Nat. Hazards Earth Syst. Sci. Discuss., 2, C3132–C3141, 2015
www.nat-hazards-earth-syst-sci-discuss.net/2/C3132/2015/

Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Linking local wildfire dynamics to pyroCb development" *by* R. H. D. McRae et al.

R. H. D. McRae et al.

rick.mcrae@act.gov.au

Received and published: 20 January 2015

B. Potter (Referee) bpotter@fs.fed.us

Received and published: 6 January 2015

REPLY

General comments:

Brian Potter (BP): This paper proposes to demonstrate that severe pyroconvection

(specifically pyroCb development) is directly associated with "extreme local fire dynamics" and specifically in the cases examined, fire channeling. (Note, MS Word autocorrects channeling to one "l," yet the authors consistently use two.) I believe they make their case compellingly, demonstrating the spatial and temporal alignment of the fire dynamics and subsequent pyroCb. In fact, I believe the case is stronger than they acknowledge and could be stated more strongly. At the same time, there are a couple of portions of the paper that do not advance the claim – they are not necessary to the premise and proof. These minor concerns aside, I have to say this is one of the better papers I have encountered in some time. The subject is scientifically significant, and the methods sound. The authors clearly lay out their evidence for the fire behavior, and the subsequent pyroCb development. They do so with limited extraneous information or discussion.

Reply: We thank the reviewer for a set of very useful comments that have allowed us to make the paper tighter and improve its flow.

We will discuss with the editor which spelling of "channelling" should be used in the final paper. The reviewer, using US practice, also spells words such as "behavior" differently.

BP: I feel that the figures are so small as to be nearly useless. I had to enlarge the view to 250% on a 24" monitor to even read the text in Fig. 1. Printed copy viewed with a magnifying lens was beyond the printer's ability to produce legible text. The figures need to be enlarged by at least that amount (250%) to be acceptable.

Reply: The reviewer is not the first to comment on the small size of the rendering of the Figures. We agree that they do require more generous space.

We will discuss this with the editor.

Specific comments: (We note that some of the details in our replies will need to vary when we incorporate the comments of all of the reviewers.)

BP: p. 7271, l. 5-14: “Extreme” and “extremely” are used 3 times in just this paragraph. In general, I encourage the authors to choose their superlatives and “extremes” carefully. At present, the abundance of extremes, verys, stronglys, etc. waters them down, and their impact in the places where they could matter most is diluted.

Reply: The reviewer is extremely perceptive. We agree and propose the following revision: “The development of these vigorous plumes, which manifest as pyrocumulus or pyrocumulonimbus (pyroCb) (American Meteorological Society, 2013), signals a transition in fire development from what is primarily a surface phenomenon to a coupled fire-atmosphere phenomenon (Potter, 2002; McRae and Sharples, 2011), in which the fire is able to interact with upper levels of the atmosphere (i.e. the mixed layer and above). Fires which make such a transition may access stronger winds and very dry air, which if returned to the surface (e.g. through convective mixing) can lead to extreme levels of fire behaviour and rates of spread (Potter et al., 2007; Mills, 2005, 2008). These fires would therefore be difficult to suppress and would be very likely to do extensive damage to any assets they impacted (McRae and Sharples, 2011).”

We will also check our overall use of superlatives during the final edit.

BP: p. 7271, l. 16: “smoke and other emissions” – what are the other emissions? Smoke, in common usage, encompasses all of the particulates and gasses produced (emitted) by the fire.

Reply: We will simplify the sentence to read:

“The injection height of smoke plumes from wildfires also has direct bearing on their effects on air quality and climate”

BP: p. 7272, l. 12: Spell out upper troposphere/lower stratosphere (UTLS.) You never use the abbreviation again, so no point using and defining it.

Reply: With reference to the reviewer’s last comment, regarding Figure 4a, we have proposed using UTLS again. On that basis the sentence will be amended to read:

“...their injection of aerosols into the upper troposphere/lower stratosphere (UTLS)...”

We will revisit this when all reviewers’ comments are assessed.

BP: p. 7273, l. 18-19: A sentence does not a paragraph make, and this sentence feels adrift. Perhaps the authors should clarify just what data is obtained from the A-Train – if such data is really used later in the paper. (“A-Train” appears on fig. 4, but there is no other analysis or mention of that reference.) Otherwise, I suggest dropping these lines.

Reply: The reviewer makes a compelling point here. We will remove the sentence.

BP: p. 7274, l. 16-20: I don’t know what the overall background is for Natural Hazards and Earth System Sciences readers, but I suspect the concept of vertical aggregated reflectivity is not common knowledge. It is not clear from these lines whether the aggregation uses only the two levels (lowest elevation and nominal cloud-base) to aggregate, or any/all levels from one to the other.

Reply: The reviewer correctly highlights an ambiguity. We propose changing the text to read:

“The aggregation is of all radar echoes between the lowest elevation scan and the nominal cloud-base altitude”

BP: p. 7275, l. 19: Define “breakout” as used here.

Reply: We are guilty of using non-standard terminology. To address the reviewer’s comment we propose using a standard Australian wildfire term: Breakaway: The points at which a fire, after it has been contained, escapes into unburnt areas across a fireline or fire edge. (AFAC Bushfire Glossary, 2012). We will make the following changes to the text: 1) The heading at 7275L18 will be changed to read: “3.2 Breakaway on 21 November”.

2) The sentence that starts the next paragraph (7275L19) will be amended to read: “A breakaway can be seen in Fig. 3b, north of AR.”

3) We will insert a new reference, after 7281L26: “AFAC : Bushfire Glossary, AFAC Limited, Melbourne, January 2012.”

BP: p. 7278, l. 11-13: This is one place I believe the authors can state their claim more strongly. “This establishes a quantitative connection. . .” could be “This establishes both spatial and temporal connections. . .” BP: On a lesser note, I found myself wondering “what about those other two tops > 9 km on Fig. 4?” here. I realize now they are discussed later, but perhaps there’s a way to say “stay tuned for more”?

Reply: We suggest adding the reviewers suggestion to our response to AR1 (C2787), so that the sentence that starts on 7278L11 would read:

“This establishes a compelling spatial and temporal connection between the intense, lateral spread associated with fire channelling and the violent pyroconvective activity detected by the radar. As stated by Finney and McAllister (2011), a large fire source will produce a plume which experiences less entrainment and is thus able to reach greater heights. This is consistent with the GV-N situation. (A similar event at CH is discussed below.)”

BP: p. 7280, l. 1-3: The list of qualifiers here is impressive – but phenomenally restrictive. They suggest that the whole list is necessary to get pyroCb, so at the least I would suggest changing “in the pyroCb blow-ups” to “in these particular pyroCb blow-ups.”

Reply: In line with our response to his next comment, we agree that it is possible to interpret our discussion in too broad a context. We will make the change.

BP: p. 7280, l. 4-8: As written, this suggests that pyroCbs require fire channeling in order to occur. I doubt this is the authors’ intent, or they would never expect pyroCbs in places like Siberia or much of Canad. I suggest simply changing “pyroCBs occurred” to “pyroCbs here occurred” on line 7.

Reply: We agree with the reviewer, and will make the suggested change.

BP: p. 7280, l. 9-29: I do not see how this section promotes the authors’ thesis. It is a discussion of factors that other authors have blamed for blow-ups, but since the thesis of this paper is stated as showing that blow-up/extreme fire drives pyroCbs – and the specific mechanism behind these specific extreme fires is stated to be channeling – the discussion of stability, wind profiles, or atypical diurnal cycles is out of place. Indeed, the final sentence here makes it sound like these lines were more a motivation for the work in McRae and Sharples (2013), than the present work. Might I suggest that, if any of this block is retained, it be the last sentence or two, appended to p. 7281, l. 1-6? This would make a logical flow from “Thus, in terms of the tools normally applied. . .” to something like “The factors at play here (X, Y, Z from p. 7280) are more appropriate for predicting extreme behavior, as reflected in the model framework proposed by McRae and Sharples (2013).”

Reply: We acknowledge the reviewer’s point that the logical flow of this section requires

attention. We feel, however, that this can be achieved through rearrangement of the existing text. Our review of these concepts is important for providing a basis for our conclusions. We propose:

"Blow-up" has been used as a term for unexpected fire escalation and has been discussed at a technical level by Arnold and Buck (1954), Byram (1954), Steiner (1976) and McRae and Sharples (2013). Byram suggested that the wind profile is a contributor to blow-up potential. The vertical profile recorded at Williamtown (the closest relevant observation site), shown in Fig. 5, indicates a wind velocity maximum at about 1 km above the observation site's elevation, cf. a jet point, Byram (1954).

"Other work on blow-up fires has focussed on the role of vertical stability (Haines, 1988; Mills, 2008; Mills and McCaw, 2010). As discussed by Fromm et al. (2012), the C-Haines value was extreme during these events. Of relevance to the stability component of the C-Haines, a band of small dry thunderstorms that passed over the region on the afternoon of 22 November ignited new fires in the region of the Wollemi Fire by means of lightning strikes (NSW Rural Fire Service, 2006). Radar data shows that this band passed over the Grose Valley Fire at about 03:20 and the Wollemi Fire at 04:20. Figure 6 shows a radar image from 04:40.

"The preceding analyses indicate that future forecasts of the occurrence of a blow-up event may need to consider some combinations of the factors identified here (and their interactions), namely: the absence of a fine fuel moistening phase during the preceding night; the maximum fire danger at the surface, and its relation to the typical diurnal cycle; a jet point in the wind profile; the terrain on which the fire is burning (ruggedness) and its orientation to the prevailing wind; the time of arrival of fire in critical parts of the landscape; and the passage of pressure troughs. This is reflected in the model framework proposed by McRae & Sharples (2013).

"Direct measurement of some of the important dynamics of a complex fire burning in a rugged landscape demonstrates that a variety of mechanisms may produce the re-

quired fire characteristics for violent pyroconvection to commence, but that the most significant development of pyroCbs here occurred in connection with the fire channelling phenomenon.

"Recent numerical modelling by Simpson, et al. (2013 & 2014) has demonstrated that pyrogenic vertical vorticity can produce atypical lateral spread consistent with this. Future work may shed new light on the physical mechanisms underlying the Grose Valley Fire."

We also propose adding these new references:

Simpson, C. C., Sharples, J. J., and Evans, J. P.: Resolving vorticity-driven lateral fire spread using the WRF-Fire coupled atmosphere–fire numerical model, Nat. Hazards Earth Syst. Sci., 14, 2359-2371, doi:10.5194/nhess-14-2359-2014, 2014.

Simpson, C., Sharples, J., Evans, J., and McCabe, M.: Large eddy simulation of atypical wildland fire spread on leeward slopes, Int. J. Wildl. Fire, 22, 282–296, 2013.

BP: p. 7281, l. 7-16: The way the paper ends feels like it gets tired and lies down, rather than resolutely declaring it has done what it proposed, or how important that finding is. We now have strong evidence that channeling initiated the pyroCbs. We do not, however, have any robust connection between pyroCb development and "significant enhancement to our capability to mitigate the threats from extreme fires and blow-up events" The introductory text proposed the possibility that the pyroCb can indicate a feedback of upper air conditions influencing fire behavior, but that was not the focus of the paper, nor was it even alluded to after p. 7271. I encourage the authors to forego the weak closure on how their results will improve operational behavior tools. Instead, firmly plant your flag on the very useful result that channeling was occurring and triggering pyroCb development. That alone is a new, and valuable finding.

Reply: We accept the reviewer's view on this. We propose a reworking of this section

of the paper, including amendments, deletions and rearranging. This is summarised below, but needs to include other changes based on other reviewers' comments.

"4 Discussion

"Blow-up" has been used as a term for unexpected fire escalation ...

"Other work on blow-up fires has focussed on the role of vertical stability ...

"The preceding analyses indicate that future forecasts of the occurrence ...

"Direct measurement of some of the important dynamics of a complex fire ...

"5 Conclusions

"In this study we have shown that atypical modes of fire propagation ...

"We have shown that from time-to-time the evolution of a fire may produce localised surges in intensity which, in the right instability setting, can produce pulses of violent pyroconvection. Fromm et al. (2012) showed there were only small differences between fire weather on this day and the preceding day. This makes it clear that for fire managers to ensure the safety of fire crews and the public, they need to think beyond established practices and assess the potential for atypical fire dynamics."

To achieve this, the following paragraphs are to be deleted:

"Fromm et al. (2012) demonstrated that two fires in the hinterland of ...

"As pointed out by Fromm et al. (2012), ...

"While fire behaviour analyses based on fuel loads, surface weather ...

"It should be noted that not all unexpected fire escalations are blow-up events ..."

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BP: Figure 3: If the legend is to be referred to as (f), then there should be an (f) on the figure. Otherwise just call it the legend when referenced in the text.

Reply: We will follow the reviewer's suggestion. This will involve:

(1) Replacing "(f)" in the caption with "Legend" in boldface.

(2) 7275L4 change text to read: "Indicative colour samples are provided in the legend for Fig. 3,..."

(3) 7277L16-17 change text to read: "based on the relatively uniform spectral signature for active or decaying flame (Fig. 3 legend)."

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BP: Figure 3 caption, panel (e): missing "i" in reflectivty.

Reply: This edit will be made.

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BP: Fig. 4a: No description of what the grey, horizontal dotted line indicates on the figure. Is 12 km significant here for some reason?

Reply: As the reviewer notes, we omitted to note that:

"The horizontal dotted line indicates the UTLS, which was at 12 km a.s.l. (Fromm et al, 2012)."

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Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 7269, 2014.