The paper "*The polarimetric characteristics of dust with irregular shapes: Evaluation of the spheroid model*" presents and discusses the development of a new dust shape model using DDA calculations. The authors simulate the effect of external forces (i.e. wind or rain) on initially perfectly shaped spheroid particles of dust nature, by removing dipoles close to the surface of the particle. Further, the effect of the binding force (the force from the particle centre of mass) is accounted for; and particles with larger binding force seem to turn to more spherical as the external force acts upon them. The authors further fit the resulting phase function of irregular shaped dust with spheroid particles (simulations for spheroids performed using the T-matrix algorithm) and compare the scattering matrix elements of irregular and spheroid particles. As a last step, radiative transfer simulations assuming both irregular shaped dust and the best-fitted spheroids are also performed and compared.

The study falls well within the scope of AMT and the results could be very significant for scientific community. Nevertheless, in order to help improving the manuscript, I would kindly suggest the authors to take into account the following specific comments.

1) As I also stated in my initial review of the manuscript, I consider the range of input parameter values selected for the calculations, quite limited. The simulations are performed in only one specific wavelength (670nm) which is a frequently used wavelength for ground-based and satellite polarimetric measurements. AOD, SZA, surface albedo and complex refractive index (m) were also selected as single values.

   For the latter, the authors select to use m = 1.52 + i0.005 for their calculations. However, the previous literature cited to justify this selection, corresponds to either dust mixtures with more absorbing particles (i.e. smoke; Dey at al., 2006) or results for dust have been omitted (Beelen et al. (2014). I realize that the main conclusions of the study won't change much, however I believe that additional values should be accounted for (see for example studies from Petzold et al. (2009) (k ranges from 0.0003 to 0.0017 at 700nm); Wagner et al. (2012) (k ranges from 0.0023 to 0.0051 at 655nm) or at least the authors should discuss possible effects of different refractive indices on their simulations.

   In the following, I try to illustrate my concerns with a simple example where I have used the spheroid kernels developed and presented in Dubovik et al. (2006). Assuming a mono-modal, lognormal size distribution with geometric radius r_g = 2.32μm with a standard deviation σ = 0.02 (see Fig. 1; as narrow as possible SD to simulate as closely a single particle), the normalized scattering matrix elements for particles of an axial ratio of **2.07** and **0.53** are plotted in Fig.2 and Fig.3 respectively. The elements are calculated for real part of the refractive index n = 1.54 and 2 different imaginary refractive index (k) values:

   - m_1 = 1.54 + ***i0.006*** (green lines) which is more close to the value selected by the authors
   - m_2 = 1.54 + ***i0.0008*** (purple lines)

   As it can be seen from figures 2 and 3, the effect of k on the scattering matrix elements can –at certain angles- cause a relative difference ($m_1 – m_2/m_1$) of up to 60% for the phase function, 20% for P_{12}/P_{11} and even higher for P_{22}/P_{11} for an axial ratio of 2.07 and similar for 0.53.

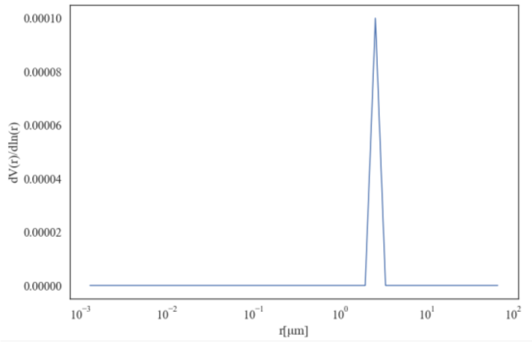

Fig.1) Mono-modal, lognormal size distribution used in the simulations shown in Fig.2 and Fig. 3

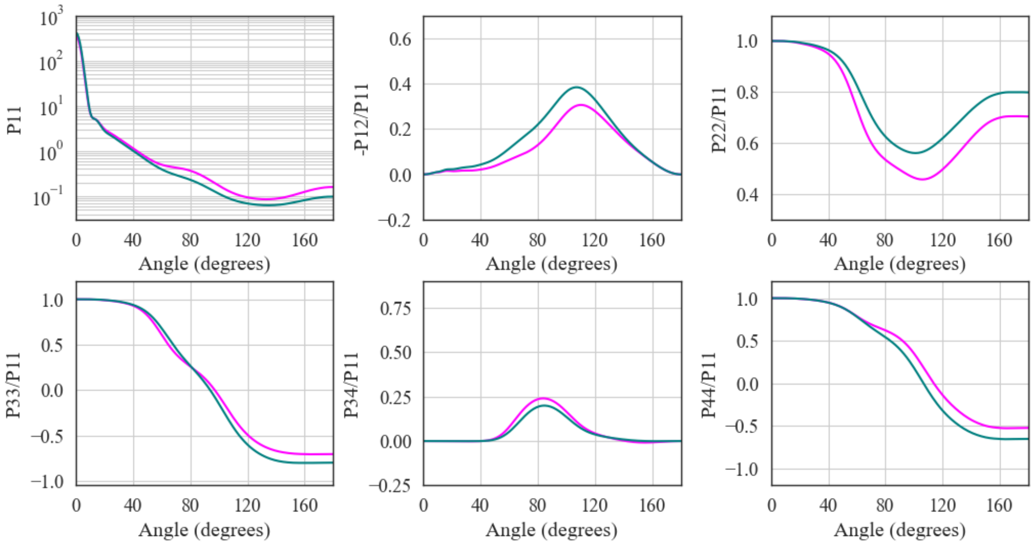

Fig.2) Scattering matrix elements for spheroids of axial ratio 2.07, the size distribution shown in Fig.1 and complex refractive index m = 1.54 + i0.0008 (purple lines)/i0.006 (green lines).

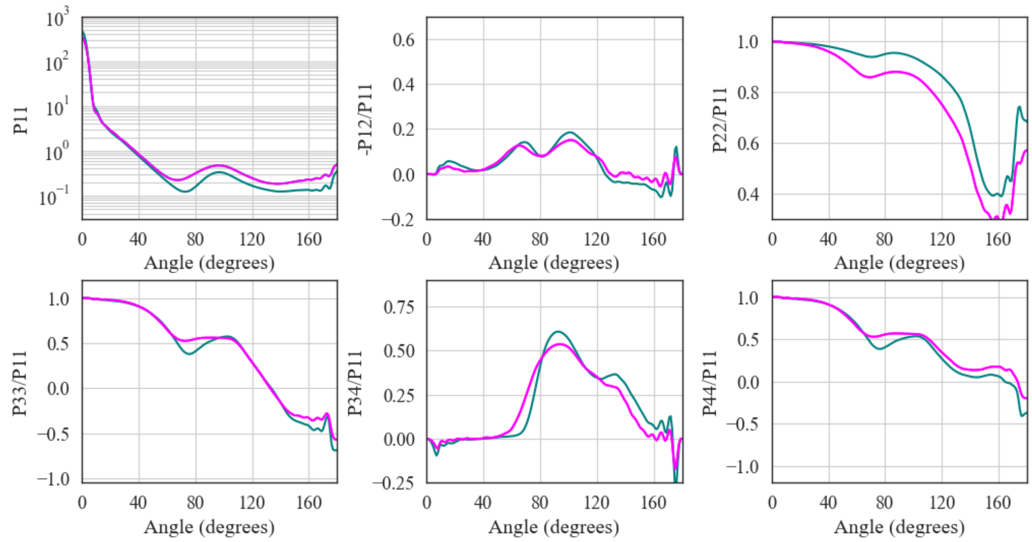

Fig. 3) Same as Fig. 2 but for an axial ratio of 0.53

References:

Dubovik, O., Sinyuk, A., Lapyonok, T., Holben, B. N., Mishchenko, M., Yang, P., Eck, T. F., Volten, H., Muñoz, O., Veihelmann, B., Sorokin, M., and Slutsker, I.: Application of spheroid models to account for aerosol particle nonsphericity in remote sensing of desert dust, J. Geophys. Res.-Atmos., 111, D11208, https://doi.org/10.1029/2005JD006619, 2006.

Petzold, A., Rasp, K., Weinzierl, B., Esselborn, M., Hamburger, T.,Dornbrack, A., Kandler, K., Schutz, L., Knippertz, P., Fiebig, M.,and Virkkula, A.: Saharan dust absorption and refractive indexfrom aircraft-based observations during SAMUM 2006, TellusB, 61, 118–130, 2009

Wagner, R., Ajtai, T., Kandler, K., Lieke, K., Linke, C., Müller, T., Schnaiter, M., and Vragel, M.: Complex refractive indices of Saharan dust samples at visible and near UV wavelengths: a laboratory study, Atmos. Chem. Phys., 12, 2491–2512, https://doi.org/10.5194/acp-12-2491-2012, 2012.

2) Calculations in the manuscript assume single particles both for irregular dust and the best fitted spheroids. Although there is no doubt that more realistic representations of dust particle shapes are needed, I wonder what happens if the authors assume randomly oriented ensemble of such irregular particles, and average their properties over a size distribution. I would expect that the characteristics of the irregular shapes smooth out. How are your results compared to those assuming poly-dispersed spheroids?

Phrasing needs significant improvements throughout the manuscript to make it more easy to follow. Some specific examples are provided below:

3) Page 2, line 25: “Dust can also modify the cloud properties by serving as the cloud condensation nucleus (CNN), so play an indirect effect on the climate”

   Consider rephrasing to something like: “Dust particles can also indirectly affect the Earth’s climate, as they can serve as highly effective cloud condensation and ice nuclei (CCN and IN) and thus modify cloud lifetimes, albedo and microphysical properties”

4) Page 2, line 30: “Ground-based remote sensing and satellite remote sensing are the main techniques to retrieve aerosols”

   -//- : “Ground-based and satellite measurements are the main remote sensing techniques to derive aerosol particle properties”

5) Page 2, line 37: “mainly derive the whole floor of aerosols”
   -//- : “Mainly derive the aerosol properties through the total atmospheric column along with surface characteristics”

6) Page 2, line 43: “The extinction coefficient”
   Maybe the authors here mean the ensemble averaged extinction cross section?

7) Page 4, line 94: “Under the erosion of the external forces, the mass of the dust would be lost. On the other hand, the binding force could constrain the loss of dust mass”

-//- : “Due to erosion forces acting on the particles, part of dust mass would be lost in the form of dust granules leaving the particle surface. However, binding force from the particle centre of mass could constrain this loss”

8) Page 4, line 113: “V_0 denotes the volume lost in the erosion process”
   V_0 here should be replaced with V_{lost}.

9) Page 4, line 114: “the dust shapes are easier becomes spherical due to larger binding force”
   -//- : “Dust particles eroded under external forces are easier to become more spherical when the binding force is large”

10) Page 5, line 120: “To reflect the Stokes vector of polarization, the normalized Stokes scattering matrix has six independent elements”
    -//- : “For rotationally symmetric, randomly oriented particles, the normalized Stokes scattering matrix has six independent elements”

11) Page 7, line 160: “The scattering matrices of dust with different shapes are shown in Figures 4 – 6”
    -//- : “The scattering matrices of dust with different irregular shapes and the corresponding spheroids that best fit the phase function are shown in Figures 4 – 6”