



EGUsphere, referee comment RC4
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Comment on egusphere-2022-187

Anonymous Referee #3

Referee comment on "Comparison of middle- and low-latitude sodium layer from a ground-based lidar network, the Odin satellite, and WACCM–Na model" by Bingkun Yu et al., EGU Sphere, <https://doi.org/10.5194/egusphere-2022-187-RC4>, 2022

RC on egusphere-2022-187

This paper reports the climatology of sodium (Na) layer with lidar observations from 4 stations (with data ranging from 362 nights to 906 nights) at the middle- and low-latitude along 120°E operated by the Chinese Meridian Project (CMP). The results were compared to those with Infra-Red Imager System (OSIRIS) spectrometer onboard the Odin satellite and a global model of meteoric Na in the atmosphere (WACCM–Na); they found general agreement with some explainable differences. They also present the observations of sporadic Na layer (SSL) and the difference in correlation to sporadic E layer (Es) between mid-latitude stations and low-latitude stations. I find the study scientifically meaningful, clearly written with good connections to the past research. The paper is suitable for ACP. As stated below, I have a couple of major and minor queries; they can be accounted for with minor revisions.

Major queries:

(1). Your brief description of 4 different methodologies used in Section 2 is appreciated. The aim is of course to help the readers to gain confidence on the reported describe physical quantities by the different methods used. Therefore, a clear connection between the "observed (calculated)" quantity and the quantity under study should be made in each case. Such descriptions would not be needed for a reader experienced in all 4 methods, not too many in our field. I think your descriptions on OSIRIS and WACCM–Na look good. In COSMIC, why is the S4max index a good measure of Es strength? Please give the definition of the S4 index! In the case of Na lidar, you could say something like, "If laser pulses with a fixed line-shape function are tuned to a fixed frequency within the Na D2-resonant absorption line at 589.6 nm, the received induced fluorescence intensity is proportional to the emitting Na density". People usually report on the uncertainty of the lidar measured Na density by its associated photon noise. There are two more sources of uncertainties. First, most practitioners convert the received photon profile at MLT to Na density there by assuming the lidar signal at a lower altitude (at 30 km for example) is the result of Rayleigh scattering from a "standard" atmosphere. The ignorance of air density at the time of measurement gives rise to uncertainty in Na density, please see Fig. 8(c) of Reference 1. Another uncertainty comes from the fact that most "stabilized" transmitting lasers do not lock to an absolute frequency reference, the laser light with bandwidth of 1.5 GHz for example could jump around within the Na fluorescence spectrum (FWHM about 1.2 GHz at 200 K). Likely with any luck, these two uncertainties would be smaller than the

photon noise uncertainty reported. However, unlike the photon noise uncertainty, these unknown uncertainties remain the same with more data. My guess is that for climatology study as in this paper, there is no real concern. Therefore you do not need to go into the details in this paper, but you should in my view note their existence. However, as the CMP lidar data accumulated, it will be a concern, should one look for small effects like the long-term trends. See p. 399 of Ref. 2, if interested.

(2). Please expand the last two paragraphs of discussion in Section 3.2 between lines 303 and 328 somewhat to make the discussion on seasonal variation of SSL derived from the 4 latitudes clearer. The SSL formation has been researched in the past three decades and different mechanisms have been proposed. With the publication of Yu et al. (2021a) and Yu et al. (2021c), the authors claim that they've finally understood the formation of SSL in midlatitudes as well as in the tropics. Unfortunately, unlike other sections, these two paragraphs are overly compressed and not as clear as they need to be. For example, why do you show the intensity of the Es layer at the Na layer peak around 92 km (blue line), while the crucial thermospheric meridional circulations appeared between 100 - 120 km? Also, are most of SSL events occurred at the Na layer peak?

Minor queries:

A. You mentioned "exceptionally high temporal and vertical resolution (usually 3 minutes and 100 m)" in line 54. Would you like to mention Reference 3, where the Na layer observed with "exceptionally" high-resolution (60 ms and 15 m) appears to be composed of many downward propagating SSLs. It would be fun to speculate the underline physics.

B. Question about CMP lidar stations. You utilized data from 4 Na resonance fluorescence lidars at Beijing (40.2°N, 116.2°E), Hefei (31.8°N, 117.3°E), Wuhan (30.5°N, 114.4°E), and Haikou (19.5°N, 109.1°E). I know of two stations near Beijing: Yanqing (40.5°N, 116.0°E) and Pingquan (41.0°N, 118.7°E). Is the Beijing (40.2°N, 116.2°E) different from these two or it includes both? Please clarify.

Other points:

Line 87: "the long-term routine measurements" is miss-leading as the word "long-term" has other connotations, as in "long-term linear trend". I would say "multi-year routine measurements", "continuing routine measurements", or simply "routine measurements".

Line 122: Please define "S4 index".

Line 171: "104°W" should be "105°W".

Line 177: What is "ares"?

Line 186: Please explain what is "and Na reference by Plane (2010)."?

Line 191: Change "Na number density" in "Figure 9c shows the Na number density" by "Na density profile" or "the height dependent Na density".

Line 204: Should "major reservoir" be "major reservoir of the neutrals"?

Line 254: By "analyzed later", do you mean "analyzed below"?

Line 259: What happens to Fig. 11(g)? It appears empty in the figure.

Line 286: In figure 14, do we compare the data under sunlit condition (OSIRIS) to nocturnal observations (Lidar) and full diurnal means (WACCM), correct? Would this be

problematic?

Line 316: Do you have an explanation for why "an annual change in the Na column number

density, with a summer minimum and a winter maximum"?

Line 318: Should you delete "Hefei," at the end?

Line 321: Should "lidaras" be "lidars".

Line 334: Should "Na concentration" be "Na column density"?

References:

- Krueger, D. A., She, C.-Y., & Yuan, T. (2015). Retrieving mesopause temperature and line-of-sight wind from full diurnal cycle Na lidar observations. *Applied Optics*, *54* (32), 9469–9489. doi: 10.1364/AO.54.009469.
- She, C. Y., A. Liu, T. Yuan et al. (2021). MLT Science Enabled by Atmospheric Lidars, in *Upper Atmosphere Dynamics and Energetics*, Space Physics and Aeronomy Collection, vol. 4, ed. Wenbin Wang and Yongliang Zhang, Chap. 20. Wiley and Sons. Doi: <https://doi.org/10.1002.9781119507512.ch20>.
- Pfrommer, T., P. Hickson, C.-Y. She (2009), A large-aperture sodium fluorescence lidar with very high resolution for mesopause dynamics and adaptive optics studies, *Geophys. Res. Lett.*, **36**, L15831, doi:10.1029/2009GL038802.