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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simultaneous in situ measurements of small-scale structures in neutral, plasma, and atomic oxygen densities during WADIS sounding rocket project" *by* Boris Strelnikov et al.

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Review Report

1 General Comments

Strelnikov et al. present the results from measurements conducted during the WADIS-2 rocket campaign on 05 March 2015 at 01:44:00 UTC to investigate the small-scale

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Discussion paper

structures like gravity waves and turbulence in neutral, plasma, and atomic oxygen densities. Fluctuations of these densities are used to understand the small-scale dynamical behaviour of MLT region. This study is interesting since rocket estimated mean turbulence kinetic energy (TKE) dissipation rate seems to be following the similar trend of mean TKE dissipation rate of winter season in most of the height regions when there was no radar echoes in MAARSY. The results are relevant and it will contribute to the understanding of turbulence activity and energetics in MLT. It discusses the physical and chemical processes governing the energetics of the MLT region. It can be accepted for publication after the revision. I suggest for major revision. Strelnikov et al. claims that atomic oxygen fluctuations are generated by small-scale dynamics such as gravity waves and turbulence; they also try to convince that atomic oxygen fluctuations are not associated with charge fluctuation through chemical reactions with help of no-echoes case in MAARSY radar. If observed fluctuations are purely governed by turbulence then those can be compared with the low-latitude turbulence intensities for enhancing understanding on mesospheric turbulence. Qualitative results are presented but results are not enough with quantitative and clarity statements. They mention rough words like some, somewhat in many places those should be replaced with quantitative results. Notably, references, methodology and assumptions are not mentioned in many places which are figured out in comments.

2 Specific Comments

1. Page 1, lines 12-13: 'GW might dissipate and thereby generate turbulence'-GW might break and generates turbulence. This statement can be supported by appropriate references of observational (e.g., https://doi.org/10.1002/2015JD024283) work(s) since a lot of studies are available but nothing cited.

2. Page 1, lines 13-14: 'Turbulence mixing and redistribution of trace constituents' can be supported by appropriate references of observational work(s).

3. Page 2, lines 6-7: 'chemical heating rates in the mesopause region of several K/day which is comparable (or even competitive) to those of turbulent heating' can be supported by appropriate references of observational work(s) whos study concluded it statistically and/or mention case study.

4. Page 4, lines 23-25: It is stated in Page 3, lines 13-14 that 'MAARSY operated continuously to detect PMWE echoes if any' but no echo is detected during the night of rocket launch. It can be mentioned that echo occurrence depends on both nature of the target and sensitivity of the radar. It is better to reveal with help of volume reflectivity map (without any signal threshold) during that night of rocket launch. And select the profile of volume reflectivity to discuss the sensitivity of MAARSY at that time of sounding in MLT since this article deals with small scale dynamical fluctuations in densities while avoiding chemical reactions. It can be mentioned that during February-March 2011/2012 and 2012/2013, PMWE of MAARSY appeared throughout day and night with dis-continuities in seasonal-local time variation (see Fig. 3 of Latteck and Strelnikova, 2015).

5. Page 4, line 27: 'temperature field measured by the lidars'. Is it measured or estimated? If temperature is estimated then provide appropriate references to methodology for temperature retrieval which is used here.

6. Page 5: In Fig. 2, 'temperature of RMR- and Fe- lidar are combined'. How do they agree?

7. Page 5: In Fig. 2 and Fig. 3, It is better to limit the steps in colormap for easy reference of temperature in Fig. 2 and Fig. 3. And also provide temperature labels in colormap of Fig. 3. And show the results Fig.2 and Fig. without interpolation.

8. Page 7: In Fig. 5, Rocket observed densities are seem to be very much smoothed. How it is smoothed?

9. Page 7: In Fig. 5, Do you find any spin frequency in up- and down-leg of rocket observations? If yes, what are the methods are used to remove those frequency and what are they?

10. Page 7: Line 14, 'Both up- and down-leg profiles are very similar interms of oscillations'. It is worth to show the detrended densities or density-normalised density fluctuations in subplot along with Fig. 5. item Page 7: Line 17, 'some GW-signatures'. It is better to quantify the GW amplitudes corresponding to Fig. 6, as you like, below 80 km, 83-90 km and 95-100 km.

11. Page 8: In Fig. 6, It is worth to describe the mothod(s) and along with valid assumptions used for temperature retrieval from densities. Include the profiles of temperature from Lidars in Fig. 6 for ready comparison of temperature oscillations between remote sensing and in-situ measurements.

12. Page 9: Line 1, 'some aurora was seen'. It is better to mention the wave length of those observed emissions.

13. Page 9: Line 14, 'O-density profiles reveal some oscillations'. It is better to show profiles of density-normalised density fluctuations in subpot along with Fig. 8.

14. Page 11: Fig. 10, It is better to have percentage of amplitude and density-normalised density fluctuations in Fig. 10.

15. Page 11: Line 9, Before comparison of results, describe the observed results of turbulence intensity from different techniques (Heisenberg and Tatarskii) to demostrate the need of different techniques here. And also present the mean of them in order to present quatification of turbulence intensity.

16. Page 12: Lines 6-7, 'This picture is reminiscent of a GW-saturation process when vertical wavelength of GW becomes shorter'. It is worth to quantify the GW activity using the lidar observations and compare them with Fig. 12 for quantitative and qualitative statements since this article mainly focus on dynamics of small-scales.

17. Page 13: Line 14, Briefly describe the assumptions behind this Heisenberg model and the value of its constants which is used in it. How those constants are obtained?

18. Page 14: Fig. 13, Fig. 13a,b & c show the spectra of neutral densities in black line. In frequencies more than 100 Hz, neutral density fluctuations are appearing as almost flattened. Is this flattening due to instrumental noise? Indicate the instrumental noise as a line in Fig. 13a,b & c?

19. Page 15: Lines 1-2, 'ϵ-value is directly derived from the spatial scale l_o'. Provide the formulea and appropriate references along with valid assumptions and constants.

20. Page 15: Line 15, 'MIL descended together with tide'. Quantify the tidal activity using the lidar temperature measurements since demostrated examples behave very good.

21. Page 15: Lines 18-19, 'This temperature enhancement also descends within a time period of several hours'. Provide the descend rate.

22. Page 15: Line 20, 'The upleg rocket data, however, are somewhat different'. What are the differences are observed and at what altitude?

23. Page 15: Line 22, 'MIL, it might have amplified it'. what are the sources might cause amplification of MIL at this altitude (provide appropriate references also)?

24. Page 15: Line 23, 'The weaker turbulence on upleg accompany âĹij10 K colder temperature maximum'. I could not understand this. Can you rewrite it to make understanding in simple way.

25. Page 15: Line 26-27, 'First, the amplitudes of GW in these tracers are different. Second, the phases can be shifted relative to each other'. Can you provide values and discuss it? Since you have unique observations.

26. Page 15: Lines 31-32, 'the neutral and ion density fluctuations must be in anti-phase'. Is it possible to quantify the angle between neutral and ion fluctuations ($< a, b >= |a|.|b|.cos(angle)$) for those three altitudes or altitude regions where coherence exist? Then, Provide the quantification of those results and discuss them.

27. Page 16: Lines 6-7, 'where all three species, i.e. oxygen, ions, and neutrals show nearly the same oscillations'. It can be discussed based on quantified angles.

28. Page 17: Line 35, 'the k-1 slope at scales smaller than those where k-$5/3$ is present'. Provide the profiles of outer scale and inner scale as like ε and indicate the altitudes in it where the spectral slope is seen as k-1. It provides the active altitude regions where two different type of diffusions take place since it is a unique measurements to deal with. And also compare these turbulence parameters with the same of low-latitude turbulence parameters since day-time low-latitude mesospheric turbulence measurements not have any affect with dusty plasma.

3 Technical Corrections

1. Care can be taken thoughout article to write 'in-situ' instead of 'in situ'. And also introduce 'intend in every first line' of every section.

2. Page 1, line 1: 'In this paper, we' instead of 'In this paper we'
3. Page 2, line 10: 'mainly' instead of 'manly'
4. Page 2, line 14: 'is the region' instead of 'is region'
5. Page 2, line 14: 'persistent turbulence field plays crucial role in global circulation' can be explained briefly.
6. Page 3, line 10: I couldn't find the expansion of 'RMR-'.
7. Page 3, line 15: 'in case if they occur' instead of 'in case they should occur'
8. Page 7: Line 12, 'temperatures, respectively' instead of 'temperatures.'
9. Page 7: Line 19, '100 km and, it is' instead of '100 km and is'
10. Page 8: Line 19, 'In Fig. 7, we' instead of 'In Fig. 7 we'
11. Page 9: Line 18, 'In the next section, we' instead of 'In the next section we'
12. Page 10: Line 16, 'In Fig. 10, we' instead of 'In Fig. 10 we'
13. Page 11: Line 14, 'In Fig. 12, we' instead of 'In Fig. 12 we'
14. Page 11: Line 14, 'fluctuations which is shown' instead of 'fluctuations shown'
15. Page 12: Line 1, 'Note that' instead of 'Note, that'
16. Page 12: Line 9, 'In Fig. 12, we' instead of 'In Fig. 12 we'
17. Page 13: Fig. 12, It is better to project the altitude in y-axis and scales in x-axis to compare easily with other results.

18. Page 13: Fig. 12, Briefly describe, how is the wavelet spectrum obtained? what type of wavelet is used and frequency of it?

19. Page 13: Line 3, 'fluctuations, we' instead of 'fluctuations we'

20. Page 13: Line 5, delete 'in Fig. 13a'

21. Page 13: Line 6, delete 'shown'. And write 'Fig. 13a which is corresponding to the fluctuations presented in Fig. 9' instead of 'Fig. 9'

22. Page 14: Fig. 13, Fig. 13 has been categorised as a, b & c based on nature of spectra in caption of Fig. 13, as assumed to be common volume/altitudes in question. Actually, different nature of spectra are seen at different altitude, so better to high-light the altitude in figure caption and title of the figure as (a) —- km, (b) —- km, and (c) —- km. And also indicate this height regions in Fig. 11a & b.

23. Page 15: Line 8, 'In this section, we discuss the results of those fluctuations' instead of 'In this section we discuss the shown above fluctuations'

24. Page 15: Line 12, 'They shown that' instead of 'They showed, that'

25. Page 15: Line 15, 'with the phase descend of tide' instead of 'with tide'.

26. Page 15: Line 24, 'sections, we shown' instead of 'sections we showed'

27. Page 16: Line 12, 'Note that' instead of 'Note, that'

28. Page 16: Line 14, 'note that' instead of 'note, that'

29. Page 16: Line 24, 'Fig. 13), we' instead of 'Fig 13) we'

30. Page 16: Line 28, '1971), we' instead of '1971) we'

31. Page 16: Line 28, ’its kinetic energy’ instead of ’its energy’
32. Page 17: Line 14, ’Now we’ instead of ’Now, we’
33. Page 18: Line 6, ’In this paper we’ instead of ’In this paper, we’