Geoscientific
Model Development
Discussions

Interactive comment on "APIFLAME v1.0: high resolution fire emission model and application to the Euro-Mediterranean region" *by* S. Turquety et al.

Anonymous Referee #2

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This manuscript presents APIFLAME v1.0, a high spatial and temporal resolution biomass burning model. APIFLAME is designed to provide biomass burning emissions for modeling atmospheric chemistry and the impacts of fires on air quality. The paper describes the model and its application to the Euro-Mediterranean region. The emission model results are compared to the emissions predicted by other biomass burning emission models. The study assesses the uncertainty of APIFLAME through an ensemble approach.

Biomass burning is of great significance in atmospheric chemistry, air quality, and climate and the scientific modeling questions addressed in this study are well suited for publication in GMD. The paper presents new tools for modeling emissions and ad-

vances the niche by furthering our understanding of the uncertainties involved with modeling of biomass burning emissions.

While the paper does have some issues with English language usage, overall it is well written. The paper is well structured and all of the tables and figures are relevant. I believe the paper meets requirements for reproducibility; the methods are well described and traceable. The study represents a significant and useful addition to the field and I recommend the paper for publication following minor revisions and consideration of comments provided below.

Comments

Introduction The Introduction very good, it is recent and it covers all significant aspects of biomass burning emission modeling that are pertinent to evaluating the air quality impacts of wildfires. The uncertainties associated with estimating fire emissions, especially with respect to air quality, are identified and described. The background provides information on similar studies that are relevant to the work. The Introduction is well referenced; important references are included and I can think of no necessary references that are missing. The Introduction is well order and flows nicely. There are some, mostly minor, English usage errors that need to be corrected.

P5492, L21-23: The sentence beginning with "However" is awkward and needs to be rewritten. For example: "However, European fires can be an important source of pollutants during the fire season (typically June to October) and may cause extreme pollution events during periods of high fire activity (usually in the summer)."

P5492, L25: change "the most affected countries" to "the countries most affected by fires"

P5493, L14-18: These two sentences are unclear and need to be rewritten.

P5493, L24-25: change "these informations" to "this information"

P5494, L13: change "Intercomparisons exercises have shown large dispersions" to

"Intercomparison exercises have shown large discrepancies"

2. Vegetation susceptible to burning P5496, L2: The text mentions 14 vegetation classes, but Table 1 lists only 13 classes.

P5496, L26: Should "L3" read "2"?

P5497, L5: change "are" to "may"

P5497, L22: change "considered" to "used"

P5498, L4: change "considered" to "used"

P5498, L6-12. Please clarify how biomass is assigned. Is the biomass assigned to a burned pixel based on the average biomass value(s) of the appropriate PFT(s) in the Orchidee 30 km x 30 km grid (or 70 km x 70 km grid for global) that contains the burned pixel?

It would be interesting to mention how the ORCHIDEE Landcover compares with CLC. For example, how does the total percent of forest cover compare over the CLC domain? I realize a comparison is not straight forward and difficult to interpret. However, a simple mention of how does the total percent of forest cover compares over the CLC domain may be of interest to the reader.

P5498, L16-17. Please provide a better description of the biomass components that are subject to burning. Does the "litter" include down dead woody debris? In many forests down dead woody debris can be a very significant portion of total biomass consumed by a wildfire (ref). Or is down dead wood included in the "wood" pool? Please define the "wood" pool. Is the "wood" pool is live wood only or does it include dead wood (standing dead or down dead wood debris)? Does "wood" include all above ground non-foliage of trees (boles and branches)? Does "wood" include woody shrubs?

P5498, L20. Please specify the origin of the seasonal cycle. Presumably this is the ORCHIDEE seasonal cycle of carbon allocation, please clarify.

3. Remote sensing observations of fire activity The authors describe 2 fire detection data types (active fire detections and burn scar detections) but it is unclear how these are combined to provide a map of burned area used in the emission calculations. In particular, are the active fire detections used in mapping the burned area? If so how are they combined with the MCD45 and MCD64? Is the Wiedinmyer et al. MODIS VCF approach applied to the hot spot pixels? How is double counting handled (see Wiedinmyer et al., 2011)? When there are overlapping detections by hot spots & burn scar, which date is used?

3.1 If the confidence levels of the active fire products were used in this study, please note that these are fields provided in the data products.

P5499, L26 – P5500, L2: FRP provides information on the fire "radiant heat energy", insert "radiant" between "fire" and "heat". Also, this sentence is awkward, suggest a rewrite such as: "The FRP provides direct information on the fire radiant heat energy and provides a measure of fire intensity that has been linked to the fire fuel consumption rate"

P5499, L3: remove "precise". MODIS active fire detections can be off by 1 to 2 km.

P5499, L13: change "areas burned" to "burned area"

P5499, L26: change "association" to "associated"

P5500, L7-8: change "Both detections" to "These fire detection products"

P5500, L10: change "induce" to "introduce"

3.3 Clarify which fire products these false detection tests applied to? Hotspots only (MOD14, SEVIRI), burn scars only, or both? The false detection tests seem designed for hot spots. Specify if any if (and if, how) the confidence levels of the remote sensing fire products were used to eliminate detections.

P5501, L14: change "fire is location" to "fire location is"

4. P5503, L12-13: Please specify which pixel? Is this the pixel of the land cover map?

P5503, L14: change "detection" to "missed detections"

P5505, L6: remove "(03:00 LT)"

P5505, L 13: Should this read "Their" results?

P5507, L 10-12: This line should be removed. In the reference to Yokelson et al. (1996) I believe the author is confusing combustion completeness / burning efficiency (the fraction of biomass consumed) with combustion efficiency (CE, the fraction of combusted carbon that is released as CO2). CE is related to the relative mix of flaming and smoldering combustion. CE approaches 1 for pure flaming combustion. Fire behavior and fuel characteristics are important factors behind the relative mix of flaming and smoldering combustion, and hence CE. However, the fraction of fuel consumed (combustion completeness / burning efficiency) does not directly relate to the relative mix of flaming and smoldering combustion. For example, organic soils can burn completely, right down to the mineral soil, but do so by mostly smoldering combustion and with very low CE (e.g. Geron and Hays, Atmos. Environ., 64, 192-199, 2013). Similar behavior, high combustion completeness by mostly smoldering combustion occurs for large woody fuels (e.g. rotten logs).

P 5507, L 24: change "of" to "on"

P 5507, L 25: delete "an"

5.1 Fuel Load The authors define fuel load (F) as the as the amount (kg dry mass per m2) of vegetation that is consumed by fire for a given vegetation class. F is the product of biomass density (B) and burning efficiency (β), both of which vary by carbon pool. The biomass density also depends on vegetation class. Are the values in Table 3 the burning efficiency (β) that is applied in Eq. 2? Or are these "available biomass" that are then multiplied by the burning efficiency alluded to at P5508, L1? In which case, the variable β in Eq. 2 is the product of value form Table 3 and some other "burning

efficiency" number from Hoelzmann et al. (2004). This must be clarified.

Table 4 & 5. Are these available biomass or biomass consumed? They should be biomass consumed as this is more useful. Regardless, please clarify in Tables. I assume the fuel loads in Table 4 and Table 5 are the load of fuel consumed (F in Eq. 2). But at

P5508, L14-15 the authors refer to "available biomass" in Hoelzemann et al. (2004). The authors need to clarify if this is the biomass consumed or the biomass available for combustion. The term "fuel load" is often used to describe the amount of biomass available for combustion, while "fuel consumption" is usually used to describe the amount of fuel consumed by fire (fuel consumption = fuel load x combustion completeness). The authors use "fuel load" as the amount of fuel consumed which is confusing. Please consider using "fuel consumed" or "fuel load consumed" to refer to the amount of vegetation consumed by fire.

5.2 Emission Factors. The Akagi et al. (2011) review is an appropriate source for EF. The authors note that an emission study of wildfires in forest of Portugal (Alves et al., 2011) reported significantly higher EF for smoldering compounds compared to the recommendations of Akagi et al. (2011). I note here for the authors that the extra-tropical forest EF in Akagi et al. are weighted heavily by prescribed fires in the southeastern US, fires which tend consume only small amounts of smoldering prone fuels (down dead wood and duff/organic soil) . In fact the Alves et al. (2011) findings are consistent with a recent emission study of wildfires in the US which found higher EF for smoldering compounds (CO, CH4) (Urbanski, 2013).

P5510, L25: FINN supplements Hoelzemann for some regions. (See Table 2, Wiedinmyer et al., 2011), however for the region examined in this study FINN does use Hoelzemann.

P5511, L1: suggest changing "real fire impact" to "impact of observed fires"

P5511, L8: change first "emissions" to "area burned"

P5511, L11: as "as" before "discussed"

P5512, L12: insert "monthly" before "emissions"

P5512, L13: change "averaged" to "average"

P5512, L15-17: For the statement "If only summer-time emissions are compared (largest values), the emissions based on either one of the vegetation databases are 2.5 larger than both GFEDv3 and GFASv1." please specify if this is compared to CLC or MOD12 based emissions.

P5512, 17-18: The sentence beginning "This indicates…" needs be rewritten. Do the authors intend to state that: "outside the wildfire season, during periods of low fire activity, the GFASv1 emission values are significantly higher than the other estimates"; or that: "the difference between summer and non-emissions is significantly smaller for GFASv1 compared to GFED and APIFLAME v1.0"?

I zoomed in on Fig. 7 Euro-Med panel but could not really tell is GFASv1 is larger than GFED and APIFLAME. Either seems likely. One would expect an FRP based method to overestimate fuel consumption (and hence emissions) for agricultural burning (which dominates the spring & fall fire in the region), since these fires burn mostly by flaming combustion while forest fires will have significant fuel consumption from smoldering combustion and FRP is poor for estimating fuel consumption by smoldering. Also, forest fires will often have peak intensity in the late afternoon after the second daytime MODIS overpass.

P5512, L23-25: Suggest restructuring the sentence "Largest differences are obtained in the Eastern regions (Eastern Europe, Ukraine,Western Russia and Turkey), especially when the MODIS vegetation classification is used, where the APIFLAME emissions are significantly higher" as "Largest differences are obtained in the Eastern regions (Eastern Europe, Ukraine,Western Russia and Turkey) where the APIFLAME

emissions are significantly higher, especially when the MODIS vegetation classification is used."

P5512, L23-28: The authors should elaborate on the difference in fuel loading between GFED, and LCL, MOD12. For example, is it related to differences in the area mapped as agriculture vs. forest?

P5513, L4-6: This sentence is awkward and unclear. I suggest the following rewrite: "Partitioning of area burned and CO and NOx emissions in the different vegetation classes, on average over the 2003-2012 time period is shown in Table 8."

P5514, L11: Replace "on the case of" with "for"

P5514, L14: insert "was" between "pollution" and "transported"

P5514, L15: Rewrite sentence that begins "A total…" as "The APIFLAME area burned for Greece during the summer of 2007 was 3290 km2, in good agreement (only 5% higher) with the value reported by EFFIS."

P5514, L21: delete "of the domain"

P5515, L5: change "emissions are" to "the fire activity is"

P5515, L16 -17: The statement "A good agreement is obtained with the peak GFAS values for the strong Greek fires" does not seem accurate and is best removed. GFAS emissions do seem to match APIFLAME in the initial increase (around day 85) up to the peak, although from the plot I cannot tell if the magnitude of the GFAS peak is in agreement. Regardless, for the ï¿5 days following the peak GFAS emissions are significantly lower than APIFLAME. I highly recommend this sentence be removed.

P5515, L17-18: Insert "for the difference in emissions" between "reasons" and "may".

P5515, L25-27: Replace ",more specifically for the Greek fires' plume" with "of plumes from fires in Greece"

P5516, L2: change "observations" to "findings of Hodnebrog et al. (2012)"

7.2 Ensemble approach P5516. L4: change "the emissions" to "emissions estimates"

P5516, L26 – 27: The sentence beginning "In Fig. 10…" is unclear and needs to be rewritten. I suggest something like: "In Fig. 10, the emission profiles for the reference configuration and the reference configuration with different vegetation maps are shown along with the GFED carbon emissions for comparison."

P5517, L8: change "reaches" to "is"

P5517, L9: Does "the regions considered here" refer to the 6 regions shown ion Fig. 10 or all 9 regions considered in the study? Pleas clarify.

P5517, L23: insert "average" between "larger"

P5518, L3-5: The sentence "This is very probably underestimated since only one model is used here for biomass density, although in different configurations" is unclear. I suggest a rewrite, for example: "This analysis very likely underestimates the uncertainty associated with fuel loading since only one model (although in different configurations) is used here for biomass density."

P5518, L8-12: This sentence is unclear and needs to be rewritten, probably as two sentences. Specify that this statement refers to GFED and note the region. Is it global? Why the reference to North America and burned area? For example, possible rewrite beginning something like: "Using a Monte Carlo approach, van der Werf et al. (2010) estimated the average uncertainty in annual, global GEFD carbon emissions…"

P5518, L 15-16: For biomass burning emission models the uncertainties themselves are fairly uncertain. This sentence should be rewritten to acknowledge this fact, for example: "Secondly, the uncertainties van der Werf et al. (2011) attributed to each of the GFED emission model parameters were lower than those assumed in our study."

P5518, L25: insert change "the" to "our"

C2207

P5518, L 22: "kilometric" is unclear. Do you mean scales of ïA¿ 1 km or 10 km or 100 km? Please specify.

P5519, L1-2: Wiedinmyer et al. (2011) did not conduct a formal uncertainty evaluation. They simply surmised that a factor of 2 was a reasonable uncertainty for FINN emissions. This sentence should be rewritten to clarify that the Wiedinmyer et al. uncertainty estimate was a qualitative guess and not the result of a rigorous analysis such as that presented in the authors' work or that conducted by van der Werf et al. or Urbanski et al. Also, specify that Wiedinmyer et al is for FiNN.

P5520, L4: Remove "additional"

P5520, L8: change "required" to "emitted"

P5520, L14: insert "are" between "but" and "significantly"

P5520, L16-18: The authors should note the contribution of agricultural burning to burned area in Eastern Europe, Ukraine, and western Russia.

P5520, L 23: Does "A large fraction of the fires" refer to burned area or actual number of fires? Please clarify. For example, "A large fraction of the fires detected occur in…"

P5520, L27: change "available" to "consumed" or include "combustion completeness", e.g. "They are derived by multiplying the area burned by the amount of fuel available, combustion completeness, and the emission factors of each included species."

P5520, L28 – P5521, L1: Rewrite as: "Since fuel load and emission factors both depend on the type of vegetation burnt, a precise knowledge of this parameter is essential for obtaining accurate emission estimates."

P5520, L3: Use of "privileged" does not make sense. Do you mean "preferred", "recommended", or "default"?

P5521, L6-7: Rewrite as: "The fuel load is derived from simulations by the ORCHIDEE model and depends on the vegetation burned and the location"

C2208

P5522, L4: change "precise" to "detailed"

P5522, L4: insert "which was" before "characterized"

P5522, L11: change "on" to "in"

P5522, L12: Change "database" to "map". The authors need to differentiate between the mapping of vegetation / land cover and the attribution of fuel loading based on the class assignment of the map. The authors found large uncertainty related to the mapped vegetation, but because they used essentially the same biomass model, they didn't evaluate the impact of fuel loading. Urbanski et al. did considered different fuel loading databases but didn't examine the influence of the vegetation mapping independently. van der Werf included an uncertainty estimate for fuel loading, but did not consider uncertainty associated with mapping.

P5522, L22: change "fires" to "fire"

Table & Figures

Table 8. Include "NOx" in caption

Table 9. The table caption refers to correlation in parenthesis, but they are not present in the table.

Figure 8. The caption should specify the start and end dates (day 1 = June 1 and day 120= -= August 31)?

Figure 10. The authors should replace one of the panels with a panel showing results for entire Euro-Med region.

Figure 11. Specify in the caption that the numbers in the legend are the average of standard deviation / mean for each ensemble set.

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C2209