Clouds 1[1]

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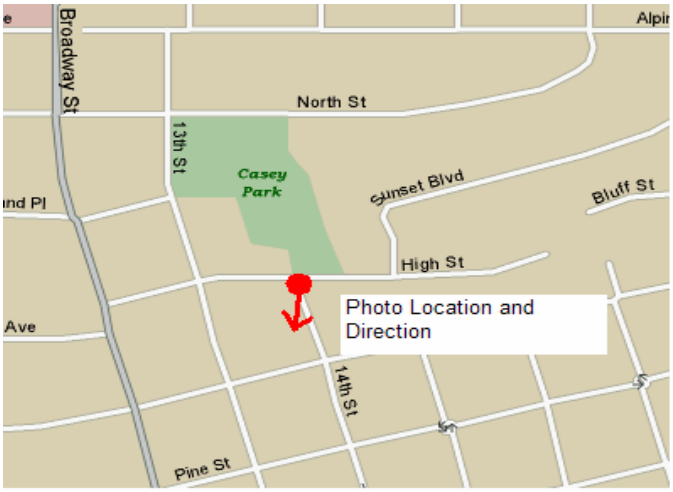
A cloud imaged on January 30th is examined in order to determine a basic understanding of the atmospheric physics that created it. The cloud bank extended across a large portion of the Boulder area foothills and remained in the same area of the sky for the majority of the day. Therefore, it appears that despite the somewhat windy weather that the atmospheric conditions were quite stable.

[1] This paper is submitted in partial fulfillment of the requirements of MCEN 5228-010, Flow Visualization: The Physics and Art of Fluid Flow

The intent of the image is to visualize atmospheric physics through the use of clouds. Unique interactions between the atmosphere and the mountains make cloud formations in the Boulder foothills area particularly spectacular. This particular image attempts to capture the height of the lenticular wave cloud which had remained in the sky above Boulder for the majority of the day.

This image was taken approximately five minutes before sundown on the 30th of January. The photo encompasses a field of view on the order of one-half mile wide horizontally and 2 miles vertically. The picture was taken facing south from the top of the small hill near the intersection of 14th and High St. near the Casey Park and the Sacred Heart Schools.



The weather on this particular day was surprisingly mild for the time of year; the temperature was a high of 53° F and a low of 22° F. The winds ranged from 5-10 mph with gusts in the range of 12-25 mph. Despite the fact that the clouds appeared to be cumulonimbus, with a towering appearance and dark underside, the clouds never resulted in any precipitation.

The clouds in this image are referred to as vertically propagating altocumulus lenticular clouds. These clouds form in the lee of a mountain range and grow in a vertical direction. The sculpted appearance is due to shear winds coming over the ridge line and cutting away the edges of the cloud. According to the FAA publication Hazardous Mountain Winds and Their Visual Indicators, these clouds are the most common in the winter months and are accompanied by large winds at ridge level as well as high gusts on the downslope. This description is quite in line with the weather observed on the day the photo was taken so the decision to classify the clouds as lenticular seems justified. These clouds are also accompanied by a relatively stable atmosphere, which was evidenced by the fact that the clouds remained fixed in the sky for the majority of the day. The vertical height of the clouds is estimated at approximately 30,000 to 40,000 feet because aircraft contrails were observed passing into and out of the cloud formation. This cloud's height helps one determine that the atmosphere had no neutrally stable layers that might have blocked the cloud from growing upward. Also, the shape of the cloud reveals a lack of any layers of wind shear which may have "torn" the top off of the cloud. In the same publication the FAA also notes that the wave of air flow, due to prevailing westerly flow, which created this type of cloud, tends to increase in amplitude with height above the mountains. This phenomenon may be the explanation for the fact that the cloud appears to increase in horizontal scope as one goes higher into the atmosphere. The more likely explanation, however, is that the top of the cloud has risen to the point were it has encountered cooler air that causes the cloud to stop rising and expand horizontally on the plane where this temperature drop occurred.

. The camera used was a Pentax ZX-5N with a 28mm to 200mm lens set at about 50mm and the shutter speed was set at $1/15^{th}$ of a second with an aperture of f/4.5 and the film used was

400speed Fuji Superia X-tra. This aperture is nearly the largest allowed on the Tamron lens and was necessary due to the low light conditions under which the image was produced. The only post-processing done on the image was to crop a tiny portion of the bottom of the image in order to remove an offending power line. All of the colors are true to the original image and there was no use of any filters.

The final image is rather gratifying because it displays an interesting cloud phenomenon as well as a vivid array of colors. I always enjoy a vibrant image that has not been altered in any way by post-processing techniques. The ability to accurately capture the delicate colors of a sunset is a test of a photographer's skill and I am happy to see that, mostly through sheer luck, I have managed to produce an image with wonderful colors. The framing of the image is ideal for the display of the colors that were visible during the sunset, but obviously more important for this project was the cloud dynamics and I feel that my image tells a good story of the atmospheric dynamics on display on the 30th of January.

Hazardous Mountain Winds and Their Visual Indicators, Federal Aviation Administration, Office of Communications, Navigation and Surveillance Systems, Washington D.C.