"The Calm Before the Winter Storm"

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1. Introduction

The purpose of this assignment was to be the second cloud assignment for Flow Visualization. For this assignment an image of a certain cloud formation was taken and analyzed for the fluid flow physics while attempting to capture a cloud formation in an artistic fashion. The image was taken on November 10, 2019 at 4:00 PM in Boulder, CO overlooking Bear Peak.

2. Image Circumstances

The image was taken at an elevation of 5,430 ft above sea level [1]. The camera was titled approximately 30 degrees from the horizontal and was facing South-West. The weather was extremely calm, and the image was taken the afternoon before a snowstorm came to Boulder.

3. Cloud Discussion

In the image there are altostratus and remnants of cirrostratus clouds. The altostratus are the clouds that are darker and center frame and are middle height clouds occurring in the Troposphere. The cirrostratus clouds are the wispy clouds that are in the background in the image and occur in the Tropopause and Stratosphere. Both of these clouds are stratus clouds and are stable. The clouds were first determined visually analyzed using weather data. To further analyze the clouds on this particular day a skew-T plot can be analyzed, as seen in *Figure 1* [2]

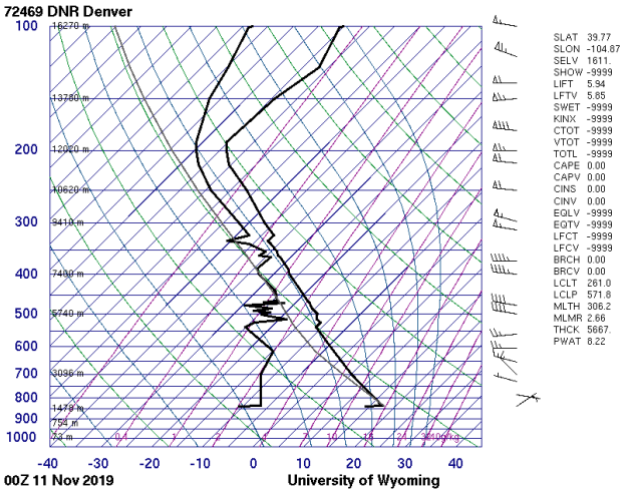

Figure 1. skew-T plot for Denver, CO area (1700 MST, 11/10/2019)

The CAPE value from the skew-T plot can provide information of whether the atmosphere was stable or unstable. If the CAPE value is 0 the atmosphere is stable but if it is greater than 0 then it is unstable. The CAPE value for this particular day was 0.00 which means the atmosphere is extremely stable and further supports the formation of the stable stratus clouds. According to the skew-T plot at elevations where the black lines become close to each other cloud formation is more likely to occur. At just below 5740 meters is where the first convergence occurs and is the elevation above ground level where altostratus are most likely to occur. At approximately 8000 meters is where the second divergence occurs and is the elevation above ground level where cirrostratus clouds are most likely to occur. The wind speed at the elevation of 5880 meters is approximately an east wind at 40 mph. At 8000 meters the wind is an east wind at approximately 45 mph. The storm front did come from the east and therefore supports the formation and path of

these clouds. To further analyze the clouds in the image a ceilometer reading can be taken to see what was occurring, as seen in *Figure 2* [3].

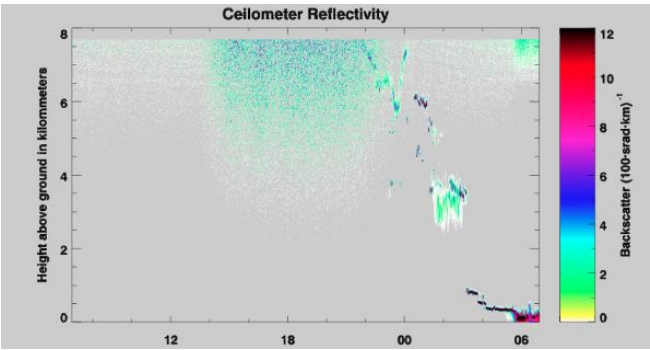

Figure 2. Ceilometer plot for Boulder, CO (11/10/2019)

The time corresponding to 4:00 PM is approximately 2300 UTC in this figure. The ceilometer works by sending an infrared or ultraviolet signal directly above and mapping in a sense what is occurring from the signal received after it reflects off the clouds. Denser clouds will reflect more of a signal which would results in darker clumps in the ceilometer plot. At 2300 UTC, there are some scattered signals meaning wispy clouds high up, approximately 6-8 km above the ground (6000-8000 meters) which corresponds to the skew-T plot on where cirrostratus clouds are expected to occur. This further supports the presence of wispy cirrostratus clouds in the image. At elevations between 4 and 6 km (4000-6000 meters) there are larger clumps forming as about 4 pm MST (2300 UTC). This would be the formation of the darker denser storm clouds. It can also be seen that towards 0600 UTC, or 2300 MST, there are very dark low clouds which was when the snowfall occurred that night.

4. Photographic Technique

A Canon EOS Rebel T3i DSLR camera was used for this image. The field of view of the image is approximately 3 miles. The distance from the "nearest" altostratus clouds to the lens is approximately 6.3 miles, by using the Pythagorean Theorem where the distance to the ground under the base of the clouds (assuming them directly above Bear Peak) is 5.5 miles, and the approximate distance from the ground to the clouds is 3 miles. The camera settings were as follows: Aperture: f/18, Shutter Speed: 1/800, ISO: 800, Focal Length: 55 mm.

The original raw image is 5184 x 3456 pixels (WxH) as seen in *Figure 3*.

Figure 3. Raw Unedited Image

The final edited image is 1300 x 865 pixels (WxH) as seen in *Figure 4*.

Figure 4. Final Edited Image

The edits were done using Adobe PhotoShop CC 2019. The curves function was used, as seen in *Figure 5* to create a darker feeling to the image to present the context of a storm coming. It also worked well to transition the mountains into more of a silhouette.

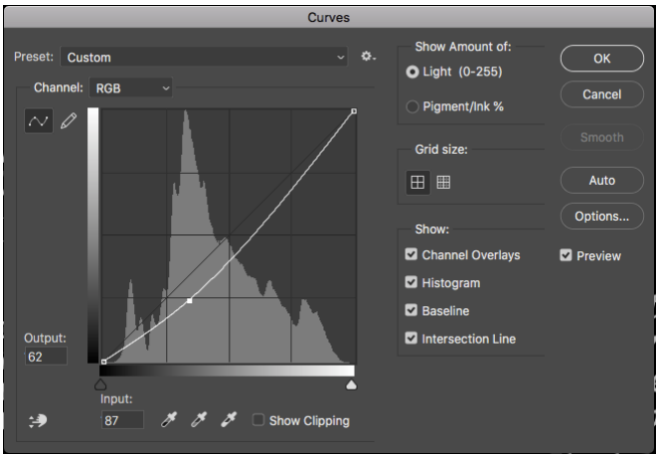

Figure 5. Edit Curves Layer in PS 2019

5. Discussion

The final image I believe works well to showcase the clouds in a natural artistic manner. I was worried at first that the mountains might be too much in the image, but they work well as an accent. The angle of the clouds also works well to look like they are emerging from the mountains. In a way they are since the east winter storm came over the Bear Peak and left Boulder, CO in a white winter blanket.

References:

[1] Boulder Convention & Visitors Bureau, 2019, "Boulder Facts", https://www.bouldercoloradousa.com/about-boulder/boulder-facts/

[2] University of Wyoming, College of Engineering, Department of Atmospheric Science, "Atmospheric Soundings Generator" http://weather.uwyo.edu/upperair/sounding.html

[3] University of Colorado Boulder, "Skywatch Observatory, Ceilometer" https://skywatch.colorado.edu