Clouds First

Bradley Schumacher

MCEN 4151: Flow Visualization

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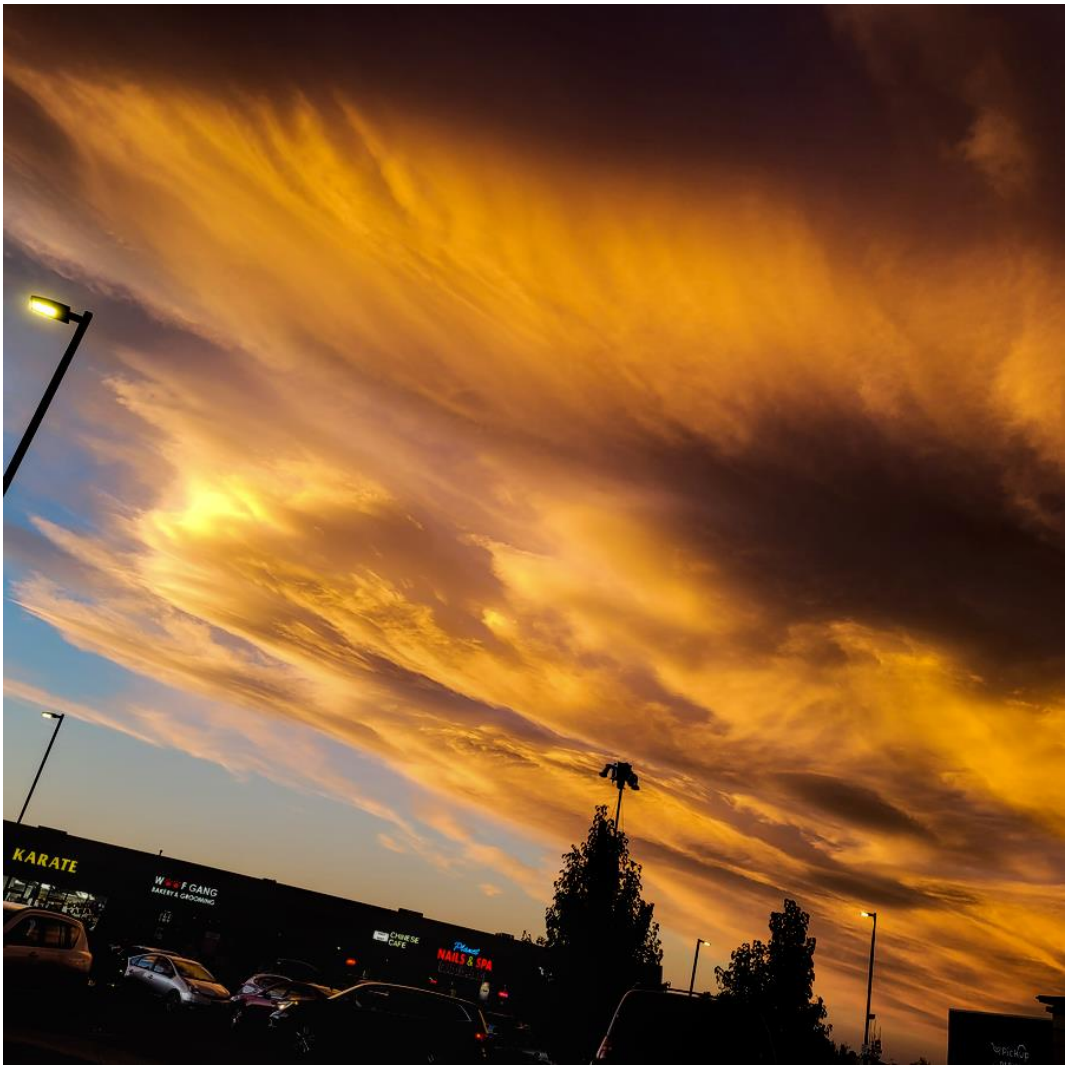

I. Introduction and Background

Clouds often go unnoticed and underappreciated. They offer some of the most captivating displays of fluid dynamics in the world and they are far more accessible to the average person than a complex fluids experiment performed in a laboratory. However, their ubiquity is exactly why they are often overlooked in favor of said experiments. Because we see them every day, it is easy to miss their complexity. Clouds offer great insight into the complex, chaotic nature of fluid dynamics, especially on a large scale in the natural world, contrasting the small scale, controlled experiments we may be more accustomed to studying.

While I took many pictures of clouds throughout September and October, I settled on this image due to the large, imposing structure of the clouds and the interplay between the clouds and the lighting of the sunset. The original image captured is shown below in Figure 1.

Fig. 1: Original Image

The sunlight provided a beautiful golden hue to the clouds and helped to highlight some of the features and the continuous, sheet-like nature of the clouds. A massive sheet of golden clouds rolling in to cover the entire sky felt very dramatic and imposing to me, something I tried to reflect with this image and its processing, described below.

II. Context of Image

This image was captured in Boulder, CO near the intersection of Arapahoe Ave. and 30th St. on October 17, 2023 at 6:22 PM. This image was taken facing north with the clouds rolling in from the east. Boulder has an elevation of 5430 ft or 1655 m above sea level. The nearest weather station is located in Grand Junction, CO which is approximately 250 miles WSW of Boulder. Grand Junction is far deeper in the mountains than Boulder and considerably closer to sea level, with an elevation of 4583 ft or 1397 m. This difference is important to know as the Skew-T diagram used later is from the Grand Junction weather station and may not accurately reflect the concurrent weather in Boulder. The image was taken at an approximate angle of 45°, although this is from memory and may not be entirely accurate.

III. Cloud Classification and Weather Data

I believe the clouds in this image to stratocumulus due to their low altitude and their large, sheet-like structure. They display the signature bumps and ridges of cumulus clouds and the sheet structure of stratus clouds. They do not appear to rise much vertically, ruling out cumulonimbus and no precipitation appears to be associated with these particular clouds. These all imply stratocumulus. Data on the weather in Boulder at this time can be seen below in Figure 2, which displays data taken from the CU Boulder ATOC program.

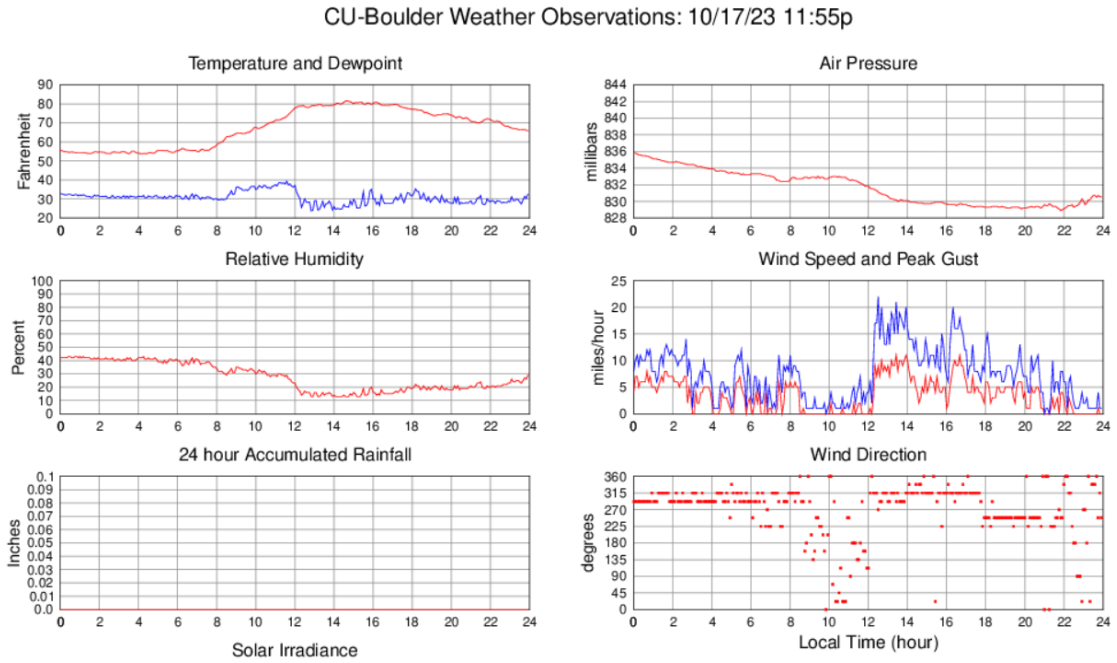

Fig. 2: ATOC weather data for Boulder on 10/17/23. Relevant time is 18 hours.

As seen in the graphs above, these clouds seem to be associated with an increase in temperature and a decrease in humidity and air pressure that occurs around noon and last for the remainder of the day. According to this data, the wind was blowing roughly SSE. My original intuition was that the clouds were moving fast as the sky west of this cloud front was devoid of clouds. However, it makes sense that this front is actually moving east. The decrease in humidity makes sense given the complete lack of precipitation, a trait also associated with stratocumulus clouds. Similar clouds were present in the days preceding October 17, as can be seen in many other students posts on flowvis.org. The rise in temperature around noon increases the distance between the temperature and the dewpoint, which should decrease the chances of cloud formation. This and the eastward wind could explain the clear skies west of these clouds; these clouds may have formed earlier in the day and moved westward throughout the afternoon.

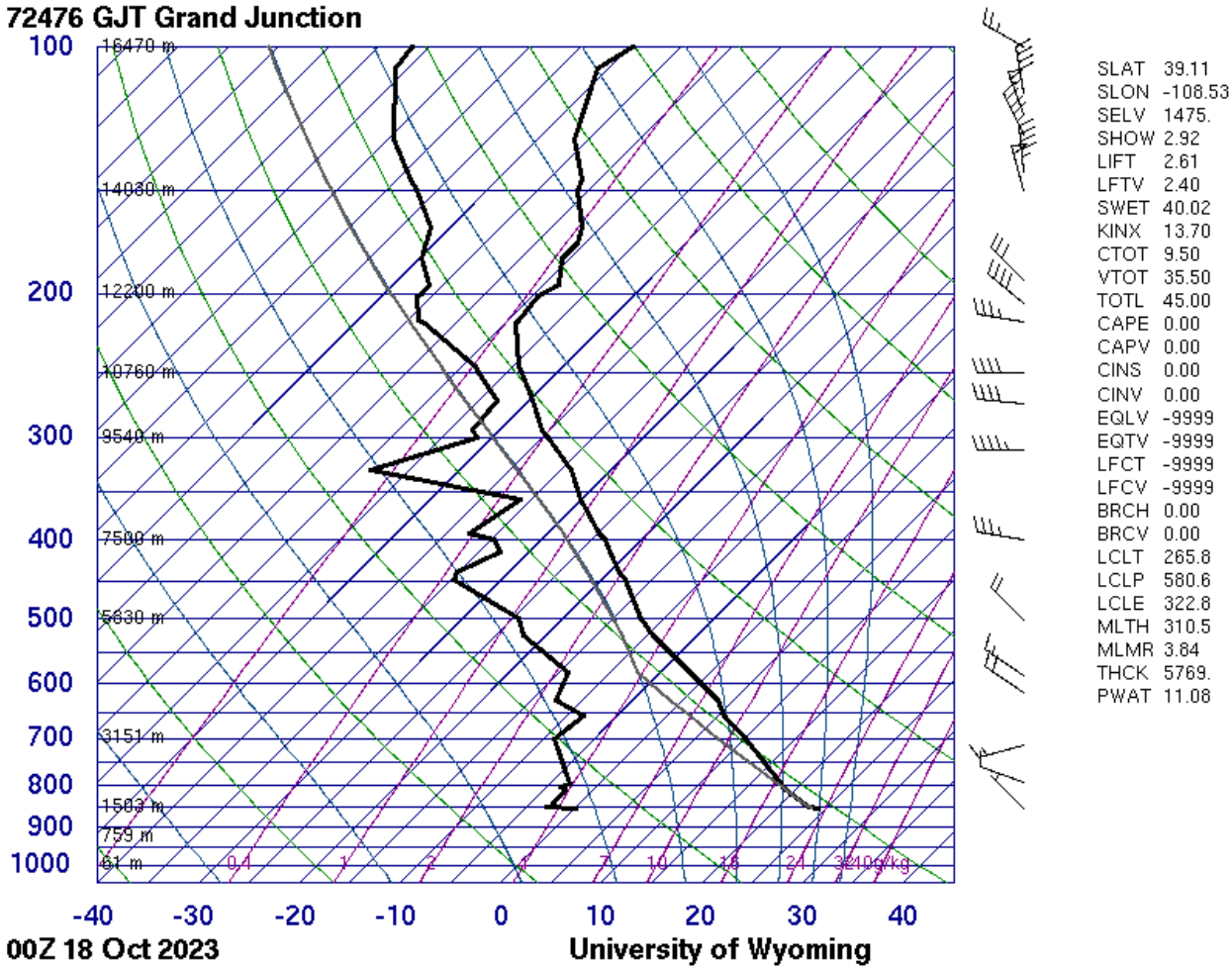

Fig. 3: Skew-T diagram for Grand Junction at 6pm MST

The Skew-T diagram for Grand Junction at 6pm local time is shown above in Figure 3. This can help us gain much more information about the clouds than the data shown above. Typically, clouds are most likely to form at altitudes where the two black lines are closest to each other. Surprisingly, we can see that the region most likely to see cloud development is 7500-12200 m. The clouds captured in Boulder seem very low, probably 3000m or less, so I was surprised to see that clouds looked fairly unlikely to develop at these height ranges. However, the wind direction displayed to the right of the Skew-T chart shows that at nearly all altitudes, wind was blowing westward. Grand Junction already lies far west of Boulder, so this leads me to believe that the Skew-T of Grand Junction does not accurately reflect the clouds in Boulder around the same time. If the wind at this time was pointed west, then any clouds formed in Grand Junction would move directly away from Boulder, meaning the clouds captured above must've originated somewhere else. However, because the wind in Boulder was blowing eastward and Grand Junction is the nearest station to the west of Boulder, it is difficult to pinpoint where exactly these clouds could've formed and if any accurate measures of them were captured by weather stations.

IV. Camera Settings and Photograph Properties

This photo was taken on my phone, a Samsung Galaxy S20. As tracked by my phone, the settings are shown in Table 1 below. I did not set these settings myself, I simply pointed the camera and the phone did the rest. These settings are fitting for this image as there is no need for the shutter speed to be very high since nothing is moving particularly quickly. The large aperture lets a high amount of light in and is appropriate for a large landscape-like image of the sky. The ISO is likely low due to the fairly slow shutter speed and extremely large aperture so as to not overexpose the image. Finally, the focal length is quite small when compared to a DSLR due simply to the nature of phone camera lenses. The original photo is 3024x3024 pixels, but at some point in the editing process or when downloading the image, it appears it was compressed to 900x900 pixels.

Shutter Speed	1/120
Aperture	f/1.8
ISO	ISO50
Focal Length	5.40 mm

Table 1: Phone Camera Settings

The editing on this photo is relatively minimal. I simply increased the saturation to really bring out color and detail in the clouds. This made the lit regions appear brighter and the shaded regions much darker. This served two functions: the increase in shadow helped highlight features in the clouds that were not as visible in the original image, which helped for identification. This was particularly useful for regions a bit further away in the picture. The second reason was because I thought the effect made the image appear far more dramatic. Witnessing these clouds in person, they felt very imposing due to their size, closeness, and the clear skies to the west. It felt like these massive clouds were rolling in to cover everything. I wanted the final image to reflect this intense smothering feeling.

V. Conclusion

I think the image does a good job of realizing this ominous feeling; however, it doesn't seem like others get this feeling. I imagine there is a different way to edit this image to more accurately reflect to others how I felt in this moment, likely something more complicated and/or subtle than just increasing the saturation. I'm also unsure about the inclusion of the ground in the image and the tilt of the camera. These were both organic effects as I took the picture out the window of my car, but perhaps they obscure the fluid mechanics at play. I am also pretty unsure about the identification of this cloud as a stratocumulus as it seems there is a significant amount of gray area and overlap between features of different cloud types. I would like to have my assessment verified or disproven by a weather expert. However, taking images over the last two months and researching cloud identification has made me feel quite prepared for the next Clouds assignment.

References

"Cloud Identification Guide: Cloudspotting 101." *Whatsthiscloud*, Why So Cirrus, LLC, 18 May 2023, whatsthiscloud.com/cloud-identification/.

"CU-Boulder Weather Observations: 10/17/23 11:55p." *University of Colorado Weather Network*, CU Boulder ATOC, 18 Oct. 2023, sundowner.colorado.edu/weather/atoc1/PAOSweather20231017.html.

Hertzberg, Jean. "Clouds 3: Skew - t and Instability." *Flow Visualization*, Flow Visualization, www.flowvis.org/Flow%20Vis%20Guide/clouds-3-skew-t/. Accessed 30 Oct. 2023.