Flow Visualization
MCEN 5151

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Introduction:

Clouds have always around us, but we never take the time to appreciate them. Looking up every once in a while sparks new insight into what causes these unique shapes to form. Growing up in Seattle, clouds were always a part of my day to day life. Usually it involved a nimbostratus cloud, which results in rain. Moving to Boulder, CO allowed me to discover new types of cloud phenomena I had not been accustom to. The goal of the image taken was to capture the unique mountain wave clouds, these commonly hang around the Flatirons (apart of the Rocky Mountain Range). The Flatirons sit on the boundary of Boulder and are the last large formation before the plains. Hiking up the Flatiron Mountains would allow me to get a closer look at these magnificent clouds.

Image:

This image was taken February 18th 2012 around 4 PM Mountain Standard Time. It was taken in the hills off Boulder Canyon Drive just west of the infamous Pearl Street. The photo was taken west at about a 30 degree angle from the horizon. It was taken on a very sunny day even though the temperature was around 32ºF.[4] The image required hiking up the mountain side to get a better angle above the horizon. The jet contrail in the far right was included because of its parallel nature to the sun's rays. It also adds contrast to the image and makes the main cloud more interesting. Another powerful feature is the hawk flying in the top middle of the page. Although not intentional the hawk draws more of a nature feel to the photo.

Cloud Physics:

The cloud in the image is called a stratocumulus lenticularis, also known as a "mountain wave cloud". [5] These types of clouds are very familiar to the Boulder area and are seen quite often. Stratocumulus clouds have a common altitude between 2000-6500 feet off the ground.[1] The altitude of the cloud in the image was approximately 2000 feet off the ground, solidifying the fact that it was a stratocumulus lenticularis. These types of clouds are associated with a moist airstream that forms into a cloud to pass over a mountain.[1] Stratocumulus clouds tend to have a wide variety of shades ranging from bright white to a dark grey. This can be seen in my image as the top of the clouds are lighter while the bottom is dramatically darker.

The following figure (Figure 1) is a skew-t plot of the weather on February 18th. As you may notice, the skew-t plot says February 19th, this is because it was measured on the Zulu time zone. Therefore the Mountain Standard Time is 7 hours behind. This skew-t plot was taken in Denver, 30 miles away and shows an accurate description of many factors occurring in the air. The left line on the plot is the dewpoint curve. The right line shows the temperature with respect to altitude. At

around 2000 meters (6500 feet) the temperature is shown to be vertical. Stability is a result of a constant or inversion of temperature as altitude is increased. This figure shows that the air was stable that day.[2]

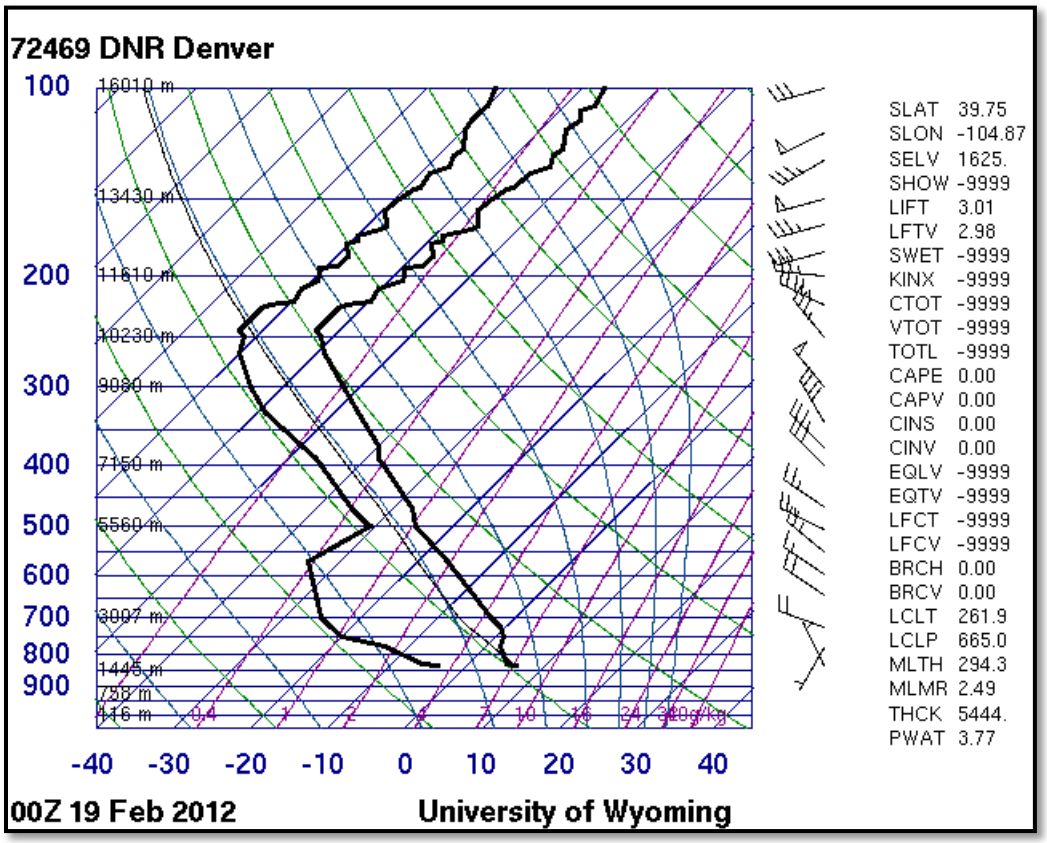

Figure 1 Skew-T plot for Feb 18th 2012 [3]

Photographic Technique:
The following is a list of the camera settings used to take the photo.

- Estimated cloud height — 2000 feet off the ground
- Estimated Field of View — 5000 vertical feet
- Lens focal length: — 18 mm
- Type of camera: — 6.3 megapixel Canon EOS Digital Rebel
  Original (3072 x 2048)
  Edited (3072 x 1746)
- Exposure Specs: — Aperture: f/18
  Shutter Speed: 1/500
  ISO 200

Original Image:

Processed Image

The original and processed image can be seen above. The processed image was cropped at the base and the mountains were blacked out to increase focus on the sun and clouds. In addition, a blue hue was added to increase the color in the image. The curves were adjusted to bring out more darkness in the image. The following figure shows the curves as they were adjusted.

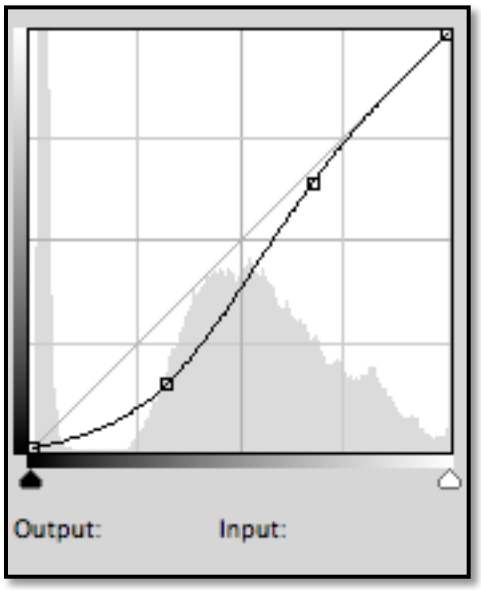

Figure 2 Adjustment curves used in PhotoShop CS5

Commentary:

I enjoy the power this image has. The most powerful part to me is the bursting sun through the clouds. The mountains provide a great framing shot of the sky and offer

a unique contrast to the color of the sky. I really enjoy my image and will continue to pursue interesting clouds formations as they come and go.

References:

1. Pretor-Pinney, Gavin. *The Cloudspotter's Guide*. New York: Penguin Group, 2006. 91-109. Print.

2. "UNDERSTANDING A SOUNDING/SKEW-T." *Lead to Learn*. N.p., n.d. Web. 1 Mar 2012. <http://www.atmos.millersville.edu/~lead/SkewT_HowTo.html>.

3. Oolman, Larry. "Upper Air." *Department of Atmospheric Science*. N.p., n.d. Web. 19 Feb 2012. http://weather.uwyo.edu/upperair/sounding.html

4. "Boulder Weather Graph." *WeatherSpark*. N.p., n.d. Web. 22 Feb 2012. <http://weatherspark.com/

5. Worthington, R.M. "MOUNTAINWAVES LAUNCHED BY CONVECTIVE ACTIVITY WITHIN THE BOUNDARY LAYER ABOVE MOUNTAINS." *Boundary-Layer Meteorology*. 103. (2002): 469-491. Web. 8 May. 2012. <http://www.springerlink.com/content/45f3tr8vwwgmur88/fulltext.pdf>.