Analysis of the Correlation of Aircraft Overflight Noise Metrics and Aircraft Visibility from the Surface

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by

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INTRODUCTION

The introduction of Performance Based Navigation (PBN) has resulted in changes in flight trajectories around major airports in the US [1]. While the noise impact of these changes has been studied, there is some concern that the changes in flight trajectory may also make aircraft more visible from the surface which in turn may increase the awareness of overflights by the community and indirectly impact the perception of noise through increased awareness.

This study evaluates the correlation between visibility of aircraft from the ground and noise metrics for a major US airport before and after the implementation of Area Navigation (RNAV). Boston Logan International Airport (BOS) was chosen as the case study location as detailed studies of the noise changes due to the implementation of RNAV had been conducted as part of the FAA, Masssport RNAV study [1].

The impact of RNAV approach and departure changes have been evaluated in both the traditional noise metrics of DNL and alternative metrics such as N_{above} which represents the number aircraft noise events above a threshold noise level in a peak day of flight operations over a specific area. A threshold of 60dB (i.e. N_{60}) has been shown to correlate well with areas of reported noise disturbance [2].

Previous studies have used aircraft noise complaint locations to look at the community noise impacts of concentrating flight paths. Complaints are generally received from locations within 10 nmi from the airport and clusters of complaints correlate with arrival and departure patterns as can be seen in Figure 1.

Figure 1: Complaints from August 2015 – July 2016 for BOS, Departures (Left) and Arrivals (Right) [1].

METHODS

Flight Data Source

RNAV implementation at BOS allows for a natural experiment in which this study can compare metrics such as noise and visibility changes before and after the new flight patterns were implemented. Flight track data from 2010 (before) and 2017 (after) is used for this analysis. All flight track data for this study was taken from the Airport Surface Detection Equipment Model X (ASDE-X). Each flight track consists of a series data points indicating the latitude, longitude, and altitude of the aircraft at each point in time along the flight track. ASDE-X data also includes aircraft type for each flight.

This study looks at peak day operations of representative departure and arrival procedures in 2010 and 2017. Runway 33L was used as the departure runway and runway 4R was used for arrivals. In order to evaluate procedure change effects the 2010 flight tracks for 4R arrivals and 33L departures were normalized to the 2017 peak days. This was done by increasing the number of flights in 2010 from each arrival and departure fix to match the 2017 flight levels. The flight tracks used in the analysis can be seen below in figure 2.

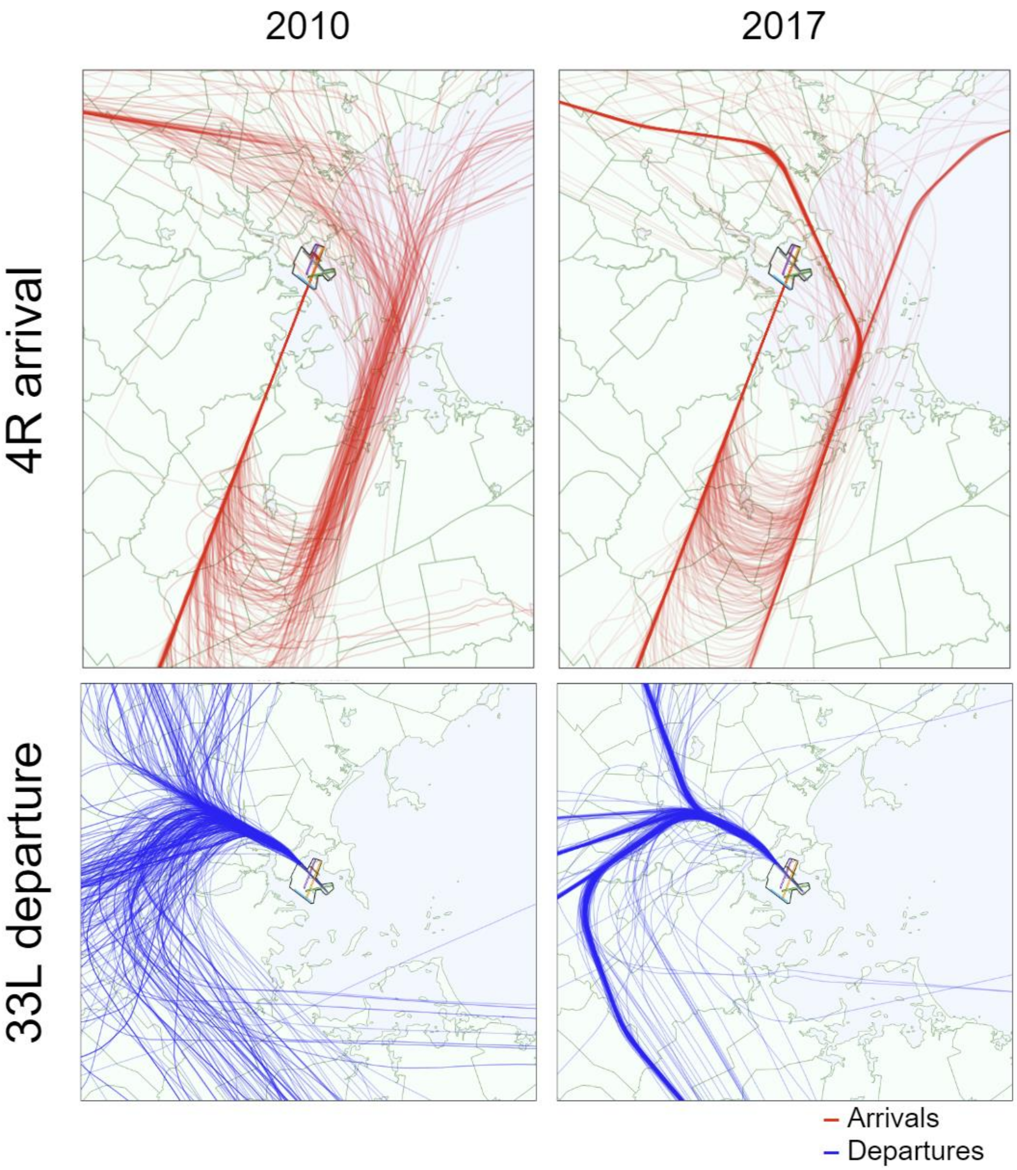


Figure 2: Flight tracks for 2017 and 2010 flight tracks for 4R arrivals and 33L departures

Noise Analysis

The noise metric used for this analysis is N_{60}. This value represents the number of times an aircraft overflight produces a noise event over 60dB LA_{MAX} during the day (7am-11pm) or 50dB at night (11pm - 7am) throughout a 24 hour period. Noise analysis is done using the Aircraft Environmental Design Tool (AEDT). The study area is broken up into a grid with 0.25nm spacing between each grid point. The analysis takes into account the trajectory and vertical profile for each individual flight track. The flight tracks are analyzed one at a time. AEDT uses Noise-Power Distance lookup tables derived from flight tests and certification data to determine noise. The noise is then propagated through standard atmospheric conditions to determine peak noise level LA_{MAX} at each grid point in the study area. If the value exceeds the 60dB LA_{MAX} threshold, the N_{60} value for that grid point is incremented by 1. This process is repeated for each flight track on the peak day and a N_{60} value is calculated for each point

Visibility Analysis

The visibility metric used for this study is N_{VIS}, or the number of times in a day that a flight is visible from the ground. An aircraft is assumed to be visible if it is above 45 degrees over the horizon (considered a reasonable average for urban areas) and below 10,000 ft altitude (higher altitudes the aircraft are more difficult to see).

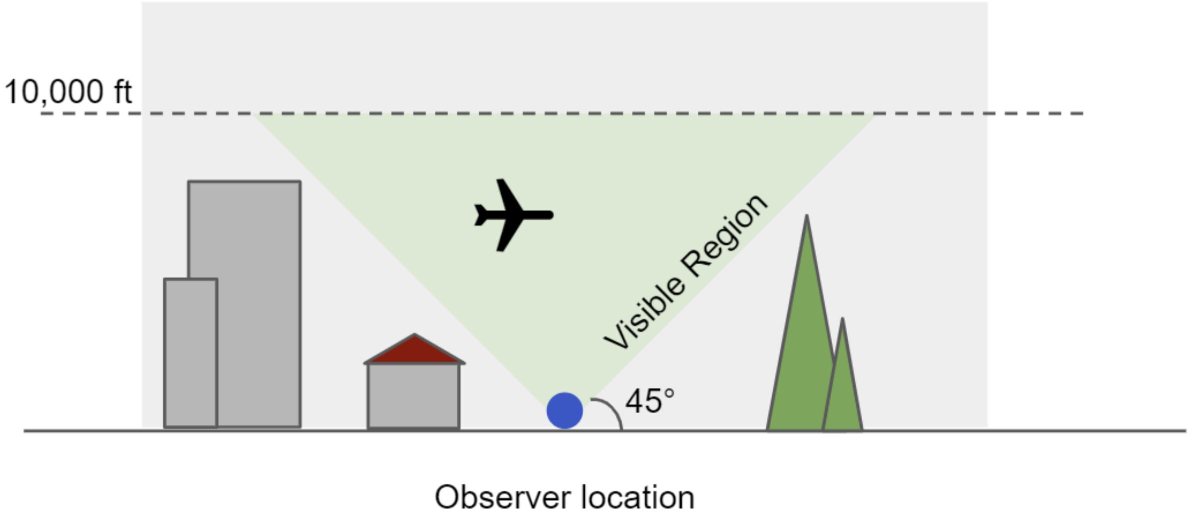
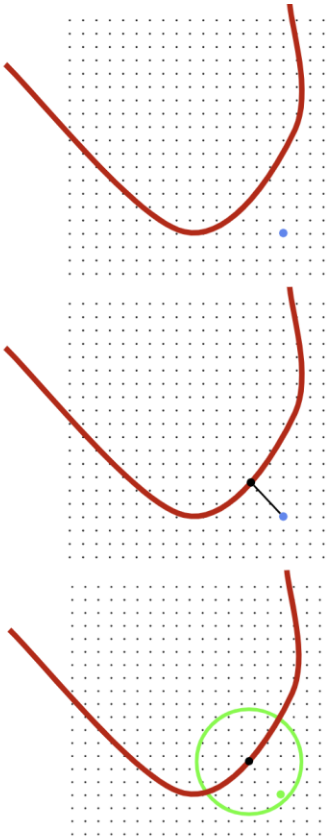


Figure 3: Pictorial representation of the method to determine aircraft visibility. The blue dot indicates the observer position. An aircraft is determined visible within a 45 degree field of view and flying under 10,000 ft as shown in the green region.

To calculate if an aircraft is visible or not, an algorithm breaks down the study area into a grid centered around the airport with evenly spaced points every 0.1nmi. Flights are processed one at a time. Iterating through each grid point, it is determined if that aircraft is visible or not. Figure 4 shows the process of determining if the aircraft is visible from a specific grid location. First, the location of the closest point on the flight track is determined. Next, based on the altitude of then aircraft, the plane is denoted advisable or not. This process was repeated for all flight tracks of interest and the total number of visible flights from each location was calculated to determine N_{VIS}.



The grid point of interest (blue) and the flight track (red)

The location along the flight path nearest the grid point of interest is determined

The green circle shows the area where the flight is visible based on the altitude of the aircraft at that point. In this example, the grid location of interest is within the visible area indicating that the flight is visible from the point of interest.

Figure 4: The process to determine if a flight is visible from a specific grid location.

RESULTS

Visibility and Noise Results Comparison for a Single Flight

Comparisons of visibility and noise patterns for a single flight reveal that more visibility does not necessarily result in more noise. While noise and visibility seem to follow the same pattern, there are significant differences in the areas close to the airport and far away from the airport.

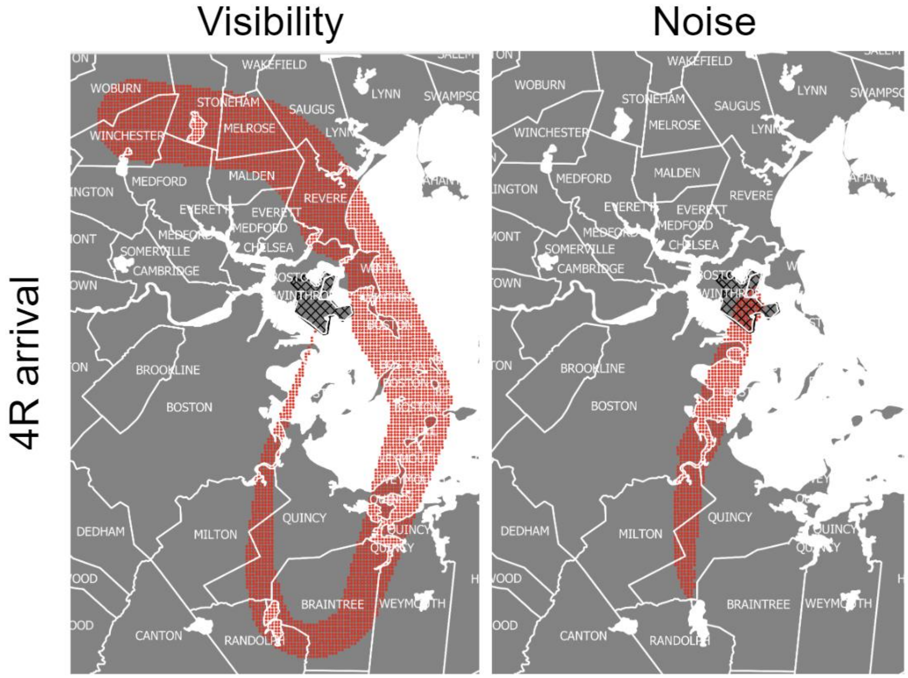


Figure 5: Visibility and 60dB noise comparison for a single 4R arrival flight

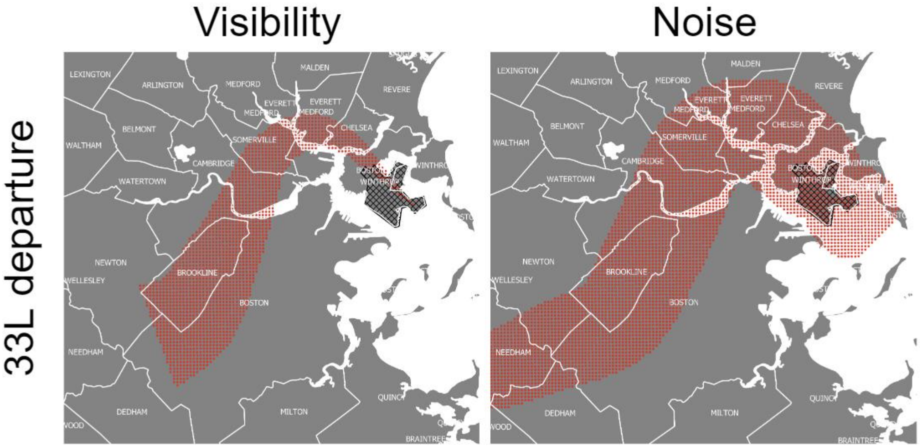


Figure 6: Visibility and 60dB noise comparison for a single 33L departure flight

Noise and visibility are inversely dependent on aircraft altitude. The higher an aircraft is, the greater the area it is visible from. The opposite is true for noise - the closer the aircraft is to the ground, the greater the area affected by noise. This is illustrated in figures 5 and 6 above. Aircraft noise is greatest near the airport and lessens when the aircraft is higher in altitude. Aircraft visibility is less near the airport and increases when the aircraft is higher (until the aircraft climbs above 10,000 ft). The results of this difference can be seen in N_{60} and N_{VIS} plots for the peak days below.

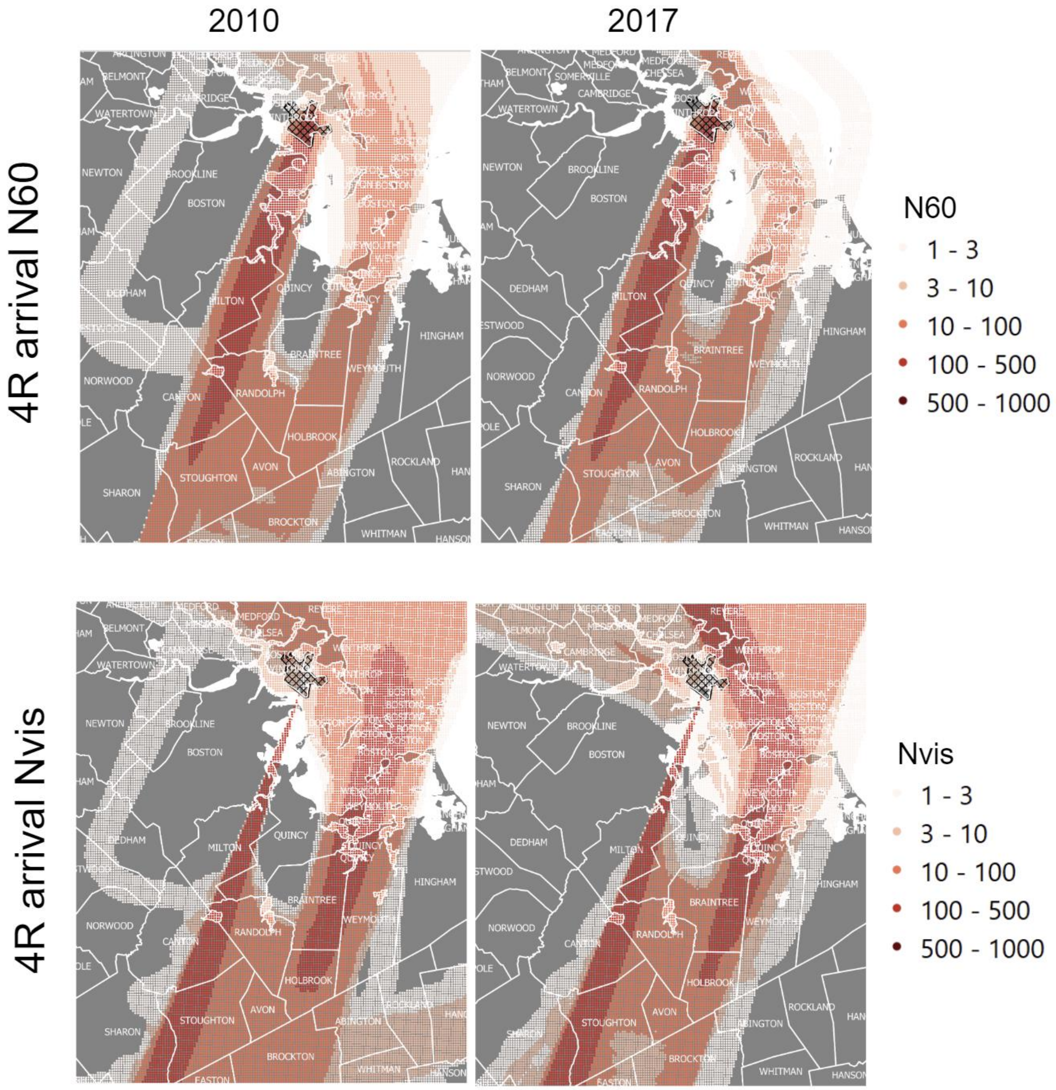


Figure 7: 2010 and 2017 N_{VIS} *and* N_{60} *for 4R arrivals*

A concentration of N_{60} is seen in 2017 compared to 2010, particularly in the western portion of the flight track. In the N_{VIS} plots, the higher N_{VIS} area continues further north in the 2017 plot than in the 2010 plot indicating the same concentration. In comparing N_{60} to N_{VIS} plots, high N_{VIS} values remain in a narrow region close to the airport and widens as the distance from the airport increases. In the N_{60} plots, high N_{60} values are present surrounding the airport and remain similar in width as distance from the airport increases.

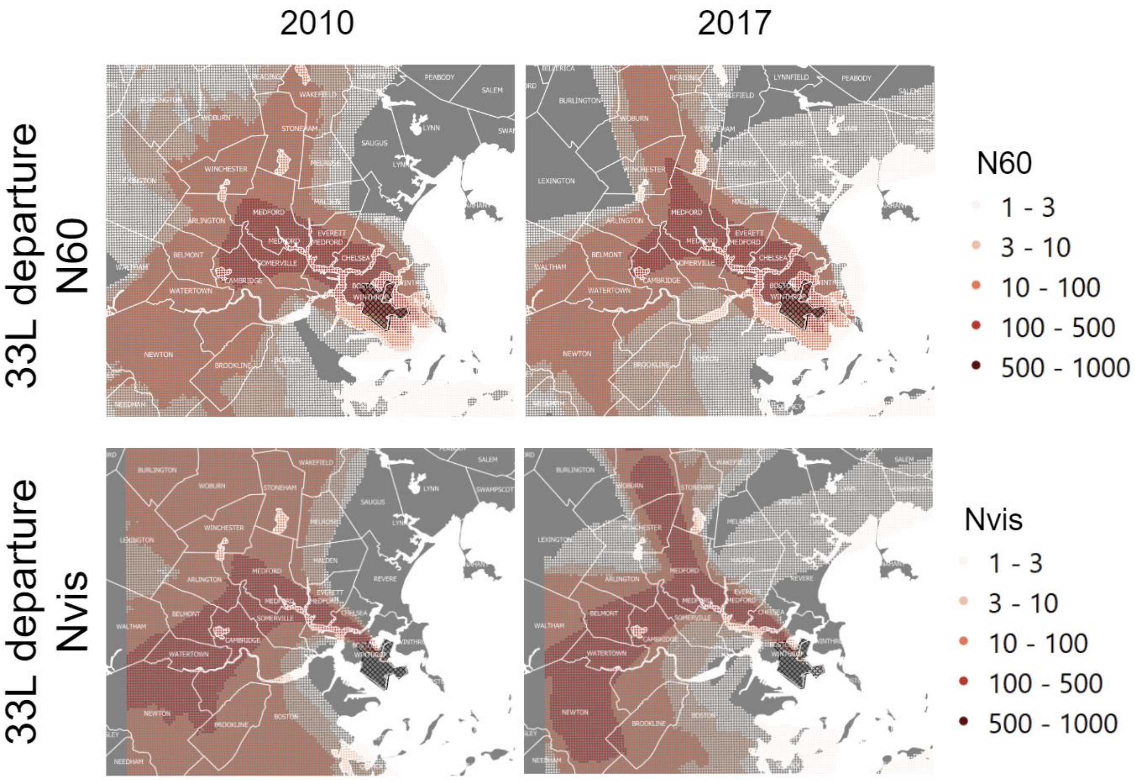


Figure 8: 2010 and 2017 N_{VIS} and N_{60} for 33L departures

33L departures show a similar trend as the 4R arrivals. A concentration of N_{VIS} can be seen in the 2017 plot compared to 2010. This same concentration is even more highlighted in the N_{VIS} 2010 and 2017 comparison. Close to the airport, high N_{VIS} regions remain narrow while high N_{VIS} values can found all around the airport.

Comparison of N_{VIS} changes and N_{60} changes

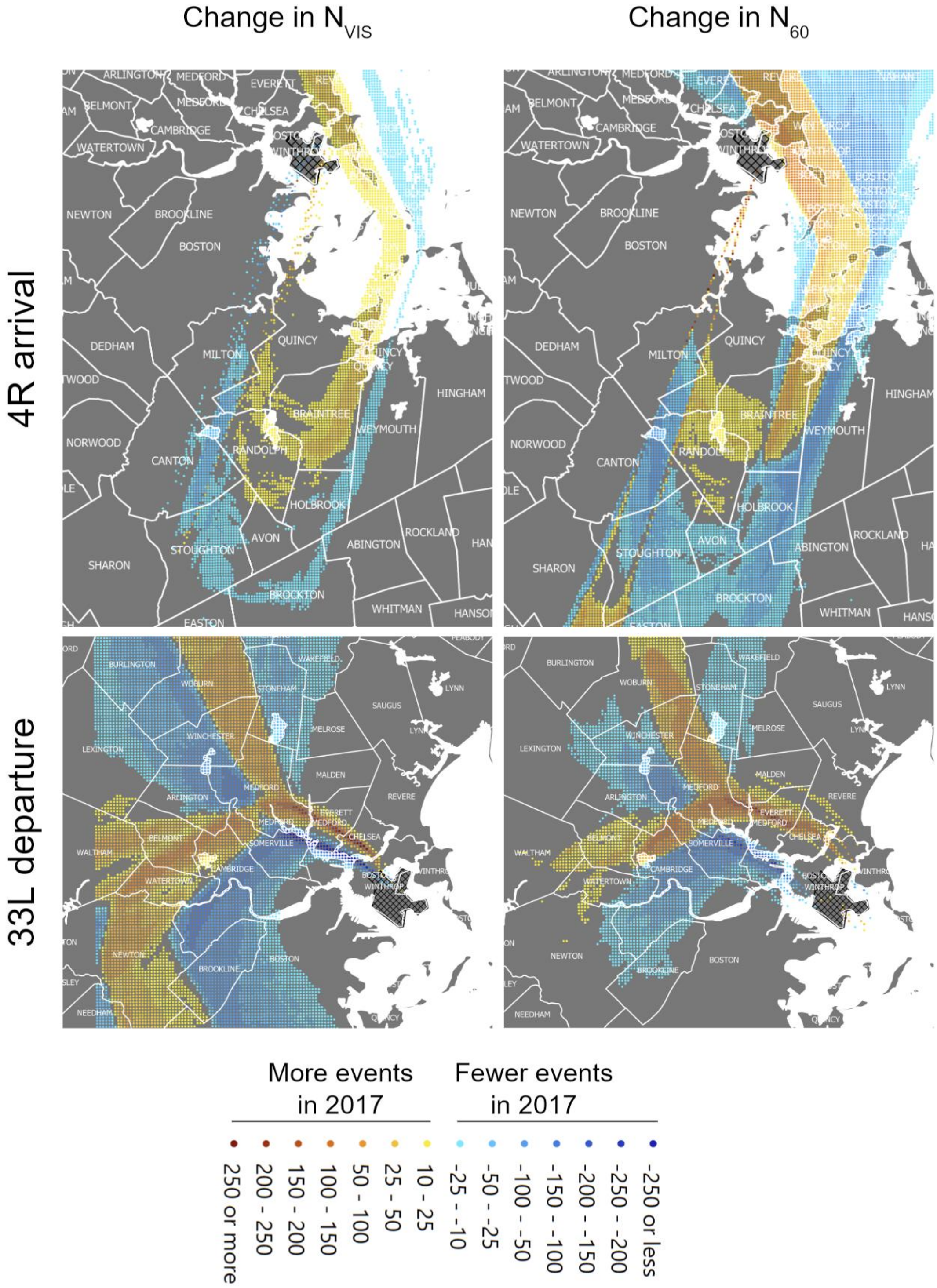


Figure 9: Comparison of N_{VIS} and N_{60} changes for 4R arrivals and 33L departures

N_{VIS} and N_{60} correlate well in the regions approximately 3nmi to 10nmi along track distance from the airport for departure paths and 5nmi to 10 nmi from the airport for arrival paths. These distances cover the areas where most of the complaints associated with these runways are received.

References

[1] Hansman et al. ”Block 2 Procedure Recommendations for Boston Logan Airport Community Noise Reduction,” ICAT Report, 2021.

[2] Yu, A. Y., “Aircraft Noise Modeling of Dispersed Flight Tracks and Metrics for Assessing Impacts,” Master’s Thesis, Massachusetts Institute of Technology, 2019.