“The Sky is the Limit at CU – Boulder”

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1. Introduction

The purpose of this assignment was to be the first 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 the cloud formation in an artistic fashion. The image was taken on September 16, 2019 at 10:30 AM in Boulder, CO near the Engineering Center at the University of Colorado Boulder.

2. Image Circumstances

The image was taken at an elevation of 5,430 ft above sea level [1]. The camera was titled approximately 60 degrees from the horizontal and was facing South-West. The weather was calm and sunny, and this helped greatly in producing a quality image.

3. Cloud Discussion

In the image there are altocumulus and cirrocumulus clouds. The altocumulus clouds are the denser clouds in the image and occur in the Troposphere. The cirrocumulus clouds are the wispy clouds in the image and occur in the Tropopause and Stratosphere. Both of these clouds are cumulus clouds and are classified as unstable. The determination of these clouds was done visually to begin. To further analyze the clouds on this particular day a skew-T plot can be analyzed, as seen in *Figure 1* [2]

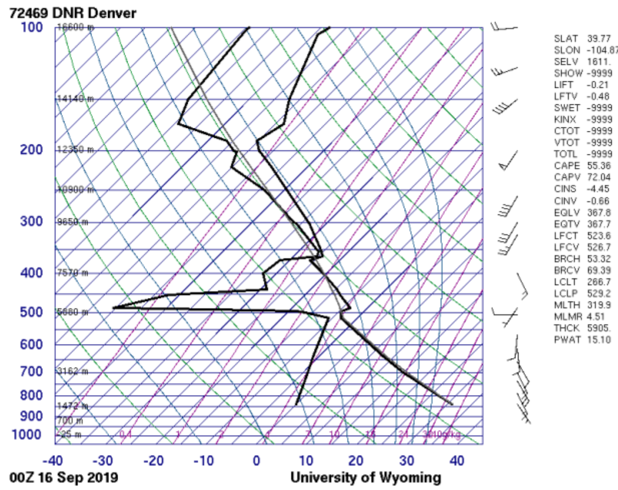

Figure 1. skew-T plot for Denver, CO area (0600 MST, 09/16/2019)

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 55.36 which means the atmosphere is unstable and further supports the formation of the cumulus 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 5880 meters is where the first convergence occurs and is the elevation above ground level where altocumulus are most likely to occur. At approximately 8000 meters is where the second divergence occurs and is the elevation above ground level where cirrocumulus clouds are most likely to occur. The wind speed at the elevation of 5880 meters is approximately an east wind at 10 mph. At 8000 meters the wind is a north east wind at approximately 25 mph. 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].

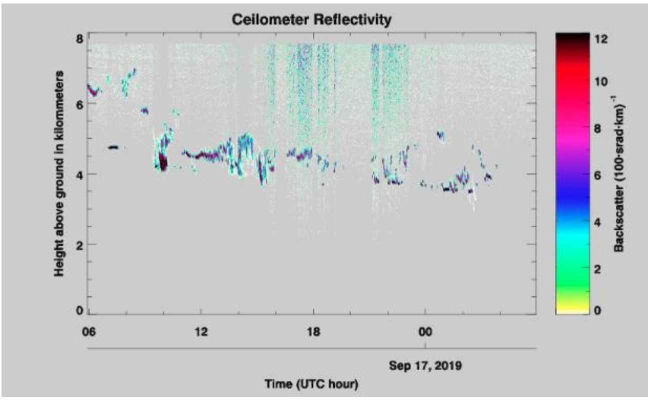

Figure 2. Ceilometer plot for Boulder, CO (09/16/2019)

The time corresponding 10:30 AM is approximately 1600 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 where reflect more of a signal which would results in darker clumps in the ceilometer plot. At 1600 UTC, there are semi-dense clumps at about 4-5 km above the ground (4000-5000 meters) which corresponds to the skew-T plot on where altocumulus clouds are expected to occur. This further supports the presence of altocumulus clouds in the image as they are semi-dense. At elevations between 7 and 8 km (7000-8000 meters) there is a scatter of light dots which corresponds to thinner more wispy clouds. This also correlates with the location of cirrocumulus clouds in the skew-T plot and the appearance of cirrocumulus clouds.

4. Photographic Technique

An iPhone 7 camera was used for this image. The field of view of the image is approximately 2 miles. The distance from the "nearest" altocumulus clouds to the lens is approximately 4.3 miles, by using the Pythagorean Theorem where the distance to the ground under the base of the clouds (assuming them directly above the flat irons) is 2.5 miles, and the approximate distance from the ground to the clouds is 3.5 miles. The camera settings were as follows: Focal Length: 3.99mm, Aperture: F/1.8, Shutter Speed: 1/5051, ISO: 20.

The original raw image is 3024 x 4032 pixels (WxH) as seen in *Figure 3*.

Figure 3. Raw Unedited Image

The final edited image is 1301 x 1734 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 vibrancy of the sky and rooftops of the buildings as a nice accent to the image, The hue/saturation function was used alongside the color balance function to adjust the colors and make the image pop and also seem semi-realistic in terms of color.

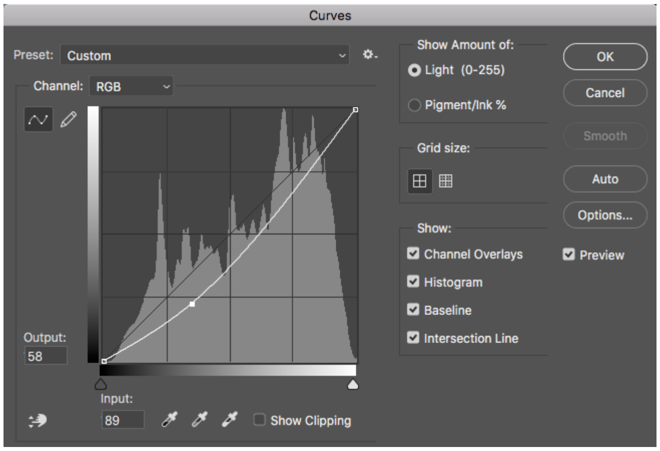

Figure 5. Edit Curves Layer in PS 2019

5. Discussion

The final image achieves the goal of capturing the clouds present in an artistic fashion. I like the framing and orientation of the image. I am worried that the presence of the buildings is a little distracting from the image, but at the same time I believe it complements the fluidic motion of the clouds by having a solid structure in the image. I would like to explore the desire for CU-Boulder to showcase this image as I believe it may have some merit in showcasing the beauty that can be found from walking around campus.

References:

[1] University of Colorado Boulder, 2019, "Living in Boulder" https://www.colorado.edu/orientation/prearrival/life-boulder

[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