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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Analytical and Numerical Solutions of Radially Symmetric Aquifer Thermal Energy Storage Problems" *by* Zerihun K. Birhanu et al.

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The manuscript intends to investigate thermal transfer in aquifers through radially symmetric flow system. The underlined goal is what could lead to possible difference in heat transfer in solid grains (matrix) and the pore water in between. It is, however, that pore waters are in small pore spaces well confined by grains that local equilibrium could be reached for water and grains, in a relatively short frame in time and distance.

The flow equation from the start is wrong in equating both sides (weight unit vs. volumetric unit) [in Eq.(1), see detailed specific comment No.5 below]. The thermal flow is not effectively coupled with water flow, because water flow is assumed a constant

throughout the space (rather than considering its variation in a radial space). So the analytical solutions are not solving the flow in Darcy's law [Eq.(1)].

The results presented are mostly for very short time as in several seconds, and thus could be considered to be insignificant due to the limited time duration. Because figures show too fast conductions that thermal effect reaches half a meter in several seconds (Figures 1,2,4), the heat transfer shows the results seemingly wrong.

The figures drawing is poor and the manuscript is hard to follow, especially in notations for the equations. The physical meaning for the parameters is difficult to understand. (See specific comments throughout detailed below.) Considering the deficiency above, this reviewer recommends a rejection for this article to be published in HESS journal.

Specific and detailed comments: 1a. Title The title is vague and misleading.

1b. Abstract Line 4 "....artificial dispersion. There is a good correspondence..." need a better transition

2. p.2 (1 Introduction) Lines 19-20 What is the usefulness regarding this paper?

3. p.2 Line 25 What is the alternative solution?

4. In p.2 There are no objectives here for the research paper.

5. p.2 Eq.(1) The Darcy's law is wrong in formulation. The left side is flow rate in weight per unit area per unit time through a unit area (e.g., kg/mˆ2/s); however, the right side is flow rate in volume per unit time per unit area (e.g., mˆ3/mˆ2/s). They are different by a ratio of density, needing the viscosity μ to be kinematic viscosity (mˆ2/s).

6. p.3 Line 19 conduction/diffusion of heat What is the difference between conduction and diffusion? Is diffusion significant here?

7. Page 4 Line 11 Eq.(12) P used for heat exchange is confused with pressure p used in Eq.(1).

8. Page 4 Line 27 Eq.(17) What is the n here in the formula? What are these terms meant for?

9. Page 5 Line 19 What is the i in the formula?

10. Page 6 Line 10 What is sensitivity analysis here?

11. Page 6 Line 22

12. Page 7 Figure 1 There are no labels for the subplots. The heat diffusion coefficient λ 0.1 mˆ2/s values differ so great that these values might become unphysical. (There needs a space before the unit for illustrating λ.) What does the κ1 1.0 m/s mean [see Eq.(23)]? This could be too big a number also.

The unit for t (time) is only having the range of 0.1 to 1 s. (Judged from what are shown in Figures 6,7,8, the time t is surely in seconds.) Since the plot is for the temperature distribution over the domain in a very short time, it is unreasonable that the temperature disturbance could be up to 0.5oC in a place 0.5 meter deep inside. Beside, the lines cannot tell apart.

13. Page 9 Figure 2 has a problem similar with that for Figure 1 (see Question 12).

14. Page 9 Line 12 The s has already used for time. Using it again for transformation causes confusion.

15. Page 11 Figure 4 has similar doubt as in Figures 1 and 2.

16. Page 14 Table 1 What are the mK, kgK used in the unit?

17. Table 2 The grain sizes in the table are uncharacteristically large as in 100 mm, 500 mm. In such a large grains, the contact interfaces might just become very small relatively so that heat transfers between grains are not that effective.

18. Figures 6,7,8 These figures miss labels for subplots. The lines are not differential, especially in a black and white print.

19. Page 16 "6. Conclusion" Lines 2-3 "...presented numerical and analytical solutions for radially symmetric flow" The analytical solutions presented are actually not for flow. The flow equations were not solved for flow velocity. This reviewer believes only heat transfer equations were solved or discussed, with the assumption that the specific flow q (in Eq.(1)) is constant (See text in Page 5 Lines 17-20, Eqs. 22, 23, 24). (In a radial flow, q should be a variable.)

20. Page 17 Lines 3-4 The results from the analytical solutions are shown at the time of only several seconds. The thermal response could be too dramatic to be realistic in such a short several seconds of time, given that the characteristic time scale for thermal conductions is much larger.

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