REVIEW
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Two-dimensional Inversion of wideband spectral data from the Capacitively Coupled Resistivity method - First Applications in periglacial environments
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SUMMARY

This paper presents data and modelling results for broadband spectral capacitive resistivity experiments performed in cold regions. The experiments appear sound in design, and the data are novel and very interesting from the perspective of electrical/electromagnetic geophysics and cold-regions research. However, the paper has a few shortcomings. The objectives of the paper are not entirely clear at first. Is the focus on SIP or CR? It becomes clear (I think) that the focus is on cold-regions application of broadband spectral CR. If this is the desired focus, the paper would be made more impactful by including: 1) a review of electrical, IP, SIP, and CR applications to cold regions and permafrost; 2) a clear description of the benefits, limitations, and favourable conditions for broadband spectral CCR, and how these relate to cold regions; and 3) a more thorough analysis of the inversion results in terms of cold-regions ground properties of interest such as water content, ice content and temperature.

DETAILS

Abstract: Lacks focus on objective and results.

p1,L19: Why? High conductivity material exhibit spectral characteristics as well.

p2,L28: What about Routh et al. (1998), Kemna et al. (2000) and several works thereafter?

p.2,L30: Introduction is somewhat unclear. It starts out focussed on SIP, then CCR, but then states the objective as investigating the field applicability of [spectral] CCR in cold regions. To support the latter, the intro needs a little more background on electrical geophysics and material properties in permafrost and/or glaciology.

eq.1: Although somewhat semantic, I view the low-frequency CCR experiment as responding to the complex conductivity where the imaginary conductivity has a contribution from the real dielectric. Of course, at higher frequency and in the presence of ice, permittivity may be more relevant. However, I do not think that equation 1 should be referred to as representing the "complex permittivity." Consider "effective permittivity" which has a contribution from the imaginary conductivity. The distinction is important because the true dielectric permittivity is what results in wave propagation in Maxwell’s equations, not the imaginary conductivity. Furthermore, to talk only of displacement currents denies the possibility of IP-type currents which may dominate at lower frequency.

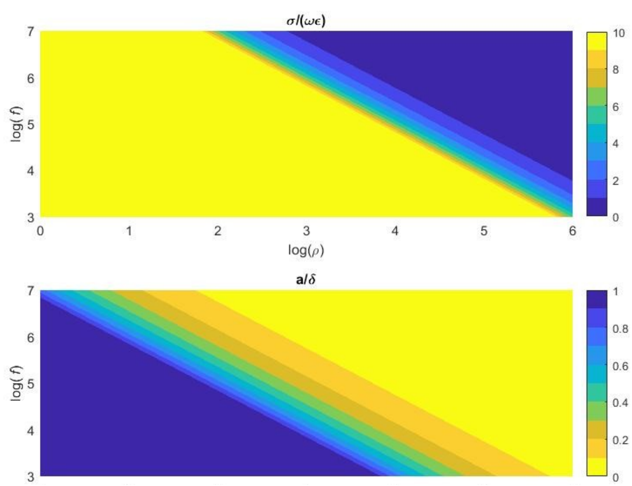
p.6,L4: You say the "conduction current" is in-phase, but then you say that IP is concerned with the conduction current part of the impedance. You need to be clearer on the distinction between the real conductivity (conduction current), the imaginary conductivity (IP current), and the real permittivity (displacement current).

eq.4: Again, consider noting that any IP effect will be wrapped up in here as $\varepsilon_{eff} = \varepsilon_R + \sigma_I/\omega$.

p.7,L8: The height effect is also discussed by Wang et al. (2016) but in a shady pseudo-journal. The authors could decide if it warrants consideration.

p.8,L3: You say the inversion is frequency dependent, but then go on to say that the system response is controlled by geometry, not frequency. Clarify.

p.8,L5: You need to thoroughly describe the "operating range" of CCR with respect to treatment of the data for the single site inversion and the 2D inversion. Application of a 2D resistivity inversion (with geometry-based sensitivity) requires low-induction number conditions (which actually appears to be violated for some of your lower frequency-resistivity combinations). Does the single-site inversion require LIN conditions? What about wave effects? For some of the high frequency-resistivity pairs encountered, quasi-static conditions are violated and a true permittivity will result in wave propagation. This should not(?) affect CC model fits, but it should(?) affect the 2D inversions using a resistivity-type sensitivity function.



a = 1.5 m, $\varepsilon_R = 3$

p8,L6: "Induction effects" would typically be understood to mean inductive source effects of current-carrying cables. You don't have these. So, do you mean magnetic coupling as described by McNeil?

p.13,L25: Well, the dielectric constants for rock and snow are both around 3-5, so...

p.13,L32: Snow cover typically inhibits frozen ground.

Table 1: Add water. More discussion is required in comparing recovered values to expected material properties.

p.15,L5: In comparing to literature values, what about the observations by Weigand and Kemna (2016) that SIP model parameters obtained from a CC model are biased? Is this alleviated by having c as a free parameter and/or by having 19 points in the spectrum?

Fig.8: Use same scales as Fig.7. Are some of the observed differences attributable to height effects or breakdown of LIN conditions?

p.18,L5: Why is the DC permittivity so (unreasonably) high?

p.18,L11: Is there any benefit to setting c constant (i.e., choosing a decomposition for the CC model). Is it reasonable for c to show so much variability? Is it highly sensitive, and if so, is it just absorbing error in the inversion?

p.18,L19: Actually, the LF permittivity of water is around 80, but you need to get up to 10^{10} to 10^{12} Hz before it drops to around 3.

Figure 10: a) Use dash and solid. b) What is the distinction between black and purple lines?

REFERENCES

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