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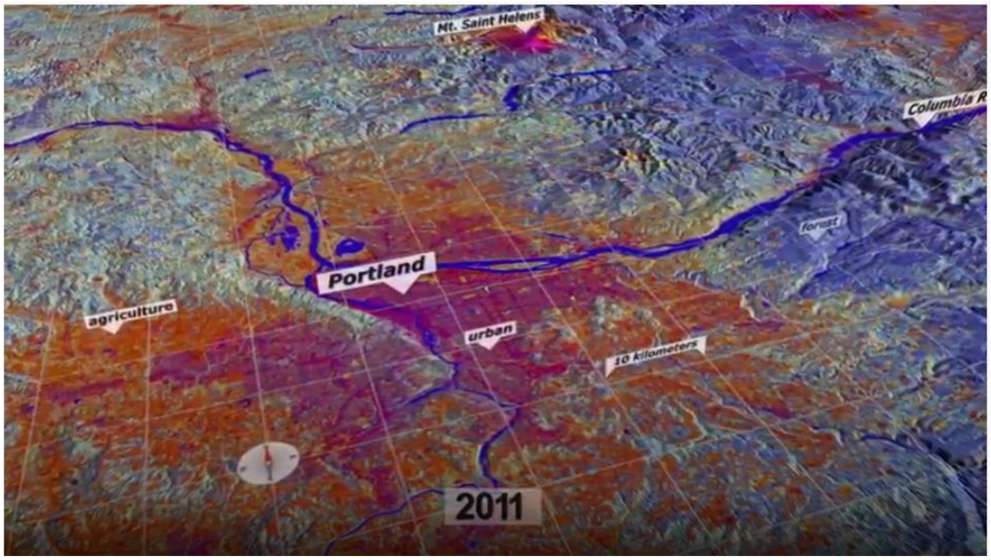
Last Updated: March 2022

EXERCISE 3

LandTrendr in EE - Fitting & finding parameters



Still from an animation demonstrating the LandTrendr algorithm in the Pacific Northwest: Life Histories from Landsat: 25 Years in the Pacific Northwest Forest.

Introduction

You have explored and reviewed JavaScript tools, methods and algorithms in EE for building scripts to analyze Landsat time series. In addition to writing simple scripts, Earth Engine allows users to build applications with user interfaces (UIs). In this exercise, we use two interactive EE UI tools to learn how to fit and evaluate the LandTrendr. We will focus on finding appropriate parameters to map disturbance on an area of the Dixie National Forest that experienced significant spruce beetle mortality followed by large wildfire.

Objectives

- Use EE UI apps to explore a complex forest disturbance mapping algorithm (LandTrendr)
- Learn how to evaluate LandTrendr fit and find good algorithm parameters

Required Data

- None!

Prerequisites

- **Completion of Exercises 1 and 2 (you can review code by accessing a copy of the script here)**
- **Google Chrome installed on your machine**
- **An approved Google Earth Engine account**

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Part 1: Explore UI apps in Earth Engine

At this point you have a good idea of how custom analysis scripts and modules can be created and shared but what about sharing EE tools with non-coders or those without an EE account? Earth Engine Apps are a way to create dynamic, shareable user interfaces for analyses.

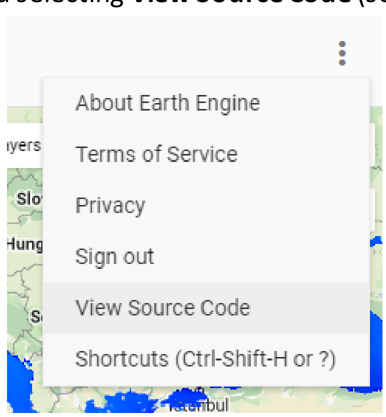
A. Review apps – Anyone can create a UI app!

1. In your browser, navigate to https://earthengine.app and have a quick look around.
2. Click on the Getting Started (this link) and quickly skim the intro and the headers. All you need to create a custom UI app in EE is an account and some Earth Engine JavaScript skills!

B. Look at an example UI app

1. From the user guide, click **back** and then click to open the **Ocean Timeseries Investigator** app (https://google.earthengine.app/view/ocean).

2. Play around with the interface by clicking on the map and viewing the chart on the left.
   i. By now you should have some insight into how something like this could be created with Earth Engine code!
3. Open the application source code by clicking on the three dots icon in the upper right-hand corner of the app window and selecting **View Source Code** (see below)



4. The JavaScript code will open in a new Code Editor window. Skim the code and see if you can spot familiar object types, methods and classes:
   i. For example, line 10 creates a filtered image collection very much like you did in exercise 1, line 15 applies a mean instead of a median reducer to create an image composite for visualization. Finally line 68 uses makes a series chart just like you did in exercise 2.

***Note**: Earth Engine Apps are a powerful way to share data and analyses. Creating a custom UI app in EE takes more advanced JavaScript skills than we can cover in this course. However, there are lots of resources available for learning JavaScript and Earth Engine and following the source code of an existing app is a good place to start.*

Since the release of Earth Engine apps in 2018, they have become increasingly popular. Check out this blog post by a user who created an Inventory of Earth Engine Apps.

Part 2: Use LT-GEE point fitting app to get parameters

In this section, we will use the LT-GEE Pixel Time Series Plotter to tune the LandTrendr algorithm to appropriately segment pixels in a mixed conifer area on the Dixie NF area affected by both spruce beetle and fire. In this case, we want to detect both gradual, slow disturbance from the insects as well as the rapid change event of the fire. We will have to fit the algorithm carefully in order to obtain meaningful segments that represent 'real' landscape change while avoiding 'overfitting' that is, fitting a model to the 'noise' in our data.

A. Open the LandTrendr Pixel Time Series Plotter

1. In your browser, navigate to the LT-GEE GitHub guide: https://emapr.github.io/LT-GEE/ui-applications.html. This document lists LandTrendr apps, and also contains a lot of info on LandTrendr. This is worth bookmarking for future reference!
2. Locate and click on the link to the UI LandTrendr Pixel Time Series Plotter to open the app.

B. Explore the user interface

1. Use the map controls to zoom/pan to anywhere in the world that takes your fancy.
2. Click on the map and note the following:
   i. The longitude and latitude values are updated in the menu on the left.
   ii. A red pixel outline appears where you clicked on the map.
   iii. A LandTrendr time series plot appears in the right-hand pane. This plot shows the pixels trajectory through time with both the original and LandTrendr fitted NBR values

C. Look at the trajectory of a point on the Dixie NF with default parameters

1. In the left-hand pane, locate the **Define Pixel Coordinates** and copy/paste in the values below:
   i. Point 1:
      (a) Longitude: -112.73836006749919 Latitude: 37.75617480195893
2. Under the **Select Indices** menu, check the boxes to activate **NDVI** (normalized difference vegetation index) and **TCW** (tasseled cap wetness) addition to the default selection of **NBR** (normalized burn ratio).
3. Leave all the other parameters at their default values and click the **Submit** button at the bottom.

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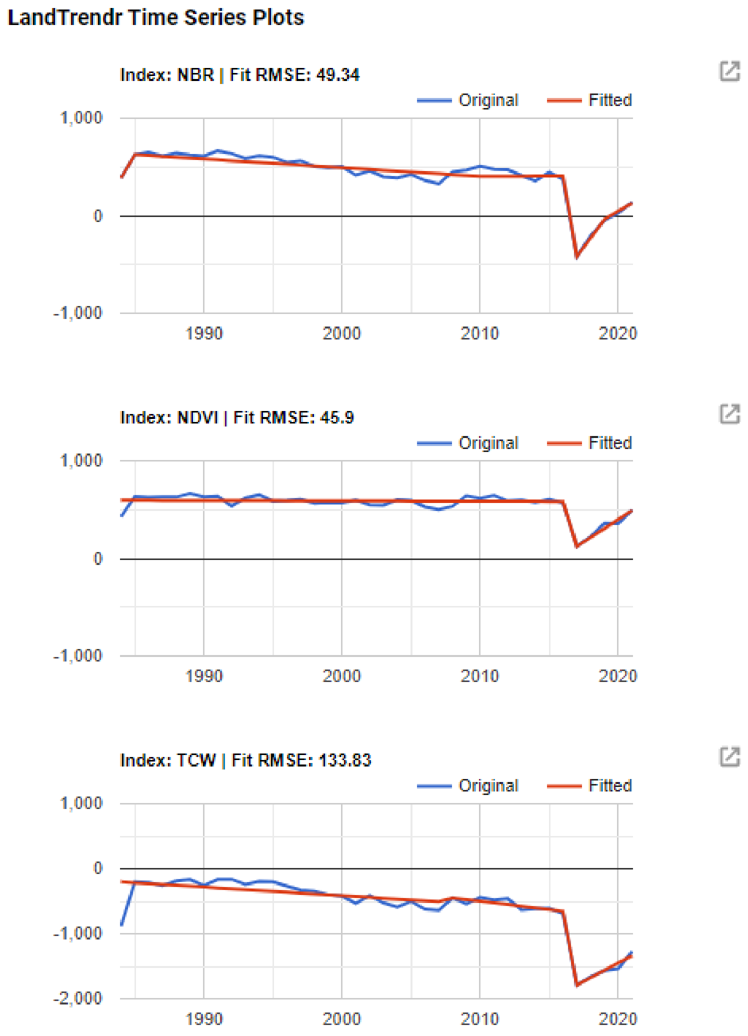
4. Wait for the model to run and the plots to load in the right-hand panel.
5. Examine the trajectory plots with the original and fitted values.
   i. The pixel trajectory is represented in Normalized Burn Ratio (NBR), Normalized Difference Vegetation Index (NDVI) and Tasseled Cap Wetness (TCW).
   ii. The blue line represents the original pixel values. The red line represents the fitted values and trajectory 'segments'.
   iii. The blue text box at the bottom of the page points out three key points about these plots.



Note:

1. The gradual decline due to spruce beetle is most apparent in the original values of NBR and TCW.

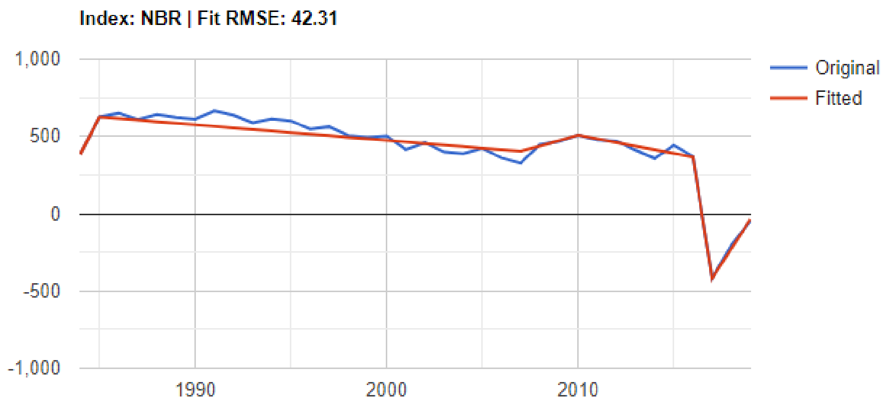
2. In this default run of the LT-GEE, NDVI and TCW resulted in 3 fitted 'segments' with the significant loss vertex occurring in 2016. NBR has 4 fitted segments, with the significant loss vertex occurring in the same year.

3. There may be some overfitting on the segments following the sharp decrease in 2016.

This initial fit with these default parameters may be adequate as LT-GEE has captured the broad trend of a slow decline followed by a rapid loss. For the purposes of this exercise however, we will demonstrate through the process of capturing subtler changes.

D. Adjust the year parameters to address potential issues due to first and last observations

1. Use the **Define Year Range** slider bar to change the end year to 2019 keeping the start year at the default value of 1984.
2. Click **Submit** to evaluate the effect of including only two post fire observations.
3. Evaluate the changes in the fitted segments. Here, we're just going to look at the plots for NBR—feel free to make your own comparisons for NDVI and TCW.



Note. *We are now capturing more detail in the slow decline due the spruce beetle.*

This looks pretty good if not a somewhat 'overfit' the period from 2007 to 2019. There is a 'recovery' segment starting in 2007 and a slow decline segment in 2010.

E. Look at different points

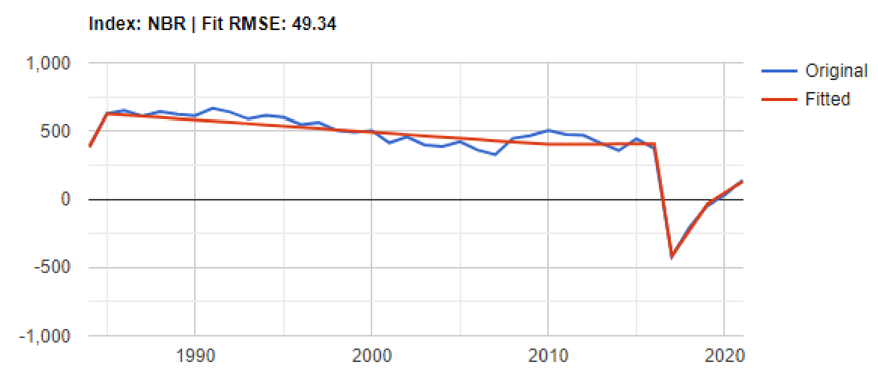
1. Keep these parameters the same and change the coordinates to the longitude and latitude below.
   i. **Point 2:**
      (a) Longitude: -112.83225983706673 Latitude: 37.71786568040169
2. Click Submit and examine the fitted trajectories.
   i. How is the trajectory of this point different from the trajectory of the first point?
3. Test a few other points by visually identifying disturbed forest near the provided point and clicking the map to rerun the model. What segments are consistent? Which ones look 'real' and which ones do you suspect may be due to 'noise'?

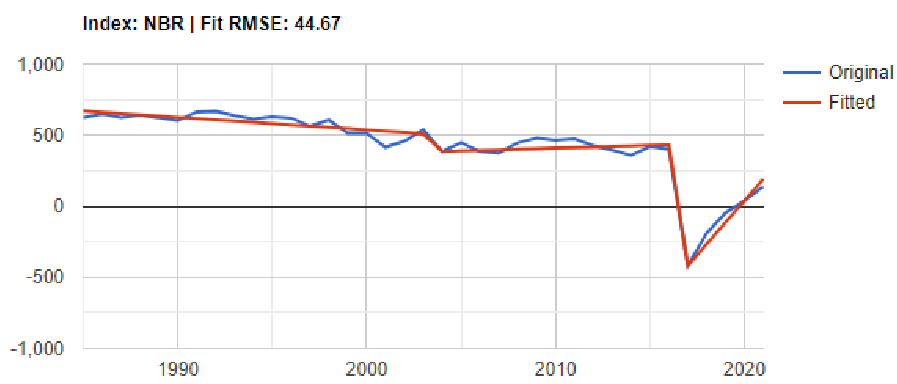
> *There is a fine line between optimizing your model fit and 'overfitting' the trajectory. While you want to get the best fit you can, you want to ensure that the segments you get from fitting correspond to 'real' landscape change.*
>
> *Remember: "Essentially, all models are wrong, but some are useful." -George Box*

F. Return to the first point and adjust the seasonal window

1. Change the coordinates back to the first point you examined in Part 1 C1.
   - **i. Point 1:**
     - (a) Longitude: -112.73836006749919 Latitude: 37.75617480195893
2. In the **Define Year Range** section, reset the years back to the original values:
   - i. Start Year 1984, End Year 2021
3. In the **Define Date Range (month-day)** section, change the seasonal dates:
   - i. Start date 07-10 and end date 09-20
4. Click the **Submit** button and observe the changes.
   - i. Narrowing the seasonal window eliminated one seemingly short recovery segment at the beginning of the time series. This segment could be the result of poor imagery, or could be due to a particularly wet spring and was capturing too much of the understory signal?
   - ii. Narrowing the seasonal window also changed the inflection point of the short recovery / stable segment—from 2010 to 2004. Perhaps earlier-season imagery was more green and wet, and didn't capture the sharp drop from 2003-2004 that predates the recovery segment.

NBR
1984-2021
Season:
6/10 – 9/20



NBR 1984-2021 Season: 7/10 – 9/20	

Note on fitting parameters:

There are quite a few parameters to play to control the fit of LandTrendr! The list below includes the three most powerful parameters and a note about their values (LT-GEE Workshop 2019):

1. maxSegments – Rule of thumb is to set this value below the number of observation years divided by 3. E.g., if you are looking at observations from 2000-2018, maxSegments should be no higher than 6.

2. spikeThreshold – Don't set this below 0.7 and if 'noise spikes' are not a problem, set it 1.0 to turn it off.

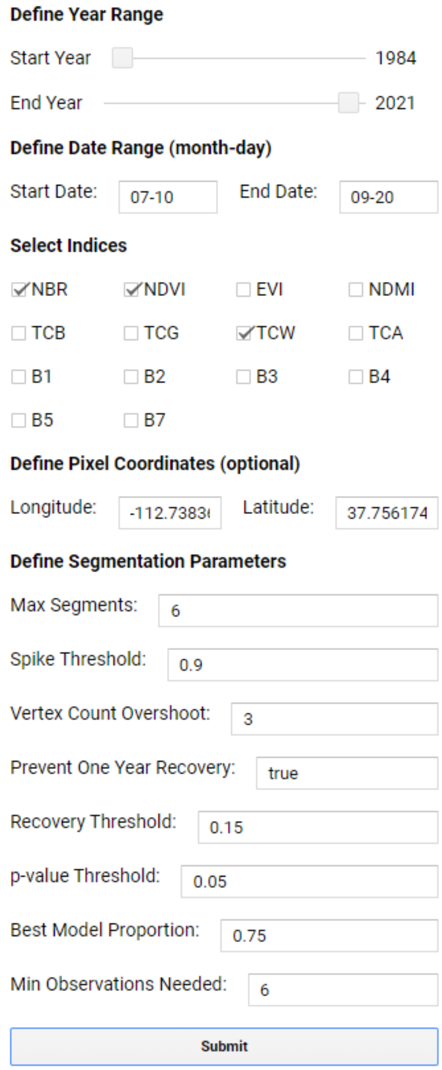
3. recoveryThreshold – If you are trying to detect rapid recovery, try setting this value higher (e.g., 0.75) but setting it too high may result in overfitting of noisy 'spikes'—a value of 1.0 turns off the recovery filter entirely.

G. Explore key fitting parameters

1. Change the maxSegments parameter to 11, click **Submit**, and observe the changes to the trajectory.
   i. The pixel's trajectory is 'overfit' with individual change segments corresponding to single year 'spikes' in the NBR and TWC trajectories!
2. Change maxSegments back to 6 then change the spikeThreshold down to 0.5, click **Submit**, and observe the effects.
3. Change the spikeThreshold to 1 and repeat.
   i. The spikeThreshold effects can be subtle and parameters work together to control how closely fitted values match the original values.
4. Change the recoveryThreshold down to 0.15, click **Submit**, and observe the changes. Here particularly for NDVI, we no longer pick up the recovery segments, but we also miss the post fire recovery in 2017.

H. Save the parameters and move on

1. Reset the parameters to match the screenshot below and keep this browser tab open so that you can look back for these parameters in the next section.



***Note:** Parameter fitting for models can be a time-consuming process, with many trade-offs—as we've explored above. The LT-GEE Time Series app is one straightforward, if less robust, way to explore and test parameters for your project. To fine tune parameters, you should start with an area where you have a local knowledge of the timing of change, and the change agents that you are accounting for. For example, as we examined points on the Dixie NF to use for this exercise, we chose a point that we knew remained forest landcover over our time series (i.e., was not developed into road, building, or other infrastructure), began experiencing slow decline due to spruce beetle in the mid-90s, and experienced the a rapid decline due to the Brian Head fire in 2017.*

More robust and quantitative ways of evaluating parameters would involve iterating through different parameter sets using code. You could also generate a reference dataset using a time series interpretation tool such as TimeSync. In this case, you could use the reference dataset as training to come up with an optimum set of parameters. However, because this is a time-intensive process, the next-best-thing is to test the parameters where you have local knowledge.

Part 3: Use LT-GEE change mapper to review fit

Once you have found appropriate parameters for segmenting trajectories to capture change, you will likely want to create a wall-to-wall disturbance map. Before we do this and download our results, we may want to see these parameters in action and the LT-GEE change mapper was built for this purpose.

A. Open the LandTrendr Change Mapper

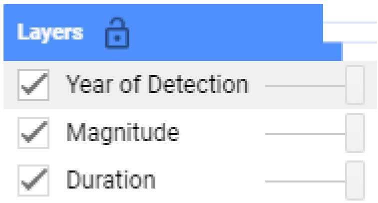
1. In your browser, navigate back to the LT-GEE GitHub guide: https://emapr.github.io/LT-GEE/ui-applications.html.
2. Click on the [GEE App Link](#) to open the app.

B. Explore the user interface

1. Review the instructions in the pane on the right.
2. Click to check the box to activate the inspector.
3. Examine the menu on the left and scroll down to view all the options.
4. Note that in addition to the **Segmentation Parameters** that we explored in the LandTrendr Pixel Time Series plotter, there are several additional options for filtering and displaying change on the map. All this information is extracted from the layers produced after the segmentation process.
   i. If you want to learn more about this, review [section 8.2.1 Steps in this document](#).

C. Map disturbance with selected parameters

1. Use the segmentation parameters you identified above and run the change mapper with defaults.
   i. Make sure the start year is 1984 and the end year is 2019.
   ii. Change the seasonal range to a start date of 07-10 and an end date of 09-20
   iii. Enter the same coordinates for Dixie National Forest that we used in previous examples:
      (a) **Point 1:**
      (b) Longitude: -112.73836006749919 Latitude: 37.75617480195893
   iv. Click **Submit** at the bottom and wait for the map to load. There is a lot of processing going on 'behind the scenes' so the map can take a few moments to load.
   v. Hover over the **Layers** control on the map. Processing has finished when all the layer bars are finished and have turned from gray to blue (see below).



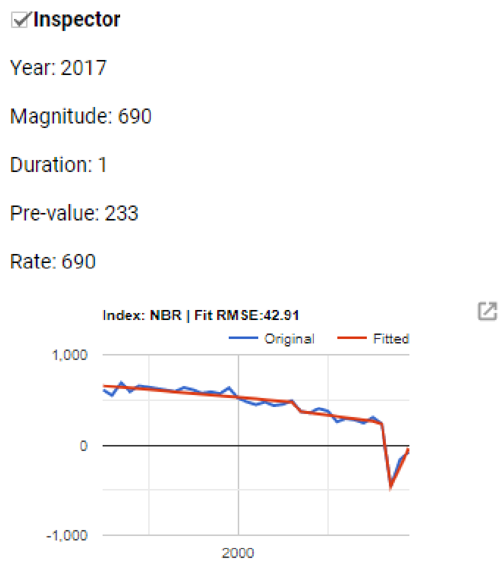
2. Observe the map that appears – do not change any layers yet!

i. The coordinates that we entered have been buffered by 50 km and LT-GEE has been run for all the pixels in that area.

ii. LT-GEE outputs have been extracted to map layers that represent change characteristics that are potentially more useful and interesting than the single pixel trajectory segmentation output we examined in Part 2.

3. Click somewhere in the red area to pull up the **Inspector.**
4. In the **Inspector** plot on the right, examine the segmentation plot and info.

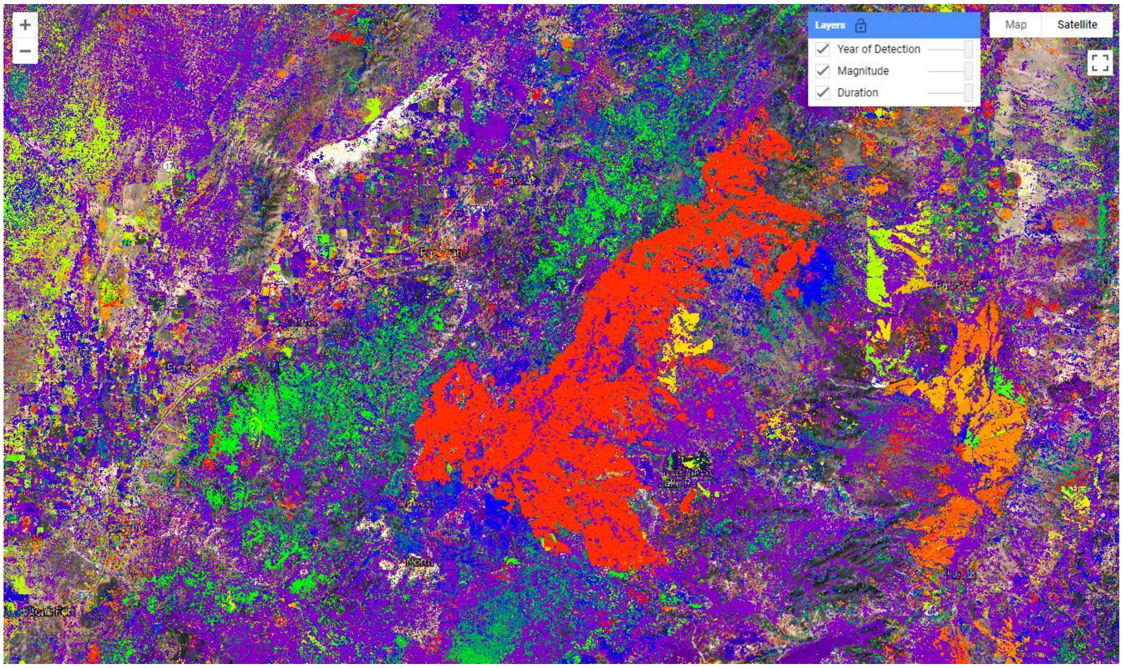
i. Note the year, magnitude, duration, duration, pre-disturbance value, rate and trajectory segmentation.



> ***Note:*** *The LT-GEE Change Mapper displays map layers of change (vegetation loss or gain) attributes including: year of detection, magnitude of change, duration of change evet and pre-change spectral value.*

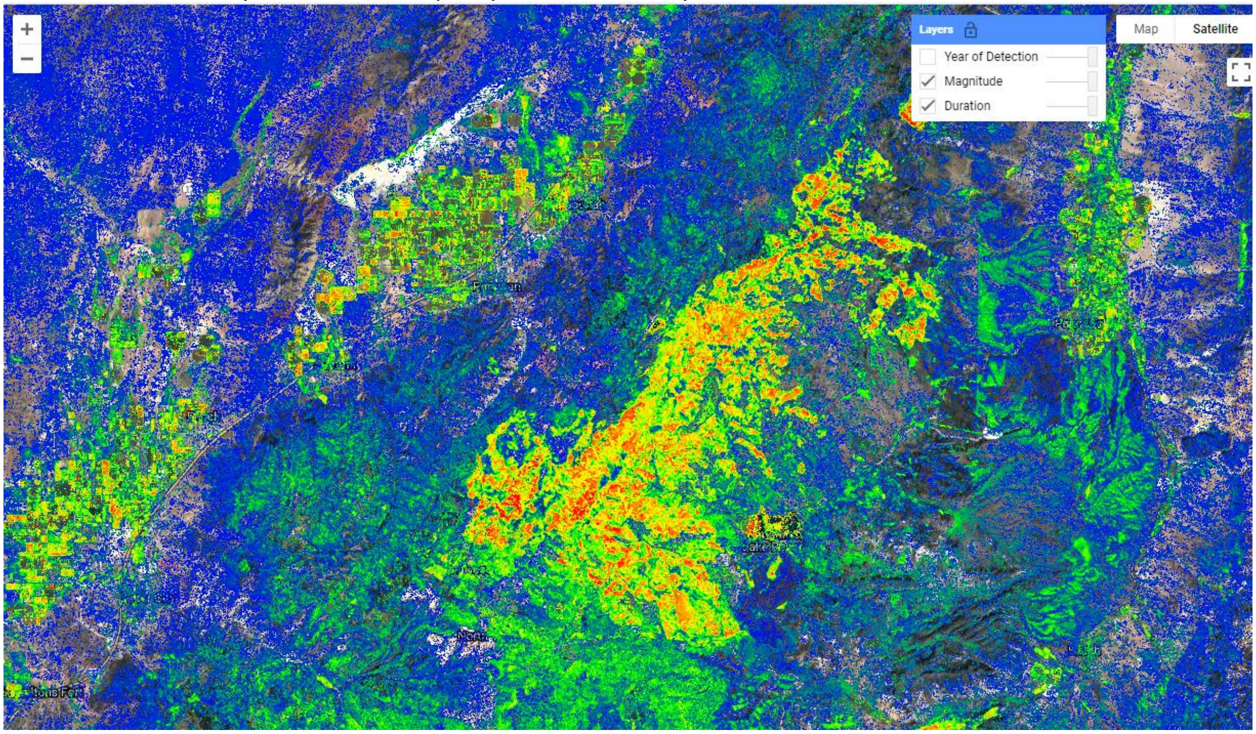
D. Examine the 'Year of Detection' layer

1. With the Year of Detection layer turned on and on top by default, you can easily see the footprint of the 2017 Brian Head fire.

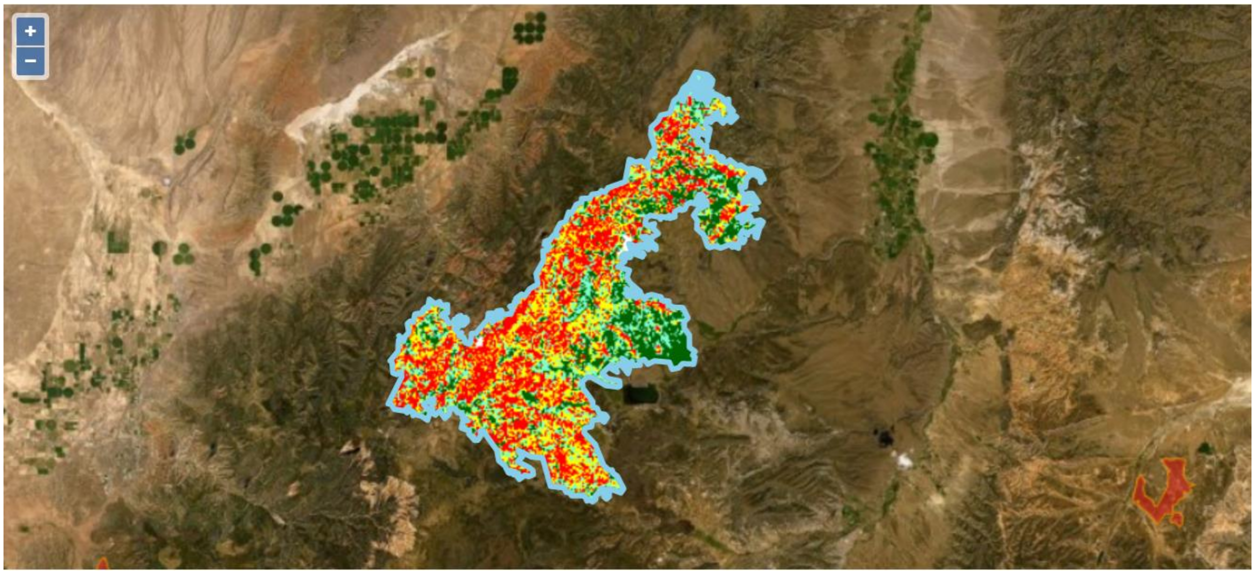


E. Examine the 'Magnitude' layer

1. Use the layer controls to turn off the year of detection or use the layer slider bar to swipe the year of detection to reveal the magnitude layer beneath, which represents the magnitude of change.
2. Observe how this layer resembles a proxy for fire severity.

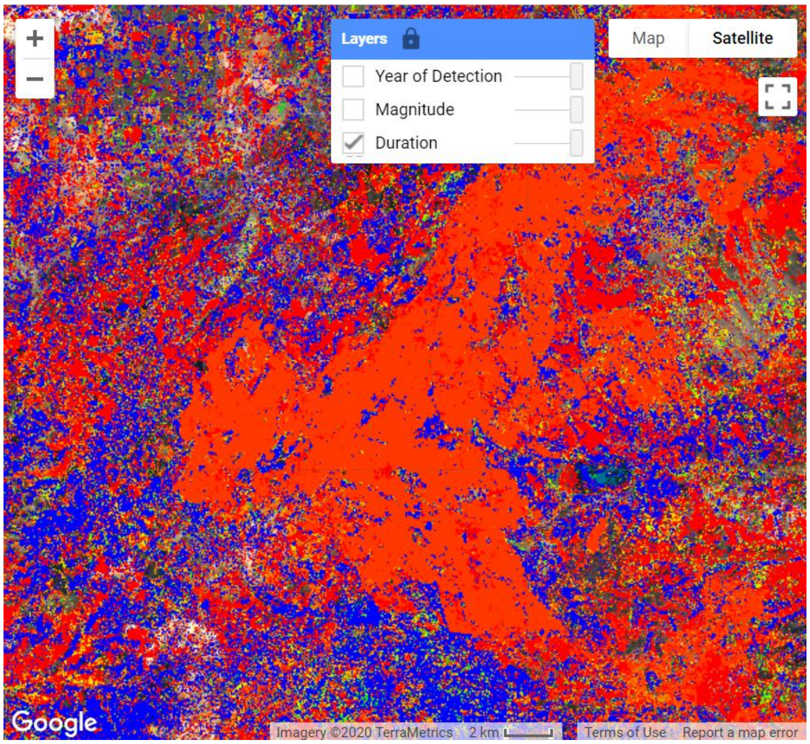


3. You can compare this to the MTBS fire severity layer for the same area, visible below.



F. Examine the 'Duration' layer.

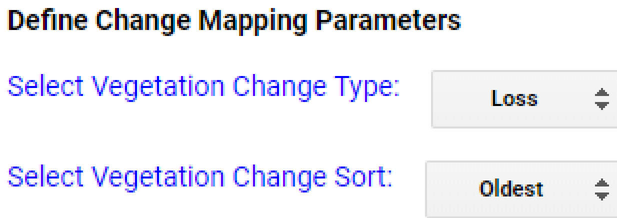
1. Use the layer controls to look at the bottom **Duration** layer.
2. Note that red and orange colors represent shorter duration disturbances such as wildfire while green and blue represent longer duration disturbances such as spruce beetle.



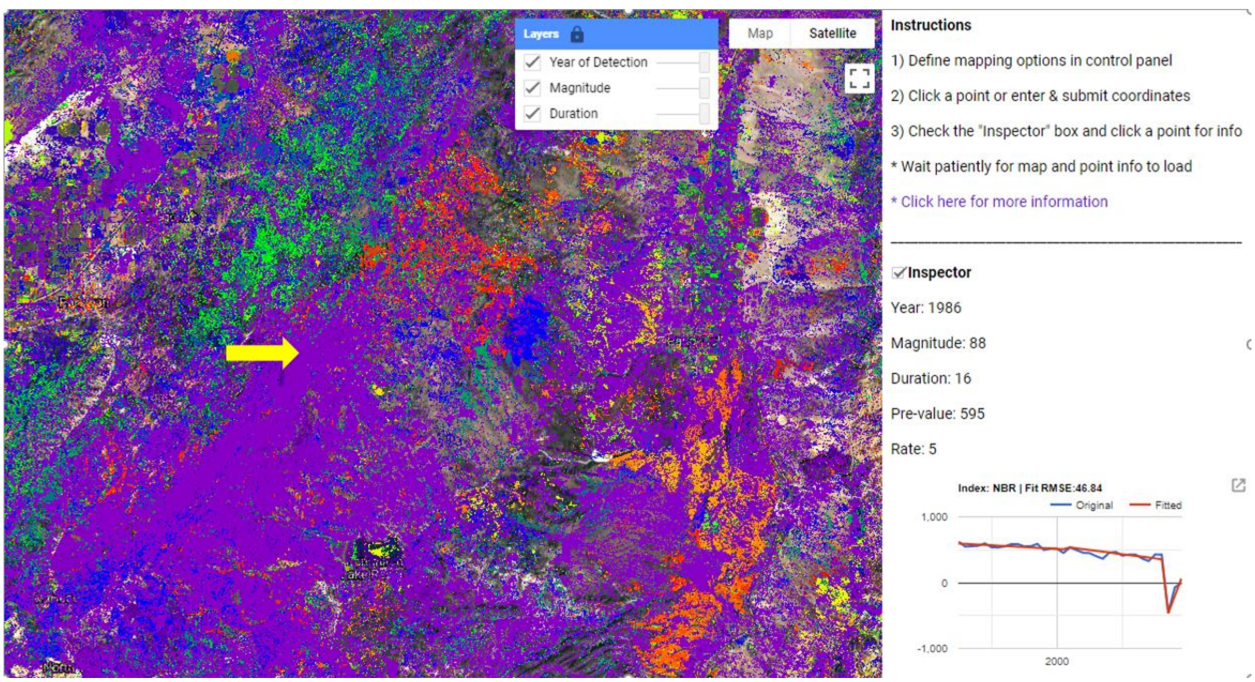
G. View the oldest disturbance

1. Previously, the **Select Vegetation Change Sort** was set to display the **Greatest** disturbance. This means that the LandTrendr change segments were queried and the segment

representing the largest change in NBR value was selected and used to generate the Year of Detection layer. While this was perfect for visualizing the effects of the Brian Head fire, let's change this Sort parameter to help us visualize the effects of the spruce beetle outbreak.



2. Change the **Define a Buffer Around Point (km)** value to 20 to reduce processing time.
3. If it's not already checked, check the box next the **Inspector** in the right-hand panel to make it visible.
4. Click **Submit** to rerun LT-GEE.
5. Wait patiently for this to load!
6. Click somewhere inside the purple within the area affected by the Brian Head fires (see below).
7. Observe the Inspector value and fitted trajectory graph that appear on the right.



Part 4: Explore LT-GEE in another area (*optional)*

You should now have a sense of how to use these UI apps to visualize LandTrendr output and change algorithm parameters and final map products. You may now want to play around with running LT-GEE and mapping disturbance in an area of your choice, where you have some local or expert knowledge.

A. Return to the LT-GEE Pixel Time Series and navigate to a study area of your choice

1. Choose an area where you have some local knowledge of disturbance.

B. Locate an area of known change

1. Use the basemap satellite imagery to pan and zoom to your area.

C. Use the Pixel Time Series Plotter tool to fit LT-GEE to map this disturbance

1. Adjust seasonal windows according to what you know about the ecology and phenology of the area.
2. Try different vegetation indices and see which one seems to best capture the change.
3. If necessary, try adjusting **maxSegments**, **spikeThreshold**, and **recoveryThreshold** to optimize your model without overfitting.
4. Are you able to use LT-GEE to capture meaningful change segments?

D. Map this area with the LT-GEE Change Mapper

1. Enter the coordinates of your selected point.
2. Change the date and segmentation parameters to the values you identified with the Pixel Time Series tool.

E. Evaluate the change map

1. Optionally change the vegetation change type and sort values to visualize different types of segments.

Congratulations! You have successfully completed this exercise and used two UI apps to better understand the LandTrendr algorithm in Earth Engine. You have used these apps to find suitable parameters for running LT-GEE in an area affected by both spruce beetle and wildfire. You have also had looked at a few different final map products that can be derived from LT-GEE. In the next exercise, you will run LT-GEE from the Code Editor and download final map results.