Cancel the Cardinals Home Opener?!? Lessons in Melting and Evaporation

by
Patrick S. Market
Department of Soil, Environmental, and Atmospheric Sciences
University of Missouri—Columbia

Part I—The Problem

Megan Riley, a meteorologist with Weather Innovations, Inc. (WINC), had just arrived on the evening shift. The time was 3:30 pm on April 9th. Among the locations for which WINC (and Megan) needed to create a forecast was St. Louis, Missouri. When she left the night before, her two-day forecast included rain for St. Louis, but it didn't look like enough to spoil the home opener for her favorite baseball team, the Cardinals. Now a day later, with the opening pitch less than 24 hours off, Megan was more concerned.

"What do you think about snow in St. Louis?" Megan asked Sean, her supervisor. He shook his head and squinted as though he had just cut up an onion.

"No way, Meg. It's gonna be too warm. It was awfully cold last night, but a warm front is approaching quickly from the south. That warm air will arrive later tomorrow, but the clouds tonight will trap enough heat to make whatever falls come down as rain."

"But the surface layer is still really dry," Megan replied. "All the way up to about 3,000 feet."

"And?" Sean demanded. He was a salty old Irishman like her grandfather, and one was advised to join that tone in battle only if she knew she could win. Megan charged ahead, undaunted.

"And the wet bulb temperatures are near freezing across that area," Megan replied. Sean stared, his Irish eyes unsmiling. Megan continued: "Plus, wet bulb temperatures don't change much with height over St. Louis."

Sean blinked. "Do you realize it's mid-April, in St. Louis, and you're talking about snow?" Sean pressed her.

"Yes, I do" she replied, nodding. "But I'll show you the analyses I've done so far. Really Sean, we could have a rain-to-snow changeover in St. Louis during the night."

"Well, we'll both be in hot water if you're wrong, Meg," he said. "We've got a lot of St. Louis contracts, including your baseball team, those Redbirds. Lot's on the line…. I'll give you until 6 pm to prove it. See me then."

Questions

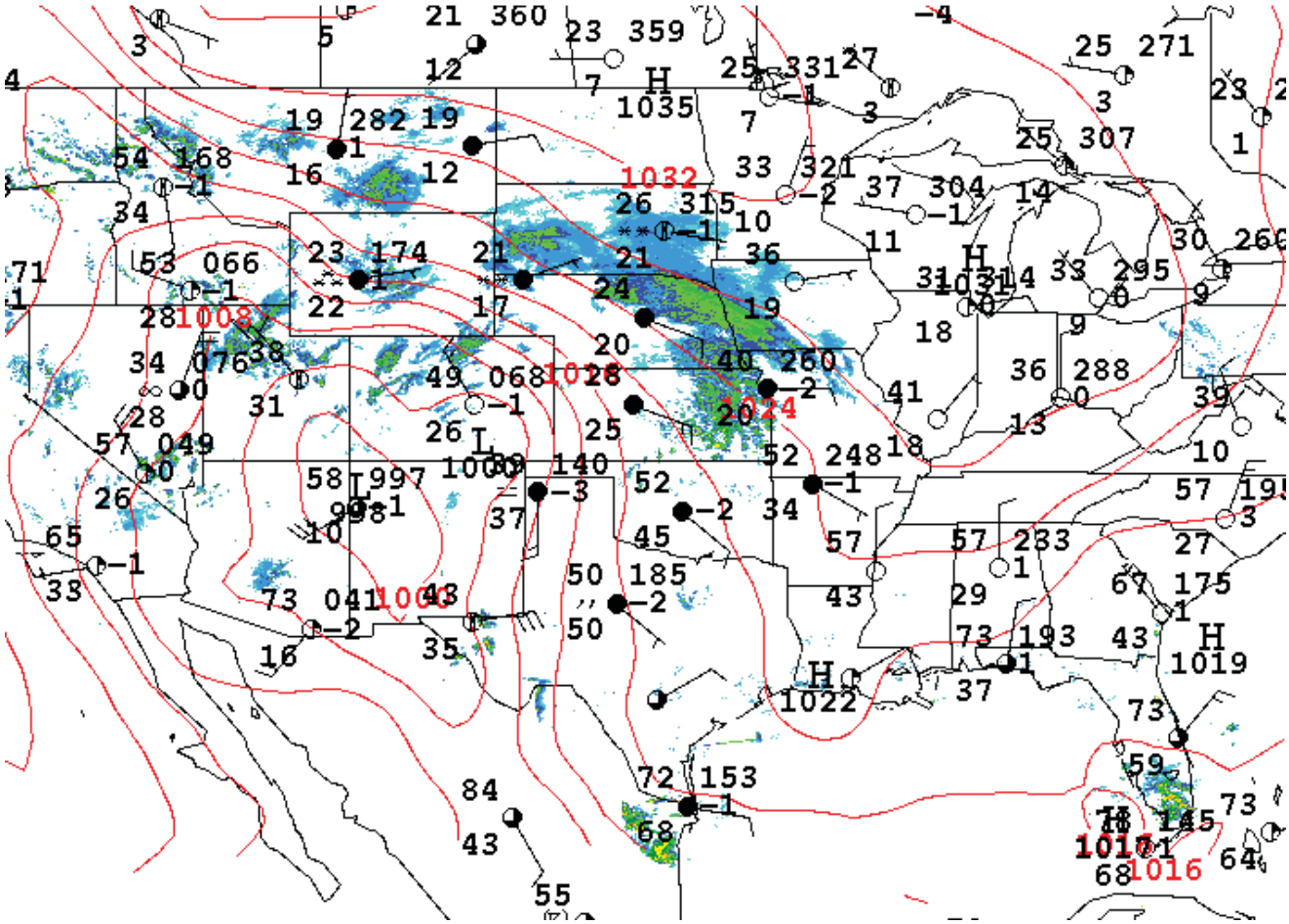
1. What is Megan concerned about?
2. What information does the wet bulb temperature provide?
3. How can the wet bulb temperature influence precipitation type?

Part II—Making a Convincing Case for Snow, 6 pm

Most of the St. Louis news broadcasts were already on the air, so Megan's television station client was telling the area about her previous forecast of rain. That particular station hadn't hired a trained meteorologist, but instead had opted for a "weathercaster" with great delivery and no sense whatsoever for the science involved. It might not have been the best move for the station, but that move kept Meg employed. As it was, this weathercaster was still using Megan's old forecast. "Not a problem," she thought to herself. "There's still the 10 o'clock news." Megan collected her notes and went to find Sean.

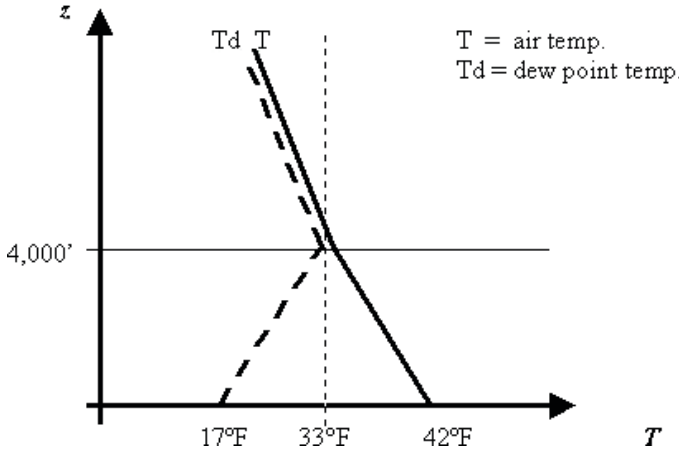
As Megan prepared herself to see her supervisor, she reviewed her argument. The weather map showed that St. Louis was still under the influence of a high pressure system, but it was retreating toward the east. Fronts and a new storm center loomed over the Rockies, and radar had detected precipitation already in northwestern Missouri, although it wasn't expected in the St. Louis area until dawn the next day:

Figure 1



Megan also noted the surface conditions at 6 pm in St. Louis, where the temperature was 42°F and the dew point temperature 17°F. This was a rather large dew point depression, but it also meant a surface wet bulb temperature of about 33°F. She then considered the 6 pm conditions aloft, and the temperature and humidity profile there:

Figure 2



Megan noted dry air near the surface (beneath 4000 feet), which was flowing in from the east, over Illinois. As she sat down at Sean's desk, she knew she was in for some tough questions.

Questions

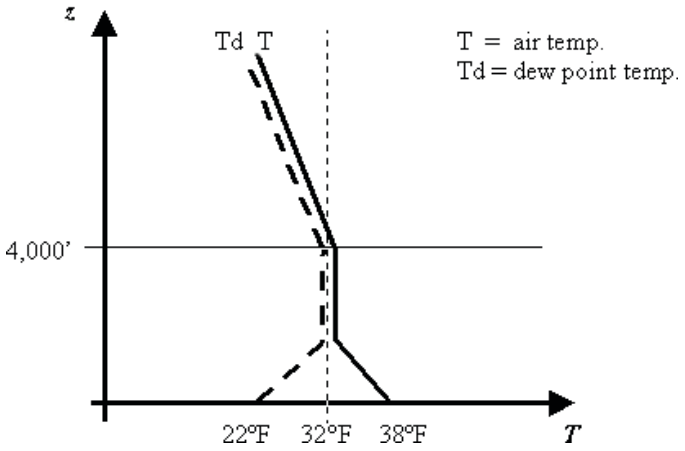
1. Is the surface layer near saturation?
2. At what elevation(s) is the atmosphere more humid?
3. At what elevation(s) will there be the most evaporation/sublimation?
4. Should Megan's forecast remain as rain or be amended to snow? Why?

Part III—Final Decision Time, 11 pm

Although the 10 pm broadcasts were over, Megan had other clients for whom snow would be a problem. Since the beginning of precipitation in the St. Louis area was still four to six hours away, there was still time for Megan to amend her forecast. School bus drivers could be called and told to stay home, snow plow drivers could be called out sooner….

Megan checked the surface observations at 11 pm in St. Louis and found a colder temperature (38°F) with a higher dew point (22°F). Above the surface, conditions had changed as well. However, she noticed that dry air near the surface (beneath ~2000 feet) continued to flow from Illinois at the same rate.

Figure 3



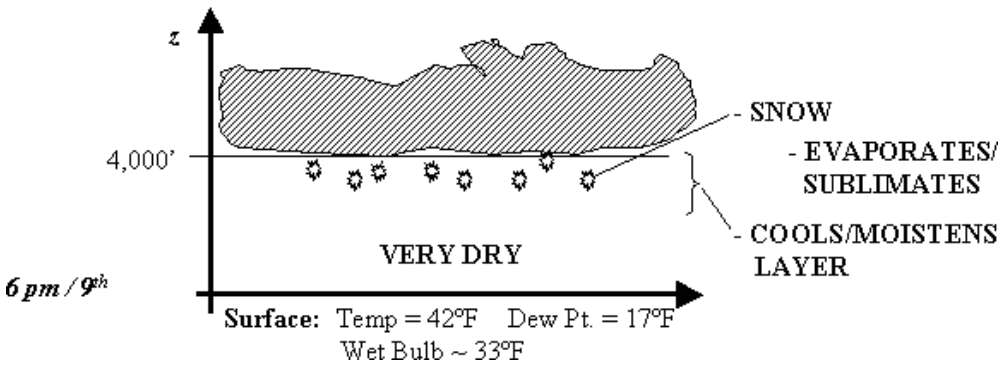
Questions

1. Is the surface air any nearer saturation than at 6 pm?
2. Can the surface air support more evaporation/sublimation?
3. At what elevation(s) is the atmosphere more humid?
4. At what elevation(s) will there be the most evaporation/sublimation?
5. Is Megan observing those two outcomes that evaporation achieves?
6. Should Megan's forecast be for a rain event or for snow? Why?

Part IV—The Outcome

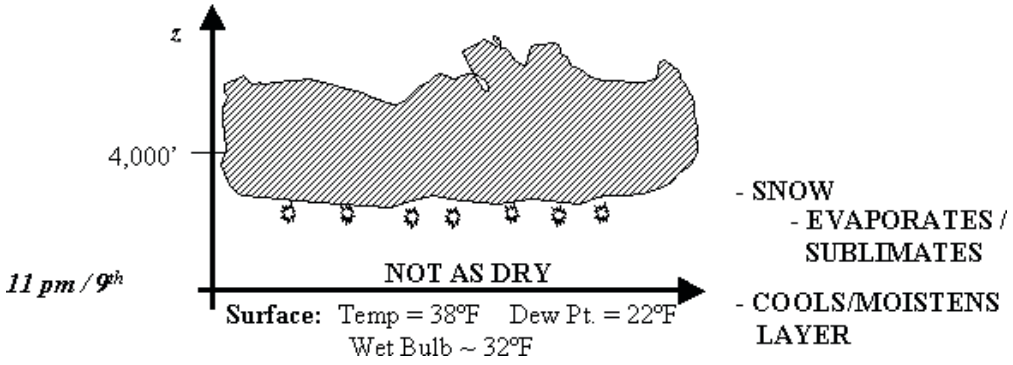
Here's what happened:

Figure 4



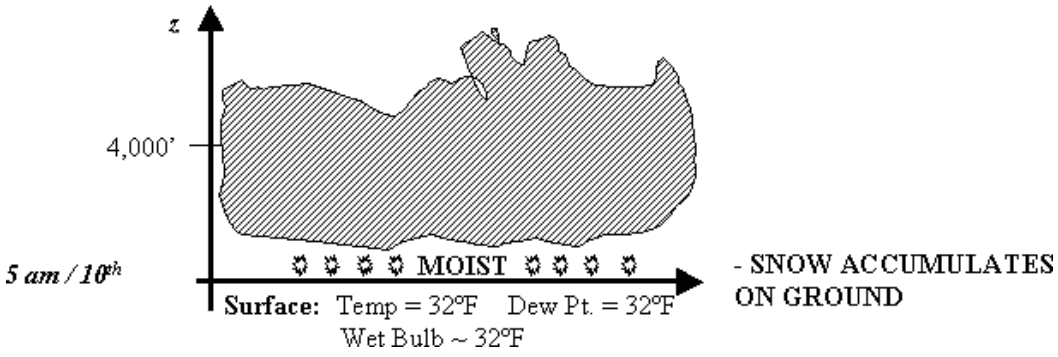
Early on, a deep, dry layer existed near the surface. Precipitation (snow) was falling out of the cloud, but it was far aloft and sublimated in the dry air before approaching the ground surface. Precipitation that evaporates or sublimates before it reaches the ground is known as virga. Yet the evaporation/sublimation process not only cools the layer beneath the cloud base, but moistens it too.

Figure 5



With generally uniform, steady-state flow under the cloud base, the process described above continued, with the cloud base developing ever closer to the ground surface.

Figure 6



Surface temperature cooled to freezing as the dew point temperature rose to nearly the same level. As the aforementioned process continued, the cooling and moistening processes arrived at the surface. The 32°F temperature was the limiting temperature in this case, as the snow was sublimating and the moisture was consuming the latent heats of evaporation and melting. The latter was the critical phase change, which occurred, of course, at 32°F.

Questions

1. Did your forecast decision for Megan change? When?
2. If you were permitted to have more data, what data would you have asked for?
3. At what point does a forecaster abandon continuity (their previous forecast)?