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Flow Visualizations
MCEN 4228-010

Assignment 2: CLOUDS

Clouds are a phenomenon that because we see them every day, we tend not to appreciate them. However, clouds can visualize some of the most extraordinary fluid flow without warning. This relatively unpredictable behavior of clouds along with our inability to manipulate them adds even more to the thrill of their behavior. The goal of this photograph was then to capture the ever changing phenomenon that we know as clouds, and show it in a very visually stimulating way. In particular, it was intended to involve not only extraordinary shapes, but colors and surrounding images as well. These images include buildings, mountains, trees, and other landscape features.

The image was taken from the open space of south Boulder, just east of Tantra Lake (See Figure 3). Because of the extremely open area, it was possible to take incredible photographs from any angle, which was necessary on the day it was taken. Knowing the approximate distance from the photograph and the height of the clouds themselves (shown in Figure 1 below), the angle of elevation was approximated to be 14° using the following equation:

$$\theta = \tan^{-1}\left(\frac{height}{length}\right)$$

Equation – 1

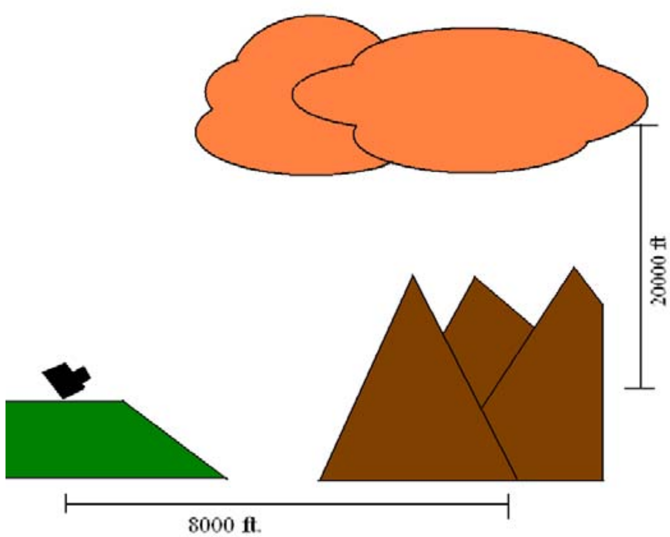


Figure 1 – Photograph Setup

Sunset can give some of the most extraordinary images due to the angle the light is reflecting off the clouds as well as the incredible colors that can appear. This image was captured on January 21st at 6:10 PM just before the sun disappeared over the mountains.

As you can see in Figure 3, the clouds in this image are relatively high and appear to form individual masses in the sky. Due to the relative height and shape of the clouds, the clouds in this image are cirrocumulus clouds(3). This goes for the rest of the sky, which was filled with many cirrocumulus clouds of various shapes and sizes. A few other images that were taken at that time are included in the appendix. Below is a Skew-T Plot from Denver (approximately 20 miles from location) at nearly the exact time of the photograph.

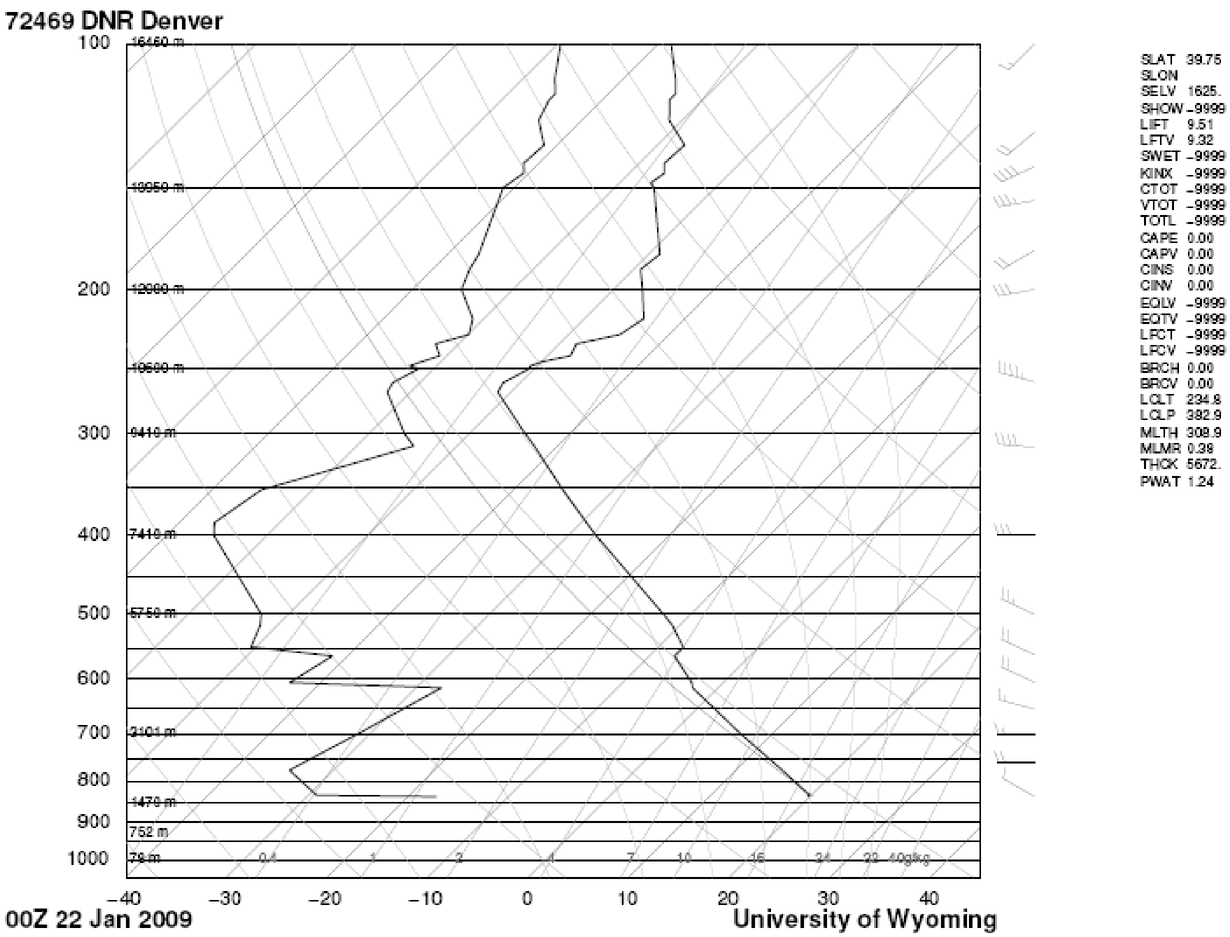


Figure 1- Skew-T plot for Denver at 6:00 PM (1)(2)

From the plot, we can estimate that the elevations of the clouds in our image are around 8000 m (or 26,000 ft). At that altitude, the dew point is closest to the temperature of the air and has the most chance of producing clouds. When comparing the change in temperature as the altitude increases of the reference line and the adiabatic line, it is apparent that the slope is greater for the reference line. This indicates that as the air rises, it will be warmer than the air surrounding it, causing it to continue to increase and become unstable. This instability is what causes the type of clouds that we see in the photograph. Because these are likely Cirrus clouds (above 20,000 feet [3]), the temperature is extremely low which has a significant effect on the clouds and their flow due to the instability. Finally, there was relatively high wind at the time of the photograph, which also plays a role in the motion of the clouds as well as the shear seen on the clouds in Figure 3.

Since the objective was to capture the motion of clouds, the image was taken at a great distance from the object. The distance from the object to lens can be approximated once again using the height and length from the object. The equation used is the Pythagorean equation below.

$$a^2 + b^2 = c^2$$

Equation – 2

With the height and length of this photograph, the distance was calculated to be 21,500 ft. The distance from the object also has a large impact on the field of view, which in this case appears to be about 3 miles wide. To calculate the exact field of view, the equation below can be used.

$$\frac{o}{d} = \frac{i}{f}$$

Equation – 3

Where "o" is the field of view, "d" is the distance from object to lens, "i" is the field stop, and "f" is the film distance (4). The lens focal length for this image was 6.7mm and was taken with an Olympus 720SW digital camera. The size of the image taken was 3072 x 2304 pixels, with an f-stop of f/3.5 and an ISO rating of 64. No information was given on the shutter speed, but it was estimated to be approximately 1/2 sec. Also, because the image was taken outdoors with such a large image distance, there was no additional lighting necessary. Finally, there were no alterations made to the image, so the final image size is also 3072 x 2304 pixels.

After reviewing my image, I think my image does a great job showing the physics behind the fluid motion of clouds and in a very artistic way. The fact that no image processing was done to my picture adds even more to the value of what the image depicts. I would like to have an image that was slightly less grainy and had more focus, but with the type of camera I used, I don't think a better picture could have been achieved. I would like to look further into exactly how wind speed, temperature, and pressure have on the clouds that we see, instead of just knowing that they affect them. I believe knowing that information would add even more value to my image. Though it was not available this time, I would also like to use a camera with adjustable f-stop and shutter speed in order to get a more focused image. I will take all that I have learned on this assignment and apply it to the next cloud picture to hopefully get an even more revealing image.

Works Cited

(1)
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http://weather.uwyo.edu/upperair/sounding.html

(2)
Hertzberg, Jean. "Flow Visualization: A Course in the Physics and Art of Fluid Flow." ©2008
http://www.colorado.edu/MCEN/flowvis/links/index.html

(3)
Cloud Chart Incorporated. Purdue University: Department of Earth and Atmospheric Sciences.
Richmond, VA © 1958

(4)
Jacobson, Ralph (et al.) (1988). *The Manual of Photography* (8th ed. ed.). Focal Press.
ISBN 0-240-51268-5. p.48

Appendix A

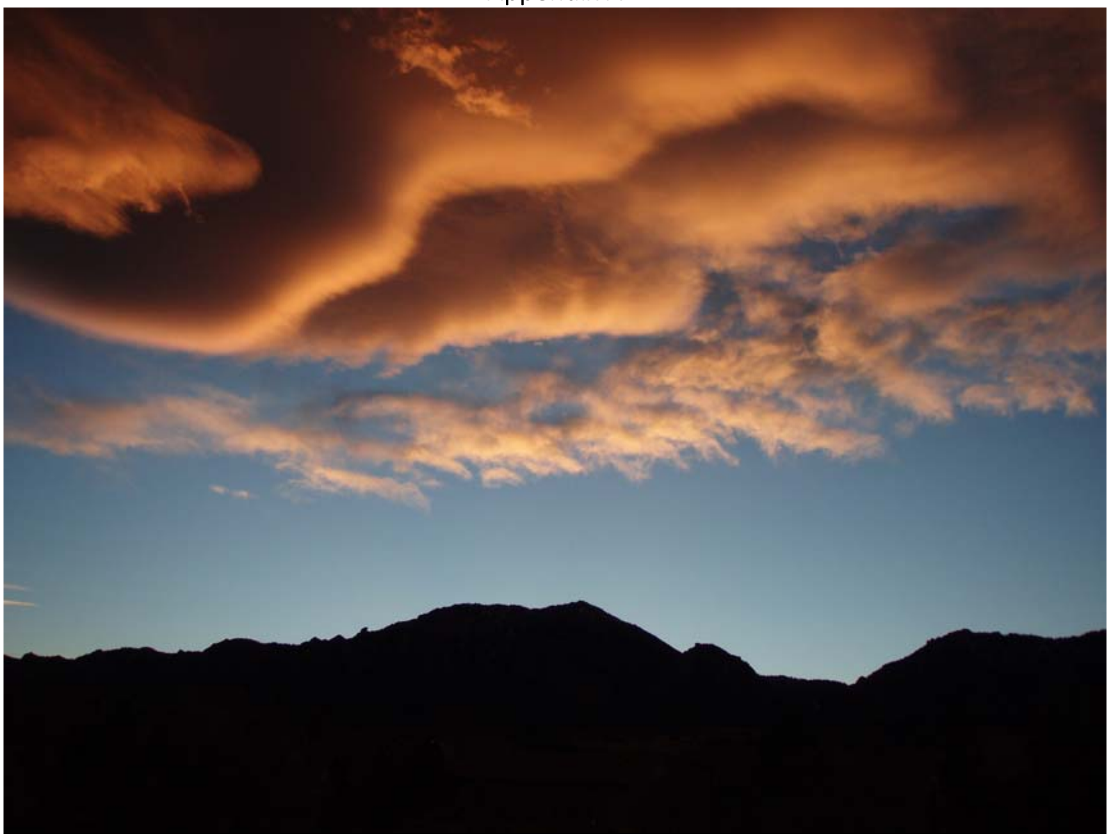

Figure 3 – Original and Final Photograph

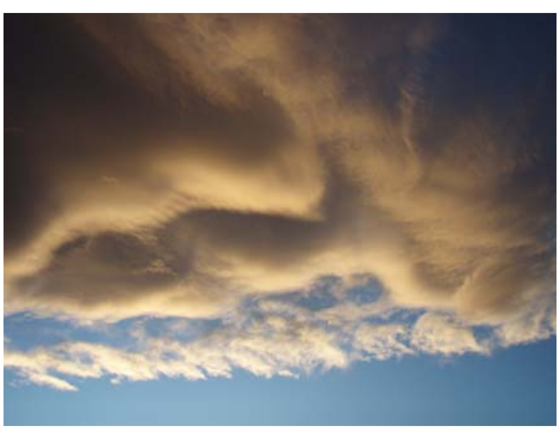

Figure 4 – Alternate Image 1 (Original)

Figure 5 – Alternate Image 2 (Original)