

Dear Authors and Editor,

This paper presents a case study for testing the utility of multiconfiguration EMI surveys to characterize the internal structure of a representative paleochannel in an alluvial plain setting of the river Seine, France. There is a growing interest in using near-surface EMI techniques for mapping relict geologic features, such as; paleochannels, towards improving our understanding of how these features influence groundwater dynamics as well as how they control the development and evolution of the modern landscape. The results from this study show an interesting application of EMI, ERI, and auger soundings to map the internal structure of a paleochannel. However, I think there are several key pieces that are missing regarding the link between methods and the “bigger picture” attempting to understand the long-term hydrological processes. Thus, it is my opinion that the paper is incomplete in its present form, but could improve if there is more emphasis on the main considerations I have outlined below. I have made comments and questions throughout the manuscript, roughly following the order of the paper, which should be considered as suggestions for helping to improve the paper.

Main considerations:

- 1) In the abstract, the authors state that “A detailed knowledge of the internal heterogeneities of such paleomeanders can thus lead to a comprehensive understanding of its long-term hydrogeological processes.” Similar statements are made in Lines 44-48, however, the findings of this study are not described within a framework of how EMI, when calibrated with ERI and auger soundings, contributes to a better understanding of the hydrological processes of the river Seine alluvial plain “La Bassée.” I realize that the main focus of this paper is to map the internal geometry of the paleochannel, but I am left wondering why the authors make the above statements without any discussion throughout the paper? The authors end (Lines 358-362) by stating that their technique “could significantly improve the accuracy of hydrological modeling...” but this will be debated later (it is unclear whether this is another phase of the project, conference?). It is my opinion that this is a critical piece that is missing from the paper. Without this important discussion, the paper is missing a key aspect of how EMI methods provide an innovative way of characterizing the geological controls on hydrologic processes, and as a result, falls short of satisfying the aims and scopes of the journal http://www.hydrology-and-earth-system-sciences.net/about/aims_and_scope.html.
- 2) Why didn't the survey go beyond the expected boundaries of the channel, visible in the LiDAR data? In other words, the surveys were only performed within the channel, making it difficult to fully characterize the variations in lithology/hydrology inside and outside the channel. Although vegetation cover (treeline) seems to be one limiting factor for the survey design, based on the LiDAR map, it seems feasible that the survey could have extended further to better capture the transition between outside and inside the paleochannel.
- 3) The structure of the paper in the Methods and Results/Discussion sections is confusing. There is a mixing of methods and results in the Methods section, and nearly all of the results and figures are presented in the Methods section, with no figures presented in the Results/Discussion section, which is only two pages long? If the authors can 1) restructure the Methods, and Results/Discussion sections, 2) incorporate a more in-depth discussion of the hydrologic influences on the EMI measurements, water table

information, weather conditions, and survey design, and 3) relate the results of the EMI surveys to how the “estimation of the geometry of the Seine river can provide valuable insight into its paleo-hydrology...” then they will have a paper that is beneficial for geologists, geophysicists, and hydrologists interested in these complex problems.

Specific comments/suggestions:

Abstract:

- Lines 23-25: As stated above, there is no discussion about this later in the paper and how the methods used in the present study can help address this important problem

Introduction:

- In general, the Introduction is not referenced enough (e.g., Lines 34-37; 54-63; 64-72). There are several other studies that have looked at very similar problems that the current paper is trying to address, and should be cited. For example, please refer to Fitterman et al. (1991); Maillet et al. (2005); De Smedt et al. (2011), which also used similar procedures to investigate paleochannel geometry, thickness, etc.
- Line 39: I suggest defining electrical conductivity as: σ , and apparent conductivity as: σ_a , and use this notation consistently throughout the manuscript. In fact, apparent electrical conductivity (Lines 50-51) is mislabeled (not σ as stated) and should be σ_a .
- Line 40: Fine sediments do not necessarily correspond to conductive, and coarse sediments to resistive materials. Fine and coarse sediments that consist of the same mineralogy (e.g., quartz) should in principle have similar resistivities. What is missing here is that the mineralogy, quartz, clay, etc. is also an important property. In addition, the porosity and fluids within the pore space, whether freshwater or saline water, also have an important influence on σ . This needs to be clarified.
- Lines 44-48: Similar to my above comment for the Abstract. The idea that EMI can be used to provide valuable insight into the paleo-hydrology and as the author’s state, climatic fluctuations, does not come out later in the discussion of the paper.
- Line 51: “over a large surface,” or is it that EMI methods are capable of covering large areas/distances over relatively short periods of time?
- Lines 54-63: There are no references in this paragraph, and citations are needed as this information regarding the background EM physics is probably not general knowledge to the reader.
- Line 61: This should be “respectively, imaginary and real”
- Line 63: I haven’t seen this term used before in the literature: “apparent depth of investigation,” and have only seen it reported as the depth of investigation (DOI), see Huang, (2005), and references therein.
- Lines 67-70: I think a fourth point to add is that the DOI is also a function of the height of the instrument above the ground.

- Line 78: What are “typical conductive properties”? Perhaps give a few examples here.

Description of the study area:

- What is missing from this section is a description of any information on the depth of the water table, as this is important for data processing and interpretation.
- Lines 105-107: This is already stated in lines 47-48, and could either be removed or combined with the earlier statement in the Introduction.
- Line 116: What kind of soundings? Borehole soundings from a hand auger?
- Line 138: Please change “this” to “these”
- Line 144: This sentence should be referenced
- Lines 145-149: This last paragraph seems a bit out of place in the Study Area section. The objectives of the study should be listed in the last paragraph of the Introduction

Methodology, Measurement setup:

- Overall, I am surprised to see that most of the results and nearly all of the figures are discussed in the Methods section and not the Results section? It is confusing to the reader and I am left wondering why the authors chose to structure the paper in this way? I think the clarity of the paper could be improved if the basic background of the methods is described in the Methods subsections, and the results be left for the Results/Discussion section. In fact the Results/Discussion section is only 2 pages long, compared to 6 pages of Methods!
- Line 153: Please provide the details of where you got the LiDAR map, i.e., what database, the dates of data collection, how it was produced, etc. Also include a citation.
- Lines 155-157: This sentence is repeated in Line 162, and is Line 158 intended to be a separate paragraph, or part of the same paragraph?
- Lines 162-164: Electromagnetic induction (EMI) is already spelled-out before, and I don't think it is necessary to write ElectroMagnetic (EMI); Horizontal CoPlanar – HPC, and Vertical CoPlanar – VCP, like this. In other words, I don't think it is necessary to capitalize the beginning of each abbreviation as this is already common knowledge in the literature, i.e., electromagnetic induction (EMI), not ElectroMagnetic Induction.
- Line 167: What is the approximate DOI for each offset? It would be useful to include this instead of just saying “a distinct DOI.” Additionally, it would be helpful to mention what the instrument height above the ground was, as well as what the step-size was (e.g., 0.5 m), what was the acquisition mode (stationary/fixed spacing, continuous mode, random walk). In other words, what were the specific survey details used in this study? Also, what is missing here is a description of the weather conditions, and how long the surveys were performed, when they were performed, as these are also important for the reader to understand what the conditions were during data acquisition.

- Line 168: Why were “slightly different sampling intervals used”? This needs to be explained. Shouldn’t the sampling intervals be the same if the intention is to compare different dipole configurations at the same acquisition point?
- Line 170: Please change “attempting to merge” to “merging” as attempting to do something implies that you were not able to do it.

Auger sounding results:

- Much of this section is results and not methods. Is it possible to briefly summarize the methods that you used for the auger sounding here and present the results in the Results section? This also follows for the other subsections in the Methods section, which are a mix of methods and results.
- Line 183: Missing PTA 06, as this also contains a peat layer according to Figure 4.

ERI results:

- Again, much of this section is mixing methods with results.

EMI calibration from ERI:

- Have the authors performed any other site-specific calibrations such as; instrument drift, temperature effects, topographic effects? These have been shown to be important for data processing (see Sudduth et al., 2001; Delefortrie et al., 2014) and is not discussed in the current study.
- Line 207: “near surface” should be hyphenated “near-surface”
- Lines 217-222: This is similar to what was already described in the Auger sounding results section and can either be removed, or combined with Lines 175-183.
- Line 241: Please change “developed in Schamper et al” to “developed by Schamper et al”
- Line 244: Please change “once the calibration done” to “once the calibration is done”
- Line 246: Please remove “Actually” at the beginning of the sentence, and start with “Despite”
- Lines 250-251: “All those non-straightforward steps...” I would suggest rewording the start of this sentence and remove “non-straightforward”

Inversion parameters:

- Line 270: Please remove the word “clearly”
- Lines 280-281: As mentioned above, the instrument height should be mentioned earlier in the paper.
- Lines 284-286: An equation sign is missing, e.g., $RMSE = \dots$, also there is no equation number assigned to this equation (1) on the right-hand side of the margin. Please check the journal formatting for equations.

- Lines 289-290: Is this sentence meant to be a standalone paragraph? This information is also listed in the Figure 8 caption (Lines 480-482).

EMI inversion results and discussion, General trend:

- Lines 294-295: The introductory sentence is a standalone paragraph? Is this a formatting error when Line 296 should be a continuation of the same paragraph? Also, same comment for Lines 307-308.

Conclusion:

- Lines 341-342: Please delete “(CMD explorer from GF instruments,” as this is already mentioned earlier in the paper.

Figures:

- Figure 1, Line 441: In the bottom panel, is the study area highlighted by the small red star on the figure? It would be helpful to either enlarge location star, or show a boxed area where the surveys were performed to help the reader easily locate the study site. Additionally, for the figure caption there is a typo: “maps” should be uppercase “Maps,” and add the word “bottom” after “plain” to denote the top vs. bottom panels.
- Figure 2, Line 443: Please change “studied area” to “study area”.
- Figure 3: It would be helpful to show where the locations of the auger soundings were performed with respect to the geophysical surveys
- Figure 4, Line 454: Please change “log” to uppercase “Log” to begin the sentence.
- Figure 5, Line 460: Please remove the word “clearly”
- Figure 7, Line 473: Please change “histogram” to uppercase “Histogram”

Best Regards

References:

- De Smedt, P., Van Meirvenne, M., Meerschman, E., Saey, T., Bats, M., Court-Picon, M., De Reu, J., Zwertvaegher, A., Antrop, M., Bourgeois, J. and De Maeyer, P., 2011. Reconstructing palaeochannel morphology with a mobile multicoil electromagnetic induction sensor. *Geomorphology*, 130, 136-141.
- Delefortrie, S., De Smedt, P., Saey, T., Van De Vijver, E., Van Meirvenne, M., 2014. An efficient calibration procedure for correction of drift in EMI survey data. *Journal of Applied Geophysics*, 110, 115-125.
- Fitterman, D.V., Menges, C.M., Al Kamali, A.M. and Jama, F.E., 1991. Electromagnetic mapping of buried paleochannels in eastern Abu Dhabi Emirate, UAE. *Geoexploration*, 27, 111-133.
- Huang, H., 2005. Depth of investigation for small broadband electromagnetic sensors: *Geophysics*, 70 (6), G135–G142.
- Maillet, G.M., Rizzo, E., Revil, A. and Vella, C., 2005. High resolution electrical resistivity tomography (ERT) in a transition zone environment: application for detailed internal architecture and infilling processes study of a Rhône River paleo-channel. *Marine Geophysical Researches*, 26, 317-328.
- Sudduth, K. A., Drummond, S. T., Kitchen, N. R., 2001. Accuracy issues in electromagnetic induction sensing of soil electrical conductivity for precision agriculture. *Computers and electronics in agriculture*, 31, 239-264.