# Clouds II Report: Altocumulus Lenticularis

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# Introduction

The picture on the cover of this report is the final edited image submitted to complete the Clouds II assignment. The intent of this assignment was to capture an interesting and beautiful image that reveals the physics and flow phenomenon associated with clouds. Investigating the physics behind the numerous cloud types creates an appreciation for one of the natural beauties of our planet that is often overlooked. Taking advantage of our location along the front range, I wanted to focus my pictures on mountain wave clouds. I took pictures from many locations to view these clouds in as many perspectives as possible. I ultimately chose this image to submit because I liked the how it showed the formation of a mountain wave cloud as it is leaving the mountains and it provided a horizontal perspective of the mountains. This image was taken, facing directly south at a 20° angle above the horizon, halfway up the foothills just off of Baseline Rd. in Boulder, CO on March 18, 2011 at 3:54 p.m.

# Atmospheric Physics and Conditions

It was easy to tell from the long strips of "puffy" and "cotton-like" clouds that were forming on the downwind side of the mountain that this was an altocumulus lenticularis mountain wave cloud [1]. Also, in the background there are some cirrus clouds which are distinguished from their fibrous and silky appearance [2]. At the time the picture was taken the weather conditions consisted of scattered clouds, a wind speed of about 5 mph, and a temperature of 55°F. Only a couple more mountain wave clouds could be seen when looking away from the mountain. The altocumulus and cirrus clouds in the background suggest that a cold front could be moving in. To see if this was the case I conducted a seven day weather study for the two days before the image and the four days after March 18th, which is shown in Table 1. From observation of this weather study data, it appears that a cold front could have moved in either the night before the image was taken or two days after. Based on the temperate drop and the rain that had occurred the previous night, I concluded that a cold front had moved in the night before the image was taken. There was not a significant change to be sure if a cold front had also moved in a couple days after.

**Table 1: Weather Conditions Four Days Before and After the Image was Taken [3]**

| Date | Mean Temperature | Average Wind Speed | Conditions |
|---|---|---|---|
| 3/16/2011 | 52 °F | 4 mph | Day – clear/ Night – clear skies |
| 3/17/2011 | 52 °F | 10 mph | Day – clear skies / Night – light rain |
| 3/18/2011 | 46 °F | 5 mph | AM – scattered clouds / PM – clear skies |
| 3/19/2011 | 48 °F | 2 mph | AM – clear skies / PM – clear skies |
| 3/20/2011 | 48 °F | 6 mph | Day – clear skies / Night – mostly cloudy |
| 3/21/2011 | 46 °F | 6 mph | Day – mostly cloudy / Night – clear skies |
| 3/22/2011 | 50 °F | 16 mph | Day – partly cloudy / Night – clear skies |

The main cloud that this image is focused on is of the altocumulus genus characterized by globular masses or rolls in layers. The cloud species is classified as a lenticularis which are stationary lens-shaped clouds that form at high altitudes (6,500 to 20,000 ft) [2]. These can also be known as mountain wave clouds which occur when the stable moist air that flows over a mountain range creates standing waves of air flow. Lenticular clouds are formed when the temperature at the crest of the wave drops to the dew point causing the moisture in the air to condense. As the air flowing through the cloud begins to descend the cloud may evaporate back into vapor [1]. Since the air waves coming off the mountain stay fairly steady and the clouds remain only at the crest of these waves, the cloud appears to be staying in almost the same position.

The Cirrus clouds in the background are formed in the upper troposphere at altitudes typically ranging from 16,500 - 45,000 ft. They are composed of falling ice crystals that evaporate in the warmer air below the cloud and thus, produce no precipitation that hits the ground. The movement of the falling ice crystals in the wind is what gives them their flossy, streak-like formations. The wind is often on the order of 100-150 mph, which means they don’t stay in one spot for long.

A skew-T plot, shown in Figure 1, is used to determine if the atmosphere was stable and the height at which clouds are most likely to form. This skew-T p lot is for 6 p.m. on March 18, which is the closest one available to 3:54 p.m.

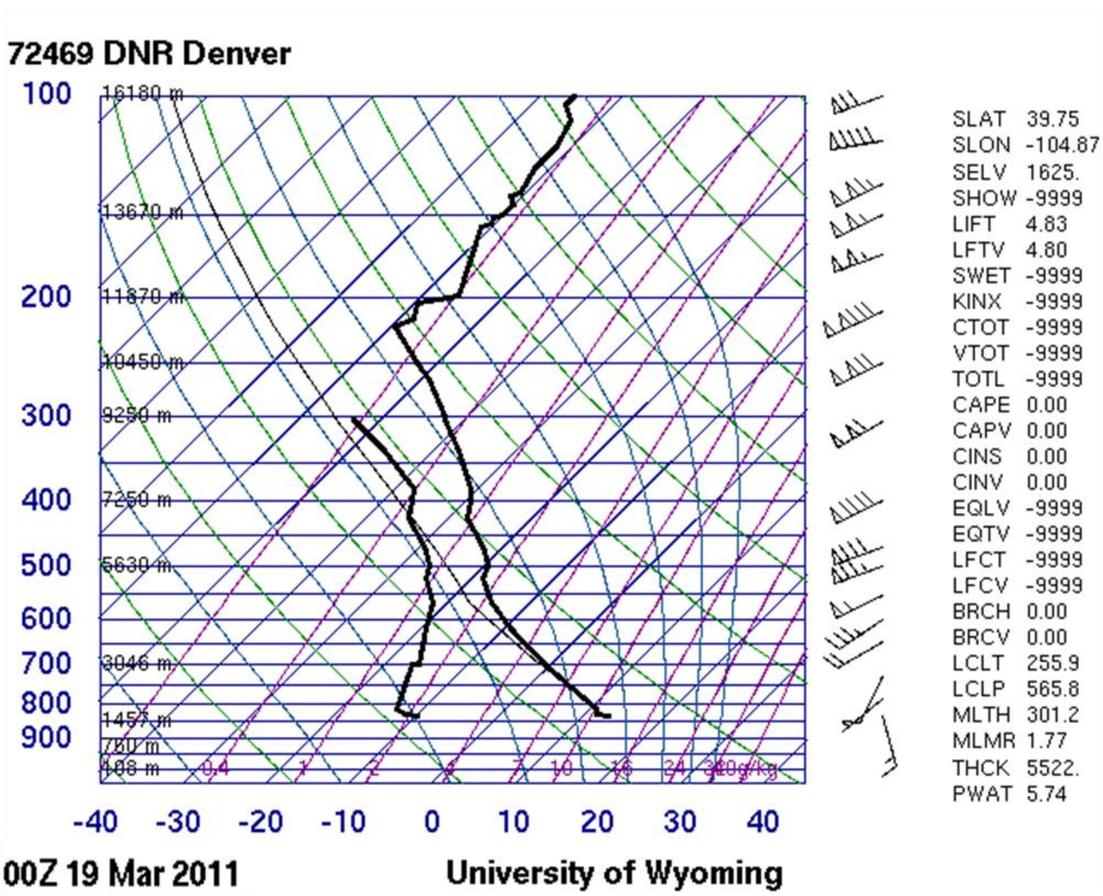


**Figure 1: Skew-T plot for March 18, 2011 at 6:00 p.m.**

Since a skew-T plot for the exact time I took the picture could not be provided, I looked at the before (3/18 12:00Z) and after (3/19 0:00Z) to determine if the atmosphere was stable. In both diagrams the CAPE value was zero meaning that entire atmosphere was stable. The two heavy black lines are used to determine where clouds are most likely to exist. The actual air temperature is depicted by right black line and the left black line represents the dew point temperature. Where these two lines come closest together is where the clouds are most likely to form. The diagram shows the lines closest at altitudes ranging from 16,500 – 24,500 feet, which lies within the highest range of altocumulus clouds and agrees with my observation.

# Photographic Technique

In the search for a perfect cloud to photograph, my main criteria was to get a picture that was interesting, beautiful, and had no distracting elements that take away from the physics of the flow. This proved much harder than one might think, with the main issues being contrails, power lines, and trees. To help with the later two issues, I increased my elevation by traveling about halfway up the foothills and used and 20° angle above the horizon. By looking through the camera and comparing points in the sky which correspond with the edge of the picture I was able to estimate the field of view to be 105°. Taking into account the 20° from horizon, my elevation of about 7,500 ft, and that the clouds were approximately 18,000 ft in altitude that allows us to calculate using simple geometry the distance from the cloud to the camera lens to be about 30,700 ft.

This image was shot using a point-and shoot Sony DSC-H10 8.1MP digital camera and gave a final image of 2448x3264 pixels and was never cropped for the final edited image. The camera was at a focal length of 0.25in (6.3mm), aperture stop of 3.5, shutter speed of 1/125s, and an ISO setting of 100. The original image is shown in Figure 2.

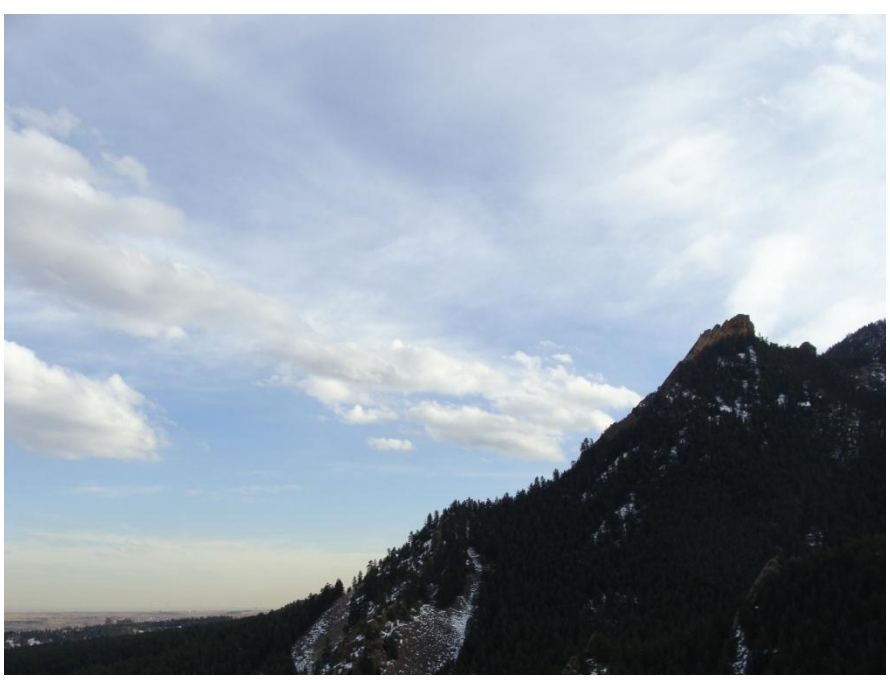

**Figure 2: Original (unedited) Image**

From looking at the original image it is a little difficult to tell were some of the edges of the cloud are because the sky is not dark enough to clearly define the edge of the cloud from the light blue background.  To fix this I used the curves setting to adjust the contrast using a nonlinear curve to help darken the blue sky.  To help put more emphasis on the clouds and not the landscape I also adjusted the low end contrast to make the mountains black.

# Conclusion

The main scientific phenomenon this image reveals is the air waves caused by cool air flowing off the downside part of a mountain which is shown by the clouds seeming to remain at the crests of the waves.  I really like the perspective of this image, how the mountains are a horizontal component in this image.  I also really like how this image shows how mountain wave clouds are formed by capturing it just as it is coming over the foothills.  The only thing I dislike about this image is the actual cloud, it is a good cloud and accomplishes my goal of this project, but I feel that with enough time I could have capture a spectacular looking cloud that would reveal the same physics.  This image displays the physics really well; the long cloud extends across crest of the first wave of air coming off the mountain. This aspect alone fulfilled my intent for this assignment.  To improve this image, I would take more images from the same location but just wait for the perfect cloud to come along and maybe I would wait until sunset to get some pink and orange colors into the cloud.

### *References*

[1]  Lenticular cloud. (2011, April 16). In *Wikipedia, The Free Encyclopedia*. Retrieved 08:21, April 22, 2011, fromhttp://en.wikipedia.org/w/index.php?title=Lenticular_cloud&oldid=424360402

[2] Pretor-Pinney, Gavin. *The Cloudspotter's Guide: The Science, History, and Culture of Clouds*. New York City: Penguin Group, 2006. Print.

[3] *Weather underrground*. (n.d.). Retrieved from http://www.wunderground.com/