Review comments on gmd-2021-88
Anonymous Referee #2

Referee comment on "An emergency response model for evaluating the formation and dispersion of plumes originating from major fires (BUOYANT v4.20)" by Jaakko Kukkonen et al., Geosci. Model Dev. Discuss., https://doi.org/10.5194/gmd-2021-88-RC2, 2022

General Comment:

The paper presents the development of a source term model that evaluates the fire plume properties just above the flame as an extension to the previously published BUOYANT model for the dispersion of buoyant plumes from wildfires and liquid pool fires under varying atmospheric conditions. The refined BUOYANT model v4.20 is then evaluated against observational data of CO2 concentrations from aircraft measurements during a wildfire experiment from the RxCADRE campaign. The model captured well the vertical profiles of CO2, while the highest concentrations were moderately overpredicted. The authors also state that the widths of the plumes are slightly underestimated, without giving an explanation for this behavior. Further, an operational version of the BUOYANT model, called FLARE, is briefly presented, although it remains somewhat unclear how it is related to the research version of the model. Currently, the evaluation against the experimental data from the wildfire plume is performed with the refined BUOYANT model, but not including the extension with the new source term model. It is a bit unfortunate that the validity of this essential new module has not been demonstrated. My recommendation is to carry out a dedicated sensitivity study of the possible input value ranges in the source term model and after interfacing it with the BUOYANT model, comparing to the experimental data. Nevertheless, I think that the development of a physical model that can deal with the early evolution of the fire plume, the plume rise, and the local atmospheric dispersion is of great value for achieving advances in the prediction of impacts from major natural and man-made fires. Overall, the paper deserves publication after my general comment and the specific comments below are sufficiently addressed.

Specific Comments:

1.) P. 2, lines 48-51: It is mentioned that hundreds of chemical compounds are emitted into the atmosphere during wildland fires. Table C1 also lists a number of different fuels for which the convective heat flux and mass fluxes during a liquid pool fire can be calculated. How much of the combustion chemistry and oxidation is BOUYANT capable of simulating?

2.) I suggest to revise the paragraph on CFD models in the Introduction (P. 3, lines 70-80) to address the treatment of plumes from the two different types of fires: wildfires
and liquid pool fires. Currently, only the dispersion models for treating liquid pool fires are described. Further, the respective description should deal with above-fire (source term), plume rise and large-scale dispersion for the two fire types. At which point, i.e. distance from source and vertical layer, does a large scale atmospheric model take over?

3.) Section 2.2: it is not really clear from the descriptions in this section, how the new source term model for evaluating the properties of the fire plume above the flame tips is interfaced with the plume dispersion in the BUOYANT model.

4.) Section 3.3: as it is now, the evaluation is done for the BOUYANT model without the source term model. This may appear reasonable at first since the fire properties for the selected wildfire case L2F are well characterized by the observations. However, in order to evaluate the source term model presented in this paper, it would make sense to conduct a sensitivity analysis, studying the probable value ranges of selected fire parameters, and comparing the outputs of the BOUYANT model - including the source term sub-model - against the measurements in L2F.

5.) Section 3.3.1: which method was used to evaluate the meteorological parameters on P. 18, lines 458-464, for use in the BOUYANT model?

6.) Section 3.3.2: a table should be provided that contains the required input parameters and the values used in the evaluation both for the BUOYANT model without the source term model (currently listed on P. 19, lines 483-484) and for the BOUYANT model when using the source term model.

7.) P. 23, line 536: the temporal evaluation should also be shown in a plot, for example at 450 m height above ground at the plume centerline.

8.) Section 4: I think the presentation of the operational version of the model should be placed before the evaluation chapter 3 to make it more visible to the readers. The operational version FLARE needs to be better related to the research version of the model. Does it use the new source term module? Information should be added about the stakeholder groups that are targeted as potential users. It would be nice to include a screenshot from a real-world example application.

9.) P.28, lines 689-690: statement “for most of the highest concentrations” seems to contradict with the finding of moderate overprediction of the highest concentrations.

Technical Corrections

Figure 4, middle plot: the green curves from modelling and measurements do not show well.