**Sharpen ECOSTRESS 70m land surface temperature to 30m resolution using Landsat 8 Surface Reflectance Data**

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**Extract ECOSTRESS LST data from AppEEARS**

<https://lpdaacsvc.cr.usgs.gov/appeears/>

Extract – Area sample

Start new request

Draw vector polygon of chosen area/city

Select time range (e.g. summertime, Jul-Sep 2019), or a preferred date that you have selected by looking at browse images in https://ecostress.jpl.nasa.gov/gmap/eco\_map2

Select layer, enter: ECO2LSTE in search

Select band SDS\_LST by clicking the + symbol to populate selected layers

File format: geoTIFF

Projection: Geographic (WGS84)

SUBMIT

**Extract Landat 8 surface reflectance data from AppEEARS**

Extract – Area sample.

Copy a previous request (from above)

Select at least 3 months of data bracketing the ECOSTRESS date range because Landsat 8 only acquires data once very 16 days for a given location on earth.

*\*NOTE: see Appendix A for using EarthExplorer to search and browse for Landsat 8 clear-sky images over selected polygon/city.*

Select layer: Landsat ARD CONUS Landsat 8 Surface Reflectance

Select bands SRB1 – SRB7 (bands 1-7 reflectances).

File format: geoTIFF

Projection: Geographic

SUBMIT

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**Calculate Landsat 8 Normalized Difference Vegetation Index (NDVI) and Albedo**

MATLAB code (can be converted to R or Python using conversion tools available online):

% Define folder where Landsat .tif data resides, e.g.

tfolder = ‘F:\ECOSTRESS\Urban Hackathon\’;

% Get band 2 reflectance (blue, 0.45-0.515 micron)

filest = dir([tfolder,'\*\_band2.TIF']);

fileband2 = [tfolder,filest(1).name];

SRB2 = geotiffread(fileband2);

SRB2 = double(SRB2); % convert to double precision

% Scale

SRB2 = SRB2.\*0.0001;

SRB2 = single(SRB2);

% Get band 3 reflectance (green, 0.533-0.590 micron)

filest = dir([tfolder,'\*\_band3.TIF']);

fileband3 = [tfolder,filest(1).name];

SRB3 = geotiffread(fileband3);

SRB3 = double(SRB3);

% Scale

SRB3 = SRB3.\*0.0001;

SRB3 = single(SRB3);

% Get band 4 reflectance (red, 0.63-0.68 micron)

filest = dir([tfolder,'\*\_band4.TIF']);

fileband4 = [tfolder,filest(1).name];

SRB4 = geotiffread(fileband4);

SRB4 = double(SRB4);

% Scale

SRB4 = SRB4.\*0.0001;

SRB4 = single(SRB4);

% Get band 5 reflectance (NIR, 0.845-0.885 micron)

filest = dir([tfolder,'\*\_band5.TIF']);

fileband5 = [tfolder,filest(1).name];

SRB5 = geotiffread(fileband5);

SRB5 = double(SRB5);

% Scale

SRB5 = SRB5.\*0.0001;

SRB5 = single(SRB5);

% Get band 6 reflectance (SWIR, 1.560-1.660 micron)

filest = dir([tfolder,'\*\_band6.TIF']);

fileband6 = [tfolder,filest(1).name];

SRB6 = geotiffread(fileband6);

SRB6 = double(SRB6);

% Scale

SRB6 = SRB6.\*0.0001;

SRB6 = single(SRB6);

% Get band 7 reflectance (SWIR2, 2.107-2.294 micron)

filest = dir([tfolder,'\*\_band7.TIF']);

fileband7 = [tfolder,filest(1).name];

SRB7 = geotiffread(fileband7);

SRB7 = double(SRB7);

% Scale

SRB7 = SRB7.\*0.0001;

SRB7 = single(SRB7);

%% NDVI

NDVI = double((SRB5-SRB4)./(SRB5+SRB4));

% Albedo

Albedo = ((0.356\*sr2) + (0.130\*SRB4) + (0.373\*SRB5) + (0.085\*SRB6) + (0.072\*SRB7) -0.0018)./1.016;

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**Sharpening code:**

**NOTE: see Dominguez et al. 2011 for background on thermal sharpening and the High-resolution urban thermal sharpener (HUTS)** <https://doi.org/10.1016/j.rse.2011.03.008>

% Read ECOSTRESS LST geotiff file. This is the native resolution (70m) ECOSTRESS LST data extracted from AppEEARS over the same area polygon you selected for the Landsat 8 data, e.g.

fileLST\_ECO = ‘F:\ECOSTRESS\Urban Hackathon\ECO2LSTE.001\_SDS\_LST\_doy2019152064322\_aid0001.tif’;

[LST,Rinfo] = geotiffread(fileLST\_ECO,1);

LST = double(LST).\*0.02;

% Get lat, lon limits

lonmin = Rinfo.LongitudeLimits(1);

lonmax = Rinfo.LongitudeLimits(2);

latmin = Rinfo.LatitudeLimits(1);

latmax = Rinfo.LatitudeLimits(2);

% Resize Landsat-8 30m data to ECOSTRESS 70m

res = size(LST);

NDVItir = imresize(NDVI,res);

Albedotir = imresize(Albedo,res);

% Fitting coefficients that model LST using albedo and NDVI variables

xt = [318.5394 47.4863 -18.7976 -213.0017 23.6037 -148.3736 251.8148 -15.4255 373.1151 306.5941 -62.2609 -6.1342 -509.3209 -253.0092];

% low res LST fit

fitt1 = xt(1) + xt(2).\*Albedotir + xt(3).\*NDVItir + xt(4).\*Albedotir.^2 + xt(5).\*NDVItir.^2 + xt(6).\*NDVItir.\*Albedotir + xt(7).\*Albedotir.^3 + xt(8).\*NDVItir.^3 + xt(9).\*NDVItir.\*Albedotir.^2 +xt(10).\*NDVItir.^2.\*Albedotir + xt(11).\*Albedotir.^4 + xt(12).\*NDVItir.^4 + xt(13).\*NDVItir.\*Albedotir.^3 + xt(14).\*NDVItir.^3.\*Albedotir;

% diff between observed and low res fit

tdiff = LST-fitt1;

% Smoothing (NOTE: this is a crucial step and needs to be performed to get accurate results)

% NOTE: you can also use Matlab smooth2a function available from MathWorks

% Building matrices that will compute running sums. The left-matrix, eL, smooths along the rows. The %right-matrix, eR, smooths along the columns. You end up replacing element "i" by the mean of a %(2\*Nr+1)-by- (2\*Nc+1) rectangle centered on element "i".

matrixIn = tdiff;

N(1) = 2; N(2) = 2; % Smooth over 2x2 pixels

[row,col] = size(matrixIn);

eL = spdiags(ones(row,2\*N(1)+1),(-N(1):N(1)),row,row);

eR = spdiags(ones(col,2\*N(2)+1),(-N(2):N(2)),col,col);

% Setting all "NaN" elements of "matrixIn" to zero so that these will not

% affect the summation. (If this isn't done, any sum that includes a NaN

% will also become NaN.)

A = isnan(matrixIn);

matrixIn(A) = 0;

% For each element, we have to count how many non-NaN elements went into

% the sums. This is so we can divide by that number to get a mean. We use

% the same matrices to do this (ie, "eL" and "eR").

nrmlize = eL\*(~A)\*eR;

nrmlize(A) = NaN;

matrixOut = eL\*matrixIn\*eR;

matrixOut = matrixOut./nrmlize;

tdiff\_lr = matrixOut;

% high res sharpening LST fit

fitt2 = xt(1) + xt(2).\*Albedo + xt(3).\*NDVI + xt(4).\*Albedo.^2 + xt(5).\*NDVI.^2 + xt(6).\*NDVI.\*Albedo + xt(7).\*Albedo.^3 + xt(8).\*NDVI.^3 + xt(9).\*NDVI.\*Albedo.^2 +xt(10).\*NDVI.^2.\*Albedo + xt(11).\*Albedo.^4 + xt(12).\*NDVI.^4 + xt(13).\*NDVI.\*Albedo.^3 + xt(14).\*NDVI.^3.\*Albedo;

tdiff\_hr = imresize(tdiff\_lr,size(fitt2),'nearest');

% Final 30m sharpened LST

LSTsharp = fitt2 + tdiff\_hr;

% Output the final sharpened LST at 30m resolution to a geotiff so you can read in e.g. QGIS

latlim = [latmin latmax];

lonlim = [lonmin lonmax];

rasterSize = size(LSTsharp);

R = georefcells(latlim,lonlim,rasterSize,'ColumnsStartFrom','north');

fileswrite = ' F:\ECOSTRESS\Urban Hackathon\ECO2LSTE.001\_SDS\_LST\_doy2019152064322\_sharp.tif’; geotiffwrite(fileswrite,LSTsharp,R);

**Appendix A**

Search for clear-sky Landsat 8 images over target region.

<https://earthexplorer.usgs.gov/>

Polygon – Use Map

Select polygon and corner coordinates of area of interest

Date range: enter range of dates (e.g. you want at least 2-3 months bracketing ECOSTRESS observation).

Datasets-> Landsat -> Landsat Collection 2 Level-1 -> Landsat 8 OLI/TIRS C2 L1

Additional Criteria -> Land Cloud Cover. Enter e.g. 0 – 20% or whatever cloud tolerance you prefer but you need clear-sky data over the target area/city to perform the sharpening with landsat 8 data

Results ->

You will see a list of Landsat 8 scenes meeting the criteria above.

Click on an image thumbnail in the list to see a larger visible browse image and make a determination if the scene is clear enough to use for the sharpening.