“Monitoring soil salinity using time-lapse electromagnetic conductivity imaging” - authors’ responses to suggestions and comments made in Public Discussion

Dear editor and referees,

We sincerely appreciate and thank your constructive comments on our manuscript. We have revised the manuscript according to your suggestions and comments. We hope that the revised version of the manuscript properly addresses your concerns.

Our answers are placed in blue below each of the referees’ interactive comments, and also below each of Referee #2’s comments and corrections, provided in the supplementary annotated .pdf. The changes to the manuscript, arising from the referee’s comments, are written in grey. We also added a section with some additional changes.

Sincerely,
Mohammad Farzamian on behalf of all authors

Authors responses to referees' comments

Anonymous Referee #1

https://doi.org/10.5194/soil-2019-99-RC1, 2020

In this paper, the authors explored the use of time-lapse EMI surveys and a 1-D inversion algorithm to predict soil salinity (ECe) at different depths at four sites in Lezíria de Vila Franca. A pre-established calibration equation was used to convert sigma to ECe. The model performance was good given the large R2, and Lin's concordance. They conclude that the method has the potential to be used for the rapid monitoring of soil salinity dynamics for agricultural management.

In general, the study is well-written and provides a nice example of monitoring soil salinity using non-invasive EMI surveys. I have a few comments about the manuscript.

We would like to thank Anonymous Referee #1 for evaluating our manuscript. We highly appreciate the overall positive comments.

1. The authors need to elaborate more on the pre-calibration of the EM38 meter. How are the variations of soil temperature (affecting soil ECa) be corrected?

The calibration of EM38 was done using the routine procedure (inphase nulling and instrument zero) recommended by the company at the beginning of measurements at each field.

We have also performed electrical resistivity tomography (ERT) surveys at the four locations and along the same EMI transects right after EMI surveys (2-3 times at each location), in order to evaluate by comparison the precision of the EMI data and models, as well as to explore the potential drift of the EM38 sensor. The ERT technique has usually a better precision in measuring soil electrical conductivity, but it is more effort- and time-consuming in the field, which limits its application for large-area investigations. The obtained ERT models agree with the EMCIs shown in this paper, which gives confidence to the EMCIs models. However, the results of this comparison are not in the scope of this paper.

Unfortunately, borehole temperature data were not available at the study sites (which are private farms) to correct the impact of soil temperature changes over the EM38 models. We agree that the lack of temperature correction will add to the uncertainty of temporal EC_e changes assessment, although the impact of temperature changes over soil electrical conductivity is expected to be relatively small compared to soil salinity. We revised the text including the introduction, results and conclusion to address this issue.

Old version (line 244)

"Furthermore, the influence of static soil properties (i.e., that do not vary in time), such as clay content, could be tackled with the use of maps of the variation of soil salinity between two consecutive dates, which allows removing the static effect in the EMCIs."

New version

"In addition, the influence of static soil properties (i.e., that do not vary in time), such as clay content, could be tackled with the use of cross sections of the variation of soil salinity between two consecutive dates, which allows removing the static effect from the EMCIs. Future attempts can be made on finding ways to quantitatively account for the impact of dynamic soil properties (i.e. θ and temperature) on the EMCIs to optimize temporal soil salinity assessment."

Old version (line 45)

"EMI measures the apparent electrical conductivity of the soil (EC_a, dS m^{-1}), which is primarily a function of soil salinity, soil texture, water content, and cation exchange capacity; however, in a saline soil, soil salinity is generally the dominant factor responsible for the spatiotemporal variability of soil EC_a."

New version

"EMI measures the apparent electrical conductivity of the soil (EC_a, dS m^{-1}), which is a function of soil properties such as salinity, texture, cation exchange capacity, water content and temperature. However, in a saline soil, soil salinity is generally the dominant factor responsible for the spatiotemporal variability of soil EC_a."

Old version (line 183)

"Furthermore, this test set is composed of measurements collected over a wider period of time (18 months). During this period, soil properties, which are also known to influence σ, such as θ, change (as shown in Fig. 3), which introduces larger variability in the measurements."

New version

"Furthermore, this test set is composed of measurements collected over a wider period of time (18 months). During this period, soil properties, which are also known to influence σ, such as temperature and θ, change , which introduces larger variability in the measurements."

2. Please discuss more on the pre-determined linear calibration equation. Since the soil water content is measured, can you include this in the model to improve the model performance? Can the variations in soil water content or soil texture explain the small misfit between the predicted ECe and measured ECe?

The water content could be included along with σ in the model for prediction of EC_e. As these variables are linearly correlated, this could be achieved through a principal component regression (PCR). But in this paper our aim was to test the validity of the regional calibration over time, which includes wide variations of water content and other conditions, because the strength of the regional calibration is that it is very practical for monitoring salinity in this large area. If the water content would be included as a predictor in the model, it would have to be measured along with σ in the field, which would increase the complexity of the monitoring process.

In previous studies we also found that, in this study area, the water content is correlated with σ, but that properties related to salinity (EC_e, SAR and ESP) have a larger influence on σ. We propose to add the following text for further clarifying this aim and its limitations. We also strengthen the importance of validating the previous approach with an independent test set, adding a new paragraph.

Old version (line 59)

"(...) and sodium adsorption ratio."

New version

"(...) and sodium adsorption ratio. In this later study, the authors performed a principal component analysis of the soil properties in the study area, and found that the water content was correlated with sigma, but with a relatively lower influence when compared to the properties related to salinity (EC_e, SAR and ESP).

Because the inversion of EC_a is relatively recent since the use of EMI for soil characterization, the lack of validation using an independent data set still limits the use of this new methodology (Corwin and Scudiero, 2019), making it therefore important to further test its accuracy in salinity monitoring."

The reference will also be added to the references list.

"Corwin, D.L. and Scudiero, E.: Chapter One - Review of soil salinity assessment for agriculture across multiple scales using proximal and/or remote sensors. Adv Agron, 158, 1–130, https://doi.org/10.1016/bs.agron.2019.07.001, 2019."

The soil electrical conductivity is a complex function of soil properties, including soil texture, water content and salinity. Therefore, water content and soil texture could impact the misfit between the predicted EC_e and measured EC_e.

3. If possible, is it possible to include soil water content in the calibration model and develop a pedo-transfer physical model coupled with a novel inversion algorithm to simultaneously retrieve soil water and ECe values from time-lapse EMI surveys of ECa values in the future?

It is mathematically possible to develop such an inversion algorithm, but it goes quite beyond the scope of the present paper. It is worth mentioning that one can not estimate both water content and EC_e from soil electrical conductivity alone as both parameters influence soil electrical conductivity. On the other hand, including water content in the EC_e estimation and possible inversion algorithm requires water content measurements along with EMI measurements in the field. Please see also our answer to the previous question.

Anonymous Referee #2

https://doi.org/10.5194/soil-2019-99, 2020

Dear Maria Catarina Paz et al., the study entitled 'Monitoring soil salinity using time-lapse electromagnetic conductivity imaging' provides an overview of salinty assessment using EMI data and inversions together with ground-truth data in an agricultural area close to Lisboa. In general, the manuscript is very well written and the narrative is nicely presented.
With this review, I enclosed some comments in the annotated .pdf ('soil-2019-99supplement.pdf') that is provided with the review process. Please consider the comments in that pdf for further improvements. Including my aspects together with the suggestions of the previous reviewer, I'd recommend publishing the manuscript in SOIL.
Kind regards, Referee 2

We would like to thank Anonymous Referee #2 for evaluating our manuscript. We highly appreciate the overall positive comments.

Supplementary .pdf

Line 24: "~~satisfactorily~~"

OK. We have revised the text accordingly.

Old version (line 24)

"The results showed that ECe was satisfactorily predicted, (…)".

New version:

"The results showed that ECe was predicted, (…)".

Line 47: salinity is dominant as long as soil is moist

We agree and have revised the text accordingly.

Old version (line 47)

"(…) however, in saline soil, soil salinity is generally the dominant factor responsible for the spatiotemporal variability of soil EC_a."

New version

“(…) however, in saline soil, soil salinity is generally the dominant factor responsible for the spatiotemporal variability of soil EC_a when soil is moist.”

Line 54: please include here some more studies that use EMI and EMI inversions. e.g., Corwin&Scudiero (Advances in Agronomy), von Hebel et al. 2019 (sensors), Kaufmann et al. 2020 (Soil Use and management), Wang et al. 2019 (JGR), Guillemoteau et al. 2019 (GJI)

We have now included more references.

Old version (line 47)

“EMI surveys have been successfully used in conjunction with soil sampling to assess soil salinity through location-specific calibration between measured EC_a and soil salinity (e.g. Triantafilis et al., 2000; 2001; Corwin and Lesch, 2005; Bouksila et al., 2012).“

New version

“EMI surveys have been successfully used in conjunction with soil sampling to assess soil salinity through location-specific calibration between measured ECa and soil salinity (e.g. Triantafilis et al., 2000; 2001; Corwin and Lesch, 2005; Bouksila et al., 2012; Corwin and Scudiero, 2019; Guillemoteau et al., 2019; von Hebel et al. 2019; Wang et al., 2019; Kaufmann et al. 2020).”

Line 62: Please rephrase the sentence that no study maps salinity. Actually, this is why the EM38 was invented back in the 1980-ties. Numerous EMI studies map salinity. Also with inversion. E.g., by Triantafillis group.

We agree that many studies inverted EMI data for soil salinity mapping. However, the sentence relates to the inversion of **time-lapse** data for **monitoring** soil salinity in time which has not been reported yet to the best of our knowledge. No changes to the text were made relative to this comment.

Line 103: Although the EM38 is well known, please include the basic information like coil distance, coil orientation, depth range of investigation. This also help "new readers" guiding through the inversion results.

Agreed. We have revised the text accordingly.

Old version (line 103)

“EMI data was acquired using the EM38 instrument (Geonics Ltd, Mississauga, Canada) on five dates at locations 1 and 4, and on six dates at locations 2 and 3, during the period of May 2017 to October 2018.”

New version

“EMI data was acquired using the EM38 instrument (Geonics Ltd, Mississauga, Canada). Technology of this instrument is based on two coils, one transmitting the electromagnetic signal, and the other receiving it, distanced 1 m apart from each other inside the instrument case. The position of these coils can be controlled by placing the instrument in a vertical position relative to the soil surface - horizontal dipole mode (the coils stand in the horizontal position), which provides a maximum depth of investigation of 1.5 m - or in a horizontal position relative to the soil surface - vertical dipole mode (the coils stand in the vertical position), which provides a maximum depth of investigation of 0.75 m. EM38 surveys were done on five dates at locations 1 and 4, and on six dates at locations 2 and 3, during the period of May 2017 to October 2018.”

Line 105: accuracy of GPS?

GPS has 5 m position accuracy. We can add the accuracy of the GPS to the sentence.

Old version (line 104)

“Measurements on the two first dates were continuously acquired along 100 m transects using a GPS (Rikaline 6010) for registration of the position.”

New version

“Measurements on the two first dates were continuously acquired at each location, along a 100 m transect, using a GPS (Rikaline 6010, with 5 m position accuracy) for registration of the position.”

Line 106: unclear description of measurement procedure along/at the transects

We have revised the text accordingly.

Old version (line 105)

“Subsequent EMI measurements were acquired at positions 1 m apart along 20 m transects (Fig. 1c), overlapping the medium section of the 100 m transects.”

New version

“Subsequent EMI measurements were acquired at each location, along a 20 m transect. The middle point of each 20 m transect was coincident with the medium point of each previous 100 m transect. Measurements were acquired at positions 1 m apart along the 20 m transects (Fig. 1c), overlapping the medium section of the 100 m transects.”

Line 107: how was the height assured?

The height of measurement was assured by using a cart built specifically to carry the EM38 in the four positions - horizontally and vertically both at 0.15 m and 0.40 m. We revised the text to make it more clear.

Old version (line 107)

"EC_a was collected at two heights from the soil surface (0.15 and 0.4 m) in the horizontal and vertical dipole orientations".

New version

"EC_a was collected at two heights from the soil surface (0.15 and 0.4 m) in the horizontal and vertical dipole orientations, which was assured by placing the EM38 on a cart built specifically for this purpose. The cart has two shelves to accommodate the instrument, one at 0.15 m from the soil surface, and the other at 0.40 m from the soil surface."

Line 111: were the data interpolated to the same position at each transect? The data of each measurement date would differ. Specify the distance between the inversion positions.

Only the first two EMI surveys at each location were performed using a GPS to collect large amounts of data and to cover a bigger area to investigate spatial variations of EC_a at the beginning of the experiment. For these specific surveys, all readings at different heights and orientations were interpolated using an inverse distance to a power algorithm to the positions of the reference profile. We used a sampling rate of one measurement per second with speed walking of about 1 m/s resulting in sampling spacing of about 1 m. Subsequent EMI measurements were acquired **manually** at **1 m** spacing and along a small transect of 20 m for monitoring. No interpolation was required in this case as all readings at different heights and orientations were made at the same point.

Line 116: Details on the model are the least information that need to be included here. How many layers? Which depth? Fixed layer depths or is the layer thickness optimized as well?

The layer thickness in the inversion process is fixed and only the conductivity of each layer is optimized during the inversion process. We have revised the text to address the reviewer concern.

Old version (line 115)

"An Occam regularization (De Groot-Hedlin and Constable, 1990) based approach was used to invert the EC_a data. To run the algorithm, several parameters are selected, such as the type of inversion algorithm, the number of iterations, and the smoothing factor (λ) that controls the roughness of the model. The optimal inversion parameters for the present conditions were obtained in previous studies for the study area (Farzamian et al., 2019)."

New version

"An Occam regularization (De Groot-Hedlin and Constable, 1990) based approach was used to invert the EC_a data. All EC_a data, collected at the four locations, were inverted by applying a five-layer earth initial model with electrical conductivity of 100 mS m^{-1} and a fixed layer thickness of 0.30 m. To run the algorithm, several parameters were selected, such as the type of inversion algorithm, the number of iterations, and the smoothing factor (λ) that controls the roughness of the model. The optimal inversion parameters for the present conditions were obtained in previous studies for the study area (Farzamian et al., 2019)."

Line 119: "1.35m" - typo? 1.5 m is meant?

1.35 m is correct. We revised the text to make it more clear.

Old version (line 118)

"At each sampling site, five soil samples were collected at 0.3 m increments to a depth of 1.35 m, (...)".

New version

"At each sampling site, five soil samples were collected at 0.3 m increments, from a depth of 0.15 m to 1.35 m, (...)".

Line 129: what is the distance between the four locations?

Location 1 to location 2: approximately 4 km; location 2 to location 3: approximately 5 km; location 3 to location 4: approximately 4.5 km. Location 1 to location 4: approximately 12.5 km.

Line 130: "~~However~~"

This word is needed here to express the fact that, although both calibrations are comparable, the regional one can be used expeditelly at any new location in the study area, which can't be done by the location-specific ones. No changes to the text were made relative to this comment.

Line 133: RMSE = 2.54 dS/m -> error in slightly-saline range

The RMSE of 2.54 dS m^{-1} is good given the large range of EC_e (0-37 dS m^{-1}). We have revised the text and included the range of EC_e in the study area.

Old version (line 132)

"The regional calibration was based on data collected during May and June 2017 and was validated using a leave-one-out-cross-validation method with good results (RMSE = 2.54 dS m^{-1})."

New version

"The regional calibration was based on data collected during May and June 2017 and was validated using a leave-one-out-cross-validation method with good results (RMSE = 2.54 dS m^{-1} in the 0–37 dS m^{-1} range)."

Figure 3: Please include on top of each figure:

left column: Transect i Theta (symbol)

right column: Transect i ECe

The figure shows θ and EC_e measured **in the sampling site** (pontual measurement) located at the middle of each transect, not θ and EC_e for the **entire transect**. Adding the transect number could be confusing for readers. Therefore we suggest revising the caption of the figure to make it more clear.

Old version (caption of Fig.3)

"Volumetric water content (θ – m^3 m^{-3}) and electrical conductivity of the soil saturation extract (EC_e – 165 dS m^{-1}), in the topsoil (0–0.3 m), subsurface (0.3–0.6 m), upper subsoil (0.6–0.9 m), intermediate subsoil (0.9–1.2 m), and lower subsoil (1.2–1.5 m), measured at the sampling site located in the middle of each transect, at locations 1 to 4, during the study period."

New version

"Volumetric water content (θ – m^3 m^{-3}) and electrical conductivity of the soil saturation extract (EC_e – 165 dS m^{-1}), in the topsoil (0–0.3 m), subsurface (0.3–0.6 m), upper subsoil (0.6–0.9 m), intermediate subsoil (0.9–1.2 m), and lower subsoil (1.2–1.5 m), measured in the sampling site located at the middle of each transect, at locations 1 to 4, during the study period. Each circled number refers to each location. Crosses refer to the dates when there were EC_e measurements but no σ measurements, due to adverse field conditions."

In the legend, please replace sigma by ECe

The mention of σ in the plot's legend is correct. In fact, in those dates, we measured only EC_e but we could not perform EM38 surveys due to the adverse field conditions. To make it more clear, we can add the following sentence in the figure caption: "Crosses refer to the dates when there were EC_e measurements but no σ measurements, due to adverse field conditions."

Old version (caption of Fig.3)

"Volumetric water content (θ – m^3 m^{-3}) and electrical conductivity of the soil saturation extract (EC_e – 165 dS m^{-1}), in the topsoil (0–0.3 m), subsurface (0.3–0.6 m), upper subsoil (0.6–0.9 m), intermediate subsoil (0.9–1.2 m), and lower subsoil (1.2–1.5 m), measured at the sampling site located in the middle of each transect, at locations 1 to 4, during the study period."

New version

“Volumetric water content (θ – m^3 m^{-3}) and electrical conductivity of the soil saturation extract (EC_e – 165 dS m^{-1}), in the topsoil (0–0.3 m), subsurface (0.3–0.6 m), upper subsoil (0.6–0.9 m), intermediate subsoil (0.9–1.2 m), and lower subsoil (1.2–1.5 m), measured in the sampling site located at the middle of each transect, at locations 1 to 4, during the study period. Each circled number refers to each location. Crosses refer to the dates when there were EC_e measurements but no σ measurements, due to adverse field conditions.”

Line 168: The prediction results are totally unexpected here. Please show the inversion results first together with a description and profound discussion.

Thank you for the suggestion. Those results will be included as a new section, that will appear before the conversion of σ to EC_e through the regional calibration. This section will be new section 4.2. Old section 4.2 will now be section 4.3, and old section 4.3 will be section 4.4. There will be a new Fig. 4. Old Fig. 4 will become Fig. 5, and old Fig. 5 will become Fig. 6.

New version

“**4.2. Time-lapse EMCIs**

Figure 4 shows the obtained EMCIs at locations 1 to 4 for each date of the EMI surveys. Globally, σ ranges from 19.44 mS m^{-1} to 1431.57 mS m^{-1} with the lowest values at location 1 and the highest at location 4. A general increasing trend of σ is quite evident from the north to the south, accompanying the previously known soil salinity gradient. In addition, σ increases with depth at locations 2, 3 and 4. At location 1, σ ranges spatiotemporally from 19.44 mS m^{-1} to 128.08 mS m^{-1}. At location 2, σ ranges from 28.02 mS m^{-1} to 469.39 mS m^{-1} with highest values at depth. A similar pattern of σ is evident at locations 3 and 4. However, a greater range of σ is seen at location 3 with values from 36.23 mS m^{-1} to 706.32 mS m^{-1}. Location 4 exhibits the largest variations of σ, ranging from 48.57 mS m^{-1} to 1431.57 mS m^{-1}.”

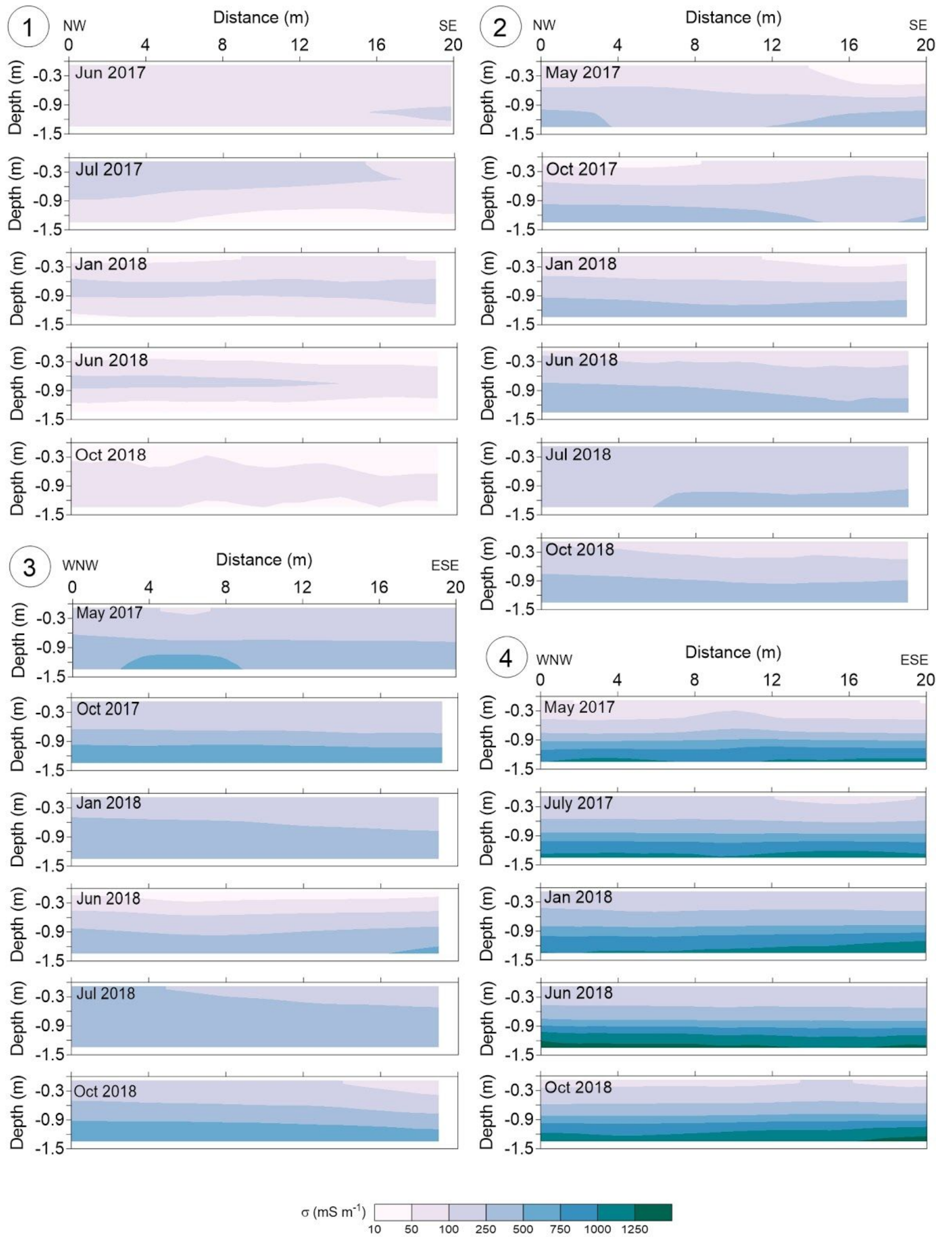


Figure 4: Time-lapse electromagnetic conductivity images (EMCIs) for locations 1 to 4.

Line 186: This high ECe (52.35 dS/m) is only at the location 4. Here, a more realistic conclusion for the larger study site that includes transect 1-3 with much lower ECe is lacking. Please add.

We thank you for your suggestion. The regional calibration has been developed to be used at any new location in the entire Lezíria region. It's true that the prediction ability is not so satisfactory in the northern location, but still it works as an expedit method for soil salinity prediction in Lezíria. For better prediction abilities, location-specific calibrations can be developed using data from each location. However, this limits the application of the calibration to each specific location and this is not the objective of this paper. We have revised the text to address the reviewer concern and added a new paragraph at line 181:

"The prediction ability of the regional calibration can be less satisfactory when analysing the performance for specific locations within the region, where the ranges of EC_e are smaller, particularly in the less saline northern locations. However, the calibration has been developed using data from the entire region, and it has been independently validated with data from that same region, with the purpose of using it for expedit soil salinity prediction in the entire study area. For optimal prediction ability at each specific location, location-specific calibrations can be developed, as done for instance in Farzamian et al. (2019)."

Line 188: With the last sentence, it seems you can perform that calibration, since you have the data. Otherwise please make clear why this is not the case.

We proposed in that sentence a continuation of the monitoring to improve the calibration and we do not have more data at this stage. We revised the text to avoid the confusion for the readers.

Old version (line 186)

"The regional calibration could be further developed by including measurements taken over a longer period of time in the calibration process, in order to include a wider range of variation of soil properties."

New version

"The regional calibration could be further refined by repeating measurements over a longer period of time in the calibration process, in order to include a wider range of variation of soil properties. In addition, monitoring at new locations with different EC_e ranges could also be included to improve the prediction ability of the regional calibration."

Line 196: "maps" - The figures present a profile and not a map. Please revise and use a word like profile, transect, or cross section throughout the manuscript.

OK, we can use the term **cross section** instead of the word **map.** The entire manuscript will be revised accordingly.

In particular, we revised the title of section 4.3.

Old version (line 195)

"4.3 Spatiotemporal mapping of soil salinity from time-lapse EMCI"

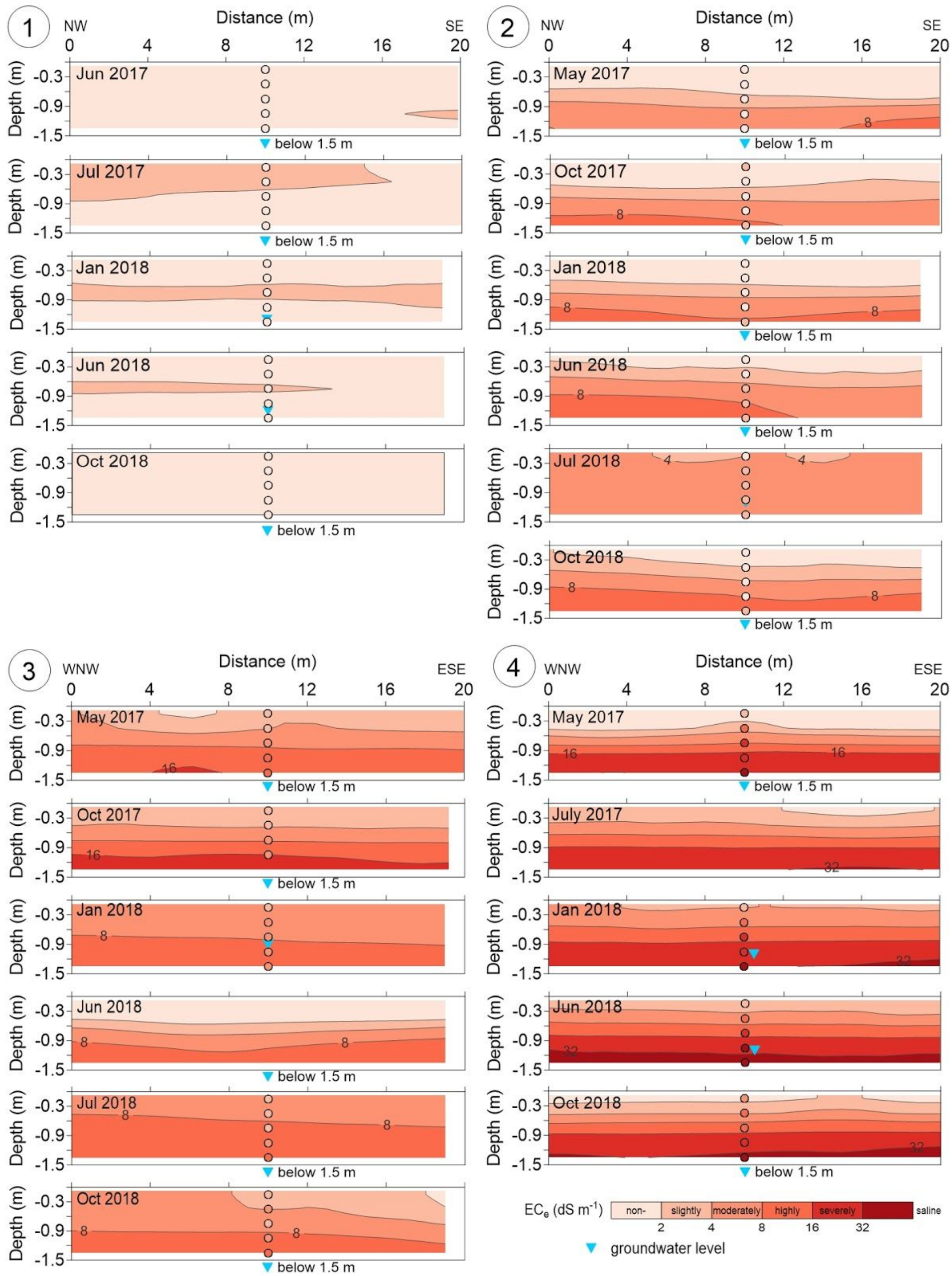
<u>New version</u>

"4.4 Spatiotemporal imaging of soil salinity from time-lapse EMCI"

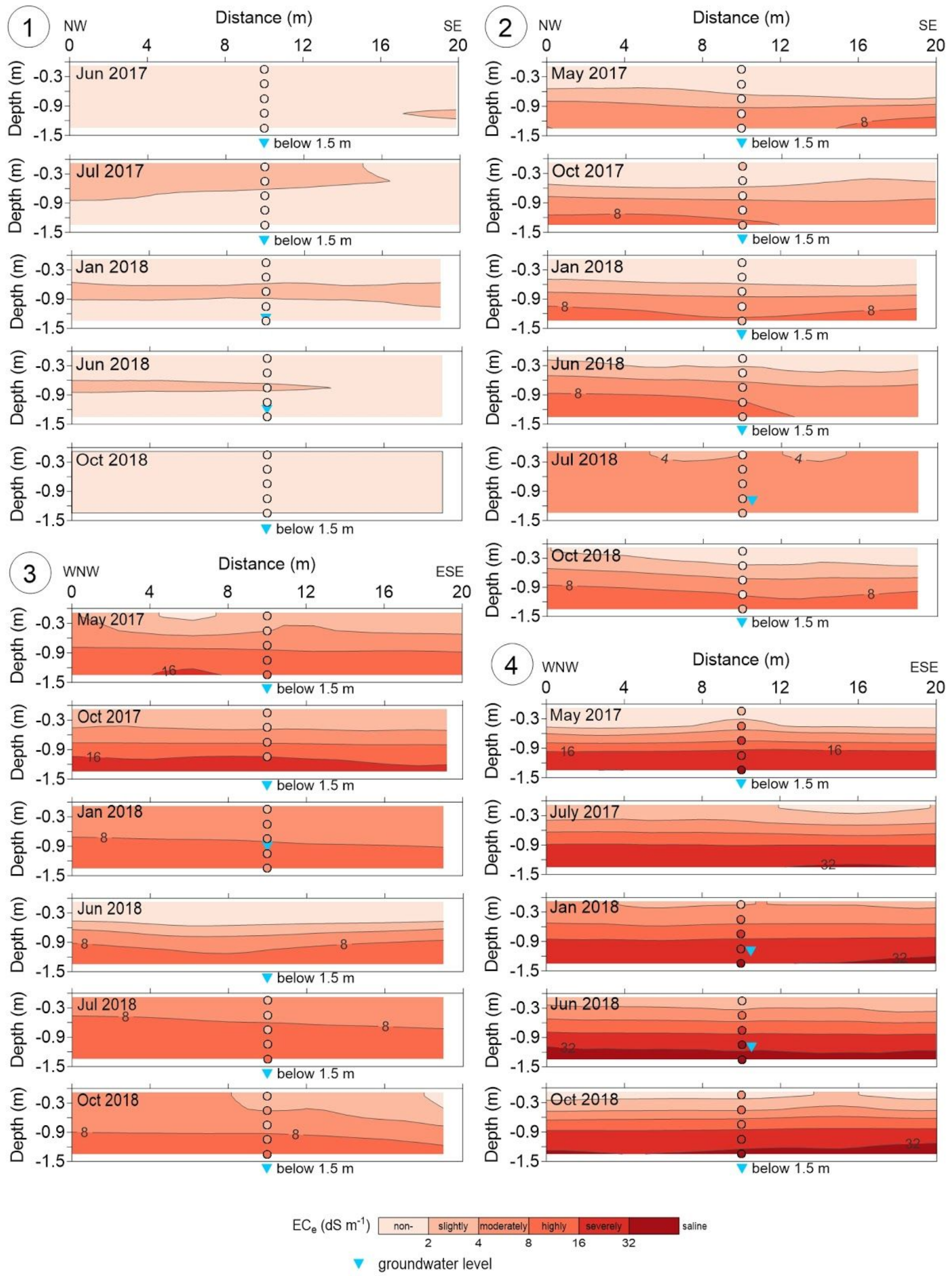
Figure 5: please also show the legend beneath cross sections of transect 1

We used a single scale legend for all four locations for an easier comparison for readers. We revised the figure and included the scale in the middle of the figure.

<u>Old version (Fig. 5)</u>



<u>New version (now Fig. 6)</u>



Line 213: At transect 2 for October 2017, please describe the differences in the topsoil between measured (moderatly saline) and modelled (non-saline) data.

The underestimation of modelled EC_e is due to the measured soil salinity of 2.03 dS m^{-1}, classified as slightly saline but still very close to the non-saline classification. No changes to the text were made relative to this comment.

Line 219: For transect 3, please describe why the cross sections show 2 saline layers in Jan 2018 and July 2018. Also due to fertigation as in transect 2?

We think that the pattern seen at location 3 in July 2018, as well as the similar one at location 2 on the same date, are due to the fertigation practices for the maize cultivation. We have revised the text to address this issue. This is not the case for the cross section seen in January 2018, when there is a non-irrigated winter crop with no fertigation practices. The rise of groundwater (0.9 m) in this period and rainfall events before the survey are expected to be the main reasons for the January 2018 pattern.

Old version (line 220)

"The groundwater level is above 1.5 m in January 2018, although the salinity of the deeper soil layers (>0.9 m) decreases compared to May and October 2017, which could be due to washing of the profile by rainfall."

New version

"The groundwater level is above 1.5 m in January 2018, although the salinity of the deeper soil layers (>0.9 m) decreases compared to May and October 2017, which could be due to washing of the profile by rainfall. The increase of soil salinity in upper soil layers in July 2018, similarly to location 2 on the same date, can be attributed to fertigation practices for the maize cultivation."

Line 229: please make two sentences here.

OK. The text has been revised accordingly.

Old version (line 229)

"Location 1 tends to have non-saline characteristics, which can be attributed to good quality irrigation water and to the fact that this location is far from the estuary, making it less prone to the presence of saline groundwater."

New version

"Location 1 tends to have non-saline characteristics, which can be attributed to good quality irrigation water. In addition, this location is far from the estuary, making it less prone to the presence of saline groundwater."

Line 239: please 2 sentences.

OK. The text has been revised accordingly.

Old version (line 238)

“This validation resulted in lower prediction ability than that previously resulting from cross-validation, not only because the test set was independent, but also because it was collected over a wider period of time, during which the variation of soil properties is larger.”

New version

“This validation resulted in lower prediction ability than that previously resulting from cross-validation. This is because the test set was independent, and also because it was collected over a wider period of time, with a larger variation of soil properties.”

Line 241: this conclusion might change. see above

Answered above.

Additional changes

We would also like to ask for changing the following group of sentences.

Old version (line 139)

"The RMSE is the square root of the mean of the squared differences between the measured and predicted EC_e, indicating how concentrated the data is around the linear regression. In this study we used two degrees of freedom for a more robust calculation of RMSE. The coefficient of determination (R2) indicates how well the predicted EC_e approximate the measured EC_e. When this is 1, it means the predictions coincide with the measurements. Lin's CCC measures the agreement between the measured and predicted ECe evaluating how close the linear regression is to the 1:1 relationship and ranges from −1 to 1, with perfect agreement at 1 (Lin, 1989)."

New version

"The RMSE is the square root of the mean of the squared differences between the measured and predicted EC_e. In this study we used two degrees of freedom for a more robust calculation of RMSE. ME is the mean of all differences between the measured and predicted EC_e and evaluates whether the linear regression consistently over- and underestimates the predicted EC_e. Therefore, the prediction is more precise and less biased when the RMSE and the ME are closer to zero. The coefficient of determination (R^2) indicates the proportion of the variance that is predicted by the model. When this is 1, it means the model totally explains the variation. Lin's CCC measures the agreement between the measured and predicted EC_e evaluating their deviation from the 1:1 relationship and ranges from −1 to 1, with perfect agreement at 1 (Lin, 1989)."

Also, one of the references (previously referred to as Paz at al., 2019a) which was in press, has been updated. Therefore, all citations in the text referring to Paz et al. (2019a) will be changed to Paz et al. (2020), and all citations in the text referring to Paz et al. (2019b) will be changed to Paz et al. (2019).

Old version (line 316)

"Paz, A., Castanheira., N., Farzamian, M., Paz, M.C., Gonçalves, M., Monteiro Santos, F., and Triantafilis, J.: Prediction of soil salinity and sodicity using electromagnetic conductivity imaging. Geoderma, https://doi.org/10.1016/j.geoderma.2019.114086, *in press*, 2019a."

"Paz, M.C., Farzamian, M., Monteiro Santos, F., Gonçalves, M.C., Paz, A.M., Castanheira., N.L., and Triantafilis, J.: Potential to map soil salinity using inversion modelling of EM38 sensor data. First Break, 37(6), 35–39, doi:10.3997/1365-2397.2019019, 2019b."

New version

"Paz, A., Castanheira., N., Farzamian, M., Paz, M.C., Gonçalves, M., Monteiro Santos, F., and Triantafilis, J.: Prediction of soil salinity and sodicity using electromagnetic conductivity imaging. Geoderma, 361, 114086, https://doi.org/10.1016/j.geoderma.2019.114086, 2020."

"Paz, M.C., Farzamian, M., Monteiro Santos, F., Gonçalves, M.C., Paz, A.M., Castanheira., N.L., and Triantafilis, J.: Potential to map soil salinity using inversion modelling of EM38 sensor data. First Break, 37(6), 35–39, doi:10.3997/1365-2397.2019019, 2019."

Finally, we detected a lapse in one of the references. The reference has been revised.

Old version (line 279)

Corwin, D.L. and Lesch, S.M.: Characterizing soil spatial variability with apparent soil electrical conductivity: I. Survey protocols. Comp. Elec. Agri. Appl. Apparent Soil Elec. Conductivity Precis. Agri., 46, 103–133, https://doi.org/10.1016/j.compag.2004.11.002, 2005.

New version

Corwin, D.L. and Lesch, S.M.: Characterizing soil spatial variability with apparent soil electrical conductivity: I. Survey protocols. Comp. Elec. Agri., 46, 103–133, https://doi.org/10.1016/j.compag.2004.11.002, 2005.