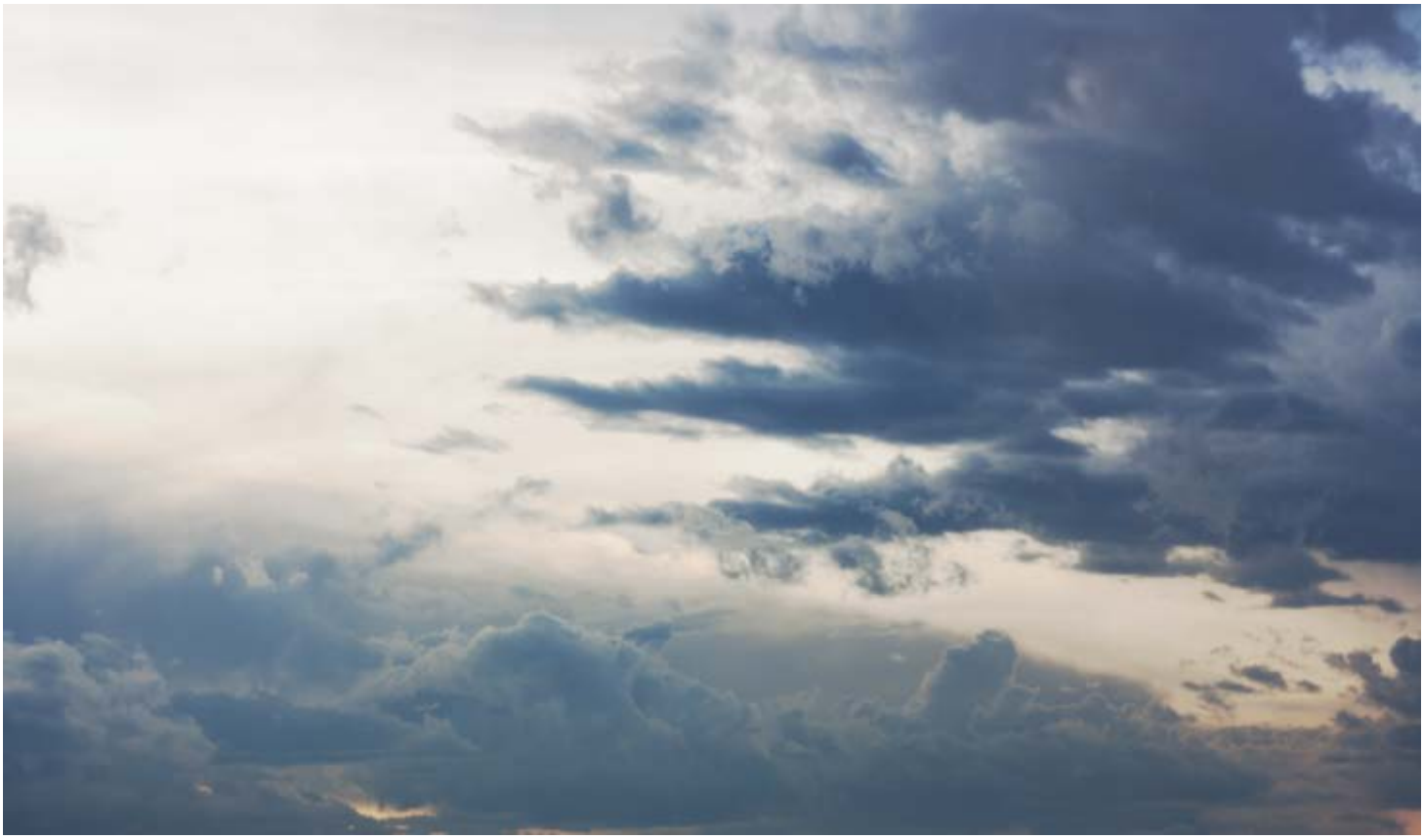
Clouds 1 | MCEN 4151 Flow Visualization



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Introduction

The purpose of Clouds 1 is to photograph a cloud and to use cloud physics to identify the type of cloud and the stability of the atmosphere. When capturing cloud images, the desired cloud formation was not defined due to the unpredictable nature of clouds; instead, any large cloud body with unique features was the main focus for the photography of the image.

The image was taken in Westminster, CO at the top of a hill of Mandalay Middle School on September 29, 2015 at 6:00 pm. This location was chosen because the area provided a clear view of the sky without obstruction from any buildings or homes in the distance. The direction of the image is facing directly west at an angle of 35° from the horizontal. As shown in Table 1, the temperature that day was 71°F, and the wind speed was low at 11.4 mph from the west.

Table 1: Weather conditions for September 29, 2015 at 6:00 pm (Local time) [1]

Temperature	71°F
Wind	11.4 mph, West
Precipitation	No
Cloud Cover	50%

Cloud Analysis

The image is comprised of stratocumulus clouds, which was not seen the day before. As seen at the bottom of the image, these clouds appear to be cumulus because of their puffy appearance, but they do not fit the cumulus description because they are not detached. Instead, they fit the stratocumulus description better because the cloud elements are joined together and cover a large area [2]. Looking at the bottom right of the image, the species of stratocumulus can be said to be castellanus, where the cloud top moderately resembles a tower. The clouds in the top right are also stratocumulus with their strong variations in tone, and they appear to be undetached with many clouds elements. The rest of the clouds in the area was stratocumulus, but there was cirrus clouds in the south direction as well.

The atmosphere was unstable with a cold front approaching from the west at 6:00 pm. The air temperature was 71°F at 6:00 pm and dropped to 63°F within an hour. Before this image was taken, there was light rain 2 hours earlier. From WeatherSpark [1], the humidity began to increase at 4:00 pm. Furthermore, as the air temperature decreases, the dew point also increased. The air temperature got closer to the dew point, and clouds are able to form more easily as the moisture in the air begins to condense.

According to Figure 1, the Skew-T plot for Denver at 6:00 pm shows that the atmosphere is unstable between 3,200 m (10,500 ft) and 11,000 m (36,000 ft). The Skew-T plot reveals the temperature recorded by a device that is sent up into the atmosphere by a balloon. The right, thick black line represents the temperature of the air, and the left, thick black line represents the dew point of the air. The dew point is the temperature at which the air is saturated with water for a given pressure. When the air temperature reaches the dew point, clouds will form because the air can no longer hold onto the moisture and begins to condense. It should be noted that this condition is not the only way clouds can form. Another way the Skew-T plot reveals cloud formation is to look at the thin black line, which is the adiabat line. In essence, the adiabat line is used to compare a parcel of air with some associated temperature to the surrounding

temperature air temperature (thick black lines). If the adiabat temperature is warmer than the surrounding temperature, the parcel of air will want to keep moving up because warm air is less dense. Conversely, a cooler parcel of air will want to sink because it is denser than its surroundings. This provides insight on the stability of the clouds as well. If the parcel air is warmer, which wants to keep rising, the atmosphere is said to be unstable. A stable atmosphere is where the parcels of air will want to settle back to earth. The adiabat temperature is lower than the air temperature for stable conditions. Since the air temperature was cooler than the adiabat temperature on September 29, 2015, the parcels of air will want to rise. This indicates an unstable atmosphere from 3,200 m and 11,000 m as stated earlier.

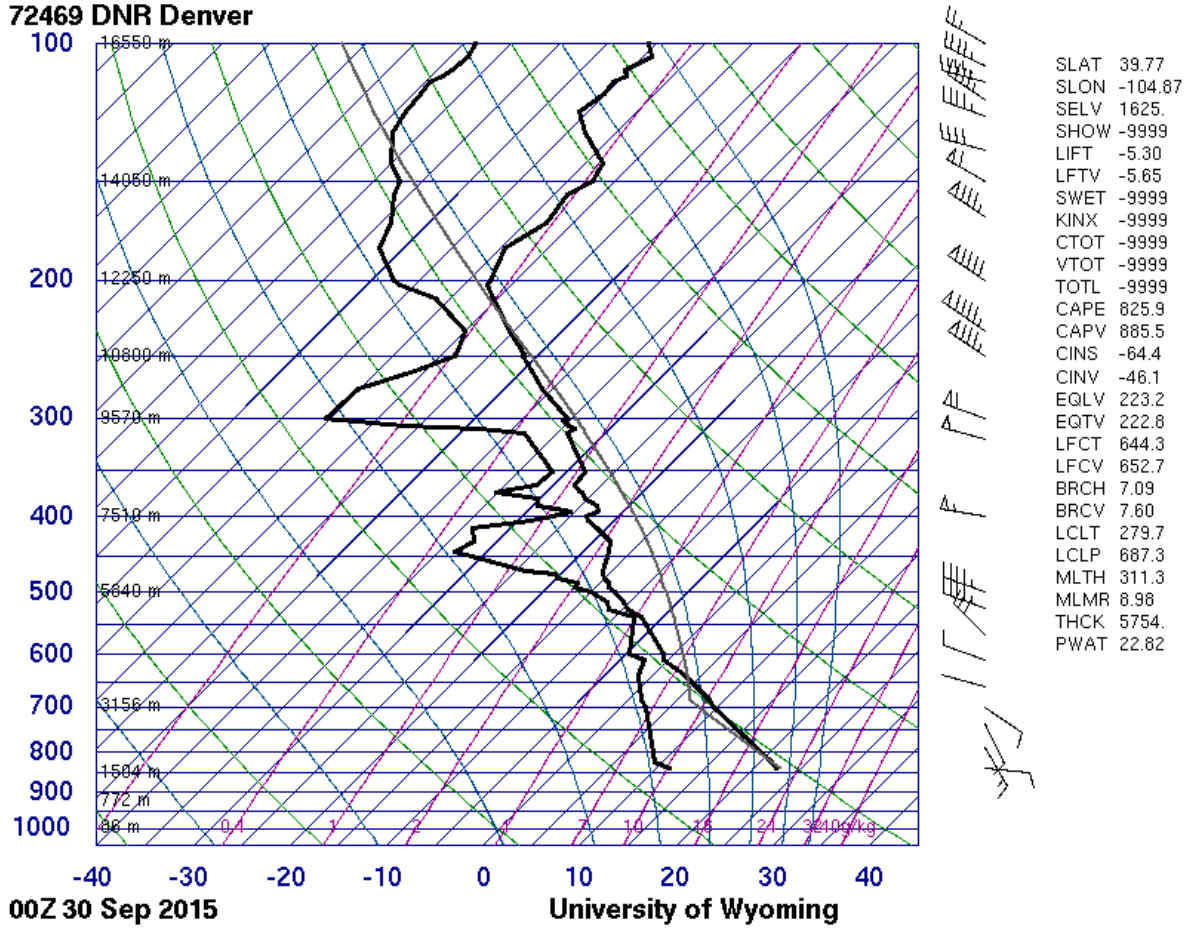

Figure 1: Skew-T plot for Denver, September 29, 2015 at 6 pm (Local time)

The cloud heights was estimated to be between 2,000 m (6,500 ft) and 5,000 m (16,400 ft). This agrees with the observations because stratocumulus clouds form under stable conditions. However, the Skew-T plot suggests that there is instability at 4,400 m, which conflicts with the initial estimates. While the adiabat is about 2 to 3 degrees warmer than the air temperature, the instability is not significant as it is when the air is at 6,000 m with a temperature difference of about 10 degrees. Below 4,400 m, the adiabat is however cooler than the air temperature, which is an indication of stability.

Photographic Technique

The evening was chosen as the ideal time for capturing clouds because of the lighting. The sun during the evening is not overpowering, and it provides a great way of highlighting the cloud features compared to the middle of the day. Also, the greater color range during the evening adds uniqueness to the image. For the photography of the clouds, a low ISO was chosen to minimize noise as much as possible. Since the sun provides a lot of light into the camera, a quick shutter speed of 1/640 was chosen. Since the sun is facing the camera's direction, the shot did not directly capture the sun to avoid any distracting lens flare and overexposure. The image specifications are shown in Table 2 below.

Table 2: Image Specifications

Date and Time	September 29, 2015 6:00 pm
Camera	Canon EOS Rebel XS
Lens	Helios 44-2 58/2
Aperture	f/4
Shutter Speed	1/640
ISO	100
Focal Length	58 mm
RAW Image Dimension	3888x2592
Final Image Dimension	3888x2268
Direction	West
Location	Westminster, CO

The distance from the lens to the clouds is approximately 12 miles, since Westminster is approximately 12 miles from the closest mountain range. Using an online calculator to determine the size of the field of view [3], provided that the lens focal length is 58 mm, a sensor size of 22.2 mm x 14.8 mm, and an estimated subject distance of 12 miles, the horizontal dimension is 4.59 miles and the vertical dimension is 3.06 miles (16,156 ft). The vertical dimension agrees well with the estimated cloud height of 16,400 ft.

Figure 2: Original image on the left and edited image on the right.

The photograph was cropped to remove the mountains and trees in the background. The curve editor was also used to bring out the clouds more by adding more contrast. The bright spot shown in the original image on the left in Figure 2 was also reduced in the curve editor.

Conclusion

The image reveals stratocumulus clouds in an atmosphere that is stable below 4,400 m. I like the color range of the image and that there is no blue sky. The blue colors are in the clouds instead, and the sky is a white, pearl color. The only thing I dislike is that I should've taken a shot that didn't capture the mountains in order to utilize the extra space to convey more information at the top of the stratocumulus. The fluid physics are shown well because it's evident what cloud is being formed. I fulfilled my intent by capturing clouds that were large and clouds that had unique elements to it. For future development, I would perform a time lapse to show the movement of clouds.

References

[1] "WeatherSpark," 29 September 2015. [Online]. Available: https://weatherspark.com/#!graphs;a=USA/CO/Westminster. [Accessed 12 October 2015].

[2] G. Pretor-Pinney, The Cloudspotter's Guide: The Science, History, and Culture of Clouds, Nature, 2007.

[3] "Atmospheric Soundings," 30 September 2015. [Online]. Available: http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2015&MONTH=09&FROM=3000&TO=3000&STNM=72469. [Accessed 4 October 2015].