Part 1Question & Answer Session

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 Lola Fatoyinbo (lola.fatoyinbo@nasa.gov) or Abigail Barenblitt (abigail.barenblitt@nasa.gov).

Question 1: How do you map mangroves ecosystems in small islands like Pacific Island Mangroves? What satellite data would be the most appropriate to use?
Answer 1: It depends on the size of the mangrove patches and for what time frame. Some datasets you can use are Landsat (30 m resolution), Sentinel 2 (10-20 m resolution) or higher resolution commercial datasets such as Planet or Worldview/Rapideye/Spot, etc. With Landsat you will be able to map change over time for 3 decades or more, with Sentinel you can map starting approx 2015 onward. Recently Planet has made more data available.

Question 2: Do you have a model that integrates rs-gis methods in the ecosystem valuation of the mangrove ecosystems? Do you have some related literature on these model?
Answer 2: There are many studies on valuing mangrove ecosystem services. In general you would use the area determined from remote sensing and GIS and multiply it by the per area value or ecosystem services. I will try to paste some examples here.

Valuing the Flood Risk Reduction Benefits of Florida's Mangroves:
https://www.researchgate.net/profile/Siddharth_Narayan/publication/336903145_Valuing_the_Flood_Risk_Reduction_Benefits_of_Florida's_Mangroves/links/5db9f6824585151435d612e6/Valuing-the-Flood-Risk-Reduction-Benefits-of-Floridas-Mangroves.pdf

Review of Valuation Methods for Mangrove Ecosytems:
https://www.sciencedirect.com/science/article/abs/pii/S1470160X12001847

Global Loss Drivers Paper: https://onlinelibrary.wiley.com/doi/pdf/10.1111/gcb.15275

Question 3: I am unable to install the class accuracy plugin. It shows there is an error.
Answer 3: We don't use the plug-in until Part 2. But in the meantime: Be sure you are using QGIS 3.10, then Download the Class Accuracy Plug-in for QGIS

(https://github.com/remotesensinginfo/classaccuracy)

**** NOTE ** Once downloaded, open that zip file (classaccuracy-master.zip) and then
REZIP the contained file without the README file.**

From there follow the instructions for installation in this video:
https://www.youtube.com/watch?v=NJRdKpmujRo

Question 4: How do you deal with cloud cover in Landsat Images, especially for
tropical latitudes?
Answer 4: When we create a composite of Landsat images, we collect images before
and after the exact date of interest. From this, we are able to create a mosaic of
images that reflects the imagery for that time period. By assembling more images in
our composite, we are able to create a cloud-free composite by taking the best pixels
from each image.

Question 5: How do you distinguish between mangrove forest and adjacent "normal"
forest?
Answer 5: This is where the map makers 'expert knowledge' is needed! Luckily
mangroves are quite distinct in their location (always on the coast), their texture and
their color. In general it is straightforward to distinguish them, but in areas with very
dense forest adjoining mangroves, it can be challenging. In those cases, it's best to
combine data from multiple types of sensors - for example optical (Landsat) with radar
(Sentinel 1) and a digital elevation model (SRTM). GPS points are very valuable for
validation. Flat, intertidal regions will be the areas to look for. Dense tropical forest
nearby is challenging to distinguish. Using a DEM to mask out higher elevations also
helps.

Question 6: In a long time series (page 39 pdf), when comparing the values of a year
with the average of a period, what would be more convenient, take a certain month, a
specific date, look for the values of all the months of the year?
Answer 6: It depends on the question you are trying to answer, but generally, it is best
to use a specific time frame where you have multiple image acquisitions for
comparison. We usually take an average across the year.

Question 7: I have a question regarding the Land Use change decision tree. How were you able to assign the mangrove loss to the different drivers? Did you overlay the mangrove loss map with maps from the different drivers?
Answer 7: Yes, this is where we use ancillary data. Global datasets of ag areas, etc. Change by cutting versus change by commodities. Please refer to our Mangrovelossdrivers.app

Question 8: How does erosion affect mangroves?
Answer 8: Erosion along coastlines strips sediment and can result in the loss of intertidal areas where mangroves thrive.

Question 9: Can we use Google earth to get these types of radar images? If yes, are they available for past years as well?
Answer 9: If you are referring to **Google Earth Engine**, yes Sentinel-1 SAR data is available from 2014-Present. There are also Global PALSAR yearly mosaic data from 2007-2018 (30 m)

Question 10: Will we be witnessing a hands-on experience of using the random forest classifier on a sample in upcoming sessions?
Answer 10: Yes, we will cover this in the 2nd session next week. We will have demonstrations on this.

Question 11: Is it possible to distinguish between true mangrove species and mangrove associates using satellite imagery?
Answer 11: Good question as we are interested in distinguishing species. It will depend on which associate associate species is of interest. We have had success in distinguishing Nipa palm in SE Asia.

Question 12: I wish to know the influence of coastline in mangrove ecosystems and how to determine the digital shot line with landsat images.
Answer 12: Can you rephrase? Thanks!

Question 13: Is 30m resolution images are enough for LULC detection?
Answer 13: Yes, it depends on the landcover and the size of the change. Landsat does a good job detecting change.

Question 14: Some mangroves, in particular the Rhizophora species, have prop roots that may be present above 1.3m. How does LiDAR detect the carbon stock or DBH of these mangrove trees, given their prop or stilt roots?

Answer 14: LIDAR does not measure DBH, but we use it for canopy height. We develop models that relate the canopy height to biomass directly (using in situ data). Terrestrial LIDAR (a field instrument) can be used but at a much smaller scale.

Question 15: How can we calculate the coastal stabilization rate/condition by mangrove ecosystem using remote sensing?

Answer 15: This is where we need the community to help develop the methods. Look at areas with mangroves vs not under similar conditions and compare the change in coastal areas between those two.

Question 16: Is there a landing page to choose between the 6 mangrove GEE apps? Or do you need to know the URL?

Answer 16: Many of our apps can be found through our lab's website:
https://mangrovescience.org/apps/

Please keep checking back as we continually update our list of published apps

Question 17: What is the accuracy of the biomass and canopy height quantified in the GEE app?

Answer 17: Canopy height accuracy on a global scale was +/- meters. Short mangroves (4 m or less). Biomass will vary. We have different models by region. The accuracy is lower vs canopy height (~60 tons/ha)

Question 18: Is it possible to use GEE to model the impact of different scenarios of SLR on mangrove biomass density?

Answer 18: GEE does not have SLR data readily available. However, if you have rasters for projections of SLR in your area of interest, GEE has the capability to run these analyses. So far there isn't gridded SLR data, but other ocean data is available:
https://developers.google.com/earth-engine/datasets/catalog/HYCOM_sea_surface_elevation

Question 19: I am planning on focusing my research on monitoring mangroves after a recent oil spill on a small island nation. Would you recommend using NDVI or a different index
Answer 19: Yes, NDVI is a good place to start. We have an app on the oil spill recently in Mauritius.

Mauritius Oil Spill App (by Liza Goldberg):
https://mangrovescience.earthengine.app/view/mauritiusoilspill

Question 20: Can you please suggest some good open-source software/module/package for dealing with satellite data, HDF or NC etc?
Answer 20: We will have step by step GEE demos in parts 2 and 3. GEE is open. QGIS is as well. Python and R are also options.

Question 21: What is the best model for comparing 30m Landsat reference data with sentinel-2 10m resolution?
Answer 21: There is not a specific model to do this. It is very dependent on the site and the datasets you are working with.

Question 22: Can we identify mangrove different species?
Answer 22: Species distinction is hard with Landsat. Combining diff types of space-bourne data helps this process. In situ measurements will be valuable here

Question 23: Do you have something similar to test for salt marshes or even seagrass? If not, would it be possible to develop similar technological tools?
Answer 23: Seagrass is difficult because it is submerged. But those methods are being developed.

Question 24: Is it advisable to map mangrove cover changes imagery from Google Earth Pro?
Answer 24: It depends on your area of interest and the available imagery. Landsat and similar satellites tend to have more consistent coverage globally. Google Earth Pro imagery has a finer resolution, but may not have consistent coverage of your study area. It may also depend on the time frame you are looking at.

Question 25: As we are all aware, some of the species are migrating to other regions because of the impact of climate. Can you identify new regions of mangrove patches?

Answer 25: Yes, we may be able to identify distribution given climate change. This is mangrove migration in regions in the Northern hemisphere where they are moving north.

Question 26: Are there methods available to integrate drone imagery into satellite imagery training processes for mangrove carbon stock measurements?
Answer 26: Yes. Using drone imagery has been very popular and interesting way evaluate between in situ and space-bourne sensors. Drones can be used as a validation measurement.

Question 27: For large scale (nationwide) modelling with random forest, is it possible with GEE?
Answer 27: Yes, depending on the size of the country, quantity of training data, number of land cover classes, etc. For large scale analyses you can run into GEE's capacity/ memory limits. However, when we just analyze coastline, we typically don't run into this problem.

Question 28: For the Mekong Delta in Vietnam, there's a system of integrated mangrove shrimp farms. Is the random forest mangrove mapping tool able to classify the extent of mangrove in this system?
Answer 28: Aquaculture with mangroves within. Yes, these ponds are large and so are the Mangroves in these areas. As long as the 30 m resolution allows you to detect them, yes.

Question 29: How do I correct for tides in mapping mangroves? I notice that in some mangrove forests, there are times that the forest is somewhat inundated by tides. Will this affect my remote sensing model?
Answer 29: Tides and water is often helpful in distinguishing mangroves. Since we make mosaics over time, tides tend to not affect the model much.

Question 30: For carbon stock assessment, did you differentiate between natural mangrove and plantation one?
Answer 30: No, not in our global map. Natural mangroves cover much more area than plantations and we did not have enough data to differentiate.

Question 31: Why did you use the reference data from 1998-2001 and an observation from 2000-2018?

Answer 31: The goal of the change map was to see changes from 2000 onward. So we needed reference data from before our study period (2017).

Question 32: Do you take into account the carbon trapped in the sediments with regards to mangrove carbon stocks? Are there any models to this effect?
Answer 32: Our carbon and biomass map focused on canopy height and biomass in mangroves (above and below ground). We used allometric equations for estimates. There are multiple global soil carbon datasets you can use. Sanderman et al has a gridded soil carbon dataset. 283 t/ha was the figure we used.

Question 33: The Simard data does not include mangroves in specific areas which we know from first-hand experience do exist. What could the reasons be for the exclusion of particular areas from the global mangrove map?
Answer 33: Simard was made using the Gaery et al dataset. It is not perfect however (cloudcover, etc). There are efforts to redo these maps.

Question 34: What is the best classifier for the mangrove species mapping?
Answer 34: Random forest classification is a robust classifier, however CART is also an option.

Question 35: What are the satellite products used to map the mangrove heights?
Answer 35: GEDI and TanDEM-X. SRTM data was compared to IceSAT-GLAS for the 2000-2006 datasets. All the details on the datasets used are available on our app page.

Question 36: Have you used in your mapping any standards in terms of physical properties, minimum area to define waht a mangrove is?. Something that can be used at an international level and also required for VCS or FREL methodologies?
Answer 36: Our Minimum mapping unit is 30 m (Landsat). An aggregate of 3-4 pixels is what we use (~ha).

Question 37: How do I correct for tides in mapping mangroves? I notice that in some mangrove forest, there are times that the forest are somewhat inundated by tides, will this affect my remote sensing model?
Answer 37: See above

Question 38: Does the mangrove global carbon stock is validated by field measurement?

Answer 38: Yes, we validated with field data globally. Used as training and validation datasets.

Question 39: Do you apply an emission factor to Mangrove loss to determine carbon emissions?
Answer 39: That is what you would do to determine that but it is not something we have done yet.

Question 40: Which microwave band is good for estimating above ground biomass of mangrove vegetation? How do we eliminate adjacent salt marsh vegetation?
Answer 40: It is difficult to separate between salt marsh and mangrove. Canopy height data helps. L-band radar (longer wavelength) would be best.

Question 41: How can you distinguish between erosion and sea-level rise? For instance, in Bangladesh, you mentioned the change in the coastline as a result of erosion, while it might only be a change in sea-level (that might or might not result in erosion).
Answer 41: All changes due to water were labeled as erosion. The underlying reason for erosion is a water effect.

Question 42: Is NDVI still reliable for studying mangrove using satellite imagery since the ground is wet soil which exposes different characteristics from mineral soil?
Answer 42: NDVI allows us to see changes in the vegetation and not the underlying soil.

Question 43: You mentioned the Tandem-X and the SRTM DEM to measure mangrove height, but I thought those models are DSM and not DTM; and I thought that those where modelling the canopy surface and not the terrain surface; can you elaborate on this? and can you maybe tell us about the coastalDEM and the new NASA dem that are supposed to be corrected for vegetation and therefore are supposed to be good DTM?
Answer 43: Yes, but the advantage we have is that mangroves only grow at sea level. So we do not have to subtract the elevation. LIDAR and field data helps us to shift the NASA DEM, which is an update of the SRTM calibrated with IceSAT Glas. Coastal DEM was calibrated to separate vegetation from the dataset.

Question 44: In 1990, Myanmar possesses over 1.2 million of Mangrove in costal area ,
after 30 years later, over 0.5 million of mangrove are remained in coastal area. How can
we use remote sensing system to be effective in the place of Mangrove ecosystem
conservation?
Answer 44: This is one end goal of our work. To monitor change over time. Knowing
what happened in th past and where helps us prioritize conservation areas.

Question 45: Can we visualize the area of mangrove community (e.g. community of
Rhizophora spp.) after identifying it on the field and analyzing it by remote sensing?
Answer 45: See the species detection answer.

Question 46: What type of classification algorithm did you use for the previous slide?
(Slide 43?)
Answer 46: We used a series of decision trees. Random Forest Classification
algorithm.

Question 47: Was the decision tree automated?
Answer47: Yes, it was automated. Input the rules run on a global scale. See
Mangrovelossdivers.app for more information on the methodology.

Question 48: How do you ground verify the classified image products?
Answer 48: Validation is done with high resolution, field measurements, or Google
Earth is a good method too.

Question 5: What is the goal of providing access to the data as a GEE App?
Answer 5: We often work with partners that have varying degrees of technical/ coding
experience. Apps make data available without requiring partners to have a coding
background. It allows us to provide tools for monitoring mangroves and calculated
indicators even without GIS/ coding skills. The apps allows us to create tools for
monitoring SDGs for anyone trying to calculate indicators and can just interact with the
app.

Question 49: Can these tools be used for Carbon credits monitoring (e.g., offsetting
projects)?
Answer 49: Yes. If you are running a Carbon credit you will need basemaps of
mangrove and change, future projections. One of the goals is for users to use for real

world applications. Please always read the methodology and pubs to know the
accuracy of the products.

Question 50: So is it possible to enter data into the app, as with citizen science
projects?
Answer 50: Not with the apps we created. Currently I am not sure if this is accessible in
GEE. There are many widgets that can be created.

Question 51: Are there similar tools/workflows for submerged aquatic vegetation, e.g.
seagrass meadows?
Answer 51: Seagrass mapping is similar but more challenging due to submersion.

Question 52: Referring to slide 39: How do you define an appropriate reference period?
E.g., why was a 4-year period selected?
Answer 52: For our reference period, we wanted to create mosaics to get average
values. More than 4 years would be preferable. Tropical regions present clouded
images so multiple passes over a region is beneficial to do so.

Question 53: When we would like to analyze time series data should we also using
series of the remote sensing data? Where can I find this data?
Answer 53: Yes, it can be done. In Parts 2 and 3 we will show you the data we have
been using to analyze in GEE. Much of the data is available for download by different
data distribution agencies.

Question 54: Is there any permanent monitoring sites on mangroves as for example
FLUXNET?
Answer 54: Yes, there are many monitoring sites. The Florida everglades have a series
of flux towers and in other regions as well. Permanent sites also exist.

Question 55: Can random forest classification be used for other type of forest
ecosystems too?
Answer 55: Yes. Random Forest Classifications are useful for classifying a variety of
land cover types (ex desert vs urban). We use it in a variety of studies such as invasive
species monitoring or resource extraction.

Question 56: Will we get into how to define a global region of interest?

Answer 56: In the next session we will learn how to draw a region of interest. There is also functionality for using a shapefile as a region of interest using geometry tools. The steps we show next week can be applied in your ROI.

Question 57: Which SAR dataset is the most useful to map mangrove loss?
Answer 57: SAR (ALOS PALSAR (2006-2018) is L-Band and Sentinel 1 is also useful.

Question 58: Another question about GEE apps, is it a good format for presentation/communication of data? as with students for example
Answer 58: We think so! It can be a great way to make data available to "play" with. Part 3 of this series covers this. Stay Tuned!

Question 16: Is there any work being done on mangrove species mapping?
Answer 16: Yes, but it is quite difficult. The datasets are not always available (hyperspectral). But a combo of optical + LIDAR+ SAR allows us to differentiate between spp.

Question 17: We know that mangroves protect the coast from erosion but after this presentation, we learned some of the mangroves have been lost due to erosion. So why is it happening? Is there any particular reason?
Answer 17: Yes. One of the common reasons is SLR (sea level rise). Erosion can also be tied to currents, discharge.

Question 18: When examining global mangrove datasets and using the Random Forest Classification at an estuary scale, there are obvious limitations with misclassification of freshwater supratidal wetlands - is it possible to incorporate elevation data into the Random Forest Classification?
Answer 18: Yes. In fact, we will be using SRTM in the process of mapping mangroves in Part 2 of the workshop. It will be part of the preprocessing.

Question 19: When examining global mangrove datasets and using the Random Forest Classification at an estuary scale, there are obvious limitations with misclassification of freshwater supratidal wetlands. Is it possible to incorporate elevation data into the Random Forest Classification?
Answer 19: See #18

Question 20: Data of Sentinel-1 in GEE are in RTC? If not, be there in the future?

Answer 20: RTC, Radiometrically and terrain corrected. I believe it is corrected, but you can check the metadata here:
https://developers.google.com/earth-engine/guides/sentinel1

Question 21: Is L-band SAR best for mapping structure (i.e., canopy, understory, ground cover, etc.)?
Answer 21: L-Band does not give you structure on its own. We use InSAR which is 2 acquisitions so we can get structure from that.

Question 22: Is it interesting to monitor the mangroves LST? Land surface temperature
Answer 22: LST, can you clarify?

Question 23: What dataset do you recommend to use for looking at mangrove destruction from cyclone impacts?
Answer 23: A timely question given the storms this year. The datasets we cover in this series is what would be most useful.

Question 24: Is there a central repository or fundamental paper that outlines the use of Random Forest in remotely sensed data (as opposed to other types of time series data)?
Answer 24: See below:

https://www.sciencedirect.com/science/article/pii/S0924271616000265

https://www.researchgate.net/publication/299636698_Random_Forest_Classification_of_Remote_Sensing_Data

https://www.researchgate.net/publication/248977544_Random_forest_classifier_for_remote_sensing_classification

Question 25: Do you follow any standardised protocol for field measurements of mangrove biomass, or do field techniques vary depending on location/species?
Answer 25: Yes. It depends on what you are measuring. We work with the US Forest Service and Blue Carbon Working group that have put our protocols on this.

Question 26: How is validated the information obtained from classification algorithm?
Answer 26: An accuracy assessment is used. The plug in we use next week goes through this. It will give an error estimate.

Question 27: In addition to NDVI, can NDWI also be useful in detecting changes in mangroves?
Answer 27: Water Index, yes. We use this in our classification.

Question 28: Does the app allow monitor physical variations e.g. temperature, caused by the degradation of Mangroves in a particular region?
Answer 28: No, the apps do not monitor any other variables other than extent.

Question 29: Can GEE be used to create interactive maps? Is there any change in AOD (aerosol optical depth) values throughout the years?
Answer 29: Yes, the apps are interactive. AOD has already been figured into these datasets.

Question 30: To what extent is velocity (SAR) being used for the mangrove context? Is subsidence a driven factor of mangrove loss?
Answer 30: We don't use deformation from SAR in mangroves, This is a good question as in some region (sinking) can be a driver. In our maps it looks like erosion or SLR.

Question 31: How do you select training area and how big is it (depending on area?) to machine learning to automatically distinguish wet lands, dry lands etc.
Answer 31: Please stay tuned for Parts 2 and 3 and we will cover this.

Question 32: Is mangrove monitoring also a good proxy for monitoring biodiversity?
Answer 32: As a proxy, yes. They are habitat of flora and fauna as an indicator.

Question 33: Does carbon stock data obtained from remote sensing compare accurately with LOI data?
Answer 33: We always use field data to calibrate. This way we can generate an uncertainty value.

Question 34: What type of GIS data we can map in GEE?
Answer 34: GEE has a variety of satellite data readily available (ex Landsat, Sentinel, MODIS). There are also some climate models and other datasets. Whatever is not in GEE you can upload as an asset, the same way you import Raster and Vector data in other GIS software. But because it is powered by Google computers, there are many datasets already in GEE.

Question 35: I would like to use a higher resolution sat imagery that are not available on google earth engine. Are you going to cover this issue somehow on this training?
Answer 35: We will not focus on this in this series. But if you have those higher res datasets, you can import that into GEE.

Question 36: What are the best/oldest datasets to map a mangrove area over the last 50/100 yrs?
Answer 36: Landsat goes back to the early 1970's. But aerial imagery can be used if available.

Question 37: What series of satellites are free for users that can be used to monitor mangroves?
Answer 37: Landsat and Sentinel are more commonly used.

Question 38: Have data been created in GEE to monitor or calculate biomass in mangroves?
Answer 38: Yes. Part 2 we will cover this.

Question 39: Does GEE support other types of spatial data, such as GBIF species occurrences or bioclim or chirps precipitation data?
Answer 39: Yes. Chirps is available. GBIF is not, but any rasterized datasets can be uploaded.

Question 40: How much knowledge of java scripting is required to use GEE?
Answer 40: A background helps but we started without any previous experience in java so one can learn on the go.

Question 41: What type of atmospheric/radiometric correction algorithms do you use to scale the data?
Answer 41: GEE has already corrected the data.

Question 42: Is there a database for aerial photography?
Answer 42: Not a database we know of. A participant suggested the Open Aerial Map Project (openaerialmap.org).

Question 43: When mapping the extent of the mangrove, is it mandated for field validation / ground truthing instead use satellite images from google earth pro for ground truthing?
Answer 43: We have done both.

Question 44: The mangrove is generally flooded, this depends on whether it is dry season or rainy season. How could the coverages be clearly identified? Differentiating water, dry soil and healthy vegetation
Answer 44: Mangroves are flooded daily. Mosaics allow us to get homogenous coverage.

Question 45: Can we use Worldview data for this monitoring analysis?
Answer 45: Yes, but it depends on your study area and how much data is available. If you are doing an annual analysis it may be difficult to find enough images for a robust analysis.

Question 46: What are the statistical models you used (except Random Forest) to model this process, and how accurate are they?
Answer 46: For mapping we use random forest. CART is also used. Allometric equations can be used for biomass/carbon stock estimates.