A CONTINUOUS FIELD APPROACH USING GIS TO MODEL WEATHER RADAR TERRAIN OCCULTATION

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1. INTRODUCTION

As demonstrated by Shipley, *et al.* (2005), Geographic Information Systems provide an excellent tool to "estimate the effects of terrain and manmade obstacles on radar beam propagation, and their resulting impact on radar coverage over regions of interest." Shipley's model of RADAR coverage follows an approach that estimates radar beam occultation following radial pulses in a "cell by cell" basis. A sample of terrain heights is compared against the height of the centroids arranged in a radial pattern representing radar data collection. This is one weakness identified by Shipley: the height of the centroid is compared to a height sample of the terrain taken at the centroid's location. It does not assess blockages elsewhere within the voxel. This research proposes a different technique; we model a continuous beam coverage surface which is then compared to elevation data, highlighting any areas of occultation. The advantages and disadvantages of this technique will be highlighted at the end of this paper.

2. PROCEDURE

Our methodology was developed using two radar sites as test cases. For our purposes, we used the Denver and Pueblo County NEXRAD locations in Colorado. These RADAR were selected based on their proximity to the Rocky Mountain Front Range. Two variables are necessary to calculate beam height based on the formula provided by the RADAR Operation Center: distance and tilt angle. The tilt angles were selected from scan strategy 11. To calculate distance from the radar, a Euclidean Distance operation was performed using ArcGIS to create a raster surface, mirroring the cell size of the NED. The beam height formula was applied to the raster distance surface to generate a representation of unobstructed RADAR coverage for a given angle.

A viewshed analysis was conducted to generate the coverage of the radar. One important problem needed to be addressed before conducting the viewshed analysis. In a typical viewshed analysis, back slopes and shaded areas may be blocked from view, but still be part of what is considered the area covered by the RADAR. To account for this, a calculation was conducted comparing the beam height to the terrain. Wherever the beam height was higher than the terrain, a constant value of -1 was recorded; wherever the terrain was higher than the beam height, the positive value of the difference was recorded. This created a flat viewing surface where the radar had clearance with peaks where the terrain obstructed the RADAR beam. The viewshed analysis was conducted using this new surface supplying controls that prevented the analysis from looking above 0° vertical elevation. The results of the viewshed analysis were used to retain the beam heights that cleared the terrain.

This analysis was repeated for the multiple tilts comprising scan strategy 11. The results were then mosaicked retaining the lowest value and capping the beam height at an altitude of 75,000 feet, showing the full coverage provided by a single scan strategy (Figure 1). The process will then be repeated for multiple RADAR locations and mosaicked to provide a complete view of the coverage of the U.S. by NEXRAD.

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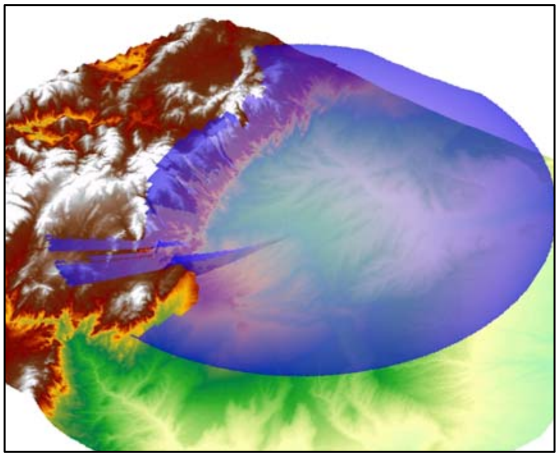

Figure 1. Radar Coverage from Denver.

3. ADVANTAGES AND DISADVANTAGES

There are a few advantages gained from developing this new technique. First, it provides a secondary validation tool that can be compared with Shipley's, *et al* technique as well as empirical RADAR results. Second, this full view coverage demonstrates how modifying RADAR radials can increase coverage by highlighting gaps in the terrain. Third, calculations comparing raster data to raster data are less intense than calculations that must compare between raster and vector data.

In addition, the calculations are flexible enough to enable other adjustments. For example, we explored a possible application by testing the affects of increasing the height of the tower (Figure 2). We also explored the possibility of addressing how much population is covered by radar by looking at the coverage of urban areas (Figure 3). Finally, this model attempts to deal with some of the problems highlighted by Shipley, *et al* in their work: the Azimuthal sampling issue is not a problem and the impact of obstacle alignment is incorporated.

That being said, there are some serious limitations. First, the model presented here does not take into account all of the details of true RADAR operation. Shipley's model better accounts for the radial collection of RADAR data. Shipley's work also accounts for the spread of the RADAR beam which is missing from the current research. It also fails to account for a Gaussian power distribution of the radar beam. In addition, combining this model with Shipley's should enhance results.

4. FUTURE RESEARCH

There are several avenues to explore to improve this model. The first is to account for the Gaussian distribution of the RADAR beam spread and its radial structure. This could be implemented using a Euclidean Direction raster to weight the beam blockage based on the Gaussian distribution. This weighting could be done in such a manner as to reflect the radial structure of RADAR data collection.

A second improvement is to compare the results generated here more thoroughly with other RADAR coverage models. Model validation through cross comparison with other modeling techniques will enhance final results. Similarly, validation against empirical results of RADAR data collection would greatly demonstrate areas where the model does not match true data collection.

Finally, the incorporation of better resolution elevation data as well as data representing land cover features (such as buildings) would produce better results.

5. ACKNOWLEDGEMENTS

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6. REFERENCES

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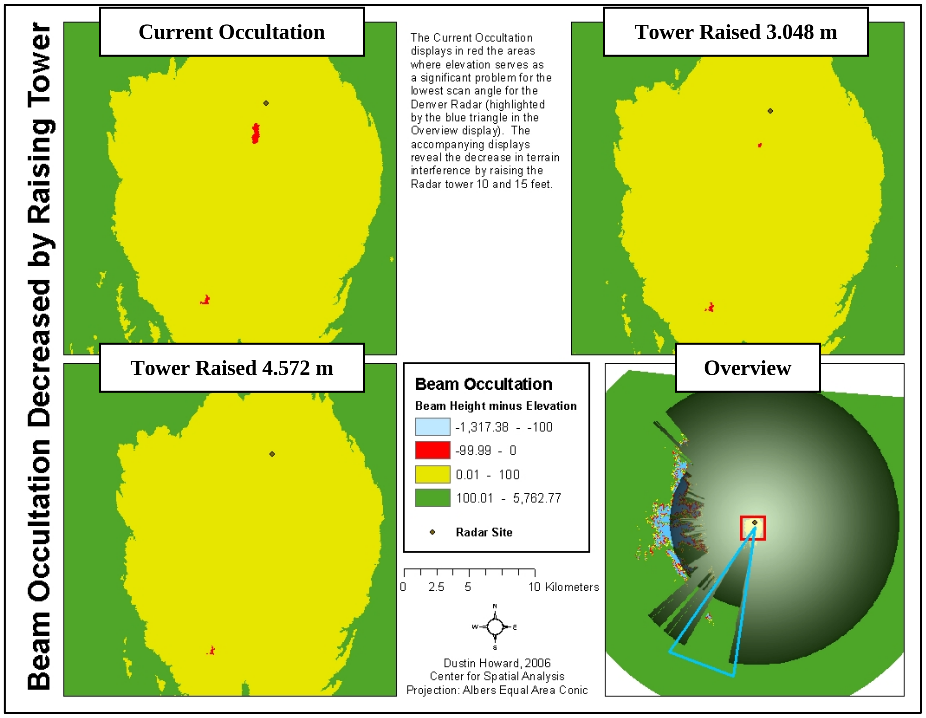

Figure 2. The affects of increasing the height of the tower.

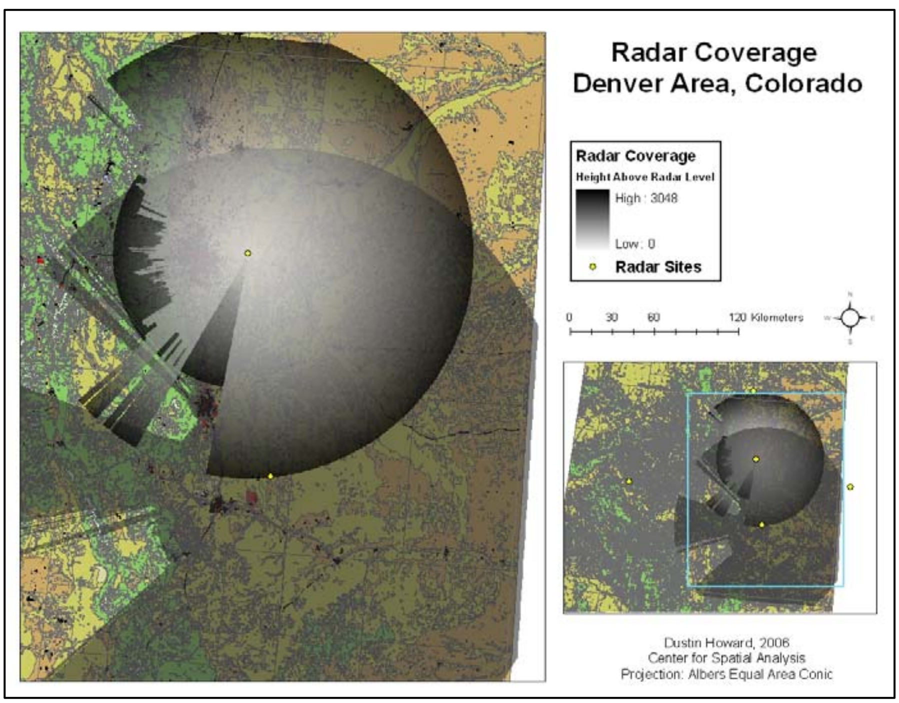

Figure 3. Radar Coverage overlaying urban areas.