Comparisons of satellite and airborne radar and laser altimetry over the ice sheets – three case studies

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Centre for Polar Observation and Modelling

cpom

Natural Environment Research Council

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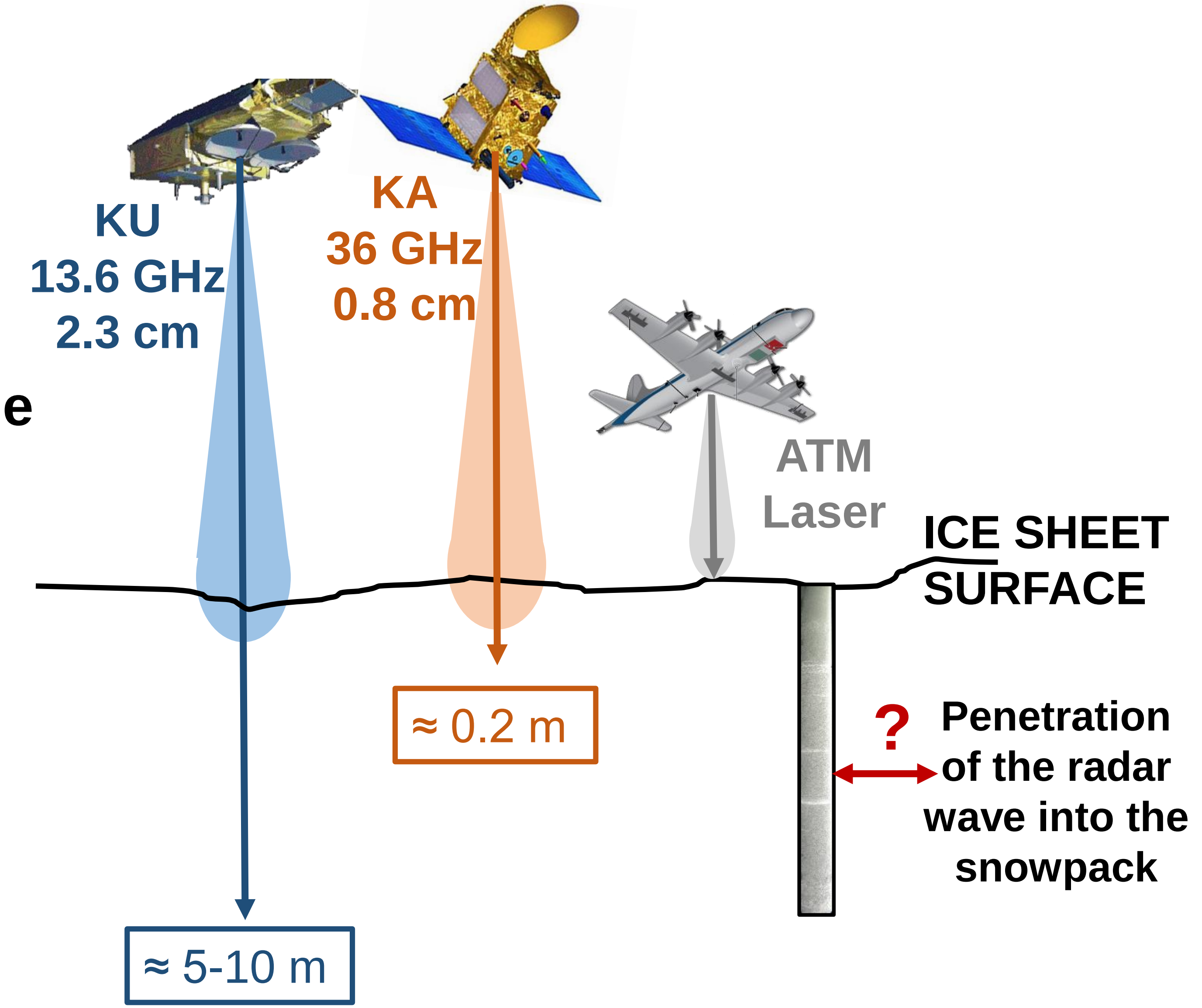
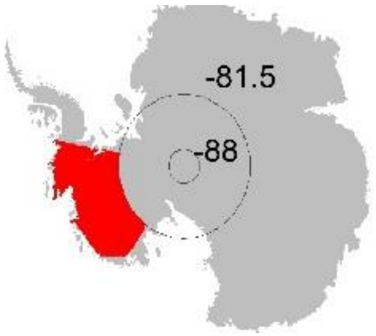
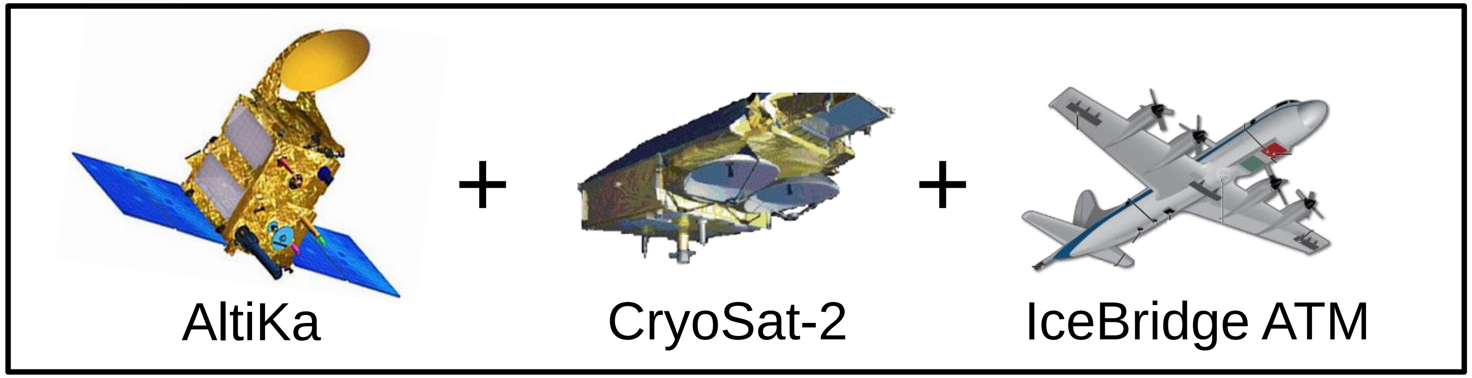
Three case studies in Antarctica and Greenland

1. **West Antarctica**
   CryoSat-2/AltiKa/OIB
2. **West Central Greenland, EGIG line**
   ASIRAS/KAREN/ALS
3. **Northwest Greenland**
   CryoSat-2/OIB







1. Ice Sheet Elevation Change in West Antarctica From Ka Band Satellite Radar Altimetry

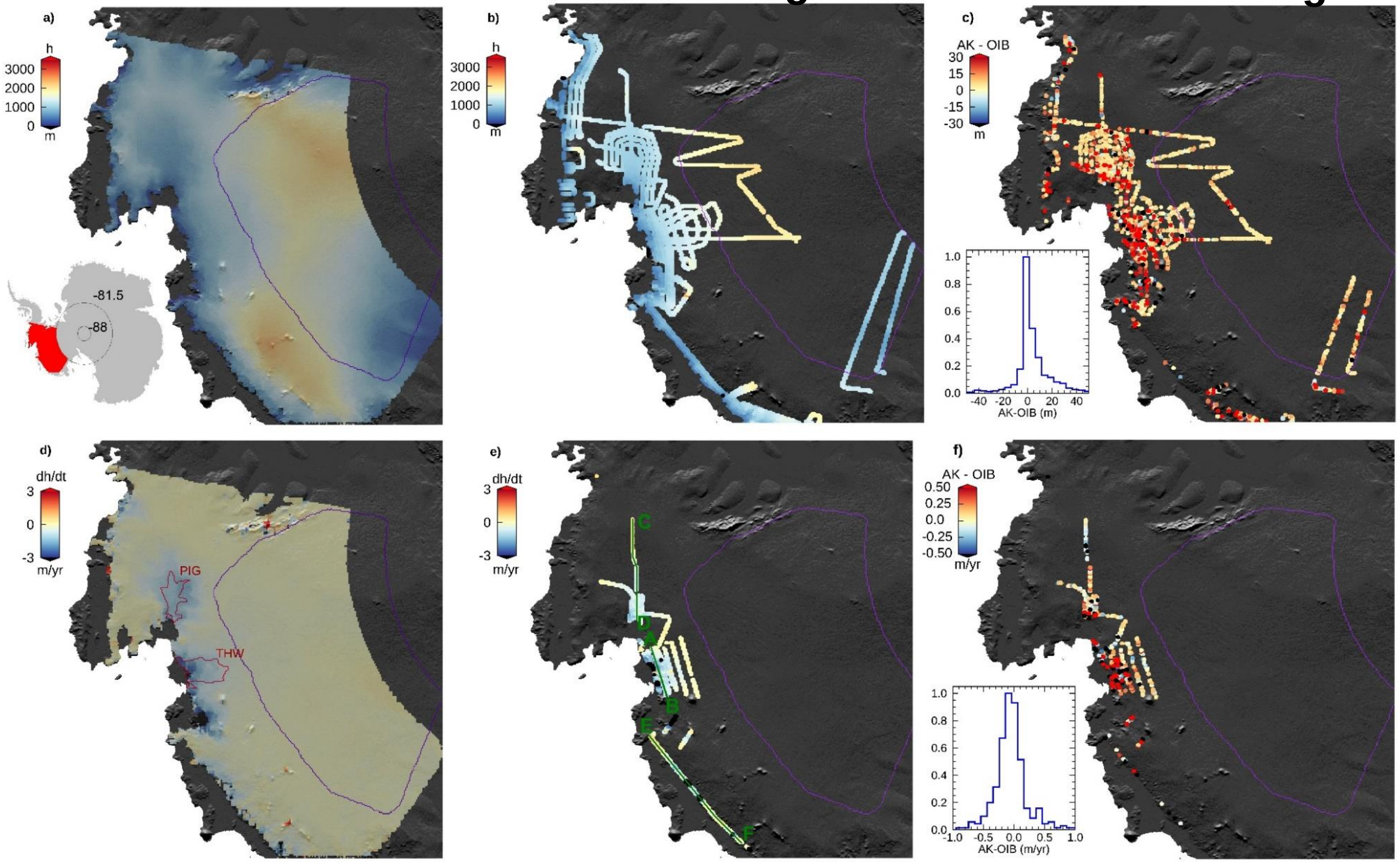
Inès N. Otosaka, Andrew Shepherd, Mal McMillan

Overall good agreement between Ka-band satellite altimetry and airborne laser altimetry

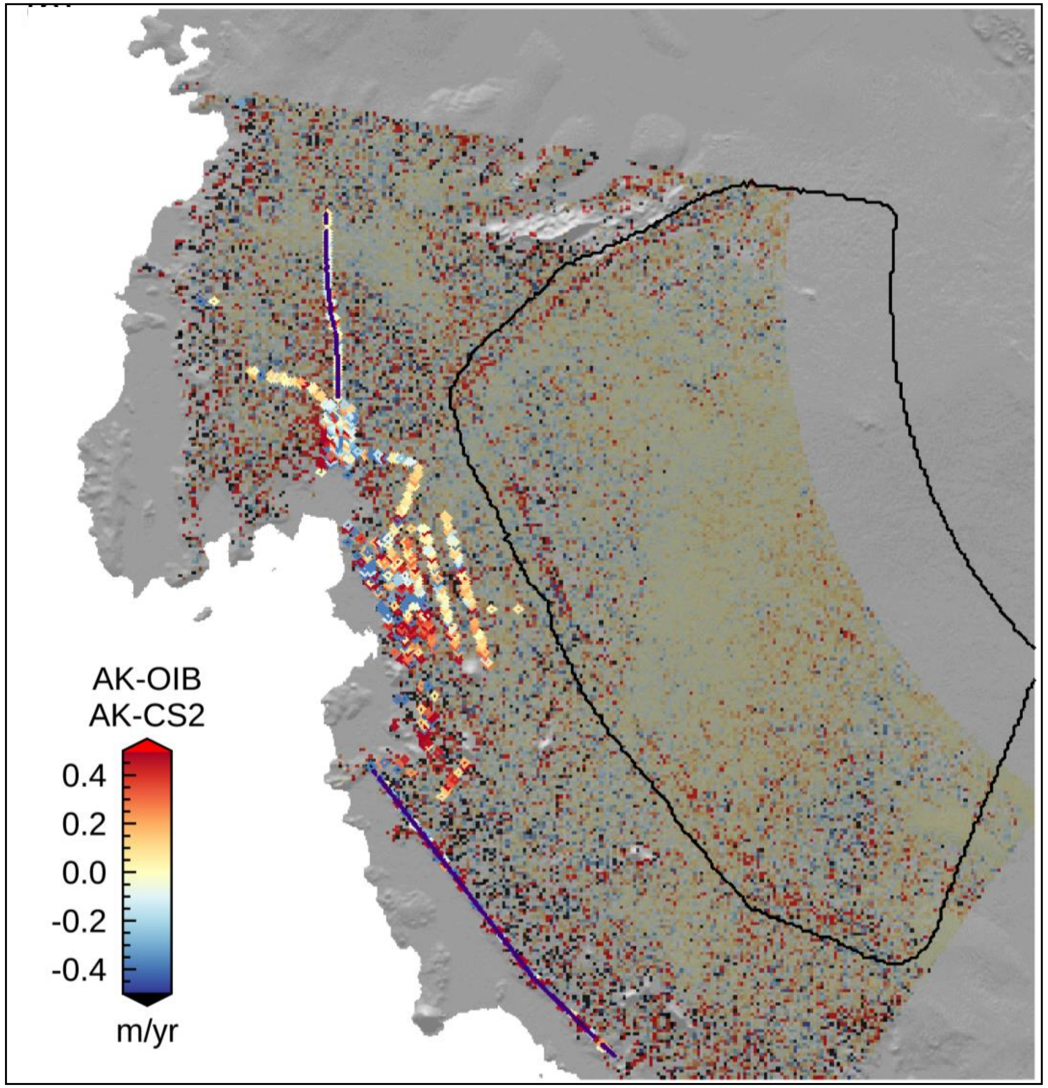
AltiKa | **IceBridge** | **AltiKa-IceBridge**

Elevation

Elevation change



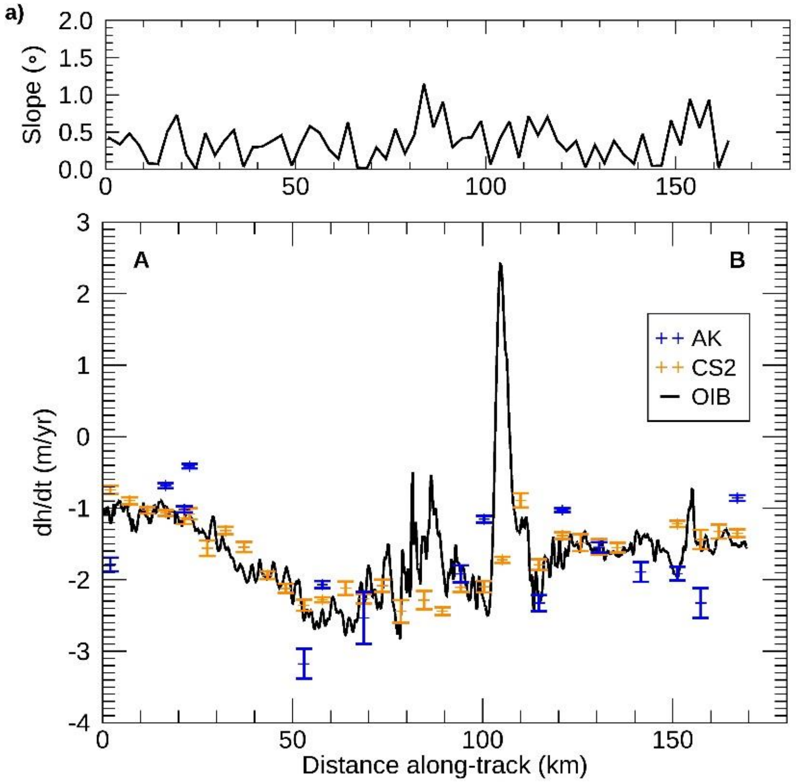
Good agreement between Ka-band and Ku-band satellite altimetry showing that trends in penetration are minor in this region



[cm/yr]	AK – OIB	CS2 – OIB	AK – CS2
Mean	-3.1 ± 2.2	-1.1 ± 1.6	-0.3 ± 0.1
Median	-3.0	-0.6	-0.1
STD	44.9	31.9	13.4

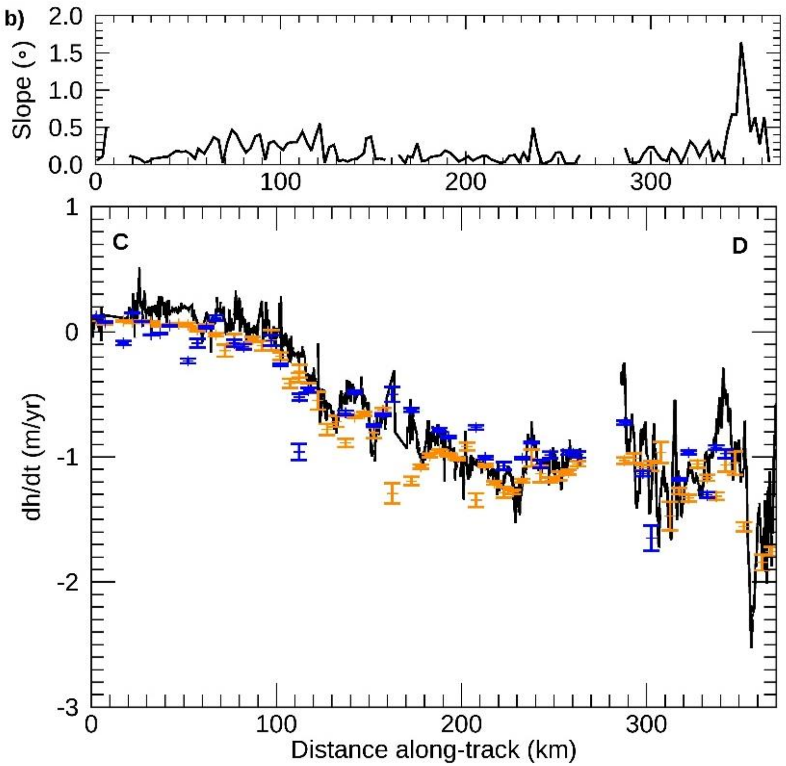
AltiKa struggles to survey elevation change over complex terrain compared to CryoSat-2 and airborne laser altimeter

Thwaites Glacier



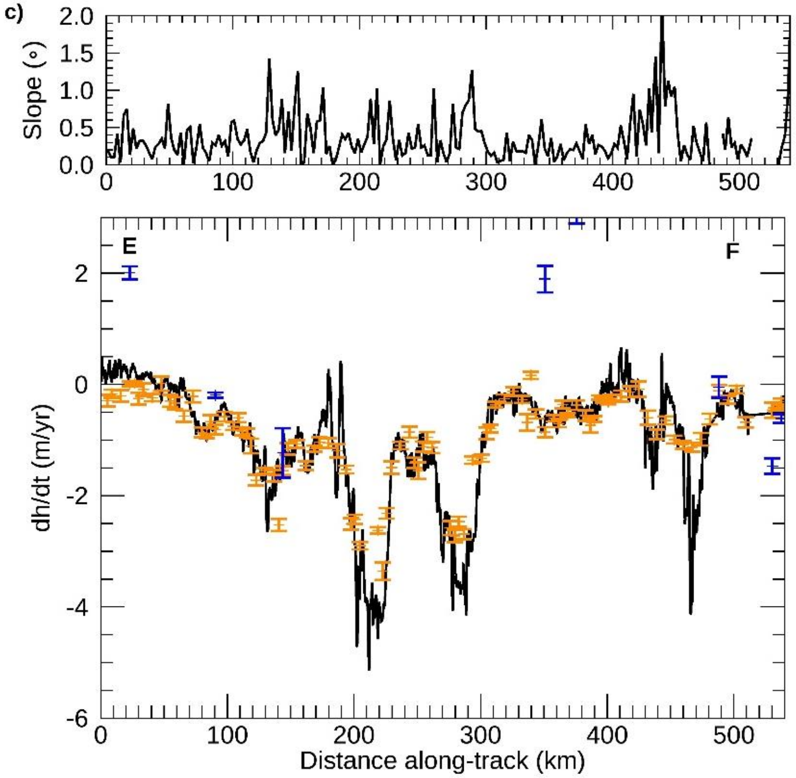
RMS(AK) = 0.58 m/yr
RMS(CS2) = 0.52 m/yr

Pine Island Glacier

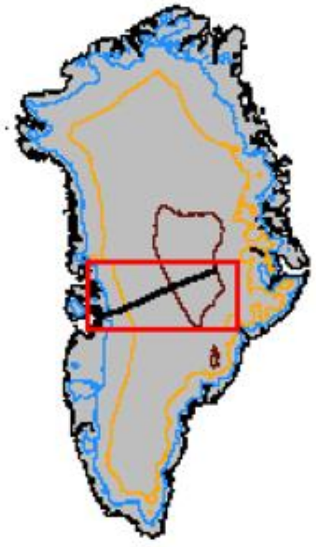


RMS(AK) = 0.22 m/yr
RMS(CS2) = 0.21 m/yr

Getz Ice Shelf

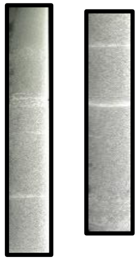


RMS(AK) = 2.85 m/yr
RMS(CS2) = 0.43 m/yr



ASIRAS, KAREN, ALS

+



Firn cores

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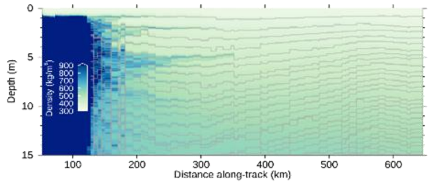
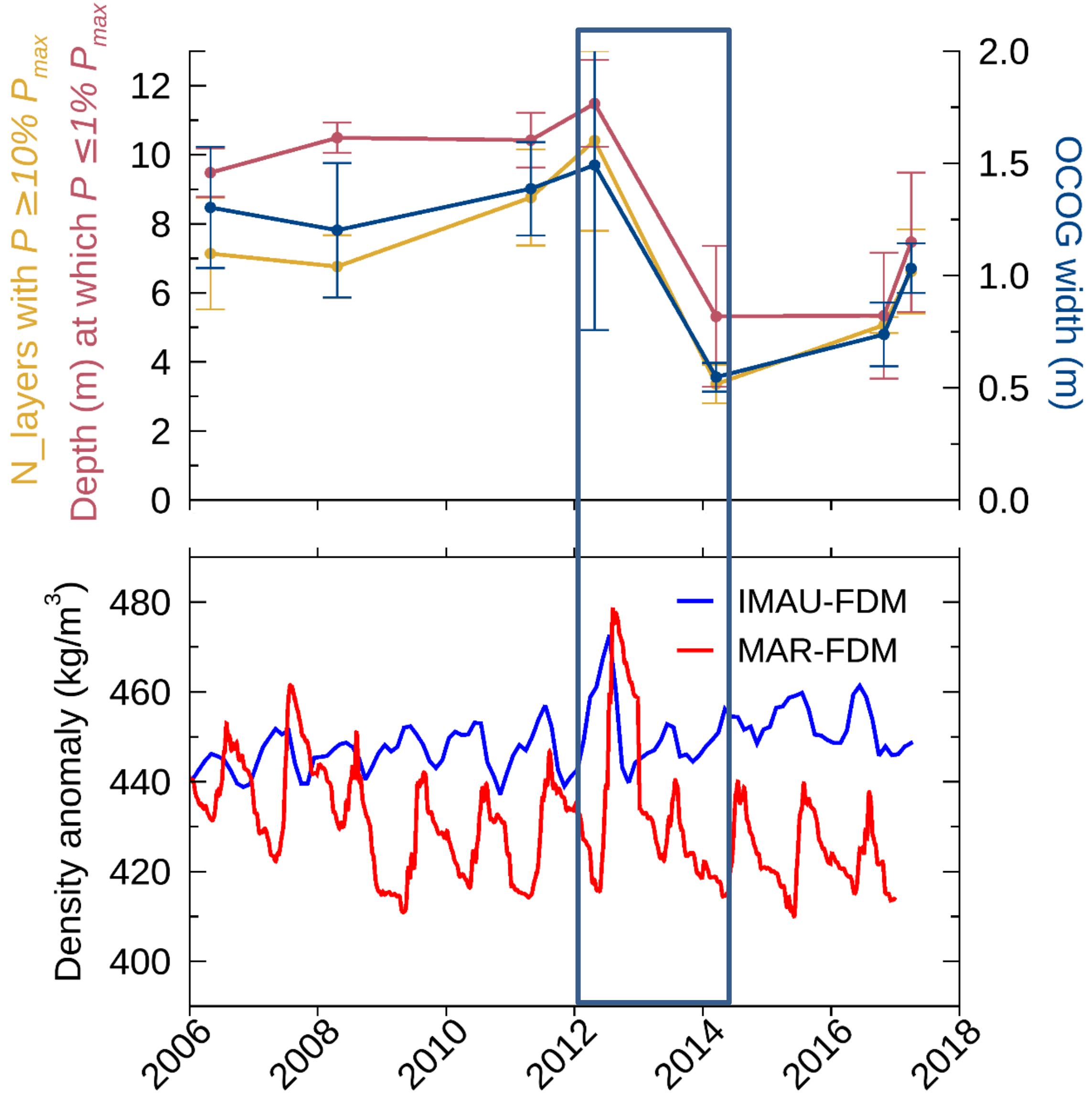


Firn models

2. Surface Melting Drives Fluctuations in Airborne Radar Penetration in West Central Greenland

Inès N. Otosaka, Andrew Shepherd, Tânia G. D. Casal, Alex Coccia, Malcolm Davidson, Alessandro Di Bella, Xavier Fettweis, René Forsberg, Veit Helm, Anna E. Hogg, Sine Hvidegaard, Adriano Lemos, Karlus Macedo, Peter Kuipers Munneke, Tommaso Parrinello, Sebastian B. Simonsen, Henriette Skourup, Louise Sandberg Sørensen

Fluctuations in radar penetration are correlated with fluctuations in densities



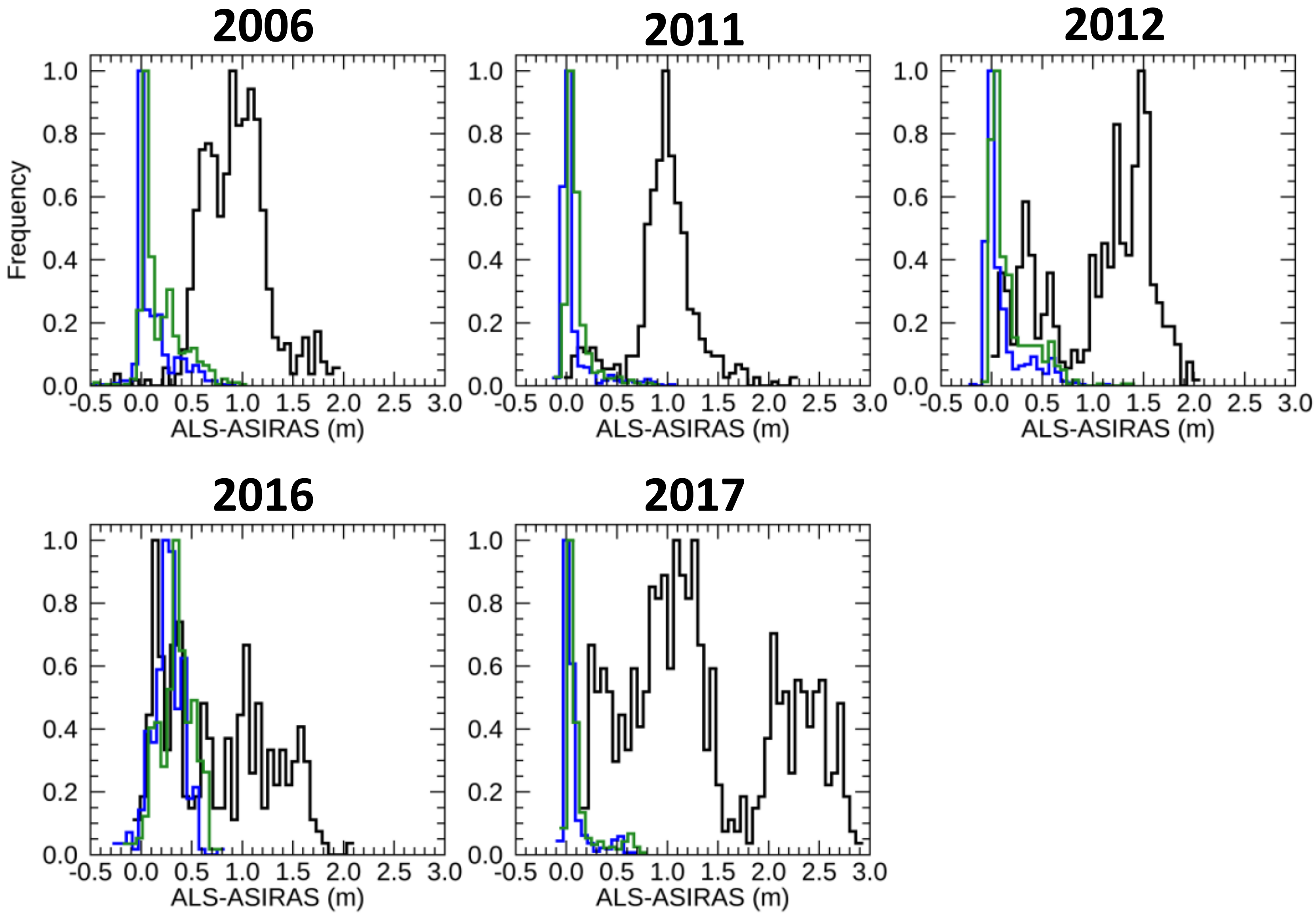
63% decrease in the OCOG width

68% decrease in the number of layers

6.2 ± 2.4 m decrease in radar penetration depth

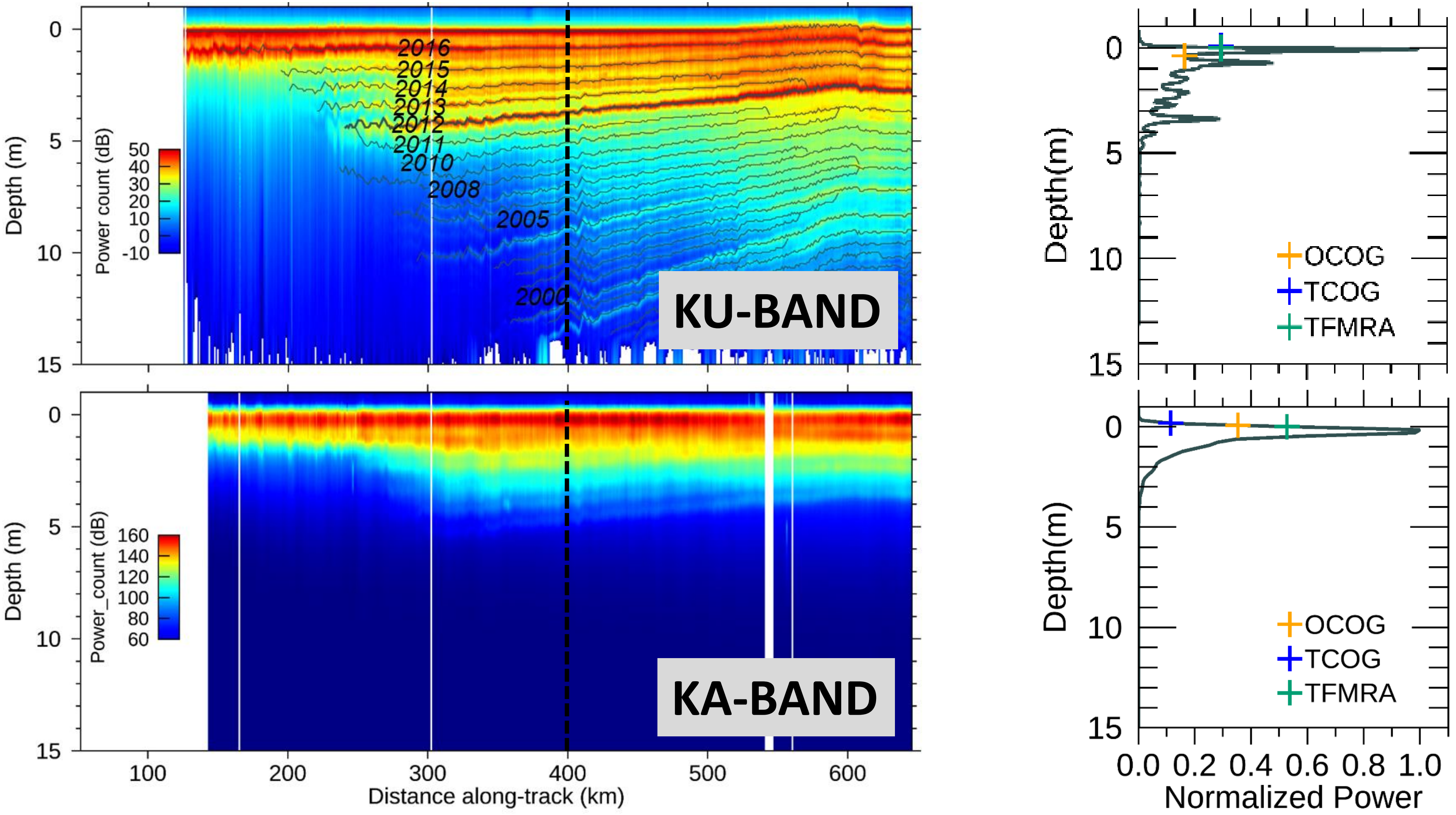
Density peak in summer 2012 twice the density of the previous summer

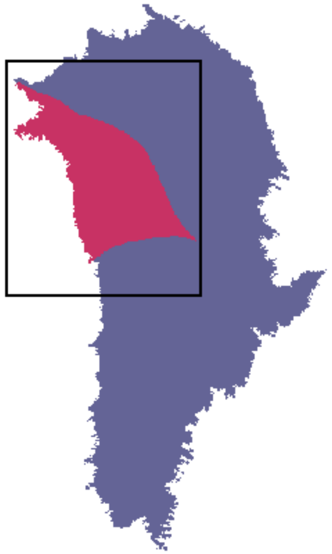
Despite large fluctuations in penetration, radar and laser surface elevation agree to within 20 cm

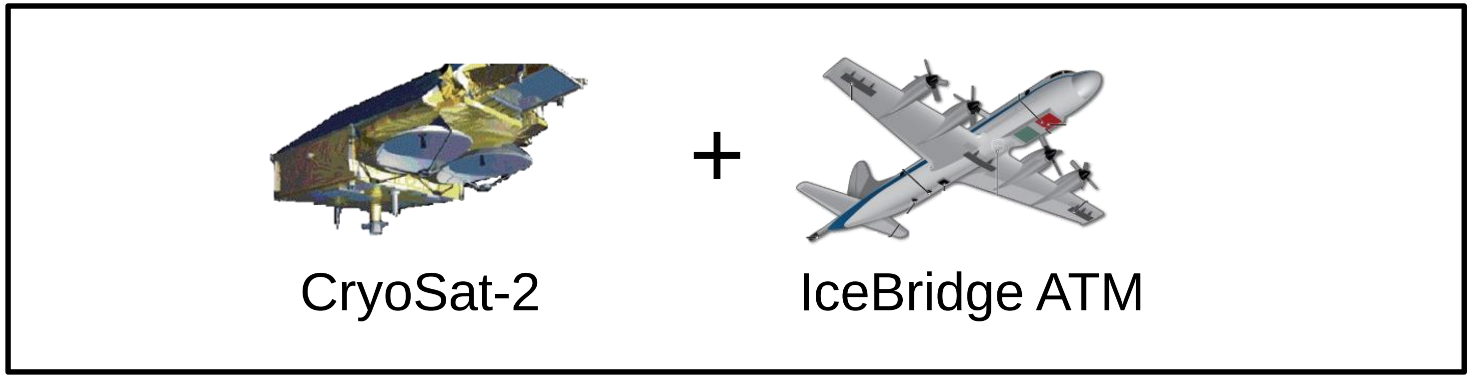


	ALS-ASIRAS (cm)
OCOG	107 ± 55
TCOG	14 ± 20
TFMRA	20 ± 21

Surface scattering is dominant in radar data acquired at higher frequency Ka-band





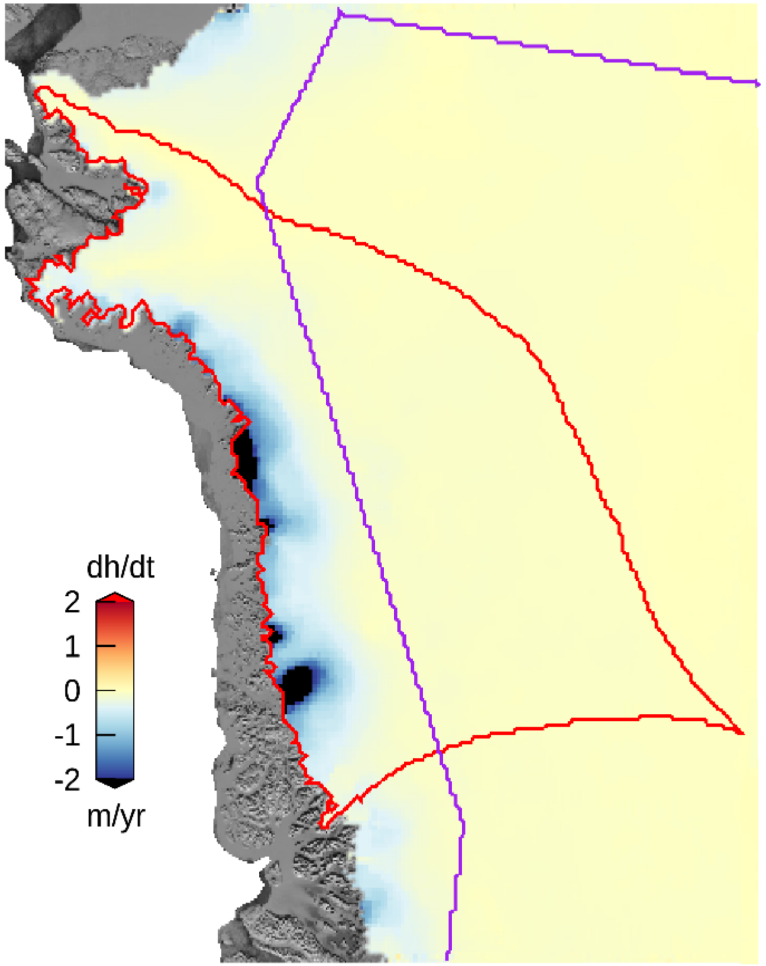


3. Comparison of Ku-band satellite altimetry and airborne laser altimetry in Northwest Greenland

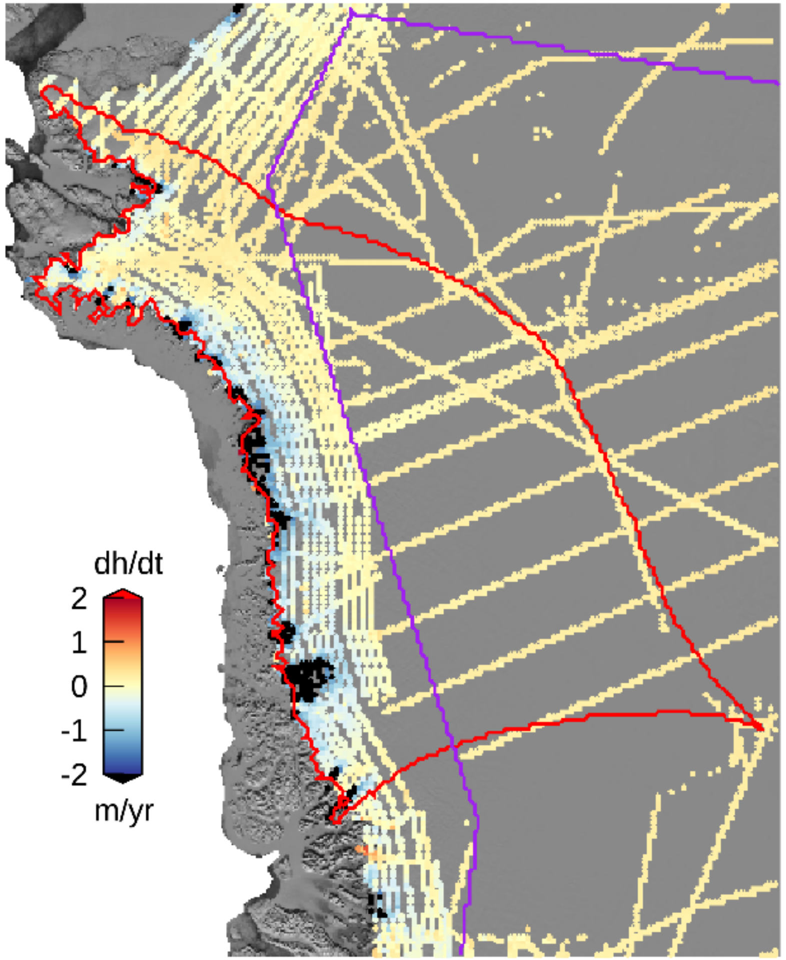
Inès N. Otosaka, Andrew Shepherd

Satellite Ku-band and airborne laser altimetry elevation change in Northwest Greenland

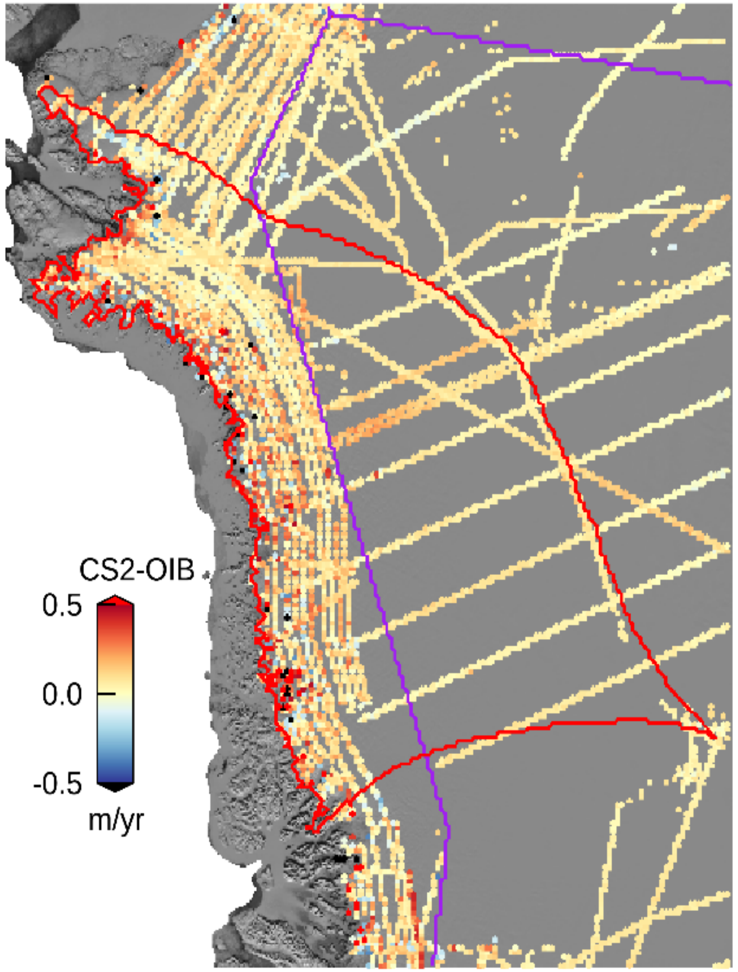
CryoSat-2



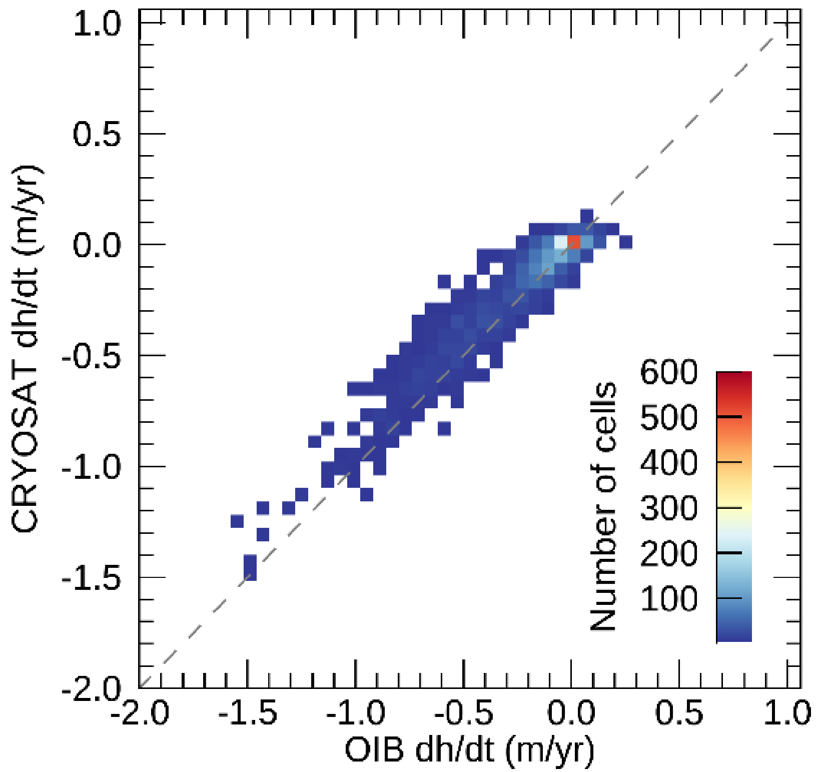
IceBridge

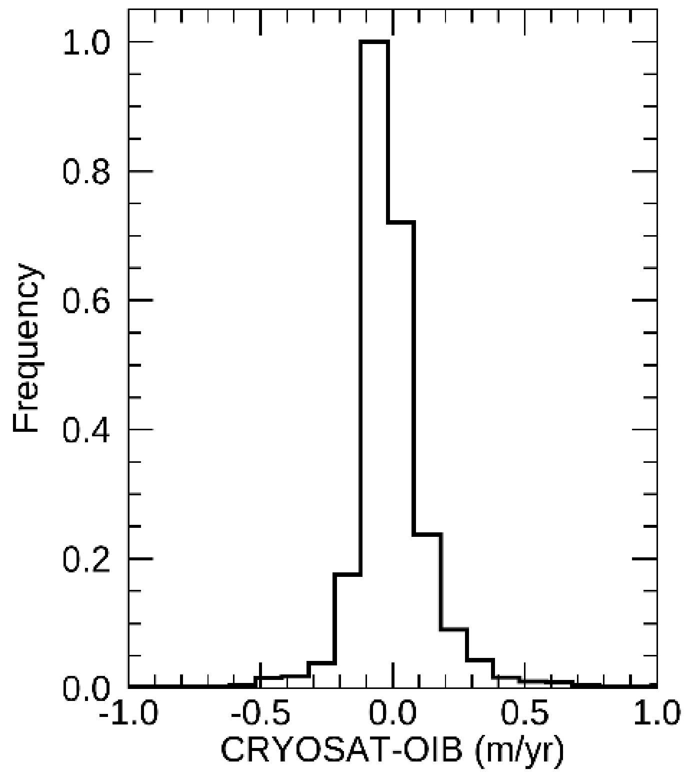


CryoSat-2 – IceBridge



There is an overall good agreement in rates of elevation change but large differences remain locally





	CS2-OIB (cm/yr)
Mean	6.5 ± 0.5
STD	31.1

Conclusions and Discussion (1)

Comparison in West Antarctica:

- Radar penetration trends are minor in this region
- The different instruments' operational mode (AK LRM/CS2 SARIn) and resolutions play a large role in the differences in elevation and elevation change
- A more dedicated experiment in Antarctica would help better understand differences between Ka- and Ku-band satellite altimetry

How to overcome differences in sensors' resolutions, spatial sampling when comparing satellite altimetry data from different instruments?

Conclusions and Discussion (2)

Comparison in West Central Greenland:

- There are large fluctuations in radar penetration, up to 6.2 m after the 2012 extreme melt event
- This can affect our ability to measure surface elevation using radar altimeters and needs to be accounted for by selecting an appropriate retracking algorithm for instance.

How to estimate and correct for trends in radar penetration in Ka- and Ku-band signals?

Conclusions and Discussion (3)

Comparison in Northwest Greenland:

- Despite an overall good agreement in elevation change between Ku-band satellite altimetry and airborne laser altimetry, there remain large differences locally close to the margins of the ice sheet
- These differences could lead to a significant bias in volume and mass change (up to 15 km/yr^3 over the SARIn area)

How to disentangle the effects of radar penetration, terrain topography and spatial sampling when comparing satellite radar altimetry and airborne laser altimetry?