→ EARTH OBSERVATION AND CRYOSPHERE SCIENCE
Advancing Knowledge of Cryosphere-Atmosphere-Ocean Interactions from Space

A Comparison of Sea-Ice Freeboard and Thickness Distributions from Aircraft Data and CryoSat-2

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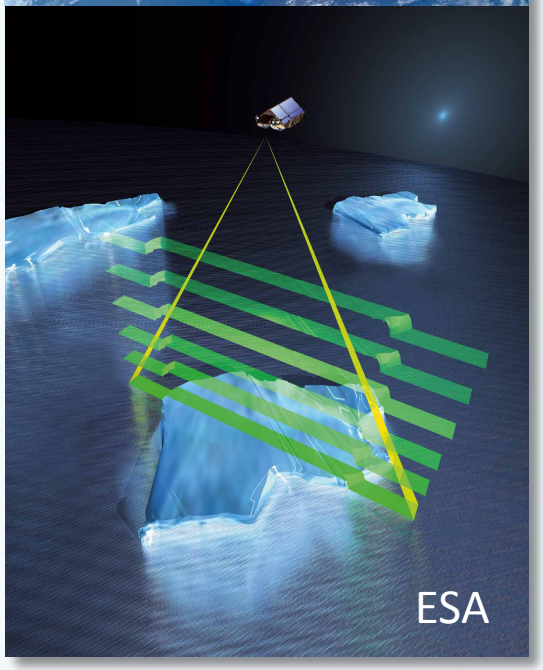
Introduction

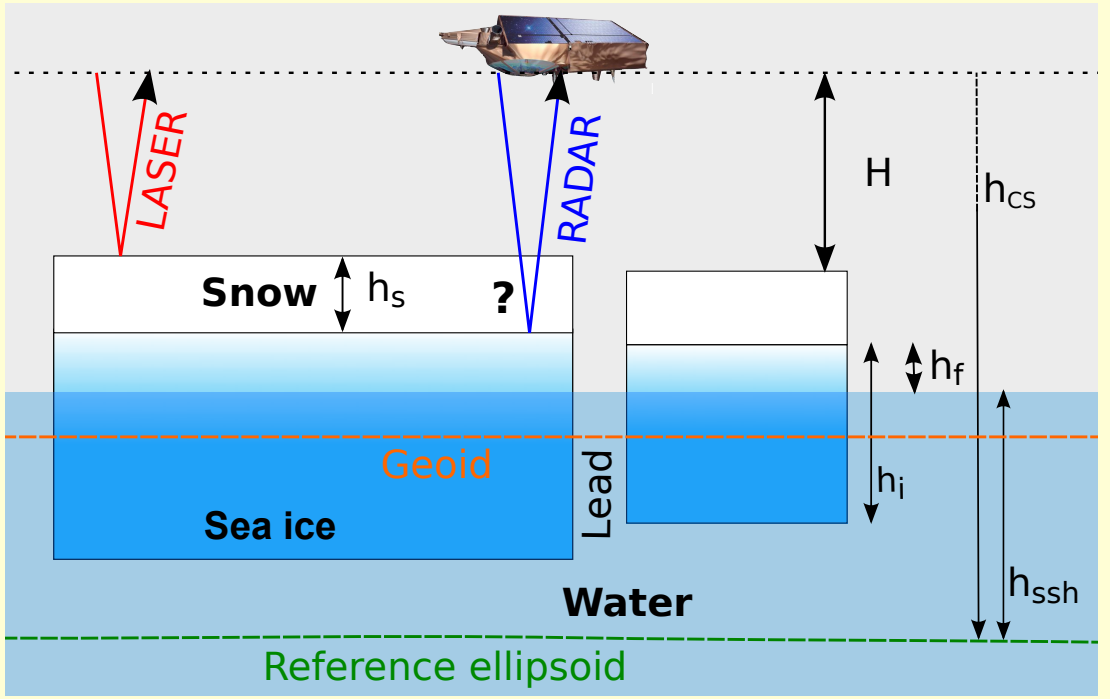
- CryoSat-2 measures the distance between satellite and surface.
- It is crucial to measure the reflecting horizon very accurately.



Measuring sea-ice freeboard

h_i	Sea-ice thickness
h_s	Snow depth
h_{fs}	Snow freeboard
h_{fi}	Ice freeboard
h_{ssh}	Sea-surface height
h_{GPS}	CryoSat-2/aircraft altitude
H	Measured distance

$$\mathbf{h_{fs} = h_{GPS} - H - h_{ssh}}$$



Introduction

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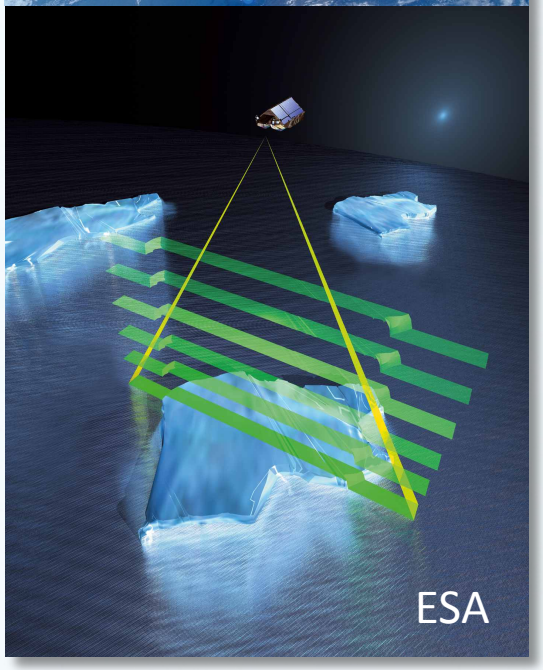
- It is crucial to measure the reflecting horizon very accurate

Hypothesis:

It is assumed that the CryoSat-2 radar is penetrating a cold and dry snow layer.

Objective of this study:

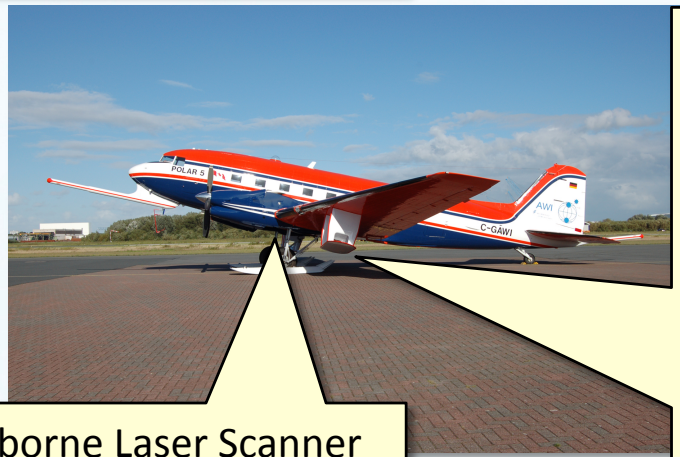
Testing the hypothesis with a comparison between airborne laser, radar and electromagnetic sounding and CryoSat-2 measurements over multi year ice in the Lincoln Sea.



CryoSat Validation Experiment (CryoVEx)

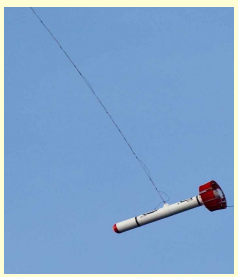
Airborne Laser Scanner

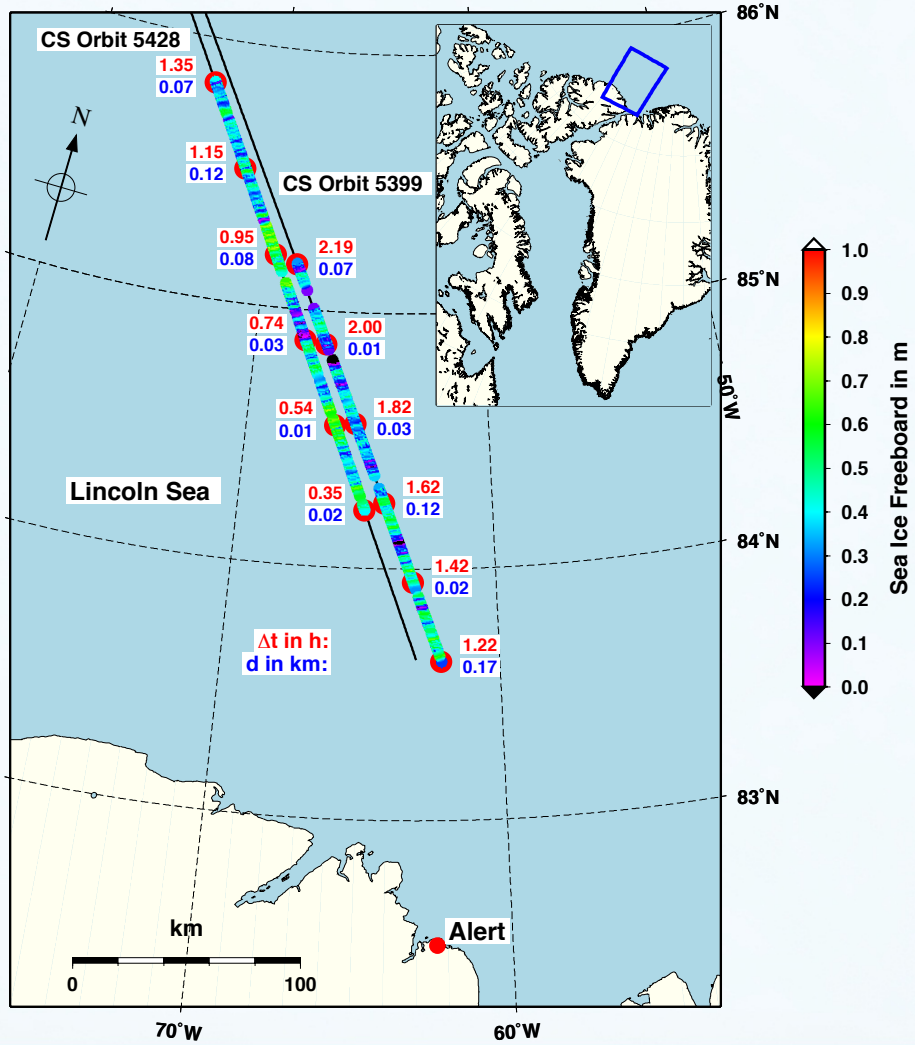
Airborne Radar Altimeter: *ASIRAS*



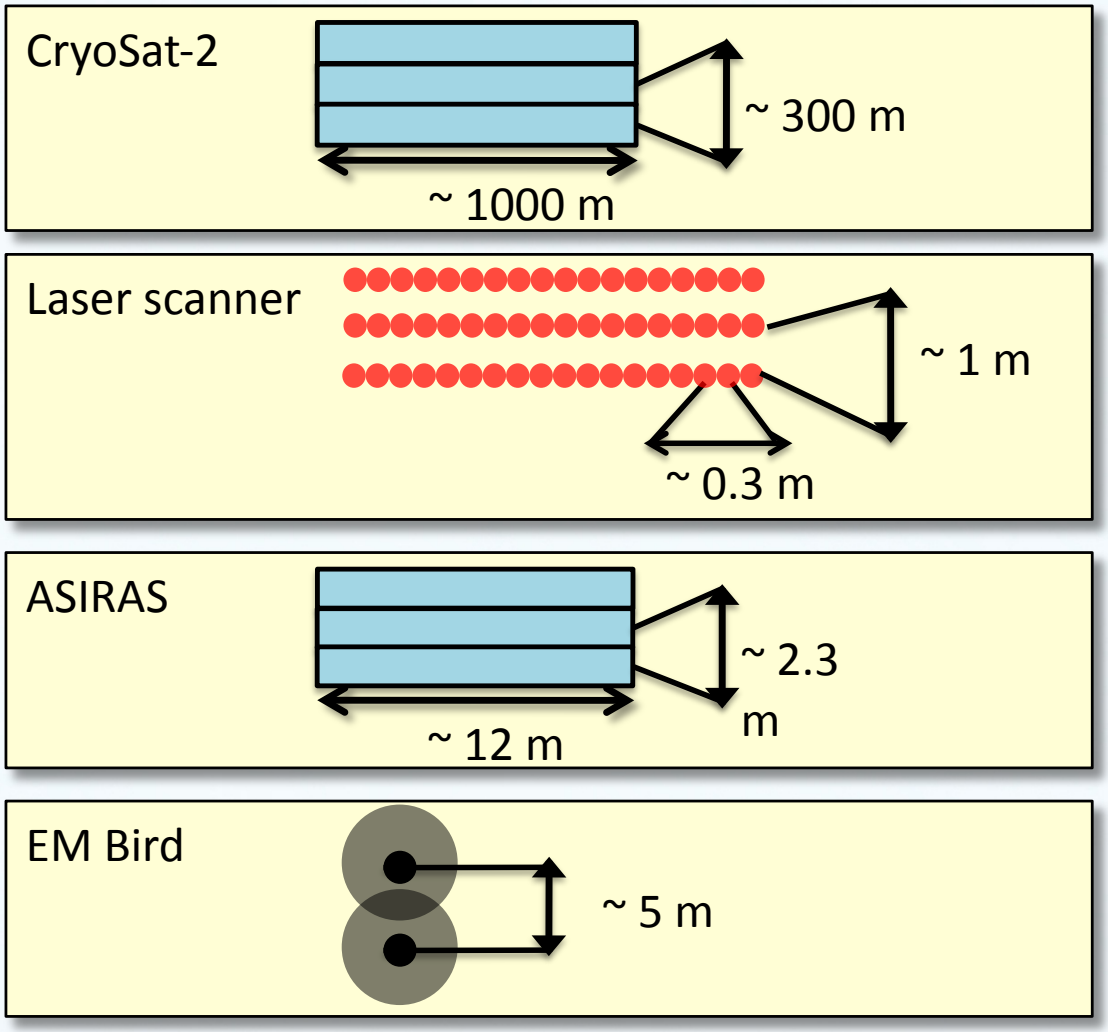
Airborne Laser Scanner

EM Induction Sounding: *EM BIRD*



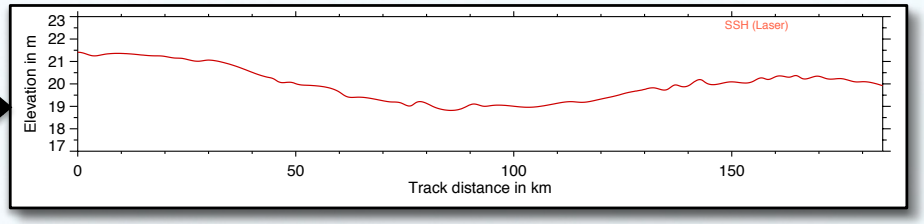


Data resolution - overview

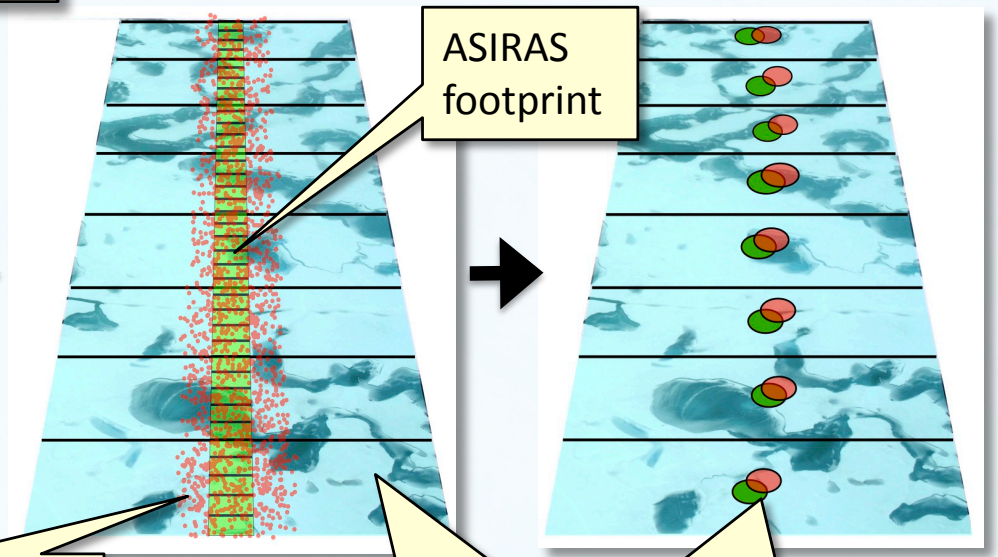


Data and methods

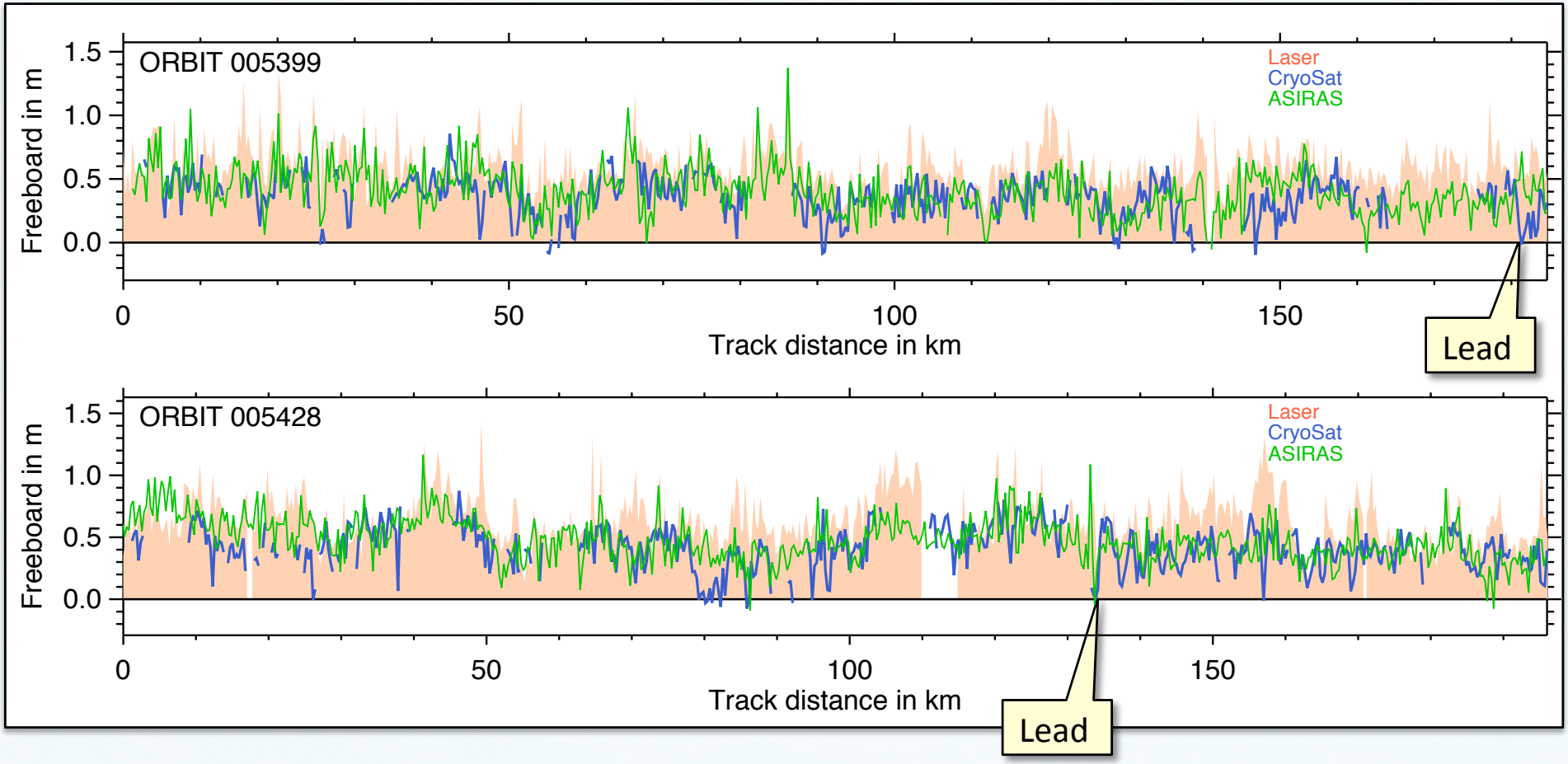
1. A manually picked sea-surface height from laser scanner data is used to calculate the CryoSat-2 and ASIRAS freeboard.



2. Laser scanner: A weighted average is formed of across-track data points.
3. Laser, ASIRAS, EM: Assigning to the respective CryoSat footprint and averaging the enclosed points.

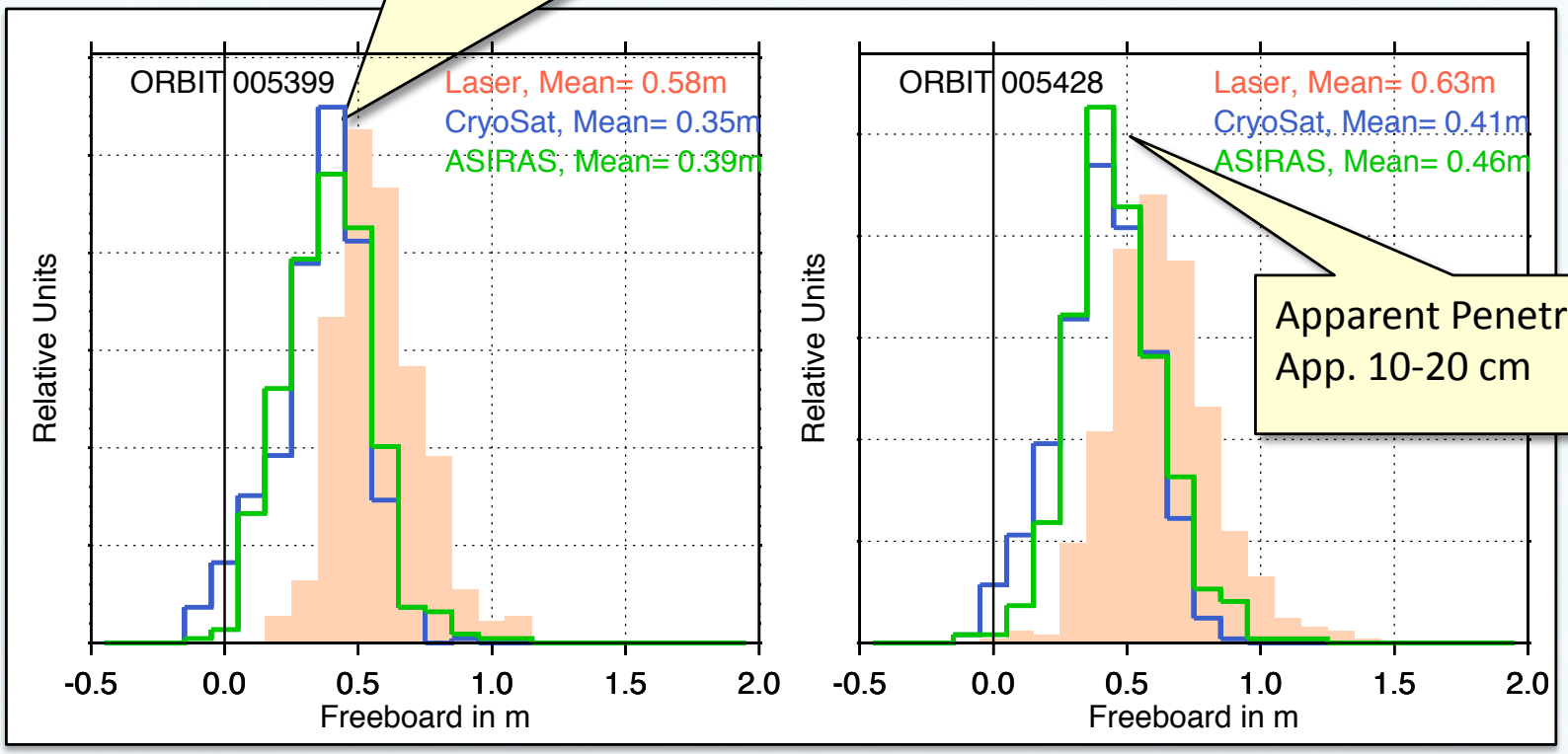


Results: Sea-ice freeboard along track



Sea-ice freeboard distribution

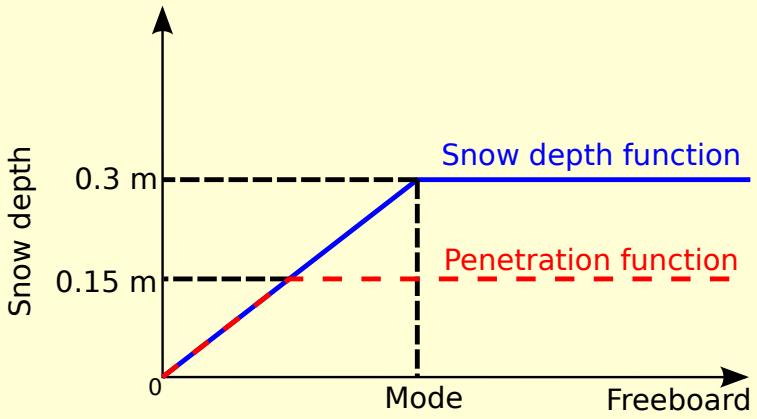
Radar modal freeboard is shifted to lower values compared to the Laser freeboard which indicates a penetration of the K_u band signal.



Apparent Penetration:
App. 10-20 cm

Calculating sea-ice thickness

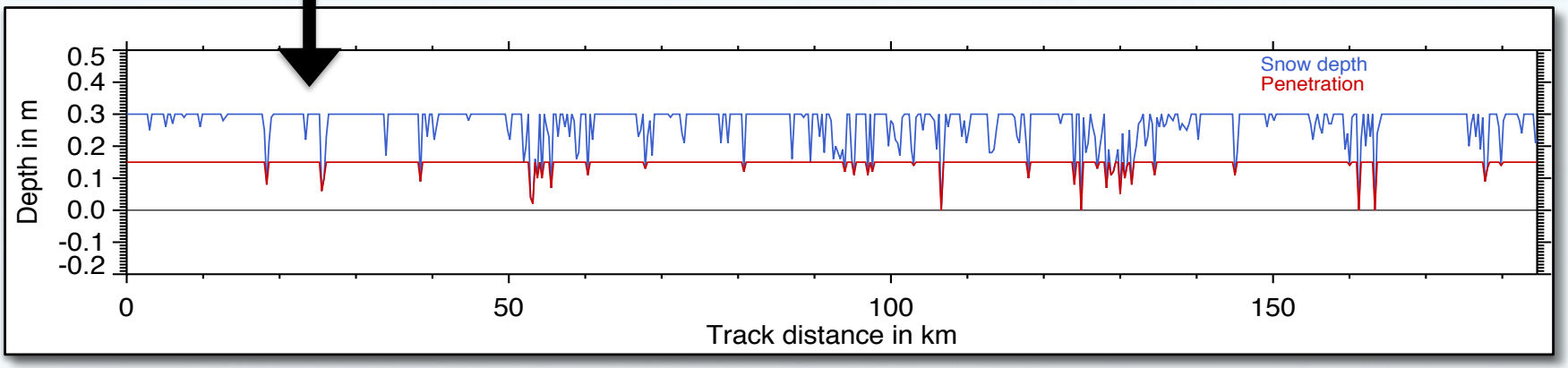
Assumed snow depth function:



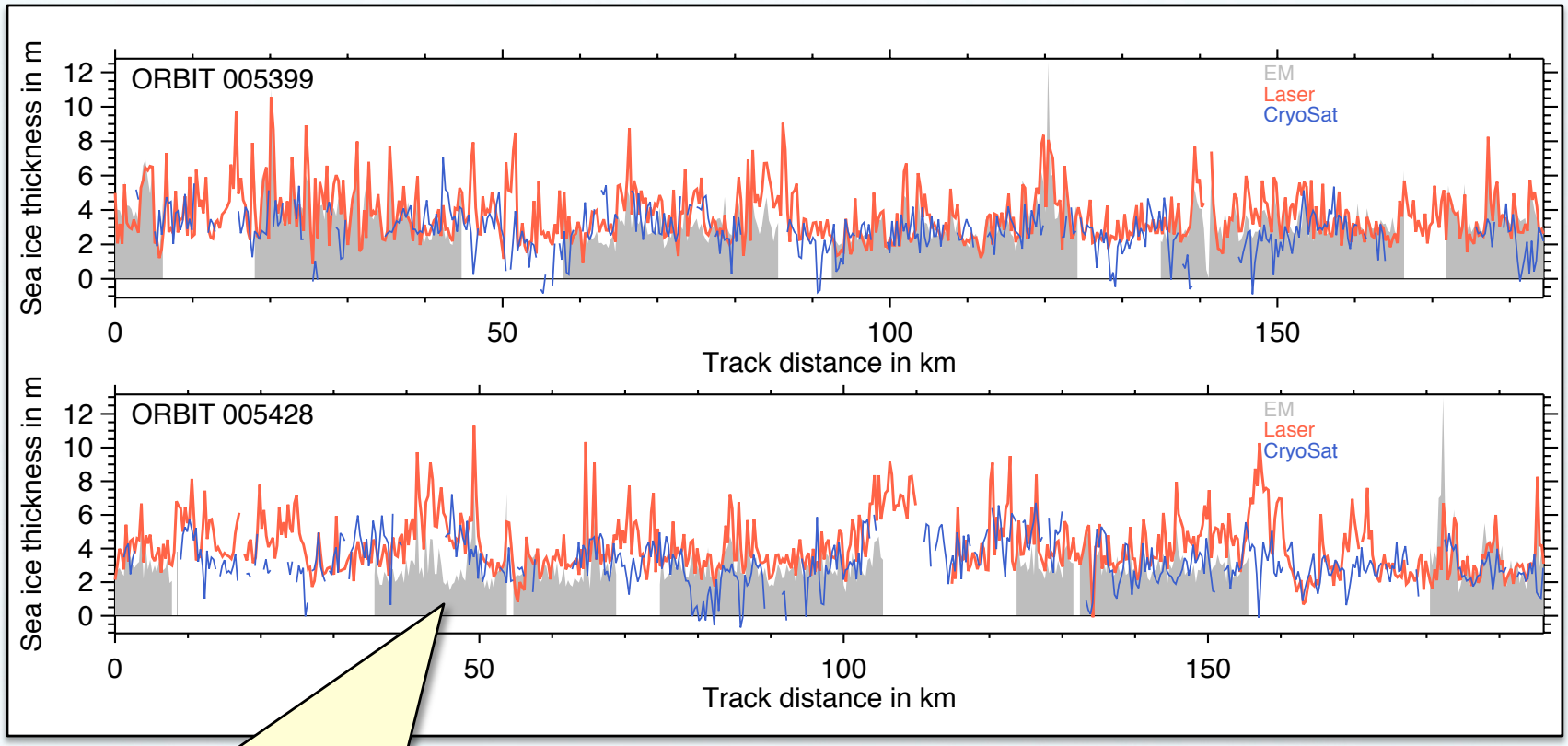
Sea-ice thickness T (with penetration term):

$$T = F \cdot \frac{\rho_W}{\rho_W - \rho_I} + Z \cdot \frac{\rho_S - \rho_W}{\rho_W - \rho_I} + P \cdot \frac{\rho_W}{\rho_W - \rho_I}$$

F	Freeboard
Z	Snow depth
P	Penetration
ρ_W	Water density: 1020 kg/m^3
ρ_I	Ice density: 910 kg/m^3
ρ_S	Snow density: 300 kg/m^3



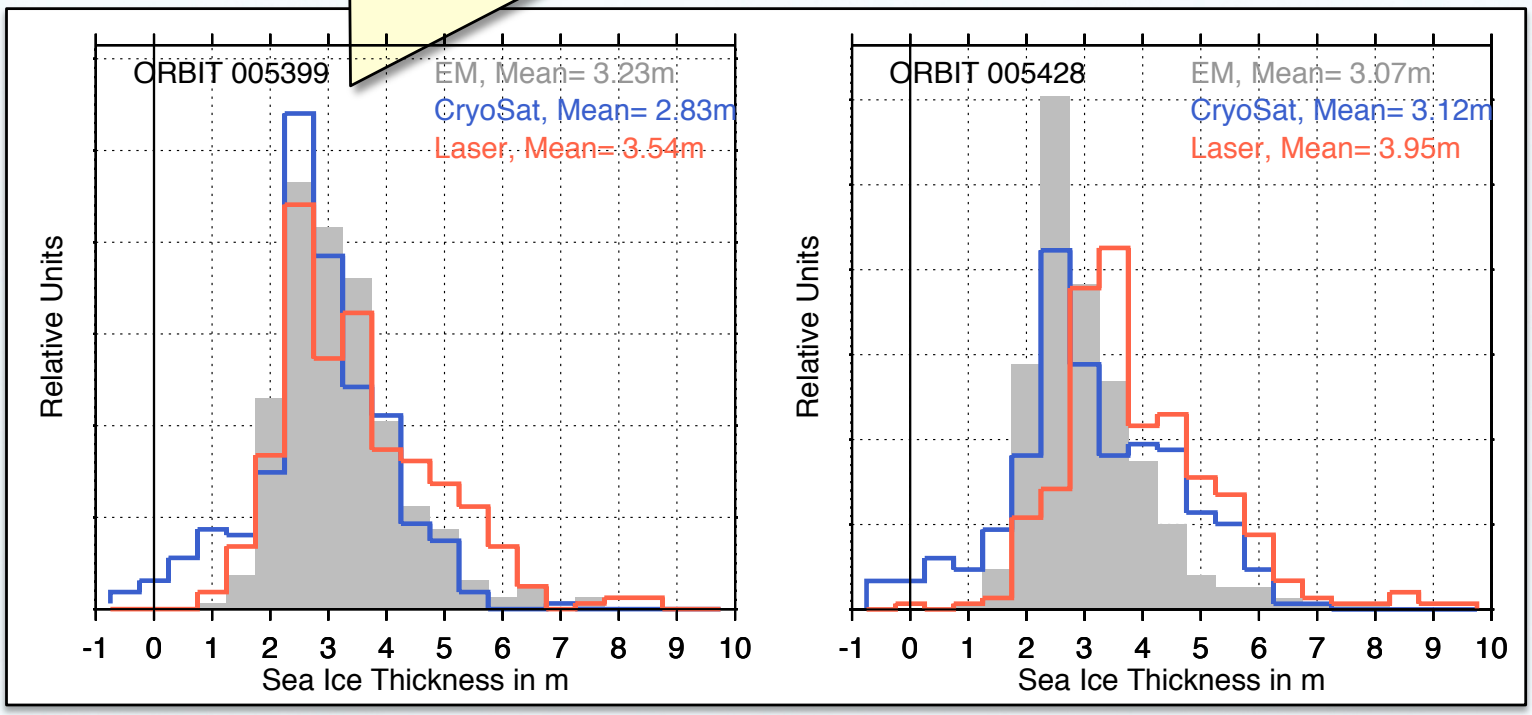
Results: Sea-ice thickness along track



Direct thickness measurements from electromagnetic induction sounding (EM Bird)

Sea-ice thickness distribution

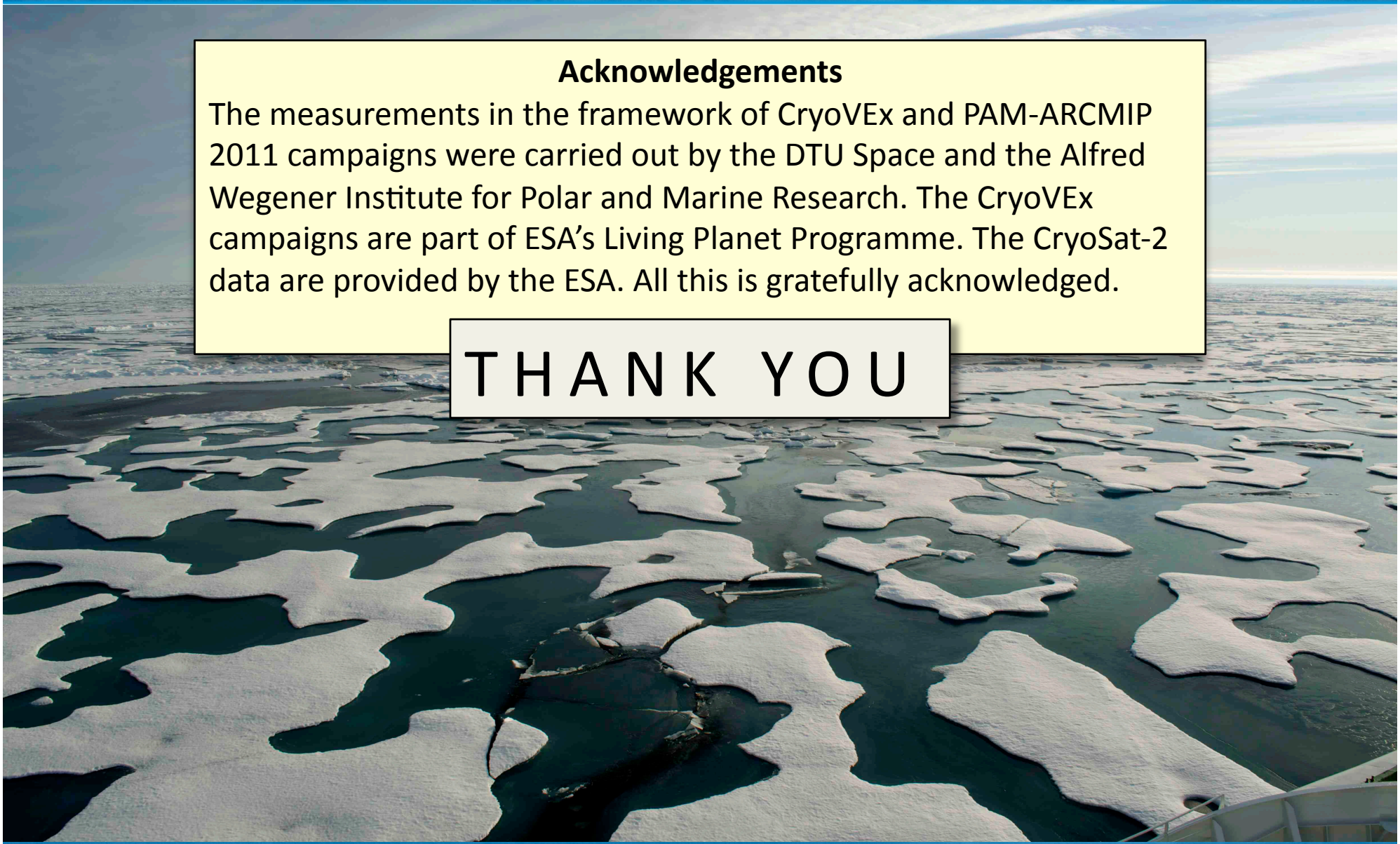
Using the assumed density values, snow depth and penetration provide a good agreement with the direct thickness measurements from electromagnetic induction sounding



Conclusion and outlook

- CryoSat-2 freeboard generally coincides with the ASIRAS freeboard.
- Radar does not penetrate the snow cover completely.
- With an assumed snow depth of 0.3 m and a penetration of 0.15 m a good agreement between Laser, radar and EM sounding thickness retrieval is achieved.

Outlook: We will investigate the influence of a snow layer and surface roughness with a forward model for CryoSat-2 waveforms.



Acknowledgements

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THANK YOU