# Cloud Image #2 Report

## MCEN 4151

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This report discusses the second cloud assignment for the MCEN 4151 Flow Visualization class. The scope of the assignment is simply to watch the sky and capture an image of interesting clouds. The intent of the photo that was taken was to clearly see the details of Longs Peak in the distance while still displaying the mountain wave clouds in the surrounding area. The phenomenon that was attempted to be shown in the image is the various low level clouds that are found around mountains.

The photo that was taken was shot in the early afternoon during a senior project flight test at 3:23PM on April 4th, 2013. The location that the image was captured from was the Table Mountain Antennae Field, 15 miles North of Boulder. The picture was shot facing West towards the foothills. The elevation angle of the camera was very close to horizontal and may have been a couple degrees above horizontal to capture the top of the clouds. The lens captured much more area than the final image shows. This allowed for the lens to be very close to level with respect to the ground.

The clouds that are seen in the image are foehn wall clouds and mountain wave clouds. This can be determined by the manner that the clouds come off of Longs Peak and the clouds that are seen along the Front Range while the rest of the sky is clear. The sky in the surrounding area was clear with the exception of similar clouds above mountains north and south towards Boulder. The weather the previous day was similar to the weather in the morning but did not display the same clouds. However, there was a front that moved through during the day after the photo was taken. There was no snowfall however there was overcast skies. At Table Mountain Antennae Field the winds were out of the South at roughly 5 miles per hour. According to the Skew-T diagram that can be seen in Figure 1, the atmosphere on the morning of April 4 was stable. This can be determined in two different manners. First, the CAPE value on the right of the plot is 0. This is a metric for the stability of the atmosphere, as the value gets higher, the atmosphere becomes more unstable. The other method to determine atmospheric stability is to view the lines on the diagram. The two lines that are required to determine stability is the rightmost bold line, temperature, and the black dry adiabat line that rises to the left from the temperature line. The two lines rise roughly parallel in the case seen in Figure 1. Instability occurs when these lines depart from parallel and the slope of the temperature line, if projected further, would cross the dry adiabat line.

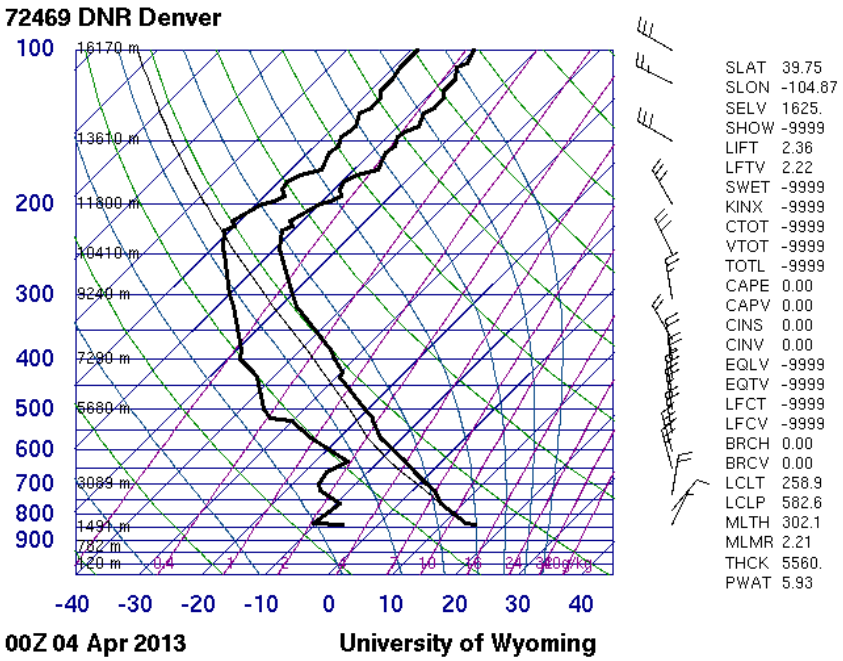


**Figure 1. Skew-T diagram for Denver - Morning of April. 4th**

Also from the Skew-T plot, an estimate of expected cloud height can be made. Determining this involves using the dew point line which is the bold line located to the left of the temperature line. Clouds can be expected where the dew point line departs from running close to parallel with the temperature line. In the Skew-T seen in Figure 1, it can be estimated that clouds would be forming around 5680 meters (18,636 feet) above sea level or about 3,030 meters (9942 feet) above the ground. This does not agree with the image that was taken. Using the mountains as known distances (from TMAF to Longs Peak), the length of the cloud from South to North is about 25 kilometers. This distance and the height of longs peak allows for the estimation of the altitude of the cloud to be about 4km above the ground. From the stability of the atmosphere and the general weather in the area, altocumulus clouds could be expected. The other clouds seen in the image are altocumulus. The physics behind the mountain clouds involve wind flowing over mountains and creating waves on the leeward side of the mountains. As the air flows up the standing wave, the temperature drops lower than the dew point and condenses forming the cloud.

The photographic technique that was used was simply to capture the full cloud as clearly as possible. The cloud could be assumed to be at an infinite distance when concerning the depth of field. As discussed previously, the field of view from left to right is approximately 25 kilometers, and from top to bottom is about 2.5 kilometers. Since the clouds form above mountains, it is assumed that the linear distance to the mountain below the cloud is approximately the distance from the TMAF to Longs Peak. Using GoogleMaps, a distance from the TMAF to Longs Peak in the image is about 25 kilometers as the crow flies. The focal length that was used was 18 millimeters which allows the maximum field of view with the lens that was on the camera. The image was taken with a Nikon D60 DSLR in the RAW formatting mode. The original and final images, which can be seen in Figure 2, have a pixel height and width of 3,900x2613 and 3900x800 respectively.

**Figure 2. Original image (top) and final image (bottom)**

To capture the original image, a shutter speed of 1/400 of a second, an aperture of 10, and an ISO of 100 was used. These settings were chosen to allow for the maximum amount of light and depth of field while still quickly capturing the image. Finally, Photoshop was used solely to crop the image and increase the contrast. The contrast was increased to bring out the details of the clouds and the depth of the blue sky. In doing this, the detail in the mountains was completely removed and turned them into silhouettes. The image was cropped to remove the majority of the ground and sky to give the image the feeling of a panorama.

The final image reveals the various mountain wave clouds consisting of altocumulus clouds and a Foehn wall cloud off the top of Longs Peak. I like the way that the photo turned out after post-processing. The original image is a little dull in my opinion but the increase in contrast really brought out the critical details. Something I wish I could have changed is increase my altitude to be able to see more of the clouds that are currently hidden by the Front Range. To develop the image further an aircraft could be used to remove the foreground mountains and clearly see the clouds. Overall, I am satisfied with the outcome of the final post-processed image.