Review of "Multiple modes of shoreline change along the Alaskan Beaufort Sea observed using ICESat-2 altimetry and satellite imagery" by Bryant et al. 2024

Summary

This work makes a significant contribution to Arctic coastal erosion research, and particularly the use of ICESat-2 for coastal applications. The authors use annual PlanetScope imagery-derived shorelines (NDWI/Otsu) and ICESat-2 backshore and shoreline (manual) locations. Open water days, cumulative wave energy, and other environmental variables are brought in from ERA5 to better understand drivers of erosion. Fine-scale features are visible in the ICESat-2 photon data. A 10.7m/a shoreline erosion rate for Drew Point between 2019 and 2021 was reported, but also contextualized within recent decades of work, the outlier of the 2019 season, and local variability in shore classification. Slope measurements from ICESat-2 are discussed in the context of erosion rates/classifications from other sources.

The key contribution is the novel application of fine-grained photon-level analysis for coastal settings, especially as a complement to optical satellite imagery-based estimates of shoreline change. Importantly, the authors provide a thorough discussion of ICESat-2 uncertainty and leverage the repeating ground tracks in the Arctic for unique measurements of change from elevation profiles, comparing them to imagery-derived estimates. While Drew Point is an outlier for its high change rates, these same rates make it particularly valuable for honing satellite-based Arctic coastal change methods, and this work makes a notable contribution by focusing primarily on satellite data. Features observed in the ICESat-2 data are thoroughly explained and used to explain/compared to erosion rates. In terms of the applicability of ICESat-2 for shoreline monitoring, the upper shoreline is shown to better match the Planet-derived shoreline estimates.

Section/Paragraph Level Response

- 2.3 Overall, this section could benefit from at least some citing of the existing, and especially recent research into sub-pixel shoreline extraction from satellite imagery. I think this method is sound and the thresholds in the Appendix are acceptable, but there's enough variation in the literature I'm curious why you went with what you did. Perhaps existing tools like CoastSat do best with sandy beaches with no sea ice, and a simpler approach does fine here. Or perhaps existing tools were challenging to integrate with PlanetScope? Would this work for other locations along the Beaufort Sea Coast? In any case I think that's worth clarifying to future readers, even if this paper is focusing more on ICESat-2 than rehashing satellite shoreline methods, which is understandable.
- 2.3. I'm convinced by your argument of the North-South simplifying assumption for this study site. However, this is likely only generally applicable for Arctic coasts, and even then, I'm not sure if the associated uncertainty of this assumption would be a problem for anywhere rates of erosion are much lower than Drew Point. Maybe a sentence here or in the discussion better clarifying why you opted not to go with standard cross-shore transects, or whether this is a valid assumption for Beaufort coast locations other than Drew Point.
- 2.3.P4 More explanation is needed about how and why you used matplotlib contour.
- 2.4.P2 (/Introduction) I agree the terrain heights provided by ATL08 are too coarse, but there are ground/vegetation classification data provided at photon resolution, and easily filterable using SlideRule. It's possible that these classifications are over-smoothing coastal features here and shouldn't be used but could be worth showing/saying so if that's the case.

Similarly, why or why not use quality_ph flags that come with ATL03 to filter afterpulsing, instead of manually applying a 0.8m cutoff?

- 2.4.P2/P3. I am curious about whether signal_conf_ph > 3 is sufficiently including photons from the face of the bluff. I doubt this warrants anything like a new plot, but given the manual inspection/selection of the shoreline features, it makes sense to mention why that threshold was selected, even if cursorily. The custom ATL06 processing you use should help filter out most, if any errors a lower confidence threshold might introduce, while including more photons, potentially improving the accuracy of slope measurements.
- 2.4.P4 It's not clear when the custom-ATL06 derived heights were used or when the photon data was used. It seems like the photon data was only used to generate the custom-ATL06 heights, and for the discussion of visible features, while the ATL06 derived-heights were used for the upper and lower shoreline detection. Maybe a small clarification here would help. Similarly, if you suspected the photon data was a toppled bluff, how should you address the manual classification of the beach/backshore?
- 2.4 Did you consider trying to classify the instantaneous waterline from the ICESat-2 profiles? Perhaps this was beyond the scope of the study, but it's not clear whether the waterline might be detectable from the ICESat-2 photon data. If only because the Planet shorelines are instantaneous waterlines, but the ICESat-2 shorelines technically aren't, I think it may be worth addressing.
- 2.4 Please clarify if you are using strong beams, weak beams, or both.
- Figure 5. A 1:1 line would be helpful for comparison.
- 4.2.P1 It's great to see the incorporation of environmental variables along-side ICESat-2 and Planet-based erosion estimates, and the annual trends are clear. Are these valuable at a finer-scale, either temporally or spatially, for similar or other study areas? I was expecting there would be more analysis of these data compared to the shoreline change rates. For example, are storm events and their corresponding increases in erosion rates measurable within a season from some combination of Planet/ICESat-2? Any numbers regarding the temporal variability of erosion rates with respect to environmental variables might complement the existing paragraph well.

Stylistic comments

The manuscript is well organized, edited, and the points to be made were clear. Figures are clear and well-designed. The following minor typos were found.

- L72. Missing space after citation.
- L83. Missing space before citation.
- L155. Needs rephrasing.
- L368. Shoreline misspelled.
- L404. Missing space before parenthesis.