Reply to comments:

1. *The authors should make it maximally clear that the results of their study are likely to be heavily preconditioned by their choice of POLDER-like measurements (real or synthetic). The measurement accuracies selected for both intensity and polarization are hardly realistic. There is no discussion of what could happen if, e.g., an APS-type dataset were used, with its higher accuracy, more scattering angles, and wider spectral range (e.g., Mishchenko, M. I., B. Cairns, G. Kopp, C. F. Schueler, B. A. Fafaul, J. E. Hansen, R. J. Hooker, T. Itchkawich, H. B. Maring, and L. D. Travis, 2007: Accurate monitoring of terrestrial aerosols and total solar irradiance: introducing the Glory Mission. Bull. Amer. Meteorol. Soc. 88, 677–691). Furthermore, the paper is focused on what and how well can be retrieved without putting the outcome in the context of what and how accurately must in fact be retrieved (e.g., Mishchenko, M. I., B. Cairns, J. E. Hansen, L. D. Travis, R. Burg, Y. J. Kaufman, J. V. Martins, and E. P. Shettle, 2004: Monitoring of aerosol forcing of climate from space: analysis of measurement requirements. J. Quant. Spectrosc. Radiat. Transfer 88, 149–161). At least a short discussion of these important aspects is desirable.*

   Response:
   We agree that the results are (partly) pre-conditioned by the choice of POLDER, especially for real measurements. We added a phrase to the paper in Sect. 3.1:
   " It should also be noted that higher accuracy aerosol retrievals are to be expected for all parameters from instruments that have higher polarimetric accuracy, more scattering angles and/or spectral bands (e.g. (Mishchenko and Travis, 1997; Hasekamp and Landgraf, 2007)). Examples of such improved instruments are GLORY-APS (Mishchenko et al., 2007), MAIA (Diner et al., 2018), SPEXone (Hasekamp et al., 2018), and HARP-2 (Martins et al., 2017). "

   We expect that the synthetic results are less affected by the choice for the POLDER setup because the synthetic retrievals have been performed on noise-free data. Given that the 'consistent' retrievals already look close to perfect for these synthetic measurement, there is hardly room for improvement by bringing in extra measurements.

   Concerning the comment about requirements, we now include a Table in the paper that lists requirements from different sources (APS-GLORY, GCOS, ACE). Now the readers can see the results in perspective of these requirements.

Table 1: Accuracy Requirements on aerosol properties from Mishchenko et al. (2004) as used for the Glory mission, Global Climate Observing System (GCOS), and the ACE study (`https://acemission.gsfc.nasa.gov/documents/ACE_Report5_Aerosol_Science_v7.pdf`).

Property	Glory	GCOS	ACE
AOD	max(0.04, 10 %)	max(0.03, 10 %)	max(0.02, 5 %)
SSA	0.03	0.03	0.02
r_{eff}	max(0.1 μm, 10 %)	-	10 %
v_{eff}	max(0.3, 50 %)	-	50 %
m_r	0.02	-	0.02
N	-	-	100 %
ALH	-	1000 m	500 m

2. *As far as I understand, the BC aerosols are in the accumulation category and hence are treated as homogeneous spheres. If that's the case, the authors should at least acknowledge that this treatment can be exceedingly unrealistic (e.g., Liu, L., and M. I. Mishchenko, 2018: Scattering and radiative properties of morphologically complex carbonaceous aerosols: a systematic modeling study. Remote Sens. 10, 1634).*

Response:

Yes. We have added a phrase in Sect. 2.2:

" (A recent study by Liu and Mishchenko (2018) indicates that this assumption becomes unrealistic for increasing fraction of carbonaceous aerosol in the fine mode.) "

3. *"All fine modes are assumed to have the same refractive index and all coarse modes have another refractive index value". This assumption is highly artificial. Can its robustness be somehow checked by mixing BC and sulfate aerosols with their actual refractive indices and then performing a synthetic retrieval assuming that the refractive indices are the same? What would be the meaning and usefulness of such a retrieval?*

Response:

Although probably not fully realistic, the separation into a 'fine mode refractive index' and 'coarse mode refractive index' is quite common in polarimetric aerosol retrievals (e.g. (Chowdhary et al., 2001; Waquet et al., 2009; Hasekamp et al., 2011)). Also aerosol retrievals have been performed using an even simpler assumption of a constant refractive index for all modes (e.g. (Dubovik et al., 2011; Xu et al., 2017)).

It seems that the sentence did not clearly explain the approach. Therefore, we changed " all fine modes are assumed to have the same refractive index and all coarse modes have another refractive index value. "
to (in Sect. 4.5.1):

" also for multi-mode retrievals we use a separate refractive index for the fine and coarse mode, respectively. In this case, the fine mode refractive index corresponds to mode number 1-6 in Table 2 and the coarse mode refractive index to mode 7-10. "

4. *The sentence "We use the Mie/T-Matrix approach of Dubovik et al. (2006) with their proposed spheroid aspect ratio distribution for computing optical properties for a mixture of spheroids and spheres" can be made factually more accurate. For example, "Nonspherical aerosols are modeled as a size/shape mixture of randomly oriented spheroids (Hill, S. C., Hill, A. C., and Barber, P. W., 1984: Light scattering by size/shape distributions of soil particles and spheroids. Appl. Opt. 23, 1025–1031. Mishchenko, M. I., L. D. Travis, R. A. Kahn, and R. A. West, 1997: Modeling phase functions for dustlike tropospheric aerosols using a shape mixture of randomly oriented polydisperse spheroids. J. Geophys. Res. 102, 16831–16847). We use the Mie/T-Matrix/Improved-Geometrical-Optics database by Dubovik et al. (2006) along with their proposed spheroid aspect ratio distribution for computing optical properties for a mixture of spheroids and spheres."*

Response:
We changed the description to (in Sect. 2.1):
" Nonspherical aerosols are modeled as a size/shape mixture of randomly oriented spheroids (Hill et al., 1984; Mishchenko et al., 1997). We use the Mie/T-Matrix/Improved-Geometrical-Optics database by Dubovik et al. (2006) along with their proposed spheroid aspect ratio distribution for computing optical properties for a mixture of spheroids and spheres. "

5. *"Number column" should be "column number" throughout.*

Response:
It has been corrected throughout the manuscript.

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