

Compute LST and NDVI in NYC for Landsat 5

Introduction

In this notebook, we compute LST for the New York City using *Landsat 5* data that is clipped to NYC boundaries. (Another notebook is used to compute LST with Landsat 8 data.) To compute LST, we follow the procedure outlined in Using McConnell's 2022 paper. The steps are

- Convert Band 6 to Top of Atmosphere (TOA) spectral radiance using two constants from Landsat metadata
- Compute brightness temperature using TOA and 2 constants from metadata
- Compute NDVI using

$$\frac{\text{NIR} - \text{Red}}{\text{NIR} + \text{Red}} = \frac{\text{Band 4} - \text{Band 3}}{\text{Band 4} + \text{Band 3}} \quad (1)$$

- Convert NDVI to vegetation fraction
- Compute emissivity using the formula specified in McConnell's paper
- Compute LST using brightness temperature, emissivity, and some constants also specified in McConnell's paper

The contents of this notebook are the following.

- In [Section 1](#), we define functions to compute the outlined procedure
- In [Section 2](#) we test the procedure on a single Landsat file and plot the result.
- In [Section 3](#) we compute LST and NDVI for all the Landsat files and export results.

Results

LST and NDVI are computed in this notebook and exported for later use. A heatmap of LST/NDVI can be generated in [Section 2](#).

Data

The data imported into this notebook is clipped Landsat data located in `02-data/landsat_clipped_nyc/`. These are raster files saved in `.tif` format. We import the files relevant to LST calculations with Landsat 5, which are bands 3, 4, and 6.

Data is exported to the folders `02-data/ndvi_clipped_nyc` and `02-data/lst_clipped_nyc`. The exported filenames contain the parameter computed with the original Landsat filename. For example, the file

`ndvi_LT05_L1TP_013032_19910801_20160929_01_T1.tif` contains the NDVI calculation in NYC for the Landsat file listed.

```
In [1]: import os
DIR_PARENT = os.path.abspath(os.path.join(os.getcwd(), os.pardir))
DIR_SCRIPTS = DIR_PARENT + "/01-scripts"

"""Push the directory to load helper scripts from"""
import sys
sys.path.append(DIR_SCRIPTS)

import helpers

import rioxtarray as rxr
import xarray as xr
import numpy as np

# For plotting
import matplotlib.pyplot as plt

# Import directories
DIR_DATA = DIR_PARENT + "/02-data"
DIR_RAW_CLIPPED_NYC = DIR_PARENT + "/02-data/landsat_clipped_nyc"

# Export directories
DIR_NDVI_CLIPPED_NYC = DIR_PARENT + "/02-data/ndvi_clipped_nyc"
DIR_LST_CLIPPED_NYC = DIR_PARENT + "/02-data/lst_clipped_nyc"
DIR_FIGS = DIR_PARENT + "/03-figs"
```

1. Import data and define functions

```
In [2]: landsat_filenames = []
helpers.get_filenames(DIR_RAW_CLIPPED_NYC, landsat_filenames)
landsat_filenames.sort()

# Filter clipped Landsat files by band
band3_filenames = [x for x in landsat_filenames if ("B3" in x and "LT05" in x)]
band4_filenames = [x for x in landsat_filenames if ("B4" in x and "LT05" in x)]
band6_filenames = [x for x in landsat_filenames if ("B6" in x and "LT05" in x)]

band3_filenames.sort()
band4_filenames.sort()
band6_filenames.sort()

print("Number of B3 files = ", len(band3_filenames))
print("Number of B4 files = ", len(band4_filenames))
print("Number of B6 files = ", len(band6_filenames))

def get_original_landsat_name(name):
    return "_".join(name.split("/")[-1].split(".")[0].split("_")[2:-1])

def import_txt_as_dict(name):
    d = {}
    with open(name) as f:
        for line in f:
            if len(line.split("="))>1:
                (key, val) = line.split("=")
                d[key] = val.split("\n")[0]
    return d
```



```

# Open nir and red
band4_test = open_masked_band(band4_filenames[select], 0.0)
band3_test = open_masked_band(band3_filenames[select], 0.0)

print(band3_filenames[select])
print(band4_filenames[select])
print(band6_filenames[select])

# Begin LST equations
toa = compute_toa_radiance(band6_test, mtl_test)
bt = compute_brightness_temp(toa, mtl_test)

ndvi = compute_ndvi(band4_test, band3_test, mtl_test)

vf = compute_vegetation_fraction(ndvi)
emiss = compute_emissivity(vf)
w = 11.45*10**-6 # From USGS, Band 6 wavelengths = 10.40 - 12.50 μm
lst = compute_lst(w, bt, emiss)

exportname_lst = DIR_LST_CLIPPED_NYC + "/lst_" + \
    get_original_landsat_name(band6_filenames[select])
exportname_ndvi = DIR_NDVI_CLIPPED_NYC + "/ndvi_" + \
    get_original_landsat_name(band6_filenames[select])

# Test export #####
# NOTE: Running this will overwrite any data already exported
# lst.rio.to_raster(exportname_lst, driver="GTiff")
# ndvi.rio.to_raster(exportname_ndvi, driver="GTiff")

```

```

/home/aderrasc/Documents/japa_final/02-data/landsat_clipped_nyc/clipped_nyc_LT05
_L1TP_014032_20110831_20160831_01_T1_B3.TIF
/home/aderrasc/Documents/japa_final/02-data/landsat_clipped_nyc/clipped_nyc_LT05
_L1TP_014032_20110831_20160831_01_T1_B4.TIF
/home/aderrasc/Documents/japa_final/02-data/landsat_clipped_nyc/clipped_nyc_LT05
_L1TP_014032_20110831_20160831_01_T1_B6.TIF

```

Plot results

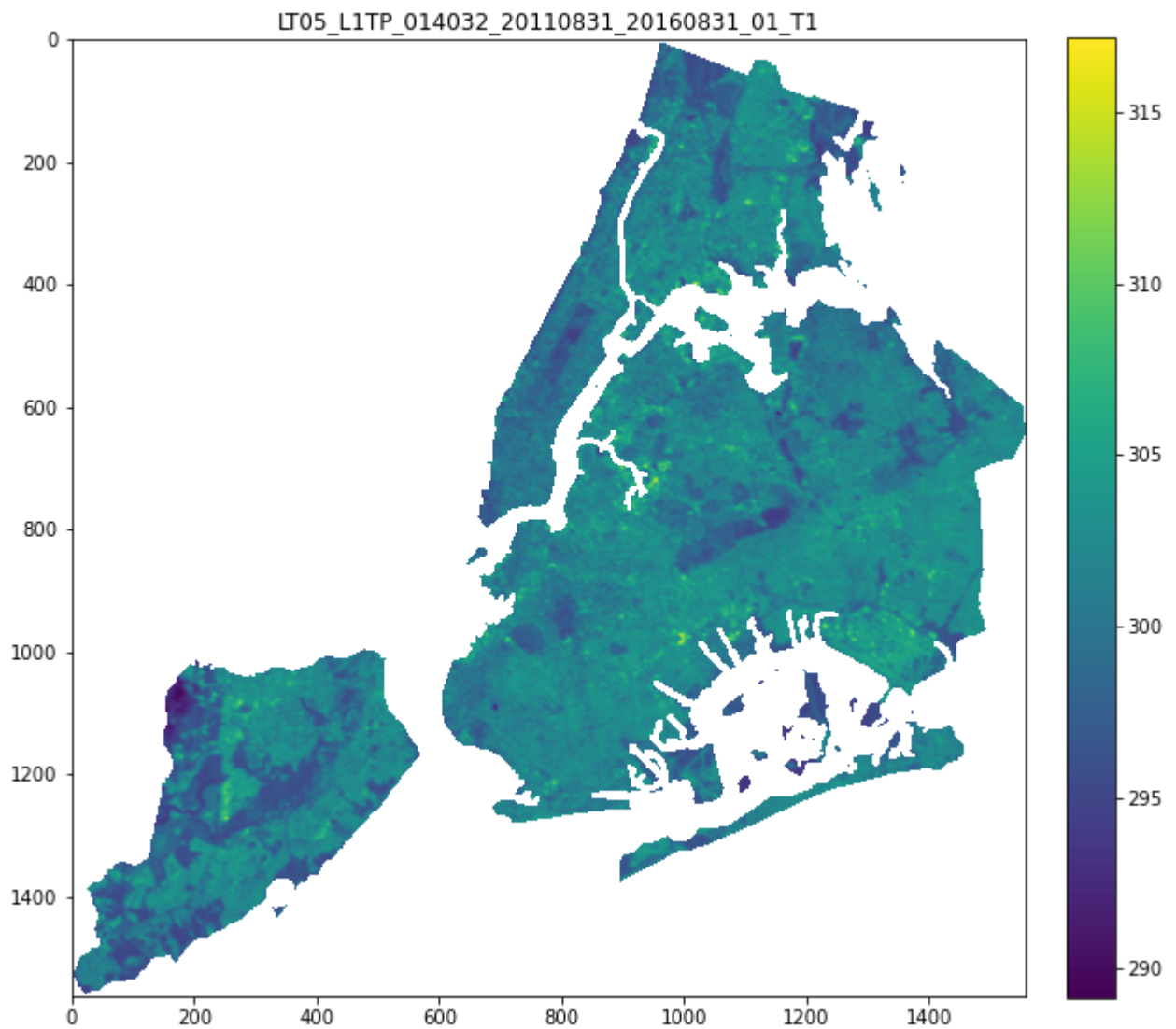
In [6]:

```

# Plot the test band
object_to_plot = lst # OPTIONS: lst, ndvi, bandX_test, toa, bt, vf, emiss
#####
fig = plt.figure(figsize=(10, 10))
im = plt.imshow(object_to_plot)#, cmap="RdYlBu")#, vmin=-1, vmax=1)
plt.colorbar(im, fraction=0.046, pad=0.04)
plt.title(get_original_landsat_name(band6_filenames[select]))
plt.savefig(DIR_FIGS + "/lst_"+get_original_landsat_name(\
    band6_filenames[select]) + ".png")

plt.show()

```



3. Export LST and NDVI for all dates

```
In [10]: for index in range(len(band6_filenames)):
# Open bands and metadata file
band6 = open_masked_band(band6_filenames[index], 0.0)
band4 = open_masked_band(band4_filenames[index], 0.0)
band3 = open_masked_band(band3_filenames[index], 0.0)
mtl = open_mtl_file(band6_filenames[index])

# Begin LST equations
toa = compute_toa_radiance(band6, mtl)
bt = compute_brightness_temp(toa, mtl)
ndvi = compute_ndvi(band4, band3, mtl)
vf = compute_vegetation_fraction(ndvi)
emiss = compute_emissivity(vf)
w = 11.45*10**-6 # Center of Band 6 = 10.40 - 12.50 μm
lst = compute_lst(w, bt, emiss)

suffix = get_original_landsat_name(band6_filenames[index]) + ".tif"
exportname_lst = DIR_LST_CLIPPED_NYC + "/lst_" + suffix
exportname_ndvi = DIR_NDVI_CLIPPED_NYC + "/ndvi_" + suffix

print("Saving ", suffix)
```

```
lst.rio.to_raster(exportname_lst, driver="GTiff")
ndvi.rio.to_raster(exportname_ndvi, driver="GTiff")
```

```
Saving LT05_L1TP_013032_19850901_20161004_01_T1.tif
Saving LT05_L1TP_013032_19850917_20161004_01_T1.tif
Saving LT05_L1TP_013032_19880621_20161002_01_T1.tif
Saving LT05_L1TP_013032_19880808_20161002_01_T1.tif
Saving LT05_L1TP_013032_19890726_20161002_01_T1.tif
Saving LT05_L1TP_013032_19900830_20161001_01_T1.tif
Saving LT05_L1TP_013032_19910716_20160929_01_T1.tif
Saving LT05_L1TP_013032_19910801_20160929_01_T1.tif
Saving LT05_L1TP_013032_19910817_20160929_01_T1.tif
Saving LT05_L1TP_013032_19910902_20161001_01_T1.tif
Saving LT05_L1TP_013032_19920920_20160929_01_T1.tif
Saving LT05_L1TP_013032_19940622_20160927_01_T1.tif
Saving LT05_L1TP_013032_19940708_20160927_01_T1.tif
Saving LT05_L1TP_013032_19940809_20160927_01_T1.tif
Saving LT05_L1TP_013032_19940825_20160927_01_T1.tif
Saving LT05_L1TP_013032_19940910_20160927_01_T1.tif
Saving LT05_L1TP_013032_19950727_20160927_01_T1.tif
Saving LT05_L1TP_013032_19960627_20160924_01_T1.tif
Saving LT05_L1TP_013032_19960830_20160924_01_T1.tif
Saving LT05_L1TP_013032_19980703_20160922_01_T1.tif
Saving LT05_L1TP_013032_19980820_20160922_01_T1.tif
Saving LT05_L1TP_013032_19980905_20160924_01_T1.tif
Saving LT05_L1TP_013032_19990706_20160919_01_T1.tif
Saving LT05_L1TP_013032_19990823_20160919_01_T1.tif
Saving LT05_L1TP_013032_20000708_20160922_01_T1.tif
Saving LT05_L1TP_013032_20000825_20160918_01_T1.tif
Saving LT05_L1TP_013032_20010727_20160917_01_T1.tif
Saving LT05_L1TP_013032_20010913_20160917_01_T1.tif
Saving LT05_L1TP_013032_20020815_20160916_01_T1.tif
Saving LT05_L1TP_013032_20030701_20160915_01_T1.tif
Saving LT05_L1TP_013032_20030717_20160915_01_T1.tif
Saving LT05_L1TP_013032_20040703_20160913_01_T1.tif
Saving LT05_L1TP_013032_20040820_20160914_01_T1.tif
Saving LT05_L1TP_013032_20050823_20160912_01_T1.tif
Saving LT05_L1TP_013032_20050908_20160912_01_T1.tif
Saving LT05_L1TP_013032_20070626_20160907_01_T1.tif
Saving LT05_L1TP_013032_20070712_20160907_01_T1.tif
Saving LT05_L1TP_013032_20080831_20160905_01_T1.tif
Saving LT05_L1TP_013032_20090818_20160903_01_T1.tif
Saving LT05_L1TP_013032_20090919_20160903_01_T1.tif
Saving LT05_L1TP_013032_20100704_20160901_01_T1.tif
Saving LT05_L1TP_013032_20100906_20160831_01_T1.tif
Saving LT05_L1TP_013032_20100922_20160831_01_T1.tif
Saving LT05_L1TP_013032_20110707_20160831_01_T1.tif
Saving LT05_L1TP_014032_19840719_20161004_01_T1.tif
Saving LT05_L1TP_014032_19840921_20161004_01_T1.tif
Saving LT05_L1TP_014032_19850823_20161004_01_T1.tif
Saving LT05_L1TP_014032_19870914_20161003_01_T1.tif
Saving LT05_L1TP_014032_19880628_20161003_01_T1.tif
Saving LT05_L1TP_014032_19880730_20161003_01_T1.tif
Saving LT05_L1TP_014032_19880815_20161003_01_T1.tif
Saving LT05_L1TP_014032_19880831_20161003_01_T1.tif
Saving LT05_L1TP_014032_19880916_20161003_01_T1.tif
Saving LT05_L1TP_014032_19890701_20161002_01_T1.tif
Saving LT05_L1TP_014032_19890903_20161002_01_T1.tif
Saving LT05_L1TP_014032_19900704_20161002_01_T1.tif
Saving LT05_L1TP_014032_19900720_20161002_01_T1.tif
Saving LT05_L1TP_014032_19910621_20160929_01_T1.tif
Saving LT05_L1TP_014032_19920826_20160928_01_T1.tif
Saving LT05_L1TP_014032_19930626_20160928_01_T1.tif
Saving LT05_L1TP_014032_19930728_20160928_01_T1.tif
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Saving LT05_L1TP_014032_19930829_20160927_01_T1.tif
Saving LT05_L1TP_014032_19950819_20160926_01_T1.tif
Saving LT05_L1TP_014032_19950904_20160926_01_T1.tif
Saving LT05_L1TP_014032_19960720_20160924_01_T1.tif
Saving LT05_L1TP_014032_19960805_20160924_01_T1.tif
Saving LT05_L1TP_014032_19970621_20160923_01_T1.tif
Saving LT05_L1TP_014032_19980912_20160923_01_T1.tif
Saving LT05_L1TP_014032_20000816_20160918_01_T1.tif
Saving LT05_L1TP_014032_20000917_20160918_01_T1.tif
Saving LT05_L1TP_014032_20010702_20160917_01_T1.tif
Saving LT05_L1TP_014032_20020705_20160916_01_T1.tif
Saving LT05_L1TP_014032_20020806_20160916_01_T1.tif
Saving LT05_L1TP_014032_20020907_20160916_01_T1.tif
Saving LT05_L1TP_014032_20030825_20160915_01_T1.tif
Saving LT05_L1TP_014032_20030910_20160914_01_T1.tif
Saving LT05_L1TP_014032_20050814_20160912_01_T1.tif
Saving LT05_L1TP_014032_20060716_20160909_01_T1.tif
Saving LT05_L1TP_014032_20060801_20160911_01_T1.tif
Saving LT05_L1TP_014032_20060918_20160911_01_T1.tif
Saving LT05_L1TP_014032_20070703_20160908_01_T1.tif
Saving LT05_L1TP_014032_20070804_20160907_01_T1.tif
Saving LT05_L1TP_014032_20070905_20160910_01_T1.tif
Saving LT05_L1TP_014032_20070921_20160906_01_T1.tif
Saving LT05_L1TP_014032_20080822_20160905_01_T1.tif
Saving LT05_L1TP_014032_20080907_20160909_01_T1.tif
Saving LT05_L1TP_014032_20090825_20160903_01_T1.tif
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