Characterizing and evaluating the Arctic Digital Elevation Model product with LiDAR data for spatial modeling

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1. Introduction

- The ArcticDEM is a public-private initiative to produce digital surface model across the Arctic (Fig 1).
- The DEM is automatically created by using optical stereo high-resolution imagery at 2m and 5m spatial resolution (Noh & Howat, 2015)
- Currently Arctic DEMs for Alaska and parts of Canada, Norway, Russia, and Iceland have been produced and are available for download

Fig1. Illustration of the proposed ArcticDEM domain. Note that only parts of the domain have currently been processed (source: pgc.umn.edu/arcticdem).

Objective:

Characterize the accuracy and nature of the ArcticDEM data set for selected regions in Alaska where airborne LiDAR is available

2a. Methods

Data sets:

- ArcticDEM (5m resolution product)
- Alaskan airborne LiDAR data set (black, Fig. 2, Hubbard et al. 2011)

Study areas:

Selected sample locations (red, Fig. 2) of the 2011 LiDAR data set:

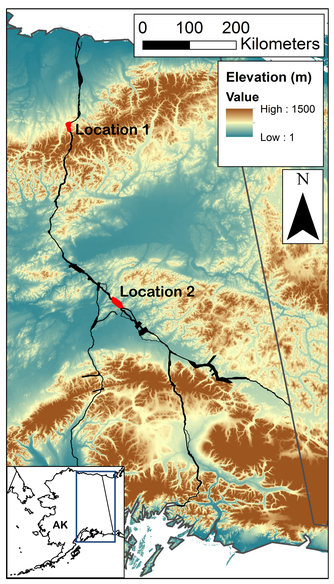

Fig 2. Extent of the 2011 LiDAR data set (black) and the two selected sample locations (red).

- Location 1: Arctic tundra vegetation, intermediate topographical complexity
- Location 2: Black and white Spruce forest (open - closed), low topographical complexity

2b. Methods

Analysis I: Compare elevation heights of the ArcticDEM to the LiDAR-derived bare earth and vegetation surface models across the selected sample locations (using 400 randomly selected pixels at a minimum distance of 100m from each other to account for spatial autocorrelation)

Analysis II: Assess effects of vegetation height in the ArcticDEM data by comparing a transect of the ArcticDEM, LiDAR bare earth, and LiDAR vegetation height metrics

3a. Preliminary results (Analysis I)

- The comparisons between the ArcticDEM and the LiDAR data sets show very good agreement (R^2s > 0.99, RMSEs < 7 m, and biases < 5 m
- The comparisons of the vegetation surface models (right panels) are more accurate than the bare earth models with reduced RMSEs and biases
- More complex topography does not reduce the overall accuracy of the relationships between the ArcticDEM and the LiDAR-derived height metrics (not shown)

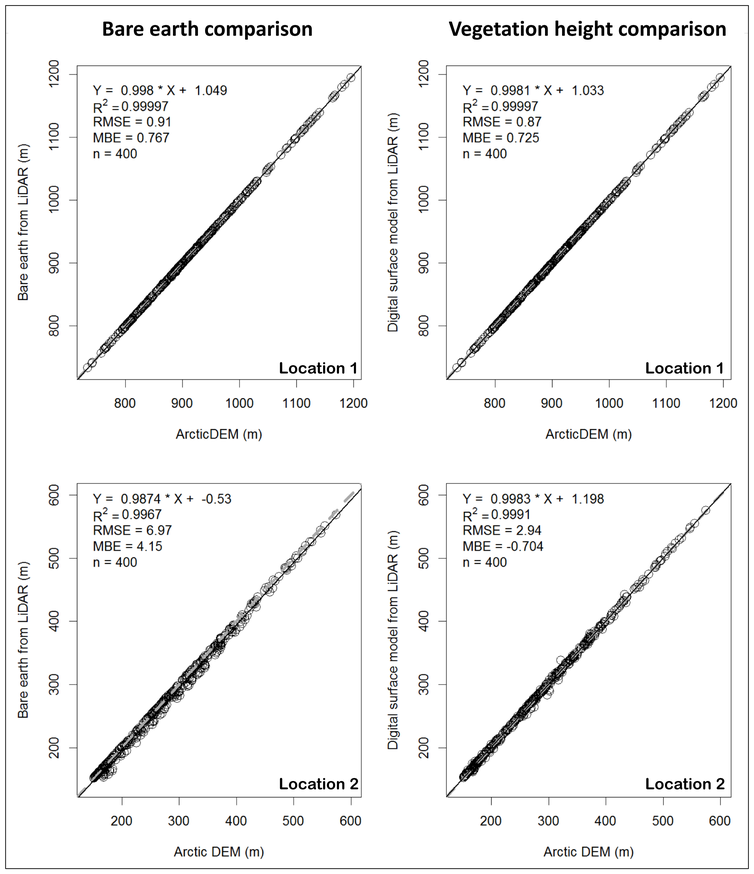

Fig. 3. Comparison between the ArcticDEM (x-axis) and LiDAR (y-axis) products (Location 1: top, Location 2: bottom; comparison with the LiDAR-derived bare earth: left and LiDAR-derived vegetation surface model: right). Data are 400 randomly selected pixels > 100 m apart.

3b. Preliminary results (Analysis II)

- In tall and dense vegetation, the ArcticDEM follows the top of the canopy rather than the underlying topography and gaps of ~10m are not captured (Fig 4.)

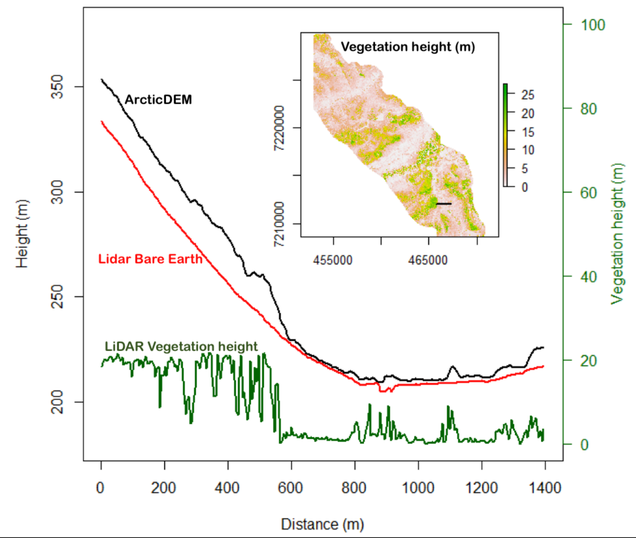

Fig 4. Transect of 1400m from dense forest towards a more open vegetation valley bottom (see black line in the inset image). In black the ArcticDEM data is shown, in red the LiDAR-derived bare earth model, and in green the LiDAR vegetation height (with corresponding second y-axis), all units shown are in meters.

4. Conclusions

- The ArcticDEM is a unique data set useful for topographic and ecological modeling among many other applications across the arctic-boreal domain (Fig. 1)
- The ArcticDEM data show good agreement to an independent high resolution LiDAR data set
- Users should be aware that when dense (forest) canopies occur in the data set, the ArcticDEM follows the top of the canopy rather than the underlying topography of the landscape

Next steps:

- Include more locations with more complex topography and vegetation structure
- Develop a vegetation structure product from the ArcticDEM for animal movement and treeline modeling

References: Hubbard, T.D., Koehler, R.D., and Combellick, R.A. (2011). High-resolution lidar data for Alaska infrastructure corridors, in DGGS Staff, Elevation Datasets of Alaska: Alaska Division of Geological & Geophysical Surveys, 291 p.

Noh, M.J., & Howat, I.M. (2015). Automated stereo-photogrammetric DEM generation at high latitudes: Surface Extraction with TIN-based Search-space Minimization (SETSM) validation and demonstration over glaciated regions. *GIScience & Remote Sensing, 52*, 198-217

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