A Process for Statistically Modeling Road Surface Temperature Using GIS and Weather Station Input

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Process to correct digital elevation model for forest canopy heights

Eotroads_123.shp
(Hanson roads)

Eotroads_82.shp
(Kingston roads)

Eotroads_231.shp
(Pembroke roads)

Massachusetts
DEM

Landuse2005_POLY_
PLYM.shp
(Land use for
Plymouth County)

Manual selection
of research route

Buffer *(set
distance to 0.5
km)*

Bufferzone0.5

Intersect

Research_route

Extract by Mask

landusebuffer

Extract by Mask *(ensure
that raster analysis is
set to the same
resolution as DEM)*

dembuffer

Polygon to Raster
*(value
field=LUCODE)*

roadelevation

Raster Calculator
*(forestareas+
dembuffer)*

Landuseraster *(may
need to project
raster back to
stateplane GCS)*

Reclassify
*(Lucodes,
3=forest=23 m,
37=forested
wetland=23 m)*

Extract by Mask

demwithtrees

forestareas

roadwithtrees

Raster Calculator
*(roadwithtrees –
roadelevation)*

treeeffect

Raster Calculator
*(demwithtrees –
reclasstree)*

reclasstree

Reclassify
*(no data=0,
23=23, 0=0)*

demsolarready

Area Solar
Radiation

Solaroutput[hour
executed]

Important Considerations

- If a single road is not being focused on, the buffer step can be eliminated. In place of that step would be a merge to combine the three road layers as one. In this case, the Research_route then becomes all roads included in the initial roads layer.
- It is important to note, that the larger the subject area is, the longer it will take for the solar radiation tool to run. One hour of daytime in the model takes approximately 1 hour and 22 minutes to run in ArcGIS when running Area Solar Radiation for all three towns.
- Points solar radiation is much more efficient when trying to extract solar radiation data from individual points.
- There are some flaws with this model which may need to be addressed in the future. All roads in this model are assumed to be 5 meters in width and all forests, 23 meters in height. It is also assumed that forest areas are impenetrable by sunlight which is not always true. There is also the issue of houses and buildings which may be close enough to the road to effect incoming solar radiation on road surfaces.
- Each run of the Area Solar Radiation tool creates an output that is an average based on the given time period. For example, a one year period would produce an output that averages all months together as one.
- Cloudcover can be corrected for by modifying Transmissivity and Diffuse Proportion in the prompt prior to the tool's run.

Data layer Descriptions

Layer name	Type	Description
Eotroads_123.shp	vector	Contains all private and public roads in Hanson, Massachusetts.
Eotroads_82.shp	vector	Contains all private and public roads in Kingston, Massachusetts.
Eotroads_321.shp	vector	Contains all private and public roads in Pembroke, Massachusetts.
MassDEM	raster	Raster layer which contains elevation data for 5x5 m points in Massachusetts
Landuse2005_POLY_PLYM.shp	vector	Polygon file which contains data relating to land use as determined by MassGIS in Plymouth County.
Research_route	vector	A manually selected section of road which is the subject of this road temperature modelling study. Includes ~20 km of Route 14 through the towns Hanson, Pembroke, and Duxbury.
Bufferzone0.5	vector	A 0.5 km buffer surrounding the research route. (able to be modified according to specifications of the study)
dembuffer	raster	An extracted section of the Massachusetts DEM that matches

		the area of Bufferzone0.5
landusebuffer	vector	An extracted section of Landuse2005_POLY_PLYM.shp that matches the area of Bufferzone0.5.
landuseraster	raster	Contains the same data as Landuse2005_POLY_PLYM.shp except in raster form with a resolution of 5,5 meters.
forestareas	raster	A raster depiction of land uses which are considered forested. Land use codes 3 (forest) and 37 (forested wetland) are given values of 23 representing the approximate tree height. All other values are represented by a 0.
demwithtrees	raster	The dembuffer with the heights of trees in forested areas represented on top of the bare earth elevation.
roadelevation	raster	The research route extracted from the Massachusetts DEM layer as a raster.
roadwithtrees	raster	The research route extracted from the demwithtrees layer as a raster. This assumes that the road sits at an elevation equivilant to tree tops. It will be used for calulation purposes.
treeeffect	raster	The result from raster calculator (roadwithtrees – roadelevation) which will be used for calculation purposes. Sections of the research route that pass through forested areas have a height of 23 meters, while all other sections are given values of 0.
reclasstree	raster	Derived from tree effect. A reclassification which adjusts cells with no value to zero.
demsolarready	raster	Derived by using Raster Calculator to subtract reclasstree from demwithtrees. The result displays adjusted elevation which includes tree heights of forested areas and cutouts of roads. This now displays road elevations at their accurate values. This layer is ready to be inputted into the Solar Radiation model.
Solaroutput[hour executed]	raster	The output layer from the Area Solar Radiation model denoted by the hour it was executed during a given day. Displays incoming solar radiation for the buffer area in W/m^2. Through using this process, the effects of forested areas on solar radiation are accounted for.

Tools Descriptions

Tool name	Description
Buffer	A tool to create a polygon which extends a set distance from an input layer. In this case the buffer layer extended 0.5 km from the Research_route.
Extract by Mask	A tool to extract a piece of a raster layer in the same shape as an inputted vector layer.
Intersect	Creates an output that contains features of two layers which overlap.

Polygon to Raster	Converts polygon layers to raster layers.
Raster Calculator	A versatile calculator which can be used to relate different raster layers and/or make calculations with data values in each cell.
Reclassify	Allows the user to alter or classify data values of raster cells in a way that best represents the data they are trying to portray.
Area Solar Radiation	Calculates average incoming solar radiation for a given time of day or year and creates an output in W/m^2 for each raster cell.
Merge	Combines two or more vector layers into one.