

Evaluating laser and Ku-band-Radar airborne retrievals of snow depth and roughness on Arctic sea ice

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Datasets

- IceBridge (2016) ATM L1B Elevation and Return Strength, Version 2
- CReSIS Ku-band SAR onboard Operation IceBridge (L1B Geolocated Radar Echo Strength Profiles, Version 2 (deconvolved))
- Magnaprobe snow depths from ECCC 2016 Snow on Sea Ice Campaign over Eureka

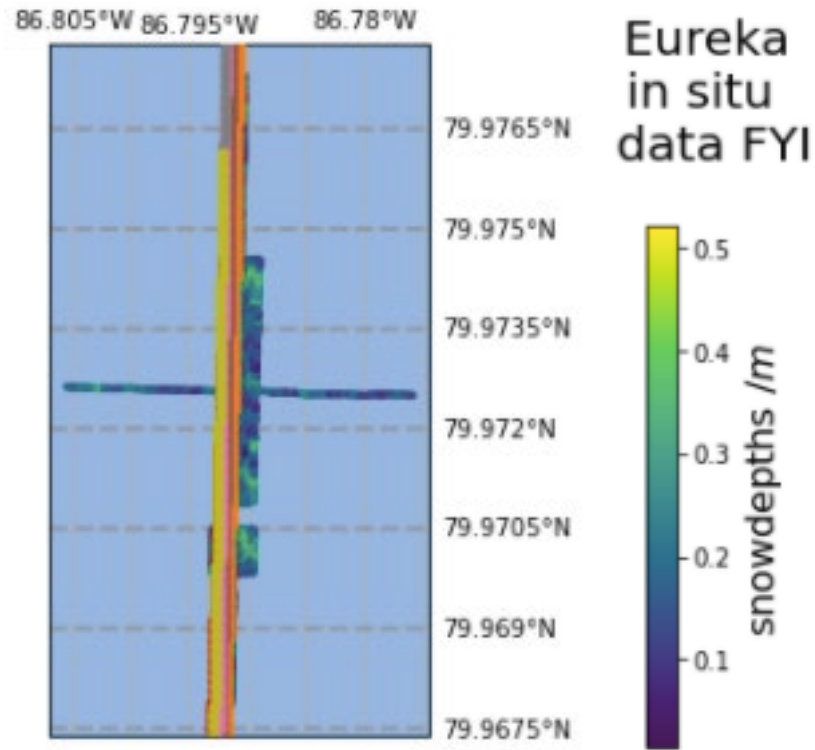
Estimating snow-
depths/roughnesses



← *In Situ Comparison*



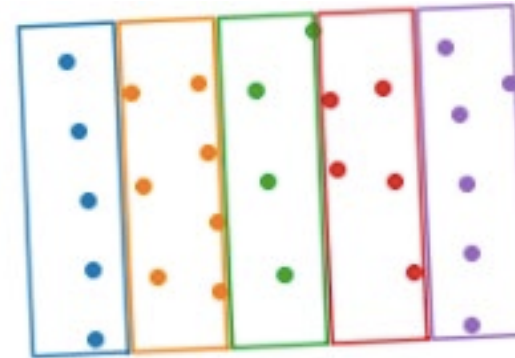
In Situ Comparisons



- Flyovers of in situ snowdepth measurements in Eureka

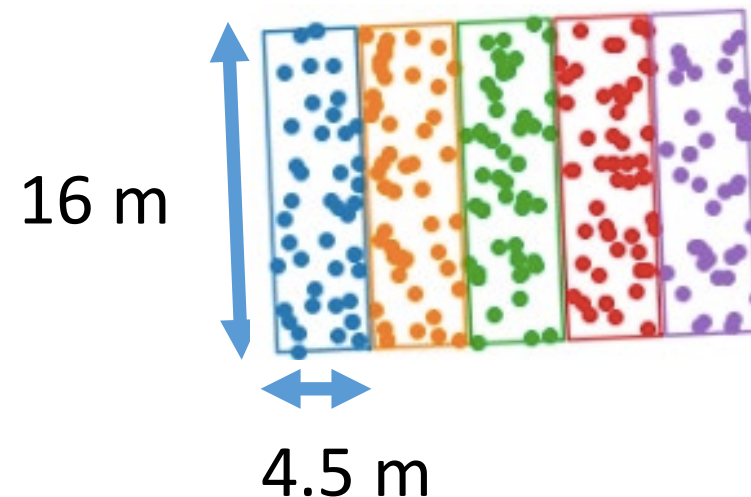
- PROBLEM: No leads for ATM laser-Ku SAR offset calibration

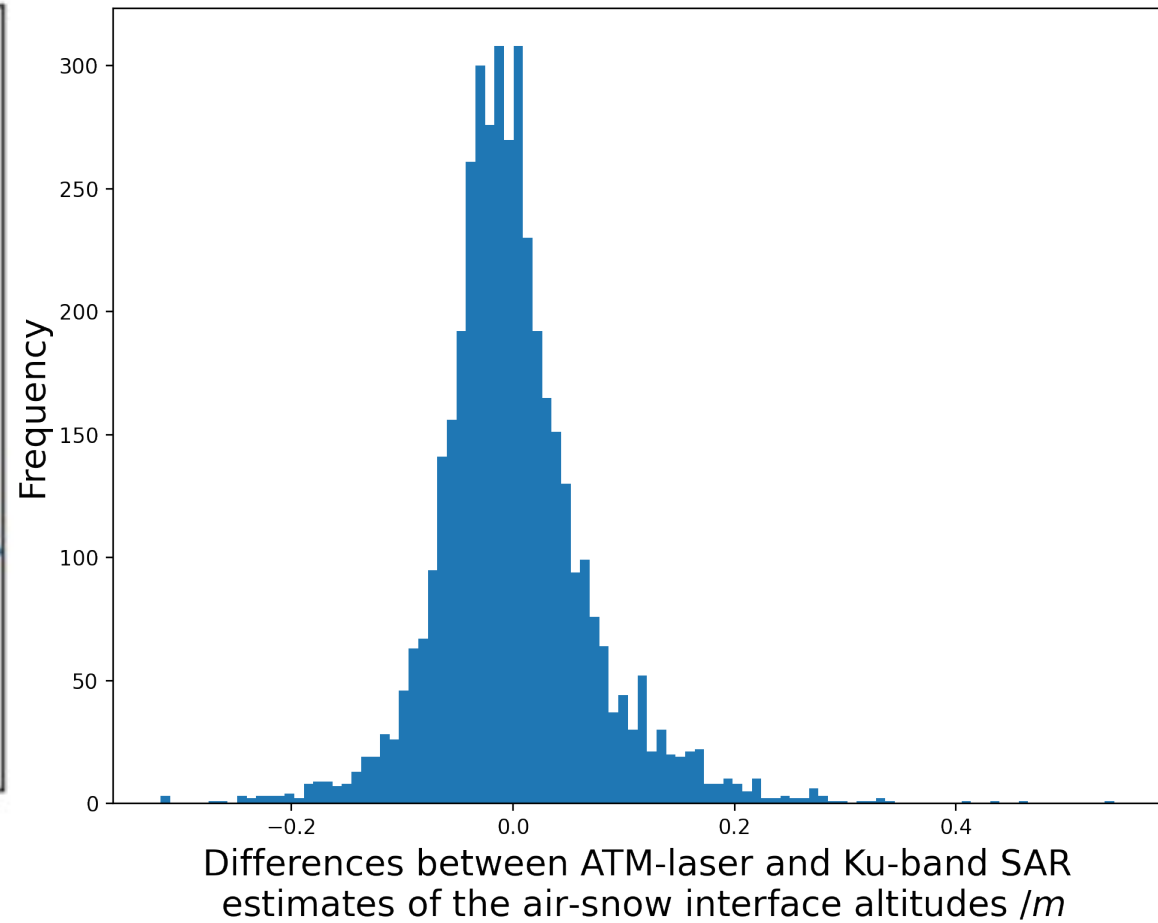
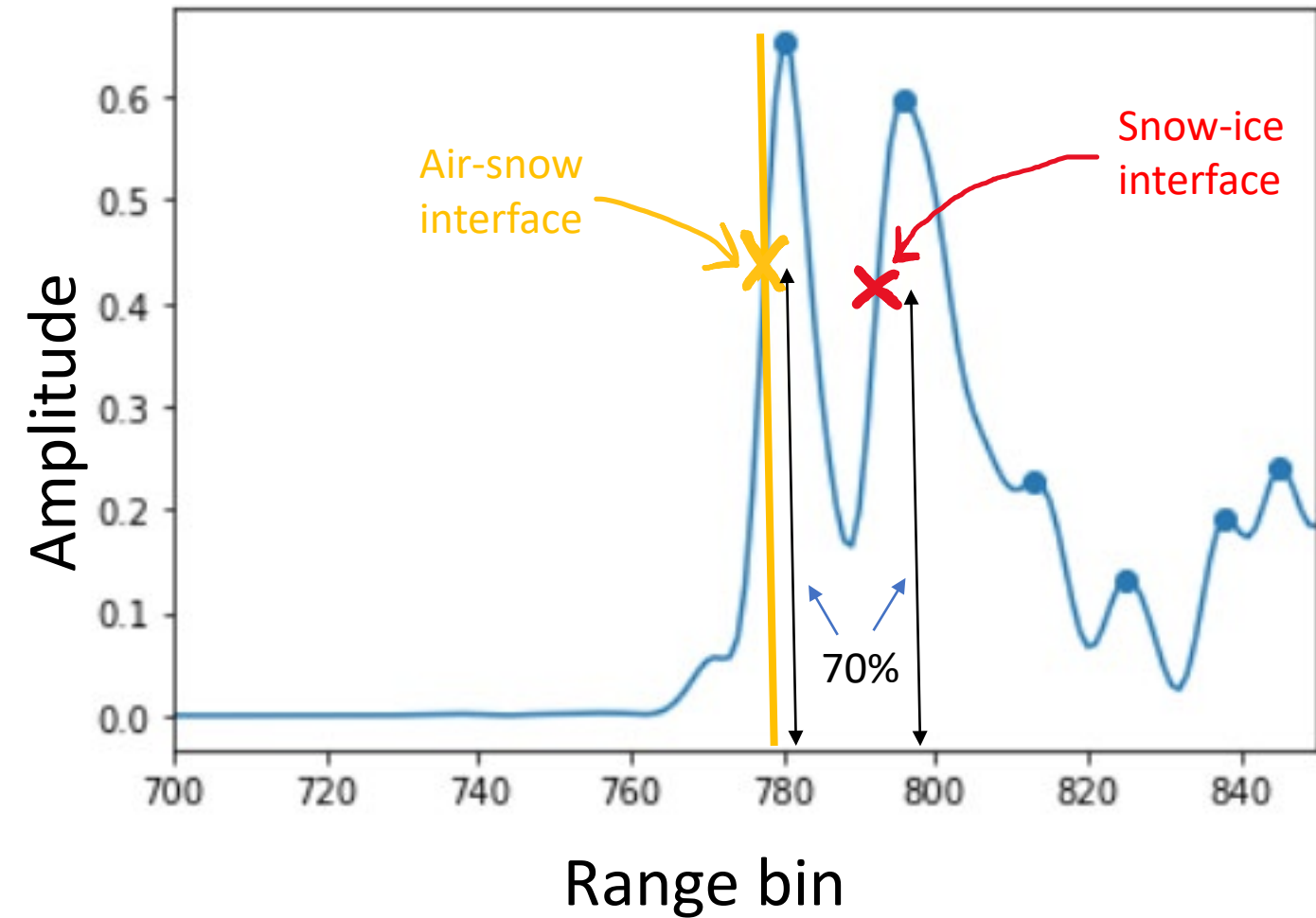
ATM Laser Data within Ku radar Footprints



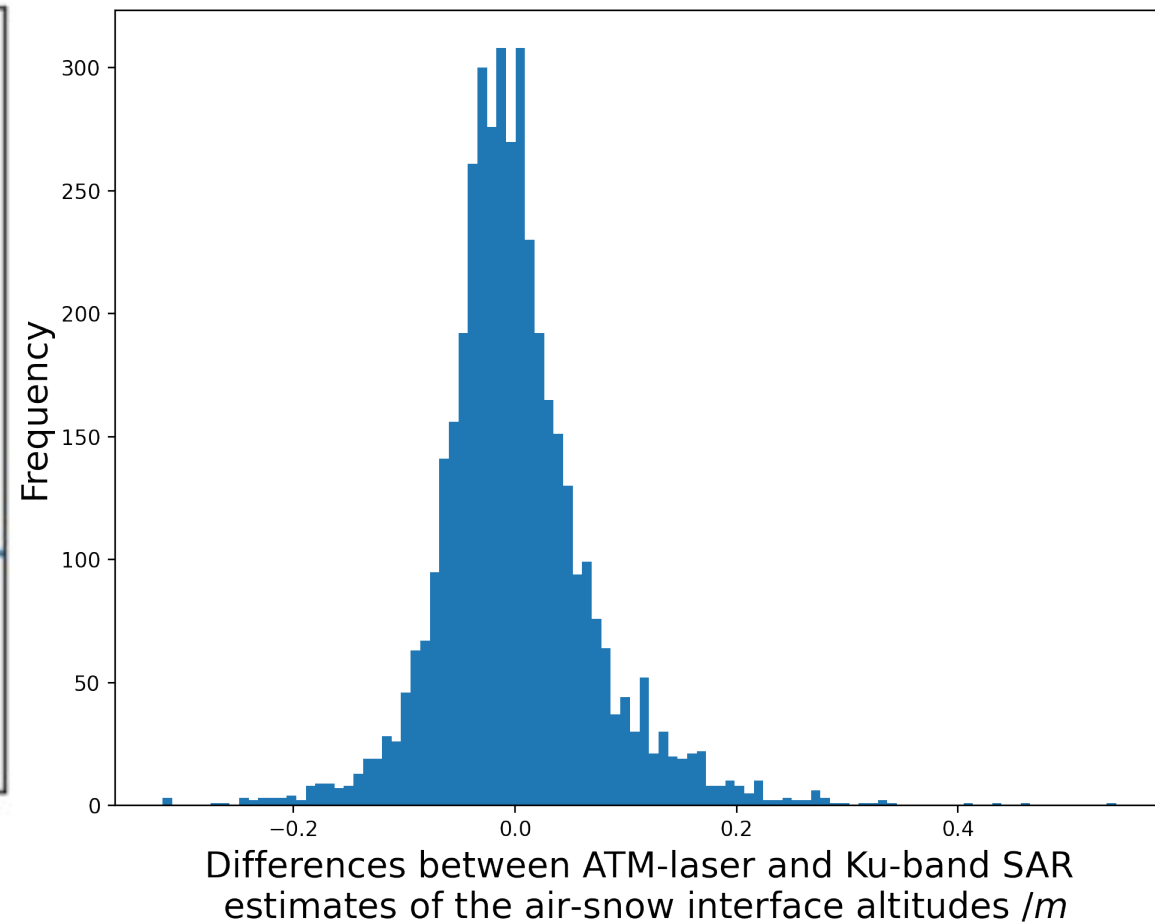
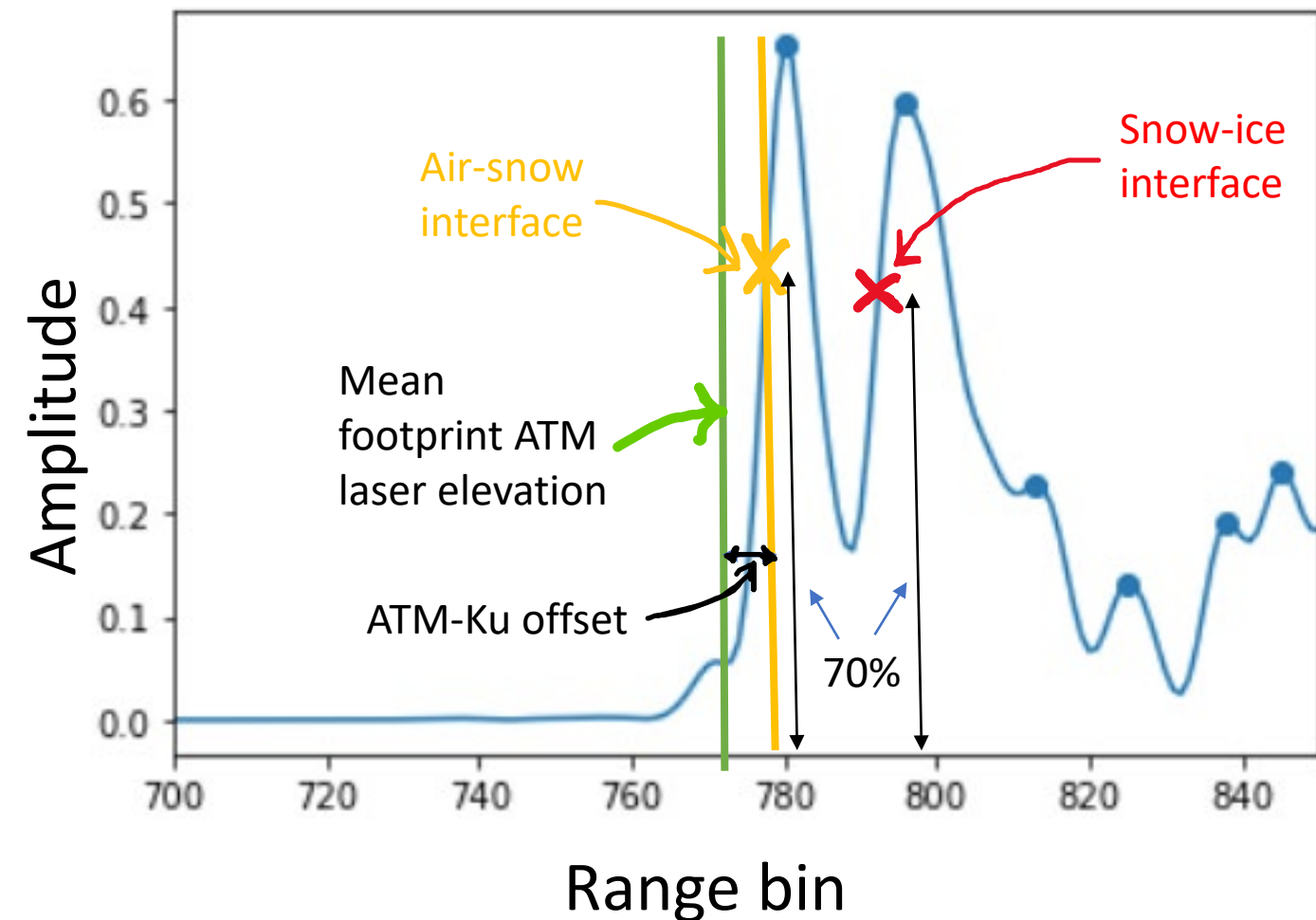
Combining
Flyovers

ATM Laser Data within Ku radar Footprints



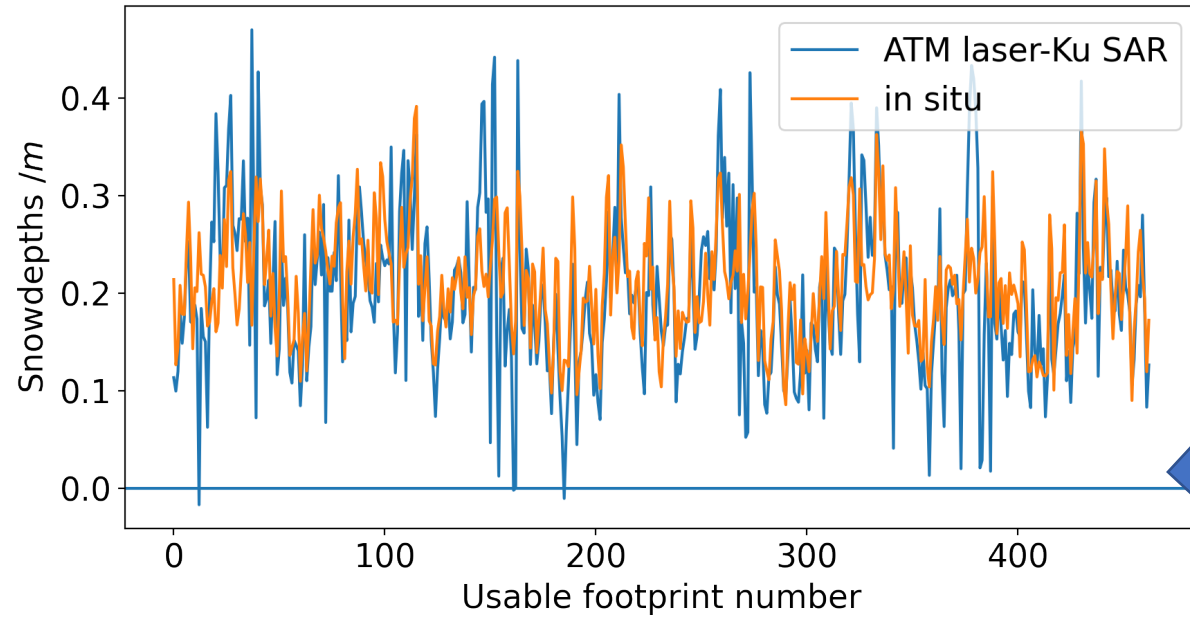


CALIBRATION SOLUTION: air-snow interface in Ku SAR echoes for calibrating with ATM laser elevation

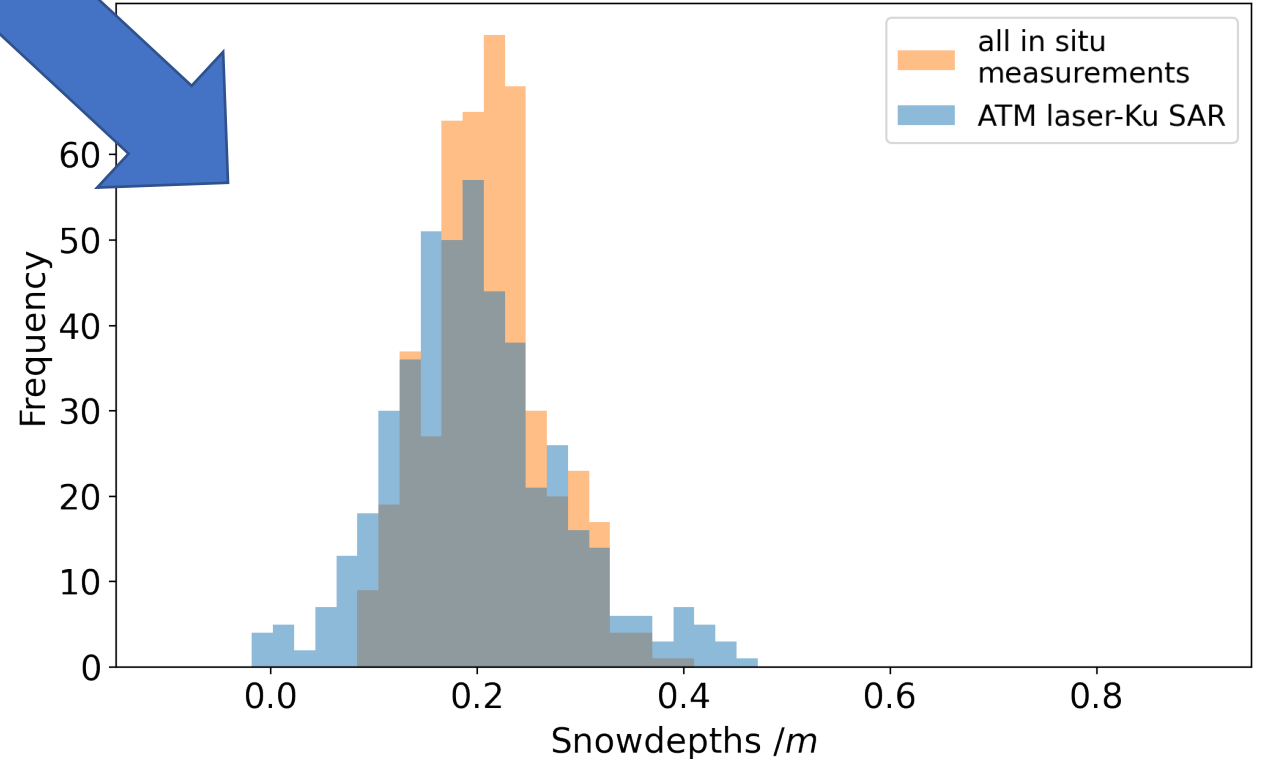


First-Year Ice

FYI



Comparing snow depths estimated from aircraft using ATM laser-Ku SAR to in situ for FYI

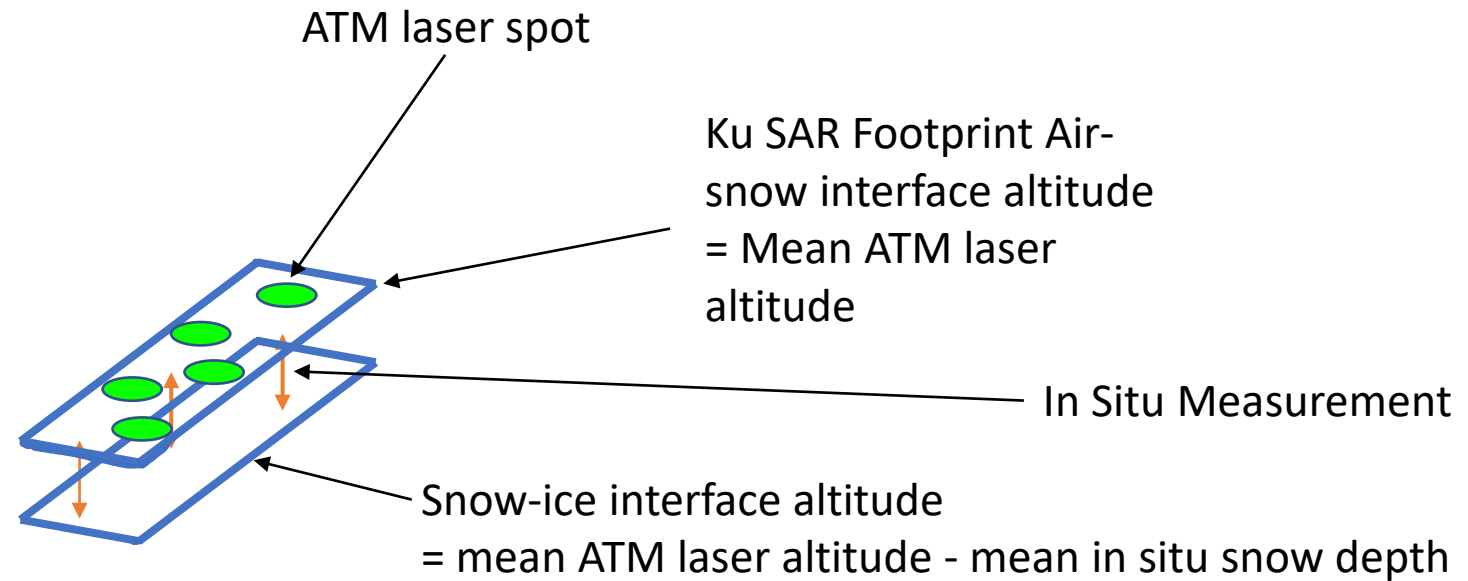


Mean estimated snowdepth: 19.8 ± 0.4 cm

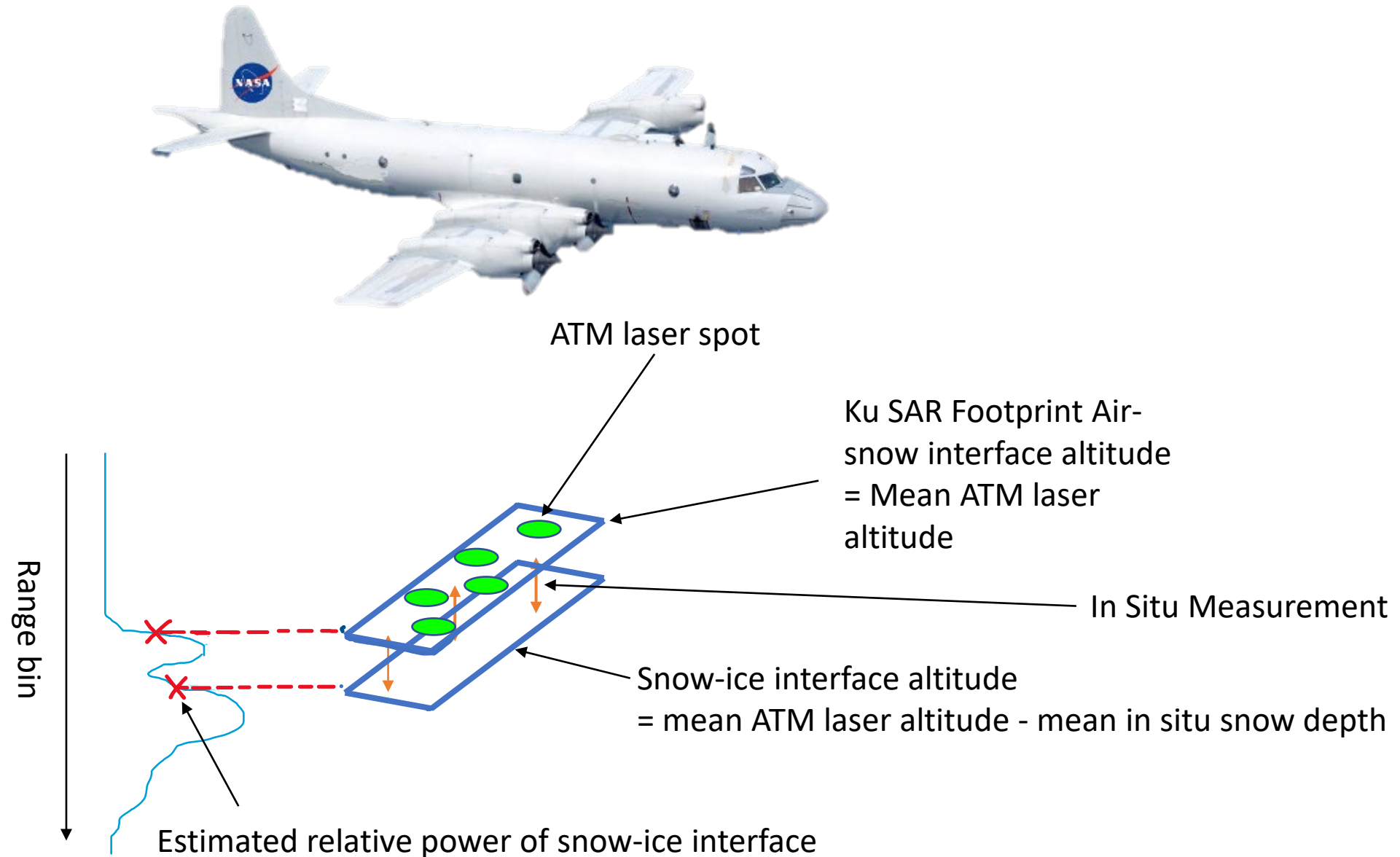
Mean in situ snowdepth: 21.0 ± 0.3 cm

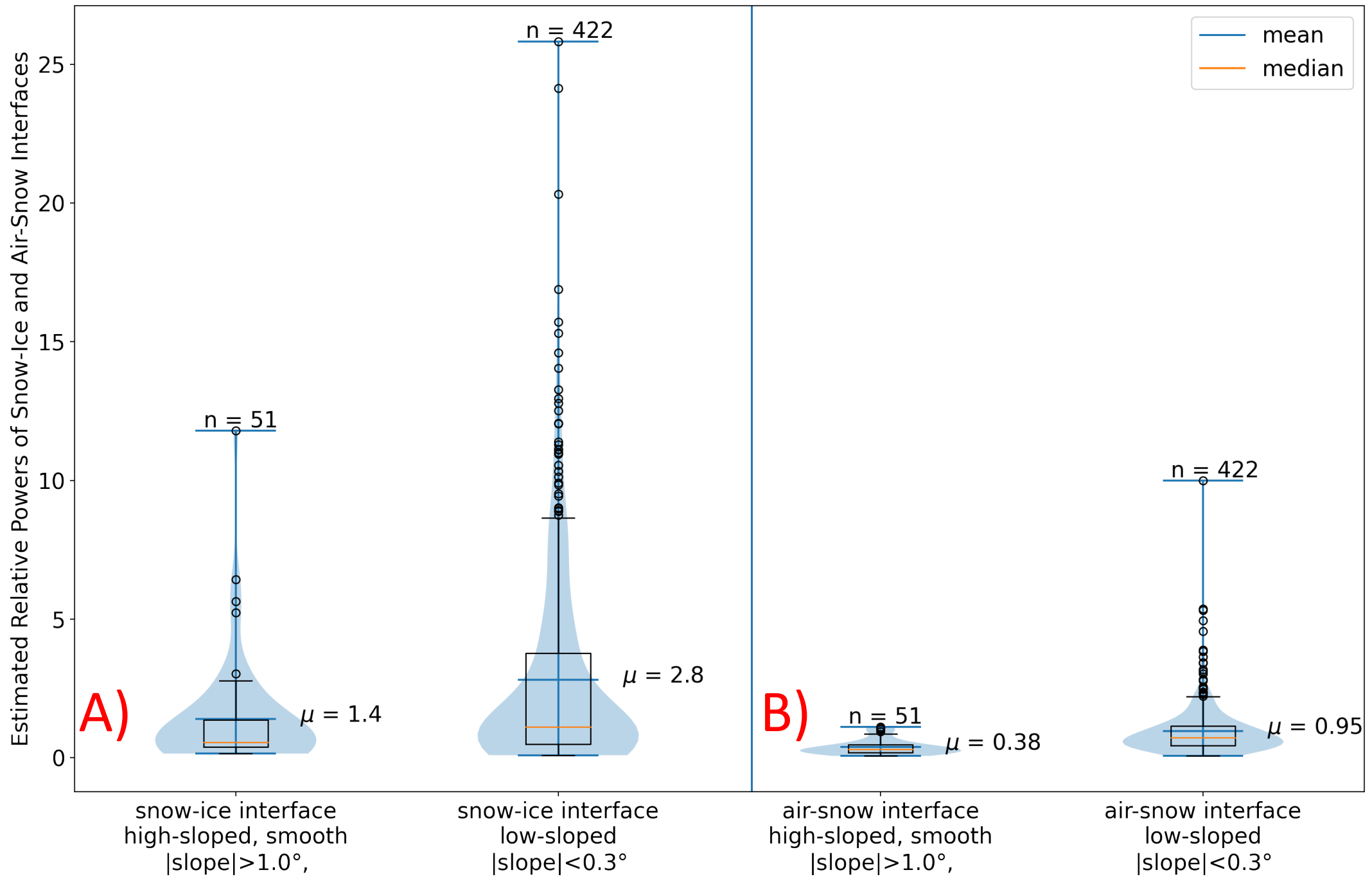
Footprint-scale mean difference between estimated snowdepth and in situ: 4.95 cm

Estimating Powers at the Interfaces

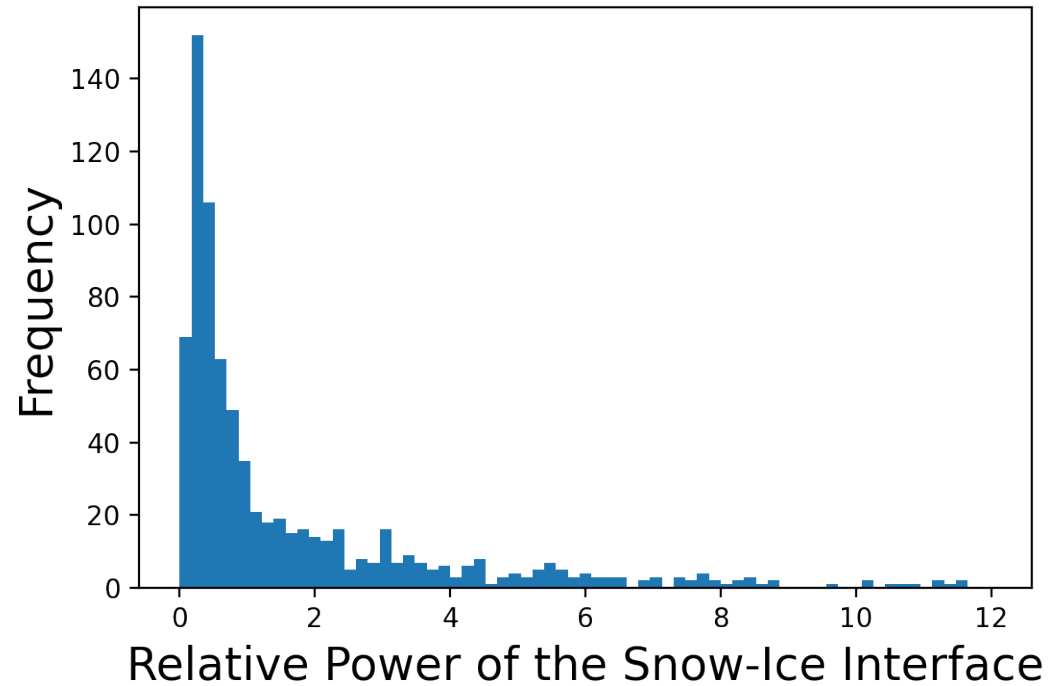
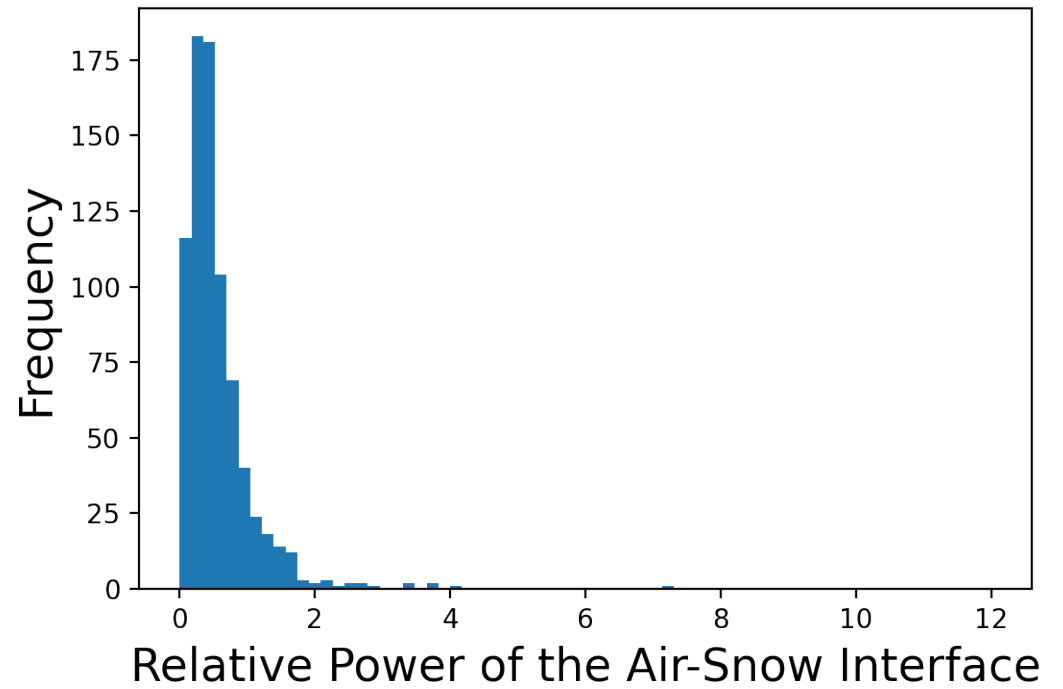
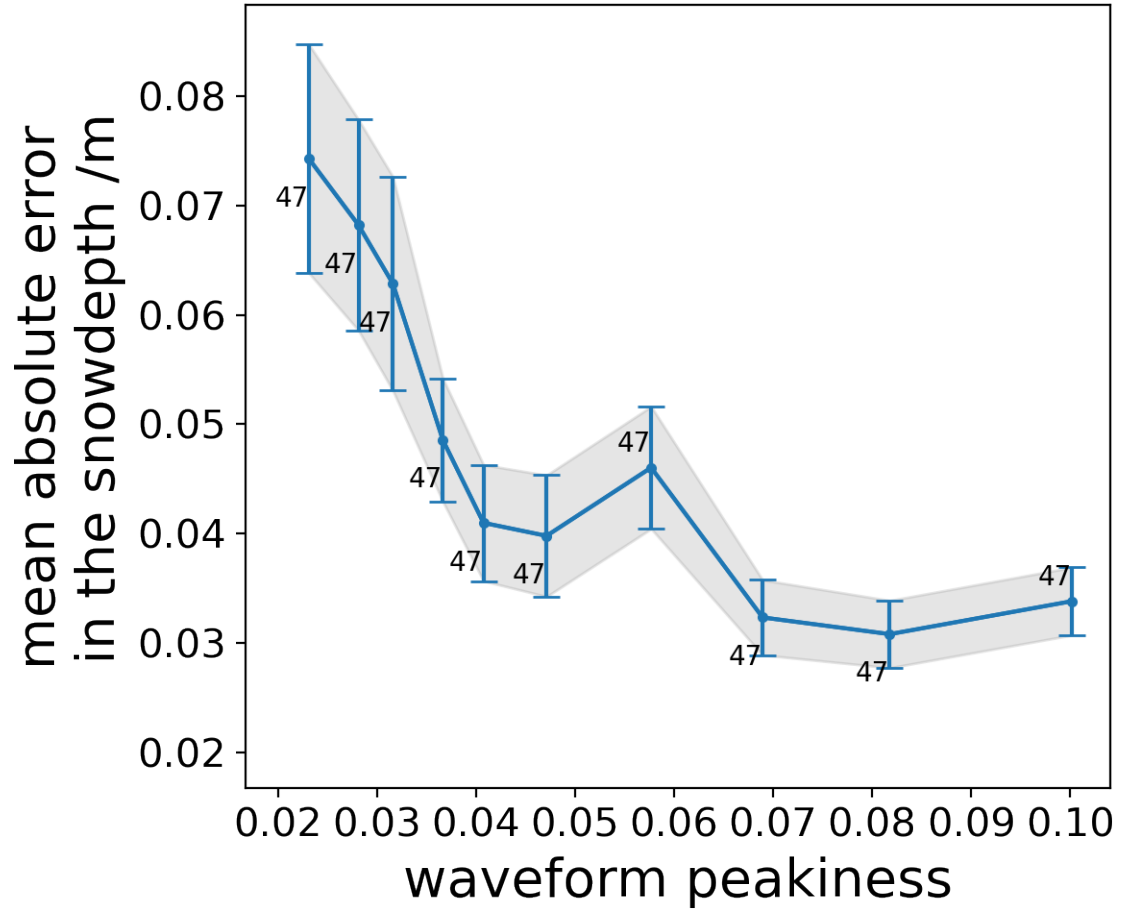


Estimating Powers at the Interfaces

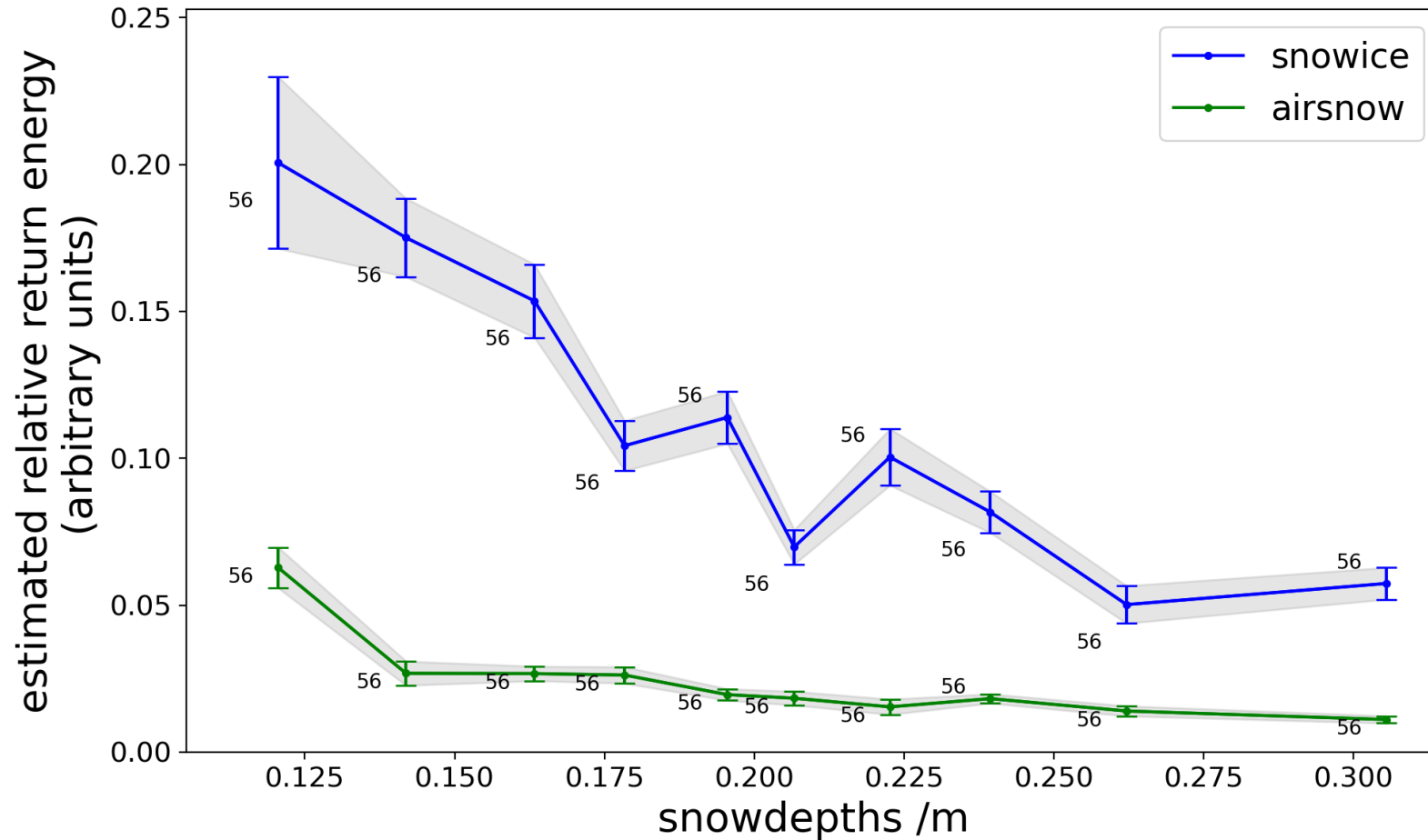




First-Year Ice



First-Year Ice



Energy \approx power at interface x time to cross
interface (based on roughness)

First-Year Ice

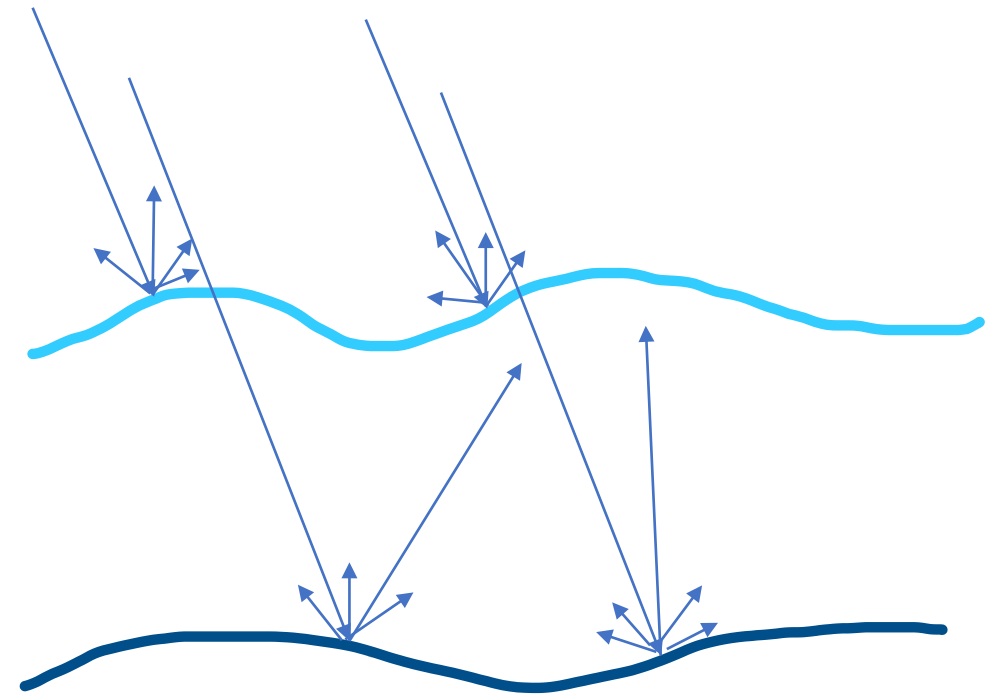
For 32.4% of samples the power of the air-snow return was stronger than the snow-ice

Despite this, the mean ratio of powers between the snow-ice interface and air-snow interface powers was 4.82 for FYI

Multi-Year Ice

For 39.7% of samples the power of the air-snow return was stronger than the snow-ice

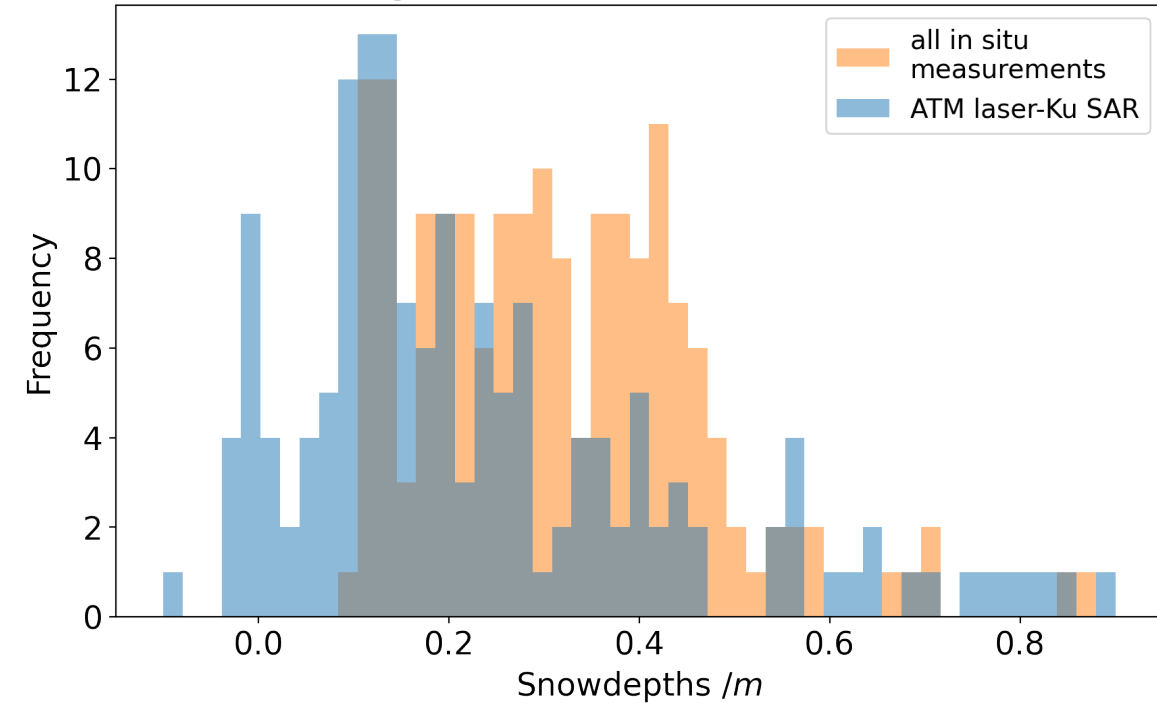
Despite this, the mean ratio of powers between the snow-ice interface and air-snow interface powers was 4.26 for MYI



This infers a probabilistic quasi-specular scattering of the snow-ice interface

Multi-Year Ice

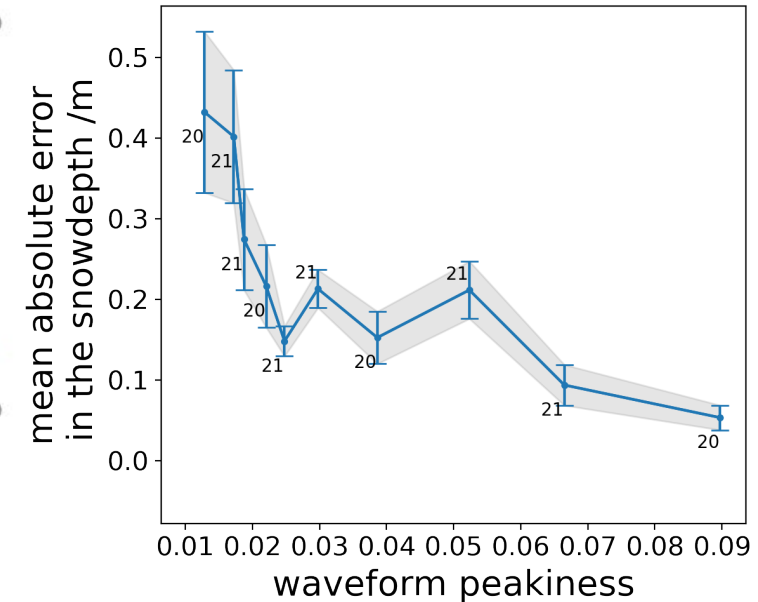
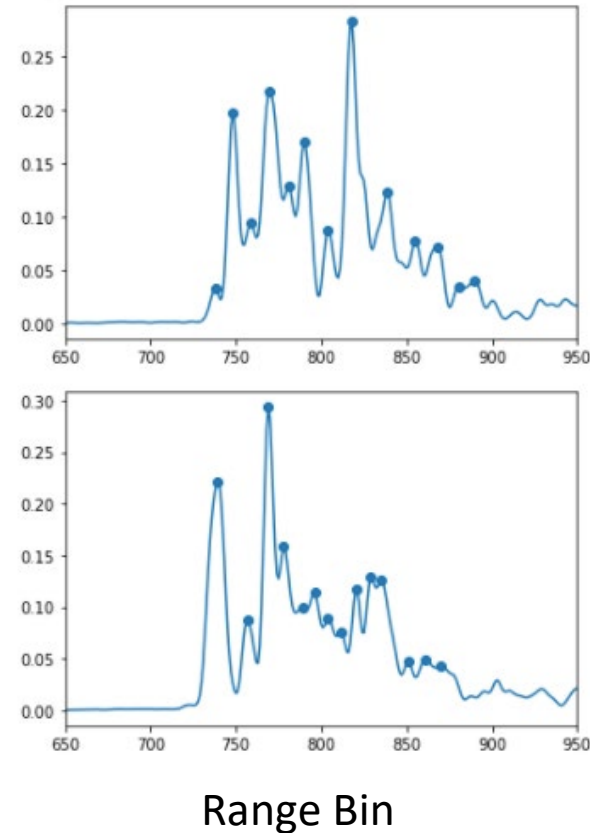
Comparing snow depths estimated from aircraft using ATM laser-Ku SAR to in situ for MYI



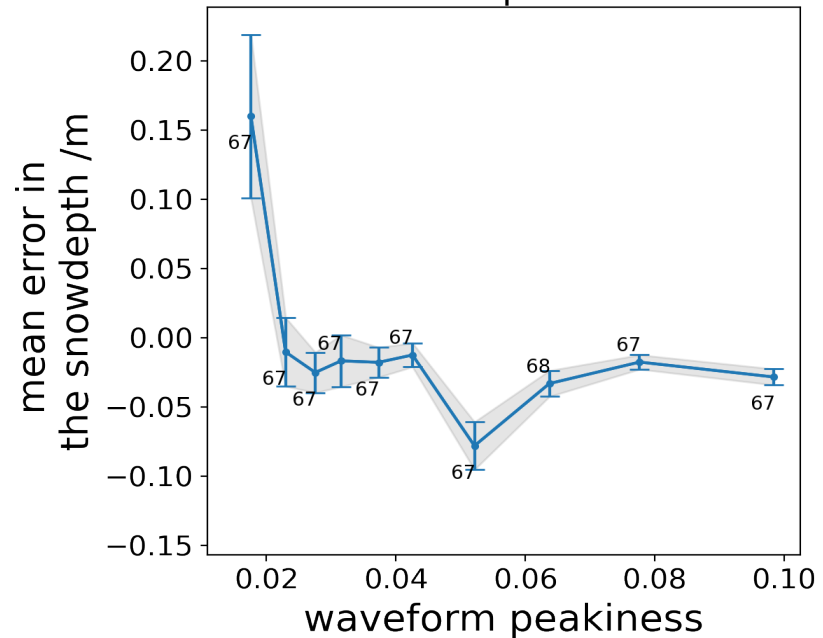
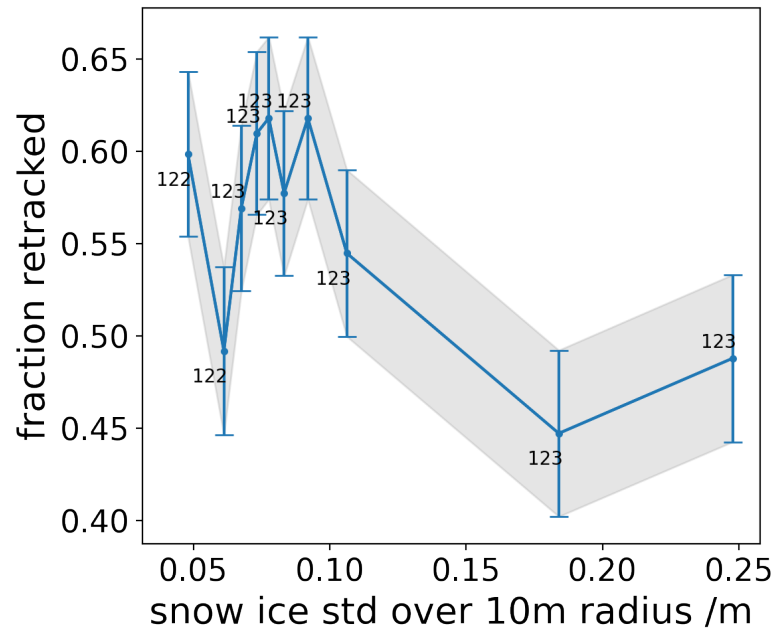
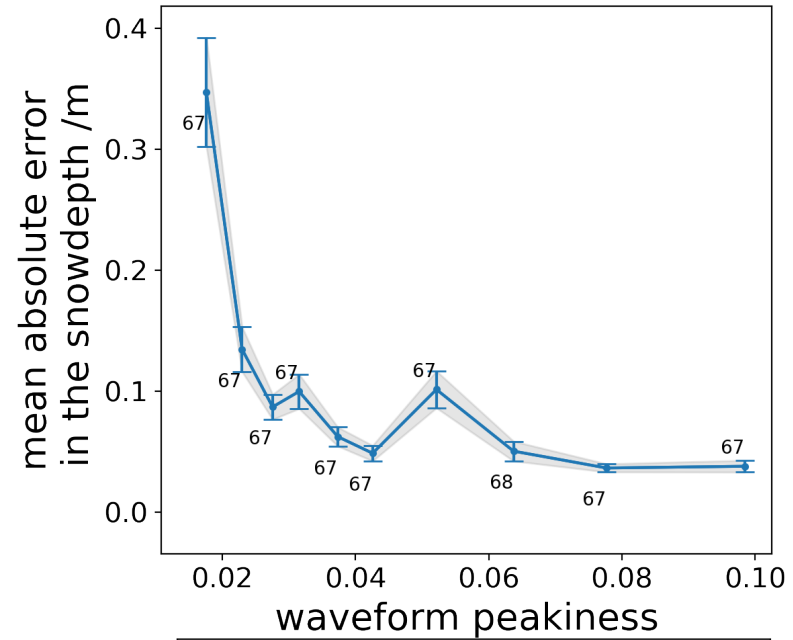
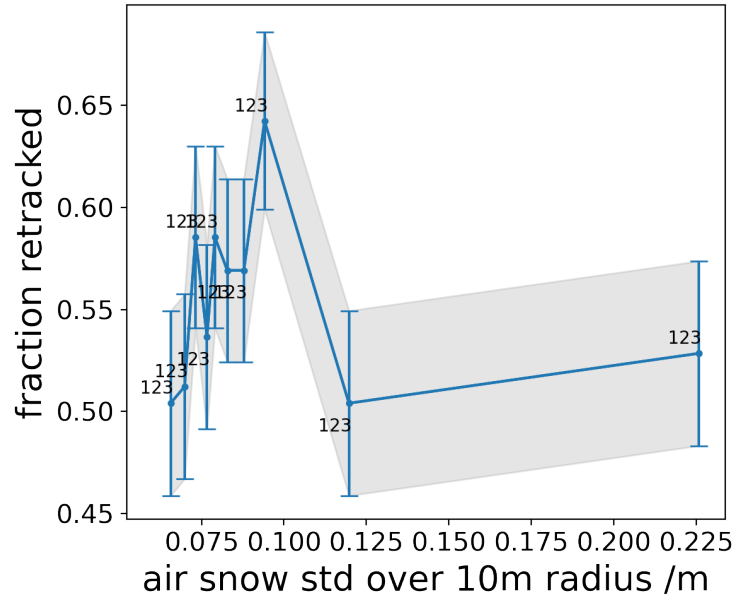
Mean estimated snowdepth: 28.0 ± 0.4 cm

Mean in situ snowdepth: 31.2 ± 1.1 cm

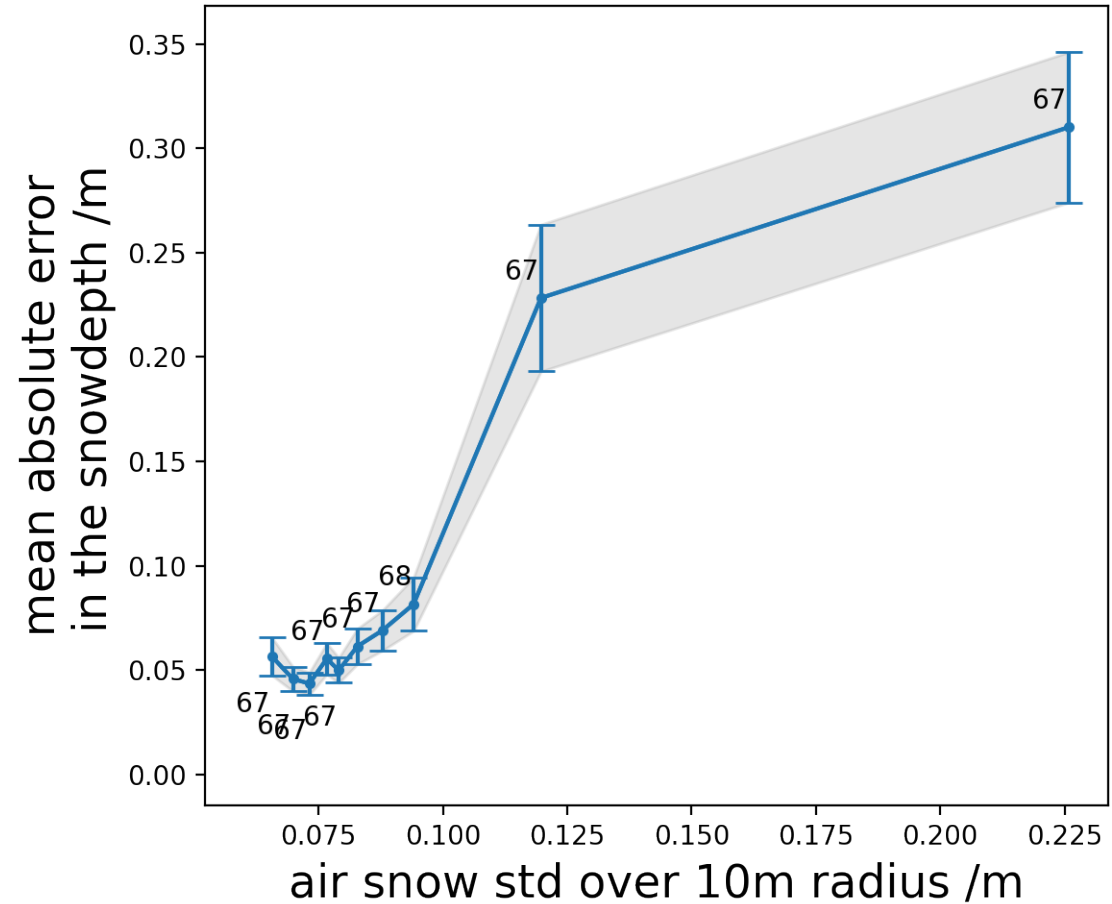
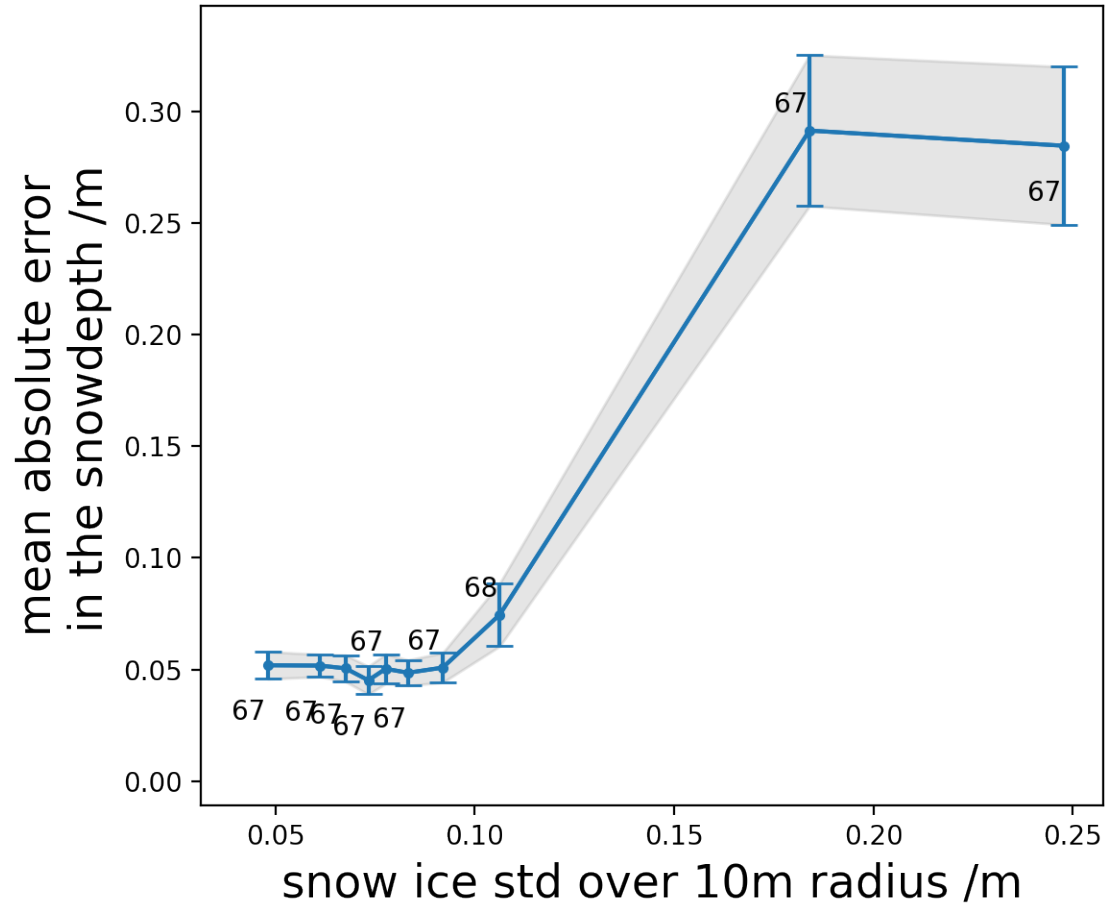
Footprint-scale mean difference between estimated snowdepth and in situ: 19.8 cm



First-Year and Multi-Year Ice Combined



The Effect of Roughness on Snowdepth Uncertainty



Takeaways

- Instruments need to be calibrated to each other to estimate snow depths
- Air-snow interface seen in aircraft Ku SAR can be used to calibrate ATM laser data in leadless areas
- FYI Data supports more diffuse scattering of air-snow interface and probabilistically strong, quasi-specular scattering of snow-ice interface
- Successful retracking over FYI and mostly unsuccessful retracking over MYI
- Roughly 4-5x more energy from snow ice interface *on average* BUT footprint-to-footprint 33-40% of waveforms have stronger air-snow interface...
- No significant underestimate in first-year ice snow depths despite high basal salinity (11 ppt in bottom 5th of FYI)

Thankyou for Listening!

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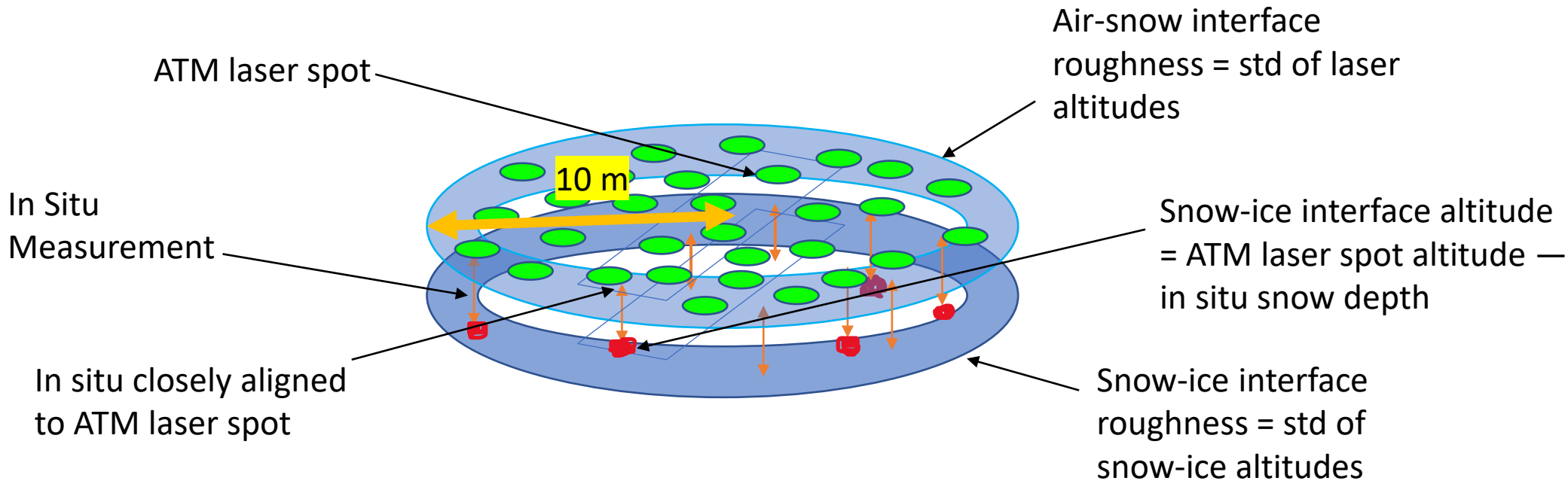
<https://github.com/ClaudeDRT/Eureka2016SnowAnalysis>



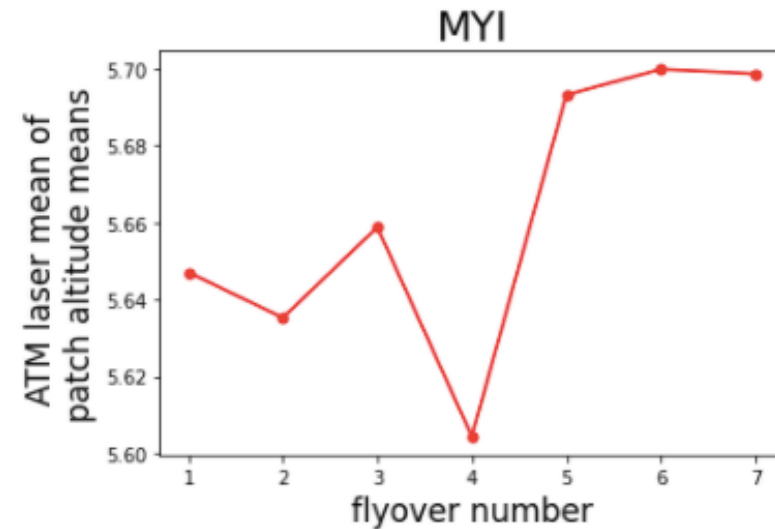
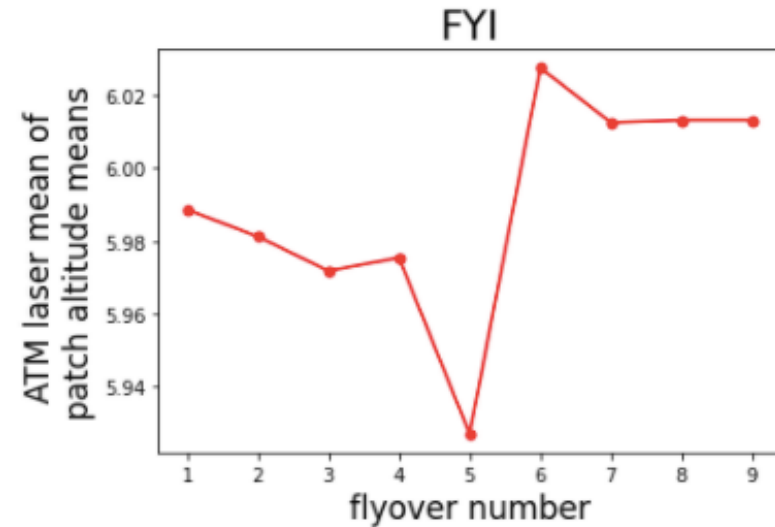
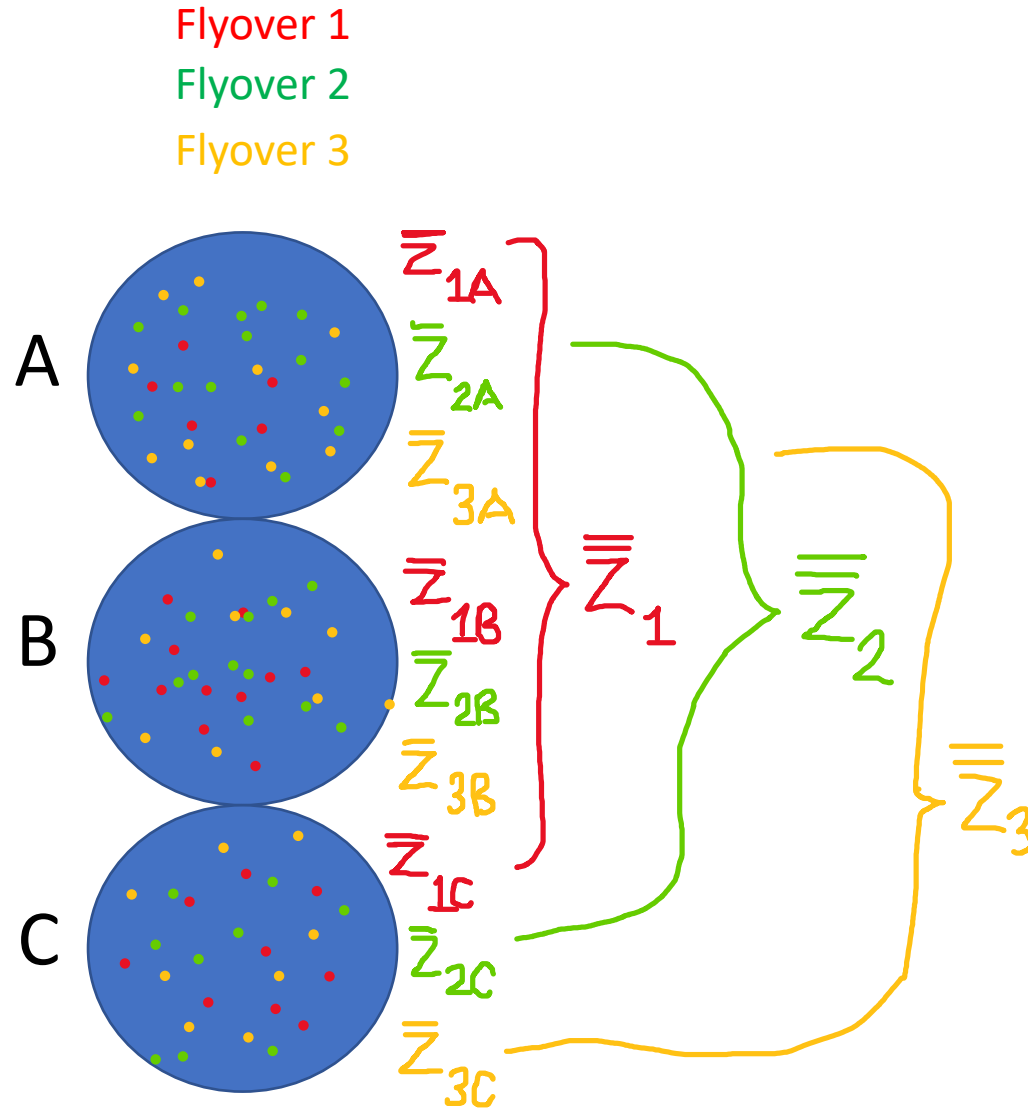
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Measuring The Air-Snow and Snow-Ice Interface Roughness

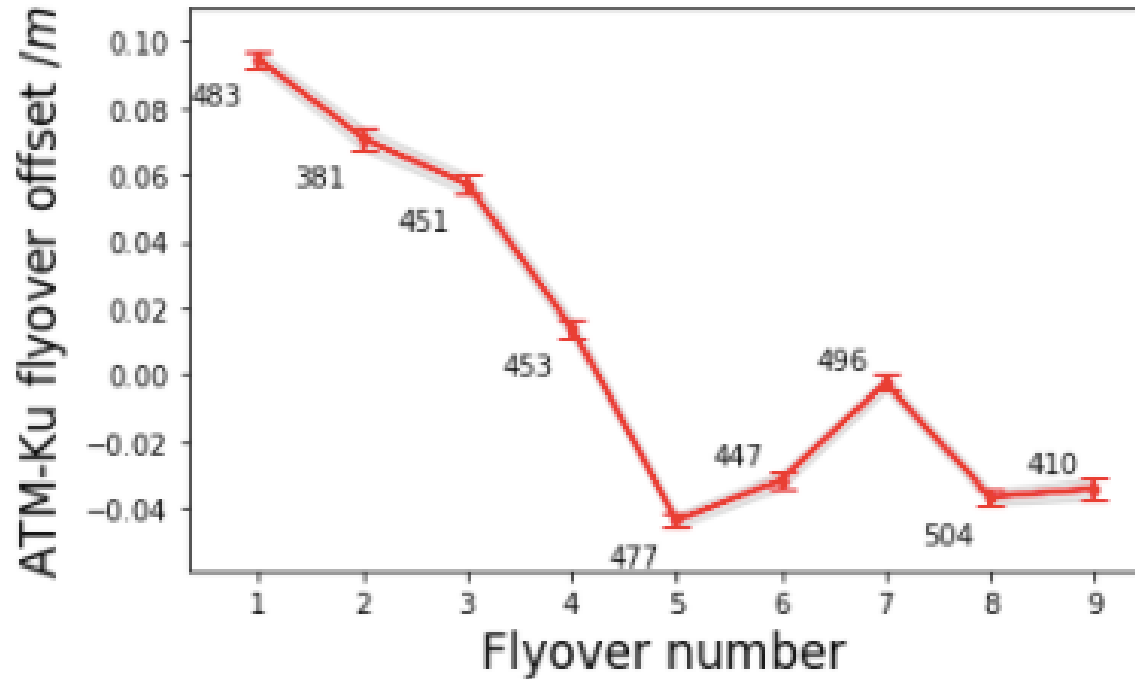


Calibrating ATM Laser Files to Each Other

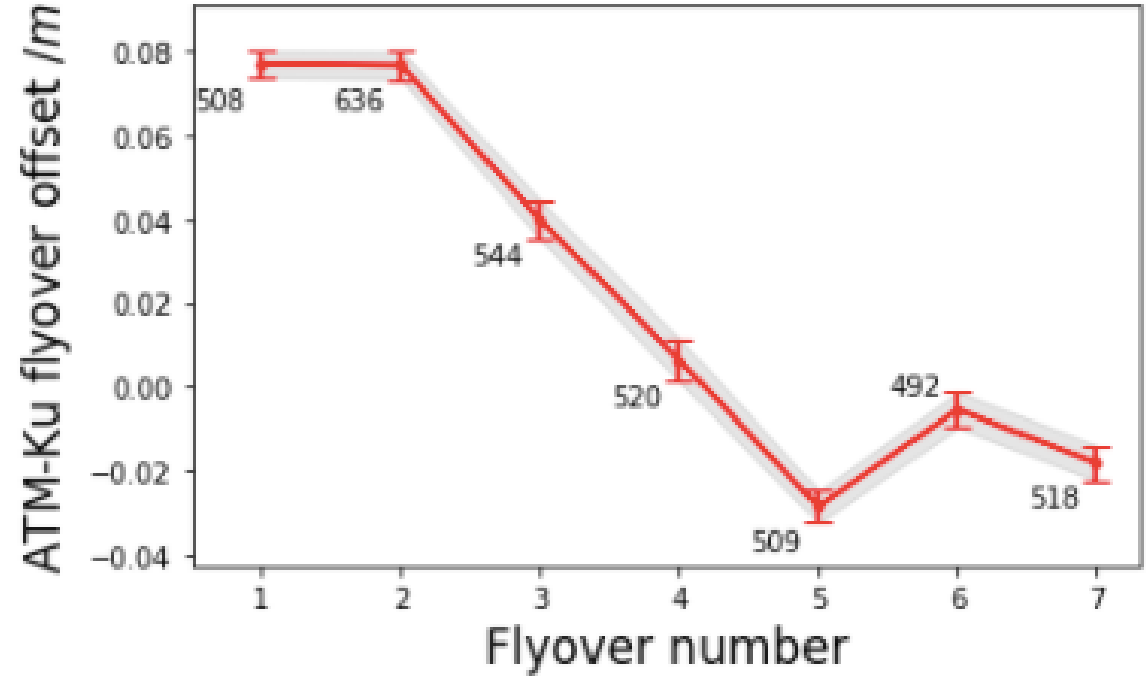


ATM-Ku Flyover Offsets

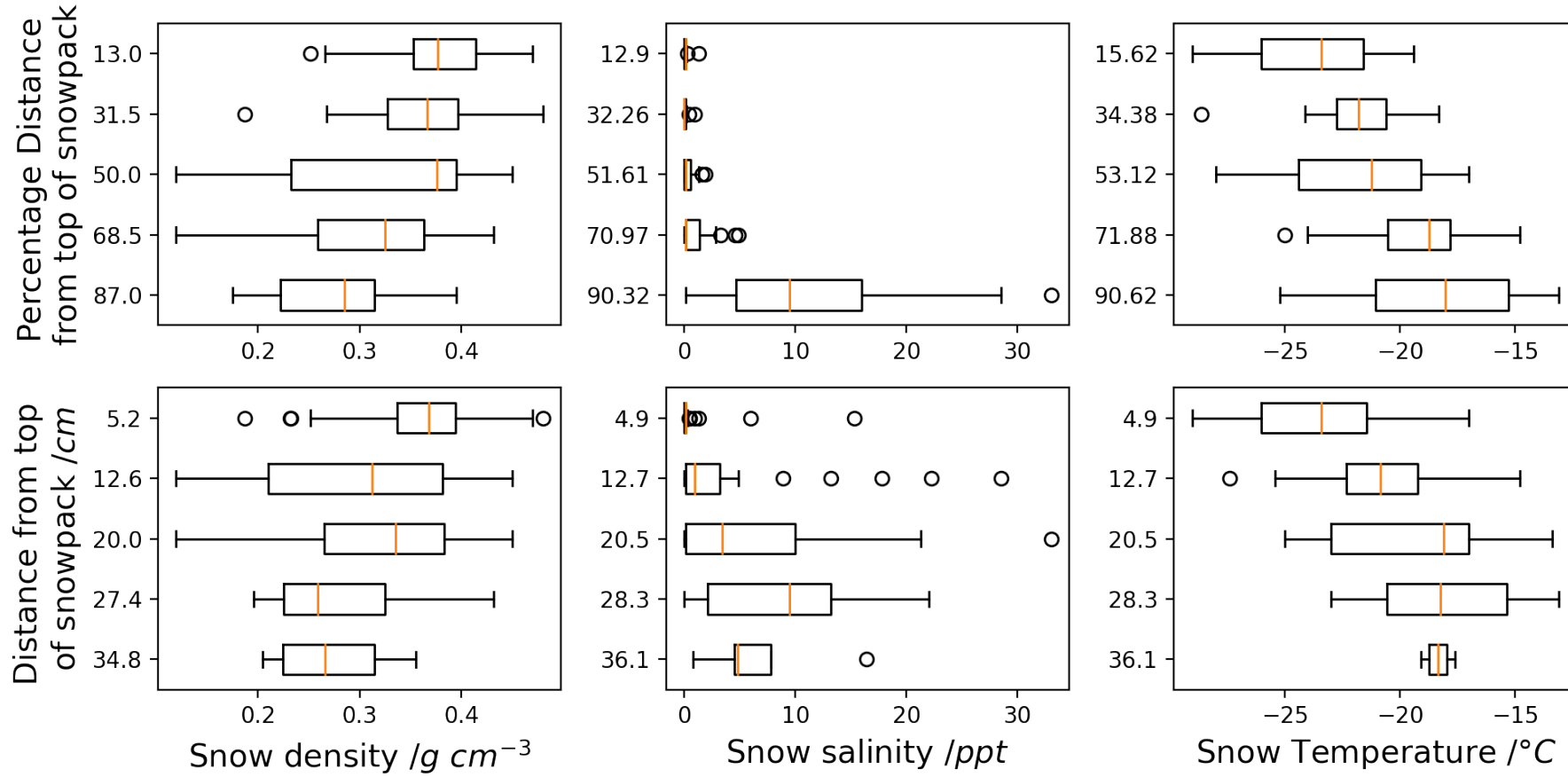
FYI



MYI



FYI In Situ Data



MYI In Situ Data

