Usage of SAR Stack Data over Sea-Ice – A First Overview

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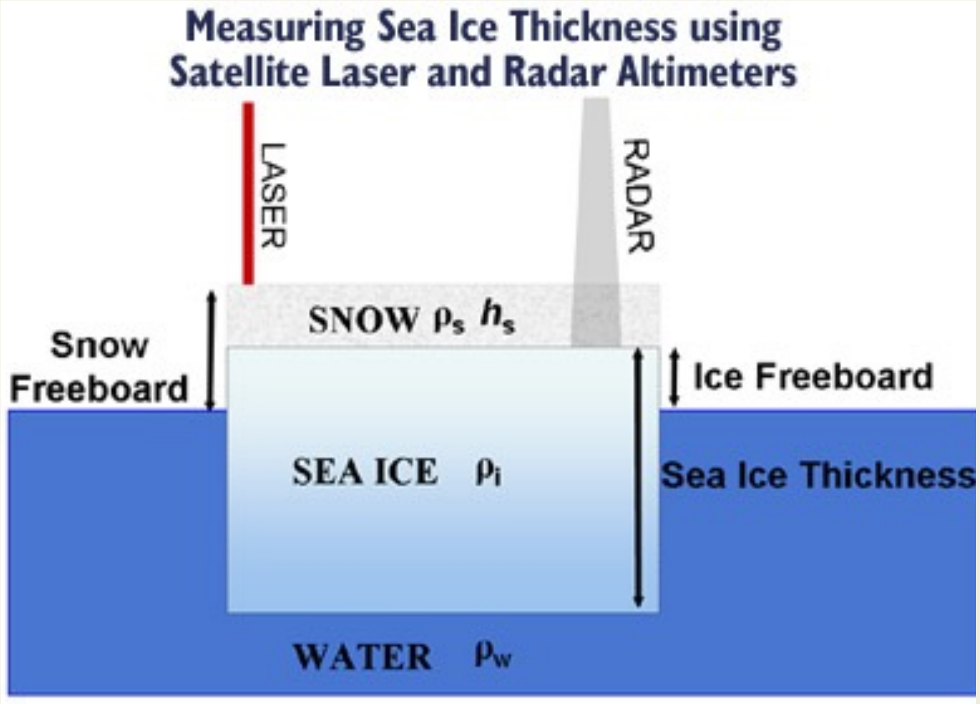
Shameless Advertisement

- We are looking for a PhD to support our team
- Focus lies on SWOT and classical radar altimetry in coastal areas
- If you are interested, please feel free to contact me via cbuchhau@umd.edu
- For more information: https://essic.umd.edu/joom2/index.php/employment/3148-post-doctoral-research-associate-in-remote-sensing-altimetry

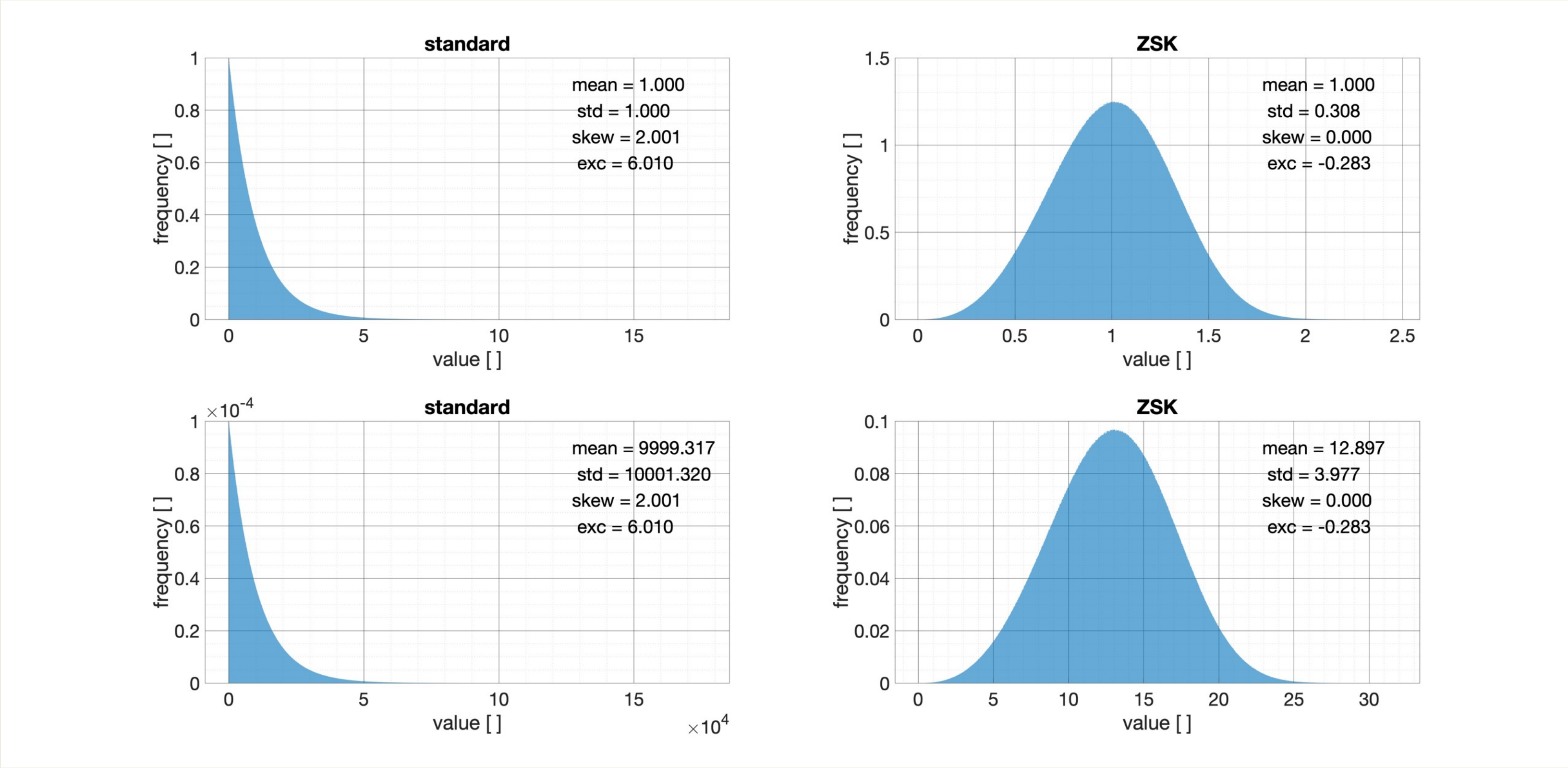
Introduction

- Retrieving sea-ice parameters from altimetry observations is still a challenging task, due to heterogenous scattering mechanics.
- We focus on stack retracking, which in the open ocean allows for the estimation of additional parameters, and the zero skewness (ZSK) transform, which brings stack samples closer to a normal distribution.
- We present first results from a new numerical stack retracker scheme adapted for sea-ice surfaces how snow-covered sea-ice can be handled in stack retracking and what kind of parameters can be retrieved from these cases.



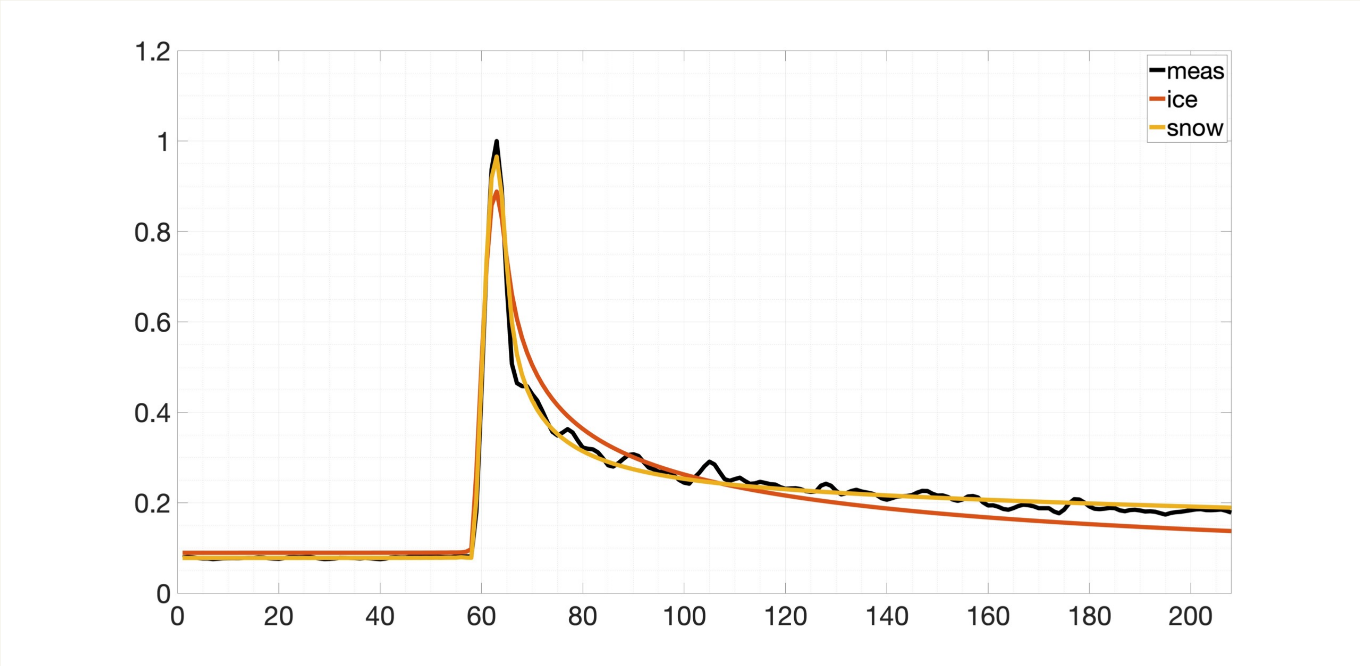
Concept of sea-ice altimetry.

We apply the ZSK transform to make smaller signals more visible and to increase the signal to noise ratio.



Introduction: Main idea

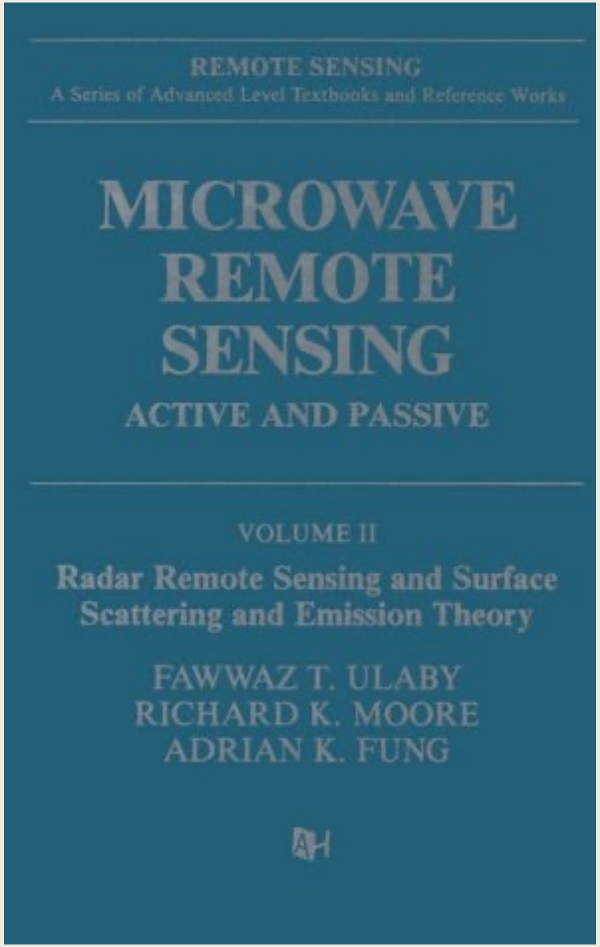
- We identified that the trailing edge decreases slower than according to Hagfors backscatter function
- Solution: Discrepancy might be snow



Senitnel-3 Ku-band waveform; black curve: measured waveform; red: sea-ice return only; orange: sea-ice plus snow.

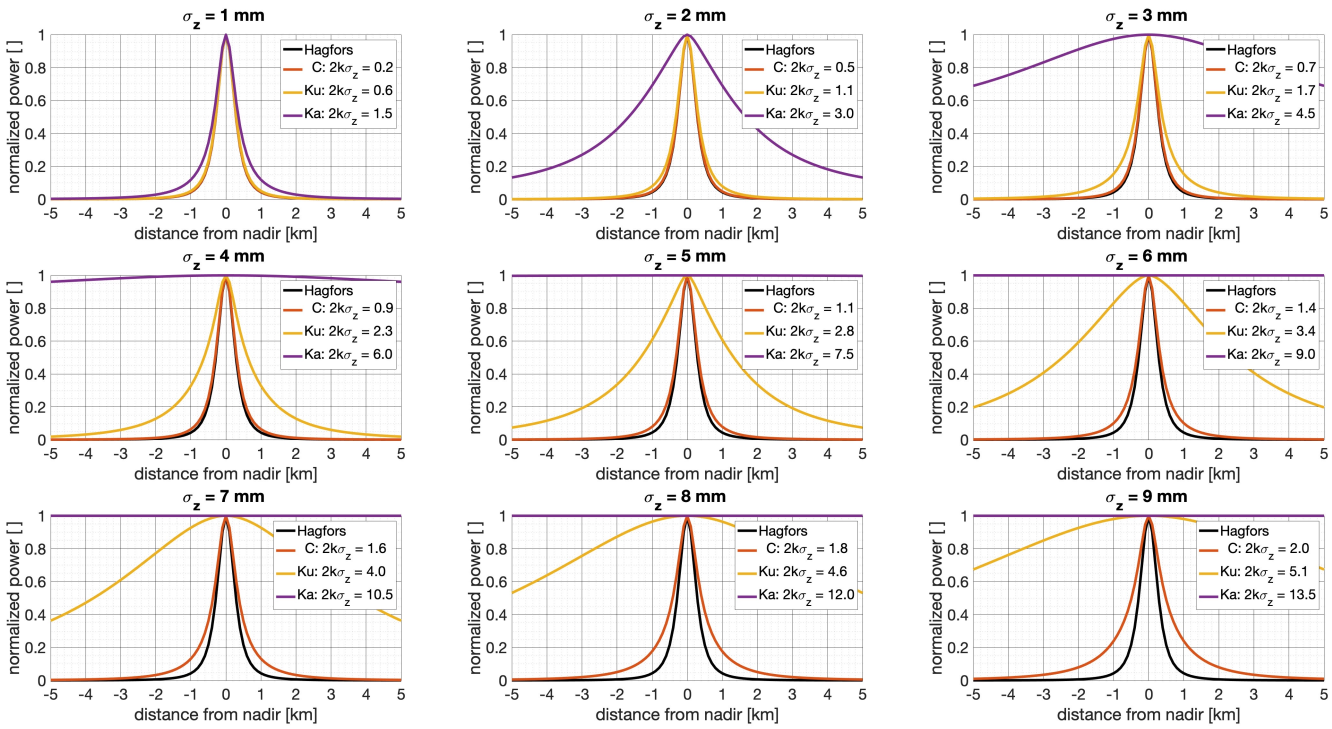
Introduction: Let’s check the Math

- Theory is well described for Gaussian elevation distribution
- However, sea-ice follows an exponential distribution and correlation function
- Therefore, we follow the approach (Scalar Approximation) presented by F. T. Ulaby (chapter 12) but use sea-ice statistics instead
- For the sake of completeness, we present the Gaussian case as well.



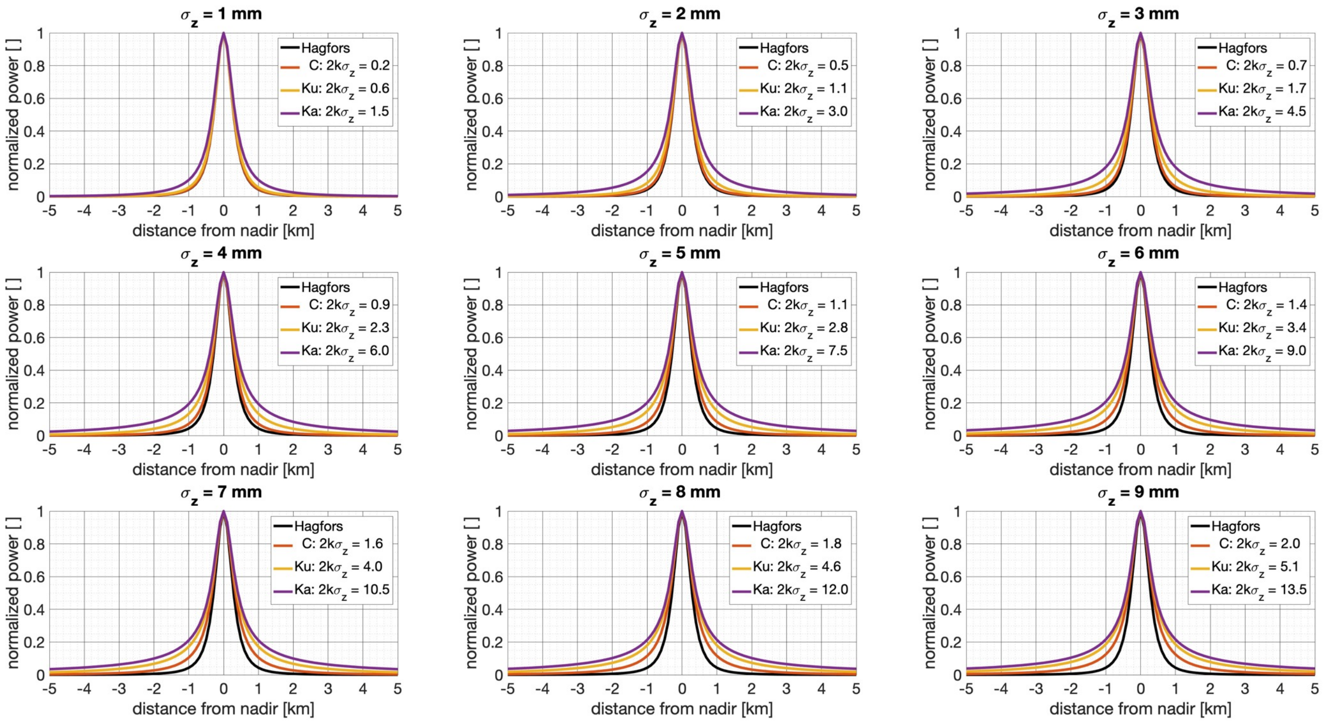
Introduction: Let's check the Math

- Gaussian elevation distribution
- Converges towards geometrical optics fast



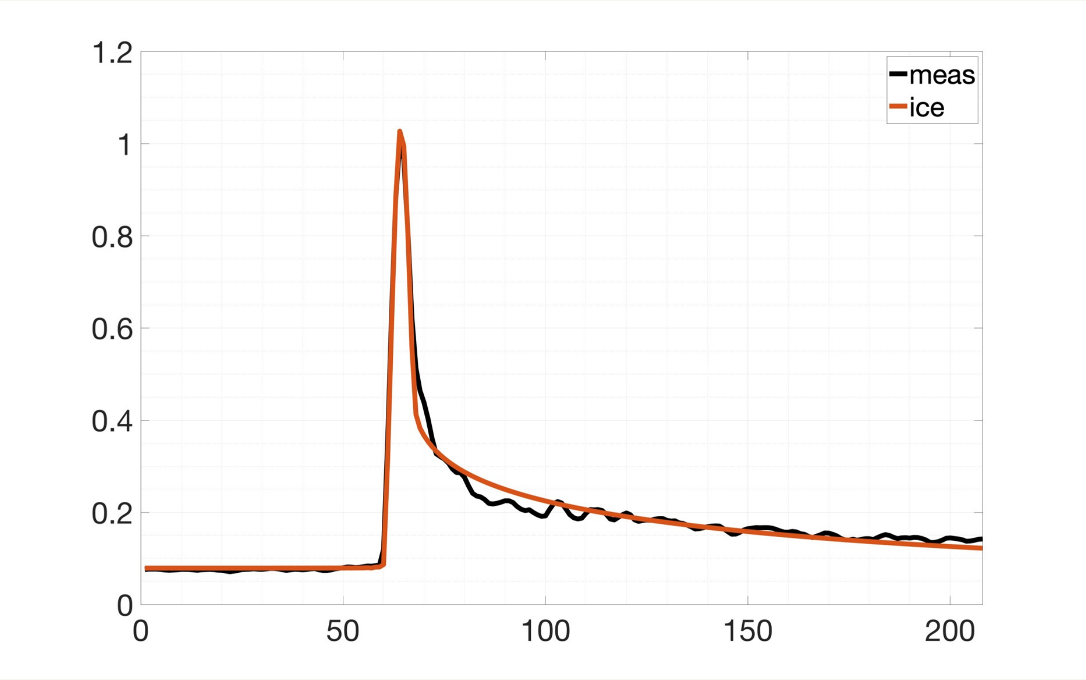
Introduction: Let’s check the Math

- Exponential elevation distribution
- Does not converge towards geometrical optics



Introduction: Main idea does not work anymore

- No more discrepancy found
- Snow not observable here
- However, we were able to observe slope effects

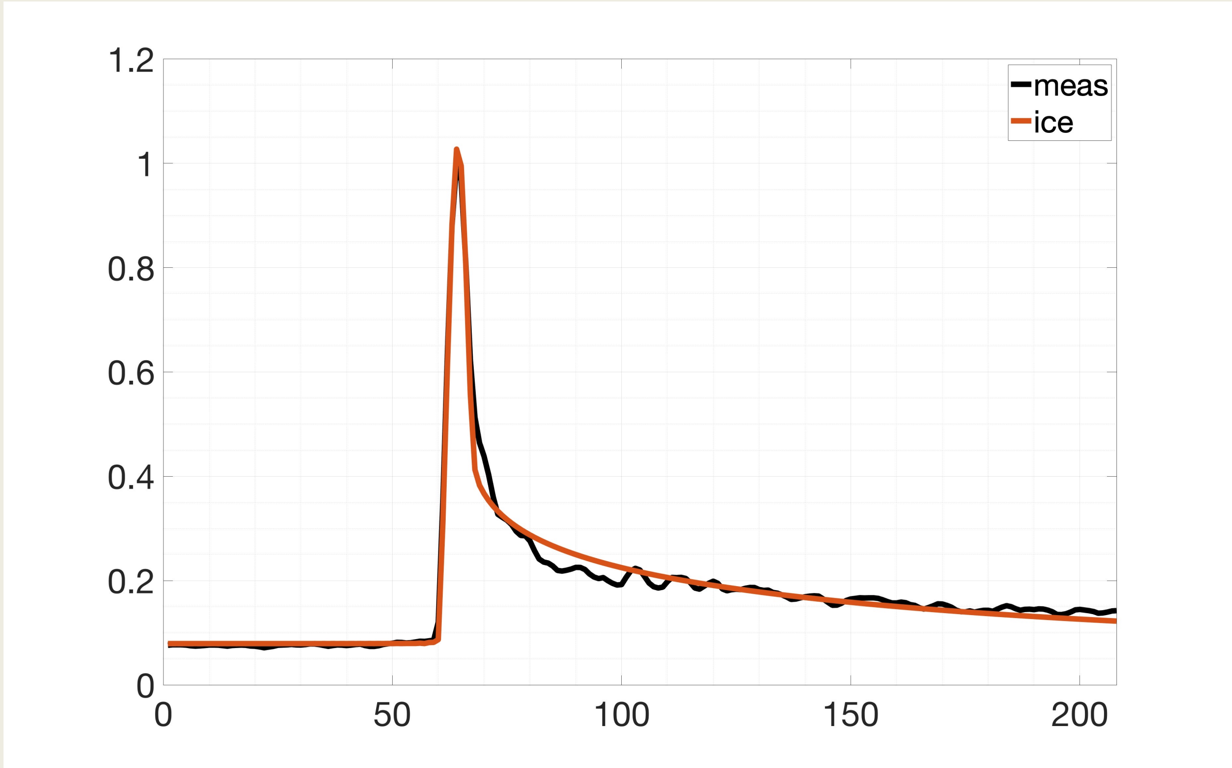


Sentinel-3 Ku-band waveform; black curve: measured waveform; red: sea-ice return only.

Retracking

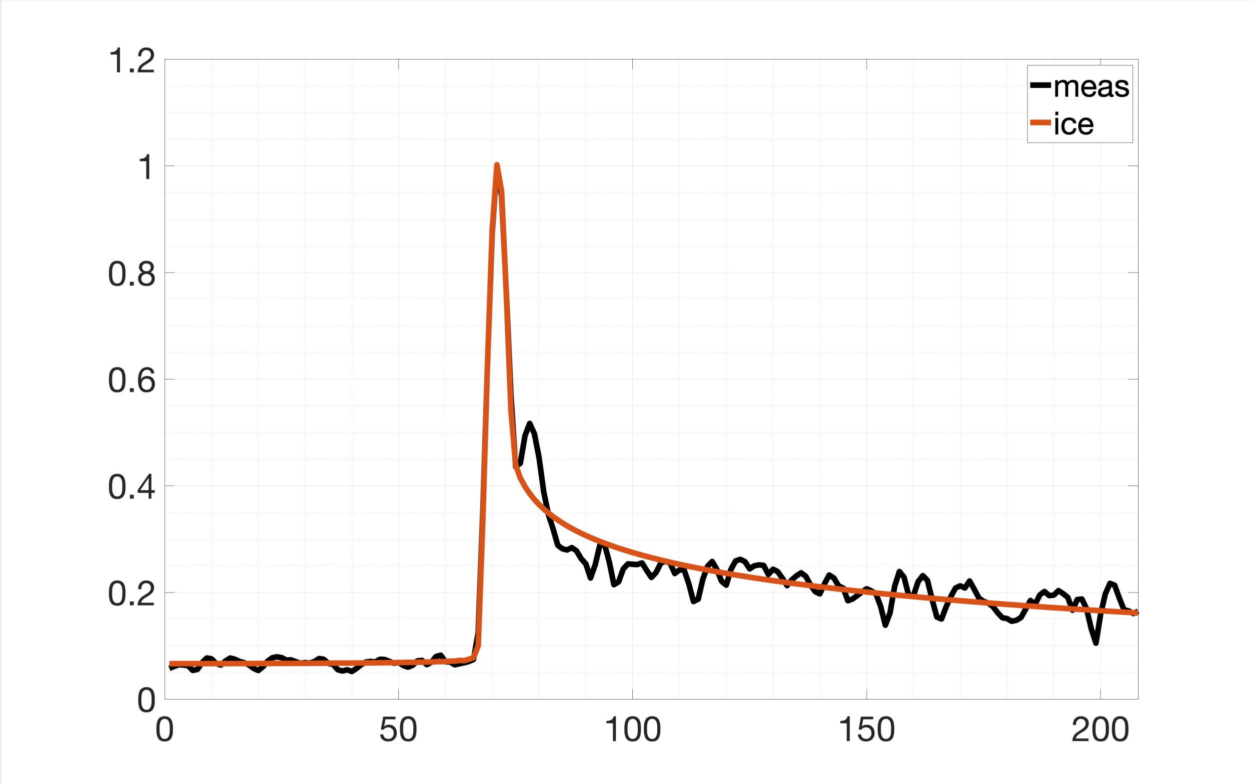
- We apply in the L1B processing Kaiser-Bessel windows to mitigate snagging effects.
- We assume that the surface roughness is very large compared to the wavelength.
- We assume that the surface roughness if small compared to the PTR width.
- Therefore, we estimate following parameters:
    - Sea-ice Amplitude
    - Sea-ice Elevation
    - Sea-ice backscattering function scaling
    - Sea-ice slope variation

Retracking result of one Ku-band sea-ice Reduced-SAR waveform



Sentinel-3 Ku-band waveform; black curve: measured waveform; red: sea-ice return only.

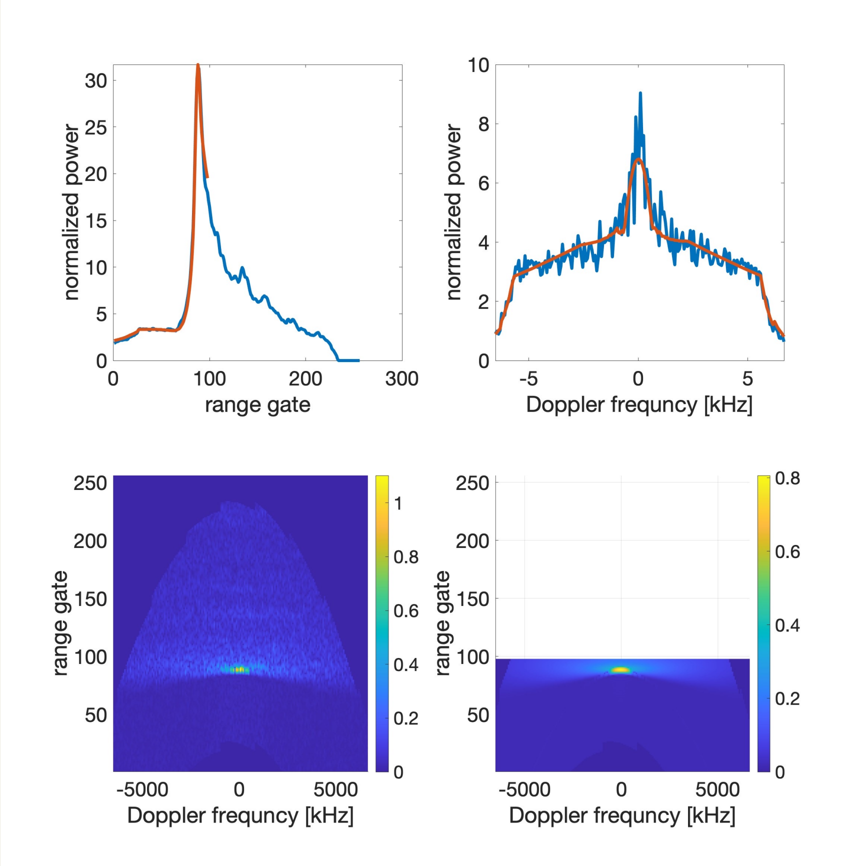
Retracking result of one C-band sea-ice LRM waveform



Sentinel-3 C-band waveform; black curve: measured waveform; red: sea-ice return only.

Retracking

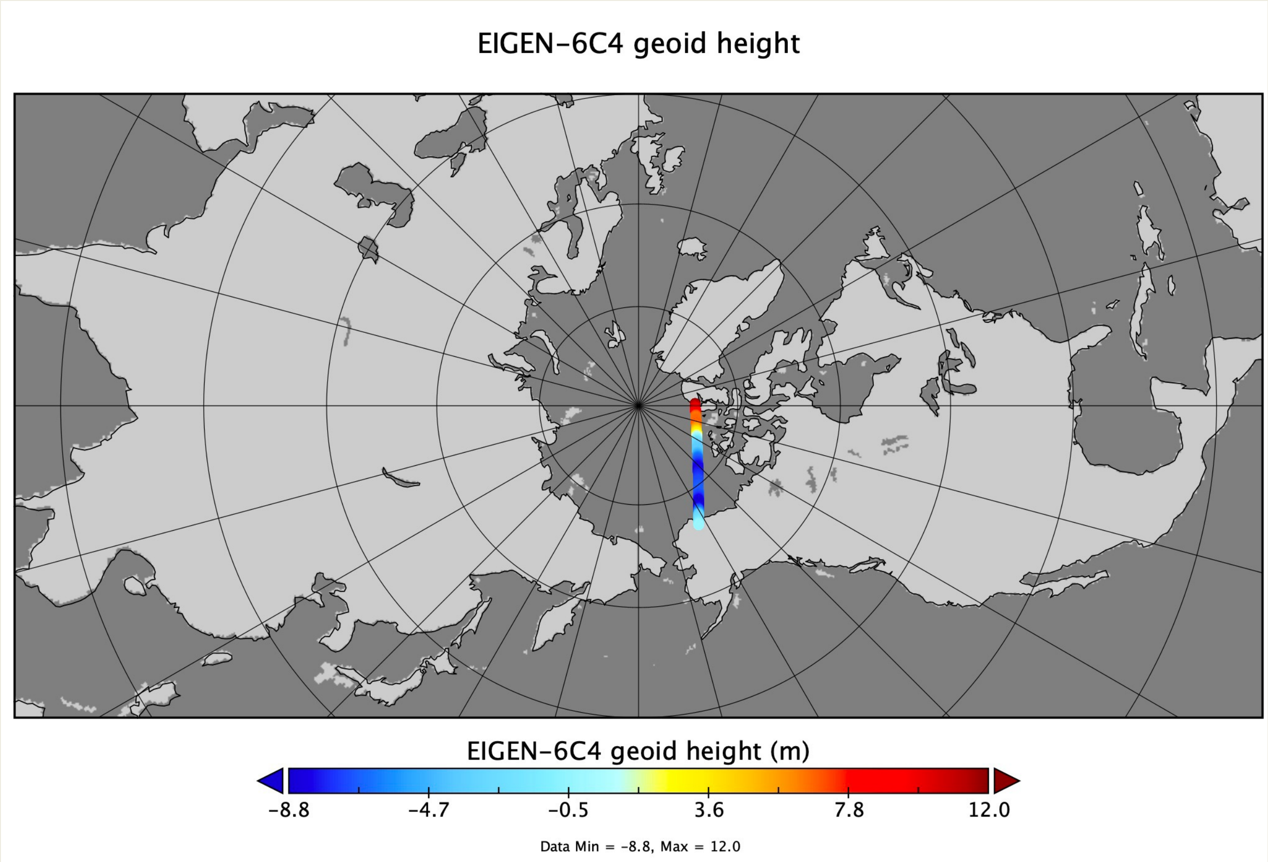
- Retracking result of one Ku-band sea-ice SAR stack
- To mitigate outliers located in the trailing edge we fit only a sub-stack up to the maximum range bin plus ten samples
- The same could be done with the waveform + RIP



Sentinel-3 Ku-band stack; black curve: measured; red: sea-ice return only.

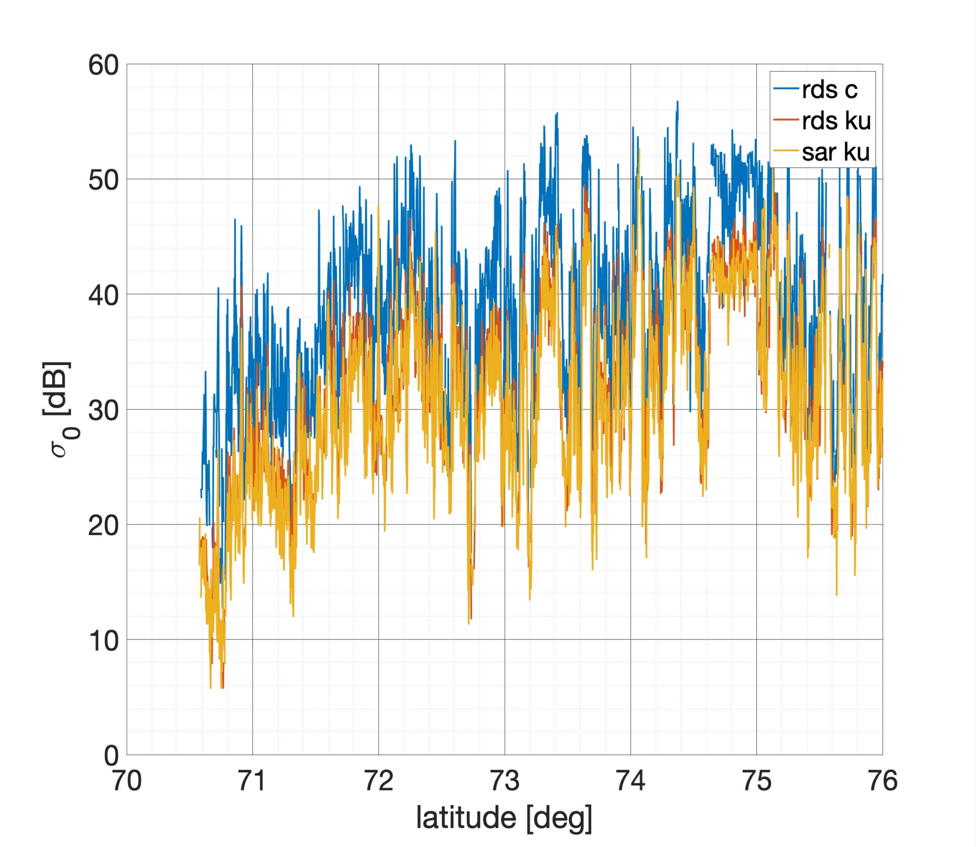
First Results

Location of the chosen pass:
S3A_SR_2__HR_LSAR_NT_003_186_20160421T214513_20160421T223539_003



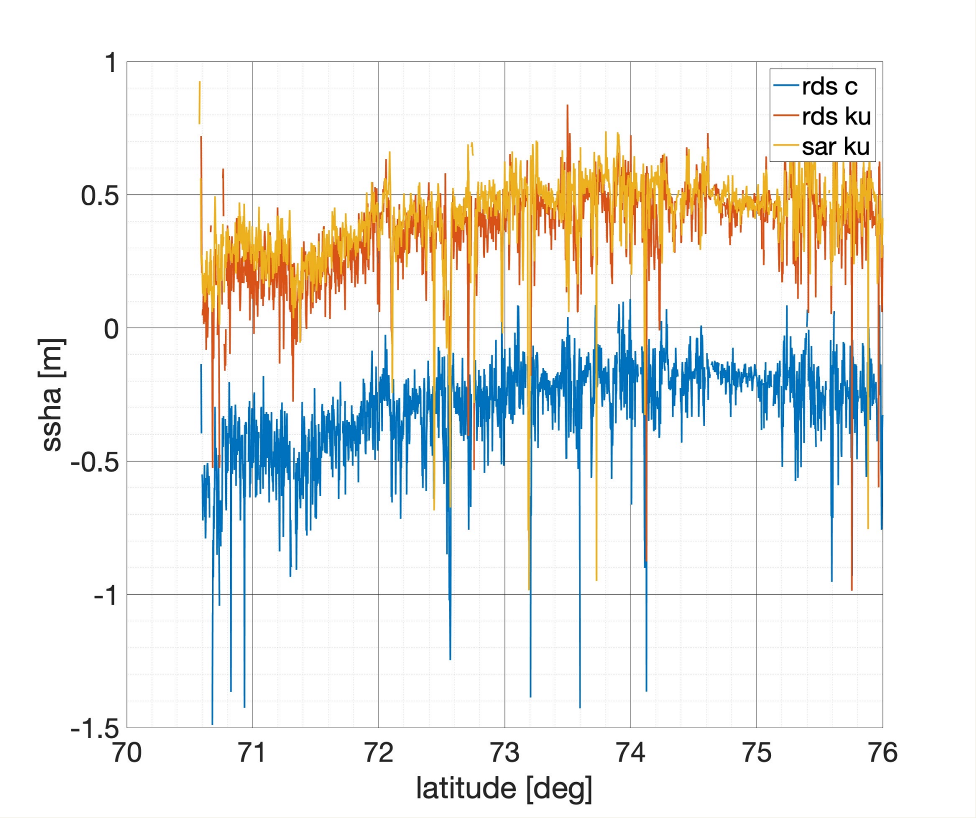
First Results

- SAR and reduced SAR Ku-band match well.
- C-band LRM is higher, but that is expected since it is less attenuated by the atmosphere and snow coverage



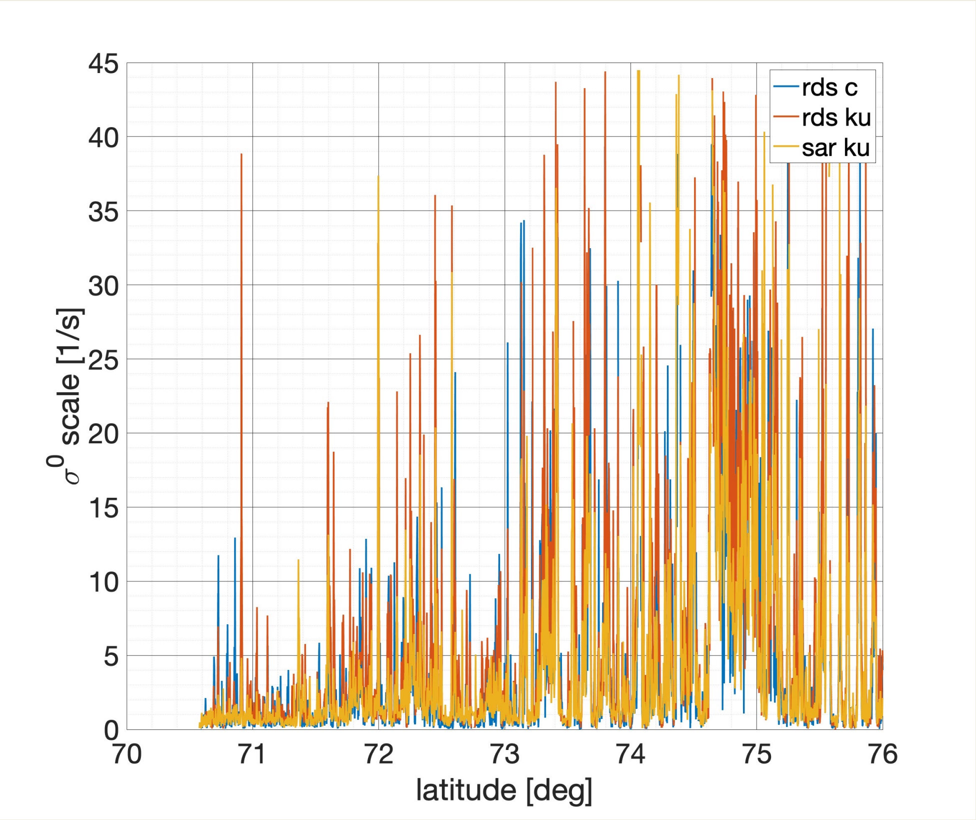
First Results

- SAR and reduced SAR Ku-band have some differences, which needs to be investigated.
- SAR is a few cm higher, which might be caused by the refraction coefficient of snow.
- C-band LRM is lower, but that might be caused by a different reference gate, which we accidentally did not account for.



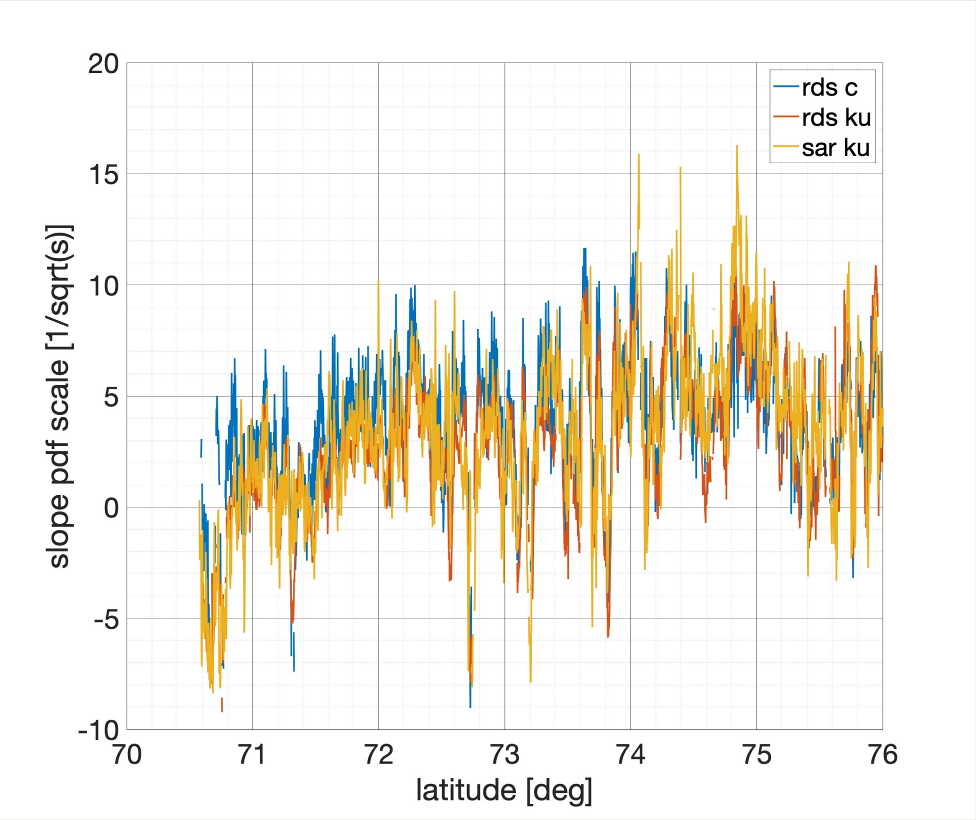
First Results

- Overall, the estimated scaling of the backscattering function is noisy, but all results show the same behavior.
- Adding leads to the retracking might solve this issue.



First Results

- This parameter related to the surface slope variation is estimated consistently by all products.
- Which makes sense as this parameter is independent on signal wavelength.



Conclusions

- We were able to improve the backscattering power function to match sea-ice signals.
- However, snow is no longer observable because the backscattering function decreases in power too slow.
- The model needs some improvements, as we applied the backscattering power function before the PTR – which is technically correct – causing aliasing effects, especially in SAR.
- This is fixable, but we were not able to implement it before the OSTST meeting.
- Waveform + RIP retracking should be sufficient, but if snow refraction affects SAR signals, then stack retracking might help.
- Leads need to be implemented and stack retracking might allow estimating the freeboard as it should be possible to estimate the sea-ice elevation independent from lead elevations.
- A lot of work needs to be done.