

3rd round review on “Formation of an additional density peak in the bottomside of sodium layer associated with the passage of multiple mesospheric frontal systems” by Narayanan et al. to ACP

After addressing two rounds of review comments, authors have improved the quality of this paper. The lidar-observed additional Na peak below the main layer peak and the OH-imager-observed mesospheric frontal systems are interesting phenomena. Authors explained the observations using downward transport of Na species, H, and O by the mesospheric bores as well as with the enhanced temperatures, which is quite reasonable. The data and explanation may inspire future modeling and observations. However, there are still some issues with the paper on three main aspects: 1) Authors still have some misunderstanding of the thermosphere-ionosphere metal layers versus the sporadic Na layers. 2) The vertical wind data have significant bias, which is not reasonable. 3) Horizontal advection should be mentioned as another possibility to explain part of the observations. There are also numerous grammar issues.

Therefore, I would like to recommend the paper for publication in ACP after authors address the following comments that go by page numbers:

1) Page 1, line 15: Change “This would have liberated ...” to “**Both factors** would have liberated ...”

2) Page 2, line 30: Change “They form due to the wind shears collecting ...” to “They form due to the **wind shear mechanisms** collecting ...”. Note that wind shears themselves cannot accumulate ions or atoms, but it is the wind shear mechanisms via $\vec{V} \times \vec{B}$ to collect ions.

3) Page 2, lines 32-39: **Authors should move Collins et al. (1996) reference from line 38 to line 32**; that is, it is a reference for sporadic Na layers (SSLs) but not a reference for the thermosphere-ionosphere metal (TIMt) layers. It is necessary to recognize that Collins et al. (1996) paper reported high-altitude sporadic Na layers, which were NOT the TIMt layers; therefore, this paper should be moved to line 32 along with Cox and Plane (1998) etc., and removed from line 38 (Chu et al., 2011; etc.). For authors information, the high-altitude SSLs reported in Collins et al. (1996) are very similar to the sporadic Fe layers around 110 km from 18 UT to 21 UT in Figure 1 of Chu et al. (2011), but they are very different from the thermospheric metal layers reported by Chu et al. (2011), Wang et al. (2012), etc. Authors should pay more attention in referencing proper papers at proper places.

4) Section 2 “Data used” – this section is very long while still not informative enough. For example, it is unclear what resolutions were used in the temperature data retrieval. Can authors use a table to tabulate related information but shorten the section text? Descriptions on how lidar data were retrieved and how OH images were analyzed are quite lengthy but aren’t they standard procedures? Anything new authors developed? If not new things, why don’t you reference some papers and then shorten the description?

If authors feel strong to tell readers how they handled the data for certain purpose, why don’t you put such contents to Section 3 when related results are presented. Otherwise, it is a bit frustrating to read the lengthy Section 2 before knowing what results you got.

5) Page 9, line 210: change “creation of sodium atoms” to “**production** of sodium atoms”

6) Page 9-10, Figure 3: Authors wrote “This is further confirmed by the observation that the column abundance was reduced after the disappearance of the lower altitude sodium peak”. However, the Na abundance level near the end of the observation was higher than that at the beginning of the observation, i.e., the Na layer did not return to the original state after the passing of frontal systems. Therefore, **it is necessary to show how Na column abundance changes through a normal night without mesospheric frontal systems**, which will check whether the increase of column abundance during the frontal systems is unusual when compared to a normal night.

- 7) Page 10, line 230: Change “horizon” to “edge of the image”
- 8) Page 12, Figure 5: What is the reference point for “Distance” in the x-axis label, i.e., “Distance” from which point?
- 9) Page 13, line 263: Change “Now we discuss” to “Now we **present**”.
Page 13, line 264: Change “The temperature profile” to “The temperature **contour**”
- 10) Page 14, Figure 7: The color scales for N^2 plot are unclear – does the blue color represent negative N^2 or not?
- 11) Page 15, Figure 10: **The vertical wind data is unacceptable** because it shows a very large negative wind bias. Majority of the vertical winds are between 0 m/s and -10 m/s, which cannot be true for the real atmosphere. It appears that the Na lidar on 19 Dec 2014 exhibited a large pulsed laser frequency offset (or frequency chirp), and authors didn’t correct the frequency offset – leading to the negative bias in the results. Authors should either correct the vertical wind data or remove the vertical wind plots from the paper – the current Figure 10 top plot is unacceptable.
- Also, the higher values of vertical velocities near 85 km (line 293) appear to be dominated by noise or measurement errors. Authors should be really careful in using the vertical wind data or in the interpretation.
- 12) Page 21, Figure 14: For the integrated densities from 88-95 km, they are positively correlated with the mean temperature quite well up to 17 UT, but then the correlation becomes negative. This result makes me wondering whether some of the variations are caused by the horizontal advection of the Na layers. This factor should be mentioned on page 25 in the paragraph above line 480.
- 13) Page 22, line 411-413: How can Na layer peak affect the formation of bores?
- 14) Page 24, line 444: Change “The principle loss” to “The **principal** loss”
- 15) Page 25, line 472: Change “...the bores have lead to ...” to “...the bores have **led** to ...”

1) Scientific significance -- Excellent

Does the manuscript represent a substantial contribution to scientific progress within the scope of this journal (substantial new concepts, ideas, methods, or data)?

2) Scientific quality – Good

Are the scientific approach and applied methods valid? Are the results discussed in an appropriate and balanced way (consideration of related work, including appropriate references)?

3) Presentation quality -- Good

Are the scientific results and conclusions presented in a clear, concise, and well structured way (number and quality of figures/tables, appropriate use of English language)?