Atmospheric Chemistry and Physics Discussions

Atmos. Chem. Phys. Discuss., referee comment RC1
https://doi.org/10.5194/acp-2021-200-RC1, 2021

Comment on acp-2021-200

Anonymous Referee #1

Referee comment on "Analysis of aerosol–cloud interactions and their implications for precipitation formation using aircraft observations over the United Arab Emirates" by Youssef Wehbe et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-200-RC1, 2021

This study analyzes in-situ aircraft measurements in summer convective clouds over the UAE. Two cases are analyzed – one is orographically triggered, and the other is over a flat desert terrain. The measurements document the sub-cloud aerosols and the vertical evolution of cloud drop size distribution and hydrometeors in the convective elements between cloud base near height of 3.5 km up to 7 km. The data are analyzed in the context of assessment of cloud seeding potential for rain enhancement.

The aircraft data analysis and its interpretation have numerous issues which have to be resolved before this paper can be accepted for publication.

There are several questions about data quality and inconsistencies:

- 7d shows generally a larger concentration of PCASP than CPC particles, which is physically impossible. The CPC concentrations are always more numerous by a wide margin, because the PCASP particles are a subset of the CPC particles. Therefore, the claim made in lines 230-232 that CPC concentrations greater than PCASP “allude to the hygroscopic nature of the ultra-fine background aerosols” is unfounded.

- The maximum FFSSP concentrations are even larger than the sub-clouds PCASP and CCP concentrations, which is again physically impossible.
- Furthermore, the FCDP concentrations are even larger than the FFSSP concentrations by up to a factor of 2.5, as evident in line 246. Nevertheless, the authors attempt to provide a physical explanation arguing that most of the cloud droplets are smaller than a diameter of 6 μm (lines 247-249), without showing it.

The physical interpretation of the measurements has the following issues:

Lines 275-276; 289-291: The broadening of the drop size distributions is interpreted as an evidence for the hygroscopic characteristics of background ultrafine aerosols. It is also ascribed to the effects of strong updraft and turbulence. However, examination of Fig. 11 shows that the peak of the FFSSP concentrations increases systematically with height and with decreasing temperature. This has to be this way in a hypothetical adiabatic cloud without coalescence, regardless of all the considerations raised by the authors. The increase beyond an adiabatic rate would be potentially explained by coalescence and the effects of turbulence and drop spectrum shape on it.

Lines 312-314: The mere existence of aerosols at the size range of hygroscopic flare particles does not serve as indication for seeding potential. The important property is the concentrations of these background aerosols compared to the concentrations of flare aerosols which is required for achieving a desirable extent of rain enhancement, at least in theory according to previous research. The authors state that more simulations should be conducted, but this does exempt them from the need to go deeper in assessing the already available knowledge about that. Some of that knowledge is given in Segal et al. (2004), which the authors referenced erroneously in another context.

Lines 314-316: The peak concentrations at cloud base is much smaller than 20 μm. According to Fig. 11 the peak drop concentrations at cloud base reaches only 7 μm in both flights.

Lines 318-319: To claim that the large salt and dust particles causes a significant competition effect requires a quantitative assessment of the observed concentrations of these large particles compared to the theoretical concentrations that would have such an effect with a magnitude of practical importance. Again, there is available relevant knowledge that should be referenced and discussed.

Line 320-321: Segal et al. (2004) did NOT claim that seeding effect is smaller with larger background CCN concentrations. He rather claimed that the seeding effect is larger with a greater amount of seeding material, up to an optimal point.

Lines 21; 341-344: The authors state that there is no collision and coalescence (CC) in the lowest 1000 m of the clouds. However, the important question is the extent of CC at all heights, and is there any evidence of CC at any height? This is very important, because precipitation can often initiate as supercooled rain drops. Furthermore, the abundance of CC promotes ice multiplication, further accelerating the precipitation initiation. This should be assessed to the possible extent from the aircraft data.

Line 75: Lawson et al. (2019) is missing in the reference list.