Utilizing a Sky View Factor Mapping Algorithm to Predict Intra-Urban Variation of Exposure to Heat Hazards

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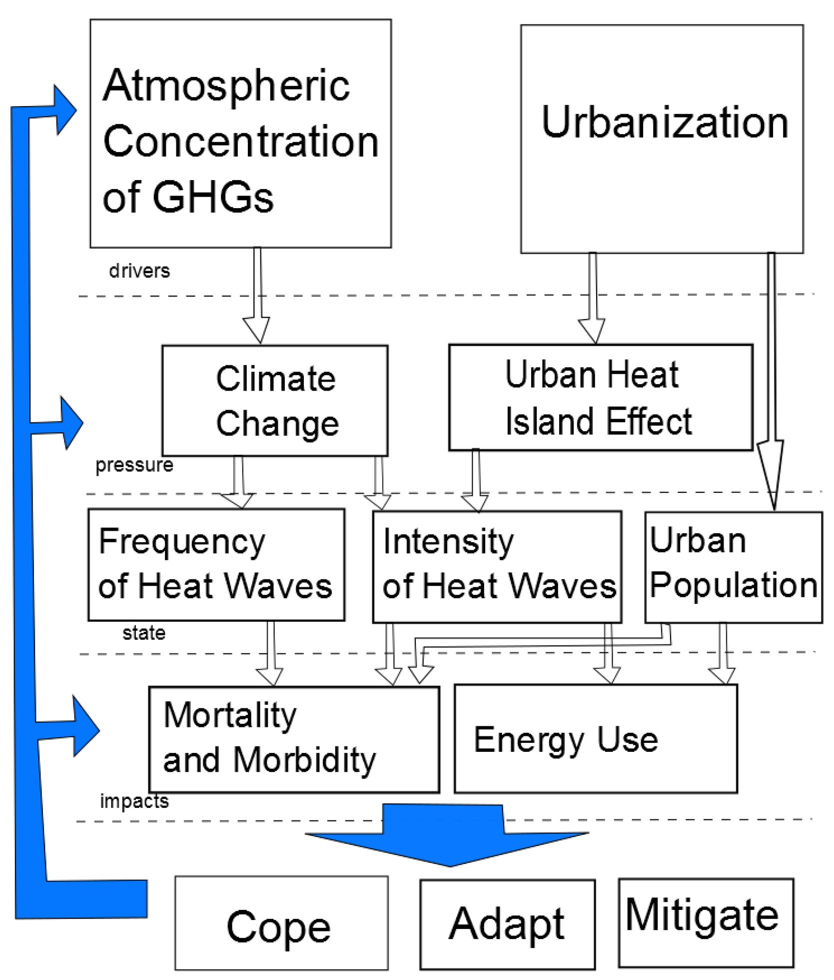
THE UNIVERSITY OF IOWA

GEEMaP Geoinformatics for Environmental and Energy Modeling and Prediction

IGERT Integrative Graduate Education and Research Traineeship

Motivation

Heat waves, or extreme heat events, cause more deaths in the United States than any other natural hazards with at least 1,200 deaths between 2002 and 2011estimates[1]. The DPSIR (driving force, pressure, state, impact, response) model below details the complex interactions that will lead to even greater threat from the hazard off heat in the future:



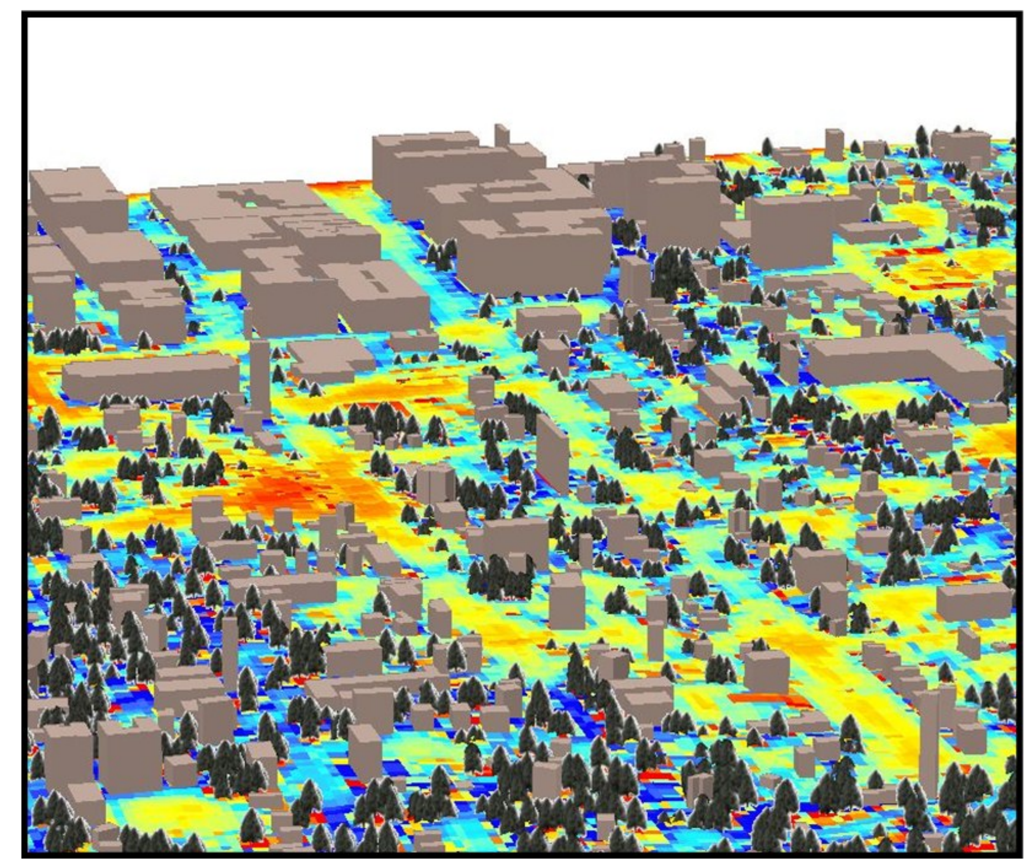
Given the current impact of heat hazards on human health, better methods to predict intra-urban exposure to heat would be useful in targeting strategies to cope and mitigate the negative impacts.

This research looks at one contributing factor to the urban heat island effect, sky view factor (the proportion of unobstructed sky above a location), with the goal of using sky view factor maps to contribute to the planning of heat hazard responses.

Figure 1— The sky view factor of the location shown above would be equal to the area of visible sky divided by the entire area of the circle. Structures such as buildings, trees and hills can reduce sky view factor and impact heat accumulation with in cities

Project Goals

- Develop new algorithm to create sky view factor maps
- Access calculated sky view factor values' ability to predict intra-urban heat exposure



The Algorithm

- Built with Python Scripting language utilizing arcpy library from ArcGIS
- Requires high resolution elevation data in raster/grid format
- Pseudocode shown below:

Step 1: Create a collection of points representing each grid cell in the raster data

Step 2: Break points down into *N* point subsets

Step 3: For each of *N* point subsets perform steps 4 through 11

Step 4: Create a raster catalog with *M* sky view graphics (pixelated version of figure 1), *M* being the total points within a subset

Step 5: Extract pixels representing unobstructed sky from raster catalog

Step 6: For each of *M* sky view graphics, create a table containing the count of pixels

Step 7: For each table other then table 1, append table to table 1

Step 8: Join table 1 to point subset on object id field

Step 9: Create sky view factor field in point subset attribute table

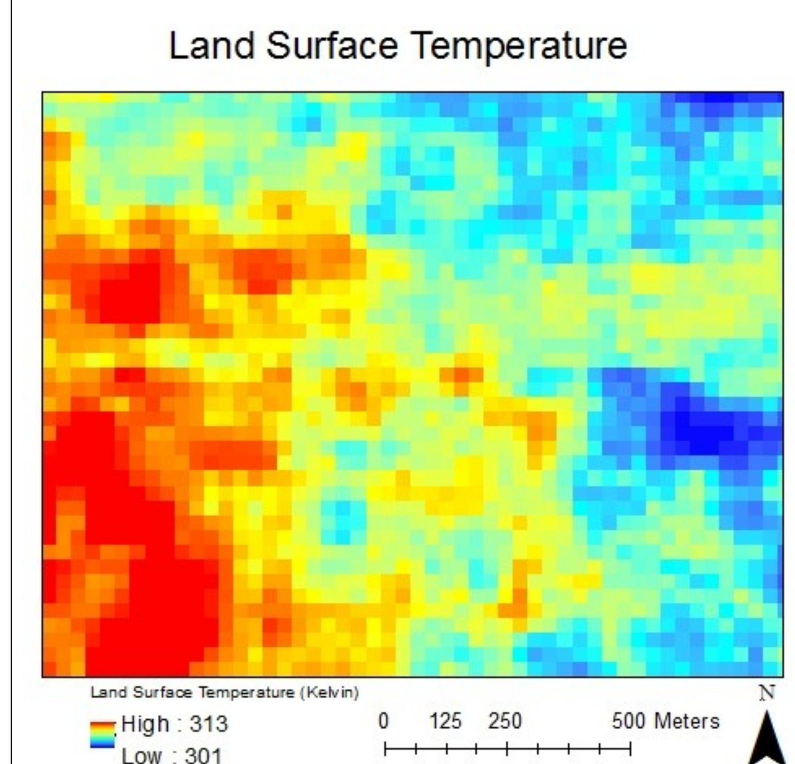
Step 10: Populate the sky view factor field with the value obtained by dividing the count of unobstructed pixels by the maximum possible count of unobstructed pixels

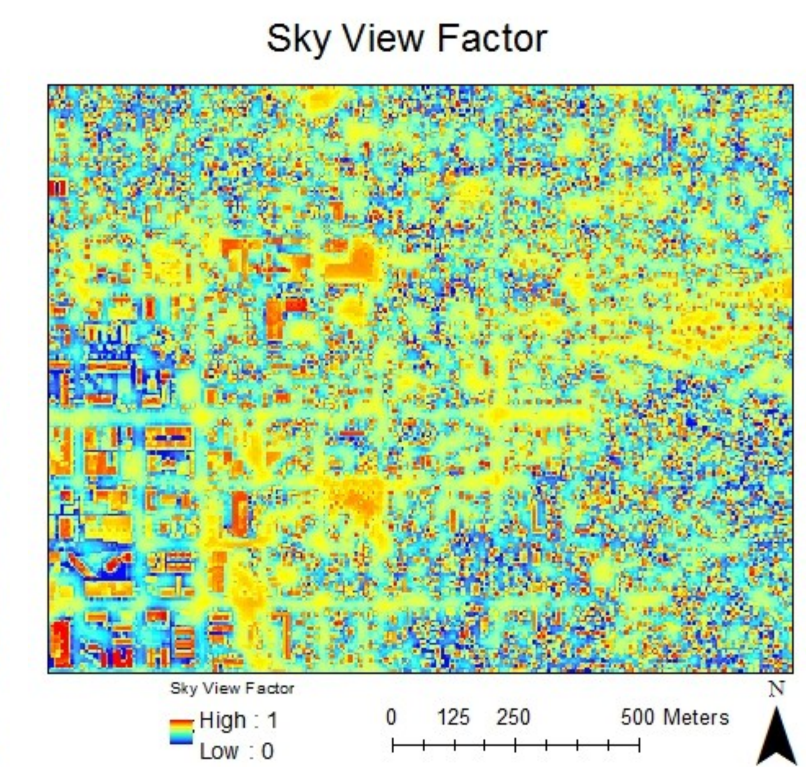
Step 11: Convert the point subset into a raster dataset with sky view factor representing the value

Step 12: Mosaic *N* sky view factor raster datasets into one continuous sky view factor map

Methods

To evaluate the efficacy of using sky view factor as a proxy for temperature exposure, a sky view factor map created for a portion of downtown Iowa City, IA was compared to satellite derived land surface temperature data of the same area. The sky view factor map was scaled up to the same spatial resolution as the land surface temperature map using an averaging filter followed by a nearest neighbor resampling. Land surface temperature was calculated for four different days.





Results

Date	Regression Equation (ºK)	R^2
7/19/2011	Temp = 0.14(SVF) + 297	10.4%
6/1/2012	Temp = 0.10(SVF) + 301	3.6%
8/6/2012	Temp = 0.19(SVF) + 295	47.3%
8/22/2012	Temp = 0.30(SVF) + 290	48.4%
9/23/2012	Temp = 0.24(SVF) + 282	50.7%

Future Research

- Investigate relationship between temperature and sky view factor at different resolutions
- Package algorithm into transferable application
- Develop a spatial heat-risk index
- Parallelize processing of algorithm to speed computation