Referee report on the paper entitled: "Modeling of the Very Low Frequency (VLF) radio wave signal profile due to solar flares using the GEANT4 Monte Carlo simulation coupled with ionospheric chemistry" by S. Palit, T. Basak, S. K. Mondal, S. Pal, and S. K. Chakrabarti, submitted for publication in ACP.

First an apology note: I apologize to the authors for delaying my review. It was not intentional and happened because of a misunderstanding.

The paper deals with modelling the observed amplitude perturbations of VLF (very low frequency) transmissions propagating in the earth-ionosphere waveguide, which are caused by solar flare X ray ionization effects in the daytime D region ionosphere. The authors combine computational codes and models, which are openly available, to produce quantitative estimates of VLF amplitude perturbations which are then compared with the observations.

The methods and models they use include: 1) A high energy physics Monte Carlo simulation code to derive the electron density production rates as a function of altitude caused by X-ray solar flare energy fluxes as measured by satellites (GOES, RHESSI). 2) The estimates of (1) are inputted in a simplified D region ion-chemistry model, used before to model lightning induced radiation belt electron precipitation (LEP) events and early fast VLF events in the D region; it consists of 4 types of ion species and the main production and loss processes (there are 4 coupled continuity equations) and is used here to obtain elevated electron density profiles in the D region during the solar X-ray event. 3) The electron density profiles from (2) are inputted in (the publicly available) long wave propagation capability (LWPC) code which can estimate the amplitude and phase of a given VLF transmission that is received at a given location (here only amplitudes are computed). Finally, the amplitude estimates are compared with the measured VLF amplitude changes during the solar flares by simple superposition in time.

The methodology is applied in two cases of an M and an X type flares and the agreement between the model results and the measurements is indeed very good. Apparently, this implies that the applied methodology, which, to my knowledge was never used before, is working well meaning that the paper deserves to be published (after some minor corrections and improvements; particularly the authors need to clarify/detail their methodology procedures better). Overall, I think this is a nice piece of work.

Minor suggestions:

1). Since the authors deal with the lower ionosphere below 90 km, that is, the D-region, they should be specific throughout their text and refer to the "D-region ionosphere", instead of "ionosphere".

2). Also better replace the term "ion production" to "electron-ion" production throughout the text, especially since all your computations refer to electron density.

3). VLF receivers measure amplitude and phase. Explain why here you simulate only amplitudes while LWPC predicts phases as well.

4). Line 29. Note that the work of Haldoupis et al. 2009 using the GPI model did not apply to LEPs but on early/fast VLF perturbations caused by direct lightning effects on the overlying D region during sprite occurrences (e.g., see Haldoupis et al., JGR, vol 109, A10303, 2004).

5). Lines 50 to 54. Please remove the paragraph symbol § and replace it with the word "section".

6). Page 3, section 2. I suggest you add a bit more of description in “Observations”. Please comment on the diurnal variation of the VLF signal and describe the reason for this pattern. It always helps a reader who is not familiar with VLF to understand better things. Also I suggest you replace the figure (a) that is for Feb, 18, 2011 with that of either day Feb. 15, or Feb. 24 in which you get the M or X type flares used in the present analysis.

7) If I am not mistaken, you are the first to be using the GEANT4 toolkit for this kind of work in the earth’s ionosphere. Since it has been developed for high energy physics, I suggest you provide a few more details about it, its advantages and disadvantages/limitations. Is it easy this toolkit to be used and is it openly available so that it can be acquired by other ionospheric researchers (e.g. provide an internet site where it can be downloaded)?

8). Lines 81 to 98. Try to improve this part of the paper so that its more intelligible for the reader. Give more details on the X-ray spectra and how they are obtained and used in the GEANT4. You mention RESSI x-ray spectra and OSPEX software in the Figure2 caption briefly but not in the text. I believe you need to discuss how you obtain the energy spectra and provide more details as how these are used.

9). In Figure 3, x-axis is Ne production rate, that means dNe/dt, but the units in the label are cm^-3. Be accurate with the terms here and in the text. In Figure 4, the axis label should be “electron production rate” and not “electron produced”.

10). Page 7, top paragraph. Yes, the GPI model is for nighttime. Can you justify better why this is sufficient for daytime? For example electron detachment is much slower during the night. Negative ions live much longer during the night than during the day when detachment is driven by sunlight photons.

11). Lines 137-139. Explain what is the gamma coefficient in Eq. 2 (detachment coefficient) and provide a reference as to what is its most likely value during the day. Since it is a very uncertain quantity can its value affect seriously the present calculations of the GPI model and how this depends on altitude?

12). Page 8 upper part. You talk about Ix and N(t) as perturbed parts relative to the ambient parts. Obviously these are the contributions of the ongoing X ray flux impacting on the lower ionosphere. The term “perturbed” and “perturbation component” refers usually to a small change away from a mean/steady state, which here is not true since the X-ray contribution alters D region ionization significantly (1 to 3 orders of magnitude). It is better to use here a more proper term or simply use X-ray distribution.

13). Lines 210-211. This sentence does not read well, please improve it.

14). Line 215. Correct to “occurrence” from “occurrance”.