

## ***Interactive comment on “On Coupled Unsaturated-Saturated Flow Process Induced by Vertical, Horizontal and Slant Wells in Unconfined Aquifers” by Xiuyu Liang et al.***

**Anonymous Referee #1**

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### **General comments**

In this manuscript, the authors develop the model for the interpretation of pumping test in an aquifer with variable saturation for both horizontal as well as partially inclined wells. The model is derived using a semi-analytical solution of the coupled saturated-unsaturated flow processes. To facilitate an analytical treatment of the non-linear Richards equation, the authors linearize the equations by assuming low pumping rates. Both the saturated and unsaturated systems is coupled by assuming continuity of pressure and fluxes at the interface. The semi-analytical solution of this coupled system is eventually used to infer the hydraulic parameters of the subsurface.

C1

The manuscript itself is well structured but poorly written. A significant revision of the English is needed. The introduction gives an adequate overview on the relevant questions and properly motivates the study. The methods section provides the reader with the necessary information on the mathematical background with more information being provided in the Supplementary Information. The results are presented twofold. The analytical solutions to the coupled systems are first derived for a number of special cases. Numerical solutions for these cases are then presented and discussed in Section 4; Results and discussion. These numerical results are given in a way that it easy to follow and understand. The data given through figures clear and sufficient to support the conclusions drawn by the authors. The presented conclusions may be relevant for the Scientific Community interested in horizontal well drilling. However, the authors fails to properly motivate the need for their study and to present results that are relevant to practitioners. In conclusion, I think the manuscript needs major revisions before being eligible for publication in HESS.

In the following, I will list a number my concerns that should be fixed to improve the manuscript.

### **Major Concerns**

- The used geometry and the considered processes were chosen to be very simple in order to facilitate the use of analytical tools for the investigation. For example, the geometry is considered to be spatially uniform and exhibits no anisotropy which is unusual for a three-dimensional medium. Such simple models aren't bad if the insight derived from them can be properly transferred to real-world problems. At this point, the authors need to explain why they think these simplifications are possible and critically assess their impact on their results.
- In my opinion, the authors fail to properly put their results into context. Instead

C2

the authors should better demonstrate why and when the difference between their model and two older models for pumping in coupled saturated-unsaturated systems matter. I am not doubting that their approach has not been done before, but this does not automatically make it relevant and interesting. To show that, the authors should begin by explaining some problems of the two older models, and subsequently demonstrate how their newer approach can remedy these problems. In particular, they should be able to discuss how these observed differences relate to actual real-world features.

### Minor Concerns

- There are consistently no captions for the Figures.
- Furthermore, the quality of the figures is generally bad. The authors may want to use another compression format or a lower compression rate.
- Line 197: I think the authors mean that the linearity of the system allows to superimpose the solutions of Equations (5) and (7).
- Line 202: The authors mention turbulent flow. How is this possible for a linear system?
- Line 207: The authors use a uniform flux rate for the spatially extended wells. Can the approach also be used with arbitrary flux rates?
- Line 238: Here the authors say that the Stehfest algorithm was sufficiently accurate for the flow problem. That is just an assertion and should be backed up by at least some evidence.

### C3

- Line 242: The use of the word 'real-time solutions' is confusing here. I first thought the authors would derive the solution on the fly. Maybe they should say 'solution in the time domain'.
- Line 242-244: This sentence is confusing. Please reformulate.
- Line 248: What is the kinematic equation? I am not familiar with this approach.
- Line 256: For most of the time the authors use the passive voice in the manuscript. Here they suddenly switch into the active voice. Although I like the active voice much better, the authors should be consistent.
- Line 266: The gray line mentioned here is actually hard to see, due to the aforementioned bad quality of the figures.
- Line 270-273: This sentence is long and confusing. Please consider to reformulate this statement.
- Line 280: The authors use the passive voice with respect to a figure. This is confusing and, to the best of my knowledge, not proper English.
- Line 318: This is not a proper sentence. Please reformulate.

### Typos

As mentioned above, the manuscript suffers from poor spelling, grammar and several typos. In the following, I will provide a short list of examples.

- Line 69: of *an* unsaturated
- Line 105: with a *slightly*

### C4

- Line 153: much *shorter* periods
- Line 155: where the influence of plant transpiration is
- Line 176: *with* respect to
- Line 176: overbar *denotes*
- Line 232: and thus *a* numerical
- Line 254: the manner *how* the
- Line 259: For convenience
- Line 259 well screen *to be situated* along
- Line 285: at *later times*
- Line 297: For large
- Line 314: to *a* smaller
- Line 325: *closer* to
- Line 326: across *the* water
- Line 329: the *impact* of
- Line 335 For early times
- Line 338: *This* results
- Line 365: of *the* unsaturated