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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.

Anonymous Referee #2

Received and published: 25 March 2019

1 General Comments

This paper describes measurements taken during the WADIS-2 sounding rocket campaign. In particular, the effects of gravity waves and turbulence on densities of atomic oxygen, other neutrals, and ion species were studied. The authors found signs of waves and turbulence in all of their observations and were able to link regions of heating to gravity wave breaking and nearby layers of turbulence. This is a novel study describing an interesting new dataset that should add to the understanding of the physics

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and chemistry of the MLT region. The paper is fairly well written, although there are a number of language faults (some of which are recorded below), and it was often required to hunt down explanations and methods in other sections or figure captions. I recommend publication in ACP once the comments below are addressed.

2 Specific comments

1. Page 2 line 8: provide citation for turbulent and solar heating rates.
2. Page 4 line 7: FIPEX - define acronym
3. Page 4 line 9: Could you give a brief description of this technique?
4. Figure 2: How are the RMR and Fe lidar data combined? What is the direction of these measurements?
5. Section 3.2, second paragraph: mention in the text (not just in the figure caption) which instrument was used to derive the total number density and temperature profiles and how the temperatures are derived from the densities.
6. Page 8 paragraph 2: What are the values of the ionospheric parameters used in the IMAZ model to produce the profile in Fig. 7?
7. "This is in accord with the fact that some aurora was seen" - by what instruments? "auroral emission detector... registered some auroral emission above 100 km" - how does this instrument work, what is measured? It might be useful to add this instrument to your list of rocket instruments in Sect. 2. Could you quantify "some auroral emission"?
8. Page 9, line 3: "The shown plasma density profiles yield relative density measurements and therefore they were normalised..." This sentence seems to be

the wrong way around: do you mean the measurements yield relative quantities that are therefore normalised to produce the profiles in Fig. 7? If so, this could also be mentioned in the caption.

9. Figures 5, 7, and 8: Please use consistent units: m^{-3} is used in Figs. 5 and 7, and cm^{-3} is used in Fig. 8.

10. Figures 7 and 8: In the captions, I am not sure I see what is the "same as Fig. 5", except that these are atmospheric density profiles, but they are from different species, measured by different instruments!

11. Figure 7: What is the quantity plotted from the IMAZ model? Is it ion or electron density?

12. Page 9 paragraph 2: I think you need to provide more details on the FIPEX instrument (either here or in Sect. 2). Could you specify why you are "mostly confident" in the descending data but not the ascending? Is this through comparison with data from the MISU photometers? Do you have an explanation as to what might be causing FIPEX to give erroneous measurements during one phase of the rocket flight but not another?

13. Page 9 line 12: Are you linking the increase in oxygen density seen by SABER above 100 km to auroral activity because of the auroral emission measured at these altitudes by the rocket-bourne MISU instrument? If so, why is a similar increase not seen in the FIPEX oxygen measurements taken at the same location as those from the MISU instrument?

14. Page 9 paragraph 3: Again, a little more information on what the "other FIPEX sensors" measure would be helpful!

15. Page 10 line 6: "small-scale stuff": colloquialism, please rephrase

16. Page 10 paragraph 3: please specify which data are used to determine the fluctuations in Fig. 10; are these up or down leg measurements?

17. Fig. 11: provide the references for the turbulence climatologies in the text (not just the figure legend)

18. Page 11 line 7: “Also the upleg and downleg turbulence data qualitatively agree with each other.” âĂŤ they do not agree below 70 km.

19. Page 11 line 9: “If compared with results of our previous rocket campaign WADIS-1 that was conducted in summer (Strelnikov et al., 2017), the observed winter turbulence field does not show big difference between up- and downleg measurements.” It would be helpful to expand a little here and give (maybe just a sentence) on the WADIS-1 turbulence field.

20. Page 12 line 2: define acronym PSD, power spectral density

21. Page 12 line 6: “This picture is reminiscent of a GW-saturation process when vertical wavelength of GW becomes shorter.” – could you provide a citation here?

22. Page 12 paragraph 1: how does the wavelet spectrum shown in Fig. 12 for the down leg compare to that of the up leg?

23. Page 12 line 9: are the O densities used here from the FIPEX instrument?

24. Figure 13: would it be possible to highlight the altitudes of each 2D slice forming the three panels? These could also perhaps be shown in Fig. 12.

25. Page 16 line 25: “usually attributed to GW” – could add a citation here

3 English language corrections (not exhaustive)

26. Page 1 line 9: "... MLT is host **to**..."
27. Page 1 line 13: "A part" (2 words)
28. Page 1 line 14: "**the** MLT"
29. Page 2 line 13: "that **the** mesopause region"
30. Page 2 line 14: "it is **the** region where... plays **a** crucial role"
31. Page 2 line 16: "it can affect" (remove 's')
32. Page 2 line 18: "concentration of atomic oxygen alongside the state of..." (remove 'with')
33. Page 2 line 28: "critically discuss our findings" (remove 'the')
34. Page 2 line 28: "summarize **our** main results"
35. Page 4 line 28: "**The** horizontal temperature field"
36. Page 7 line 16: "demonstrates typical winter behavior" (remove 'a' and 'for')
37. Page 11 line 1: "turbul**ent** energy dissipation rates"
38. Page 11 line 5: "as **the** method's uncertainty."
39. Page 11 line 10: "does not show **a** big difference"
40. Page 11 line 14: "we show **the** wavelet spectrogram of **the** neutral density fluctuations"

41. Page 12 line 6: “when **the** vertical wavelength of **the** GW become shorter”

42. Fig. 13 caption line 2: “measured during desc**ent** of WADIS-2”

43. Page 15 line 3: “spectra from **the** region just below **the** one described above **(shown in Fig. 13b)**”

44. Page 15 line 12: “They showed that this signature was observed by **the** MLS instrument over **a** large region. . . for **a** long time.”

45. Page 15 line 14: “could be qualified as **a** mesospheric inversion layer”

46. Page 15 line 30: “In **the** pure adiabatic limit case”

47. Page 16 line 10: “waves with a vertical wavelength of 2-3 km **are** saturated . . . and **break**, producing turbulence layers”

48. Page 16 line 14: “the altitude region below 82km reveal**s** features similar to **those** observed. . .”

49. Page 16 line 26: “a power increase in **the** spectrum. . .”

50. Page 16 line 29: “that is **they** do not influence the flow and are conservative, i.e. **their** value is not affected by the flow”

51. Page 17 line 3: “Recalling **the** above discussion about **the** relationship. . .”

52. Page 17 line 12: “raises the question **of** how. . .”

53. Page 17 line 16: “Both spectra in the middle. . .” (remove ‘**the**’)

54. Page 17 line 26: “The difference in their response to turbulence arise**s** due to difference of their diffusivity. Thus, **the** diffusion constant. . .”

55. Page 17 line 33: “Such models implement **the** theory of Batchelor (1958). . .”

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