CLOUDS SECOND REPORT

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Figure 1: Edited Cloud Second Image

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UNIVERSITY OF COLORADO - BOULDER
MCEN 4151: Flow Visualization

For the “Clouds Second” assignment, students were tasked with capturing mother nature and the beauty of everyday clouds. Students were also tasked to analyze the physics behind the clouds they were capturing and examine the weather patterns both before and after the image was taken. For my Cloud Second image, I decided to capture the clouds I saw traveling across the Flatiron Mountains, located in Boulder, Colorado, on April 9th, 2018 at 9:32 AM. At the time, the low bearing clouds were transparent enough to see a rough outline of the mountain peaks.

As previously mentioned, the photo seen in Figure 1 above was taken during sunrise on the morning of April 9^{h}, 2018. I took the image while I was parking in the Idea Forge parking lot located on the southern edge of the University of Colorado – Boulder main campus. Boulder is positioned roughly 13 miles northwest of Denver, Colorado and lies right around a mile above sea level. Further, I captured this image at exactly 9:32 AM and was facing directly west where the morning sun illuminated the partly clear skies. I took this picture holding my camera about eye-level, approximately 5.5 feet off the ground, and at an estimated 30° tilt towards the sky. I was on my way to one of my classes and was lucky enough to see plenty of clouds west of my location.

To further our analysis of Figure 1, we must analyze the exact physics behind multiple aspects of the captured clouds. Clouds are a well studied natural phenomena and were at one point considered to be “massless”, and thus able to oppose Earth’s gravitational force and float. From our Flow Visualization class, there are three basic types of clouds: cumulus, stratus, and cirrus. Within each one of these cloud categories, there are several subcategories dependent on the altitude, color, and shape. However, how do each of these clouds form? To answer this question, multiple measurements and weather patterns must be taken.

In Figure 1, I have identified these clouds as primarily altostratus accompanied by some altocumulus clouds. It is also interesting to note the rest of the sky not pictured in this image. If you were to look directly south, north, and east of my position, there were no clouds present in the sky and there seemed to be an invisible north-south line drawn in the sky where the captured clouds are present and where dark blue skies begin. Nevertheless, the clouds were the primary focus of this assignment and the phenomena has yet to be explained. The driving force behind all cloud formation originates from the weather patterns of the previous calendar days. Now, I have already stated that I labeled the clouds, seen in Figure 1, as primarily altostratus clouds… But what is an altostratus cloud? According to my research, altostratus clouds are defined as having an appearance of "layered bread rolls" and are lie within 2,500 – 18,000 feet above ground level (Nenes).

Now, when looking at Figure 1, it is not quite clear to me that these clouds resemble bread rolls at all, but they certainly fall within the elevation range of altostratus clouds. Using this elevation range, further information is needed to confidently classify the clouds seen in my image. The captured clouds are thin and wispy, but not as much to say they are cirrus clouds. More so, the clouds also are not "full" or puffy which correlates to cumulous clouds. Therefore, the clouds seen in Figure 1 must be stratus clouds. Due to the various types of status clouds, the reason these clouds are considered altostratus clouds is solely depended on the altitude of the cloud ceiling, which I will discuss later on. The University of Wyoming Atmospheric Research Center defines altostratus clouds as being formed by the "lifting of a large, mostly stable, air mass that causes invisible water vapor to condensate into a cloud… [and are] usually a sheet, but can be wavy as a result of wind shear through the cloud" (University of Wyoming). Ultimately, this means that in order to confidently name the exact types of clouds seen in Figure 1, the exact weather parameters leading up to April 9th must be analyzed. Below, the weather parameters occurring at the University of Colorado - Boulder for the dates April 7th – April 11th are listed according to the archives of Weather Underground:

April 7th, 2018 (Weather History)

- Mean Temp = 41 F
- Avg. Humidity = 68%
- Mean Dew Point = 30 F
- Precipitation = 0.01"
- Sea Level Pressure = 29.88 (inHg)
- Visibility = 9 miles
- Wind Speed = 2 mph NNE

April 8th, 2018 (Weather History)

- Mean Temp = 54 F
- Avg. Humidity = 42%
- Mean Dew Point = 27 F

- Precipitation = 0
- Sea Level Pressure = 29.72 (inHg)
- Visibility = 10 miles
- Wind Speed = 11 mph W

April 9th, 2018 (Weather History)

- Mean Temp = 47 F
- Avg. Humidity = 61%
- Mean Dew Point = 29 F
- Precipitation = 0.05”
- Sea Level Pressure = 30.17 (inHg)
- Visibility = 10 miles
- Wind Speed = 5 mph ESE

April 10th, 2018 (Weather History)

- Mean Temp = 53 F
- Avg. Humidity = 35%
- Mean Dew Point = 22 F
- Precipitation = 0
- Sea Level Pressure = 30.13 (inHg)
- Visibility = 10 miles
- Wind Speed = 4 mph WSW

April 11th, 2018 (Weather History)

- Mean Temp = 65 F
- Avg. Humidity = 20%
- Mean Dew Point = 20 F
- Precipitation = 0
- Sea Level Pressure = 29.81 (inHg)
- Visibility = 10 miles
- Wind Speed = 10 mph SW

Using the mean temperature information above, April 9th was the ending of a cold front and welcomed the onset of a warm front. The excitation of the cold front and arrival of a warm front causes high atmospheric wind speeds and wind shearing, signs of altostratus cloud formation. Below, there is more data highlighting the weather information, by the hour, more accurately depicting the surroundings resulting in Figure 1. When analyzing the data in Table 2, particular attention needs to be paid to the wind speeds and direction leading up to, and following, around 9 AM when Figure 1 was captured. The wind speed drastically increases from 7 AM to 9 AM and could be considered one of the largest factors in the production of the altostratus clouds. Going even deeper, the Skew-T Diagram provided by the University of Wyoming (Figure 2) shows the close positional relation between the dew point temperature line and air temperature line, occurring just below 3055 m, or 11,000 ft. The significance of this observation stems from the common knowledge stating that most cloud formation occurs when the dew point point temperature is closest to the air temperature. For reference, 11,000 feet is equivalent to 5,000 feet above ground which supports the altostratus classification of the clouds seen in Figure 1.

MARCH 4th, 2018 (Weather History)

Time (local)	Temp. (F)	Dew Point (F)	Humidity (%)	Pressure (inHg)	Wind (Dir & Speed, mph)	Conditions
7 am	35.6	35.6	100%	30.17	NE12.7	Rain
8 am	33.8	33.8	100%	30.20	S6.9	Light Snow
9 am	39.2	35.6	87%	30.20	SSE3.5	Scattered Clouds
10 am	44.6	33.8	66%	30.23	E4.6	Clear
11 am	44.6	33.8	66%	30.23	E.5.8	Mostly Cloudy
12 pm	46.4	33.8	62%	30.22	E8.1	Mostly Cloudy

Table 1: Key Weather Variables

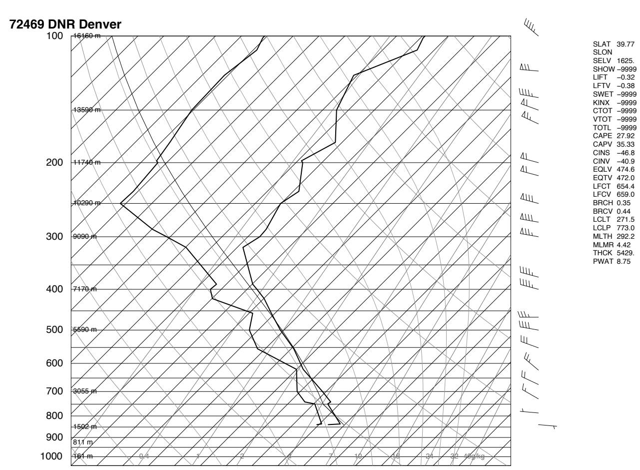

Figure 2: Skew-T Diagram of Boulder, Colorado

To capture the beauty of these clouds, specific camera settings had to be taken into account. I took this image using my Samsung SM – G955U camera integrated into my Samsung Galaxy S9+ smartphone. The reason I had to use my smartphone instead of my Sony camera was strictly due to the lack or preparation when going to class that day. By looking at Figure 1, it is difficult to visualize the exact field of view captured, even with the buildings in the foreground. I would estimate my field of view to be roughly 300 feet wide and 800 feet tall that is then projected approximately 2 miles. To fully understand the cloud image and the relative size of the clouds, I used a ballpark estimate and approximate the cloud lengths seen as over 5 miles long. Furthermore, the exact camera settings used to capture Figure 1 can be seen in Table 2, below:

Camera Setting	**Value**
Resolution	4032 x 2268
Focal Length	4.25 mm
Aperture	F1.7
Exposure Time	1/3125 Seconds
ISO	50

Table 2: Camera Settings

I tried to use as high of a resolution as possible in order to capture the finite details of the individual clouds. Specifically, I noticed very clear clusters in the top most cloud and the relative smoothness of the clouds in the distance and wanted to use the highest camera resolution possible in order to draw contrast between the cloud distances. One other key camera setting in capturing my cloud image is the ISO setting. I used the lowest ISO setting, thus highest shutter speed possible, to decrease the grain in my image and highlight the details of the sky. I was aiming to capture the clouds and was not focused on capturing the darker foreground. Although I tried to optimize the camera settings for the best quality picture, I inevitably had to post-process my original image for the sole reason of focusing my audience on the clouds in the sky and the beauty lying within them. In Figure 3 below, you will see my unedited, original image of the morning sky above Boulder, Colorado. I implemented several minor post-processing techniques in order to go from Figure 3 to Figure 1. First and foremost, I increased the contrast of the image to create a silhouette effect of the mountain tops in the foreground. After increasing the image's contrast, I cropped the image to eliminate the extraneous foliage in the bottom and chose to keep the larger tree and sky as my primary focal points. With a cropped and contrasted picture, the last step I took to create the final image was to boost the colors. By boosting the colors after increasing the contrast, I was able to keep the silhouette effect and further highlight the rising sun's illuminating effect on the clouds.

Figure 3: Unedited Cloud Image

Looking at this image's photographic techniques, scientific origins, and supplementary evidence, Figure 1 reveals one type of cloud phenomena captured at one of the most beautiful times of day. Unfortunately, in today's world, not enough people are able to appreciate the true natural beauty of the rising sun and the numerous fluid phenomena that take place. Explicitly, the visual aesthetics and physics of clouds are the most prevalent during sunrise and sundown. Figure 1 is a stunning example of natural aesthetics. Personally, I appreciate the color scheme captured in Figure 1 and the dichotomy between the closer, singular cloud and fluidity of the grouped, distant clouds. If I were to capture this image again, I think I would choose a different setting that allows for less distracting elements like the dead trees seen on the left and right hand sides of the image.

Works Cited:

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