Correlative Effect of Prominent Objects with Lightning Flash Density

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Abstract

Does lightning preferentially strike tall towers? Above a certain height, the rate of lightning is expected to drastically increase. Various hypotheses have been formed regarding the correlation between height and lightning flash rates, but our research suggests that there is a certain height at which lighting rates exponentially increase, resulting in a logarithmic relationship. The importance of finding a height at which lighting rates increase could allow for more modern building construction codes and more economical engineering of prominent objects. Our research considers several clusters of towers around the state and the rate of lightning flashes within each with a range of heights. To determine the critical height, we survey towers across the state of Florida and determine flash densities in small areas surrounding the tower. The densities are then graphed with the tower height, which allows us to find an inflection height in lighting flash density.

Background

Cloud-to-ground lightning is a discharge of electric current between a cloud and a surface. The formation of a lightning strike starts with the formation of a stepped ladder, when charge begins to descend towards the ground. Upon making contact with the ground, the bright return stroke produces a bright flash. But for objects above a certain height, this process is reversed (Schumann, 2019). The fact that lightning tends to strike taller objects has been established, but more recent research suggests that this might be attributed to the rate of upward propagation rather than downward propagation (Shindo, 2018). A defined height range could help developers and engineers create buildings and towers to be more prepared for the amount of electric discharge they expect to receive.

Due to the almost instantaneous nature of lightning, its prediction is almost impossible. But by taking large amounts of data over a significant time period, trends can be formed on when and where lightning tends to strike. Lightning in the United States cost over $2 billion in insurance claims (Worters, 2021), with Florida leading the nation in the amount of lightning insurance claims. By mapping and analyzing lightning climatologies, insurance companies can better understand where the majority of lightning cases occur, and by analyzing specific events, lightning strike claims can be verified.

Materials and Methods

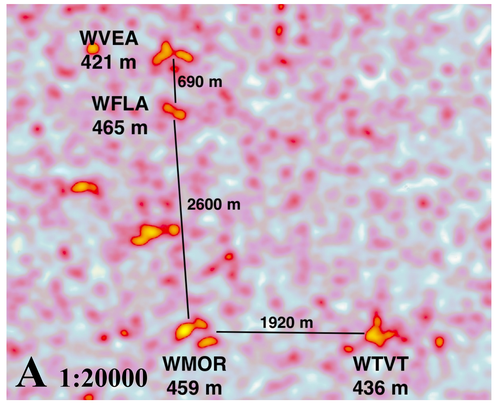
Materials:

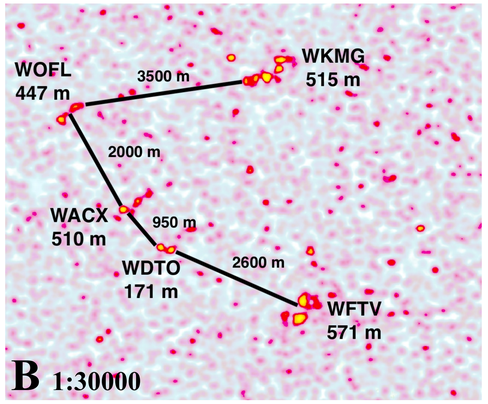
- csv data of cloud-to-ground lightning flashes across the state of Florida
  - Data obtained from Earth Networks Total Lightning Network
- GIS Lab computer capable of compiling and analyzing data

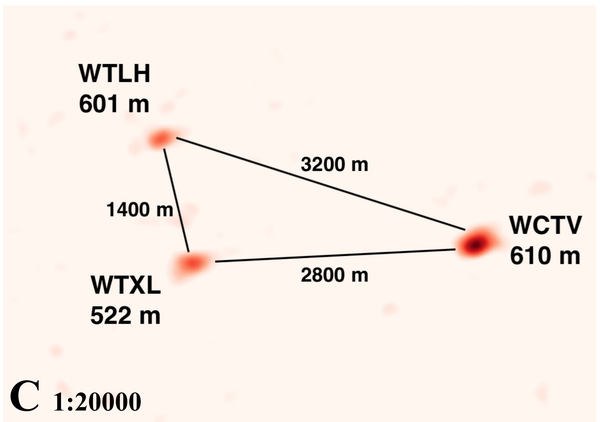
Methods:

- .csv data for lightning flashes for the entire region is compiled over five years
- Various clusters of prominent towers are chosen over Florida
- Latitude and longitude of lightning flashes plotted on a basemap using python and ArcGIS Pro
- Flash densities for each cluster are calculated
- Flash densities are compared within each cluster of towers
- The trends within each cluster are compared based on factors like height, distance, and possibly tower material
- Graphs made showing the relationships between statistically correlated variables
- This process is repeated for every group of clusters
- The trends within each cluster are compared with the data from the other clusters to determine the correlative factor of the data trends

Data

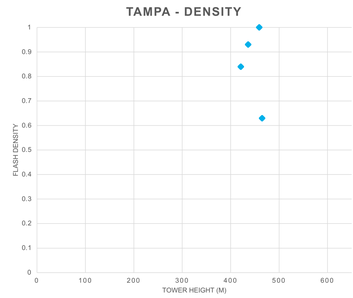


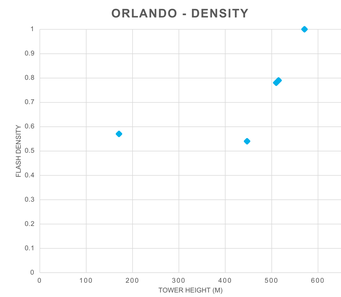


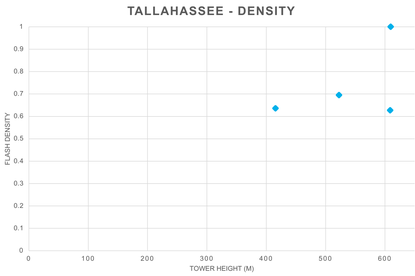


These images symbolize the lightning flash densities in A. Tampa, B. Orlando, and C. Tallahassee.

Results

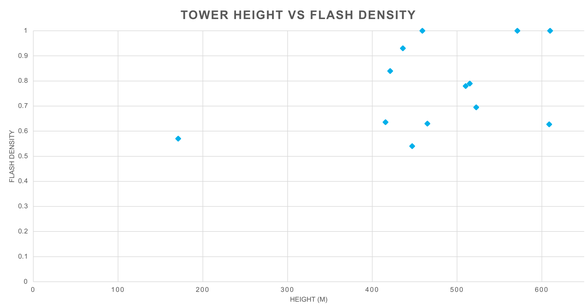






These charts display the lightning flash density compared to tower height for the Tampa, Orlando, and Tallahassee area towers.

Analysis



The combined tower height vs. flash density plot does not display any concrete evidence of a tightly correlated trend, but more data is needed between the values of 200-400 meters to determine if there is any height at which there is an inflection point. But our analysis shows that the presence of a tall tower does lead to an enhanced lightning flash density.

References

Schumann, C., Saba, M. M. F., Warner, T. A., Ferro, M. A. S., Helsdon, J. H., Thomas, R., & Orville, R. E. (2019). On the Triggering Mechanisms of Upward Lightning. Scientific Reports, 9(1), Article 1. https://doi.org/10.1038/s41598-019-46122-x

Shindo, T. (2018). Lightning striking characteristics to tall structures: Lightning Striking Characteristics to Tall Structures. IEEJ Transactions on Electrical and Electronic Engineering, 13(7), 938–947. https://doi.org/10.1002/tee.22649

Worters, L. (2021, June 17). Cost of Lightning-Caused Claims Soared Due To 2020's U.S. Wildfires | III. https://www.iii.org/press-release/cost-of-lightning-caused- claims-soared -du e-to-2020s-us-wildfires-061721