Questions & Answers Session 2

Please type your questions in the Question Box. We will try our best to get to all your questions. If we don't, feel free to email Cindy Schmidt (cynthia.l.schmidt@nasa.gov) or Amber McCullum (amberjean.mccullum@nasa.gov).

Question 1: How is it possible to combine different time series, of different satellites (such as Sentinel 2, Landsat (L5,L7,L8)) to have a complete series?
Answer 1: This can be done, however there are important things to consider. For combining multiple Landsat series, you will need to use the surface reflectance products that have been atmospherically corrected and radiometrically calibrated. For example, Landsat 5 and 8 have different radiometric resolutions, so in order to be combined you need to use the surface reflectance. On EarthExplorer you can now find Landsat ARD (Analysis Ready Data) products. The ARD data have algorithms applied to be able to compare across the different Landsat sensors. Details here: https://www.usgs.gov/land-resources/nli/landsat/us-landsat-analysis-ready-data?qt-science_support_page_related_con=0#qt-science_support_page_related_con)

For comparing Landsat and Sentinel, there are other things to consider, for example Sentinel-2 has a higher spatial resolution (10 m) than Landsat (30m), so you need to have some common features in order to analyze time series of these together. For comparing Landsat and Sentinel, there is a harmonized product that folks are working on, find more information here:
https://www.sciencedirect.com/science/article/pii/S0034425718304139

Question 2: Is the time of the year the same for each of the years eg 1984, 1995 and 2004? (Slide 18)
Answer 2: Yes, it is best to use imagery from the same time of year for each year, because then you can expect things like vegetation properties to be similar. For the LandTrendr GEE, it is set as the default to generate an image each year from 6-10 to 9-20, so it will generate one image per year within that date range. You can modify this if you want to analyze different time periods.

Question 3: Is LandTrendr open source? I.e. could it be applied to intra-annual Time Series?

Answer 3: Yes, you can run Landtrendr GEE User Interface for free using the Google Earth Engine platform. You can also run your own scripts in GEE in Javascript or Python. It is only used for annual comparisons, NOT interannual. This program, and I believe most algorithms, use yearly comparisons. There are a lot of questions about modifications to the LandTrendr algorithm and I've included - and I'll talk about it in some other questions - you could code all of this yourself in Javascript or Python within GEE if you don't like the UI settings. We won't go over that, but there are scripts available online. Currently the way the UI is set up is for annual comparisons, as you noticed through the exercise demonstration. However, if you're running the algorithm through your own coding, I believe you might be able to change those parameters. But for the LandTrendr UI its annual comparisons currently

Question 4: Can we use LandTrendr for a group of pixels, e.g., a GIS-shapefile or polygons?

Answer 4: Not currently in the User Interface. In order to use shapefiles in Google Earth Engine, there is an arduous process of converting a shapefile to a KML, then uploading it to your Google drive, then writing a script to display it on the map. I believe this process will change soon, and Google will be making this easier. It may be possible to run the Landtrendr algorithm on a different platform, but I am not familiar with this. I would suggest investigating the algorithm further or contacting Robert Kennedy's lab: http://geotrendr.ceoas.oregonstate.edu/landtrendr/

Within - the way GEE is structured currently - it's a really arduous process to pull in your own shapefiles, whether they be shapefiles or points. Right now you have to convert a shapefile to a KML file, upload to google drive, and then create a specific link to that shapefile - the zipped KML file - to pull it in to be displayed in GEE. So, I believe this is changing soon from some folks I've talked to soon that are working with Google. They're going to be streamlining this process, so stay tuned. But right now there are some tools and examples available of how to do this. I also want to make a plug for climate engine where you can do some of these similar analysis (with NDVI, etc) and they have a tutorial on how you upload a shapefile in that interface. It also sits on top of GEE. Within the current interface you have to analyze on a pixel-by-pixel basis.

Question 5: what kind of algorithm can we use to detect the change in marine habitats?

Answer 5: This really depends on the type of change you are investigating. I am not a marine expert, but I would imagine if you are looking at something like kelp forests (change in NDVI), you could use these algorithms presented here. There are more complications in marine ecosystems as they are more dynamic. But I do understand the marine ecosystem is very dynamic and constantly changing - it doesn't tend to stay in one place over multiple years (like a forest). There's probably a lot of other complications to consider when running these algorithms over a marine area. Papers above on monitoring wetland, coral reefs, and seagrass over time. Here are a few papers I found about this topic:

- Wetland change mapping: https://www.fws.gov/wetlands/Documents/Remote-Sensing-as-a-Tool-for-Monitoring-Wetland-Habitat-Change.pdf
- Coral reef change mapping: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.500.8526&rep=rep1&type=pdf
- Seagrass change: https://www.frontiersin.org/articles/10.3389/fpls.2018.00096/full

Question 6: the algorithms presented beside Landtrendr - Is it possible to implement them with gee and are the scripts openly available?

Answer 6: I am not sure about the implementation of the other algorithms here. We just focused on LandTrendr GEE because it is a very commonly used algorithm and has already been implemented in this open-source tool. I would suggest reading through those papers and/or contacting the developers of them. It is very likely that you could write your own scripts in GEE if you have the detailed knowledge of how to implement the algorithms. It's very likely you could use those algorithms with your own coding - whether it's JavaScript or R. R has a lot of packages to run change detection algorithms, such as random forest, which we did an ARSET training on recently. I would do a little digging if you're interested in running some of these algorithms on your own.

Question 7: Are there plans to add data from 2018 and 2019?

Answer 7: Yes, as the Landsat data become available via GEE, you can access them in the Landtrendr GEE tools. You can now see the 2018 data and some of the 2019 data, depending on the date of interest.

Question 8: Which algorithm is used by University of Maryland for the Global Forest map?

Answer 8: We've talked about GFW in some of our other trainings, and it's a really fantastic tool for mapping forest change. For those of you that may not be familiar, I would suggest googling that and taking a look at their online tool. The algorithm used by Hansen's group at UMD for creating the GFW change maps is different than LandTrendr, and we've included the paper citation above for more info about that specific algorithm, but it is different than LandTrendr. They have a specific algorithm outlined in this paper here: Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–58

You can also find a bit more information on the GFW technical blog here: https://blog.globalforestwatch.org/data-and-research/technical-blog-caveats-to-the-2016-tree-cover-loss-data

Question 9: Which algorithm is the most adequate one for studying agricultural/phenological changes throughout the whole growing season, where yearly composites wont be beneficial?

Answer 9: You may be able to run these algorithms on your own for interannual timescales (scripting in GEE, R, Python), but you cannot use the LandTrendr UI for interannual analysis. Another algorithm you could investigate is Random Forests, where you can outline interannual change. Take a look at our change detection webinar, where we highlight this for landcover mapping and change detection: https://arset.gsfc.nasa.gov/land/webinars/adv-change18

Also, again, making a plug for climate engine. But within climate engine, you can also zoom in to an agriculture region of interest, create your own polygon - for e.g., on an irrigation plot - and look at NDVI over time from the Landsat record. With that tool you can create those figures online using the power of GEE and you can see interannual phenological changes. That's just based off of looking at NDVi values - that might be a nice resource for you.

Question 10: Can the Change Mapper maps (Year of detection, etc) be exported as geotiffs?

Answer 10: Yes, but you will need to do this by coding in GEE (JavaScript or Python), I don't believe this is possible within the User Interface. See this site for the example scripts available: https://emapr.github.io/LT-GEE/example-scripts.html

Question 11: How can I use NBR for seasonal burning of crop residues?

Answer 11: For seasonal change you will need to acquire the dates of imagery that are useful to you and use something like QGIS or ArcGIS to process. The Google Earth Engine Landtrendr API only looks at annual change. So that's a little more involved in terms of timing, but you can also download the Landsat data on your own for dates of interest and run something in your own geospatial software. Either with some of these algorithms, or Random Forest, or some other tools out there.

Question 12: Is there a technique to analyze the change in the urban area, i.e. urban growth?

Answer 12: There are many techniques but here is a good paper to read about using remote sensing for urban change:
http://landcoverchange.com/wp-content/uploads/2014/09/schneider__woodcock_2008.pdf. We're going to be doing another advanced webinar in July where we're showing Trends.Earth which you can use to analyze trends in urban areas as well as forest. Hopefully we'll be putting out the registration for that in the next month or two. You can apply these algorithms for urban mapping - some may be better than others - included a paper about monitoring urban change. Urban systems do tend to be a little more difficult. If you think about urban areas, there's a lot of mixed pixels. E.g., there might be tree-lined streets that might have a spectral signature of a plant as well as a building.

Question 13: For the pixel time-series plotter, for any index of interest (e.g. NDVI), would the graphs generated show years where there is missing data i.e. breaks in the line (if any)? Is it necessary to download the CSV file and inspect whether there is one point for all years of interest?

Answer 13: The GEE Landtrendr algorithm interpolates values for years that have missing data. The ability to interpolate new values for years between vertices is very useful. It ensures that each observation is aligned to a trajectory consistent with where the pixel has been and where it is going. We can think of this as hindsight-enhanced

image time series data. It has two practical utilities. It can fill in data from missing observations in the time series (masked because of cloud or shadow) and it maintains consistency in predictive mapping through time; e.g. an annual forest classification is not likely to bounce between mature and old-growth conifer because of minor differences in spectral reflectance from atmosphere or shadow difference

Here is a link to all the Landtrendr references: https://emapr.github.io/LT-GEE/references.html

I also want to take this time to talk a bit about how GEE creates these Landsat composite images. I mentioned this when we talked about the exercise, but you have the ability to ID the start/end date within each year you want to obtain the image. The way GEE displays the image to alleviate missing data. From within that range, it will take pixels from different Landsat scenes from that date range. You might have 5-6 images within that time period, and you won't know in GEE what dates are displayed for that pixel unless you make the date range small enough to be one landsat overpass. That's really different from where this analysis has been done in the past - where you download a particular date and use that. It's one caveat I want people to be aware of. If you want to make sure you're getting a pixel from a specific date from what's being shown in GEE you have to be very narrow in your window. Otherwise you might have pixels next to each other from slightly different dates. Just something to be aware of.

Question 14: Is it possible to modify the scripts (e.g., to calculate NDVI) originally used online by Earth Engine, so the user can set additional parameters to his/her specific modeling requirements?

Answer 14: Yes. You can write the scripts on your own and set all of these parameters. You can create an NDVI calculation itself within the GEE coding editor. So you have the flexibility to do all that, you just have to be familiar enough with the coding. Google has some really great resources - they have a *lot* of example scripts on how to do some of these things on your own. See this site for the example scripts available: https://emapr.github.io/LT-GEE/example-scripts.html

Question 15: How does the engine deal with the SLC-failure in landsat 7 data, which started in 2003?

Answer 15: Landtrendr does not fill the gaps so you will see the gaps in those years if you use Landsat 7. Within Earth Engine, they have algorithms to generate composite

images, if Landsat 5 data are available for the same time period for example. Take a look at the details here: https://developers.google.com/earth-engine/landsat

Question 16: If I understand correctly, the pixel time series plotter allows a user to understand the original and fitted curves of an index of interest in a timeframe. If I want to combine the time-series data for 'n' number of randomly selected pixels, is that achievable in a streamlined manner within GEE? As opposed to generating these pixel time-series plots individually and downloading each CSV separately and combining them all into one time-series plot.

Answer 16: Currently the User Interface only allows analysis of a single pixel at a time. See answer to Q4:

In order to use shapefiles (points or polygons) in Google Earth Engine, there is an arduous process of converting a shapefile to a KML, then uploading it to your Google drive, then writing a script to display it on the map. I believe this process will change soon, and Google will be making this easier. It may be possible to run the Landtrendr algorithm on a different platform, but I am not familiar with this. I would suggest investigating the algorithm further or contacting Robert Kennedy's lab:

http://geotrendr.ceoas.oregonstate.edu/landtrendr/

But again if you are interested in that area analysis, there are other tools for doing that. We talked about AppEEARS last session, and there are other packages and tools for doing this within other software as well.

Question 17: Could you please tell us if there is a link between Landtrendr (or another algorithm that has been previously cited) and Global Forest Change (Hansen et al., 2013)?

Answer 17: Landtrendr and the Hansen et al. approaches are different. You can read more about their approaches in the papers cited previously

Here is the Kennedy paper:

http://geotrendr.ceoas.oregonstate.edu/files/2015/05/Kennedy_etal2010.pdf

Question 18: can you get a summary of NDVI change over certain area (eg. watershed) instead of pixel change?

Answer 18: See previous answers. Currently the User Interface only allows analysis of a single pixel at a time. I'd take a look at climate engine - it's the first thing that comes to mind. And then AppEEARS for MODIS, and it should be getting Landsat imagery soon, too.

Question 19: how could I download the processed images if I want to play with them on my local computer?

Answer 19: You need to code this yourself, I don't think you can do this in the UI currently. See previous links to GEE scripts. But I would also recommend using to one of the data portals, like Earth Explorer (a great way to obtain Landsat and others imagery). Also USGS Landlook, a few others, but I would start with Earth Explorer. Yes, you can download them and open them using QGIS or Arc or whatever software you're most familiar with. Again, that's - if you're interested in a very specific date, that might be the best route.

Question 20: I was wondering if there is a similar application to get soil moisture point data like SMAP?

Answer 20: Not that we know of. Here are some visualization tools for soil moisture:

https://airmoss.ornl.gov/visualize/

https://weather.msfc.nasa.gov/cgi-bin/sportPublishData.pl?dataset=smap_conus

Look at those to see if they have tools for assessing soil moisture and change over time. The time for SMAP data is much shorter (2015 onward) than Landsat, but you can at least investigate changes in soil moisture properties over different dates.

Question 21: Can we use LandTrendr for marine habitats such as corals or seagrasses?

Answer 21: Landtrendr only uses Landsat imagery so there is limited capability to penetrate water columns to see corals. The same goes for seagrasses unless you can see them above the water. There was a marine question earlier - we provided a couple links on monitoring change detection - again, the marine system has complications the land system doesn't. Penetration of the data through the water column is an issue. For corals, especially, sometimes the seagrasses tend to float on the surface and you can pick up things like NDVI a little easier. Corals are really difficult, due to the fact that they're under water - at least with these passive optical sensors.

Question 22: How can we integrate our own algorithms through the GEE? Is there a tutorial/link to help us get started?

Answer 22: Please see the online Landtrendr guide: https://emapr.github.io/LT-GEE/index.html

Question 23: What about deal with spatial resolution through the different images?

Answer 23: Landtrendr only uses Landsat imagery so there is no difference in spatial resolution. If you're using Landsat data they'll all have the same spatial resolution of 30x30 m. If you want to include other data types like Sentinel, you'll have to do something to resolve those issues. You'll have to do some sort of resampling to conform to the Landsat data.

Question 24: We do know that Landsat image (Landsat 7 ETM+) has stripping because of an optic failure or broken lens, is that disturbing pixel value? how to fix it?
Answer 24: Landtrendr does not fill the Landsat 7 gaps so you will either have to use Landsat 5 or Landsat 8 data for those areas. See question 15.

Question 25: Are you working on GGE with Sentinel images?
If so, when do you consider that there will be products (algorithms) similar to those seen in this session with Sentinel images?
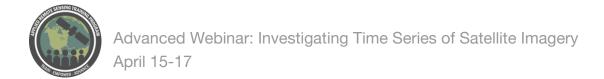Answer 25: You can run these similar algorithms on Sentinel- 2 images, and I believe the image collection is now in GEE too. Here is a link to the documentation:
https://developers.google.com/earth-engine/datasets/catalog/sentinel/

Question 26: are there any tools similar to LandTrendr for Marine data that could be used together with land data for a holistic analysis? Is it possible to analyze data for shoreline change detection LandTrendr?
Answer 26: I am not aware of specific marine tools, but please take a look at the answer to question 5 where we provided links to marine change detection analysis. Theoretically you can apply this type of analysis to monitor shoeline changes, but there are many challenges with this, like mixed water-vegetation pixels, rapidly changing dynamics, etc.

Question 27: If we use Landsat Surface Reflectance bands and use their QA bands for cloud and shadow removal, will it be sufficient to combine all Landsat data from different sensors? And do ARD add anything to this?
Answer 27: You can definitely conduct your own cloud and shadow masks if you would like. The Landsat surface reflectance products already have a cloud and shadow mask applied, but it is not perfect, so you could do this on your own. Here is more information about the ARD products: https://landsat.usgs.gov/what-us-ard

Question 28: Can we import additional data sets that can supplement or enrich this one? For example, socioeconomic indices? and if so, what data format?

Answer 28: If you are running an analysis in GEE you need to pull data from their collections. It is difficult to add your own data to GEE, but possible. GEE does have some layers, like census data: https://developers.google.com/earth-engine/datasets/catalog/TIGER_2016_States

You can search for other data collections here: https://developers.google.com/earth-engine/datasets/catalog/

Question 29: Can I extract the reliability of linear regression for studies such as land degradation? In addition, has some smoothing been implemented to eliminate outliers in the time series?

Answer 29: I would take a look at the specific papers mentioned for each algorithm. For Landtrendr, there is one specific step that removed outliers based on a set threshold. It also starts with the most complex model fit, runs statistics (like p-value etc.), then modifies the model based on these parameters. It is an iterative process. Take a look at the Kennedy et. al 2010 paper for those details.

Question 30: Can we use MODIS data with the Landtrendr in GEE?

Answer 30: Not in the User Interface, this only uses Landsat data. However, you may be able to write a script to call the MODIS collection instead of Landsat. Check the link to the GEEE scripts provided above. You can also use AppEEARS for MODIS data.

Question 31: GGE as an open source tool, who is responsible for validating the algorithms before they are available and used?, that is, for users to work with validated and useful algorithm

Answer 31: If you are writing your own code, you are responsible for understanding the limitations of each algorithm used. For use of the Landtrendr algorithm, I would contact Kennedy's lab or read the paper on how the algorithm has been validated.

Question 32: Can you offer some insight regarding the differences between the Fitted RGB delta mapper versus the change mapper? The RGB delta mapper seems to integrate 2 of the 3 layers that are being shown in the change mapper (i.e. year of change detection, and magnitude)... or am I mistaken, and instead of being redundant, they are actually complementary to one another? Earlier you mentioned you prefer

using the Fitted RGN delta mapper first, before investigating further with the change mapper and the pixel time-series plotter.

Answer 32: They are complementary to one another. The RGB mapper may be a good place to start with identifying if change is occurring on the landscape. The colors shown indicate are mapped in a ternary diagram fashion based on the date when change detection occurred. I have not used the RBG mapper very much.

Question 33: Landtrendr has works also on Europe? It has access to Landsat Images taken in Europe?

Answer 33: Yes, the data are global. It access the Landsat archive.

Question 34: Is there a way to estimate per-pixel uncertainty or confidence? Likewise, is there a way to estimate statistical uncertainty of resulting area estimates, e.g., disturbed area = X acres +- 1 standard error? If not, how do users decide how much confidence to place in map results?

Answer 34: Yes, I think you would need to assess this through running the algorithm yourself, this is not provided in the UI. I would suggest taking a look at the example scripts and the Kennedy et al. 2010 paper for those specifics.

Question 35: Is there a technique your team uses to detect shoreline change activity and if you can share your methodology

Answer 35: This is not something I have done before. However, you can use similar techniques for shoreline change. I am not aware of specific marine tools, but please take a look at the answer to question 5 where we provided links to marine change detection analysis. Theoretically you can apply this type of analysis to monitor shoeline changes, but there are many challenges with this, like mixed water-vegetation pixels, rapidly changing dynamics, etc.

Question 36: What tools would you suggest for beach corrosion imaging (with high spatial resolution) and other coastal monitoring (eg dunes habitats)?

Answer 36: Same as answer to Q 36: This is not something I have done before. However, you can use similar techniques for shoreline change. I am not aware of specific marine tools, but please take a look at the answer to question 5 where we provided links to marine change detection analysis. Theoretically you can apply this type of analysis to monitor shoeline changes, but there are many challenges with this, like mixed water-vegetation pixels, rapidly changing dynamics, etc.

Question 37: is it possible to use GEE for forest fire simulation ? if so, can you please afford any example script link for that

Answer 37: You can use GEE to map burned area, but I am not sure about simulating a forest fire. I assume you would need a specific model for that. I would suggest taking a look at some of the example code provided by GEE.

Question 38: GEE results raster of Landtrendr analysis are downloadable?

Answer 38: Not in the User Interface, this is something you would need to write a script for. See answers to previous questions.

Question 39: So for the RGB mapper white = constant change?

Answer 39: It looks to me like white and black indicate no change (or change that occurred prior to 1984). It looks like the urban or bare ground pixels with no change appear white while the vegetation pixels with no change appear black. However, I would suggest contacting Robert Kennedy's group on those specifics: https://emapr.github.io/LT-GEE/updates.html

Question 40: How does pink (change between 1984 and 2016) different from green (change in 2000) in fitted index delta mapper?

Answer 40: Each color red, green, and blue are assigned a year of spectral data, then those data are composited to an RGB image where each of red (1984), green (2000), and blue (2016) are mixed by weighting of the spectral intensity for the year represented by each color. It is useful as a quick way to visualize change or non-change over time along with providing a relative sense for spectral intensity. So the pink pixel had change occur closer to 1984 (earlier in the record), where the green pixels show change occurring in 2000. For more clarification, I would suggest contacting Robert Kennedy's group on those specifics: https://emapr.github.io/LT-GEE/updates.html

Question 41: Can there be other tools like LandTrendr which use Brightness Temperature change over time using Pixel Time Series Plotter. The BT is same as NDVI values but at different scale range. What do you say?

Answer 41: Right now in the GEE LandTrendr there is no option to look at temperature (the Landsat thermal band). However those bands are included on GEE, so if you wanted to run this analysis, you would need to do the scripting yourself in Code Editor.

They have lots of resources online, check out the scripts on mathematical operations here: https://developers.google.com/earth-engine/playground

Question 42: Why do some of these algorithms can only be used for forests? What about dense shrubs, such as chaparral?
Answer 42: These algorithms can be used for any terrestrial land cover. They're often used for forests because forests are easier to detect change. Shrubs and chaparral are much more challenging and sometimes the changes are much more subtle.

Question 43: Hi, can I create my own index instead of using TCA,TCG,TCB and TCW and how to use it in GEE?
Answer 43: You would need to script this on your own in GEE Code Editor. They have lots of resources online, check out the scripts on mathematical operations here: https://developers.google.com/earth-engine/playground

Question 44: How do we download the processed images? How can the images be viewed year by year?
Answer 44: You cannot download the images through the user interface, but you can download them via the Code Editor scripts. The LT-GEE group has also provided some example scripts, check on the one on mapping vegetation loss:
https://emapr.github.io/LT-GEE/example-scripts.html
To view a single image per year, you can modify the date ranges on the side panel on the left. If you only want to see change in one year you could also modify the legend to only display one year on the map too. Again, for displaying or downloading the map layers, you will likely want to do the coding yourself.

Question 45: In Change Mapper, can the magnitude layer be used to identify the severity of the wildfire in different regions?
Answer 45: To some extent you can use that layer to look at severity but it is not intended for that. NBR is better (and DNBR) is the better product for that.
https://www.mtbs.gov/

Question 46: Is there a limit on the size (e.g. 1 hectare minimum) or area of interest wherein we can use the LT-GEE Change Mapper for analysis?
Answer 46: Minimum for Landsat is 30m.

Question 47: Can I do the forecast of an area like it will be for the year 2030? How would the methodology be, an annual sequence or every 10 or 20 years?

Answer 47: No, this will not allow for forecasting (historical only, no modeling).