College of Geosciences

Department of Geology & Geophysics, College Station, TX 77843-3115
Hongbin Zhan, Ph.D.
Professor of Geology and Geophysics, Professor of Water Management and Hydrological Sciences
Holder of Endowed Ray C. Fish Professorship in Geology
Tel: (979) 862-7961, Fax: (979) 845-6162, Email: zhan@geos.tamu.edu
http://geoweb.tamu.edu/zhan

April 16, 2014

Memorandum
To: Dr. M. Sabine Attinger, Editor, Hydrol. Earth Syst. Sci.

Subject: Revision of hess-2013-461

Dr. Attinger:

Upon the recommendations from two anonymous reviewers, we have carefully revised our manuscript hess-2013-461 entitled "Forchheimer Flow to a Well Considering Time-Dependent Critical Radius". The following is the point-point response to all the comments.

Response to Reviewer #1:

General Comments:

1. The manuscript deals with the modeling of well flow in the subsurface. It suggests a modification of the dual domain (Darcian and non-Darcian) approach developed in the past by adopting a time dependent critical radius, which delimits the two regions. The manuscript is well written and organized, and the topic is of potential interest for the HESS reader.
Reply: Thanks!

2. The innovation brought by this contribution can be considered as incremental; the method is interesting but it mainly brings some fine-tuning to the otherwise known two-region approach. Thus, I believe that the contribution is more suited to a technical note rather than a full paper. This is also somewhat suggested by the nature of the discussion, the figures and the conclusions; most of the items reproduced in the conclusions seem rather a technical check of the model rather than a novel finding.
Reply: We have changed the manuscript as Technical Note.

Specific Comments:

1. It is still unclear to me why a single non-Darcian region should not work well within the entire domain. When the velocity is low, the inertial term is small and the model approximates the Darcian one. This issue is briefly touched in the Introduction, but it is not adequately discussed in my view. This point raises a question mark about the usefulness of the two-region approach, as well as the present contribution.
Reply: We have added more explanation (see P8 Lines 1-3 and Lines 15-20; P9 Lines 1-3). In addition, the results show that the difference between the single non-Darcian region model and the two-region model is obvious even at late stage (see P8 Lines 1-3), as show in Fig. 4b.

2. The advantages of the method are not fully clear. What are the benefits in introducing a time variable critical radius? Is the method more accurate? This is not immediate as the conceptual model adopted (two distinct regions with two flow behaviors) is anyway an approximation.
Reply: We have given some detailed explanations (see P8 Lines 15-20; P9 Lines 1-3).

108 Halbouty
3115 TAMU
College Station, TX 77843-3115

Tel. 979.845-2451 Fax 979.845-61627
Geoweb.tamu.edu

3. The interested reader may want to know when the non-Darcian models are needed: can you please provide some values regarding head gradient or flux, as compared to the hydraulic parameters?
Reply: The condition that non-Darcian happens depends on the critical Reynolds number, which is not only related to the head gradient, but is also related to the porous media properties (see P10 Lines 1-6). For instance, one can see from Eq. (1) that in addition to the Darcy velocity and viscosity of water, the characteristic grain diameter is also needed to calculate the critical Reynolds number.

4. Page 14100, line 20: Why Pec is set equal to 10?
Reply: Re_C has been changed to 100 to make sure non-Darcian flow happens (see P10 Lines 8-10).

5. Equation 2. The solution is given before having discussed the various approximations involved (fully penetrating well, homogeneous and isotropic formation, etc.)
Reply: We have given the conditions for Eq. (2) (see P10 Lines 17-18).

6. Choice for beta in the examples: the value seems rather large to me; please provide a range of realistic values for it. Clearly, a large beta overestimates the effect of nonlinearity in the flow solution.
Reply: We have explained this point (see P13 Lines 3-10, P14 Lines 13-15).

7. Is the convergence of the method always warranted?
Reply: The answer is yes (see P18 Lines 4-7; P19 Lines 9-10).

8. Figure 4. The sudden change of slope and regime in the drawdown regime (two region models) look rather unrealistic, and it indeed reflects the two-region conceptual model that is adopted here. Same for Fig. 7. Can the Authors provide a sound physical justification of such behavior, beyond the model adopted?
Reply: We have given the explanations on this observation (see P20 Lines 11-14).

9. Line 14110, line 24: the choice for beta is important; please better explain your choice, beyond the Wen et al. citation
Reply: We have presented the explanations for this point (see P13 Lines 3-10; P14 Lines 13-15).

Response to Reviewer #2:

General Comments:

1. The paper presents a new concept of describing the critical radius between Darcian and Non-Darcian Flow in a time dependent way. The work is well embedded into previous work on the issue of Forchheimer flow near wells. It contains a comparison with previous solutions dealing with Forchheimer flow near wells and clearly describes difference and extensions. The derivation of the time-dependent critical radius uses established methods and is sufficiently complete. The paper contains an appropriate discussion of results. The authors examined the impact of several important quantities/parameters on the behavior of the newly derived solution for the time-dependent critical radius. The presentation of results is of mixed quality. The paper is well structured and presents a sufficient number of figures and tables.
Reply: Thanks!

2. It should be considered to reduce the draft to a technical note.
Reply: We have changed the manuscript as Technical Note.

Specific Comments:

1. p 14097, line 15:”some researcher”: clarify who
Reply: We have changed “some researcher” into “George and Hansen (1992)” (see P6 Lines 3-4).

2. p14098, line 14/15/16: content of the sentence is unclear
Reply: We have revised it (see P7 Lines 6-9).

3. p14099, line 6: clarify under which conditions the analytical solutions of Sen (1988) and Wen et al. (2008) are valid
Reply: We have clarified it. The analytical solutions of Sen (1988) and Wen et al. (2008) were valid for the groundwater flow in the quasi-steady state (see P8 Lines 7-9).

4. p14099, line 11: why referring to Sen (1988) and Wen et al. (2008) in the context of quasi-steady state flow (with respect to the sentence in line 6)?
Reply: We have revised it (see P8 Lines 7-9).

5. p14101: line 2: give literature reference of this formula
Reply: We have added the literature reference of this formula (see P10 Lines 17-18).

6. p14102: line 5: Where does this sentence refer to? Is that assumption taken for the following statement? Then "We assume...“ or "Under the assumption of ...“
Reply: We have revised it (see P12 Lines 5-7).

7. p14103: line 1-4: account for the fact that hydraulic conductivity is assumed to be constant (homogeneous aquifer), this is an important assumption when dealing with well flow problems
Reply: We have revised it (see P11 Lines 13-15).

8. p14107: line 13/14: please specify the sets of aquifer parameters
Reply: We have revised it (see P18 Lines 4-6).

9. p14108/14109: Why it is necessary to introduce the solution of Sen (1988) in detail in equations (33)-(36)? And if the solution is introduced, why are not those of Papadopoulos & Cooper (1967) and Mathias et al. (2008), as stated in line18? Recommendation: remove Eq (33) - (36).
Reply: We have deleted Eqs. (33) - (36).

10. p14109: line 10: specify what figures 4a and b show: a comparison of the distance drawdown curves for all 4 models/solutions
Reply: We have revised it (see P19 Lines 17-20).

11. p14111: line 26: How can that be explained by using Eq.(37)?
Reply: We have revised it (see P22 Lines 9-11).

12. p14113: line 2: Why r_D=0.1, when explaining figure 8 which refers to r_D=1?
Reply: We corrected it, and r_D=0.02 (see P23 Lines 14-15).

13. p14113: line 9: "The convergence of this iteration method has been verified.“ How? (Where was that done in the previous sections?)
Reply: We have revised it (see P24 Lines 1-3).

Figures:

1. figure 2a: dotted lines are very difficult to distinguish
Reply: We have revised it (see Fig. 2a).

2. figure 2b: lines in legend difficult to refer to lines in the plot
Reply: We have revised it (see Fig. 2b).

3. figure 4a,4b: either in the legend or in the caption should be assigned which flow model (Darcian, fully non-Darcian,...) refers to which model/solution (Mathias et al. (2008)...) dotted lines are very difficult to distinguish (4a), recommendation of using the same line style in both plots
Reply: We have revised it (see Figs. 4a-4b; P31 Lines 7-12).

4. figure 5: specify the caption: the plot shows the time-dependent critical radius R_CD(t) for different values of the inertial force coefficient beta
Reply: We have revised it (see P31 Lines 13-14).

5. figure 6: specify the caption: the plot shows the time-dependent critical radius R_CD(t) for different values of the critical specific discharge
Reply: We have revised it (see P31 Line 15).

6. figure 7/8: Why using different scales at the y-axis? Recommendation of using log-log-plots for both figures
Reply: We have revised them and plotted two figures in the log-log coordinate system (see Figs. 7 and 8).

7. figure 5,7,8: recommendation of using the same line style in all plots (same lines for the same values in beta) and keeping the order in the legend constant dimensions are missing at labels (Figs. 2, 4-8)
Reply: We have revised them (see Figs. 2, 4-8).

8. In general: plots should be made more fashionable (strong recommendation)
Reply: We have revised all figures according to the reviewer's comments (see Figs. 2, 4-8).

Technical corrections

1. p14097, line 2: in respect of/with respect to
Reply: We have revised it as "with respect to" (see P5 Line 11).

2. p14097, line 28: what is dolostone?
Reply: We have revised it (see P6 Lines 13-15).

3. p14098, line 2/3: greater than
Reply: We have corrected it (see P6 Line 17).

4. p14100: line 4: simplify
Reply: We have revised it (see P9 Line 15).

5. p14100: line 20: set to
Reply: We have corrected it (see P10 Line 9; P17 Line 13; P18 Line 12,).

6. p14100: line 21: is in linear relation to
Reply: We have revised it (see P10 Line 11).

6. p14100: line 23: space character after calculate is missing

Reply: We have added a space there (see P10 Lines 13-14).

7. p14101: line 3: in case of
Reply: We thought it should be “in the case of”, and have revised it (see P10 Line 20).

7. p14103: line 7: compose (without of), probably change the sentence construction
Reply: We have revised this sentence (see P13 Lines 13-14).

8. p14115: line 10: "Wasserbewegung durch den Boden“
Reply: We have revised it, and “Wasserbewegung durch den Boden” should be changed into “Wasserbewegung durch Boden” (see P26 Line 19).

9. p14110: line 13: "Therefore, the new solution agrees...“ (skip the "it is not suprise to see that“)
Reply: We have deleted “it is not surprise to see that” (see P20 Lines 19-20).

10. p14110: line 15: "Another fact that can be seen in Fig. 4b is that the new solution...“
Reply: We have revised it (see P20 Line 20; P21 Lines 1-2).

11. p14111: line 8: skip the "that“
Reply: We have deleted “that” (see P21 Lines 14-15).

12. p14111: line 13: "Therefore, R_CD does not depend on beta under quasi-steady state flow conditions, it only depends reciprocally...“
Reply: We have revised it (see P21 Lines 19-20).

13. p14111: line 23: "show“ instead of "represents“
Reply: We have changed “represents” into “show” (see P22 Line 9).

14. p14112: line 17/18: "...deflection point in the curve , that becomes larger in time with increasing beta_D.“
Reply: We have revised it (see P23 Line 6-8).

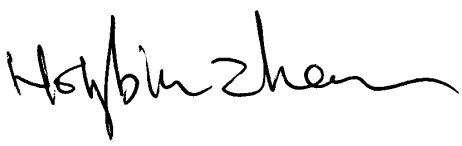
15. p14114: line 5: "larger“ instead of "longer“
Reply: We have changed “longer” into “larger” (see P25 Line 1).

16. Very often space characters are missing (in particular in front of brackets)
Reply: We have checked the whole manuscript, and added the space character if necessary.

17. In general expression in English should be improved
Reply: We invited a native English speaker to check the grammars of the article, and revised them accordingly.

Please contact me if you have further questions.

Sincerely Yours,



Hongbin Zhan, Ph.D., P.G.