Ms. Ref. No.: AGRFORMET-D-23-01404  
Title: Fuel constraints not fire weather conditions limit fire behavior in reburned boreal forests  
Agricultural and Forest Meteorology  
  
Dear Dr Katherine Hayes,  
  
I have now received both reviews of the above manuscript.  
  
The manuscript will need some minor revision before it can be accepted for publication. Please take the reviewers' comments into consideration when you prepare your revised manuscript.  
  
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Reviewers' comments:  
  
  
Note from handling editor: Dear authors, We have received comments back from both reviewers and both suggest minor revisions. I agree and request you to revise the manuscript according to these suggestions. However, regarding the suggestion of reviewer 1 on 10-100 times simulation, I understamd WFDS cananot be used in ensemble runs and computationally expensive as it is for single runs. However, convergence of the simulations is still an important issue, so please consider adding a section showing the results are reproducible, if possible by adding and averaging one or two more simulations.  
  
  
Reviewer #1: The paper 'Fuel constraints not fire weather conditions limit fire behavior in reburned boreal forests' by Hayes et al. touches upon an interesting question.  
Deciduous forests are indeed thought to constrain fire spread in Alaskan boreal forest, yet we don't know have these limitations will be altered by changing fuels and fire weather.  
The paper is well written and generally easy follow.  
Here are a few comments which I hope that the authors will consider in improving their manuscript:  
- Need to account for smoldering fires: the paper is very much focused on aboveground fuels. This is understandable as aboveground fuels sustain fire spread. Yet, smoldering combustion is an imnportant characteristic of boreal fires, and I feel that the authors should provide this context in their manuscript.  
- Limited number of simulations: the current paper's conclusion is drawn from very few simulations. I would invite the authors to generate 10 to 100 times more simulations with randomly drawn fuels. This would lead to a more robust analysis.  
- What about twice burned forests: the paper focuses on differences in fire behavior in forests that burned once or thrice. What about forests that burned twice? Can this be more explicitly included in the paper?  
- Some more comments in attachment.  
  
  
Reviewer #2: The paper presented provides an interesting simulation modeling experiment parameterized using field data representing fuel load and structure in Alaskan forests, transferred to the fire-physics model WFDS. The manuscript is well written and presents interesting results that are relevant to important and ongoing conversations in fire management and science. I have a few relatively minor questions and suggestions related mainly to making sure that the methods are clear to the reader, and that the simulation scenarios can be completely understood.  
First, it is a bit distracting that the number of repeated burns being examined changes so often throughout. For example, In Figure 3 we see data from 0, 1, 2, and 3 times burned sites. Tables 1 & 2 are limited to 1 and 3 times burned, and then Figure 5 shows data for 1, 2, and 3 times burned, but not 0. Similarly, it is not reported why only the once-burned and thrice-burned landscapes were selected for modeling, over the twice-burned landscape (or the inclusion of a mature forest control simulation). Presumably this is simply due to limitations related to computation time, but it would be nice to report that and justify to the reader why this choice was made. As it is, it seems a bit confusing or unnecessary to report the fuel conditions in twice-burned landscapes in multiple places (e.g., Figures 3 and 5), but then not discuss them very much or use them in model parameterization. The fuel conditions in twice-burned sites are also different from the once- and twice-burned landscapes in both cases, which might suggest it would have a different fire behavior than was observed in either of these scenarios, so the reader is left wondering why it was excluded. At a minimum, I think a statement justifying and explaining the selection of these two scenarios is needed.  
Additionally, the model outputs could be better understood with more detail reported about the parameterization. Specifically, the model run time or stopping point (if a built-in triggered model stop by fire cessation) needs to be reported. I also wondered why the authors limited surface fuel moisture (10%) to be the same in both the moderate and extreme weather scenarios. It seems reasonable to expect that dead fuel moisture would also vary to some extent alongside live fuel moisture. Historical datasets report litter moisture contents ranging from 1 to 1000% (e.g., Wotton and Beverley, 2007), so 10% is quite low, which makes sense for these scenarios, but there is also substantial variability in that range. Given the importance of the litter cover in the thrice-burned landscape (60%) holding this measure stable between all 8 scenarios this is presumably quite important the outcomes of fire spread observed.  
Finally, although the modeled fires appear to have halted, it may be worth adding some more discussion of the simulated fire behavior where they did spread, in terms of things such as spread rates and suppression capability. The authors emphasize that the fires ceased within a short distance of the transition zone, which is very important, but nonetheless, the observed behavior in the areas that did burn (including in the example that burned continuously throughout the domain) is actually quite extreme if the modeled rate of spread (ROS) is accurate. Beginning with an ROS between 1.5 - 2 m/s and dropping to a sustained/equilibrium ROS of 1.1 m/s (66 m/min) indicates a fire that is capable of spread over 1 km within the next 30 minutes, and is burning at an intensity (kW/m) that is largely too great for any direct attack if attempting fire suppression. Those are some scary rates of spread, if you are a fire manager, particularly if you're relying on old burns as firebreaks around communities. How realistic are they? How often are these weather conditions likely to occur in a year?  
  
Line 5: Abstract - Drier vs. Dryer  
Lines 64 - 65: Perhaps missing a description of the rest of the gradient. Seems somewhat odd to mention all, but only describe 3-fire landscape conditions in detail.  
Line 134: How many 1x1 plots?  
Line 134: How many 200 m^2 tree plots?  
Line 143: First mention of sampling cubes. Elaborate on what they are used for and how they were distributed.  
Line 174: Does surface fuel moisture not vary with daily weather (10% in both scenarios)? Given the importance of surface fuels, particularly in the thrice-burned landscape I wonder if this affected the results. I recognize that 10% is definitely on the low end for surface moisture content, so it is probably a good representation of a pretty extreme moisture, or at least a moderate one, I just wondered why this was the only variable held constant between the two weather scenarios.  
Line 178: How do these conditions (97 & 109% vs. 77 and 89%) compare to the NFMD data? Are they also 90th percentile conditions? How were moderate vs. extreme weather thresholds selected and how do the compare to typical fuel moisture?  
Lines 180-181: Why not unburned, and twice burned landscapes? Seems odd to bother reporting their fuel loads (and doing fuel sampling in them) if not going to model, although I do understand the unburned fuel measures were used in the runup zone. Perhaps at least an explanation of why this choice (1- and 3-x burned only) is needed?  
Lines 191 - 199: Please report the simulation duration/run time. It is implied that the fires extinguished but without knowing the simulation duration it's possible to misinterpret that the simulation simply stopped. How was the model run stopped? Did the fires need to fully stop spreading? Could they have sustained a slow creep to the far end of the simulation domain if given more time?  
Figure 2. What do the colors mean?  
Line 220. Typo in what is meant to be 'downed', I believe.  
Figure 5. Could be interesting to include 'unburned' or mature forest/reference plots here.  
Figure 7. The labels (a & b) are not actually on the panels.  
Line 274/ Figure 9: These are very, very fast rates of spread! Even the scenarios that stopped spreading, the lowest ROS is about 45 m/minute. Assuming equilibrium spread, that indicates an expected run of over a km within the next 30 minutes of spread. Depending on the fuel, that is presumably between an intensity class 4 or 5 fire, so something like 4000 - 10,000 kW/m, making direct attack impossible and having flame lengths 3 - > 6 m. It's a bit surprising that they extinguished, but not impossible given adequate gaps in the fuel.  
Figure 11. Difficult to see the size of the points, due to overplotting. Perhaps they should be transparent?  
Line 283: The plots included don't consider canopy fuel loads except in the scenarios selected for simulation, and therefore the mature forest is at a serious disadvantage in reporting this lower fuel load. Although the statement is presumably being limited to 'reburned' forests, Figure 3 is also titled 'reburn history' and includes the 0-burned sites (which do follow the trend reported, I realize). Maybe some rephrasing for clarity (limit to fine and large downed fuel?), or could report the total fuel load at the unburned/0-burned sites. These values were presumably calculated, in order to parameterize the runup zone, but are not reported in Table 1 or 2.  
  
Terminology throughout: I think quartile is generally only used for quarters (e.g., 25% of the data falls in the first quartile, 50% below the second etc.). Perhaps the term should be quantile or percentile, when not referring to these values.  
It is a bit inconsistent in the manuscript between whether the most severe weather scenario is referred to as "high weather" (figures) vs. "extreme weather" (text). Although the high scenario is often defined as "extreme" in the figure captions, it might make sense to just use a consistent term throughout, but this is optional change based on author preference.  
  
  
  
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