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Hydrology and Earth System Sciences Discussions

Interactive comment on "Quantifying freshwater resource in coastal barriers: the joint use of transient electromagnetic and magnetic resonance soundings" *by* J.-M. Vouillamoz et al.

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I thank very much the reviewer for her detailed comments which are useful for improving both form and content of the manuscript.

1/ General comments: You are right, our paper aims at presenting a ready-to-use methodology for assessing groundwater resource, and I gave attention to the interest of coupling hydrogeology and geophysics based on the capabilities and limits of the tools we used.

2/ Specific comments:

*P5262, L11-17, I completely understand the arguments that drilling and hydraulic testing is not always possible, but was any performed to check the results achieved from applying the suggested methodology in the current survey?

–> Yes, we drilled 9 observation piezometres for monitoring the water table and the water electrical conductivity (see figure 3 where the piezometers are located on profile 2) in areas where local wells were not available (we also monitored 65 local wells) . However, we did not implement hydraulic tests for avoiding salty water up-rising. I will make this point clearer in the abstract.

*P5264, L10, "..to estimate the properties in 1-D of coastal aquifers in Myanmar but it was applied in confined aquifer conditions." This "but" indicates that the aquifer in this survey is unconfined, and I don't know if it should be obvious, but mentioning it explicit earlier could help the reader.

–> Yes, you are right: I will mention it explicitly.

*P5265, L28, "In this paper, we compare Sy measured on sand samples with phiMRS". This is indeed very interesting and relevant. The results are described on P5274 from L7, where the resulting sample porosity is mentioned and compared to the MRS water content. If any additional information of this comparison exists (for example uncertainties, sample variations, illustrations etc), it could be very relevant to expand this section.

–> Ok, I will give more details in the manuscript on these results. For the 5 samples we collected: 28.3%<porosity<33.6% with an average relative uncertainty of 0.1% (due to uncertainty in weight measurement). Dry samples have been weighted and then fully saturated: the increase of weight was used for calculating the porosity(see P5272L6-10).

*P5269, L14, What is saturated geometry? Water saturated layers?

–> Yes, by "saturated geometry" I mean "water saturated layer". I will modify the

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manuscript to avoid any confusion.

*P5272, L15, I agree that the first layer cannot be resolved by TEM, but what about the second layer that is less than 5 m thick, isn't this also problematic to resolve?

–> You are right the second layer can not be resolved with TEM alone, but it is resolved when using the sequential inversion process (P5269, L10-25). However, because the thickness of the fresh water layer (if exists) is thin, the second layer is a single layer for both fresh and brackish water. I did not discuss in this section the equivalence on the second layer because we are only discussing the 3rd layer resolution to solve Archie equation. However, the equivalence on the second layer and its impact on the estimate of fresh water volume are discussed in the next section (Fig5B and 5C and P5274 ,L25).

*P5272, L20-23, Description of the fourth layer is missing, the other 4 layers are described. And just a question; can the third and fourth layer really be distinguished from each other with the resistivities being quite similar? Maybe they can because of the low resistivities at relatively low depth.

–> I will describe this 4th layer more explicitly in the manuscript: I mentioned (P5272, L22) that this layer is probably the weathered gneiss, and I suppose that it is clayey (I drilled several deep boreholes few kilometres from this location and I found quite thick clay-weathered gneisses). Yes, the 3rd and 4th layers are really distinguished: adding this 4th layer reduces the error (RMS) from 1.9% to 0.6%.

-P5273, section 1, the procedure in this section is a little unclear. In L19 "..the water EC is linearly increasing with depth", and the arguments for this simplification is information from the monitoring wells, but mentioned is only one ECpiezometer value. Can it be mentioned what the uncertainty of this assumption is and what uncertainty it causes on the resulting aquifer thickness? When first reading I did not have figure 5c because it disappeared when printing, which may have caused my confusion.

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–> For demonstration purpose, I only presented one example of EC piezometer value, but we monitor the EC values in 65 wells on a weekly basis (P5272, L2). This monitoring is the basis of our assumption regarding the linearly increase of water EC with depth. However, it is obviously a simplification which is clearly mentioned in the section "5. Limitations". I think that the main uncertainty in the fresh water thickness is driven by the TEM equivalence which results on an uncertainty on the water volume of about +/-10%, P5274, L25).

*P5275, section 3, Is the estimated KMRS and TMRS used in the conclusive estimation of the fresh water thickness and volume?

–> No, KMRS and TMRS are just mentioned in this section for illustrating how MRS can also be used for estimating T: it is not the topic of this paper but I think it could be useful for engineers who are not used to MRS but who need K values for modelling purposes.

*P5275, L16, It would be interesting to see the parameter uncertainty of the depth to the salt water for the TEM interpretations. Is it less than 1 m in order to resolve the variations illustrated in fig. 7?

–> Yes, the uncertainty is only 0.3m because of the very low conductivity of the sea-water layer.

*P5276, L7, if the MRS boundary uncertainty is +/- 8 cm, wouldn't you have expected to observe the variations with MRS to some extend since the variations interpreted with TEM is 10-15 cm if I understood right?

–> No because +/- 8cm is the uncertainty of MRS depth to the saturated layer but 10-15cm is the change in the depth to the sea-water intruded layer. Because the static water level is not really changing (see fig 8), MRS can not distinguish any change in the depth to the saturated layer, and thus TEM monitoring reveals that the thickness of the fresh/brackish water layer is changing.

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*P5277, L21-p5279, L2, the description of less successful attempts with different geophysical methods are very relevant and valuable, so thank you for including these descriptions.

–> Thank you for your comment because it has been a huge work to compare (based on modelling but also on numerous field measurements) all these methods!

3/ Technical corrections: Thank you again for your suggestions concerning the English editing, I will modify the manuscript accordingly.

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 9, 5261, 2012.