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Comment on hess-2021-380

Anonymous Referee #2

Referee comment on "Advances in the Hydraulic Interpretation of Water Wells Using Flowmeter Logs" by Jesús Díaz-Curiel et al., Hydrol. Earth Syst. Sci. Discuss., https://doi.org/10.5194/hess-2021-380-RC3, 2021

Comments on the paper HESS-2021-380 entitled: “Advances in the hydraulic interpretation of water wells using flowmeter logs”, by J. Diaz-Curiel et al.

This contribution revisits the concepts of flowmeter logs (i.e. measuring water velocities within the casing of a well) to discuss on the ability of the technique to identify various hydraulic behaviors (mainly hydraulic conductivity) of flowing water bearing bodies cross-cut by a pumping well. These water bearing bodies are referred to as stretches by the authors, some kind of sub-series of neighbor superimposed sedimentary layers with presumably homogeneous hydraulic behavior.

The key question motivating the revisiting is that each stretch could be under the influence of its own hydraulic head gradient (which is logical, if those stretches are weakly or not connected within the subsurface aquifer system), a feature usually not accounted for in classical interpretations.

As the application targets a deep and large-diameter well cross-cutting several stretches under forced flow (from large extraction rates in the monitored well above the depth investigated via flow logs), the interpretation of logs needs for a preprocessing of the raw data. My understanding is that flow within the blind or the screened casing of the well stands between inertial and turbulent flow. In any case, the water velocity measured by the impeller of the flow log probe is not the mean velocity through the whole section. This raw velocity is corrected by relying upon classical formulas of turbulent flow in pipes to provide actual velocities at various depths along the cased well. These profiles also allow for calculating the local head loss (Delta-h) along the well by relying upon the Darcy-Weisbach relationship stating that the head loss (or head gradient) is proportional the squared velocity of water. It is worth noting that the authors are very picky on the way they pre-process the data. It is not clear in the writing if this procedure is mandatory for getting reliable information. I could also figure out that this procedure is specific to the application of log interpretations over wide wells and under large extraction rates. One can doubt on the usefulness of all that stuff in small wells. Do we become over-gunned for example, when passing through fractured (karstified) layers, with small-diameter wells weakly stressed by the extraction rates of a few liters per second (a classical investigation in that context). Anyway, who can do more, can also do less! I keep still in mind the fact that head losses within the wide-diameter wells (as stated by the authors with a different phrasing, lines 341) are negligible compared with hydraulic head loss in the diverse water bearing bodies cross-cut by the well. Stated differently re-interpreting inflows from stretches in a well could also consider that the head within the well is uniform over its whole depth… Good news!

Another interesting feature of the study is that it investigates a single well for water supply (of 475 m depth) passing through several separated and confined aquifers. This is completely prohibited by the legislation of many countries! In these countries a single well should be completely blind-cased and cemented until it reaches the targeted aquifer. Reaching and monitoring another aquifer above or beneath would need for another distant well, also blind cased over its wellbore through the above formations. It goes without saying it that a single well passing through several stretches is an opportunity to record continuous flow logs, with less errors than those of reconstituting a synthetic log from different distant wells. Another way to say that is to consider that the well investigated by the authors is probably an outlier (at least an exception) in the Literature, which deserves exposure in a scientific paper of large audience.

The diverse flow stretches are analyzed under the forced flow conditions that allow for the interpretation of their hydraulic property. My understanding is that the authors employ the classical formula of the drawdown in the well in the form of the Jacob equation: s = aQ + bQ^p with s the drawdown, a and b constants, Q the extracted flow rate from a stretch, p a power law factor. With several extracted rates Qi over the diverse stretches (i), for the different sum of extracted rates (sum Qi) above the log, the authors force the Jacob relationship with a factor p=1… Then, (a+b)i is proportional to the hydraulic conductivity of the stretch and identified (via the Thiem equation) if the static head far from the pumped well is known… Not that much tricky but absolutely not clearly explained at all in the paper… I would urge the authors to put dots on I and cross on T, especially in Section 4.6, on the way they derive conductivities from local measurements of flow rates (from flow logs) and an overall head drawdown between the monitored well and a distant location. It took me time and a few head scratch, to conjecture how the authors did it. For the rest, everything is clear…

Finally, I thing that the paper could be published almost as it appeared at its first release. A few imprecisions could be cured with cosmetics adjustments.

- Line 96. Not well said. A single scalar value (that of a conductivity in a layer) is always proportional to another one (that of the whole wellbore) up to a multiplying constant: a = (a/b)*b!
- Fig. 1-left (or Fig. 6). I would have swapped in one of the figs the horizontal and vertical axis, so they can read exactly the same way without leaning the head at 90° in Fig 1-left, to find the same plot as in Fig-6. By the way, in Fig. 1-left the coefficient "A1" = 0.6 should read "A4" = 0.6.
- Line 180. Specify which terms are involved in the Reynolds number, especially the "length" that I guess to be the diameter (radius) of the well.
- P. 7, Fig. 2. Specify that k in the notations Rek is the iteration index of the convergence algorithm, and not anything else.
- Line 200, Eq. 7. Please also remind the form employed for the Darcy-Weisbach equation. Several form exist, even if one can guess that in here the form is: Gradh (or Deltah) = (f/2g)*(V^2/D) (D effective diameter of the well, g gravity, V water velocity, and f friction factor).
- P. 13, Table 2. Not clear how the deltah in the table are calculated. Is that a mean from bottom to top handling a mean friction factor and a mean velocity over the whole depth investigated? Or is that (what I think better) the cumulated Delta h adding the successive local delta values relying upon local friction factors and local water velocities?

- P. 15, Fig.8-a (the three left plots). It I unclear to me what mean the alternating grey and white bars beneath (left to) the three curves. They do not seem to be the alternation of geological layers, as they are not the stretches (#1 to #6) reported in Fig. 8-B (the three right plots). Do they correspond to intervals where the monitored velocities in the flow logs are quite uniform?