

Summary

The submission presents COMBUST, a set of gridded fields at 250 m resolution across the continental U.S. describing the combustible fuel mass and related fields accounting for buildings materials, building contents, refineries and gas stations. Previously generated gridded fields from Frantz et al (2023) and the methodology of Frishcosy et al. (2021) were heavily relied upon, specifically using the Frantz et al. grids for the building material component and the Frischosy et al. methodology for the building content component. Various satellite observations and public data bases were used for locations, areal footprints, building height estimates, and use-classification of U.S. residential and building units, as well as to determine required information for refineries and gas stations.

Review

Overall, I find the work comprehensive and of value to the community. I have no issue with the general approach for the calculations. It is also good that the grids include all main contributing terms, in particular including refineries, vehicles and gas stations to expand beyond buildings.

However, the use of Frantz et al. for building materials and Frishcosy et al. for building contents is not explained by the authors to provide the reader any justification or understanding of this. This must be corrected before I would recommend for publication. Other issues besides this should be addressed to make the presentation clearer. Details are provided below.

Main Issue: Building Content versus Materials

The main issue is the splitting building mass between contents and materials. Specifically, the authors use the Frantz et al. grids for building materials and the Frishcosy et al. methodology for contents, and by doing so implicitly claim that these studies provide independent accounting of each term in COMBUST. However, nowhere in the paper is there any explanation of how this is justified. My independent reading of the Frantz and Frishcosy studies for purpose of this review also does not indicate to me that this split exists. A key underlying methodological aspect of COMBUST therefore does not appear valid unless the authors can convince otherwise in a revised submission with detailed explanation.

This is an important issue to resolve since it is commonly not clear from my experience utilizing fuel load estimates in the literature what the underlying mass represents. My experience is that underlying estimates and supporting literature are often referenced but not explained in detail. This leaves a “black box” aspect to these fuel load estimates,

including COMBUST. I am encouraged by authors' effort to decompose the materials from contents in COMBUST, but this needs to be clearly justified.

Here are the key points from my review of these studies that base my assessment:

Frantz et al (2023)

- From "Methods" pages 8 – 9. Note underlined '... and furnishing' which implies contents and materials.

"Mass factors for buildings in units of mass per volume [tm⁻³] for all building types were developed and re-estimated based on information on the materials' composition of specific, typical buildings across the US, including underground components like basements and foundations. We sourced this information from a total of 23 studies conducting life cycle assessments and material flow analysis for buildings, including structural components, underground components, as well as internal walls and furnishing (Supplementary Table 9)."

- Supplementary Discussion 4 "Geographic origin of material factors for buildings" does not make any mention of literature base only being structural material and not content.

Frishcosy et al (2021)

- Abstract (note underlined "total energy release", which implies sum of content and material).

"This paper proposed a novel method to estimate the mass of fuel load from urban area. The model comprehensively studied the parameter, fire load density (FLD), which is used to account for the total energy released by the surveyed building."

- From Section 2.2 (paragraph 1): Underlined text indicates FLD for total, including all components of building mass together.

"To calculate the amount of energy, the present research adopts the parameter, Fire Load Density, commonly referred as FLD. It can reflect the total energy released by the entire compartment, not only the fixed fire load, such as walls, ceilings or floors, but also the moveable contents including furniture, equipment and supplies brought in for the occupant."

- Finally, Appendix B of the COMBUST submission describes the Frischcosy work estimating "combustible mass of the built environment", and later "While this is a valid

approach for the estimation of urban fuels and their distribution at the level". No specific language for these being only materials.

On the other hand, the literature cited by Frantz et al. are largely Life Cycle Analysis studies, which from my understanding tend to isolate structural content mass. Frishcosy cited studies are instead largely of Fuel Load Density from fire safety community, which tend to emphasize materials from my understanding. So perhaps this split is justified. However, the Bush et al study cited by Frishcosy appears to be for total estimates of U.S. cities. Anyway, at this point it is all very confusing and needs to be clarified by the authors.

There is also concern about double counting material mass if Frantz et al represents the total and Frishcosy materials. Then some subtraction from Frantz would be required to not double count the material component. Perhaps extracting Frantz et al for the same Washington DC area as Frishcosy and comparing would provide some insights, which the authors may have done or choose to do and report on?

In any case like I said, this issue absolutely needs to be clarified before publication. I suggest an entire new section of the paper to fully explain this issue and justify this important aspect of COMBUST.

Other Issues

Aside from the main issue, there are other areas where the submission should be improved before recommending publication.

- A black box. Not enough explanation of basic approach, underlying data, and literature basis for building mass densities arrived at by others and the strategy on how these are applied in this study. A key issue pointed out above is how materials and content are distinguished, however even aside from this the lack of any discussion of this topic in the submission leaves the reader (at least me) feeling COMBUST is a black box. Simply citing other studies puts burden on reader to dig this out. And once done, even from these studies, the presentation is a "literature salad" of 20+ cited studies therein, nearly impossible for the reader to gain any coherent understanding without substantial background in the field. I feel an entire section of the COMBUST submission should be dedicated to literature review of studies for building densities cited so reader understands. This is the key part controlling the numerator of fuel load calculations, so is a topic of primary importance.
- The motivations for the study explained in the Introduction are overly broad and lengthy, and it is not clear to me what the authors' specific prime focus motivation

is. Why are certain topics highlighted at expense of others? The authors appear to emphasize time variations of gridded fields obtained from 1975 – 2020, but why this is a particular area of focus is not clear. A better articulation of the authors' specific motivation aside from those that are general would be good for the reader to better understand context. Perhaps a short single paragraph on general motivations, and two more detailed paragraphs on authors' specific motivation will help reader place better context on what will later be presented in the submission.

- The evaluation of COMBUST is deemed “plausible” (lines 341 and 405), however this is not convincing, a weak choice of words. Overall, a better evaluation method for more precisely characterizing the accuracy of the COMBUST, reconciling with other estimates, is needed. This will lead for a more precise, stronger and qualified statement of the accuracy of the results rather than “plausible”.

A sampling of more minor, editorial points is below. Please review the entire document to ensure all things said are clear, consistent and explained in sufficient detail.

- Method of Section 3.6 is not clearly explained.
- Appendix B Equation (3) has $m = 1$ to 7 (building classes) but tables preceding do not list seven. Unclear. Hard to follow.
- Eq (1) does not include vehicles.
- Section 2 Dataset Description: Perhaps this is standard for this journal, but I think this section would be better placed after Methodology once basic methods and terms are defined. As a reader, the section reads like a lot of material none of which can be understood at this point since it is before Methodology. For example, no basis for reader to understand sentence “The suffixes “low”, “mean”, and “high” denote the three scenarios implemented in the MSMC data (Frantz et al. 2023)”. If this section is presented after Methodology or perhaps as the last section it would be better.
- Section 2: What is a “theme” versus “component”? Confused by terminology and organization.