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Geoscientific Model Development Discussions

Interactive comment on "One-dimensional simulation of fire injection heights in contrasted meteorological scenarios with PRM and Meso-NH models" *by* S. Strada et al.

Anonymous Referee #3

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This paper presents results from two models including an explicit representation of buoyancy-driven plumes applied to three different fire scenarios. One model is used at the kilometric scale while the other is meant to be used coupled with a large-scale model. Such intercomparison is interesting, however the ultimate aim of the paper is not clear, which makes difficult to catch important messages. In addition, similitudes and differences of the two approaches used are not enough identified and discussed, which makes the interpretation of the results sometimes difficult. In particular, the methodology used to force each model needs to be clarified.

I think it is important to explain more clearly that the MESO-NH model simulates the

modification of boundary-layer turbulence and vertical transport in the presence of fires (enhanced surface fluxes) on a domain equivalent to the total burned area, while the PRM model simulates a plume generated above a fire by the latent heat released with the assumption that it does not modify mean atmospheric properties of a domain corresponding to a grid-cell of large-scale models.

The paper is much too long, with repetitions and details given on the models that have been already published and don't need to be given here. As the aim of the paper is not clearly established, pertinent messages are lost in the total amount of descriptions and information given.

What is the aim of this study? We could think that it is to demonstrate that plume-rise models are too uncertain to be trusted, but the authors encourage further developments on them in the conclusion. Is it to identify key processes driving the vertical distribution of fire emissions in the atmosphere and highlight the limitations in their representation in different models? If this is this latter point, then the focus should be put on those processes. Or is it to discuss the different methodologies to be used to represent pyro-convection in a large-scale model (in which fires does not impact their environment) versus a model at the kilometric scale (in which fires do modify their environment)?

Abstract: it is too long: what is the main point of this study and what are the key results and messages?

1.Introduction

The introduction is quite long and addresses a lot of issues: processes, large-scale transport of pollutants, observations of injection heights, link with volcanic plumes, how injection of pollutants are taken into account in CTMs, description of some plume-rise models, etc... Please, clarify your main point and focus the introduction more.

2.Data-sets

Here, discuss each case just once, by discussing together the soundings and ECMWF profiles. Be more concise, and focus on main information we need to know: environmental conditions, characteristics of fires: area burned, heat flux released, observed injection height, any additional fire characteristics that were measured. You don't give any information that will help to discriminate between model performances on the different cases, most importantly you don't say anything about the expected injection heights.

Discuss more the impact of the differences between the soundings and the ECMWF profiles for this study. Soundings are representative of a local profile in the atmosphere while the ECMWF profiles represents means over a larger domain. For example, it could be argued that ECMWF profiles are more relevant for the PRM model which was developed for large-scale models, while the soundings could be more relevant for MESO-NH which uses a kilometric resolution. What is the point of considering two different environmental forcing? To show the sensitivity of the injection heights to environmental conditions or the limitations linked with the forcing dataset?

3.The 1D models

Description of MESO-NH:

The description of how you use MESO-NH is confused and unclear. Why do you use a 1km horizontal resolution and what is the impact of the resolution in such 1D framework? As you say in the conclusion, a 1km resolution is just the worst resolution that can be used to run an EDMF-type model. By the way, does the resolution play a role at all in 1D? (except in your definition of surface fluxes).

Regarding the activated parameterizations, you mention the turbulent scheme of Bougeault and Lacarrère and then the EDKF scheme, but the turbulent scheme is the "ED" part of EDKF. It is not clearly said that those parameterizations are parameterizations developed to represent turbulence and non-local transport in a quite homogeneous convective boundary-layer forced with homogeneous surface fluxes, and

that the EDMF scheme is not initially designed to represent convection associated with fires. This could be the place to discuss a-priori limitations of the EDKF scheme to represent pyro-convection.

It seems a quite awkward to me to specify the same soil conditions in the Mediterranean area and in the Amazon. Does that have any impact on the results?

The equations of the MESO-NH model are not necessary. In addition, you say that dynamical variables (winds) are constrained (end of page 733): is it only w or also u and v? If u and v are prescribed there is no need to mention u and v equations nor to discuss the transport of momentum in the EDKF scheme as done later.

The description of the EDKF scheme could also be shortened given that everything is already published in Pergaud et al. You should insist on what you think is important for your study: w equation, hypothesis about entrainment and detrainment rates, and limitations of the EDKF scheme to simulate fire plumes. You insist on momentum which is no use if winds are prescribed. You insist on mixing rates as the key but another very important feature is the initialization of the mass-flux at the basis of the plume.

I think you have to discuss further the way you are using MESO-NH. Approaches like EDKF are meant to represent the impact of an ensemble of plumes over a domain sufficiently large to contain an enough statistics of such plumes. Using a 1km resolution is not the best suited as it is in the grey zone of boundary-layer thermals as you mention in your conclusions. However, the choice of 1km resolution is crucial here as it will determine the surface fluxes that will drive the EDKF scheme (equation 15). For the exact same case, the more you increase your resolution (Smnh), the more you will dilute the effect of the fire, and the weaker the injection height will be. I think it is a problem to have such a model so dependent on the horizontal resolution used. How did you choose 1km resolution? How sensitive are the results to this choice. I think 1km can be relevant in this case because this is the size of your total fire, so that you somehow represent a single plume and its associated subsidence. But how would you handle to have same results for the same case with coarser resolution? And will the approach still be valid in a 3D framework if you would like to simulate the advection of pollutants with MESO-NH on a large domain?

In MESO-NH you somehow simulate how the presence of a fire will modify turbulence and convection over a domain of 1kmx1km, while in PRM you simulate the injection height corresponding to mean environmental conditions over a large domain, without modification of the environment on the fire. I think those 2 different approaches have to be discussed and explained more. For example, Rio et al. (2010) uses the thermal plume model but in a way more similar to the PRM plume model. The pyro-thermal plume model is meant to be used in a large-scale model with typical resolution of 100km and so does not affect atmospheric conditions but is used to compute properties of a plume generated by the latent heat released locally by fires. In MESO-NH, if you increase your resolution, the effect of fires will be more and more diluted and you will tend to underestimate the associated injection height at some point.

In fact I do not understand what ISBA is used for in MESO-NH as surface fluxes are imposed by equation 15. What does ISBA compute? How is it combine with the surface flux related to fires?

The 1D PRM model:

In the same way as for MESO-NH you do not need to remind all equations of the PRM model (eq 23 to 29), just remind those which are important for your study and which allow you to comment main differences between the EDKF and the PRM approaches and to comment important physical processes.

Regarding the instantaneous burning area used, as far as I understand, you use 3.35ha for MESO-NH while using 100ha for PRM. Given the strong sensitivity of injection height to the burning area considered highlighted in previous studies, this can lead to important discrepancies between the 2 models. Why not using the same instantaneous burning area for the 2 models? How are results sensitive to this?

4.Results and analysis

The section 4.1 is not at the right place. Important quantities related to each scheme should be discussed when you present the models, not when discussing the results. In addition, the EDKF scheme also computes rv in boundary-layer updrafts. Why don't you show it? What you say about the computation of the vertical velocity in MESO-NH is not correct: the vertical velocity is not pronostic, and w varies in the altitude following your equation 8. The mass-flux Mu is computed independently using equation 7 and then the fractional cover is deduced from Mu and wu using equation 9.

Presentation and discussion of the results is too long and not enough focused. You describe figures but what do we learn: is that good or bad that models give different answers in different environments (ECMWF versus RSOU)? This is the purpose of such models to simulate injection heights sensitive to environment properties and the ECMWF and RSOU profiles are quite different, particularly over Amazonia. What seems to be most important to simulate realistic injection heights: heat flux released by fires, burnt area, definition of mixing rates? If this is mixing rates as your results tend to suggest, why don't you perform sensitivity tests to tuning parameters involved in mixing rates definition to quantify the impact? In there a way to reconcile the 2 models by modifying their mixing rates?

Again, what is the point you want to make here? What injection heights would you find with the other existing theoretical approaches to compute them you mention in the introduction? What is the additional value of such more sophisticated approaches used in this paper? Is only the final injection height which matters or also the vertical profile of emissions in the atmosphere? You say that injection heights can be quite different between the two models but is a 1 or 2 km difference really so bad if it allows to inject emissions in a layer between 4 and 6km instead of in the boundary layer?

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