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Atmospheric Chemistry and Physics Discussions

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Interactive Comment

Interactive comment on "The climatology, propagation and excitation of ultra-fast Kelvin waves as observed by meteor radar, Aura MLS, TRMM and in the Kyushu-GCM" *by* R. N. Davis et al.

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Reply to Referee 2

The authors are very thankful for the constructive comments we have received from the editor Dr. Baumgaertner and the anonymous referees. They were very helpful, and have contributed to strengthening the paper in many places. Two new figures have now been included in the paper as a result of the suggestions and so please note that some of the original figure numbers have changed, an updated copy of the paper in

ACPD format has been included with this response. A number of points were raised, which have been addressed as follows:

Referee's comment 1) I strongly recommend the satellite results to start with period-wave number spectrum or function of wave period vs height (or latitude) E1 wave (similar to Figure 3) obtained from all 6 years data. If you obtain a period-wave number spectrum, then you convince the reader from the beginning that such wave (UFKW E1) is really present in the considered data and the spectrum defines its prevailing period.

Our response: We have newly inserted a figure (Figure 1 in this document, which is now Figure 7 in the paper) showing the results of a 2D FFT at the beginning of the satellite's results section, immediately after presenting the data used in the FFT. Figure 1 shows amplitude vs period for E1, E2 and E3 waves. This figure was obtained by splitting the Aura MLS temperatures collected within a 10 degrees latitudinal band centred over the equator into 18 sectors of 20 degrees longitudinal width, and then subtracting the daily mean from each sector, so that a time series (in half-day steps) of temperature perturbations was produced for each longitudinal sector (i.e. similar to the data that was plotted in the Hovmoller figure). A 2D FFT was then taken of this data, which identifies the dominant frequencies (from the time domain) and wavenumbers (from the longitudinal domain). The figure shows only E1, E2 and E3 for reasons of clarity. It can be seen in the figure that amplitudes at periods between 2.5 and 4.5 days are much greater for the E1 component than for E2 or E3. We thus restricted the paper's scope to the E1 components of the UFKW since these have larger amplitudes.

We have also added a figure showing the dominant wave-period vs height derived from the Aura MLS data, similar to the paper's Figure 3. This is presented in Figure 2 (which is Figure 10 in the new version of the paper). This was obtained by taking the average over all six years of wave amplitudes (derived by the least squares fit method) for each satellite height gate. As the amplitude growth with height dominated the colour scale of the figure, the mean-amplitudes were normalised within each height gate to better

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show how the amplitudes varied with period at lower heights. The figure shows that at the heights observed by the meteor radar the dominant wave periods are 2.5 - 4.5 days. The figure also shows a tendency for wave periods to increase at lower heights. This is in good qualitative agreement with the model results of the paper's Figure 3. The new figure has also been included in the paper and the text has been expanded to include an explanation of the figure.

Referee's comment 2) As you are interested in climatological feature (this is written in the paper title) then the average, for the considered 6 years of measurements, latitude and altitude structures have to be calculated.

Our response: The climatology aspects of the paper were focused on that seasonal activity shown in the paper's Figures 5, 13, 14 and 16. For the latitude/altitude structure shown in the paper's Figure 9, we have only included 16 large events so that times at which there are no Kelvin waves present are not included.

Referee's comment 3) My second general point is only recommendable: I think that any data analysis paper in general needs a quantitative errors analysis.

Our response: Figure 3 of this response is a plot of the errors on the satellite temperature E1 wave amplitudes obtained from the least squares fit method, averaged over the six years of data considered. It can be seen that the errors peak at heights around 85 km at equatorial latitudes. However the mean error doesn't exceed 0.5 K, thus we assume amplitudes greater than 0.5 K to be above the noise level. For reasons of length we have not included this figure in the paper but comments have been added to include this errors approximation.

Referee's comment 4) Figure 1: Probably the low-pass filtered red line is not necessary as the 3-4-d wave in zonal wind and 2-d wave in meridional wind are well outlined. Probably an example for Jul-Aug will be also useful because then the UFKW are particularly strong in the zonal wind (according to Figure ()a) and the quasi-2-d wave are relatively weak in the meridional component.}

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Our response: We have kept the lowpass-filtered lines because they help guide the eye, but have made them less obtrusive. We would prefer not to include an additional figure showing June 2005 for reasons of space, although the wave is clear in this data as well.

Referee's comment 5) Figure (2): As you are interested in climatology of the UFKW please, present mean spectra for the zonal and meridional winds calculated from all meteor radar data. As the meteor data have many gaps probably it will be better first to obtain the composite year data and then to calculate the spectra for both wind components.

Our response: We had calculated these spectra from the radar data, but concluded that the running Lomb-Scargle analysis was more informative. Given that the paper was already quite long, we decided to include only the running Lomb-Scargle results in the submitted paper. Nevertheless, Figure 4 of this response presents the long-term Lomb-Scargle spectra (used as the datagaps were too large to be interpolated for FFTs) of the full six years (2005-2010) radar data for both the zonal and meridional winds. The y-axis has been cut off at 5 m/s as the 24h tide is so large. A number of significant peaks are apparent at wave periods 2.5 - 4.5 days. The amplitudes are relatively small, only a few m/s, probably because of the intermittency of the UFKW activity (i.e. the waves occur in short-lived bursts). Given that the running Lomb-Scargle spectra are more informative, we would prefer to use these instead of the results of Figure 4.

Referee's comment 6) P. 9, last paragraph: how long window do you use for extracting the UFKW E1 from the data?

Our response: For the least squares fitting process, windows of length ten days were used as a compromise between temporal and spectral resolution. This information has now been included in the paper.

Referee's comment 7) Figure 9: Yes, this plot shows average, i.e. climatological latitude

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structure of the UFKW E1 as it is obtained by averaging 16 events observed between 2005 and 2010. If you however carefully considered the latitude structure of the wave amplitudes at each altitude may notice that most of the amplitudes maximise not just over the equator, but at 5-10oN. This is an indication for a slight phase change with latitude therefore this is not purely equatorially trapped mode.

Our response: Some of the peaks do indeed maximise at 5oN rather than over the equator. However, we do not believe that this effect is significant because the peak latitude often changes slightly depending on how many wave events we actually include.

Referee's comment 8) Figure 12: I cannot understand well how the altitude structure of the phase can be obtained when the period is not fixed. The considered period range of 2.5-4.5 days is too large then at different heights you may consider different waves.

Our response: In each individual case the wave period was calculated and the variation of phase against height determined at that period. We did not assume a single wave period for all wave bursts. The period was fixed at the value at which the amplitude maximised for each event. For example, on 3 August 2005 (the event whose height/phase structure is shown in the paper's Figure 12) the highest amplitude was found at a period of 92 hours, and so the phases at this period were plotted. A comment has been added to explain this in the paper.

Referee's comment 9) P. 11, last paragraph: ...are in months February and July-August,...

Our response: This has been corrected, thanks.

Referee's comment 10) P. 17: paper Chen and Miyahara (2011) is not for UFKW E1; it is for fast Kelvin E1 wave s with periods between 6 and 10 days.

Our response: The paper we cite in the references is about both FKW and UFKW (the latter with periods near 3 days). This paper has been submitted but is not yet publically available.

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Thankyou again for your comments.

Please also note the supplement to this comment:
http://www.atmos-chem-phys-discuss.net/11/C14285/2012/acpd-11-C14285-2012-supplement.pdf

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Interactive comment on Atmos. Chem. Phys. Discuss., 11, 29479, 2011.

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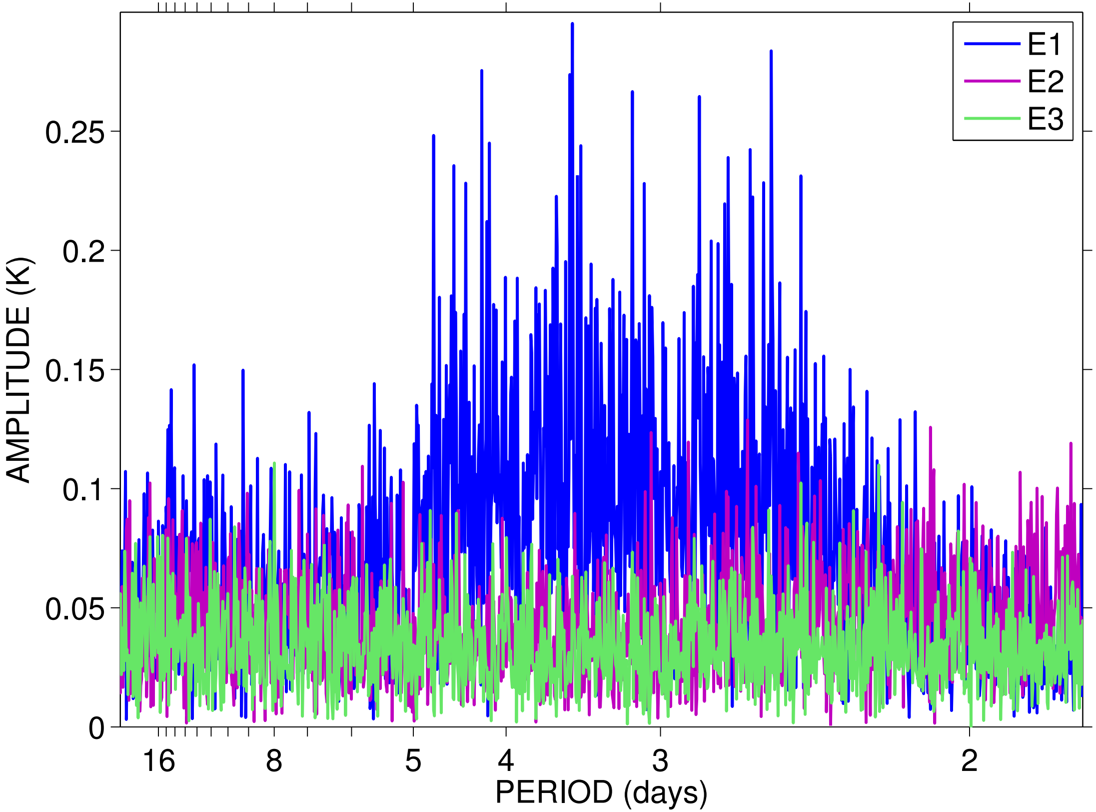

Fig. 1. Spectra showing amplitudes for E1, E2 and E3 wavenumbers resulting from a 2D FFT of the temperature perturbations as a function of time and longitude. The data are for a height of 97 km, 2005 - 2010.

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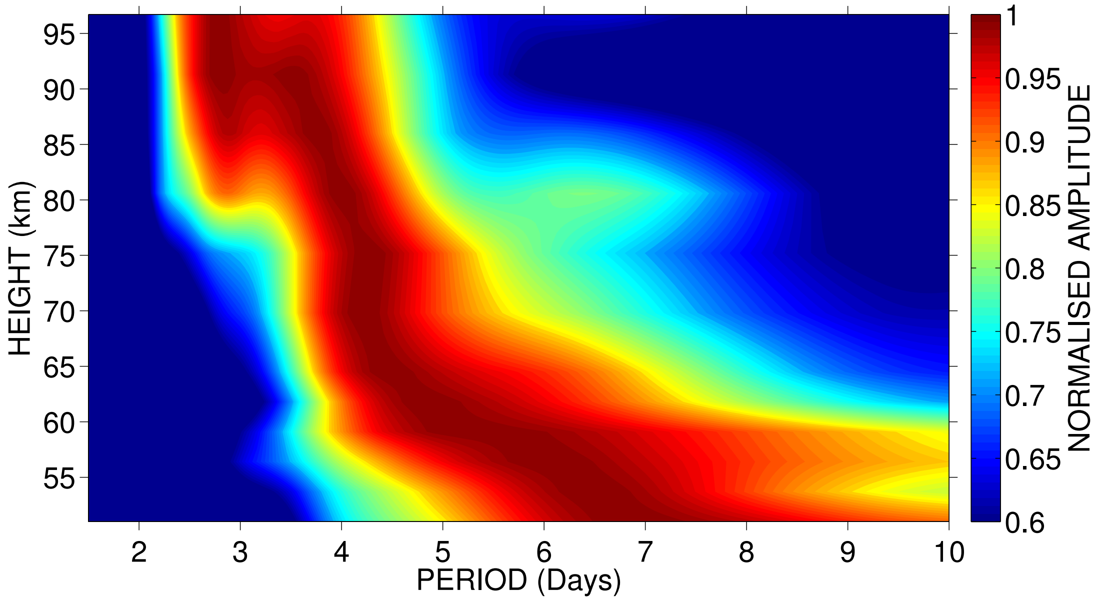

Fig. 2. Period vs Height of annually-averaged E1 wave amplitudes obtained by least squares fits on the satellite temperatures. Each amplitude within a height gate is normalised to that height's maximum.

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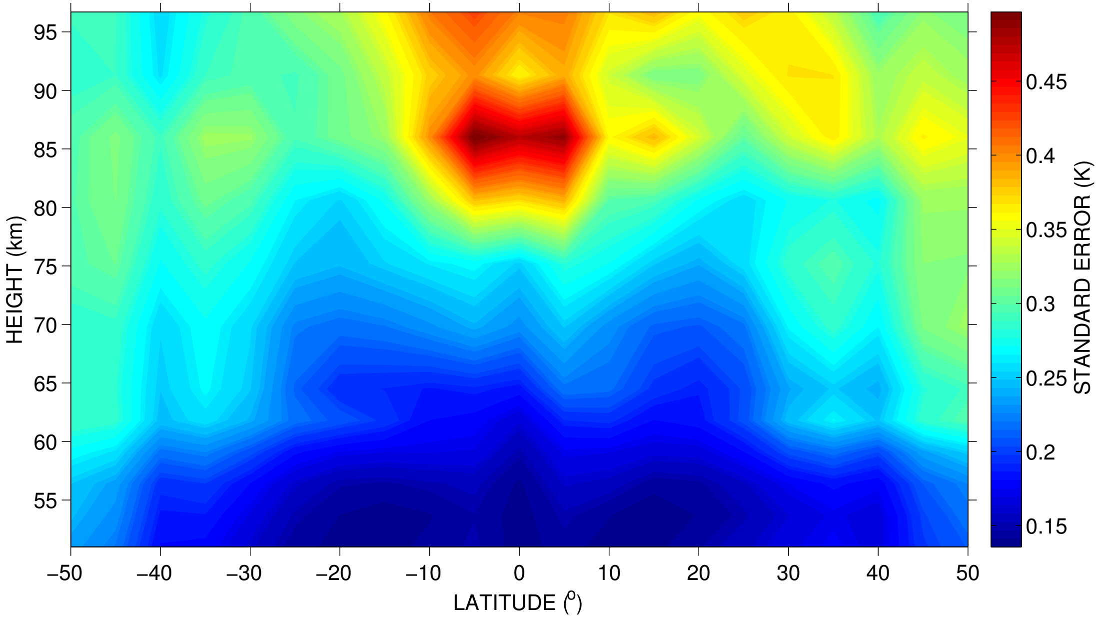

Fig. 3. Standard error on E1 wave amplitudes least squares fitted to Aura MLS temperatures, averaged over six years of data (2005-2010).

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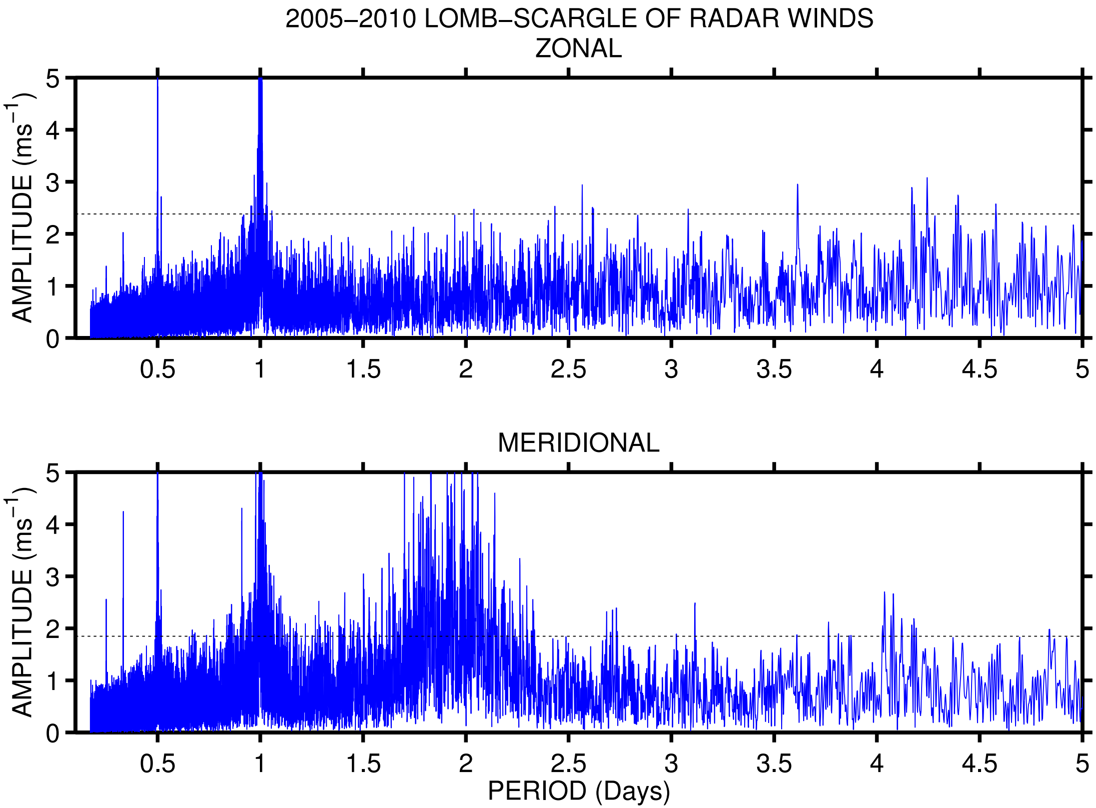

Fig. 4. Lomb-Scargle periodogram of all six years (2005 - 2010) of zonal and meridional radar winds. The horizontal dashed lines represent the 95% confidence limit.

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