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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "A classification scheme to determine wildfires from the satellite record in the cool grasslands of southern Canada: considerations for fire occurrence modelling and warning criteria" *by* Dan K. Thompson and Kimberly Morrison

Anonymous Referee #1

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General comments

The authors present an interesting study that has practical implications for wildfire management in Canada and potentially beyond. The authors explore the discrimination of grassland wildfires from agricultural/managed) fires in South Central Canada. Using terrestrial datasets and high-resolution Landsat 8 data, the authors carefully construct and classify a dataset of MODIS fire clusters and explore the relationships between

these two classes of fire and various environmental/meteorological variables using GAMs and regression tree (RT) models. The work results in a series of parameter thresholds and value ranges that appear to be useful for pinpointing periods when wildfires are most likely, and could likely be used to enhance operational wildfire management in future.

This manuscript certainly merits publication in NHESS, however there are several areas where it could be improved prior to publication:

1) The narrative and structure could be improved throughout (see specific comments)

2) The methods need expanding, particularly with respect to the predictors chosen for inclusion in the models (some of this may be suited for inclusion in the supplementary materials).

3) Some of the results/discussion points could be elaborated on further, and the importance of this work better highlighted.

Specific comments

Abstract I would specifically refer to MODIS in the abstract, so it is immediately clear to readers what your primary RS dataset is.

1 Introduction

[39] For clarity I would amend to something like ". . .control) is somewhat limited, and can erroneously count responsible fire use. . ."

[44] also add precipitation here?

[65-70] It would be good to elaborate on the goals slightly here. From reviewing this paper, my understanding is that you are particularly trying to use the GAM for goal 1, and then goal 2 is informed by both models, so I would state this more explicitly. Also, related to this, I would probably address here (or perhaps in Section 2 somewhere, under the current structure possibly in 2.4) why you are building 2 different models e.g.

you use the tree approach primarily for explanation, and the GAM for both prediction & explanation? I don't think you clearly state anywhere your motivation for using 2 different approaches.

[66] I would say "documented grassland wildfires" here just to make the focus completely clear.

2 Materials & Methods General comment on methods: A lot of my questions / comments on Section 2 relate to dataset attributes that are either not provided or found in different subsections of the text. You use a lot of different datasets from different sources in this study, so a concise 'datasets' or 'materials' subsection that provides a list of each of these with useful basic information (data source, spatio/temporal coverage, resolution etc, as relevant) at the beginning of Section 2 would be useful – then readers can find all this information in one place without having to move backwards and forwards through different sub-sections.

2.1 Study Area

Figures 1 & 2: These figures are very nicely presented, however it is not immediately obvious which areas are the study area. At first, I thought it was all of the area for which landcover data are provided, i.e. including the forested regions. From looking at later figures, I think the Ecumene delineates the study area? I would suggest you consider changing the name of this to 'study area' for clarity, and change the colour of the boundary to something more obvious that the current grey, then maybe emphasise exactly where the study area is in the Figure 1 caption. Also, consider adding some of the info from the main body on the LC dataset to Figure 1 caption, and adding lines and/or ticks indicating lat/lon to these maps, as you refer to lat/lon locations in text - a reader not familiar with the region will have no context for this.

In figure 2 – What data is shown in this plot exactly? The full MODIS fire record (i.e. contains fires in non-grassland as well as grassland fires) or just data after the filtering step described on line 138? The label 'Grass hotspot clusters' – makes me think the

latter? As with Fig 1, I would expand this caption to include this kind of detail for clarity, also probably adding: whether this map is post-persistent hotspot filtering; the specific MODIS product it was derived from; the associated MODIS dataset citation.

2.2 Fire occurrence records

[93] I would consider stating the number of fires recorded over the study period from the CNFDB and evacuation dataset somewhere in this paragraph.

[94] I find the logic a bit confusing in the sentence on lines 94-96 (starting 'in the agricultural zone. . .') – perhaps reword it? You say that large fires are included in the CNFDB, but also that the CNFDB is 'only a partial sample' of fires in the region – so maybe you should be highlighting the fires that are not captured in this region by the CNFDB, rather than those which are?

[106] what is the source of the FWI data? Presumably the official CFFDRS datasets, but worth clarifying here.

[101-110] I think you should probably state the number of total MODIS fire detections and introduce the clustering concept here with detail on the number of fire 'clusters' resulting from the clustering process described in the supplement.

2.3 Satellite grass curing

[125] I'm confused as to how exactly this metric works. Eq 1 is the widely used min/max scaling (aka normalisation) applied to the NDVI climatology, so high values should imply high 'greenness' i.e. low curing? As such it is confusing to refer to this metric as 'percent curing' (also indicated in your GAM figure panel (b) x-axis as 'per-pixel relative cured grass fraction (%)'). Inverting this relationship (or renaming it) might be more intuitive? Moreover, from reading line [188] in the results you say "high percent curing (i.e. low NDVI. . ." which seems to be the opposite of Eq. (1), so there seems to be some confusion regarding how this metric is calculated somewhere? Did you actually invert this metric but omit this detail from this section?

I would also add the comment you make in the Landsat figure (the first Figure 3) caption to the main text somewhere here – that extremely high curing values can (somewhat counterintuitively) reflect prior agricultural burning/ploughing activity rather than dry veg – as this an important observation.

[138] I do not think the paragraph starting 'All hotspot clusters...' belongs in Section 2.3 as it stands. You don't really mention 'fire clusters' until Section 2.4, so it should go after this point. However, if you altered the MODIS paragraph [lines 100-110] in Section 2.2 by briefly describing the clustering process (that you describe in detail in the supp. materials), then this 'All hotspot clusters...' paragraph could follow fit in 2.2. Furthermore, it is probably worth explicitly stating how variables were aggregated by clusters, rather than your current explanation in the supplement "An attribute was merged by max value, min value or mean, for each hotspot cluster, whichever was most appropriate" [line 39], as this not very detailed.

2.4 Classification of thermal detections

[145] more background information regarding (1) the model predictors and (2) model construction process is definitely required in Section 2 (some of which could go in the appendices, if necessary). For clarity purposes, I think you definitely need to explicitly state and describe all the predictors that were added to the two models, along with their source (information could be in table form, and possibly a 'datasets' subsection as mentioned earlier), and where relevant, why those specific predictors were chosen over others. For example, FFMC, FWI, ISI often convey similar information -why was FFMC and not FWI or ISI chosen as predictors in the GAM, but ISI is used in the RT?

From reading the results section, I see that 'hour of detection' is derived from the MODIS dataset, however conceivably this could be information contained in the NFDB, and this sort of thing should be obvious from the methods.

I would indicate any standardisation / scaling of variables used in models here – e.g. DMC and DC were presumably scaled, as indicated in Fig 5(d) and detailed in section

3.

Did you test for and exclude any variables from the models based on collinearity using e.g. a simple correlation threshold? I assume you made some such decision here, as for example, you have omitted ISI & FWI as GLM predictors, and they are typically strongly correlated with e.g. FFMC. Similarly, I suspect RH and FFMC could be highly (negatively) correlated. Please explain how you addressed this. [149] what is your reasoning for not including interaction terms? Is this something that was initially explored and found to be unimportant, or were they not considered for simplicity reasons? I would be surprised if there were no relevant interactions between at least some of the predictors you have chosen to use.

[150] re: the argument for excluding curing from the RF model – does this logic not also extend to the GAM?

3 Results

[160-170] if you add a description of the predictor variables/datasets in Section 2, you can omit the 'background' info you include here: defining the DMC, explaining derivation of the FFMC, explaining the fact that FWI vars are observed at noon etc. These type of descriptions probably shouldn't appear in a results section.

[176] I would expand slightly here by highlighting what the significant splines show (I don't think you actually do this anywhere in the main body, but you do refer to the DoY criterion in the abstract?) e.g. wildfires are highly likely when: values of DoY $< \sim 130$, WS > 30, curing 65-85%.

Figure 5: You should explain panels (a)-(c) in the caption – at the minute you only mention panel (d). e.g. what are the blue lines (confidence intervals?) and black 'dashes' next to the axes (some kind of rug plot/distribution?).

Panel (d) of Figure 5 is a table, and so should be presented as such in the main body rather than as a panel of this figure. From Section 2.4 you suggest hour of detection

was incorporated as a spline not a linear predictor, but in (d) it is a linear predictor – which is correct?

Is there a reason why you didn't also include a plot of probability vs. FFMC in Figure 5 (as well as hour of day, if it was included as a spline?)

As mentioned earlier, DMC and DC are scaled before being used in the model, so this should be stated in the methods. Why does RH have an asterisk next to it? I would not use this symbol here as you already use asterisks to signify significance in the same table, which is confusing.

[184-201] decision tree results: This section is currently a bit confusing - I suggest it is restructured slightly, and some clarifications added. Firstly, how many fire clusters in total did you analyse here? I was expecting n=143 (113 wildfires + 41 agricultural fires stated on line 143, minus the 11 DC < 100 fires mentioned later) but adding up the denominators in Figure 6 it appears that n=95. Assuming I am reading Figure 6 correctly, shouldn't these two numbers match? After introducing the regression tree in Figure 6, It might be worth immediately stating the number of fires analysed, and that you removed the 11 low DC wildfires (plus any other filtering you did?) before discussing the specific results shown by the regression tree, so readers don't spend time looking for the 'missing' fires in figure 6.

[185] where is the 92 % accuracy figure from? Should this say 97 %? 92 % is not in Figure 6 or Table 1.

[186] Not sure why you talk about FFMC here – was FFMC actually used in the regression tree model? It doesn't appear in Figure 6.

[191] similarly, where does the 82 % value come from? not in Figure 6 or Table 1.

[192] I'm not sure about introducing Appendix A here, or actually including it in the paper at all (1) you don't really highlight what it adds to the study and (2) it uses the large fire dataset (>3000 fires) that you haven't really introduced yet.

[193-195] I would move the sentences comparing the GAM to the tree model, because you go from talking about just the tree model on line 192-3, to comparing the two models (193-195], and then back to discussing just the tree model [195-201], which is structurally hard to follow.

[203-215] this is interesting. Did you try including FRP & wind speed in the tree model? Seems like doing so could have added to tree classification skill?

[217-220] this paragraph (GAM applied to all clusters) feels like it might work better following the other paragraph on the GAM [lines 175-183]

[218] should this point to what is labelled as Figure 7 (the one with with two panel plots) rather than Figure 8?

Figures 7, 8 and 9: These are interesting figures, but you do not have much on them in either the results or discussion section (and in the case of figure 8, the 'avg. no. days per year figure', I don't think you mention this figure at all!). Some explanation is definitely required, otherwise why are they here?

4 Discussion

General comment on discussion:

Overall, you make some interesting points here, but several of them feel like they need expanding upon. I feel like you also don't draw much from the 'final' outputs of the study (Figures 7-9) – surely these results warrant discussion? Also, this paper clearly has important implications for operational fire management in grassland/agricultural complexes of Canada (and possibly beyond) – while you do mention this, I think you should try to highlight this aspect further in the discussion.

[222] this paragraph might go better in the introduction/datasets sections of the paper, as it is effectively a justification of why you chose to examine MODIS rather than other options

[232] “> 7500 fires” this statistic is from which dataset?

[244-252] I’m not sure what the key point you are trying to highlight here is, so this probably needs clarifying. I think your main point is that FFMC is a reasonable proxy for grassland moisture content/fire occurrence in the study area? If this is the case, it is interesting to me that (1) FFMC is not significant in the GAM and (2) FFMC is not included in the decision tree model (Fig 6), and this observation might merit further discussion here.

[261-266] Interesting observation, and this makes intuitive sense because managed fires that escape and become wildfires are probably usually the ones that reach the suppression limit. You should probably expand on this slightly though: (1) you could justifiably highlight that this adds to the validity of your work, as you have derived thresholds from a ‘top down’ RS/modelling approach that agree well with physical, bottom up observations of fire behaviour. (2) maybe you draw this out further? e.g. what might this finding have any applied fire management implications?

[268-276] You highlight an important point - that grasslands are increasing, and likely to keep doing so under climate change and current agricultural conversion trends. But you do not then use these points to highlight the importance of the work you have done here, and that it will be increasingly important in future – I think you should definitely emphasise this!

5 Conclusion

[283] maybe rephrase to say “a noon ISI threshold of > 15 was the most powerful threshold for discriminating wildfires from agricultural fires, while grass curing. . .”

Supplementary materials

[8] do you mean UTC rather than UTM date and time?

[39] How were each variable aggregated by fire cluster? E.g. FRP average vs max might be important to know. . .

[40] the 5% buffer you describe here, is this the same buffer you indicate in eq S2, or is this an additional buffer?

[117-122] this paragraph contains useful detail justification on the number of clusters you used. I would integrate at least some of this information into the main body, as it is important.

Technical corrections

Figures: Figure numbers are often incorrect in captions, and in places throughout the text. Please review and amend. Also consider generally expanding figure captions to include more information on the features of the figures or datasets used etc (see specific comments on figures where I believe these could be improved).

[60] consider deleting “. . ..despite higher spread rates. . .”. Probably adds to an unnecessarily long sentence

[87] “..northern fringe of agriculture..” - not sure if this applies to both areas (i.e. the ‘main’ southern Prairie area and the distinct northern agri-forest area?) or just the main southern one, please clarify

[96] “agencies” should have an apostrophe?

[Figure 4] is labelled as figure 2. You refer to panel letters (a, b etc) in the text but they are missing from the figure. I think this shows results for fire clusters, not MODIS pixel detections – make this clear in the caption and text. Also, the ‘Day of year’ panel only extends slightly beyond DoY 300 – is this intentional? (maybe there is never fire after this date?)

[150] is ‘Additionally’ a better word choice here than ‘Alternately’ as you build both models?

[155] I think you are referring to fire clusters here – if so, I would make this obvious by saying ‘distribution of agricultural vs. wildfire clusters’

[173] I would state the median no. of pixels for agricultural fires here for comparison to the median wildfire pixels

[178] should this say “increased rate of wildfire likelihood per integer increase in predictor value”?

[257] I’m not very familiar with the use of odds ratios, so ignore this comment if it has a different technical interpretation - but might this be better phrased as “..results in the increase in the odds of a wildfire over an agricultural fire by 2.45. . .”?

[273] I think you want ‘exacerbated’ rather than ‘exasperated’ here?

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