Response to Reviewer #2

We appreciate your very meaningful comments. Here we have prepared a response and explanation to your suggestion, and have incorporated it into the main text.

Section 2, Line 131

The authors are inadequately describing the SMA and its role in GEMS observations. Readers are left with the impression that GEMS polarization characteristics are only known for one view angle, which is not the case. Please explain that deviations in SMA from zero cause the entire view to shift north and south and are not part of nominal operations.

→ Revised. Yes, I agree with the opinion that this can easily lead to misunderstanding. As you suggested, we mentioned in the manuscript a deviation of the SMA from 0˚ position induces a shift in the entire view toward the north or south, thereby diverging from nominal operations. As you know, unlike TEMPO where polarization testing was performed for 5 SMA positions (each different location), GEMS only performed polarization testing for SMA 0 degrees. This is why it is difficult for us to accurately determine polarization characteristics in the north/south directions.

Line 138

Please clarify what you mean by decreasing signals with increasing distance. What distance is increasing?

→ Revised. This implies that the response sensitivity to the polarization source from the integrating sphere decreases not only in the North-South direction but also across the wavelength spectrum on the CCD, making it difficult to reliably detect a consistent signal. We mentioned this in more detail in the manuscript.

Section 3, Line 174

Please comment on the size of these rotations. Is the polarizer angle mostly aligned to the meridian plane or are the differences signficant? Most readers don't want to wade through the minutia of your coordinate transformations to figure that out.

→ Revised. In the boresight frame, the polarizer angle of 0 degrees is aligned with the eastern direction of GEMS observations. As a result, the transformation from LMP to IRP is similar to a counterclockwise rotation of approximately 90 degrees (Fig. 6). we mentioned these in the manuscript.

Section 3, Line 212

I suggest the authors start a new subsection here. As written, the text jumps without a break from a discussion of the coordinate transformation of the polarization angles into a description of data processing.

→ Revised. As you suggested, the paragraph below shows the configuration flow of the overall algorithm, so we started session 3.2 with the configuration of the polarization correction algorithm.

Section 3, Line 221

Please describe how you handle partially clouded scenes. Do you use an independent pixel approximation and mix clear-sky reflectivity at the terrain and 0.8 albedo clouds at a lower pressure? Or do you place all clouds at the terrain height? I see no other description of cloud reflectivity in Section 3. This should be described in a bit more detail somewhere.

→ Revised. We described it in more detail. Each individual observed pixel is considered like partial cloud using the IPA method, which assumes that photon movement occurs only vertically, not horizontally, and that it consists of cloud-free surface impact and partial clouds. The cloud reflectivity was assumed to be a typical 0.8.

Section 4, Lines 374-384

The discussion here is important. In my opinion, it is more important than the preceding discussion of LUT lookup errors, which are of little interest to readers because they can be minimized by simply making the LUT denser. Of more interest are the modeling errors, and that discussion belongs in this section. The authors allude to errors associated with Lambertian cloud assumptions and aerosol loading, but then defer to Section 5. Discussion of model uncertainties is central to the evaluation of algorithm performance and belongs here.

In my opinion this paper would would be more useful to readers if the authors repeated some of the investigations of errors cited in Choi et al using real GEMS scenes. What range of polarization errors can we expect from a range of AOD and particle height distrubutions? Likewise, how might non-Lambertian clouds change the GEMS polarization sensitivity? I think that such investigations fall within the scope of this paper and should not be deferred to future work.

→ Yes, we fully agree with your comment. LUT nodes are important, but may not be significant (As you said, it can be solved by making the spacing denser or finding the optimal node). We have additionally described in the text information about the polarization changes by aerosol height, AOD, and cloud treatment. The degree of polarization attenuation varies depending on the AOD and aerosol height. This suggests that even if aerosol influence is inherent in the cloud processing process, polarization error may be overcorrected if corrected for the clear sky without considering aerosols. The difference of effects on polarization between Lambertian cloud and Mie cloud (non-Lambertian clouds) is relatively low (slightly higher by Mie clouds for very high cloud).

Section 4.2, Line 393 and Figure 11 caption.

I think the authors are simply discussing the polarization correction. The terms "degree of corrected polarization error" and "corrected polarization error" are confusing. Please change this or, if I am mistaken, explain exactly the quantity you are describing and plotting.

→ Sorry for the confusion. We use the expression "corrected polarization error" consistently.

Section 4.2

The discussion of diurnal variation in the polarization error seems to belong in Section 3. After all, these are not residual errors. The authors are claiming these errors are corrected by their algorithm.

Section 4.2 is merely describing the geophysical variation caused by viewing conditions, similar to the discussion in Section 3.2.

→ Yes, what is shown here using actual GEMS data is to present and show the daily change in polarization error that can occur due to observation conditions, as you mentioned. This is the polarization error that can be corrected with the proposed polarization correction algorithm. It is unknown how much residual error remains. As you mentioned, it refers to changes depending on observation conditions, but considering that it can be applied and presented to actual data, we think it would be better to cover it in 4.2.

Response to Reviewer #3

We appreciate your very meaningful comments. Here we have prepared a response and explanation to your suggestion, and have incorporated it into the main text.

Line 33: – Please change to "...radiance spectrum can include a polarization error of 2%"

→ Revised. We modified the sentence as you suggested.

Line 70: "fractional polarization of atmosphere" isn't a generally well-known quantity. It may be worth defining in terms of the Stokes parameters (1⁄2(1-Q/I))

→ Revised. We rephrase as "Stokes fraction (Q/I)"

Line 96: Change "of LUT" to "in the LUT"

→ Revised.

Line 136: Please clarify. I think you are trying to say that the measurements were done at the nadir position because the signal was lower at off-nadir positions. Is that correct? Depending on your confidence in the models, perhaps the authors would consider mentioning the PS angular variability predictions to give a sense of the order of magnitude of these variations (without including the plots)

→ As other reviewer also has made similar points, a deviation of the SMA from 0˚ position induces a shift in the entire view toward the north or south, thereby diverging from nominal operations. This implies that the response sensitivity to the polarization source from the integrating sphere decreases not only in the North/South direction but also across the wavelength spectrum on the CCD, making it difficult to reliably detect a consistent signal. We explained that part in a little more detail in the text.

Line 150: This description is a little unclear. Perhaps something like "...radiance response is non-uniform across wavelength due to the non-uniform PF spectrum, which can lead to degraded performance." (I believe you are missing a word, possibly "degraded", here.)

→ Revised.

Line 160: The details that were added to this section are helpful. However, could you clarify why so many transforms are needed to get from the instrument GEMS reference frame to the GEMS boresight?

→ Incident light on the payload sequentially passes through each part frame inside various instruments on its path to reach the CCD, and each part frame has its own axis. Therefore, the axis is converted step by step until it is converted to the final GEMS boresight frame.

Line 234: "and enable" to "enabling"

→ Revised.

Line 385: Perhaps "raggedness points" is not a common descriptive term either. I recommend “spectral features” instead.

→ Revised.