

Interactive comment on “A new technique using the aero-infiltrometer to characterise the natural soils based on the measurements of infiltration rate and soil moisture content” by M. A. Fulazzaky et al.

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Interactive comment on “A new technique using the aero-infiltrometer to characterise the natural soils based on the measurements of infiltration rate and soil moisture content” by M. A. Fulazzaky et al.

Anonymous Referee #4 Received and published: 2 May 2014

I was invited to review the paper entitled “A new technique using the aero-infiltrometer

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to characterize the natural soils based on the measurements of infiltration rate and soil moisture content” by Fulazzaky. I would like to thank the editor team for inviting me and apologize for the delay. At first I read the manuscript before reading the comments from the other reviewers. Then I reread the manuscript after reading the other reviewer comments. My opinion did not change but I still cannot make my choice between rejection and major corrections.

To my point of view, the topic of the paper is in the scope of the journal and the willing to link aero-infiltrometer techniques to water infiltration experiments sounds a great issue. Clearly, this subject could be treated and published in HESS. Yet, I consider that the manuscript must not be published in its present form and that a substantial number of drawbacks must be fixed before. In continuity with the other reviewers comments, my main concerns are related to a) the physics or air and water flows, ii) the presentation of the experimental setup and method that could be improved and c) the layout of the manuscript and its form (research paper ? technical note ?).

Regarding the physics of air and water flow, I agree with the fact that it would be fantastic to link both kinds of flows and establish a clear relationship. Yet, the physics are different, as highlighted by one of the reviewer. Water is the wetting fluid whereas air is not. Water will visit micro-porosity or matrix porosity whereas air may visit mostly macroporosity of even the center of the largest pores. Mechanisms are complex and air and water fluxes are linked to different kinds of friction losses. In addition, mechanisms are strongly dependant on air and water phase connexity. In soils with water contents close to saturation, the air phase connexity may no longer be ensured, the air phase constituting an ensemble of disconnected bubbles. In opposite, in very dry soils, the water phase is no longer connex and water locates at the junctions between particles. In these cases, the flow of the non-connex phase is complex and linking flows of a connex and non-connex phases may be a controversial issue. The fickian (or darcean) approach may be unappropriate. The authors should review theoretical aspects about the relations between air and water flows for the specific problem under study. Let say

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the authors are interested in air and water infiltrations. The authors should address the problems of the links between initial conditions (initial air pressure versus initial water content accounting for hysteresis) and boundary conditions (imposed air pressure versus imposed water pressure head at surface). The revised version of the manuscript may include more details about the links between the physics of air flow and water flow in soil and as well the restrictions of applications of the studied models. Or, if the authors want to avoid these aspects, they should drastically shorten the manuscript and propose a technical note dealing only with simple technical aspects.

- The following statement has been made to include into Introduction, such that: “The movements of air and water through the soils have been measured to conform to equations connecting the rate of motion with the permeability and capillarity constants of the soils. Therefore, the measurement of physical constants could replace the determination of the sizes of the soil particles as in the usual mechanical analysis of soils (Green and Ampt, 1911).” (see page 3 lines 101-105 in Marked Manuscript after Referees 1,2,3,4)

- The following reference has been inserted into the list of reference, such that: “Green, W. H., and Ampt, G. A.: Studies on soil physics, J. Agric. Sci., 4, 1-24, doi:10.1017/S0021859600001441, 1911.”

- The following statement has been made to include in Introduction, such that: “The vertical flow of air and water into a soil has been investigated that instantaneously applying a constant head of water to the soil surface initially produces a rapid diffusive change of air pressure and a slow diffusive change of water content in the soil. Fluid flow within the vadose zone, the unsaturated zone between the land surface and the water table, is greatly influenced by unsaturated hydrostatics and comprises a region of descending water at air entry conditions, below which is a transitional layer of both air flow and water flow, which connects to a region with essentially the initial capillary pressure (Weir and Kissling, 1992).” (see pages 3-4 lines 132-140 in Marked Manuscript after Referees 1,2,3,4)

- The following reference has been inserted into the list of reference, such that: “Weir, G. J., and Kissling, W. M.: The influence of airflow on the vertical infiltration of water into soil, *Water Resour. Res.*, 28, 2765–2772, doi:10.1029/92WR00803, 1992.”

- To have a clear explanation on the restrictions of applications of the studied models, the statement in the text has been improved as follows: “For the first time, both the measurements of L_w and L_p at the same time are necessary for calibration and validation of the models because temporal changes in the study area can point out a lot of parameters varying with time, such as seasonal changes of water table, grass growth and changes in soil physical properties.” (see page 6 lines 229-232 in Marked Manuscript after Referees 1,2,3,4)

Regarding experimental setup and calculations, I was unable to understand certain points regarding the treatment of the experimental data and experimental conditions. Firstly, the authors could detail the reasons for their choices in imposed air pressure and water pressure head at surface and the link between these values. Do air infiltration and water infiltration correspond since respective boundary conditions do not correspond necessarily? Secondly, the effect of lateral flow strongly differ with the apparatus since the aero-infiltrometer has small radius and water infiltration is supposed to be 1D with the double ring infiltrometer. Thirdly, the experimentations differ by their durations and volumes of sounded soil. Air infiltration seems quick and may correspond to a small volume of air whereas the water infiltration experiment is much longer (see table 1). As a result the characteristics derived from these experiments correspond to different volumes of samples.

Regarding the treatment of data, could the authors explain how they combined the two kinds of data. In particular, they gathered the data of air infiltration (e.g. columns 1-2 of Table 1) with the data from water infiltration (columns 3-4, table 1) to get more precise data for both air level of pressure drop and cumulative infiltration. I really don't see how they combined the data. This point is all the more crucial that the procedure of combination may affect the relations between air and water variables proposed in

Figure 4 and 6. At last, as quoted by one of the reviewer, equation (4) is false since the initial water content can be non negligible and it assumes the profile is uniform in water content (allowing to use mass balance considerations to derive an averaged water content).

- To improve the explanations on how two kinds of data combined have been made as follows: “As starting point to establish the empirical equations that the variable t data reading from the aero-infiltrometer (see Table 1 Column 1) and those from double-ring infiltrometer (see Table 1 Column 3) were inserted into one column (Column 5) of cumulative t (Cum. t). The following calibrations (Fig. 3) were made that: (1) both interpolation at Cum. t = 5.0 minutes and extrapolations at Cum. t = 10.0, 15.0, 20.0, 25.0, 30.0 and 35.0 minutes of plotting L_p (Column 2) versus τ_{av} (Column 1) can be performed to avoid lack of the cumulative L_p (Cum. L_p) data of 10.5, 15.1, 18.8, 21.9, 24.6, 27.1 and 29.4 kPa (Column 6), having then the correlation of plotting Cum. L_p versus Cum. t gives us confidence in the fidelity of the calibrated model for air diffusion into the soil and (2) interpolations at Cum. t = 0.7, 2.0, 4.9 and 8.9 minutes of plotting L_w (Column 4) versus t (Column 3) can be performed to avoid lack of the cumulative L_w (Cum. L_w) data of 0.5, 0.8, 1.0 and 1.2 cm (Column 7), having then the correlation of plotting Cum. L_w versus Cum. t gives us confidence in the fidelity of the calibrated model for water infiltration into the ground.” (see page 7 lines 276-288 in Marked Manuscript after Referees 1,2,3,4)

Regarding the layout of the manuscript, the reading gives the feeling that some information was added at specific places in the manuscript in response to reviewers' comments. But this has rendered the manuscript too long. In addition, some parts should be placed elsewhere in the manuscript. For instance, lines 5-20 of page 2525 are too general to be in the material and method section. Please, place these in the introduction. Instead of these general statements, the material and method section should present more specific details in particular about the way data are combined or statistical analyses. A specific section should include also a proper description of all

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the soils under study. Or, the authors can turn the proposed paper into a technical note and to show only some of the data of the aero-infiltrometer and water cumulative infiltration and give more details about how the connection can be done between these two kinds of data to derive the maximum of information on the soil hydraulic properties.

- All the following statements (lines 5-20 of page 2525) have been placed into Introduction, such that: "Saturated hydraulic conductivity depends more strongly on bulk density, organic carbon content, and land use (Jarvis et al., 2013). The effects of soil sorptivity decrease with time, and the final f asymptotically approaches the saturated hydraulic conductivity of the soil (Diamond and Shanley, 2003; Reynolds et al., 2002). The movement of water and air in a vadose zone is studied within soil physics and hydrology particularly hydrogeology and is of importance to agriculture, contaminant transport, and flood control. Water flows in a vadose zone are often described using the Richard's equation, which partially derived from Darcy's law (Kumar, 2004). Part of the voids in soil is occupied by water and the remainder by air. Rainfall flows through a vadose zone are the primary sources of recharge for aquifer. Spaces in soil that are not occupied by solids are known as the soil pores; the total volume of pores is the soil porosity, which consists of the part of the soil volume occupied by air and water (Rahardjo et al., 2004; Chinevu et al., 2013). If the vadose zone envelops soil, the water contained therein is termed soil moisture. Since θ is defined as quantity of the water contained in the soil porosity, the portion of the soil volume occupied by water is measured by θ . This property is used to a wide range in scientific and technical areas and is expressed as ratio of the water volume contained in the soil porosity, comparing the total volume of pores." (see page 3 lines 112-128 in Marked Manuscript after Referees 1,2,3,4)

- The following section has been made to include in the manuscript, such that: "Section of 2.1. Soil type and study area: Three sites of field natural soil experiment were carried out at Parit Raja around the campus of Universiti Tun Hussein Onn Malaysia (UTHM), a sub-district (town) of Batu Bahat district in Johor state, Malaysia. The area of this

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town is about 12 km² with land-use comprises residential, agricultural, commercial, industrial, and lawn/open space. The climate is characterized by warm and humid throughout the year with an average annual rainfall between 2,000 and 2,500 mm. Average daily temperature ranges from 26 to 34 oC with a mean relative humidity of 88%. The rainfall is highly localised and dominated by convective storms type. The monthly rainfall pattern is quite uniform with the highest usually recorded in April and December. All the soil types in the area of study are alluvial soils, around 30 m depth below the land surface typified by clay underlying from soft to very soft clay and around 35-40 m depth characterized by bedrock layer. Depth of groundwater table ranges from 0.5 to 2.5 m.” (see page 4 lines 167-180 in Marked Manuscript after Referees 1,2,3,4)

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 2515, 2014. C1239

Please also note the supplement to this comment:

<http://www.hydrol-earth-syst-sci-discuss.net/11/C1290/2014/hessd-11-C1290-2014-supplement.zip>

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 11, 2515, 2014.

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