

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.

Anonymous Referee #1

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This paper reports the observation of a secondary Na layer which formed around 85 km in the mesosphere during the passage a frontal system. The study involved a Na wind-temperature lidar which made measurements in the vertical and at 4 cardinal points, as well as an all-sky OH airglow imager. The imager was used to record the passage of four frontal events, and the lidar measured Na, wind and temperature. This data was combined to show that the front caused a marked temperature increase in a layer between 80 and 85 km, where the secondary Na layer then appeared. The wind and temperature data were also used to calculate the static and shear instability

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surrounding the passage of each front.

The Na increase is interpreted to be caused by release of atomic Na from its reservoir NaHCO_3 , due to the higher temperatures which activate the reaction $\text{NaHCO}_3 + \text{H}$, as well as downward transport of H and O from above 85 km and a corresponding decrease in O_3 . This interpretation seems quite plausible. Overall, this is a very nice piece of work which illustrates the importance of using multi-instrumented observations.

However, there are several issues which the authors should address in a revised manuscript. The first is there must be a statement somewhere acknowledging the limitations of making observations in a Eulerian framework. That is, you are not observing the same air mass over 8 hours. This means that your interpretation of events requires that the atmosphere is horizontally homogeneous over roughly 2000 km. Whereas, in fact you only know the degree of homogeneity over about 35 km (the distance between the off-zenith lidar beams), with some additional information over a larger scale from the all-sky imager. There is nothing you can do about this, but it should be stated in the paper.

The second issue is about the downward transport of H and O to below 85 km. From the way you describe this, the reader will imagine that the NaHCO_3 reservoir is left unchanged below 85 km, to be joined by O and H from aloft. However, the NaHCO_3 below 85 km will also be transported downwards. So it is actually a parcel of air containing NaHCO_3 , H and O from above 85 km that is transported downwards and heats adiabatically, releasing Na. Note that the mixing ratio of total Na increases with height up to the ablation peak of Na which is above 90 km (see recent papers e.g. Carrillo-Sanchez et al., (2020), Icarus, 335, art. no. 113395). So downward transport will also increase the total Na concentration (i.e. Na + reservoir species) below 85 km.

A third issue is that you list a large number of temperature-dependent rate coefficients, but do not do anything quantitative with them. That looks a little odd. For example, at

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line 390 you provide the rate coefficient for $H + O_3$, and state that this increases with temperature. But why not say how much? For example: "the rate coefficient increases by 40% when T increases from 200 to 230 K". That gives the reader some quantitative understanding of the point you are making.

None of these are major issues, and should be easily dealt with in a revised manuscript.

One other point - although the paper is well written and straightforward to read, there are many grammatical errors - particularly the absence of the definite article "the" and indefinite article "a". It is not the job of a reviewer to correct these basic errors.

Below is a list of minor corrections:

line 23: change to: "...as a consequence of meteoric ablation (e.g. Plane)"

line 24: the statement "In high latitude winters, the peak altitudes are close to 88 km due to atmospheric circulation." is not really correct - it is chemistry which determines the height of the Na layer; the role of circulation is principally in changing the local temperature profile.

line 41: "occur at lower altitudes"

line 73: "sodium lidar and airglow imaging observations from a high latitude location"

line 79: in what way is the lidar "state of the art"? Please specify. The performance parameters you mention sound fairly standard.

line 200: "This is further confirmed by the ..."

line 225: "...UT. The front continued ..."

line 269: "above 93 km before..."

line 314: "thermal ducting was possible"

line 319: "m and k stand for"

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line 384: "would have been initiated"

line 399: in fact, the Na compounds (NaOH, NaHCO₃ etc.) photolyse in the near-UV above 200 nm. So change EUV to UV.

line 446: "have led to "

The References need to be sorted out and checked. They are not all in alphabetical order, and the same author appears with different initials in difference references!

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