Flow Visualization: The Physics and Art of Fluid Flow

Cloud Image Report #1

Professor Hertzberg
Sam Sommers
ME ID: 891 611

The second assignment in the Flow Visualization course (MCEN 4151) is to capture clouds. My personal intent for this assignment was to capture an interesting effect in the clouds, and make an overall appealing image that enables the viewer to observe part of this beautiful natural phenomenon that occurs just about every day. Most people take little notice of the clouds above them, unless there is some sort of precipitation occurring. This assignment was not only used for personal benefit, but also to share the majestic views of what resides above us. Having a residence in or near Boulder, Colorado is quite the advantage to this assignment, as being so close to the mountains enables an amazing scene with extraordinary weather patterns.

While riding home from classes in the late afternoon on February 20th, 2012, I noticed astonishing clouds over the mountains. Rushing to get home and into my car with the camera, I made it up to Chautauqua Park, at the base of the Flatirons on the Front Range, just in time before the sun began to set. There were many interesting cloud formations, and the few that caught my eye were located towards the north, extending about a mile from the Flatirons. The image was captured at approximately 5:49 pm MST. The camera was set on a tripod at about 5 ft from the ground angled parallel to the earth. The surface temperature was about 36^{0}F, and the winds were gusting at about 20 to 30 mph [1].

According to the Skew-T plot shown below in Figure 1, the clouds likely formed around 10,750 m above sea level. This can be seen by the atmospheric temperature line (thick black line on right) and the dew point temperature line (thick black line on left) coming close to contact with each other. Just above this section, these two lines begin to follow the diagonal constant temperature lines, indicating that these temperatures remain relatively constant with increasing altitude. This phenomenon indicates the location of the tropopause. Therefore, the clouds were most likely located in the upper section of the troposphere. The atmosphere can be identified at stable at this time due to the Convective Available Potential Energy (CAPE) index of 0. With the atmospheric stability and approximate location of the clouds known, it then becomes possible to make an assumption about what type of clouds are in the image and the likely cause of formation.

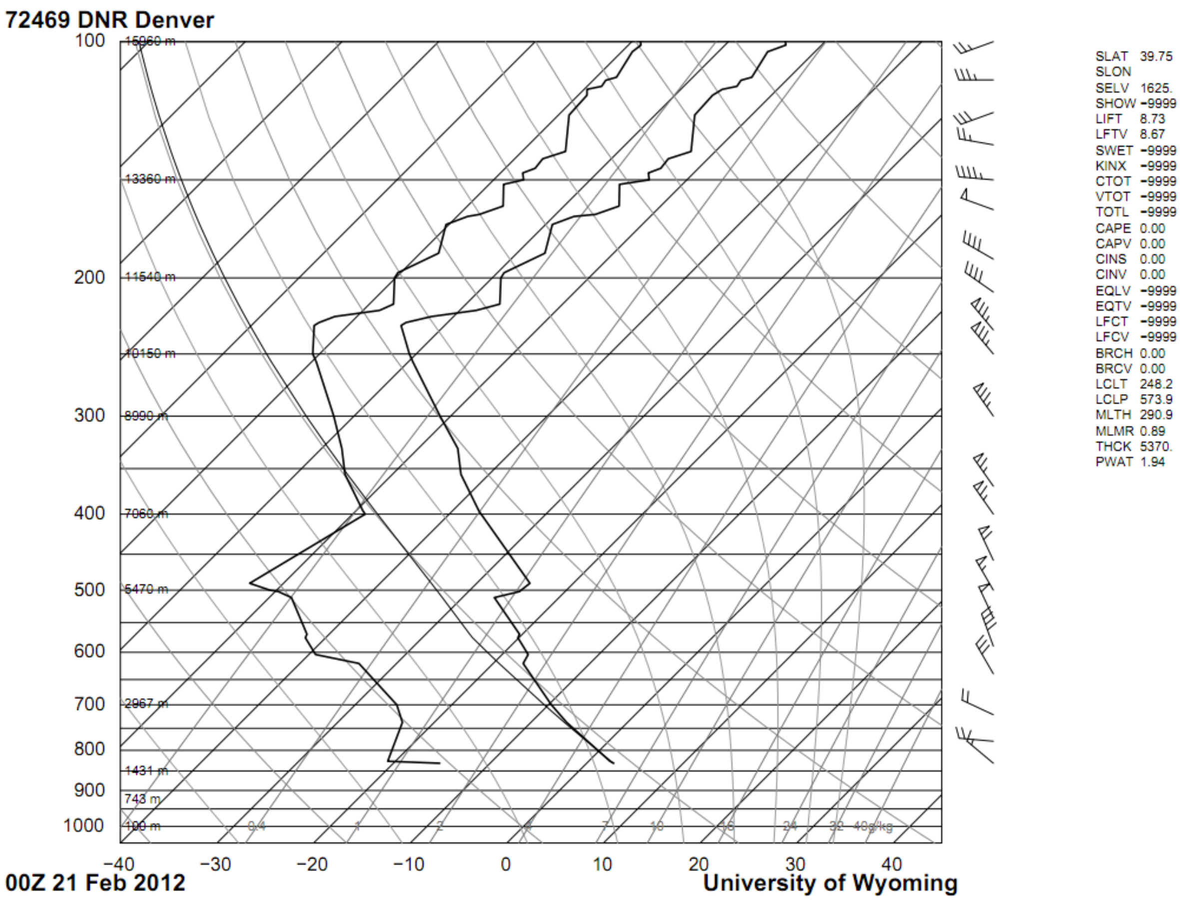

Figure 1: Skew-T Plot. Provided by the University of Wyoming Engineering Department. [2]

At a level above 10,750 m or about 35,000 ft, cirrus clouds are the most prevalent. This is consistent with both the weather sounding as well as the image. Cirrus clouds can be characterized by their wispy nature, as at that height there is a relatively low air density which makes them transparent. These clouds are also very thin, which is a characteristic of a stable atmosphere. Since a perturbed parcel will cool upon rising, it will lower in density and fall back down to its original position, thus following the definition of a stable atmosphere and agreeing with the CAPE index shown at the right of the Skew-T plot. The wind speed and direction at the height of the clouds can be seen by the flags to the right of the plot. At the time of the sounding, the wind is coming from the northwest and heading towards the southeast at about 85 mph. These high winds can change rapidly at any moment, but appear to be consistent with the image.

The clouds are likely a cirrus fibratus, due to the long, fine filaments that extend in the direction of the wind. They are orographic clouds, meaning they were caused by the geography. The mountains can create some interesting patterns, and since there are about three distinct sections of clouds with similar characteristics and vacancies in between, they could have been caused by standing waves above the mountains. On an atmospherically stable day with high winds, cool breezes can shoot through the Rockies, and end up passing over the Front Range. The cold front is quickly forced over the mountains, but instead of continuing to rise, the stability causes it to flow back downward. This phenomenon follows characteristics of an under damped system when the then descending air warms on its way down, and bounces back up again. When the warm air climbs in altitude, it cools below the dew point, and clouds form. This repeats for a few cycles, which explains the three distinct cirrus fibratus clouds shown in the image.

The camera used to capture this image was a Canon Digital Rebel XT, with a standard EF-S 18-55 mm lens. As stated above, the clouds were a vertical distance of about 10,750 m above sea level, which is about 5,000 ft above the camera, due to the ground elevation of Boulder. Horizontally, the distance varies from the clouds directly overhead to anywhere from one to two miles in the distance. The field of view is an estimated half mile across. The ISO was set at 100 in order to produce the crispest image possible, along with an aperture at f/10 to focus on everything in the picture without letting too much light in. The shutter speed was 1/50th of a second. This shutter speed was found by trial and error, as it was easy to take the same picture a few times with the camera in the same spot on the tripod and decide which one suit the image the best afterwards. The only post processing used was the “brush” tool in Adobe Photoshop Lightroom 4 Beta Edition, because the lens had a few scratches on it. Original and final image dimensions are both 3456x2304 pixels, which is the largest available format while shooting in RAW mode, in order to maintain image quality at a maximum.

The image reveals some interesting fluid flow. I was able to capture an appealing picture that shows clouds formed in an atypical manner. I like the depth of field, and how everything in the image appears in focus. The clouds have nice detail, and with the landscape in the picture it is much easier to gain a perspective on the relative scale of the photograph. In developing this idea further, it would take more patience and a few good weather patterns.

Works Cited

1. Weatherspark Beta. Web. 1 Mar. 2012. <http://weatherspark.com/#!graphs;a=USA/CO/Boulder>.
2. "Atmospheric Soundings." *Wyoming Weather Web*. Web. 01 Mar. 2012. <http://weather.uwyo.edu/upperair/sounding.html>.