Questions & Answers Part 3

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 Britnay Beaudry (britnay.beaudry@nasa.gov), Juan Torres-Pérez (juan.l.torres-perez@nasa.gov), Sativa Cruz (sativa.cruz@nasa.gov), and/or Amber McCullum (amberjean.mccullum@nasa.gov).

Question 1: Do you know vertical profile metrics obtained from conventional drones?
Answer 1: There are more than 100 different statistical metrics that can be derived from ALS and drone LiDAR. All are based on the point cloud structure or variation in modeled surfaces in the LiDAR data. Vertical profile metrics are an active area of research of ALD and drone based LiDAR data. Drone LiDAR data is still experimental. Refer to the documentation as listed in this document.

Question 2: How many pts/sq.m was the UAVSAR data in the Wax Lake Delta study?
Answer 2: The UAVSAR data was radar data (so doesn't have a pts/m2), but the ALS data was ~4 pts/m2. In regards to resolution, it is 10 meters.

Question 3: For the LiDAR data animation (before slide #13), when I download the data, what will I see? I don't think we can see the colored 3D animation that you showed. Also, what does each color represent? How were they assigned?
Answer 3: You will see a cloud of points (try opening it in cloud compare). The colored data showing classification will require some extra processing steps that requires matching the UAVSAR classification to the ALS point cloud. You will not see canopy data with the raw data or data downloaded from the website. Open Topography link: https://opentopography.org/

Question 4: The spatial resolution of LiDAR is 0.1 degree, which can consist of more than one tree or be just part of a tree (in the tropical areas). How do we know if we are seeing more than one tree or just part of a tree to determine the biodiversity?
Answer 4: Airborne LiDAR spatial resolution is typically ~1 m resolution (for canopy height models), so tree crowns are clearly visible. It can be very difficult to isolate

individual tree crowns in closed canopy forest, but it is possible with high resolution LiDAR.

Question 5: Why is there a lack of LiDAR specifically in mangrove ecosystems?
Answer 5: Mostly an understudied ecosystem - probably because it is not a managed forest ecosystem and rarely ALS data is captured because there is very little topography. LiDAR data is mostly collected by governments to map topography, especially in coastal areas. LiDAR is also expensive and for some regions of the world can be cost prohibitive. Airborne flights in tropical regions are also challenged by weather.

Question 6: Is it always possible to find ground points to create a model?
Answer 6: No, sometimes the canopy is extremely dense and the ground is unable to be seen. This happens often in dense tropical forest. Also it is a problem in wetlands when grasses are extremely dense and the ground has a lot of microtopography that you may want to capture.

Question 7: Slide #21 and #22, what is PAVD on the x-axis of the graph?
Answer 7: Plant Area Vegetation Density - It is the density of leaves throughout the canopy.

Question 8: What are the R packages used for creating ground point and canopy point models?
Answer 8: You may want to check out **lidR**.

Question 9: Regarding slide 13, could you please explain more about the mismatch between the result from LiDAR data and the result from Hyperspectral data? For example, what caused the misclassification result from hyperspectral data? On the other side, how did LiDAR produce a better result?
Answer 9: The first answer is resolution. LiDAR captures higher resolution and this makes it much easier to identify and classify small objects. Second, the LiDAR provides a more direct measurement of structure, so identifying vegetation with small differences in height is a simple and certain task.

Question 10: In the Gabon case study, it is amazing that your TLS data can also capture the top canopy structure. How did you achieve that? Because I thought TLS is not good at canopy top structure.

Answer 10: This is true. It is a very difficult task and the TLS data was still incomplete in some places. In this case, we used a very slow, high-res scan mode (250 million points measured per scan location) captured over 15 min. The high resolution helped reduce occlusion because we could more clearly capture small canopy gaps.

Question 11: Why are there seemingly no shadows in the LiDAR data and imagery?
Answer 11: LiDAR is an active sensor, so all objects are illuminated, which removes any form of shadowing. LiDAR does experience "occlusion," which is the blocking of some LiDAR measurements by intercepted objects (e.g., trees). This creates a kind of "shadow" effect.

Question 12: On slide 29, you mentioned a field campaign. How were the 3D infrared images collected?
Answer 12: This infrared imagery was collected from a terrestrial laser scanner, so it is an image reconstructed from ground-based laser scanning data.

Question 13: Can a satellite-based LiDAR be as accurate as an airborne LiDAR?
Answer 13: The short answer is no, but really this is a matter of scientific question. For global scale questions we accept the trade-off between the high resolution ALS data over small areas vs. more coarse resolution but global spaceborne datasets. The actual vertical accuracy is quite similar between the two instruments though, which is amazing!

Question 14: I am amazed by the detail that has been captured and I wonder how long it takes to analyze such a wealth of high-res data? What information/data exactly were surprising to you and your team in terms of structural diversity in the mangroves? In other words, what is the real value added for biodiversity assessments for improved natural resource management?
Answer 14: Depending on what portion of the project/talk you are referring to, it can take quite some time! Most of our analysis is automated though, so we can process a lot of data automatically. The hard part really is developing the tools - then we can efficiently automate our processing on the cloud or using local computing resources at NASA. One of the most interesting aspects of this structural analysis to me is the diversity of structural profiles under forests of the same species and similar height. The ability to tease out these structural signatures will give us the tools to identify habitat structure and types that can be directly linked to different species with conservation interest. We see this technology as having a huge number of biodiversity applications!

Question 15: What is the difference between Aboveground Biomass from GEDI and Aboveground Biomass from Global Mangrove Distribution?
Answer 15: The GEDI biomass estimates are not explicitly calibrated for mangrove systems, so it is still unknown how different these estimates are from our global mangrove map. We are developing a merged GEDI mangrove biomass product and will have the answer to this question soon in an upcoming publication.

Question 16: In the case of GEDI, can you only get the height, or can you also get intensity?
Answer 16: GEDI can provide a type of intensity data, since it has an estimate of the outgoing laser energy and return energy. This allows then to calculate something similar to reflectance or return intensity.

Question 17: Has there been a study done that used the structural and reflectivity data using machine learning that made plant identification more accurate?
Answer 17: There are many examples of this in past LiDAR studies. Intensity data is a regularly included predictor variable that can be used to identify conifer vs. broadleaf trees. Since it is a single wavelength, the classification applications can be limited.

Question 18: For decades, there have been references to how the wetland structure has "benefits" for hurricane protection (in Louisiana.) Is there any reliable data that quantifies how much wetlands reduce storm surge impacts?
Answer 18: LiDAR can answer this question, but so can simple optical data. The presence of coastal ecosystems like mangroves offer dramatic flood protection (mostly due to wave attenuation and attenuation/slowing or storm surge).

Question 19: How are the seasonal differences in plant reflectivity compensated for? For the BioSCape project, the flights are planned for early summer to ensure the least amount of cloud cover, but this is also the dry season. This means many plants dry out and do not represent the plant's actual "green" color.
Answer 19: From an image processing standpoint, we have several corrections that we apply to compensate for differences in sun-sensor-target illumination. But that does not get at your real concern: indeed we can only measure characteristics at the time of imaging. However, when we have time series we can model changes in traits (especially using something like Landsat or Sentinel). These concerns will decline when satellite hyperspectral imagery with 10-20 repeat visits will become available later in the

decade. Indeed, this "dry season" concern has affected us both in the California work as well as work in India, where the imagery had to be acquired during the dry season.

Question 20: Can you use the monthly change pattern of LMA, Phenolics, and Potassium for classifying vegetation species?
Answer 20: Yes indeed! The seasonal signal is pretty distinct. However, there is even more information in the full hyperspectral data (spectra) that can probably lead to even better classification. Also, species may have some plasticity in their traits, and there are some species with similar trait profiles. So rather than mapping species as a function of their traits, map them from the imagery.

Question 21: Can you please say more about the flux tower measurements? How are they exactly done?
Answer 21: Flux towers are placed within a canopy of vegetation and have sensors along their length that measure "eddies" of CO_2 and H_2O as well temperature and wind speed that enable estimation of the "net ecosystem exchange" of gases. From this we can employ models to infer total canopy photosynthesis.

Question 22: Can LiDAR be used to do fine-scale mapping of structural diversity of wetlands that have low-growing vegetation, such as our fynbos wetlands in the Western Cape, South Africa?
Answer 22: LiDAR definitely enables mapping structural diversity. Here's a paper with more information: https://doi.org/10.1088/1748-9326/ab9e99 and another one: https://www.nature.com/articles/s41467-017-01530-3. Whether it will work well in really low stature vegetation depends on density of returns.

Question 23: Do you have plans to use EnMAP Spaceborne Imagery to tackle your question pertaining to assessing ecological processes across similar ecosystem types since that data is being made available by DLR?
Answer 23: Yes. These are exciting new data sets that I cannot wait to use.

Question 24: As someone who is new to LiDAR, are there any suggestions for gaining experience with image pre-processing/correcting? I am an ecology phd student at the University of Houston. I would like to incorporate LiDAR into my work, but I don't know where to begin.
Answer 24: I would definitely look at the lidR package in R. There are others. Most R packages have vignettes that help you get started.

Question 26: For the imaging spectrometer (hyperspectral) data, how do you compensate for variation in solar geometry (e.g., cross track/along track illumination) in adjacent flight lines? Is it significant to reduce this effect in algorithms used?
Answer 26: This is our biggest challenge, but we think we have nearly nailed it!

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