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Interactive comment on "A statistical study of spatial distribution and source region size of chorus waves using Van Allen Probes data" *by* Shangchun Teng et al.

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Interactive comment on "A statistical study of spatial distribution and source region size of chorus waves using Van Allen Probes data" by Shangchun Teng et al.

We would like to thank the reviewer for helpful suggestions.

[Page 3, first paragraph, you might want to include/discuss Taubenschuss et al., 2015 results in your intro since they also looked at rising and falling tones in the THEMIS data Taubenschuss, U., Y. V. Khotyaintsev, O. Santolík, A. Vaivads, C. M. Cully, O. Le Contel, and V. Angelopoulos (2015), Wave normal angles of whistler mode cho-

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rus rising and falling tones, J. Geophys. Res. Space Physics, 119, 9567–9578, doi:10.1002/2014JA020575.]

Thanks for pointing out this work. We have discussed this paper in the revised manuscript.

[Page 3, Line 29: What were the parameters of your fft? How many samples? Any overlap? I think it would be good to state/discuss what you did since it can make a big difference on the resolution and the types of structure you will see in the spectra.]

The FFT parameters are as follows: FFT samples are 1024 point with an overlapping 512 points (50%). And we have added this information in the revised version. The resulting spectrogram is shown in Figure 1, which shows that the parameters are good enough for our purpose.

[Page 4, Line 6: How is a chorus event (rising or falling) exactly defined? Is only a single element needed in a snapshot to be an event, or a number of elements? How "clear" does the element need to be to be defined as a riser or a faller? For example, in your Figure 1a, I think I can see rising elements buried in the broad band more hiss like structure, but from your test I believe this type of event was excluded from your chorus list. Can a 6 second snapshot period have both rising and falling tones? Please describe your methodology in more detail so we can better understand your process on determining a riser and/or faller event. Also, from my experience with the EMFISIS burst data, I am a little surprised there were that many falling tone events, so I want to be sure I understand how they were defined.]

Thanks for pointing this out.

First, the events (rising and falling) collected in this study is mainly based on visual inspection. This inevitably introduces some subjectivity as pointed out by the reviewer using Fig 1a as an example. As far as we were aware of at the time we prepared the database for this study, the only published method that could automatically determine

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"chorus" events and "hiss" events was by Li et al.

Li, W., R. M. Thorne, J. Bortnik, X. Tao, and V. Angelopoulos (2012), Characteristics of hiss-like and discrete whistler-mode emissions, Geophys. Res. Lett., 39, L18106, doi:10.1029/2012GL053206.

The Li-method was based on the variation of the peak PSD with time. We have also tried this method to automatically determine the events type, but we found that it could fail easily on some chorus events because of the overlapping of elements and the fluctuated frequency range used to determine the peak PSD. Note that Li et al also confirmed their automatically obtained results by visual inspection. We have also tried using techniques from imaging processing to develop an automatic method to identify chorus elements, but failed to find a method that gives high enough positive identification rate.

Therefore, we agree with the reviewer and we fully understand that the method based on visual inspection could miss some "chorus" events, but this is the best we could do. On the other hand, there is some ambiguity on labeling a given spectrogram such the spectrogram in Fig 1a as pointed out by the reviewer. For this study, we chose a more conservative approach when visually identifying chorus elements: we require that discrete elements should be clearly identifiable such as those in Fig 1b and 1c. Unfortunately, it is hard to give a quantitative criterion for visual identification. So we list here some representative spectrograms of falling tones (see Fig. 1).

Finally, by using a large amount of data, this approach should not affect our statistical results in a significant way, which is the lowest order estimate of the source region size.

It is possible to have both rising tone and falling tone elements in a 6-second burst. We have found a small number of events of this type, but they were not included in our database, because it is not clear which category (rising or falling) we should put them.

The number of falling tone events is large here, probably because we surveyed a large

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amount of wave bursts (1237851). The total number of falling tone events we found was 10477 out of 1237851 bursts, which gives a probability of roughly 1%. Among chorus events we selected, most of them are rising tone chorus (66739 out of 77216 events).

In short summary, it is not easy to automatically pick out "chorus events". We mainly used visual inspection and did the best we could. There is some subjectivity introduced by this process, but with large amount of data, we think this kind of subjectivity should not change our conclusion significantly.

[Page 5, Line 24: I think you need to describe how you determine the electron density. Are you using the UHR band (Kurth et al., 2015), the EFW proxy density, or some other method? The Kurth reference is below in case that is what you are using. Kurth, W. S., De Pascuale, S., Faden, J. B., Kletzing, C. A., Hospodarsky, G. B., Thaller, S. and Wygant, J. R. (2015), Electron densities inferred from plasma wave spectra obtained by the Waves instrument on Van Allen Probes. J. Geophys. Res. Space Physics, 120: 904–914. doi: 10.1002/2014JA020857.]

The electron density we use is from the EFW proxy density. The time resolution of EFW proxy density data is about 10s, which can meet our requirement. On the other hand, EMFISIS L4 data, based on Kurth method, also provides density information. But its time coverage is limited, so we choose the EFW proxy density. We have added clarification about this in the revised version.

[Minor suggestions Page 3, Line 28: I believe the sampling rate for the EMFISIS burst is set at 35 kHz and cannot be modified, so I would replace "up to" with "of"]

Thanks. We have changed "up to" to "of".

[Figure 1 and 4: I would put the time and date of these data so the reader could plot the original data if they wanted to do their own analysis to compare to your plots.]

We have changed the labels in figures 1 and 4 as suggested.

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We thank the reviewer again for these helpful comments.

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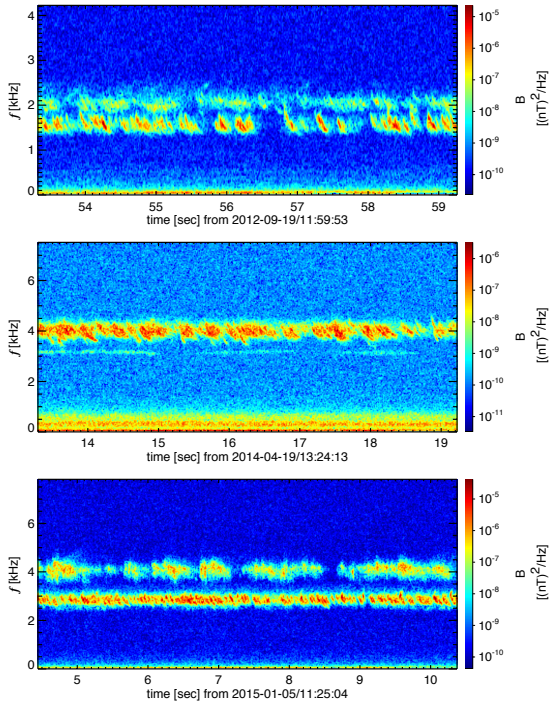

Fig. 1. falling_exam

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