Das, Colarco, Bian, Gasso: Improved Simulations of Biomass Burning Aerosol Optical Properties and Lifetimes in the NASA GEOS Model during ORACLES-1 campaign.

This paper presents an improved scheme for modeling of aerosol optical properties and their time evolution, based on airborne observations made during the 2016 ORACLES field campaign over the South-East Atlantic Ocean. The title accurately reflects the scope of the work, which is withing the scope of ACP. The abstract is an accurate summary of the body of the paper.

Novel airborne data is presented from several instruments on two aircraft on one day of the campaign, and this is used to modify the aerosol optical parameterization in the GEOS model. Credit is given to the instrument teams whose results are used in the analysis. Differences between the baseline model and the improved model using several scenarios of altered aerosol optical parameterization are shown, and the radiative impacts are explored. The results are placed in a broader context by reference to AERONET time-series data and monthly-mean satellite measurements. The conclusions reached point towards a necessity for a more detailed investigation into the mechanisms driving the modified aerosol microphysical scheme developed for this study.

The authors consistently steer well clear of any sort of quantitative assessment, with a strong tendency towards the use of colloquialisms and imprecise language. Improvements in the results are frequently claimed, however reference is not often made to how the improvements are quantified by the authors. This seems like a squandering of the obviously substantial resources that were dedicated to making sophisticated field measurements, not to mention the subsequent modeling efforts performed to produce this paper. As the pre-eminent experts in the field working within a well-funded agency, it would behoove the authors to at the very least educate the reader as to what, quantitatively, they would assess to be an "improvement", a "good agreement" or a "bad agreement". Methods and assumptions made are clearly outlined. The descriptions of experiments would allow reproduction of the results by a well-funded and motivated team.

The following specific comments refer to line numbers in the pre-print:

12: "outflow region" – there are several outflow regions from the Southern African sub-continent. This study (and ORACLES) only includes one of them.

20: "mimic" – this is a rather odd anthropomorphization of the model. "model" might be more appropriate.

26: "showed a better performance" – delete "a"

44: "One of the possible reasons of the DRE mismatch" – "…for the DRE mismatch"

45: "optical properties assumptions," – "optical property assumptions"

46: "model SSAs were found to be usually higher than the aircraft" – "mostly higher…" or "frequently found to be higher…"

70: "changes in SSA along the aerosol vertical profiles" – "…within the aerosol vertical profiles"

71: "possibly with ageing smoke plumes" – "possibly with smoke plume ageing"

74: "Once we tuned…." – "After tuning…"

75: "we also utilize the larger spatial…" – "we utilize the larger spatial…"

105: "retrievals of column aerosol properties" – "retrievals of partial-column aerosol properties"

106: "under certain flight conditions" – "under ideal flight and atmospheric conditions…"

107: "due to suspected stray light contamination" – this may also be due to an incorrect retrieval of the column NO2, leading to a misattribution of observed total extinction to aerosols.

115: "above-column SSA" – it's not clear what this is, do you mean "above-aircraft column SSA".

116: "… was used to emphasize on SSA of smoke layers" – " to focus on SSA of smoke layers"

123: "we mainly use the aerosol extinction and lidar ratio…" – it's not clear what you mean. Did you, or did you not, use other data from the HSRL?

126: "interpolated to the aircraft GPS times" - it's not clear what this means.

128: "… MBL which is mostly capped" – "frequently capped/always capped/sometimes capped". "Mostly" is quite meaningless in this context. What is the significance of MBL stratocumulus clouds here? Do they have an impact on the space-based lidars that is not a factor for the ER-2 HSRL?

136: "we convert them to ambient conditions…" is this done by the team writing this paper, or by the HIGEAR team?

140: where was the UHSAS mounted on the aircraft? Which aircraft?

143: Where was COMA mounted on the aircraft? Which aircraft?

169: The way you phrase it here, it seems like the row anomaly is an additional consideration, but you don't say what you have done to mitigate it.

~175: Why is the NNR better than the MODIS C6.1 data for your work? It's not clear why this is the better choice, without the reader going and reading and comparing Levy 2013 ad Randles 2017.

181: "The target of the NNR algorithm is the log-transformed AERONET…" – it's really not clear what this means. AERONET provides effectively a point measurement, yet NNR provides a 10km spatial resolution product. Is AERONET used as training data for the NNR? Clearly, saying that the NNR provides AERONET AOD is nonsensical, since these are different instruments.

198: Does DMS have a wind-blown source? Sea-salt production may be related to windspeed, but is DMS not biogenic? How does the windspeed influence ocean productivity? Please clarify and provide a reference, if this is indeed how it is represented in the model.

209: "… following (Kim et al, 2015)" – "following Kim et al (2015)"

210: "conversion of VOC to SOA a simple function…" - "…modeled using a simple function…"

215: "aerosol species are externally mixed…" – this is a very odd sentence construction. "…species are considered to be externally mixed…"

232: is Collow et al still in preparation?

233: "see also Das et al 2017)" – missing parenthesis.

239: "(Table 1)" – perhaps something like "(compared with the other simulations in Table 1)"

240: "day of the week its emissions…" – "day fo the week on which its emissions were injected"

243: It's too late to change this study now, but surely using a non-perishable tracer such as Julian day would be better?

265: "closer together is to the translate" – delete "the"

275: "After the Colarco et al study…" – "Since the study by Colarco et al…"

282: "almost the same" – how do you quantify this?

283-4: "See Colarco et al for a detailed description of the AI simulator" – no need to say the same thing twice…

286: "Linux-distribution" – is the hyphen necessary/correct? Your editor may have an opinion.

286-290: Three sentences in a row start with "We use…"

293: It's not clear how these offsets are done. Is the entire meteorological field shifted while keeping the initial position the same? Is there some reference describing this in detail?

294: "all-possible" – hyphenation is dubious.

299: "Sept 2016 in context of…." – "in the context of…"

302: The aircraft did not observe anything, they just fly through the air. The instruments do the observing (or perhaps strictly speaking, not even that; however this is more a question of philosophy) Perhaps: "…observed from both the P-3 and ER-2…"

307: "We suggest the vertical variation of SSA…." This seems completely out of context here. Is this one of your hypotheses?

310: "vertical flight trajectory" – "vertical flight profile". "Trajectory" is strictly speaking something that is followed by e.g. artillery shells or re-entry vehicles. In the horizontal plane, the aircraft would follow a "track".

311: What is the time difference between the airborne measurement and the GEOS model time-step?

313: "… with part of P-3 flight path" – "with part of the P-3 flight track".

316 & Fig 3 & Fig 4. The P-3 appears to have been flying northbound until approx. 11:30UTC, then turning southbound. The ER-2 appears to have been flying northbound until around 10.1 UTC. Thus, these plots are folded back on themselves in latitude. This is quite confusing, and a clearer description of these plots is warranted.

317: Refer to the specific plot (i.e. Fig 3?). "About 13UTC" is very imprecise; the profile starts well before 13UTC. Please furnish the exact times that you are referring to. Similarly: "About 6km to 1km" – please furnish the exact altitudes that you are referring to. Also, improve the horizontal scale markings on the plot so that the reader can follow these exact times that you furnish.

318: (~9.5 UTC) – please furnish the exact time. You highlight a box prior to 9.5 UTC on the plot. Is this the time you refer to, or is it the high-extinction plume between 3.2km and 5.2km altitude, shortly after this time that you wish to draw the reader's attention to?

322: "extinction magnitudes can be explained in part…" – This is a rather qualitative assessment, with a equally vague description. Can you provide a quantitative assessment of this?

325: "at least for the upper level smoke layer" – "upper level smoke layer" might be subject to interpretation. Starting off your analysis of the profiles with a precise description of what you see (e.g. an upper smoke layer measured by the ??? instrument in the P-3 aircraft while descending between 4.2 – 5.2 km and a lower smoke layer at 1.6- 3.6km…) would get you and your reader on the same page and allow you to clarify a lot of the vague language in these and following paragraphs.

325: "model simulated" – your editor might want a hyphen here, since "model-simulated" is an adjective, although Copernicus language editors seem to ignore this common feature of English grammar.

Fig 5c: have you tried plotting temperature on this plot? The existence of absolutely stable layers in the winter atmosphere over the sub-continent is a feature that was described decades ago by Tyson. It would be interesting to see that they exist over the ocean too.

326: "having a very good match of simulated RH" – delete "having"

339: "underestimated in the model overall" – by what measure? can you quantify this?

339-340: "multiplume" – this is not an established term, and has all sorts of connotations which will differ from one reader to another. Perhaps "layered" is better?

341: "Here, BC is the primary…" are you referring to a specific figure, or a specific profile, or a specific model simulation? This is not clear.

343: Same comment. Are you referring to a specific figure?

346: "(Table 1, Section 2.4.1)" – it would be polite so say "(described in Table 1 and Section 2.4.1)" rather than barking at your reader.

346: "almost monotonic" is meaningless. It's either monotonic or not, and it seems from the plot that is is clearly not. What do you mean?

351: "demonstrating that the models are in close agreement" – by what metric?

352 & Fig 7b. Would it not be clearer to use something like a box-and-whisker plot on the vertical profile. How does the distribution of extinction fraction in the "clean" layer at 3.8km look?

359: "…causing the weighted mean smoke age to be younger than it possibly is" could this be rephrased to make it clearer?

362: "… composition of aerosols change with smoke age" – "changes"

366: If these quantities are correlated, could they be plotted against each other? This would make your point clear, rather than the qualitative "by inspection" correlation that you claim.

369: "nitrate:BC and SO4:BC" – consistent nomenclature: choose words or formulae

374: This introduces your hypotheses, however this sentence is quite weak, almost an afterthought.

377: "with perhaps different…" – this is your hypothesis. "Perhaps" makes it weak and negotiable. State it clearly and boldly.

380: "origin locations" – delete locations.

385: It's not clear how Fig 9a is arrived at. Is this from QFED introduced in line 216, then never mentioned again?

390-392: "further suggest that the contribution… are possibly causing the…" – "suggest" + "possibly" in one sentence makes for overwhelming uncertainty. What do you want to say here?

393: "suggest… almost…" here makes me think that you have no faith in this tool whatsoever. Why do you use it?

396: "as a proxy for vegetation type". Surely the OA:BC is *determined* by vegetation type?

399: Fig 10 is introduced rather suddenly here, and the reader is left to figure out its meaning with no guidance from the author.

407: "do not even differentiate" – delete "even"

409: "the most different fuel types" – it's not clear what is meant by this.

410: savannas: check for consistent spelling cf. line 422.

Table 2: where does the multiplier of 1.8 come from? Is this an empirically established ratio? Is there a reference for this?

417: "emission ratios based to fire characteristics…" – "based on fire char…"

422: spelling of savannah, cf. line 410.

422: "savannah and grassland region" – plural "regions"

424: "outside plume (>6km) values" – "values outside the plume (found at altitudes > 6km)"

427: "Therefore…" here you refute your hypothesis. I would consider having this sentence stand as a paragraph on its own.

442: "increase in particulate oxygen" – it's not at all clear what this is. Is this a change in oxidation state? Are there unbound oxygen atoms resulting from a chemical reaction? Are particles being oxidized?

448: "prescribed at emissions…" – at the point of emission?

448: "the burning fuel type" – delete "burning"

452: "further aged smoke" – in plain language: "older smoke"

462: "brought the modeled SSA curve closer to 4STAR" – by what metric? Some wavelengths look "close", some wavelengths look "far". What are the implications of this? If you are giving a qualitative assessment, base it on some numbers.

470: you could refer to Fig 10 here, if I understand it correctly.

485 & Fig 13: f(RH) nomenclature in Fig 13 axis labels is confusing and unclear.

486: f(RH) is high/low, whereas here you mention low followed by high. This is confusing.

489: here you use measurements between 1.5 – 6km. On line 479 you use 1.0 – 5km ostensibly to achieve the same aim.

496: "Sulfate hygroscopicity increases…" do you mean "hygroscopic growth factor"? These are not the same thing.

501: "tracks with BC" – this is an extreme colloquialism. Meaningless. What are you trying to say?

501-2: "closest match to observations" - can you provide some numbers that you used to guide your assessment?

506: "blue (or 355nm) channel" - is it blue, or is it 355nm? or is it blue and 355nm?

507: "by (Veleovskii et al, 2020) : V. et al (2020)

510: "were set" – past tense? "was set…"

511: Give the precise definition and be done with it. If there is a need for a looser definition, provide this afterwards.

Fig 14 & lines 510, 517, 519, 520: is it k_340 or k_350? The figure and the text do not correspond.

521: Why is it worth mentioning this? How does this impact your study? Perhaps a better phrasing would be "it is worth mentioning that GOCART assumes particles to be spherical, notwithstanding Meng et al (2010)…"

525: "we call as 'updated optics'…" – delete "as"

527: "these optics update" – "this optics update"

528: "slight decrease" – what constitutes a slight decrease?

529: "very close" – what constitutes very close?

533: "assumptions that is leading to.." – "that are leading to"

534: Explian by what metric it shows a "better match"? You have some measurements here that took incredible resources to make, yet you provide a qualitative description.

541: "the September" – delete "the"

543: does not deviate much. Add some numbers to your qualitative assessment. These measurements took incredible resources to make.

546-7: "suggests that model is missing" – insert "the"

552: "over complete SE Atlantic" – "the broader SE Atlantic region" or something like that.

556: "the Model and MODIS NNR AOD" – it would be worthwhile to remind the reader here how the model AOD is derived.

557: "Overall, there is a good match…" – by what metric?

558: "…compared to the source region…" it's not clear what this means. Is the "overall good match" better over the ocean than over the source region? By what metric?

Perhaps a plot of AOD from MODIS and the model runs along the 10deg S latitude line would illustrate the point you are trying to make more clearly.

575: you speak of retaining OMI pixels without cloud contamination, in the context of the model-based AI calculator. This is clearly meaningless; the discussion about cloud contamination should come after you introduce the OMI observations in line 576.

585: I can see hardly any difference between Fig 17c and Fig 17e. How do you quantify the "much more favorable comparison"?

591: The direct radiative forcing of the aerosols is what it is in the real world out there over the SE Atlantic. You are talking about the modeled DRF.

598-600: "due to aerosol difference between our two runs… the other without the aerosols" – do you mean without aerosols, or do you mean the difference between the baseline model and the modified/updated aerosol scheme?

603: this is the first mention in this paper of the "main cloud feature". What is this cloud feature?

606: "reflected radiation to space" – "radiation reflected to space"

607: it's not clear where the border of DRC and Zambia is. What lon/lat are you referring to.

613: You introduce the cloud features in the last line of your section. What clouds are you referring to? Modeling of cloud features has not been mentioned prior to this.

621: "move observing smoke plume" – do you mean "absorbing"?

622: "We hypothesize a loss process … explains…" - "We hypothesize a loss process … that explains" or "loss process… explaining"

624: "mimic" is again an odd anthropomorphizing of the model.

634: "a better performance…" issues of how you quantify this have been addressed in the sections above.

639: consider deleting "In terms of future directions" and start the sentence with "The simplistic approach…"

643: "mimic"