

Interactive comment on “Controls and characteristics of variability in soil moisture and groundwater in a headwater catchment” by H. K. McMillan and M. S. Srinivasan

Anonymous Referee #1

Received and published: 25 August 2014

General Comments:

This paper investigates variability in soil moisture and groundwater tables in a small catchment in New Zealand. The authors observe temporally and spatially changing variabilities and aim to explain what controls them. In order to do this they look at seasonal cycles as well as individual precipitation events and also at some physical catchment characteristics. The approach of looking at the whole catchment system instead of just observing individual hydrologic processes to explain catchment response is interesting and deserves attention. Therefore, I think that this manuscript is well-suited for publication in the HESS journal.

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Still, there are some problems concerning the structure of the manuscript that should be addressed. The authors should provide a better sequence of arguments, one building on the other. For example, in the results section the authors often already interpret the results instead of just reporting what they have observed. Afterwards the summary/discussion section reads like a collection of individual observations that sometimes lack connection since the authors jump from one topic to the next without describing the links sufficiently (if you read the manuscript and some of its sections a couple of times then the connections become clear but it would be much easier for the reader to get some more help when reading it for the first time). So the discussion section where the main findings are summarized and presented could use some restructuring: maybe start by explaining the observed temporal differences in soil moisture before looking at the groundwater table differences. Then continue by explaining the reasons for the temporal changes in variability of both soil moisture and water tables. Then turn to the spatial differences. Also, it is mentioned that there are many types of variability occurring in the catchment. A brief overview (systematic description) of these types would be helpful.

The paper is well-written in terms of spelling and grammar. What the authors could still improve is the structure, especially by untangling some of the nested sentences that are quite frequent.

Specific Comments:

Title: ‘Characteristics and controls...’ is the more natural order for this title. Also, it flows better. But that is a matter of taste, I guess...

p. 9476, l. 2: Do you need to classify the catchment as ‘new’. It doesn’t really mean anything.

p. 9476, l. 7: Which ‘seasonal cycle’ are you referring to exactly? The seasonal cycle of precipitation? Evaporation? Climate in general?

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p. 9476, l. 10: Does this already refer to spatial variability? It is a bit confusing whether you talk about temporal or spatial variabilities when you mention partial saturation. Also, what does 'calculated per time step' mean? Do you use a moving window to capture the variability of different precipitation events?

p. 9476, l. 16-20: This is a sentence that should be divided into smaller sentences, it is hard to read.

p. 9476, l. 23-25: This sentence is unclear, maybe better write: 'The dominant variability type changes with catchment wetness conditions according to which water stores are active. In particular, the variability type is sensitive to those stores that are close to a threshold.'

p. 9479, l. 5: 'experimental data' is, in my opinion, data that was collected during an experiment (i.e. while someone was controlling and/or modifying the boundary conditions of a catchment. You did not perform experiments.

p. 9480, l. 2: What do you mean by 'significant variation was found'? Maybe that 'significant differences in variation were found'? Please be more specific.

p. 9480, l. 22: Better not say 'ASPECTS of land use...'. This could cause confusion.

p. 9480, l. 23: Concerning the structure of this section I would recommend to start with controls of soil moisture before continuing to controls of soil moisture variability.

p. 9480, l. 23 – p. 9481, l. 2: It would be useful (if not necessary) to add to this summary how the controls influence soil moisture. You write that upslope area was identified as a control – but does an increasing upslope area cause higher or lower mean values?

p. 9481, l. 10-19: Again in this summary I would like to read more about the actual results of these studies (so what is this relationship between topography and subsurface flow dynamics?). The way it is presented now is not very informative for the reader.

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- p. 9482, l. 3: What evidence? Same problem here. You do not need to explain the whole paper but if you cite, you should provide the essentials.
- p. 9482, l. 23-27: Make this data a table, it would be much clearer.
- p. 9483, l. 11: What measurements were more detailed in the one slope and how were they more detailed? You were talking about aerial photographs and GPS mapping.
- p. 9487, l. 1: Maybe better 'we average by location' instead of 'we summarize'.
- p. 9487, l. 19: What does 'induce water tables' mean?
- p. 9488, l. 7-12: A table would be easier to follow.
- p. 9490, l. 2: What kind of 'seasonal cycle' are you referring to? Please be more precise.
- p. 9490, l. 5: Which typical event did you select?
- p. 9492, l. 19-22: Unclear sentence, please rephrase.
- p. 9494, l. 6-9: This is just one of quite a few sentences that could be phrased much clearer for the reader if it wasn't so nested and sloppily formulated (commas in the right locations would already help a bit). You write: 'During the year, the catchment experiences a shift between variability in summer controlled by shallow processes e.g. soils and vegetation, and in winter controlled by deeper processes e.g. groundwater pathways and bypass flow.' Actually, what you mean is that the controls of variability shift from summer to winter (which also eventually affects the catchment response).
- p. 9494, l. 10-12: You better call it 'variable groundwater storage' since you don't know the total groundwater storage.
- p. 9494, l. 12-20: There is an interesting study by Bachmair et al. (2012) that deals with water table fluctuations in different hillslope positions. You should have a look and compare your results on the different winter/summer dynamics.

p. 9494, l. 24: This is a result and should not be reported in the summary section for the first time.

p. 9494, l. 5 – p. 9496, l. 13: In general, this section needs better connections and synthesis between the single sentences. It reads like a list of unconnected statements.

p. 9495, l. 7: Unclear, please rephrase. Which relationship between which seasonal cycle and controls on variability?

p. 9496, l. 7-11: Variability also controls how fast water flows through a catchment. For a recent paper on variable transit time controls please refer to Heidbüchel et al. (2013). They also describe how changing storage states cause different predominant flow paths with different characteristic transit times.

p. 9497, l. 8-15: Please insert some more hard facts into the conclusions. For example, you state that ‘catchment variability (what is that?) is composed of multiple variability types (which ones?) and is dominated by different stores (which stores?) according to catchment wetness condition’

Figures & Tables:

Figure 4 & 5: It would be nice to combine these two figures into one.

Figure 7 & 8: It would be nice to combine these two figures into one.

Figure 10: It would be helpful to have a precipitation time series at the top. And where are the depicted depth to water table sensors located?

Figure 11: Again, it would be helpful to add a precipitation time series at the top.

Technical Corrections:

p. 9482, l. 1: ‘Even in [] headwater catchments. . .’

p. 9482, l. 6: ‘. . .catchment is LOCATED in the. . .’

p. 9482, l. 7: A river that ‘rises’?

p. 9482, l. 13: Just writing 'mean 943 mm' sounds lazy.

p. 9482, l. 17: '...gravelly...'

p. 9482, l. 19: Fig. 2 is mentioned before Fig. 1 is mentioned for the first time.

References:

Bachmair, S., M. Weiler, and P. A. Troch (2012), Intercomparing hillslope hydrological dynamics: Spatio-temporal variability and vegetation cover effects, *Water Resour. Res.*, 48, W05537, doi:10.1029/2011WR011196.

Heidbüchel, I., P.A. Troch, S.W. Lyon (2013), Separating physical and meteorological controls of variable transit times in zero-order catchments, *Water Resources Research*, 49, 7644-7657, doi:10.1002/2012WR013149.

Interactive comment on *Hydrol. Earth Syst. Sci. Discuss.*, 11, 9475, 2014.

HESD

11, C3341–C3346, 2014

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