I. Overview
The Sigma Space Micro Pulsar Lidar (MPL), a 100 channel photon counting instrument, collected very dense returns of data (~5 photons/m²) over the Jakobshavn glacier and fjord and adjacent ice sheet regions in July 2009. This presentation provides an overview of the procedures used to produce simulated ICESat-2 Advanced Topographic Laser Altimeter System (ATLAS) returns from this data and analyzes the projected ATLAS instrument performance over these Greenland regions.

II. Source Data
The Sigma Space MPL, collected data over the Jakobshavn glacier and fjord and adjacent ice sheet regions in July 2009. (Fig 1-3) (Ref 1, 2)

III. ICESat-2 Simulated Data Creation
The current ATLAS instrument design includes 6 beams, grouped in threes of two beams spanning 6-6 km in total width (Fig 4). The beams are oriented slightly from the flight path to allow for a cross track distance of ~100m between each weak and strong beam pair on the ground.

IV. Ground Elevation Calculation
1. Aggregate all data within a given along track distance (20m-90m) in time–averaged returns used for testing.
2. Histogram aggregated data in elevation using a 2m binsize.
3. Select 3 bins – the one with the highest number of photons and two surrounding bins. Histogram this 5m elevation using a 5m binsize of 10cm.
(Fig 7) Requires that the 3 photons in the most populated bin be ~50% signal (0.125 m2/photons and scaled accordingly).
4. Calculate the “true” ground elevation in the average of the photon elevations in all bins in the histogram that had at least half the number of photons as the most populated bin.

V. Ground Elevation Evaluation
To evaluate how accurately the ground elevation calculated from the ICESat-2 simulated data, we apply the ground elevation algorithm to the full set of signals (~1 photon/1m²) and designate this as “ground-truth”. We then compare this to the ground calculated from the simulated data. Fig 8 shows these elevation profiles for Segments A and B.

VI. ICESat-2 Performance Evaluation
Each dual beam of the ICESat-2 configuration gives us a measure of the instantaneous cross track surface slope over distance scales on the same level as the variation in the ground track spacing among the different replicates (5m-26m). This allows us to separate the real ground elevation changes from apparent changes due to each repeat measurement at slightly different locations by using the cross track slope to project the elevation to the reference track location. The Sigma Space MPL data collection gives detailed surface elevations for a swath of several hundred meters moving along the flight line so it can be used to evaluate how accurately we can correct for cross track variation between repeats which is required to perform elevation change calculations using repeat ICESat-2 data.

1. Create simulated ICESat-2 data along flight tracks parallel to the aircraft track every 5 m covering ~750 m cross track for the strong beam and ~350 m cross track for the weak beam.
2. Calculate ground elevations for each of the above using aggregated returns distances of 20, 40, and 90m from the derived elevations.
3. Combine the tracks into dual beam pairs (one strong, one weak) to replicate dual beam results spacing from 50m to 150m and strong beam cross track variation from ~50m to ~75m from the reference track (flight line nadir).
4. For each pair calculate the cross track slope at every location (Fig 12-14) and project the slope to each repeat cycle.
5. Present the elevations from the strong beam to the reference track using the above cross track slope.
6. Calculate the statistics of the difference from the projected elevation to the derived elevation along the reference track.

VII. Performance Evaluation Summary
1. The precision with which we can project the elevation onto the reference track varies from 5-10 cm for regions A and B from 20-30cm for rougher region C using the methods in this study.
2. The best performance is achieved when the two beamsstraddle the reference track.
3. A larger cross track distance on the ground between the two beams increases the ability to project the elevation to the reference track over a wider range of repeat track variations.
4. For rougher regions A (V > 0.01) an increased aggregation distance can increase the precision of the projected elevation onto the reference track.

VIII. ICESat-2 simulated data and documentation
The documentation listed below are available at: [reference link]

2. C. Field, Description of Greenland Sigma Space MPL data.