CLOUDS FIRST REPORT

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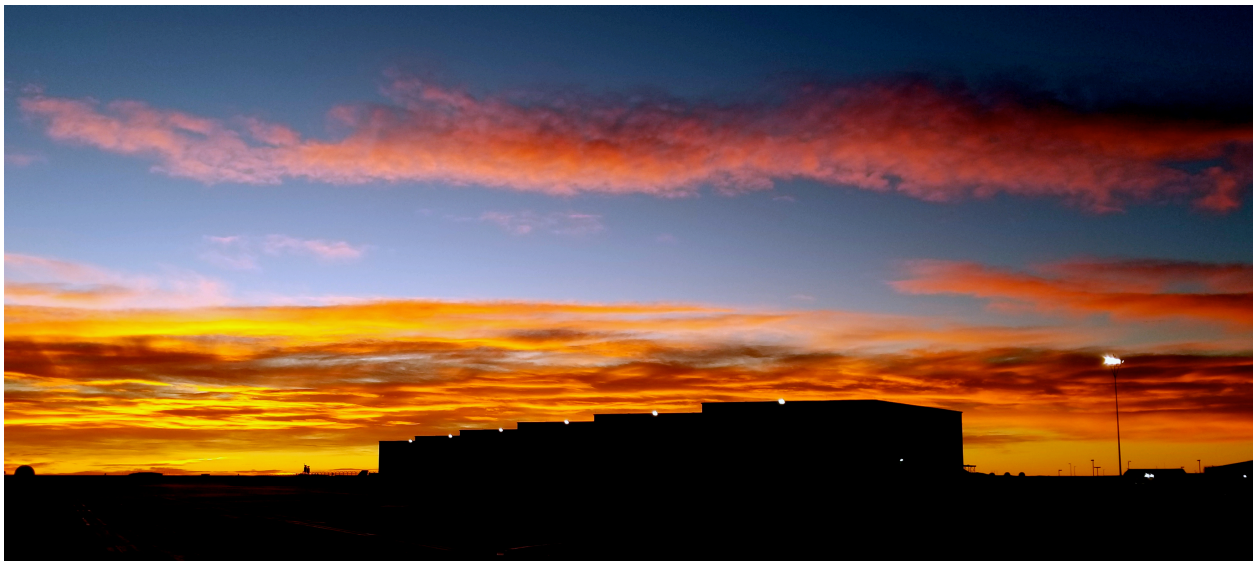

Figure 1: Edited Cloud First Image

MARCH 20, 2018

UNIVERSITY OF COLORADO - BOULDER

MCEN 4151: Flow Visualization

For the “Clouds First” 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 First image, I decided to capture the clouds I saw at sunrise while at work down in Aurora, Colorado on March 4th, 2018. By taking the image at sunrise, the sky yielded beautiful colors and painted onto the many cirrus clouds in the sky.

As previously mentioned, the photo seen in Figure 1 above was taken during sunrise on the morning of March 4th, 2018. I took the image while I was working at Buckley Air Force Base located in Aurora, Colorado. Aurora is positioned roughly 20 miles southwest of Denver, Colorado and lies right around a mile above sea level. Further, I captured this image at exactly 6:15 AM and was facing east-southeast where the rising sun was not yet visible, but the illumination of the sky is evident. 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 working for about two hours at this point and stepped outside when I noticed the sky starting to brighten for daybreak. Luckily, there were plenty of clouds east of my location which were able to canvas the light diffraction from the rising sun.

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 west 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 6,500 – 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 March 4th must be analyzed. Below, the weather parameters occurring at Buckley Air Force Base for the dates March 2nd – March 6th are listed according to the archives of Weather Underground:

March 2nd, 2018 (Weather History)

- Mean Temp = 49 F
- Avg. Humidity = 25%
- Mean Dew Point = 25 F
- Precipitation = 0
- Sea Level Pressure = 29.81 (inHg)
- Visibility = 10 miles
- Wind Speed = 13 mph SSW
- Comments:
    - Partly cloudy for most of the day until ~6 pm MST when it clears up
    - Steep drop in pressure around 7 am and losing .2 inHg, balances itself out to a lower value starting around 4 pm

- Strong wind gusts between 9-10 am and 2-3 pm, reaching max gust of 30 mph (1-2) with max wind speed of 23 mph
- The wind seems to be explicitly coming out of the South for most of the day

March 3rd, 2018 (Weather History)

- Mean Temp = 56 F
- Avg. Humidity = 15%
- Mean Dew Point = 5 F
- Precipitation = 0
- Sea Level Pressure = 29.71 (inHg)
- Visibility = 10 miles
- Wind Speed = 13 mph SSW
- Comments:
  - Clear during the morning hours, turning partly cloudy b/w 8am – 6pm, finally turning to scattered clouds 7pm – 10pm
  - Steady, somewhat drastic, drop in pressure starting at 7 am until 4 pm, losing .2 inHg
  - Unlike the day before, moderate winds in the morning (1am – 11am), calmer in the afternoon, and picks up again in the evening
  - Winds were primarily coming out of the south until the evening where it starts to come more out of the west where it would eventually turn back and come out of the south more
  - Max wind (17 mph) = max gust speed

March 4th, 2018 (Weather History)

- Mean Temp = 48 F
- Avg. Humidity = 19%
- Mean Dew Point = 3 F
- Precipitation = 0
- Sea Level Pressure = 29.55 (inHg)
- Visibility = 10 miles

- Wind Speed = 15 mph SSW
- Comments:
    - Steady decline in pressure from the early morning until 3pm, dropping .3 inHg, before sharply rising from 3pm – day end, rising .5 inHg
    - Max wind speed = 25 mph (10pm)
    - Max gust speed = 38 mph (3pm)
    - Fairly steady wind until the later morning and early afternoon where the winds, and especially the gusts, shoot up
    - Wind was steadily coming from the south from early morning – 4 pm where the wind quickly shifts to the north for 4pm – 7pm where it then steadily returns back to the south

March 5th, 2018 (Weather History)

- Mean Temp = 32 F
- Avg. Humidity = 25%
- Mean Dew Point = -2 F
- Precipitation = 0
- Sea Level Pressure = 30.02 (inHg)
- Visibility = 10 miles
- Wind Speed = 24 mph WNW
- Comments:
    - Saw a steady rise in the barometric pressure all day long, rising up to .4 inHg throughout the day
    - Max wind speed = 38 mph
    - Max gust speed = 48 mph
    - The cloud coverage maintained partly cloudy for over 90% of the day
    - Saw large gusts of wind all day, reaching the peak wind speeds around midday. The wind somewhat calmed after 7pm, meaning there were no more large gusts but not calm in any sense of the word
    - The wind direction was consistent all day long, coming from the West and never deviating more than a few degrees in any direction

March 6th, 2018 (Weather History)

- Mean Temp = 32 F
- Avg. Humidity = 30%
- Mean Dew Point = 1 F
- Precipitation = 0
- Sea Level Pressure = 30.23 (inHg)
- Visibility = 10 miles
- Wind Speed = 13 mph NE
- Comments:
    - Unlike the previous days, the barometric rose but not in such a dramatic fashion. The pressure only rose around 1.5 inHg throughout the entirety of the day
    - Max wind speed = 23 mph
    - Max gust speed = 32 mph
    - The wind only seemed prominent during the morning hours on the 6th, reaching the peak wind gusts at 5am. After the early morning passed, the day saw calm breezes instead of the typical howling storms
    - Additionally, the wind direction saw a sharp contrast at almost exactly 9 am. The wind direction was in the NW direction until business hours stopped. Then, the winds seemed to shift towards the east and finished the day coming from the south
    - The 6th saw more clear skies than the previous 5 days combined, but was still plagued with intermittent partly cloudy skies

Using the mean temperature information above, March 4th was the pivotal transition day welcoming the onset of a cold front. The excitation of the warm front and arrival of a cold 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 3, particular attention needs to be paid to the wind speeds and direction leading up to, and following, around 6 AM when Figure 1 was captured. The wind speed drastically increases from 5 AM to 6 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 7250 m, or 23,786 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, 23,786 feet is equivalent to 18,000 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
3 am	45.3	4.3	19%	29.58	S15.0	Partially Cloudy
4 am	46.4	3.9	17%	29.55	SSE13.8	Partially Cloudy
5 am	45.1	1.6	17%	29.55	S9.2	Partially Cloudy
6 am	48.0	-0.6	13%	29.54	S17.3	Partially Cloudy
7 am	46.8	-1.5	14%	29.57	SSW13.8	Partially Cloudy
8 am	53.1	0.0	11%	29.55	S15.0	Partially Cloudy

Table 1: Key Weather Variables

METAR, March 4th, 2018

Time	Wind info	Visibility	Cloud info*	Temp & Dew Pt (Celsius)	Altimeter setting
3 am	17013KT	10 SM	FEW200	07/M15	A2974
4 am	16012KT	10 SM	FEW200	08/M16	A2971
5 am	19008KT	10 SM	FEW200	07/M17	A2970
6 am	19015G20KT	10 SM	FEW200	09/M18	A2968
7 am	20012KT	10 SM	FEW200	08/M19	A2969
8 am	18013KT	10 SM	FEW200	12/M18	A2968

Table 2: Meteorological Atmospheric Report (METAR) of Buckley Air Force Base

*"FEW" = 1-2 oktas, or eighths of the sky occupied by a cloud

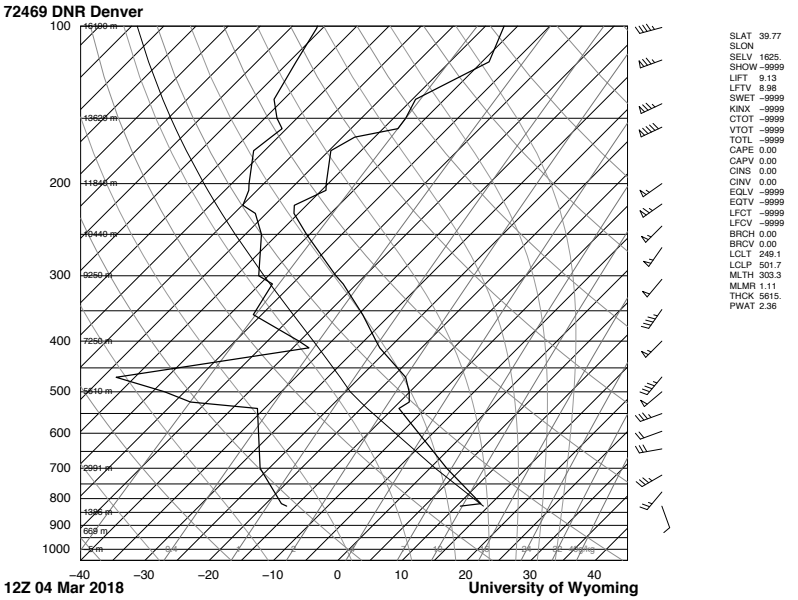

Figure 2: Skew-T Diagram of Buckley Air Force Base

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 regulations surrounding photography around military aircraft. 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 500 feet wide and 300 feet tall that is then projected approximately 5 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 20 miles long. Furthermore, the exact camera settings used to capture Figure 1 can be seen in Table 3, below:

Camera Setting	Value
Resolution	4032 x 2268
Focal Length	4.25 mm
Aperture	F1.7
Exposure Time	1/158 Seconds
ISO	50

Table 3: 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 brighter parts of the sky. I was aiming to capture the bright sky 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 Buckley Air Force Base. 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 buildings in the foreground. After increasing the image's contrast, I cropped the image to eliminate the extraneous concrete foreground in the bottom left-hand corner and chose to keep the building 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. Additionally, Figure 1 shows the beautiful color gradient between clouds giving the audience a sense of relative distance and the amount of sunlight manifesting in the sky. If I were to capture this image again, I think I would choose a different setting that allows for less distracting elements like the structures seen on the horizon line.

Works Cited:

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