Investigation and estimation of penetration-related TanDEM-X elevation bias

— A study over the Greenland Ice Sheet

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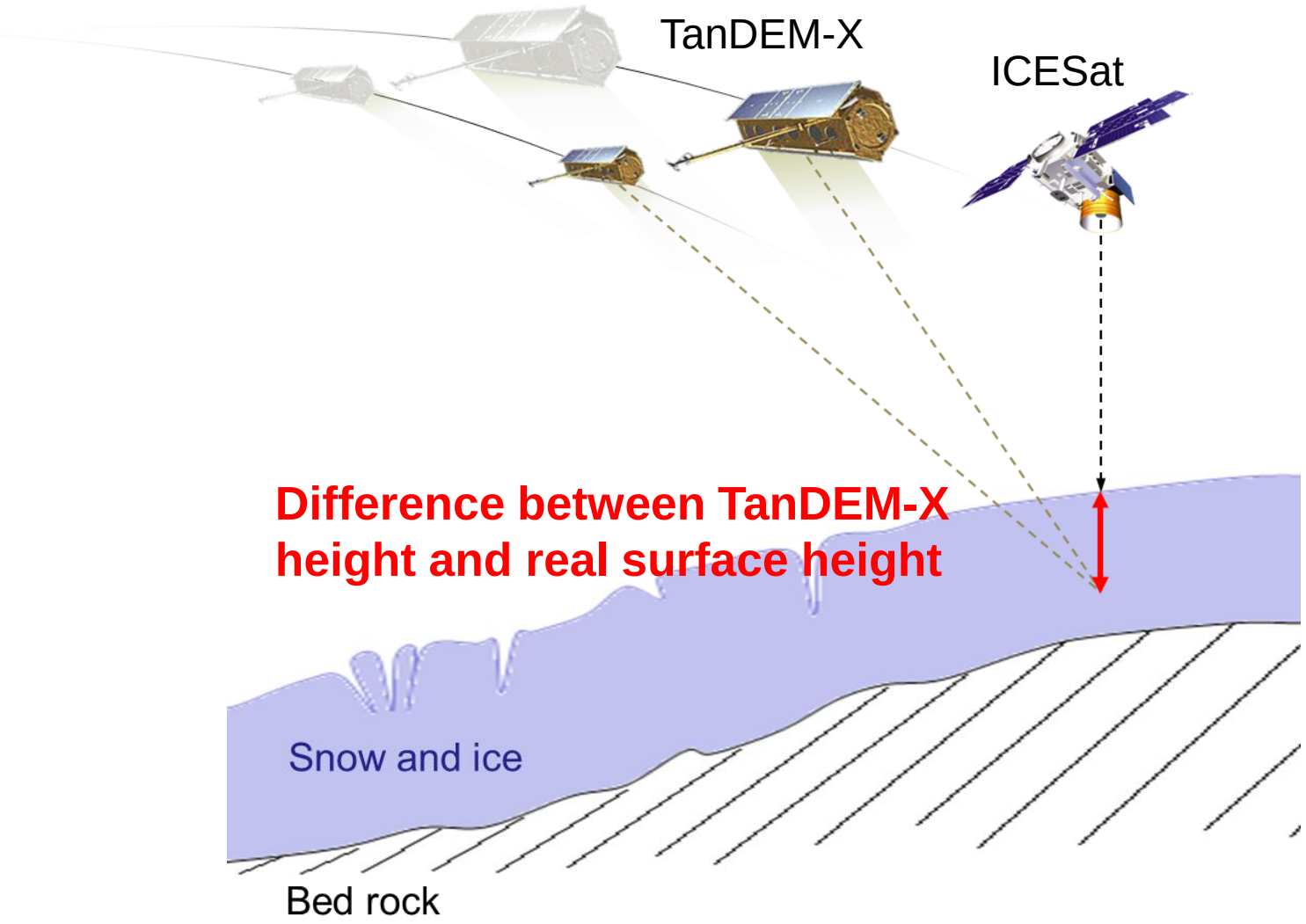
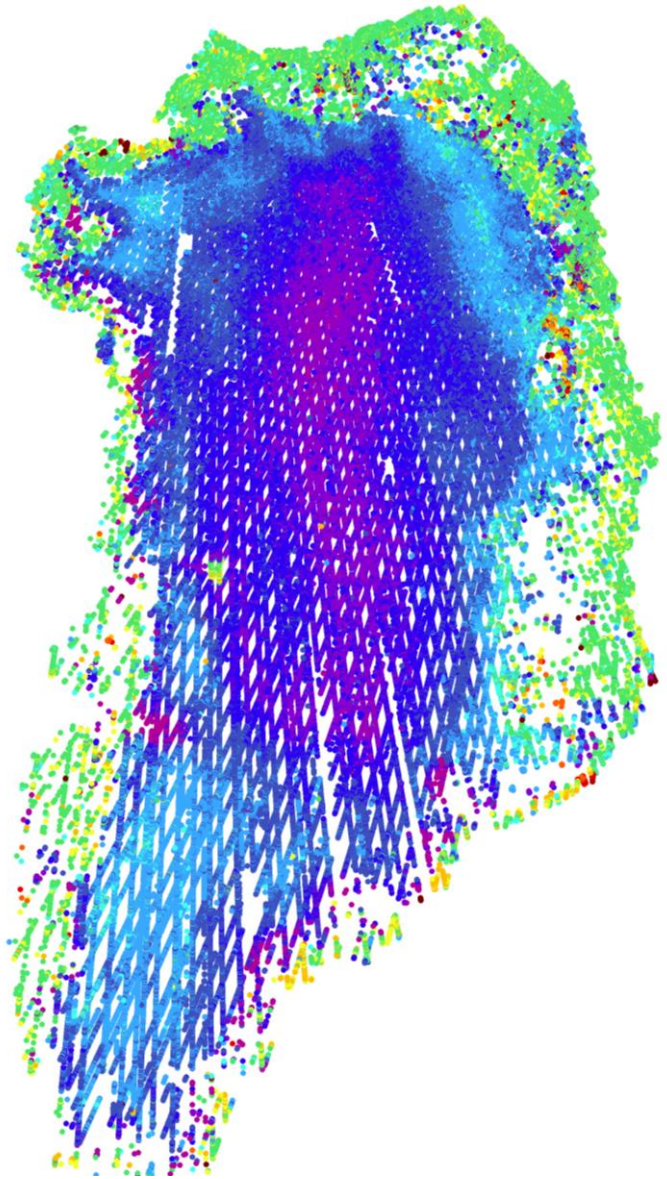
TanDEM-X Penetration Bias

The TanDEM-X penetration bias is defined as …

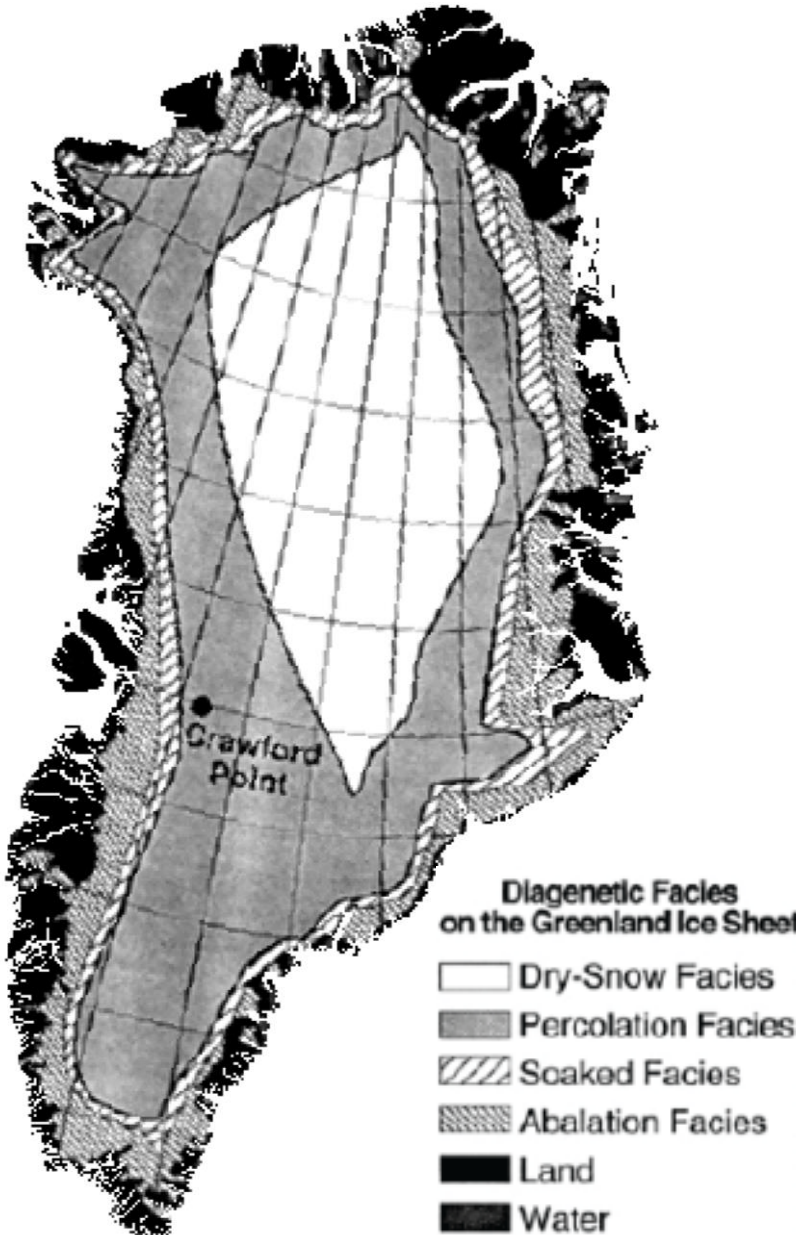


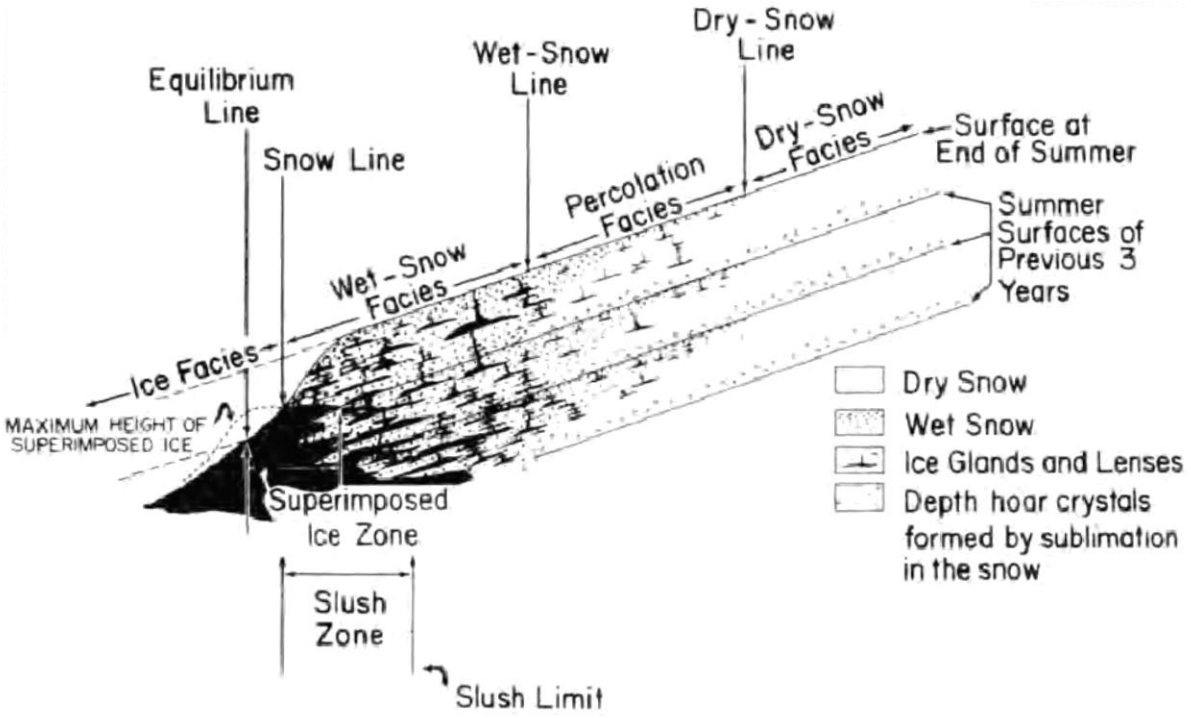


Difference to laser measurements (m)
(TanDEM-X minus ICESat)

< -10 | -8 - -6 | -4 - -2 | -1 - 1 | 2 - 4 | 6 - 8
-10 - -8 | -6 - -4 | -2 - -1 | 1 - 2 | 4 - 6 | 8 -10

… and is related to glacier facies.





Benson (1962) *Stratigraphic Studies in the Snow and Firn of the Greenland Ice Sheet.*

… and is related to glacier facies.

Glacier Facies according to Benson (1962)

Dry snow zone

High penetration bias

Percolation zone

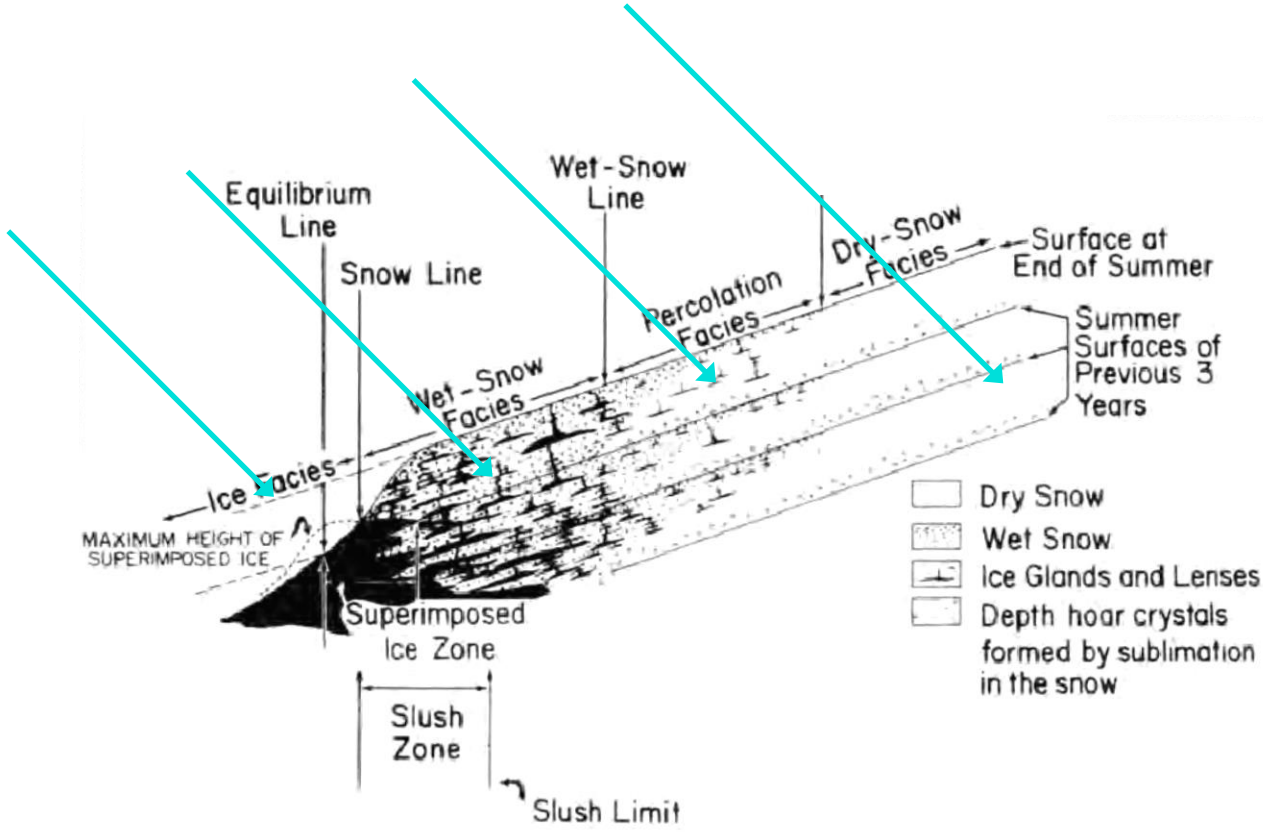
Low penetration bias

Wet snow zone

Low penetration bias
(but higher than in the percolation zone)

Superimposed / bare ice zone

Very low penetration bias

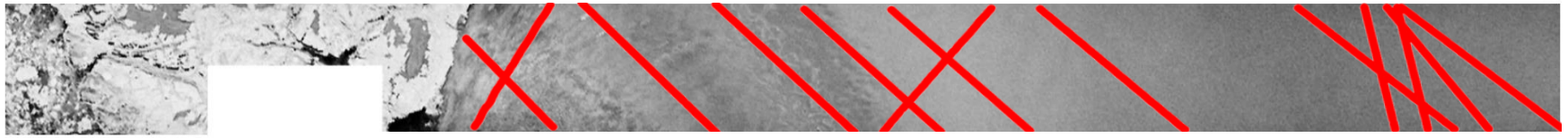


Small-scale as well as intra- and inter-annual variations within the zones

Estimation of Penetration Bias

Interferometric coherence and backscatter intensity are correlated with the snow characteristics …

Interferometric coherence



IceBridge footprints

Backscatter coefficient (dB)

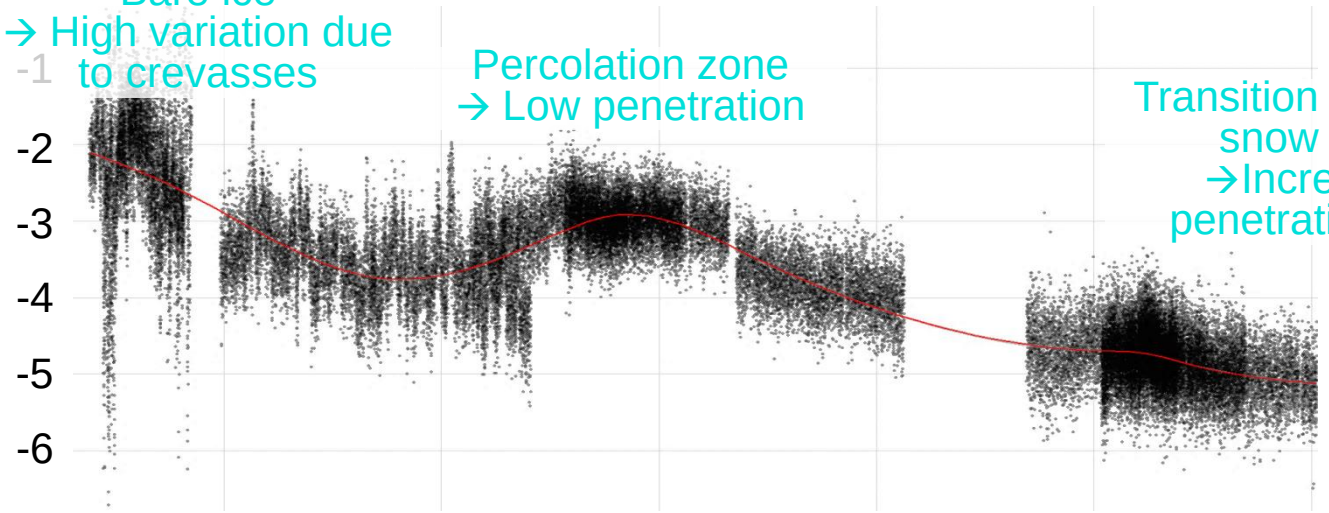
N

Bare ice
→ High variation due to crevasses

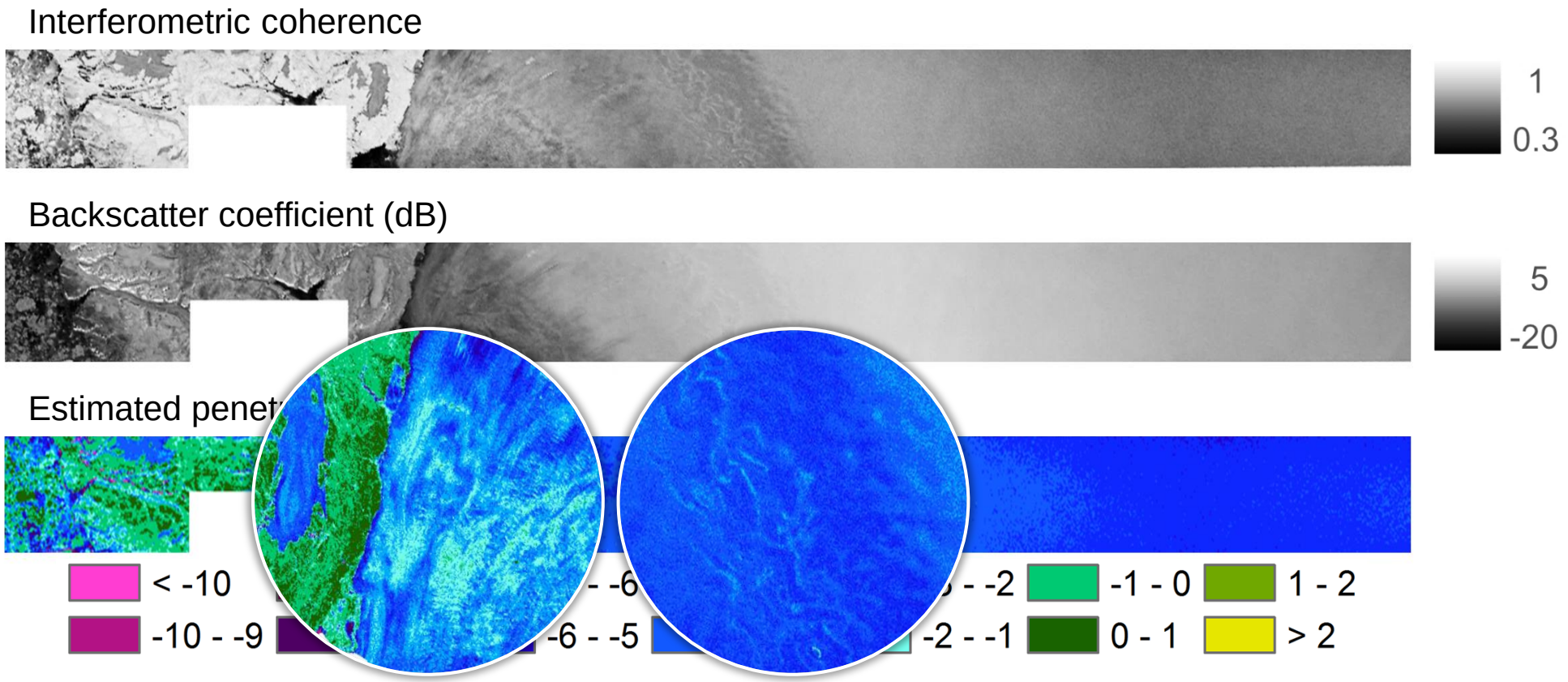
Percolation zone
→ Low penetration

Transition to the dry snow zone
→Increasing penetration bias

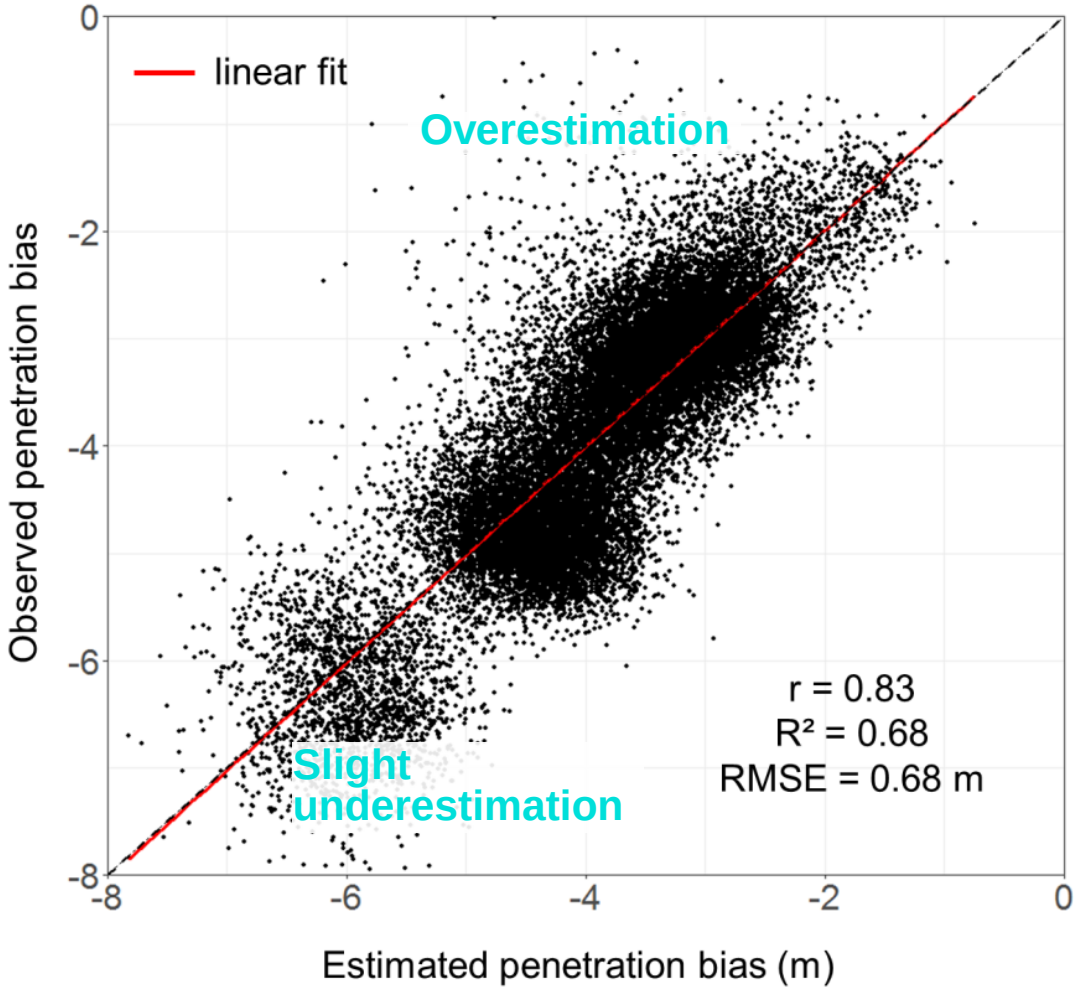
Penetration bias (m)
(TanDEM-X minus IceBridge)

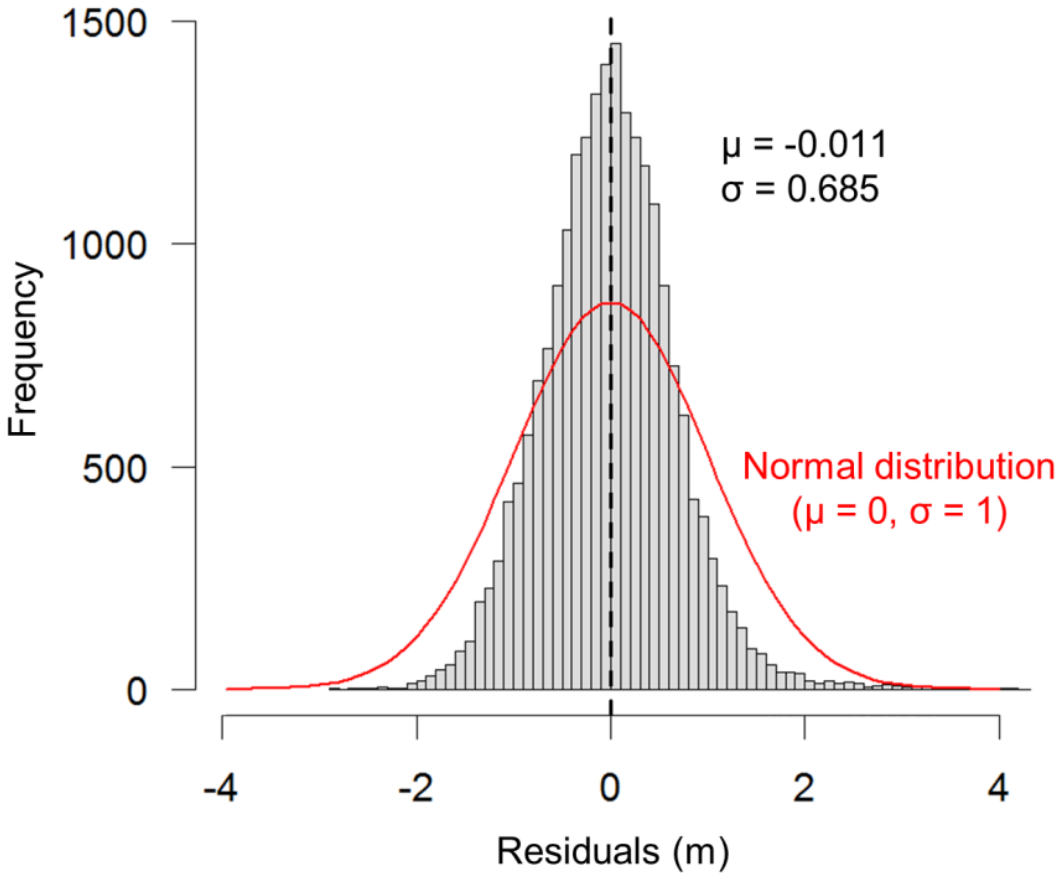


… and can be used for penetration bias estimation …

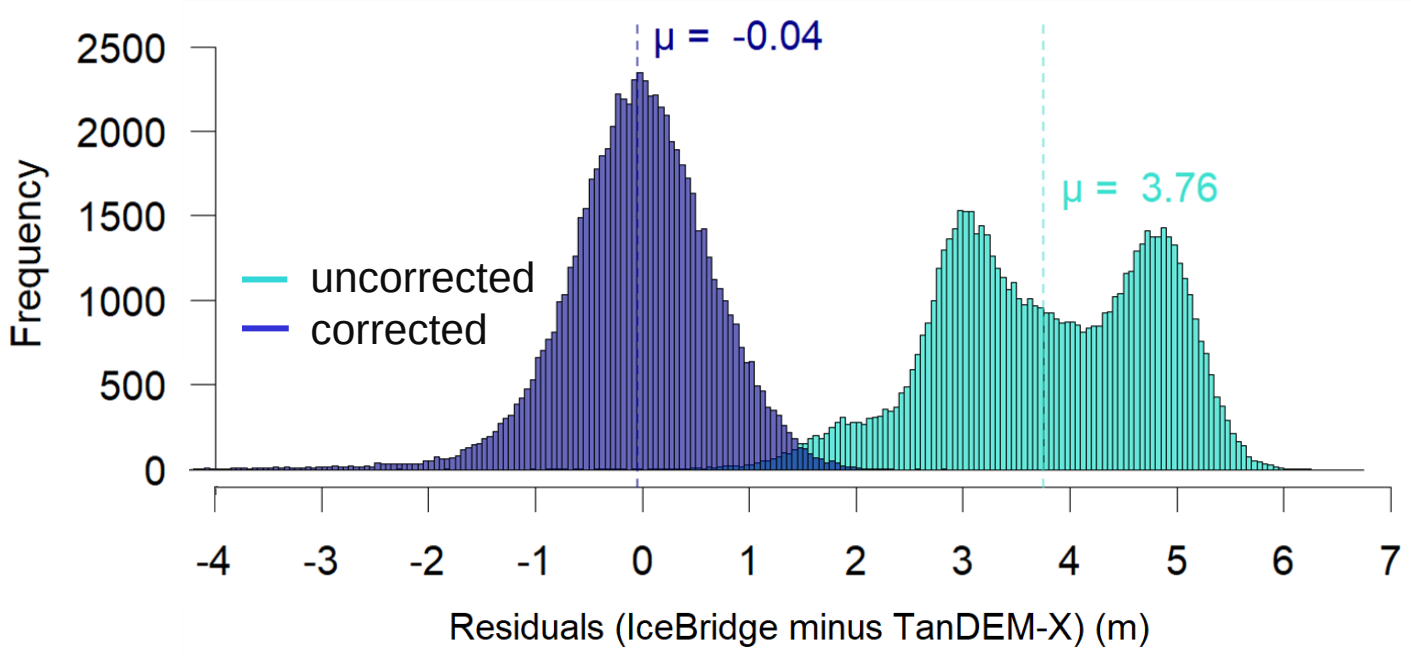


… and can be used for penetration bias estimation …

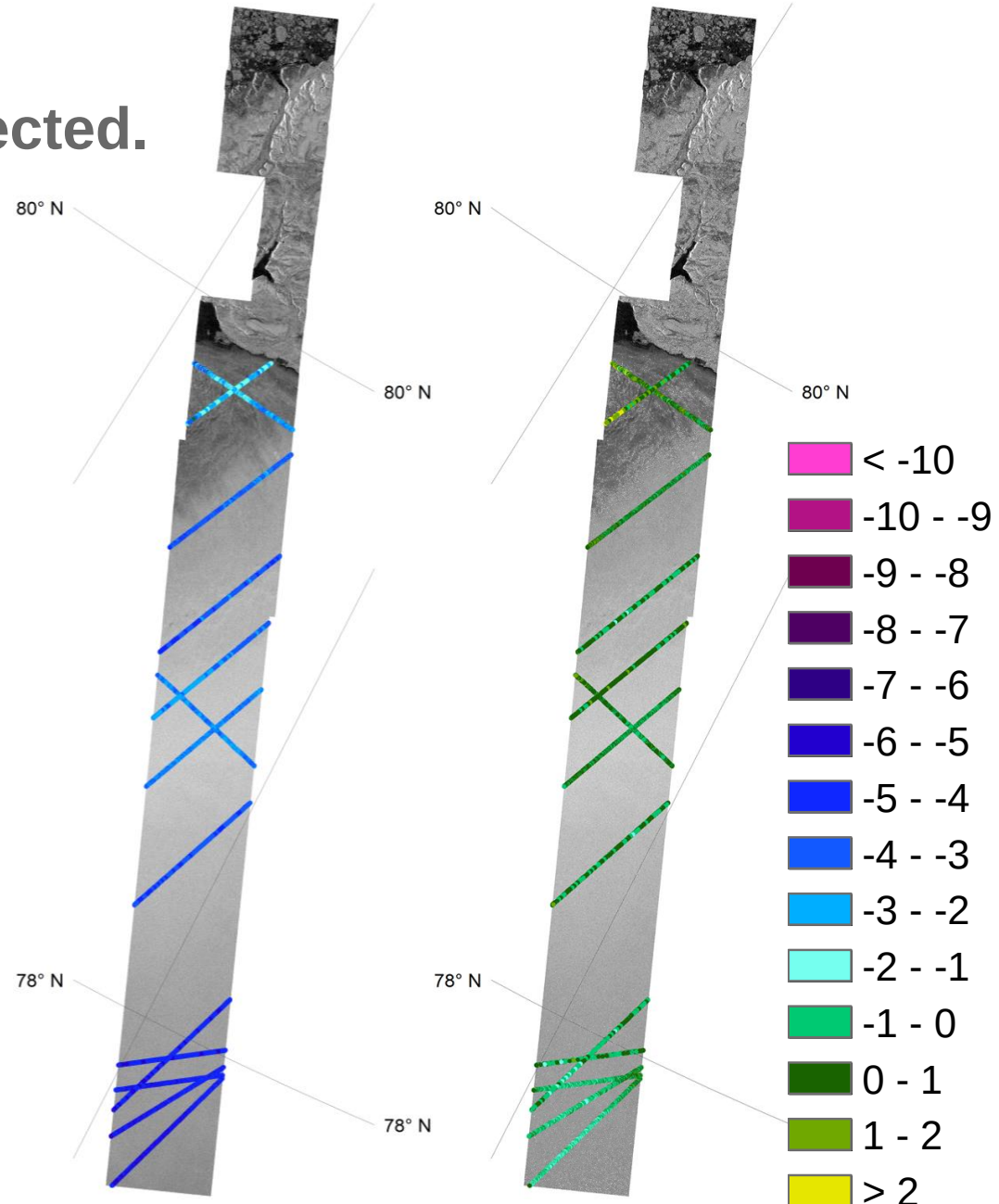




… and thus the TanDEM-X DEMs can be corrected.



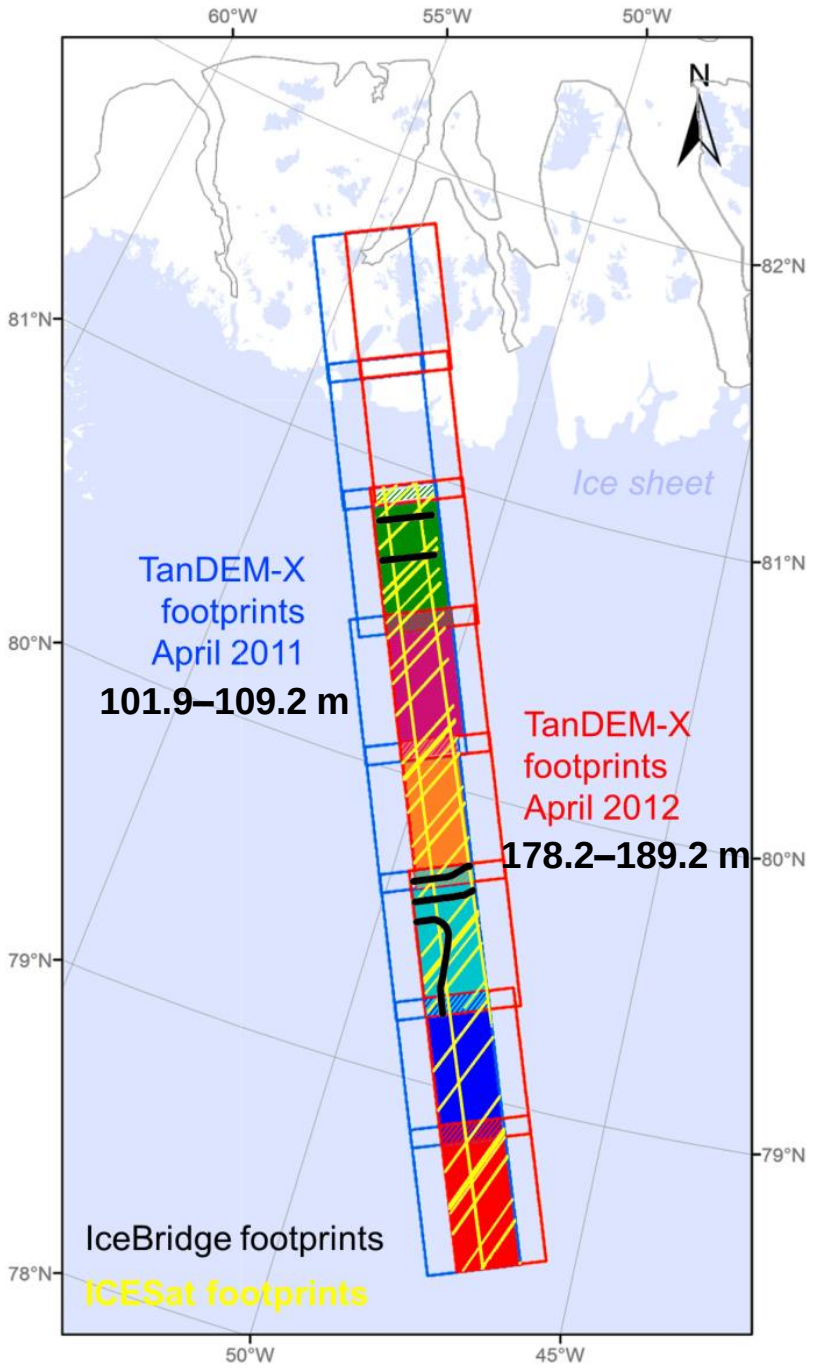
Mean difference between uncorrected and corrected TanDEM-X = **-3.24 m**

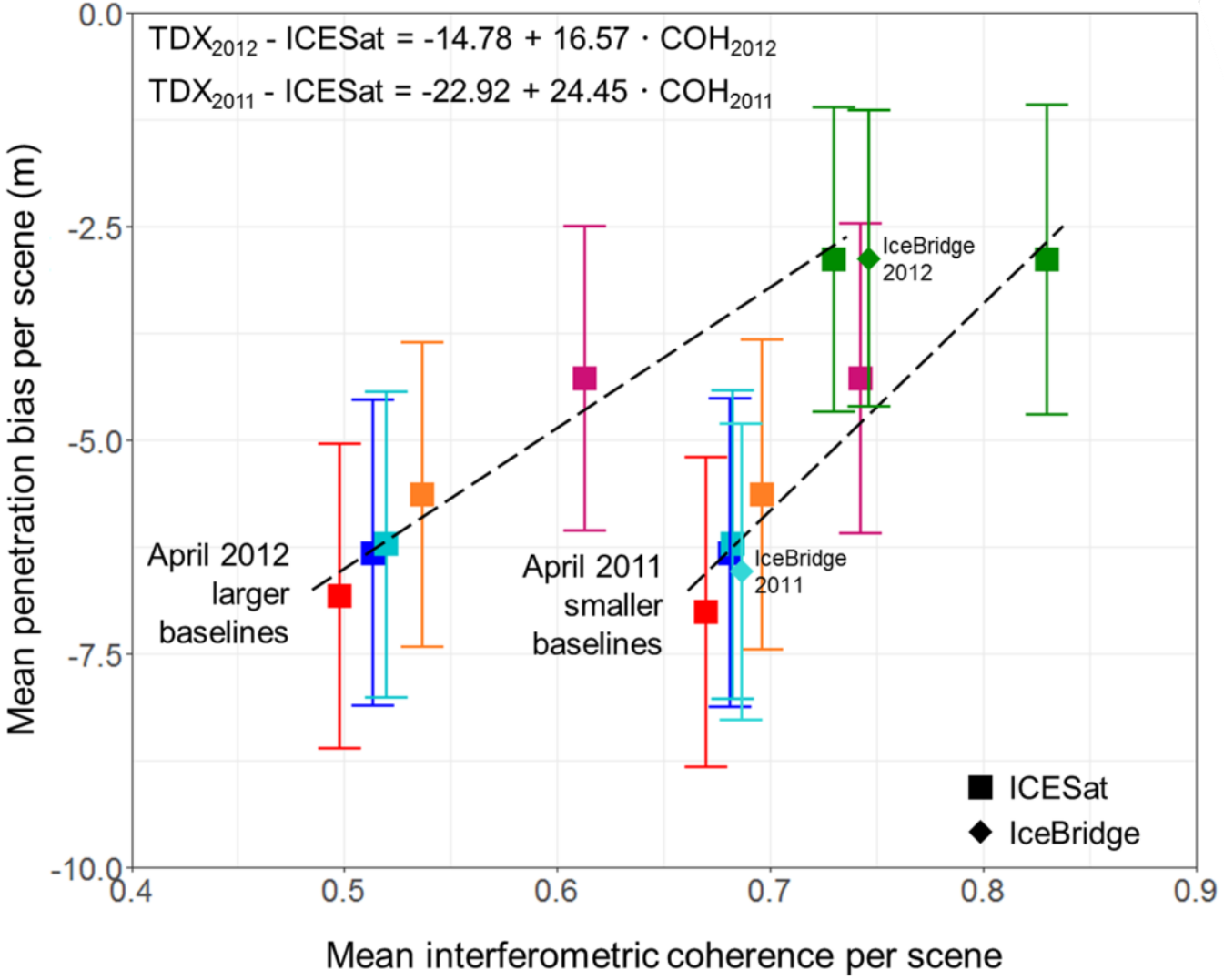


DEM-X minus IceBridge (m)

Corrected TanDEM-X minus IceBridge (m)

Estimation of Penetration Bias at Large Scale

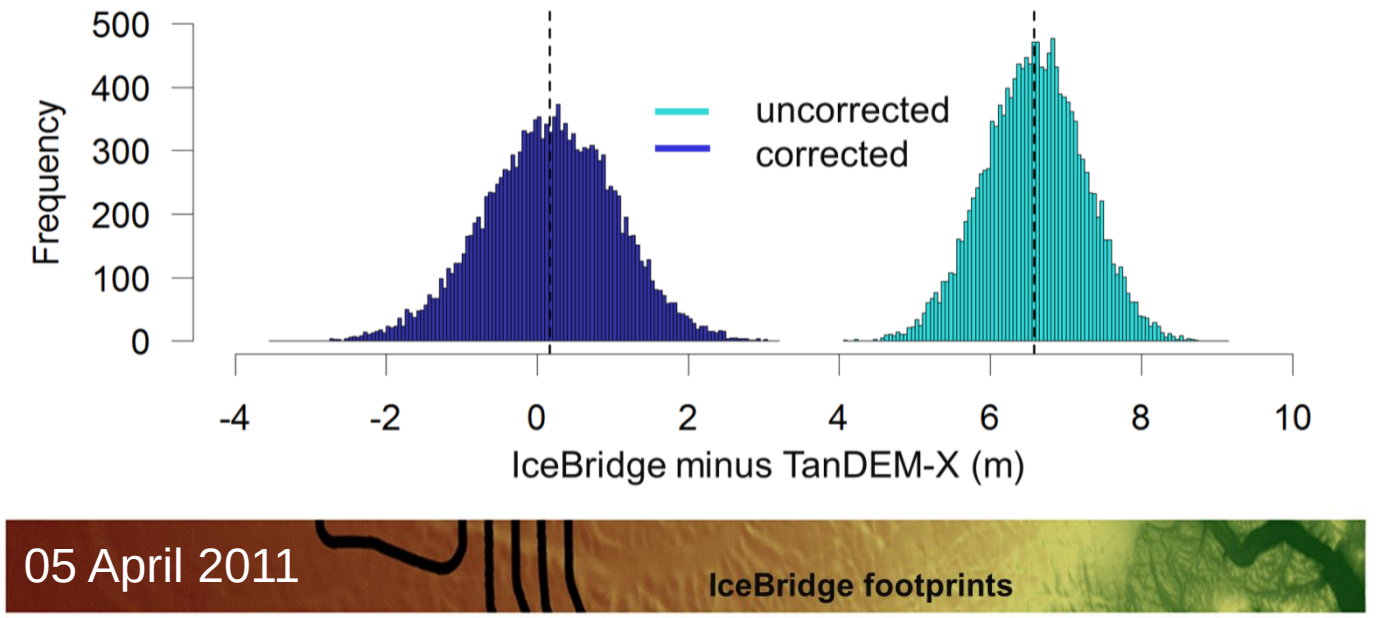

60°W
55°W
50°W
N
82°N
81°N
80°N
79°N
78°N
Ice sheet
TanDEM-X
footprints
April 2011
101.9–109.2 m
TanDEM-X
footprints
April 2012
178.2–189.2 m
IceBridge footprints
ICESat footprints
50°W
45°W

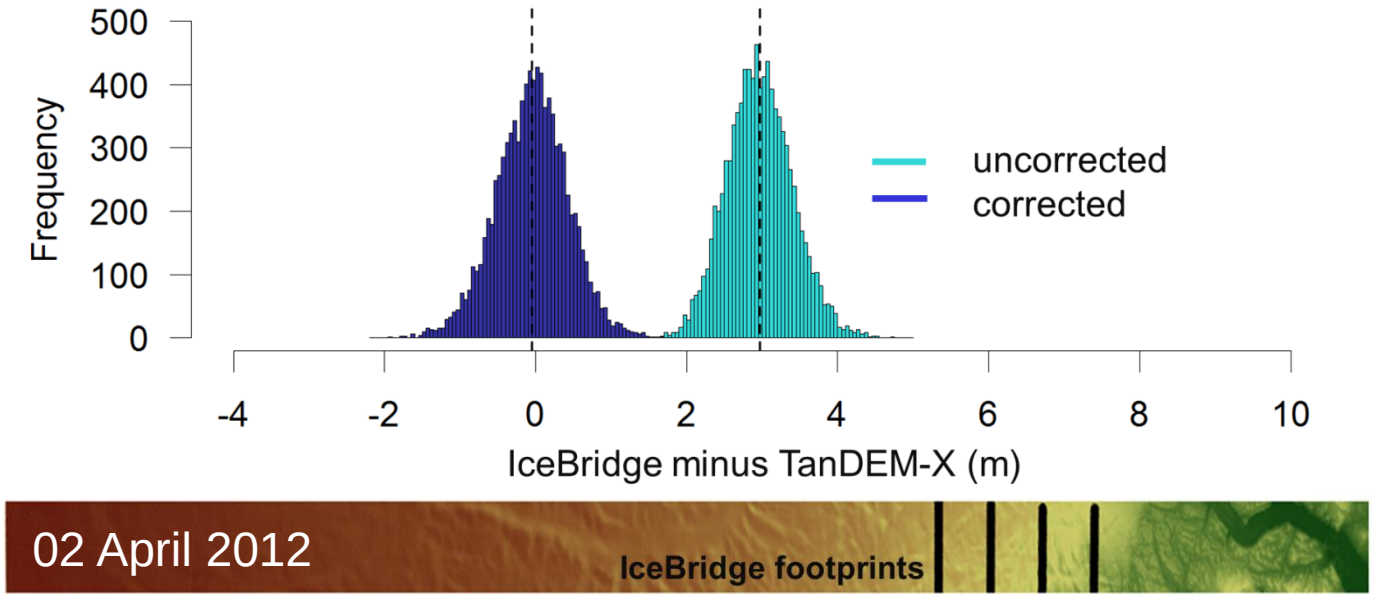

TDX2012 - ICESat = -14.78 + 16.57 · COH2012
TDX2011 - ICESat = -22.92 + 24.45 · COH2011
Mean penetration bias per scene (m)
0.0
-2.5
-5.0
-7.5
-10.0
0.4
0.5
0.6
0.7
0.8
0.9
Mean interferometric coherence per scene
April 2012
larger
baselines
April 2011
smaller
baselines
IceBridge
2012
IceBridge
2011
ICESat
IceBridge

Interferometric coherence 05 April 2011

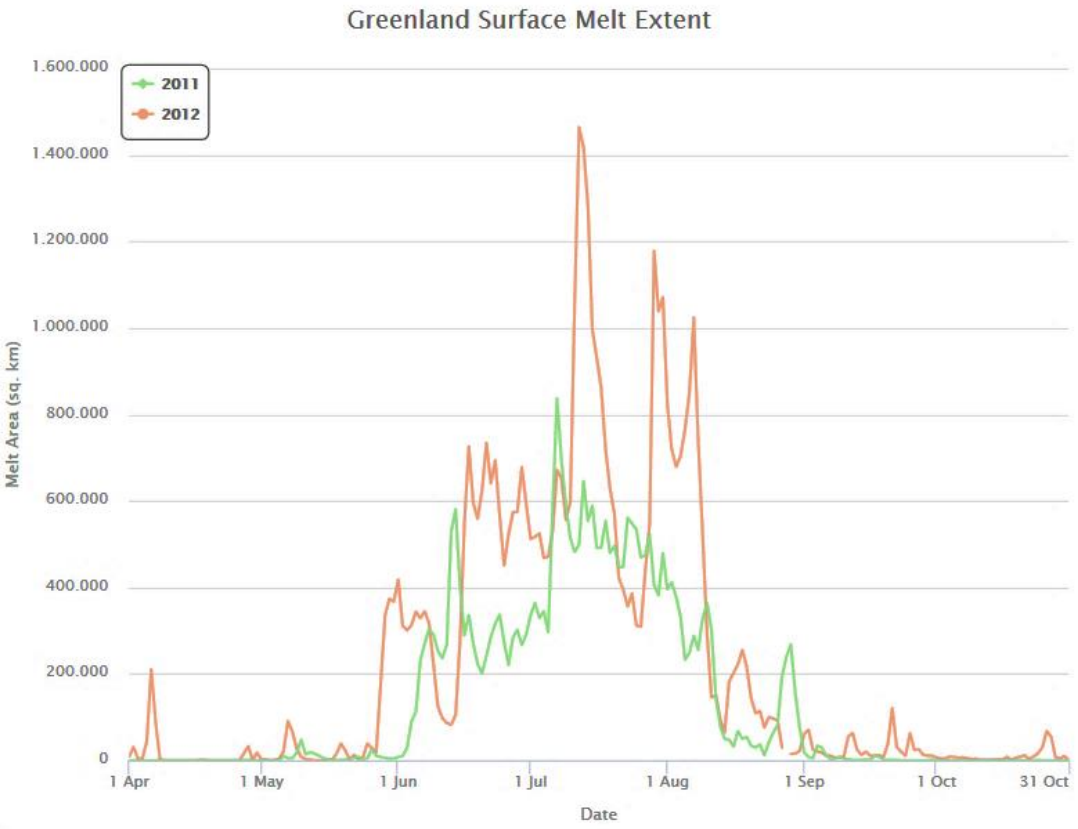
Baseline adjusted Interferometric coherence 05 April 2011

Interferometric coherence 02 April 2012





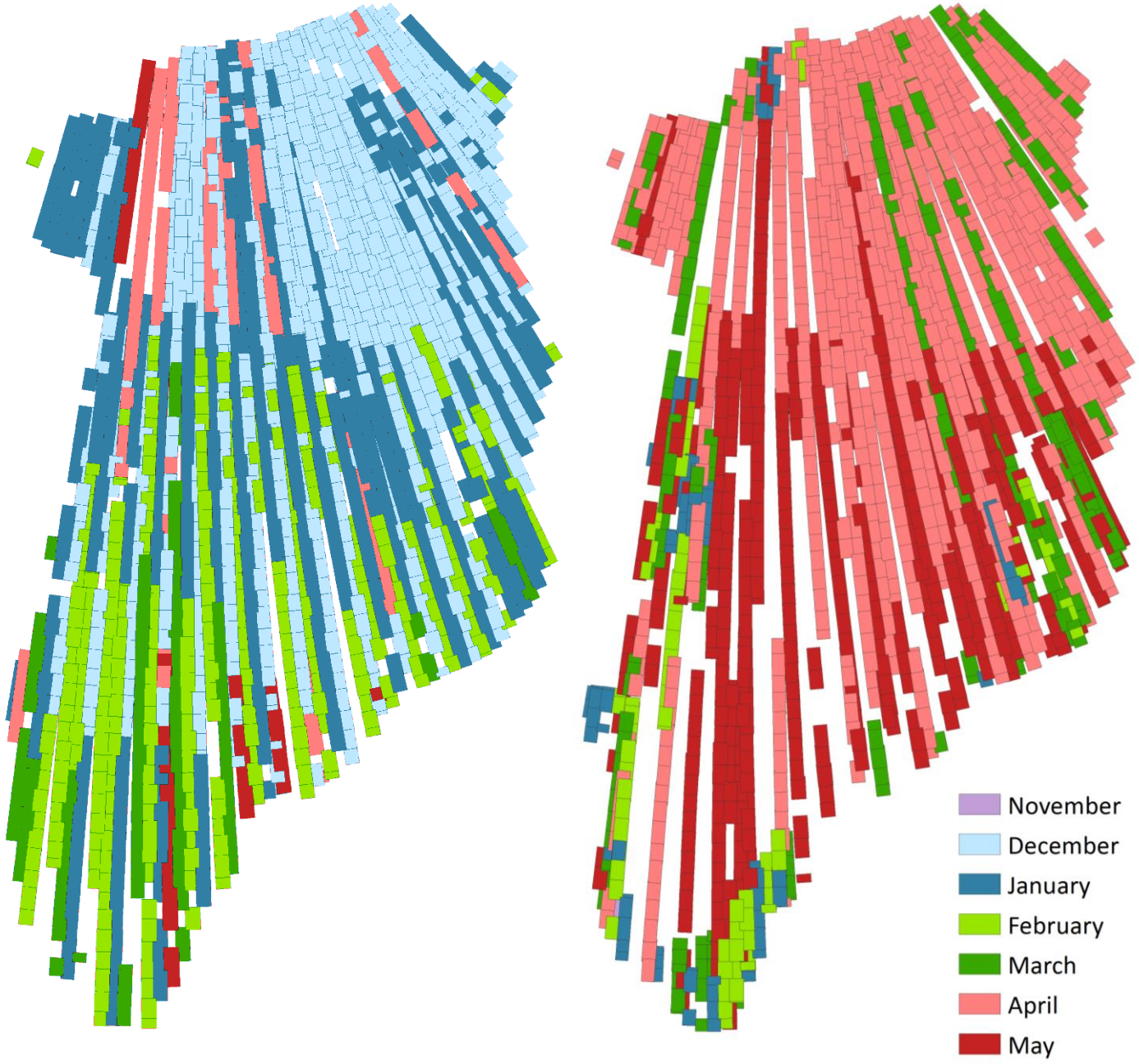
… and the acquisition time.



National Snow and Ice Data Center, University of Colorado Boulder

2010/2011

2011/2012



Conclusion

- **Estimating penetration bias** based on the relationship to interferometric coherence and backscatter intensity
- Significant **improvement of the accuracy** of TanDEM-X DEMs
- **Satisfying accuracy** (over- and underestimation)
- **Transferability** to other test sites, different data sets (acquisition geometry, acquisition time)

Abdullahi, S.; Wessel, B.; Huber, M.; Wendleder, A.; Roth, A.; Kuenzer, C. Estimating Penetration-Related X-Band InSAR Elevation Bias: A Study over the Greenland Ice Sheet. *Remote Sens.* 2019, *11*, 2903.

Thank you for your attention!