Humidity Gradient Sheets Between a Cloud Top and a Dry Layer Intrusion Above

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During the Shigaraki UAV–Radar Experiment (ShUREX) campaign in the summer of 2016, a dry layer intrusion occurred over the prevailing cloud top at 3,500 km altitude (ASL) due to a sharp moisture front moving eastward over Japan due to prevailing westerlies. The Middle and Upper (MU) radar at Shigaraki, Japan, operated in high-resolution range-imaging mode throughout the event, showed that the intrusion resulted in the formation of two high humidity gradient sheets with a turbulent layer sandwiched in-between, instead of a single high humidity gradient sheet at the cloud top. The two high humidity gradient sheets, separated by about 300 to 400 m in altitude at the interface between cloudy and dry layers, persisted for nearly 16 hours, while descending to around 3,000 m altitude. The unmanned aerial vehicle (UAV) DataHawk, equipped with various pressure, temperature, humidity and Pitot sensors as well as an IMET radiosonde and flown in the vicinity of the MU radar, sampled this structure, during both ascent and descent. Data obtained from a Vaisala radiosonde launched at about the same time, provided complementary information on the prevailing stability in these structures. The UAV and radar data analyses showed that turbulence due to convective instability, possibly triggered by cloud top radiative cooling, occurred just below the cloud top, at the bottom of the double sheet and layer structure. Weak convective type turbulence was also seen to occur between the two sheets, the cause of which is unknown. The characteristics of the echo layers, the dynamic conditions during which they occurred and turbulence parameters inside the structure (TKE dissipation rate ε and temperature structure function parameter) are used to interpret the observational data and shed light on the unusual double sheet and layer (DSL) structure at the interface between the cloudy layer and the intruding dry layer above.

Keywords: Dry air intrusion, Cloudy boundary layer, MU radar, humidity gradient sheets, Double sheet and layer structure, UAV