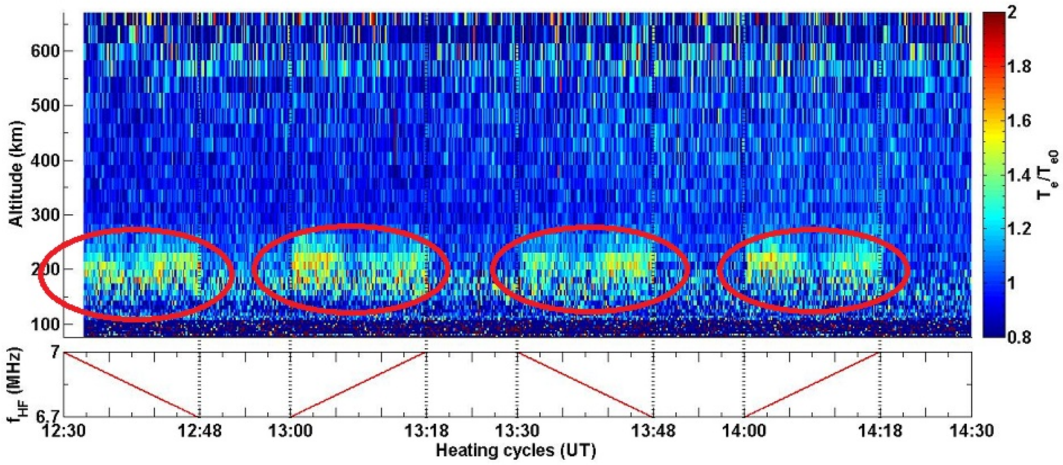
Reviewer 1

Thank you for the comments and suggestions. The comments given by reviewer are listed in black and ours replies are listed in red as below:

Comments to the Author

1. The paper describes the behaviour of high frequency plasma line (HFPL) during an experiment conducted near the 5th electron gyroharmonics at EISCAT heating facility on 11th March 2014. The same experimental data by these authors have already been published in a series of manuscripts (e.g. Wu et al., The extending of observing altitudes of plasma and ion line during ionospheric heating, JGR, 123, 918-930, 2018 and Wu et al., The behavior of electron density and temperature during ionospheric heating near the fifth electron gyrofrequency, JGR, 122, 1277-1295, 2017).

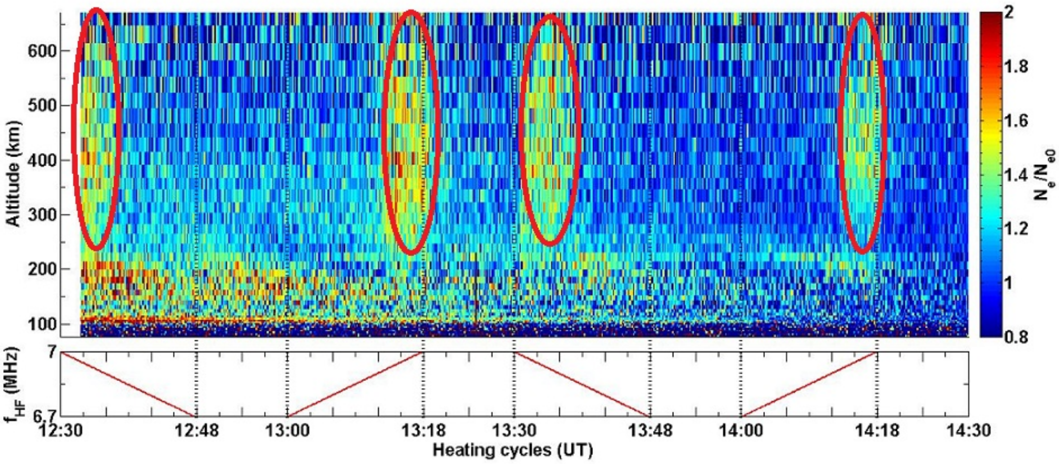
The fact is that from the experimental observations performed in the interval of 12.30 – 14.30 UT on 11 March 2014, we find **six** interesting phenomenon (scientific questions), as those followings,



The enhanced electron temperature as a function of pump frequency

Fig 1. the enhanced electron temperature as a function of pump frequency

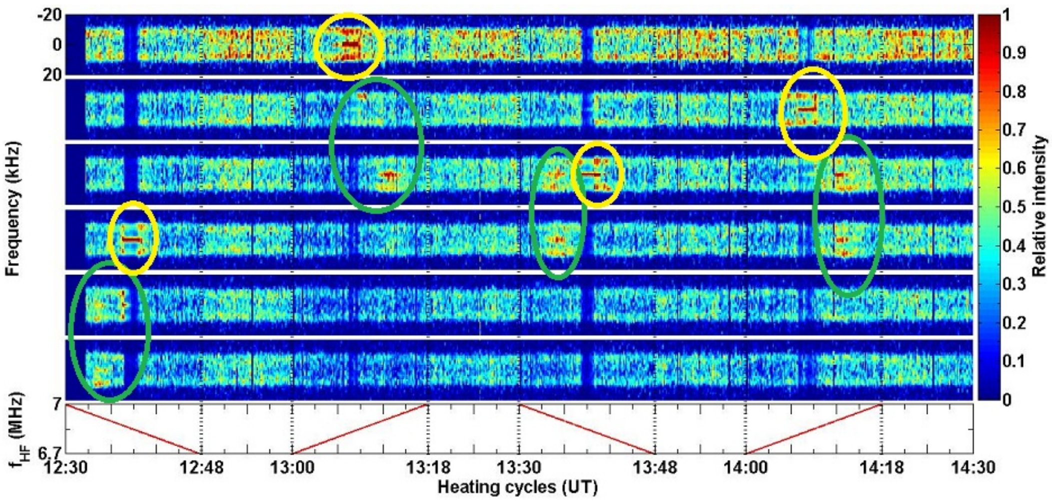
(1) the enhanced electron temperature as a function of pump frequency as shown in **Fig 1**. This result was reported in published paper [*Wu, J., J. Wu, M. T. Rietveld, I. Haggstrom, H. Zhao, and Z. Xu, The behavior of electron density and temperature during ionospheric heating near the fifth electron gyrofrequency, J. Geophys. Res. Space Physics, 122, doi:10.1002/2016JA023121, 2017; Wu J, J. Wu, H. Zhao and Z. Xu, Analysis of incoherent scatter during ionospheric heating near the fifth electron gyrofrequency, Plasma Sci.Technol., 19(4), doi:10.1088/2058-6272/aa58db, 2017*.].



The extending enhancement in electron density

Fig 2. the altitude extending enhanced electron density

(2) the altitude extending enhanced electron density as shown in **Fig 2**. This result was reported in published paper [*Wu, J., J. Wu, M. T. Rietveld, I. Haggstrom, H. Zhao, and Z. Xu, The behavior of electron density and temperature during ionospheric heating near the fifth electron gyrofrequency, J. Geophys. Res. Space Physics, 122, doi:10.1002/2016JA023121, 2017; Wu J, J. Wu, H. Zhao and Z. Xu, Analysis of incoherent scatter during ionospheric heating near the fifth electron gyrofrequency, Plasma Sci.Technol., 19(4), doi:10.1088/2058-6272/aa58db, 2017.*].



The HFIL in the HB is extending in altitude (green circle), whereas the HFIL in the GB is not (yellow circle).

Fig 3. a remarkable extension of observing altitudes of the HFIL

(3) a remarkable extension of observing altitudes of the HFIL as shown in **Fig 3**. This result was reported in published paper [*Wu, J., Wu J., Rietveld M. T., Haggstrom I., Xu Z., Zhao H. The extending of observing altitudes of plasma and ion lines during ionospheric heating. Journal of Geophysical Research: Space Physics, 123(1), 918-930, doi.org/10.1002/2017JA024809 2018*].

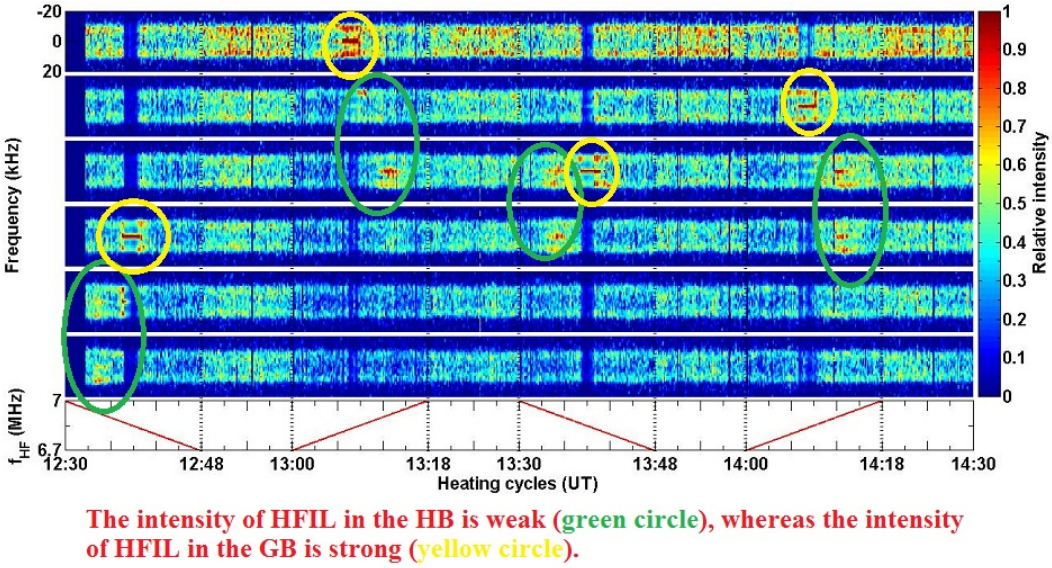


Fig 4. the variation in the intensity of the HFIL as a function of pump frequency

(4) the variation in the intensity of the HFIL as a function of pump frequency as shown in **Fig 4.** This result was reported in published paper [*Wu J., Wu J., Rietveld M. T., Haggstrom I., Xu Z., Zhang Y., Xu T., Zhao H. The Intensities of High Frequency-Enhanced Plasma and Ion Lines During Ionospheric Heating. JGR Space Physics. 124(1). P.603-615. doi:10.1029/2018JA025918, 2018.*]. In addition, as a phase work, we reported the original idea about the intensity of the HFIL in paper [*Altitude and intensity characteristics of parametric instability excited by an HF pump wave near the fifth electron harmonic, Plasma Sci. Technol., 19(12), 2017*.]

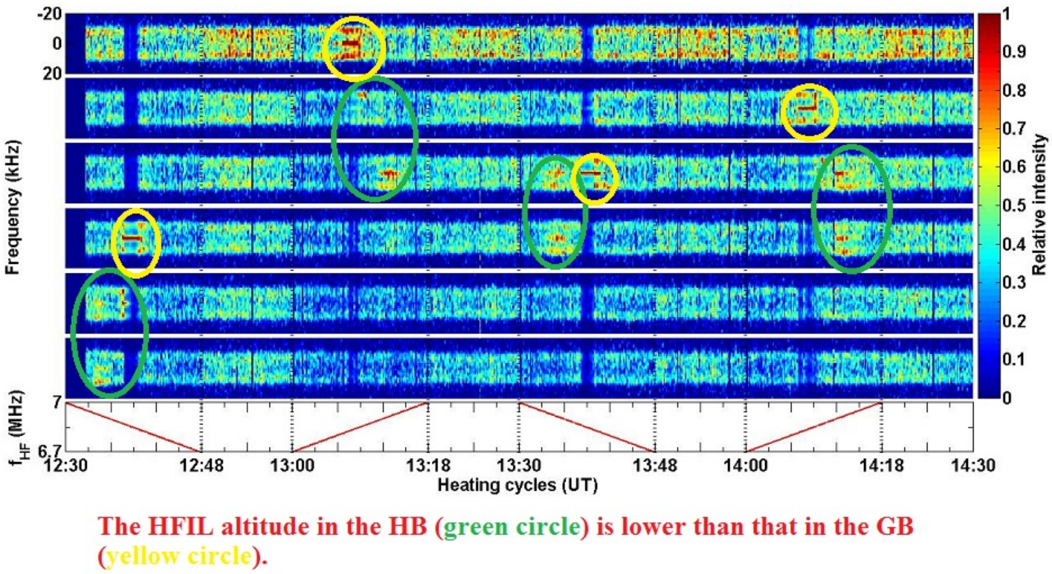


Fig 5. a systematic variation in the altitude of the HFIL as a function of pump frequency

(5) a systematic variation in the altitude of the HFIL as a function of pump frequency, namely, the altitude of the HFIL in the HB is lower than that in the GB, as shown in **Fig 5.** This result was reported in published paper [*Wu, J., Rietveld, M.T., Häggström, I., Zhao, H., Xu, T. & Xu, Z. (2018). Systematic variation in observing altitude of enhanced ion line by the pump near fifth*

gyroharmonic. Plasma Science and Technology, 20(12), 125301. https://doi.org/10.1088/2058-6272/aadd44]. In addition, as a phase work, we reported the original idea about the intensity of the HFIL in paper [*Altitude and intensity characteristics of parametric instability excited by an HF pump wave near the fifth electron harmonic, Plasma Sci. Technol., 19(12), 2017*.]

(6) a systematic variation in the altitude of the HFPL as a function of pump frequency, namely, the altitude of the HFPL in the HB is lower than that in the GB, as shown in **Fig 6**. However, it seems that this observation is in conflict to our usual knowledge that the HFPL altitude in the HB should be slightly higher than that in the GB due to the monotonicity of the altitude profile of ionosphere. This study result was submitted ANGEO with number angeo-2019-23.

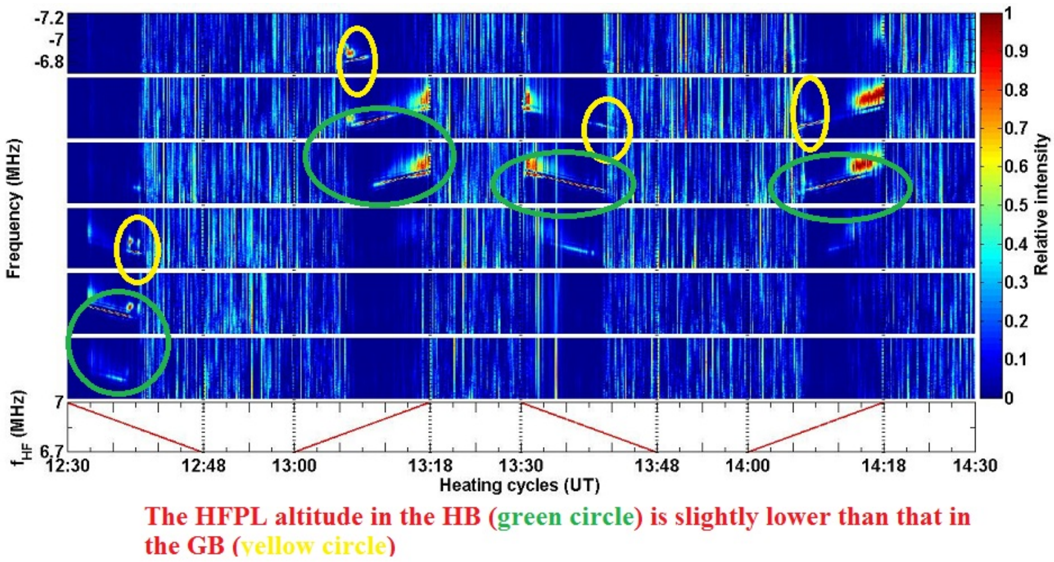


Fig 6. a systematic variation in the altitude of the HFPL as a function of pump frequency

As those statements above mentioned, using those observations (data) obtained in the interval of 12.30 – 14.30 UT on 11 March 2014, six interesting phenomenon (scientific questions) were studied and published respectively, implying that although the same observations (data or figures) were used in those published papers, but the focused question in those published papers is very different from each other. Thus, this manuscript (angeo-2019-23) does not repeat those study results which have been published by authors, but only repeats those radar observations. As author, however, we have the right to re-use those observations (data) in other published according to the Usage Permissions by AGU and IOP.

In this paper, we only focus on the descents of the HFPL in the HB as shown in Fig 6.

2. In this paper, the authors are discussing the effect of electron temperature on the altitude decent of the HFPL and they conclude that HFPL altitude is dependent on the dispersion behaviour of the enhanced Langmuir wave and Bragg condition, and is determined by the profiles of the electron density and enhanced electron temperature. Their discussion and conclusion adds nothing new to what has already been published and discussed by many authors.

Indeed, the descents of the HFPL and HFIL altitudes at EISCAT UHF, VHF and MUIR were frequently observed, which were only attributed to the change in the profile of electron density

[*Djuth et al.* 1994; *Kosch et al.*, 2004; *Dhillon et al.*, 2005; *Ashrafi et al.*, 2006; 2007] or the artificial descending layers [*Streltsov et al.*, 2018].

In this paper, however, we suggested an alternative explanation for the descents of the HFPL, namely, the descents of the HFPL may be ONLY due to the enhanced electron temperature on the traveling path of the enhanced Langmuir wave rather than the change in the profile of electron density.

3. To make any firm conclusion on the altitude variation of the HFPL, you need to know the altitude that these are generated accurately, but in this paper there is no proper discussion and calculation of the reflection height and upper hybrid height for each stepping frequency based on independent measurement such as Dynasonde, which can be obtained at EISCAT heating facility.

As shown in **Fig 6**, the altitude of the HFPL in the HB is lower than that in the GB. This observation is in conflict to our usual knowledge that the HFPL altitude in the HB should be slightly higher than that in the GB due to the monotonicity of the altitude profile of ionosphere.

Indeed, when the pump is stepping up and down, the reflection height and upper hybrid height will change. Due to the very small step of the pump frequency of ~ 2.804 kHz, however, the change in the reflection height and upper hybrid height of the pump should be so small that they will be covered a range gate of radar and Dynasonde and will not be distinguished accurately.

Moreover, this paper focus the observing altitude of the HFPL rather less the exciting altitude of the HFPL. For no confusion for reader, we analyze the altitude of the HFPL using a single frequency ω_L rather less a frequency range induced by the pump. Indeed, those enhanced Langmuir wave induced by the pump should share the same traveling characteristic as ω_L. In this paper, we would like to describe that the pump reflection altitude in the HB should be higher than that in the GB, but the observing altitude of the HFPL in the HB is lower than that in the GB.

4. It is also important to note that when heating along the local magnetic field line, then the reflection altitude changes and is below the reflection height for vertical incidence, but can be calculated using ray tracing.

The reviewer believes that when the pump wave beam is pointing toward the geomagnetic field, the pump wave at frequency higher than 6 MHz will reflect below the upper hybrid height. Indeed, those papers (Mishin et al., JGR, 2004, V.109, A02305; Ann. Geophys., 2005, 23, p.47-53 and Fig.21 from Gurevich, 2007) share similar conclusions, but these conclusions are obtained based on the ray tracing method rather than on a more realistic plane wave assumption. In our experiment, the wave width of the pump wave is ~15 degrees. When the center of the pump wave beam points toward the geomagnetic field, a half of the pump wave beam is still above the geomagnetic field, that is, a half of the pump wave power can be above the upper hybrid height. The most important is that the PDI and OTSI were excited during the experiment on 11 Mar. 2014, as those evidences of HFIL and HFPL shown in observations, implying that the pump was not reflected near the upper hybrid altitude, but reach the parametric resonance altitude.

5. It should also be noted that the linear dispersion properties of Langmuir waves in un-magnetised plasma which has been used for interpretation of the results are not appropriate and have its limitation.

In our experiment, the UHF radar wave beam is also directed toward the geomagnetic field, and is observing the Langmuir wave and ion acoustic wave propagating along the geomagnetic field, which should not be effected by the geomagnetic field. Thus, the linear dispersion properties of Langmuir waves in un-magnetised plasma should be appropriate for our observations.

6. We sincerely request the reviewer to re-consider the comment and conclusion. If so, we will make some modification and clarity.