Data Quality Report - 2014

Full Waveform LiDAR

ARSF - Data Analysis Node

Updated on: September 21, 2015

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1 Overview

This report describes issues that should be considered when further processing any of the 2014 Airborne Research Survey Facility (ARSF) datasets. The document may be updated over the course of the year, with the latest version available at:

http://arsf-dan.nerc.ac.uk/trac/wiki/Reports

2 System Overview ALS50-II

The Airborne Research and Survey Facility (ARSF) Leica ALS50-II LIDAR system is a small footprint LIDAR with capabilities for discrete and full waveform recording. The system works by emitting a (4 or 9ns) laser pulse downwards and measuring the round trip time for the light pulse to return, then converting this to a distance (range). The system can record up to four discrete returns for each emitted pulse. Moreover, to record full waveform LIDAR data, the manufacturers have added a digitization terminal to the system with a digitization sampling period of 1 or 2ns. The sampling period defines the time intervals of sampling. The waveform is hence not integrally recorded but only for a predefined maximum number of samples, one of 64, 128 or 256. These samples are recorded from the time of the first return, with a small buffer before that (default 5m) that allows the capture of the lead-in to the first pulse. Figure 1 shows an example of a digitised waveform.

As well as the time / range of the echo return, the system also measures the intensity (peak power) of the echo. Currently this value is not calibrated nor comparable along the flight line. This is due to the automatic gain control of the system (AGC), where the echo power is amplified by different amounts dependant on the return strength. This can result in a "striping" effect in the intensity images. Although the gain value changes along the flight line it is consistent for a return pulse, that is, for a recorded waveform the same gain value is used along the entire waveform.

The AGC value is saved in the 'User Data' field for each point with delivered data and is constant for a given pulse, that is, for a recorded waveform the same gain value is used along the entire waveform.

The footprint of the pulse on the ground is approximately 22cm when fired from 1000m altitude.

Note that the ALS50-II waveform digitiser does not necessarily collect a waveform for every point (due to real time data collection rates). So some points within the LAS1.3 files will not have an associated waveform.

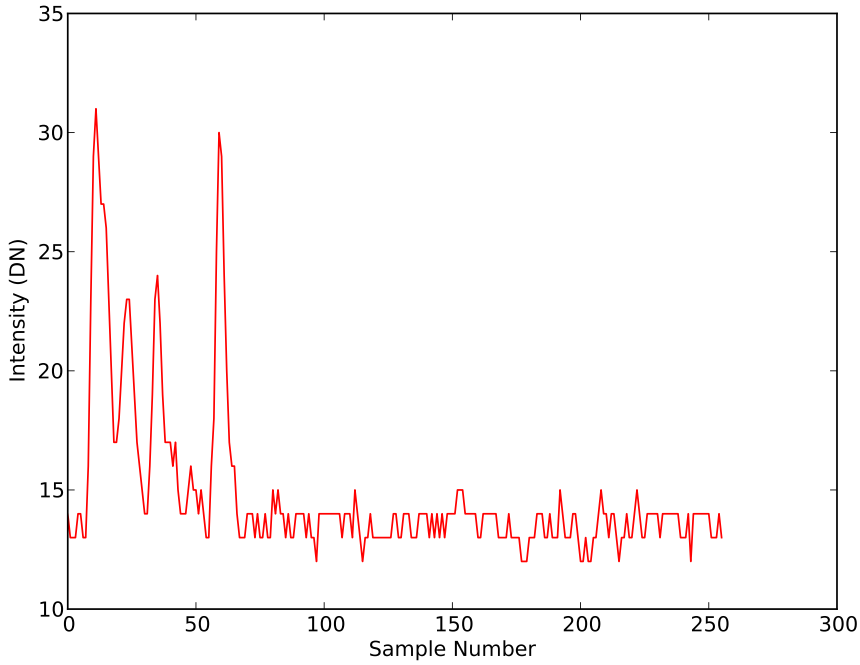

Figure 1: *Example Waveform for a forested area.*

3 Timing Issues

There is currently a timing uncertainty between the full waveform digitiser and the discrete returns received from the LIDAR system. This manifests itself as a time offset in the data similar to that shown in Figure 2 below, where the waveform peak is misaligned to the discrete return. Leica currently attribute this offset to lag in the electronic systems causing the two systems (waveform digitiser and discrete return measurement) to be slightly out of sync with each other. This offset is of the order of 8 or 9 nanoseconds and should be approximately constant for each point along a flight line. The error appears to be systematic (always in one direction), and during instrument calibration multiple offsets are measured to calculate a mean and this is applied to the processing software. This offset is then assumed to normalise the error, to within a standard deviation, and is used for processing data up until the instrument is recalibrated. Due to the lack of available tools this is done by hand and not repeated for each data set collected. Note that this does not correct the error, but minimises the average offset of all (measured) points. After correction, the mean offset is typically of the order of a few 100ps with a standard deviation of approx 500ps. This standard deviation is equivalent to a distance of approximately 7.5cm. It is not known as to whether the error is in the discrete or the waveform data, but the Leica processing software applies the shift to the waveform data.

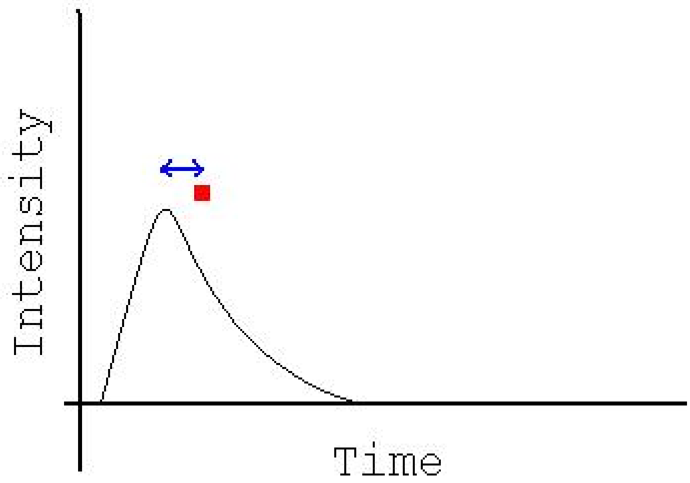

Figure 2: *Waveform peak and corresponding discrete return (red square) occur at different times.*

3.1 Consequences

The consequences of this error are that comparisons between the waveform and discrete points, in terms of time/distance, are more difficult and will contain an error of the order of a few cms. For making comparisons between multiple discrete points or between multiple waveforms the error will be minimised (negligible to within system specs) as it only affects comparisons between discrete and waveform data.

If the normalising correction stays consistent between data collections, then comparing data from repeat surveys should be possible with a small error budget. However if the normalising correction changes between flights, then essentially the data can be considered not normalised, and comparisons between the data sets will contain larger errors.

4 Data Format

The ARSF full waveform data is delivered as a standard LIDAR data set (including ASCII point clouds of the discrete point returns) with additional LAS 1.3 files which contain both the discrete and waveform data.

Currently LAS 1.3 files are not as widely supported as LAS 1.0, 1.1 or 1.2 files. LASlib and LAStools are capable of reading the LAS 1.3 format. (http://www.cs.unc.edu/~isenburg/lastools/). We maintain a list of other open source and commercial tools for working with LAS files (discrete and full-waveform) on the ARSF-DAN Wiki

If you wish to write your own, the LAS 1.3 specification can be downloaded from:
http://www.asprs.org/a/society/committees/standards/LAS_1_3_r11.pdf.

5 Data Post-Processing

Currently no post-processing is performed on the full waveform LAS data. This is partly due to a lack of available processing tools and not knowing what the user community would find useful from full waveform data. This will likely improve in the future when more tools become available and we receive more user feedback. However, the classification of the discrete LAS 1.2 files is copied over to the LAS 1.3 version, so point classification should match between LAS files. It is possible for us to extract waveform data into ASCII format for small areas. If you wish to take advantage of this then please supply us with coordinates defining the areas where you would like extractions from. If you would like help with any of the post-processing of your data, then please contact ARSF-DAN for advice on

arsf-processing@pml.ac.uk.

6 Waveform Length

The waveform data is digitised at different rates decided during the planning / collection phase. The usual sampling rates will be either 1 or 2ns, this is approximately equivalent to a distance of 0.15m or 0.3m between samples. Typically one of the following settings will be used for collection:

Number of samples and sampling rate	Equivalent length of waveform
256 @ 1ns	38.4m
128 @ 1ns	19.2m
256 @ 2ns	76.8m
128 @ 2ns	38.4m
64 @ 2ns	19.2m