Questions & Answers Part 3

Please type your questions in the Question Box. We will try our best to answer all of your questions. If we don't, feel free to email Malin Johansson (malin.johansson@uit.no) or Erika Podest (erika.podest@jpl.nasa.gov).

Question 1: What other fluids can we detect using SAR? Can we detect other types of water pollution?
Answer 1: We can detect a fluid at the water surface however, the radar signal doesn't penetrate through the water surface. It is possible to detect fluids on the ocean that reduce the capillary waves, though they must of course have a lower density than the surrounding water in order to detect them. Optical images are the main source used to monitor other types of water pollution.

Question 2: In 2010, the Deepwater Horizon Spill resulted in oil entering the coastal wetlands of southeast Louisiana. Is it possible to monitor oil within the wetlands, where SAR results in "Double-bounce" return? / Can SAR detect oil on a beach or a rocky shoreline, or other surfaces?
Answer 2: The SAR images will not be ideal to detect oil in rocky shorelines, as what we are identifying is the damping of the ocean surface capillary waves. Work on using SAR for oil detection in the coastal wetlands of Louisiana can be found here: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/2011GM001113

Question 3: L-band is showing the least oil detection capabilities, what may be the reasons? In general, what band is the best to use for oil spill detection? X-band, S-band, C-band or L-band?
Answer 3: The L-band wavelength is longer than that of other frequencies. The damping of the Bragg resonant waves is expected to be more efficient at shorter wavelengths. Radars with higher frequencies (shorter wavelengths) may be more efficient for oil spill detection than radars with lower frequencies (longer wavelengths).

L-band is good for continuous monitoring due to the good signal-to-noise ratio. X-band is the best for detection but it does have a disadvantage as it generally has a lower signal to noise ratio compared to the other frequencies.

Question 4: Can we apply an IEM (Integral Equation Method) dielectric model to classify oil spills?
Answer 4: When looking at oil with different thicknesses, such as sheen and emulsions it's challenging to extract the dielectric constant from SAR, and to use them to separate different oil types. However, given that water has very different dielectric values, studies have attempted to exploit this to derive mixture indices.
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2012GL052304

Question 5: Can we use thermal IR images for the very shallow coastal regions to identify the oil spill area?
Answer 5: Yes you can. The thermal IR images are sensitive to the oil thickness and presence. Here you can find an open access review of oil spill detection using e.g., thermal images https://www.mdpi.com/1424-8220/18/1/91
Information about oil spill detection with a range of satellite sensors can also be found here: https://www.sciencedirect.com/science/article/abs/pii/S0034425712001563

Question 6: How do you estimate the Noise Equivalent Sigma Nought? Do you need to calculate NESN for each image?
Answer 6: Each SAR image normally contains information in the meta data or as an attached file, that can be used to derive Noise Equivalent Sigma Zero. It can be provided directly, as in the Radarsat-2 and Sentinel-1 images. If not provided, you can derive it using predefined ways of doing the calculation, using parameters from the metadata such as those found in TerraSAR-X images.

We need to derive the NESZ for each image, though we can use the same NESZ for each set of images from the same sensor mode. However, be cautious that sometimes data providers identify bugs in their data and then update the data.

Question 7: You mentioned rainbow, sheen, and metallic. Based on the image that was on the slide, is it correct that sheen is always on the edge of the oil spill? If correct, then based on the difficulty in detection of sheen, can we create a buffer around the oil spill region to make sure that the sheen is captured effectively every time?
Answer 7: Sheen is the thinnest and hence most often located at the edge of the spill. Yes, we could try and use a buffer around the detection to account for this.

Question 8: If oil spills in an arctic or polar region occur at the beginning of winter or when the sea starts to freeze, then what will be the scenario, how is that going to affect the backscatter or dielectric state?
Answer 8: Both the sea ice and the oil will dampen the capillary waves, and the dielectric constant will change as well. Some work providing more details on this can be found here:
https://www.sciencedirect.com/science/article/abs/pii/S0034425714000285 and here:
https://ieeexplore.ieee.org/document/8338332,
https://ieeexplore.ieee.org/document/9591590,
https://www.sciencedirect.com/science/article/abs/pii/S0025326X19307775, and I also recommend to look for other works by scientist at the University of Manitoba Canada, outlining the effect of oil on and within sea ice.

Question 9: Which software would you recommend to use if one has a time series of SAR images on oil spills? Is SNAP able to handle time series data?
Answer 9: SNAP can handle time series data through batch processing so yes, this is possible.

Question 10: Does the extraction strategy change with the thickness of the oil? If so, can you briefly elucidate the oil extraction process?
Answer 10: Different strategies will be used, depending on the type, thickness and environmental conditions. For example, low sulfur oils are stiffer and will be thicker and more challenging to extract. Thicker oils may also be burned. More information about oil spill response can be found here:
https://www.itopf.org/knowledge-resources/documents-guides/response-techniques/

Question 11: Can you do these analyses on inland water bodies or large, wide river systems? If so, what special problems do they present?
Answer 11: Yes, the process will be similar for large bodies of water. The dielectric values for freshwater will be slightly different. In small rivers you may have contamination of the pixels from the size of the river.

Question 12: How do you identify the noise contamination in the image? And how do you determine them with the SNAP tool?
Answer 12: For Sentinel-1 images you can often easily see it by opening the HV channel in SNAP. You'll often see a stripy appearance in the image, this is the noise.

If you are working with a SAR image you can often derive the signal-to-noise values, by deriving the noise (see Q6) and the normalized radar cross section and from this derive the signal-to-noise ratio.

Question 13: Can the same method apply for water quality detection and monitoring rivers or lakes?
Answer 13: Refer to Q1 and Q11. Optical images would be best for water quality detection.

Question 14: Can we use these techniques to detect oil spills on land?
Answer 14: No, the techniques were developed for marine oil spill detection and monitoring. To observe the reduction in the capillary waves, the oil needs to be located on water.

Question 15: Is it possible to combine intensity LiDAR images with SAR images to detect oil bodies?
Answer 15: Yes, there has been work on the use of LiDAR, e.g.,
https://opg.optica.org/ao/abstract.cfm?uri=ao-29-22-3218
https://ieeexplore.ieee.org/document/1526165 for LiDAR and SAR
For some more information see the Bonn code:
https://www.bonnagreement.org/site/assets/files/17600/aoh_part_ii_remote_sensing.pdf

Question 16: Are there more indices available for oil delineation in open waters?
Answer 16: Besides the damping ratios, you can look at the intensity values alone or for fully polarimetric images, there are a range of polarimetric features. A list of some of them can be found here: https://ieeexplore.ieee.org/document/7498554 and further analysis is shown here: https://doi.org/10.1038/s41598-021-88301-9

Question 17: How does burning the oil impact the ecology of the surrounding area, especially the fish and mammals in the region?
Answer 17: Although not ideal, burning is sometimes one of the only means in colder regions (+15 C), which is better than leaving the oil in the water. In warmer waters you can catch the oil in recovery or emulsion.

Question 18: Is the different salinity value between tropic and non tropic areas involved with the oil spill pattern?
Answer 18: No, not really.

Question 19: There is an algorithm called S1Denoise, can I use that to pre-process the SAR dataset to get rid of unwanted noise?
Answer 19: You can get rid of some of the noise using that algorithm and it's a great first step. Noise continues to be a large issue, and is still an active field of research e.g., https://ieeexplore.ieee.org/document/8126233

Question 20: Is it possible to detect both crude oil and natural films? Is it possible to categorize those two categories in a SAR image?
Answer 20: It is challenging, and as pointed out in the lecture, natural films and oil spills are look-alikes. L-band can be a useful sensor as it can separate the 2 better, as pointed out in this paper: https://agupubs.onlinelibrary.wiley.com/doi/abs/10.1029/97JC01915.

Question 21: Can SAR images be used to detect subsurface occurrence of oil, just a few meters below ground surface? If so, do the same techniques shown here apply? Or do we need additional datasets?
Answer 21: Unfortunately not with radar.

Question 22: Can you use information in the SAR image to say something about the drift in the next hours?
Answer 22: The SAR images can be used to detect the oil slicks and to derive instantaneous wind and current information. These can themselves then be used as input into ocean modeling, for one example see the following paper https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016JC012113
And for oil and sea ice in the same area: https://www.sciencedirect.com/science/article/pii/S0025326X22000753?via%3Dihub.

Question 23: How can we assess the effect of Bragg Resonance in SAR backscattering? Can we quantify the backscatter power due to constructive or destructive?
Answer 23: Information about the Bragg Resonance and how we account for it in oil spill detection and ocean applications can be found in this book chapter outlining oil spill detection using satellite images: https://digital-library.theiet.org/content/books/10.1049/sbra521e_ch9 and here: https://ieeexplore.ieee.org/document/8316244 and for more ocean applications here: https://ieeexplore.ieee.org/document/6377256 and here: https://ieeexplore.ieee.org/document/8742586