Lightning and Air Traffic Delays

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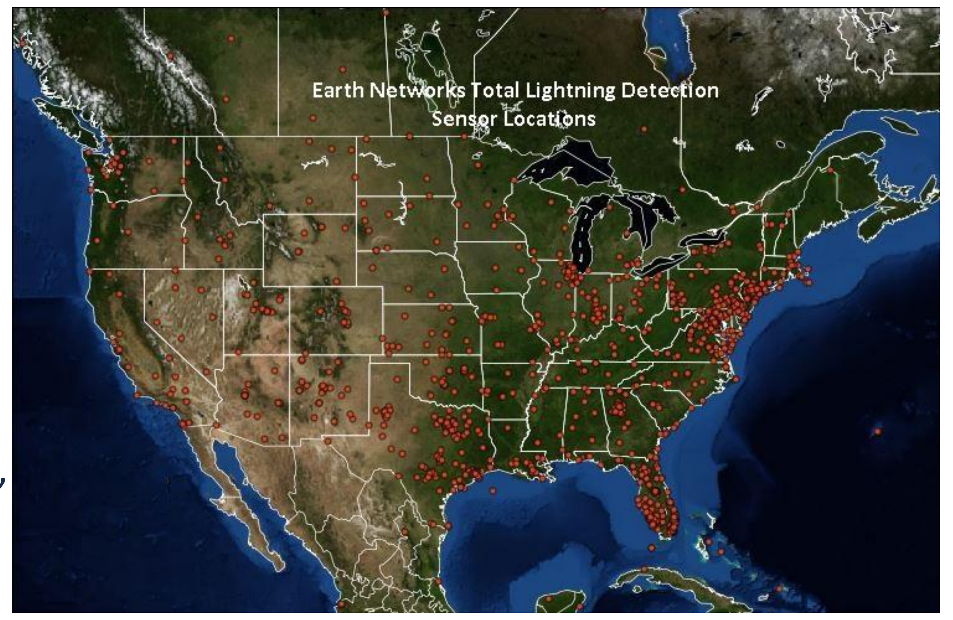
Airport delays and closures due to lightning threats total more than $30 billion each year. These costs are mostly burdened on the major air carriers, so lightning is a dangerous and expensive problem for airport operations. However, there are no standardized lightning safety rules employed across the aviation industry. This study aims to determine the optimal threat parameters to trigger closures, which could save airlines billions of dollars each year and ensure safety.

Important Terms Used In This Study

- **Lead time** is the duration between when the alert radius was triggered and when lightning struck the target**.**
- **Strike Zone** is the area within 500 meters of the target.
- **All Clear** is when there is no lightning detected within the alert radius for the specified interval.
- **Hits or Strike the target** mean there was lightning detected within the strike zone.
- **Re-alert after all-clear** occurs when lightning strikes the target within the alert radius after the all clear alert is issued.
- **Total duration** is the number of hours annually a given airport was under alert. This is averaged over the past 5 years and for 40 sites within 1 degree latitude and longitude of each airport.

The Earth Networks Total Lightning Detection Network



Our global lightning detection network has nearly 1,800 sensors covering over 100 countries. The network integrates cloud-to-ground and in-cloud detection to maximize reliability. The unique sensor technology utilizes a broad frequency range extending from 1 Hz to 12 MHz, which allows for high-efficiency capture of total lightning activity.

The Analysis Methods

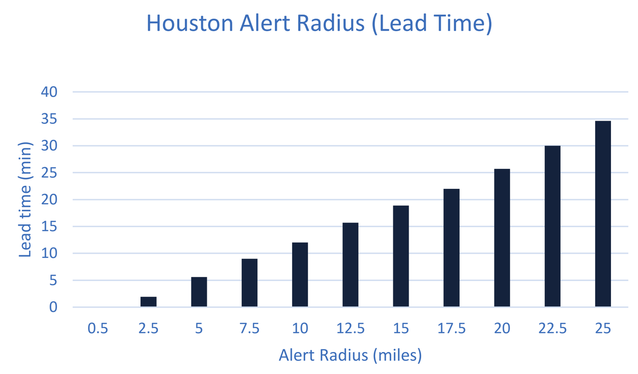
Using ENLTN data for 2014 to 2019, statistical analysis was performed on lightning occurrences at 4 major U.S. airports: Denver International (DEN), John F. Kennedy International (JFK), Miami International (MIA) and William P. Hobby International (HOU). These airports capture many of the different climates across the U.S. that have varying amounts of lightning. For major U.S. airports, the typical operations radii are 3 and 5 miles.

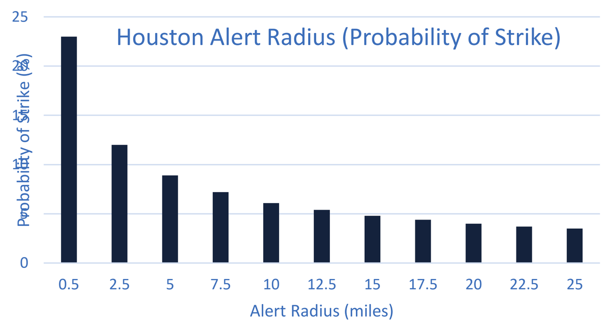
Theoretical closures were tabulated for varying trigger radii and lightning free "all-clear" windows. Data was then used to calculate frequency of closures, amount of closure time and probabilities for subsequent "hits" in the airport "strike zone." For each batch of airport alerts, the all clear time was varied while keeping the alert radius constant at 10 miles. Then, the alert radius was varied while keeping all clear time constant at 30 minutes. For each airport, alerts were simulated at 40 different locations, randomly distributed within +/- 1 degree latitude and longitude of the airport.

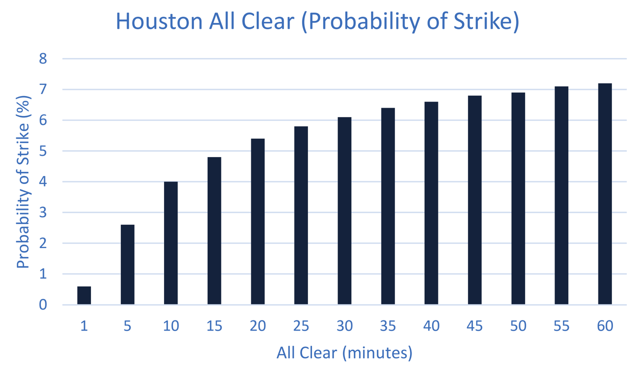
To determine the optimal radius, the target range was selected to ensure there is at least 10 minutes of lead time to get staff cleared off the runway to safety while limiting the total, annual time duration under an alert. To determine the optimal all clear interval, 20% or less probability was used, for a storm to produce lightning within the optimal radius and trigger a new alert. 20% is the threshold chosen as go/no-go decision point for re-deploying staff and resuming normal operations. However, this risk point would only be optimal for the airport if the risk was the point where they limited their losses.

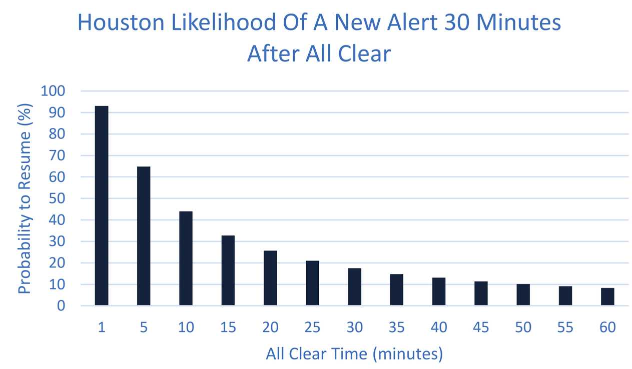
Results

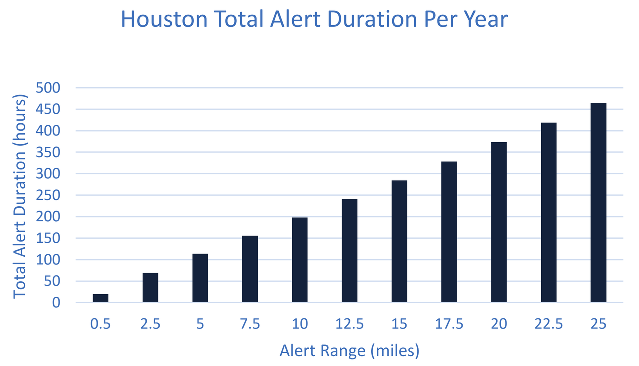
Houston









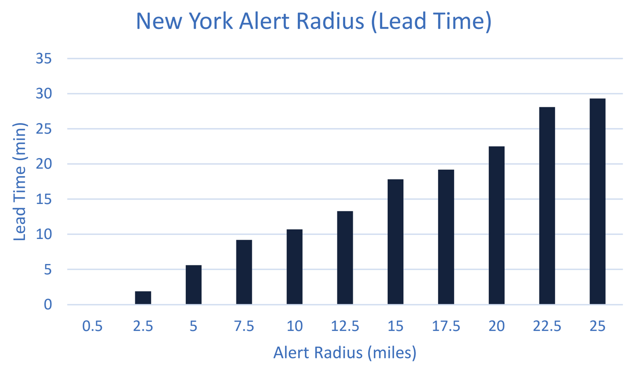


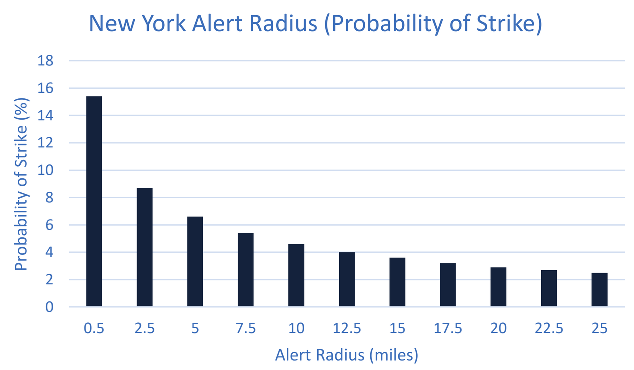
Houston

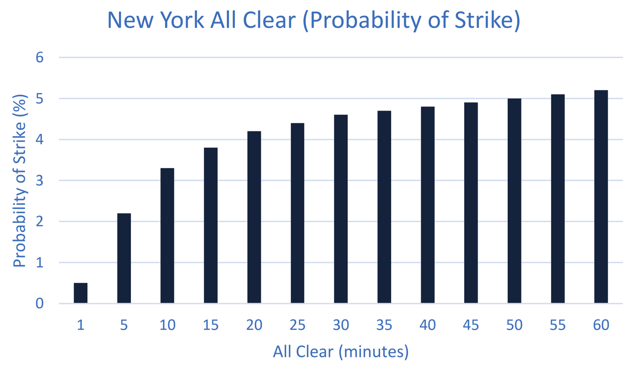
Optimal Alert Radius: **9 miles**

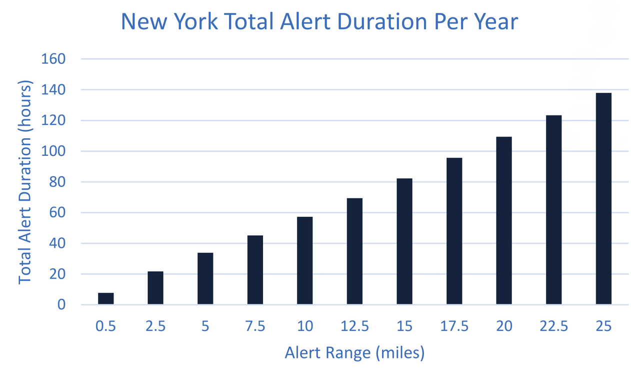
Optimal All Clear Time: **26 minutes**

New York







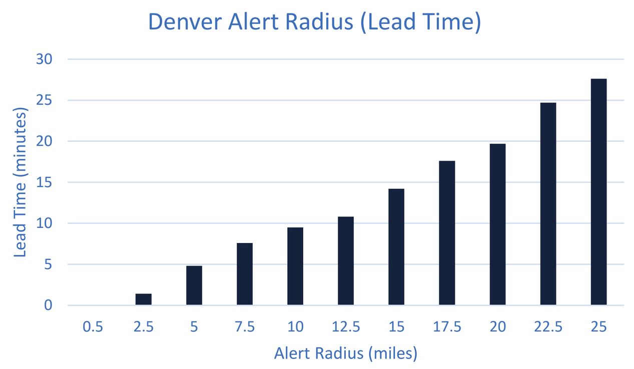


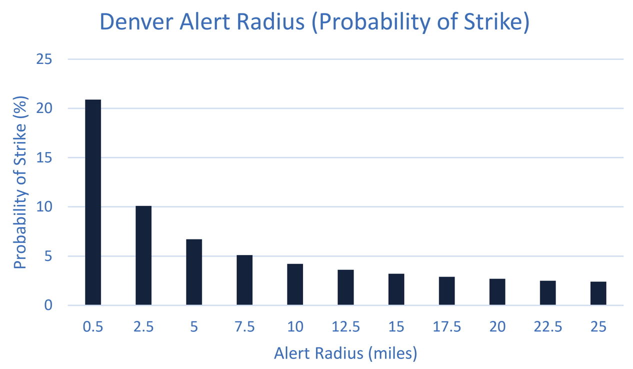
New York

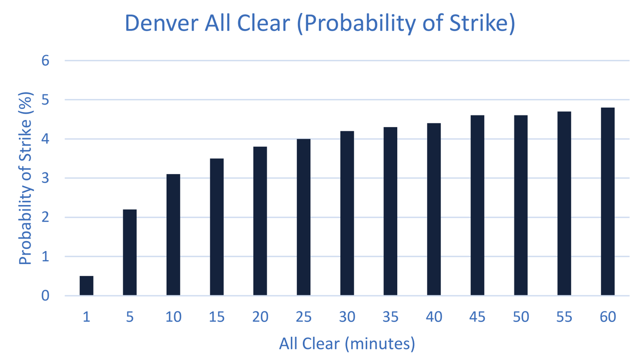
Optimal Alert Radius: **8 miles**

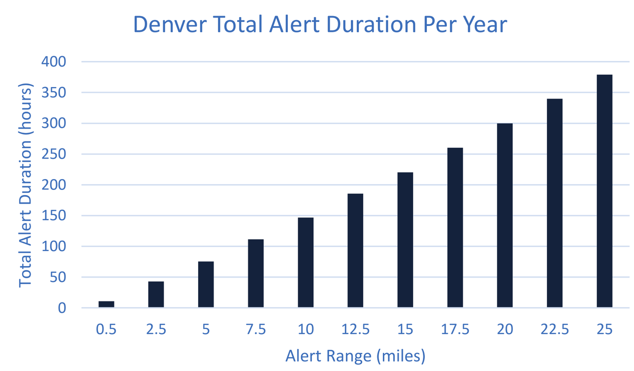
Optimal All Clear Time: **19 minutes**

Denver







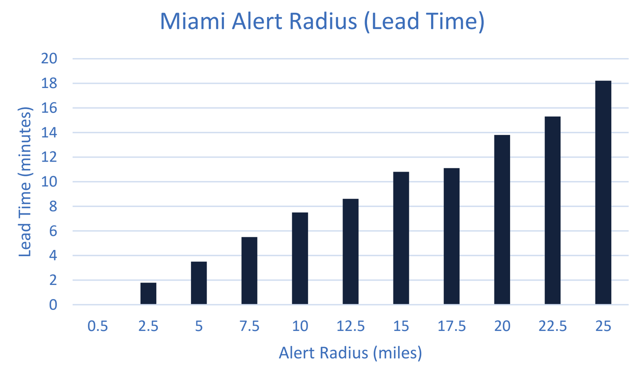


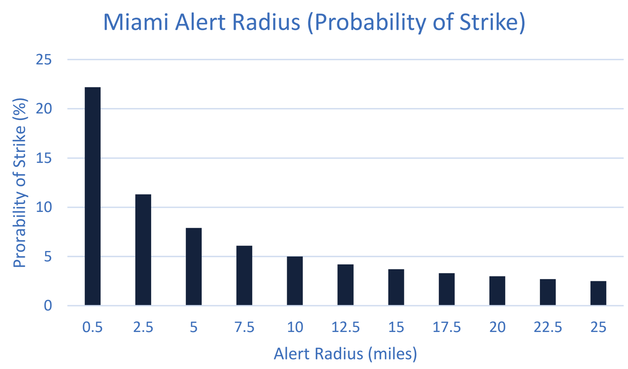
Denver

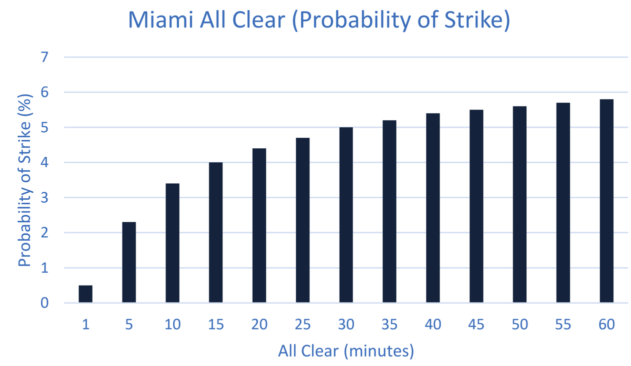
Optimal Alert Radius: **10 miles**

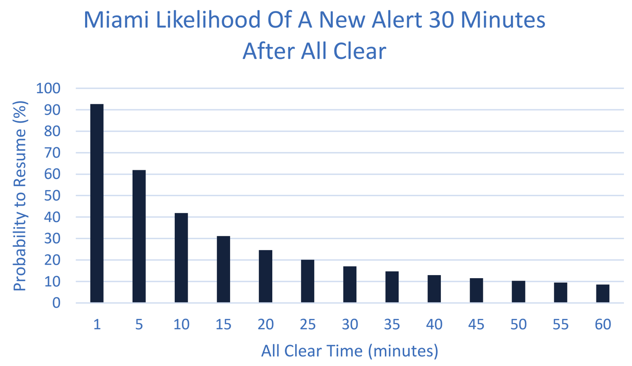
Optimal All Clear Time: **21 minutes**

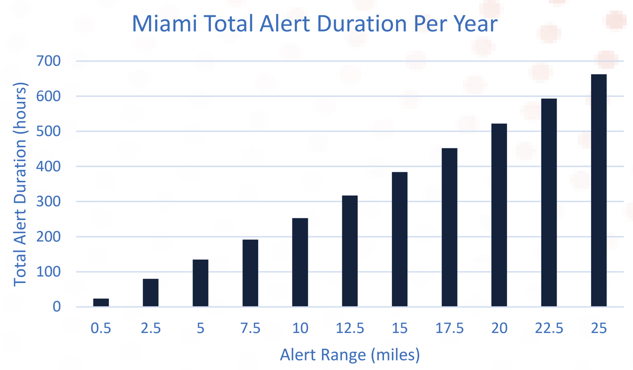
Miami











Miami

Optimal Alert Radius: **14 miles**

Optimal All Clear Time: **25 minutes**

Airport	Optimal Alert Radius (miles)	Optimal All Clear Time (min)
Houston	9	26
New York	8	19
Denver	10	21
Miami	14	25

Conclusion

Data shows there are optimal radii and all clear intervals that will limit lost time due to evacuations, re-deployments and subsequent re-evacuations due to short all-clear windows. Optimal alert radii and all clear intervals are dependent on geography and climate. Miami and Houston are located in tropical, humid climates that have frequent thunderstorms due to the combination of heat, humidity and sea breezes on both the Gulf and Atlantic coasts. These thunderstorms typically pulse up and down, and exhibit slow movement due to lighter upper-level winds. These factors yield a larger alert range and all clear time.

Denver and New York, located in the mid-latitudes, have a smaller alert range and shorter all clear time. The Rocky Mountains typically act as a thunderstorm trigger for Denver while fronts and disturbances primarily deliver thunderstorms to New York. Stronger upper-level winds in the mid-latitudes tend to produce quicker storm movement and thus, smaller alert range and shorter all clear time.

This study illustrates that when all clear time is reduced, the airport is under alert for fewer minutes, but there is a higher false alarm rate and greater chance for lightning to return to the radius. When the alert radius is increased, the airport receives a longer lead time, but is under alert for more minutes.

20% was used as the risk threshold for the optimal all clear interval, but it would only be optimal for the airport if the risk was the point where they limited their losses. Airports can obviously assume more risk, so the radius and interval would go down. The risk for any business would be set on the cost factors. Higher cost factors would assume more risk, up to a point where more money is lost than gained. We didn't have cost per minute information for this study, so we had to set a risk factor somewhat arbitrarily. Future work that includes operations costs could be done for airports throughout the U.S. to provide a clearer picture into the financial effects from thunderstorms.

Additional analysis could hone in on the optimal alert radius and all clear interval for each airport for each season. Time of day could be utilized to decide the optimal alert radius and all clear interval for each airport. Air traffic data could be incorporated to determine the effectiveness of the optimal radius and all clear interval for each airport.

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