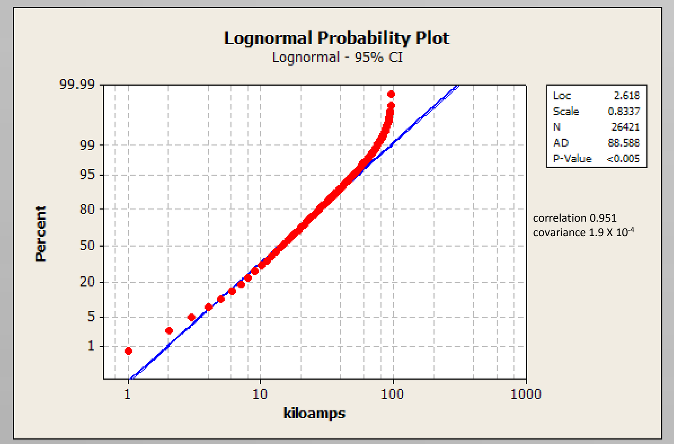
At a given site location, events must have a peak current above a threshold established by detection parameters and the type of solution utilized. Comparison to the peak current density distribution results in a estimate of the fraction of events going undetected at that location.

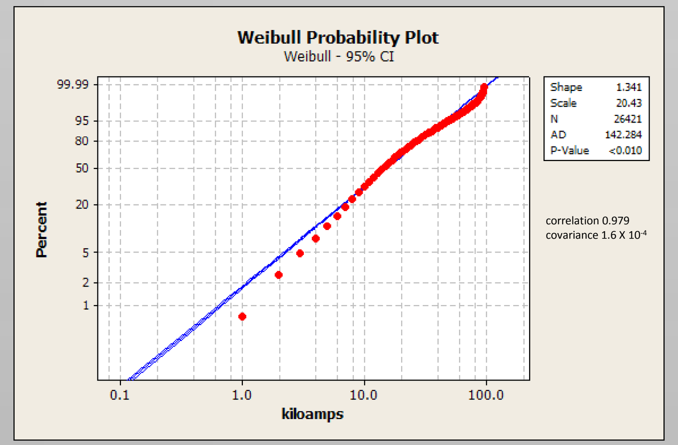
The results are summarized by detection efficiency contours and estimates of the distribution of events over the service area.

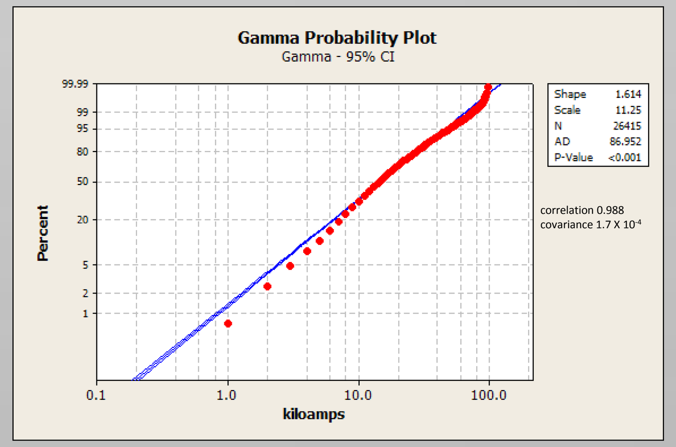
Data Modeling and Analysis

The empirical peak current density distribution is compared to three distributions . The resulting p-p plots listed in the graphs are the estimated shape (location) and scale parameters . In addition to these parameters a threshold parameter was included in each of the distributions.   The threshold value for all cases is 4.0 kiloamps.   Only events with a peak currents of 100 kiloamps or less were considered in this analysis.

A n ideal match would result in all data points falling on the scaled straight line. Variation of individual data points from the model is measured in percent. The fit is rated in terms of the AD and p values. Though each of these skewed distributions can be classified as acceptable , the gamma probability distribution shows the best fit.







Double Exponential Probability Distribution Function

The traditional gamma probability distribution function gives the probability of observing a 'sequence' of events, all having the same exponentially decaying probability of being observed individually.   If the events differ in decay probability (shape) then the probability distribution for the 'sequence' varies from the gamma profile. The formulation of the probability distribution function for a 'sequence' of two events having different shape constants is illustrated below.

This distribution is compared to the empirical data in the graph shown below. This comparison also includes a threshold of 4.0 kamps.

Double Exponential Probability Distribution Function

$$\frac{1}{\beta_1}e^{-x/\beta_1} \quad \text{and} \quad \frac{1}{\beta_2}e^{-x/\beta_2}$$

$$\int_0^x\left(\left(\frac{1}{\beta_1}e^{-x_1/\beta_1}\right)\left(\frac{1}{\beta_2}e^{-(x-x_1)/\beta_2}\right)\right)dx_1 =$$

$$\frac{1}{(\beta_1-\beta_2)}\left(e^{-x/\beta_1}-e^{-x/\beta_2}\right)$$