# Tracking ICESat-2 Arctic Sea Ice Freeboard


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**Abstract:**

Arctic sea ice coverage has changed considerably over the last few decades. Sea ice extent record minimums have been observed in recent years, the distribution of sea ice age now heavily favors younger ice, and sea ice is thinning.

To investigate changes in the ice pack as a result of climate forcing, we have developed a technique to track individual Arctic sea ice parcels along with associated properties as these parcels advect through the Arctic Ocean.

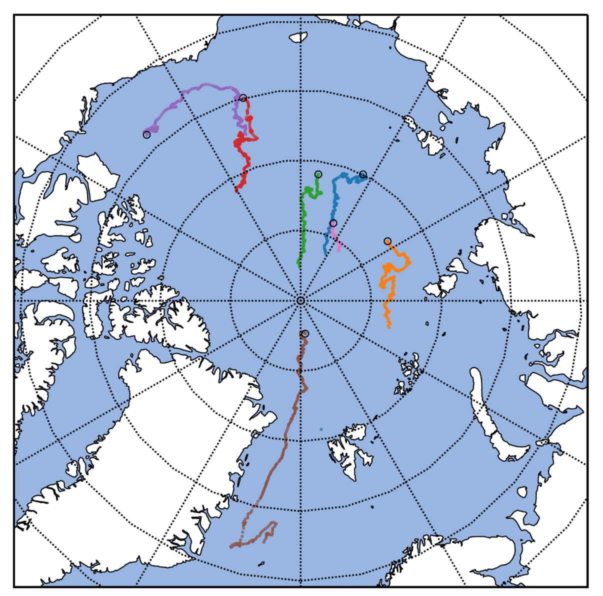
Here, we focus on tracking sea ice freeboard produced from NASA's ICESat-2 along the paths of buoys deployed by the International Arctic Buoy Program (IABP)., produced from NASA's ICESat-2 observations.

Analysis of sea ice freeboard time series serves to evaluate how the ice is growing and deforming over time. It also serves as a consistency check for the ICESat-2 freeboard product.

We find that the freeboard product shows a thickening of the ice along the buoy tracks through the winter season. Future work, pending support, will incorporate "virtual buoys:" sea ice parcels that are tracked using our sea ice motion product from NSIDC.



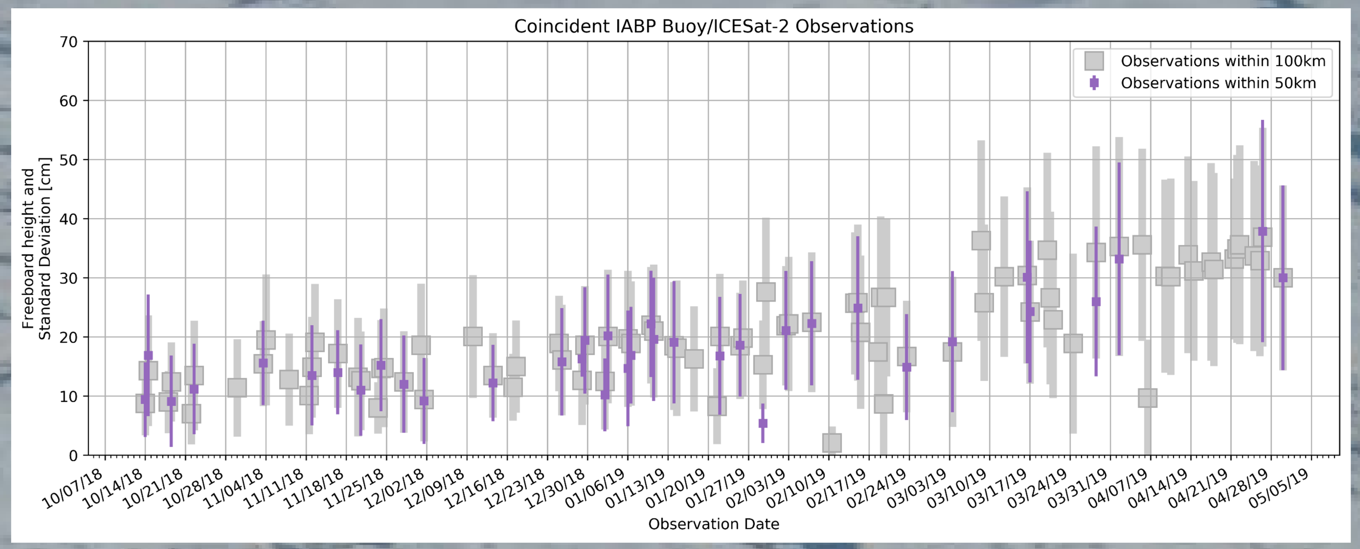
This study has been undertaken at CCAR, Dept. of Aerospace Engineering Sciences, University of Colorado-Boulder. The sea ice motion product and associated parcel tracking was supported by the NASA Cryospheric Science Program.

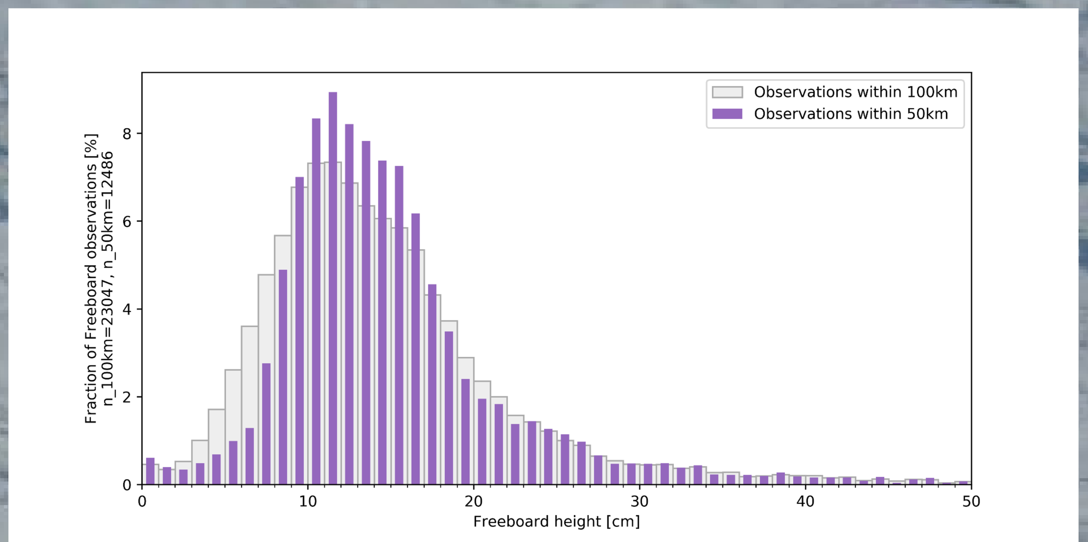



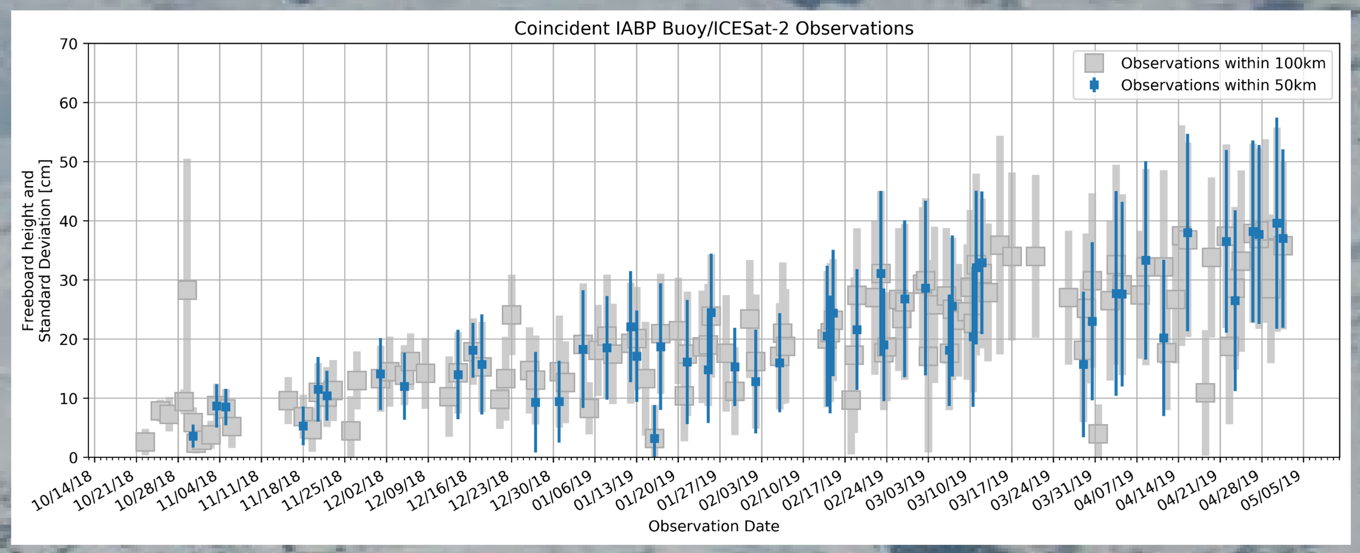
In this study, six IABP buoys are followed as they drift in the Arctic Ocean from Oct 14, 2018 – May 2, 2019 (ABOVE – open circles are the beginning of the track). As the buoys drift, they are periodically overflown by NASA's ICESat-2 satellite. However, the duration between overpasses is large (repeat time is 91 days), so we search for overpasses within 24 hours and within 50km, then 100km of the buoy's position to accumulate ICESat-2 freeboard data.

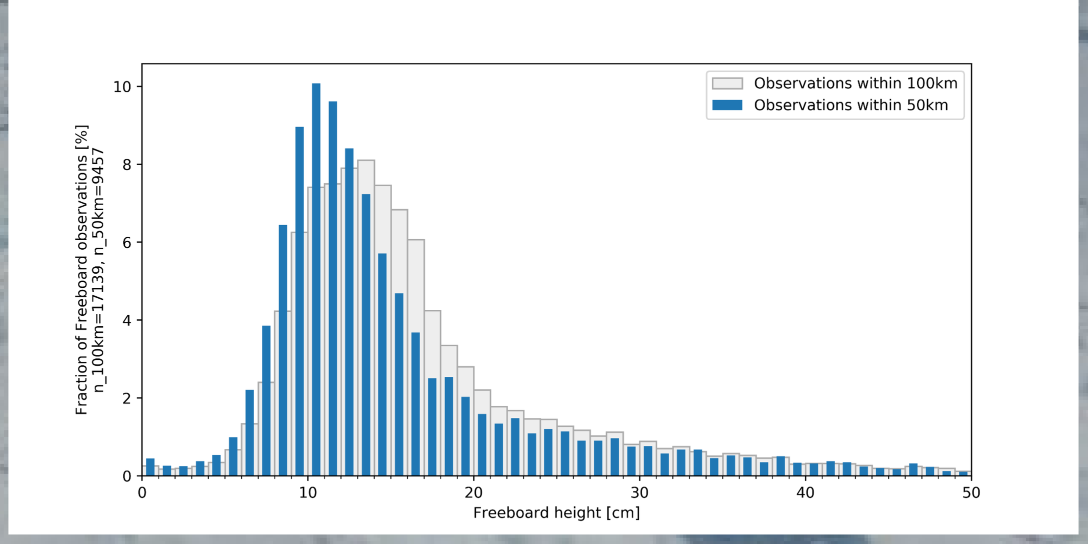
Time series of freeboard for three of these drift tracks are shown to the RIGHT. The mean and standard deviation of the sea ice freeboard (cm) of all ICESat-2 overpasses in a 24-hour window within 50km of the parcel location is plotted using the color of the track. Extending the search to 100km yields the grey plotted values. In each case, the freeboard increases by 20-30cm through the freeze-up season.

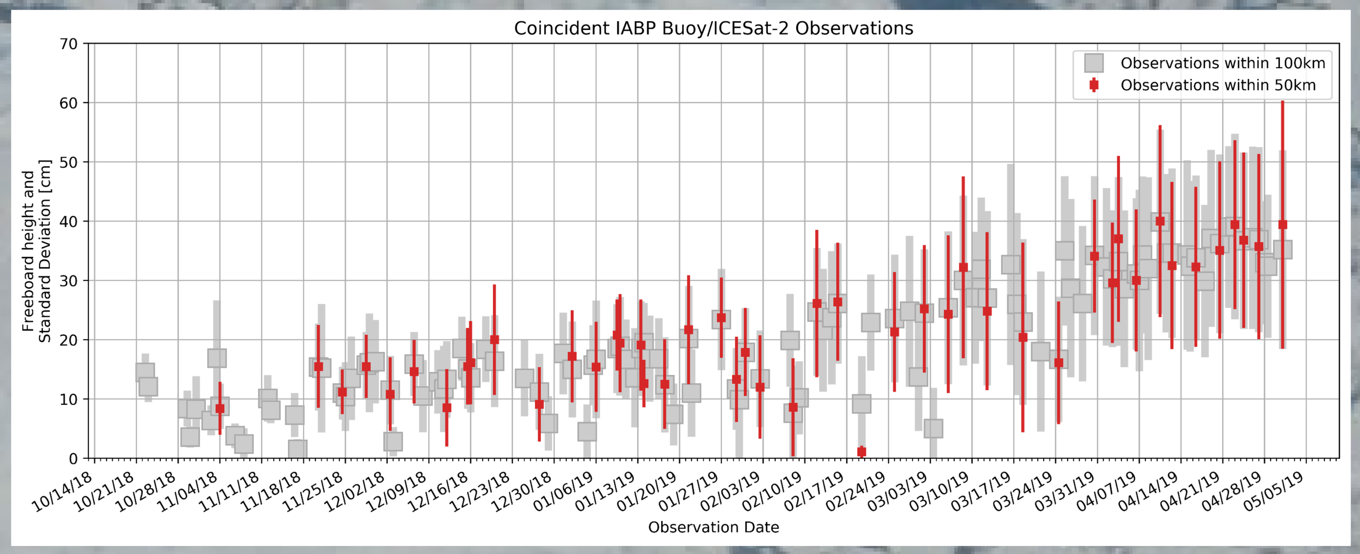
Histograms of the sea ice freeboard for a single day of ICESat-2 observations are shown to the right of each time series, using the color of the track for observations within 50km and grey within 100km. The histograms are used to ascertain the representativeness of searching within 50km of the buoy location vs 100km. Of course, a smaller search radius is optimal, but there is a balance between getting enough freeboard data and minimizing the distance between the buoy and the ICESat-2 overpass.

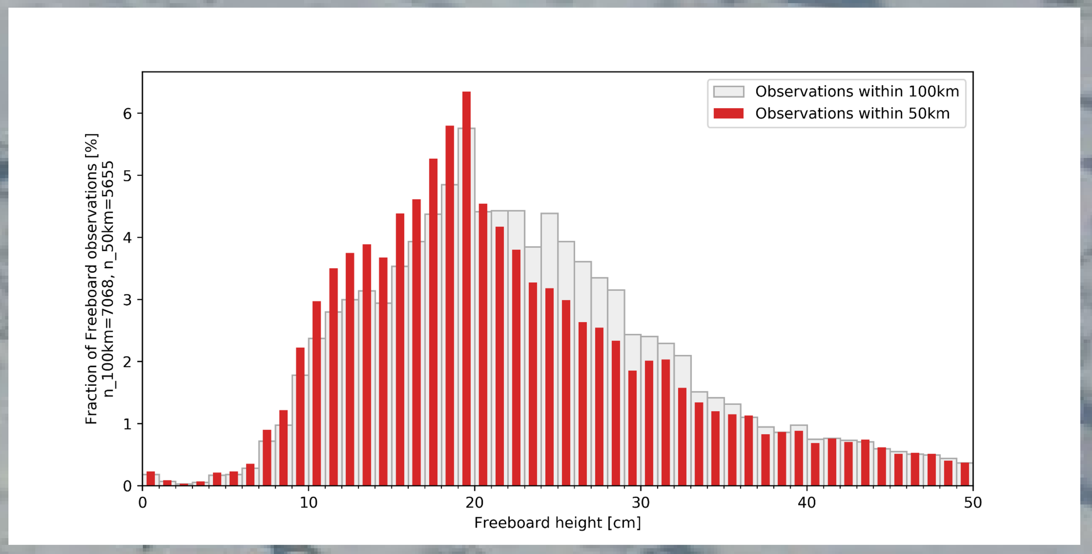



**Conclusions:** By following IABP buoys moving in the Arctic Ocean, changes in sea ice freeboard from NASA's ICESat-2 satellite are observed. The time series of freeboard mostly show a consistency in the freeboard product as the on-ice buoys advect through the winter season. Furthermore, we note an increase of 20-30 cm in sea ice freeboard during this period.

The next step in this research, pending support, is to create "virtual buoys" by utilizing our NSIDC sea ice motion product to track hundreds of parcels as they move about the Arctic Ocean and intersect ICESat-2 overpasses. This will enable more validation of ICESat-2 freeboard (and thickness), and will allow investigators to observe seasonal changes in sea ice freeboard. Untangling the thermodynamic growth of sea ice vs its deformation may be assisted by noting local sea ice elevation differences, which may be more attributed to ridging than variations in growth. Ancillary data, such as SAR, would also be beneficial for this type of analysis.

**References:**


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Photo: sea ice in Chukchi Sea, ~ 50 km off the NW Alaska coast, June 19,2008. Acquired by M. Tschudi from a USCG C-130.


AGU Fall Meeting
December 9-13, 2019