Genesis of Powder Snow

A winter upslope snowstorm brought several inches of powder snow to the Colorado Front Range on 14 February 2008. Temperature, humidity and liquid water profiles from a Microwave Profiler clearly show the evolution of the storm and provide unique insights into the physics of water phase changes inherent in the creation of powder snow (Fig. 1).

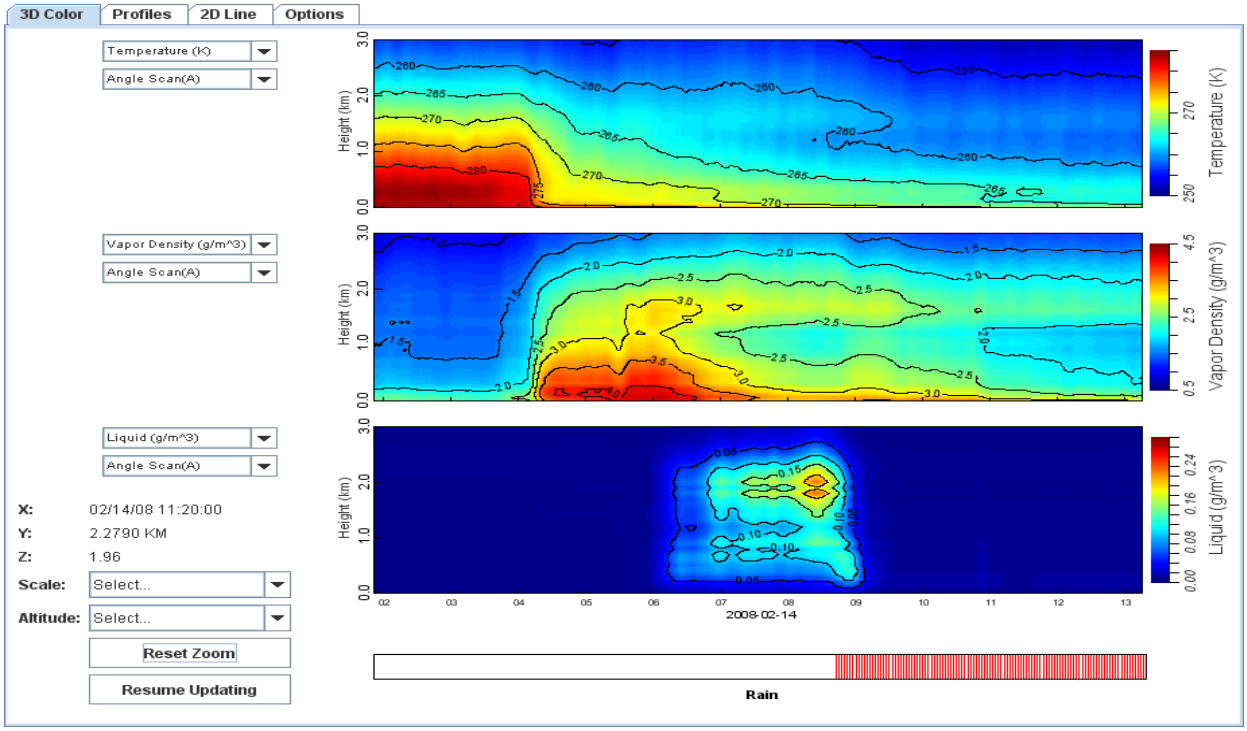

Figure 1. Temperature, vapor and liquid density profiles to 3 km height show the onset and development of a winter upslope snowstorm along the Colorado Front Range.

After 0600 UT, condensation of supercooled liquid (third contour) at 0 to -13 C (top contour) depleted the water vapor (second contour). Powder snow began falling after 0900 UT, continuing the depletion of water vapor. The typical exponential decrease in vapor was dramatically modified as “gettering” of vapor into ice crystals took a “bite” out of the lowest 2 km of the vapor density profile (Fig. 2).

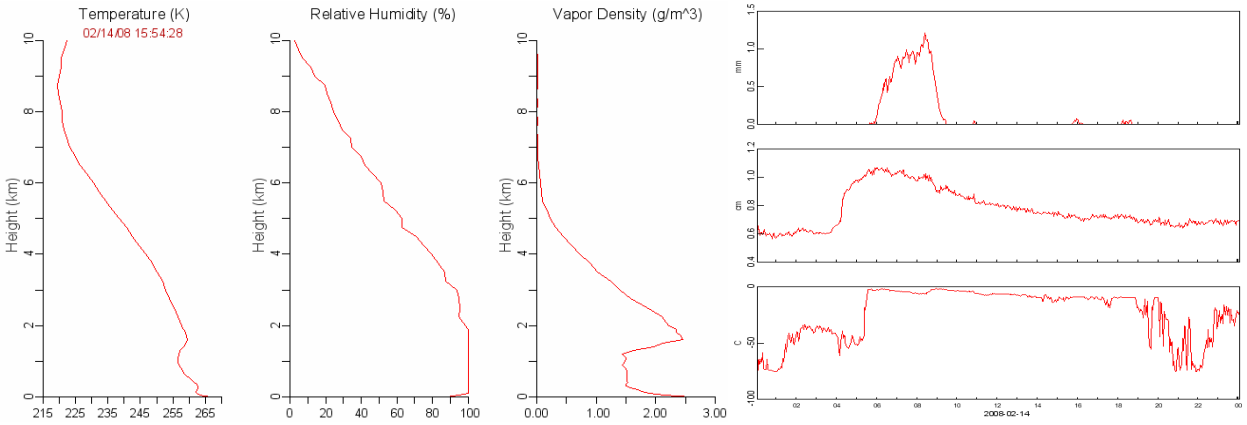

Figure 2. Temperature, humidity and vapor profiles (left) at 1554 UT; integrated liquid (mm), integrated vapor (cm), and cloud base temperature (K) for the entire day on 14 Feb 08 (right).

After 0900 UT water vapor decreased (Fig. 1 center, Fig. 2 center left and right) and supercooled liquid water disappeared (Fig. 1 bottom, Fig. 2 top left) as powder snow crystallized and activated the rain flag (Fig. 1 bottom).

Ice crystal growth at the expense of liquid droplets, a subtle but fundamental physical mechanism in the creation of snowflakes, is known as the Wegener-Bergeron-Findeisen process [Korolev, 2007]. Since vapor pressure over liquid water is higher than it is over ice, vapor crystallizes ("getters") onto ice or other condensation nuclei. This process is fundamental to the natural creation of powder snow and to winter cloud seeding.

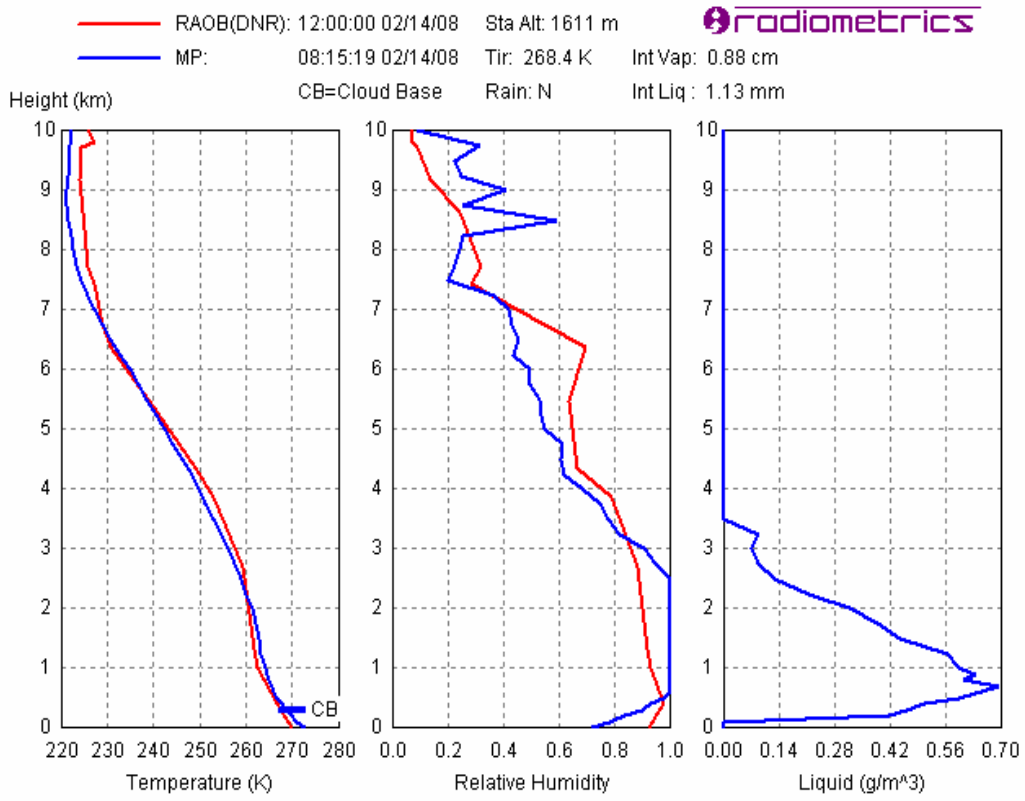

Figure 3. Denver radiosonde (red) at 1200 UT and Boulder radiometer (blue) temperature (left), relative humidity (center) and liquid (right) profiles at 0815 UT, the time of maximum liquid density.

Radiometric profiling provides new insights to complex relationships between temperature, humidity and liquid structures during cloudy conditions. These unique continuous data are valuable for accurate short term weather forecasting and for productive weather modification.

References

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