Practical Session - Exploring satellite multispectral data

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Objective:

To explore online tools for viewing satellite data archives.

Case study: Investigating changes in mangrove cover in Malaysia.

Optical remote sensing data from medium resolution multi-spectral optical sensors can provide information on vegetation health, land use change and habitat classification. You have been asked to explore how the mangrove cover has changed in the last 30 years near Klang, Malaysia and investigate options for monitoring coverage.

In this exercise you will look at data from:

- the Landsat series of satellites (up to 30 m resolution, 16-18 day repeat) 1972 - present
- Sentinel 2 (10-60 m resolution, 5 day repeat with constellation of 2 satellites) 2015 – present

1. Google EarthEngine Timelapse

One of the first things you may want to explore is whether you can see change over time in your area of interest. There are a few online tools which can help you to visualize satellite imagery archives to make an initial assessment.

Google EarthEngine Timelapse allows you to view global cloud-free annual satellite imagery mosaics from 1984 to 2020. The majority of the imagery is from the Landsat series of satellites.

a) Go to google Timelapse: https://earthengine.google.com/timelapse/
b) Navigate to Klang, Malaysia using the search bar in the top left and zoom in to the islands.

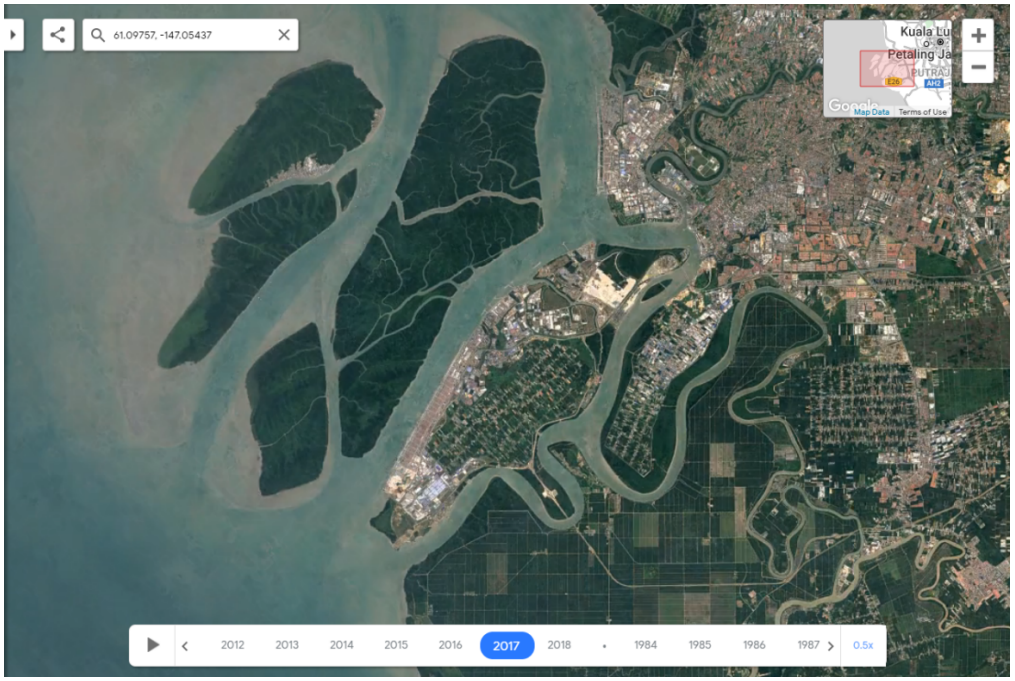

Figure 1: View of the Klang Islands, Malaysia in Google EarthEngine Timelapse.

c) Scroll through imagery using the slider at the bottom to change the date.

Q1: Looking at this timeseries, which islands experience the most change in land cover, which islands change the least? What changes in infrastructure can you see?

2. EO Browser

Google EarthEngine Timelapse allows you to make an initial assessment if change is visible in your area of interest using Landsat mosaics, as a next step you may want to explore the data in more detail, create images for use in a GIS software or documents, or identify particular scenes for downloading and further processing. For this EO Browser is a useful tool.

In EO Browser it is possible to browse and compare full resolution images from Sentinel 1, 2 and 3, the Landsat series, MODIS and MERIS among others. You can also visualise images using different band combinations to help differentiate key features in the image. You can also display indices such as the normalised difference vegetation index to tell you more about the land cover in your image.

a) Navigate to https://apps.sentinel-hub.com/eo-browser/
b) Sign up by clicking ‘log in’ then ‘sign up’ (don’t worry if you do not get an email straight away, you can complete the majority of this practical - up to step l - without logging in).
c) For this example, use the search bar to navigate to Klang Malaysia again and zoom in to the same area as before.

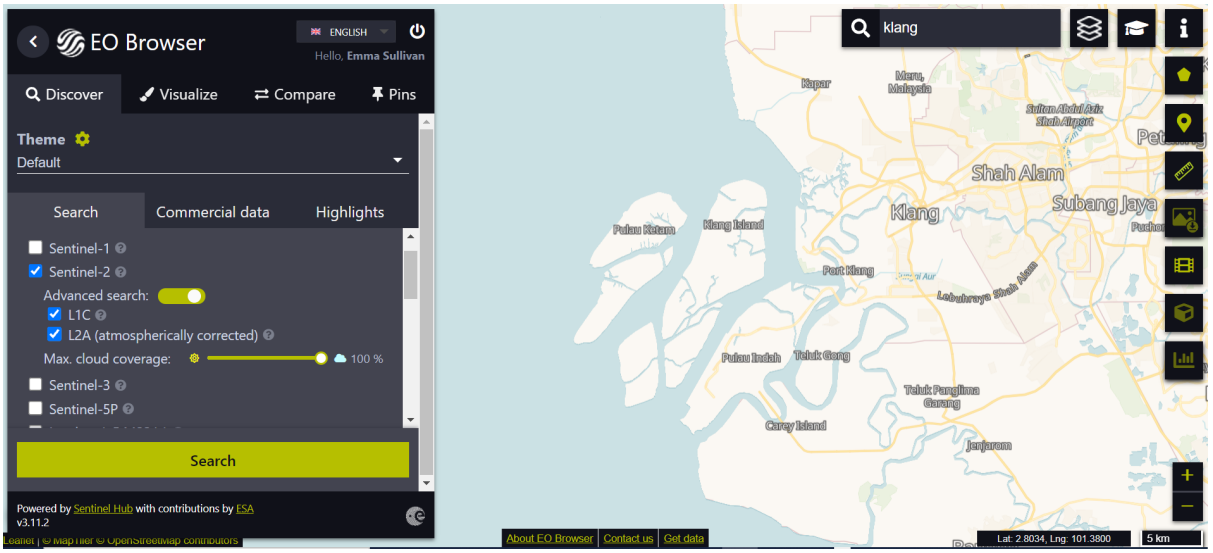

Figure 2: EO browser 'Discover' tab.

We are going to look at Sentinel 2 imagery for the Klang region to assess the extent of mangrove cover in this area.

Q2: Based on some of the considerations we talked about earlier, why might you choose to use Sentinel 2 imagery over Landsat imagery?

d) Select the data source you want to look at – in this case Sentinel-2. Click on Advanced search. You will see here we can view both the L1C and L2A imagery, as well as filtering the results based on the cloud coverage.
e) Select the L2A tick box.
f) Select a time range of interest (or leave the defaults) and click 'Search'
g) You will now have a list of L2A scenes under the 'Discover tab'. To look at a scene click 'Visualize'. To go to the next scene, you can either use the list in the 'Discover' tab to view thumbnails of the images and select them from here, or scroll through using the 'Date' calendar on the 'Visualize' tab (figure 3).

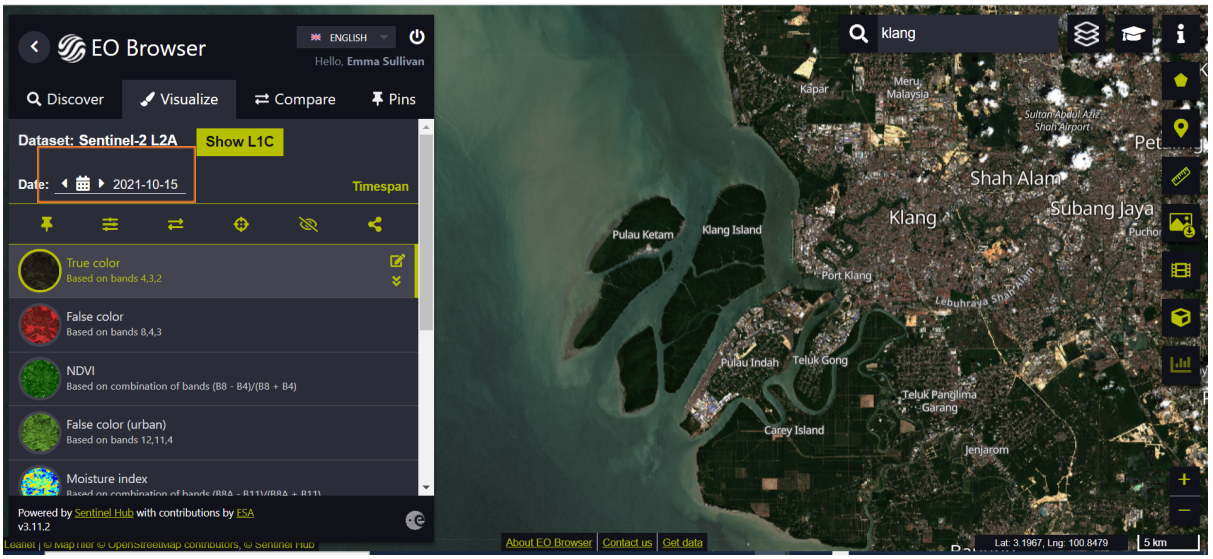

Figure 3: EO browser ‘Visualize’ tab with the date calendar highlighted, this can be used to scroll through imagery.

h) Search the scenes to find a clear, low cloud image of the area.

i) We are going to compare the L1C and L2A Sentinel 2 imagery. To do this we will save a scene with the pin function and use the compare view. Pinning a scene means it is saved in the ‘Pins’ tab; this can be useful if you are trying to find scenes for further analysis and want to compare them to find the most suitable (e.g. lowest cloud cover) or want to see how an area has changed. First pin the L2 scene by clicking the pin button  , then navigate back to the ‘Visualise’ tab and click ‘Show L1C’ and pin this scene too. You should now have two pinned scenes, a L2 and L1A. Now in the ‘Pins’ tab click the compare  button on both scenes. You can now compare these scenes by going to the ‘Compare’ tab and using the sliders to control the split screen.

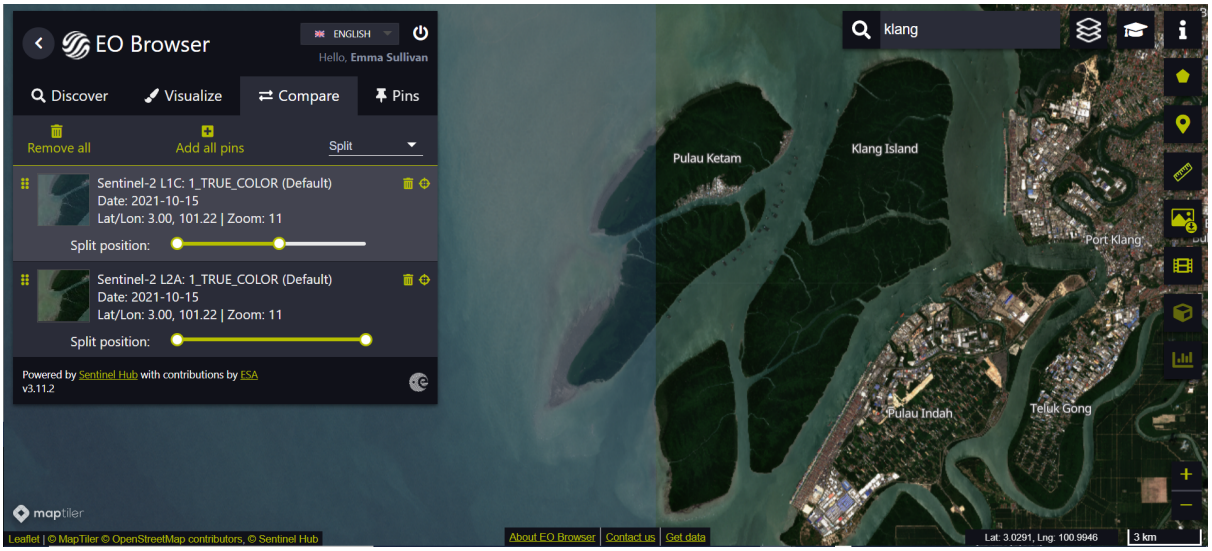

Figure 4: EO browser 'Compare' tab with the level 1C and level 2A Sentinel 2 scene from 2021-10-15 selected. The green sliders are used to control the split screen, here split with the Level 1C imagery on the left and Level 2A on the right.

Q3: What are the main differences you notice between the L1C and L2A Sentinel 2 imagery?

j) In EO Browser you can explore different band combinations and indices such as NDVI to find out more about the land cover in the image. Go the 'Visualize' tab and make sure you are viewing the L2A imagery. On this tab, you will see some standard band combinations and indices which you can apply. For example:

- False colour (R: Band 8 NIR, G: Band 4 red, B: Band 3 green) – Useful for assessing plant density and health as plants reflect near IR and green and absorb red, cities appear grey or brown and water looks blue or black.
- SWIR (R: Band 12 SWIR, G: Band 8A NIR Red edge, B: Band 4 red) – SWIR can help indicate much water is present in plants and soil, as well as snow and ice, cloud and different rock types. Water absorbs all three wavelengths so appears black, sediment loaded water and saturated soil appears blue. Newly burned land reflects strongly in SWIR bands so it appears red and hot areas like lava flows or fires will appear red or orange. Plants reflect NIR very strongly so vegetated areas are bright green.
- NDVI Normalized Difference Vegetation Index (Band 8 -Band 4/(Band 8 + Band 4) – Simple index for quantifying green vegetation. Negative values of NDVI correspond to water, values close to zero (-0.1 to 0.1) generally correspond to bare areas of rock, sand, or snow. Low, positive values represent shrub and grassland (~ 0.2 to 0.4), while high values indicate dense forest.
- NDWI Normalized Difference Water Index (Band 3 -Band 8/(Band 3 + Band 8)- Index to separate water and land.

Press the double down arrow next to the band combination to show the scale and some more information.

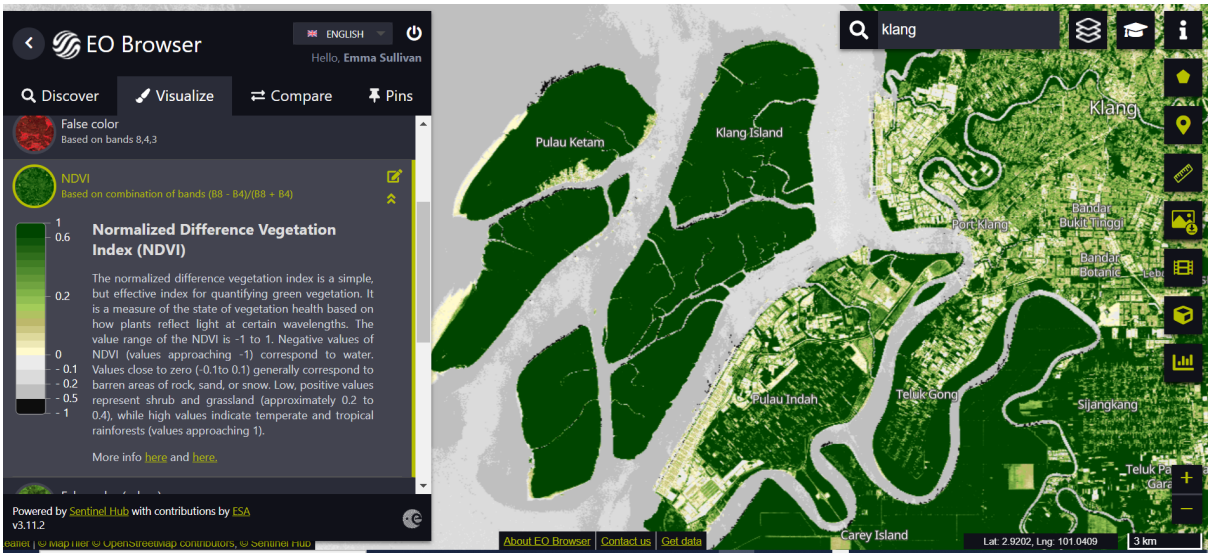

Figure 5: NDVI displayed in EO browser derived from Sentinel 2 imagery over the Klang Islands.

k) You can also apply your own index or band combination to the imagery by selecting 'Custom' at the bottom of the list. For our task, looking at mangrove cover, while the false colour and NDVI are useful, it is hard to separate mangrove forest from surrounding vegetation. A custom band combination (B8,B11,B2) helps us separate these vegetation types more clearly. To create this, drag the bands to the RBG slots. Experiment with other band combinations in your image and see what features you can highlight.

Figure 6: An example of a custom band combination in EO Browser. Note the difference between the red mangrove vegetation next to the water and adjacent orange agricultural vegetation.

For more information on band combinations see here and NDVI see here & here.

l) The final thing you may want to do is download images or create a time-lapse video for an area. You can do this with the tools on the right hand side of the screen (make sure you are

signed in for this part). In the download images  menu you can choose basic images (for documents, ppt), analytical (high res, formats suitable for GIS), or high-res prints. We are going to create a timelapse animation. Click  will take you to a Timelapse window. Select the date range of interest, the image frequency and the maximum cloud cover threshold and click 'search' to load your scenes (as this is just a test, if you want to look over a long time period I recommend choosing one image a month, otherwise it can take a long time to find all the images). You can play your time-lapse using the play button at the bottom of the screen and remove any unsuitable scenes in the list on the right using the tick in the corner of the image.

Q4: From your timelapse you may see a lot of scenes that are impacted by cloud. Looking at the list of data sources in EO browser, are there any other satellites which may be helpful for exploring mangrove cover in this area?

These online tools are great for finding areas of interest, quickly getting images for documents and presentations, familiarising yourself with fieldwork sites and identifying scenes. However, for further analysis you will need to download the full resolution imagery – we will cover how to download Sentinel 2 tomorrow.

3. Look at your own area of interest

If you have time, use these tools to have a look at your own study area or area of interest and experiment with band combinations. If you create any band combinations or timelapse videos which highlight specific features of interest in your images please save these to share with the group.

If you would like some ideas of areas to explore:

- Eruption of the Cumbre Vieja volcano, La Palma in the Spanish Canary Islands (20/09/2021-30/10/2021 HINT: try testing the different Sentinel 2 band combinations here)
- Sentinel 2 and Sentinel 3 imagery of a coccolithophore bloom around the Isle of Arran this summer (21/06/2021)
- Sentinel 2 imagery of the Dixie forest fire near Lake Almanor, California (13/07/2021 onwards HINT: again try testing the different Sentinel 2 band combinations here)

If you want to know more about the area this practical was based on, see Hattam et al. "Using nexus thinking to identify opportunities for mangrove management in the Klang Islands, Malaysia." *Estuarine, Coastal and Shelf Science* 248 (2021): 107157.