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Questions and Rationale
Does lightning cluster in certain areas when observed over repeated storm events? If so, does clustering vary with increasing levels of urbanization and pollution? How does this vary with different grain sizes?

More specifically, is there an amplification in recorded flashes with greater road density—perhaps associated with wind tunneling or pollution? Is there a unique effect associated with Atlanta that can be spatially modeled?

By comparing lightning flash density with metrics of urbanization—such as road density, distance from Atlanta, direction from Atlanta, pollution levels—we can determine the possible effects urbanization might have on flash density clustering.

Study Area & Data

<table>
<thead>
<tr>
<th>Data type</th>
<th>Sources</th>
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<tbody>
<tr>
<td>CG Lightning</td>
<td>National Lightning Detection Network</td>
</tr>
<tr>
<td>Road</td>
<td>ESRI Data</td>
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<tr>
<td>City</td>
<td>U.S. Census Package</td>
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Methodology

Cloud-to-Ground (CG) flashes are selected from 93 northern counties in Georgia, avoiding all tropical meteorological influence. Only warm season single cell storm CG flashes for May through August are included. Special attention is paid to Gwinnett County, identified as a lightning hotspot by Stallins and Bentley (2006).

Pointwise correlation (Getis Ord G-function) is executed to verify that repeated CG flashes is not a random or Poisson process, but demonstrates clustering. Upon clustering validation, grid cell sizes for analysis were chosen at 1km, 4km, 16km, and 64km grids. Covariate data layers include the following: 2010 Census block population; road, highway and interstate density data; distance to Atlanta; and FAA aviation obstacles.

After processing the flashes and covariates at various grain sizes, a linear regression is executed to determine the flash density variation with covariate variation. Multicollinearity is checked, and collinear layers are removed when necessary. A backward step algorithm is used to eliminate unproductive explanatory variables.

Most preprocessing was completed in ArcGIS10.0, and the other preprocessing, G-functions as well as regressions were completed in R Statistical Software.

Methodology Figures

All of North Georgia Grids
Spatial Modeling: 1km²

The left shows road density at 1km², Middle: flash density positively correlates with road density, the right shows no trend between flash density and distance to Atlanta.

Spatial Modeling: 4km²

Left: Road density; Middle: n=2000 grids flashes positively correlate with roads; Right: flashes negatively correlate with distance from Atlanta

Spatial Modeling: 16km²

Left: road density, Middle: flashes positively correlate with road density; Right: flashes negatively correlate with distance to Atlanta

Spatial Modeling: 64km²

Left: road density, Right: flashes positively correlate with road density.

Discussion and conclusions

The point-wise correlation demonstrated clustering in all subsets for CG flash densities. Population was removed as an independent variable due to collinearity with road density (r²~98; r~90). All scales demonstrate a positive correlation between road length (km road/km² area- a metric for density). Only the larger scales demonstrate a negative correlation between distance to Atlanta and flash density. There is no correlation between distance to Atlanta and flash density at 1km².

Spatial Modeling: Gwinnett County : 1km²

Gwinnett County, GA has previously been identified as a hotspot for lightning (Stallins & Bentley 2006). The left shows road density at 1km²; Middle: no trend between flash density and road density, the right shows no trend between flash density and distance to Atlanta.

Gwinnett Modeling: 4km²

Left: Road density in Gwinnett; Middle: no trend between flash density and road density; Right: flashes negatively correlated with distance from Atlanta at large values

Gwinnett Modeling: 16km²

Left: Road density in Gwinnett; Middle: no trend between flash density and road density; Right: flashes not significantly correlated with distance from Atlanta and flash density.

Modeling of FAA Aviation Obstacles

The Gwinnett analysis suggests Gwinnett County being a hotspot for lightning, and within Gwinnett County, the incidence of lightning not being dependent on road density. At larger values, distance from Atlanta becomes negatively correlated with flash density in Gwinnett.

The FAA aviation obstacles, expectedly, exhibit higher incidence of lightning than North Georgia as a whole. This trend is consistent across years. Inferential modeling yields new insights into the field of urban lightning.