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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Radiative Effect and Climate Impacts of Brown Carbon with the Community Atmosphere Model (CAM5)" *by* Hunter Brown et al.

Anonymous Referee #1

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This paper advances the understanding of the global radiative impacts of light absorbing PM organic species (BrC). It appears to be the first research to included BrC in an earth system model (CESM), which goes beyond previous models that only considered BrC direct radiative forcing effects. This more advanced model considers factors such as surface albedo, clouds and various atmospheric dynamic processes. By including the important process of BrC bleaching, Wang et al 2018 made a substantial improvement over previous models of BrC global impacts that assumed it was largely invariant once emitted. This model also considers bleaching, (although only resulting from particle reaction with OH), and with added secondary BrC effects, is likely the most advanced to date.

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Discussion paper

All these models, including the one described in this paper, are still overly simplistic and so the results highly uncertain. The fundamental problem is that not all the processes that influence BrC are known, and there are really no global scale data sets of BrC which can be used to test the model predictions. As has been done in some prior studies, AERONET data are used in this work, but provide only limited validation (inclusion of BrC shows better agreement with AAEs). Because of the advances in modeling BrC over what has previously been done, this paper is a worthwhile contribution, but the specific results are highly uncertain and speculative.

In addition to (or maybe instead of) using a model to simply assess BrC climate impacts that really can't be verified at this point, additional discussion could be added on what the authors feel could be done to help assess various model performance and move research of BrC radiative impacts forward. For example, are there places where measurements of BrC would be most beneficial? The authors could show more detailed spatial distributions (including vertical profiles) of BrC and BC (maybe include mineral dust too). TOA forcing is highly sensitive to the vertical distribution of light absorbers, and there is evidence that BrC can be enhanced at higher altitudes relative to BC, how confident are the authors of the vertical distribution of BrC in their model, how does the model consider vertical transport of BrC, what is the effect of this uncertainty on radiative forcing. Only spatial distributions of POM are shown, similar results for BrC would be of interest. If BrC vertical structure is also important for stability, cloud formation etc, (affects other than direct radiative forcing), what are the limitations with the model in this respect. Another question that may be of interest is how does the model-predicted lifetime of BrC vary geographically? This was alluded to in the paper, but maybe could be expanded more. In summary, maybe the authors could list what are the major uncertainties in their analysis of BrC radiative impacts and what is needed to address them.

Minor comments.

P2, L12: Feng et al did not consider BrC bleaching, so this is likely a large over esti-

mation, which should be noted.

Don't really understand the layout of the first 3 equations. Eq 1 should be something like RI = . . .

P9 L18, typo BRC_CL ??

Fig 6 and associated discussion and in the sections that follow; by specific about the brown carbon included in the model, ie, was it BRC, CRC_CNST or BRC_BL?

The model considers BrC bleaching just due to OH. Is this the only route for bleaching? Please justify. What are the limitations with this assumption?

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