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Hydrology and Earth System Sciences Discussions

Interactive comment on "Use of soil moisture dynamics and patterns for the investigation of runoff generation processes with emphasis on preferential flow" *by* T. Blume et al.

Anonymous Referee #1

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The manuscript illustrates the results of a field monitoring campaign conducted in a small catchment of the Andes in Southern Chile. The aim of the investigation is to identify the processes controlling runoff generation in this catchment, covered by forest and characterized by a deep and layered volcanic ash soil.

The experimental effort is valuable. Vertical profiles of soil moisture within the top 100 cm have been measured occasionally at 11 locations, arranged along two hillslope transects close to the catchment outlet. Soil moisture profiles have been also monitored in three locations with a high temporal resolution. An interesting graphical method, based on color maps, has been employed for evaluating the temporal variation of the soil moisture profiles during and after rainfall events, with respect to antecedent conditions. The analysis of the soil moisture variation at the event scale suggests that the spatial distribution of the infiltrating rain water into the soil is controlled by preferential flow paths. Preferential flow has been then investigated by dye tracer rainfall experiments. These experiments confirmed the occurrence of preferential flow within the top 100 cm of soil. The authors argued that the water repellency could play a significant role in triggering preferential flow in these soils. The potential hydrophobicity of the soil has been verified by specific tests on air dried soil samples. The actual water repellency in the field may vary significantly within the soil, being affected by the actual soil water content. The variability of the hydrophobicity would produce “self reinforcing” preferential flow path. Preferential flow could be enhanced in summer, since the soil water repellency tends to increase as the soil gets drier. This could also explain the fact that the response times of the soil moisture, the groundwater level and stream flow are smaller in summer than in winter. Other factors, such as soil heterogeneity and roots could also enhance preferential flow. However, during the dye tracer experiments a few preferential flow paths appeared to be triggered by the roots. Persistent small scale variability of soil moisture has been observed even at decimeter scale, which could be explained by preferential flow within apparently homogeneous soil. The fact that some locations are persistently drier than others and thus more likely to develop water repellency, could be also due to the large heterogeneity of the throughfall induced by the forest cover in the catchment. The analysis of the soil moisture patterns both at the decimeters and hillslope scale evidenced that soil moisture varies more in space that in time, suggesting that the preferential flow patterns are stable in time.

In summary, the paper presents valuable experimental data on the water dynamics into such volcanic ash soils. However there is very little evidence that this data, collected only in a small area close to the catchment outlet, could explain “the entire system-catchment” response, which is one of the main research questions stated in the introduction. No quantitative investigation has been carried out to

HESSD

4, S1311–S1314, 2007

EGU

explore the relation between the observed soil moisture spatial and temporal variability and the runoff observed at the catchment scale. It is also not clear the role of the groundwater observed at one of the wells. A description of the potential runoff generation processes across the entire catchment is missing. I found therefore the title of the paper and the introduction misleading with respect to the actual contents of the paper.

I also found difficult to follow the discussion throughout the paper, since it is fragmented by several details and considerations, with little integration between the several sections. In some sections it is difficult to distinguish the experimental evidences from subjective considerations or results cited in other refereed papers. The discussion on the analysis of the experimental data is interrupted by details on the performed experiments or collected data, already introduced in previous sections.

A section of the paper should be dedicated to the description of the soil properties (including hydrophobicity) in the investigated area: a clear picture of the variability of soil properties along the vertical profiles would make easier to understand the considerations on the observed soil moisture data and dye tracer experiments. This section should include a description of the soil profile in the locations where soil moisture probes are installed or at least where dye tracer experiments are performed. Also the experimental effort in characterizing the soil properties should be more clearly illustrated. Soil textural data, soil water retention and soil hydraulic properties measured at the various depths should be clearly listed in separate tables, as it has been done for the hydrophobicity. A better description of the method followed for estimating the soil hydraulic conductivity curve should be provided, since section 3.7 is too generic.

A second section should be focused on the description of the criteria followed in the selection of the experimental sites and in the installation of the soil moisture probes. The results of the FDR profile probe calibration should be also illustrated. In which horizons have been collected the soil samples employed for the calibration? What is the range of soil content values has been investigated? Does the measurement error of 3% apply to the measurements in volcanic ash soils?

HESSD

4, S1311–S1314, 2007

Interactive Comment

It would be more useful to read the analysis at seasonal and annual scale before the discussion at the event scale, in order to get a preliminary picture of the local climatic characteristics and of the antecedent and boundary conditions during the rainfall events examined in the following sections. Statistics of the observed rainfall and soil moisture variability in all measurement locations should be provided. Also a diagram describing the timing of the episodic soil moisture measurements and of the selected rainfall events with respect to the seasonal pattern of rainfall and soil moisture should be provided. The analysis at seasonal and annual scale should be extended to the runoff and the groundwater, if the relations between the local soil moisture observations, stream discharge and groundwater are to be explored.

Since the soil moisture dynamics at the event scale has been analyzed for 34 rainfall events, it maybe worth to summarize the characteristics of these rainfall events and the outcomes of the observed soil moisture dynamics by quantitative indicators or qualitative attributes, beside the impressive color maps for just three events.

The “small scale variability” of the soil moisture should be presented in the form of tables or diagrams evidencing the variation of the local soil water content relative to a reference direction, in order to better appreciate the local differences in soil water content.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 4, 2587, 2007.