Review of "Numerical quantitation on the effect of coating materials on the mixing state retrieval accuracy of fractal black carbon based on single particle soot photometer" by Liu et al.

Summary:
In this paper, the authors perform several modeling experiments to evaluate the ways in which different coating materials are likely missed by the DMT SP2 and their effects on retrieved coating diameters, absorption enhancement, and radiative forcing. They find that organic carbon and sulfate coating lead to larger relative errors of the mixing state than black carbon coated with brown carbon and this effect leads to moderate-to-large impacts on the radiative forcing. This work is interesting and provides insightful context on the limitations and potential errors of using SP2 measurements to assess black carbon effects on climate and is well motivated, but the paper is not written well to make these point compelling based on the results. Many details are missing, and the discussion is vague without specific directed attention to the very detailed figures and tables. A large driver of this lack of clarity is the poor writing. The authors should make a concerted effort to carefully review and revise the syntax and diction of this paper so that thoughts are clearly and fully described. I do not recommend this paper for publication in its current form but encourage the authors to make use of the comments and suggestions provided below to improve the paper. Because the issues were somewhat numerous, I was not able to comment on every single one but have highlighted a number of them that I believe can be applied in general.

Major Comments:
- The introduction of this paper is not written well. Many grammatical errors and sentence structure issues persist throughout. On my first pass of the introduction, I started to provide some comments and suggestions (in the Technical Corrections below), but they became far too numerous and minute. The current state of the introduction makes it hard for the reader to follow the motivation of this work. I would suggest taking the specific suggestions provided below and apply them generally throughout this section.

- I am not convinced on the fidelity of this work based on the writing of the Methodology section. Many citations are missing, and the writing is unclear. Several components of this section are not defined and there are far too many variables and parameters to keep track of. I have provided a few suggestions (many issues exist here than I have time and space to note) below that could help with the clarity of this section, but the authors should take more time and care in revising this section so that it can be clear to readers what was done and how.

- The results sections of this work is difficult to follow and lacks specificity. I believe there is a lot (of useful) information provided in each figure and table, but they are not fully described and detailed in the text when they key findings are discussed. I would recommend to the authors to, in addition to providing better figure detail, place their results in context by citing previous literature.

- I believe the conclusion section of this work is inadequate. A vague listing of very general results is not appropriate. More detail, specifically quantified errors in summary, should be provided to what is already included in the text of this section. This section would also benefit from describing the implications of the results that are found in this work. Given the rather large error in radiative forcing, what does this imply for BC effects on climate that motivate how SP2 measurements are used and how they can be improved in the future?

Technical Corrections:
- Abstract: This whole section needs to be revised for clarity and flow. There are several run-on sentences here, missing or redundant commas, and missing articles ("the" before nouns such as, "the SP2"). I will not provide guidance line-for-line, but an example place of improvement includes lines 22-24 which have 3 separate thoughts: (1) the absorption enhancement retrieval deviations due to coatings, (2) the radiative forcing error from coating of BrC, and (3) RF error from sulfate and OC. It is possible that these three thoughts can be combined in one sentence, but the current verbiage is not coherent and far too long of a sentence.

- Line 36: I suggest adding "and" in the sentence: "melting of snow and ice, [and] alters the atmosphere…"

- Lines 37-41: The two sentences in these lines contain disjointed thoughts and do not connect ideas. These should be improved for clarity.

- Lines 42-43, Lines 45-47: These sentences joined by commas should be broken up into two sentences. Appropriate citations for claims should also be added where appropriate.

- Line 49: If the authors are referring to, as I assume, the DMT SP2, they should identify the manufacturer (Droplet Measurement Technologies) and provide a citation for this instrument.

- Line 53: an example of where an article is missing: "The optical cavity of [the] SP2…"

- Line 95: "According to the observations using electron microscopes, …" What observations? Are these the authors' observations or from literature? Please clarify and provide citations where appropriate. The sentence also contains disjointed thoughts; please revise.

- Section 2.1-2.2: Can the authors please provide a table detailing the parameter settings for the models/numerical simulations and provide citations where appropriate. The listing of these parameters in the text alone are very difficult to follow

and keep track of. A table or list of the variables defined in this work (likely as an appendix) should also be provided as there are many variables provided in this section.

- Line 134: MSTM is not defined in the main text before it is used here. Please specify this acronym. In addition, the MSTM algorithm that you used is not detailed anywhere in the methodology section. Did you use a previously written algorithm or did you develop your own. This should be clarified.

- Line 165-167: is there a citation for ASTM G173-03 so that readers can reference where these parameter numbers come from?

- Line 198: clarify "leakage points"

- Discussion of Figure 1 in the main text: The authors should direct the reader to which panel they are discussing when they refer to results shown in the plots.

- Figures 1-3: The authors should quantify the differences in the lines of these plots. Throughout the results section, the differences are discussed as "identical", "similar", "smaller", but these differences are not convincing based on these vague qualities.

- Line 216: If the authors are going to discuss retrieval errors, the table listing these errors should be referenced.

- Tables 1 and 2: please provide in the table caption or footer, a description of the acronyms in the table (RR, RE, etc...)

- Section 3.2: The authors need to write out the numbers that are referenced in Table 1 when they describe the differences. Lots of vague language about what is shown in this section. "The relative error of black carbon particle swarm retrieval results..." what does that mean? If the authors are going to use verbiage such as "significantly different" then a statistical test of difference needs to be done and described.

- Section 3.3: It is unclear to me if a lognormal BC particle distribution was employed for comparison (lines 263-279). If so, how was the lognormal distribution characterized (number concentration, diameter, width) and did you test the sensitivity of these selections?

- Section 3.4: The authors should speak to the atmospheric/climatic implications of the retrieval errors between the SP2 and their model results based on the coating and fractal shape.

- Conclusion: Except for point (4), points (1)-(3) should have quantified differences included. Language such as "similar", "swarm", "small", "different" is not appropriate to describe the differences. The authors need to include numbers to detail what was observed. It also preferred that implications are described based on your results. These should be placed in context with previous literature and what these new results bring to the field.