Supplement

The Potential Usage of Radar Reflectivity

In addition to the satellite data, the C-band weather radars in the UAE provide another data source to detect cloud features. However, only the radar in Al Ain overlaps with the observation area of three research flights (SF03, SF06, and SF07) and offers continuous vertical profiles of reflectivity. We explored the potential relationship between the radar reflectivity and the cloud's microphysical features. Figure S1a shows the vertical radar reflectivity profiles at the exact location and at the same time with some CPs from SF03, which has the best overlap with the radar data. The reflectivity profiles for the other CPs are not included due to the lack of overlap between the datasets, which might be due to the far distance (around or further than 100 km) from the radar to the locations of those CPs. The reflectivity profiles are categorized into two groups (red and blue) according to their features. The red group captured the reflectivity from ~3.5 km to 13 km, which overlaps (~3.5 – nearly 7.0 km) with the aircraft measurements. In those profiles, the reflectivity value increases with height from ~3.5 km to nearly 7.0 km, related to the increase of cloud particle size with height in the cloud case SF03, as described in Section 3. At the maximum reflectivity near 7 km, the aircraft captured several large ice cloud particles in the 2DS images with 2DS particle concentration reaching 227 per liter at a temperature of -12.9 °C (e.g., Figure S1b). In this cloud case, the maximum reflectivity around 7 km height is a critical layer for ice production. The blue group of reflectivity profiles has little data below 7 km, which means no overlap with the aircraft measurements. Thus, estimating any relationship between those reflectivity profiles and cloud features observed by aircraft is not appropriate.

The radar data could be a valuable source for refining the 5-zone framework. However, the limited number of available samples makes it difficult to build a connection between the radar data and the cloud microphysical zones. More studies are needed to investigate the potential usage of radar data in detecting the cloud microphysical zones.

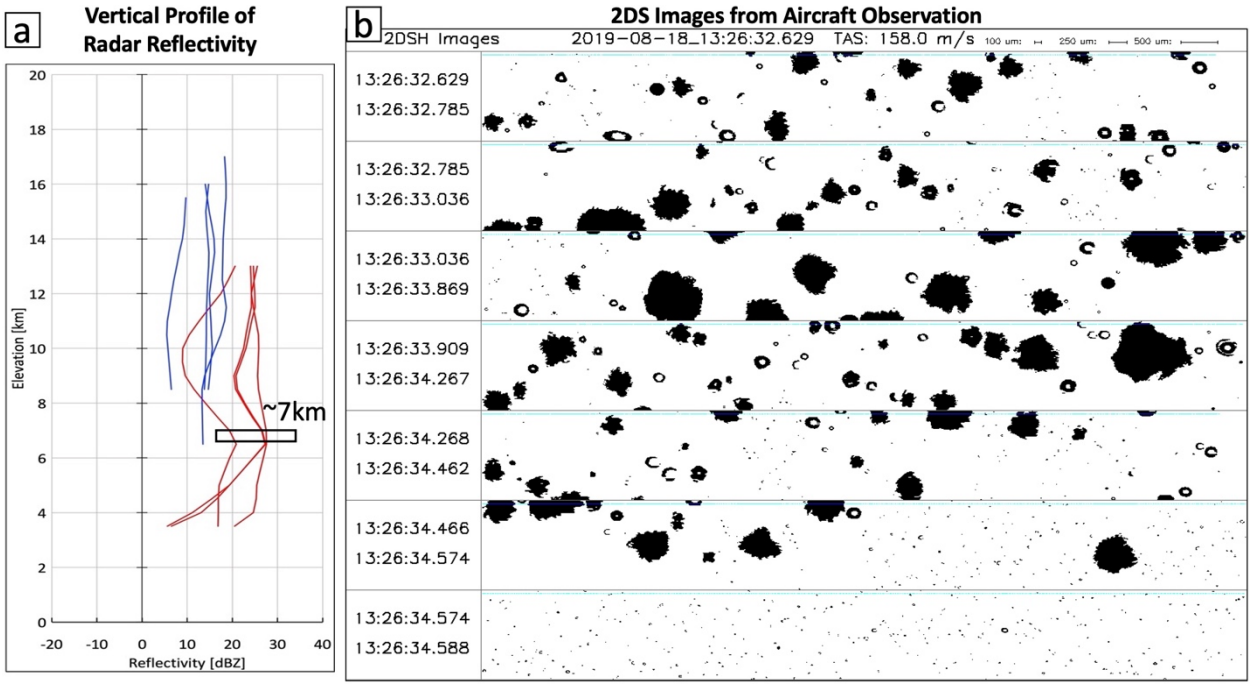

Figure S1. (a) The vertical profiles of radar reflectivity for cloud penetrations in SF03 from the C-band weather radar at Al Ain. (b) The 2-DS image from the aircraft observation at about 7 km elevation.