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Interactive comment

Interactive comment on "Evaluation of Possible Corrosion Enhacement Due to Telluric Currents: Case Study for Brazilian Pipeline" *by* Joyrles Fernandes de Moraes et al.

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Comment about the technical corrections: Thank you referee for all the technical comments. We have implemented them and some other changes with the help of other referee.

Page 1, line 18: Is there a specific reason why the PSP is maintained at negative potential? Why at least -850 mV? Page 5, line 22: what does it mean "cathodically protected"? Is it related to the -850mV maintained PSP? Answer: The cathodic protection is a technique that inject electrical current in the pipeline to avoid natural corrosion, caused mainly by environment characteristics. In this process the pipe becomes the

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cathode of the circuit, receiving electrons instead of losing material. To work well, the pipe must remain at a potential of at least -850 mV with relation to the ground. This value is set based on the surface area of the pipe and properties of the pipe material. The company that operates the pipe is responsible for using technical standards to set this value, in our case, standard N 2298 from Petrobras. When the potential is less than -850, the pipe is cathodically protected.

Page 2, line 13: I suggest include at this point some parameters about the 17th March 2015 Geomagnetic Storm, e.g. DST index, Kp, and others just as a reference about the event. Answer: Thank you for the suggestion. A table with information about all the events under study was added in the paper. The intensity was characterized by the DST (Disturbed Storm Time) index.

Page 2, line 19: The only experimental data are from the magnetometer at the São José dos Campos station. Is that correct? Answer: Yes, you are right. The data are only from São José dos Campos. We chose the site since it has data to cover all the events under study. Furthermore, the site is the closest to the pipeline. If we use data from the other stations, thousands of km far from the pipe, the model proposed by Trichtchenko and Boteler (2002) probably will not work very well.

Page 3, equation (1): Emphasise that the equation for the general case is vectorial,so z is actually a 2x2 tensor. The horizontal components of Electric Field (Ex and Ey)and Magnetic Filed (Hx and Hy) at the surface should relate as follows: Ex=Zxx.Hx +Zxy.Hy ; Ey=Zyx.Hx + Zyy.Hy. In the case where is assumed a stratified homogeneous model (1D model), as proposed in Table 1, the Zxx=Zyy=0 and impedance z can be treated as a scalar, relating the orthogonal components of the fields: Ex=z.Hy andEy=z.Hx; or as shown in equation (1) E_surface=z.H_surface. What's was the value used for "z"? Was it consider a scalar or a tensor? Was that obtained by the model in Table 1 and consider constant for the whole pipeline? If that is the case it should be considered that the geological resistivity may vary a lot, even locally. For a structure with more than 1000 km the z should change completely. Answer: The value used for z is obtained by applying a recursive relation. Then, z in the top of the first layer (surface) can be expressed in terms of the characteristics (thickness and conductivity) of the bottom edge of the layer. The layer-model considered is 1D, then, z is a scalar and, like you said, we are relating orthogonal components of the electric and magnetic field. We do understand your concern about the variation of the geological structure. Unfortunately, we do not have enough geological information that covers the whole route of the pipeline. Furthermore, our work is a pioneer in Brazil and, perhaps in future, we can combine it with more geological information.

Page 4, line 6: in equation (2) I recommend specifying what represents Ep and Vp. Is Ep the Electric field estimated using the surface impedance z and the magnetic data at São José dos Campos? Answer: Thank you for the suggestion. We rewrote the sentence before the equation to clarify what Vp and Ep means. The Ep is the electric field in the pipeline. For the frequency used in our data we can assume that the electric field inside the pipeline steel is equal to the electric field at the Earth's surface.

Page 4, line 13: I suggest to describe what the termination impedances represents in the pipeline. Answer: It was a valuable suggestion. The description of what the termination impedances represents was written in the paper.

Page 4, Table 2: Were the values in table 2 used to estimate the Ap, Bp and other constants in equation (2)? How do you estimate Ap and Bp? Answer: It is an interesting question. The values in table 2 were used to compute the propagation constant, parallel admittance and the series impedance, i.e, the circuit information. Equation 2 is a solution of a partial differential equation and Ap and Bp are constants. These constants are determined when we apply the boundary conditions for equation 2. When we apply the conditions Ap and Bp are expressed in terms of the circuit characteristics. That is how we obtained these constants. The modelling details can be found in the paper produced by Trichtchenko and Boteler (2002) that is referenced in the paper.

Page 5, line 10: I suggest to explain how the electric field was estimated. The elec-

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tric field was obtained using the magnetic data and equation (1)? If yes, take into consideration the previous comment about the impedance z and the relation between orthogonal components of H and E. Answer: You are right. In the new version of the paper we included more information as suggested.

Page 5, line 10: figure 2 shows the electric field that I presume was estimated using equation (1), a given z and the magnetic data, correct? I suggest discussing a little bit more the methodology to estimate the eastward and northward electric field and make it clear that it is obtained from the magnetic horizontal data of the São José dos Campos magnetometer. It may be worth to include in the figure the magnetic field horizontal component for the period. Answer: Thank you for the suggestion. More details about the value of z, the electric field in the surface and pipeline were included.

Page5, line 23: figures 3 and 4 shows the PSP for 0.1 and 1000 ohm terminating impedances at different sites. What exactly are these different sites of the pipeline? Are they different locations along the pipeline? If yes, these locations should be included in figure 1. Another concern about this topic is the value of the estimated electric field.Although the surface magnetic field can be approximately the same at a given latitude for a large regional area, the electric field in the surface may vary completely due to changes in Earth's resistivity and therefore in the surface impedance z. The model of Table 1 can not be considered for the whole extension of the pipeline. So, if the electric field is been estimated to São José dos Campos (SJC) site it should not be taken as equal to the rest of the pipeline. Another possibility is that the DSLT theory needs the electric field at only one point and then it can estimate de Vp, in equation (2), for the different points of the pipeline. If that is the case it should be made clear in the text and described with more detail in the methodology. Anyway, I think it is worth to discuss more how the PSP is been estimated as well as if the electric field is been calculated only at SJC or for the whole pipeline. Answer: We can calculate the PSP anywhere along the pipeline. These sites are points in the beginning, middle and ending of the pipe route. The length of the first route of GASBOL, which is the

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focus of the experiment, is 1814 km. The reviewer is right, we used the electric field computed in São José dos Campos as an input to DSLT theory, then, computed the PSP for several locations along the pipeline. Thanks for your suggestion we tried to clarify this point to the future readers.

Page 5, line 30: How can I identify the ends of the pipe in figures 3 and 4? Answer: I do understand your doubt. We included the information of the length of the pipe in the subtitles and in the text.

Page 6, line 2: What does it mean exactly "Durgin one half electric field"? Answer: Thank you for the question. We recognize a mistake at this point. Now, it is correct in the new version. We were trying to say that at one end, the negative potential of the pipe with respect to the ground causes a current to flow into the pipe; whereas at the other end, the positive potential causes the current to leave the pipe.

Page 6, line 4: data in Figures 6 and 7 are calculated using equation (3)? Just to be clear. Answer: Yes, they are.

Page 7, figure 3: What does it represent exactly the numbers in km at the top right of each subfigure? If it is the position in the pipeline what is the reference or origin point?Same to figure 4. Page 9, figure 5: What are the locations represented at 0 and about 1750 km distance?There should be a reference position. Answer: Yes, it is the position in the pipeline. The point x=0 is the beginning of the pipe, and the point x=1814, i.e, the length of the pipe, it is the ending point. We thank for the questions.

Page10, figure 6: the legend shows "Metal loss estimation". For "metal loss" it seems it should be represented by the loss of volume (mm3) or the loss of mass (kg) of the material. However, the graphics show mm/year. I understand that the corrosion rate in equation (3), page 5, is represented in mm/year through a hole of 1 cm diameter. The hole has an equivalent area so the corrosion rate will represent at last a loss of volume per year (mm3/year). Is that correct? I suggest mentioning that again when explaining figures 6 and 7 as well. Answer: We do appreciate the suggestion. You are right,

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the correct term is corrosion rate since we are evaluating how much the hole that we assume to exist is penetrated by the event. We rewrote the legend to avoid confusion.

Please also note the supplement to this comment:
https://www.ann-geophys-discuss.net/angeo-2019-132/angeo-2019-132-AC2-supplement.pdf

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