Questions & Answers Session 4

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 Erika Podest (erika.podest@jpl.nasa.gov), Amber McCullum (amberjean.mccullum@nasa.gov) or Juan Torres-Peréz (juan.l.torresperez@nasa.gov).

Question 1: Given that the ground surface is continuously changing in hilly or mountainous regions, will extracting tree height in these regions give any kind of error?
Answer 1: We haven't done a full error analysis on mountainous terrain yet. However, since the algorithm depends on temporal decorrelation, instead of volumetric decorrelation, then it is expected to be less sensitive to those sources of error than you would see for lidar and other similar methods for estimating forest stand height.

Question 2: Can SAR Imagery be used to monitor those forested areas that are damaged by insects?
Answer 2: People do that with SAR (and InSAR). I would say that those applications are still experimental. That topic is not covered in today's webinar.

Question 3: When is NISAR going to be launched? Will the data be freely available?
Answer 3: NISAR will be launched mid- to late-2022. One of the uncertainties with this date has to do with the effects of the COVID-19 shutdown, which is still ongoing. After the commissioning period of NISAR (120 days I think), the data will be made freely available. Now is a good time to learn how to use the data through ASF DAAC.

Question 4: How accurate is C band for Crop Monitoring; especially for Indian subcontinent conditions?
Answer 4: It depends on what you mean by "crop monitoring." Sentinel-1 C-band data can be downloaded now from the ESA satellite and the Alaska Satellite Facility. You can probably find some images today for the area that you are interested in.

Question 5: What does "modes of acquisition" mean? For instance, when you say Sentinel has 4 modes of data acquisition, what does it mean? Does it mean the platform has 4 types of sensors or is it something else?
Answer 5: Hmm, I don't recall saying "four" modes of acquisition. NISAR has two, mostly-independent synthetic aperture radars on board. One operating at L-band, the

other at S-band. S-band data is not collected globally. L-band is. The background land data will mostly be dual-polarized (HH and HV).

Question 6: Is it possible to distinguish between deciduous and coniferous forest on radar images?
Answer 6: Not really. The radar cross section differs by about 1 dB (maybe 0.5 dB) between those two types of forest, but there are so many other things that vary in magnitudes greater than that. It is a difference that is barely noticeable. Radar is sensitive to structure and it would require a combination of radar and optical.

Question 7: Please clarify, did you say this technology could determine stem volume [Stem Area Index]? Or, does it require independent data, say from LiDAR, to model and calibrate the data?
Answer 7: First, it does not determine stem volume, but you could imagine if you are looking for an index of some sort, that you could create a relationship that might relate the two. Regarding independent data, yes, it does require that somewhere. We did that for the state of Maine, where we had one region where we did have lidar data, and then we used the FSH algorithm and multiple InSAR scenes to extend the result to the wider region.

Question 8: What is the smallest area of forest disturbance that could be obtained from current SAR data and the future NISAR?
Answer 8: The single-look complex imager (SLC) basic resolution of NISAR will mostly be 8m x 12m. This can vary depending on if you are working in radar coordinates or geographic coordinates, which is a projection that depends on the incidence angle. It can vary across the swath too.

When working in geographic coordinates, the resolution will be 20m for the 20 MHz mode of NISAR. At that resolution, there are about 3 independent looks per resolution element, so speckle could still be an issue. Given that, you would be able to see some disturbance at that scale. For mission requirements, it is being tested at 100m resolution. Disturbance is defined as a 50% change of it's 100.

For the mission requirements, an algorithm for disturbance is being developed and tested at a 100m resolution (1 ha). More algorithms will likely be developed.

Question 9: Is it not currently feasible to calculate canopy height with Sentinel-1 C-SAR? Do we need to wait for the L-band?

Answer 9: C-band SAR has too much temporal decorrelation. Temporal decorrelation is how this FSH algorithm works. You can do standard interferometry with C-band. Because of the temporal decorrelation over forests, the estimate of topographic height over forests can be quite poor. That is, unless you have two satellites observing at the same time, like TanDEM-X.

At any rate, there is archived L-band data that is available from ALOS-1. There are instructions at the end of this webinar indicating on how to get that.

Question 10: Is the coherence just the amplitude of one slc multiplied with the amplitude of another slc?
Answer 10: Close. You have to divide by the geometric average of the powers. Also, the coherence of a single-look image is equal to one… always. You have to do multilook averaging (4-25 SLC pixels) to get a more useful measure of coherence. What the coherence is doing is measuring the consistency of the signal phase over neighboring resolution elements.

Question 11: Can you please clarify forest moving? Is that tree growth, or something else?
Answer 11: No, not forest growing. That happens over a much longer time scale. What is meant by moving, is like breezes, winds, and changes in the tree water content. That is, the forest may look the same over relatively short time periods, but in reality, elements of the forest are always in motion; and this is what gives rise to the temporal decorrelation that technique uses to estimate the forest stand height.

Question 12: What is the basic difference between LiDAR Data and SAR Data? Are these NISAR data available for urban areas where there is some wetland and vegetation? What is the regulation of these images?
Answer 12: Regulation varies based on the collecting agency. Lidar, depending on who collected it, it may be available. ISS has LIDAR from GEDI and that is open.

Question 13: Where trees are tall with canopy, interferometry takes into account multiple heights, which I believe might not be available through optical sensors. Therefore, how reliable is the DEM, which is now readily available, derived from optical sensors at narrow range?
Answer 13: Good question about the reliability of the DEM. As we know, that can vary from region to region and depending on how the DEM was derived. Also, what is meant by DEM in a forest environment? The bottom of the canopy, the middle, or the top?

There are different terms for that, like DTM, etc. I get confused about what is meant by the different terms, but these can be looked up readily enough. From what I have seen, one of the most reliable methods of determining a DEM, outside of land-surveying, is to use a lidar.

Question 14: If the timeframe is short enough can you mix L-band and C-band (ideally x-band), since C-band could provide the top of canopy (angle dependent) and L-band for the elevation of the ground?
Answer 14: Yes, you certainly can. And the timeframe is quite forgiving (related really only to how fast the forest is physically changing). However, you cannot do interferometry between different frequencies (e.g. L- and C-band). The frequency for both of the images that you are interfering has to be the same. You cannot cross over frequencies.

Question 15: Do you have an opinion on the Pantropical Forest Height product (accuracy/utility) produced by Woods Hole for 2007, and are you aware of any similar products or recent updates?
Answer 15: Is that the one from Walker et al.? If so, I think that it is reasonable enough. If I remember correctly, it depends on ICESAT data, which can have problems related to topographic variation within the 70m spot size of the instrument. These days, GEDI is probably a much more useful instrument for that application. GEDI mostly flies over the tropical belt.

Question 16: How sensitive are INSAR estimates of forest height to substantial changes in dielectric properties between time-1 and time-2?
Answer 16: “Substantial” is the key word here. If it is changes in soil moisture for bare surfaces, then that would certainly confuse the algorithm. If it is soil moisture beneath a forest floor, then it will be less sensitive.

Question 17: Could you please explain why the two scenes are called 'master' and 'slave'?
Answer 17: The “master” scene is assumed geometrically correct. The “slave” image will have slight misregistration errors compared to the “master” and must be warped. Your eye would probably not notice much of a difference, but this “sub-pixel” co-registration of the two images is important for making interferometry work, especially in optimizing the determination of correlation magnitude.

Question 18: Did you use the LVIS L2 Elevation and Height Products to calculate the correlation magnitude, or did you do extra processing from the L1B data?
Answer 18: I don't remember what processing level of LVIS data was used. Whatever it is that gives "tree height." Even if it is in error every so often, as long as those errors are not biased high or low, that would be sufficient input for the FSH algorithm.

Question 19: Looking at the difference between ALOS and NBCD there are bands/stripes in the ALOS image. Where are they coming from, and why are they not in the NBCD image?
Answer 19: There are two parts to this answer: 1.) The FSH algorithm can be affected by weather. That would make the result spatially variable across the result. For that reason, you should be careful about which interferograms are selected for estimating FSH. Often there are multiple radar images available, so you can choose those that give the most spatially consistent results. 2.) The NBCD seems to saturate at some point. You can see that by the lack of contrast in the result. I think that this is a characteristic of the NBCD algorithm, which is that it saturates for certain values of FSH.

Question 20: If I want to obtain shrubland, is it possible to obtain it using this method and eliminate forest land using a height threshold?
Answer 20: You could try that, but some care should be taken in selecting the data. The reason being that the soils of shrublands are exposed, and so variations in the soil moisture might create temporal decorrelation that would appear as variations in FSH. In short, what should be done in those cases is to select scenes that are collected during the dry season. Although I don't have ground validation for the region, the result from the Colombia data is a good example of where that kind of classification might work. It hasn't been properly tested, but it is possible.

Question 21: Trees do not have "indeterminate growth," they do not grow in size, forever. However, a forest canopy will increase in elevation, every year, until some time when senescence slows the growth and/or stops it. Has anyone looked at annual change in canopy elevation as a way to "calibrate" the age of a stand?
Answer 21: I think that people do that. Certainly it is useful for looking at habitats, etc., which is why forest structure is considered such an ecologically important variable. What can complicate this measure is that because of competition, young trees tend to grow just as tall as mature trees; so it really is the tree density times the height that might be more important. I would say that this is still a topic of useful research that could be done; which is to relate things like radar cross section magnitude and FSH to

topics like the stem density and forest height. Looking at geospatial variation of forests can determine many ecological factors such as biodiversity.

Question 22: A strong defoliation between two dates from InSAR analysis can be a problem when estimating tree heights?
Answer 22: Maybe not. Some of our best interferograms for estimating FSH were between July and October, when the leaves fall off in this part of the US. The reason why I think that that still worked, even through that type of event, is because the L-band is seeing more of the woody structure of the forest than the leaves. Losing leaves on trees has less of an effect than previously thought.

Question 23: Are current, publicly available radar images good enough to monitor vegetation interfering with high tension electric transmission lines?
Answer 23: That is unlikely. They are probably not high enough resolution.

Question 24: How do these sort of height estimations work in very pronounced relief regions?
Answer 24: See the answer to question 1. This is something that could still be investigated.

Question 25: For areas that have no LIDAR data, how can estimation error be reduced?
Answer 25: These days because of GEDI, Lidar is available globally (mid to lower latitudes). Another option is to measure in situ FSH. You only need a few points. Just something that overlaps with the available radar data. Another way is to use an optical image, and try to figure out where there is or is not consistent forest. Where you see forest they tend to mature at the same rate so this is a “back of the envelope” method.

Question 26: Is there a rule of thumb on how incoherent an interferogram can be before it is not useful for the FSH algorithm?
Answer 26: Things with correlations below 0.4, this will be the lower edge. 0.2 - 0.3 are getting close to useless. 0.5 or higher is best. You may also consider reducing the resolution.

Question 27: Can this technique be used on agriculture (shorter planting areas?) Would C band be better to use in this application?
Answer 27: Yes. For agriculture regions, those are managed lands, staying consistent. The height accuracy is on the order of 3 to 4 meters, being large for an agricultural view. For airborne, things are different.

Question 28: Is it possible to use RSS approaches to estimate forest stand height for linear plantings that have a width of about 15-25 meters (for example shelterbelts) if we have only ground/field data with estimated tree height?
Answer 28: I am not sure what RSS means. For satellite SAR, viewing angle is a bit of a headache.

Question 29: It seems like most analyses use image pairs. Is there a reason to not use multiple image groups (i.e., many images and look at variance through time)?
Answer 29: You can and people do that. For the simplistic algo here, you are looking for one number (FSH). Even Lidar measured is not always the most accurate (is it the last leaf on the tree, ect). Consider averaging results.

Question 30: Are current publicly available radar images good enough to monitor vegetation interfering with high tension electric transmission lines?
Answer 30: No.

Question 31: Is it possible to use a similar algorithm to measure building height?
Answer 31: Not this algorithm. But people use InSAR for all types of height measurements. You would use the phase and measure the topography directly.

Question 32: Could you explain the concept of moving forest and its relation to estimating forest stand height?
Answer 32: It is the small motion of the forest. The taller the tree, the more motion you will see.

Question 33: Could you please explain why making a mosaic increases the accuracy of forest height estimation and whether the mosaic is made with images taken at different times (does that influence the interferogram?)?
Answer 33: Yes, it does. Each image of correlation magnitude, it depends on temp decorrelation. Mosaic, if you had a lidar measurement, you can use that as a known and correct for this. Use the intervening scenes to inform the scenes you have lidar data for via propagation.

Question 34: When you say "motion of the trees," do you mean the apparent (i.e., parallax) due to different imaging positions?
Answer 34: No.

Question 35: Should one expect effects from using ascending and descending modes for InSAR height estimation? And would there be effects from combining the modes in estimation change in InSAR height over time?
Answer 35: It would be great to combine ascending and descending passes. It would help resolve issues with layover and shadowing in mountainous regions.

Question 36: Do you see any potential for automation of selection of image pairs for building the interferograms? Seems like a big limitation to using the data at large (CONUS) scales.
Answer 36: You are certainly correct about potentially being a limitation. However, this problem lends itself well to automation. Like you saw in the scatter plots of the talk (slide 47 “18 SAR Scenes in Central Maine (118_890)”), all possible combinations for the 18 scenes were calculated. From that, you can calculate the average correlation for each interferometric pair, and plot them on a graph, as you see there. From that, choose those pairs that have the highest correlation. That is the brute force way of doing it. Under the assumption of consistent weather patterns across a region, once you have selected an optimum set of dates for forming these interferograms, then you can use “same-orbit” same-date scenes for creating the interferograms for the whole pass. This was what was done for the Maine mosaic. That is, find optimal scenes in the E-W direction (different orbits), and then once those dates for each orbit were determined, use those for the entire satellite track.

Another option would be to choose adjacent pairs (in time), and under the assumption that those pairs would have the best correlation, use one of those instead. Even a scene that didn’t have the “best” average correlation can still be used with this algorithm.

By the way, somewhere along the presentation, I mentioned that it might have taken me one hour to process one of the interferograms. Usually it doesn’t take that long… and it should take on the order of minutes. This can be easily parallelized and/or left to run as an overnight job on a computer. Certainly, the Northeastern US mosaic that we did had more than 50 scenes, and we did that in a reasonable amount of time.

Question 37: What is a single look complex radar and what would be the full resolution for such images?
Answer 37: An SLC is the highest resolution available out of a Synthetic Aperture Radar. The resolution of the SLC depends on the radar’s design and operating mode. For NISAR, most of the SLCs data will have a resolution of 8 m x 12 m.

Question 38: Can we measure the depth of open cast mine pits?
Answer 38: People do that using time-series of cross-track interferometry for measuring topography. Those methods are not the same thing as FSH that has been described here.

Question 39: One of the solutions for resolving such issues in Lidar was using multi-wavelength emitters to which the different materials responded differently, and hence can resolve the range walk issues. Is there any such mechanism in SAR?
Answer 39: I don't know anything about that.

Question 40: How does mountainous terrain affect forest height and is there any way to correct for it?
Answer 40: see answer to question #1

Question 41: how can SAR resolve the Range Walk Issues that usually exist in LiDAR?
Answer 41: I don't know what the "range walk" issue is with lidar.

Question 42: Please describe what layover is.
Answer 42: layover has to do with the viewing geometry of a SAR. It is side-looking, rather than nadir looking (like an optical sensor). There are many resources that describe what this is… one of those is in Figure 2.4 of the SAR Handbook that can be found at the SERVIR website https://servirglobal.net/Global/Articles/Article/2674/sar-handbook-comprehensive-methodologies-for-forest-monitoring-and-biomass-estimation. See also Slide 31 of the first session of this SAR Seminar Series that you have been attending.