Using Viewshed Models in GIS to Analyze Island Inter-connectivity and Ancient Maritime Pathways of the Pre-Columbian People in the Caribbean
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Abstract

Studies have been conducted using ArcMap to generate viewshed models to help understand Pre-Columbian island migration through the Caribbean. Often, the limitations in scale and resolution result in over generalized inter-island connections and pathways. These models are based on spatial calculations that integrate points of reference with observable and non-observable features. By placing the viewer along the highest elevation point, many studies focus on island-to-island visibility with little connection to the spatial location of sites and settlements. The focus of this paper will take advantage of high-resolution data elevation models (DEM) of Antigua and Barbuda to study how the vantage point of people traveling along oceanic pathways can help us identify how communities are connected and islands identified. By increased spatial resolution, we are able to create a more accurate model for future research studying settlement location, ancient maritime routes and mobility.

Introduction

Antigua and Barbuda, located in the Lesser Antilles, represent a case study where maritime viewsheds can be used to determine island interconnectivity 4000 years ago for pre-Columbian peoples. Travel through use of water transportation was essential for migration and trade. Modeling through using ArcMap has been widely used as a tool in archaeology. It involves the simulation of geographic processes, assuming they would work the same as they would work in the real world (Maguire et. al 2005). Viewshed modeling implements the use of geographic processes but from the standpoint of the observer. The calculations explore the intervisibility of neighboring regions; the ability to see from one site to another. In order for intervisibility to be calculated, raster data is needed; a raster digital elevation model (DEM) is used from data points collected. Raster data consists of equally sized map cells in the form of a grid in which each cell contains a value for an attribute of that location. For DEMs, the main attribute for each cell contains the value for the elevation.

Once an accurate DEM model of island landscapes are created, we must then place an agent within the landscape as the viewer. The attribute data included for the agent is the height for this observer. The reason for this to be taken into account is because the height of the individual affects what can be visible to them as they stand. The height of the observer during this study is based upon placement within a canoe along maritime pathways.

Intervisibility is calculated from a target where a straight line of sight is projected from it. The elevations of the cells determine whether the viewshed model will show intervisibility. The cell elevations that fall below the line of sight will appear as being
intervisible and those above the line of sight will deem the two points as not being
intervisible and display the line of sight as being interrupted (Conolly and Lake 2006).

**Methodology**

ArcMap 9.3 was used to create the viewshed model from raster data of Antigua and Barbuda. The data was obtained from NASA Land Processes Distributed Active Archive Center. In conjunction with Japan’s Sensor Information Laboratory Corporation, they created ASTER GDEM with automated processing of 1.5-million-scene ASTER Level-1A archive, including stereo-correlation to produce 1,264,118 individual scene-based ASTER DEMs, cloud masking to remove cloudy pixels, stacking all cloud-screened DEMs, removing residual bad values and outliers, averaging selected data to create final pixel values, and then correcting residual anomalies before partitioning the data into 1°-by-1° tiles (not sure how to reword this sentence) (NASA LPDAAC).

The colors indicating elevations were modified for better representation. A separate feature class, which was created as a point feature, was used as the observer point. Through 3D Analyst, viewshed analysis was based upon the observer point chosen. The use of single viewsheds was implemented. Single viewsheds involve the determination of visible target cells from a single viewpoint on the map. The single viewpoint, observer, was selected to lie between Antigua and Barbuda. The height of the observer was selected to be 0.5m. This is taking into consideration the height of one sitting within a canoe. After running the viewshed, the model outputted visible and non-visible features, as indicated by two colors. However, the colors dominated the map, washing out the defining elevations of Antigua and Barbuda and covering most of the surrounding ocean.
In order to rectify this situation, we wanted to create a map where solely the visible areas on the islands, and not the ocean, from the observer point were highlighted on the raster maps and the areas not visible, would not be highlighted. In order for this to be done, the viewshed had to be limited through adjustment of the vertical view of the observer. The upper (VERT1) and lower limit (VERT2) of the vertical view was adjusted through the observer point feature class. VERT1 and VERT2 had to be added as extra fields to the observer point feature class. VERT1 was set at 90, 90 degrees above the horizontal plane, and VERT2 was set to 0 degrees, not below the horizontal plane (ESRI). This takes into account of how one’s head is positioned when looking straight at the horizon.

In addition, the fields AZIMUTH1 and AZIMUTH2 were added to the observer point feature class. The AZIMUTH fields take into account the horizontal angle limit (ESRI). AZIMUTH1 and AZIMUTH2 were kept at their default values, 0 and 360, indicating 360 degree sweep of the landscape (ESRI). As, well as, OFFSETA, OFFSETB and SPOT were added as fields to the feature class to add vertical distance in surface units to the z value (ESRI). The values were 1, 0 and null, respectively. RADIUS1 and RADIUS2 were omitted as fields to be added to this feature class because we did not want to limit the search distance from the observer point. We wanted all visible areas on land to be marked as visible.

Results/Discussion

In our analysis we were able to illustrate to what extent the coastal areas for both Antigua and Barbuda are visible from the observer located between the two islands at sea. While Barbuda is half the size of Antigua, its visibility is significantly less due to its low lying elevation and lack of prominent landscape features. Of greater significance is that we can begin exploring more complex questions of settlement location and land use.
The primary objective is to portray topographical representation from the standpoint of the individual rather than from the perspective of the mapmaker. In order to do so, increased spatial resolution was required. With higher quality, we were better able to accurately represent reliefs, peaks and coastal areas that were visible to an observer from the water.

It can be said that with better accuracy, representation of the correlation between intervisibility, island interaction and maritime route paths can be better illustrated. This allows for a viewshed model within the Lesser Antilles to be created with greater accuracy than has been done in the past.

The addition of archaeological sites to the viewshed map would create a model emphasizing the location of settlements within viewsheds, thus understanding how Pre-Columbian communities are tied together. Analysis of these regions of settlement in correspondence to view from the water can begin suggesting both the possible intent and reasoning behind these localities (Watters). The reasoning behind the human inhabitation of these regions can give insight into why the settlements were founded there. The location of these settlements can be an indicator of resources available on the island. The addition of coastal settlement sites to Barbuda and Antigua, those of which we do have spatial locations of, would allow for the interpretation of how coastal location played a central theme within island interaction. In Rodriguez and Torres’ (2008) viewshed model of intervisibility between islands of the Lesser Antilles, general overlapping views are displayed, but there is omission of the illustration of visible parts of the island to travelers. It cannot be assumed that all parts of the island were visible from water or from land. By creating higher resolution DEM models we can begin inputting settlement location with regards to island contact.

**Conclusion**

In order to begin modeling Pre-Columbian oceanic navigation throughout the circum-Caribbean, it is vital that we integrate seasonal currents, storminess, frequency of hurricanes, and navigational borders. During our early phase of research we chose to focus
on creating accurate viewshed models in order to better understand visibility from the perspective of the traveller.

Albeit, the models are based upon the island being inhabited by modern vegetation, for this study it has been assumed that conditions were similar. Future modeling will incorporate ongoing paleoenvironmental research already underway. By creating more accurate DEM models, a viewshed model can be scaled from islands to people (Lloba 2003). The observer from the water is able to view the coastline where there is habitation, it is an indicator of sustainability on the island inhabitants’ part. If prominent visible features can be identified from the vantage point of the traveller, we can begin studying how location and visibility of settlements play a role during increased exchange as well as disproportionate access to resources (Look 2009, Hoffman et al 2007, Reid 2009). This visibility allows for increased interaction between the islands where there are settlements viewable from the coast. Correlating visibility, settlement sites and ancient maritime passageways, can display a smaller scale but more accurate portrayal of island interaction and travel within the Lesser Antilles.
Works Cited


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