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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Assessing the perturbations of the hydrogeological regime in sloping fens through roads" *by* Fabien Cochand et al.

Anonymous Referee #2

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1 General Comments

The manuscript addresses the issue of how road construction impacts surface water/subsurface water flow in sloping fens. The authors present experimental as well as computational results on the investigation how different types of road constructions impact the flow dynamics particular with regard to negative implications like gully erosion.

The paper is well structured and written. In particular, the figures are meaningful and well prepared. The content is of scientific interest. However, I see potential for improvement, particular in the presentation and interpretation of simulation results. After

revising the manuscript according to the comments below, I see fit for a publication of the manuscript.

2 Specific Comments

Section 1

The author give a thorough literature review on the subject of road construction and its impact on flow, erosion and vegetation. The reader is well introduced to the topic of research and the motivation of the study. However, background information on the three road structures developed in Switzerland is missing (lines 90-93). Have there been more structures developed than those presented? What are advantages and disadvantages? Are there economical and/or constructional constrains to the choice of road types? Readers might benefit from (short) answers to these questions in the introduction or conclusion, understanding better the motivation for investigating the different road types.

Section 2

Section 2.2.1 + section 2.2.3:

Section 2.2 should be reworked. The authors use a well established subsurface-surface-water simulation software HGS where process equations are well known and documented. The equations (general processes) are given in the text, but the more relevant aspects of parameter choices and boundary/initial conditions (problem specific) are not or hardly discussed. Subsection 2.2.1 resembles a repetition of the HGS manual (e.g. the sentence in l. 197 on rivers and lakes is redundant). I fully agree with stating the relevant processes and naming the equations and parameters involved, but what is the benefit of giving the mathematical equations? Have they been modified in the code for the numerical study? The authors might consider cutting out the equations

and giving proper reference to the used forms. Instead, the author should address all choices of model parameters. Give reference to Table 2. State the values of all input parameters (maybe additional table) and reason the choice and the source (measured values, educated guess, literature value etc.); e.g. explain the choice of the different Van-Genuchten parameters. Which are the most relevant parameters? Why is the sensitivity study chosen for the slope and K-values specifically? In total, the author should focus in this subsection on the core facts of the mathematics/physics behind and the relevant aspect for this specific case study. The authors should also give details on the choice of hydraulic conductivity values for the soil not only giving a reference (l. 235). The same for the values for the road drains (l.236) where there is not even a reference is given.

Figure 5 + section 2.2.2)

The resolution of the mesh cross sections in Figure 5 is rather low. It does not allow to identify any mesh structure. Specify the refinements made in the mesh (l.217). In figure 5c, are soil cells upstream connected with the soil cells below the road (not visible in figure with this resolution)? The mesh modifications for cases 5d, 5e and 5f show an artificial increase of inactive cells below the road (step shape instead of continuous slope form). This is not in line with the conceptual model structures given in Fig. 4. Shouldn't there be soil cells below the road construction? This might significantly modify the simulation results.

paragraph l.243-249

The text does not really refer to the sensitivity study but are more part of the model setup and analysis. To my opinion the locations of the observation points (Figure 6) are crucial for the interpretation of the different scenarios (see statement later). The author should clarify the coordinates of the observation points, particularly the distance to the road structures. The same holds for the observation depth. Are the velocities taken at a specific depth or are they depth averaged? Please specify in the text and

in Figure 6. I further recommend additional observation points. E.g. for comparison to flow velocities upstream, beneath the road structure and directly behind the road structure. Velocity profiles for the different road structures (and specific choices of parameter combinations) would be of interest.

Section 3

section 3.1 + Figure 7:

The resolution of the hydraulic head profiles should be adapted to the observed values in the first column for the sites SCH and STO, where the head profiles are not clearly observable in the current display form. The results for the EC contrasts (3rd column) are difficult to identify in the current form of presentation. I recommend a similar presentation as coloured pattern as in the 2nd column but preferably with a different colour scheme.

Section 3.2:

This section requires significant revision. The text is partially repetitive. Whereas several key aspects of the model results are not discussed and at some points explanation are missing.

paragraph l.288-292/Figures 8-10:

Skip figure 9 since the results presented are identical to figure 10 and therefore figure 9 is redundant. The y-axis should be labelled (v in m/d) or at least it should be stated (with units) in the caption. There are artifacts in the middle column of Figure 8 (and 9) with circles and '+' in the label area of the y-axis.

paragraph l. 293 – 301:

The entire paragraph is repetitive and not to the point. Stick to the core message and argue with Darcy's law. I find the results for the flow velocities questionable. Or at least I see necessity for further analysis and discussion on the reported flow velocities. Lets

focus on the reference case without road construction and undisturbed flow. There are almost the same flow velocities reported for the KS1 and KS2 (Figure 8) although the soil conductivities are one order of magnitude different. The effect amplifies for increasing slope (Figure 10). Making a coarse estimate with Darcy's law (assuming constant gradient, full saturation and neglecting the effect of recharge, which is of course a simplification): $v = q/n = K/n\nabla(h)$. With a porosity of $n = 0.25$, $K = KS_1 = 8.64$ m/d and $\nabla h = 0.1$ (slope of 10%), we find $v = 3.456$ m/d. This value is more than one order of magnitude higher then the highest reported velocity of 0.274. Is this related to the surface runoff? There seems to be a upper flow velocity threshold of around 0.269 (l. 294, 303). Please explain and determine the general pattern for the flow dynamics.

paragraph l. 302-313:

The same as with the previous paragraph. Again an upper velocity threshold seems to be present. There seems also an apparent velocity threshold for the different drain conductivities (e.g. first column of figure 10). The explanation in l.309 – 313 is unsatisfying. Why are the results not comparable? I cannot see why flow velocities at the observation points should not be comparable for the grid adaption.

paragraph l. 314-324:

Again repetitive, not to the point, missing explanations. What is meant with "observed in the same transect". It is unclear to what the sentence in l. 318-319 refers to. Explain what is meant with "the difference along the transect is smaller" (l. 320). The message of the last sentence (l. 322-324) is unclear.

paragraph l. 325-335

The paragraph seems to repeat the arguments just stated in the previous paragraph. Thereby the numbers given are not identical (l. 333 compared to l. 319-320). In l. 333-335, the authors mention the effect of infiltration of low-conductivity soil layers, but it is not clearly displayed. Can infiltration above/through the road structure occur? Another

possible explanation: observed velocities depend on the distance of the observation points from the road structure. For very low hydraulic conductivities the flow dynamics downstream of the road have already formed similar to those upstream of the road. For high conductivities and thus high flow velocities the distance between the road and the observation points is not big enough to establish the previous flow pattern. Therefore the author should investigate additional observation points and provide velocity profiles (in x-direction) for the different road structures.

paragraph l. 336-347

The text is again repetitive, e.g. cut out sentence in l.339). The sentence in l. 345-346) does not make sense. The preferential pathways are not small-scale processes, they are subject to the heterogeneity of hydraulic conductivity. This can be resolved by continuum scale models, but not if assuming a spatially homogeneous conductivity. Furthermore, "the exact hydraulic head in an individual mini-piezometer" is not a process. I cannot agree with the sentence in l. 346-347; simulation results using a spatially homogeneous conductivity are not an average across preferential flow paths.

3 Technical Corrections

- l. 129: subsurface flows perpendicular→ subsurface flow is perpendicular
- l. 176: The mathematical representation of the nabla-operator is not fully correct. Please put the partial derivatives in brackets to symbolize its vector character.
- l. 176: modify formulation "with the outside of the simulation domain"
- l. 306 if the hydraulic conductivity → if the hydraulic soil conductivity
- l. 319: correct "from to 0.017"

- l. 367: rephrase to “both sides of the road where hydraulically connected for all investigated road structures”
- check references (particularly appearance and positions of doi’s) as well as ref in l. 411

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