Estimating the Spatial Distribution of Power Outages during Hurricanes for Risk Management

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Project Summary

• Build a model to estimate the spatial distribution of power outages using GIS and statistical analysis techniques

• Use comprehensive and transparent methods – Clear understanding of all variables

• Fill gaps in previous research

• Focus on US Northeast / Tri-State area
Northeast US Major Storms

• Frequency of storms causing major outages is increasing.
  – Isabel 2003 (4.3 million customers)
  – Irene 2011 (5 million customers)
  – Sandy 2012 (8 million customers)
  – Nor’eastern of Feb 2013 (650,000 customers)
Goals

- Inform response planning
- Reduce outage durations
- Assess grid resilience and plan mitigation measures
What’s Been Done?
A Statistical Model for Risk Management of Electric Outage Forecasts

- Typical weather forecasts are based on continental-scale weather models with a spatial resolution on the order of 10 km and temporal resolution of 3-hour intervals.
  - This not sufficient detail for a utility service territory.
  - Does not incorporate surface features that effect mesoscale meteorology.

- Utilizes numerical prediction model for local, high-resolution weather predictions

- No discussion of variables beyond weather (wind gusts and rainfall)
Academic Research


- S. Han, S.D. Guikema, S.M. Quiring, K. Leed, D. Rosowsky, R.A. Davidson. *Estimating the spatial distribution of power outages during hurricanes in the Gulf coast region*


• Look at several geographic variables
• Can benefit from industry collaboration and more sophisticated GIS analysis
General Concept

GIS: Vulnerability

Base Topography
Power Grid
Land Cover / Vegetation
Soils
Weather: Wind Gusts / Rainfall
Composite Vulnerability

Model Training:
Historical Data for Outages and Corresponding Conditions
Historical Data

- Utilize historical power outage data from electric utility companies

**Occurrence:**
- Equipment Effected

**Weather conditions**
- Synoptic conditions
- Mesoscale conditions
- Gusts / rainfall

**Environmental conditions**
- Soil characteristics
- Land cover / vegetation
- Topography
Model Variables: Environmental

- Soil drainage and soil depth – from STATSGO
- Topography – from USGS
  - Can be used to predict flooding
- Land cover (forested vs. non-forested) – NLCD
  - This could also be classified from high resolution aerial photos.
- Detailed vegetation data
  - Was not included in academic research due to lack of available data.
  - Useful GIS data may exist with T&D ROW management
Model Variables: Power Grid

- Raster or vector?
  - Raster may be adequate for response planning
  - Most weather and environmental data will be raster

- Summarize
  - Number of poles
  - Number of substations
    - Number of switches
    - Number of transformers
Model Variables: Weather

Existing studies show that wind gust speeds and rainfall have the strongest correlations to outages.
Model Variables: Weather (continued)

• The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs.
  – Supported by NOAA and NCAR
  – Latest model to be adopted by the National Weather Service and the US Military
  – Can produce mesoscale wind forecasts down to 3km resolution up to 72 hours into the future.
  – Hurricane WRF (HWRF) is a specialized model run while a hurricane is present
Risk Assessment: Final Results

**Likelihood** (determined by GIS/statistical model) + **Severity** (number of customers effected or repair time)
Conclusions

• Industry collaboration can help build a better model
  – Historical outage data
  – Detailed grid data
  – Knowledge base

• Transparent methods (no “black boxes”)

• This project can help fill gaps in previous research