Cloud Image Report

Dominic DiMarco

Senior Mechanical Engineering

MCEN 4151: Flow Visualization: Dr. Jean Hertzberg

April 17, 2011

This photo shows an amazing phenomenon in cloud formation. A very beautiful sight to see, upslope fog occurs with just the right conditions and time of the year, along with being in the right topography. The overall effect of the fog is beautiful in both a thermodynamic, fluid mechanic, and artistic perception. What also stands out about this type of fog is the fact that the atmosphere locally can be completely different from the surrounding atmosphere to cause a very interesting dynamic between the fog and the surrounding air. The purpose of this photograph is to describe this intriguing dynamic that occurs between a calm atmosphere and a locally cooled region in a simplified manner to show the beauty that can be also visually striking. The picture was taken on March 17, 2011 at 7:15 AM off of Table Mesa Drive approaching Broadway in Boulder, Colorado, facing west toward the Flatiron mountain range. The picture itself was modified to leave out the street but the effect was not altered with the cropping of the main roads. Much of the information which can be observed is a result of local weather conditions from both the morning and the previous night.

This cloud is a Stratus Opacus within a locally cool atmosphere. Near the flatirons there is a warm wind front called a Chinook wind which causes warm air to come over the mountains. However, the formation of this cloud is somewhat reverse to the Chinook wind. This particular cloud was formed through a process called orographic lift. Amazingly, the clouds form when a warm air mass flows upward along a mountain range and adiabatically cools as it rises. Because of the lowered temperature, the air has a higher relative humidity and this is what causes the cloud shown. A typical reference to this type of orographic shown is called the Foehn Wall cloud. What is extraordinary is the fact that the water vapor condenses near the top of the mountain, but the drier foehn wind makes the water evaporate as it descends. This allows the fog to appear as if the fog is being created by the rock edges. This type of fog is quite common in along the Rocky Mountains due to the drier atmosphere and little moisture that does come via the Gulf Stream or the Pacific Ocean.[1]

---

[1]Whiteman, Charles David. *Mountain Meteorology: Fundamentals and Applications*. 1st ed. New York City, New York: Oxford University Press. Print.

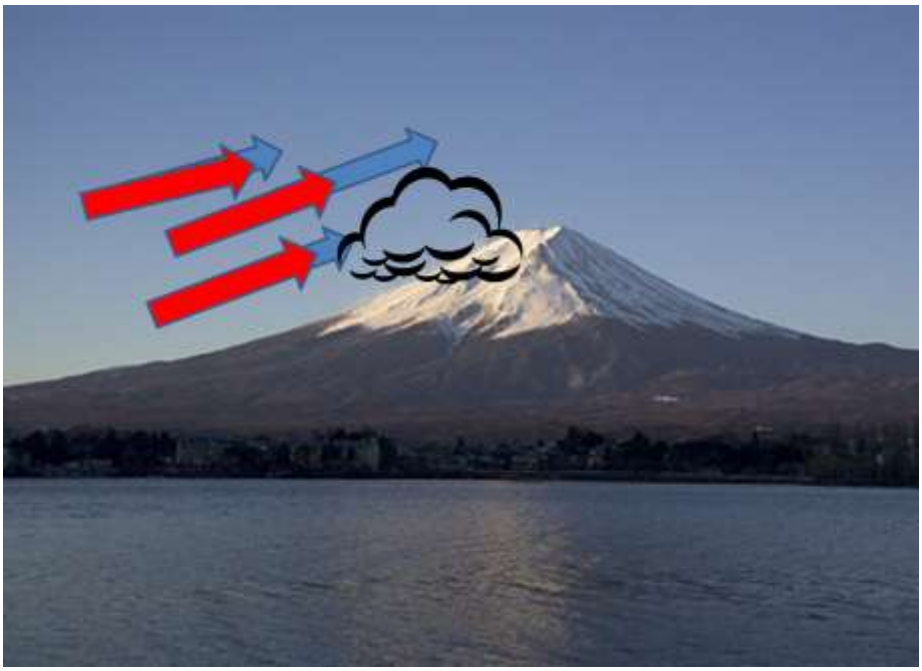


Figure 1: Diagram of how orographic lift creates clouds.

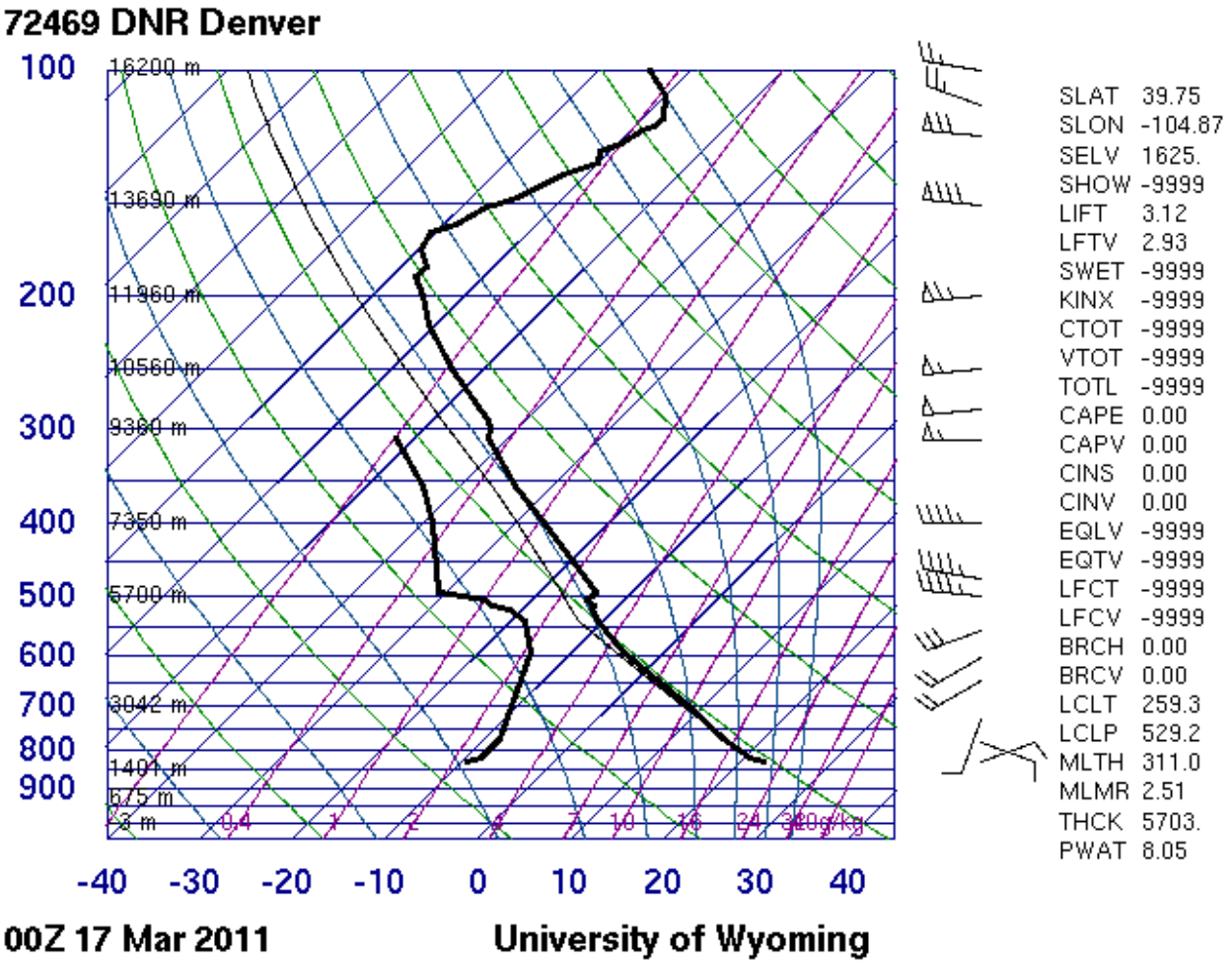
Interestingly enough, the local atmosphere has hardly any effect on the atmosphere above it, at least recognizably. When looking at the sky from the picture, no clouds are visible. The temperature around Boulder this day reached a high of 75°F. This was the hottest recorded day in Boulder history.[1] While the temperature was quite high for what we typically see in March in Boulder, the skew-T will tell us more about the conditions surrounding the general atmosphere.

To see why the day showed no clouds, the Skew-T plot of the local atmosphere at this time of the day must be analyzed[2]. While the picture was taken at about 7 AM, we have available a skew-T plot for 6 AM. This will help us better understand the trend by examining the CAPE value and the trend of the lines on the plot.[2]

---

[2]McClathy-Tribune Information Services. "BRIEF: Boulder temperature reaches record high." Web. 20 Apr. 2011.

[3]Skew-T Plot DIA, 3/17/2011 00Z, Retrieved April 20, 2011, 8:24 PM. University of Wyoming Sounding Database. http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=PDF%3ASKEWT&YEAR=2011&MONTH=03&FROM=1700&TO=1700&STNM=72469



What is first recognizable is that this plot is <u>not</u> of Boulder, but of Denver International Airport. However, the sky surrounding the Denver Metro area was very similar to Boulder, as can be readily noticed. The CAPE value was 0.00, which implies a very stable atmosphere. Also, there is no ready intersection of plot for where humidity meets with condensation temperature, which implies a clear sky.[4] Because of the high pressure as well, very few clouds will be formed along with

---

[4] Hertzberg, Jean. PhD. Class Lecture: Cloud Physics: Skew-T, stable vs unstable. MCEN 4151: Flow Visualization: The Physics and Art of Fluid Flow. University of Colorado at Boulder, ITLL Room 1B50. February 7, 2011.

the higher local temperature. Considering this, the foehn cloud is an interesting sight to see in the sky on such a calm day.

The camera used to take this picture was a Canon Exilim EX-H5, having a pixel count rating of 12.1 Mega Pixels. The ISO was set to a value of 400 for a pretty average day of sunlight. The F-stop was also at a value of f/11 and a shutter speed of 1/400 of a second, which gave a nice resolve of the cloud so that there didn't have too much sun exposure but enough inlet to show the details of the cloud. The focal length was at 16 mm and a maximum aperture of 3.4. Overall, the details of the cloud were not compromised but gave a sense of mystery with a good exposure.

The cloud was an amazing sight to see at such a late time of the day to see fog. The physics behind this particular type of fog is a very interesting phenomenon and was an amazing opportunity to witness the beauty in which clouds can be formed on the gound level. Along with this, the weather surrounding the general Denver Metro area creates a binary to compliment the opportunity to see radiation fog in such a favorable condition. Overall the picture shows how fog can be created to instill a very unique mood to see, right here in the Rocky mountain range.