An Augmented Viewshed Analysis of Complex 3-Dimensional Environments

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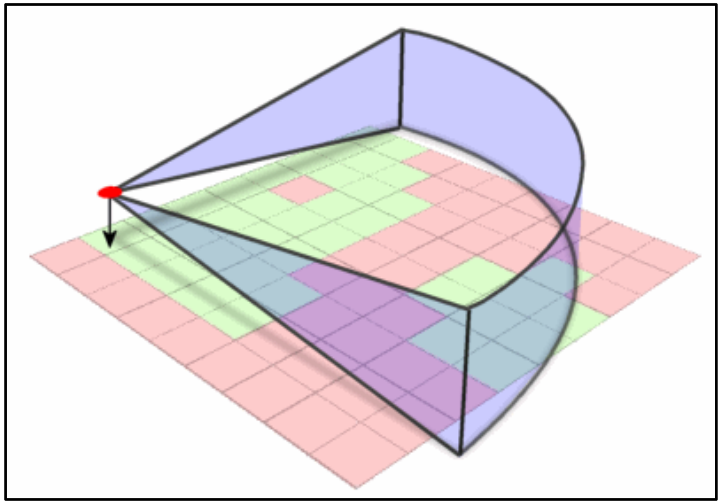
MAPPING & GEO INFORMATION ENGINEERING

Introduction

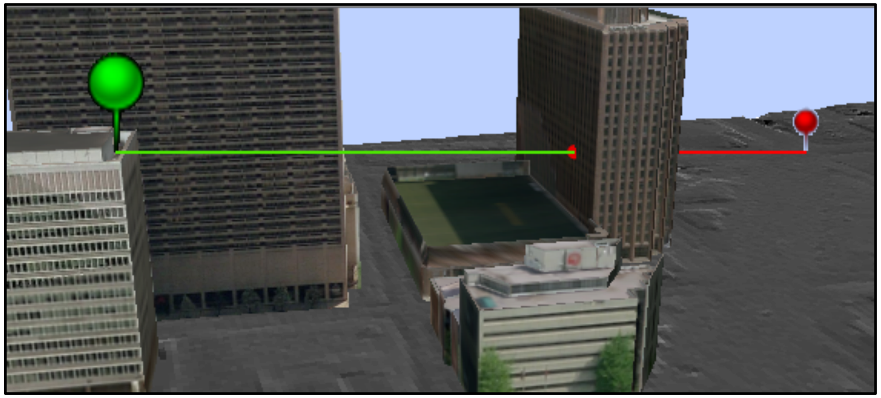
- GIS software provide a solution for visibility analysis, such as viewshed and line of sight
- Viewshed represents the geospatial area that is visible from a certain location in the environment

Viewshed



http://www.geography.hunter.cuny.edu

Line of Sight



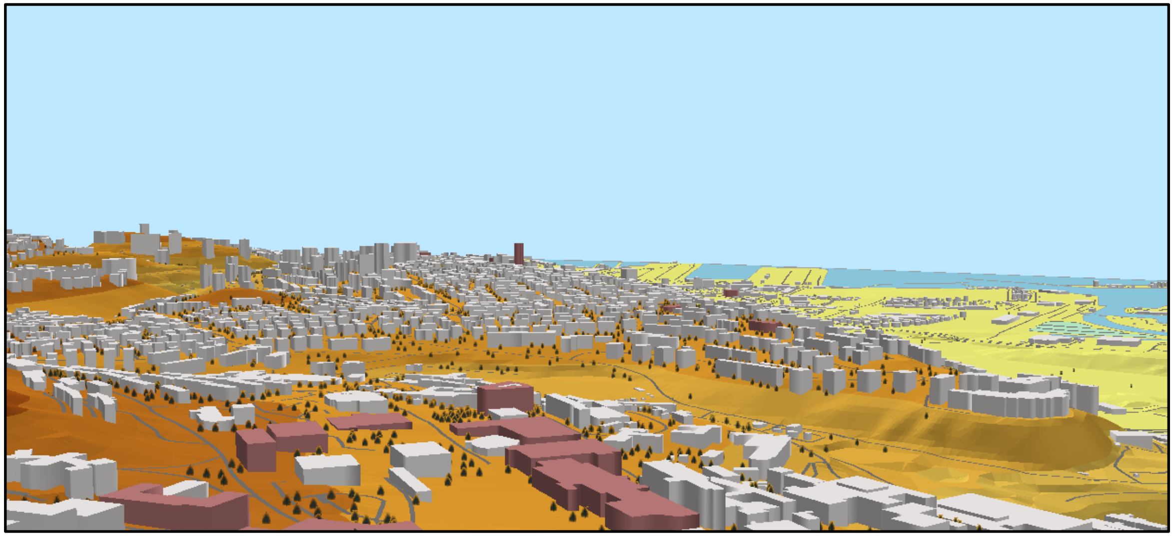
http://pro.arcgis.com

Research Goals

- Augmenting GIS environment and existing tools to produce a location-based viewshed application in full 3-dimensional complex environments
- Use of multipatch format to represent 3D objects having more complex and detailed geometry
- Examine the visibility to a specific 3D target object
- Model the Earth's curvature and the existing refraction

Work Environment & Database

- The work environment is ESRI's ArcGIS ArcScene software, using the python script tool
- The database required:
  - Triangular Irregular Network (TIN) representing the terrain
  - 3D building models represented as multipatch
  - Observer point



Methodology

Workflow

Extract the geometry of the 3D target object

Calculate the viewshed parameters and the rectangular point cloud

Convert the target object to a point cloud

Model the Earth's curvature and refraction corrections

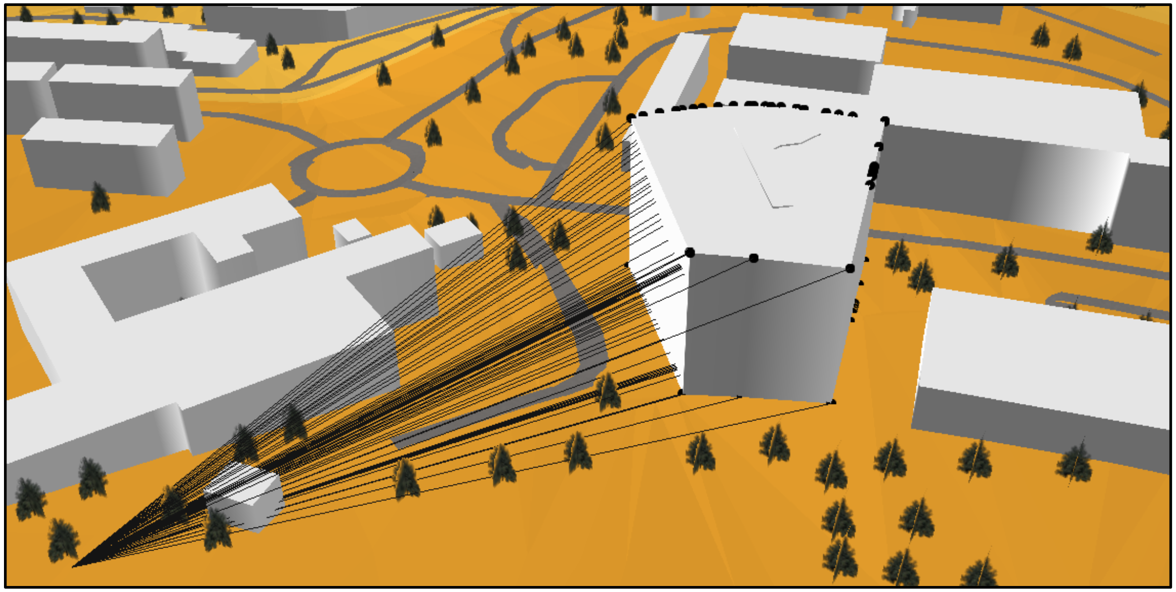
Calculate the lines-of-sight

Visibility area on target object

Methodology

Extract the geometry of the 3D target object

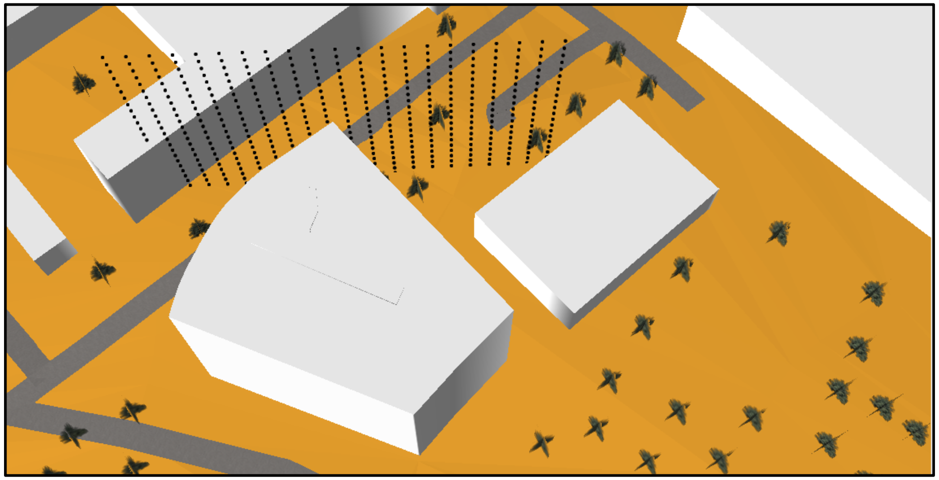
- All node points of the target object's shape are calculated
- Lines are built from the observer point to each of these node points



Methodology

Calculate the viewshed parameters and the rectangular point cloud

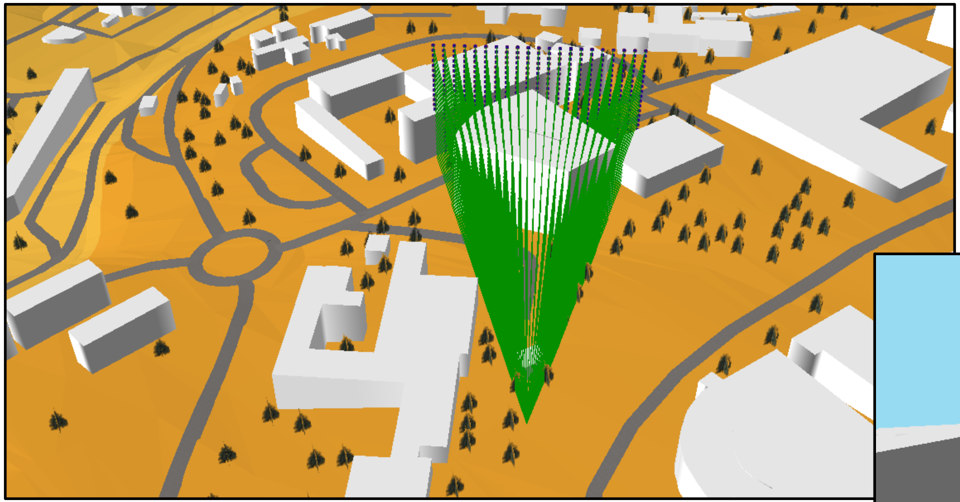
- For all lines, calculate:
  - minimum and maximum azimuth
  - minimum and maximum vertical angle
  - maximum distance towards the target object
- Derive a rectangular-shaped point cloud located behind the target

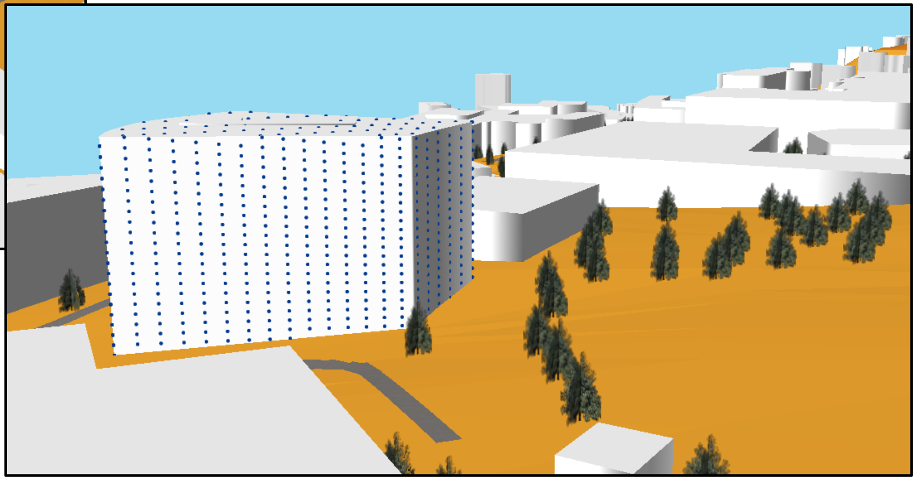


Methodology

Convert the target object to a point cloud

- Construct lines from the observer point to each point in the point cloud
- Find the point cloud depicting the target object by intersection





Methodology

Model the Earth's curvature and refraction corrections

- Correcting the height of the target points and addressing the atmospheric conditions of the analyzed area:

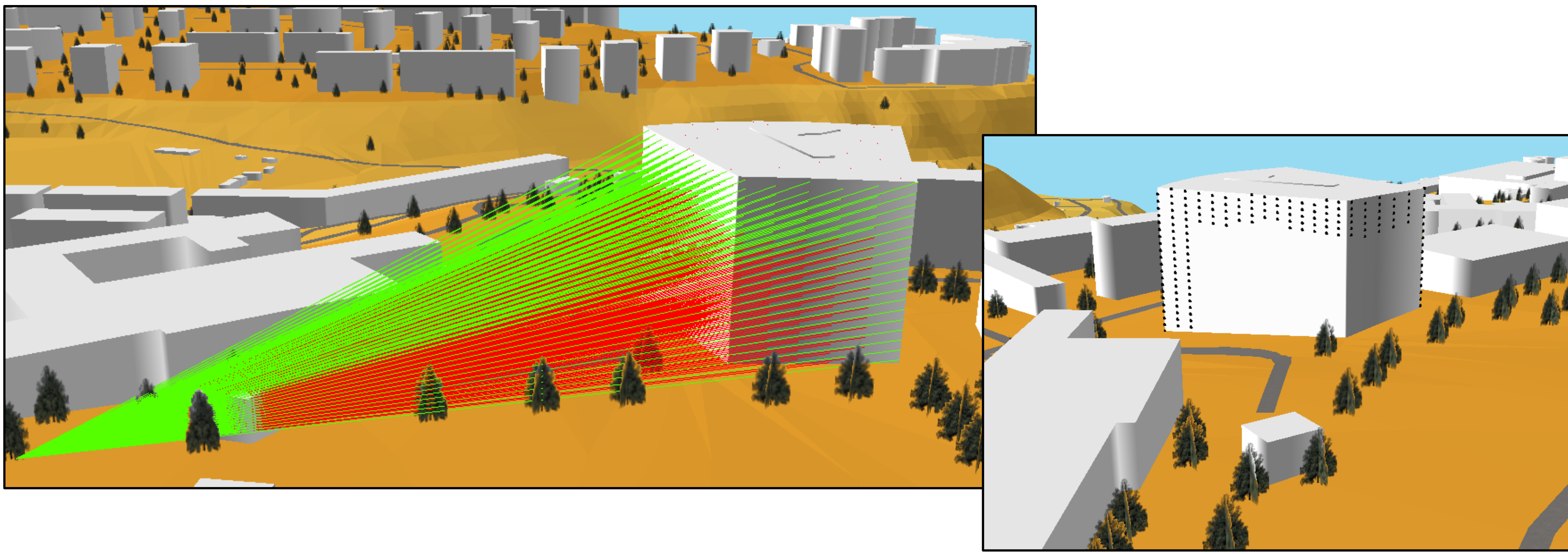
$$Z_{actual} = Z_{surface} - \frac{d^2}{diam_{earth}} + R_{refr} \cdot \frac{d^2}{diam_{earth}}$$

- Where:
  - d - The horizontal distance between the observer point and the target
  - $diam_{earth}$ - The diameter of the earth
  - R_{refr} - The refraction constant

Methodology

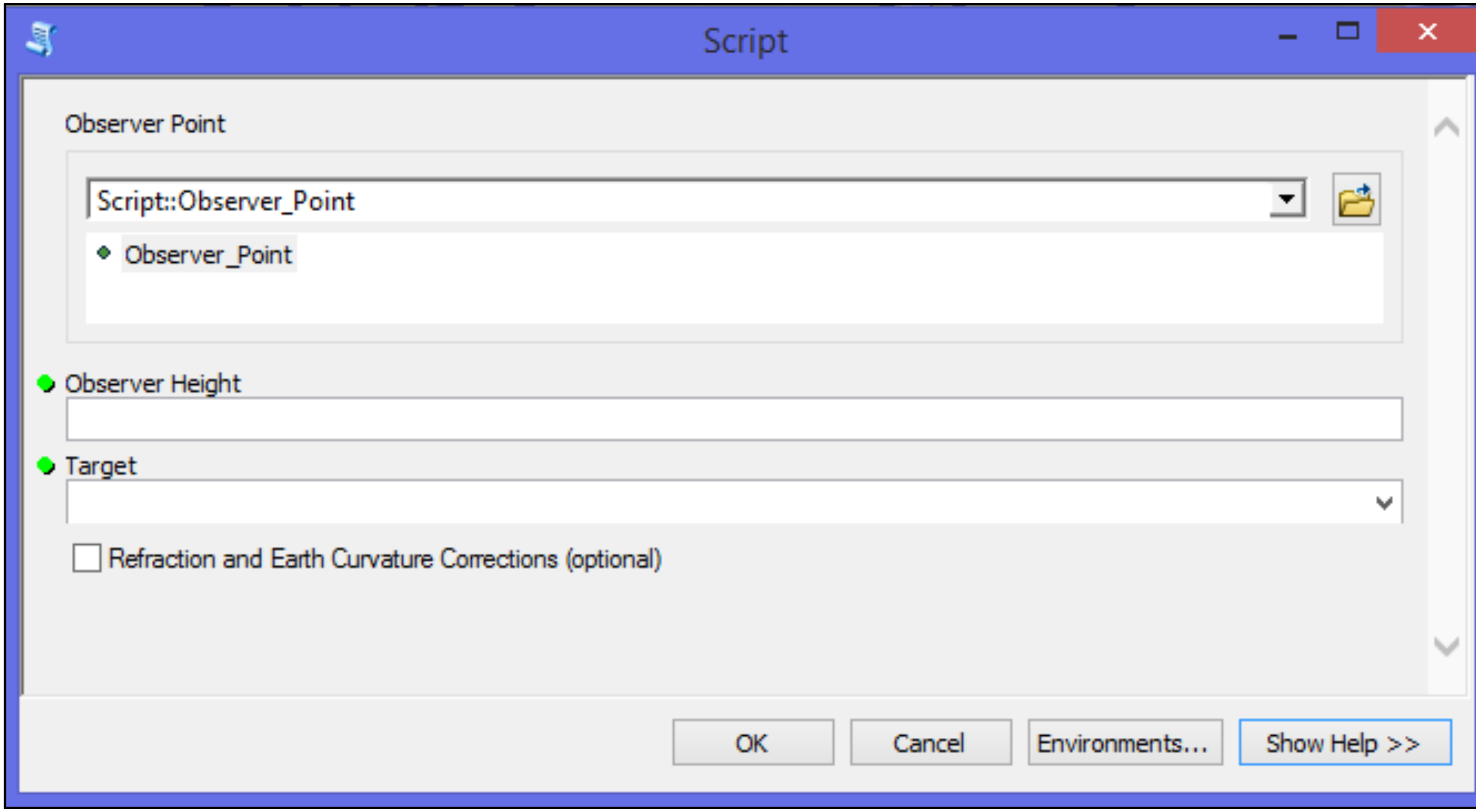
Calculate the lines-of-sight

- Construct lines-of-sights from the observer point to the target points
- Determine the visibility from the observer point to the target points according to the constructed lines-of-sight

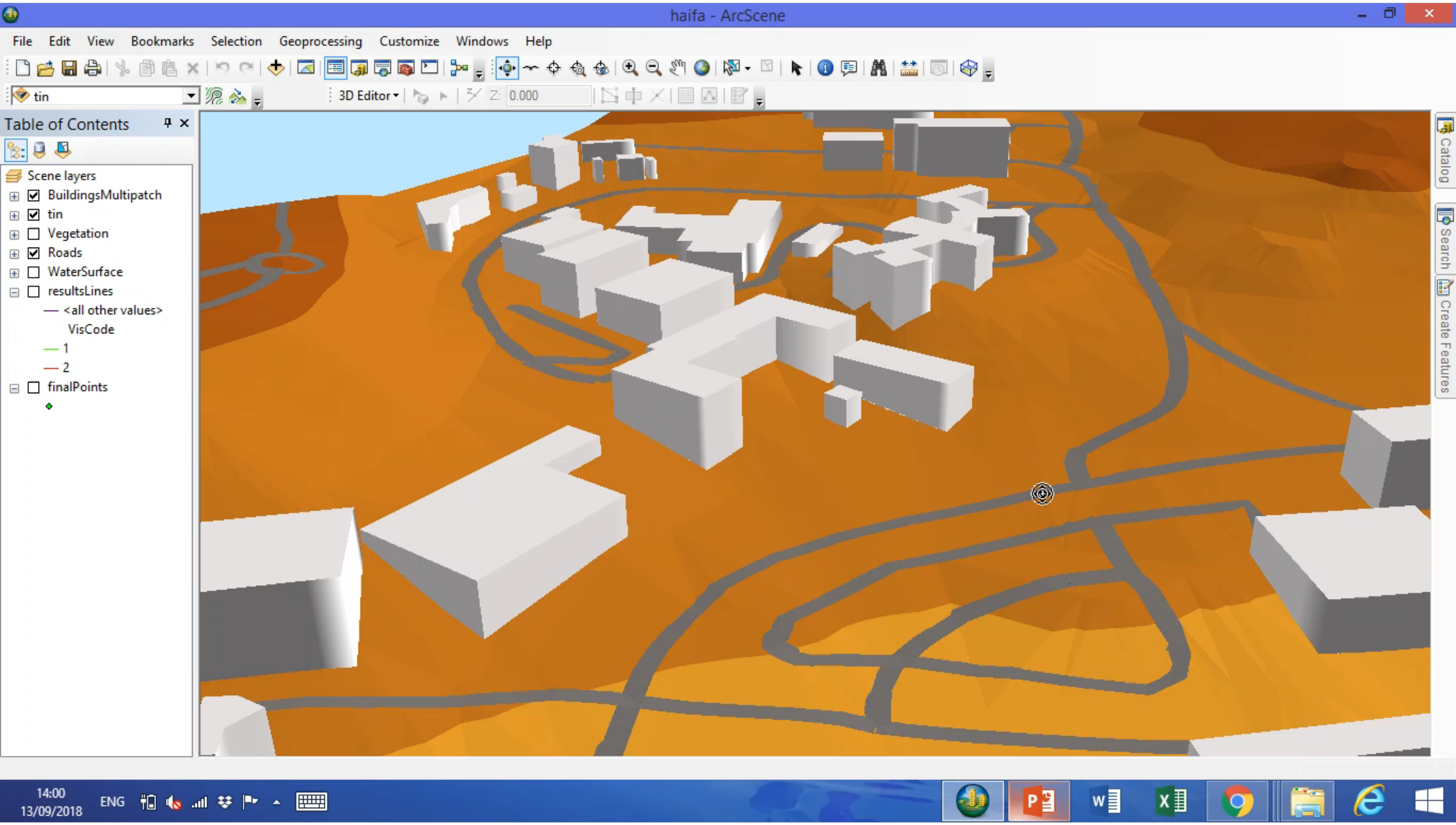


Running Method

Python script tool in ArcScene environment



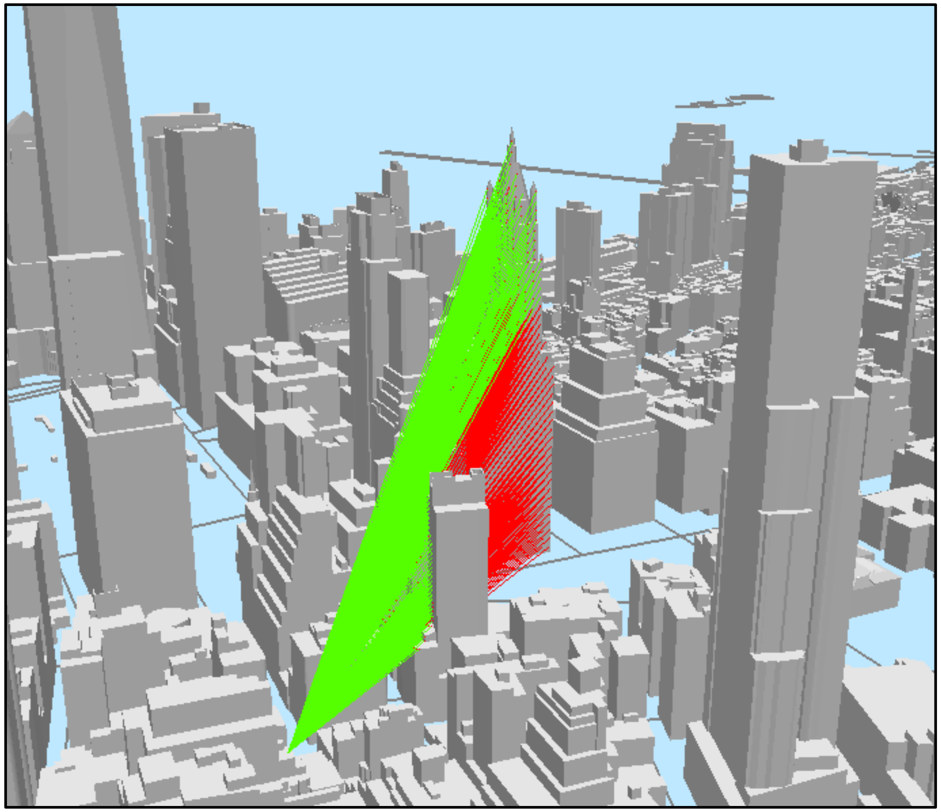
Implementation Example

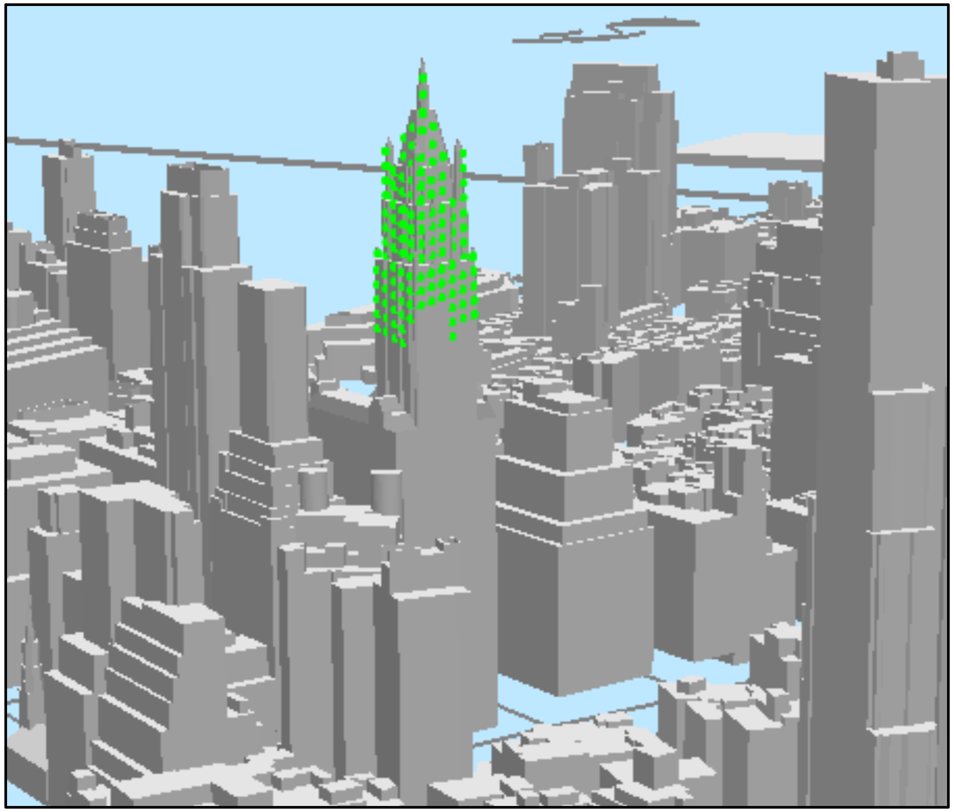


Implementation Results

Visibility Analysis – Woolworth Building, Manhattan, New York

Distance = 500 [m]

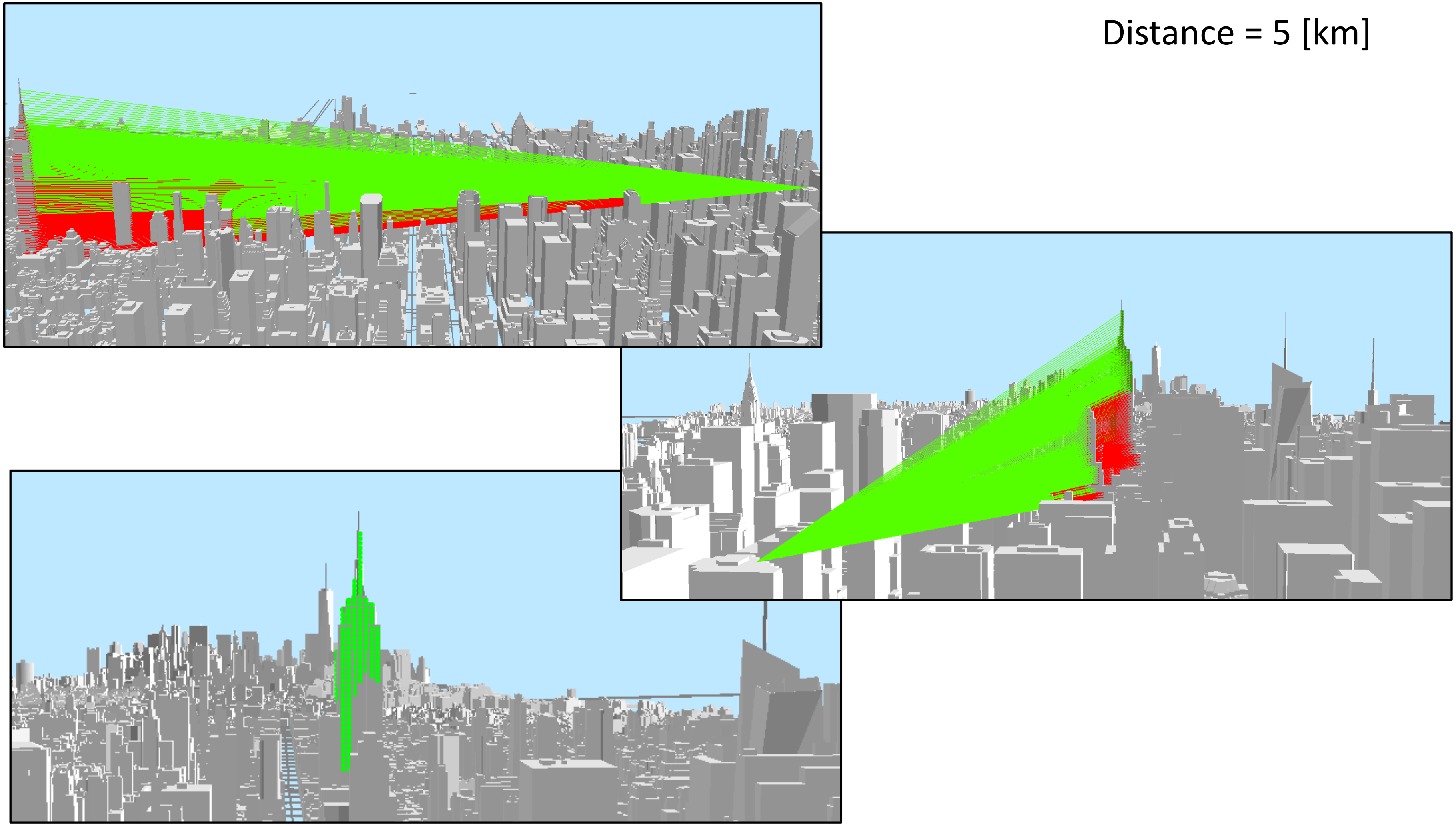




Implementation Results

Visibility Analysis – Empire State Building, Manhattan, New York

Distance = 5 [km]



Results and Reliability Analysis

- For a large database the run time is increased respectively
- The more distant the observer positions are, the runtime increases
- The developed tool worked robustly and accurately, correctly visualizing the viewshed
- The resolution of the point cloud plays a crucial role in the efficiency of the algorithm
- The higher the resolution – the finer the visible and concealed areas calculated

Summary and Conclusions

- The algorithm supports a variety of 3-dimensional objects – this is made possible due to the use of the multipatch format
- The Earth's curvature and refraction corrections are fully supported
- The user chooses the target object, instead of a range of vertical and horizontal angles
- Improve smart cities analyzes, where city models become more complex, detailed and accurate while supporting many formats and having high reliability and accuracy

Thank you !

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