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Supplemental Material

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Effects from time dependence of ice nucleus activity for contrasting cloud types

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Figure 1-3 shows the time-height profiles of water contents of microphysical properties such as cloud-liquid, cloud-ice, snow, graupel and rain for the simulated APPRAISE clouds. From Fig. 1a, it is predicted that liquid water exists at lower levels (between 0.3 to 1.5 km) over a period of day. In the second half of the simulation, two distinct cloud layers are seen at levels between about 0.3 and 1.5 km and between 2.5 to 3.9 km, whereas the atmosphere is subsaturated at levels between 1.5 and 2.5 km. The cloud layer near the surface (0.3 to 1.5 km) is saturated with respect to liquid water, whereas the layer near cloud-top (2.5 to 3.9 km) is predicted to contain both liquid water and ice.

In all the simulated cases (APPRAISE, ACAPEX and MC3E) (Fig. 1-3), it is predicted that the atmosphere is nearly saturated and both liquid and ice phase coexist. In all these simulated cases, it is evident that ice-crystals nucleated (through heterogeneous and/or homogeneous freezing) grow to snow following vapor diffusion which may rime to form graupel (Fig. 1-3). This snow and graupel may melt once it reaches levels warmer than freezing level (0°C) or precipitate on its own (Fig. 1-3). Moreover, water content of snow and graupel is predicted to be about 1-2 orders of magnitude higher in the simulated ACAPEX and MC3E clouds (characterized by strong vertical velocities) compared to that in APPRAISE clouds. Which signifies that the ice-crystal process is the dominant process of precipitation formation in ACAPEX and MC3E clouds at all subzero levels.

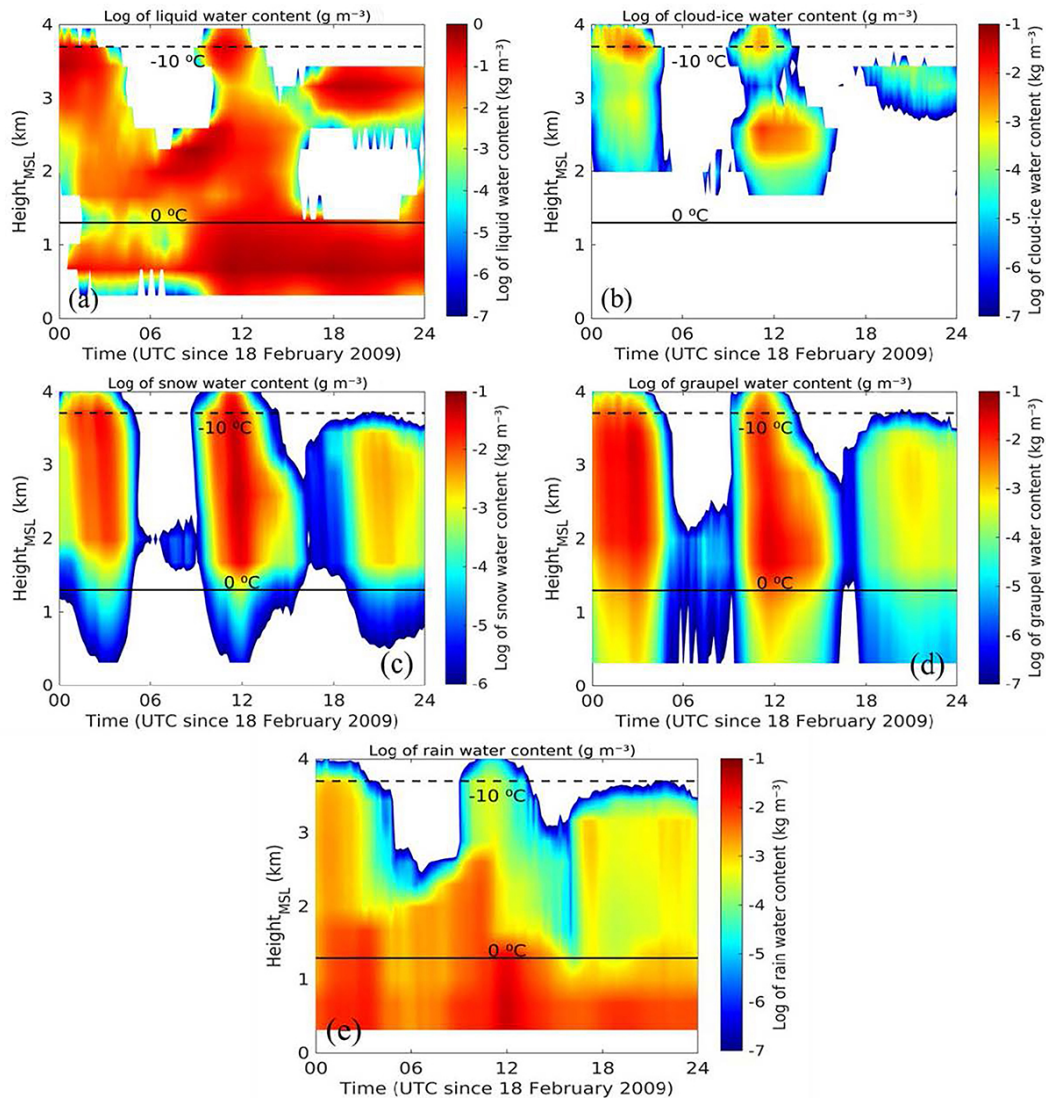


Fig. 1: Time-height profiles of the domain averaged water contents of (a) cloud-liquid, (b) cloud-ice, (c) snow, (d) graupel, and (e) rain for the simulated APPRAISE clouds on 18 February 2009 between 00:00 and 24:00 UTC. All the water contents are in log scale.

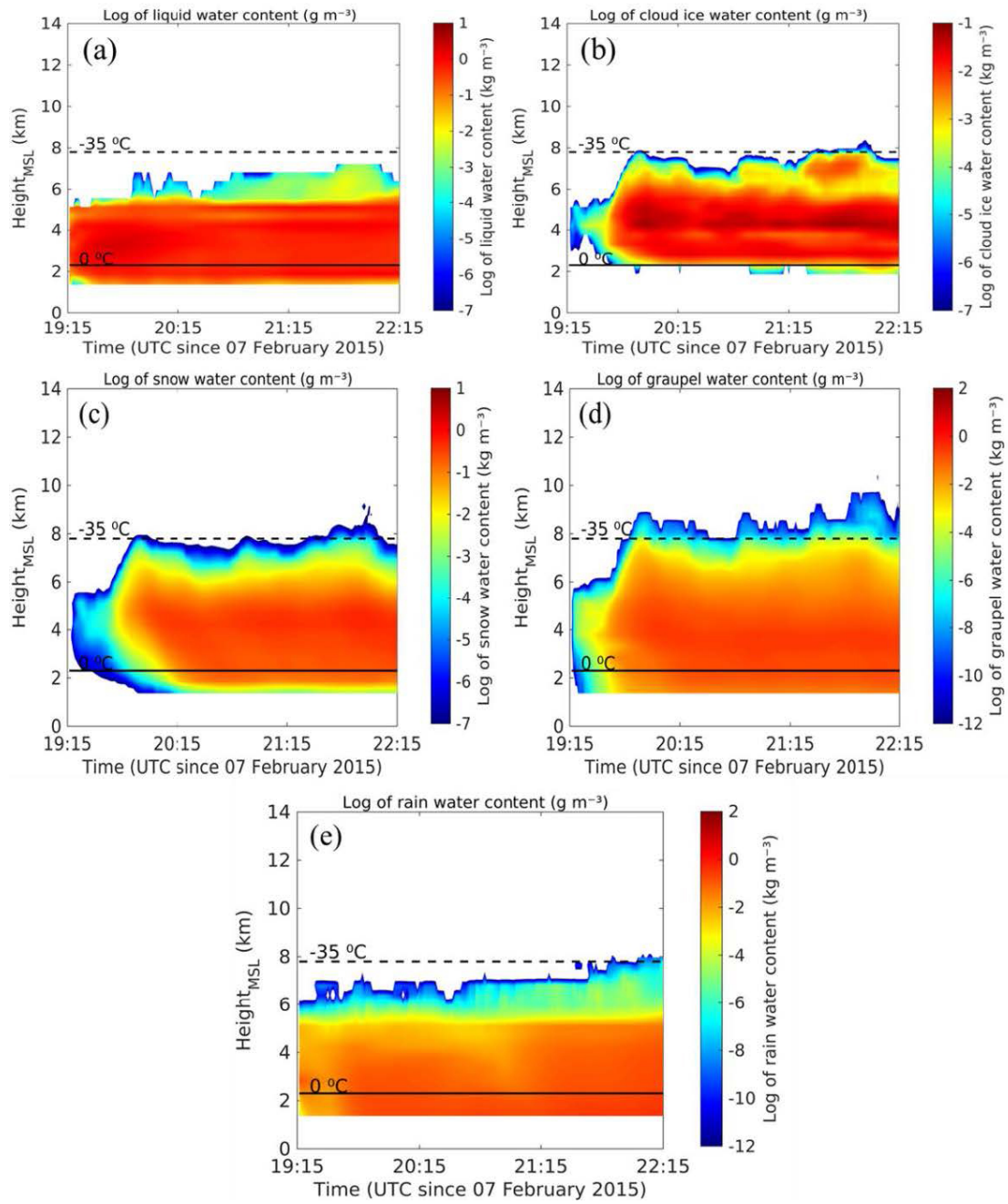


Fig. 2. Time-height profiles of the domain averaged water contents of (a) cloud-liquid, (b) cloud-ice, (c) snow, (d) graupel, and (e) rain for the simulated ACAPEX clouds on 07 February 2015 between 19:15 and 22:15 UTC. All the water contents are in log scale.

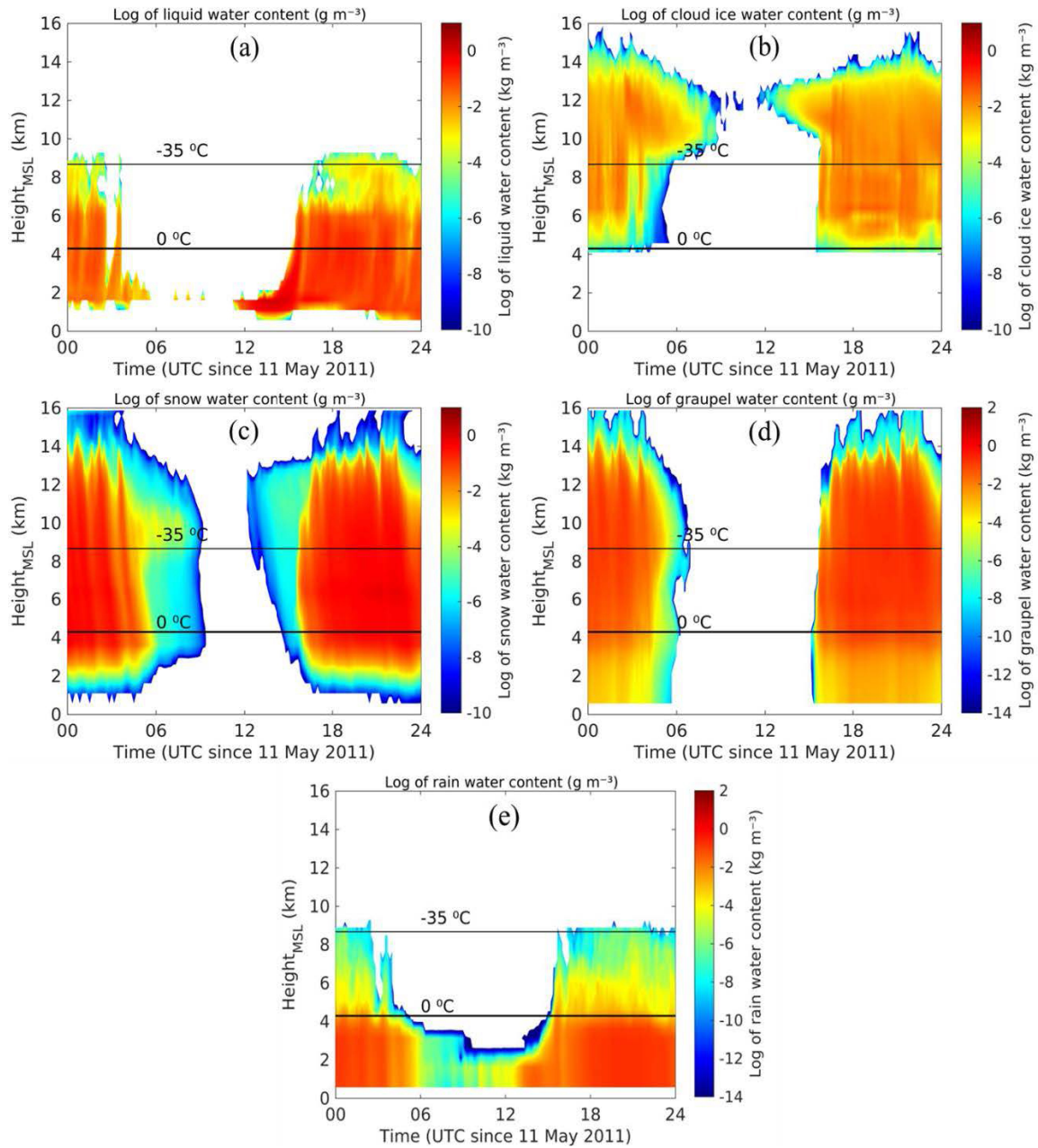


Fig. 3: Time-height profiles of the domain averaged water contents of (a) cloud-liquid, (b) cloud-ice, (c) snow, (d) graupel, and (e) rain for the simulated APPRAISE clouds on 11 May 2011 between 00:00 and 24:00 UTC. All the water contents are in log scale.