Part 3 Questions & Answers Session

Please type your questions in the Question Box. We will try our best to answer your questions. If we don't, feel free to email instructors Erika Podest (erika.podest@jpl.nasa.gov), Franz Meyer (fjmeyer@alaska.edu), or Heidi Kristenson (hjkristenson@alaska.edu).

Question 1: I'm looking for free SAR data within the 1998 to 2006 time period. I prefer L-band SAR data. Where might I find this?
Answer 1: This is indeed a difficult period for accessible L-band SAR data. For most of this period, no openly accessible L-band sensor was in orbit. The primary L-band SAR data available during the 1998-2006 period came from JERS-1 (until 1998 at the very beginning of your time period of interest) and, towards the end of this period, ALOS/PALSAR, which began operation in 2006. You may already be accessing both of these sensors.

Question 2: Is Amazon Web Service freely available?
Answer 2: Yes and no. NASA stores all its data in the Amazon Web Services cloud and makes these data available to its users free of charge. So, yes, you can discover, access, and download ASF's SAR data at no cost. NASA is also making some limited processing capabilities available to users, such as the generation of a limited amount of higher-level products per month. The amount of processing available should meet many of your application's needs. However, if you want to process larger volumes of products, you may have to host your own processing solution at your own cost, similar to purchasing your own processing server.

Question 3: Is it possible to apply SAR or InSAR data to change detection between two dates? If it's possible, in which resolution? Is it possible to do it in Google Earth Engine?
Answer 3: It is possible, but you might find that image-to-image change detection will not be as robust as comparing one new image (or a set of new images) to the full time-series of past data. There are two different methods that scientists can use to perform change detection with SAR data - coherence and amplitude based methodologies. Here's a good primer on the coherence approach, and Dr. Handwerger

has a good paper on the amplitude-based approach that makes use of Google Earth Engine.

Question 4: Can we access ASF data by using the GEE (Google Earth Engine) cloud server?
Answer 4: The GEE team has been making Sentinel-1 SAR data available to its users. We expect that this will continue in the future but it is, of course, the decision of the GEE team. We do not know if GEE is planning to also host a copy of the upcoming NSAR data to integrate it into its data archives. I am sure the GEE team is interested in hearing your thoughts on this and will respond to your questions about data availability plans.

Question 5: How can we get the map of displacements from the interferometry rainbow fringes?Is there any easy tutorial or Python script you can recommend?
Answer 5: ASF has a tutorial that explores the On-Demand InSAR products that Heidi presented. These services provide you with the original interferogram (the rainbow fringes) but will also provide you an unwrapped version of this data that can be scaled into displacements. We have Jupyter Notebooks available that can help with turning these interferograms into displacement time series using software tools such as MintPy. Some workflow information can be found here: (https://www.youtube.com/watch?v=tq8nZpsWK6k&ab_channel=NASAEarthdata).

Heidi also mentioned the NASA OPERA project (https://www.jpl.nasa.gov/go/opera/), which will provide InSAR-derived Surface displacement data for North America, all the way down to Panama. This data will be available from ASF starting at the end of January 2025.

Question 6: Where can we check for updates on the release of ALOS-2 PALSAR-2? Is it currently available through JAXA? I am hoping to incorporate that dataset into a project starting mid-January.
Answer 6: ASF will be releasing a global copy of the ALOS-2 PALSAR-2 ScanSAR data in December this year. These lower resolution (50ish meters resolution) ScanSAR data were released openly to the public. The higher resolution (Stripmap) SAR data are not openly available but JAXA releases regular science calls where free access to limited data can be requested.

Question 7: Are there multi-spectral and SAR image pairs available at ASF? I am working on SAR colorization.

Answer 7: ASF mostly hosts SAR data. You would have to access most multi-spectral datasets from other sources. The one exception is the ALOS-1 mission, which carried both the PALSAR-1 and AVNIR-2 sensors. ASF hosts both of these datasets, so the ALOS-1 mission (2006-2011) may offer some potential for comparing SAR and multi-spectral imagery.

You could also try searching for both SAR and optical datasets on NASA's Earthdata Search platform (https://search.earthdata.nasa.gov/search), which includes data from Landsat, MODIS, and Sentinel-2, along with ASF's SAR holdings.

Question 8: Is it true that we use GRD data only for PolSAR and SLC data only for InSAR? Or can we use these data products in other ways?

Answer 8: Single-Look-Complex (SLC) data capture both the amplitude and phase information contained in a SAR image. As such, it is the necessary product for all InSAR workflows. SLCs are often also needed for polarimetric SAR workflows, as many of them also utilize the phase information in the data. GRDs are mostly useful for mapping and change detection workflows. But even for this application, I would recommend using ASF's on-demand resources to generate Radiometric Terrain Corrected (RTC) products. These RTCs are fully geocoded and fully calibrated and most useful for mapping and change detection applications.

Question 9: Is it possible to use SAR imagery to estimate water saturation in slopes?

Answer 9: SAR imagery is sensitive to soil moisture variations. Typically, an increase in soil moisture increases the radar brightness in a pixel. To map soil moisture in slopes I would do the following:

- Use long-wavelength SAR data (such as L-band) if available to reduce the impact of vegetation on your radar brightness.
- Derive a Radiometric Terrain Corrected (RTC) data set to remove slope impacts on radar brightness.
- Analyze your data as a time series and it should correlate with changes in vegetation moisture.

Question 10: Is NISAR going to be launched from Cape Canaveral?

Answer 10: NISAR will not be launched from Cape Canaveral. NISAR is being realized in a collaboration between NASA and the Indian Space Research Organization (ISRO). ISRO will be responsible for the launch, which will occur from the Satish Dhawan Space Centre. You can follow updates on NISAR here: https://blogs.nasa.gov/nisar/

Question 11: For Sentinel-1 SLC data, apart from interferometry, you mention you can use other workflows that use phase. Can you give some examples?
Answer 11: Many PolSAR (SAR Polarimetry) applications require phase, and there are different approaches for analyzing soil moisture that also require phase.

Question 12: Is there a data limit to acquire on-demand products?
Answer 12: Yes, we do have to limit the amount of on-demand data each user can request to stay within our budget. The full details are on our cost page, but for the default settings we provide each user 1,000 InSAR jobs and 2,000 RTC jobs per month.

Question 13: Does an infographic exist that summarizes the observation platform, observations, datasets (including process level), and the tools where that data can be obtained? These presentations are great, but I was also thinking something quickly digestible by the general public or novice users would be helpful. Basically a visually appealing and summarized process flow diagram covering this.
Answer 13: This is a great idea. I don't think we have an infographic like this right now but this is a good idea and we will investigate options.

The SAR Handbook is a great resource for introductory workflows when using SAR.

Question 14: Is all the ASF data pre-processed?
Answer 14: For Sentinel-1 in particular, ASF hosts a wide variety of different processing levels. We offer the level-0 unfocused data, the level-1 SLC (single look complex) data (processed by ESA), and provide on demand InSAR and RTC data via HyP3 (processed by ASF). We also host some other analysis-ready products, such as those generated by the OPERA and ARIA projects at JPL. NISAR will offer higher level data products such as RTC images and next-neighbor InSAR pairs operationally for each new image that is being acquired.

Question 15: Can we apply only data taken from the Copernicus browser without using the ASF? And what would that lead to?
Answer 15: Sentinel-1 data can be accessed from a number of different repositories. ASF is just one option. You can download the data from whatever location/service you find easiest, or that offers the services you prefer. All raw, GRD, and SLC Sentinel-1 products will be the same, but once you start looking at higher-level datasets, such as ASF's On-Demand products, or terrain corrected products available from other providers, there will be differences.

For NISAR data, you will get most of your data through ASF. Over time, other services such as Google Earth Engine will likely also offer the NISAR data sets to the user community.

Question 16: Can I only use Sentinel-1 datasets for comprehensive dam deformation monitoring?
Answer 16: In principle, Sentinel-1 can support this application. In practice, I guess the correct answer is "it depends :)". It will depend on the local characteristics of your site. For instance, heavy vegetation cover will make deformation tracking difficult and an L-band sensor may be better suited. Also, your observation geometry matters. The viewing geometry on your dam has to be carefully selected to ensure you see the type of information you are interested in.

Question 17: Which datasets can be interchangeably? Which satellite sensors can be used in place of another. Are there any fused datasets present?
Answer 17: If this is in reference to the dam deformation study, you can use multiple SAR sensors in parallel, perform displacement mapping for all these sensors and then merge your results.

Regarding general mapping applications, there are efforts afoot to build so-called "foundational SAR models" that are merged between different sensors. These efforts use a variety of machine learning and deep learning techniques to transform different SAR data sets into a consistent data set.

Question 18: I was wondering what are the advantages of looking for SAR data from Sentinel-1 in ASF vs the Copernicus website?

Answer 18: You can use whatever platform you prefer. ASF offers different options for On-Demand product generation, and also provides access to other analysis-ready datasets (such as the OPERA RTC and the ARIA GUNW products) that are not available through the Copernicus website. But the same RAW, GRD and SLC products are available from both websites. The advantage of having more than one center offering the data is that data download and access loads can be shared and more data can be accessed at the same time.

Question 19: What are/will be some use case examples for NISAR?
Answer 19: NISAR has relevance for a broad set of applications and we will be developing workflows for the community as data becomes available. You can browse the NISAR applications white papers to get an idea of the breadth of things that can be done with NISAR data.

Question 20: What is the difference between GRD and SLC data? Please suggest some references. Could you explain the differences between the GRD and the Opera RTC products. Is one better than the other for analysis?
Answer 20: GRD data is geo-referenced and contains only the amplitude component of the SAR data, conversely SLC data is still in the native radar geometry (i.e., it requires further processing to use it alongside other geospatial data) and it contains both the amplitude/phase component of the SAR data. In general GRD data is used in a similar way to optical imagery, and SLC data is the data you use to perform InSAR analyses. In general though I'd recommend using RTC data instead of GRD data. RTC data includes additional data corrections that help to accurately calibrate and geo-locate the SAR data.

Question 21: ASF searches for all images that touch the area of interest boundary, which returns a lot of images that are only on the edge and not useful. Can we tell ASF to search only for images which contain the area of interest entirely?
Answer 21: That is not a current search feature, but once you perform a search, you can edit your AOI interactively (click on vertices and drag them closer to the center) to exclude edge footprints that are not of interest. You can also restrict searches to specific paths or frames.

Question 22: Can you provide some application examples of how InSAR and Burst InSAR are used? How do I know when it is suitable to use Burst InSAR instead of InSAR?
Answer 22: Both use a very similar algorithm, so the real distinction is how large of an area you're looking to perform InSAR for. If you're looking at deformation at the scale of a full SLC (250x180 km) use SLC InSAR. If you're looking at deformation at the scale of a burst (90x20 km) use burst InSAR. We're working on offering multi-burst InSAR to accommodate users looking at deformation between these two scales.

Question 23: For the Python script bulk download option, I believe (to the best of my knowledge) you need the metalink file as well. Has this changed or is the metalink file not required?
Answer 23: The Python script is entirely self-contained and has everything needed to download the requested files. The metalink file is used by external download managers, and is not required to use the downloaded Python script.

Question 24: In the case that I have to download the information in the Python script, is there any guide or extra material to work with in a better way?
Answer 24: The Python script is entirely self-contained and has everything needed to download the requested files. You do need to have Python installed on your computer in order to use it, but beyond that, you simply double-click the downloaded script. It will prompt you for your Earthdata Login credentials, then start downloading the items from your download queue one at a time.

Question 25: Is the GAMMA software freely available?
Answer 25: GAMMA Remote Sensing is a commercial company and the GAMMA RS software is commercially sold. So no, this particular software is not freely available. ASF is currently working toward offering similar RTC and InSAR services using the open-source software ISCE (InSAR Scientific Computing Environment). This will give you a fully open-source alternative.

Question 26: Can we do the InSAR processing ourselves without needing to use on-demand?
Answer 26: Yes you can. You can use open source tools such as ISCE or SNAP to perform the processing yourself. There are also a number of commercial tools available that give you this capability.

Doing the processing locally will, however, require you to download large volumes of data. The demands on your local computing environment are also pretty high.

Question 27: Could you kindly alert us when NISAR will be launched early 2025?
Answer 27: We will broadcast the launch date once it is finalized. You can also follow the latest developments of NISAR here: https://blogs.nasa.gov/nisar/.

Question 28: I want to map a mangrove restoration site. Can you suggest how and which SAR data I should use for this mapping?
Answer 28: I would suggest using L-band SAR data to monitor changes in mangrove vegetation. Some researchers also add Lidar and other DEM information to estimate mangrove biomass and changes of that biomass. Marc Simard from JPL has some nice publications on this topic. A Google Scholar search for his papers might provide you with some good literature to get started.

Question 29: Imagine you're searching for repeat-pass scenes for InSAR (same path, row and mode) within a threshold perpendicular and/or temporal baseline (Bperp, Btemp).... how can this be accomplished?
Answer 29: Heidi presented this use case in the presentation. ASF offers exactly this capability through its search and discovery service. Please rewatch the recording to find more information, or reference either the InSAR On Demand or Burst-Based InSAR for Sentinel-1 On Demand tutorials.

Question 30: I would like to know the availability of SAR/Sentinel-1 data on Sri Lanka and suitability for agricultural applications such as yield estimation and nitrogen studies in rice fields.
Answer 30: Sentinel-1 data should be available at a 12-day cadence for Sri Lanka. Here is a Vertex search for Sentinel-1 data for the area. For agriculture applications, using an L-band data set such as NISAR may be more optimal, though, as this wavelength provides better capabilities to characterize the vegetation canopy. NISAR, after its launch, will also provide observations every 12 days

Question 31: Can the output of the burst product be used in SNAP Desktop?
Answer 31: Yes, but there are some caveats. The burst SLCs you can download directly from our website are not directly compatible with SNAP because they are not in ESA's SAFE format. However, you can use our new burst2safe Python tool to

download and transform burst SLCs to the ESA SAFE format. In the near future, we plan to make SAFE the default format for the burst SLCs. If you run into any issues using SAFE-formatted burst SLCs in SNAP, please let us know!

Question 32: What is the difference between gamma0 and sigma0 radiometry?
Answer 32: They are two different radiometric projections of SAR data. Sigma naught is the radar cross section, which takes into account the incidence angle of the sensor. Gamma naught is the radar cross section, which takes into account the local incidence angle through a DEM.

Question 33: What are the best methods for distinguishing water bodies from wet soils in SAR imagery to avoid misclassification when applying a water mask?
Answer 33: While open water pixels are typically darker than saturated soil pixels, their radar signatures can be quite similar, making them difficult to distinguish using a single image. A time series analysis may provide better separation capabilities.

Question 34: Will we be able to order these on-demand processes with ALOS-2 and NISAR imagery?
Answer 34: ASF does not currently provide On-Demand functionality for ALOS-2 products. The NISAR mission will provide a number of analysis-ready products without requiring On-Demand processing. We may provide some On-Demand processing capabilities for NISAR depending on the needs of the community once datasets are in use.

Question 35: If I want to work on both Sentinel-2a optical data (10m resolution) and SAR data (30m resolution), is there any problem with working with both datasets simultaneously?
Answer 35: The original Sentinel-1 product is actually of higher resolution (closer to the 5-10m resolution), comparable to the Sentinel-2 dataset. You can use a DEM to geocode them to similar spatial sampling to arrive at a data set that is geometrically harmonized.

Question 36: How can soil moisture retrieval algorithms account for the effect of surface roughness, vegetation, and water bodies simultaneously?
Answer 36: These algorithms use a lot of external information on vegetation types and soil types to resolve for soil moisture. It is often easier to map changes of soil moisture

rather than soil moisture itself. By focusing on change, certain variables such as surface roughness can be removed, simplifying the retrieval algorithms.

Question 37: To analyze the settlement of buildings, which data should be used for analysis, what DTM resolution should be considered for the analyses?
Answer 37: For mapping building subsidence I would recommend shorter-wavelength data such as X-band, as X-band data often support higher spatial resolution. C-band data can be used as well but will provide less spatial detail. I would recommend a persistent-scatterer-type time series processing technique. This workflow will not only derive displacements but also estimate a “topographic error” for each pixel. This decouples you from the DEM requirements to some degree. I would use the Copernicus GLO-30 DEM for topographic correction.

Question 38: What are generally used vertical and temporal baselines for choosing SBAS pairs for InSAR?
Answer 38: This varies by satellite platform, SAR wavelength, and the area you’re looking at. For Sentinel-1, good rules of thumb are a max temporal baseline of 50 days and a perpendicular baseline of 200 meters. To confirm this for your data, look at the coherence of the InSAR pairs you’re producing. If the average coherence for the full image is less than 0.3, consider tightening these values. Do the opposite if you see average values above 0.7.

Question 39: Is it possible to get IW VV images from ASF Data Search? I've managed to get them from GEE, but not from ASF.
Answer 39: ASF provides access to the full Sentinel-1 archive, including the GRD and SLC products for VV IW acquisitions. You can also submit IW VV imagery for on-demand processing. Try not applying any filters to your Vertex search (other than a date range); you may be inadvertently excluding the desired products.

Question 40: I can not understand the difference between SLC and GRD data and use of purpose, please suggest some references?
Answer 40: The SLC includes both phase and amplitude information, and it includes all of the collected radar returns. The GRD is more highly processed, with overlapping data acquisitions aggregated into a single GeoTIFF with square pixels. The GRD is only suitable for amplitude-based applications, while SLCs are required for workflows that require phase.

Question 41: What benefits for offshore oil spill monitoring could be expected using the S- and L-band capabilities of the NISAR mission if compared with the currently available C-band systems such as Sentinel-1 and RADARSAT?
Answer 41: ARSET has a previous training that covers this application (Part 3): https://appliedsciences.nasa.gov/get-involved/training/english/arset-disaster-assessment-using-synthetic-aperture-radar.

Question 42: Credits are only used for processing or also for downloading raw data? Where can we see how many credits we have used?
Answer 42: Credits are only for on-demand data processing, you can download as much raw data as you want! Vertex will show you how many credits you have remaining in the On Demand Queue window when you submit on-demand jobs.

Question 43: What is the role of soil texture and structure in SAR-based soil moisture retrieval, and how can algorithms be adapted for small-scale farms with diverse soil types?
Answer 43: Sounds like an interesting research question. The two major factors that influence the returned SAR signal are the dielectric properties and structure of the surface it's interacting with. The soil texture will certainly influence the surface structure, but I'm unsure if you'll be able to account for these small variations when using Sentinel-1 data as most soil-moisture measurements I've seen using this data are at the kilometer-resolution scale. I'd encourage you to dive into the literature and see what you can find.

Question 44: What are the best radar images for research/studies on coastal regions like coastal monitoring?
Answer 44: For coastline monitoring, I would recommend longer-wavelength datasets as they increase the contrast between ocean and land. They can also help evaluate coastal vegetation.

Question 45: Is there an ARSET training that covers using SNAP or Google Earth Engine for ground displacement analysis?
Answer 45: Yes, searching for SAR on ARSET's webpage will bring up a number of trainings that use SNAP in its homework exercises.

Question 46: What software is used in the background to create the interferograms? ISCE2? Vertex creates a co-registered interferometric stack when we select the option of SBAS? Or do we have to co-register the interferograms?
Answer 46: We currently use GAMMA to generate full frame INSAR and RTC images. We are using ISCE-2 for the burst-based interferograms. We are working toward offering full frame processing using ISCE-3 in the near future as well.

Question 47: Can radar images have an advantage in delineating shorelines if combined with the use of optical images? In the case of work on time series. Which method do you suggest as the most suitable for extracting shorelines? Any paper suggestions?
Answer 47: Many analyses benefit from the combined use of SAR and optical data, and my suspicion is that shoreline delineation would also benefit, but I haven't done any work in this space. This paper has some nice work on glacier front delineation, but I'm unsure if it will be applicable to your work.

Question 48: How do you deal with the atmosphere, and are the global atmosphere models efficient?
Answer 48: Atmospheric delay is still one of the main factors limiting the accuracy that can be achieved with InSAR. High-resolution atmospheric models help with removing large parts of this delay, but small-scale atmospheric variations are often not well covered. Therefore, most time series workflows use a combination of atmospheric modeling data and spatio-temporal filtering techniques to remove as much atmosphere as possible without biasing the displacement signal.

Question 49: Which band is the most suitable for land deformation mapping and infrastructure deformation? Is Sentinel-1 SLC data suitable for detecting time series surface deformation in urban areas?
Answer 49: The C-band wavelength supported by Sentinel-1 is suitable for a wide range of applications, but is often not the optimal wavelength. For example, Sentinel-1 *can* be used to map deformation in urban environments, but a higher-resolution X-band sensor is probably more suitable. For natural terrain, Sentinel-1 is quite useful but NISAR, with its L-band frequency, is probably a more optimal choice.

One of the big advantages of Sentinel-1 is, however, that it currently provides a consistent time series of 9 years of InSAR data, and the mission is due to continue for years to come. This long time series offers research opportunities that can't be met with the current X-band or L-band archive.

Question 50: NASA has used radar on Mars to infer deep groundwater formations. Is there a space-based sensor available for this application on Earth?
Answer 50: To my knowledge, no sensor of this type is available for Earth.

Question 51: Is it possible to integrate RTC directly into a MintPy workflow, or should it be done separately with SNAP or ISCE?
Answer 51: MintPy generally uses interferograms (InSAR) for time-series analysis. RTC does not contain deformation information. RTC is designed for detecting scattering changes using the amplitude component of the SAR signal, while InSAR (the type of data MintPy uses) uses the phase component between successive images to detect small amounts of deformation.

Question 52: Can I use SAR data to detect forest disturbance such as infestation of forest pests? If so, can different polarizations give me different insight into forest infestation progress and damage?
Answer 52: Yes you can. Longer wavelength SAR sensors (e.g., L-band) are particularly useful for this task. For more information on these applications. I recommend to look through the SAR Handbook, which can be found here:
https://servirglobal.net/resources/sar-handbook