Technical Document: Using EnviroAtlas Data and Remote-Sensing to Identify Locations for Urban Heat Island Abatement

This document was written to accompany the EnviroAtlas use case: *Using EnviroAtlas to Identify Locations for Urban Heat Island Abatement*.

Data Sources

Weather Underground: https://www.wunderground.com/history/

1. Historical air temperatures for reference location at Portland International Airport


Landsat 8

USGS Earth Explorer: http://earthexplorer.usgs.gov/

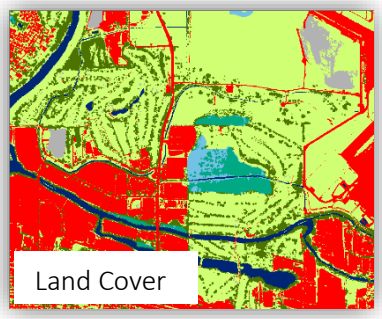
2. Landsat 8 thermal infrared cloud-free images for summer dates in 2013, 2014 and 2015 were downloaded from USGS Earth Explorer. Seven were included in the study.

Table 1. The imagery for seven dates shown in this table were included in the creation of the UHI Index.

USGS File Name	Date	Year	Time (UTC)	Day/Night	Min Temp (deg F)	Max Temp (deg F)
LC80460282013184LGN00	3-Jul-13	2013	18:58	Day	60	85
LC80460282014187LGN00	6-Jul-14	2014	18:55	Day	63	88
LC80460282015190LGN00	9-Jul-15	2015	18:55	Day	62	87
LC80460282013216LGN00	4-Aug-13	2013	18:57	Day	61	89
LC80460282014219LGN00	7-Aug-14	2014	18:55	Day	57	82
LC80460282013232LGN00	20-Aug-13	2013	18:57	Day	57	83
LC80460282015238LGN00	26-Aug-15	2015	18:55	Day	55	90

EnviroAtlas: https://www.epa.gov/enviroatlas

3. Portland, OR Meter-scale Urban Land Cover
4. Estimated percent of tree cover within 26m of a road edge
5. Boundaries for US Census 2010 Block Groups for Portland, OR
6. Population over 70 years old
7. Population under 13 years old


Land Cover

Portland's Metro Data Resource Center: http://www.civicapps.org/datasets

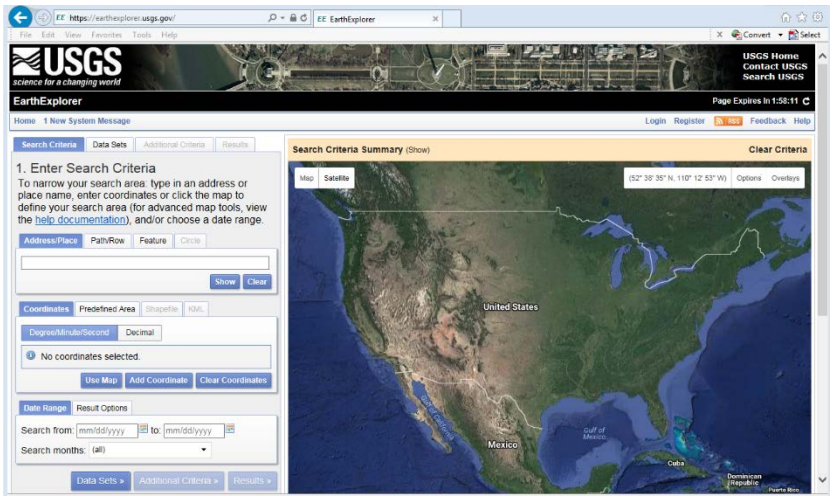
8. Streets (Region)
9. Neighborhood Organizations

National Hydrography Dataset for Oregon: http://nhd.usgs.gov/data.html

10. Streams and Rivers from "NHDArea" shapefile
11. Lakes and Ponds from "NHDWaterbody" shapefile

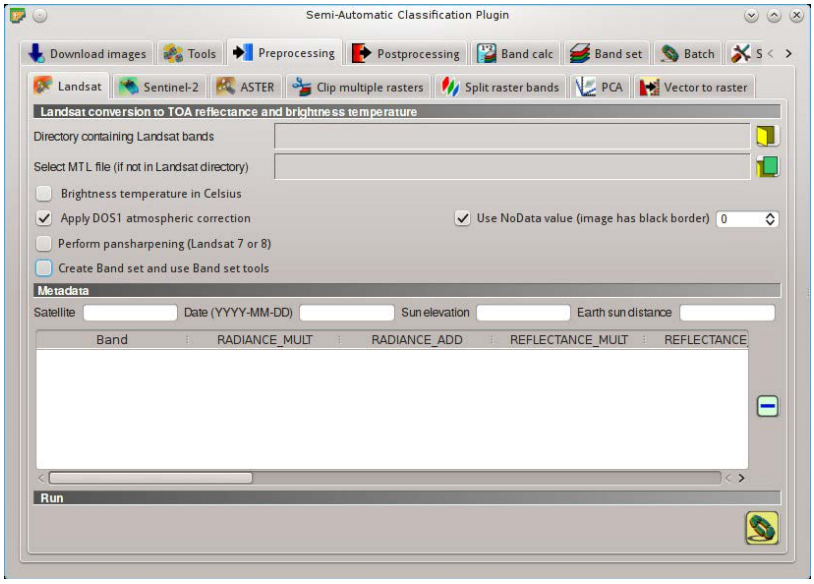
Methods

1. From USGS EarthExplorer, use multiple criteria to select Landsat 8 scenes to include in the analysis:
    a. High maximum air temperature at reference location of Portland International airport (according to Weather Underground's historical record),
    b. Low percent cloud cover over image,
    c. Complete coverage over the study area, and
    d. Collection at the same time of day.



Download Landsat 8 imagery from USGS EarthExplorer.

2. In QGIS, use the Semi-Automatic Classification Plugin
    a. Apply DOS-1 Atmospheric Correction, yielding an image of brightness temperature for band 10, which contains the thermal infrared information.



In QGIS, unpackage the Landsat 8 imagery to yield the brightness temperature for band 10.

3. In ArcGIS, create a raster of emissivity corresponding to land cover
    a. Reclassify Portland 1m land cover TIF to 1m emissivity, using the following emissivity values from Setturu, Rajan and Ramachandra (2013):

Table 1. Surface emissivity values by land cover type, taken from Setturu et al. (2013).

	Land Cover	Emissivity
1	Built-up / Impervious Surfaces	0.946
2	Non-Crop Vegetation	0.985
3	Water	0.990
4	Agriculture	0.974
5	Other	0.950

    b. Aggregate cells, with resulting 30m cells having the mean emissivity of the original 1m cells.
    c. The result is a 30m raster of emissivity, with grid snapped to Landsat raster imagery.
4. In ArcGIS, estimate land surface temperature
    a. Use raster calculator to adjust at-satellite brightness temperature (Kelvin) to land surface temperature (LST; Kelvin).

        From Congedo (2014):

        LST = b / (1 + (10.8 * b / 14380) * ln(a))

        where a is the emissivity raster and b is the brightness temperature raster.

    b. Convert units from Kelvin to Fahrenheit.

5. In ArcGIS, calculate final UHI raster
    a. Remove areas in larger streams, rivers and lakes so that the relative scale is for land areas only.
    b. Selected Forest Park as the location for the reference temperature, due to its high amount of land cover that is natural (given the location).
    c. Rescale each day's LST map by setting the mean temperature of Forest Park to zero, and calculating the difference above and below this reference temperature in degrees F.
    d. Average across the seven LST maps to yield a single map of summer daily UHI index. It displays the average difference from the Forest Park reference LST, i.e. the warming or cooling response of a pixel's LST on a summer day relative to mean LST in Forest Park.
        i. Our daily maps had Forest Park reference temperatures ranging from 67.1 °F to 73.8 °F.
        ii. The mean of the reference temperatures is 70.6 °F.

Resources

Butler, K. (2014). "Deriving temperature from Landsat 8 thermal bands (TIRS)." Retrieved from the ArcGIS Blog from Esri: https://blogs.esri.com/esri/arcgis/2014/01/06/deriving-temperature-from-landsat-8-thermal-bands-tirs/

Congedo, L. (2014). "Estimation of Land Surface Temperature with Landsat Thermal Infrared Band: a Tutorial Using the Semi-Automatic Classification Plugin for QGIS." Retrieved from the From GIS to Remote Sensing Blog: http://fromgistors.blogspot.com/2014/01/estimation-of-land-surface-temperature.html

Setturu, B., Rajan, K. S., & Ramachandra, T. V. (2013). Land surface temperature responses to land use land cover dynamics. *Geoinfor Geostat Overview*, 1, 4.

USGS. (2015). Landsat 8 (L8) Data Users Handbook. Retrieved from https://landsat.usgs.gov/l8handbook_section5.php

Zhou, W., Qian, Y., Li, X., Li, W., & Han, L. (2014). Relationships between land cover and the surface urban heat island: seasonal variability and effects of spatial and thematic resolution of land cover data on predicting land surface temperatures. *Landscape Ecology*, 29(1), 153-167.