lab4_submission

Jon Sheppard

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0.1 Lab 4: Gridded data in Python

Objectives: * We will learn how to read, inspect, and write gridded data using rasterio and xarray. * Learn how to index, slice and manipulate our gridded data. * Export our data as GeoTIFF or NetCDF format.

[1]:
```
# 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
import xarray

## Finding day of year
from datetime import datetime, date

## Finding address from coordinates
from geopy.geocoders import Nominatim

import warnings
warnings.filterwarnings("ignore", category=FutureWarning)
```

[2]:
```
# Define filepath
filepath = './data/'

# Define list of Landsat bands
files = sorted(glob.glob(filepath + 'landsat/*.tif'))

# 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)

# Get corners of dataset
full_extent = [src.bounds.left, src.bounds.right, src.bounds.bottom, src.bounds.
 ↪top]

# Convert values to a range of 0-255
all_bands_image = np.uint8((all_bands / 65536) * 255)
```

[3]:
```
# Read data
xds = xarray.open_dataset(filepath + 'era/usa_t2m_tcc_2020.nc',␣
 ↪decode_coords='all')
xds_daily = xds.resample(time='1D').mean()
```

0.2 Question 1 (10 points):

Find the following numbers in the climate reanalysis dataset:

- a) the air temperature (in F) **and** cloud cover (in %) in Florence, OR (in 2020) on **January 31, 2020**?
- b) the air temperature (in F) **and** cloud cover (in %) in **Eugene, OR** (in 2020) on **February 15, 2020**?

You can use the following table to convert from a **date** to a **day-of-year**: https://landweb.modaps.eosdis.nasa.gov/browse/calendar.html

[26]:
```
# Specific date
day_of_year_1 = date(2020, 1, 31).timetuple().tm_yday
print("Day of year: ", day_of_year_1)

# find the index of the grid point nearest a specific lat/lon.
florence_weather = xds_daily.sel(latitude=43.974659, longitude=-124.103142,␣
 ↪method='nearest')

mean_temp = (florence_weather['t2m'][day_of_year_1-1].mean() - 273.15) * 9/5 +␣
 ↪32
print('Mean air temp. in Florence in 2020 = %.2f F' % (mean_temp))
mean_cloud = florence_weather['tcc'][day_of_year_1-1].mean()
print('Mean cloud cover in Florence in 2020 = %.2f %%' % (mean_cloud * 100),␣
 ↪"\n")
```

```
# find the index of the grid point nearest a specific lat/lon.
eugene_weather = xds_daily.sel(latitude=44.0521, longitude=-123.0868,␣
 ↪method='nearest')

day_of_year_2 = date(2020, 2, 15).timetuple().tm_yday
print("Day of year: ", day_of_year_2)

mean_temp = (eugene_weather['t2m'][day_of_year_2-1].mean() - 273.15) * 9/5 + 32
print('Mean air temp. in Eugene on February 15, 2020 = %.2f F' % (mean_temp))
mean_cloud = eugene_weather['tcc'][day_of_year_2-1].mean()
print('Mean cloud cover in Eugene on February 15, 2020 = %.2f %%' % (mean_cloud␣
 ↪* 100))
```

```
Day of year:  31
Mean air temp. in Florence in 2020 = 53.82 F
Mean cloud cover in Florence in 2020 = 99.98 %

Day of year:  46
Mean air temp. in Eugene on February 15, 2020 = 42.00 F
Mean cloud cover in Eugene on February 15, 2020 = 99.99 %
```

0.3 Question 2 (20 points):

Find the following grid cells in the climate reanalysis dataset and provide the lat/lons **and** a rough location of where they are located.

- a) Highest average air temperature (i.e. hottest place)
- b) Lowest average air temperature (i.e. coldest place)
- c) Highest average cloudiness (i.e. cloudiest place)
- d) Lowest average cloudiest (i.e. least cloudy place)
- e) Place with highest range in air temperature
- f) Place with the absolute coldest temperature on a single day

You can copy and paste the lat/lons into Google Maps to find a rough location of where these places are.

[5]:
```
max_value = np.mean(xds_daily['t2m'], axis=0).argmax()
index = np.unravel_index(max_value, np.mean(xds_daily['t2m'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

#use a geocoder to reverse search for address
geocoder = Nominatim(user_agent="jsheppar@uoregon.edu")
location_list = geocoder.reverse((lat,lon))
location = location_list[0]
```

```
print("The location with the highest average temperature is: %s" %location)
```

```
lat = 28.990000, lon = -111.250000
The location with the highest average temperature is: Granja Guadalupe,
Hermosillo, Sonora, México
```

[21]:
```
min_value = np.mean(xds_daily['t2m'], axis=0).argmin()
index = np.unravel_index(min_value, np.mean(xds_daily['t2m'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

location_list = geocoder.reverse((lat,lon))
location = location_list[0]
print("The location with the lowest average temperature is: %s" %location)
```

```
lat = 43.990002, lon = -109.750000
The location with the lowest average temperature is: Park County, Wyoming,
United States
```

[22]:
```
max_value = np.mean(xds_daily['tcc'], axis=0).argmax()
index = np.unravel_index(max_value, np.mean(xds_daily['tcc'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

location_list = geocoder.reverse((lat,lon))
location = location_list[0]
print("The location with the highest average total cloud cover is: %s"␣
 ↪%location)
```

```
lat = 49.240002, lon = -125.000000
The location with the highest average total cloud cover is: Stirling Arm Road,
Area D (Sproat Lake), British Columbia, Canada
```

[23]:
```
min_value = np.mean(xds_daily['tcc'], axis=0).argmin()
index = np.unravel_index(min_value, np.mean(xds_daily['tcc'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

location_list = geocoder.reverse((lat,lon))
location = location_list[0]
print("The location with the lowest average total cloud cover is: %s. The␣
 ↪geocoder is a little vague, "
      "but \n google maps shows that this is located in the Gulf of California"␣
 ↪%location)
```

```
lat = 31.490000, lon = -114.750000
The location with the lowest average total cloud cover is: México. The geocoder
is a little vague, but
 google maps shows that this is located in the Gulf of California
```

[24]:
```
max_range = (np.max(xds_daily['t2m'], axis=0) - np.min(xds_daily['t2m'],␣
 ↪axis=0)).argmax()
index = np.unravel_index(max_range, np.max(xds_daily['t2m'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

location_list = geocoder.reverse((lat,lon))
location = location_list[0]
print("The location with the highest range in temperature is: %s" %location)
```

```
lat = 48.990002, lon = -72.500000
The location with the highest range in temperature is: Girardville, Maria-
Chapdelaine, Saguenay-Lac-Saint-Jean, Québec, G0W 1R0, Canada
```

[25]:
```
min_abs = np.min(xds_daily['t2m'], axis=0).argmin()
index = np.unravel_index(min_abs, np.min(xds_daily['t2m'], axis=0).shape)
lat, lon = xds_daily.latitude[index[0]], xds_daily.longitude[index[1]]
print("lat = %f, lon = %f" %(lat, lon))

location_list = geocoder.reverse((lat,lon))
location = location_list[0]
print("The location with the highest range in temperature is: %s" %location)
```

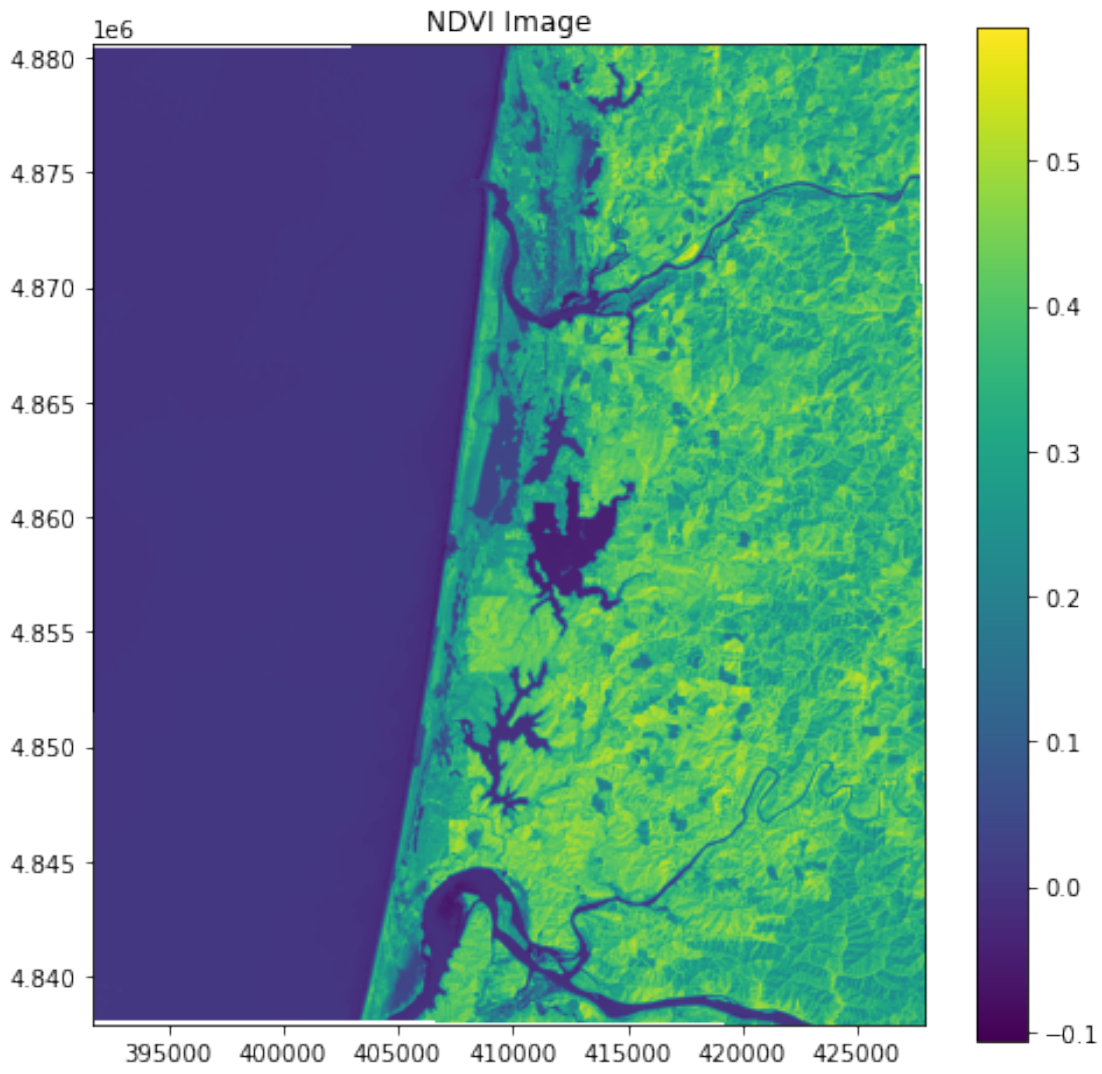
```
lat = 48.740002, lon = -111.250000
The location with the highest range in temperature is: Oilmont Road, Liberty
County, Montana, United States
```

0.4 Question 3 (20 points):

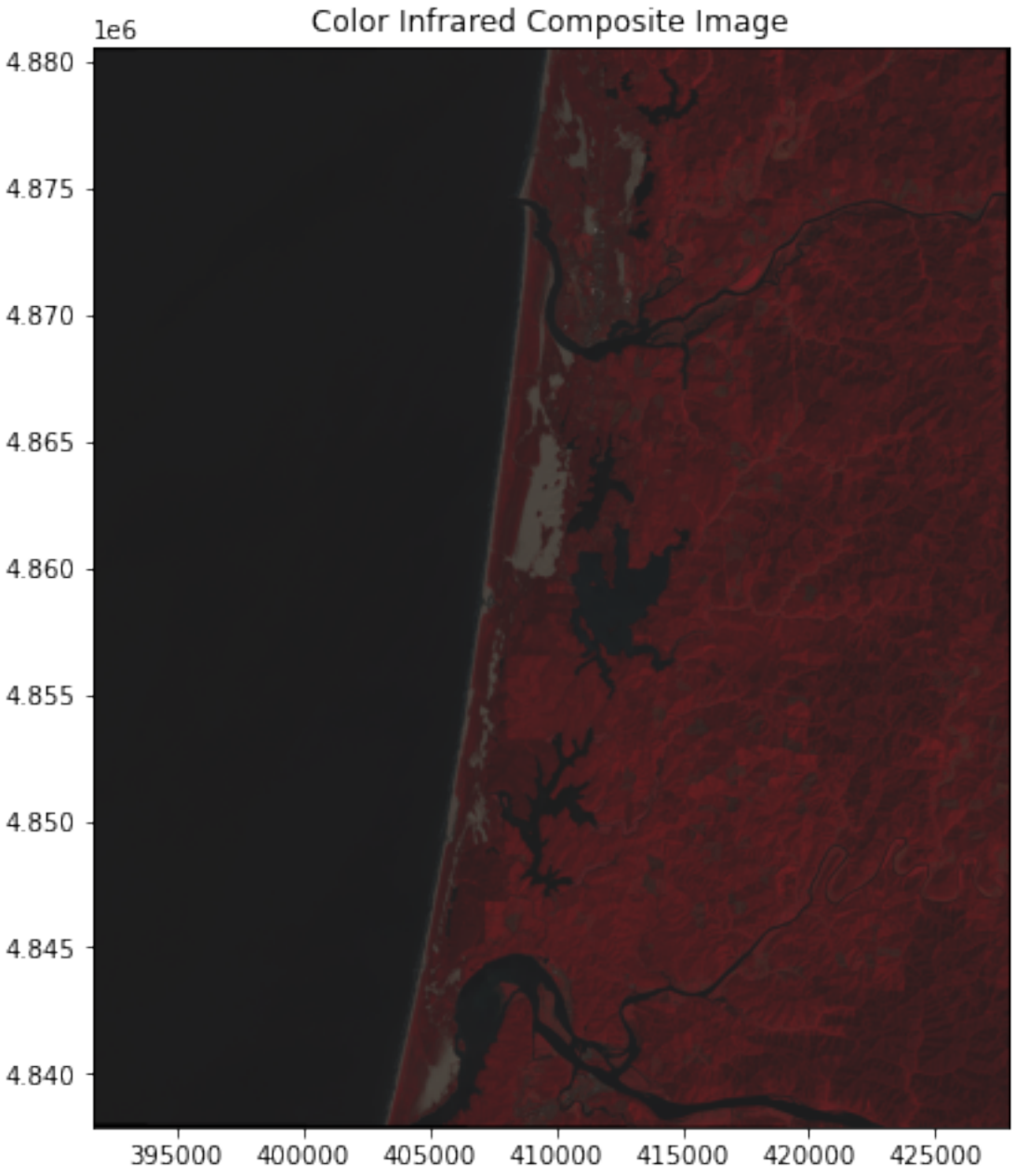
Display the Landsat image of Florence, OR as:

- a) an **NDVI** image (i.e. (Band 5 - Band 4) / (Band 5 + Band 4))
- b) a **color infrared composite** (i.e. bands 5, 4, 3)

[11]:
```
# 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()
```



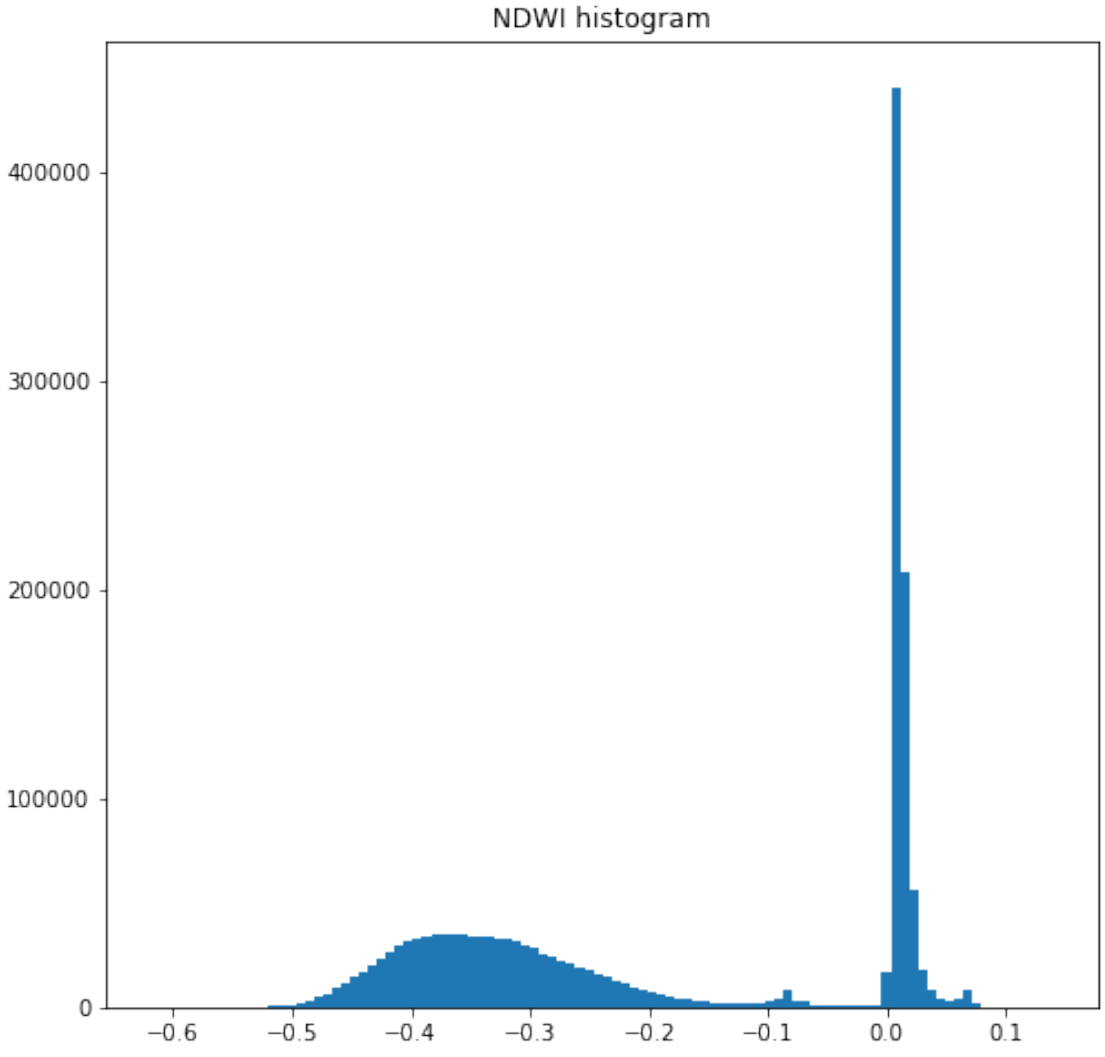
[12]:
```
# Produce a new array by stacking the RGB bands
inf_comp = np.dstack((all_bands_image[:,:,4],all_bands_image[:,:
 ↪,3],all_bands_image[:,:,2]))

# Plot as RGB image
fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(inf_comp, extent=full_extent)
ax.set_title("Color Infrared Composite Image")
plt.show()
```



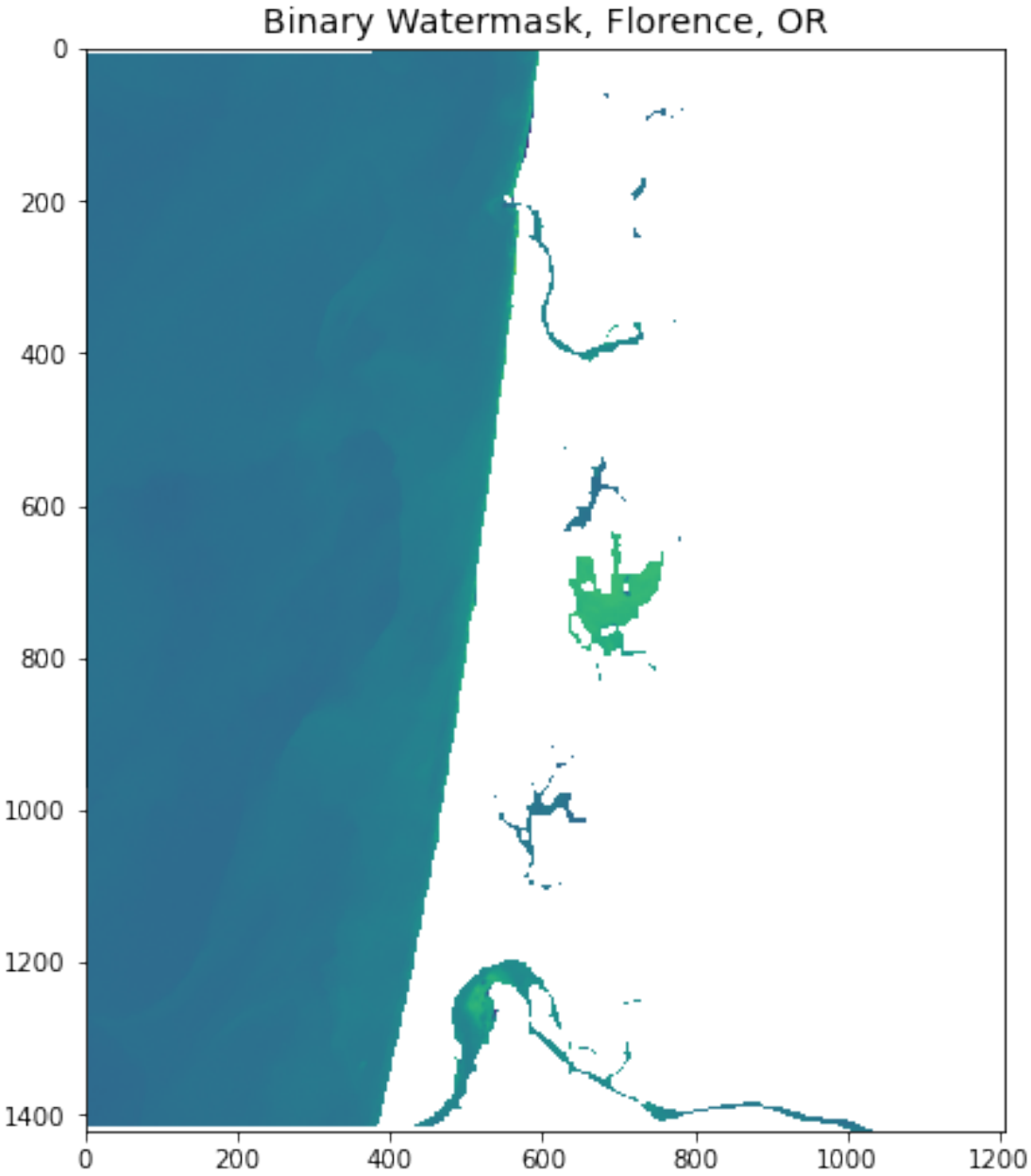
0.5 Question 4 (for grad students/extra credit)

- a) Produce an NDWI histogram for the Landsat image of Florence
- b) Choose a threshold and produce a binary water mask
- c) Compute the area of water in the image (including ocean)

[29]:
```
# 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)))

# Plot NDWI histogram
fig, ax = plt.subplots(figsize=(8,8))
im = ax.hist(ndwi[~np.isnan(ndwi)], bins=100)
ax.set_title("NDWI histogram")
plt.show()
```



[14]:
```
# threshold
thresh = -0.07
ndwi_masked = np.ma.masked_array(ndwi, mask=(ndwi < thresh))

fig, ax = plt.subplots(figsize=(8,8))
im = ax.imshow(ndwi_masked)

ax.set_title("Binary Watermask, Florence, OR", fontsize=14)
plt.show()
```



[15]:
```
gt = src.transform
pixelSizeX = gt[0]
pixelSizeY =-gt[4]
print("Each pixel is %f x %f meters." %(pixelSizeX, pixelSizeY))

water_area = ndwi_masked.count() * (pixelSizeX*pixelSizeY)
water_area /= 1000000
print("There is approximately %f square kilometers of water in the image."␣
  ↪%water_area)
```

```
Each pixel is 30.000000 x 30.000000 meters.
There is approximately 709.748100 square kilometers of water in the image.
```

[ ]:
```

```