Solar Radiation Rooftop Analysis

A study of the best location for the placement of solar panels on District of Columbia Owned Buildings

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Innovation using Geospatial Data Sets, Techniques, and Technologies to Innovate for a Greener Society

- Leverage existing physical infrastructure
- Innovate on Efficiency
- Provide a common good
- Design a Sustainable Future

Purpose and Outcome
Leaner & Greener Government

- Reduce energy cost (major part of budget)
- Distribute risk across the entire city
- Provide alternative energy to citizens
- Workforce Development for the Green Industry

Goal of the Analysis in This Project

- Determine the best location for the placement of solar panels on District of Columbia owned buildings, in order to generate the largest amount of solar power and get the largest return on investment for the District Government from the installation of solar panels on City owned rooftops.
- This is an NLT, internally funded case study.

Elements Needed For Analyzing The Potential For Solar Power Generation

- ArcGIS
- Property layer with ownership attribute
- Building footprint or rooftop footprint data
- Digital surface model (DSM)
- Spatial Analyst

Building Footprints

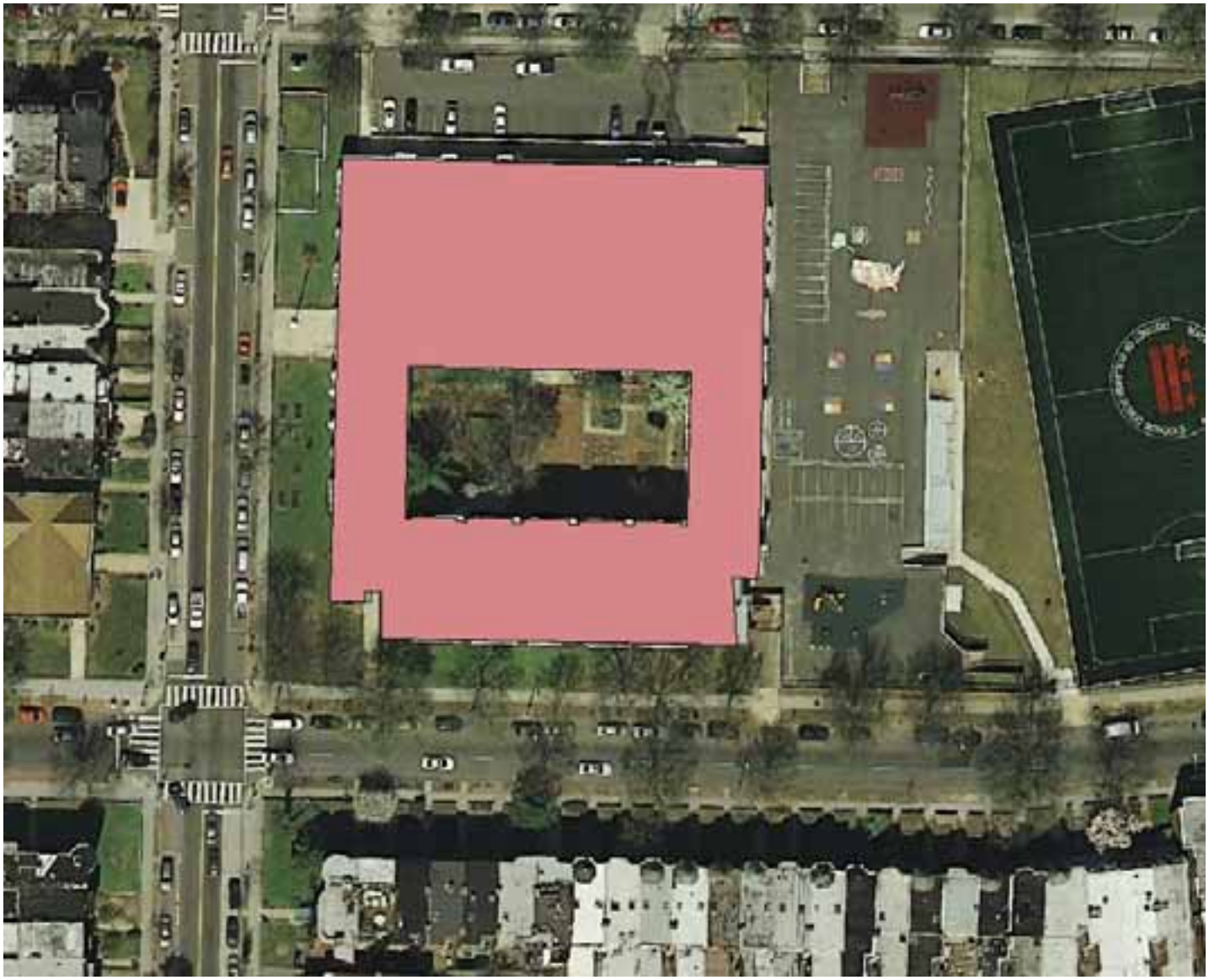
- DC GIS data source
- Planimetric data set
- Polygon representation of all the buildings in the District of Columbia.
- "Planimetric elements are represented on two-dimensional maps as they are seen from the air, or in aerial photography, and often include features such as: roads, building footprints, sidewalks, trails, rivers, lakes, etc. These features are often digitized from orthorectified aerial photography into data layers that can be used in analysis and cartographic outputs." -Wikipedia

Polygon Property Layer

- DC GIS data source
- Citywide data layer that contains the dimensions of all of the properties within the District of Columbia as well as owner and property tax information.
- The data layer was created and is updated by both DC GIS and the District of Columbia Real Property Tax Office.

- Queried the DC GIS “OwnerPly” layer by the “Owner” attribute to select only District owned properties.
- Using this selection, spatially selected all the DC GIS “BuildingPly’s” that were contained in the selected, District Owned, “OwnerPly’s”.
- Created a layer from this selection.
- Queried all “BuildingPly’s” that were contained within the DC GIS “SchoolGroundPly”, to add to the previous selection, because a number of school buildings are located on federal property that the District is leasing from the federal government.

- Created a layer from this selection.
- Selected “UDC” from the DC GIS “UniversityPly”.
- Used this selection to spatially select all of the “BuildingPly’s” that were contained within the “UDC” property poly.
- Created a layer from this selection.
- Used the “Union” tool to create one layer out of the three sets of buildings created from the data manipulation performed above.

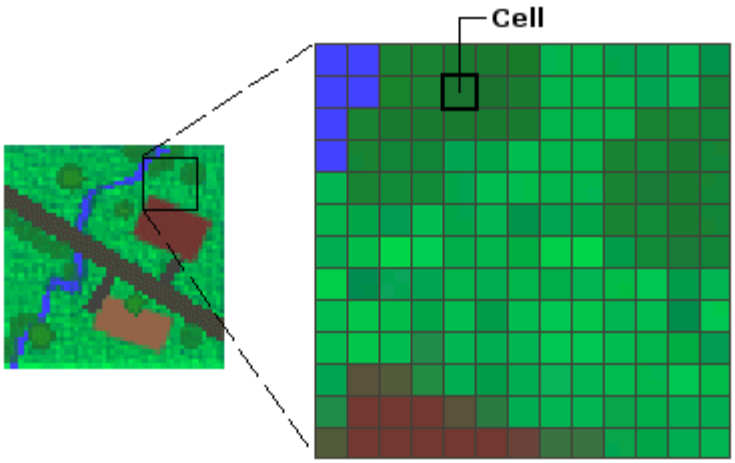


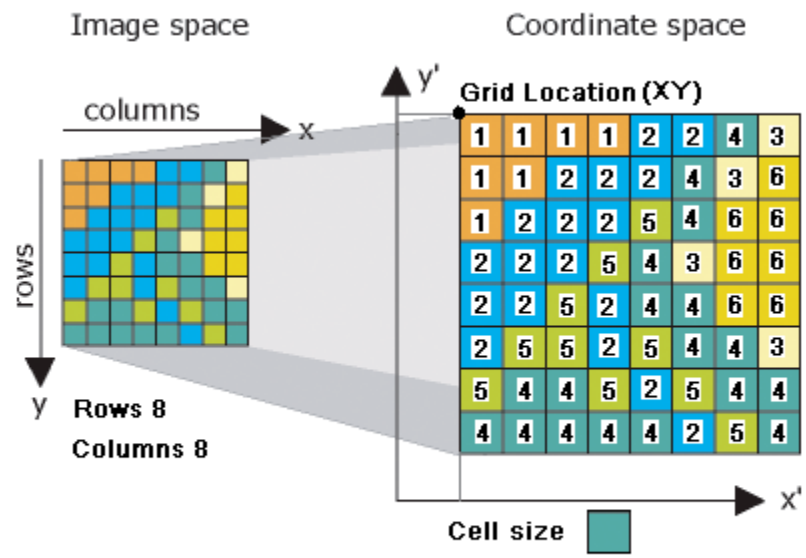
- The layer created from the “Union”, represents all of the building footprints that the District of Columbia Government could potentially install solar panels onto.
- Buffered this “DC Government Owned” building footprint layer by -5 ft. to bring the potential roof area away from the very edge of roofs.

Spatial Analyst

- ESRI extension for creating, analyzing and mapping raster data.
- "In its simplest form, a raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as temperature. Rasters are digital aerial photographs, imagery from satellites, digital pictures, or even scanned maps." -ESRI

ESRI Images of Raster Data



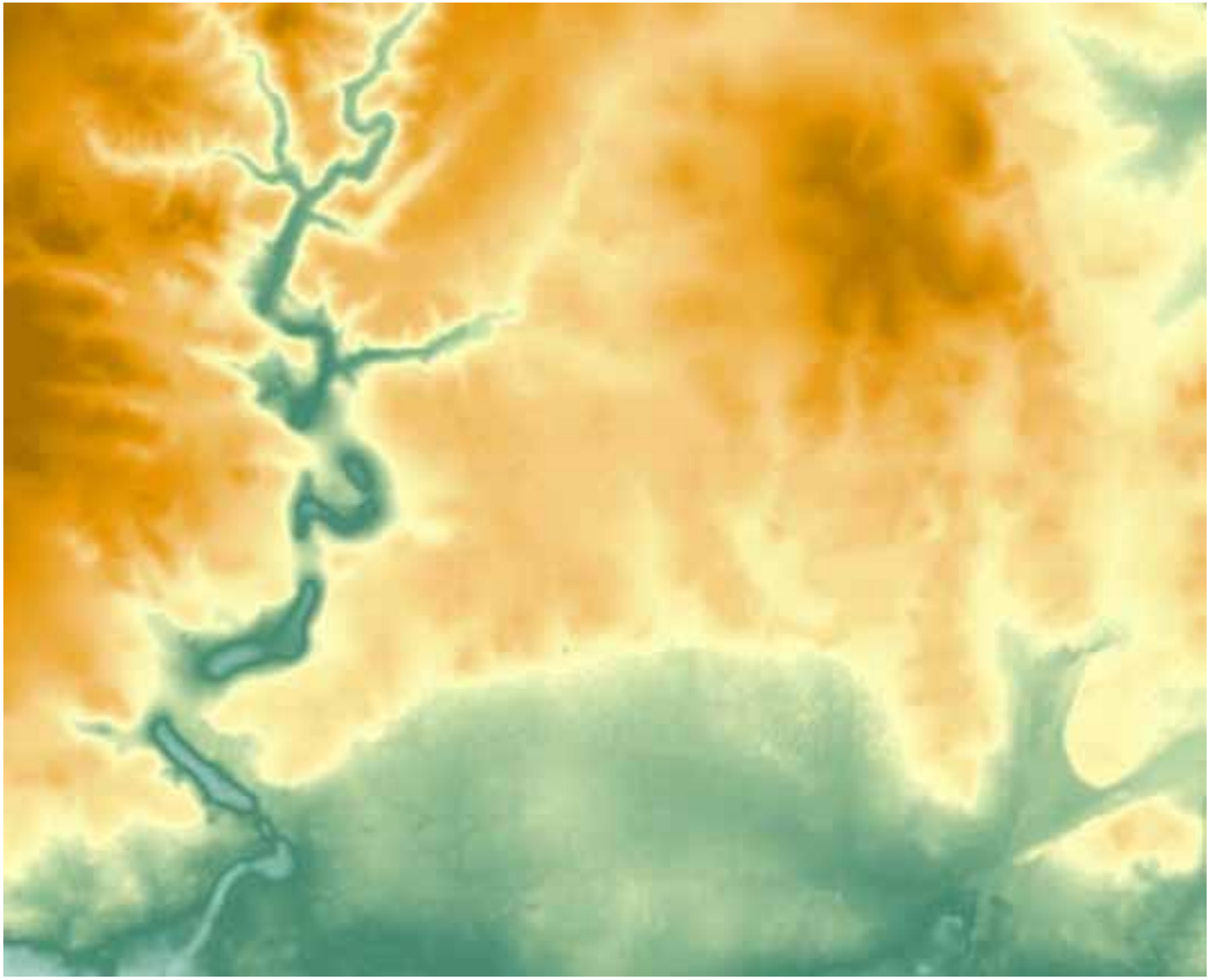


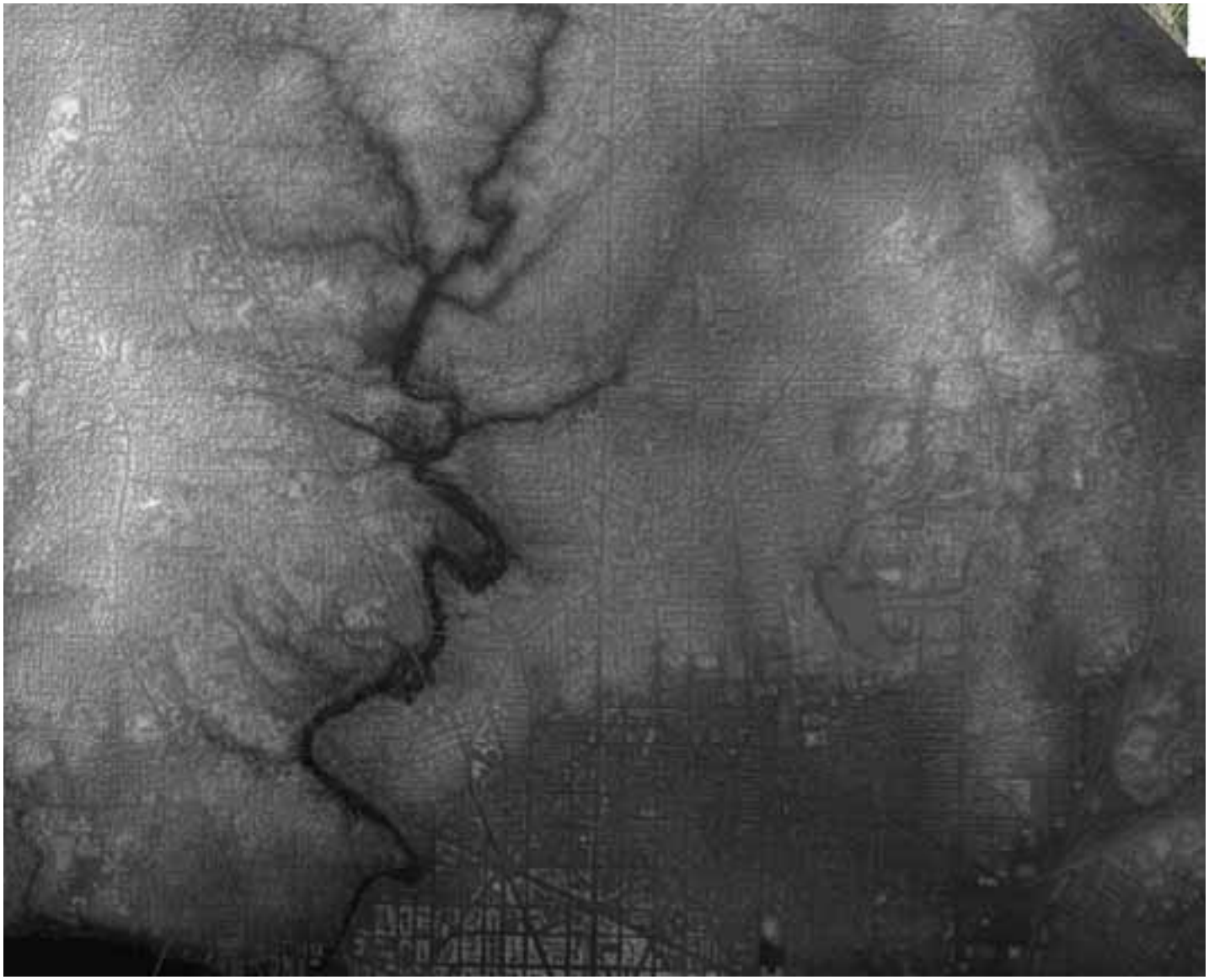
List of cell values

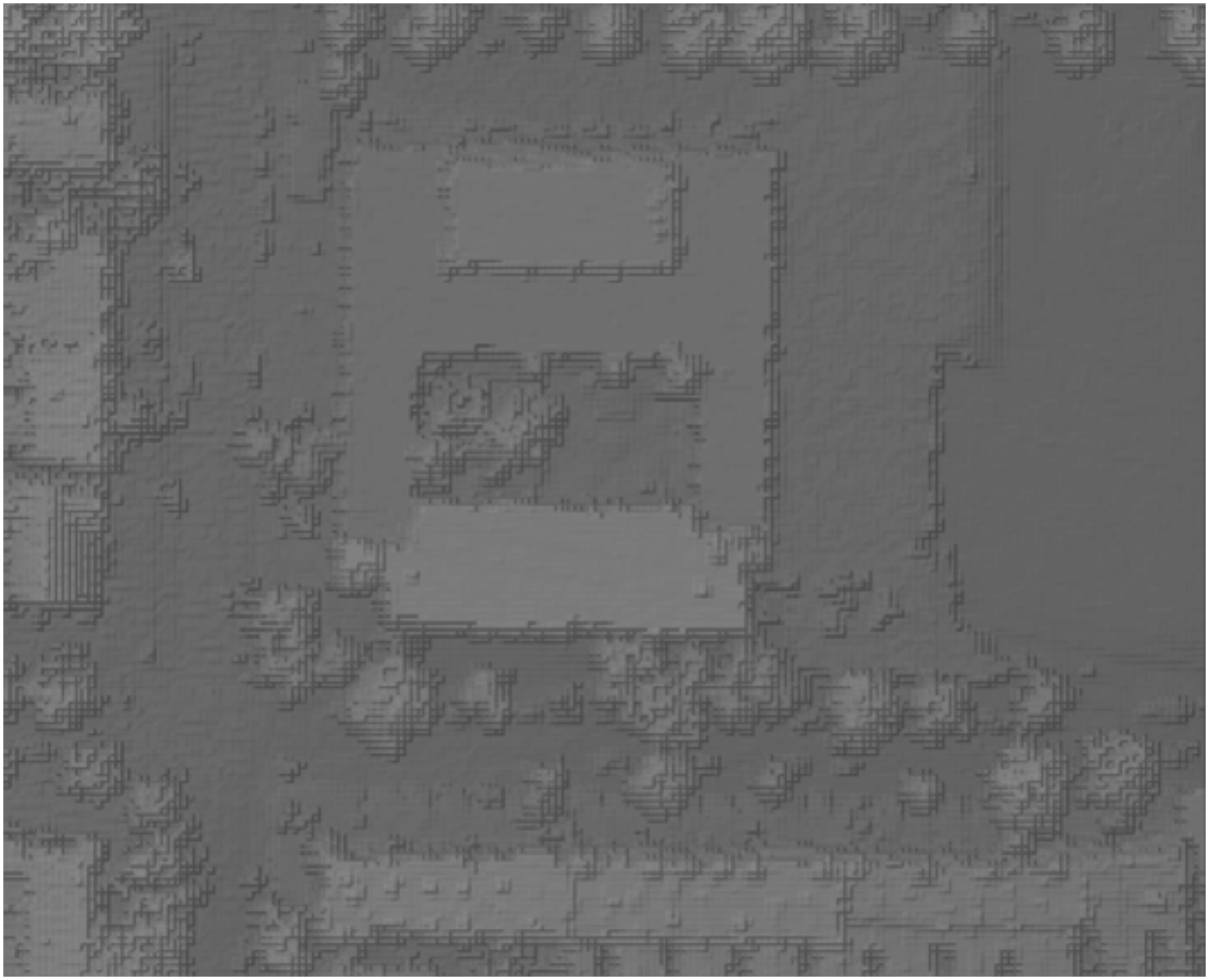
[111122431122243612225466222543662252446625525443544525444444254]

Digital Surface Model

- DC GIS Data Source
- The DC DSM raster data was created from LIDAR Data
- A DSM is a type of DEM; different than a Digital Terrain Model (DTM) in that it includes structures above the ground surface.







ESRI Solar Radiation Tool

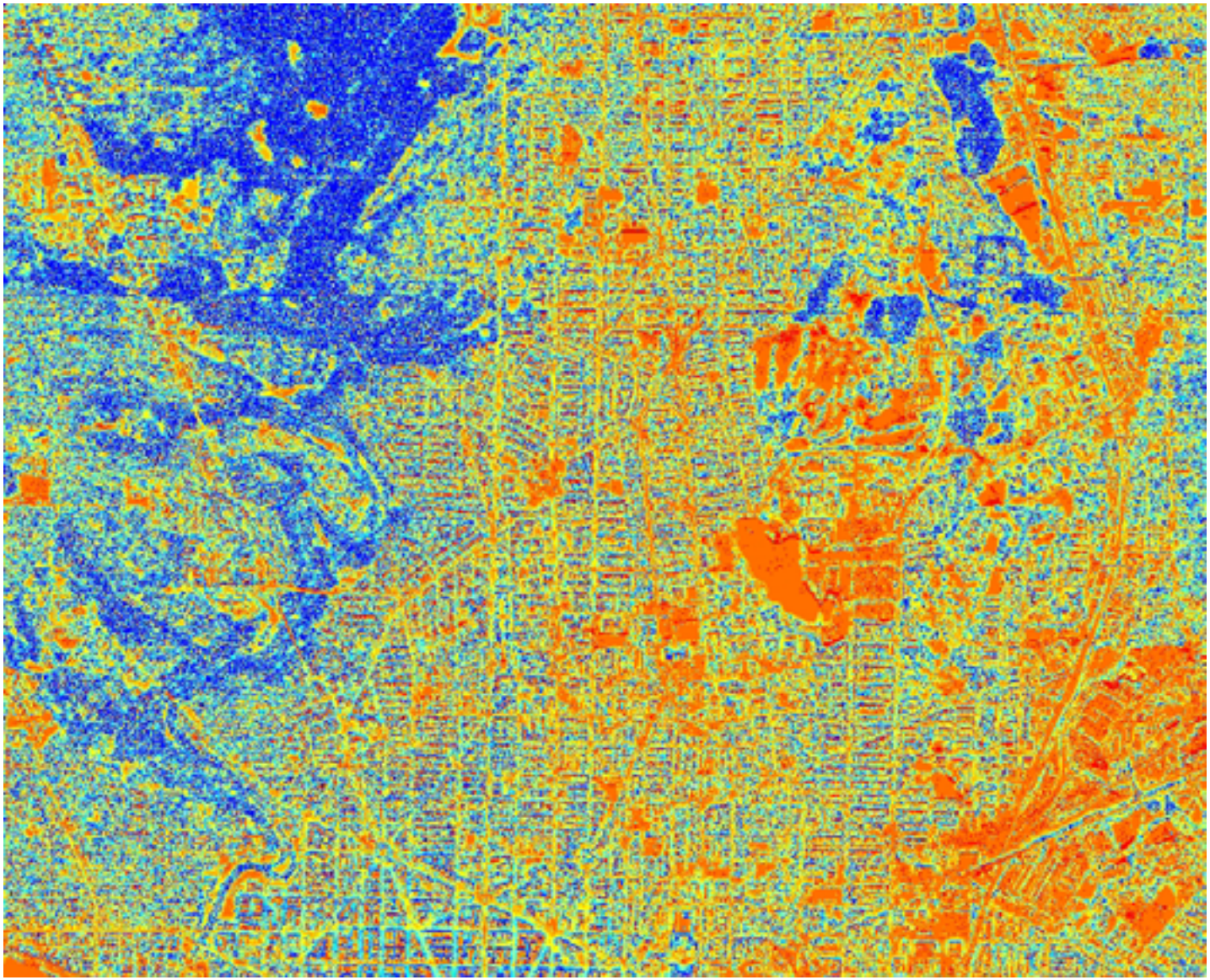
- Spatial Analyst tool that analyses the solar generation potential of an area of a DSM.
- "Area solar radiation analysis is used to calculate the insolation across an entire landscape. The calculations are repeated for each location in the input topographic surface, producing insolation maps for an entire geographic area." - ESRI
- "Insolation is a measure of solar radiation energy received on a given surface area and recorded during a given time." - Wikipedia

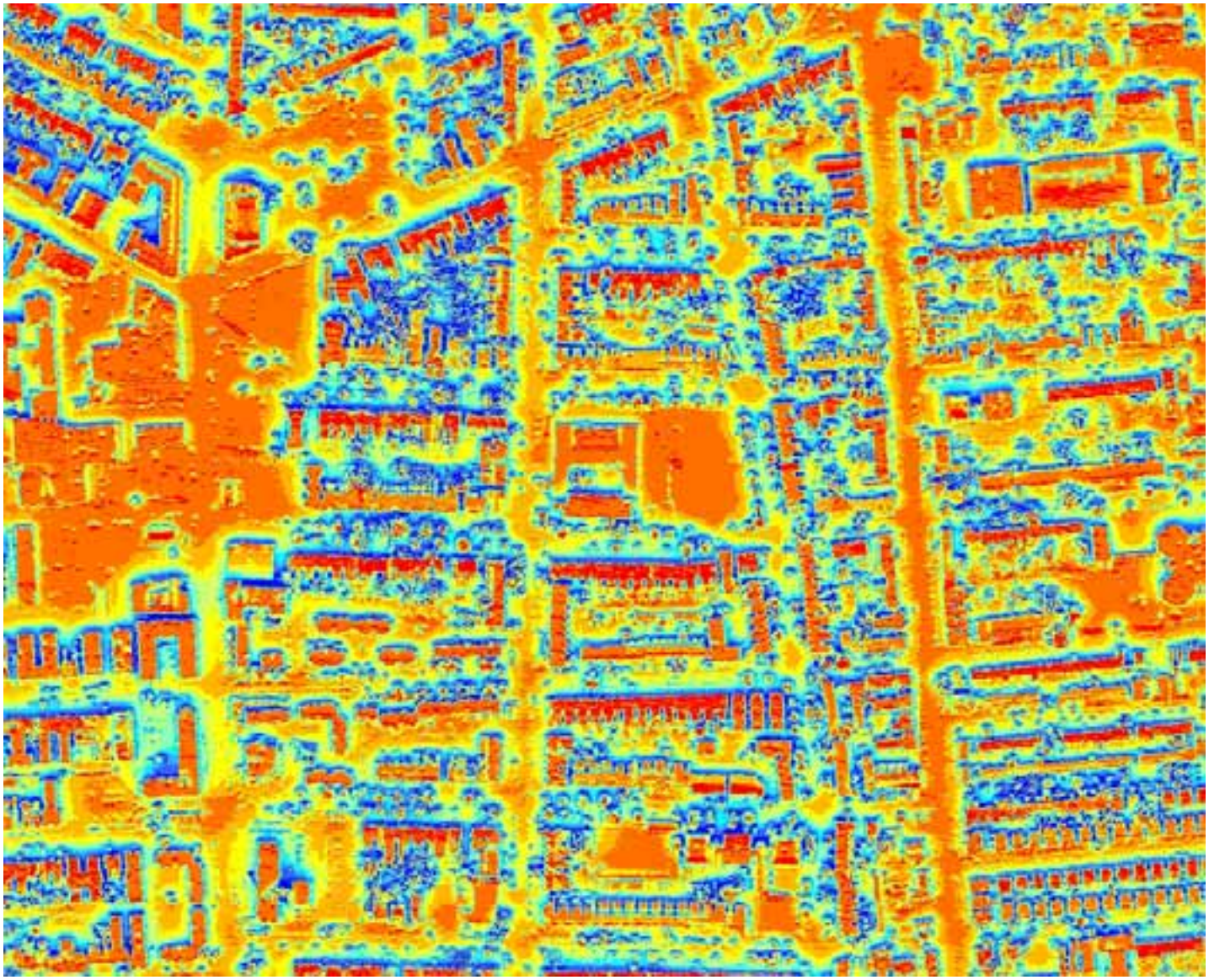
- “The solar radiation analysis tools, in the ArcGIS Spatial Analyst extension, enable you to map and analyze the effects of the sun over a geographic area for specific time periods. It accounts for atmospheric effects, site latitude and elevation, steepness (slope) and compass direction (aspect), daily and seasonal shifts of the sun angle, and effects of shadows cast by surrounding topography.” –ESRI
- Our study looked at the insolation of 1 square meter cells across the entire city over the course of one year

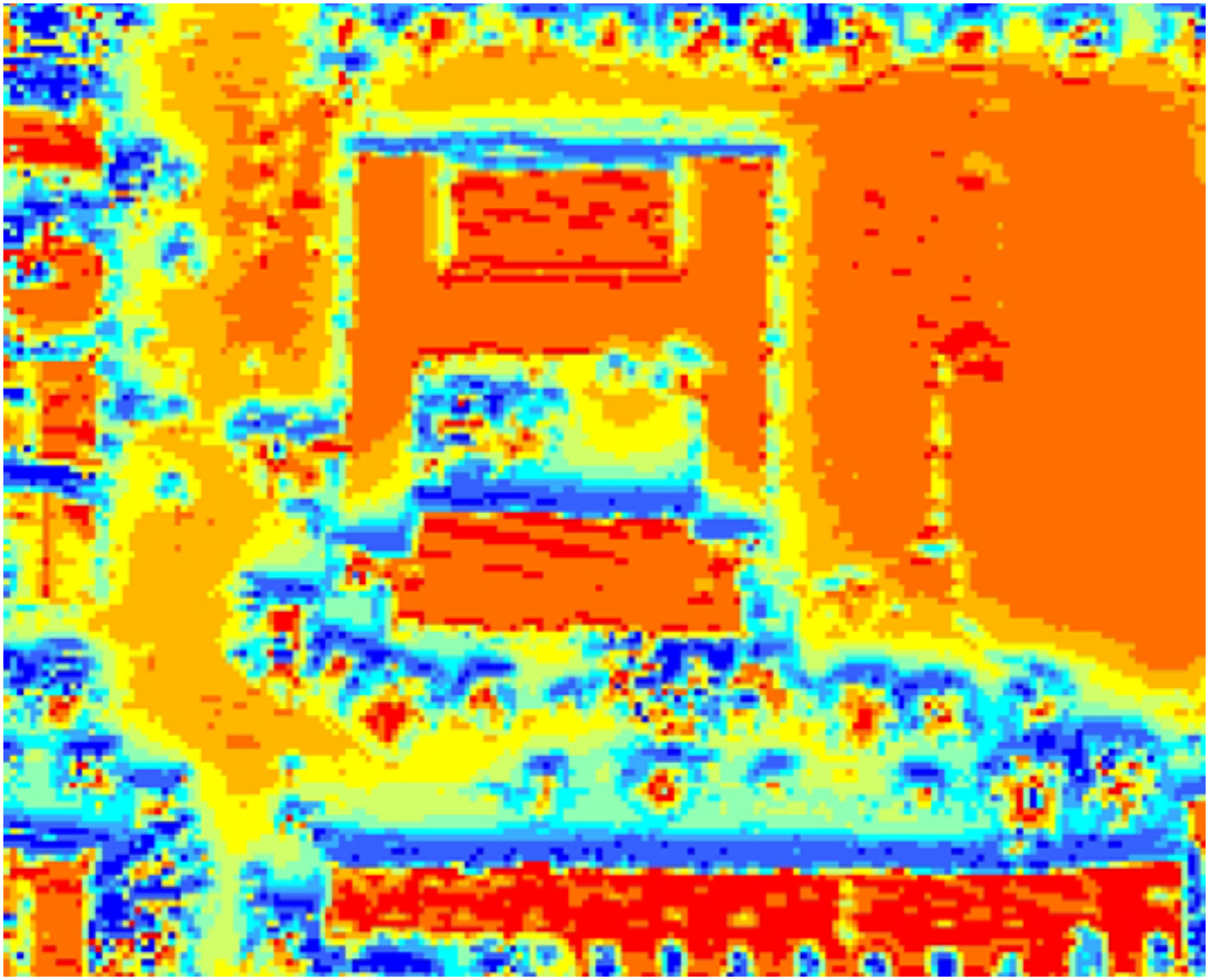
- Ran the solar radiation tool on a small area first to make sure the tool and all of it's inputs and variables was set up correctly.
- This is necessary because the tool takes a long time to run on an area the size of Washington, DC. It took around 15 to 20 hours to run on a machine with a 2.4 GHZ processor with 3.5 GB of RAM.

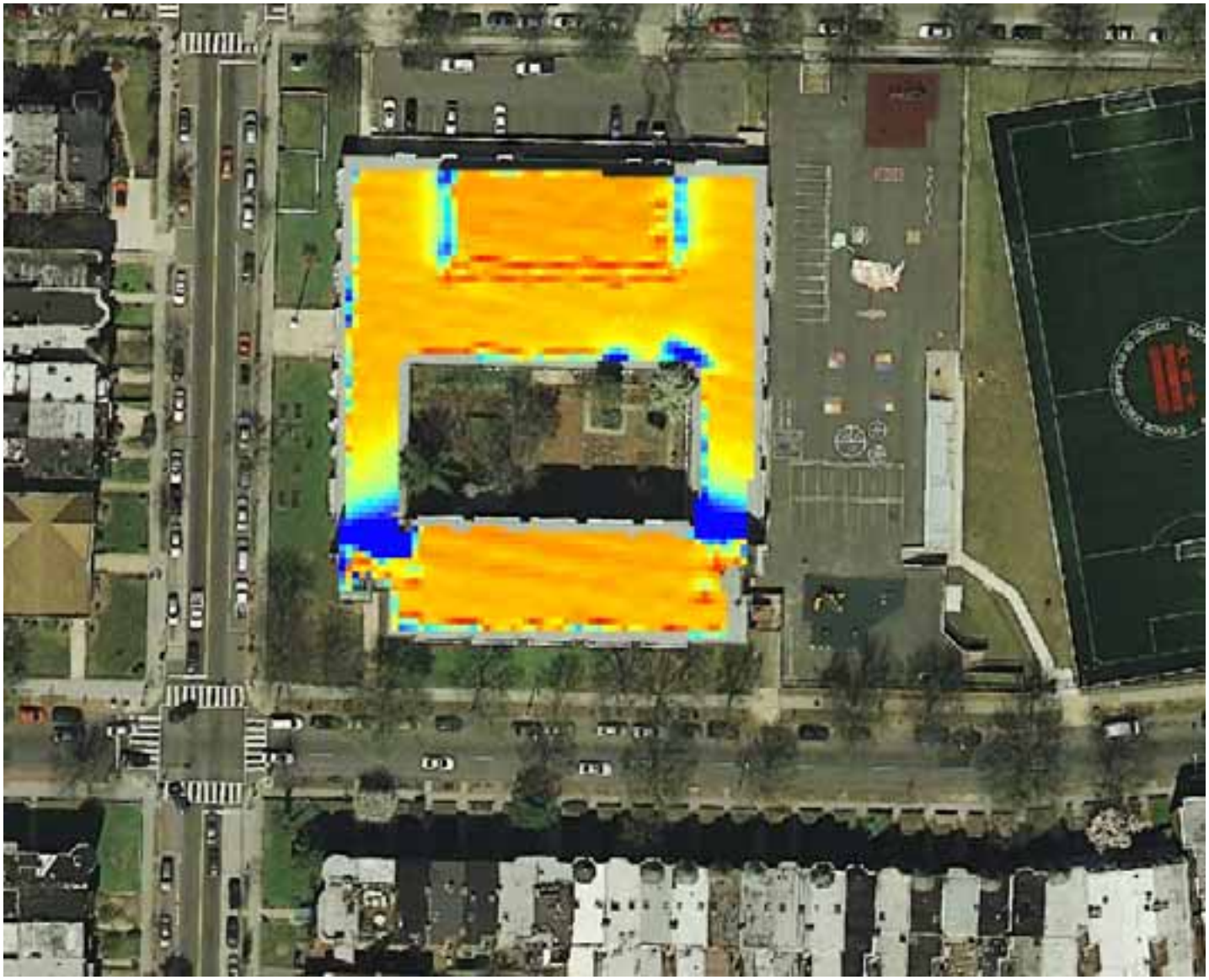
- Before running the tool, all of the citywide DSM's were mosaiced and then clipped with the District Boundary Polygon layer.
- The mosaic was too big to run the Solar Area Tool on.
- Split the mosaic into smaller tiles, so that the Area Solar Radiation tool would not be overwhelmed. In order to accomplish this, used the "Split Raster" tool, using the "Number of Tiles" "Split Method". I used 20 for the number of X coordinate and Y coordinate tiles.

- Ran the “Area Solar Radiation” tool as a batch process on the tiled DC citywide DSM.
- Kept the default settings for the tool, except for the “Time Configuration” setting, which was set to “The Whole Year”.
- Mosaiced the rasters that were produced by the “Area Solar Radiation” tool.
- Clipped the citywide “Area Solar Radiation Mosaic” with the “DC Owned Buildings” polygons that have a -5 buffer on them.







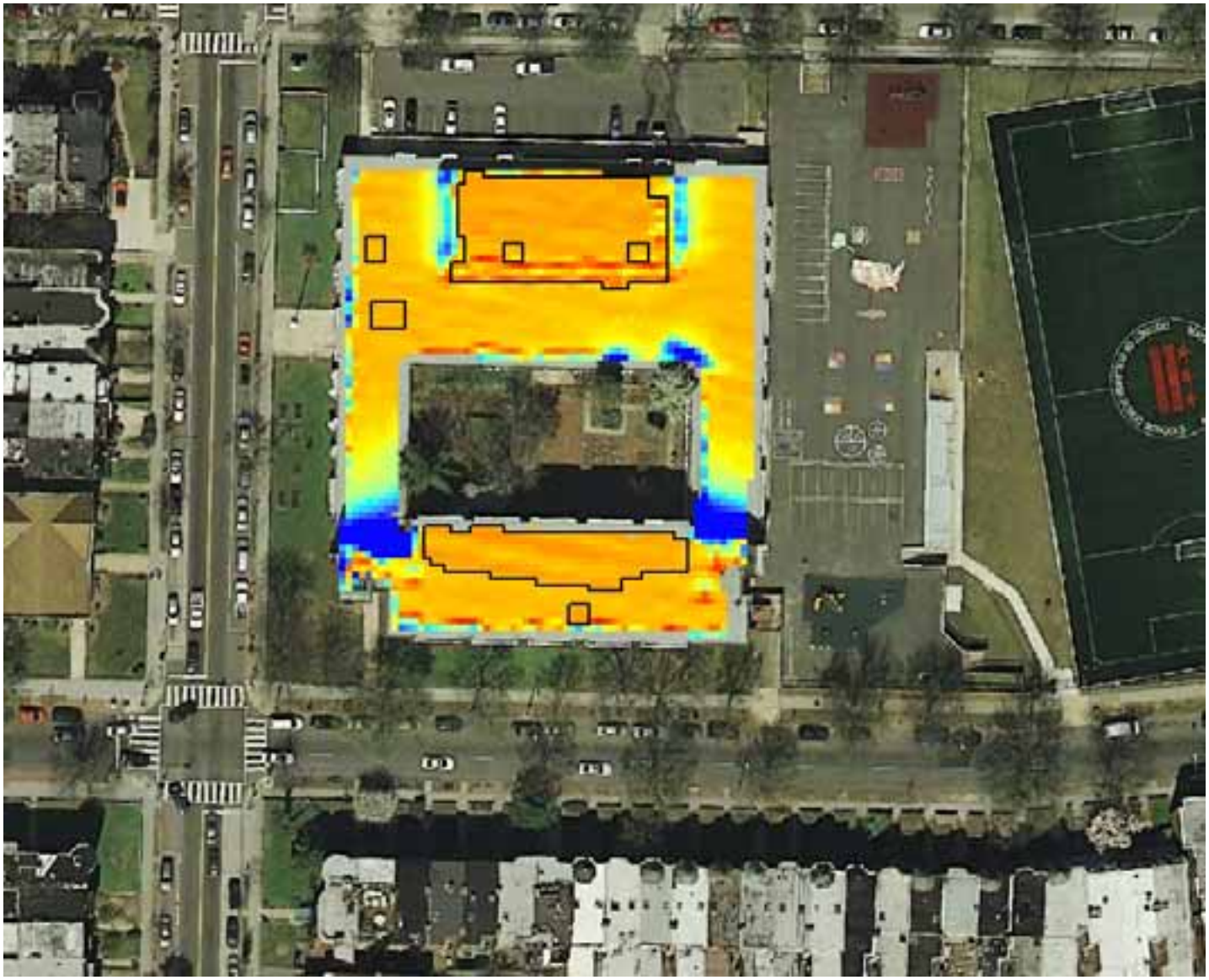


Generalizing and Reclassifying the Solar Radiation Tool's Output

- Reclassified the raster solar roof data of the top 200 DC owned roofs into quintiles, using the "Reclassify" tool.
- Used the "Majority Filter" tool to smooth the results into larger and more uniform blocks of roof. This tool helped to eliminate small holes in areas of high solar radiation and small islands of high solar radiation in the middle of larger low solar radiation areas.

- Converted the reclassified and cleaned raster image to a polygon shapefile, using the "Raster to Polygon" conversion tool.
- Used the "Spatial Statistics", Calculate Area" tool to calculate the areas of the polygons in the newly created polygon layer.
- Selected all of the areas that had an area value of 4 cells, or larger than 4 cells; exported that selection to a new shapefile.

- Converted this altered shapefile, back to raster format to be used as a “Mask” to be used in the “Nibble” generalization tool. The smaller areas that have been queried out of the original raster, and currently have a value of no data, are the areas of the original rather that the “Nibble” tool fills in with neighboring values.
- By using the “Majority Filter” and the “Nibble” tool, small islands of solar radiation values were eliminated and incorporated into neighboring, larger value areas. This smoother and more generalized dataset is more visually appealing and is more practical, in that there are larger zones in which to install solar panels.



Putting The Project On ArcGIS Online

- ArcGIS Online allows you to easily upload and display vector data to a web portal and share that data with groups of people or the public at large.
- ArcGIS Online allows users to symbolize data, including the use of transparencies and pop up windows with attribute and feature information.

- Used the “Zonal Statistics” tool to calculate the sum solar radiation value for each clipped and buffered building polygon area.
- The highest sum values indicate the DC Government roofs that have the most solar energy production potential for the city.
- In order to make the data more manageable and in order for the numbers not to get cut off in the conversion from floating point to an integer dataset, I normalized the roof sum solar radiation results by dividing all the values by the lowest value making the lowest roof solar radiation sum equal one.

- Converted the floating point raster into an integer raster using the Spatial Analyst “Int” tool, in order to be able to convert it into a shapefile.
- Converted the integer raster to a shapefile.
- Selected the top 200 roof sum values and made a new shapefile of that, so that it would fit under the ArcGIS Online 1000 feature limit for unique value symbolization and so it would eliminate all of the smallest buildings.

- Added a short integer field, sorted the table in descending order with the existing solar radiation value and populated the new short integer column with a 1 to 200 column sequence, which was copied from excel and pasted into the ArcGIS layer table. These sequential numbers will be an attribute that ranks the solar radiation potential of a roof from 1 to 200.
- Spatial join with the “Ownerply” layer, in order to get address info in the Attribute table of the top 200 solar roofs for radiation.

- Zipped the shapefile and uploaded it to ArcGIS Online.
- Classified this data into 10 classes using the "Jenks Natural Breaks" classification tool.
- Symbolized the data with a color spectrum that runs from blue, which represents the lowest solar radiation potential, to red, which represents the highest solar generation potential.