

Interactive comment on “Formation of a bottomside secondary sodium layer associated with the passage of multiple mesospheric frontal systems” by Viswanathan Lakshmi Narayanan et al.

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Received and published: 7 December 2020

Response to the reviewer 2 comments on the manuscript ‘Formation of a bottomside secondary sodium layer associated with the passage of multiple mesospheric frontal systems’

We thank the reviewer for going through our work and providing suggestions on the same. Here we address the concerns raised by the reviewer and indicate the necessary modifications made in the revised version of the manuscript. Reviewer’s com-

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ments are given between double backslashes and our responses are below the comments. (i.e \\ Reviewer Comment \\ Our replies).

\\ This paper studies the formation mechanism of the secondary Na peak that appears within the altitude range of the main Na layer but below the main peak and near the bottomside of the main layer. The data quality (both lidar and airglow imager near Tromsø) is high, and the analyses connecting the lidar-observed secondary Na peak below its main layer peak with the OH-imager-observed mesospheric bore event are extensive. The topic is interesting to the middle atmosphere science community. On this aspect, the paper is worth considering for publication in ACP after extensive reviews and revisions.

However, there are three major issues with the current manuscript: 1) The paper title is misleading or improper, 2) its Abstract reads badly with the first sentence distract people's attention, and 3) its Introduction contains misunderstanding of metal layer sciences.

All these issues likely stem from authors' misunderstanding of the meteoric metal layers. The main Na layer ranges from ~75 to 110 km, and the layer (below 85 km) they reported here is well within the main Na layer. Therefore, it is NOT an extra layer to the main layer, but an extra peak to the main layer peak. We have seen many times that Na layers go well below 85 km forming variable peaks during wintertime in the polar region, most likely caused by various wave activity. Therefore, what authors observed isn't new, but their studies of connecting such Na peaks to bore/frontal events are new and worth publishing. \\

We thank the reviewer for the positive opening remark. Though the peaks of sodium layer occasionally form below 85 km, in this case we find a clear separation between the main peak and the lower peak and hence referred it as layer. Now the terminology is changed to 'peak'. The reviewer may also note that we never claimed that the observation of lower altitude sodium layer is new. Below we have addressed the three

issues pointed by the reviewer.

\\ 1) Paper title: First, as written above it's not a new Na layer, but it's the secondary Na peak within the main Na layer; second, "in lower altitudes" has a grammar issue – lower than what? Therefore, such a paper title is not acceptable. Authors may consider to change the paper title to "Formation of an extra Na peak below the main layer peak associated with passage of multiple mesospheric frontal system" or something better.\\

The reviewer may note that, while the sodium layer exists between the altitude region of 75 and 110 km, it does not fill the whole range of altitudes. Often, more than one peak is observed within the altitude range. When the different peaks are well separated, they can be referred as 'layers' in our opinion. The reviewer may kindly note that the term 'layer' is used for clearly distinguishable peaks in the sodium concentration in the context of sporadic sodium layers, most of which occur within the altitude range of 75 to 110 km. Nevertheless, respecting the opinion of the reviewer and following the suggestion to change the title, we have changed the title of the manuscript as 'Formation of an additional density peak in the bottomside sodium layer associated with the passage of multiple mesospheric frontal systems'.

Regarding 'in lower altitudes': There is no such term in the title. In the updated version of the manuscript, we clearly mention in the text that: 'We refer to the peak occurring below the main sodium layer peak at 90 km as 'lower altitude sodium peak' in this work'. The updated manuscript version will be uploaded in a few days.

\\ 2) Abstract: The first sentence in the Abstract is very misleading and it is frustrating to read it. Your paper is on the secondary Na peak below the main layer peak, but you started with mentioning something that is non-relevant to your subject. Please remove this sentence to avoid misleading readers. Also, change "additional sodium layer" to "additional Na peak". \\

The first sentence of the abstract is changed following the reviewer's suggestion as

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'We present a detailed investigation of the formation of an additional sodium density peak at altitudes of 79-85 km below the main peak of sodium layer based on sodium lidar and airglow imager measurements made at Ramfjordmoen near Tromsø, Norway on the night of 19 December 2014.'

While we believe that it is not a mistake to call such a separated peak as an additional layer, we understand the concern of the reviewer that on many other occasions, there are peaks below 85 km that are not separated from the main layer to the extent of the present case. Therefore, we change the terminology from 'lower altitude sodium layer' to 'lower altitude sodium peak' as suggested. As mentioned in the response of previous comment, we also explain in the manuscript text what is 'lower altitude' in the context of this work.

\\ 3) Introduction: There is some lack of understanding of the thermosphere-ionosphere metal (TIMt) layers (mentioned in review paper by Plane et al. (2015)) in the Introduction, including thermosphere-ionosphere Fe and Na (TIFe and TINa) layers that were discovered to reach the altitudes of lower F region (Chu et al., GRL, 2011, 2020; Tsuda et al., GRL, 2015; Raizada et al., 2015; Chu and Yu, 2017). None of these pioneering papers were acknowledged. Instead, authors referenced Collins et al. (1996) and Wang et al. (2012), and adapted a bad phrase "double sodium layers". This "double sodium layers" phrase is improper and misleading, thereby it has been discarded by the field. Therefore, the current paragraph (the 3rd one in Introduction) is totally not acceptable. However, these TIMt layers aren't the focus of this manuscript, so authors may choose to remove this paragraph entirely and focus on the main Na layer. If authors want to include TIMt layers in the introduction, then they should update their understanding of the TIMt layers and cite proper references \\

We are sorry but we do not find this comment relevant to the present manuscript. We believe this comment was already addressed during the access peer review stage of the manuscript. The third paragraph of previous version was already removed before the manuscript was put in to discussion. The third paragraph of the current manuscript

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explains the research problem addressed in the work. We never use the term 'double sodium layer' in the whole manuscript. Moreover, we note that all the references except Chu et al., 2020 and Chu and Yu, 2017 are already present in the manuscript. We now include Chu et al., 2020 which is recent and we were unaware of earlier. The reference Chu and Yu, 2017 discusses only about Fe/Fe⁺ in the thermosphere while our manuscript discusses about Na in the mesosphere. Therefore, we are unable to include the reference and sorry about that.

We once again thank the reviewer for assessing the work and providing suggestions for the improvement of the manuscript. We hope we have satisfactorily addressed the concerns.

Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2020-803>, 2020.

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