

### General comments:

In this manuscript, the authors combined the dust and non-dust CCN “reservoir” estimates derived by POLIPHON method with the cloud droplet number concentration ( $N_d$ ) at cloud base retrieved by dual-FOV polarization lidar. The data were obtained at Dushanbe from June 2019 to July 2023, and totally 1602 cloud events were included. The authors concluded that the aged and hygroscopic dust has strong influence on  $N_d$ , or even controls  $N_d$ , during the dust season, while its effect is weak in winter. The dataset is very unique. Multi-year, co-located and vertically resolved retrievals of CCN proxy and  $N_d$  in the dust belt region are rare, and this manuscript is well fitted to the scope of ACP. However, in my opinion, the main conclusions about the attribution are not well supported yet, at least not at the level stated in the abstract and conclusions. The main problems include: (1) the temporal matching between aerosol and cloud data is weak; (2) The ratio  $N_{CCN,d}/N_d$  is explained as the fraction of droplets formed on dust, but this is based on the assumption that all dust particles larger than 100 nm are activated; (3) the supersaturation assumptions are not quantified; (4) the argument of “only explanation” for dust hygroscopicity cannot stand in present form. These problems can be solved, but substantial additional analysis is needed.

### Major comments:

1. The CCN estimates are  $\pm 24$  h mean values, which are averaged from 500 m a.g.l. to 300 m below cloud base, and most of them come from nighttime Raman data. However, the median duration of cloud events is only about 1 h. This can be clearly seen from Fig. 5:  $N_{CCN}$  is almost flat, while  $N_d$  changes by one order of magnitude. The authors also mentioned in Sect. 4.2 that the column mean value dominated by near-surface dust may seriously misrepresent the conditions near cloud base. So more analysis should be done:
  - 1) Sensitivity tests with shorter time windows (e.g.,  $\pm 3$  h,  $\pm 6$  h,  $\pm 12$  h).
  - 2) Average only in a limited layer, for example, the 300–800 m layer just below the 75%-RH level.
  - 3) Show that the main conclusions can still hold in both tests.
  - 4) In addition, because the 48 h windows are overlapped, the neighbouring events are strongly autocorrelated. So the effective sample size is much smaller than 1602, and this should be considered in the statistical analysis.
2. In Line 525, the statement that “10–100% of the activated CCN were dust particles” is based on the assumption that all the dust particles with  $r > 100$  nm were activated. In fact, about 20% of summer cases have ratios larger than 1, which already indicates that this ratio cannot be explained as a fraction. Someone may argue that the large and coated dust particles have the lowest critical supersaturation, so they will be activated firstly under competition. If the authors agree with this, this argument should be stated clearly and also be tested. Before that, it is better to call this ratio as “potential dust contribution”. Also, the wording in the abstract (“sensitively influence or even control”) should be softened.
3. The supersaturation is only assumed but not constrained, and the assumptions are not used consistently. The values of 0.2% in summer and 0.05–0.1% in winter are based on GDAS stability analysis and an instrument development paper (Sapkal et al., 2025), not on the observations of vertical velocity. Moreover, Case 2 is in December, but the authors inferred s

$\approx 0.2\%$  from  $N_d \approx N_{CCN,t}$ , which is contradictory to the winter assumption used in Sect. 4. If there are Doppler lidar data, please use them. If not, the vertical velocity from reanalysis data or the estimation based on radiative cooling can be used, and the limitation should be clearly stated.

4. Sect. 3.1.3 and Sect. 5: The authors claimed that the decrease of PDR from about 0.24 to 0.15 “can only be explained” by the dust particles becoming spherical. However, this claim cannot pass a simple mixing calculation. At 1.2–1.5 km, if we assume 80% backscatter from dust with  $\delta_d = 0.31$  and 20% from haze with  $\delta_{nd} \approx 0.05$ , we can get  $\delta_p \approx 0.25$ . Then, if only the haze backscatter increases by a factor of about 4–4.5 at RH of 90–92%, the  $\delta_p$  of the mixture will decrease to about 0.16, even though the dust shape does not change at all. Actually, the authors themselves gave exactly the same alternative explanations for the PDR decrease in the Morocco case (Sect. 3.1.4). Besides, the Ouarzazate 2006 comparison used different instruments, radiosonde data and fresh dust, so it can only be regarded as a qualitative contrast, not a controlled comparison. It is suggested to give a quantitative two-component mixing analysis, to show which combinations of dust and haze growth are consistent with the observed  $\delta_p$  (RH) and  $\sigma$ (RH). Also, the conclusion should be expressed as “consistent with”, instead of “can only be explained by”.

#### Minor comments:

1. Tajikistan is UTC+5, but in the manuscript all the conversions are based on UTC+4. Please check L305 (14:00–05:00 UTC should be 19:00–10:00 local time), L306 (20:00 UTC is 01:00 local time, not midnight), and L425.
2. Table 1: The unit of water-vapor mixing ratio should be “g kg<sup>-1</sup>”, not “g kg<sup>-3</sup>”.
3. Sect. 4.3 gives the uncertainty of  $s_{ACI,liq}$  as 30–40%, but Sect. 5 gives  $\pm 0.12$ . Please make them consistent.
4. Abstract: “ACI” is not defined.
5. L56: “roughly 10%”) has an extra parenthesis.
6. L84: “these requirement” → “these requirements”.
7. L86: “populations” → “populations”.
8. L88: “Together the lidar-derived ... as presented by (Hofer...” → “Together with the lidar-derived ... as presented by Hofer et al. (2017, 2020a, b)”.
9. L167–168: “European Center for Medium Weather Forecast” → “European Centre for Medium-Range Weather Forecasts”. Same in reference list.
10. L236:  $N_{CN,t}$  should be defined.
11. L256: “anthrogogenic” → “anthropogenic”.
12. L295: “analyses further explains” → “analyses further explain”.
13. L299–300: “...pollution particles the slow travel...” → “...pollution particles during the slow travel...”.
14. L318: “groud” → “ground”.
15. L343: “supersaturation on 0.2%” → “supersaturation of 0.2%”.
16. L352: “minium” → “minimum”.
17. L371: “An one-hour” → “A one-hour”.
18. L391: “and additional argument” → “an additional argument”.
19. L420: “the observation 24 December” → “the observation on 24 December”.
20. L516: “values increases” → “values increase”.
21. L656: Please give a complete competing interests statement.
22. Fig. 2: “Kyrgyztan” → “Kyrgyzstan”.
23. Fig. 13 caption: “December ot February” → “December to February”.
24. The phrase “As a reminder” is used many times in the manuscript. It is suggested to reduce it.