RC2: Major Comments

1. Insufficient explanation of the mechanisms linking σ′ and σ″, and their relationships with SOC and σ″. The introduction section did not adequately explain the theoretical background of σ′ and σ″. Each parameter represents what and how the two are related in the context of SOC interpretation.

To address the comments from the reviewer, we consider large edits in the "Introduction". We introduce now the conductivity and capacitive properties of the soil expressed by means of σ' and σ'', followed by an improved revision of the literature linking those electrical parameters to SOC as observed from recent studies in the laboratory. These comments also address the concerns of the Reviewer 1.

2. The conclusion that the polarizable anomaly "can only be explained by variations in SOC (Lines 119–120)" is too strong, given the range of possible contributors to σ″ in mineral soils. The frequency dependence of σ″ is central to the interpretation, yet the manuscript did not sufficiently justify why SOC-driven polarization should peak at ≤1 Hz, particularly in light of previous studies reporting variable frequency responses. Please provide quantitative or experimental evidence that rules out alternative explanations. I would also recommend providing more comparisons between your observed frequency patterns and those reported in previous studies, along with a clearer justification for why the low-frequency peak is diagnostic in this case.

To address the comment of the Reviewer, we have edited the introduction, where now we provide a more detailed revision of the existing literature lining the complex conductivity with soil properties and, in particular, with organic carbon. These references are used in the discussion to sustain our interpretation.

3. Lack of quantitative uncertainty analysis for the inversion results and SOC estimates. Although the manuscript acknowledges the mismatch in sampling volumes, no quantitative uncertainty assessment is provided. Additional analysis of uncertainty or sensitivity is necessary, given that the interpretation relies on the subtle differences in σ″ between B1 and B2.

We agree with the reviewer, and we added a new Appendix where we discuss the sensitivity of the imaging results. We address the comments from the Reviewer through a numerical study in which the accuracy and sensitivity of the method is tested by means of numerical simulations after varying the size and contrasts of a polarizable anomaly, related to varying the size and SOC of the carbon stock.

4. A number of typos were found in the text, so the language and grammar should be further checked throughout the manuscript.

We appreciate the comment from the Reviewer. This has been corrected.

Minor Comments

The following lines have been corrected:

Line 56: is "66 ha catchment" correct?

Lines 94–96: The authors note that CEC values are similar in B1 and B2, but they do not discuss the

potential implications of this observation, particularly given that mineralogy plays a major role in SOC stabilization.

Line 134: Please confirm whether the correct spelling is “McAnalen” or “McAnallen”.

Line 137: “sample sis” seems to be a misspelling.

Line 147: “soil organic caron” should be “soil organic carbon.”

Line 229: Figure A2: The unit μS/m should be made consistent with the main text, where mS/m is used in the preceding sections.