Hydrol. Earth Syst. Sci. Discuss., 5, S1914–S1917, 2008
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Hydrology and Earth System Sciences Discussions

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5, S1914–S1917, 2008

Interactive Comment

Interactive comment on "Controls on the temporal and spatial variability of soil moisture in a mountainous landscape: the signatures of snow and complex terrain." *by* C. J. Williams et al.

C. J. Williams et al.

Received and published: 20 November 2008

Final response of authors to anonymous Referee #1 comments on "Controls on the temporal and spatial variability of soil moisture in a mountainous landscape: the signatures of snow and complex terrain" - C. Jason Williams, James P. McNamara, and David G. Chandler

(Reviewer comments in italics, author responses in normal text with text changes noted in bold, all referenced page numbers and figures are to the on-line version of the discussion paper)

Responses to major and minor comments of anonymous Referee #1

1) *I think that the reason you don't see a decrease in variance with increasing moisture content is that the moisture conditions during your study did not get really wet on average for very long, if at all (Fig. 4). Maybe you have addressed this in the paper, or maybe it has already been discussed online. However, if the moisture content keeps increasing, there is only one way the distribution can go - that is, theoretically, all saturated with no variance. So the model variance versus mean moisture content that emerges is one where variance is at a minimum at the wet and dry ends of the spectrum, with a max (and hysteresis) in the middle.*

Figure 3 of the original discussion paper illustrates the mean, minimum, and maximum measured near-surface soil moisture by measurement date along with 15-min time series soil moisture measured at multiple depths by time domain reflectometry. The range of the spatial near-surface soil moisture data clearly increases with increased spatial mean soil moisture and decreases with decreased spatial mean soil moisture, as does the standard deviation shown in Fig. 4b. The highest mean near-surface soil moisture contents measured (see Figs. 3 and 4) represent approximately 50-60% saturation based on a saturation index presented for the site by McNamara et al. (2005). The data are consistent with soil moisture contents presented by McNamara et al. (2005) for previous wet period measurements at the site. Therefore, wet-period soil moisture contents at the site likely approach 50-60% saturation, and soils at 50-60% saturation are not wet enough to reduce model variance to the same levels as measured for the driest periods of the year. The authors agree model variance under saturated conditions should approach that of the driest conditions, particularly under more uniform topography and soil characteristics. However, as pointed out by Referee #1, these conditions do not occur with this data set. These conditions likely do not occur at the study site due to the precipitation regime and soil and terrain influences on water input and routing (presented as dynamic and static influences within the manuscript). The information brought to light by this comment supports the existing discussion in section 5.3, mainly that the positive relationship between mean moisture content and the standard deviation of moisture content exists during discrete wetting and drying periods as well

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as during prolonged stable dry periods. And, no threshold moisture content emerges at which the variability-mean moisture content relationship changes. The following text is added relative to this comment, Page 1946, Line 4, after "...controlled by the interaction of soil and vegetation properties with precipitation.":

Famiglietti et al. (2008) found, on gently sloping rangelands, the standard deviation versus mean soil moisture exhibited a convex upward curve, standard deviation peaking at approximately 0.18 m^3 m^{-3} mean soil moisture content, and soil moisture variance decreased with increasing mean soil moisture. The decreasing variance with soil moisture contents greater than 0.18 m^3 m^{-3} was largely due saturated soil conditions. Soils during the wettest periods of this study were 50-60% saturated ($\sim$0.20 m^3 m^{-3} mean soil moisture content, Fig. 4). These results were consistent with soil moisture conditions previously observed in a TDR monitored soil pit at Treeline by McNamara et al. (2005). Saturated conditions at Treeline are likely limited by the precipitation regime and terrain attributes that influence water availability.

2) *Another thought is that you have covered the soil moisture variability literature quite well, but not the snow variability. Have you seen any papers on pdfs of snow. I have seen Barry Goodison talk about this in much the same context that we talk about soil moisture. It would be interesting to look at how the pdf of snow (height?; SWE?) compares to that of soil moisture alone (pre-snow season?) and affects the shape of the soil moisture distribution. See the papers by Ryu on rainfall/soil moisture pdfs (2004-WRR) and scaling (2006-GRL).*

The authors have considered this comment and have reviewed extensive literature on snow distribution. However, the literature is limited with respect to correlation of soil moisture and snow patterns, particularly in the context of small catchments and field collected data. We included the most relevant studies to our knowledge (Grant et al., 2004; Litaor et al., 2008). We have not found any additional relevant peer-reviewed literature on this comment.

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