Clouds 1

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Intent

Some of the most spectacular sunsets can be viewed on the Front Range east of the Rocky Mountains. The particular clouds present at sunset can have a dramatic impact on the overall beauty of the scene. I wanted to capture one very common cloud formation that contributes to our beautiful sunsets, known as altocumulus lenticularis, and study the atmospheric conditions and physics that lead to the formation and shape of these beautifully smooth clouds.

Atmospheric Physics and Conditions

This particular cloud in my image is classified as altocumulus lenticularis, a type of mountain wave cloud. It was formed when stable air blew over the mountains, known as Foehn Winds. As the air travels over the Rocky Mountains it is lifted, but because it is stable, it falls downward over the Front Range. This upward and downward motion creates a wave; a ripple in the wind current. If a portion of this wave wind current reaches an altitude where the air cools to the dew point, a cloud will form, which is what my image depicts. The cloud is streamlined and flat due to the strong winds associated with its formation.

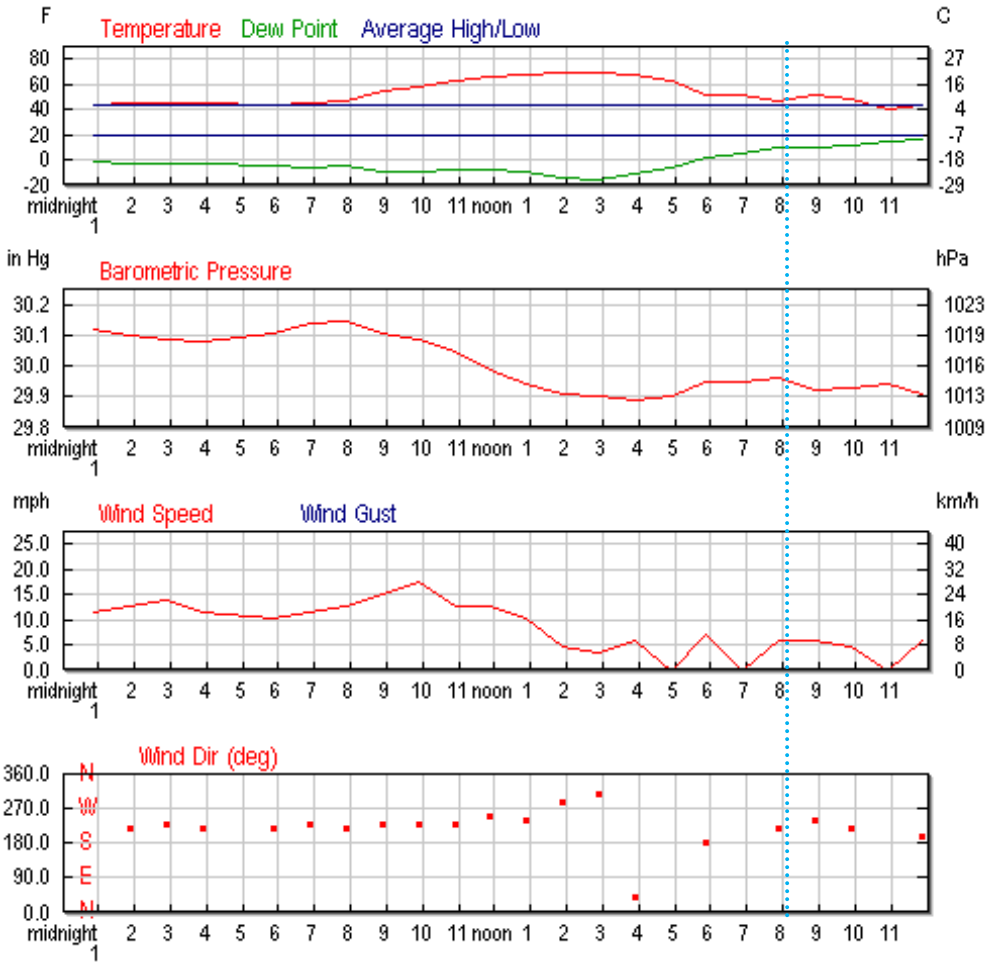

Figure 1: Weather Conditions for January 21, 2009 [Weather Underground]

Figure 1 shows local weather data for the Denver area on the date of the photograph. The dashed blue line marks the time that the photograph was taken. We can see that the surface temperature at the time the photograph was taken was approximately 10 °C and the dew point was approximately -14 °C. This information can be used to estimate the cloud height using the dry adiabatic lapse rate [De Nevers, 2000]:

$$\frac{dT}{dz} = -9.8\frac{°C}{km}z + T_0$$

By setting dT/dz equal to the dew point temperature and T_0 equal to the surface temperature, the cloud height estimated by the dry adiabatic lapse rate is approximately 2.5 km above ground. A similar procedure using the standard atmospheric lapse rate,

$$\frac{dT}{dz} = -6.5\frac{°C}{km}z + T_0$$

yields an estimated cloud height of 3.7 km above the surface. Neither equation is a good model of the actual environmental lapse rate that occurred on that day, but they serve as a starting estimate for the approximate cloud height.

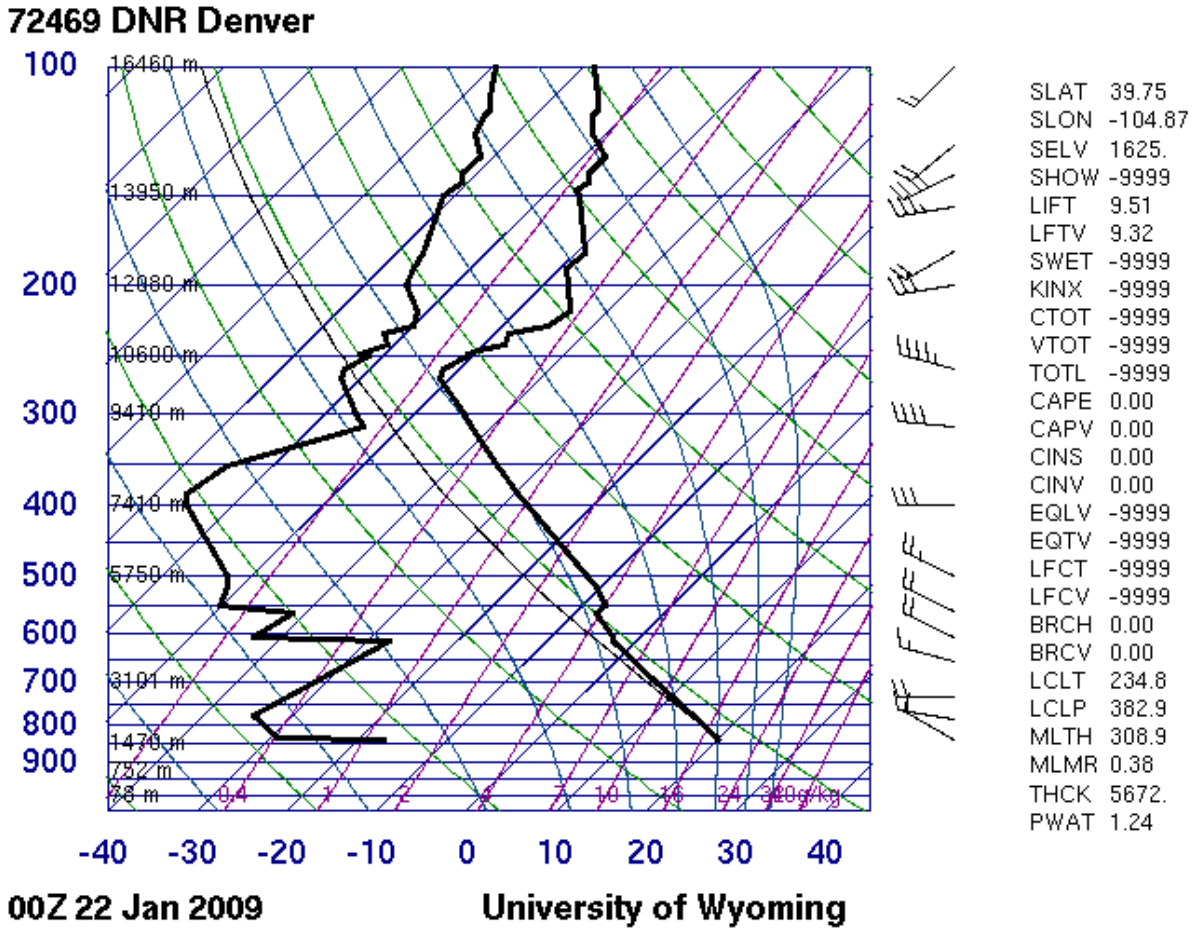

Figure 2: Skew-T Diagram for January 21, 2009

Figure 2 shows a skew-T diagram that represents atmospheric conditions at 6:00 PM on January 21, 2009, about two hours before the photograph was taken. The actual air temperature is depicted right-most thick black line in the figure, whereas the left-most thick black line represents the dew point temperature. The thin black line depicts the dry, adiabatic temperature profile. The skew-T diagram demonstrates that atmospheric conditions were very stable near the time of the photograph, which is expected because altocumulus lenticularis clouds form from stable mountain waves, as discussed previously.

Photographic Techniques

All photographs were taken using an Olympus FE-370 8.0 megapixel digital camera. This camera has a focal length range of 6.3-31.5mm and an aperture range of 1:3.5-5.6. The photograph was taken using the camera's "outdoor" setting with automatic focus and no flash. The camera was held in hand for all photographs. Table 1 lists detailed information about the final photograph.

Table 1: Details of photograph

Photograph Date and Time	Jan 21, 2009 8:02PM
Direction Facing	SSW
Location	Lafayette, CO
Lens Focal Length	11.2 mm
Original Image Size	3264 x 2448 pixels
Final Image Size	3264 x 2180 pixels
Shutter Speed	1/250 sec
Aperture	f/4.6
ISO Setting	100

Image processing was performed using the Paint.NET image editing software. Other than cropping the bottom portion of the original image, no other alterations were made to the photograph. The original image can be found in the Appendix.

Image Discussion

Though it is likely that my image may have benefited from some contrast adjustment using computer software, my intent was to leave the image in its natural form exactly as it appeared to the naked eye. I think this preserves the natural aspect of the cloud and I believe my image succeeded in this respect. I am pleased with my image because not only is it a beautiful representation of a Colorado Front Range sunset, but it also depicts the atmospheric physics involved quite well. I wish I could have attained more applicable weather data to further analyze the cloud and its formation. I also like the array of colors expressed in my image. Besides the usual blue, white, and grey associated with any cloud, I was able to capture very beautiful yellow and brass colors. I also like how large the cloud is and how it fills the entire upper portion of the image. It makes the cloud seem infinitely massive and powerful. Additionally, I'm glad that the atmospheric data I found coincide with conditions necessary for this cloud to form.

References

De Nevers, N. *Air Pollution Control Engineering*. McGraw-Hill, Boston (2000): 97

University of Wyoming Department of Atmospheric Science:
http://weather.uwyo.edu/upperair/sounding.html

Weather Underground:
http://www.wunderground.com/history/airport/KAPA/2009/1/21/DailyHistory.html?req_city=Denver&req_state=CO&req_statename=Colorado

Appendix

Original Photograph