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Interactive comment on "Investigation of sources of gravity waves observed in the Brazilian Equatorial region on 08 April 2005" *by* Oluwakemi Dare-Idowu et al.

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Referee 1, Report 1 Comments

(1) Referee's Comments (2) Author's response (3) Author's changes in manuscript

(1) Page 1, line 15: A reserve ray-tracing (2) Thank you, we have corrected this grammatical error as in (3). (3) "A reverse ray-tracing analysis was performed to research possible sources of these detected waves".

(1) Page 1, line 16: to research the (2) Thank you very much we have rewritten this in the manuscript as in (3). (3) "to research possible sources of these detected waves"

(1) Page 1, line 24: Do the authors mean influence of gravity waves on climate or influence of climate on gravity waves or influence of gravity wave climate on ionosphere? (2) Thank you very much for the comment, we meant to imply how gravity waves impact the upper atmosphere as they transport energy and momentum. We have rephrased this sentence and made the correction as in (3). (3) "Since the publication of the pioneering works of Hines in the 1960s on the detection of irregular motions 'gravity waves' in the upper atmosphere, there has been numerous improvement work-outpours"

(1) Page 1, line 28: and solar eclipse (2) Thank you, this word has been removed from the sentence, and the text has been reworded. (3) "solar eclipse (e.g Marlton et al., 2016) as well."

(1) Page 1, line 29: as well (2) Thank you, this has been removed in the text of the manuscript. (3) solar eclipse (e.g Marlton et al., 2016)

(1) Page 2, line 17: Should include studies by Medeiros et al. (2005) as well as Taylor et al. (2009) as cover waves of the similar characteristics in the same region as this study. A.F. Medeiros, H. Takahashi, R.A. Buriti, K.M. Pinheiro, D. Gobbib, "Atmospheric gravity wave propagation direction observed by airglow imaging in the South American sector", J. Atmos. Sol. Terr. Phys. 67, 1767âĂŤ1773, 2005. M. J. Taylor, P.-D. Pautet, A. F. Medeiros, R. Buriti, J. Fechine, D. C. Fritts, S. L. Vadas, H. Takahashi, and F. T. Sao Sabbas, "Characteristics of mesospheric gravity waves near the magneticequator, Brazil, during the SpreadFEx campaign", Ann. Geophys., 27, 461–472, 2009. (2) Thank you for the comment, we have included some of the works as in (3) (3) "These atmospheric structures have been identified as a key component in the transportation of energy in the mesosphere and lower thermosphere (MLT) region (e.g., Fritts, 1993; Medeiros et al., 2007; Campos et al., 2016). Using the dispersion relation, the vertical wavelength can also be computed (Vargas et al., 2009). Gravity waves can be summarized as large-scale waves, medium-scale waves, and small-scale waves. Small-scaled gravity waves are characterized by horizontal wavelengths in tens of kilometers (Taylor et al., 1995; Medeiros et al., 2003); medium-scaled gravity waves propagate at $\sim$ 170

km altitude (Vadas et al., 2009); and large-scale waves have high phase speeds and travel farther horizontal distances compared to others (Vadas et al., 2009). In the MLT region, there are several and continuous chemical reactions such as the OH airglow emissions (e.g Sivjee et al., 1991; Taylor et al., 2009; Campos et al., 2016). These emissions among several others have been used by many authors as a proxy for investigating gravity wave activities. Airglow are faint luminescence that are produced as a result of the emission of solar radiations (ultraviolet and x-radiation) by ionized air molecules. These luminosity are usually captured by the all sky imagers (ASI) (e.g Chamberlain, 1954; Krasovskij et al., 1964)".

(1) Page 3, line 1: what are the satellite coordinate range used for these measurements? (2) Thank you, the referenced coordinates are 7.4o S, 36.5o W. We corrected it as in (3). (3) "In this study, at 7.4o S, 36.5o W, the vertical temperature measurements from 20 to 108 km were obtained from SABER".

(1) Page 3, line 7: What is this acronym? (2) Thank you, the acronym stands for All-Sky Interferometric Meteor Radar (3) "The All-Sky Interferometric Meteor Radar (SKiYMET) system located at 7.4o S, 36.5o W". provided measurements of the horizontal wind speeds and direction of the mesosphere (81-99 km)".

(1) Page 3, line 6: Is the radar also located at 7.4o S, 36.5o W? (2) Thank you, yes, the radar is located at the same observatory (7.4o S, 36.5o W) (3) "The All-Sky Interferometric Meteor Radar (SKiYMET) system located at 7.4o S, 36.5o W provided measurements of the horizontal wind speeds and direction of the mesosphere (81-99 km)".

(1) Page 3, line 22: What is the feature identified as the gravity wave in the raw or filtered image? (2) Thank you, the ripples represent the effect of the gravity waves. We have improved the resolution of the airglow image in the manuscript, and modified the description as in (3). (3) "The ripples enclosed in the black box in Figure (1a) represents the gravity waves.

(1) Page 4, line 3: Was this done to fill in data gap between 23:51 and 8:35 UT? What about time between 20:00 and 23:46 as most of your gravity waves fall within this period? Also how reliable is your interpolation when you have only a small sample of data to spread over such a long time period? (2) Thank you very much, the MSIS model https://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html provided us with the numerical values for temperature for times (12h to 22h) on 08 April 2005. The interpolation was done from 23:46 (08 April) to 08:40 (09 April) so that we could have a 2hr temporal resolution. We have effected the necessary corrections by explicitly stating the sources of our measurements and rewording our texts for the sake of clarity. (3) "In addition, numerical values for temperature obtained from https://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html from the time (1h to 22h) on 08 April 2005 was used to complement the SABER measurements. Afterwards, linear interpolation from 23h46 (08 April) to 08h40 (09 April) was used to create 13 profiles with a temporal resolution of 2hrs"

(1) Page 4, line 8: How can you get periods during the time when you have no observations; according to the statements above temperature data covers the period 23:46 8 April and 8:40 on 9 April? (2) Thank you for your correction, we had data during this period because we used measurements from the MSIS model as supplementary data specifically for our observatory's geographical location. We have reworded the manuscript for better clarity.

(1) Page 4, line 9: What is the time period of this radar's observations (2) Thank you, we used a time period of (0h to 23h) for 08 and 09 April, 2005. (3) "The SKYiMET radar provided the zonal and meridional wind measurements from 81-99 km every 3 km between 0h to 23h on 08 and 09 April 2005 with a resolution of 1h"

(1) Page 5, line 1: Please give details where or how you obtained values for density and molecular weight. (2) Thank you, we obtained the density measurements for our specified period and date from https://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html. And for the molecular mass values, we used this equation: XMW

=1/2(XMWO-XMW1)[1-tanh((s-a)/Δa)] +XMW1. We have explicitly stated this in the manuscript as in (3). (3) Where is the density obtained from https://omniweb.gsfc.nasa.gov/vitmo/msis_vitmo.html, and the molecular weight was estimated from XMW =1/2(XMWO-XMW1)[1-tanh((s-a)/Δa)] +XMW1. Where XMW0, XMW1, Δa, and a are constants given by 28.90, 16.0, 4.20, ad 14.90 respectively, and s= lin() (Vadas et al., 2009). Additional details about the reverse-ray tracing parameters can be found in (Vadas et al., 2007; Vadas et al., 2009).

(1) Page 5, line 8: Are U,V,W different components of the velocity (e.g. Vx,Vy,Vz)? If that is the case I suggest not using V as a component to avoid confusion or use a boldface to denote that its a vector with components U, V, W (2) Thank you, you are right about this, we meant to use U, V, W as the 3-D wind components. And we changed this as in (3). (3) Every gravity waves gets influenced by the atmospheric winds with velocity V = (U, V, W) according to the following equations:

(1) Page 5, line 10: Please explain all parameters in this equation, for e.g. what is k and what is subscript j (2) Thank you, i, j = 1,2,3 indicate the indices of the components x, k, and V. cg represents the group velocity of the waves. We have however corrected this in the manuscript and stated explicitly the significance of each parameter as in (3). (3) "where V is the wind velocity with 3-D components U, V, W, i, j = 1, 2, 3 ... are indices of the components x, k, and V."

(1) Page 5, line 13: How is this determined? (2) Thank you, we obtained the intrinsic frequency by using the dispersion relation as given in equation 40 and 48 of Vadas and Fritts, 2004. We have however done necessary corrections by clearly stating how we determined this in the manuscript. (3) "ωIr is the real part of the intrinsic frequency obtained using the dispersion relation in the Equation 40 and 48 of Vadas and Fritts, 2004".

(1) Page 5, line 17: Give the differential equations for clarity (2) Thank you, we agree with the referee and we have written out the four differential equations in the

manuscript.

(1) Page 5, line 26: Is not clear whether the results mentioned here are from Fig 1d or Table 1 or somewhere else (2) Thank you, here, we were making reference to the results in table 1. (3) "The spectral results shown in Table 1 shows an observed wavelength with a standard deviation of 24 km and mean value of 130 km with large amount of variability among the detected waves"

(1) Page 6, Figure 2: What are the velocities represented by each circle in the polar plot? (2) Thank you, each circle represents 20 m/s. We have restructured the manuscript as in (3). (3) "Compass graph showing wave velocities and direction of propagation, each circle denotes a velocity of 20 m/s. "

(1) Page 7, line 8: How do you get propagation azimuth from Fig 4a? (2) Thank you, it was an error, we were making reference to compass graph in figure 2 (3) Figure 2 shows all gravity wave propagating southeastward.

(1) Page 7, line 6: it would be useful to discuss what would the vertical speed of the waves be to reach the OH height emission height for these 5 cases discussed here. (2) Thank you, we agree with the referee and we have made appropriate discussion in the text.

(1) Page 9, line 7: Please revise sentence, it is not clear. (2) Thank you, we have revised as in (3). (3) In Event 1, in comparison to others, the bottom side of the convective sources (deep blue clouds) appear to be farther from the point where we traced the gravity wave source (black and blue dots). However, this particular wave is still linked to the convective processes as its source. According to Vadas and Fritts, 2009, the actual convective area is usually larger than the cloudy areas.

(1) Page 13, line 16: Proper introduction of figure 9 is necessary for block-diagram non-experts. (2) Thank you, we agree with the referee, and we have included a brief introduction of blocking diagrams as in (3). (3) "According to cH= Ucos ø + Vsin ø,

where cH represents the phase speeds of these gravity wave, U is the zonal wind component and V is the meridional wind component, we constructed blocking diagrams using the azimuthal angles (ø). With input winds from the Horizontal Wind Model, we aimed to understand the wind filtering effects on the gravity waves, investigate why all the waves have a preferential propagation direction, and also to detect regions where the phase speed of the GW is $\leq$ the velocity of the winds. The results of the 3-D blocking diagrams are shown in the following figures".

(1) Page 13, figure 9: The axes need better labeling - which components of the velocities are in each axis. (2) Thank you, the x-axis represents the zonal wind component, and the y-axis is the meridional wind components. We have labelled the blocking diagrams appropriately in the manuscript.

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