Response to the Referees

Kilometric wave emission observed on pre-midnight side in the vicinity of the Earth's magnetic equatorial plane at 1-2 L-Shell

First of all, we thank both reviewers for their constructive comments and suggestions. In the title, we have written 'Kilometric wave emission' instead of 'terrestrial kilometric radiation', and indicated where DEMETER detected such radiation. In the upgraded version we have re-considered and re-written essentially the Section 3 taking into consideration the reviewer comments. It is evident that the confusions between DEMETER kilometric wave emission and the terrestrial kilometric radiation are due to three main reasons: spectral beam, i.e. 'Christ tree', are similar, the parallel bands and the beaming around the magnetic equatorial plane. In the discussions Section, i.e. Section 3, we have summarized the main results and insisted on one side, on the spectral features of the kilometric wave emissions and on the other side on the similarities and the discrepancies between the DEMETER kilometric emission and the terrestrial kilometric radiation. The Z-mode is considered as a generation mechanism candidate. Our responses to referee are listed below.

Response to Referee #1

Reviewer1: The authors state that kilometric continuum (KC) is observed by the DEMETER spacecraft, which is at an altitude of ~700 km. The scatter plot in Figure 4 shows the bulk of the emissions occurring below 100 kHz. At 100 kHz the plasma density is ~120 cm-3. Since KC is a free space mode radiation its frequency (f) must be above FPE or FR [eg. Shaw and Gurnett, 1980, Kennel et al., 1987]. I don't know the DEMETER location for Figure 1 so used 2 magnetic field strengths in the table below.

N_E(cm^{-3})	B(nT)	F_{PE} (kHz)	F_{CE} (kHz)	F_R (kHz)	F_L (kHz)
10000	30000	900	839	1413	573
1000	30000	284	839	927	87
100	30000	90	839	849	9
10000	20000	900	559	1222	662
1000	20000	284	559	679	119
100	20000	90	559	573	14
The cutoffs F_R is f where R=0, F_L is f where L=0; R&L are from Stix [1962] F_{PE} -plasma frequency, F_{CE} -electron cyclotron frequency.					

The authors suggest that the emissions observed by DEMETER could be related to plasmaspheric plumes. For one to believe these emissions observed by DEMETER are free-space KC, a plasmaspheric drainage plume/channel would have to extend down to ~700 km altitude with minimum densities of say ~ 100 cm-3 or less at that altitude; an altitude where ~ 104 to 4x104 cm-3 is common near the equator. Looking at Figures 2 and 3 of Chen et al., [2018] NE dropping below 104 cm-3 on the nightside or dayside around the equator is rare. So, if DEMETER is frequently seeing this emission around the equator then I don't believe these emissions are free-space. Z-mode radiation occurs at f between FL and FUHR (upper hybrid resonance f) the authors need to check if this radiation could be Z-mode. A key issue must be resolved, before the reviewer can accept this paper for publication.

MAJOR COMMENTS

R1_A: A key issue must be resolved, before the reviewer can accept this paper for publication. Since this is a major claim that DEMETER detects KC, a detailed event analysis should be given in the paper that demonstrates the radiation is free space mode. You have not convinced me that your type 1&2 events are free space radiation. I suggest that you show one of more example spectrograms of events with the frequency of the & FPE & & FR & FL & FCE lines overlaid on the spectrogram. This will give the reader a feeling of whether or not the radiation is free-space. If ISL Langmuir probe paper Lebreton et al. [Planetary and Space Science 54 (2006) 472–486] data is not available for any of your events, you could try IAP or infer the plasma density from the E/B ratio using data below 17.4 kHz, assuming you can identify the wave mode and the E&B measurements are reliable. 100 per cc might be the threshold of ISL so f(l=0) & fpe & fuhr would be a upper limit.

> A1_A: As suggested by the referee, we have checked and found that the considered kilometric wave emissions can't a free space radiation. In all events the gyrofrequency (FCE) is above the frequency associated to the LF kilometric emission. In Fig.1 or Fig.2 the gyro-frequency is indicated.

R1_B: If you can correlate some of your events with KC events observed by GEOTAIL PWI. The GEOTIAL PWI 24 hr survey plots are located at http://space.rish.kyotou.ac.jp/gtlpwi/. I see no KC in the GEOTAIL PWI spectrograms for the 2 days given in your paper, of course GEOTAIL could be at the wrong LT or the KC generated at low RE does not always escape the plasmasphere/ionosphere.

> A1_B: GEOTAIL orbits were mainly far, at least 10 RE, and on the day side. We have checked the PWI dynamic spectra for the investigated period and did not find comparable spectral features as recorded by DEMETER. This may be due to the distance of the satellite which is bigger than 5 RE.

R1_C: On your spectrogram plot please indicate where the IGRF (or similar) model field aligned magnetic minimum crossing occurs. If centered about the Type 2 emissions then this would cast doubt in my opinion about the emissions being KC.

> A1_C: As suggested by the referee, we have indicated in Fig.1 and Fig.2 the gyrofrequency.

R1_D: No discussion of the interpretation of the harmonics of type 2 is given. Looking at the type 2 in Figure 1, the spacing between the harmonics is ~25 kHz. Using a simple dipole and standard continuum emission model this places the equatorial source at about ~3.2 RE, with a sharp plasma gradient, with Ne extending up to at least (fpe=600 kHz) ~4500 cm-3 at that location. Fpe at 600 kHz at ~3.2 RE is at the upper range of observed plasmaspheric plasma frequencies at ~3.2 RE, further casting doubt in my opinion.

> A1_D: We totally agree concerning the harmonics of type 2. The frequency spacing of 25 kHz of Figure 1, recorded mainly in the southern part of magnetic equator, is variable from one event to another. This structured component disappears when we consider all events, i.e. as can see in the first panel of Fig.4. However in the northern magnetic equatorial plane, the frequency interval is, on average, about 150 kHz at magnetic latitude 20°N.

R1_E: It is not clear to me if harmonic spacing of ~25 kHz can be explained in terms of local plasma conditions and/or non-linear processes. Because FCE is large I would like to see at least one the spectrogram of the entire ICE frequency range out to 3.25 Mega-Hz.

A1_E: We have added in Fig.1 and Fig.2 an overview (i.e. total frequency range) and a zoomed part (i.e. from few kHz up to about 900 kHz) for the two examples.

R1_F: Have you to tried to correlate Type 2 with the particle measurements (IAP, ISL, IDP)? It's important to understand these emissions. Have you searched for other explanations for these emissions? Could this be an example of instrumental spherical probe pre-amp oscillations due to localize plasma conditions?

A1_F: In reality, we did not check the particle measurement on aboard DEMETER. This may be done in further investigation of this work. Of course, we did not try to search for other explanations since we thought that we deal with terrestrial kilometric radiation particularly because of the spectral beam. Concerning the instrumental influence, Bertherlier (PI of ICE experiment) did not address such instrumental effects in his paper (i.e. Berthelier et al., 2006). The frequency bandwidth is not constant but variable from one event to another.

OTHER COMMENT

R1_G: Free-space or Z-mode emission in an equatorial plasma bubbles might be another possibility instead of drainage plumes. Equatorial bubbles are observed by DMSP on about 1 out 8 orbits [Huang et al., JGR 2001] whether the internal density of bubbles can be low enough to accommodate the DEMETER observations is not clear.

A1_G: We though to the drainage plumes because of the development of the emission beam in the case of the terrestrial kilometric radiation. In the upgraded version, we only refer to the source location as reported by Green & Boardsen (2006) and avoid the confusion between both kilometric emissions.

R1_H: Line 28. 'We use a manually technique which consists to follow and to save with the PC-computer mouse'. Instead of manual selection did you try an automated selection method. Looking at Figure 1, it seems like automated selection followed by visual inspection of those selections might save one time, this would allow you to scan a larger time interval.

A1_H: The manual technique has been adapted because of: (a) the weak intensities of kilometric wave emission when compared to AKR and also to the instrumental noise level, (b) the phenomenological aspects of this emission where we have attempted to classify/distinguish other spectral components observed at mid-latitude and sub-auroral regions and (c) the presence of LF transmitters which are overlapping the investigated kilometric wave emission.

R1_I: You don't give enough information about your survey. Start/stop dates that your survey covered. We looked a X nightside equatorial crossings finding Y events? We looked a X dayside equatorial crossings finding Y events?

A1_I: In the paper, we have indicated the probability of occurrence of such kilometric wave emissions observed only on the night-side of the Earth. We found that the crossing of the magnetic equatorial plane by DEMETER is usually followed by the detection of kilometric wave emissions, as displayed in Fig.4. The difference from one orbit to another is the intensity level of the emission and also the frequency bandwidth which is found in the range between few kHz and 800 kHz.

R1_J: Where these emissions not observed before 2010? If so why, or did you not look before 2010?

A1_J: We started in the beginning of 2010 because of the low solar activity. We followed the work of Kuril'chik et al. (2001) who reported that the terrestrial kilometric radiation is regularly observed during quiet solar activity.

R1_K: Figure 1 is not of publication quality. I would also include a dayside example, maybe 2 dayside and 2 nightside examples, with better annotation as described earlier in the review.

A1_K: As suggested by the referee, we have considered two examples with better annotations. We have no dayside events.

R1_L: Figure 2 Lack of clarity in how the histogram is computed: for example, looking at Figure 1 at 14:01:40 are all harmonics summed in a given latitude bin? I would make a weighted histogram instead, summing the weights in each latitude bin. For example if you selected 800 points in Figure 1, then I would weight each selection by 1/800 for that equatorial crossing.

A1_L: We attempt in this paper to provide a global view of the occurrence of all events. The use of manually method is not adequate for 'weighting' the bin in latitude and longitude. For the data processing, we did not use conditions on: (a) the time and frequency spacing between two points, and (b) on the intensity level. We have emphasized on the spectral pattern of the emissions like the fluctuation in time and frequency, and the variable frequency bandwidth.

R1_M: Why not split histogram into day/night? Scatter plot of power versus frequency might be revealing. An annotated spectrum at the center of Type 2 would also be helpful. Power level (defined as square root of the power spectral density)

A1_M: We observed the kilometric wave emission only when DEMETER was on the night-side. Fig.4, 5, 6, and 7 displayed the dependence of the emission frequency on the power levels. We have considered three intensity levels associated to the three maxima derived from the second panel of Fig.3. The power level has been corrected and expressed as $\mu V\ m^{-1} Hz^{-1/2}$.

R1_N: Figure 3: include legend of what the 3 colors correspond too, don't just say it in the text, this makes it hard for the reader.

A1_N: The colors associated to the power levels are corrected and indicated in the new legend of Fig.3.

R1_O: Figure 4: include legend of what the 3 colors correspond, don't just say it in the text. Why not split into day/night?

A1_O: We also precise in the new legend of Fig.4 the corresponding power levels.

R1_P: A scatter plot for Type 2 of the frequency spacing of harmonics versus frequency of harmonic might be revealing. From standard theory this can be used to estimate the fc/fp ratio at the source under the assumption that the density gradients are sharp.

A1_P: We have previously indicated that the frequency bandwidth is variable. The assumption about the density gradients have been discussed in the upgraded version if the observed emission is the terrestrial kilometric radiation. The fc/fp ratio may be applied if the plasma frequency is higher than the gyrofrequency frequency. It is not the case in this study.

References

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