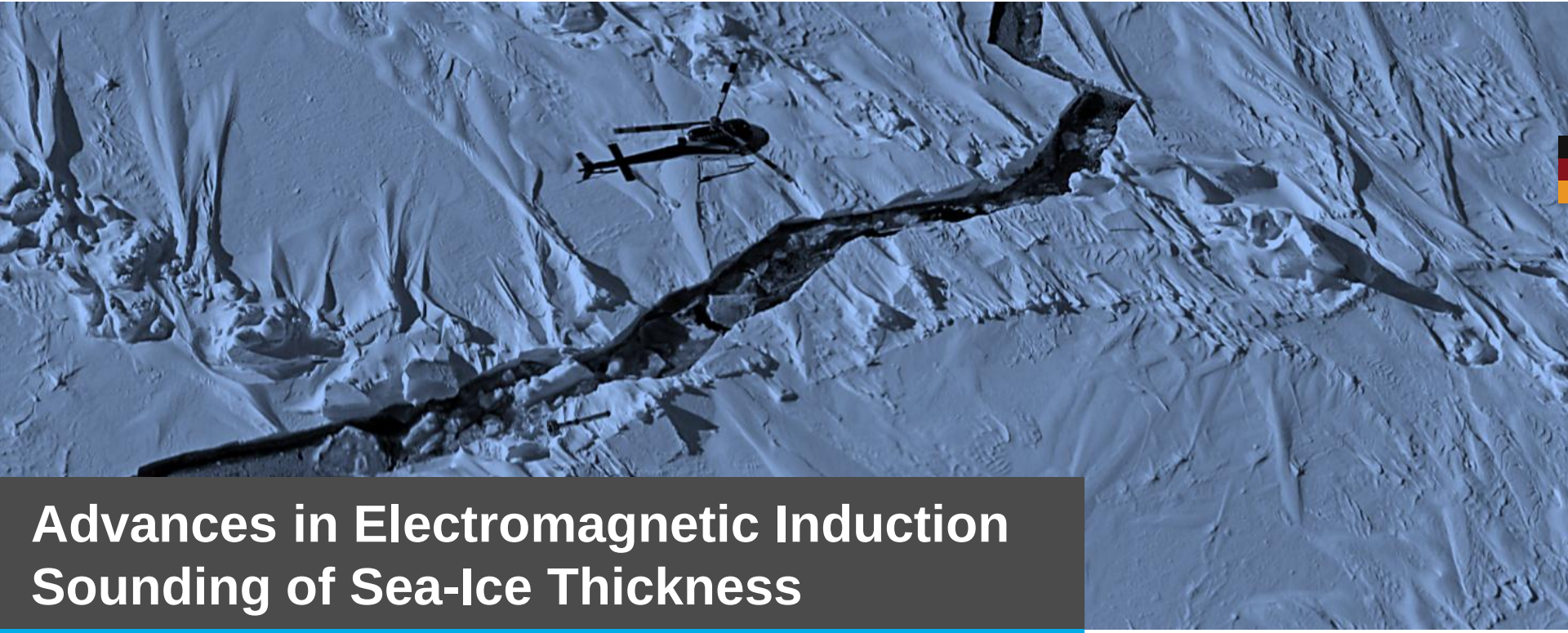
YORK UNIVERSITÉ UNIVERSITY

NGI

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG



Advances in Electromagnetic Induction Sounding of Sea-Ice Thickness

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HELMHOLTZ ASSOCIATION

EM Sea-Ice Thickness Systems

Helicopter (towed)

Helicopter (mounted)

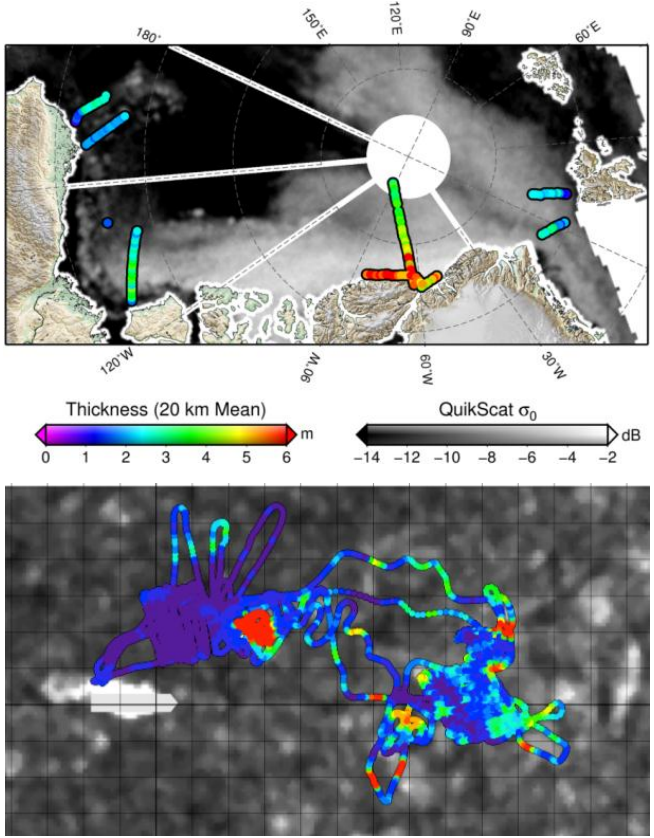
Fixed Wing (towed)

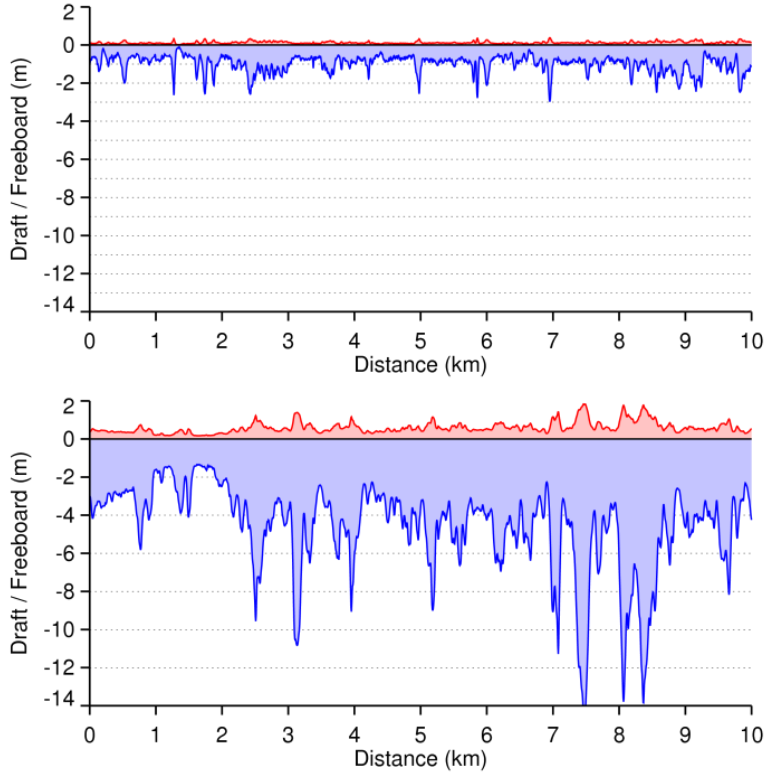
Handheld (sled, skidoo)

Handheld (Hovercraft)

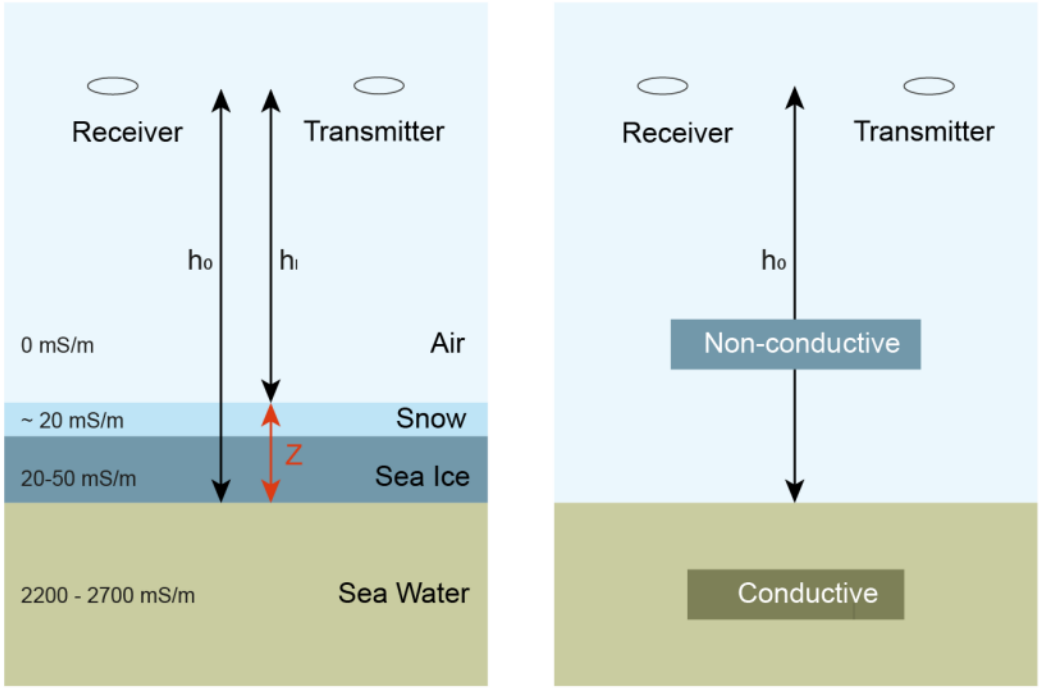
Handheld (ship-borne)

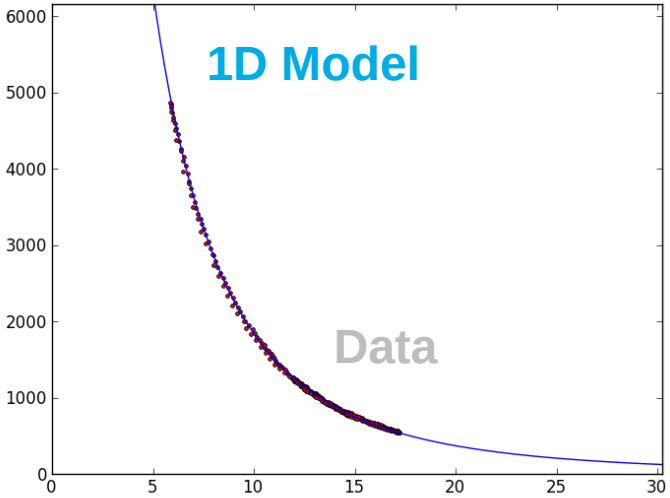
EM Sea-Ice Thickness Examples





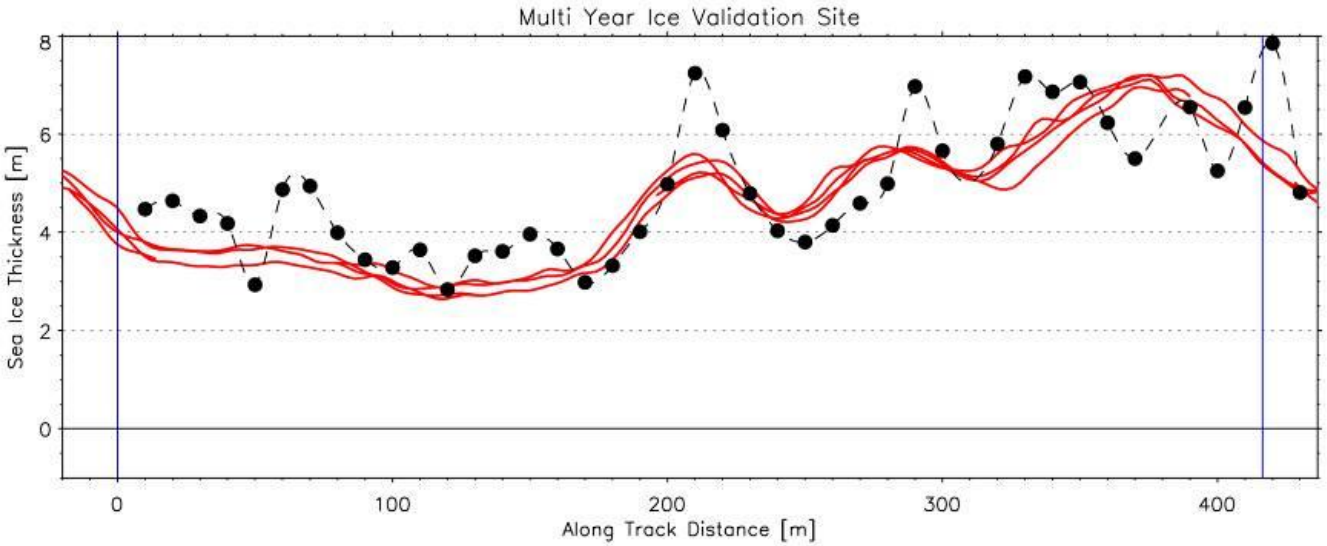
1D EM Interpretation





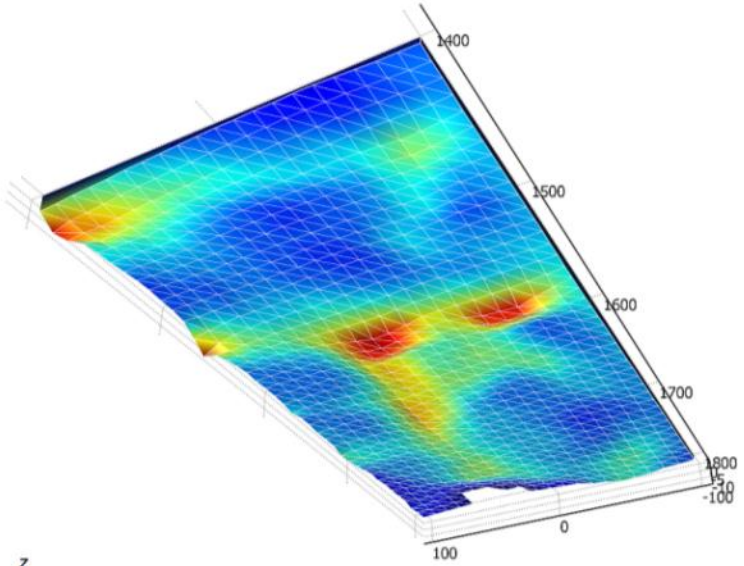
EM Response = Inphase + Quadrature · j

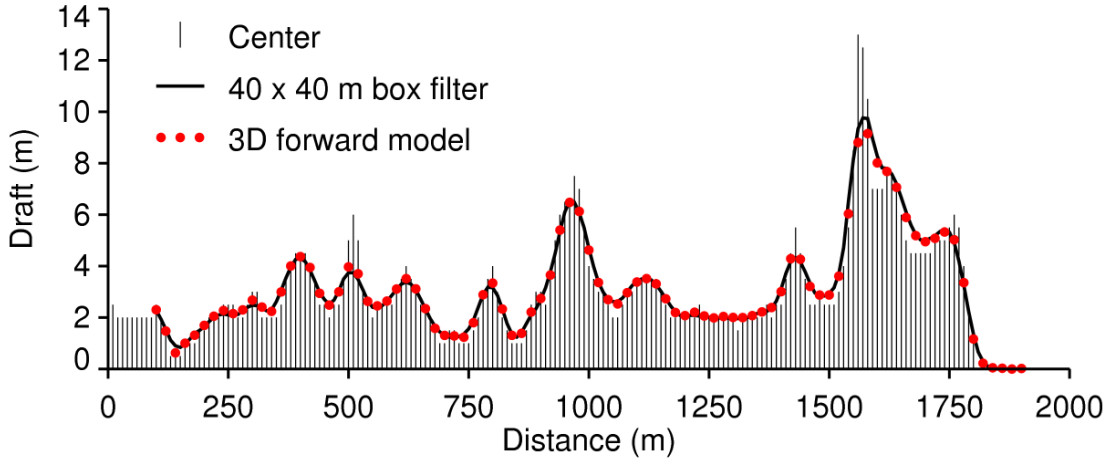
Common Problem of 1D EM



Underestimation of peak ridge thickness

1D Interpretation of a 3D Problem



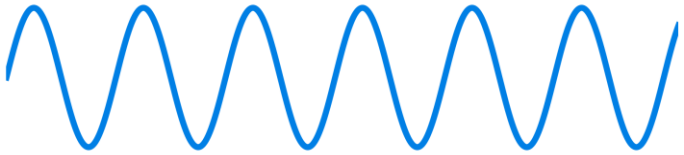


Underestimation of peak ridge thickness just footprint smoothing?

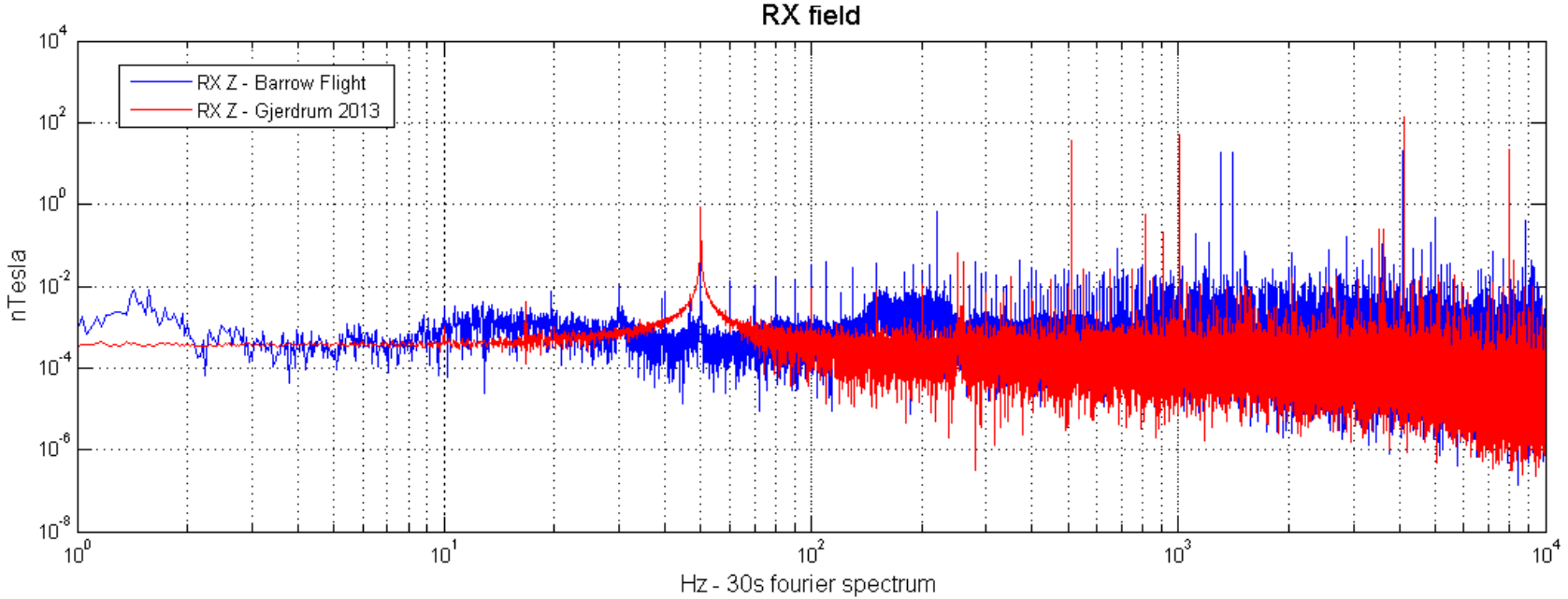
Challenges of 1D EM Sea-Ice Thickness Retrieval

1D Assumption	Reality	Approach
Sea ice as level plates	Ice deformation zones on sub-footprint scale	2D Interpretation of adjacent data and variable sounding depth
Sea ice is a non-conductive medium	Brine inclusions in young ice and pressure ridges	Information from different sounding depth
Sea ice can be describes as one layer	Porous sub-ice platelet layer below solid sea-ice	Multi-layer analysis with sensitivity to a range of conductivities

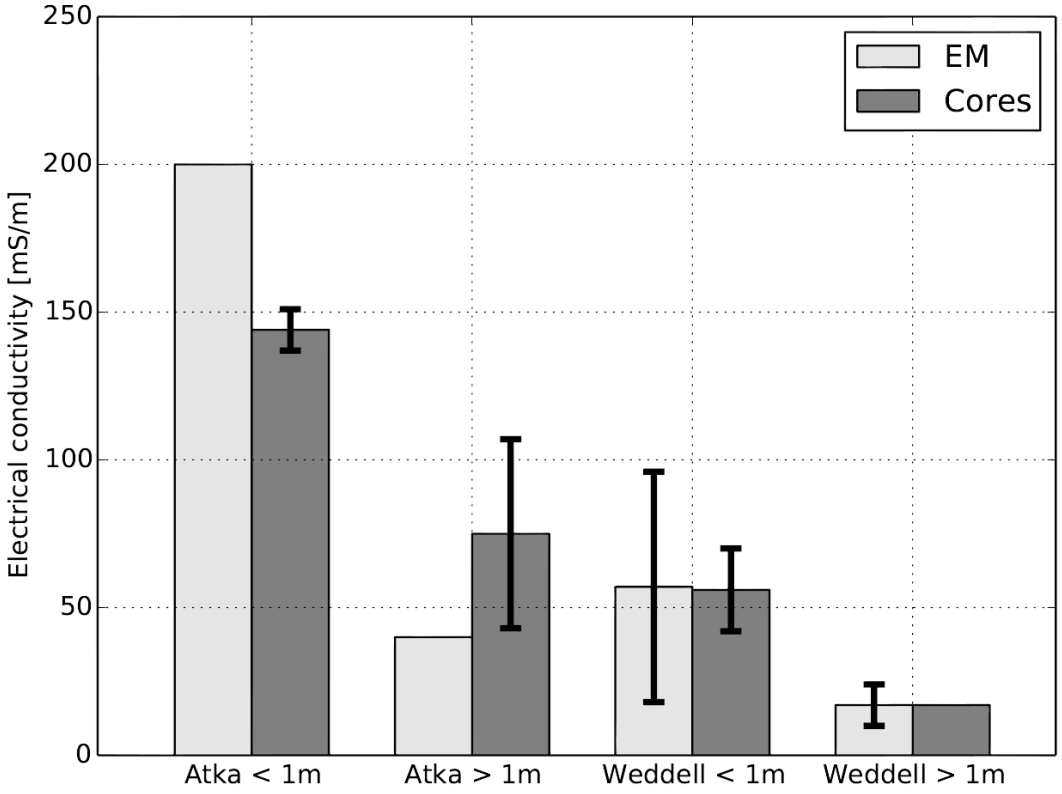
Single Frequency



Multi Frequency



What can you do with Multi-Frequency EM?

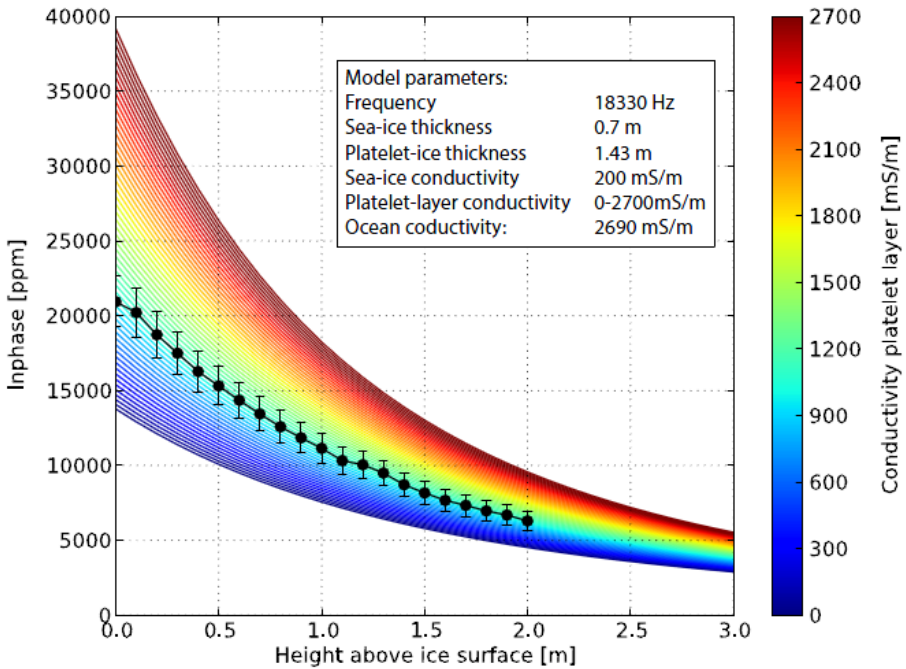


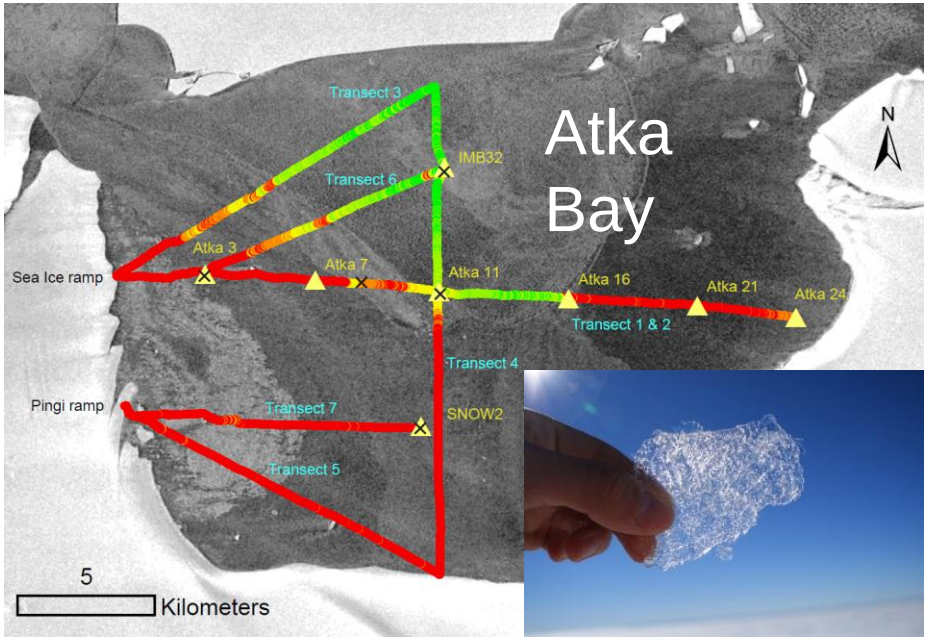
High frequencies (> 60kHz) are sensitive to sea-ice conductivity

But relationship to porosity is complicated

What can you do with Multi-Frequency EM?

a)





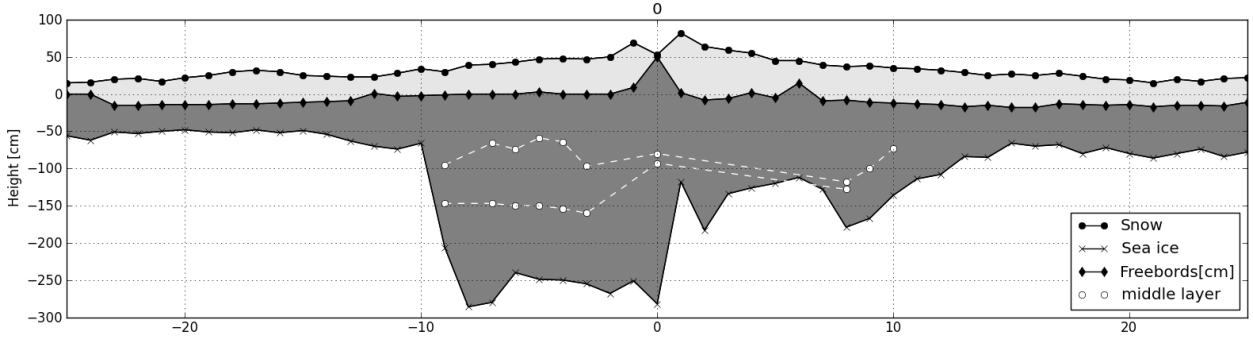
Sub-ice platelet layer

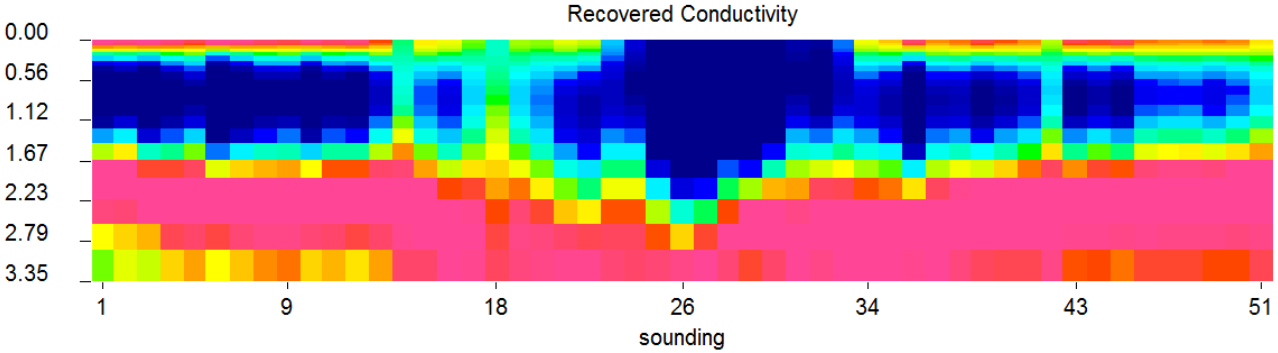
What can you do with Multi-Frequency EM?

Drilling Antarctic MYI ridge:

- 2 days (-20°C)
- 4 lost drilling flights + bit
- 2 wrecked thickness gauges
- 3 broken power cords

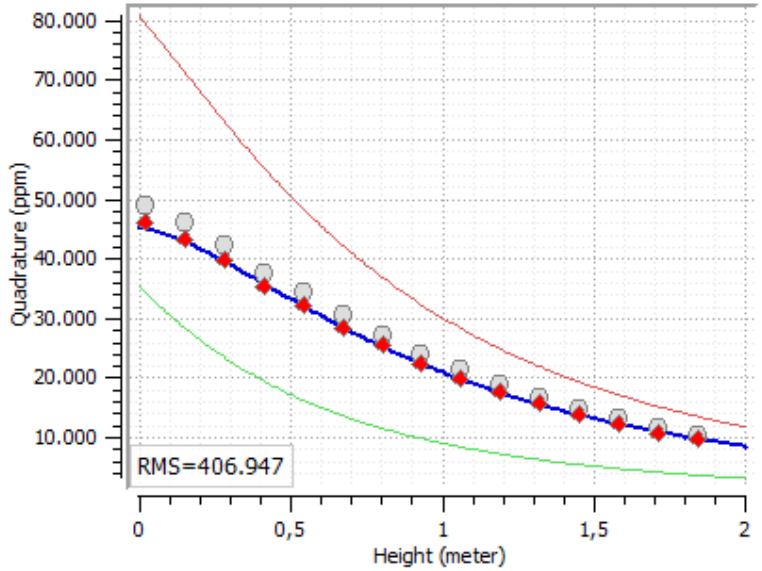
What can you do with Multi-Frequency EM?

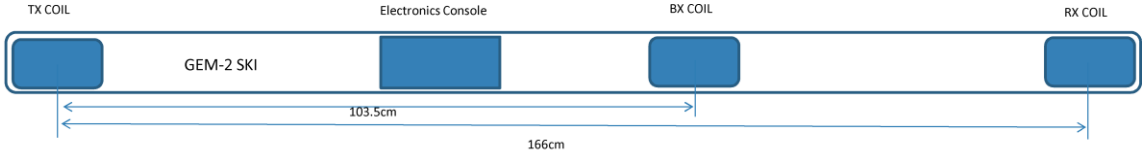




1D Inversion: EM1DFM (UBC)

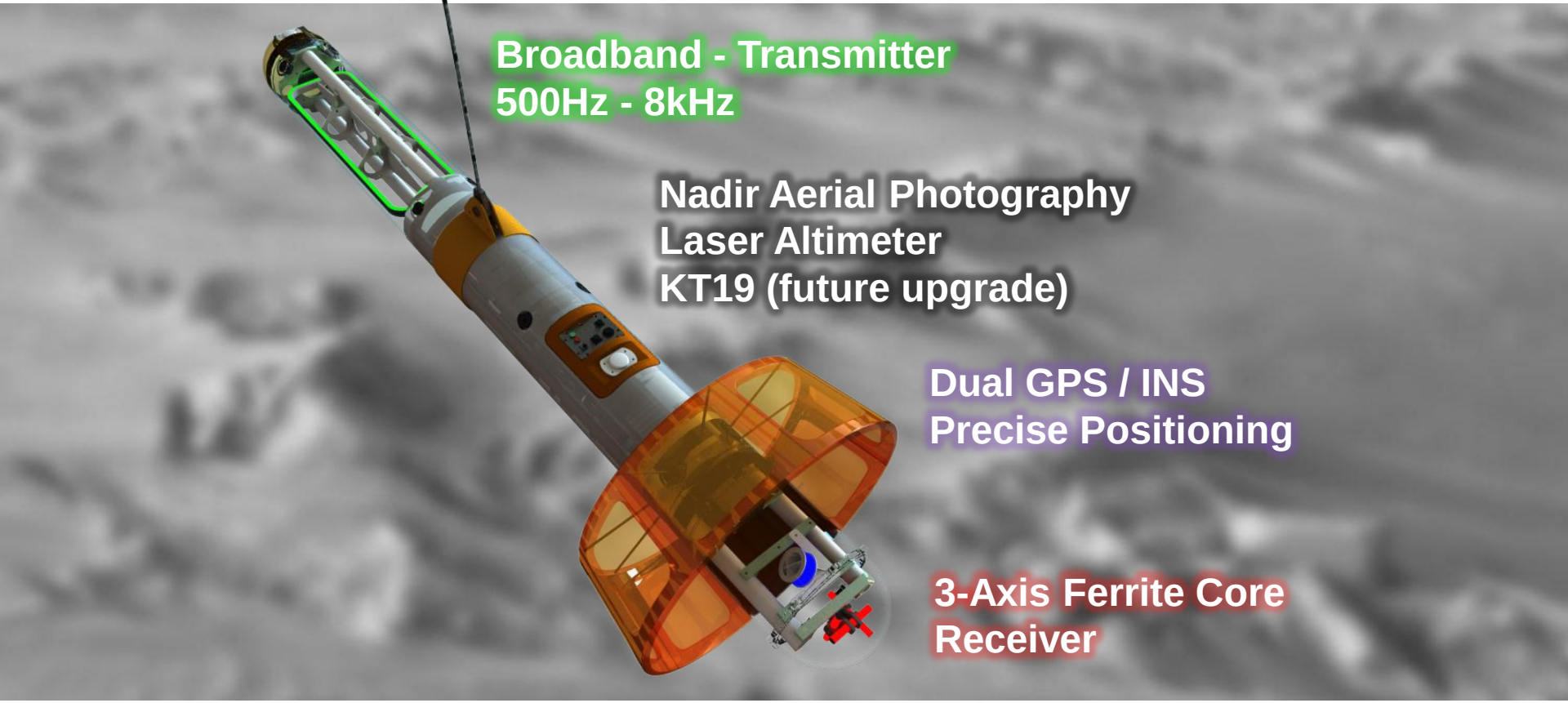
Commercial Sensors (GEM-2, Geophex Ltd.)



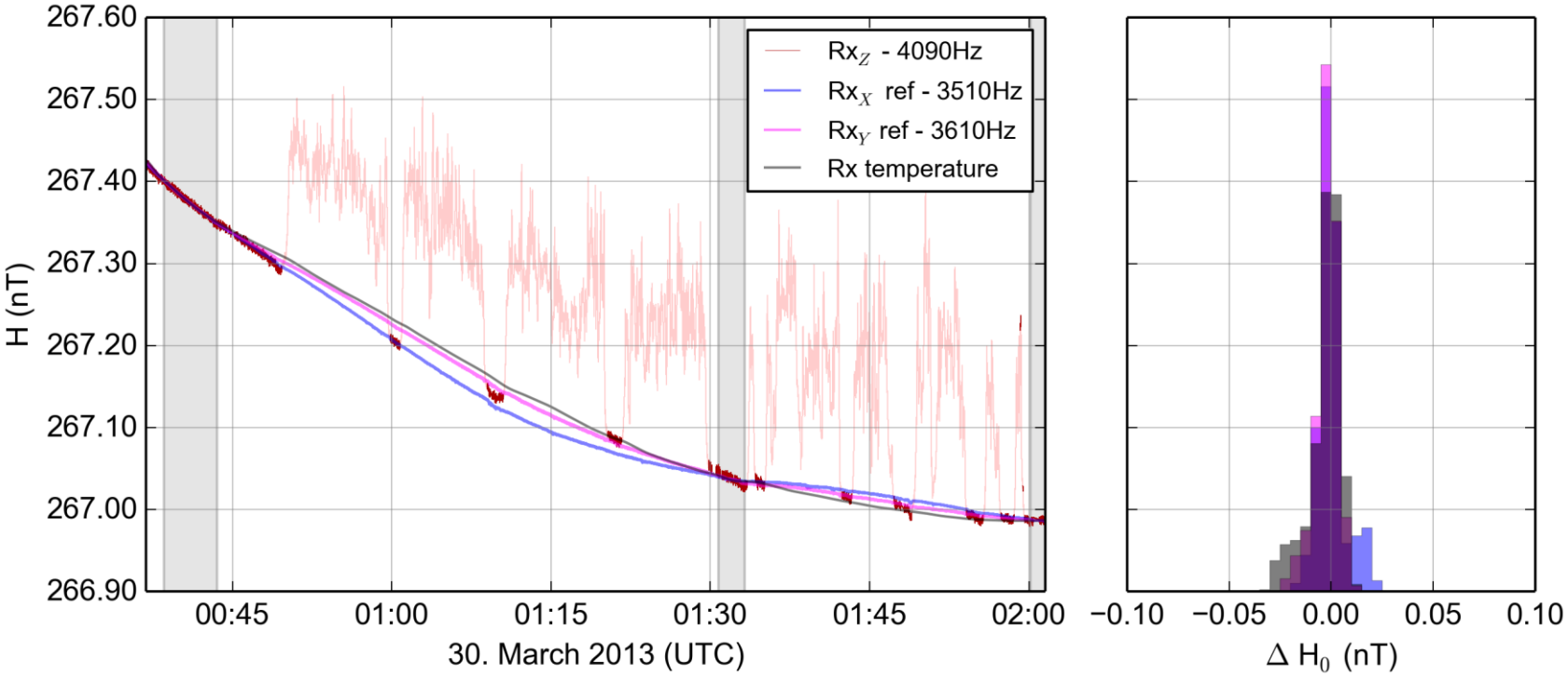


Tx **Bx** **Rx**

MAiSIE: Multi-Sensor Airborne Sea Ice Explorer

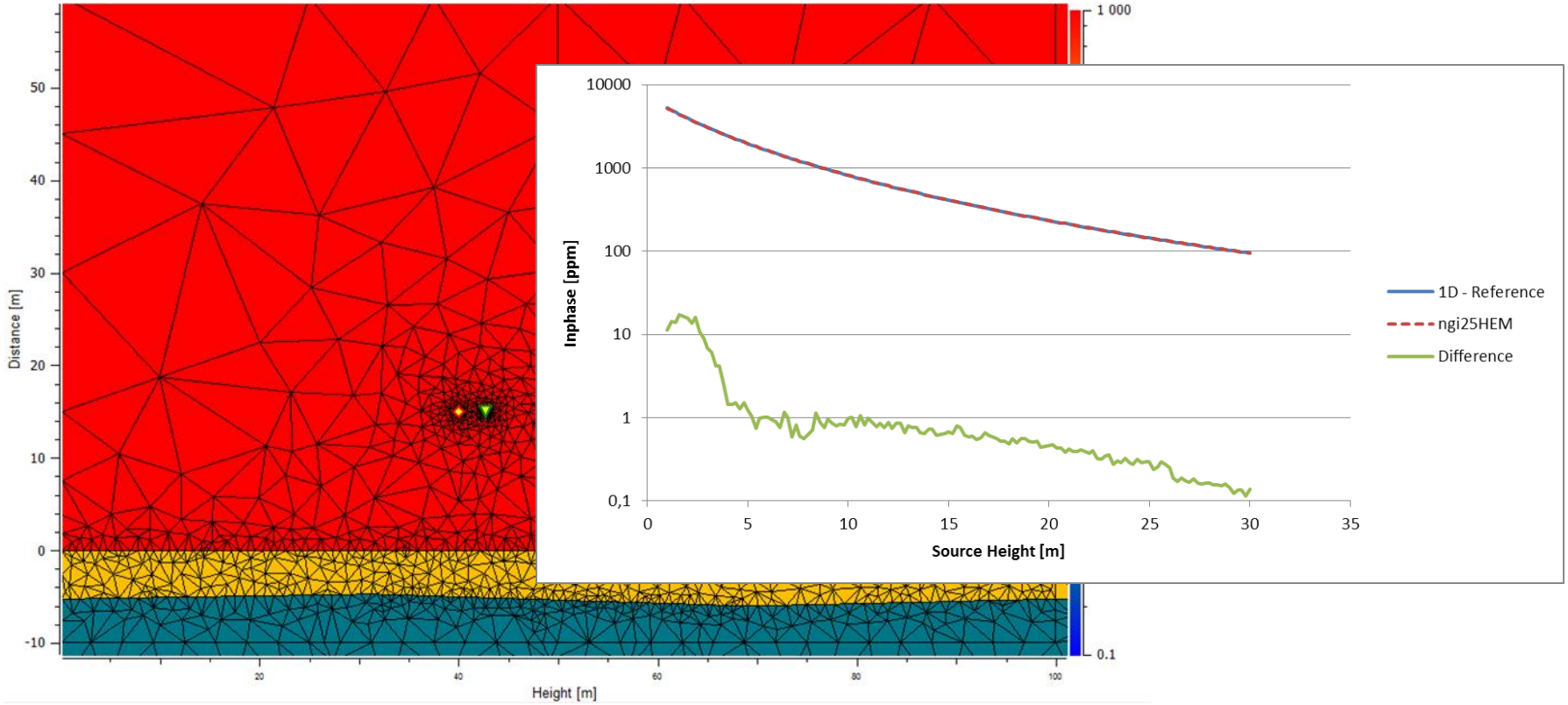


Innovation of airborne EM



No Bucking / Reference Signal for Drift Correction

2D Inversion of Airborne Data



2.5D Inversion ngi25HEM (NGI) under development

Summary

1D & single frequency EM sea-ice thickness retrieval is and has been a standard tool with a variety of applications

Multi-frequency EM is a bit more tricky but potentially rewarding for rapid estimation of internal sea-ice properties

Technical developments (MAiSIE) and 2D inversion schemes are being developed for better understanding of deformed sea ice

Questions?