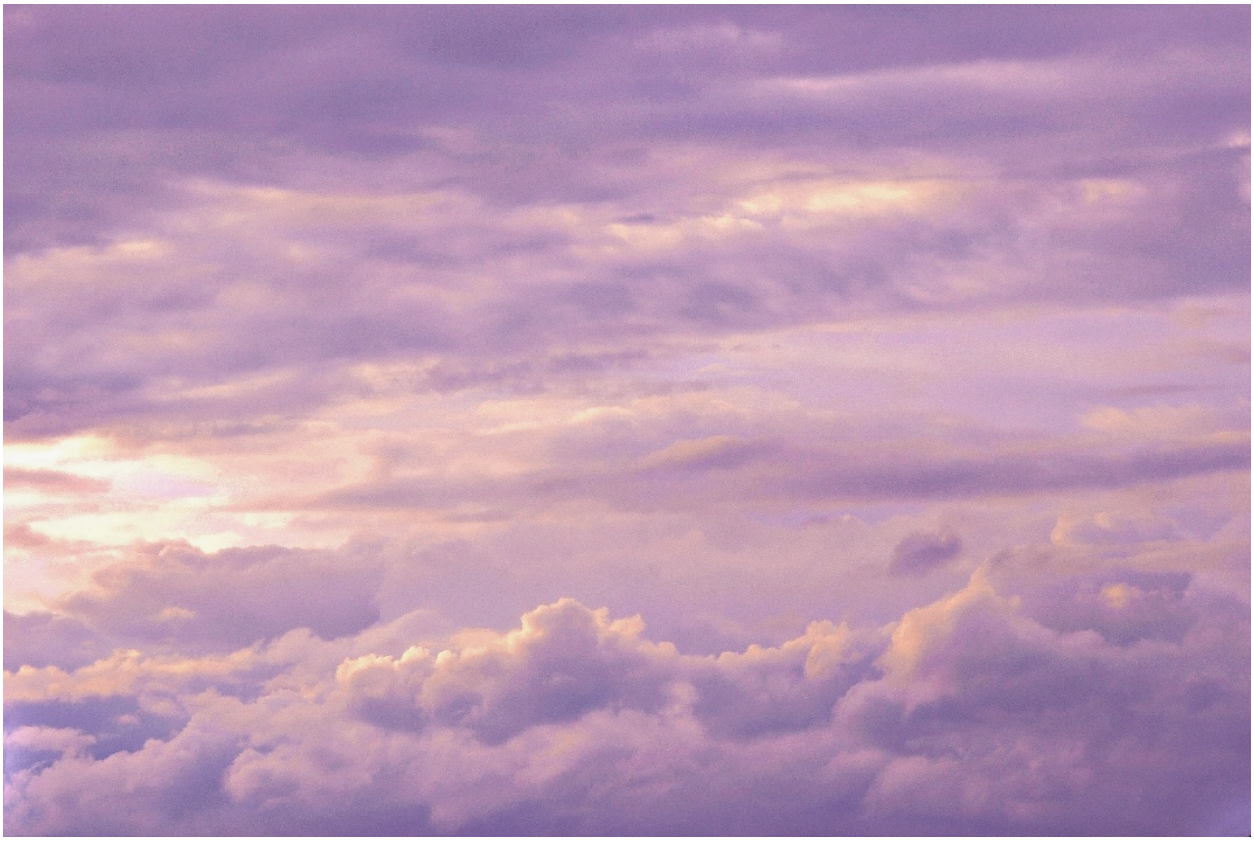
Visualizing Atmospheric Properties of Clouds



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1. Introduction

The purpose of this image was to capture interesting/beautiful clouds and understand how these types of clouds are formed (atmospheric conditions) as well as what their implications were. No specific cloud formation was desired other than one that would provide enough information for analysis and had the most potential for an aesthetically pleasing image. The most ideal images were found to be in the early morning around 0700, just after sunrise and in the evening around 2100 when the moon was high in the sky (evening photos taken on dates just after the lunar eclipse where moon was brightest and fullest). The locations for imaging were mostly determined by obstacles obstructing the image (i.e. trees, power lines, poles, buildings). Locations that were found to be the most ideal were rooftops of tall buildings away from and above trees and powerlines. Many attempts were made in clearings at high altitude, however powerlines and trees proved to be too large of obstacles and prevented a clear shot.

2. Setup and Circumstances of Image

For the final image shown on the cover page, a cannon T3i camera was set up on top of Folsom stadium above gate 5 (elevation was 5490 ft) at 0728 on 29 September 2015 in Boulder Colorado. The camera lens was facing south east at approximately a 10 degree angle above the horizon. The temperature was 55 degrees F with southeast winds of 3.4 mph and 90% cloud cover. The cloud ceiling and layer were both at 10,000 ft. At 1800, there was light rain and temperatures were in the seventies.

3. Cloud Formations Captured

The cloud types in this image are stratocumulus and altostratus clouds in a stable atmosphere. Stratocumulus clouds are generally low, gray, in lines or waves, and have a “lumpy” look too them. Stratocumulus clouds form usually between 1,600 and 3,220 meters. The clouds at the bottom of the image demonstrate this behavior and according to the skew-T diagram seen in figure 1, cloud formations were between 2,970m and 8,470m that morning. The clouds at the top of the image demonstrate the properties of altostratus clouds which form a uniform gray sheet/layer, in a midrange altitude of 2,400m to 6,100m. The stratocumulus cloud layer in the image is estimated to be at 2,970 meters and the altostratus layer in the image is estimated to be at 5,070 meters based off of the skew-T diagram.

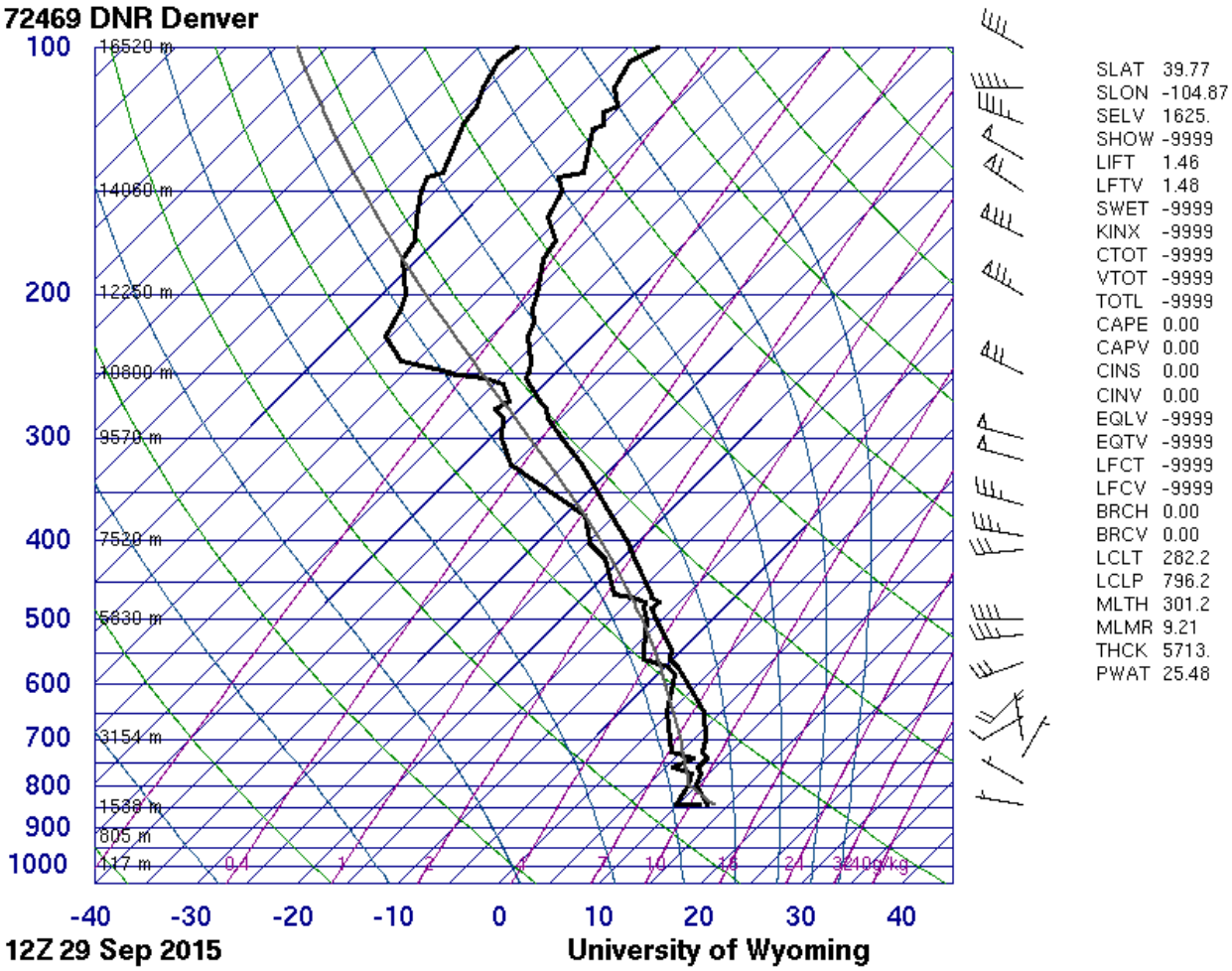

Figure 1: Skew-T diagram for 12Z, or 0600 MST in Denver on the morning of September 29, 2015.

The skew-T diagram also confirms the stability of the atmosphere with a cape of zero. In a stable atmosphere it is very common to see these two cloud formations. The skew-T diagram indicates that it was likely for other cloud formations to occur at 8,470 meters such as cirrostratus, however the layers of altostratus clouds at approximately 5,070 meters were obstructing the view as shown in the final image.

When the image was taken, the surrounding sky also had various stratocumulus and altostratus formations filling the sky as shown in figure 2.

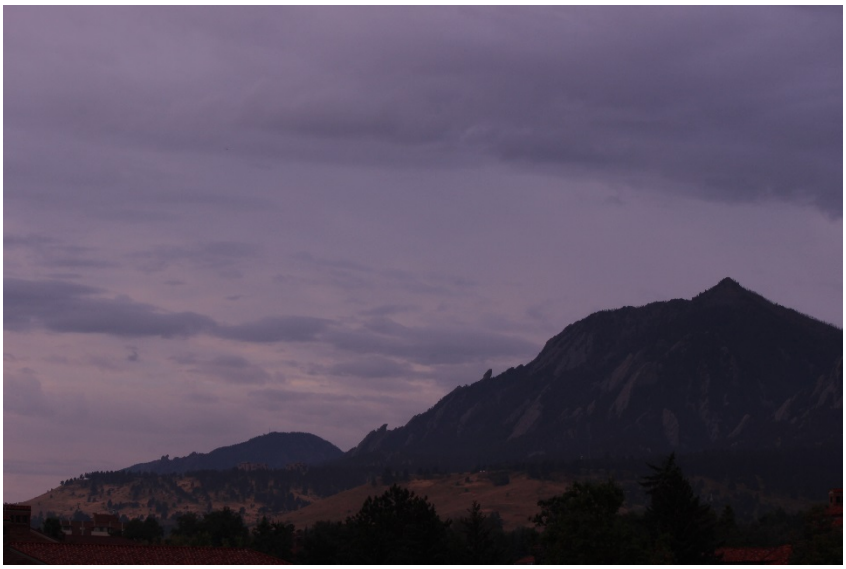

Figure 2: Unedited image of surrounding area at same time and location as final image.

The image in figure 2 appears dark for being just after sunrise; this was due to the limited breaks in the stratocumulus and altostratus layers which collectively will allow only a limited amount of sunshine through. The weather throughout that morning was in the mid-fifties with 90% cloud cover and 94% humidity. Later that day the temperature was in the mid-seventies with minimal cloud cover until the early evening with light precipitation at 1800. The previous day had mostly clear skies for the whole day until the evening with temperatures in the mid-fifties in the morning until mid-seventies in the afternoon and evening. Earlier that week, temperatures averaged in the 90s. The cloud cover observed on the 29th was typical for the conditions leading up to and during that day. The stratocumulus cloud formations occur during periods of weak and shallow convection currents. Additional upward development is prevented by an inversion on top of the well-mixed boundary layer above the clouds. Typically, stratocumulus clouds are concentrated in postfrontal cold air masses and with temperatures decreasing by approximately 20 degrees that week, these cloud formations were to be expected. Generally for altostratus clouds, they will develop further throughout the day and by late afternoon or early evening precipitation is likely. According to the website Pilot Friend, when an altostratus cloud formation is above a stratocumulus formation, "it may indicate a trough with possible rain or even thunderstorms either during the afternoon or within the next few days" (reference [2]). On Friday October 2nd that same week, there were heavy thunderstorms throughout the day.

4. Photographic Technique

This image was captured using a Canon EOS REBEL T3i camera. The estimated field of view for the image is around 2,000 to 3,000 meters horizontally and 1,000 to 2,000 meters vertically. This estimation is based off of the average distance between cloud level formations for stratocumulus and altostratus clouds and the information regarding altitude given in the skew-T diagram. The image shows the top section of the stratocumulus and base of the altostratus clouds which can range from 1,000 to 2,000 meters apart. The image was captured using a 123mm focal length and considering the subject size (approximating at 2,500 meters), the distance from the clouds to the camera lens is estimated to be 14,000 meters away by using the online database Cambridge in Colour (reference [5]) to calculate this value. Additional lens specs are an aperture of f/16,

exposure time of 1/16 seconds, ISO of 100, and a 0 step exposure bias, resulting in an image of 5,184 x 3,456 pixels for both the original and post processed image.

The intent for the post processing of the image was to bring out the details in the cloud formations as well as highlight the differences in particle densities and saturation by making the following adjustments. The vibrance setting was adjusted to +66 and saturation to +21, as well as the hue/saturation levels were set to hue +10, saturation +3, lightness -3 in order to bring out the detail within the clouds. To highlight the differing particle saturations the color balance was adjusted to cyan +8, Magenta -10, yellow -31. And finally to detail the edges of the cloud formations, the unsharp mask amount was set to 82%, with a radius of 118.7 pixels, and the threshold at 0 levels.

The areas of purple/pink tone in the final image, highlight the areas of higher saturation and particle densities. The lighter yellow crests of the stratocumulus clouds show the termination point of the stratocumulus cloud layer to help differentiate from the cloud layers far off in the distance. The final post processing step was to remove the small area of building roofs from the base of the image with the clonestamp. The original image can be seen below in figure 3.

Figure 3: Original unedited image.

Conclusion

It is important to understand the behavior and weather conditions surrounding cloud formations especially as a pilot. In this situation, altostratus clouds are a potential danger due to the high probability of ice accumulation on the wings of a plane. Additionally, stratocumulus clouds create friction with the surface of the earth which causes turbulence. This image helps to precisely determine the cloud formations at that time and day. With the help of the skew-T diagram and local weather reports, the altitude of the cloud formations can be determined as well as their stability and other meteorological factors. The post processing of the image not only adds an alluring effect

but it also brings out the intensity of the saturation levels and clearly defines them in a way that helps understand the composition of the clouds. The image provided enough information to confidently determine the cloud formations as well as the atmospheric conditions that lead to these cloud formations with full support from the skew-T diagram and local weather reports. To further develop an understanding of cloud formations and atmospheric conditions, it would be beneficial to image an unstable atmosphere and compare the data collected and cloud formations to that of the stable atmosphere established in this image. Another approach would be to photograph the highest cloud layers in the uppermost atmosphere such as cirrus clouds or the upper layer of a cumulonimbus cloud to further understand the conditions at the highest point of cloud formation.

5. References

[1] "72469 DNR Denver Sounding." *72469 DNR Denver Sounding*. N.p., n.d. Web. 1 Oct. 2015. <http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2015&MONTH=09&FROM=2912&TO=2912&STNM=72469>.

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[3] "Meteo-Blog.Net." *Stratocumulus Clouds – A Summary*. N.p., n.d. Web. 1 Oct. 2015. <http://www.meteo-blog.net/2012-09/stratocumulus-clouds-a-summary/>.

[4] "Stratocumulus." *Weather Facts:*. N.p., n.d. Web. 1 Oct. 2015. <http://www.weatheronline.co.uk/reports/wxfacts/Stratocumulus.htm>.

[5] "UNDERSTANDING CAMERA LENSES." *Understanding Camera Lenses*. N.p., n.d. Web. 1 Oct. 2015. <http://www.cambridgeincolour.com/tutorials/camera-lenses.htm>.

[6] "WeatherSpark Beta." *Beautiful Weather Graphs and Maps*. N.p., n.d. Web. 1 Oct. 2015. <https://weatherspark.com/#!dashboard;q=Boulder%2C%20Colorado%2C%20United%20States>.