Dear Editor and referees, we have revised the manuscript according to referees' s remarks. Their reports and our point-by-point answers marked by color are given below.

Referee 1

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

The paper has improved a lot through the latest revision. My comments have been addressed adequately. The science content is now much more sound than in the previous version. The relations found between the occurrence of coherent fluctuations in geomagnetic field and foF2 with the parameters investigated are rather weak. According to 10b, the improvement in the frequency correspondence (absolute difference) between magnetic and foF2 pulsations for the coherent events is less than 5% compared to the same difference calculated for all events. This needs some explanation and discussion.

Actually, the result in Figure 10 compares frequency distributions not between coherent intervals (group 4) and non-coherent ones, but between all the intervals with geomagnetic pulsations (group 2) and those, when foF2 fluctuations were also registered (group 3). Figure 10 (b) presents the results of comparison of mean square difference between frequencies of spectral maxima Δ_{f2} within group 3 for the spectra of simultaneous geomagnetic and foF2 pulsations and those calculated at random (generally, not equal dates). The explanation of this point is extended (lines 220-234)

The relative occurrences of the coherent events (vs different parameters) are presented at two levels of coherence. For me, it seems unnecessary and rather confusing then helpful. I suggest to keep only the distributions at the gamma_squared = 0.5 level. At higher level, the occurrence rate of coherent events remains mostly below 5%. It just means that highly coherent events are rare.

The second threshold for coherence is excluded

However, the main problem with the current version of the paper is that it is still very difficult to read.
Firstly, because the organisation of the paper is not reader-friendly. Section 2.3 (Pre-processing), especially from line 143 is a mere listing of the spectral, statistical quantities applied later in the paper. Without giving examples, it is difficult to follow what is the function and purpose of the different quantities in

the data analysis, and also the definition of the quantities is sometimes unclear. (e.g. “the fraction of intervals Rγ with over-threshold maximal γ2 is presented”).

The information given in the previous version in Section 2.3 (lines 148-155) is now presented in Section 3.

Secondly, because of the confusing use of the terminology and notation. Different terms are used for the same thing, however, it is not explained to the readers that they refer to the same thing. E.g. “a fraction” (that is itself very confusing) is also called “coherent ratio” in the meaning of ‘relative occurrence of coherent events’. Another example: “meridional distribution” vs. “south-to-north ratio” in the meaning of ‘frequency dependence of the south-to-north ratio’ or ‘south-to-north spectral ratio.

In the revised version, the only term “Meridional PSD ratio” is used

It is also confusing, that the same letters are used to denote very different things. E.g. P means probability, PSD, and also PSD peak (although in the latter- P_f,b - meaning it is always referred to as PSD maximum in the article. ‘PSDmax’ or similar would be more natural and understandable choice for the latter).

Some indices seems unnecessary, e.g. since PSD (except for the very last figure) is only calculated from magnetic signals, so P_f,b or PSD_f,b could be simply PSDmax.

Now all the PSDs are given in the Figures explicitly and some of indices are excluded

Both ‘F’ and ‘f’ are used for frequency.

The explanation for different notations is included in the beginning of section 2 (lines 89-91).

Phi denotes both phase and magnetic latitude.

Actually, different notations are used for phase, ϕ and magnetic latitude Φ. However, they really look similarly in Figures 11 and 15 and we have used the explicit description PSD_{SOD}/PSD_{MAS} in the axis labels.

‘R’ stands for PSD ratio and relative occurrence, etc.

In the revised version, we use R for the PSD ratio, while “Rel. Oc.” is used for relative occurrence in axis labels of Figures 9 and 12-14.

Finally, the English of the paper is still very poor. I add a list of some of the typos I found. This list is very far from being complete!

27 filed > field +
73 …AE > … AE indices. +
75 :: > : +
78 at, in > between, at +
106 foF2 which > foF2 for which the +
136 for the > for +
152 at > of +
161 the its > its +
201 the distributions of the parameters of foF2 variations with the magnetic local time > MLT-dependence of the occurrence rate +
202 occurrence of foF2 interval [confusing phrase] removed
204 a fraction of > the occurrence rate of coherent events [?] The phrase is rewritten
205 bb maximum: what is bb? Two threshold values is excluded from the text and Figures, and this phrase is omitted
205, 206: the noon > noon +
Fig 11 in the legend 1 should be 2 or the text should be adjusted - done
242 which it is [?]. The paragraph is rewritten.
253: 3 times higher: I cannot see what you mean – the PSD_{max} values for both groups are included into the text
261: A difference … is seen: I cannot see it
261 probablity of the … interval [?] The phrase is rewritten
Fig 13 R_gamma : the Greek letter should be used here +

Referee2

Suggestions for revision or reasons for rejection (will be published if the paper is accepted for final publication)

This revised manuscript explores the statistical behaviour of ionospheric variations in the frequency range of 1 -5 mHz and simultaneous low-frequency geomagnetic pulsations observed at auroral latitudes during periods of quiescence but also under moderately disturbed geomagnetic conditions. Using a newly developed method for the automated detection of ionospheric F2 region's critical frequency, foF2, from ionograms, Yagova et al. investigated time intervals where fluctuations of the ionosphere's FoF2 frequency are accompanied by similar temporal variations of the magnetic field's northward component as this has been measured by ground magnetometers. They identified several cases of high coherence indicating a convincing relationship between low-frequency geomagnetic pulsations and the modulation of the ionosphere's F2 layer. They also looked into favourable solar wind conditions to find that solar wind pressure pulses, known to

excite magnetospheric ULF waves, are among the possible drivers of both geomagnetic pulsations and particle modulation.

The presentation of their methodology and analysis' results have greatly helped the support of the manuscript as well as its readability. This revised manuscript has a few issues that I would like to see addressed to the editor's satisfaction before I could recommend publication of this manuscript.

In line 1 of the Abstract, it would be more convenient for the reader to know that the coordinates provided for the Sodankyla Geophysical Observatory are the geographical coordinates rather that to have to look this up in Table 1. done

In line 3 of the Abstract and throughout the manuscript, the authors talk about Pc5/Pi3 waves. I would caution the authors against referring to Pc5 and Pi3 waves together, when Pc5 waves are considered to have a sinusoidal wave form and last longer than Pi3 waves that have an irregular wave form. Pi3 waves can be the ground counterpart of Pc5 waves with moderately high-m numbers observed by spacecraft, as it was found by Vaivads et al (2001), but this study is centred around geomagnetic pulsations observed on the ground. The authors cite several published results of research carried out with focus on either Pi3 or Pc5 waves. Among others, Kleimenova et al. (2002) showed that auroral substorms influence Pi3 activity but Baker et al. (2003) isolated Pc5 waves whose amplitude did not grow nor was damped as is the case of irregular pulsations for their study of Pc5 waves. Furthermore, Posch et al. (2003) adopted a ULF index that allows to minimise the power contribution of large, irregular pulsations along with the total ULF wave power which may include the substorm counterpart of ULF waves. Although, Pc5 and Pi3 waves' frequency falls in the same range, adequate justification for the choice to consider the two types of waves together needs to be provided.

The explanation is now given in the end of the beginning of section 2.3 (lines 127-132). As we do not analyze pulsation types and analyze all the pulsations at frequencies 1-5 mHz, we have change Pc5/Pi3 to Pc5-6/Pi3 throughout the text.

In line 77 of Section 2.1, the authors note that geomagnetic pulsations are searched for in the BX component of the magnetic field measured by ground magnetometers (it should read "Bx"). Later in line 119 of Section 2.3, the symbol bx is used for variations of the same component. However, it is not made clear how these variations have been identified. Has a mean value been calculated that corresponds to the Earth's main magnetic field, and variations been defined as deviations from this mean? Has a different approach been adopted for the derivation of magnetic field variations?

An explanation of different notations for variations of foF2 and B and their absolute values is moved to the beginning of Section 3.1, where filtered time

series are shown in Figure 3 (lines 177-179)

In line 79 of Section 2.1, the authors refer to Table 2 that includes a list of more than 80 intervals that have been selected for further analysis. (It is redundant to provide the same table in the Supplement.)

The double tables are excluded

In Section 2.3, these intervals where foF2 has been retrieved utilising the new methodology have been divided into four groups. Please add group 5 to the list which has not been introduced until in Section 3.1.2

done

and point out the assumptions that have been used in statistical analysis of data covering time intervals of varying length unambiguously.

Actually, the time intervals are of equal length (64 points), and all the analysis is based on the spectra for these standard intervals. The explanation of this point is extended (lines 156-159)

It is also strongly recommended to provide sufficient details of the grouping of foF2 frequency data in 2764 overlapping intervals, as this is mentioned in line 151, to prove the validity of the statistics.

In the revised version of the MS, a more detailed description of intervals with the account taken of overlapping is given in the text (lines 160-170)

For instance, it is not so clear how it was concluded that foF2 frequency fluctuations and geomagnetic pulsations are more likely to occur coherently in the recovery phase of moderate geomagnetic storms.

We use a 4-day minimum of Dst index, i.e. pulsations at the recovery phase are included into analysis. Now an explanation is given (lines 265-273) and the details of time delay distribution at 3 levels of minimal Dst are available in a supplementary file.

In the last two paragraphs of Section 2.3, the authors provide details of the power spectral density calculations and cross-spectral analysis. It is, however, not clear whether the Blackman-Tukey correlogram/periodogram analysis has also been used for the calculation of PSD in the Bx and By component.

This part of Section 2.3 is modified, and the description of spectral estimates is given in more details (lines 152-170)

In line 171 of Section 3.1.1, it would more correctly read “Peak amplitudes of geomagnetic pulsations and foF2 variations are about 8 nT and 0.05 MHz.” and in line 183, “Their peak-to-peak amplitude was about 0.7 nPa …”. In line 178, it should read “…start time of the interval (12:20 UT).”

Done

On page 16, please consider adding a colour bar in Figure 1 with the three ionograms from the Sodankyla Geophysical Observatory provided as examples. This would also help make clearer the first of the two criteria set for the automated detection of foF2 and specifically, the condition that the intensity of reflection should fulfil.

Done

Please consider providing the units of measurement in line 97 of Section 2.2 for the lower value of the intensity.

The reflection intensity in Figure 1 is given in dB, while for the approximation in Eq.1. linear scale is used (voltage in arbitrary units). The units are now given in the text (lines 95-96) and in the Figure 1 capture.

Please note that there are numerous typos making it necessary to carefully revise the manuscript in terms of spelling and punctuation as well as language. For example,

in line 6 of the Abstract, the authors must mean “automated retrieval of foF2, the critical frequency of the F2 layer from ionograms.” done

In line 27, “filed line resonances” should be “field line resonances”. done

In line 37, the comma after “observed oscillations is, …” should be deleted. +

In line 56, it is not clear to me and perhaps the reader what the term “principle opportunity” means.

This fragment of the text is extended and re-formulated and a direct reference to soft electrons modulation by long-period ULF waves is included (Ren et al., 2019, lines 55-57).

In line 66, “ionosond” should be changed to “ionosonde”. +

In line 83, it would more correctly read “variability of the intensity of reflected signals, background noise, sporadic layers and irregularities, broadcast interference, etc.” done

In line 88, it would more correctly read “near linear growth” and, in done

line 89, “Lorentzian function” instead of “Lorentzian shape function” which makes one think of spectral line shape. done

In line 164, it should read “$\gamma b2 = 0.64$, $\gamma 2 > 0.375$”. This phrase is deleted in accordance with the suggestion of Referee 1 to give only one threshold value for coherence.

Lastly, the format of citations should be revised. For example, in line 25, “(Wright et al., 1997) should be changed to “Wright et al. (1997)” and in line 47, “(Pilipenko et al. 2014b)” should be “Pilipenko et al. (2014b)”. done

References

Saito (1978), Long-period irregular magnetic pulsation, Pi3, Space Science Reviews, doi: 10.1007/BF00173068

Vaivads et al. (2001), Correlation studies of compressional Pc5 pulsations in space and Ps6 pulsations on the ground, Journal of Geophysical Research, doi: 10.1029/2001JA900042