**CBL calibration exploration**

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Data source: Brisbane corridor scans of calibration panels made by John. Data points (DN, reflectance, range) are compiled by Ian. Note here that the ranges in the data points are all nominal ranges of panel locations, not actual ranges from CBL scanning data.

Lidar equation:

Where is calibration constant related to *outgoing power* and *detector gain*, is range, is reflectance, and is telescope efficiency function that is supposed to go from near 0 to plateauing at 1. If we plot against and assume at large ranges plateaus to 1, we should see a nice linear line given by data points from large ranges. However we do not see this linear relationship even from the largest range (15) as shown below. It could mean our current data is not beyond CBL telescope efficiency range yet ( does not plateau yet in any range of our current data).



Base on DWEL’s calibration experience, it is very difficult to estimate and of even a known function form because of heavy nonlinear optimization involved in this estimation. Another path to find the relationship between DN, reflectance and range is using a variable range power as the following equation. Now is implicit in this range power .

One thing to notice here is includes both outgoing power (nominally constant) and detector gain (could be constant or could not be). is constant for a lidar with linear-responsive detector but not constant for a lidar with nonlinear-responsive detector.

A simple manipulation of above equation gives us:

This suggests a supposed linear relationship between and . The slope of the line is range power and the intercept is . Here we will see some quite interesting thing about CBL.



From the right panel, we see each subpanel of a certain reflectance clearly show a nice linear line. However different subpanels with different reflectances have different lines. But all lines have very close slope, i.e. but different intercept.

|  |  |  |  |
| --- | --- | --- | --- |
|  | Range power: | Intercept: |  |
| 0.895 | 0.2284 | -6.7793 | 879.423 |
| 0.5415 | 0.2475 | -7.2516 | 1410.312 |
| 0.303 | 0.2646 | -7.7659 | 2358.735 |
| 0.1639 | 0.2613 | -8.2780 | 3936.383 |
| 0.1112 | 0.2535 | -8.5780 | 5313.730 |
| 0.0887 | 0.2488 | -8.7452 | 6280.242 |

The same means all the data points suggest the same telescope efficiency. However the different intercept means different . If CBL’s is not constant but related to reflectance, or more precisely related to return power (watts), it means CBL’s detector gain is not constant but varies according to return power strength. High return power, low gain and low return power, high gain as suggested by in the above table. I tentatively dissected the into the following parts.

Which includes the gain and outgoing power . And based on the above graph we can assume the CBL’s gain varies with return power . Since is nominally constant, can be seen as a function of .

In this case, it would be worthy to plot for different against as following.



Notice that the left panel is against . It shows a very nice linear relationship which really surprised me! I expected an ascending curve between and like a curve of . But we see a totally line! Now it’s easy to figure out a function to model .

Where and are two constant parameters. After we fit a line to the points in the left panel of the above figure, we get and , and the is nicely 1.

Summarize the CBL’s empirical calibration equation,

Where , , (mean value from the range powers in the above table). I used this function to model the return DN. Here is the plot between modeled DN and the actual CBL DN. The is 0.9996, which suggests a very good semi-empirical prediction. I think this is good to use for now.

But one thing to be noticed is the very low which suggests that CBL’s telescope efficiency takes a very long range to plateau to 1. I tried using range power of 2 and the same empirical as EVI used to hack more on the CBL’s telescope efficiency. However the fitting result doesn’t look robust. I see is still 0.4 at 100 meters. The could plateau to 1 around 200 m. Maybe the function form is wrong for CBL’s . But what does it look like? Hard to guess. I suspect it could contain some geometrical form factor because the laser and receiving path is not co-axial as EVI or DWEL. One paper in Alan’s lidar seminar talked about this kind of optical configuration for an atmosphere lidar. But that’s for now.

