Questions & Answers Part 3

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 Franz Meyer (fjmeyer@alaska.edu) or Erika Podest (erika.podest@jpl.nasa.gov)

Question 1: How can temporal coverage be selectively higher in certain parts of the globe (here in Europe, 6 days, and 12 days elsewhere)? I was thinking it would be somewhat the same.
Answer 1: Good question. The two-satellite constellation of Sentinel-1 does provide in principle the capability for 6-day sampling everywhere. However, data rate and duty-cycle limitations restrict 6-day coverage to only certain areas. As Sentinel-1 is funded by the European Commission, the 6-day coverage is mostly reserved for Europe as well as some high impact hazard regions.

Question 2: What is the most appropriate way to choose the threshold value for flood detection from SAR data?
Answer 2: It's best to adaptively choose a threshold depending on the scene. Refer to the presentation.

Question 3: Is it a good practice to use SAR flood maps for validation of flood maps from other hydraulic flood inundation models?
Answer 3: Good question. Using SAR flood extent maps is appropriate to validate inundation models, especially in areas dominated by open land. You will see later in the lecture that SAR (especially C-band SAR) has some limitations to detect water under vegetation. Therefore, in areas heavily covered by forests, there may be differences between the SAR flood extent and the model solution (which presumably will also provide information on water under vegetation).

Question 4: Can radar also detect sedimentation change under the water that is under the sea or rivers?

Answer 4: Unfortunately not. Radar wavelengths are not able to penetrate into water surfaces and cannot analyze the water column or the sea floor. Some LiDAR and optical techniques have better capabilities there. We can, however, analyze the water surface including surface roughness (and its relationship to wind), the presence of surfactants such as oil slicks on water, and similar things. In coastal zones, people have also used SAR to estimate shallow bathymetry by exploiting the imprint of bathymetry on wave patterns.

Question 5: What is the expected real-time latency for NISAR and Sentinel-1?
Answer 5: Sentinel-1 data are available to use within, say, 8 hours of image acquisition. NISAR will have latencies similar to that especially for data acquired over ongoing hazards. In areas not affected by hazards, you will receive data within 1 or 2 days after acquisition.

Question 6: SAR sounds interesting. Where can I learn more? Is there any short-course or training related to this? Manual?
Answer 6: Yes, there is a wide and growing range of resources available to learn more about SAR. The ARSET program has some good SAR-focused short courses available since 2017, such as its training on the Introduction to Synthetic Aperture Radar: (https://appliedsciences.nasa.gov/get-involved/training/english/arset-introduction-synthetic-aperture-radar). Beyond ARSET, we have made a range of resources available such as:

- A three-course intermediary-level training on SAR Applications available on edX: https://www.edx.org/certificates/professional-certificate/alaskax-synthetic-aperture-radar-sar-applications
- A full-semester course on Microwave Remote Sensing (all materials freely available) accessible at: https://radar.community.uaf.edu/
- A summary of additional resources can be found here: https://learnsar.open.uaf.edu/sar-resources/

Question 7: Is it advisable to use the L-band data for flood monitoring in a densely vegetated area? What is the resolution and how do you get this data?
Answer 7: Yes, L-band data is useful for monitoring flooding in vegetated areas. There are examples shown in the lecture. L-band data from NISAR will be acquired at the 5-10m resolution. L-band data from SAOCOM is available for South America.

Question 8: Which band would be the most optimal for the mapping of rice paddy fields?

Answer 8: This is a good question. There is good data on rice using polarimetric C-band data from Radarsat-2, as well as using time-series observations from C-band Sentinel-1 data. However, X-band data have also been used successfully for rice mapping. I am not sure if we have rough information yet to say which wavelength is best. It may be worth looking at the ARSET training on crop mapping using SAR available here: https://appliedsciences.nasa.gov/get-involved/training/english/arset-crop-mapping-using-synthetic-aperture-radar-sar-and-optical.

Question 9: Is SAR L-band able to penetrate highly dense and tall trees such as those found in tropical areas like Ecuador or Colombia to create reliable InSAR and GRD products? Or would P-band be advised for such cases?
Answer 9: L-band will have good vegetation penetration capabilities, but for reliably monitoring the ground in densely forested regions such as the rainforest, P-band will be even better. Which is better will depend on the region. Luckily, soon both P-band and L-band data will become available over areas such as South America, Africa, and South-East Asia through NISAR (https://nisar.jpl.nasa.gov/) and the ESA Biomass mission (https://www.esa.int/Applications/Observing_the_Earth/FutureEO/Biomass). I suggest comparing data from these two sensors.

Question 10: My request for an account in opensciencelab is pending. Is there any other way I could access the data? In Part 2, participants had questions about how long it takes for their ASF account to be approved.
Answer 10: OpenScienceLab accounts will be approved within one to two days. Unfortunately, we had to suspend the automatic open enrollment on the platform for now as we had a few bad actors on the platform and are currently approving new users manually. We are currently looking for ways to accelerate the approval of accounts while keeping the platform safe.
If your goal is to discover and download data to your local machine, you can always stop by the ASF Search Client Vertex, which has all data available for you at your fingertips: https://search.asf.alaska.edu/#/.

Question 11: What is the difference between Shv and Svh?

Answer 11: For monostatic radars (all current spaceborne radars are monostatic), the HV and VH polarizations provided by a sensor are essentially identical. Most sensors provide only one of those two bands (e.g., Sentinel-1 provides observations in VH).

Question 12: Is there a difference between the VV and HH polarization modes considering subsidence measurements on the same area?
Answer 12: For subsidence monitoring, you should stick with the co-pol bands such as HH or VV as they provide better signal to noise and therefore better interferometric coherence than the cross-pol bands VH or HV. I hope this answers your question.

Question 13: I am experiencing dark pixels in areas surrounding the river in the before-flood image and bright pixels in the after-flood image. Moreover, some researchers use pre-processing even in Level 1 GRD too. Why is that?
Answer 13: Brightening during flooding may indicate that you have water under vegetation creating increased brightness due to increased double-bounce scattering.
We usually use pre-processing before flood mapping such as geocoding and radiometric terrain correction. This ensures that the radar images line up with the correct geographic coordinates and that the images are fully radiometrically calibrated. This enhances flood mapping capabilities. Information on the pre-processing is also included in the lecture.

Question 14: Could stormy sections of oceans be confused with land cover due to the scattering from the rough surface?
Answer 14: Yes, especially in co-polarizations (VV or HH), wind blowing over water will increase the scattering brightness and reduce our ability to distinguish between water and land. One approach to mitigate this issue is to also use cross-pol data in your flood mapping analysis. The VH or HV bands are less sensitive to wind roughening.

Question 15: Can Sentinel-1 be used for reservoir capacity analysis? Or can I use it for sedimentation assessment in the dam?
Answer 15: You can use Sentinel-1 and NISAR to monitor the water availability in a reservoir by monitoring the spatial water extent. An increase in spatial water extent relates to increases in water volume.

To estimate changes in water volume, additional information in water height is needed. This can be derived with the help of a DEM or through external data such as altimetry data points.

Question 16: While doing sampling in classification, if we are certain about the local area that inundation occurred but the SAR is not showing it, what do we do? In that case do we have to follow local observations, or rely on what SAR is showing?
Answer 16: SAR can miss flooding when it occurs under vegetation. It may also miss flooding when only a part of a SAR pixel is covered in water. In that case, the observed radar brightness will be a mix of the inundated fraction and the non-inundated fraction of the pixel area. There may also be a time difference between your local observations and the SAR data collected, causing an observed difference.

Question 17: How could I apply SAR data to coastal geomorphology, which is my dissertation topic?
Answer 17: Good question. It depends on what exactly you are interested in. There are some applications of SAR for coastline retreat, for instance. You can always contact me via email to discuss your specific topic further and I can send you some literature links or connect you with an expert on the topic.

Question 18: Can we have a GitHub link for the homework notebook from the 'HYDRO30 via Binder'? I can't download the notebook from the binder.
Answer 18: Yes. The notebook is on github and can be found here: https://github.com/ASFBinderRecipes/Binder_SAR_Hazards_Floods.

Question 19: You said flooding between trees becomes bright pixels. How about flooding in a residential area?
Answer 19: Excellent question. Also there, flooding may lead to an increase of brightness if buildings are rather close to each other. In this case, water in urban settings can lead to an increase in double bounce and an increase in brightness. SAR water mapping in urban settings is still a research area and its performance depends on the density of buildings, the resolution of the sensor, and more.

Question 20: Does soil moisture scattering used for flood detection behave similarly in slopes? In other words, could the same principle be used to monitor soil saturation on slopes?
Answer 20: The brightness increase with increasing soil moisture should also hold up in slopes, depending on the surface type. I myself am not a soil moisture estimation expert, but could connect you with colleagues that are experts in this area if you want to know more.

Question 21: On slide 41, I've seen a white and bright line on SAR images. What is that?
Answer 21: Great question. For this example I used Sentinel-1 GRD rather than Sentinel-1 SLC images as input. In contrast to the GRD images, neighboring SLCs slightly overlap, which ensures gap-free imaging in all situations. The GRD images do not overlap and there can be slight gaps between images in some situations. The bright line you see is such a gap between neighboring frames. Thanks for the question. I should have pointed that out.

Question 22: I'm not familiar with mybinder. Is it like Google Colab?
Answer 22: Binder is a service that provides free computing environments to exercise a notebook in a free environment. It provides a temporary cloud computer and some temporary storage to run a notebook to exercise a workflow. It does not, however, provide permanent storage and the computing resources are limited.
It is similar to Colab in its capabilities but doesn't require a login or account. If you want to run a workflow, modify it, or return to work that you've started in the past, a service such as OpenScienceLab (https://opensciencelab.asf.alaska.edu/) is better as it provides perpetual storage attached with your account.

Question 23: Is the Sentinel-1 data showing bright pixels over inundated vegetation?
Answer 23: In some cases Sentinel-1 does show some brightening in areas of inundated vegetation, if the vegetation density is sparse enough to allow the C-band Sentinel-1 signal to penetrate through the canopy so that it can interact with the water surface. Vegetation density is key here. Denser vegetation and most forests do not allow for enough penetration for C-band SAR data to show water under vegetation. In these higher-biomass environments, an L-band sensor will be better.

Question 24: Are the axes on this chart supposed to be inverted? Slide 47.

Answer 24: Slide 47 shows image histograms where the x-axis corresponds to the pixel brightness and the y-axis corresponds to how many pixels have a specific brightness. The exes labels are correct but may not have been clear.

Question 25: How will lakes, rivers, and oceans have a different threshold backscatter value?
Answer 25: Good question. Assuming we have a single SAR scene that contains lakes, rivers, and ocean water, then in principle the threshold for those should be the same during low-wind situations. If there is significant wind, then lakes can show lower brightness (and a lower threshold) as they are smaller water bodies and often sheltered from wind by surrounding topography. Our approach currently doesn't discriminate between these water bodies when calculating a threshold.

Question 26: Is it easy to distinguish flooding in urban areas with SAR? I suppose that flooding in urban areas has similar backscattering as in flooded vegetation. But because the double bounce is already present before flooding in the urban areas, is it possible to distinguish flooded regions?
Answer 26: Mapping flooding in urban areas using SAR is not as straightforward due to the slide-looking geometry of SAR, the 10-ish-meter resolution of most SAR sensors, and due to the complex geometry of the environment in urban settings. So currently, mapping water in urban settings with SAR is still an area of research and approaches depend on the sensor resolution and on the urban setting.

Question 27: In slide 47, you are mentioning the threshold of Radarsat. What about Sentinel-1?
Answer 27: This slide is the only Radarsat example. All the other examples are from Sentinel-1. As both are C-band sensors, the approaches shown here should work for both Sentinel-1 and Radarsat.

Question 28: Which band is SAR data most useful for urban flood monitoring?
Answer 28: While water mapping in urban settings with SAR is still a research question, it seems that high-resolution SAR sensors are better at detecting water in these complex urban environments. X-band sensors such as TerraSAR-X, Cosmo Skymed, ICEYE, Capella, and Umbra should be better than medium-resolution sensors such as Sentinel-1 and NISAR.

Question 29: Are you able to estimate water volume by leveraging phase history data to see how much the water has risen? I imagine you would need historical volume estimates as a baseline.
Answer 29: Unfortunately, InSAR techniques are not very useful over water bodies as water surfaces de-correlate very quickly. You can estimate water height and water volume using SAR combined with ancillary data such as DEMs or LiDAR data such as those from ICESAT-2.

Question 30: Does the adaptive threshold in HydroSAR work also under wind conditions (rougher water surface) or in the presence of bare dry soils (that have very low backscatter and may be classified falsely as water)?
Answer 30: Wind roughening is a problem for a thresholding approach such as HydroSAR.

Question 31: On slide 55, how did you map the days of inundation? How much data was combined to form that color map? What was the method?
Answer 31: We used Sentinel-1 to estimate days of inundation. Data was available roughly every 8 days. We made the assumption that if a pixel was inundated in time step 1 and time step 2, that it was inundated also in the days between those acquisition dates. This is a simplification of course.

Question 32: Regarding wind roughness on water, can you estimate the wind speed from the SAR backscatter in SAR scenes, if you know the wind direction? Both in oceanic and inland waters?
Answer 32: Yes, NOAA actually runs an operational service doing wind-speed estimation from SAR observations. Examples can be seen here: https://www.star.nesdis.noaa.gov/socd/mecb/sar/sarwinds_tropical.php.

Question 33: In your view and experience, especially in regards to Sentinel-1, which cross polarization works best in open water, vegetation inundation, and water inundated on mixed settlements?
Answer 33: We use both polarizations provided by Sentinel-1 (VV and VH) for water mapping. VV has better signal-to-noise and VH has better robustness to surface winds. By using both we believe to have an overall more complete flood extent product. Inundated vegetation is difficult to map with C-band Sentinel-1 data. NISAR will be better here.

Question 34: Is there any difference between the L-band datasets from ALOS-2 and NISAR?
Answer 34: ALOS-2 and NISAR will use similar wavelengths. The main difference can be found in the acquisition cadence and the data availability. NISAR will acquire data over all land masses every 12 days and will provide this data in a free and open manner. ALOS-2 data are not sampled with similar frequency and, while data are becoming more available, currently some of the higher-resolution mode data requires a proposal to JAXA for free data access.

Question 35: What if an entire basin is not covered in one single-day image? Is it alright to mosaic different images from different dates? Furthermore, if the river path shown in Open Street Map does not coincide with the SAR image in GEE, what do you do?
Answer 35: You can certainly mosaic data along an orbit trajectory as these data are acquired within seconds of each other. Mosaicking frames acquired on different dates is possible if an event evolves slowly. We do that, for instance, when monitoring the HKH monsoon floods, which are remaining in place for longer time durations. If monitoring short-lived events such as flash floods, mosaicking images acquired at different times may be less appropriate. Some river channels have changed quite a bit since the most recent maps were released. I would trust the SAR-mapped water extent more than what you see in open street maps, especially in areas dominated by meandering rivers.

Question 36: Do we have an instruction sheet for these optional lab exercises?
Answer 36: The notebook contains some information on how the notebook can be run and what the different code cells are doing. Additionally, you will have access to a recording of this session for more information.

Question 37: Is it possible to extract the water bodies or flooded areas as a separate archive (e.g., shapefile or raster)?
Answer 37: Currently, the water maps are provided as GeoTIFF raster files. There are methods in ArcGIS or QGIS to turn these GeoTIFF into shapefiles.

Question 38: For optimal results with this algorithm, what would be the minimum length of the time series recommended?

Answer 38: The HydroSAR approach does operate on single images. No time series is needed to run the method, but of course a time series is useful to monitor how an event unfolds.

Question 39: Is there anything regarding depth? If yes, How could I find the depth of inundation as similar to extent?
Answer 39: Yes, flood extent and flood depth are linked through the DEM. If one knows the water extent and the shape of the surface through a DEM, one can infer depth from it (to the accuracy provided by the DEM). We are providing operational flood depth information following this approach for areas in the Hindu Kush Himalaya (https://geoapps.icimod.org/Floodinundation/).

Question 40: Really very informative. Is there any other mission except NISAR that provides the L-band?
Answer 40: Yes, there are a couple of ongoing missions that provide L-band data (Argentina's SAOCOM and Japan's ALOS-2) as well as a few upcoming missions (NASA's NISAR; Japan's ALOS-4; ESA's ROSE-L).

Question 41: Are there any techniques for getting rid of pavement misclassified as water in thresholding?
Answer 41: Pavement, like water, is a very smooth surface that can be misclassified as water. The easiest way to remove these missed detections is probably using external information such as road and airport runway information.

Question 42: Some researchers use change detection as an improved flood mapping approach by either subtracting before and after flood images or doing division of before and after flood images? What is your comment on this?
Answer 42: Change detection can be quite powerful for flood monitoring and has been used successfully in many test cases. We focused on single image approaches to have an applicable solution even if no pre-event data are available (this can be the case for some SAR missions). Change detection is useful but keep in mind that lots of things are changing during a severe weather event and not all changes are flood-related.

Question 43: A question about the usefulness of this technique: Can we employ specular reflection to identify minor changes in the region, such as detecting any new flow in the region of interest?
Answer 43: The approach is good at detecting open water areas. If new surface water appeared in a region, the approach should be able to detect it.

Question 44: Can flood depth be estimated using SAR data or any other satellite data?
Answer 44: See answer to Question 39.

Question 45: Is it possible to apply it to coastal flooding cases?
Answer 45: Yes, we have applied this approach for coastal flooding in Australia.

Question 46: What is the novel research happening in the field of SAR related to flooding?
Answer 46: Oh, there is a lot of work going on in the area, mostly focused on developing robust versions of flood mapping algorithms that can be applied automatically. In addition to our work, the OPERA project (https://www.jpl.nasa.gov/go/opera) is developing a surface water mapping algorithm based on SAR. There is also a European SAR-based flood mapping service in place now. Ongoing research still addresses water under vegetation and water in urban environments.

Question 47: Given that SAR is side-looking, do ascending and descending modes consistently provide compatible data? Can these modes be effectively used together, and if so, what is the recommended approach for achieving the best results?
Answer 47: After radiometric terrain correction, we find that ascending and descending data are sufficiently comparable to combine them for water mapping using thresholding approaches.

Question 48: Can flood susceptibility areas be mapped using SAR alone?
Answer 48: SAR can contribute to flood susceptibility mapping, say, by analyzing many years of surface water extent in an area. I probably would not use SAR alone but combine it with other resources such as models, topography information and the like.

Question 49: Sentinel-1 SAR, terrain corrected for areas exceeding 60-degree Latitude (https://developers.google.com/earth-engine/datasets/catalog/COPERNICUS_S1_GRD). Your comment on this?
Secondly, can I use Radarsat-2 C-Band (Launched in 2007) – Canadian Satellite Mission? Are their results also the same as Sentinel-1 SAR?
Answer 49: the Sentinel-1 SAR data in GEE is geocoded but not radiometrically terrain corrected. This causes some brightness biases in sloped terrain. That being said, as flooding mostly occurs in flatter regions, the impact on threshold-based flood mapping methods is small and you should be able to use thresholding approaches just fine on GEE. If you want to do change detection, the lack of radiometric terrain correction has a bit more of an impact. I would only do change detection between data acquired in the same orbit direction on GEE.

Question 50: For increased brightness over a crop field, is there a way to determine whether this is from an increase in soil moisture or an increase in roughness (e.g., the field is tilled)?
Answer 50: Soil moisture and roughness impact brightness. One way to separate the two impacts is by using time series.