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Predicting Slope from Full Waveform LiDAR

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We present a new approach to predict ground slope angles based on raw return signals of full waveform LiDAR, independent of any external data. This novel approach is applicable to all LiDAR waveforms and allows slope predictions to be made at the footprint scale. Slope increases the probability of deriving spurious data in waveform LiDAR metrics, such as vegetation heights, crown dimensions, and biomass estimates. Hence correct slope information is of utmost importance in performing corrections to such metrics. At present NASA's Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) is typically used to identify sloped terrain over a broad range, for filtering purposes, however, it's coverage is limited between $\pm 60^\circ$ latitude at 90 m resolution (at the equator). The new approach is based on Geoscience Laser Altimeter System (GLAS) data, previously recorded onboard the Ice, Cloud, and Land Elevation Satellite (ICESat), and allows the derivation of a slope map concurrent with GLAS footprint positions at a similar resolution, or higher (dependent on footprint dimensions), to SRTM. GLAS footprints were analysed for slope across seven different sites, three in Canada, three in Europe, and one in Australia, with slope ranging between $0^\circ - 50^\circ$. Resulting predictions were validated against high-resolution airborne LiDAR derived slopes for identical footprints, with regards to orientation and dimensions, yielding a combined (by site) Pearson Correlation Coefficient of R=0.82 and a root mean square error RMSE=5.8°. The slope prediction model performs well over varying levels of slope severity.