Questions & Answers Part 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 Erika Podest (erika.podest@jpl.nasa.gov) or Sean McCartney (sean.mccartney@nasa.gov).

An additional resource can be found here: A Q&A Session on Radar Remote Sensing (or Everything You Always Wanted to Know About SAR)
https://arset.gsfc.nasa.gov/land/webinars/19-SARQA

Question 1: Which is the best polarisation for rice crop classification?
Answer 1: [Heather McNairn] What we have found in our research is that regardless of crop type, the crop polarization which is HV or VH is the single best classifier for all crop types. So that would be the one we recommend. I would add that if you were to select a second favorite polarization for crop classification that would be VV. For Agriculture Canada, we have an application that uses SAR data for crop classification, and those are the two polarizations we use.

Question 2: What is a single tillage operation?
Answer 2: [McNairn] What we mean by a single tillage operation - this is perhaps more specific to agriculture in Canada. It means that farmers will typically till their fields multiple times between when they harvest and plant the next crop. They may till the soil once, twice, or even three times. It can be quite a complex tillage system. So what I mean by single tillage operation that would be using a single tillage implement and tilling the field once.

Question 3: Do optical images give better results than microwave images?
Answer 3: [McNairn] That's a complicated question to answer because it really matters in terms of application what you're most interested in. And what kind of data you have available. A simple crop classification example: in that example if we have a very good temporal coverage of optical data - optical data throughout the entire growing seasons capturing all crop development stages - optical data can do a very good job for crop classification. The problem is cloud cover. If we miss some optical images during the crop season that can significantly reduce classification accuracy. We've done some

recent comparisons looking at available optical data in the growing season and compared it to good temporal coverage of radar data, and we're finding comparable results. We also talked about soil moisture, and notedly, to estimate soil moisture from satellite data, microwave and SAR data are by far the best due to their sensitivity and penetration depth. So this is a bit of a complicated question because it depends on the application and the sequence of data you have for that application.

Question 4: When you are using free datasets, which is typically Sentinel or JAXA data, how would you adjust your analysis?
Answer 4: [McNairn] I think Nina went through the Sentinel data for sure - and the processing is not that much different whether the data is free or available in another way. The access of the data doesn't have a big impact on how the data is processed.

Question 5: How does a higher number of scattering impact the quality of information obtainable from a SAR image?
Answer 5: [McNairn] Again, this is a bit of a tough question. We really rely on large variations in types of scattering in order to separate targets. When you think about crop classification for example, if we have a lot of diversity in terms of scattering between one crop type and another - if we have more types of scattering - this can help us separate one crop from another but monitor crop development over time. Scattering from crops is a mixture, so we have a diversity of scattering coming from targets and that scattering depends on crop type and age. Increase in diversity and scattering helps us separate out those targets.

Question 6: Integration of data from different SAR satellites in detection of agriculture crops is advantageous. What are about crop diseases and damage?
Answer 6: [McNairn] I'll address this in 2 ways: in terms of directly estimating the impact of crop - or the presence of crop damage - if that disease or that damage is causing in particular a change in the structure of the crop, then I would hypothesize SAR data would be quite sensitive to that. A very good example: if you have an insect infestation in a field and they eat a lot of the leaves off the crop, that changes the structure. In Canada, I've seen grasshoppers invade wheat fields. Since that changes the canopy/structure of the crop, that's detectable using SAR data. I would hypothesize if there's a change in the structure, SAR data would be able to detect that damage. When we're thinking about disease and crop damage, we want to catch this early on. One thing to consider is not directly measuring damage, but using SAR data

to estimate the conditions that would lead to the development of the disease. We had a project looking at soil moisture using radar data, because extreme wetness can cause/create the right condition for disease to occur. You can also use radar data in that capacity. Crop history is also important. You can use radar data to monitor crop type over time. That can also be a factor in the development of crop disease. There's a direct detection component, but you can also use the data to track conditions that would lead to the disease.

Question 7: How would you measure vertical height?
Answer 7: [McNairn] Not sure that I entirely understand what you mean, but I'll take a guess. If you're talking about the root mean square roughness or correlation length in terms of roughness on soil, it can be done a few ways. Typically we put an instrument in the field, like a gridded panel - something called a pin board - and we take photographs of how the surface displaces against the gridded board. Or how the roughness displaces the pins. Then we take photographs and do some post-processing to fit a horizontal plane through those photographs and calculate root mean square roughness. Some researchers have access to a laser profiler, and that would provide data as well in terms of surface height variation. You can contact us later and we can send you more information on these instruments and how they're used.

Question 8: Can I say that SAR RS techniques needs a lot of field-based calibration and validation than all other RS techniques? (e.g. photogrammetry data, spectrometry data, etc.)
Answer 8: [McNairn] I don't think field calibration is unique to SAR data. We have some methods that we're developing to estimate biomass from SAR data. That requires - to create those models we need biomass and soil moisture field data. And we need to validate the models developed. But if I'm using an optical sensor, I still need the same field data to create and validate the model. It's a standard principal in RS and it's not unique to SAR. In terms of SAR, the data providers are doing a lot of calibration of the sensor - but that's true of optical, as well. Especially if you're deriving biophysical estimates, the calibration requirements are quite similar.

Question 9: Would backscatter be affected by contaminated water (such as brackish or industrial wastewater)?
Answer 9: [McNairn] I don't know about industrial wastewater. We did have a discussion recently on whether SAR data is sensitive to salinity in soil. There has been

some research to demonstrate there is some sensitivity, especially at higher salt contents. This is because it affects the imaginary part of the dielectric. In terms of standing, brackish water, for example, I would hypothesize that wouldn't be something the SAR would be sensitive to. The SAR is most sensitive to structure, so it's responding to the smoothness or roughness of the water. For ocean applications, we either have specular or diffuse scattering because of surface ocean features. It's more related to the structure in open water and ocean environments than to the physical qualities of the water.

Question 10: The more water in a target, the higher the backscattering and the brighter the image from the radar, whether vegetation or soil type. But on slide 17 of the 1st presentation, the rivers and reservoirs shows up as very dark. Why is this?
Answer 10: [McNairn] When we think about targets, whether it's vegetation or soil, the parameter with the biggest radar response is structure. For water here, as I was just saying, smooth water that doesn't have surface waves is very smooth and causes specular reflection. Water - like open ocean - with waves occurring, that roughness is by far the most important factor that affects the radar response. We need water in the target for there to be a response. But the overwhelming target parameter with the biggest impact on structure, think of that in terms of soil, surface water, or vegetation.

Question 11: How can we differentiate different types of crop fields in small farm land? Is it possible to do with above mentioned SAR?
Answer 11: [McNairn] Yes, absolutely - the techniques and theory on how to classify and extract soil moisture - all of those techniques and methods can be applied to different scales. It's really less of a question in terms of the scale. The data that Nina and Sarah were showing are from Sentinel and RADARSAT - the data we were using, the resolution is perhaps too coarse for smaller farming/crop systems. The theory and physics is the same. The methods will work if you can access data at the appropriate resolution.

Question 12: Can we use the one-year temporal baseline to calculate the annual subsidence rate using Sentinel-1A SLC?
Answer 12: [McNairn] I think this is a question more related to InSAR applications - that's not something I'm an expert in. There has been a lot of work looking at Sentinel-1 for InSAR applications. We just delivered a 5-day training workshop and we provided background on InSAR theory then used SNAP to create InSAR products using

Sentinel-1 data and SNAP. We can share that training material with you so you can understand how to use SNAP data and apply that to Sentinel-1 data.

Question 13: What is the pixel (in the square area) of each interferogram?
Answer 13: Not sure what this question is for (since that wasn't part of the presentation). Again - we have training material on data processing of Sentinel-1 and SNAP and that might answer that question.

Question 14: Do we have miniature SAR sensors, for example, to be carried by UAVs?
Answer 14: The short answer is, yes. I have not used any myself, but have had conversations with others where we have this development occurring. I can't comment specifically on how that technology is working, but research groups are looking into fitting UAVs with SAR. A literature search, or you can contact [Heather McNairn] and she can put you in contact with research groups.

Question 15: Cropix technology are calculating the ESVI and they claimed that it is similar to NDVI. Is it possible using Sentinel-1 and what is the formula for it?
Answer 15: [McNairn] Not sure what they mean by ESVI - it's maybe something I'm not familiar with. Nina and I are working on trying to develop a radar index for crop conditions and we're trying to inter-calibrate with NDVI. Although NDVI comes from optical data and indices, they're following the crop development in a similar way. We see the curves are often quite similar. NDVI is responding to biochemical changes in crops and SAR is responding to physical changes in the structure of the crop. Physically, responding to different things but trying to calibrate radar and optical ourselves.

Question 16: Can we obtain a link to the RADARSAT2 dataset used in the demo by Xianfeng so we can play around with the data?
Answer 16: [McNairn] The difficulty we have with RADARSAT2 data is that it's commercially available, so we can't distribute it without permission from Canadian Space Agency and NDA. If you're interested in some of the value-added products derived from RADARSAT2 we could perhaps share those. The best data to work with would be Sentinel-1 or going through DLR and trying to get data from TerraSAR-X

Question 17: Apart from soil moisture applications can we use SAR to identify contamination of the soil?

Answer 17: [McNairn] I don't have an answer for that - I'm not familiar with any researchers that have been doing that. But again, you'd have to think about what radar's responding to - structure and moisture. If it's a biochemical change in the soil, then I would suggest optical data might be the best data for that purpose.

Question 18: Is this soil moisture Graph Builder in SNAP suitable for tropical climates?
Answer 18: [McNairn] I don't think it's specific to any particular geography, so that graph builder and soil moisture retrieval can be applied anywhere. Keep in mind the model and C-band radar data, in particular, are not able to estimate soil moisture under large, dense canopies. So we've been focused on applying that retrieval under bare soil conditions.

Question 19: If you are working in a developing country, where would you obtain the sand/clay fraction map and how detailed does the soil land cover map need to be?
Answer 19: [McNairn] Don't have a particular answer to where you would find clay/sand fraction. I think FAO has global datasets of soil type, and the available data is problematic everywhere. We're using the best available data we can access. That's a globally recognized problem - that our datasets aren't as detailed as we would like. There's an initiative where a consortium of researchers are producing 250 m soil data. If you contact me, I can put you in touch with my colleague part of that initiative.

Question 20: These methods for soil moisture retrieval are only possible with Quad Pol imagery, correct? Is it possible with Sentinel-1? In this case, can you say something about the 'openness' of Radarsat 2 imagery, and it's pricing if it's not freely available?
Answer 20: Radarsat2 data is only available commercially. Canada RCM has open data, as does Sentinel-1. Some retrievals require HH and VV polarized data. RadarSAT 2 doesn't have a dual-like polarization, and we can't set it for HH and VV. We do Quad Pol to simulate that. In soil moisture retrieval - for Sentinel-1 you need to use dual incidence angle for that approach. Using VV from 1 sentinel-1 acquisition and a 2nd from a second acquisition. You want to minimize the time between the two so soil moisture doesn't change. We sometimes use am/pm for 12 hours.

Question 21: Would I have to know the soil content for the region I am applying the Graph Builder Soil moisture tool before I use it?
Answer 21: [McNairn] Using the IM model with SAR data with SAR data retrieved the real dielectric constant. What we need is the soil, clay, and sand fractions to convert

that dielectric constant to true volumetric soil moisture. If you don't have info about the soil, you can still retrieve the dielectric, but it's very related and correlated with soil moisture. So you can still use the dielectric constant to indicate the state of water in the soil, but you'd need a way to convert the dielectric to soil moisture and you do that through clay and sand fraction.

Question 22: How can you compare SNAP vs PCI Geomatica for radar processing? I'm aware of the advantages of free software, but what if we have access to both? Will we have access to the R2 image used in the webinar?
Answer 22: [McNairn] I think I covered the issues about RadarSAT-2 data - we can't share the raw data. If there's a processed dataset we can share that. We presented on Sentinel and R since they are free and open. We use SNAP, PCI, C-5 and a few other pieces as well. They all have advantages/disadvantages. PCI is a great tool for processing SAR data. At the moment it doesn't have IM retrieval for soil moisture, but it's a good piece of software to do all the other radar processing.

Question 23: Is there a way we can get the sample datasets for crop classification?
Answer 23: [McNairn] Certainly we can share Sentinel and training data if there's interest in that. The TerraSAR-X data, we'd have to get permission from German Space Agency, but the other data we can share.

Question 24: Is it possible to access all of the data used to produce the soil moisture map (including the Radarsat images, the SNAP graph, the *.mat file, the classification maps in the drop down menu etc.)?
Answer 24: [See Q25] I think as I was saying, everything beside raw RadarSAT data we can share.

Question 25: If you don't have field data, is there any way to derive this information if you know the major crops, and growing season?
Answer 25: [McNairn] That would be difficult to achieve. As I mentioned, at Agriculture Canada we have a crop inventory. Our group produces a map of every crop grown in every field, and we need the data to feed the classification. There are other ways to collect field data - you can go in the field and make observations, we also access crop insurance data. In the U.S. there's a cropland data layer produced by USDA. There may be other ways and datasets you may have access to if you don't have direct field observations. Others have talked about crowdsourcing - getting data from general

community in terms of observations in the field. To do any classification, you need field knowledge and to do the validation.

Question 26: In the soil moisture map, in which units are the values of each pixel?
Answer 26: Final soil moisture maps are volumetric soil moisture, so we're displaying in cubic m by cubic m. (m3 x m3) you can also display in cubic cm or in percentage as well.

Question 27: Do you have a script that can do soil moisture estimation in Google Earth Engine?
Answer 27: [McNairn] Nina's shaking her head so no we don't. We're doing our processing on local computers and banks of servers. Web processing is the way of the future, but we're not involved in that. But we are looking at that as an option going forward.

Question 28: Can you give some details regarding the validation that was done to test the soil moisture process you showed in SNAP?
Answer 28: [McNairn] That's a good question. In Canada we have 3 networks of in situ stations. There are about 25 stations in total. Those stations have been operating since 2011. These stations measure volumetric soil moisture at the surface and root zone using probes. Measurements are taken every 15 min and that data is sent every hour to headquarters and we apply calibration equations and quality check flags. So we are doing continuous validation of all RadarSAT data products being produced over in situ stations. We compare field measurements with when the satellite overpass is, using the IM.

Question 29: In the metadata of e.g Sentinel-1 data, is there a glossary which indicates what the abbreviations used mean?
Answer 29: [Nina] If you google Sentinel-1 data for that description, you'll find a PDF file that index file is all of Sentinel-1 information including calibrations that apply. If you download that file you'll know all the terms.

Question 30: As I can see, it is unsupervised classification. Is there way to do supervised classification with ground (test) data in SNAP using SAR data?
Answer 30: [Banks] We don't use SNAP a lot for classification, but there's a way to run random forest in a SNAP environment. But one thing to keep in mind is that there's

less flexibility if you want to work in SNAP compared to something like R or Python. It's possible, but you'll have less flexibility.

Question 31: What type of calibration image is better for soil moisture analysis? sigma0 or gamma0 band? And why?
Answer 31: [Nina] All methodologies are on sigma0 and gamm0 are geometric angles.

Question 32: (random forest) What's the maximum target (species) we can put on random forest?
Answer 32: [Banks] There's no limitation because of how the method works. How the code was implemented in R, I believe there's a limit of 30 classes. So something around 30, but I believe it was a limit because of how it was implemented in R.

Question 33: How can we download the Random Forest R-script used in the tutorial?
Answer 33: [Banks] We would be willing to share the code we showed. Just contact us, and we'll share that code with you.

Question 34: Was each pixel in crop classification example labeled, or each field was labeled? In other words, what was predicted, a pixel label or a field (some aggregation of pixels) label?
Answer 34: [Banks] In this case, we just did a pixel wise classification, but you could do object-based classification with Random Forest, you just have to modify code depending on how you do it. It's probably the preferred method for agriculture since everything is the same class within that field object.

Question 35: How would you plot the data as a time series and what value would it provide?
Answer 35: [Banks] You can look at multiple different SAR-derived values and plot them as a time series. This can show you things like changes in phenology and crop density which would vary on crop type or condition. That's something you can get from SAR. Looking at changes in backscatter, for example. I'll make a note of what's great about SAR data, you don't have to worry about the effects of cloud cover or haze so you have the capacity to do high frequency time series analyses. Whereas with optical, you don't get useful info about crop type on the ground when there's clouds.

Question 36: Is it possible today's webinar can be completed in Google Earth Engine rather than using SNAP or R? All of them are free software, but it would be nice if we do it in GEE in order to save time and space.
Answer 36: [Answered above] Yes, it's definitely possible to do everything we did in GEE, but it's important to remember the RADARSAT-2 data isn't available. The RadarSAT constellation will also not be available, but you do have access to the Sentinel archive and Landsat archive. And yes, it is possible to run Random Forest in GEE.

Question 37: Is SAR data useful for classification of vegetation and forest?
Answer 37: [Banks] I think this depends on how similar the backscatter is between the two landcover types. Over forests you usually see a lot of volume scattering, which is basically a random scattering process. You could see a similar scattering process over certain crop types. But it's really case-dependent, but it may be possible.

Question 38: Can we differentiate tree species and model their growth by using SAR? If yes, which is the best model to use?
Answer 38: [Banks] I'll start this off by saying I'm not a specialist, but something we've observed is that you can sometimes tell the difference between coniferous and deciduous by looking at temporal backscattering. For leafing over the canopy we see change over time in backscatter, but we don't see that change over time for deciduous species. But down to specific species-level I'm not sure.

Question 39: As Random Forest classification is demonstrated here, it is the best classifier for agriculture. What about the accuracy exhibited by other supervised or unsupervised algorithms for classification?
Answer 39: [Banks] How you choose your classification algorithm really depends on the data you have available and what your objectives are. We showed Random Forest because it's easy to implement and not a lot of adjustment is required. In this case you don't need a high number of training and validation samples to get high accuracy.

Question 40: How do we mix optical and SAR data for crop classification? Do you have examples combining optical/multispectral and radar bands in the same classification?
Answer 40: Optical provides best results but sometimes it's hard to guide the optical to critical crop time periods. So if you combine optical and SAR data, it can provide better results. Heather's presentation mentions some slides that has combined optical

and SAR data that shows better results. But it depends on your crop type. Some crop types, optical images do a good job. But some crop types really work with SAR data.