MAP - Forest Carbon - Canopy Height

June 12, 2021

Dominic Hewitt do6743he-s

1 Import modules

[1]:
```
import geopandas as gpd
import fiona
import rasterio
import earthpy.spatial as es
import earthpy.plot as ep
import matplotlib.pyplot as plt
from rasterio.plot import show, show_hist
import numpy as np
```

2 Load and check data

First I must merge las files into a single file called 'point_cloud.las'.

[2]:
```
!pdal merge IC13.las IC21.las IC33.las IC37.las IC50.las IC63.las IC14.las IC24.
↪las IC34.las IC38.las IC51.las IC67.las IC19.las IC25.las IC35.las IC48.las␣
↪IC52.las IC20.las IC32.las IC36.las IC49.las IC53.las point_cloud.las
```

A good idea to check the info for first point.

[3]:
```
!pdal info point_cloud.las -p 0
```


```
{
  "file_size": 1434970601,
  "filename": "point_cloud.las",
  "now": "2021-06-12T10:00:17+0200",
  "pdal_version": "2.2.0 (git-version: 3dd320)",
  "points":
  {
    "point":
    {
      "Blue": 0,
      "Classification": 2,
      "EdgeOfFlightLine": 0,
```

```
      "GpsTime": -15721194.08,
      "Green": 0,
      "Intensity": 101,
      "NumberOfReturns": 1,
      "PointId": 0,
      "PointSourceId": 1,
      "Red": 0,
      "ReturnNumber": 1,
      "ScanAngleRank": -6,
      "ScanDirectionFlag": 0,
      "UserData": 160,
      "X": 267998.77,
      "Y": 3097999.28,
      "Z": 1043.42
    }
  },
  "reader": "readers.las"
}
```

3 Create DTM raster

To use certain modules in Pdal, the perameters need to be provided in JSON format. Below is the contents of the file I created for extracting the ground points and converting to Geotiff

[ ]:
```
# pipeline jspn file for extraction and conversion

'''[
    "point_cloud.las",
    {a
        "type":"filters.smrf",
        "window":33,
        "slope":1.0,
        "threshold":0.15,
        "cell":1.0
    },
    {
        "type":"filters.range",
        "limits":"Classification[2:2]"
    },
    {
        "type":"writers.gdal",
        "filename":"dtm.tif",
        "output_type":"min",
        "gdaldriver":"GTiff",
        "window_size":3,
        "resolution":1.0
    }
```

```
]'''
```

Next I used the following command for extraction and converstion

[5]:
```
!pdal pipeline dtm_pipeline.json
```

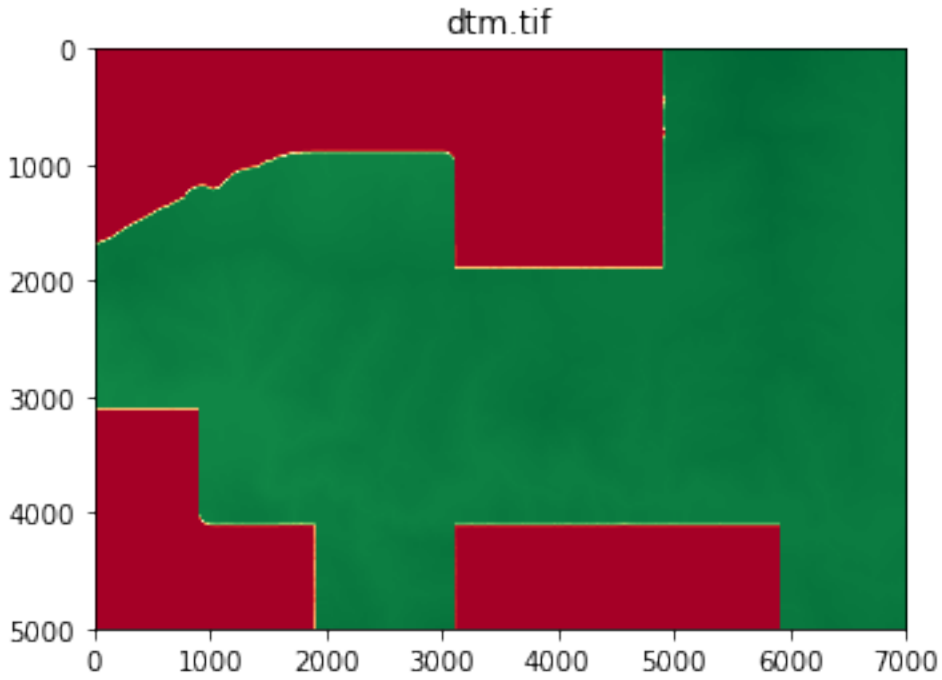
...and then to fill/ interpolate the no data values using GDAL.

[6]:
```
!gdal_fillnodata.py dtm.tif
```

```
0...10...20...30...40...50...60...70...80...90...100 - done.
```

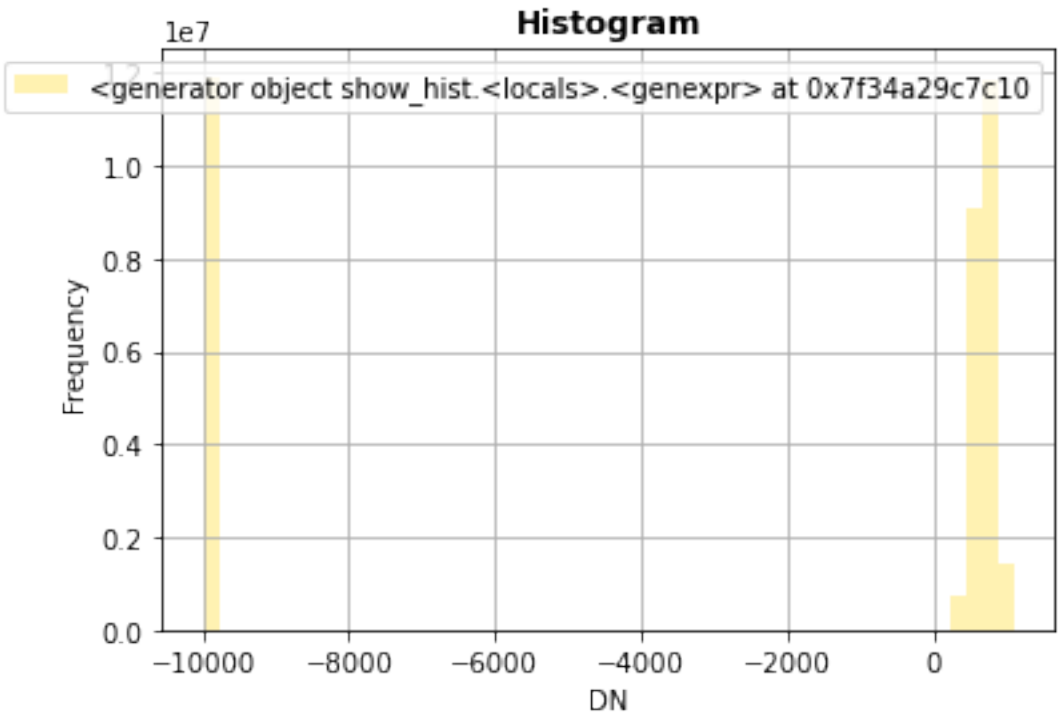
Now to load and render the raster.

[7]:
```
dtm = rasterio.open('dtm.tif')
dtm = dtm.read(1).astype(float)

plt.imshow(dtm, cmap='RdYlGn')
plt.title('dtm.tif')
plt.show()
```



The above figure dosent look right, its most likely due to the image being stretched between the min and max values. To check, I looked at the distribution histogram.

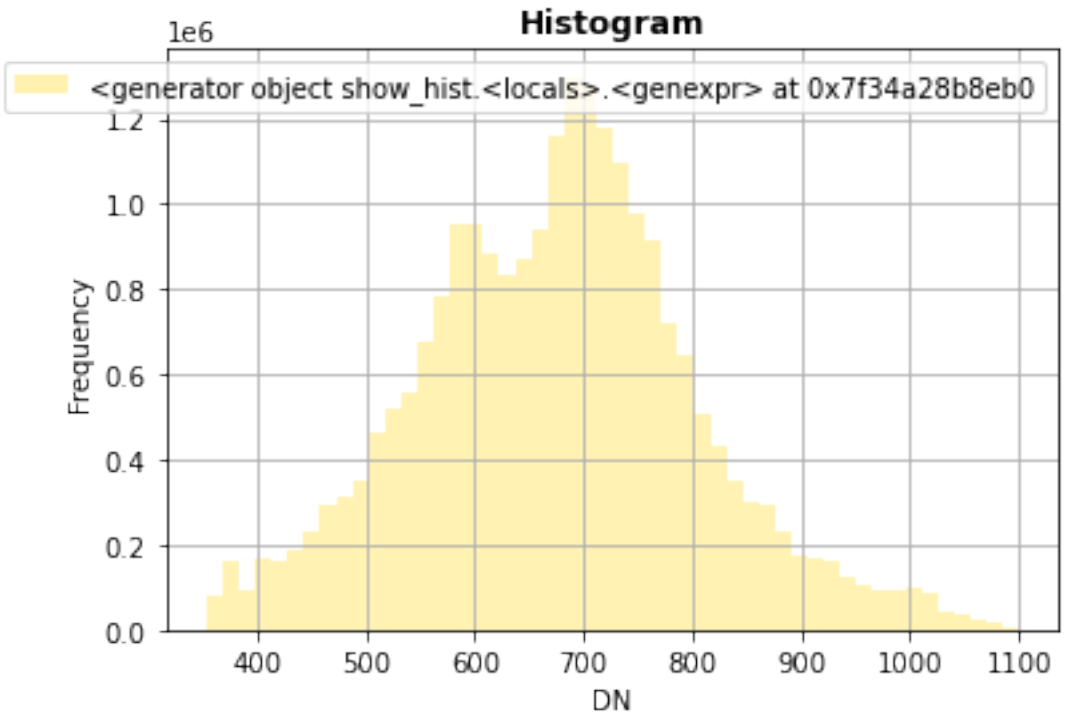
[8]:
```
show_hist(dtm, bins=50, histtype='stepfilled', lw=0.0, stacked=False, alpha=0.3)
plt.show()
```



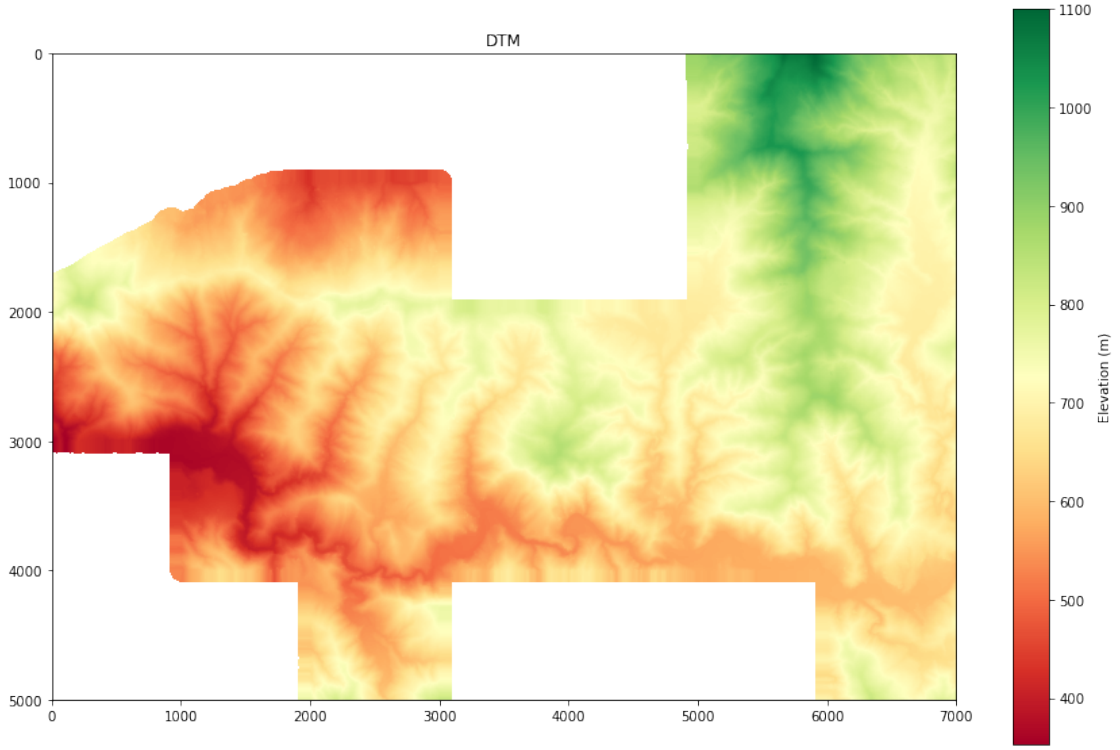
Above I can see there are values (likely as no data) at around -9999. So in the next step i will convert these to a NoData value and check the distribution again

[9]:
```
dtm[dtm < 0] = np.nan
```

[10]:
```
show_hist(dtm, bins=50, histtype='stepfilled', lw=0.0, stacked=False, alpha=0.3)
plt.show()
```

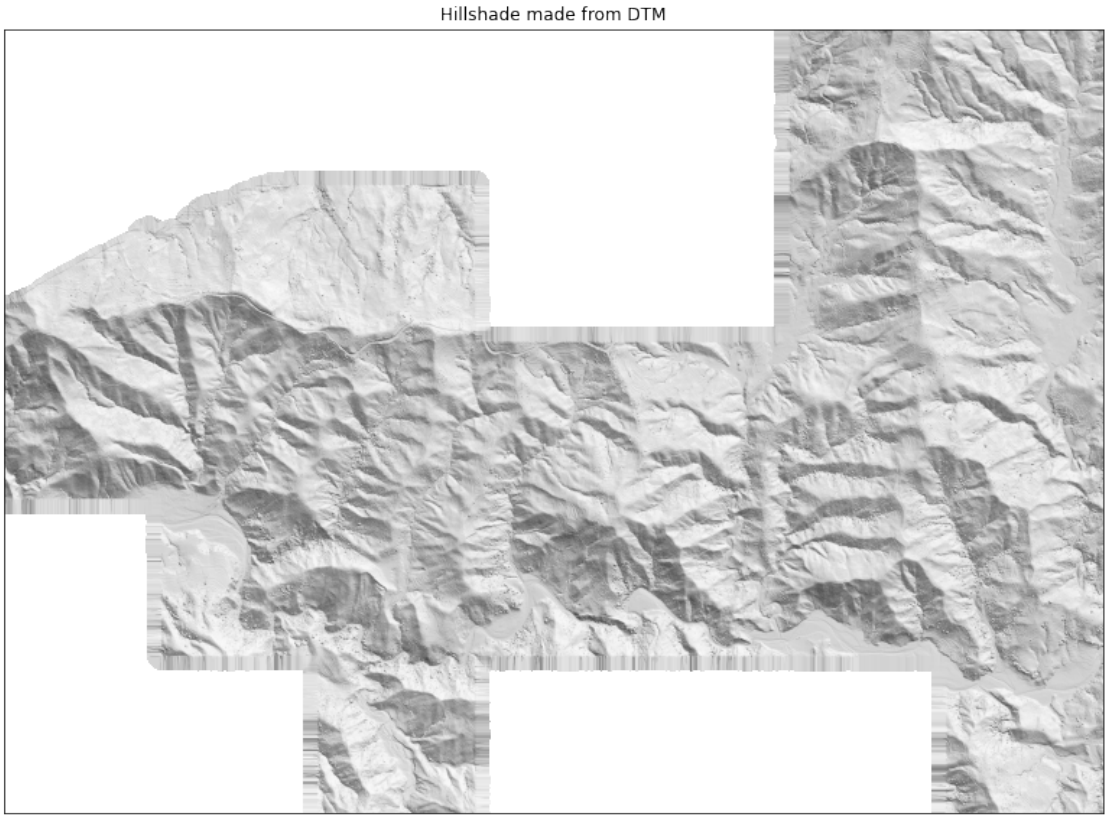


[11]:
```
plt.figure(figsize = (15,10))
plt.imshow(dtm, cmap="RdYlGn")
plt.colorbar(label='Elevation (m)')
plt.title('DTM')
plt.show()
```



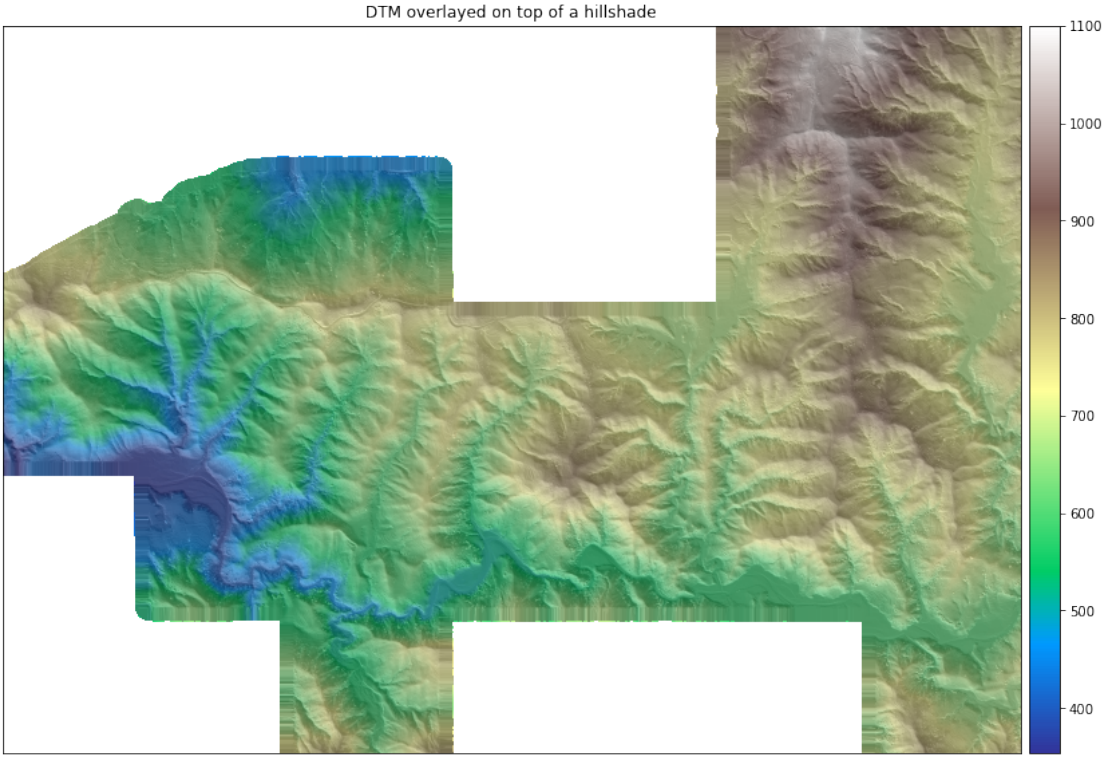
For interperatabiltiy, I added a hillshade effect and also overlayed the original DTM raster.

[12]:
```
hillshade = es.hillshade(dtm)

ep.plot_bands(
    hillshade,
    cbar=False,
    title="Hillshade made from DTM",
    figsize=(15, 10),
)
plt.show()
```



...and overlayed the raster.

[13]:
```
fig, ax = plt.subplots(figsize=(15, 10))
ep.plot_bands(
    dtm,
    ax=ax,
    cmap="terrain",
    title="DTM overlayed on top of a hillshade",
)
ax.imshow(hillshade, cmap="Greys", alpha=0.5)
plt.show()
```



4 Create DSM

Again I needed to create a JSON file with the peramaters and run the required comamnds. Below is the content of the file.

[ ]:
```
# pipeline json file for extraction and conversion

'''[
    "point_cloud.las",
    {
        "type":"filters.smrf",
        "window":33,
        "slope":1.0,
        "threshold":0.15,
        "cell":1.0
    },
    {
        "type":"filters.range",
        "limits":"Classification[1:1]"
    },
    {
        "type":"writers.gdal",
```

```
        "filename":"dsm.tif",
        "output_type":"min",
        "gdaldriver":"GTiff",
        "window_size":3,
        "resolution":1.0
    }
]'''
```

[15]:
```
# command for extraction and converstion
!pdal pipeline dsm_pipeline.json
```

[16]:
```
#use gdal to fill/ interpolate the no data values
!gdal_fillnodata.py dsm.tif
```

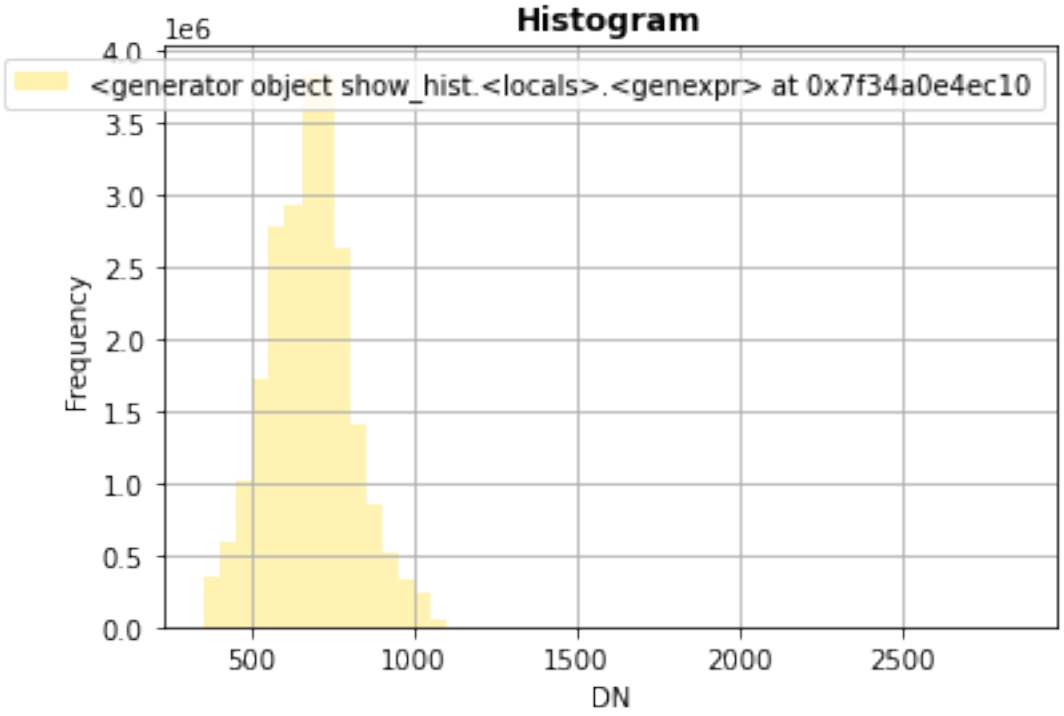
0…10…20…30…40…50…60…70…80…90…100 - done.

Here there is the same issue with no data as with the DTM, so I converted the values -9999 to NoData after loading and rendered the result

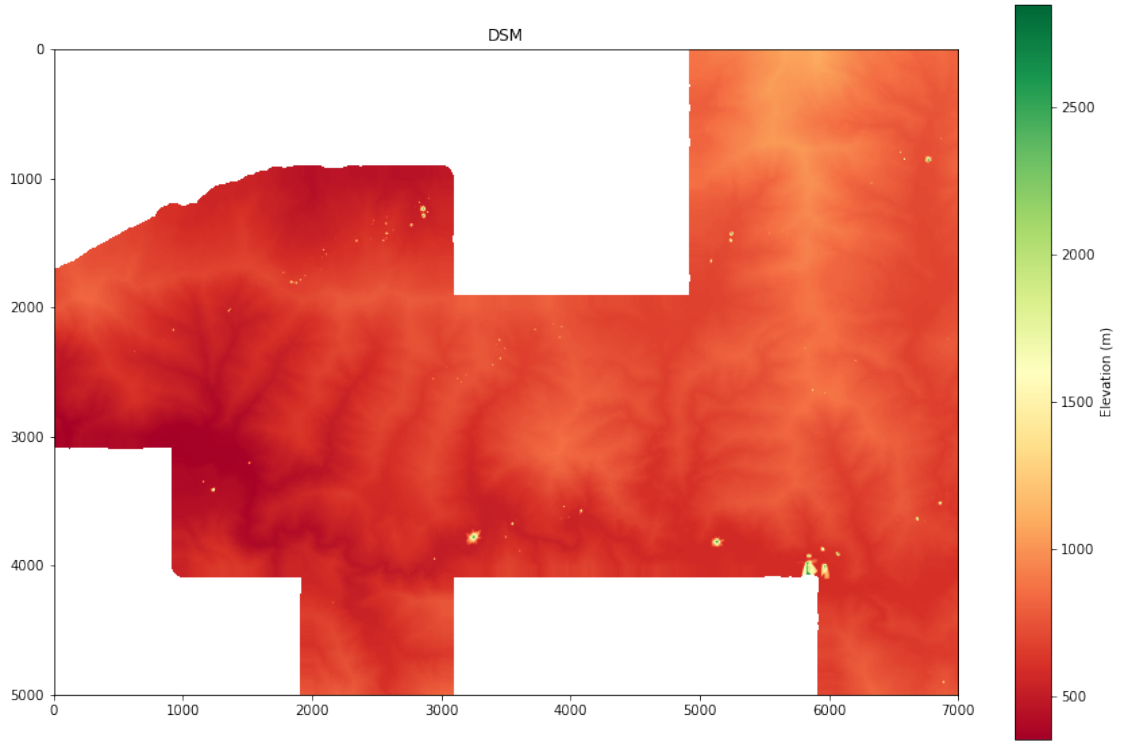
[17]:
```
dsm = rasterio.open('dsm.tif')
dsm = dsm.read(1).astype(float)
```

[18]:
```
dsm[dsm < 0] = np.nan
```

[19]:
```
show_hist(dsm, bins=50, histtype='stepfilled', lw=0.0, stacked=False, alpha=0.3)
plt.show()
```

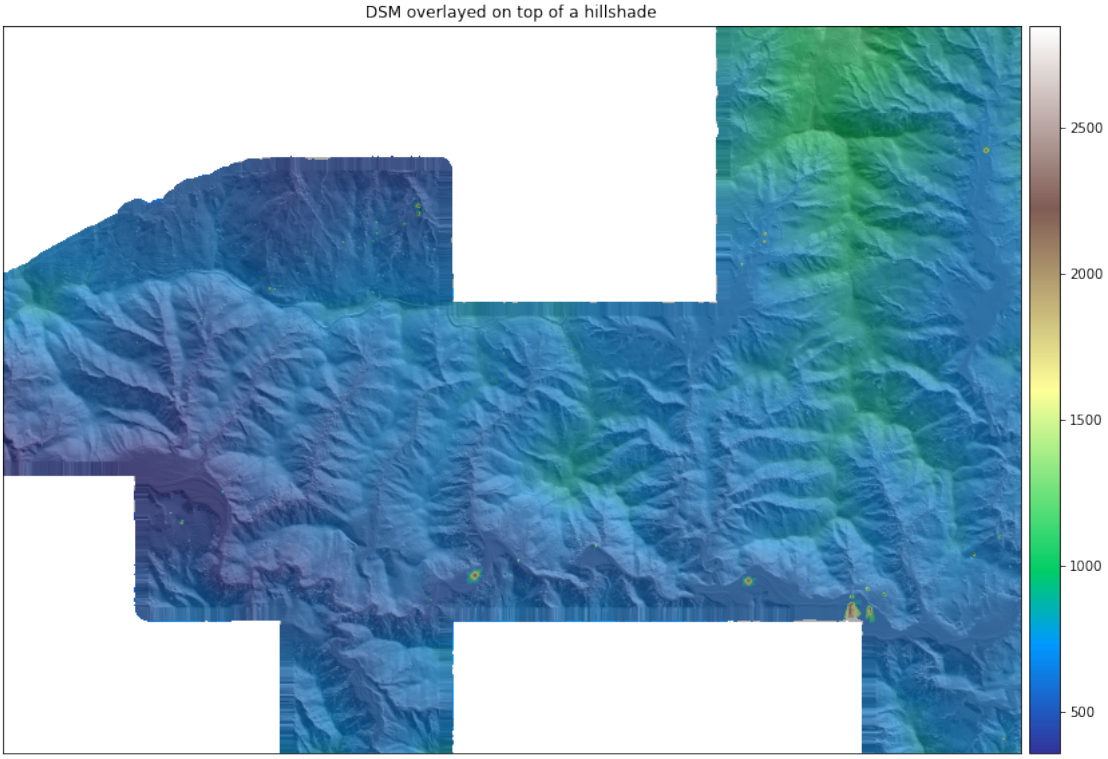


[20]:
```
plt.figure(figsize = (15,10))
plt.imshow(dsm, cmap="RdYlGn")
plt.title('DSM')
plt.colorbar(label='Elevation (m)')
plt.show()
```



... and added the hillshade again

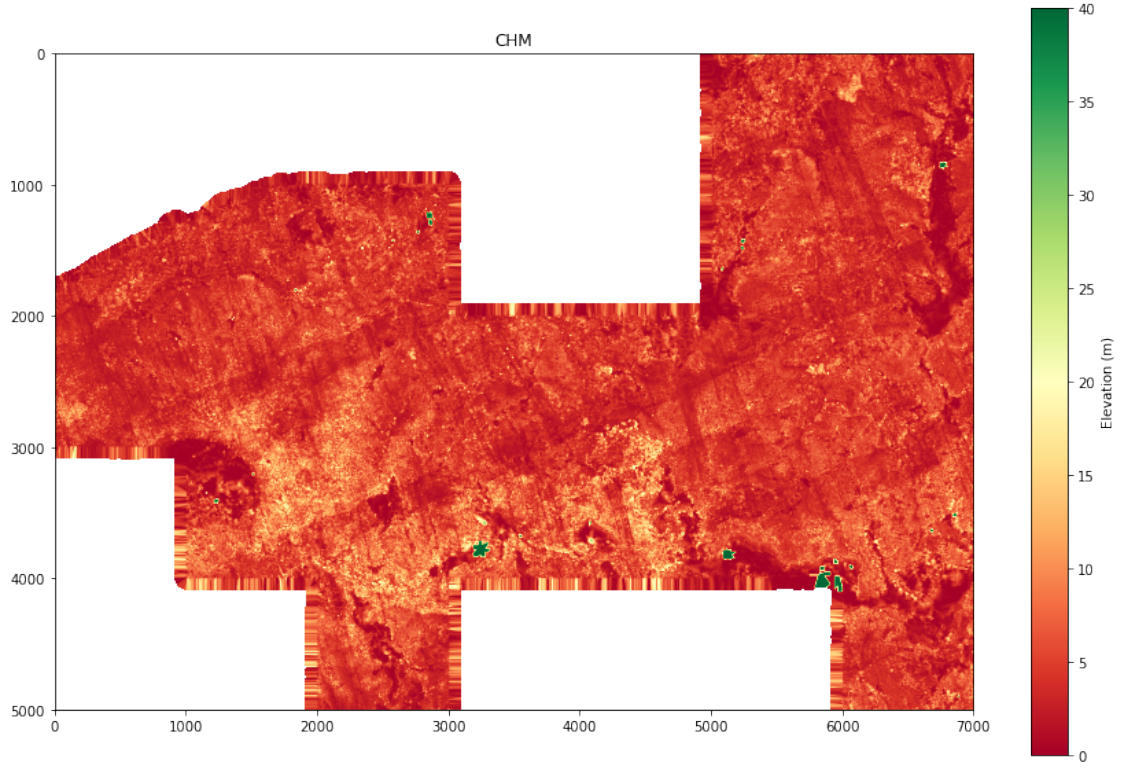
[21]:
```
hillshade = es.hillshade(dsm)

fig, ax = plt.subplots(figsize=(15, 10))
ep.plot_bands(
    dsm,
    ax=ax,
    cmap="terrain",
    title="DSM overlayed on top of a hillshade",
)
ax.imshow(hillshade, cmap="Greys", alpha=0.5)
plt.show()
```



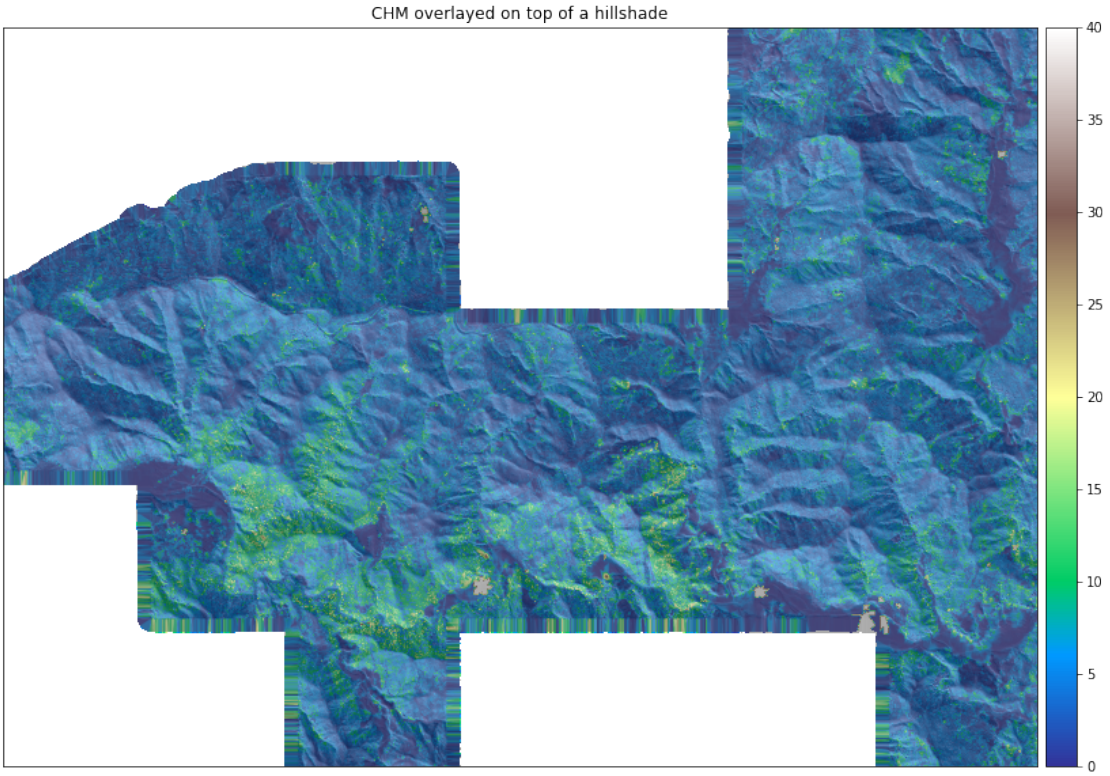
5 Create the CHM

As the rasters are stored as numpy arrays, I can calculate the CHM with the simple formular below and then removed the values below 0 and above 40 before rendering the result and adding a hillshade effect.

[33]:
```
chm = dsm-dtm

chm = np.clip(chm, 0, 40)

plt.figure(figsize = (15,10))
plt.imshow(chm, cmap="RdYlGn")
plt.title('CHM')
plt.colorbar(label='Elevation (m)')
plt.show()
```



[23]:
```
hillshade = es.hillshade(chm)

fig, ax = plt.subplots(figsize=(15, 10))
ep.plot_bands(
    chm,
    ax=ax,
    cmap="terrain",
    title="CHM overlayed on top of a hillshade",
)
ax.imshow(hillshade, cmap="Greys", alpha=0.5)
plt.show()
```



[24]:
```
#save as .tif

with rasterio.open('dsm.tif') as src_dataset:

    profile = src_dataset.profile

    profile.update(
        count=1,
        crs='EPSG:32645',
        compress='lzw')

    with rasterio.open('chm.tif', 'w', **profile) as dst:
        dst.write(chm, 1)
```

6 Clip to shapefile extent

Finally to clip the raster to the extent required for further anaysis I first had a look at the shapefile...

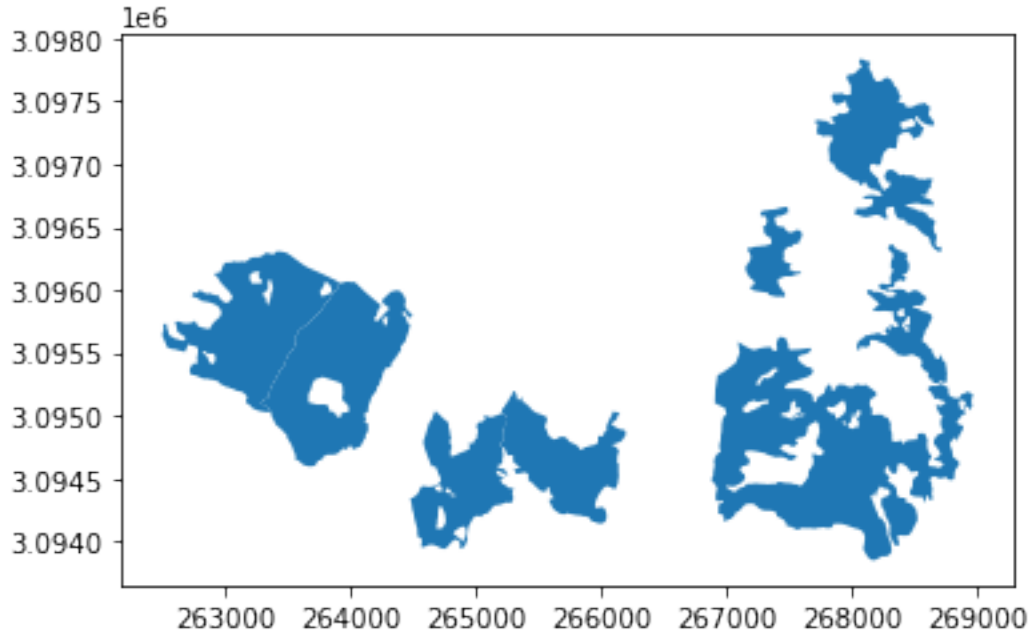
[25]:
```
clip_extent = gpd.read_file('/home/dom/Documents/uni/MAP/Forest_Carbon/
 ↪Digital_image_and_shapefile/Selected_CF.shp')
clip_extent
```

[25]:

	ID	AREA	PERIMETER	HECTARES	NAME	plot_numbe	plot_more	geometry
0	0	508447.599	4580.829	50.845	Shikhar CF	5	8	POLYGON ((265420.779 3094483.867, 265419.738 3…
1	0	835757.148	7335.233	83.576	Birenchok CF	8	13	MULTIPOLYGON (((262681.505 3095505.697, 262682…
2	0	500355.751	5776.863	50.036	Chisapani CF	5	8	POLYGON ((264807.559 3094674.572, 264811.489 3…
3	0	922692.028	6245.162	92.269	Kuwadi CF	9	15	POLYGON ((264467.688 3095682.522, 264465.396 3…
4	0	2707130.210	35123.522	270.713	Ludi Damgade CF	27	43	MULTIPOLYGON (((267672.382 3095523.268, 267666…

[26]:
```
clip_extent.plot()
```

[26]: <AxesSubplot:>



cropped the raster to the shapefiles geoemtry…

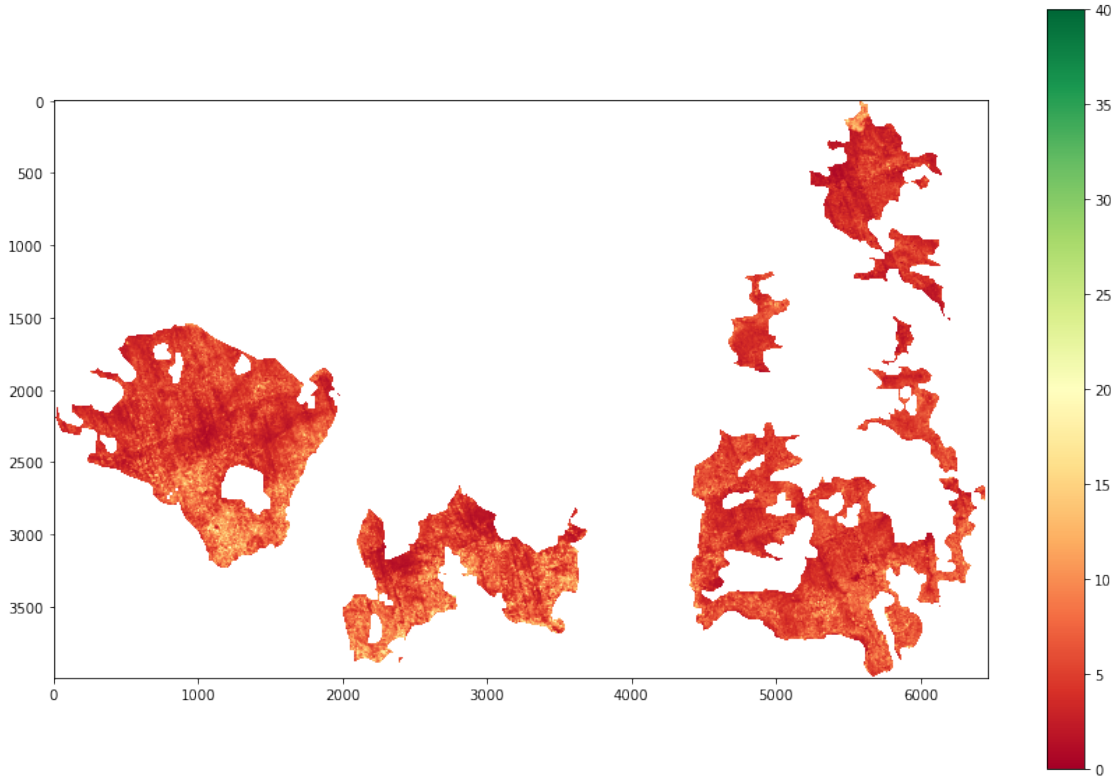
[27]:
```
# Read Shape file
with fiona.open("/home/dom/Documents/uni/MAP/Forest_Carbon/
 ↪Digital_image_and_shapefile/Selected_CF.shp", "r") as shapefile:
    shapes = [feature["geometry"] for feature in shapefile]

# read imagery file
```

```
with rasterio.open("chm.tif") as src:
    out_image, out_transform = rasterio.mask.mask(src, shapes, crop=True)
    out_meta = src.meta

# Save clipped imagery
out_meta.update({"driver": "GTiff",
                 "height": out_image.shape[1],
                 "width": out_image.shape[2],
                 "transform": out_transform})

with rasterio.open("chm_mask.tif", "w", **out_meta) as chm_mask:
    chm_mask.write(out_image)
```

again fixed the NoData values and rendered the result.

[28]:
```
chm_mask = rasterio.open('chm_mask.tif')
chm_mask = chm_mask.read(1).astype(float)
chm_mask[chm_mask < 0] = np.nan
```

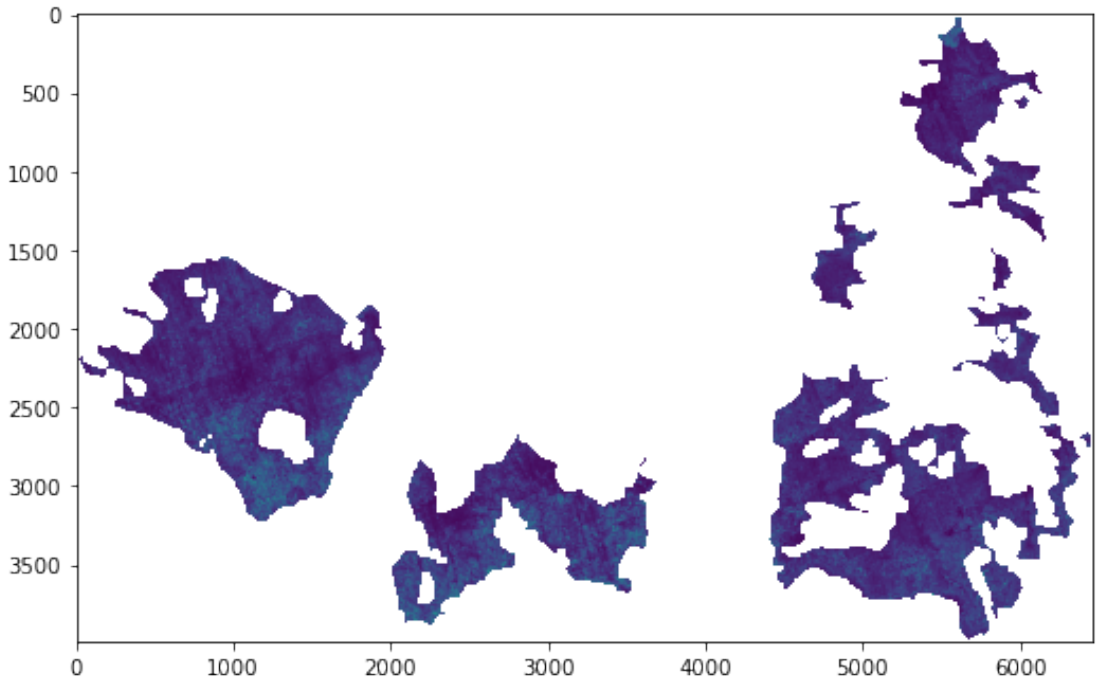
[29]:
```
plt.figure(figsize = (15,10))
plt.imshow(chm_mask, cmap="RdYlGn")
plt.colorbar()
plt.show()
```

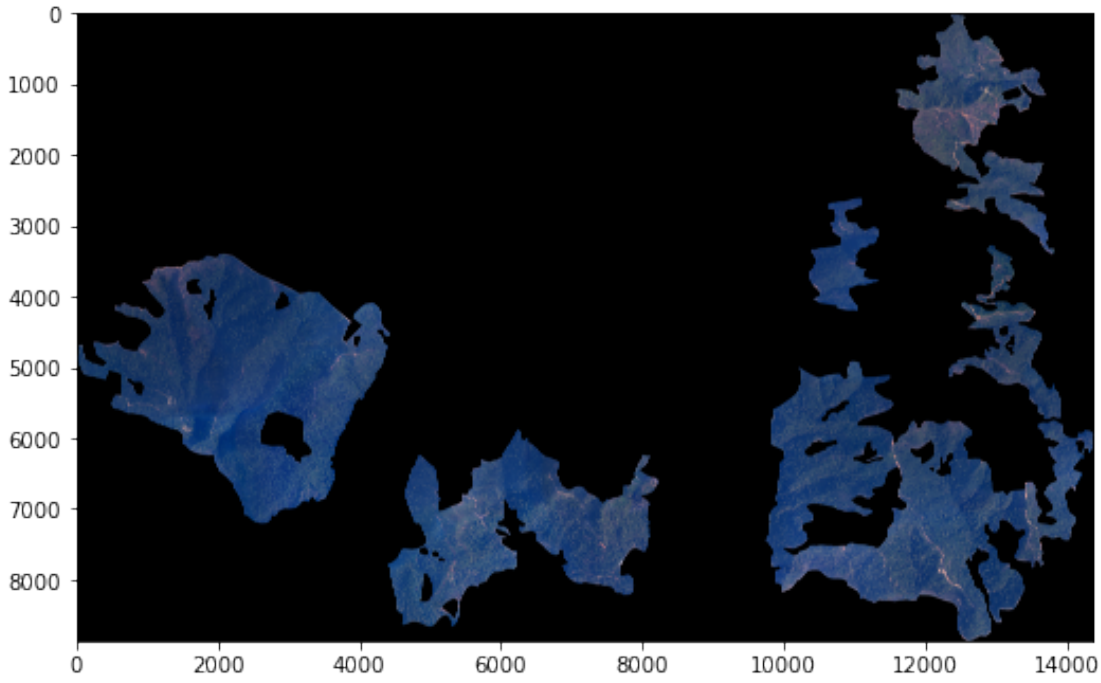


Finally I compared the result to the RGB file.

[30]:
```
img = rasterio.open('/home/dom/Documents/uni/MAP/Forest_Carbon/
↪Digital_image_and_shapefile/cf_ortho1.tif')
img = img.read()
```

[31]:
```
fig, (ax, ax2) = plt.subplots(2, 1, figsize=(12,12))
show(chm_mask, ax=ax)
show(img, ax=ax2)
plt.show()
```





Although the CHM appears slightly different, I also compared these files in QGIS and they appear the same. Therefore I think it just the rendering by matplotlib shown above.