

Interactive comment on “Soil-water dynamics and unsaturated storage during snowmelt following wildfire” by B. A. Ebel et al.

Anonymous Referee #2

Received and published: 14 March 2012

Review of Ebel et al., HESS-2011-423

General comments

This paper touches a very interesting subject, the effects of aspect on snowmelt and soil water storage in burned areas. As the authors state, little is known about this subject while it is very relevant for mountainous regions. The topic is relevant to the journal as it touches hydrology and fire – the latter being an underrepresented topic in HESS, despite its effect on earth surface processes. The approach is sound, but the methods deserve additional attention. Although a lot of data is presented, I miss a quantitative statistical analysis of the effects observed. This needs to be included before publication in HESS. Statistical analysis of the results needs to be added to both methods and results sections, and all research questions need to be statistically

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addressed if possible. Ideally, a statistical analysis would not only cover differences between the separate treatments, but rather the effect of aspect and fire in general on the various parameters assessed. The literature review presented is sound (though note the specific comment below), and the paper is generally well written. Although the reasoning is most often clear, I feel that the clarity of the paper can greatly benefit from a number of small improvements to treatment names, figure layout and other things (hence the long list of specific comments and technical corrections below).

Specific comments

As stated above, the literature review presented by the authors is sound, although I am surprised by the small number of HESS papers cited (just one). A number of papers were published in HESS about snowmelt (Renner & Bernhofer 2011, Schulz and De Jong 2004, Li and Wang, 2011 to name some) and two about fire (Rosso et al 2007 (runoff, sediment, woody debris) and Stooft et al 2012 (role of canopy interception and soil moisture on streamflow, effects on recharge)). If the HESS papers support part of the work in the present paper, consider including references to them.

Line 35: recharge greater on burned slopes because of earlier soil thaw — and thus reduced overland flow?

Line 66, snow-water equivalent. Can you specify whether this is the amount of water reaching the soil surface? Or total input at the canopy level? I assume the former.

Line 71. As many fire scientists may not be aware of snowmelt processes, I recommend defining which part of the variation in location matters most- elevation, aspect, latitude, etc?

Line 78 and 79: This Massman and Frank paper indeed studied the effect of fire on thermophysical properties, but their fire was not a wildfire but rather a controlled burn which 'continued to burn or smolder for several hours to days after'. I am not aware of publications reporting the same thing for wildfires (with much shorter residence times),

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but if you want to make this statement for wildfires, I suggest finding a reference that supports this statement for wildfires.

Line 90: Note that removal of the vegetation canopy can have similar effects - Stoof et al 2012 (HESS) found significant hydrological changes in a burn that did not affect soil hydraulic properties.

Line 137, 138: Please help the reader remember that the Fourmile Canyon site is the burned site, and Gordon Gulch is the unburned site. It would be very helpful to add the words 'burned' and 'unburned' to these catchment names at multiple locations in the text, such as also in (but not limited to) line 561, 564 and 566.

Line 152: I did not find anything about recommended naming of soils in HESS, but because it is a European journal I recommend adding the corresponding FAO soil types here.

Line 168, 39.99 N, -105.48 W. I assume this should be 39.99 N, 105.48 W (without negative sign) or 39.99 N, -105.48 E (with negative sign but E instead of W) – please correct.

Line 178. I understand that it is necessary to abbreviate the treatment types here, but I have a hard time remembering the meaning of the abbreviations throughout the paper. Consider using SRidge (or S_Rid, S-Rid), NRidge, SMid, NMid so that abbreviations are less abstract and easier to understand for the reader. It would also be helpful if the UB sites would have more intuitive names, or if their names are at least explained or consistent (1 2 3 or something with words, there is no system now).

Line 173-183. Is there a reason that you only have one plot of each type (South facing ridge, south facing midslope, etc), i.e. that you didn't replicate the plot types, but only chose to do replicate measurements within each plot? Or do you consider the different plots (mid, ridge) to be replicates for the different aspects? If so, mention this here.

Line 180. Add reference to Table 1 after 'or southeast facing'.

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Line 189 and for other equipment (i.e. Decagon line 208): give manufacturer location

Line 196: did you do something to ensure that previous sampling locations had no effect on current readings?

Line 198. I suggest revising the end of this sentence to 'reported as the ratio of . . .' (or 'between')

Line 200. Do you mean precipitation record? ('complete record')

Line 208. The plot S Control has not been defined above. Is it correct that soil water contents were not measured at UBTemp?

Line 214-216. Maybe you can add a sentence here why you didn't do this/ was not considered important to do in your paper.

Line 228. I know from field observations in burned areas that soil moisture often has a very steep profile in the top 5 cm of the soil, because of evaporation from the bare soil surface. This can be different in winter/snowmelt conditions, so please include information (an observation or a reference) that provides a ground for this assumption, or mention the limitations of this assumption if this was the best you could do.

Line 235. Why were soil water retention curves determined for a subset of sites only?

Line 242. I am a bit surprised by the matric head chosen for field capacity (-340 cm), and could not find this in the given reference. Koorevaar and Menelik do state that 'soils with deep groundwater tables at field capacity generally show matric heads of about -3.0 m' (page 85) but the soils in the present study are only 0.5 m deep. It seems hard to create a suction of 3.4 m in a soil that is this shallow. I am not an expert on how to determine field capacity of shallow soils, but do know that the definition of field capacity varies between countries (see <http://www.cabdirect.org/abstracts/20113299698.html>). I recommend explaining why you chose this definition of field capacity, and update the value for shallow soil if feasible.

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Line 247. Why is it relatively small, compared to elsewhere, or to average snowpack conditions?

Line 332: it would be helpful if you could specify (here or in a graph) when this was

Figure 6: indicate depth of measurement in caption of figure

Line 337: I think UBNF has not been defined before – please include it in the methods section

Line 339: Rephrase to 'soil hydrologic response'

Line 365-366: please include a reference to a table where we can see this. It would be very helpful if the field capacity data were presented in a separate table or figure, to facilitate comparison.

Line 373. Change to 'did not considerably affect NFM' - a little peak is visible

Line 421. It would be very helpful if you could again very shortly define here how unsaturated storage was defined or determined here

Line 454. Change into 'depletion', if desired by 'depleting (by drainage or evaporation)'. The '/' could confuse readers that you're referring to a ratio between drainage and evaporation, and it is certain that it is depletion, the interpretation is likely but not certain.

Line 536 to 555. It is unclear to me whether this paragraph is based on the present study's work, the companion paper that is in review, or on other literature. It would be very helpful if references to Figures, tables and/or references could be added.

Line 551, flow initiation. Do you just mean preferential flow, or really the start of preferential flow? The next sentences suggest that it is mostly the process in general.

Line 552, thus preventing. I suggest adding the word possibly - although ash can infiltrate into the soil pores, and it has been suggested that this can inhibit infiltration,

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this has not been proven yet.

Line 555. Include reference to where we could see that if you measured this, or literature reference where this is different on north and south facing slopes, and say how this reduced structure would affect preferential flow. Part of this may be in the next paragraph but because it is a new paragraph that is not clear in this sentence.

Line 559 This was also found by Stoof et al. 2010, who had no soil structure because of repacked columns.

Given your next sentence, I have the idea that you want to link loss of water retention in the wet range to soil structure - which is sensible given the literature available on this topic (see for instance Dexter et al 2008 <http://dx.doi.org/10.1016/j.geoderma.2007.11.010>). Add a sentence here linking the two things.

Effects of fire on aggregate stability soil structure are discussed or referred to by Garcia-Corona et al (2008, http://www.publish.csiro.au/?act=view_file&file_id=WF03068.pdf) and by Bento-Goncalves et al, 2012 (<http://dx.doi.org/10.1016/j.geoderma.2012.01.004>)

(Specific comments to tables and figures below)

Technical corrections

Remove the dashes in 'soil-water content' and 'soil temperature' and 'soil-water retention' throughout the paper

Is there a double space after 'South' in line 25? If so, remove it. Same for line 197 after 'particularly'

Line 35, 571 and elsewhere. Undo capitalization of paragraph titles

Line 116 – replace '2-100' by '2 to 100' I erroneously thought it was a strange number instead of a range.

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Line 199. Insert space after 'NADP site'

Line 207. cm³ cm⁻³ - change to m³ for SI and to be consistent with your tables

Line 208: I think this should be 2-minute intervals (with dash)

Line 218: replace 'zero °C' by '0°C'

Line 242: Koorevar should be Koorevaar.

Line 286 and elsewhere (line 295, 625) : Soil temperatures can be lower but not colder, so either say that soils were cooler, or that soil temperatures were lower. Same throughout the paper for 'dry and wet soil water contents' (line 404-405). Soil water contents are low or high, and soils can be dry or wet.

Line 289. Insert space after north-

Throughout: insert space after value and before the unit (such as in line 306: 10cm)

Line 321: add dash between sigma and values

Line 332. Add dash between near and surface

Line 377: indicate that the 'shaded regions' are in fact the blue horizontal bars

Line 464, 465: Define TDR

Line 471, this finding: do you mean the finding that soil water storage was unaffected or that field capacity was slightly different at each plot? Also, remove dash between very and dry, and remove comma after conditions in line 472.

End of line 517: add 'near freezing' after references to avoid confusion.

Line 533. I think you mean aspect-affected differences?

Line 542-543. Do you want to say that they 1) were not collected, or that they 2) were collected but not to study preferential flow? In case of 1) change sentence to '... not collected to examine preferential flow at the Fourmile Canyon site'. In case of 2) leave

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sentence as is

Line 558- add reference to figure or (new) table before the comma

Tables and Figures– specific and technical comments

Table 1 remove period after Table caption

Move degree sign to after slope instead of after range

Please indicate what value you use for soil depth - is this the average of the different measurements per site, or the highest value? If you can, give standard deviation. Also, it may be more appropriate to give this value in meters (S.I.)

Table 2. Can you add a column indicating whether the precipitation for these events was snow or rain? (or otherwise frozen or not frozen?)

Table 3. Add units in top row of table instead of below mean, median, etc.

It would be very helpful if the data in this figure were rearranged to facilitate comparison between the treatments (which is what is discussed in the text)- by first giving all data for the 5 cm depth, then all data for 10 cm, etc. The current layout mostly allows assessment of effect of depth.

Is soil temperature reading really accurate to two digits? I suggest rounding to one digit only.

Figure captions.

Fig. 7. Add dash to 1-minute intervals. Use number 0 for zero degrees

Figures.

I often found it hard to interpret the graphs because so much information was presented in them. Also, a number of the graphs can be improved by cleaning up tick marks and time axis labels, or by avoiding repetition of figure legends for each figure panel where legends are the same anyhow. Specific comments follow:

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Figure 1. The layout of this map is a bit strange as the sites are all cluttered together. Would it be an option to reduce the size of blue area (and not show the creek) so that the pink area can be larger? Also, consider showing a small inset map of the USA too with Rocky Mountains, and make sure that blue and pink are distinct enough when readers print in black and white. The UB north site is not discussed in the methods, and it looks like this site was in an unburned spot in the burned area. Is this true, and were more UB sites chosen within B areas?

Figure 2. Indicate in caption what the different dates are that are written out on the x-axis - are these sampling dates? Otherwise use regular monthly intervals starting on the 1st of each month. I also suggest revising final part of caption to "... nearby Sugarloaf climate station (site CO94) operated by..." Or something like that. Now it looks like the NDAP program is CO94. The horizontal bars in the temperature data look a bit odd - I think everybody understands that you drew lines between the daily values, so consider removing these dashes. Do add to the caption that the values are daily values of temperature and precipitation though.

Figure 3. Because freezing conditions are important in this graph, it would be very helpful to have a horizontal line at 0°C. Consider stopping the air temp axis at -20 because it didn't get -40. Again, indicate what you mean with the dates on X-axis or use monthly time intervals. Finally, consider using a dashed line for either of the two parameters shown here to make differences visible in black and white print too.

Figure 4. I have a hard time interpreting this figure and recommend choosing different colours/dash lines, and splitting these data up into two figures. If both subpanels are aligned vertically (one above the other) and use the same x-axis scale, they can be easily compared. Consider putting x axis labels vertical - and give all of them for all sampling moments, or use regular monthly intervals. Finally, it would be helpful if you could define abbreviations and give the sampling interval in the figure caption. What is DAM2?

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Figure 5. This figure is clear and needs no rearrangement, though do note that the tickmarks are off. I recommend flipping the temperature legend so it runs from negative (left) to positive (right), which is more intuitive, defining abbreviations in the figure caption and mentioning how you acquired these data (automated/continuous measurements using XXX or something like that). Finally, you may want to call the black circles 'black horizontal bars' or something alike, since I initially did not recognize these as circles.

Figure 6. I really like the shaded clouds drawn in Fig C to help interpretation of this graph. I think this panel can be further clarified by using one fill type for burned (filled shapes) and another for unburned (open shapes) and then use similar shapes for similar aspects, such as squares for north and triangles for south facing slopes. I do have a hard time interpreting figs A (and B to a lesser degree). Consider splitting these up by adding two more subfigures in which you show B vs UB, or south vs north, whichever you want to stress most. Another or an additional way to clarify this figure is to condense the space between the sampling in November and March by 'breaking' the x-axis here.

Figure 7. Please add to caption whether field capacity value is for one sample or an average (give n). Can you use the same color as in Fig. 5 to indicate frozen soil?

Figure 8. It is hard to quickly see the effect of depth on soil water content distribution in this graph because the bars are all cluttered together. I suggest rearranging this graph by splitting each subpanel up into three subpanels, one for each depth. They don't have to be very large but it would improve the quality of this figure. Also, indicate what dashed line is, and for what depth field capacity is valid.

Figure 9. Great to see you're using the same y-axis scale for all panels. Note that the tickmarks are off in the bottom panel, and that it would be good to have monthly tickmarks to all upper panels too.