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Discussions

# *Interactive comment on* "Diurnal pattern of the drying front in the desert and its application for determining the effective infiltration" *by* Y. Zeng et al.

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We thank the reviewer very much for the helpful comments. According to the comments, we have the following response to specific comments and questions.

Response to General Comments

Comment 1: Many explanations appeared in 2.3.3 related to the soil surface boundary condition are, I think, not correct. In this version of HYDRUS, the "actual" but not "potential" evaporation rate is calculated using Eq. (10). Eq. (8) is then not applicable. Eq. (8) has been used in HYDRUS to mimic actual evaporation from the soil surface even when vapor transport has not been considered. As for h_s, the authors said that

it was set to zero because there was no runoff. That is incorrect. When h_s is set to zero, all excess water is removed as "runoff." If the user does not want to consider any runoff, a finite value, e.g., 10 mm, has to be assigned for h_s. For both cases, please see the HYDRUS manual for details.

Response 1: In the desert, if the maximum potential evaporation rate was used to mimic the evaporation from the soil surface, it is not correct. When the desert sand is saturated, the evaporation rate might reach the potential rate. However, in the field site, the desert sand was never saturated. The actual evaporation rate calculated using Eq.(10) is applicable. Here, thanks a lot for reviewer's comments. The use of Eq.(8) is not correct here. Actually, in HUDRUS, we choose the surface boundary condition determined by the "Surface Energy Balance Equation", which used the Eq.(10) to calculate the evaporation rate. And, accordingly, the surface boundary would be determined by surface energy balance calculation using the net radiation and surface temperature data. Here, we have rewritten section 2.3.3 to clarify the description of the initial and boundary condition.

As for the h_s, in HYDRUS, it is usually set as zero (HYDRUS-1D Manual (Version 4.08), January 2009, Page 36). In the field measurement, the rainfall is not enough to saturate the surface sand layer, not even to form runoff. At this sense, we just set the h_s as zero, considering the maximum pressure head at surface was far smaller then zero in this case.

Comment 2: In Figure 7(a), the authors divided the domain into two types, A- and B-type, based upon the behavior of downward fluxes. Although the authors took downward fluxes appeared in the bottom part of the domain something significant and meaningful, I think those downward fluxes are merely the effect of the zero-gradient boundary condition (free-drainage) applied to the lower bottom. The zero-gradient boundary condition keeps the bottom flux equal to the unsaturated hydraulic conductivity that corresponds to the pressure head at the bottom. This means that no matter how dry the soil is at the bottom, there is always a downward flux across the bottom boundary during the simulation. I think that is the reason there is a continuous darker area observed in Fig. 7(a). If so, the whole discussions related to A- and B-type need to be revisited.

Response 2: In HYDRUS, there are eight types of lower boundary conditions (LBC). In this case, the water table is located far below the domain of interest. Then, according to the measurement, which showed that the water content below the depth of 40cm kept almost constant, the constant water content could be used as the LBC. Then, it meant that the water content at the depth of 100cm (bottom of the domain) must keep constant. However, after running HYDRUS, the water content at the depth of 100cm decreased and there were downward soil moisture fluxes near the bottom. At this sense, we set free drainage as the LBC instead of constant water content.

Comment 3: In Introduction and the following chapter, the authors talk a lot about the Badain Jaran desert. However, in Results and Discussion and Conclusions, there is almost no single word or discussion related to this particular desert. This is very odd. I think the originality of this work comes mainly from this particular desert as simulation tools are not something new. Therefore, the authors need to add more discussions related to the Badain Jaran desert.

Response 3: This manuscript is trying to show a certain part of rainfall is possible to be captured by the sand dune. In the instruction, we showed the importance of this part of effective rainfall in the Badain Jaran Desert and cited many papers on determining the effective infiltration in the Badain Jaran Desert. After this, according to the method and material, we specify the idea on how to determine the effective infiltration using HYDRUS. Especially, in section 3.3, we detail the method of determining the effective infiltration. At last, according to the detail explanation on how to determine the effective infiltration, we claimed that the recorded precipitation is not enough to penetrate below the depth, which would keep the rainfall in the sand dune as the product of the effective infiltration. And, considering the low annual precipitation in the Badain Jaran Desert, we estimated how many millimeter rainfalls could be restored in sand dune. Actually,

the manuscript is trying to detail a method to determine the effective infiltration in the Badain Jaran Desert.

Response to Specific Comments

1. P1031 L16: Is this model fitted to the laboratory measured retention curve or to the field measured curve? Please make it clear.

Response: P1031 L16:" The fitted result between the in-situ $\theta$-h data pairs and the van Genuchten model was shown in Fig. 2b."

Here, the van Genuchten model represented that the laboratory measured retention curve. And, Fig.2b is going to show the accuracy of the water retention curve parameters got from the laboratory by the comparison between the in-situ $\theta$-h data pairs and the measured van Genuchten model. Here, the word of "The fitted result" means comparison. It is better to use 'comparison'. This has been revised.

2. P1033, L23: Just for correctness, heat transport is not part of the Richards equation.

Response: You are right. That is why we said that "..., which has been modified into the HYDRUS1D..." P1033, L22.

3. Fig. 4 and related texts: Although simulated water contents do not show diurnal cycles before the rainfall, observed water contents show clear daily variations. Why simulated water contents do not show such variations?

Response: It is related to another issue I am working on, that is how many mechanisms need to be considered for water vapor transport in soil. The HYDRUS consider the vapor transport with an enhancement factor, which describes the increase in thermal vapor flux as a result of liquid islands and increased temperature in the air phase. In addition, it is formulated by Fick's law, although with separated driving force of temperature gradient and matric potential gradient. Actually, the advection and dispersion mechanism should also be considered for the water vapor transport, both of which haven't been included in the HYDRUS. In the desert sand, the sand layer is quite dry.

In this kind of extreme arid environment, the vapor transport is important in assessing the soil wetness. It is related to the physical mechanisms for vapor transport in soil.

4. P1036, L18-21: I don't understand this statement.

Response: "However, the soil moisture flux driven by soil matric potential gradient would be kept in soil due to the existence of zero potential gradient planes that varied from the surface to the depth of about 26 cm."

In HYDRUS, the moisture flux was driven by two forces: one is the matric potential gradient; the other is the soil temperature gradient. In Fig.5b, we can find a zero matric potential gradient plane, which means that the soil moisture flux driven by soil matric potential gradient will be zero at the plane. At this sense, we said that the soil moisture flux driven by soil matric potential gradient would be kept in soil. However, if we considered the temperature gradient together, then, the soil moisture flux would be determined by the summation of both driven forces. And, indeed, it would confuse reader about this statement without understanding there are two driving forces. We have revised this.

5. P1036, L27-28: I think almost everybody knows that the soil temperature amplitude decreased with depth. There is no need to write it down.

Response: In order to keep the context to be consistent in this whole manuscript, we wrote down this common knowledge.

6. P1038, L5-8: Contradiction? Darker areas correspond to downward fluxes, which are negative fluxes. How come positive fluxes are greater than negative fluxes?

Response: "The isolated shapes of A-type darker areas were activated when the positive matric potential gradients driven fluxes were greater than the negative temperature gradient driven fluxes."

When the absolute value of the matric potential gradients was greater than the absolute value of the negative temperature gradients, after counteraction between these two

driving forces, the soil moisture flux would be driven by the positive matric potential gradients. At this sense, we made above statement in the manuscript. Considering it would confuse reader, we have revised it.

7. P1040, L17-20: I don't understand

Response: "On the other hand, if the rainfall does penetrate into the deepest drying front, the determination of this part of rainfall requires the calculation of the cumulative infiltration under the deepest drying front, which can be determined by the HYDRUS with field data."

When the rainfall is enough to penetrate below the deepest drying front, this part of rainfall could be recognized as the effective rainfall. And, the volume of the effective rainfall equals to the cumulative infiltration below the deepest drying front. Then, according to the HYDRUS, we can get detail information on how deep the rainfall penetrated and what is the variation of the soil moisture content between the deepest drying front and the deepest penetrated depth (See Fig.8).

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 6, 1021, 2009.