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Interactive comment on "The Alberta Smoke Plume Observation Study" *by* Kerry Anderson et al.

Kerry Anderson et al.

kerryanderson@shaw.ca

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Though the topic of the study is rather important and interesting, the proposed approach is probably not the best one to tackle the issue. It is also unclear what is the real value of the presented data (even authors recognize subjectivity and large uncertainty of this approach). It is unclear how the observations were included in the fire modelling? What is the value of calculated correlation? Do they improve our understanding of the plume rise processes and if they do this is not articulated in the paper at all. Was meteorological/air quality equipment used to support these observations (e.g. ceilometers, or aerosol instruments for particle size distribution or

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Discussion paper

chemical composition characterization)?

The authors thank the reviewer for providing their review and questions. The concerns they bring up are challenging and we hope that we can address these.

Certainly the most significant concern is the real value of this data. The purpose of this project was to collect data to validate a plume rise model the authors are developing. This was not explicitly stated in the original manuscript but has been stated in the revision. This concern was expressed by the first reviewer and the response to that reviewer applies here as well.

With that in mind, this manuscript does not specifically present a methodology to predict plume rise; that will be left for a subsequent paper. Instead, this manuscript documents the observations, which, in turn, will be used to validate the plume rise model. Given the issues uncovered with this data, it was deemed important to publish these results first so as not to confound the subsequent paper.

So to answer the reviewer's specific questions:

- The observations are not included in the fire model. The fire model is intended to capture the fire characteristics, as shown in equation 3, associated with energy release leading to plume rise. Ultimately, the fire characteristics along with atmospheric stability will be use to predict plume rise in a more detailed thermodynamic model, of which these observations will be used in the validation.

- The value of the correlations for individual predictors are meant to support the physical processes of the energy of the fire, as shown in equation 3.

- The observations alone do not improve our understanding of plume rise. The intent is to provide data that will be used to validate the plume rise model.

- No meteorological/air quality equipment was used in this study beyond the simple inclinometer described in the manuscript. Upper air data will be included in the later

paper to capture atmospheric stability.

p. 1, l.7 – did you use inverse modelling to adjust the source term?

The reviewer's question is not clear. We assume you are referring to the use of fire-growth modelling and the reference to inverse modelling as growing the fire backward and forward in time. Is this the source term the reviewer is referring to?

There are two separate events happening, which, we believe, the reviewer is confusing. There are the plume observations from the lookout towers and there are the assessed fire sizes, as reported by fire fighters when they arrive at the fire. These two are independent and one is not the source of data for the other. On the other hand, the times of the two events do not match and so the assessed fire size is adjusted in time to the plume observation time using fire-growth modelling. We have addressed this in section 2.5 in response to the reviewer's related question later in this discussion. Does this need to be in the abstract? We don't think so.

p. 1, l. 11 – how this human subjectivity is take in consideration in calculation of uncertainty of your observation?

The data is reported as is. The discussion from page 8, line 17 to page 9, line 15 describes how the human subjectivity impacted the data. Page 9, lines 9 and 10 notes an average difference of 40% between observations of the same plume taken by two towers.

p. 1, l. 13-14 – have the collected data been used in any assimilation system or compared with the model output?

The intent of this data is to use it to validate a plume rise model being developed by the authors. The authors felt this study needed to be published prior to the plume rise model to discuss issues involved with the data. This comment is included in the response to the first reviewer and has been added to the revised manuscript.

p. 2, l. 16 - "more difficult" – unclear more difficult than what?

Poor choice of words on our part. The intent was to suggest that of all the steps involved in forecasting smoke (e.g. emissions, dispersion, concentrations, etc.), plume rise is the most challenging. The manuscript has been corrected to remove this qualifier.

p. 2, l. 24 - The equipment used is very primitive. It is clear that research equipment is much more expensive, but probably use of lidars that measure back scatter can provide much more insights into the dynamics of the plume than presented here observations.

True, but it seemed a practical way of collecting an amount of data necessary to validate our plume rise model. The revised manuscript provides a more detailed literature review that addresses the lack of ground-based observations of wildland fire smoke plumes. Most LiDAR studies are detailed studies of individual plumes while many other studies are based on remotely sensed satellite data.

p. 2 – "Methodology" How many points per plume was collected? How the position for the measurements was selected?

Each observation is included in the data set. Each observation is one measurement at a specific time. In most cases, an equilibrium and the maximum plume height is reported.

Page 6, line 16 notes "There were 39 cases of plumes being observed multiple times over the course of the day"

Page 3, line 23 describes "Observers were asked to report equilibrium and maximum plume heights based on the plume's final levelling height and the maximum lofting height, respectively (Figure 2)" using the inclinometer.

p. 3, l.10-15 – how do observers estimate the distance to the fire?

Page 3, line 6 describes "Observers at these towers monitor the forest and are well trained in recognizing plumes from wildland fires, reporting the azimuth for fire detection purposes." To this we have added "Two towers reports are used to triangulate to the fire location. Also, fire suppression resources report the precise location upon arrival. From this and the lookout tower location, distance to the fire can be assertained."

p. 5, l. 13-16 - the inverse modelling part for the source term adjustment requires more explanations.

As discussed earlier, we believe the reviewer is confused about the relationship between the fire size and the plume observations. We are comparing the observed plume height to fire size in the results section but the fire size does not in any way enter into the observed plume height through inverse modelling.

This section was rewritten as follows: "Finally, fire size was then adjusted from the assessed time to the plume observation time using elliptical fire growth (Forestry Canada Fire Danger Group, 1992). Fires tend to grow in elliptical shapes and given the rate of spread (i.e the velocity) of the fire, one can calculate fire shape and size over time. For this study, these equations were applied in reverse to derive a time of ignition (when the fire size is zero) or 6:00 MDT for larger, multi-day fires, then recalculated forward in time to the plume observation time."

For the purposes of further clarification, a note was added to section 2.2 Fire Assessment Reports stating "Note that these reports are collected independent of the plume observations in this study."

p. 5, l. 25 –the statement is unclear

The section is question has been rewritten as follows: "Due to buoyancy, a smoke plume will rise through the atmosphere until it reaches a point of temperature equilibrium with the environment. Yet as it rises, the plume builds vertical velocity and thus will overshoot the equilibrium level, only to fall to the equilibrium level afterwards. This overshoot is reported as the maximum lofting height."

p. 5, Section 3.1 – it is difficult to trust data presented in this section, because even authors recognize that different observers estimate the same plume differently. It is unclear what is the added value of this subjective information.

The intent of section 3.1 was to quantify the uncertainty. This is later noted in the discussion on page 9, lines 9 and 10 that an average difference of 40% between observations of the same plume taken by two towers.

The following section has been rewritten to clearly state this intent: "Finally, there were six cases where two towers reported the same plume at approximately the same time (Table 3): SWF120 on 22 June 2010; PWF068 on 11 July 2012; GBZ002 on 6 August 2014; LWF161 on 24 June 2015; and PWF131 on 2 July and again on 19 July 2015. An examination of these cases help to quantify the uncertainty of all observations in this study".

p. 7, l. 25-28 – what kind of relation did you check with this analysis?

Page 7, line 25 has been rewritten as follows: "Linear regressions were conducted to test for any relationships between plume heights and fire weather conditions, comparing each of the variables in Table 4 individually against observed equilibrium and then maximum plume heights."

p. 7, l. 32-33 – correlation between which parameters was analyzed? Could you please also write your regression equation.

Page 7, line 32 has been rewritten as: "As was done with fire weather conditions, linear regressions were conducted to test for any relationships between plume heights and the fire behaviour variables listed in Table 5."

Regarding the regression equations, the authors do not see the need to include these as stated on page 8, line 8 "the intent of the work at this stage is simply to validate the confidence in physical relations (in this case, P = 0.00007). Further analyses have been left for a future plume rise model, and are outside the scope of this study."