General Comments:

The authors are presenting the mathematical formulation behind an extended approach of the three-signal technique, developed for calibrating depolarization lidar instruments. Complementary to the theoretical approach, the authors are presenting also some experimental results, verifying in that way the stability and efficiency of their method. The manuscript is well written, acknowledging previous relevant studies, and has strong scientific merit. Therefore, in my opinion worth of being published in the Atmospheric Measurement Techniques journal. In order to be improved I would kindly suggest to the authors to take into consideration the following specific comments.

Specific Comments:

1. Page 3, Line 9: "…consists of 2''achromatic lens…". Consider providing in a parenthesis also the equivalent of the 2'' in units of mm.
2. Page 3, Line 13: Is the value of 650 m theoretically calculated or experimentally measured? In any case consider providing a reference at this point.
3. Page 5, Line 26: Maybe "described" is more appropriate than "considered".
4. Figure 3: Consider annotating this figure with the letters (a), (b), (c), (d), in accordance to the figure legend. Moreover, make clear also in the figure that (a) and (b) refer to the emission while (c) and (d) to the receiving units.
5. Page 7, Line 13: "…for the calibration is to insert an additional polarization…"
6. Page 7, Line 21: "…, Müller matrices representing…"
7. Page 7, Line 27: "P_o is the number of emitted laser photons…"
8. Page 8, Line 6: Consider replacing the sub scripts with capital characters, in order to be consistent with the annotation followed in the manuscript.
9. Page 9, Line 12: "…, but depends on the receiver…"
10. Page 10, Line 14: Eq. 38 is the product of Eq. 25 divided by Eq. 24, and not the inverse.
11. In Eq. 42 I am missing the information of the variable C. Please specify to which quantity C refers to.
12. Page 11, Line 20: "… provides an overview of …"
13. Page 11, Line 21: "(above ground level)"
14. Consider presenting clearer the x-label of Figure 6 (e.g. $\eta_{tot} \,/\, \left[\eta_{\parallel,P} \cdot (1+\varepsilon_r)\right]$)
15. I would kindly suggest to the authors to show the profiles presented in Figure 7 up to higher altitudes (e.g. 4 km). Moreover, the profiles obtained by the ratio $N_P \,/\, N_{tot}$, compared to the rest two, seems to demonstrate greater variability with atmospheric height, in a way that I would say artificial layers are introduced. This can be seen for atmospheric heights inside the water cloud but also below (2.4 - 2.7 km). Is this also a result of the low SNR, even though

that the profiles refer to 3 hours of measurement period? In any case the authors are kindly requested to comment on this.

16. Figure 9 is very important. Legend: My suggestion is to use the phrase “(extended 3-signal method)”. Additionally, it would be beneficiary for the manuscript if in the same figure, the profile of volume depolarization obtained by the conventional 3-signal technique (Reichard et al., 2003), is also shown. This will clearly demonstrate the improvement achieved by following the extended method proposed here, which takes into account various types of instrumental effects (e.g. the not perfectly polarized emitted laser light).
17. The manuscript contains many equations and variables and this may easily confuse a reader. Therefore, I would kindly suggest to the authors to list all the variables used in a table (Appendix section), along with a small phrase describing them.