

## **Overview/General Comment**

The manuscript entitled "Regional transport of aerosols from Northern India and its impact on boundary layer dynamics and air quality over Chennai, a coastal megacity in Southern India." by Ali et al. attempted to study the critical influence of aerosols on boundary layer dynamics. The research problem is highly significant and holds considerable importance within the scientific community. However, the results are very loosely presented with inadequate justification. The present analysis ranging from ABL identification to TAL transport, relevant interpretation requires greater depth and clarity to attempt the present problem. The estimation of ABL-H, ABL-AOD need to be revised in all the sections before presenting the analysis. Given these shortcomings, I believe substantial revisions are necessary. Therefore, I recommend resubmission, provided the authors address the following comments,

## **Specific Comments**

Line no 105: The statement "during December – March between 2015 and 2024" is inaccurate as the CALIPSO mission ended on August 1, 2023. needs clarification on this statement.

Line no 153: The authors refer to "The climatological mean spatial distribution of columnar AOD." However, defining 2015 to 2024 as a climatological period is inappropriate. Please revise accordingly.

Line no 158-160: The statement, "The RTE and clear days are observed to be 119 and 70 days... RTE shows an enhancement of more than 0.7 over the eastern coast of India compared to clear days," requires clarification: (1) What latitude/longitude range was averaged to derive the value of 0.7? (2) Is the RTE enhancement consistently above 0.7 for all 119 days?

Line no 195-197: "decreasing gradient in aerosol extinction values between surface and 2 km" between RTE and Clear days. This observation is very important. However, it is also important the uncertainty associated with it, (i) author mentioned Fig 2a and 2b is a mean extinction between Dec and March 2015 to 2023 and the (ii) passes considered for the present study is  $\pm 5$  deg longitudes which include land and ocean. Considering that the following uncertainty arises,

December features strong ABL inversion ( $\sim 1$  km), while March inversions can extend to  $\sim 2.5$  km. Similarly, oceanic passes may yield aerosol peaks near 1 km, whereas land passes could show concentrations up to 2 km. I recommend presenting RTE and clear-day analyses for individual months and separating land and ocean data to address these uncertainties.

Line no 210: "Can be seen above the ABL during the RTE periods" I recommend to show the 3 or 5 days backward trajectory analysis from surface upto 4 km during RTE and Clear sky days.

Line no 213 – 214: "temporal variation ....AOD" I have noticed several instance the ABL AOD towards Zero. This reflects the ABL estimation in figure 2c has been associated with uncertainty. For instance, on 27-01-2024 after 18 LT the ABL height and the first altitude bin are at the same altitude. In real atmosphere it never exists. This needs to be taken care in all the section of ABL height identification otherwise the claim of ABL height reduction, boundary layer dynamics may not be valid . It is also to be noted the entire manuscript depends on ABL identification to discuss the TAL and BL dynamics.

Line no 217: "..ABL (integrated extinction within surface and ABL-H) decreases from ~0.4 to less than 0.2.." re-estimation of ABL altitude, ABL-AOD needed.

Line no 220-221: "...the altitude, where the TAL presents, is observed to be warming...." "...contrary to the earlier findings, the surface temperature is also observed to be warming ..." it is confusing. 1) What analysis supports the warming conclusion? Temperature profiles typically decrease with height in Fig 2c. 2) Which earlier findings author mentioning? As similar how authors concluding the surface temperature warming? Is author mentioning the diurnal variation ? with respect to what it is warming ?

Line no 224: "..ABL-H also decreased from ~1.4 km to ~0.3 km.." I can see the ABL temperature inversion of at ~ 1.0 km during 25-01-2018 from the radiosonde observations.

Line 225: "The climatological ABL-H".. can be replaced to "The mean ABL-H.." use of climatological may not valid.

Line no 226-227: "RTE events in altering the boundary layer dynamics" it is loosely stated, I recommended authors should propose the mechanism, appropriate explanation with proper evidence.

Line no 237: "strong inversion at the altitude of ABL and the top of the TAL during the hazy days, attributed to the aerosol heating" the strong inversion layer is related to the large-scale seasonal variation Sinha et al (2013), Ganguly et al (2006). Interpretation needs to be revisited.

Line no 242-243: "RTE (10 days) and clear (6 days) day cases within 2018 and 2023 obtained from MPL". I recommend the author to present within a month or within the season of particular year to avoid the uncertainty related to inter and intra variability.

Line 249-255. "...significantly reduce the short-wave radiation of incoming solar radiation, hence reducing the surface heat flux and development of ABL...." The author's claim is not relevant from the present observation. I recommend perform flux direct observations or at least from reanalysis data to support this statement.

Line 259 – 298: Section 3.2. I did not understand why the author decided to present the meteorological observation between Chennai and Karaikal. When the TAL is from the IGP?. Spatial analysis, or data from stations along the transport pathway from IGP to Chennai, would be more appropriate.

Section 3.3. The analysis presented is insufficient to substantiate discussions on BL dynamics. Consider including spatial analyses from CALIPSO or other reanalysis datasets to strengthen this section.

**Minor Comments:**

Line 100: The statement "AOD over land at 1 km" mention including Ocean as well.

Line 146: The phrase "eastern coast within  $\pm 5^\circ$  longitudes" is ambiguous. Clarify whether this refers to a specific latitude/longitude or the entire eastern coast. Define the latitude/longitude range considered in this study.

Line 155: The authors state "during these months is evident," but do not specify which months are being referenced.

Line 205: The acronym TAL should be introduced here, rather than in Line 209, for better readability and context.

Lines 156–157: Specify the latitude/longitude range averaged to derive the AOD values for RTE days ( $0.42 \pm 0.08$ ) and clear-sky days ( $0.23 \pm 0.06$ ).

Line 239: Replace "during the dry season" with "during the winter season" for consistency and clarity.