Volume

1

ACADEMIC CONSULTANCY TRAINING

Wageningen University & Research

Manual Google Earth Engine

Manual for GEE and Viwi for Wiertsema & Partners

Persa Koutsouradi
Shoyo Nakamura
Marieke Buuts
Kristie Swinkels
Davey de Groot

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1

Context of the manual

Using Google Earth Engine (GEE) is a cloud-solution based application for processing large amounts of temporal satellite data. It provides cloud-computing, without the need for storing data on private servers. It scales easily, is flexible in choosing an 'area-of-interest', and when made into a web-application intuitively to use.

GEE is used because "*Earth Engine provides easy, web-based access to an extensive catalog of satellite imagery and other geospatial data in an analysis-ready format. The data catalog is paired with scalable compute power backed by Google data centers and flexible APIs that let you seamlessly implement your existing geospatial workflows. This enables cutting-edge, global scale analysis and visualization."* (Source: Google)

The reader of this manual will learn to select and analyze areas of interest by focusing on temporal trend analysis of NDVI-values. Meaning: have vegetated areas gained productivity or has productivity been declining?
The skills the reader needs to use the application is common sense. The GUI in the GEE should be intuitively used by any person experienced in basic computer use and basic GIS knowledge.

The solution requested by the company of Wiertsema & Partners should be **easy to learn, easy to use and easy to explore**.

The application provides a quick way to assess temporal trend analysis in vegetated areas. This result can further be used by Wiertsema & Partners in deciding potential measuring positions. As for the processing of data, GEE is especially useful in preventing the need for extensive importing of datasets on private servers.

This manual consists of two parts. The first part shows the quick guide, such that readers can quickly follow and run the application. The second part describes the details of the application and readers can better understand the advanced use of the application as well as the background and processes.

Chapter

2

Quickstep manuals for NDVI slope and Viwi

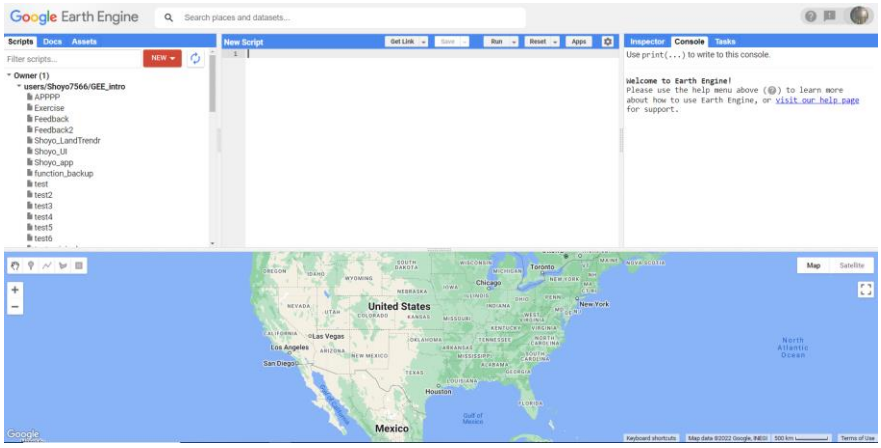
This provides a quick overview of the most basic and useful functions of the GEE application. Following these steps, one can easily achieve results in a few minutes. This GitHub repository containing the code, manual, and report can be found here.

To quickly go to the NDVI Slope (greening-browning) application click here. The application assumes assets are already loaded if results are to be exported. How to import an asset can be viewed on page 21.

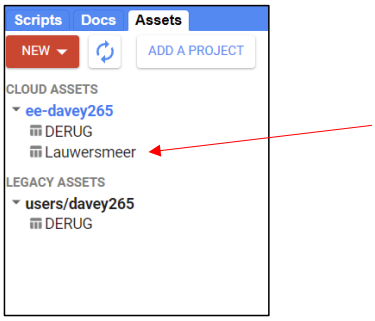
To quickly go to the LandTrendr Application, click here. This goes the LandTrendr Quickstep manual, click here.

Quickstep Manual for NDVI Slope

Step 0: Open the Google Earth Engine and log in.

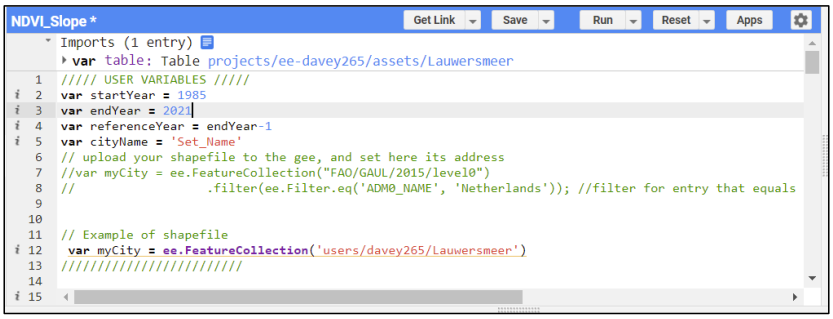


Step 1: Add assets to imports. Click name of asset. All assets should be in EPSG:4326 (WGS 84). If not, reprojection is needed. For more information about uploading assets, click here or see chapter about importing assets in GEE on page 21.

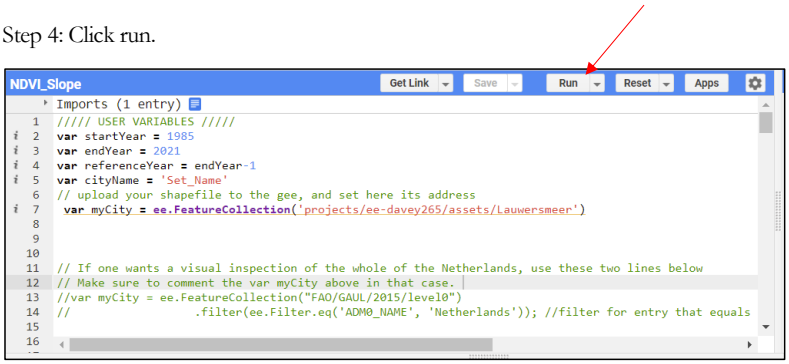


Step 2: Click import. Table will be imported and ready for use.

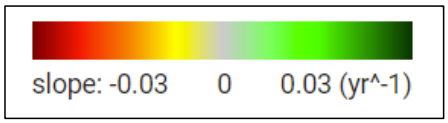
Step 3: Set startYear and/or endYear. Default startYear is 1985 (also minimal) and endYear 2021 (also maximal. Year should always be current year – 1).



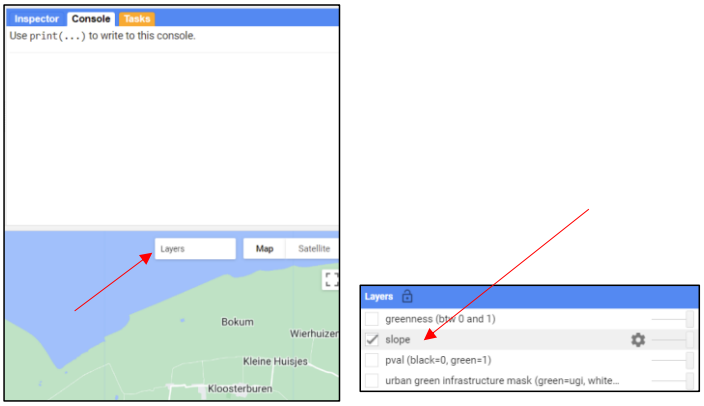
Step 4: Click run.



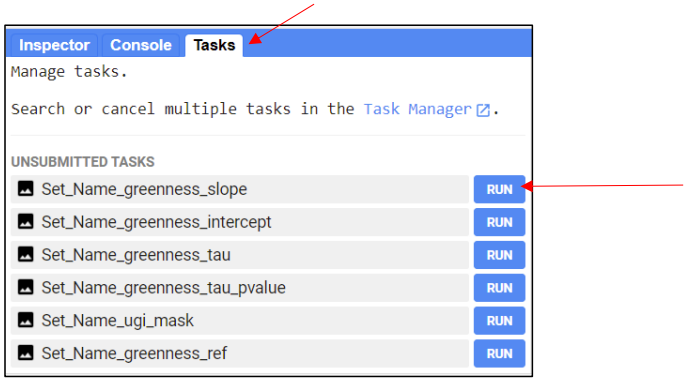
Step 5: Map will appear. The legend of slope can be seen. Slope is in *NDVI Unit per year.*



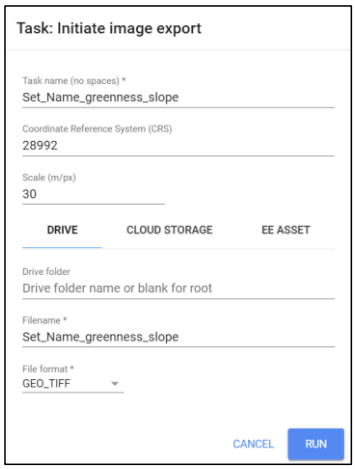
Step 5: Select slope in the layers button.



Step 6: Downloads will appear in 'Tasks'. Click Run.



Step 7: Export image to Google Drive. Settings then can be changed: Coordinate system, scale, Drive Folder, Filename and FileFormat.



Step 8: Change imagery (.tif) is situated after completion in Google Drive folder, ready for download for own usage.

Commented [NS1]: Maybe add visualization shown by QGIS in step 9

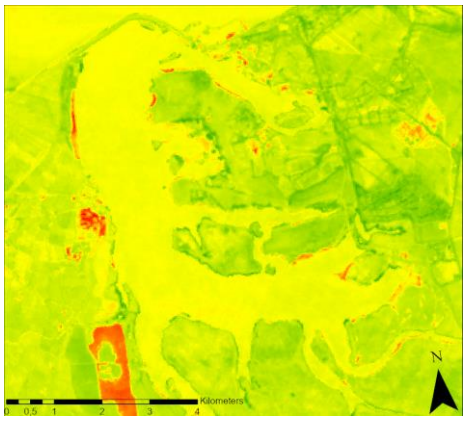
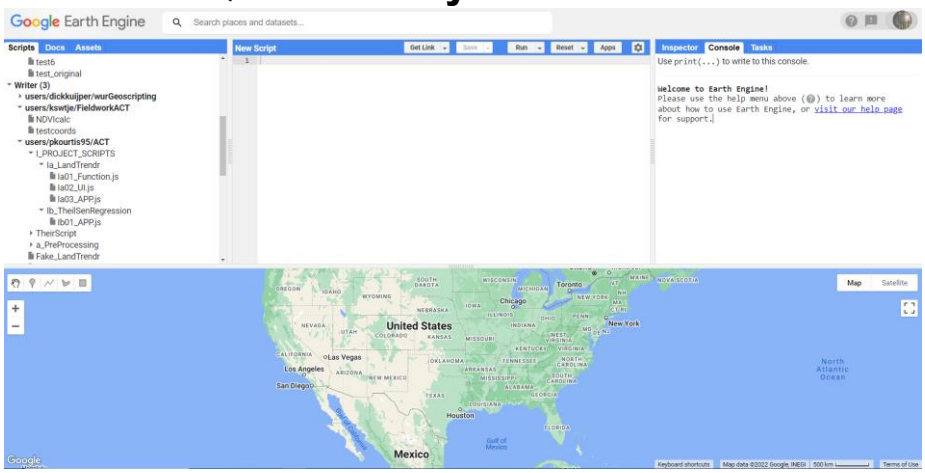
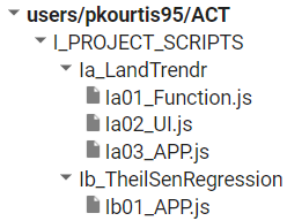


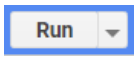
Figure 1: Example of NDVI Slope output

LandTrendr Quick and Easy manual

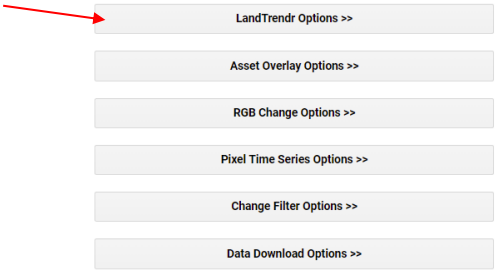


1: Open repository and click APP

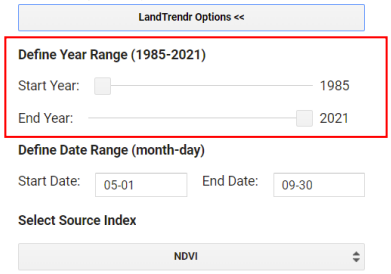


2: Click 

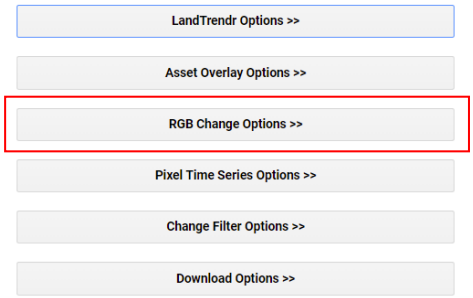
3: Click LandTrendr Options



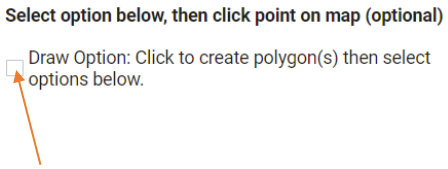
4: Define range of years (Default: 1985-2021)



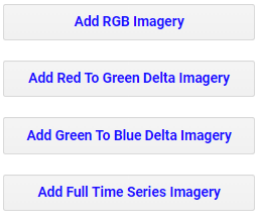
4: Click 'RGB Change Options'



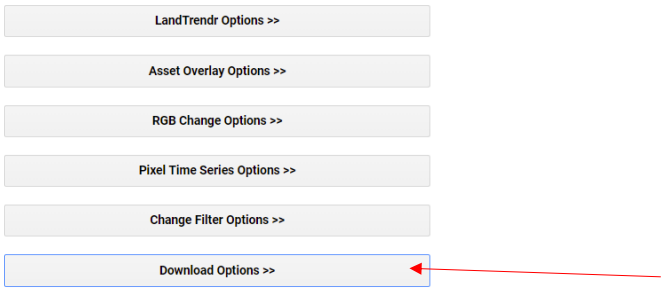
5: Draw polygon of research area



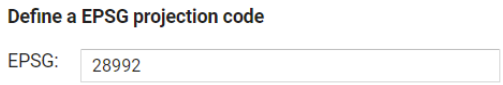
6: Click *all four* buttons to add imagery of change



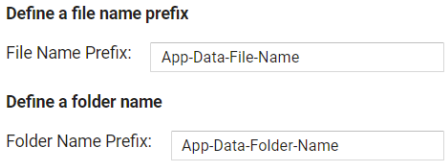
7: Click Download Options



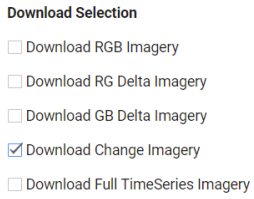
8: Set EPSG code (Default: 28992)



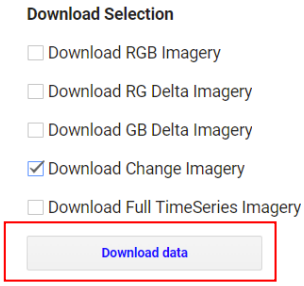
9: Define file name and file folder



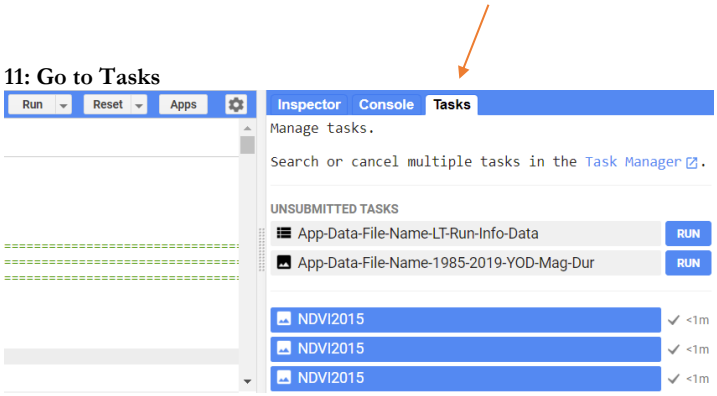
9: Check boxes for Download Change Imagery (CHANGE TO GREATEST LOSS)



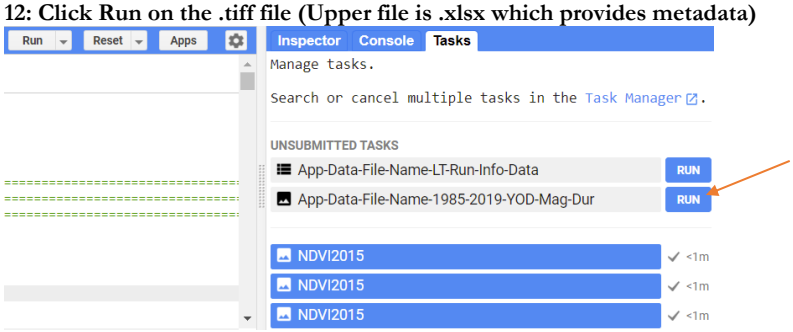
10: Click download (Image .tiff exports to Drive)

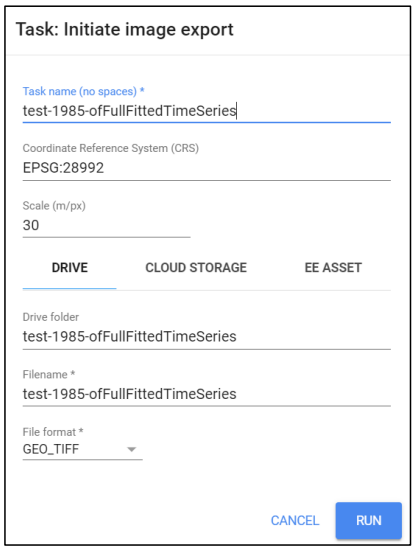


11: Go to Tasks



12: Click Run on the .tiff file (Upper file is .xlsx which provides metadata)





13: In the new window it is possible to change coordinate systems, scale of pixels (m/px), saving folder, filename and file format (default GEOTiff).

14: Change imagery (.tif) is situated in Google Drive Folder, ready for download to own storage

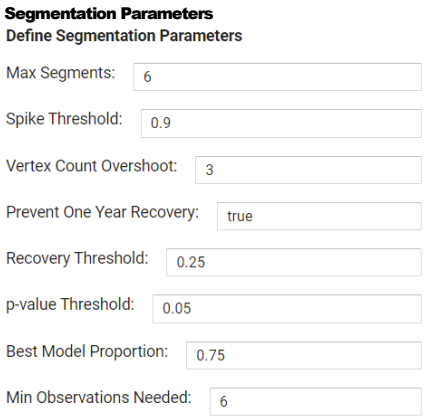
Commented [NS2]: Wanna see the example visualization by QGIS

Chapter

3

LandTrendr options

LandTrendr has several options for optimizing the analysis. All functionalities will be explained in this chapter.



Explanation of segmentation parameters is found below (from https://pro.arcgis.com/en/pro-app/latest/help/analysis/raster-functions/landtrendr-analysis.htm)

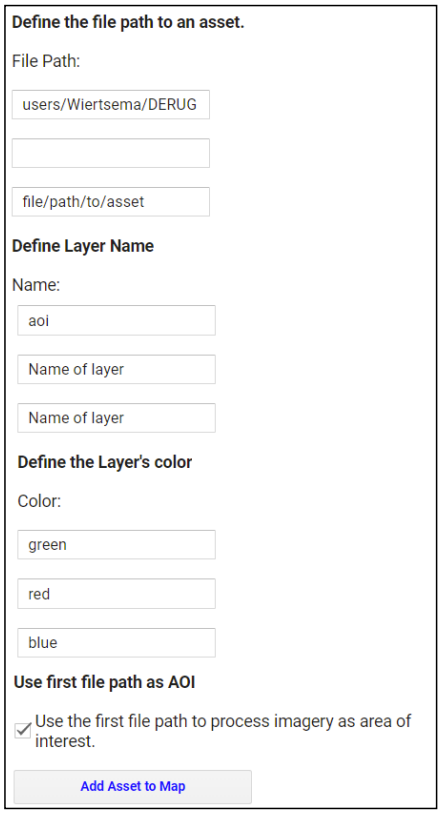
PARAMETER	DESCRIPTION
SOURCE INDEX	The vegetation index name to use for segmenting the pixel value trajectories over time. Choose the index name that will best capture the changes in the feature you want to observe.
YEAR RANGE	The range of years used to define the change between two temporal dimensions.
DATE RANGE	The date range used to find the 95% percentile (used as maximum) NDVI value in a year.

MAXIMUM NUMBERS OF SEGMENTS	The maximum number of segments to be fitted to the time series for each pixel. The default is 6.
SPIKE THRESHOLD	The threshold to use for dampening spikes or anomalies in the pixel value trajectory. The value must range between 0 and 1 in which 1 means no dampening. The default is 0.9.
VERTEX COUNT OVERSHOOT	The number of additional vertices beyond max_num_segments + 1 that can be used to fit the model during the initial stage of identifying vertices. Later in the modeling process, the number of additional vertices will be reduced to max_num_segments + 1. The default is 2.
PREVENT ONE YEAR RECOVERY	Specifies whether segments that exhibit a one year recovery will be excluded. • Checked—Segments that exhibit a one year recovery will be excluded. This is the default. • Unchecked—Segments that exhibit a one year recovery will be not be excluded.
RECOVERY THRESHOLD	The recovery threshold value in years. If a segment has a recovery rate that is faster than 1/recovery threshold, the segment is discarded and not included in the time series model. The value must range between 0 and 1. The default is 0.25.
P-VALUE THRESHOLD	The p-value threshold for a model to be selected. After the vertices are detected in the initial stage of the model fitting, the tool will fit each segment and calculate the p-value to determine the significance of the model. On the next iteration, the model will decrease the number of segments by one and recalculate the p-value. This will continue and, if the p-value is smaller than the value specified in this parameter, the model will be selected and the tool will stop searching for a better model. If no such model is selected, the tool will select a model with a p-value smaller than the lowest p-value × best model proportion value. The default is 0.01.
BEST MODEL PROPORTION	The best model proportion value. During the model selection process, the tool will calculate the p-value for each model and identify a model that

	has the most vertices while maintaining the smallest (most significant) p-value based on this proportion value. A value of 1 means the model has the lowest p-value but may not have a high number of vertices. The default is 1.25.
MIN OBSERVATIONS NEEDED	The minimum number of valid observations required to perform fitting. The number of years in the input multidimensional dataset must be equal to or greater than this value. The default is 6.

Asset overlay options

This is used for importing an area of interest, instead of drawing your own polygon, and using this for analysis. Three areas of interest can be used at the same time.



FILE FORMATS
Shapefiles (shx, shp, dbx, prj or zip
csv
TIF
TFRecord (+ json)

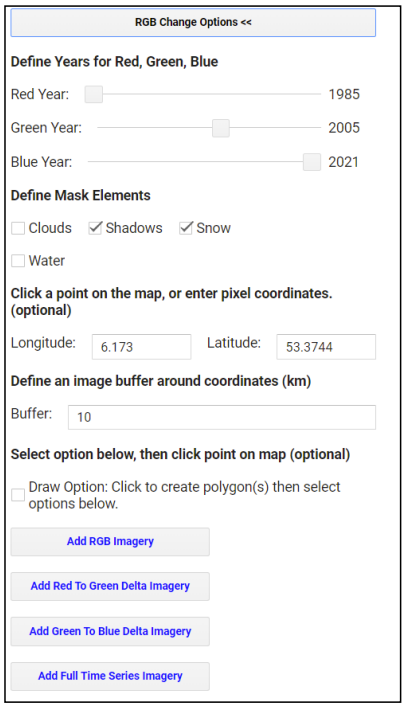
1) **Define the path to an asset.** This asset will be loaded into the map view as a layer. The asset path can be found by clicking on an asset (go to the assets tab) and recording the path under "Table ID".

2) Optional, define a name to call the loaded asset.

3) Optional, define the color of the asset.

4. **Check box to use first file** as area of interest in analysis. Add asset to map.

RGB Change Options



1) **Define years to represent red, green, and blue** color in the final RGB composite. The Red Year value is the year value for the Full Time Series Display image. Detailed explanation for Delta Imagery can found here.

2) **Define Masking options**. Each item selected will be masked out as NoData to the best of its ability

3) **Optionally** define a pixel coordinate set to view the time series of, alternatively you'll simply click on the map. Note that the coordinates are in units of latitude and longitude formatted as decimal degrees (WGS 84 EPSG:4326). Also note that when you click a point on the map, the coordinates of the point will populate these entry boxes.

4) Define a buffer around the center point defined by a map click or provided in the longitude and latitude coordinate. The units are in kilometers. It will draw and clip the map to the bounds of the square region created by the buffer around the point of interest.

5) **Draw a polygon by clicking the check box**. Then click on the map to draw a polygon that will be the extent of the imagery displayed. To remove the polygon and us the point buffer extent simply uncheck the draw box.

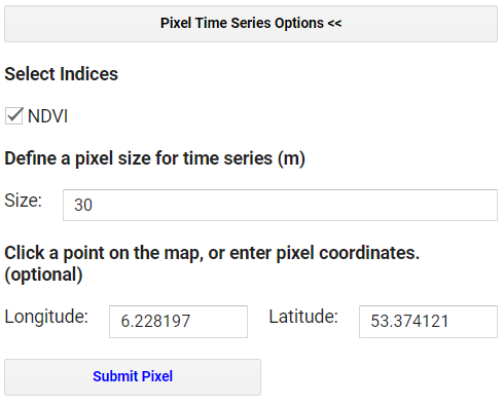
6**) Click the Add RGB Imagery button to add red year, green year, and blue year composite to the map view**. The extent of the imagery displayed is define by a point buffer or drawn polygon. Detailed explanation for Delta Imagery can found here.

7) **Click the Add RED to Green Delta button** to add an image of magnitude and direction from the red year to the green year to the map view. The extent of the imagery displayed is define by a point buffer or drawn polygon.

8) **Click the Add Green to Blue Delta button** to add an image of magnitude and direction from the green year to the blue year to the map view. The extent of the imagery displayed is define by a point buffer or drawn polygon.

9) **Click the Add Full Time Series Imagery** to add an image of the whole time series

Pixel Time Series Options



Sometimes one wants to analyze a single pixel (30x30m). This is the tool to use.

1) **Select spectral indices** and bands to view. You can select one or two.

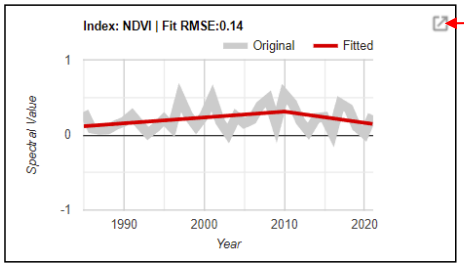
2) **Define pixel size** for time series (m)

3) **Identify location** with one of two options:

a) **Click on the map**. The coordinates of the point will populate the latitude and longitude (coordinates are in units of latitude and longitude formatted as decimal degrees (WGS 84 EPSG:4326).

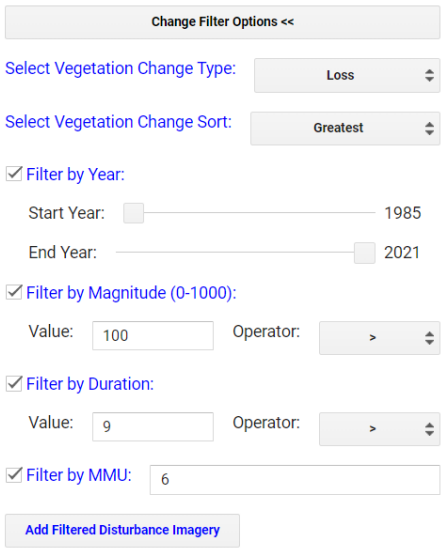
b) Or **enter pixel coordinates** in decimal degrees.

4) If you want to change anything about the run, but keep the pixel coordinate, make the changes and then hit the ReSubmit Pixel button.



5. Create and view full size graph. Graph can be exported in the new window opened by clicking the button and be downloaded to csv.

Change Filter options



1) **Define the vegetation change type** you are interested in - either vegetation **gain** or **loss**.

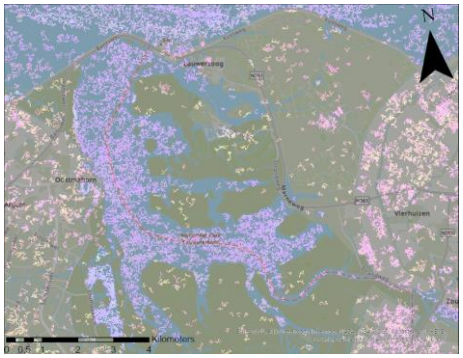
2) **Define the vegetation change sort** - should the change be the greatest, least, longest, etc. This applies only if there are multiple vegetation changes of a given type in a pixel time series. It is a relative qualifier for a pixel time series.

3) Optionally filter changes by the year of detection. Adjust the sliders to constrain the results to a given range of years. The filter is only applied if the Filter by Year box is checked.

4) Optionally filter changes by magnitude. Enter a threshold value and select a conditional operator. For example, if you selected the change type as vegetation loss defined by NDVI and wanted only high magnitude losses shown, you would maybe want to keep only those pixels that had greater than 0.1 NDVI units' loss - you would set value as 1000 and select the > operator. The filter is only applied if the Filter by Magnitude box is checked.

5) Optionally filter by change event duration. Enter a threshold value and select a conditional operator. For example, if you only want to display change events that occurred rapidly, you would maybe set the value as 2 (years) and the operator as < to retain only those changes that completed within a single year. The filter is only applied if the Filter by Duration box is checked.

6) Optionally filter by a minimum disturbance patch size, as defined by 8-neighbor connectivity of pixels having the same year of change detection. The value is the minimum number of pixel in a patch. The filter is only applied if the Filter by MMU box is checked. **As pixels are 30x30m, filter should be off to look at specific patches.**

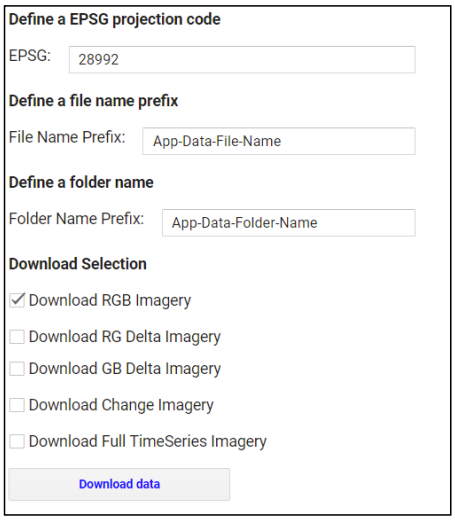


7) **Click the Add Filtered Disturbance Imagery** to the map viewer.

Commented [NS3]: Wanna see example output

Figure 2: example of filtered disturbance imagery in QGIS

Download options



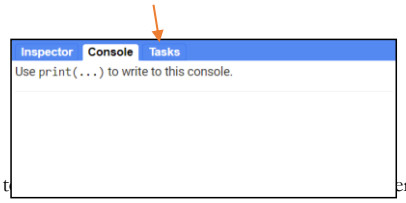
1) **Define the output imagery projection** in the form of a EPSG code.

2) **Define a file name prefix**. Image information such as selected years and other info will be appended the file name prefix.

3) **Define a folder name prefix** to store the imagery in your Google Drive. Image information such as selected years and other info will be appended the folder name prefix. Also, each image represented by a checked box will be downloaded into its own folder. This will help manage mergers of image chucks if necessary.

4) **Select the checkboxes** for the data you wish to download.

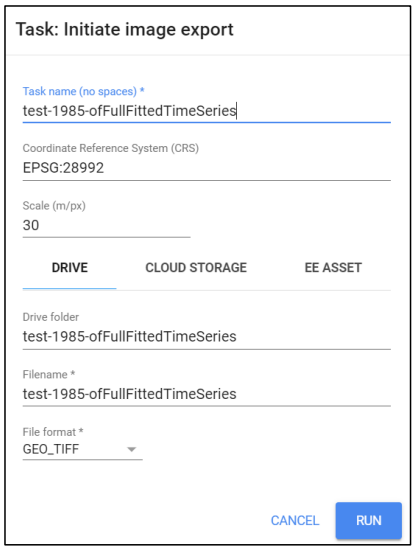
5) Click the **Download Data** button to start tasks.



6) Look under the **Tasks tab** for the export processes.

7) Click the **RUN** button to start the downloading process t en.

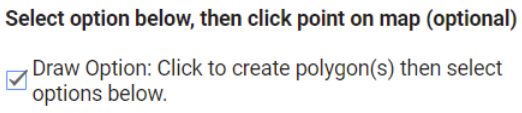
8) In the new window it is possible to change coordinate systems, scale of pixels (m/px), saving folder, filename and file format (default GEOTiff).



Google Earth Engine Settings

Creating a polygon in Google Earth Engine using the application

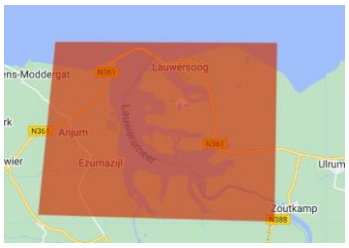
1: Check the 'Draw Option' box. The cursor will automatically into a polygon draw tool.



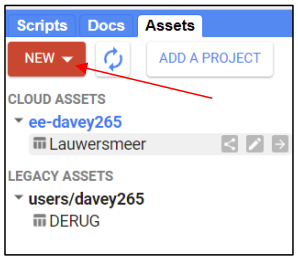
2. Click on a point to start drawing the polygon.

3. Repeat clicks until ideal shape of polygon is created.

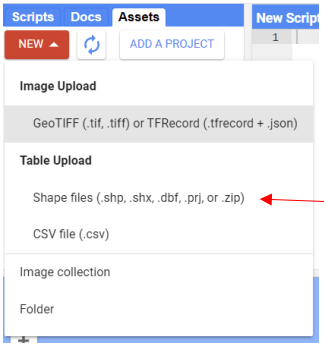
4. Polygon is created.



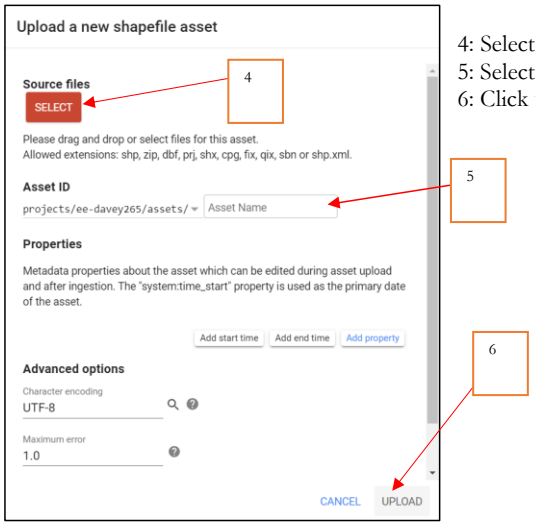
Importing assets into Google Earth Engine



1: Go to Assets
2: Click NEW

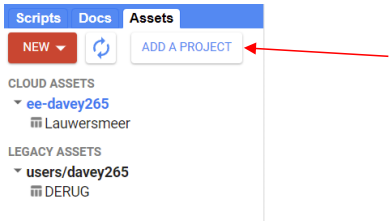


3: Select Shape files or what you want



4: Select source files (important to add all other files
5: Select where to save asset and file name
6: Click upload to upload file as an asset

7: Asset is now in the assets folder



Detailed NDVI Slope Application explanation

This table is intended for interpreting the results of the trend slope map

Class	Description
≤ -0.015 → major browning	Downward trend (Browning) due to housing policies, development of industrial and commercial areas, new grey infrastructures
-0.015 < x ≤ -0.0001 → slight browning	
-0.0001 < x ≤ 0.0001 → no changes	
0.0001≤ x ≤ 0.007 → slight greening	Upward trend (Greening) due to green infrastructure management; vegetation growth, climate change
> 0.007 → major greening	

How to interpret the results of Viwi

The goal of LandTrendr is to detect vegetation change. It does this by producing three products. These are: the year of change detection, the magnitude of change and the duration of change. These are explained below. For a more detailed and in-depth explanation, click here.

Year of Detection

The LandTrendr detects the year in which the significant change starts to occur. In the figure below this is indicated as "Start year".

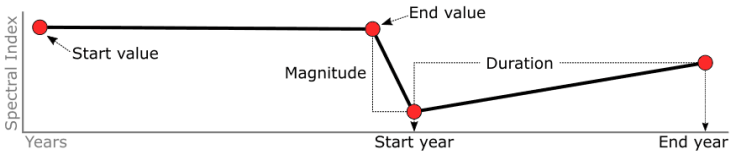


Figure 3: Source https://emapr.github.io/LT-GEE/lt-gee-outputs.html

Magnitude

Magnitude refers to the change in the quantity of the spectral properties. The more the NDVI is changed, the more likely there is a change in the spectral properties and hence in magnitude of change over time. This scale goes from 0-1000.

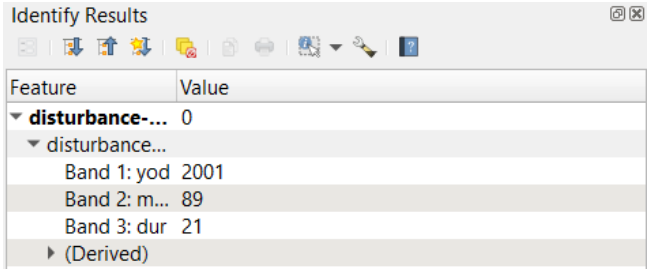
Duration

Duration means the time when a consistent change is occurring, i.e., vegetation is recovering or decreasing (stress). The duration goes from Start year to End year.

Output file will be a raster. Pixels with detected change contain information on three bands.

Band	Description
1	Year of detection
2	Magnitude of change
3	Duration of change

Import the raster in QGIS. Using the Inspection tool in QGIS each pixel can be inspected. Results appear in the top right corner. Selecting only specific bands is also possible.



One can easily just inspect the magnitude of change, as can be seen in figure 2.

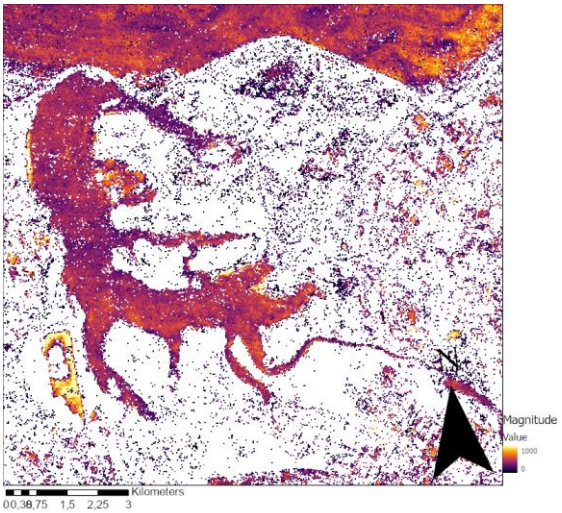


Figure 4: Magnitude of change map

FAQ

How do I sign up to Google Earth Engine?
Visit signup.earthengine.google.com to sign up for the platform.

Where can I find more information about GEE?
You can find more, such as scripts, API's and datasets on https://developers.google.com/earth-engine/

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Who owns the algorithms I write in Earth Engine and the results of my analyses?
You do. The results of all analyses you perform are yours. All algorithms that you write with our API are yours.

My Google Drive storage is running out. What do I do?
If storage is running out, move the .tif-files to your own private storage to create room for new files.