We would like to thank the two anonymous reviewers for their comments. We present below our responses to these comments as well as the modifications we made in the paper following these comments.

In order to respond to the different comments and to make the article more robust, we reran our simulations to diagnose the AAOD and SSA of the different aerosols of the TACTIC scheme. Several figures have been added in the revised article. Figure 7 shows the contribution of the model BrC absorption to the total aerosol absorption. In the light of these results we added in our article the evaluation of the aerosol AAOD and SSA at 350 nm (Figures 8 and 10).

Anonymous Referee 2

This manuscript presents a global model simulation of brown carbon and its climate effect in the ARPEGE-Climat global climate model. The authors provided a detail review of current modeling schemes for BrC and a detail introduction to their own parameterizations. They evaluated the simulated AOD, SSA, AAOD with satellite and ground-based sun-photometer measurements.

The biggest issue of this manuscript is the model-observation comparison part, which in my mind, doesn't provide much useful information. The comparisons use AOD, SSA, and AAOD at 440nm as well as AOD at 550nm. Since BrC could contribute only a small part to those total aerosol properties, the model biases are more likely to be related to other aerosols: We agree that this model-observation comparison part needed improvement. First, we reran our simulations in order to diagnose the AAOD and SSA of the different aerosols of the TACTIC scheme at short wavelengths (350 and 440 nm). With these diagnostics, we produced a new figure that appears as Figure 7 in the revised article. This figure shows how the model BrC absorption contributes to the total aerosol absorption, and in the light of these results we added in our article the evaluation of the aerosol AAOD and SSA at 350 nm. For doing that, we processed additional reference datasets, namely the OMI-OMAERUVd and MACv2 products. Concerning the AOD at 550 nm, it is tuned in each simulation to be as consistent as possible with the merged AOD product FMI_SAT (see text of the article for details). So its evaluation is of less interest and figures have therefore been placed in Appendix.

- At 550nm, BrC absorption is too small to significantly affect total AOD. In contrast, the uncertainty of other aerosols in the simulation are much larger due to the assumptions such as: no anthropogenic SOA is considered, applying constant scale factors for emissions globally, etc. We agree that conclusions of our analysis could be quite different with different assumptions we could make in our TACTIC aerosol scheme. It would certainly be of great interest to the aerosol community to know about the relative importance of various assumptions. This relative importance is of course model-dependant, and model-objective dependant. So the work is quite immense. We chose here to evaluate addition of the BrC species keeping the rest of the model (which has been evaluated in various contexts, see references in the article) unchanged. As previously mentioned, the AOD at 550 nm is tuned in each simulation to be as consistent as possible with the merged AOD product FMI_SAT. The different corresponding figures have been placed in appendix (Figures A1, A2, A5 and A6) to focus our evaluation on the aerosols SSA and AAOD at 350 and 440 nm (see also above our response to the previous comment).

- Even for AAOD at 440nm, black carbon usually contributes more absorption than BrC. An evaluation of BC AAOD is needed (at least based on previous literature) and its influence on the model-observation comparison should be discussed. In order to provide as much information as possible on this subject, we have added in the introduction several references comparing the absorption of BrC to BC at different wavelengths:

"Different studies highlighted that the BrC absorption is not negligible, and is even comparable to that of BC at short wavelengths (Alexander et al., 2008; Bahadur et al., 2012; Chung et al., 2012; Kirchstetter and Thatcher, 2012; Pokhrel et al., 2017). Using aerosol optical properties derived from Aerosol Robotic Network (AERONET) measurements, Bahadur et al. (2012) estimated that BrC absorption at 440 nm could be about 40% of BC absorption. On the other hand they also showed, at 675 nm, that BrC absorption is less than 10% of BC absorption. Kirchstetter and Thatcher (2012), using residential wood smoke samples, found that BrC absorption contributes 49% of carbonaceous aerosols (BC + OA) absorption at wavelengths below

400 nm. Lastly, based on laboratory measurements using a multi-channel photoacoustic absorption spectrometer, Pokhrel et al. (2017) showed that BrC absorption at shorter visible wavelengths is of equal or greater importance to that of BC, with respectively maximum contributions of up to 92% and 58% of total aerosol absorption at 405 and 532 nm."

To our knowledge, there are no data available to evaluate our BC AAOD only. On the other hand, in the "Model results" section, Figure 7 has been added to provide quantitative information on the BrC absorption compared to that of BC in our model at 350, 440 and 550 nm. We added the following sentence in our article:

"This figure shows an important BrC absorption, comparable to that of BC at short wavelengths, especially during the JAS period. In details, BrC absorption is about 45% of BC absorption at 350 nm and 35% at 440 nm. These results are consistent with the study of Bahadur et al. (2012) that estimates a BrC absorption at 440 nm of about 40% of BC absorption. At 550 nm, Figure 7 shows a lower BrC absorption, which is less than 30% of BC absorption. For comparison with other studies, Samset et al. (2018) show with the LMDZ-INCA model a simulated BrC AAOD at 550 nm of about 20% of that of BC. In this section we will therefore evaluate the aerosol scheme at 350 and 440 nm, which are the wavelengths where BrC contributes the most to the total absorption."

In addition, the authors should be clear about the datasets they used:

- How are the SSA and AOD retrieved in the satellite products? Are the retrievals including any assumptions? Are those assumptions consistent with those in your model? Thank you for these questions. A reference is provided for each satellite product or reference dataset indicating their main characteristics and the method used. In addition, the uncertainties on parameters studied in the article are indicated for each product if available. We also indicate in the article the assumptions we could identify in the documentation of the reference products we used. In our model we can output some diagnostics that really comply to satellite observations. These diagnostics come from the CFMIP (Cloud Feedback Model Intercomparison Project) Observation Simulator Package (COSP), embedded in the CNRM model. However this version of the COSP package does not output model diagnostics for satellite products we are interested in this study (OMI, PARASOL-GRASP). The evaluation we made can thus be improved.

- The OMI observations used here was in fact the OMAERO product, please clarify. On the other hand, OMAERUV may be a better choice for this work. We have clarified the OMI aerosol product used in this study: it is the OMAERUVd satellite product. Its description has therefore been updated and detailed with appropriate references. For clarity reasons we now use the term OMI-OMAERUVd instead of OMI.

- For AERONET, level 2.0 data were used, which only have SSA and AAOD information when AOD>=0.4. Therefore, monthly average values are not able to represent the real monthly condition and tend to overemphasize the high AOD hours. They are not appropriate to be compared with monthly values from the model. In order to compare the AERONET data and our model results, we finally used the AERONET level 1.5 data. Indeed, unlike level 2.0, level 1.5 reports SSA also for AOD 440nm $\leq$ 0.4 so these data appeared to us more appropriate to be compared with our model data. The description of the AERONET data has therefore been changed in the article.

Specific comments:

p.4, line 31: Could you please provide which six bands are used in shortwave? This could be important as BrC absorption is very sensitive to spectral bands. The limits of six spectral bands used in the shortwave radiation scheme are now listed in the article (0.185, 0.25, 0.44, 0.69, 1.19, 2.38 and 4.00 microns).

p.7, line 15: Please provide justification or reference for BrC size distribution. GMD of 100nm looks small for biofuel and biomass burning organics. Thank you for noting that. This was a mistake. 100 nm is the radius and not the diameter. The BrC geometric median diameter has therefore been corrected in the text. We have also added references for the BrC size distribution

(GMD and standard deviation):

"The BrC geometric median diameter is assumed to be of 0.2 µm (Saleh et al., 2015) with a standard deviation of 1.6 (Wang et al., 2018; Tuccella et al., 2020)."

p.7, line 18: Does it mean you assume all the freshly emitted OA from biofuel and biomass burning are hydrophobic? Is there any difference between your hydrophilic and hydrophobic BrC, other than the optical properties? Are treatments in BRC and NOBRC simulations same? The freshly emitted OA (BB+BF+FF sources in NOBRC and FF source in BRC) is treated in the same way in the NOBRC and BRC simulations (50% hydrophobic and 50% hydrophilic with a characteristic time of 1.63 day for the passage hydrophobic-hydrophilic). In the BRC simulation, all the freshly emitted brown carbon (BB+BF sources) is considered hydrophobic (with a characteristic time of 1 day for the passage hydrophobic-hydrophilic). Except for the optical properties and the scavenging there are no differences between our hydrophilic and hydrophobic BrC.

p.7 line 11: I assume you mean “not all of the burning conditions are represented” for “all burning conditions are not represented”. Done.

p.9, line 21: Better use “with or without” for “including or not” Done.

p.9, line 23: What do you mean for “two members”? We meant that the covered period (2000-2014) was simulated twice for each simulation by changing the initial state of the atmosphere. We have rephrased our sentence in the revised version: "All simulations consist in 30-year AMIP-type simulations with prescribed monthly sea surface temperature (SST) and sea ice fraction. The period covered is 2000-2014, it is simulated twice for each simulation (by changing the initial state of the atmosphere), so the total number of simulated years is of 30."

p.13, line 14: Change “Our last comparisons concerns” to “Our last comparison concerns” Done.

p.17, line 17: Change “non only” to “not only”. There are many grammar errors are indicated in the above comments. Please check your writing carefully. Done.