

## Review of

*“Biomass-burning smoke properties and its interactions with marine stratocumulus clouds in WRF-CAM5 and southeastern Atlantic field campaigns”*

by Howes et al. (2023)

### **General comments**

This study compares aerosol and cloud properties observed during three separate field campaigns and simulated by WRF-CAM5 over the southeastern Atlantic during the biomass-burning season. Due to the wide coverage of stratocumulus clouds over the region and therefore the strong radiative forcing, understanding aerosol and cloud properties and their interactions over the area is crucial for the climate model improvements. The study has revealed many key discrepancies between observations and WRF-CAM5; for example, the lower hygroscopicity  $\kappa$  in the simulations, the lack of aerosol loss processes in the model that may have led to an erroneous aging process and/or number concentrations, and the rainfall tendencies (i.e., the drizzle problem). These points are important for the future aerosol/cloud model developments, and hence the study conveys important messages. Figures and tables present simulated and/or observed results well, which get explained thoroughly in the main text. The structure of the paper and the presentation of the results can be somewhat improved before the publication, as it may be confusing in the current format. While this is understandable given the number of different variables presented from many field campaigns and instruments, I suggest the re-organization of the paper structure so that a few most important messages stand out, rather than keeping them as one of many findings, which I believe will convey the messages more easily to the readers.

### **Specific comments**

**General structure:** Given the amount of information in the paper, I believe the clear structure of the paper is crucial for readers to understand the content as much as possible. Currently the main section is structured as follows;

#### 3. Results

##### 3.1 Free troposphere smoke

###### 3.1.1 Physical properties

###### 3.1.2 Aging processes in the free troposphere, WRF-CAM5 vs. ORACLES

##### 3.2 Boundary layer performance

###### 3.2.1 Boundary layer smoke composition

###### 3.2.2 Boundary layer size distributions

### 3.2.3 Hygroscopicity in LASIC

### 3.2.4 Smoke entrainment, removal, and rain at Ascension Island

### 3.2.5 Aerosol activation and turbulence

For example, before starting 3.1 (right after “3. Results”), the authors can explain that the results are presented firstly for the free troposphere and secondly for the boundary layer, and why the two are presented separately. This will give readers an idea of the overall structure and the reasons for the separation. The same thing can be done right after “3.1” and “3.2”, so that readers understand why the subsection is split into multiple subsections, and what contents are expected within the subsection. This also applies to Section 2 (Methods) as well; the authors can add a few sentences between “2. Methods” and “2.1 Observation systems” on what each subsection contains and why the section is split into five subsections.

The subsection title for 3.1 and 3.2 should be comparable, for instance, “Free troposphere” and “(Marine) Boundary layer”. Once these are defined in the subsection titles, then the subsection titles do not need to include “free troposphere” or “boundary layer” again (as it’s obvious). Ideally, 3.1.1 and 3.2.1 have comparable titles and contents, for example “Physical properties” for both 3.1.1 and 3.2.1, so that each subsection has the same/similar subsections and similarly structured. While this may be some work and re-organization of the contents, I believe the paper will convey the messages better to readers. It would be even better if each subsection has a clear message or finding, which gets summarized at the end in Conclusions (and also in Abstract).

**Abstract:** Related to my general comments above, the abstract seems to include too much detailed information on many topics, but it should be a concise summary of a few key findings of the paper. In addition, in the current format, readers may get the impression that aerosol size and composition in the free troposphere are the only variables that the model was able to simulate well, and the rest was not well simulated/reproduced, though this is not the main point of the paper. I believe summarizing a few key discrepancies and their cause in brief words will give a better idea of the paper content.

**Figure 2:** The red crosses in the plots are not explained, but I believe these are outliers? Please add this information to the figure caption.

**Line 418:** Should this be “above” 3  $\mu\text{m}$  rather than “below”, if the topic is the lack of coarse-mode particles?

**Line 588:** “excluding the clean period” – why was it excluded? From the figure, the overprediction is also seen during the clean period.

**Conclusions:** I suggest that the authors list the key findings either in bullet points or in numbers, and make them concise. The detailed numbers do not need to be repeated here for all the items, except for a few key important numbers.

**Figures 2g-h, 4b-I, 6f-g:** Some of these figures are not referred to in the manuscript, or their contents are discussed but they are not exactly referenced/referred to in the manuscript.

**Figure A3:** Is this figure referred to in the manuscript?

### **Technical corrections**

**Abbreviations:** Throughout the paper, there are a few words that are defined earlier (e.g., ASI, FT, SEA, MBL) but the full words are used again afterwards, or defined twice. I suggest that the authors make sure abbreviations are defined only once, and they're used throughout the paper after the definitions.

**Line 73:** “Intergovernmental”, not “International”.

**Line 238:** Add “(2022)” after “Barrett et al.”

**Line 268:** Missing the reference for the WRF-Chem model.

**Line 272:** Delete “Niemand et al., ” in the bracket, as only the year is necessary here.

**Line 427:** I believe this is a typo, the “μ” at the end needs to be deleted.

**Line 516:** This should be “downward” without an “s”.

**Line 563:** I believe it should be either “..., which is generally” or “..., (which is) a difference that is generally”

**Line 595:** It should be either “, which corresponds to...” (with a comma) or “that corresponds to...”

**Line 598:** Remove “which”

**Line 598:** “smoke-free” instead of “smoky free”

**Line 635:** Add “κ” between “than” and “in”

**Line 671:** Add a period after “periods” to end the sentence.

**Line 673:** “periods” instead of “period”

**Line 721:** I think it should be “provides” instead of “providing”, assuming that the subject is “This” in the beginning. Or, it should be “..., while providing...”.

**Figure 9 caption:** Add “and” between “each campaign” and “WRF-CAM5” (6th line).

**Line 777:** Add “to” after “due”.

**Line 786:** Add “MBL” before “compared to”.

**Line 797:** The beginning of this sentence needs to be corrected – I believe it is “The fact that”?

**Line 817:** “are often when” should be “often correspond to the time period when” or something similar.

**Line 834:** Replace “measure” with either “compare” or “evaluate”.

**Line 836:** This sentence is more appropriate in Introduction, not in Conclusions.

**Line 886:** Add a dot after “comparison”.