# Satellite Imagery for Human Rights Monitoring

*Training for Transitional Justice Working Group*
*2019 December*
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**Background**

This training provides an overview to the possible ways of rapidly and easily accessing and analyzing remotely sensed geospatial data. This training was developed based on questions from the Transitional Justice Working Group on remote sensing data access and analysis. There are many factors to consider in accessing and analysing geospatial data such as satellite images. Among the background knowledge necessary is an understanding of the basics of GIS and geospatial data (e.g. vector vs raster data types and formats, coordinate reference systems, electromagnetic spectrum, satellite orbits, etc.). I highly recommend that anyone serious about doing this type of work get specialized training (i.e. a degree or similar) in the topic area. A good source for starting with this work, would be to go through the free course materials in the FOSS4G Academy. http://spatialquerylab.com/foss4g-academy-curriculum/

This training focuses on the below areas of interest:

- North western Rakhine (surroundings of Sittwe, Rathedaung, Buthidaung, Maungdaw) in Myanmar
- Bashan Char and surrounding in Bangladesh

The training includes:

- Direct responses to TJWG questions.
- Notes on moving forward with the more technical modules below.
- A module on Accessing Data (with video).
- A module on Imagery Processing (with video).
- A list of useful links for moving forward.

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**Responses to TJWG Questions**

1. *What are the sources of this imagery?*
    a. The primary types of images you will use are satellite such as free Landsat or Sentinel-2 or purchased images from Maxar and other providers. You may get aerial imagery from other sources, but this is often not in multiple bands (has just a light sensor that does not detect many parts of the invisible range of the electromagnetic spectrum) so is useful primarily for visual analysis by the human eye and may be extremely expensive.
2. *How can people go about contacting providers/ getting the sources?* At the below EOS website, you can quickly access up to 10 free high resolution images a day and visualize automatic conversions into scientific indices.
    a. You can see a reasonable purchase price for relatively high resolution (10 m) images if they are available for your area of interest (AOI). You need an account. https://eos.com/make-an-analyses/
    b. If you decided this resolution is insufficient, you likely will need to work with commercial providers like Maxar to get 30cm resolution imagery. http://www.digitalglobe.com/products/securewatch
3. How can they navigate the existing open source imagery?
    a. USGS Earth Explorer is the best source for the most up to date open source imagery as it consolidates from almost every possible source. You will need an account. Instructions for accessing images via USGS Earth Explorer are below. If just rapid, simple analyses are needed then use I recommend using the EOS.com link above. https://earthexplorer.usgs.gov/

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**Summary Notes on Moving Forward**

1. There are several ways to access imagery - create it, get it for free, or pay for it. The best images will come by paying or creating, but there is a lot available for free.
2. If you are willing to pay, Maxar SecureWatch is one of the best. Maxar is a company that has consolidated DigitalGlobe (and GlobalEye) with other services. No additional software is required and it provides the latest high resolution images.
    ***a. 30 cm resolution.***
    b. It sells some of these images to Google for Google Earth. http://www.digitalglobe.com/products/securewatch
    c. It also has an open data program for natural disasters.
        i. https://www.digitalglobe.com/ecosystem/open-data
        ii. https://blog.maxar.com/open-data-program

3. You can get most free/open source images from USGS Earth Explorer. You will need to learn how to handle and manipulate these images in a program like ArcGIS, Sentinel Toolbox, GRASS, or QGIS.
4. If you just need a quick analysis without conducting lots of data handling there are many possibilities to accomplish this online, among the best is https://eos.com/make-an-analyses/
5. There are two primary approaches to image classification: unsupervised (it runs off a predetermined algorithm) and supervised (you have to tell the computer what you want it to find based off of your previous work doing manual classification of spectral signatures). If you want to track specific details such as disturbed soil or burnt homes, then you will likely want to do supervised classification and need to download images and master analysis in a software application.
6. I highly recommend going through this module before doing anything presented in the videos/modules below as it helps ground people in the basics of remote sensing. http://www.spatialquerylab.com/FOSS4GAcademy/Lectures/GST101/L6/Understanding_Remote_Sensing_and_Aerial_Photography%20output/story_html5.html
7. Before proceeding, installation of QGIS (with Grass) and (optionally) Sentinel Toolbox might help people follow along.
    a. https://qgis.org/en/site/forusers/download.html
    b. http://step.esa.int/main/download/snap-download/

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**Accessing Data (Video 1)**

*Video link : https://youtu.be/w_enbRT4-5Q*

*Getting coordinates for later use*

Use Google Maps or Google Earth to find lat long decimal degrees for an area of interest (AOI). Store these coordinates in a text file or note keeping application for later use:
22.367255, 91.387435

These coordinates can be used to find a central point in USGS, Google Earth Explorer, or most any GIS program in which we need to be sure we are analyzing the same location.

*Google Earth: Using common, easy, free open sources to their full capacity*

https://www.google.com/earth/versions/

- Google Earth overview.
- GE history function.
- Positives and negatives of using Google Earth for quick imagery viewing and basic location analysis.

- Positives: easy, free, high quality.
- Negatives: not able to conduct analyses on the data, often not the latest data.

*EOS and Sentinel Hub EO Browser: Using an online data acquisition and visualization platform*

https://eos.com/make-an-analyses/

- You should already know what type of data you need. For more on the difference of different types of Sentinel data see the useful links at the bottom of the document and read through this website: https://medium.com/sentinel-hub/sentinel-2-l2a-products-available-on-sentinel-hub-beab58903285
- Positives: free, do not need complicated software or strong computer processing, can purchase images through the interface for reasonable amounts, provides most recent data.
- Negatives: cannot conduct analyses of specific details (no options for classification that are not already in the interface), can only access 10 images a day (but this should not be a problem as you can setup multiple accounts and you may not need more given the area of interest), need to have some background knowledge in remote sensing imagery analyses/indices and environmental monitoring in order to interpret results.

*USGS Earth Explore: More complex and thorough (free) sources with better temporal and spectral resolution*

- USGS Earth Explorer https://earthexplorer.usgs.gov/
- Rough outline of steps to access Landsat data: https://gisgeography.com/usgs-earth-explorer-download-free-landsat-imagery/
- Need an account.
- There are many options for selection of area of interest options, probably the easiest is to use the map search or have a prepared kml to upload for a specific area. You can export a kml from Google Earth.
- Use the data pre-filter to set cloud cover as low as possible.
- Landsat 8: Level-2 is atmospherically corrected (Surface Reflectance) Landsat data, whereas, Level-1 is not corrected but is free. We can conduct atmospheric correction in software such as QGIS with a plugin.
    - Cloud cover settings.
    - Record path and row.
        - Path:136
        - Row:44
    - Download geotiff.
    - Multiple bands explained.
- Sentinel-2
    - Tile Number:T46QCK
    - Visualize to make sure it is capturing area desired.
    - Download the jpeg2000 format.

- Positives: more control over identification of objects and spectral signatures, more control over raw data and ability to combine raw data with other sources.
- Negatives:More technical training needed to analyze, requires better computer processesors and more data storage, mistakes can be unforgiving if classification is done wrong.

*Transitioning from Accessing Data to Analyzing Data.*

- Overview QGIS and other software potential.

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**Imagery processing (Video 2)**

*Video link: https://youtu.be/bid9ZgsbCXE*

*Overview of Analysis Techniques and Creating Spectral Signatures*

We need to emphasize that remote sensing imagery analysis is not difficult, but it can be highly technical and time consuming. Moving forward will take some additional training or collaboration with those who are already technically trained in GIS and Remote Sensing. The video above walks you through basic resources and holds many tips about how to proceed. The below links provide resources beyond the video.

> An entire 3-6 hour workshop on how to use QGIS with SCP Plugin to do remote sensing analysis. http://bit.ly/remotescp
>
> Semi-automatic Classification Plugin manual (excellent resource for leaning the basics). https://fromgistors.blogspot.com/p/user-manual.html
>
> An introductory step by step process is described here, explaing how to use SCP to download images from ESA and USGS rather than going through EarthExplorer. https://fromgistors.blogspot.com/2018/02/basic-tutorial-1.html
>
> Additional tutorial using QGIS and SCP plugin. https://fromgistors.blogspot.com/p/semi-automatic-classification-plugin.html
>
> An entire course and several labs on how to do remote sensing with QGIS and GRASS. http://spatialquerylab.com/foss4g-academy-curriculum/gst-105-introduction-to-remote-sensing/

*Sentinel Missions*

This is just a brief overview so that you do not get overwhelmed with all the different Sentinel types. Sentinel-2 is what you will use for 10m resolution images on a free, regular basis. Landsat can also be used but provides much less resolution (30m) could be focused on for filling in gaps in time between Sentinel-2 or should be used for long term comparisons (ranging back to the 1970s to early 2010s before Sentinel was launched)

- Sentinel-1 provides all-weather, day and night radar imaging for land and ocean services. The first Sentinel-1A satellite was successfully launched on 3 April 2014, by an Arianespace Soyuz, from the Guyana Space Center.[12] The second Sentinel-1B satellite was launched on 25 April 2016 from same spaceport with similar rocket.
- **Sentinel-2 provides high-resolution optical imaging for land services (e.g. imagery of vegetation, soil and water cover, inland waterways and coastal areas). Sentinel-2 will also provide information for emergency services. The first Sentinel-2 satellite, Sentinel-2A, successfully launched on 23 June 2015.[13] The second Sentinel-2 satellite, Sentinel-2B, followed 7 March 2017. Both satellites launched aboard Vega rockets from Guiana Space Centre.**
- Sentinel-3 provides ocean and global land monitoring services. The first Sentinel-3A satellite was launched on 16 January 2016 by a Eurockot Rokot vehicle from the Plesetsk Cosmodrome in Russia.[14][15] The second Sentinel-3B satellite followed 25 April 2018, also from Plesetsk aboard a Rokot.
- Sentinel-4, embarked as a payload upon a Meteosat Third Generation Satellite, will provide data for atmospheric composition monitoring. It will be launched in 2023.[16]
- Sentinel-5 Precursor - is a subset of the Sentinel 5 sensor set. It was launched on 13 October 2017 by a Eurockot Rokot vehicle from the Plesetsk Cosmodrome in Russia.[17] The primary purpose of this is to reduce the data gap (especially SCIAMACHY atmospheric observations) between the loss of ENVISAT in 2012, and the launch of Sentinel-5 in 2021.[18] The measurements will be done by the Tropomi spectroscope.[19]
- Sentinel-5 will also provide data for atmospheric composition monitoring. It will be embarked on a EUMETSAT Polar System Second Generation (EPS-SG) spacecraft and launched in 2021.[16]
- Sentinel-6 is intended to provide continuity in high precision altimetry sea level measurements following the Jason-3 satellite. Sentinel-6A, also known as the Jason Continuity of Service (Jason-CS), is scheduled for launch in November 2020 by a SpaceX Falcon 9 vehicle from Vandenberg SLC-4.[20]

*Next Steps*

For most groups, the use of online platforms should suffice for basic monitoring. These online platforms are typically free and offer more options in terms of analysis every year. For more advanced individuals and organizations, using QGIS and other software applications like STEP (for Sentinel-2) will provide the most utility for conducting analyses.

While the two presentations show a rapid introduction to many of the best open source options for remote sensing for human rights monitoring, more can be learned by following the additional useful links are below. In addition, approaches such as object oriented identification and specifics about how to combine bands can be learned in the below materials or future workshops.

**Useful Links**

Purchasing Images
EOS: Quickly access up to 10 high resolution images a day and automatic conversions into indices.
https://eos.com/make-an-analyses/

Sentinel Hub
https://www.sentinel-hub.com/explore/eobrowser
https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi/overview
https://www.sentinel-hub.com/explore/education

USGS Earth Explorer
https://earthexplorer.usgs.gov/

QGIS Tutorial

- Tutorial or QGIS SCP Plugin https://fromgistors.blogspot.com/
- Long list of tutorials that touch on various topics in GIS/Remote Sensing https://gracilis.carleton.ca/CUOSGwiki/index.php/Main_Page#QGIS
- Five full free, open courses (of which the last focuses on remote sensing) http://spatialquerylab.com/foss4g-academy-curriculum/

About Remote Sensing

- Remote Sensing Module http://www.spatialquerylab.com/FOSS4GAcademy/Lectures/GST101/L6/Understanding_Remote_Sensing_and_Aerial_Photography%20output/story_html5.html
- Videos of remote sensing labs (full course GST 101) https://canvas.instructure.com/courses/941260
- User manual for QGIS SCP plugin, but contains a wealth of information on remote sensing https://fromgistors.blogspot.com/p/user-manual.html?spref=scp
- NASA/UW open information on the science of satellite observation http://profhorn.meteor.wisc.edu/wxwise/satmet/
- SERC Carleton general information and modules across a broad range of GIS/Remote Sensing topics https://serc.carleton.edu/NAGTWorkshops/gis/imagery_data.html
- Detecting fire with Sentinel 2: https://notebooks.gesis.org/binder/jupyter/user/sentinel-hub-education-illnkkbr/notebooks/wildfires/Wildfires%20from%20Satellite%20Images.ipynb

About Satellites

- Working with Sentinel 2 data in QGIS
  https://www.hatarilabs.com/ih-en/working-with-sentinel-2-imagery-on-qgis
- List of satellites with temporal, spectral, and radiometric resolution (bands)
  https://semiautomaticclassificationmanual.readthedocs.io/en/latest/remote_sensing.html#multispectral-satellites