The work presented here evaluates a number of polarization measurement schemes for sensitivity to errors introduced by non-ideal optical elements. This analysis includes consideration of different polarization calibration schemes that, as far as I can tell, the author has previously published.

The work presented here is thorough and detailed and I saw no obvious errors. That said, I have trouble finding any novel aspects to the work. It seems like this would be better suited as a white paper.

I have two major and related criticisms that I think significantly weaken this work and make it very difficult to review this work for any novelty.

It belabors a number of topics that have been thoroughly addressed in other published works while completely ignoring other aspects, creating the false impression of a comprehensive analysis

The following are a few examples. This list is not comprehensive.

Section 2.1 Depolarization atmospheric aerosol

There have been a large number of works that cover the backscatter matrix of randomly oriented particles, many of which are already referenced in this section. There are 6 equations that could be summarized in 2.

Eq. (9) and (10) are completely obvious from Eq. (8).

Eq. (11) is belaboring an obvious and trivial point that can be made in one sentence.

Eq. (12) might be worth keeping, but it does not need every step of algebra. Just include the result. It is obvious how you get this result.

Eq. (13) is covering the obvious. Hopefully the reader already knows how to do matrix multiplication.

For all the maticulous steps in this section, there is absolutely no mention of oriented particles. In my view, the reader may be given the false impression that this scattering matrix is somehow comprehensive, which it clearly is not, since it only covers single scattering by randomly oriented particles.

Section 2.2 Optical Parts:

In Eq. (14) (and others) pick a matrix form and stick to it. You don't need multiple forms of a diattenuating retarder, the terms of which, you subsequently define in the very next equations.

Eq. (45) conveys nothing to the reader. The Mueller matrix and Stokes vector are completely arbitrary. Again, hopefully the reader already knows how to pull a common term out of a matrix.

It spends too much space evaluating matrix equations to produce lengthy scalar equations with too many variables.

The presentation in this work uses far more equations than necessary. Frankly, most of the results and derivations are actually just evaluations of matrix equations into a scalar form. I don't really see the value in that. Matrix equations are a nice concise way to present Mueller calculus. They are designed for the purpose of concisely and elegantly handling systems of equations. Computers with all the most popular numerical analysis software handle matrix operations without any difficulty. There really isn't a reason to evaluate to a scalar equation unless it produces a result that is simple, concise and reveals some previously not obvious fact. That is, evaluating the matrices should produce a reduction in complexity, not the other way around.

A better approach is to leave most of the equations in their matrix form. There are not a lot of different matrix forms in use, so provide those definitions once and allow the reader to substitute them. My guess is that a few matrix equations and a few plots would go a long way in reducing the size of this work.

This is a pretty consistent criticism of nearly every section. One example of this is the beginning of section 4, where you could easily take a reductionist approach. Present the overall Mueller equation describing I_s (Eq. (64)?), then give the evaluation in Eq. (68), but get rid of all those coefficients in front, which can just as easily fold into G and H and aren't important since absolute intensity measurements are almost never used in atmospheric lidar. One can obtain this result without ever assuming a cascade of particular polarization element matrices. All the equations between (64) and (68) look like noise to me. I can't keep track of all those variables, and frankly, they probably are not representative of my lidar. I'd rather do the Mueller calculus myself, and I can't follow your inbetween steps anyway.

The explicit definitions of G and H seem unnecessary. Again, can I really expect this to be representative of my lidar? And again, I can't keep track of what all the variables mean. Do these equations ever get used again in the paper? If not, all the more reason to get rid of them.

Final comments to improve readability:

My view is that this work is most likely to be used by those unfamiliar with polarization theory and Mueller calculus. Assuming that is the audience, I have the following suggestions:

Keep in mind that it is extremely unlikely that a reader will be reading this work the entire way through, so try to make the it easy to skip through. I know this is a vague comment, but keeping this fact in your mind will make the paper readable. It is good there is a table of variable definitions, but maybe it would be better to break them up a bit based on where they are used in the paper. Also, make a table of assumptions used in these derivations or put those assumptions at the beginning of the relevant section.

Drop the <bra|ket> notation. That is going to confuse readers more than anything. All the operations you are trying to convey already exist in standard matrix notations. Stick to dot products or transpose, which can be used equally well to express the same operations. The <bra|ket> notation will more than likely just cause the reader to “check-out” when reading.

Consider presenting the result (what the user will actually use in calibration) before any of the derivations. This makes the outcome more accessible.

Be very clear about the assumptions applied in this work (preferably itemize them or keep them in a table). Users unfamiliar with polarization are likely to take your work and run with it, without ever double checking the assumptions you give. Take measures to make sure your work isn’t misused. For example, these corrections only apply to scattering matrices in the form presented by Gimmestad AO 2008. So oriented ice crystals, and of greater concern rain (see Hayman Opt. Express 2014), are not likely to have accurate polarization corrections. Also, you assume optical elements are some combination of retarder and diattenuator. That is not always true, mostly depending on what level of accuracy you are hoping to obtain. The point is, your assumptions seem reasonable to me, but they may not be a reasonable for *all possible* cases, so make sure you are clear about them and make sure they are easily accessible.

A Personal Opinion from the Reviewer:

I don’t really understand all this interest in obtaining “correction equations” for scalar polarization variables. The approach used in Kaul Appl. Opt. 2004, Hayman, Opt. Express 2012, Volkov Appl. Opt. 2015 and countless other polarimetry papers avoids any need to belabor “corrections” and just retrieves the relevant scattering matrix terms based on the lidar’s operational parameters--”errors” or whatever you want to call them. It is trivial to adjust the approach presented there for a randomly oriented matrix and a stationary polarization (which I use as standard practice in my own analysis). Framing the problem like this makes one realize there are a *maximum* of 9 parameters that describe the standard stationary depolarization lidar. Obtaining the those parameters by some means is necessary, so the calibration techniques outlined here are important, but obtaining an accurate depolarization measurement is needlessly complex when it is presented as a scalar correction formula to a depolarization ratio measurement. Let the computer do the hard part.