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. This manuscript repeats the results which have been yet published by authors for the same experiment on 11 March 2014 and for the same time interval from 12.30 – 14.30 UT in following articles:

(1) 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.

(2) 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

(3) 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.

(4) Wu J., J. Wu, M T Rietveld, I Haggstrom, H. Zhao and Z. Xu, Altitude and intensity characteristics of parametric instability excited by an HF pump wave near the fifth electron harmonic, Plasma Sci. Technol., 19(12), 2017.

(5)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.

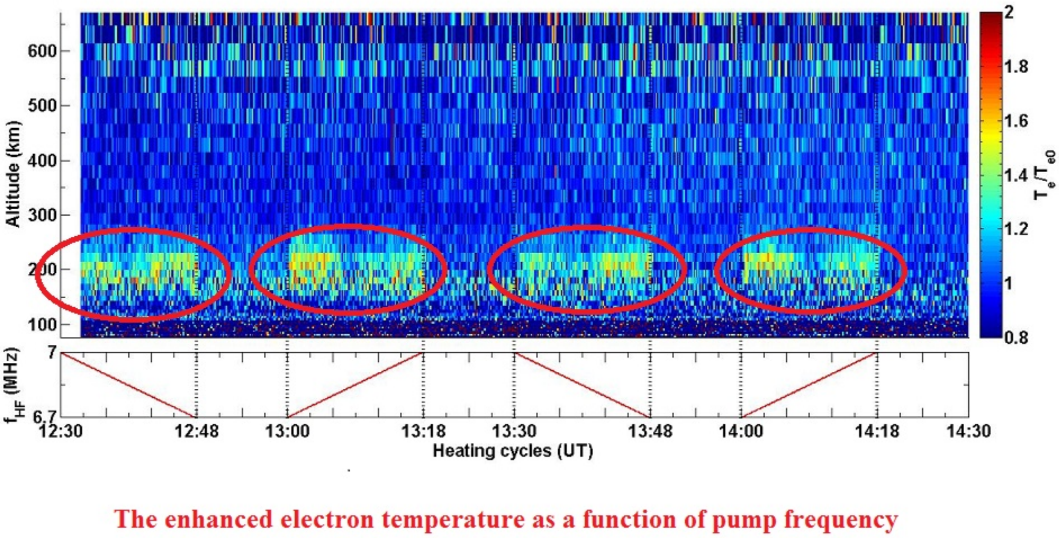
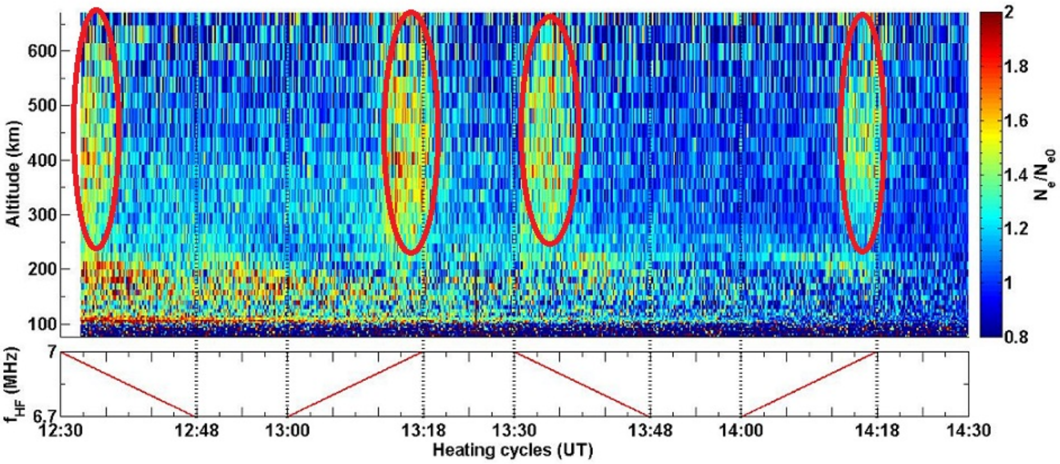


Fig 1. the enhanced electron temperature as a function of pump frequency

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), namely,

(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,*

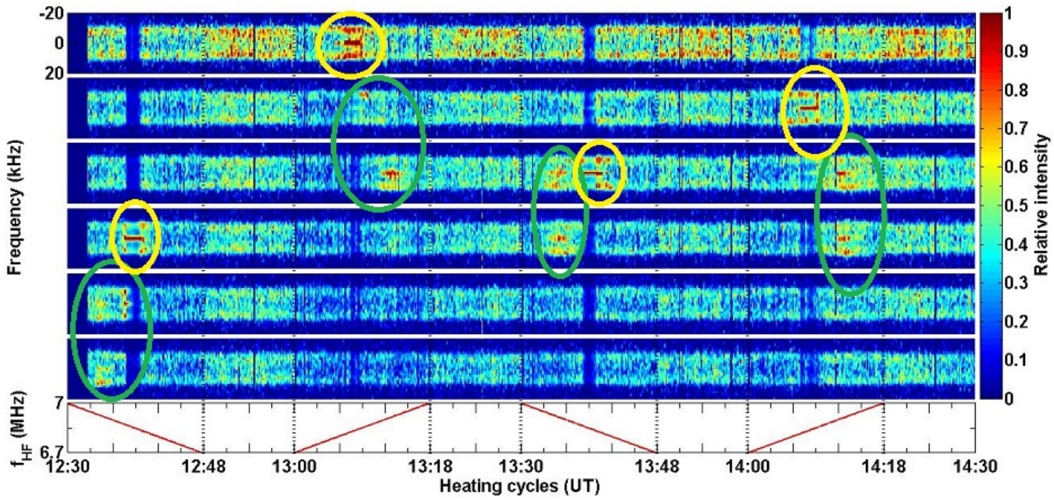
and Z. Xu, The behavior of electron density and temperature during ionospheric heating near the fifth electron gyrofrequency, J. Geophys. Res. Space Physics, 122, doi:10.1002/2016JA023121, 2017; Wu J, J. Wu, H. Zhao and Z. Xu, Analysis of incoherent scatter during ionospheric heating near the fifth electron 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

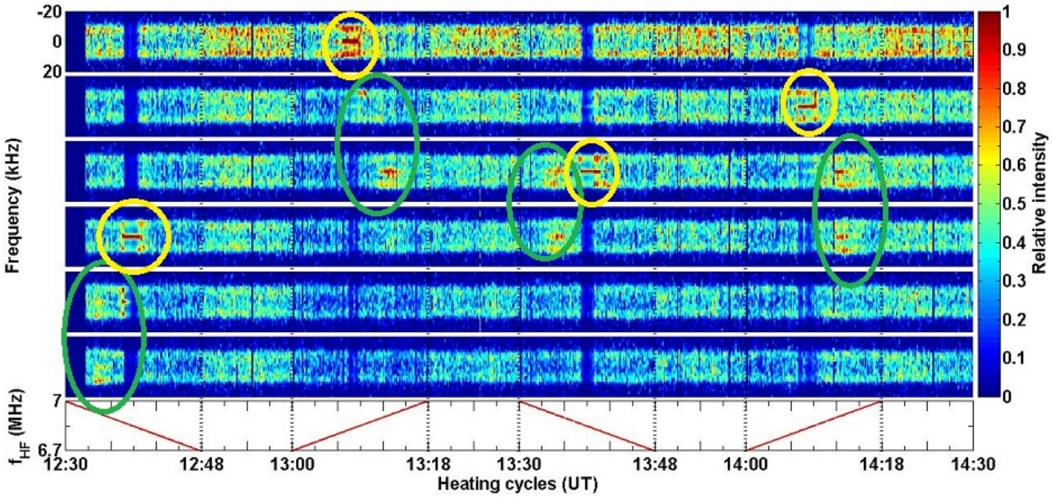
(2) **the altitude extending enhanced electron density** as shown in **Fig 2**. This result was reported in published paper [*Wu, J., J. Wu, M. T. Rietveld, I. Haggstrom, H. Zhao, and Z. Xu, The behavior of electron density and temperature during ionospheric heating near the fifth electron gyrofrequency, 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

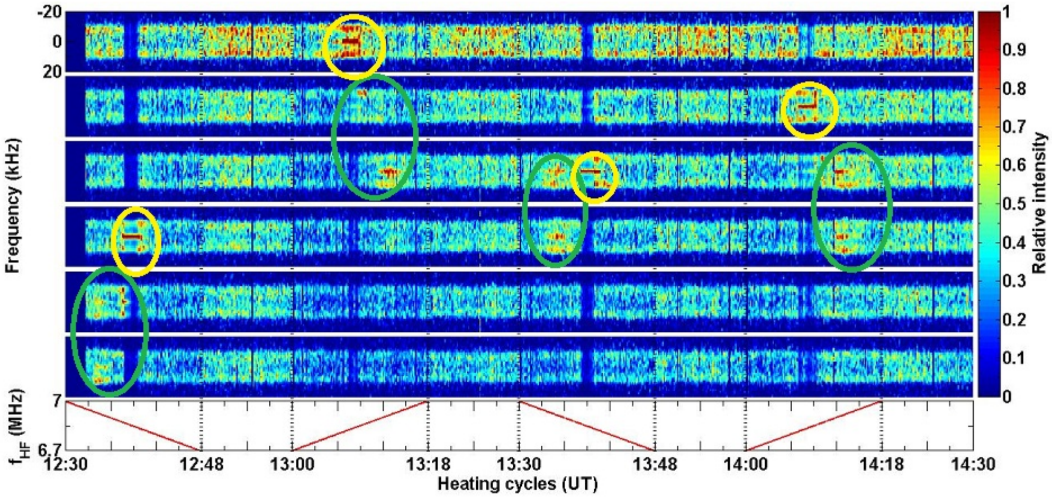
(3) **a remarkable extension of observing altitudes of the HFIL** as shown in **Fig 3**. This result was reported in published paper [*Wu, J., Wu J., Rietveld M. T., Haggstrom I., Xu Z., Zhao H. The extending of observing altitudes of plasma and ion lines during ionospheric heating. Journal of Geophysical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



The intensity of HFIL in the HB is weak (green circle), whereas the intensity of HFIL in the GB is strong (yellow circle).

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*.]

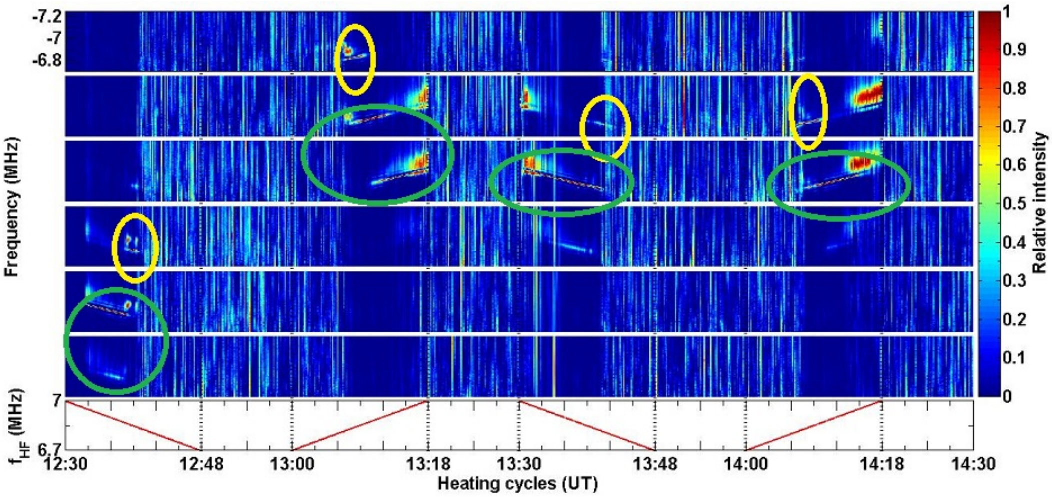


The HFIL altitude in the HB (green circle) is lower than that in the GB (yellow circle).

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. This result was submitted ANGEO with number angeo-2019-23.**



The HFPL altitude in the HB (green circle) is slightly lower than that in the GB (yellow circle)

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.

2. Note, that the only experiment on 11 March 2014 is not unique itself. There were a lot of other frequency stepping experiments near the electron gyroharmonics at EISCAT. For a example, Borisova et al (Radiophys. & Quantum Electron., 2016, 58, 8, 561-585) has described and analyzed a series of EISCAT O-mode HF pump frequency stepping experiments near the fifth electron gyroharmonic carried out on 22, 23, 25 and 26 October 2013, when the features and behaviors of HF-enhanced ion and plasma lines from EISCAT UHF radar observations were considered in the combination with the artificial field-aligned irregularities from the CUTLASS

(SuperDARN) observations and spectral features of the stimulated electromagnetic emission measurements.

Yes, it is true that the experiment on 11 March 2014 is not unique itself. Russian colleagues Borisova et al. has carried out the same experiment on 22, 23, 25 and 26 October 2013. However, (1) the fact is that Chinese collogues also carried out those experiment on 3, 4, 5, 6, 7 Dec. 2012. Due to the bad ionospheric condition, however, the observation was not good. On 11 March 2014, Chinese collogues repeated those experiments. (2) According the EISCAT data rule, those data for special experiment should be open in the world after one year. (3) Using those data obtained on 11 March 2014, Chinese collogues studied PDI and OTSI such as the altitude and intensity of HFIL and HFIL, which are very different from Russian colleague's studies and does also not conflict with Russian colleague's studies. Thus, Chinese colleague's works should not conflict with the scientific ethics.

3. The important comment is also that the Discussion section, based on the articles by Stubbe et al., 1992; Djuth et al., 1994, is appropriative only for the vertical incident angles. However, the experiment on 14 March 2014 was conducted under HF pumping towards the magnetic zenith. O-mode HF pump waves at the magnetic zenith reflect below the standard reflection layer at vertical incident angles (see Mishin et al., JGR, 2004, V.109, A02305; Ann. Geophys., 2005, 23, p.47-53 and Fig.21 from Gurevich, 2007). Moreover, at high pump frequencies near the 5th electron gyro-harmonic (fH _ 5fce) the pump wave is reflected near the upper hybrid resonance altitude. Therefore, the careful estimations of the reflection altitudes at MZ pumping are necessary.

The fact is that during the experiment carried out by Djuth et al., HF heater and UHF diagnostic beams were both positioned at 5° zenith angle in the direction of geomagnetic south [Djuth et al., 1994]. Additionally, in the papers [Stubbe et al., 1992 and Djuth et al., 1994], no limitations were given. Moreover, in our experiment, the UHF radar wave beam is also directed toward the geomagnetic field, observing the Langmuir wave and ion acoustic wave propagating along the geomagnetic field, which should not be effected by the geomagnetic field. In addition, 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.

4. It should also be noted that the analysis of changes in the excited height of PDI and OTSI instabilities, taking into account the dispersion relations, is carried out under the assumption that the parameters of the ionospheric plasma are monotonous. However the spatial changes of the electron density and temperature versus fHF (the time of heating cycles) are more complicated

that are not taken into account in the analysis of pump frequency variations around the fifth electron gyro-harmonic.

Sincerely, I would like to remind that we analyzed the changes in the observing altitude of HFIL and HFPL rather less the exciting altitude of PDI and OTSI. By taking into account the dispersion relations, our analysis is carried out under the measurements by EISCAT UHF radar rather less the assumption.

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

Indeed, The descents of the HFPL and HFIL altitudes at EISCAT UHF, VHF and MUIR were frequently observed, which were 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 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. We are trying to express that this paper should be new and meaningful.