The Sinking Stratocumulus

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Clouds 2: Flow Visualization MCEN 5151

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Introduction

The intent of this photograph was to capture, both artistically and demonstratively, the shape and general characteristics of a stratocumulus cloud. The submitted photograph is intended solely for the fourth assignment of the class Flow Visualization at the University of Colorado at Boulder, as taught by Prof. Hertzberg. The submitted image shows one large stratocumulus cloud hanging over areas of down town Denver.

The driving forces for this image arise from the front range imposing the movement of the air as it is moved toward Denver. As the atmosphere is forced upward it cools creating clouds which then continue moving along the front range until eventually dissipating.

The inspiration for this image came in an attempt to visualize the peacefulness of clouds over a landscape of where the city chaos could also be seen. Although there wasn't as much of the city visualized as originally intended the attached image captured most of the intent.

Image Conditions

This image was created just off of Colorado Blvd. and 23^{rd} avenue on a knoll at City Park in central Denver. The exact image location can be visualized with the following map in figure 2.

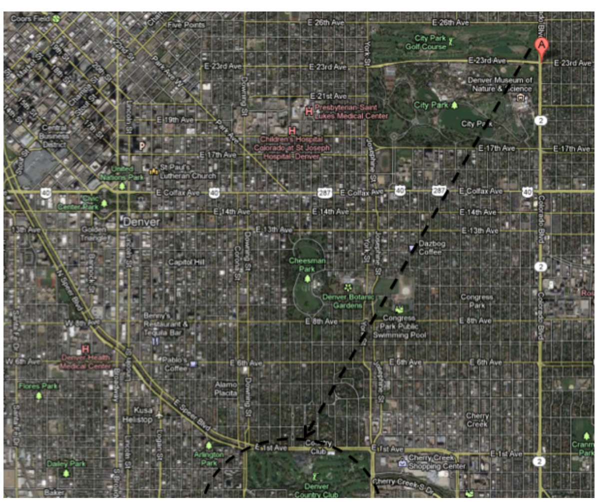

Figure 1: Location of Shot With Direction of Clouds Visualized [1]

The cloud imaged was roughly 5.11 km away from the photograph location and the height can be estimated based on the angle of capture. For this photograph the angle was roughly 10^o and the elevation can then be estimated at 0.9 km from the following equation.

$$Elevation = tan\,(10) * 5.11 = 0.9km \quad (1)$$

The timing of this photo was on 3/29/2013 at 8:03 PM roughly 40 minutes after sunset (7:21 PM) [2]. Knowing this time the SKEW-T from Denver at 00Z 3/30/2013 was used which will be discussed later in this paper.

Cloud Analysis

The cloud imaged resembles a stratocumulus cloud as seen by its low streaky nature with small undulations upward characteristic of cumulus clouds. Stratocumulus clouds tend to form at elevations around 1.9 km and present themselves as extended flat, sometimes wispy, clouds [3]. These clouds can form on the backside of mountains as the rising air cools producing light clouds which form in sheets and then propagate upwards. The difference in elevation between the estimated and formation ideal is most likely because the cloud visualized has been travelling and sinking for quite some time after formation at the front range. The SKEW-T diagram shown below in figure **??** can give further insight.

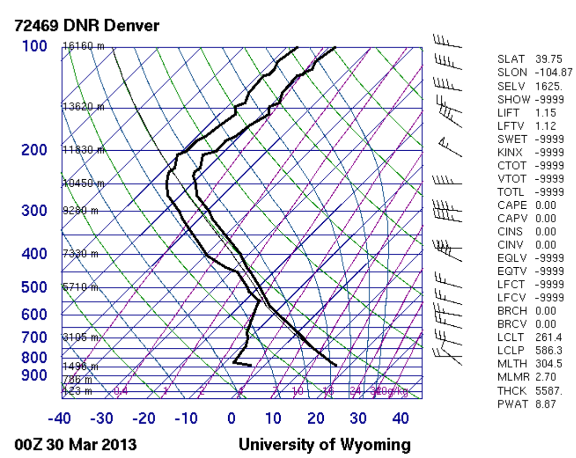

Figure 2: SKEW T for the Cloud Visualized [4]

The SKEW-T diagram can show at what elevation clouds should occur for a given time and location. This particular SKEW-T was taken at 6:00 PM that day in Denver. Judging from this diagram, clouds should not occur for this given time frame. This is derived by comparing the atmospheric temperature (the right black line) to the dew point temperature (the left line), and where they cross clouds should form. From this SKEW-T it can be said that the ideal height for clouds to form would be 5.6 km, however it was calculated that these clouds were much lower. This discrepancy in data is most likely caused by the fact that this cloud is in a stable atmosphere. As the cloud is lifted (while going over the front range mountains) the air is cooled and condenses, however as it then moves out toward Denver it begins to sink. This is all in an effort to remain in equilibrium with its surroundings.

The stability of the atmosphere is another statistic which is derived from the SKEW-T. A CAPE (convective available potential energy) of 0 allows the user to establish stability and the lack of condensation. The direction of the wind at this time can also be derived. At this elevation the wind was blowing slightly south east (moving air from the mountains and then over Denver). This furthers the argument supporting a cloud formed by rising air.

The physics of this phenomena are quite simple and have been mentioned briefly previously in this paper. As the stable atmosphere moves toward the mountain it is warmer than the dew point resulting in a blue sky. As the air parcels are forced upward adiabatic expansion occurs which lowers the temperature of the parcels (perfect adiabatic expansion can be visualized with the non jagged black line on the SKEW-T). As these parcels cool enough the dew point is reached and condensation is allowed to occur. This results in the parting line between blue and cloudy skies as visualized in the image submitted.

Photographic Technique

This photo was taken roughly 5.11 km away from the stratocumulus cloud visualized. The camera used was a Canon EOS Rebel Xsi DSLR with a 4272 X 2848 pixel resolution. Because of the low lighting, as this image was taken after sunset, settings which would allow for a lot of light exposure were used. This was accomplished with a shutter speed of $\frac{1}{64}s$, an ISO of 800 and an F-Stop value of f/5.6. This allowed for ideal lighting in the submitted photograph.

Through editing the image was changed slightly. The resolution was reduced to 4272X2388 pixels as to remove non important foreground information. The contrast was adjusted slightly and the reds and blues were brought out to exemplify the dark clouds and red sunset.

Conclusion

This image was the second cloud image and gave more insight into the beauty of clouds. Being an engineer the chances to go out and simply find interesting natural phenomena to photograph are few and far between. This assignment gives that opportunity and provides for a nice change of pace..

This being my 5^{th} delve into photography let me reflect on my progression throughout this class. Looking at this image, and then looking at all of my images throughout the semester it's incredible to see how much better they have become. It is gratifying to notice a significant progression throughout my work in this class, and I'm excited to see how it ends up for the final submitted image.

Overall, I am excited about the image which was submitted and look forward to future work which will build on this second introduction to flow visualization.

Bibliography

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4. "SKEW-T Diagram." University of Wyoming Soundings. University of Wyoming, n.d. Web. 2 Mar. 2013. http://weather.uwyo.edu/cgi-bin/sounding?region=naconf