Questions & Answers Part 1

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 Malin Johansson (malin.johansson@uit.no) or Erika Podest (erika.podest@jpl.nasa.gov).

Question 1: What are we looking for between Freezing and Melting? Are we talking about change detection?
Answer 1: The sea ice has a seasonal cycle. We start with the freezing in September and the melting starts sometime between April and June (depending on location). Once the melting starts we observe changes in the backscatter signatures due to the melting of the snow and sea ice. In areas with stationary ice we can call it change detection if we are trying to analyze when the melt season starts. But in areas where the sea ice is drifting the change between two images may largely be based on different sea ice.

Question 2: If we use L-band SAR, can't we estimate the thickness of sea ice using coherence and phase values, as L-band has a higher penetration or maybe a band with higher penetration?
Answer 2: We can estimate sea ice thickness using L-band images up to approximately 0.5m. But for thicker sea ice it is not possible. For this we can use the VV/HH backscatter ratio. To read more about this I recommend a paper led by Hiroyuki Wakabayashi from 2004: https://ieeexplore.ieee.org/document/1356055.

Question 3: How helpful are optical satellites in detecting sea ice? I'm assuming there will not be a great cloud problem near the poles?
Answer 3: They are excellent if there are no clouds or fog and if there is daylight. In the marginal ice zone, fog and clouds are a bigger problem. The summer months are also more fog- and cloud-prone. It may also be a challenge to see ridges and deformation in the optical images if there are no shadows. But optical images are excellent for separation between open water and sea ice. It also helps with machine learning applications, as we can use optical images to aid training and validation data retrievals.

Question 4: Ice is not getting older. Defrosting in shorter times. Plus, less ice formation itself...lower albedo...more local warming....lesser ice formation...even

lower albedo...has anyone tried albedo change comparison for predictive purposes?
Answer 4: There is some recent work on the albedo retrieval found here: https://tc.copernicus.org/articles/17/1053/2023/ and some from the large MOSAIC sea ice drift campaign: https://online.ucpress.edu/elementa/article/10/1/000103/190677/Arctic-sea-ice-albedo-Spectral-composition-spatial

Question 5: What sea ice properties are more easily classified by changing the polarization (HH, VV, HV)?
Answer 5: The HV is useful for ridges, we are then looking for areas where the polarization changes with the interaction with the surface. The two co-polarization channels are useful for the thinner sea ice areas. The HV channel is less sensitive to wind speed and direction over open water, i.e. the water appears dark which provides better separation between open water and MY and FY ice, level and deformed ice, rough thin ice – open water. Moreover for the HV channel there is less sensitivity to incidence angle effects.

Question 6: What scene sizes are you used to using for this type of application (from ScanSAR for example)? What resolution are these images typically?
Answer 6: For sea ice detection and monitoring we normally rely on ScanSAR images, due to their large aerial coverage. These images typically have a 40-50 m pixel resolution, with a swath width of 300-400 km.

Question 7: How did you calculate the backscatter of each single point in the curve? Does the point represent the average area?
Answer 7: The backscatter was calculated using a Region of Interest (ROI) over the same area on one ice floe. The same sea ice floe was used for all the points. You can see some illustrations here: https://www.researchgate.net/publication/374191885_From_winter_to_melt_season_C-band_radar_backscatter_evolution_of_fast-drifting_sea_ice_floes

Question 8: What is the reason for variation in C-band compared to L-band?
Answer 8: The different wavelength means that the radar penetration depth is different. For C-band, we are primarily seeing a backscatter signature related to the surface roughness, and for L-band, we are seeing an interaction between the sea ice itself and

the radar signal. This also means that different levels of surface roughness cause changes in the SAR signatures.

Question 9: Does the combination of L and C support flood detection as well?
Answer 9: This question will be addressed in Part 3 in this webinar series.

Question 10: Do we need to calibrate to sigma0 before aligning?
Answer 10: Ideally, yes. For some work where L- and C-band data has been aligned for drifting sea ice (a very challenging problem) you can read more here: https://ieeexplore.ieee.org/document/10210043

Question 11: I only have a PDF in my image file. Did I download incorrectly?
Answer 11: We will look into this further.

Question 12: Can graphs be used to monitor trends and changes in sea ice?
Answer 12: We will look into this further.

Question 13: Elaborate more on the multi-frequency approach.
Answer 13: In recent years, the availability of multi-frequency data has expanded significantly. Particularly using Sentinel-1 data, and JAXA are currently releasing the ALOS-2 ScanSAR data as freely available data. NISAR will also be providing more L-band data. Using differences between L and C-band data can help to detect more detailed information regarding sea ice. Both bands also provide varying information in regards to sea ice melting as well and the combination provides more confident data.

Question 14: Is this SAR Interferometry or SAR polarimetry?
Answer 14: This lecture only covers SAR polarimetry. Some InSAR sea ice work already conducted includes:
https://tc.copernicus.org/articles/11/1967/2017/
https://ieeexplore.ieee.org/document/9250474
https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2016GL069583
https://www.sciencedirect.com/science/article/abs/pii/S0165232X17300277
https://ieeexplore.ieee.org/document/8126964

Question 15: Is it possible to monitor rivers?
Answer 15: It is possible. Since it is freshwater ice, the information is a bit different.

For some river ice work:
https://www.sciencedirect.com/science/article/abs/pii/S0034425720304922

Question 16: I can see that HV is a great polarization for sea ice - can you explain a bit more about why? I've seen a lot of publications regarding the use of VV for sea slicks, which I imagine would be similar to grease ice. Is there a difference between these applications for HV vs. VV, or is there an opportunity to further leverage VV for sea ice detection?
Answer 16: Oil slicks and grease ice do indeed look very similar in SAR images. For cross polarization channels, backscattering issues can arise due to a low signal-to-noise ratio. The upcoming NISAR mission, as well as the existing Sentinel-1 mission, will use VV scattering to monitor oil slicks.

Question 17: Is the thermal noise removal in SNAP a simple subtraction of the noise equivalent sigma zero (NESZ), or does it use the Nansen Center algorithm?
Answer 17: It does not use the Nansen Center algorithm.

Question 18: How do you decide which SNAP pre-processing steps are necessary to undertake when looking at sea ice?
Answer 18: The steps used here in the exercise are based on established standardized methods over the years. Some argue that the flatness of the sea ice topography does not render it necessary to apply terrain correction, but that step can be added if one so wishes.

Question 19: Can you speak to the utilization of KU band (if any) in your research and airborne sensor utilization vs satellite data?
Answer 19: KU band is more related to snow pack and can be useful to measure that. Some Ku-band sea ice work can be found here:
https://ieeexplore.ieee.org/document/8126967
https://ieeexplore.ieee.org/document/9000883
https://www.sciencedirect.com/science/article/abs/pii/S0034425717302882

Question 20: How do multi-frequency approaches work given that sea ice moves between images? Can a unified time series of multi-frequency images be created using bandpass adjustments, similar to the Harmonized Landsat/Sentinel dataset?

Answer 20: We have to adjust the images accordingly to account for the movement of sea ice. We use a master image and treat other images as if they were taken at the same time. Here is some recent work that has aligned multi-frequency SAR images: https://ieeexplore.ieee.org/document/10210043, https://www.sciencedirect.com/science/article/pii/S0034425717304819.
C-band and L-band images are also taken at separate times, and for drifting sea ice we always need to align the data. For fast ice (stationary) we can simply georeference the data: https://www.sciencedirect.com/science/article/pii/S0034425720304193.

Question 21: Is there a way to track the Python code of analyses from the SNAP desktop? So that we could use these same methods inside cloud computing formats? Furthermore, allowing us to train models based off of recent classifications we built in SNAP.
Answer 21: I am not sure if it is possible to track the code. We will look into this further. There is a Python API for accessing SNAP tools. The best way maybe is installing SNAP and configuring the Python accessibility during the install process.

Question 22: Is updated satellite imagery accessible free of charge? If yes, can we have a link?
Answer 22: Yes! In regards to Sentinel-1, imagery is provided within a few hours of capture. We will elaborate on this further in Part 3.

Question 23: How can SAR images be best used for permafrost studies/monitoring? 1.) Which frequency (C,L, X) is optimum for it? 2.) What polarization bands are useful? 3.) What time-period does one need to consider? 4.) Can the current data from commercial satellites like ICEYE, Capella SAR be useful for it?
Answer 23: We will provide literature in this document regarding this topic. The current commercial satellites are also useful for these applications.
Some information can be found here: https://climate.esa.int/en/projects/permafrost/
https://www.mdpi.com/2072-4292/11/16/1865
https://link.springer.com/article/10.1007/s10712-023-09770-3.

Question 24: What have you found are the largest challenges to using SAR data? It seems like there is a lot to consider when using the data.

Answer 24: The biggest challenge regarding sea ice is the separation of multi-year ice from young ice, as backscatter between the two can look similar. If you know the challenges being faced in measurements, we can train algorithms to account for these.

Question 25: Do changes in salinity values in the Arctic Ocean from the melting of freshwater glaciers on Greenland affect the spectral/backscatter signatures of sea ice?
Answer 25: If you have a freshwater layer and it freezes, it will affect the backscattering values.

Question 26: I'm interested in knowing ways to solve the incidence angle effect. It's usually not clear in the literature and in the community. Usually, it refers to ScanSAR images and some people even believe the calibration step in SNAP deals with it. Which procedures do you recommend to eliminate the incidence angle? Do we have to apply them to different types of images as ScanSAR and Stripmap? And especially for Stripmap, in a single SAR image maybe we don't realize the incidence angle effect, however, do we need to have in mind for example normalizing to a specific angle?
Answer 26: We do need to account for it. The calibration step in SNAP does not deal with it, but there is literature that highlights this.
For some sea ice work regarding this please see:
https://ieeexplore.ieee.org/abstract/document/8393469
https://tc.copernicus.org/articles/16/237/2022/
https://www.mdpi.com/2072-4292/13/4/552
https://www.cambridge.org/core/journals/annals-of-glaciology/article/mapping-seaice-types-from-sentinel1-considering-the-surfacetype-dependent-effect-of-incidence-angle/4D3591E724BC905D31AD55FEBD4077DF

Question 27: You mentioned an advantage of combining SAR scenes with different bands. Are there any plans to design a satellite with multiple, different SAR bands?
Answer 27: The upcoming NISAR mission will help with this.

Question 28: SAR is said to be transparent for dry snow, however, there are studies from the sea ice and glaciology community on this. How useful is the use of SAR for snow thickness? I'll appreciate some references if possible.

Answer 28: We will provide literature regarding this topic.
https://www.sciencedirect.com/science/article/abs/pii/S0034425717302882
https://ieeexplore.ieee.org/abstract/document/9000883

Question 29: Are there possibilities to use SAR for surface water pollution?
Answer 29: Refer to our previous SAR training regarding oil spills.

Question 30: Does ionosphere or rainfall play a role in pulse retrieval in SAR images? Is that something taken into account in the QC band? And if it is, is it a reliable indicator of the quality of the pixel?
Answer 30: The ionosphere does play a role, specifically in L-band. Some of those effects still remain.