

How to use the Africa Regional Data Cube (ARDC) for investigation of urbanization, land change (deforestation) and flooding

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Step #1 - Sierra Leone User Interface Tool

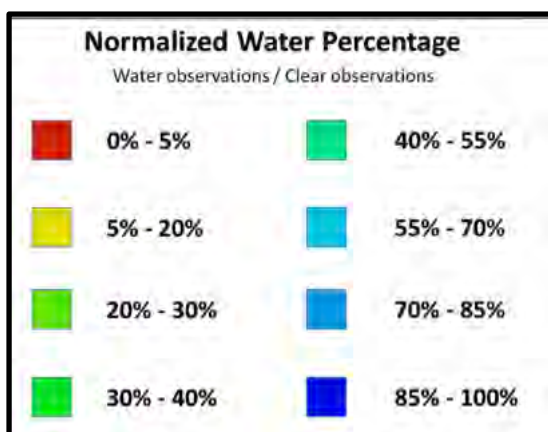
Website: <http://18.188.69.114/>

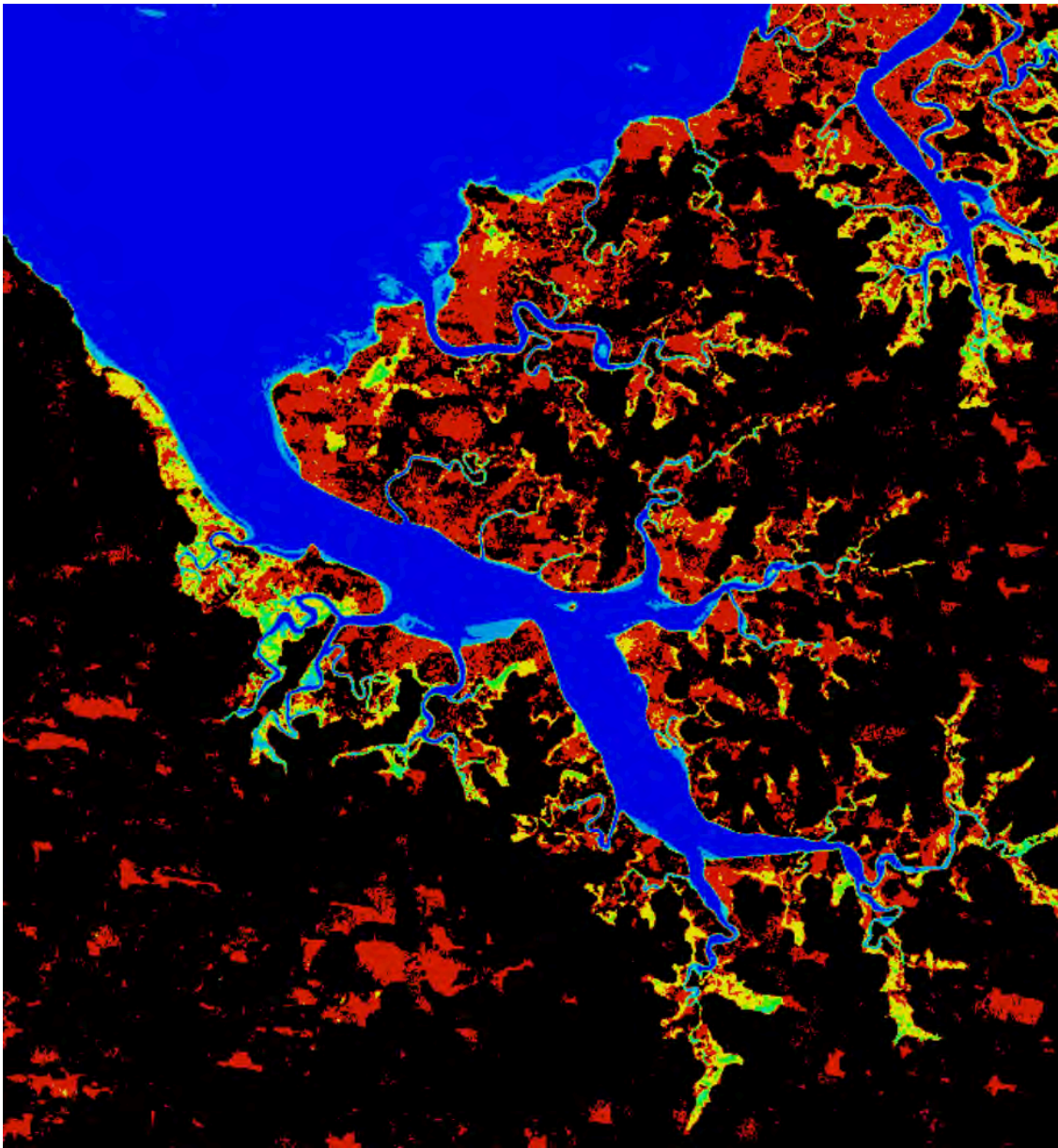
One of the best ways to analyze water extent is to use the online ARDC user interface. The following case study shows how to create a water extent product and understand the details of this output.

Menu: Tools > Water > Water Detection > Sierra Leone

The user needs to select a region and then select the parameters from the "Data Selection" menu. It is usually best to select a long start and end date to gather water information for entire time series. The product is based on the Water Observation from Space (WOFs) algorithm, developed in Australia. The results can be used to identify regions of periodic flooding, flood risk and the times of historic flooding. An example is below for the area of Freetown.

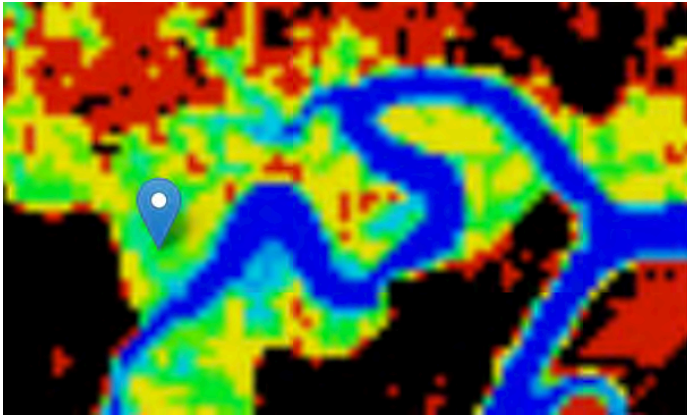
Below is the legend for the WOFs product. The colors represent the percent of time a pixel has experienced water out of all of the clear observations. Regions of rare water will be red and yellow colors. Regions of persistent water (rivers, lakes, etc.) will be dark blue.



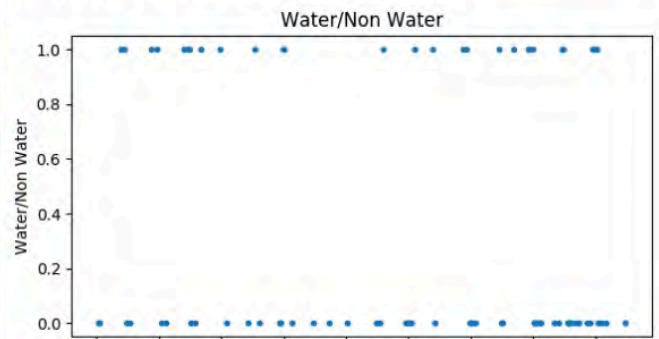


WOFS Water Extent for eastern Freetown from Apr-1999 thru Dec-2016.

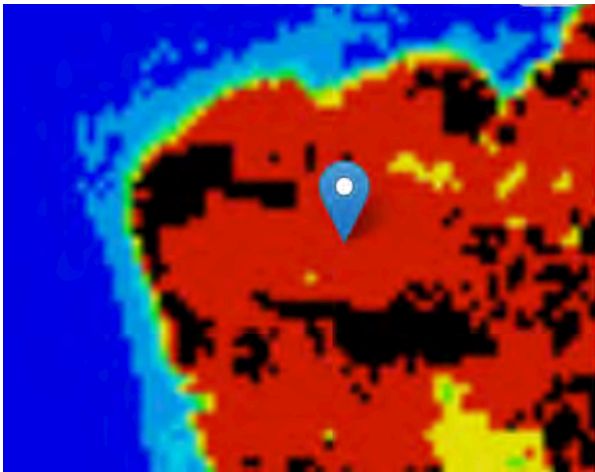
The pixel-dropper can be used to assess any single location in the final product. An example is below.



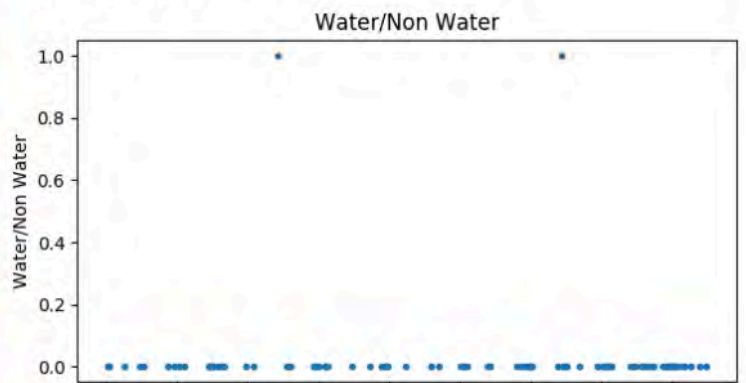
task can be seen below.



The results above suggest this location experiences flooding during seasonal rains, as the flooding is spread across the entire timeline and does not persist for long periods of time.



task can be seen below.



The results above show an area near the coast that experienced water only 2 times in the 17-year analysis period. This occurred in 2005 and 2012.

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Step #2 - Sierra Leone Jupyter Notebooks

Website: : <http://18.188.69.114:8000>

Password: ardcuser

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Case Study #1 - Cloud Statistics

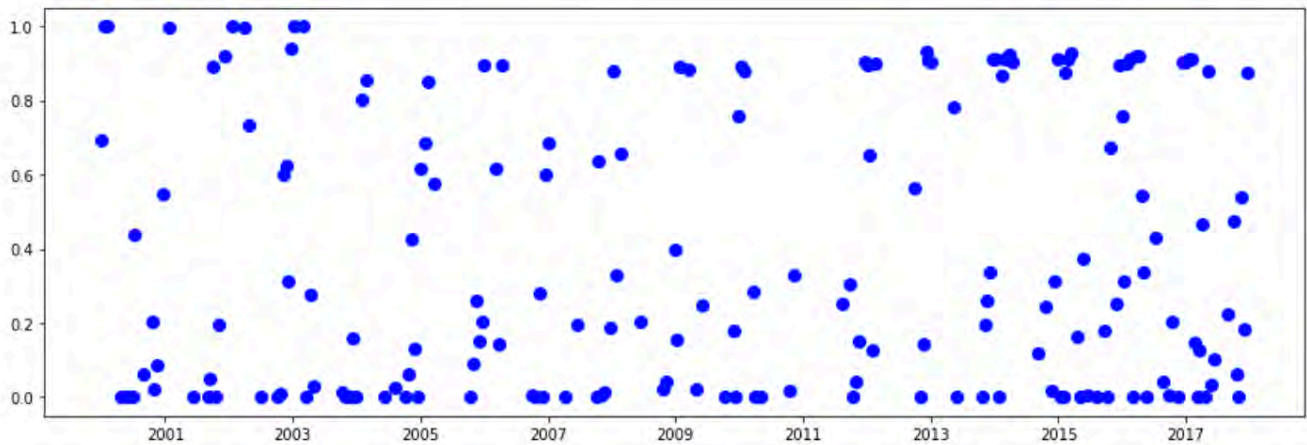
Filename: [Demo_Cloud_Statistics](#)

Optical data (e.g. Landsat) will always have issues with clouds. This notebook calculates cloud statistics for selected regions for both Landsat-7 and Landsat-8 data cubes. This is valuable information for performing further analysis. For example, if there are extensive clouds for a season it may significantly impact the mosaic product or index values. Another example is that a user may want to identify a single date when there are no clouds to assess land features.

The user will select a mission (L7 or L8), a region, and a time period. The code will produce a table of time "slices" and their corresponding cloud statistics (e.g. clean percentage). In addition, the user will find a plot of cloud coverage over the time period and some code to create an RGB image of any time slice. Examples of the outputs are below.

	times	clean_percentage	clean_count
0	2000-01-02 11:03:20	0.695397	60802
1	2000-01-18 11:03:17	1.000000	87435
2	2000-02-03 11:03:18	0.999440	87386
3	2000-04-23 11:02:49	0.000000	0
4	2000-05-25 11:02:29	0.000000	0
5	2000-06-10 11:02:22	0.000000	0
6	2000-06-26 11:02:13	0.000000	0
7	2000-07-12 11:02:00	0.437777	38277
8	2000-08-29 11:01:26	0.061806	5404

The table above displays the time slice (date), clean pixel percentage and the clean count (number of clear pixels).



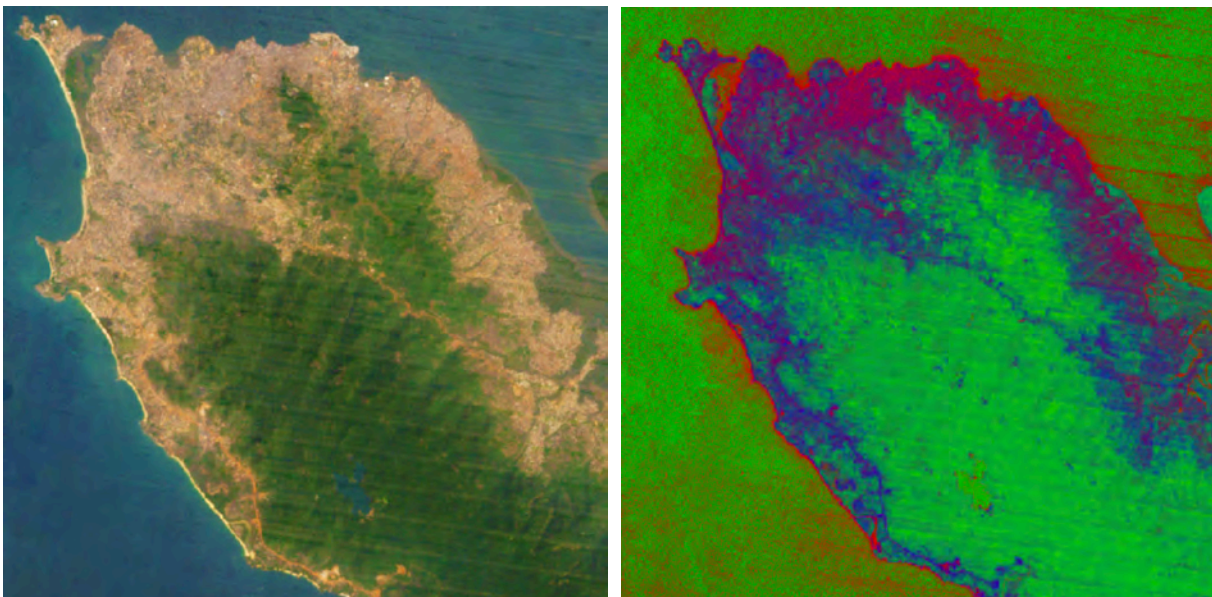
The figure above shows cloud cover statistics from Landsat-7 for 2000 thru 2017 over Freetown.

Conclusion: Sierra Leone is a VERY cloudy region. There are very few clear (1.0) scenes in 17 years of Landsat-7 data. Therefore, combining multiple cloudy images into cloud-filtered mosaics is the only method to obtain decent images.

Case Study #2 - Urbanization

Filename: **Demo_Urbanization**

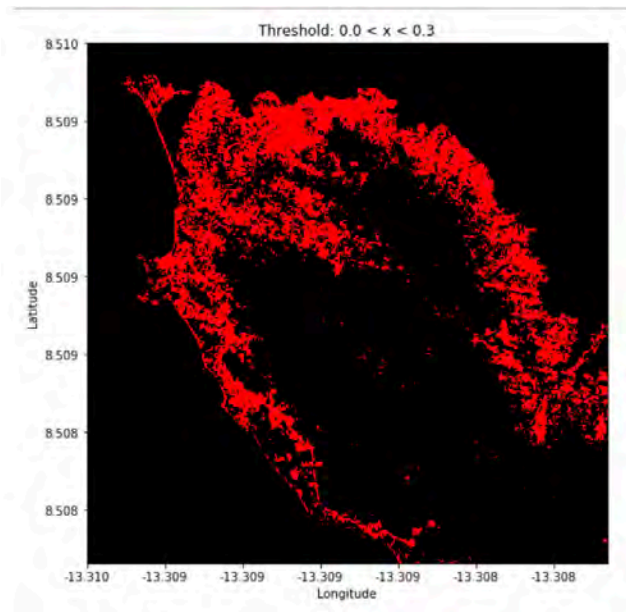
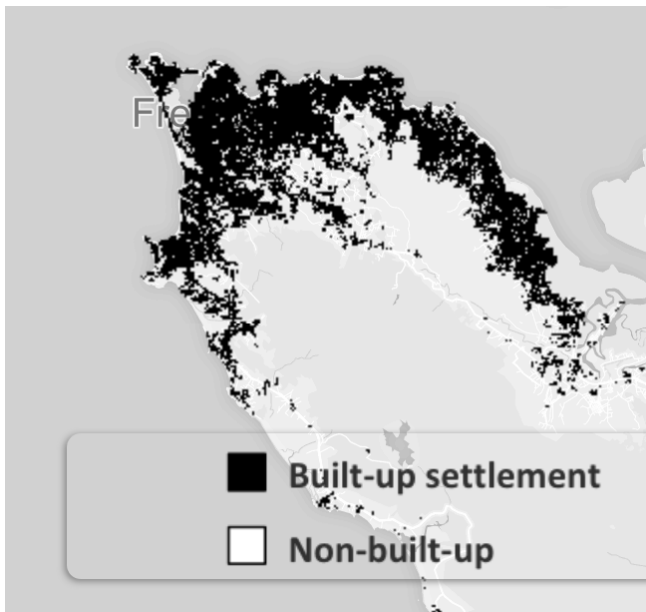
The urbanization notebook includes several spectral indices for land characterization (e.g. fractional cover, NDVI) and also includes several indices for urbanization characterization (e.g. NDBI, BU). Examples of these indices and output products are shown below.



2012 Landsat-7 Images

LEFT: RGB image (colors enhanced using Photoshop)

RIGHT: Fractional Cover (Green=vegetation, Blue=non-photosynthetic vegetation, Red=Bare Soil)

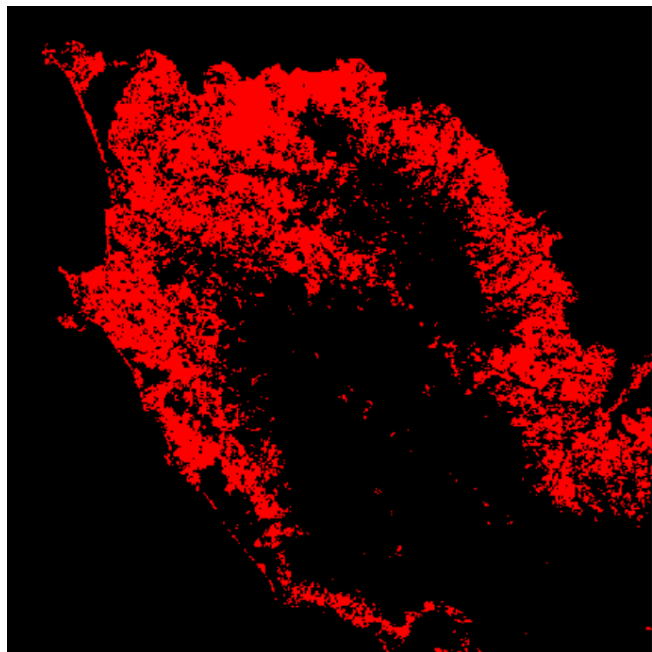
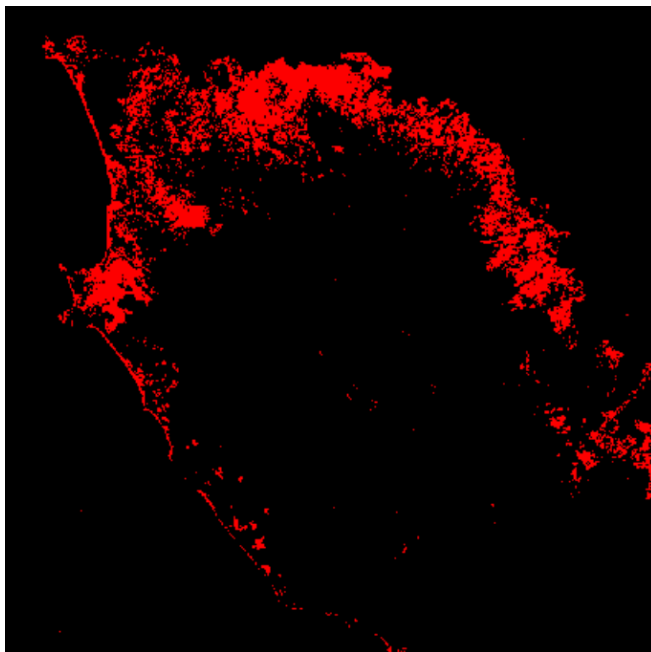


Urbanization Extent for Freetown (2012)

LEFT: ESA Urban TEP (<https://urban-tep.eo.esa.int/geobrowser>)

RIGHT: Open Data Cube - Normalized Difference Build-Up Index (NDBI)

- 14.1% of the pixels are in the NDBI threshold range (0.0 to 0.3)



Change in Urban Area (2000 to 2017)

Normalized Difference Build-Up Index (NDBI) with a threshold range of 0.0 to 0.3

LEFT: 2000 Urban Area = 7.3%

RIGHT: 2017 Urban Area = 18.7%

Case Study #3 - Land Change and Deforestation

Filename: [Demo_NDVI_Anomaly](#)

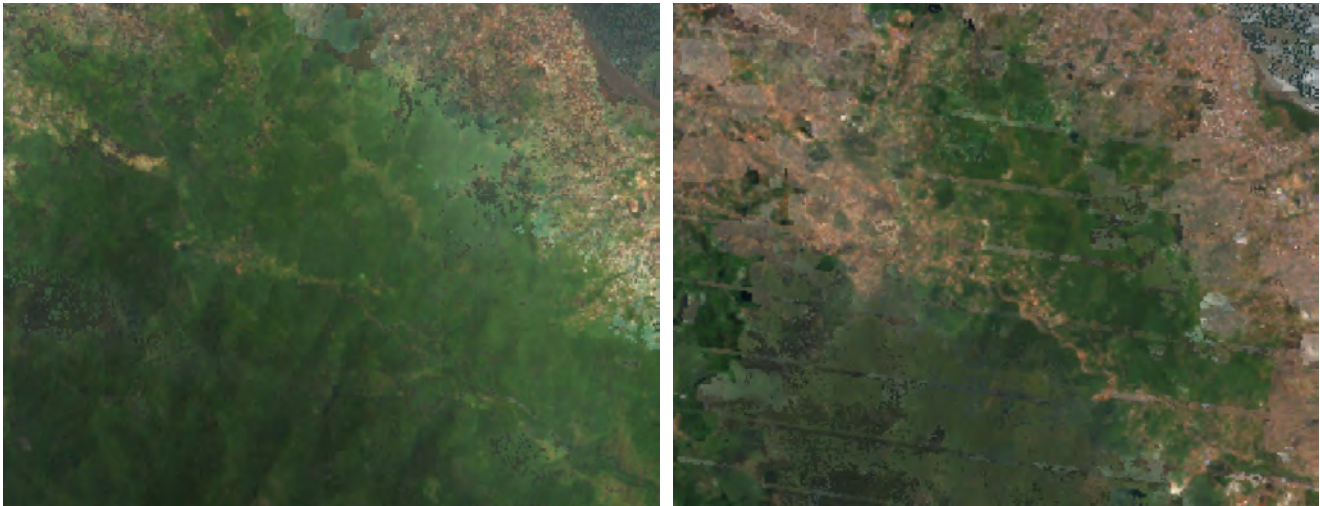
This notebook compares NDVI between two time periods to detect land change. In the case of deforestation, the NDVI values will reduce from (0.6 to 0.9 ... typical for forests) to lower values (<0.6). This change can be detected and used to investigate deforestation or monitor the extent of the land change.

The user will select a dataset (L7 or L8), an analysis region, a baseline time period, an analysis time period, and a method for mosaics (e.g. median, max NDVI, Most Recent Pixel). Due to cloud cover, the baseline and analysis time periods may be long to allow a sufficient number of clear pixels for the analysis. In the case of Landsat-7, the "banding" issue" also requires more scenes to obtain enough clear data. The user should refer to the "Cloud Statistics" notebook for more information on cloud filtering.

The user will also select an "NDVI Baseline Threshold Range" which will screen pixels by their NDVI. For example, if the user is interested in only considering pixels that were likely forests in the baseline image, then the "NDVI Baseline Threshold Range" may be 0.6 to 0.9.

Below you will find a number of output products for the Freetown area. Some of these products are compared with similar output products from Global Forest Watch.

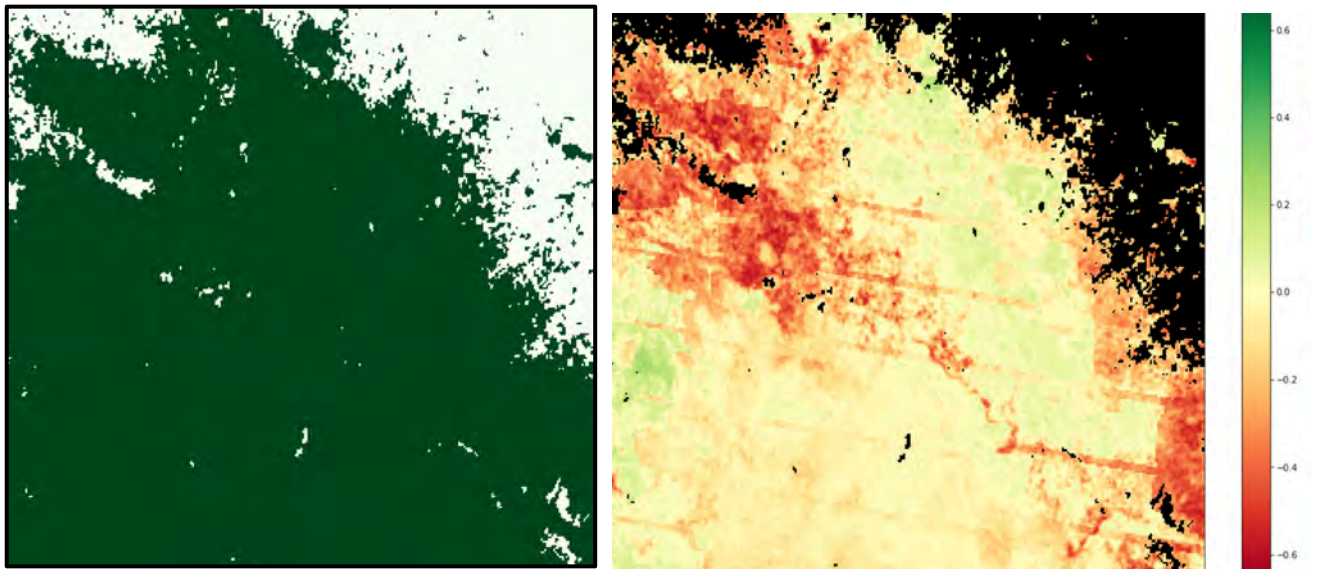




Landsat-7 RGB Images

LEFT: Year 2001

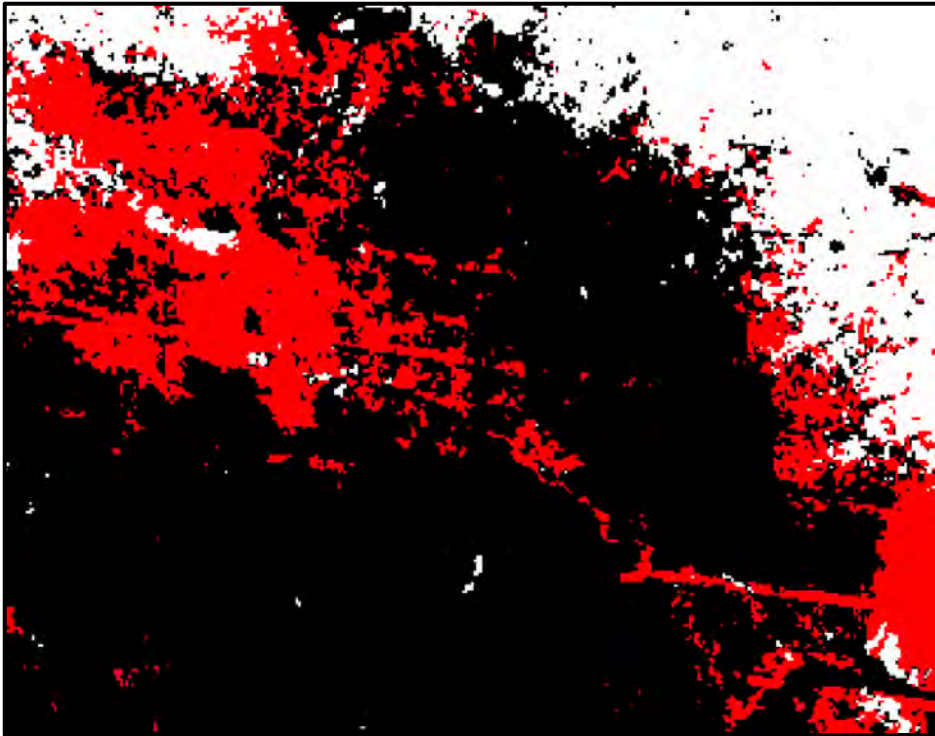
RIGHT: Year 2017 (notice the lines in the image due to the Landsat-7 scan line issue)



LEFT: Forest Mask using and NDVI Threshold (0.6 to 0.9) for 2001 (baseline year)

RIGHT: NDVI Anomaly from 2001 to 2017

- Regions of decreased vegetation are shown in RED.
- Regions of unchanged vegetation are shown in YELLOW.
- Few areas of increased vegetation are shown in GREEN.



NDVI Change Threshold Image

- Pixels with NDVI decreases between 0.2 and 0.6 are shown in RED. It is likely these pixels experienced deforestation, as these pixels originally started as forests (0.6 to 0.9 NDVI).
- Pixels in BLACK did not fall in the change threshold region and were considered "unchanged"
- Pixels in WHITE are non-forest or clouds and not considered.

18.4% of the region experienced significant decreases in vegetation extent.

Considering a mean pixel size of 30m x 30m, this equates to **14.5 km² of forest loss.**

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Case Study #4 - Water Extent

Filename: **Demo_Water**

In addition to the online user interface (page 1), users can also use a Jupyter Notebook to perform analyses on water extent over time. The notebooks allow a bit more flexibility in output products, but also generate the same products as the online tool.