Kuentz Lab 4 Assignment
01/28/2022

```
# Import packages
import os
import glob

import matplotlib.pyplot as plt
from mpl_toolkits.axes_grid1 import make_axes_locatable

import numpy as np
import rasterio
from rasterio import transform
from rasterio.plot import show_hist
from rasterio.plot import show
import xarray
```

Question 1

a) What is the air temperature (in F) and cloud cover (in %) in Florence, OR (in 2020) on January 31, 2020?

```
# Read data
xds = xarray.open_dataset(filepath + 'era/usa_t2m_tcc_2020.nc',
decode_coords='all')
xds_daily = xds.resample(time='1D').mean()
# Next, find the index of the grid point nearest a specific lat/lon -- in
this case, the city of Florence
florence_weather = xds_daily.sel(latitude=43.974659, longitude=-124.103142,
method='nearest')

# Convert temperature values to Fahrenheit
fahrenheit = (florence_weather['t2m'][31].values - 273.15) * 9/5 + 32

# Note: Jan 31 is DOY 31
print('On January 31, 2020 air temperature in Florence, OR was %.2f F and the
cloud cover was %.2f %%' % (fahrenheit, florence_weather['tcc'][31].values *
100))
```

```
On January 31, 2020 air temperature in Florence, OR was 54.04 F and the cloud
cover was 99.88 %
```

b) What is the air temperature (in F) and cloud cover (in %) in Eugene, OR (in 2020) on February 15, 2020?

```
# Next, find the index of the grid point nearest a specific lat/lon -- in
this case, the city of Eugene
eugene_weather = xds_daily.sel(latitude = 44.052071, longitude = -123.086754,
method='nearest')

# Note: February 15th is DOY 46
# Convert temperature values to Fahrenheit
eug_fahrenheit = (eugene_weather['t2m'][46].values - 273.15) * 9/5 + 32
```

Kuentz Lab 4 Assignment
01/28/2022

```
print('On February 15, 2020 air temperature in Eugene, OR was %.2f F and the cloud cover was %.2f %%' % (eug_fahrenheit, eugene_weather['tcc'][46].values * 100))
```

```
On February 15, 2020 air temperature in Eugene, OR was 43.79 F and the cloud cover was 97.51 %
```

Question 2

a) Find grid cell and rough location of the highest average air temperature (i.e. hottest place)

```
hottest_place = np.mean(xds_daily['t2m'], axis=0).argmax()
index = np.unravel_index(hottest_place, np.mean(xds_daily['t2m'], axis=0).shape)
xds_daily['t2m'].shape
(366, 99, 233)
np.mean(xds_daily['t2m'], axis = 0).shape
(99, 233)
hottest_long = np.mean(xds_daily['t2m'], axis = 0)[81,55].longitude.values
hottest_lat = np.mean(xds_daily['t2m'], axis = 0)[81,55].latitude.values

print('The coordinates of the hottest place are %.2f, %.2f.' % (hottest_lat, hottest_long))

The coordinates of the hottest place are 28.99, -111.25.
```

Reverse geocoding the above coordinates shows that the hottest place in this dataset is located at: Plan de Ayala, 83325, Hermosillo, Sonora, Plan de Ayala Hermosillo, México.

b) Find grid cell and rough location of the lowest average air temperature (i.e. coldest place)

```
coldest_place = np.mean(xds_daily['t2m'], axis=0).argmin()
index = np.unravel_index(coldest_place, np.mean(xds_daily['t2m'], axis=0).shape)
index
(21, 61)
coldest_long = np.mean(xds_daily['t2m'], axis = 0)[21,61].longitude.values
coldest_lat = np.mean(xds_daily['t2m'], axis = 0)[21,61].latitude.values

print('The coordinates of the coldest place are %.2f, %.2f.' % (coldest_lat, coldest_long))
The coordinates of the coldest place are 43.99, -109.75.
```

Reverse geocoding the above coordinates shows that the hottest place in this dataset is located in Cody, WY, United States.

Kuentz Lab 4 Assignment
01/28/2022

c) Find grid cell and rough location of the highest average cloudiness (i.e. cloudiest place)

```
cloudiest_place = np.mean(xds_daily['tcc'], axis=0).argmax()
index = np.unravel_index(cloudiest_place, np.mean(xds_daily['tcc'],
axis=0).shape)
index
(0, 0)
cloudiest_long = np.mean(xds_daily['tcc'], axis = 0)[0,0].longitude.values
cloudiest_lat = np.mean(xds_daily['tcc'], axis = 0)[0,0].latitude.values

print('The coordinates of the cloudiest place are %.2f, %.2f.' %
(cloudiest_lat, cloudiest_long))
The coordinates of the cloudiest place are 49.24, -125.00.
```

Reverse geocoding the above coordinates shows that the cloudiest place in this dataset is located in Port Alberni V9Y, British Columbia, Canada

d) Find grid cell and rough location of the lowest average cloudiest (i.e. least cloudy place)

```
least_cloudy_place = np.mean(xds_daily['tcc'], axis=0).argmin()
index = np.unravel_index(least_cloudy_place, np.mean(xds_daily['tcc'],
axis=0).shape)
index
(71, 41)
least_cloudy_long = np.mean(xds_daily['tcc'], axis = 0)[71,
41].longitude.values
least_cloudy_lat = np.mean(xds_daily['tcc'], axis = 0)[71,
41].latitude.values

print('The coordinates of the cloudiest place are %.2f, %.2f.' %
(least_cloudy_lat, least_cloudy_long))
The coordinates of the cloudiest place are 31.49, -114.75.
```

Reverse geocoding the above coordinates shows that the least cloudy place in this dataset is located off the coast of Baja California, Mexico in the Gulf of California.

e) Find the grid cell and rough location of the place with the highest range in daily air temperature

```
# Resample the original dataset to reduce the time data dimension
xds_daily_min = np.min(xds_daily['t2m'], axis = 0)
xds_daily_min
xds_daily_max = np.max(xds_daily['t2m'], axis = 0)
xds_daily_max
xds_daily_range = xds_daily_max - xds_daily_min
xds_daily_range
max_daily_range = xds_daily_range.argmin()
index = np.unravel_index(max_daily_range, xds_daily_range.shape)
```

```
index
(46, 7)
max_range_long = xds_daily_range[46, 7].longitude.values
max_range_lat = xds_daily_range[46, 7].latitude.values

print('The coordinates of the place with the highest daily range in
temperature are %.2f, %.2f.' % (max_range_lat, max_range_long))
The coordinates of the place with the highest daily range in temperature are
37.74, -123.25.
```

The coordinates of the location with the highest daily range (37.74, -123.25) are located in the Pacific Ocean just off the coast of San Francisco, CA.

f) Find the grid cell and rough location of the place with the absolute coldest temperature on a single day

```
# Calculate the absolute min of any day from the minimums data array created
in the previous question

xds_abs_min = xds_daily_min.argmin()
index = np.unravel_index(xds_abs_min, xds_daily_min.shape)
index
(2, 55)
abs_min_long = xds_daily_min[2, 55].longitude.values
abs_min_lat = xds_daily_min[2, 55].latitude.values

print('The coordinates of the place with the coldest absolute temperature on
a single day are %.2f, %.2f.' % (abs_min_lat, abs_min_long))
The coordinates of the place with the coldest absolute temperature on a
single day are 48.74, -111.25.
```

The coordinates of the location with the absolute coldest temperature on a single day (48.74, -111.25) are located near Chester, MT, USA just outside of Mt. Brown.

Question 3

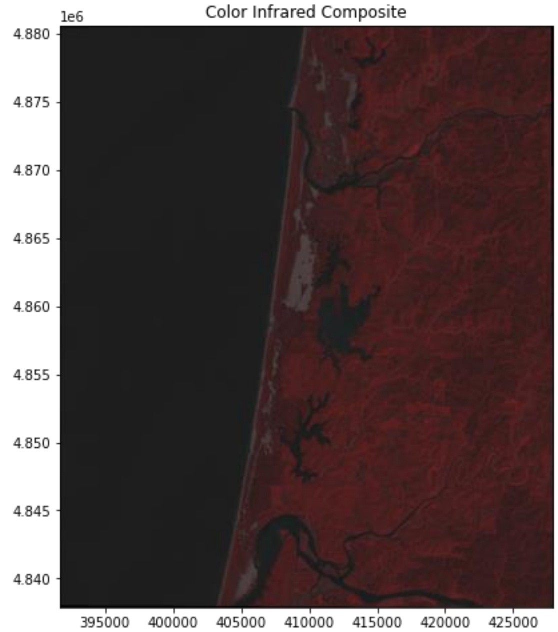
a) Creating a color infrared composite of the Landsat image over Florence, OR

```
# Define file path
filepath = '/Users/lily/Documents/GitHub/geospatial-data-science/labs/lab4/'

# Define list of Landsat bands
files = sorted(glob.glob(filepath + 'landsat/*.tif'))
print(files)
# Open a single band
src = rasterio.open(files[0])
band_1 = src.read(1)
# Find metadata (e.g. driver, data type, coordinate reference system,
transform etc.)
print(src.profile)
```

Kuentz Lab 4 Assignment
01/28/2022

```
# Get corners of dataset
full_extent = [src.bounds.left, src.bounds.right, src.bounds.bottom,
src.bounds.top]
print(full_extent)
# Plot dataset
fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(band_1, cmap='gray', extent=full_extent)
ax.set_title("Band 1")
fig.colorbar(im, orientation='vertical')
plt.show()
# Open all bands in a loop
list_bands = []
for file in files:
    # Read band
    src = rasterio.open(file)
    band = src.read(1)

    # Append to list
    list_bands.append(band)
# Convert from list of arrays to n-dimensional array
all_bands = np.dstack(list_bands)

all_bands.shape
# Convert 16-bit values to an 8-bit range of 0-255
all_bands_image = np.uint8((all_bands / 65536) * 255)

# Produce a new array by stacking the RGB bands
color_ir_comp =
np.dstack((all_bands_image[:,:,4],all_bands_image[:,:,2],all_bands_image[:,:,
2]))
# Write an array as a raster band to a new 8-bit file. For the new file's
profile,
# we start with the profile of the source
profile = src.profile

# And then change the band count to 3, set the dtype to uint8, and specify
LZW compression.
profile.update(dtype=rasterio.uint8, count=3, compress='lzw')

with rasterio.open(filepath + 'landsat/color_IR.tif', 'w', **profile) as dst:
    # Write array
    dst.write(np.rollaxis(rgb, axis=2))
# Plot as Color Infrared Composite image
fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(color_ir_comp, extent=full_extent)
ax.set_title("Color Infrared Composite")
plt.show()
```

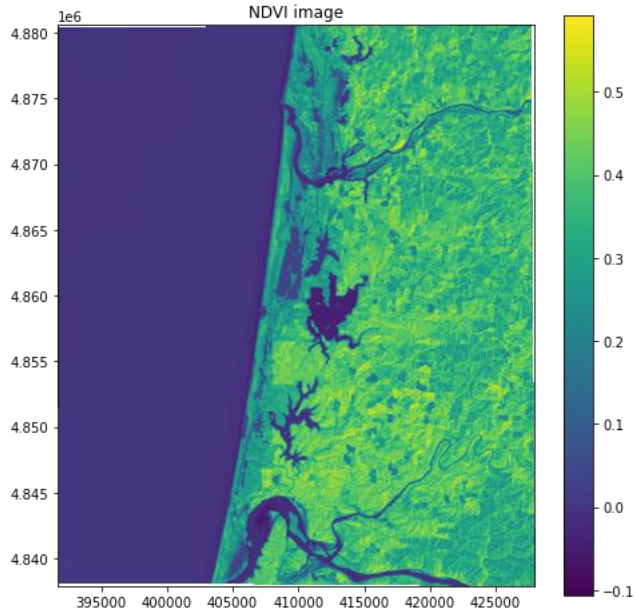
Kuentz Lab 4 Assignment
01/28/2022



b) Creating an NDVI image

```
# Compute NDVI
np.seterr(divide='ignore', invalid='ignore')
ndvi = np.divide((all_bands[:,:,4].astype(float) -
all_bands[:,:,3].astype(float)), \
                 (all_bands[:,:,4].astype(float) +
all_bands[:,:,3].astype(float)))
# Plot NDVI image
fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(ndvi, extent=full_extent)
ax.set_title("NDVI image")
fig.colorbar(im, orientation='vertical')
plt.show()
```

Kuentz Lab 4 Assignment
01/28/2022

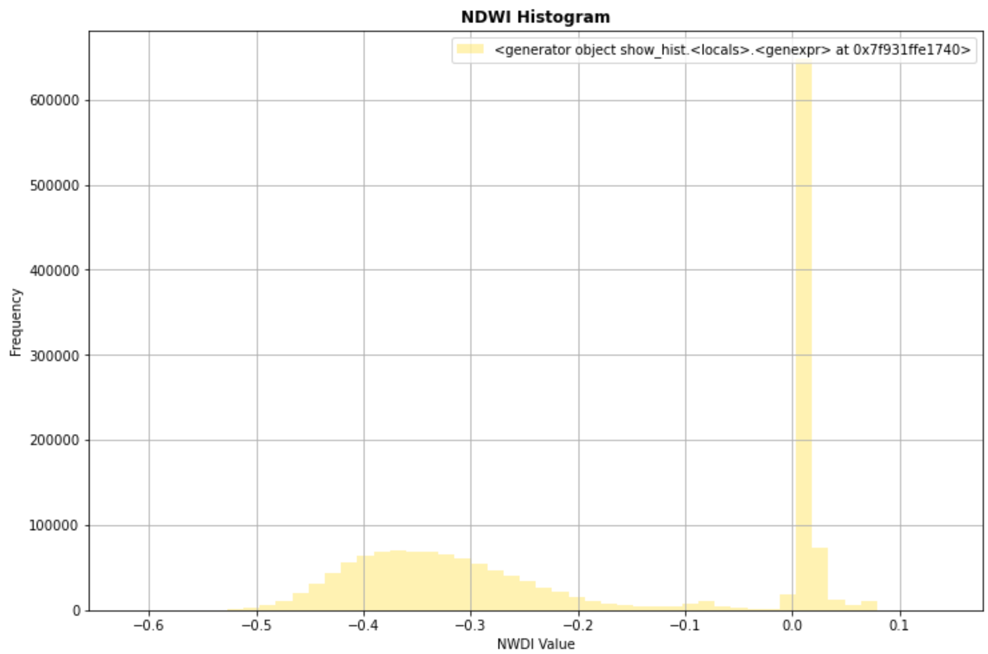


Question 4

a) Produce an NDWI histogram for the Landsat image of Florence

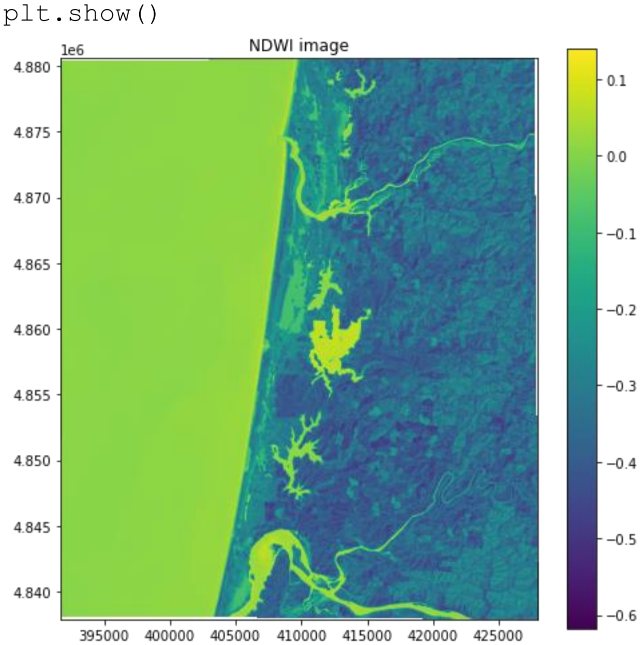
```
# Compute NDWI
np.seterr(divide='ignore', invalid='ignore')
ndwi = np.divide((all_bands[:,:,2].astype(float) -
all_bands[:,:,4].astype(float)), \
                 (all_bands[:,:,2].astype(float) +
all_bands[:,:,4].astype(float)))
ndwi
array([[        nan,         nan,         nan, ...,         nan,
                nan,         nan],
       [        nan,         nan,         nan, ...,         nan,
                nan,         nan],
       [        nan,         nan,         nan, ...,         nan,
                nan,         nan],
       ...,
       [        nan,         nan,         nan, ..., -0.29082536,
        -0.31481248, -0.30104966],
       [        nan,         nan,         nan, ..., -0.32622883,
        -0.30386218, -0.27118251],
       [        nan,         nan,         nan, ..., -0.34158455,
        -0.27173558, -0.30858688]])
# Plot NDVI Histogram
fig, axes = plt.subplots(figsize=(12,8))
show_hist(
     ndwi, bins=50, lw=0.0, stacked=False, alpha=0.3,
    histtype='stepfilled', ax = axes, title="NDWI Histogram")
axes.set_xlabel("NWDI Value")
Text(0.5, 0, 'NWDI Value')
```

Kuentz Lab 4 Assignment
01/28/2022



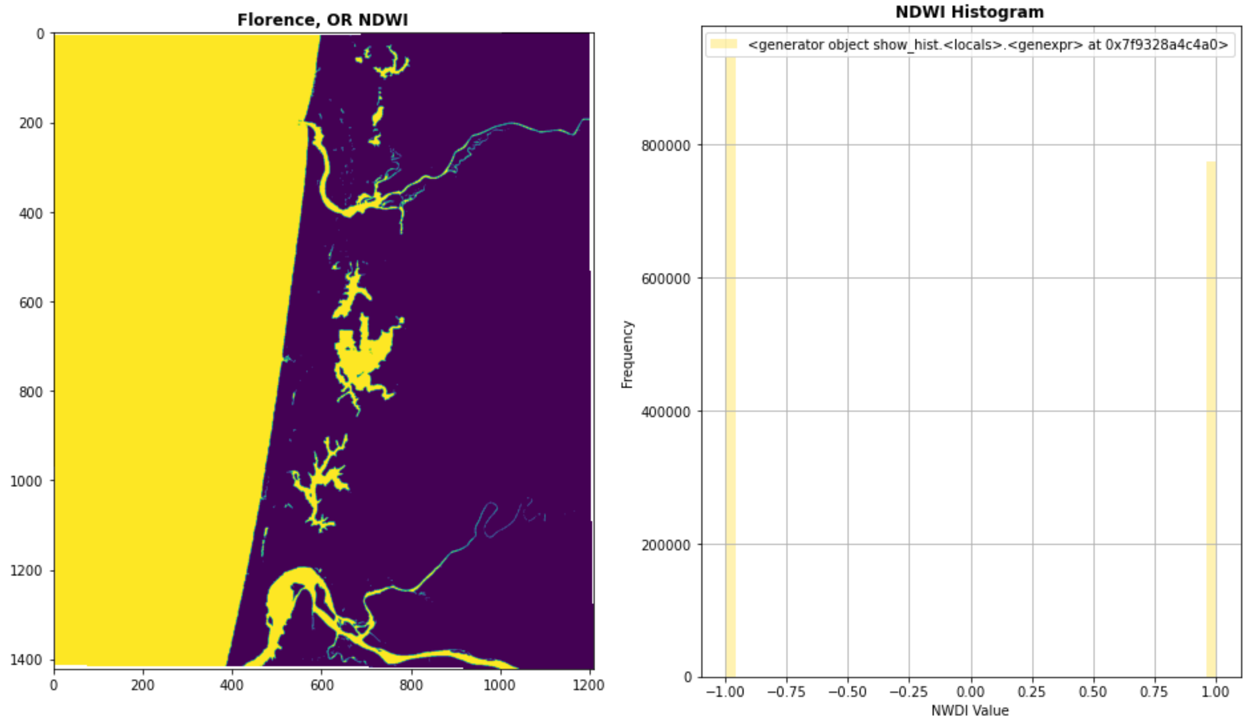
b) Choose a threshold and produce a binary water mask

```
# Plot NDVI image
fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(ndwi, extent=full_extent)
ax.set_title("NDWI image")
fig.colorbar(im, orientation='vertical')
plt.show()
```




```
# Note: The water in this image shows up in the 0.05-0.1 range
# Create a binary mask
ndwi_mask = np.copy(ndwi)
not_water = ndwi_mask[ndwi_mask < -0.05] = -1
```

```
water = ndwi_mask[ndwi_mask >= -0.05] = 1
# Plot NDWI binary mask and binary mask histogram
fig, (ax1, ax2) = plt.subplots(1, 2, figsize = (16, 9))
show(ndwi_mask, ax = ax1, title = "Florence, OR NDWI")
show_hist(ndwi_mask, bins = 50, histtype='stepfilled',
           lw=0.0, stacked=False, alpha=0.3, ax= ax2, title = "NDWI
Histogram" )
ax2.set_xlabel("NWDI Value")
plt.show()
```



c) Compute the area of water in the image (including ocean)

```
water_px = np.sum(ndwi_mask == 1)
water_px
774639
# Note: Landsat spatial resolution is 30x30 m
# Calculate area of water px
water_area = water_px * 30
# Convert to square km
water_area_km = water_area / 1000000
water_area_km
23.23917
```

In this Landsat image of Florence, OR, there is 23.23917 km^2 of water (including the ocean).