Review of

Technical note: High density mapping of regional groundwater tables with steady-state surface nuclear magnetic resonance – three Danish case studies

General comments

This paper describes the application and results of the steady-state SNMR method recently developed by the Aarhus working group on different sites in Denmark. The water content models of the inversion results (inversion with vertical smoothness constraints) are depicted and compared to transient electromagnetic data. The authors estimate water tables from the maximum gradient of the shallowest water content increase in these models. The water tables are depicted in maps and are compared to the water levels measured in boreholes.

The manuscript is well structured and easy to follow. The measurement progress of the steady-state method compared to the standard SNMR method is impressing. However, I have some concern regarding the relevance of these case studies, at least in the form in which these are presented in this initial version of the manuscript. It reads like a pure documentation of the measurement progress that the new system can make. However, it is not possible to assess the output. Thus, I suggest major revisions:

1. An uncertainty analysis of the water table results is missing. The reader is not able to assess them. Differences between estimated and measured water tables (from boreholes) remain undiscussed. In Fig. 5 discrepancies of several meters can be seen. What is the problem here? Is this an issue for future research? Can it be solved in some future?
2. The authors state that the decrease in the water content models can be attributed to clayey sediments in the subsurface without providing any evidence. They stress that regions with low resistivity (from TEM) indicate clay layers that explain the decrease of the mobile water content, but many water content models are not in agreement with this assumption. Corresponding examples are ignored in the discussion.
3. The sensitivity of the applied pulse sequences with depth should be presented and taken into account for the interpretation of the results. Maybe the decrease of water content mentioned above is simply due to the decreasing sensitivity with depth in many measurements.

In addition to showing at least one example sensitivity function for the SNMR measurements, I further suggest a detailed documentation of at least two data examples – maybe one of the best and one of the worst measurements. This could demonstrate the potential and also the limitation of the proposed SNMR method.

Specific comments

P3L83: Fig. 1

P4L90-92: The style of the pulse…

- Please give a reference for the interested reader who wants to learn what the difference is and why it matters to control the polarity of the pulse.

P4L93: The number of pulse moments…

- More explanation is necessary:
    - What is the current range?
    - What impact has the sampling density given by the number of pulses?

P4L95: with -> considering !? Why one minute, not more or less?

P4L96: I suggest switching the last two sentences of this paragraph to refer to the tables in the order in which they actually appear.

P4L97: information regarding -> "general information regarding" or "an overview of…"

P4L101: The spectral analysis approach is not standard in SNMR post-processing, please give a reference.

P5L112: What is a stabilizer function? Please give a reference.

P5L120: It is hard to believe that these alternative regularization approaches will really give "identical" results -> maybe formulations such as "very similar" or "the same with regard to the uncertainty of the measurements" are more appropriate.

P5L129: At what depth does the clay approximately appear? As we learn later, the SNMR results are maybe affected by it.

P6L133, Table 2:

- The label of the first row "pulse" is misleading. Obviously, you apply more than just four pulses. I suggest "pulse protocol" or "scheme".

P6L140: What are the criteria for this heuristic determination? Your statement reads very arbitrarily. It is better to exclude those datasets that do not allow the application of the described procedure.

Even with the data presented (Fig.2), I cannot understand how your procedure can lead to the marked water tables for S6 and S7. For these two, the marked lines do surely not correspond to the maximum gradient of the water content increase. In my optinion it would be better to admit that your procedure cannot be applied to all the data and that future research is necessary on this issue. For S6 and S7, I suggest setting the water tables for S6 and S7 to zero, which seems reliable given the SNMR data.

The same is true for S3 and S5 in Fig.3.

P10L190: This is an effect…

- Please reformulate this statement. Of course, there will be shallower water tables when the terrain slopes.

P10L200: “Evident” is too strong in this context unless you present ground truth. Again, please provide at least an estimate of the depth at which clay layers were found on your test sites.

P10L204: shows

P10L206: Please discuss the decrease of the mobile water content of S3 (Fig.5b) in detail. Here, there are no indications of a conductive layer in the subsurface.

P10L207: Also in Fig.5c, there are undiscussed discrepancies. Regarding the TEM results, the models of S1 to S4 should be very similar. Please discuss why this is not the case.

P10L209: That statement is not true. Please reformulate or erase this sentence. By having all these water table estimates it is possible to track nothing more than the water tables in the region.

P11L217: I totally agree. Do you plan to implement such constraints in the future?

P11-12, Figure 4 and 5: I do not see the point why you focus the analysis on three different profiles in this area, when all these profiles show in principle the same water levels without significant changes. As a matter of fact, there is some variation that could be interesting to focus on, e.g. the two yellow points with water tables at about 15 m. However, these are excluded from the profile analysis. Even if these estimates are not plausible it is much more interesting to discuss them and to learn about the limitations of the method.

Anyway, if you prefer to show different profiles, please label all the different involved measurement points clearly, e.g., from S1 to S20 for the current analysis, and include these labels in the map to guide the reader through these two figures.

P13L247: I cannot accept this conclusion, at least not as direct conclusion of your analysis. Of course, we expect that the content of mobile water descreases with increasing clay content. However, this relationship is not doubtlessly evident by the depicted datasets. For many of the depicted water content models, the decrease actually starts at depths shallower than the corresponding decrease in resistivity, see for instance S1, S2, and S4 in Fig.3 and S6 in Fig.5a. And there are even models where the mobile water content decreases without any indications of having a clay layer in the subsurface, see e.g., S3 in Fig.5b.