Gregory Lundeen

Cloud Image Report 1

Flow Visualization

Prof. Jean Hertzberg

This image was taken for the first cloud image assignment. It was an effort to capture some less common cloud formations over Boulder Colorado. Considering the proximity of Boulder to the Front Range mountain formations, it is no surprise that Boulder and the surrounding area commonly experiences some dramatic and rather unique weather. Given that the intent was to capture some less common formations or especially unique formations, many images were taken and then assessed before the resulting image was chosen. There were some interesting other phenomena captured, but this one was the most intriguing.

The image was taken in Boulder, on the University of Colorado campus. The exact location was near the corners of Regent Drive, and Colorado Avenue. The camera was facing North West towards the northern Front Range. The image was taken at about 45 degrees off of horizontal. The image was also taken at 3:05 PM on February 22, 2012.

After looking at the sounding data from that day and time period, it seems the highest probability of these clouds forming was at either 6500 meters (21,325 feet), or maybe 12,000 meters (39,370 feet) above sea level, or 16,025 and 34,070 feet above ground in Boulder respectively [1]. Boulder was in the process of transitioning from a relatively warm day, to a cold front moving in. The high temperature for Wednesday was 57 degrees, while the low temperature for Thursday was 16 degrees at 8:00 PM [4]. There were very strong winds from the west all through the week, being the strongest on Wednesday. There may have been some minor precipitation on Thursday in the form of snow on Thursday. The skew-T plot shows a stable atmosphere all day Wednesday as can be seen in Figure 1. It also shows a CAPE value of zero, which also indicates a stable air mass [1]. There was a massive Foehn wall looming over the mountains close to where the imaged cloud formations were seen. Given all of this information, the pictured formation is believed to be either a Cirrus Undulatus. Or more likely, the clouds were an Altostratus Undulatus [2]. Given that the wind was strong at the surface, but the atmosphere was mostly stable, the clouds expected to form would be of the stratus type moving east of the Front Range Mountains. The physics of these cloud formations is generally that gravity waves aligned normally, or perpendicularly to the direction of the wind flow will created the undulating appearance of the clouds as it is influenced by the gravity waves [3]. The undulating effect of the gravity waves shifts the temperature closer and further from the dew point at that level in the atmosphere cause cloud condensation at one part of the wave, and closer at another [3]. This is what gives the formation its name as well as ribbon like appearance.

To capture this image, A Sony DSLR A-230 was used. The camera was out fitted with a Sony SAL 55200-2 zoom lens. The F-stop for the image was f/13. The shutter speed was 1/320 seconds, and the ISO speed was ISO 100. The focal length was 55 millimeters, and no flash was used. The field of view was estimated to be about one mile across by one mile tall. The

distance to the cloud formation can be found using fundamental geometry. Given that the Sine of an angle is equal to the length of the opposite side divided by the length of the hypotenuse we can find the length of the hypotenuse by rearranging the terms. The angle of the camera was determined to be about 45 degrees, and the height of the cloud formation is estimated from the sounding data. So, the length of the hypotenuse will be found by dividing the vertical distance to the cloud formation by the sine of 45 degrees. As stated before the most probable heights of the cloud formation were 18,000 feet, or 44,300 feet. The sine of 45 degrees is 0.7071. So, the likely distance to the cloud formation is either 25,456 feet, or 62,650 feet. The final image captured is 3872 pixels in width and 2176 pixels in height. It also had 350dpi resolution in both height and width. The goal was to capture an interesting cloud formation, so there was literally almost no post processing done to the image. The only post processing done was to convert it from a JPEG image to a lossless TIFF format file.

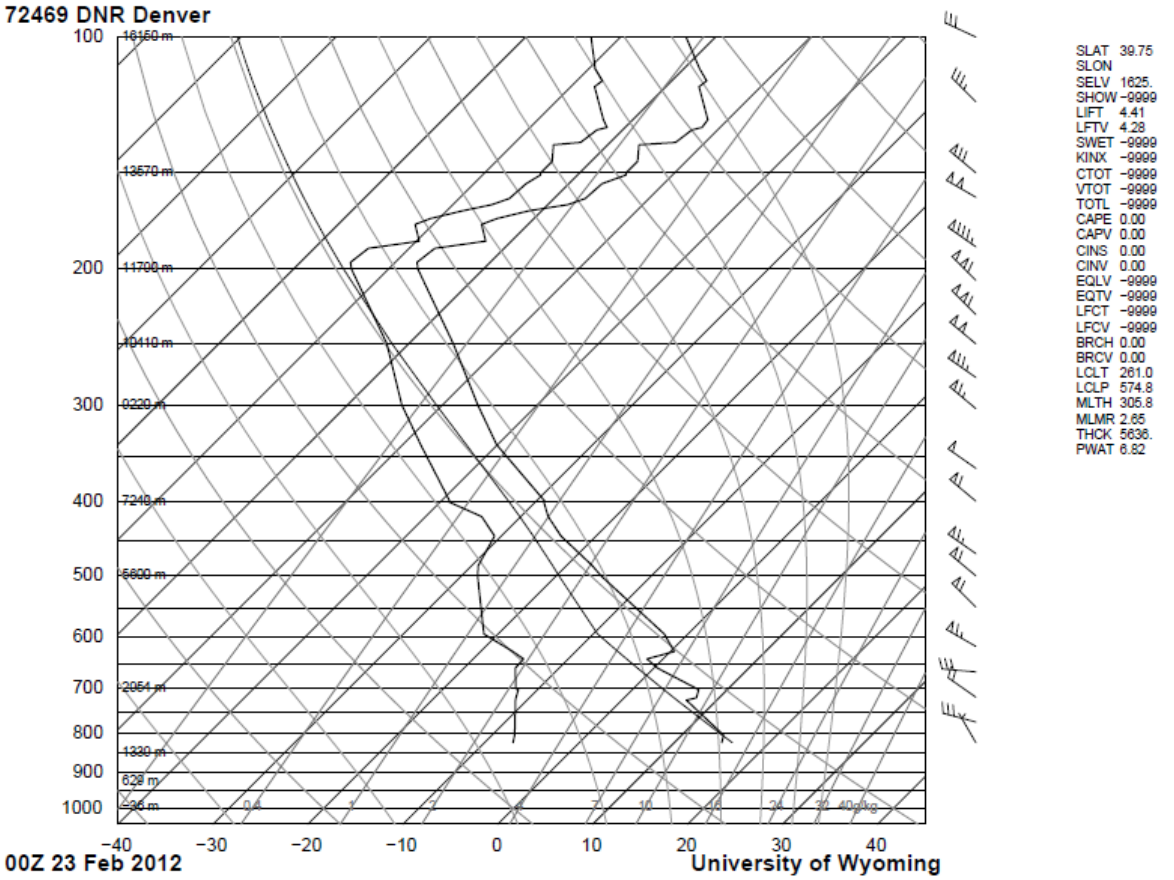

Figure 1: Skew – T Plot

This image reveals some extremely interesting fluid physics occurring in nature. The cause of the undulating clouds in the image show gravity waves essentially, which are very difficult to see in many cases. In attempting to catch just any unusual cloud formation, this image captured an interesting phenomenon in fluid flow as well. To develop this idea further one could either make use of more post production to give it a more artistic feel, or try to hunt out more dramatic examples of this same phenomenon elsewhere. Overall, the goal of obtaining an interesting cloud image was achieved but, as with most things, there is always room for improvement. This is still an interesting cloud formation image.

References:

[1] http://weather.uwyo.edu/upperair/sounding.html

[2] http://cloudappreciationsociety.org/

[3] http://en.wikipedia.org/wiki/Undulatus

[4] http://weatherspark.com/