Questions & Answers Part 2

Please type your questions in the Question Box. We will try our best to answer all your questions. If we don't, feel free to email Eric Fielding (eric.j.fielding@jpl.nasa.gov) or Erika Podest (erika.podest@jpl.nasa.gov).

Question 1: Is the transmitted wave considered in the decorrelation effects?
Answer 1: The radar satellites have an extremely stable system for transmitting the same wave pattern every time for many years. This is a key requirement for SAR satellites used for InSAR.

Question 2: With L-Band datasets, can I estimate the ground deformation caused by soil water potential on a steep slope in the case of landslide and subsidence? How can multifrequency be an added advantage for the same application?
Answer 2: L-band SAR can be used to estimate the soil moisture in many areas where the vegetation is not too dense. The NISAR mission will produce soil moisture maps from the L-band SAR amplitudes. Similar soil moisture analysis can be done with the S-band radar wavelength that will be more sensitive to the shallowest part of the soil.

The L-band SAR phase can be used with InSAR analysis to measure ground displacements due to landslides or subsidence. The S-band SAR phase can also be used for InSAR analysis, and differences between the two wavelengths can be studied to understand the effects of the ionosphere, soil moisture, and vegetation on the InSAR measurements.

Question 3: What climate regions have you noticed that these surface subsidences occur the most in from groundwater extraction?
Answer 3: People extract groundwater in areas where they don't have enough water from rivers and rain or snow for all their needs (i.e. urban areas and agricultural applications), so groundwater extraction is typically much greater in areas with less precipitation.

Question 4: Can this Jupyter notebook be used to conduct InSAR analysis over any area in the world? How much processing time and computational power is required to do this processing on a local machine Jupyter notebook?
Answer 4: This Jupyter notebook is using the ARIA processed Sentinel-1 Geocoded Unwrapped (GUNW) interferograms available from the NASA ASF data archive. These are processed for some parts of the world, but not everywhere. The processing time to do the time-series analysis will depend on the number of scenes you process. GUNW interferograms will also be available from NISAR globally.

Question 5: How do you check for atmospheric interference in the interferogram stack you use for the small baseline in order to remove them if needed?
Answer 5: Time series analysis is a key way to check for atmospheric interference. Some other ways to check for interference include using some weather models and this is available with MintPy.

Question 6: How long will it take us to be approved for the ASF account?
Answer 6: It is dependent on demand. On average it takes a day or two. We will discuss this further in Part 3 of this training series.

Question 7: Could you please send the Github repo link?
Answer 7:
See https://github.com/EJFielding/ARSET_notebooks.git or https://github.com/EJFielding/ARSET_notebooks/tree/main

Question 8: To date, I have used two methods to perform InSAR analysis - (1) SNAP Tool as per the ESA Tutorial, and (2) pyGMTSAR open source python InSAR tool. If I get the final Line of Sight (LOS) Displacement maps from either of these methods, can I use MintPy to perform visualizations on these final products? The visualization capabilities of MintPy seem to be pretty good.
Answer 8: There are ways to process a stack of interferograms using SNAP then uploading them to MintPy. pyGMTSAR is a modified version of GMTSAR. The original GMTSAR is supported by MintPy, but it is not sure that the pyGMTSAR version has the same output format.

Question 9: If you had a GPS measurement for a reference point during the time-series how could you include the measured displacements to the processing flow?
Answer 9: All of the InSAR measurements are relative. As a reference point, we may use a GPS station that is relatively stationary and use that for measurements. In the InSAR time-series analysis, the reference point is set to zero velocity. If the reference point is at the location of a GPS or GNSS station that is moving, then the displacement or velocity of that station can be used to add the reference point velocity to the time-series fit. It is important to convert the GPS to the InSAR line-of-sight.

Question 10: How do you compute the deformation rate (cm/year) from the time-series displacements?
Answer 10: We can do a linear fit to the time series measurements. It is also possible to estimate a seasonal signal in addition to the linear fit.

Question 11: How can we create a dataset for SBAS InSAR analysis?
Answer 11: You can use ARIA preprocessed interferograms or the ESA SNAP tool among other products, including ISCE2, GMTSAR, Gamma, or ASF HyP3 Gamma.

Question 12: Does MintPy use other techniques besides SmallBaseline?
Answer 12: MintPy is designed to use Smallbaseline (SBAS). There is a new package designed to work with MintPy called MiapsPy is available from https://github.com/insarlab/MiaplPy.

Question 13: Why should I choose a fixed point to determine the velocity? Will the Line of Sight (LOS) not be sufficient?
Answer 13: We cannot get absolute displacement from InSAR measurements, so we always have to choose a reference point where the displacement will be set to zero in the time-series analysis and velocity. See also question 9.

Question 14: Do you have any experience with using InSAR displacement data as a calibration dataset for groundwater models (such as modflow)?
Answer 14: This has been done before to understand groundwater flow.

Question 15: Can this data be used to measure groundwater recharge just as it measures subsidence? Is it as simple as saying positive subsidence values equal groundwater recharge?

Answer 15: That is true. This is also known as groundwater uplift.

Question 16: Is InSAR-based land deformation possible irrespective of area (particularly forest) or season?
Answer 16: Sentinel-1 uses C-band (6cm) wavelength and will not work in dense forest. NISAR will do a better job of analysis within these areas.

Question 17: In the case of urban areas, what is the effect of construction on the accuracy of the assessment?
Answer 17: We can only do interferometric analysis on objects that stay constant. As urban areas and construction within these areas are not constant, it is hard to get accurate measurements.

Question 18: Could fluvial geomorphological changes be studied using InSAR?
Answer 18: These measurements would generally include erosion and other measurements. Using a dataset like Tandem-X bistatic DEMs (single-pass interferometry) would help with this analysis.

Question 19: Are those data available for all the world?
Answer 19: Sentinel-1 raw data is available for most of the world. ARIA S1 GUNW are only available for selected areas. NISAR GUNW will be available globally. All data is freely available.

Question 20: How did you select the spatial and temporal thresholds for the InSAR processing? How can you validate that the SBAS processing was carried out correctly?
Answer 20: With Sentinel-1, they operate the satellites in a way to where we don't have to worry about the spatial baseline. The temporal threshold is dependent on the amount of vegetation and wavelength in your study area.

Question 21: Is subsidence specifically related to groundwater extraction? Could it be generated from other activities like oil & gas extraction? If so, would we use the same methodology as today?
Answer 21: We can use the same methodologies for subsidence of other causes, such as oil and gas extraction. Here is one paper applying InSAR measurements to oil and gas extraction:

Fielding, E. J., R. G. Blom, and R. M. Goldstein (1998), Rapid subsidence over oil fields measured by SAR interferometry, *Geophysical Research Letters*, *25*(17), 3215-3218, doi:10.1029/98GL52260.

Question 22: Could we expect, as an extra feature of MintPy, to be able to compute UP/DOWN and EAST/WEST deformation, besides only LOS?
Answer 22: We only measure one LOS as a general rule, but it is possible to do both using ascending and descending LOS time-series analyses but as separate processes. Then you can combine the ascending and descending LOS velocities to estimate the vertical and east-west horizontal components. See the MintPy “asc_desc2horz_vert.py” program.

Question 23: Do you think we can correlate InSAR LOS displacement results with GRACE Groundwater Trend data? Would this be meaningful?
Answer 23: It is possible, but we have to take into account spatial scale. GRACE uses a 400km spatial scale and InSAR uses a 100m spatial scale.

Question 24: Can SAR track and monitor groundwater content in an alluvial aquifer that surrounds a river, as streamflow increases and decreases?
Answer 24: The amplitude of these variations may be smaller versus InSAR.

Question 25: What are the potential applications of these techniques that were discussed during this session for interplanetary missions? How are the current missions that are being planned for interplanetary missions using this technique?
Answer 25: The NASA VERITAS mission is planning on using interferometric measurements on Venus, both for topographic mapping and for mapping possible surface displacements.

Question 26: What will be the difference in ground deformation derived from L-band and X-band? Which one will be more suitable for geohazards?
Answer 26: The difference will be primarily in coherence. In vegetated areas, X-band will become incoherent and not be able to make measurements. The L-band wavelength will work best in vegetated areas.

Question 27: Is it possible to monitor urban water pollution through SAR data?
Answer 27: SAR data does not penetrate into water and is not sensitive to the chemical properties of the water. Optical is a better sensor for that. However, SAR is sensitive to

differences in water surface roughness and can detect oil spills. Session 3 of the Oct. 2022 SAR training covered this topic: https://appliedsciences.nasa.gov/get-involved/training/english/arset-disaster-assessment-using-synthetic-aperture-radar

Question 28: Have there been significant developments in land subsidence prediction? If possible, could you share some resources for further reference?
Answer 28: The California Department of Water Resources has been using InSAR to monitor groundwater extraction for several years. As a result a groundwater control law will be put into effect soon, and the area of the San Joaquin Valley, near Corcoran, that we used for our demonstration will be one of the first areas to be studied for controlling groundwater extraction.

Question 29: Have there been developments made towards real-time InSAR analysis? Again, can you share any references if any on this topic?
Answer 29: The processing of SAR imagery takes time, so there will be no current real-time SAR products as of now. SAR works primarily as near-real-time data. It typically takes half a day to downlink the data from the satellites after acquisition and process it to InSAR products.

Question 30: How is the measured subsidence affected by crop phenology? For example if we are measuring an area where there are crops growing (or maybe trees). Also, what is the spatial resolution we are looking at in this product? Is it 10m?
Answer 30: The growth of vegetation usually causes a loss of coherence. You might see a loss of coherence as a change in vegetation. Using a longer wavelength will help to resolve some of these issues. The resolution of the ARIA S1 GUNW processing is done at 90m. It is possible to get down to 30m using Sentinel-1 data with custom processing.

Question 31: How accurate is a Digital Elevation Model (DEM) derived using InSAR?
Answer 31: It depends on the distance between the two radar antennas and the resolution of the images used. InSAR height accuracy from SRTM is about 10m while Tandem-X DEM accuracy is better than 3m.

Question 32: Is crop water consumption mapping possible with SAR? Which is the best method?

Answer 32: InSAR is only sensitive to the ground surface displacements. This would be better served using soil moisture measurements.