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

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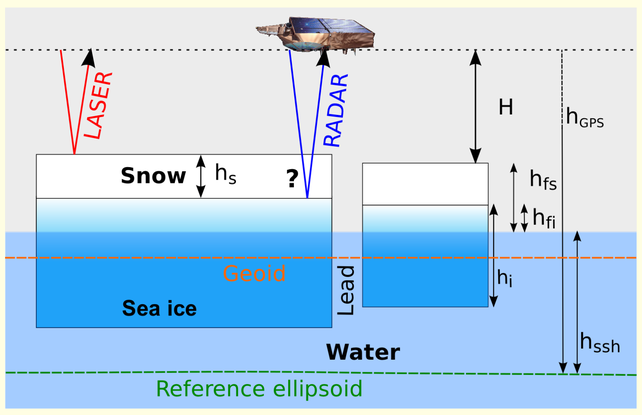
Motivation

The CryoSat-2 satellite is equipped with a Ku-Band radar altimeter which measures the distance H between satellite and surface [Wingham et al., 2006]. In order to convert sea-ice freeboard to sea-ice thickness it is crucial to know the reflecting horizon very accurately. It is assumed that the radar is penetrating a cold and dry snow layer [Willatt et al., 2011].

During the CryoSat Validation Experiment (CryoVEx) in the Lincoln Sea in 2011 Cryosat-2 underpasses were accomplished with two aircraft. Both aircraft flew in close formation at the same time of a CryoSat-2 overpass.

The **Objective** of our study is to investigate how snow cover and surface roughness are effecting the CryoSat-2 freeboard retrieval. Therefore the CryoSat-2 freeboard is compared with freeboard measurements of an airborne radar altimeter and an airborne laser scanner. Laser beams are always reflected at the surface and therefore can be used as a reference.



The sea-ice freeboard

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

Data/Methods

Airborne laser scanner (ALS):

1. A manually picked sea-surface height is used to calculate snow freeboard h_{fs}.
2. A weighted average is formed of across-track data points.
3. Assigning to the respective CryoSat footprint and averaging the assigned points

ALS FREEBOARD (MEAN)

Airborne Radar Altimeter (ASIRAS):

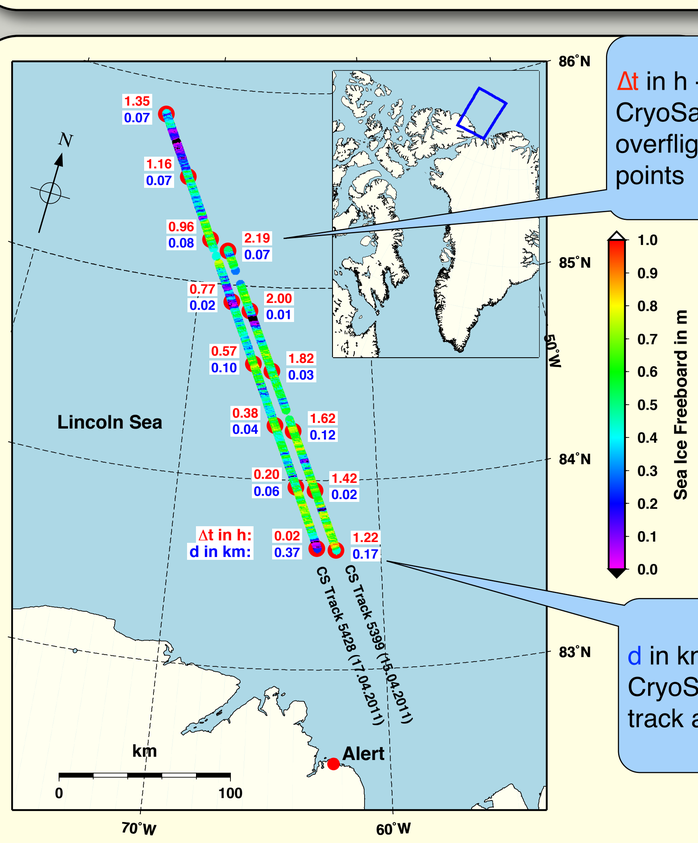
1. Laser scanner sea-surface height is used to calculate the freeboard.
2. Same as step 3 of **airborne laser scanner** methods
3. Removing constant offset by identifying open water spots

ASR FREEBOARD (MEAN)

CryoSat-2 (CS):

1. Laser scanner sea-surface height is used to calculate the freeboard.
2. Removing constant offset by identifying open water spots

CS FREEBOARD (ALS)



Δt in h - time span between CryoSat-2 and aircraft overflight at regular spaced points

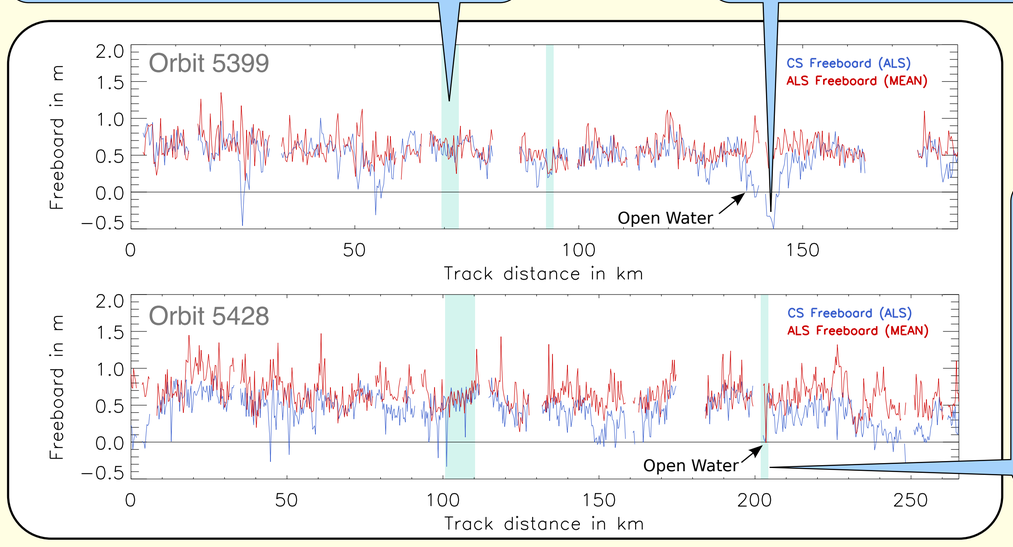
d in km - distance between CryoSat-2 and the aircraft track at points of Δt

Survey area overview and CryoSat-2 freeboard from coincident track sections.

Results

common features of CryoSat-2 and laser scanner freeboard

mismatches due to surface roughness?

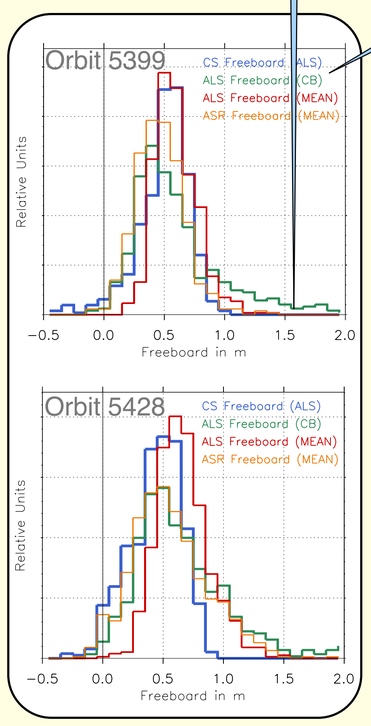


sea-surface height in CryoSat-2 elevation data is identified manually by open water detection

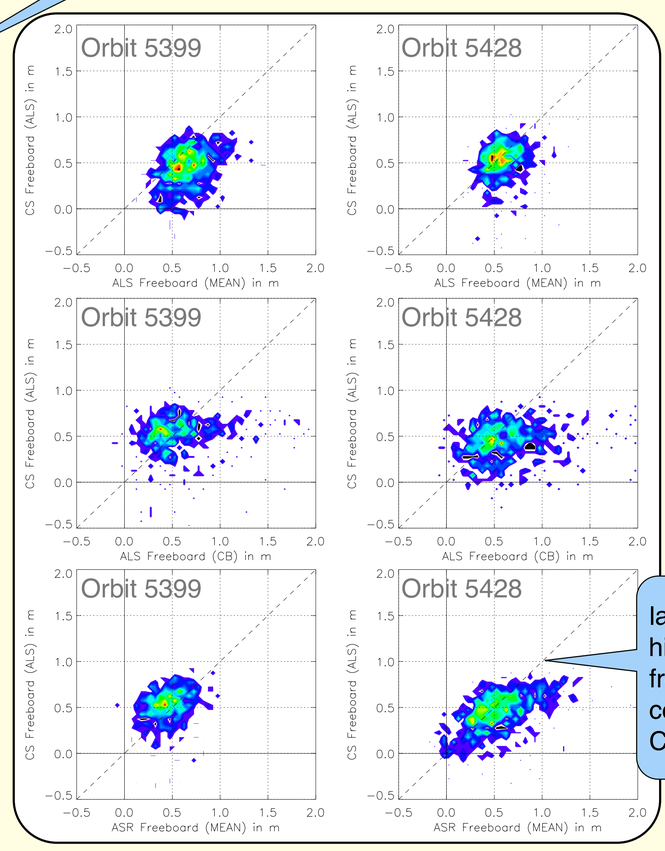
Sea-ice freeboard along flight lines of the two considered orbits

lack of high-level freeboard content in CS Data

ALS FREEBOARD (CB) is formed by taking into account laser scanner center-beam points next to the CryoSat-2 points



Probability density functions for calculated freeboards along the coincident track sections



lack of high-level freeboard content in CS Data

Scattering plots for sea-ice freeboard

Conclusion

- CryoSat-2 freeboard coincides with laser scanner and ASIRAS freeboard over flat surfaces.
- A penetration of snow cover by the radar is not clearly noticeable.
- Surface roughness seems to cause errors of the range retracking.
- **Outlook**: We will investigate the influence of surface roughness and physical properties of the snow layer with a forward model for CryoSat-2 waveforms.

Acknowledgments

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References

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