Comment on egusphere-2022-207 by Anonymous Referee #1

Referee comment on "Polarization Performance Simulation for the GeoXO Atmospheric Composition Instrument: NO2 Retrieval Impacts" by Aaron Pearlman et al., EGUsphere, https://doi.org/10.5194/egusphere-2022-207, 2022.

In this manuscript, the authors report on a study of the impact on NO_2 retrieval of instrument polarization of the Atmospheric Composition Instrument (ACX) planned for NOAA's Geostationary Extended Observations (GeoXO) constellation specifically by using currently known instrument specifications. This investigation is very relevant in case ACX will not be equipped with a polarization scrambler. The paper is written well and the conclusions that can be drawn from the stude are written clear and concise, but the method description could do with some more details.

Major comments

The description of the instrument (response) model in Sect. 2.1.2 gives very little details and there is no reference to a more detailed description. How does polarization influence the measurement? What kind of spectrally-dependent polarization features may be expected? What knowledge is available from GEMS and TEMPO, instruments that do not have a polarization scrambler? Could a figure be provided showing polarization sensitivity (PS) vs. wavelength?

Minor comments

- Page 1, line 5: Given the formulation of names and acronyms of the other instruments, it is more logical to write "... and OMI (Ozone Monitoring Instument), ..."

- Page 2, line 26: Given the formulation of names and acronyms of the other instruments, it is more logical to write "... such as TROPOspheric Monitoring Instrument (TROPOMI), ..."

- Page 2, line 27–28: The "GEMS" discussed by Hollingsworth is an entirely different GEMS than the Korean geostationary spectrometer. Please add an appropriate reference for GEMS. The paper of Hollingsworth is more appropriate for line 30.

- Page 2, line 35: The paper by van Geffen et al. (2020) describes the TROPOMI NO2 retrieval and is more appropriate in line 26.

- Page 2, line 51: Since both GEO and LEO have been spelled out in line 25, the line can read "... in both GEO (...) and LEO, though ..."

- Page 3, line 62: For clarity please write "... its circular polarization through ..."

- Page 4, Sect. 2.1.1: The light scattered by the surface may also become partly polarized. An example is the scattering by a water surface (e.g. principle behind Polaroid sun glasses). Is this taken into account, and could this affect the analysis?

- Page 5, line 110: A space is missing in "shrubs(30%)"

- Page 5, Table 1: Please explain the parameters AOD and sigma. Are the aerosols a mix of scattering and absorbing aerosol types?

- Page 6, line 132: The second occurrence of "all" at the start of the line needs to be removed

- Page 7, line 145: Surely the cloudy radiance L_{cld} is meant here.
  Are these radiances polarized, or unpolarized? Would that influence the result?

- Page 7, line 150: A comma is missing in "... cloud radiance fraction, f_r, ..."

- Page 8, lines 171–172: The "temperature correction" appears out of nowhere and it is not clear what it refers to. Is it related to the temperature dependence of the NO_2 cross sections, which is compensated by a temperature correction term in the AMF calculation in the NO_2 retrievals of e.g. OMI and TROPOMI?

- Page 8, line 173: The sentence is a little difficult to follow; suggest to write "This error can be considerd as the change in radiance the PS effect leads to, which . . . "

- Page 8, line 175: You write: "Note that this changes negligibly as a function of wavelength". Why? Could the instrument polarization response (m_{01}, m_{02}) not be strongly wavelength dependent?

- Page 9, line 195: A comma is missing after "respectively"

- Page 9, line 199: You write that $m_{01} = \pm PS$. Is PS a constant here, independent of wavelength. Why?

- Page 10, figure caption: For clarity suggest to write "(blue line and right axis)"

- Page 11, line 220: Parenthesis are missing around "Zoogman et al. (2017)"

- Page 11, line 224: The second occurrence of the word "cases" can be removed

- Page 13, Fig. 8: These plots are not so easy to understand. Could you explain the shaded regions in more detail?