

## ***Interactive comment on “MABEL photon-counting laser altimetry data in Alaska for ICESat-2 simulations and development” by K. M. Brunt et al.***

**Anonymous Referee #2**

Received and published: 11 May 2016

Using photon-counting lidar is a new method for mapping ice sheets and glaciers. The paper presents the first results obtained by the MABEL system over complex glacier surfaces, such as heavily crevassed glaciers and lakes during melt conditions. These results are vital for assessing the performance of the ATLAS system to be flown on ICESat-2. They also highlight some of the advantages of the dense spatial sampling of photon-counting laser altimetry, for example for estimating crevasse geometry or melt pond shape and depth.

The paper could benefit from reorganizing the results and discussion sections by organizing them according to the surface feature types and measurement goals, instead of cycling through the different sites and goals several times. For example, the description of the altimetry profiles, photon histograms, and drop in the number of background photons over melt ponds are presented in three different sections. Also, some of the

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figures are too minuscule to appreciate the details of the surface as depicted by the photon-counting system. For example, parts of the Bagley Icefield MABEL transect and corresponding photographs (Figure 6) covering the melt ponds and crevasses could be enlarged to the surface features (photograph) and structure (photons) more clearly. The drop in the number of background photons over the melt ponds is very evident in Fig. 6.b – a beautiful example. However, the importance of this observation is almost lost in the details. Less convincing is the explanation about the melt pond depth determination. Showing the major elements of the melt pond in Figure 7 would help. Where is the elevation corresponding to the surface of the melt pond? And the bottom? Comparison of Figures 3 and 7 suggest that either the surface of the melt ponds is rough, or the maximum return is from below the surface. Can the authors distinguish between these cases? Also, I assume that the  $\sim 0-2$  photons per bin between 1397.5 and 1399.8 meters is due to returns from the ponds, i.e., volume scattering. Is this correct? Does the histogram depict the bottom of the pond?

The connection between the results obtained by the MABEL measurements and those expected from ATLAS is not well articulated. In particular, the paper should explain better how slope accuracy and spatial scales impact the accuracy of change detection with ATLAS. Also, the errors of the MABEL measurements should be better quantified to assess its performance and the implications for ATLAS/ICESat-2. For example, on page 4, line 29- page 5, line 3, the authors mention a different range bias of each of the MABEL beams. As the local slope is determined from elevations measured by different beams, this bias is expected to have an impact on the accuracy of slope determination. How stable are the range biases? How were the beams calibrated to one another? Was there any pointing bias, which would translate to additional elevation and slope errors? Page 7, lines 7-9 describe a calibration over ocean surface but does not mention how stable the offset was and if there was a pointing bias or not.

The explanation of DEM “migration” over the Lower Taku Glacier needs an overhaul. It is very hard to follow the details. Maybe a map with velocity vectors could help? What

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is the expected accuracy of the WV-2 DEM? Page 13, line 1-6: what is “the difference between the DEM and the true elevation”? Lines 4-6: was the MABEL range bias determined from ocean measurements? How was the surface melt estimated, any reference?

Detailed comments:

Mention the wavelength domains for 532 nm – green, and 1064 nm – near infrared and briefly summarize the current knowledge of penetration, surface and volume scattering with references.

Page 2, line 29: "ATLAS model"? Do you refer to the sensor model of ATLAS?

Page 2-3: A figure comparing ATLAS and MABEL geometries would be helpful

Page 3, 9-12: A brief summary about the expected accuracy and potential interpretation difficulties of the photon-counting altimetry in winter and summer conditions would be useful, e.g., penetration depth of green laser beam or impact of high surface reflectance on range bias (dead time issue)

Page 4, line 3-5: What assumptions are made to classify the photons into signal and noise/background?

Page 5, line 13: what is the resolution of the camera? Number of pixels, rows/columns? Is it a B/W or color camera? How often were images taken? Was there an overlap between consecutive images at the nominal flying height?

Page 5, line 25: Was the “standard” Landsat 8 spectral reflectance product used or did the authors derive their own reflectance? What wavelengths were used for the model? Was the panchromatic band used for Bagley Field because of the better spatial resolution?

Page 8, line 17: how large was the slope caused by wind stress or dynamic ocean topography? How large is the geoid undulation?

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Page 8, line 27: under some operational conditions, such as??

Page 9, line 1: Was the second pulse removed by visual inspection and manual editing?

Page 10, line 20: flat, HORIZONTAL surface?

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Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2015-225, 2016.

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