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Comment on essd-2022-108

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Referee comment on "Climatology of aerosol component concentrations derived from multi-angular polarimetric POLDER-3 observations using GRASP algorithm" by Lei Li et al., Earth Syst. Sci. Data Discuss., https://doi.org/10.5194/essd-2022-108-RC3, 2022

"Climatology of aerosol components concentration derived by GRASP algorithm from multi-angular polarimetric POLDER-3 observations" submitted to ESSD is a well written paper that studied the global climatology of aerosol species based on GRASP-Component algorithm on POLDER-3. The paper describes the GRASP-Component algorithm, highlights its advantage in retrieving aerosol component, presents the aerosol component global climatology, and compared it to MERRA-2 reanalysis. There are many interpolations of the GRASP results and explanation of potential error sources. The paper is well organized, and the presented climatology can be helpful in terms of understanding the global aerosol type distribution and changes. My main issue first is it requires more discussion of uncertainties in GRASP-Component algorithm and similarly some of the typing climatology. Second is that it needs some more discussion of how this community can use this information, especially in terms of bridging the gaps between remote sensing and modeling communities, which I think is the real advantage of this product.

- When in the beginning defining these aerosol components, it will be intuitive to relate these with commonly defined nature aerosol species.
- Both in BC and BrC annual maps, I couldn't find elevated signature of smoke over Southeast Asia. But we know that that is one of the major regions that smoldering burring occurs with most of the dry year during El nino phase. Is it due to large cloud coverage? If so, can data availability also line contoured on top of the global map?
- In CNAI map Figure 13, we see a belt of coarse non-absorbing insoluble aerosol near central-south Africa. That is one region that burning of savanna will occur, but very limited dust shall be found there. Similar region was highlighted up in BC map, which shows that these are burning region as well. The cause of these signal needs to be explained.
- The explanation of FNAS map in Figure 17 mentioned aged dust, however, it is hard to believe that aged dust will occur over land. Thus, it is unclear to me what is causing

FNAS signal over Africa during DJF, JJA, and SON. To me these looks like signals from biomass burning again, but is burning produce fine mode non-absorbing soluble aerosols?

- MERRA2 has more BC than GRASP-C globally, especially over East Asia. First of all, the recent GOCART model included BrC as well. (G.P. Schill, K.D. Froyd, H. Bian, A. Kupc, C. Williamson, C.B. Brock, E. Ray, R.S. Hornbrook, A.J. Hills6, E.C. Apel, M. Chen, P. Colarco, and D.M. Murphy, The ubiquity of dilute, aged smoke in the global remote troposphere and its effect on climate, Nature Geoscience, 13(6), doi:10.1038/s41561-020-0586-1, Jun., 2020.) Author can use that version to compare BC and BrC separately. Second, it does seem like some of the biomass burning signal is shown in dust related component (see what I pointed out before.)
- MERRA2 has a lot more dust over dust belt. I agree that if GRASP-C produced dust cannot be represented only by one component, the systematic low at North Africa is expected. But the high value from GRASP-C product over southern Africa needs to be explained.
- Line 236. How are these refractive indexes determined for components? Especially for mineral dust, large variation can occur based on the origin of the dust. Summarize the approach and uncertainties associated with it.

Other minor stuff

- Line 439-444 mentioned both volume ratio and mass ratio. It is confusing for reader to do the conversion, so providing a mass ratio range from the used volume fraction might be easier for reader to understand author's point.
- Line 389-390. The statement of BC and BrC relation with smoke is not entirely accurate. Many papers discuss the more absorbing vs. less absorbing smoke, including those from AERONET groups (Tom Eck), the recent one is here (Junghenn Noyes KT, Kahn RA, Limbacher JA, Li Z. Canadian and Alaskan wildfire smoke particle properties, their evolution, and controlling factors, from satellite observations. Atmospheric Chemistry and Physics Discussions. 2021 Nov 3:1-34.)
- Why are standard deviation plots using 4 identical color bars while seasonal map using one unified color bar? Can they be consolidated?
- Color bar in seasonal map should have units on it.
- Line 325-326 "that low…is small." This sentence is confusing. Low STD/MEAN is observed when intensity of emission is small? or low STD/MEAN is observed due to low emission. Nevertheless, in MAM the STD of BC is high in Asia, indicating changing of BC emissions.
- Line 279 "minimal bias", be specific.
- Line 96. Flower has some volcanic paper with Ralph Kahn.
- Line 83. Data assimilation paper adding these two citations (Zhang J, Reid JS, Westphal DL, Baker NL, Hyer EJ. A system for operational aerosol optical depth data assimilation over global oceans. Journal of Geophysical Research: Atmospheres. 2008 May 27;113(D10).; Shi Y, Zhang J, Reid JS, Hyer EJ, Hsu NC. Critical evaluation of the MODIS Deep Blue aerosol optical depth product for data assimilation over North Africa. Atmos Measure Tech Discuss. 2012 Oct 24;5(5):7815-65.)
- Line 32, "The aerosol optical properties" means what properties? Need clarification.