Arctic freeboard and snow depths from near-coincident CryoSat-2 and ICESat-2 (CRYO2ICE) observations over sea ice: A first examination

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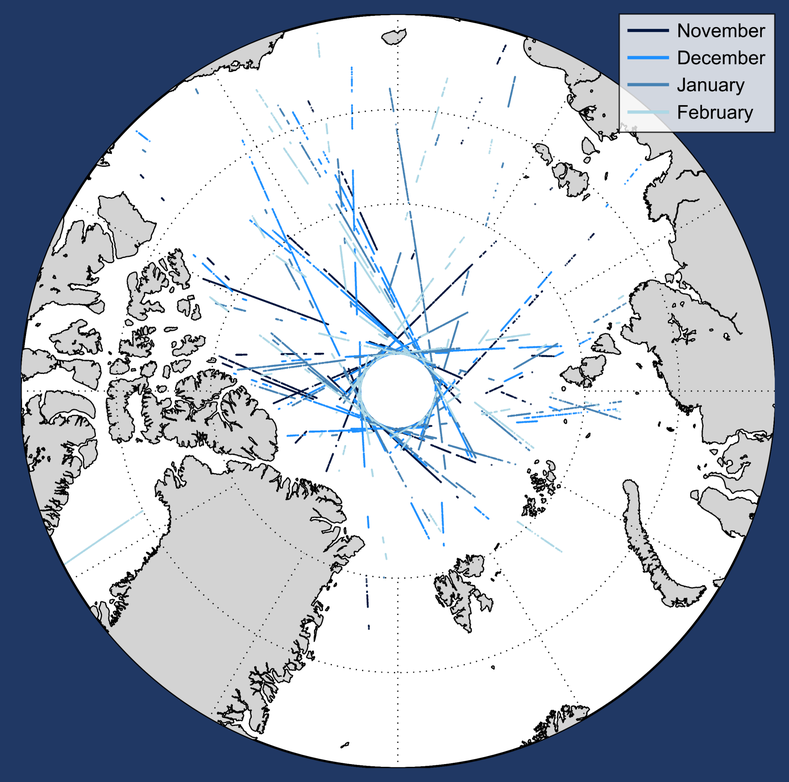
Limited CRYO2ICE observations in the **Arctic.** Common thresholds used for altimetry-derived freeboards **significantly removes data.** **Satellite-derived snow depth** observations over sea ice **shows inconsistencies**, likely caused by the radar observations.



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MOTIVATION

The orbit maneuver, known as CRYO2ICE, that periodically aligned CryoSat-2 with ICESat-2 in summer 2020, allows for unprecedented near-coincident radar and lidar observations of polar regions. CRYO2ICE presents a possibility of investigating along-track radar and lidar freeboard, and derived snow depth.

OBJECTIVES

Our particular focus is on how the CryoSat-2 and ICESat-2 derived freeboards respond along-track to various conditions and how this effects the snow depth retrieval. This study will investigate the freeboards and derived snow depth in relation to changes in surface roughness, sea ice concentration and sea ice lead identifications, and show comparisons of radar and laser freeboards with auxiliary data.

METHODS

Retrieval of relevant parameters including laser/radar freeboard (from different re-trackers for radar observations), mean sea surface (MSS) and geophysical corrections, auxiliary data for comparison. Binning of data into comparable observations – selection of various binning criteria was crucial. Comparison with prior studies (although few published studies on CRYO2ICE data are available) and auxiliary data (nearest-neighbor search). Discussion on future work and comparability over the Antarctic (CRYO2ICE phase 2).

RESULTS

Negligible difference shown between using search radius of 1500 m or 3500 m when binning CRYO2ICE data. Inconsistencies when searching for correlation between surface roughness parameters (SSD, PP or gaussian width) along CRYO2ICE track. Significant reduction in data coverage when applying common thresholds for removal of complex waveforms. Potential link between low sea ice concentration and inconsistent freeboard observations. Passive-microwave-derived gridded snow depth higher than CRYO2ICE derived, although with less variability. No direct link between number of leads identified and inconsistent freeboard observations.

CONCLUSIONS AND FUTURE WORK

Investigation of more along-track CRYO2ICE comparisons and pan-Arctic comparisons as well. Incorporation of additional radar freeboard products for comparison. Potentially include auxiliary roughness information to derive additional conclusions. Antarctic studies may prove more difficult.

Table 1. Selection and binning methodology of CRYO2ICE observations.

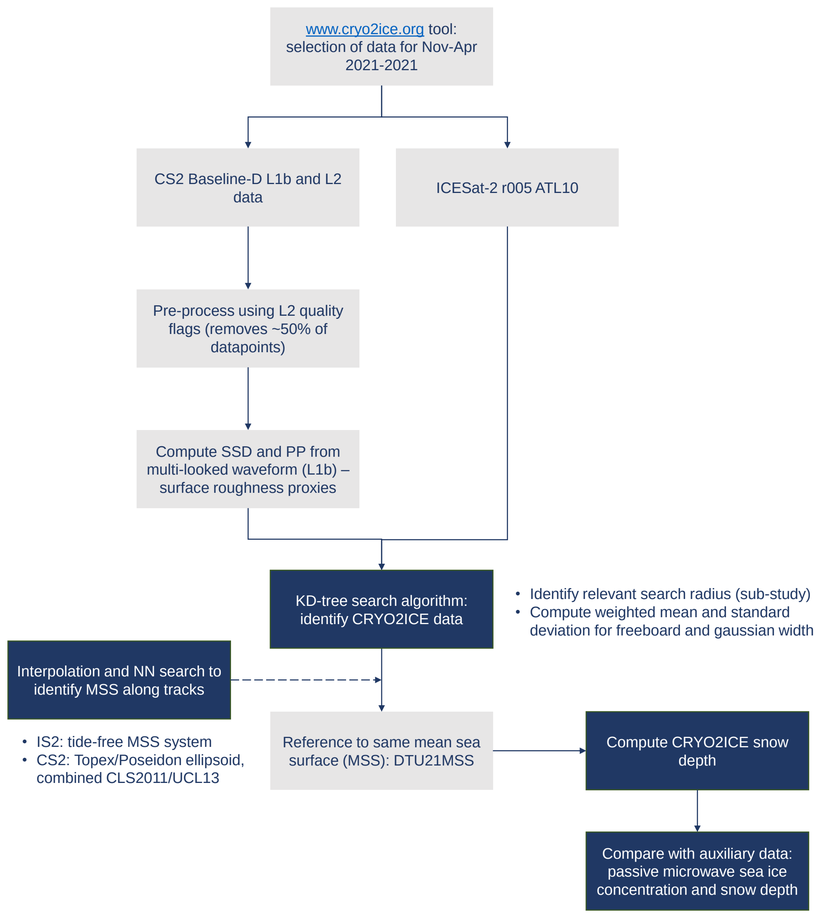


Table 2. CryoSat-2 and ICESat-2 specifications.

	CryoSat-2	ICESat-2
Period	2010-onwards	2018-onwards
Type	Interferometric SAR radar altimeter	Photon-counting laser altimeter
Frequency/wavelength	Ku-band (13.575 GHz)	Green (532 nm)
Resolution	SAR: 1.5 km x 300 m	Footprint: ~10m Separation ~10-200 m
Products used	Baseline-D: L1B, L2	Release 005: ATL10
Products to be used	Lognormal Altimeter Re-tracker (LARM) Climate Change Initiative (CCI) TFMRA50%	

Figure 1. Variance of the difference in freeboard and number of CRYO2ICE observations as a function of search radius for November 2021.

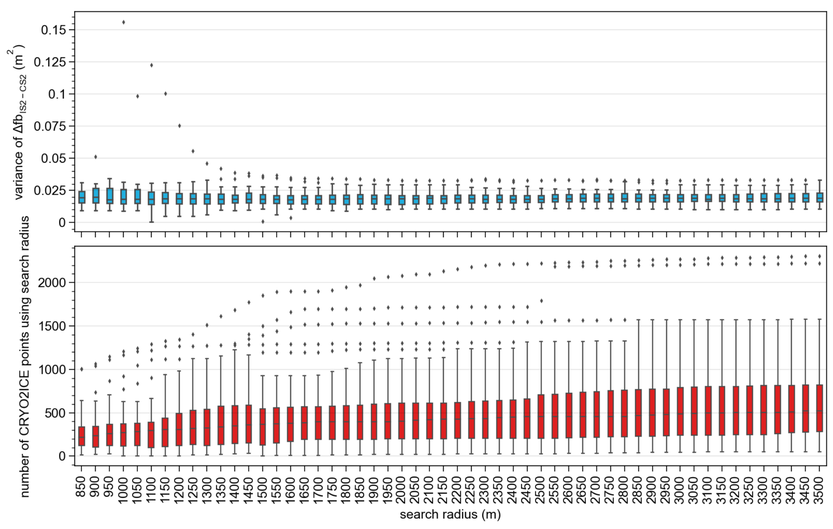


Figure 2. Specific CRYO2ICE track in November 2020 compared with auxiliary data and common thresholds shown. Note the axes.

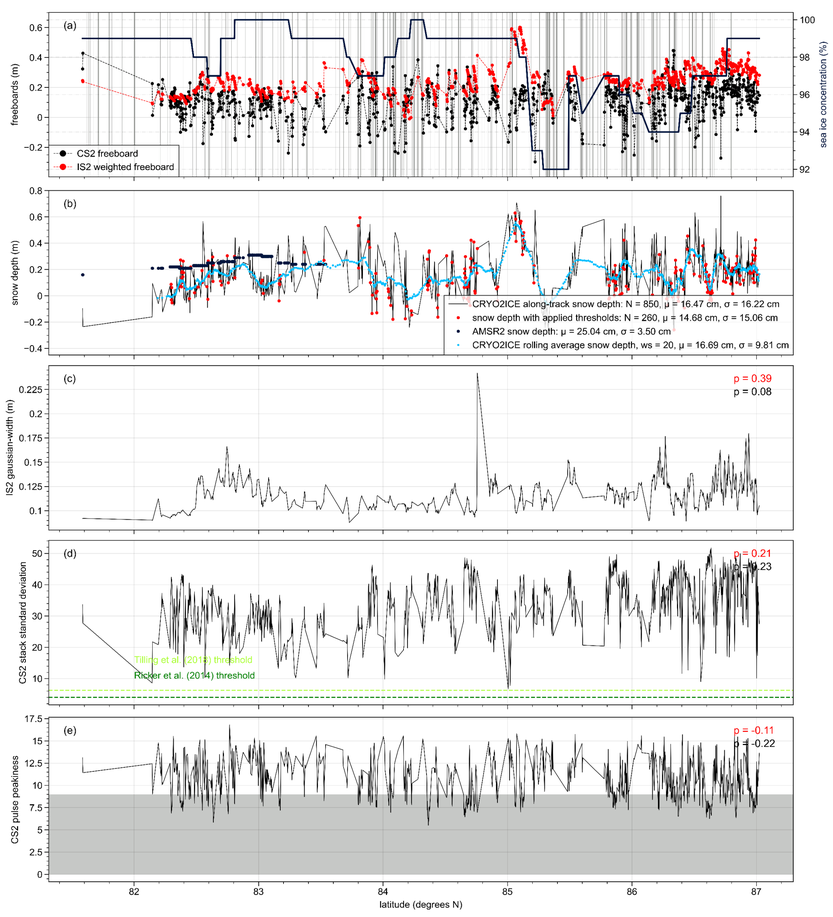
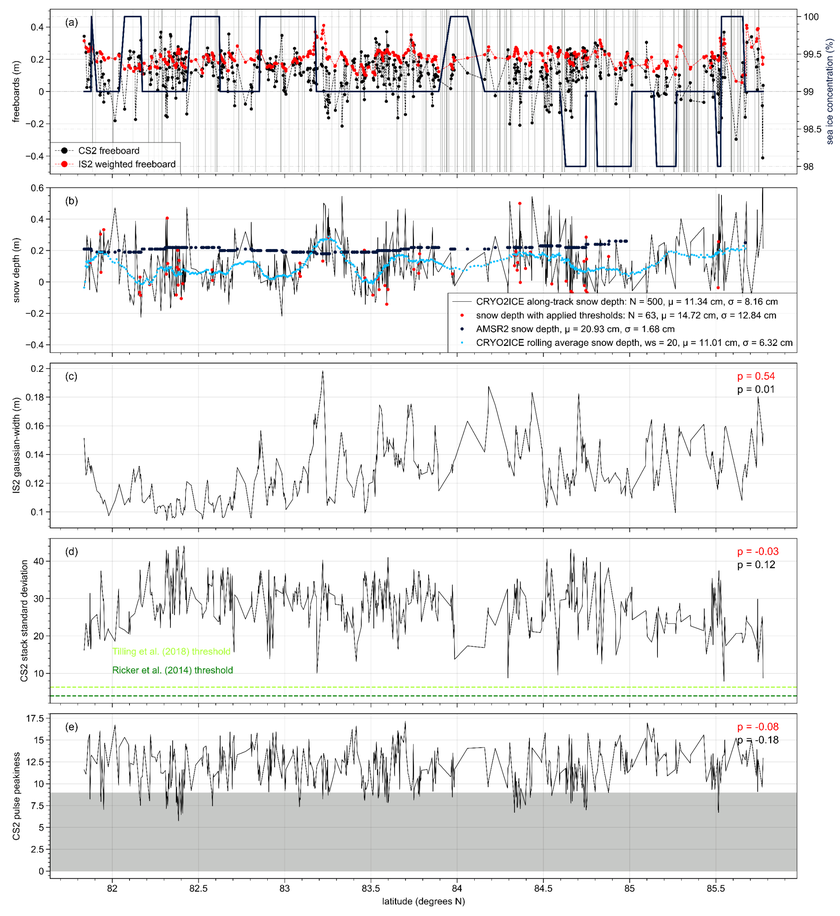


Figure 3. Specific CRYO2ICE track in January 2021 compared with auxiliary data and common thresholds shown. Note the axes.



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