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Reply on RC2

Margaretha Myrvang et al.

Author comment on "Modelling the influence of meteoric smoke particles on artificial heating in the D-region" by Margaretha Myrvang et al., Ann. Geophys. Discuss., https://doi.org/10.5194/angeo-2021-39-AC2, 2021

Respone to Anonymous Referee #2

We would like to thank the Anonymous Referee #2 for their thoroughly review of our manuscript and for the correction of spelling errors and grammar faults.

We have taken all the suggestions and comments from the referee into account. We address all the suggestions and comments below. The referee report is marked in bold, while our answers are marked in normal text.

Line 117: The heating time is much less than 100 ms, it is less than 1 ms below 90 km (Stubbe et al., 1982).

The referee is right. The heating time given by Stubbe et al., 1982 is 1 ms at 90 km and approximately 10 μs at 60 km. We will change the phrasing from "… less than 100 ms" to "… less than 1 ms".

Line 134 and Fig.1: It would be informative to give the height and some other relevant parameters used in calculating the results shown in Fig. 1, presuming they are relevant to the present modelling.

The focus of figure 1 is to illustrate the implementation of the electron temperature calculations during heating. However, as the referee suggests, it would be informative to mention the parameters used to calculate the results in figure 1. We will add the relevant parameters to the manuscript, both at line 134 and in the figure caption.

We have changed the text in line 134 from:

"In Fig. 1 we show Q - L as a function of T_e with I_0, where the zero-point is illustrated as a blue coloured star. Also in Fig. 1 we show the changed intensity, illustrated as I_1 and the zero-point for Q - L with I_1 is marked as a magenta coloured star."

to (now in line 138):

"Figure 1 shows Q - L as a function of T_e. This figure illustrate that loss due to absorption can change the location of the zero-point of Q - L. We have used the following parameters

to calculate Q - L: Height 75 km, ionospheric night conditions, model run with the presence of MSP, frequency 5 MHz and power 700 MW. Figure 1 shows the zero-point of Q - L with I_0, illustrated as a blue-coloured star and the zero-point of Q - L with the changed intensity I_1, illustrated as a magenta-coloured star." We have added the following text to the figure caption for figure 1: "We have used the following parameters to calculate Q - L: Height 75 km, ionospheric night conditions, model run with the presence of MSP, frequency 5 MHz and power 700 MW."

Figure 2: This is fine, but it is not indicated that the 'Modelling during heating" is performed at each height from below before incrementing to the next height. This is well described in the text. I suggest that at least a sentence is added in the figure caption describing this.

It is true that we do not mention this in the figure nor in the figure caption. We will do as the referee suggests and add a sentence to the figure caption describing that the modelling during heating is performed at each height from below before going to the next height. We have added the following text to the figure caption of figure 2: "We perform the modelling during heating at each height from below before going to the next height, moving upward from the initial height to the final height."

Line 175: The acronymn "SIC" is mentioned here for the first time. It should be explained what it stands for and a reference should be given.

The referee is right; we have forgotten to explain what SIC stands for and forgotten to give a reference. We will add a reference to the SIC model and write out the acronym. Now the sentence reads: "For the initial conditions, the following parameters are taken from the Sodankylä Ion Chemistry (SIC) model (Turunen et al., 1996)."

Section 3: Although the details of the MSP model are given in the references Baumann et al. 2013 and Megner et al. 2006, it would be useful for the reader without a detailed knowledge of MSP to have a brief, probably simplified description of the MSP height distribution without having to look up these references. Is it an idealised model or from measurements? For example are the MSP fairly uniformly distributed over the height ranges mentioned or are they in thin layers?

This is a good suggestion from the referee. We have added a brief description at line 173 (section 3) of the MSP height distribution to the manuscript: "Megner et al. 2006 calculates the MSP number density profile by using a one-dimensional model, where the MSP height distribution varies with size. The number density of smaller MSPs (less than 15 nm) increases with altitude, while larger sizes are more abundant at lower altitudes between 60-70 km. Overall the number density of MSPs increases from 60 km to a maximum at around 80-83 km, and then decreases above. For an overview of the different MSP number density profiles, we refer the reader to figure A1 in the appendix."

Figure 3: The red shaded box the reaction from P to Pp would seem to be photo-detachment so should the wiggly arrow labelled h(nu2) not be pointing away from P instead of towards P?

The wiggly arrow indicates the incoming solar photon that detaches an electron from the surface of a neutral or negatively charged MSP. We have added the following to the figure caption of figure 3: "….where the wiggly arrow indicates the incoming solar photon that detaches an electron from the surface of a neutral or negatively charged MSP."

Line 194-195: This sentence is a repeat of the sentence in line 193 but with a wrong "five cases" instead of four cases. Delete it.

The referee is correct; line 194-195 is a repeat of the sentence in line 193. We will remove it.

Section 5, in particular line 220: In discussing the 'open question' of the discrepancy between calculated and modelled electron temperature enhancements, a suggested explanation put forward in a later paper by Senior et al. should be mentioned, namely that the ERP of the heater may be overestimated because of the assumption of a perfectly conducting ground under the heating antennas is probably not met. This is discussed in section 6.6 and the conclusions of the paper 'Measurements and Modelling of Cosmic Noise Absorption Changes due to Radio Heating of the D-Region Ionosphere', Senior, A., M.T. Rietveld, F. Honary, W. Singer, M. J. Kosch, J. Geophys. Res., 116, A04310, doi:10.1029/2010JA016189, 2011.

As suggested by the referee, we will mention the explanation put forward by Senior et al. 2011. At line 266, we have added a paragraph: "An explanation for the discrepancy between models and observations suggested by Senior et al. 2011 is that the modeled heater ERP is lower than predicted because the assumption of a perfect reflecting ground around the antenna might not be applicable. Senior et al. 2011 found that the overestimation is reduced when modelling the ERP with more realistic ground assumptions."

Appendix, line 281: Does atomic oxygen really play an important role at these heights since it is a minor constituent here? This is discussed in section 6.3 of Senior et al. 2010.

As mentioned by Senior et al. 2010, the concentration of atomic oxygen is very small at the relevant height region of 60-100 km. At theses heights, atomic oxygen is less important compared to the other species, i.e. molecular oxygen and molecular nitrogen. However, above 100 km, the concentration of atomic oxygen increases. At 120 km, the concentration of atomic oxygen is in the same order of magnitude as the concentration of molecular oxygen. We choose to include atomic oxygen since our modelling is from 60-120 km. The phrasing that atomic oxygen plays an important role is incorrect; therefore, we will change the sentence in line 281 from:

"In addition, atomic oxygen [O] plays an important role through the impact excitation of fine structure levels of its ground state (see Pavlov and Berrington 1999 references given there)."

to (now line 349):

"Even though the concentration of atomic oxygen is very small between 60-100 km (as discussed by Senior et al. 2010), we will include electron cooling rates for atomic oxygen [O] through the impact excitation of fine structure levels of its ground state (see Pavlov and Berrington 1999 references given there). We do this because our modelling is between 60-120 km, and the concentration of atomic oxygen increases above 100 km. At 120 km, the concentration of atomic oxygen is in the same order of magnitude as the concentration of molecular oxygen."

Equation A6: One bracket is not closed.

It is true that equation A6 is not closed. We have removed the excess bracket to the left. Now the equation is identical to the equation in the reference paper by Pavlov and Berrington 1999.

Reference:
Stubbe, P., H. Kopka, M. T. Rietveld, R. L. Dowden, J. Atmos. Terr. Phys, 44, 12, 1123-1135, 1982,
ELF and VLF wave generation by modulated heating of the current carrying lower ionosphere.

Technical errors

In the attached .pdf text I have marked spelling and grammar faults by highlighting in yellow
without specifying the error except in some cases listed below. Many of the grammar faults are
typical for Scandinavian writers: conjugation of verbs for singular or plural (adding or missing an 's' on the verb). In other cases plural nouns are missing the 's'.

We have looked through the attached .pdf text and fixed the spelling errors and grammar faults.

Lines 109 and 280: Should be "lose".

We have now changed it to “lose”.

Line 210: "conditions".

We have changed it to “conditions”.

In addition, we have made a number of modifications suggested by the other referee.

In line 341 (appendix), we have added the following regarding the MSP number density profiles: “Figure A1 shows the different MSP number density profiles: panel a) shows the MSP autumn case (Megner et al. 2006) for 8. September, panel b) shows the MSP winter case (Megner et al. 2008) for 1. January and panel c) shows the MSP summer case (Megner et al. 2008) for 20. July. The MSP number density profile for autumn and winter is quite similar. However, the difference between the winter and summer case is quite significant, particularly for the larger sizes above 5 nm, which is more abundant for the summer case and extends to a higher altitude as well.”

Please also note the supplement to this comment:
https://angeo.copernicus.org/preprints/angeo-2021-39/angeo-2021-39-AC2-supplement.pdf