Assessment of ICESat-2 ice surface elevations over the CHINARE route, East Antarctica, based on coordinated multi-sensor observations

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General Reviewer Comments:

This paper presents the results of a validation effort for ICESat-2 ice surface elevations in East Antarctica. The campaign was coordinated with the CHINARE Antarctic expedition from December 2019 to February 2020. The authors focused on an assessment of both the ATL03 (geolocated photons) and ATL06 (land ice elevations) along-track ICESat-2 Level 3a data products. The goal of this effort was to determine the ICESat-2 product vertical accuracy and precision using four different approaches.

The four resources for ICESat-2 validation are:

- 520 km GNSS traverse from the coastal Zhongshan Station to the inland Taishan Station
- Two line arrays of corner cube retro-reflectors
- Two retroreflective target sheets.
- Imagery from two UAV platforms

The authors designed this campaign as a complementary approach to those efforts performed previously by the ICESat-2 mission team and confirm the regional accuracy to support uncertainty determination within mass balance and change rate calculations for East Antarctica. The logistics accomplished in this coordinated approach for validation are commendable and I congratulate the authors on such an effort.

My primary concern with this work is primarily with two of the validation techniques that use ground based retroreflectors. These results are very limited as there are only 7 data points evaluated for the target sheet and 1 data point evaluated for a CCR. Clearly, the traverse comparison provides a robust performance assessment for vertical accuracy based on a reasonable sample size for statistical aggregation. The same does not seem not true for the CCR and RTS approach.

- The authors should include the appropriate data product citations (via NSIDC) in addition to the references to the ATL03 and ATl06 Algorithm Theoretical Basis Documents by Neumann and Smith.
- The Neumann et al., 2020b should be replaced with:

    - Magruder, L. Brunt, K., and Alonzo, M. (2020) Early ICESat-2 on-orbit geolocation validation using ground-based corner cube retro-reflectors. *Remote Sensing*, 12(21), 3653; https://doi.org/10.3390/rs12213653
- 'two sets' of CCRs would be better represented as two line arrays. 'Sets' is not applicable to individual CCRs nor does it describe the implementation effectively.
- Is an RTS a 'set' as well?
- L65: CCRs do not 'capture' photons, they reflect them so that the unique signature they provide to ATLAS can be analyzed relative to their known height and position.
- Why do the authors use 6 cm diameter CCRs for ICESat-2 when clearly for 532 nm that size optic would suffer from velocity aberration? Was this considered in the selection? Does that make a difference in the analysis if the returns are coming from the lobes of the diffraction pattern rather than the central disk?
- What are the elevation differences between the 10 CCRs- or what is the combination of elevations in the line array?
- 3.1.3- The ICESat-2 laser pairs are separated by 3.3 km in the across-track direction.
- L195- The authors report a laser diameter value of 11 m in the introduction and then move to estimating a ~13 m. Where does this new value come from?
- Since the weak beam detectors are saturated at ~4 photons how does this contribute to your radiometry study. The ~10 photons for the strong beam is not saturated (which would be 16).
- Figure 6 (c) Should this height be dh_{CCR}? That was described as the distance between the top of the pole and the middle of the CCR, presumably not at the meter scale that is shown here? Also, in this figure why is there a bulge in the CCR signature rather than a straight line as shown in Figure 6 (a)? This seems as if the footprint illuminated multiple CCRs at different heights? This doesn't seem to be normal streak characteristics.
- Section4.2: The ATL03 CCR streak is 40 pulses across 35 m, how is that with 0.7 cm per pulse. It should be closer to 28 m in length.
- How does the selection of the CCR returns impact the results, meaning if you included more of the streak's length does it negatively impact the comparison or change the quantitative values you are achieving?
- Do you average the elevations per pulse or delta time? There is not a pulse id parameter.
- The authors should emphasize in the paper that the CCR and RTS techniques are localized assessments with results that vary with satellite orientation and time of year (e.g. solar angle). This is particularly important when there are so few opportunities to evaluate the performance (e.g. 1 CCR overpass and 7 RTS points). These techniques cannot yet be compared to those associated with the traverse without further aggregation of opportunities for analysis.
- An additional issue with using just 1 CCR overpass is the impact of the atmosphere on the signal or background noise levels to understand precision. The numbers reported here would represent the variability for one environmental scenario but doesn't capture a representative data quality variability relative to the many influences.