University of Colorado - Boulder

MCEN 5151
Flow Visualization

Clouds First Report

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1 Introduction

1.1 Image Summary

I captured this image from a bowl on my way down from Huron Peak at about 10:50 am on September 8th, 2024. I was at an elevation of about 12,265 ft (3738 m), and according to the skew-t diagram for that day, these clouds are probably at about 19,350 ft (5890 m) or so, only a mile and a half or so above me! I don't believe these clouds are orographic; they spanned across peaks and valleys, didn't have a wave-like pattern, and didn't appear to be fixed in one place above a crest. More likely, these are regular altocumulus clouds.

1.2 Motivation

Clouds are one of the most commonly available visual fluid flows. We may take for granted that rivers and streams are a flowing fluid; it is much less common to consider how the atmosphere is actually flowing because it is less obviously visible. By learning about clouds and what they can tell us about how the air is moving above us, we unlock a vast world of stunningly beautiful fluid physics that's been just waiting right in front of us our whole lives.

2 Methodology

2.1 Test Setup

Cloud photography is completely about being in the right place at the right time, especially if there is no need for more than still images; time lapse videos may take more planning. This image was captured on the hike down from a 14er (a mountain peak reaching above 14,000 feet or 4267 meters), at about 10:50 am on September 8th, 2024. That morning during sunrise, there was zero cloud cover anywhere in the sky. By the time most hikers started reaching the summit on Huron Peak, these clouds had started forming off to the north west of the peak; by the time people were heading down between 10am and noon, these clouds were pulling overhead. It rained shortly there after. Figure 2.1.1 shows the exact location where the image was taken, relative to Huron Peak and some of the rest of the Collegiate Peaks (the set of peaks Huron is a part of, in the Rocky Mountains in Colorado). Figure 2.1.2 shows the approximate view from above and behind the image location; both images are from Google Earth [2].

2.2 Visualization Technique

Visualizing clouds is just about pointing a camera up! Nothing to it. The image contrast is altered to bring out the depth of the cloud layer.

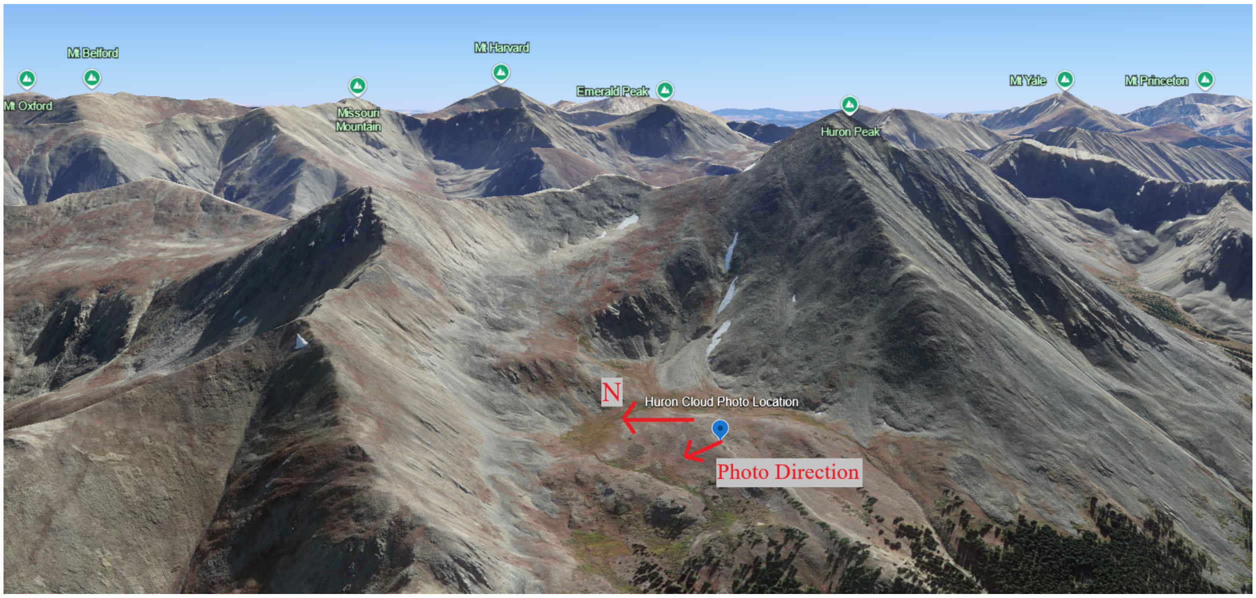

Figure 2.1.1: Image Location and Direction.

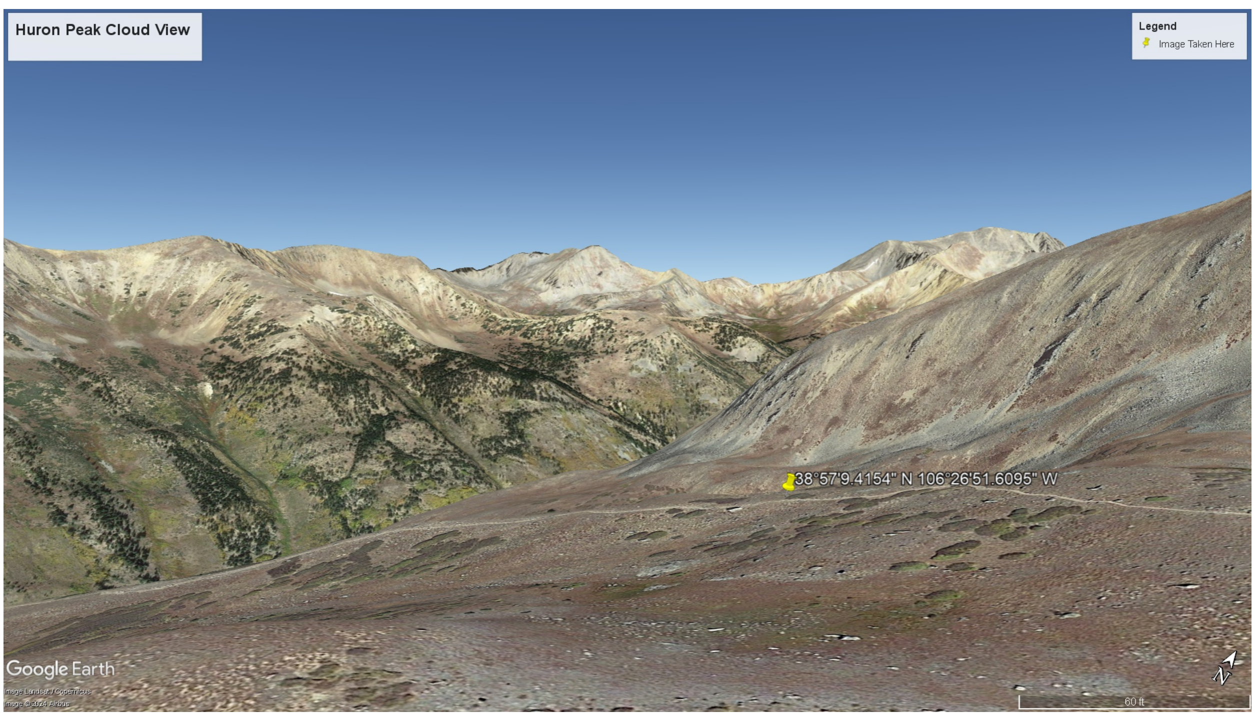

Figure 2.1.2: The same shot, from Google Earth.

Figure 2.3.1: Compressed JPG of the original, unedited RAW.

2.3 Photographic Technique

The report image was captured with a Google Pixel 7 using the 6.81mm (48mm equivalent 35mm focal length) back camera, f/1.9 aperture, 1/4200 sec exposure, and ISO 48. Pixels do lots of high dynamic range processing in-chip before saving any data to an accessible file, and so the raw image comes with a lot of apparent brightening and high color saturation. The image was captured using the default Pixel Camera app, set to save to RAW and JPG.

The RAW version of the image, right out of the Pixel, looks pretty strange, as the images are mostly intended to be exported fully complete from Google's software. The final image processing consists of several of small things. The RAW image came with a color profile from Google; "Adobe Landscape" is applied to the final image instead. This does a lot of subtle heavy lifting to make the image look less washed out and more natural. The image tone point curve is largely lowered from the midline, in a steep "S" shape; this draws down highlights, brings out detail clarity, and increases contrast in the clouds. The highlights and vibrance are also turned down, compensating somewhat for the harsh Pixel HDR effect. Figure 2.3.1 shows what the image looked like before any post processing was applied, and Figure 2.3.2 shows a side-by-side comparison of the original and final images. Of particular note is the difference in mountain color and detail between the two, as well as the increased depth in the clouds. All post-processing was done using Adobe Lightroom Classic.

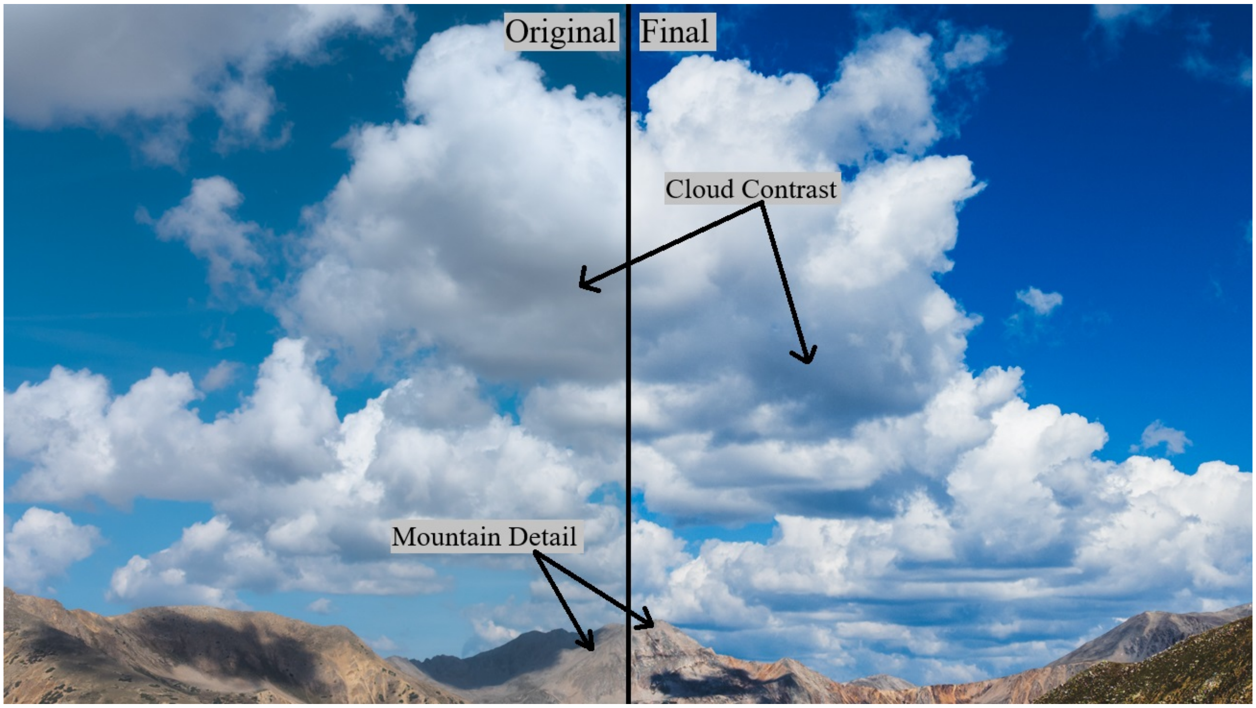

Figure 2.3.2: Original and Final images, side-by-side comparison

3 Flow Discussion

The image was taken on September 8th, 2024, at about 10:50 am MT, from a GPS-indicated altitude of 12,265 ft (3738 m). According to the nearest Skew-T diagram for that day, shown in Figure 3.0.1, the pictured cloud layer is most likely at around 19,350 ft (5900 m). The imaged clouds are altocumulus clouds when classified using the image capture altitude, but this neglects the complexity of the surface environment below them. The clouds are only about 5,500 feet up when viewed from the mountain tops, but are nearly 10,000 feet above the valley floors. Normally anything at or below about 6,500 feet AGL is considered a low-level cloud, and anything between 6,500 and 15,000 feet would usually be a mid-level cloud [1]. Depending on where these clouds get classified, they are either cumulus clouds (if they are low-level) or altocumulus (if they are mid-level). Because mountains generally disrupt surface air flow patterns, it may be reasonable to classify clouds covering a mountain range using the peak ground height as a basis. Doing so puts the pictured clouds at about 5,500 feet AGL, firmly in the low-level range. This matches up better with the appearance of the clouds, which look much more like the traditional fluffy cumulus clouds than the more disperse altocumulus.

Mountain clouds are often "orographic", meaning they form as air is forced up and over a mountain ridge, cooling as it expands out into the air above. The pictured clouds, while above mountains, do not have many other characteristics of orographic clouds. They do not appear stationary above mountain ridges, and they do not appear in a wave pattern extending away from mountain ridges. Rather, they are high above even the mountain peaks, and were moving fairly quickly in a south-easterly direction. More likely these clouds

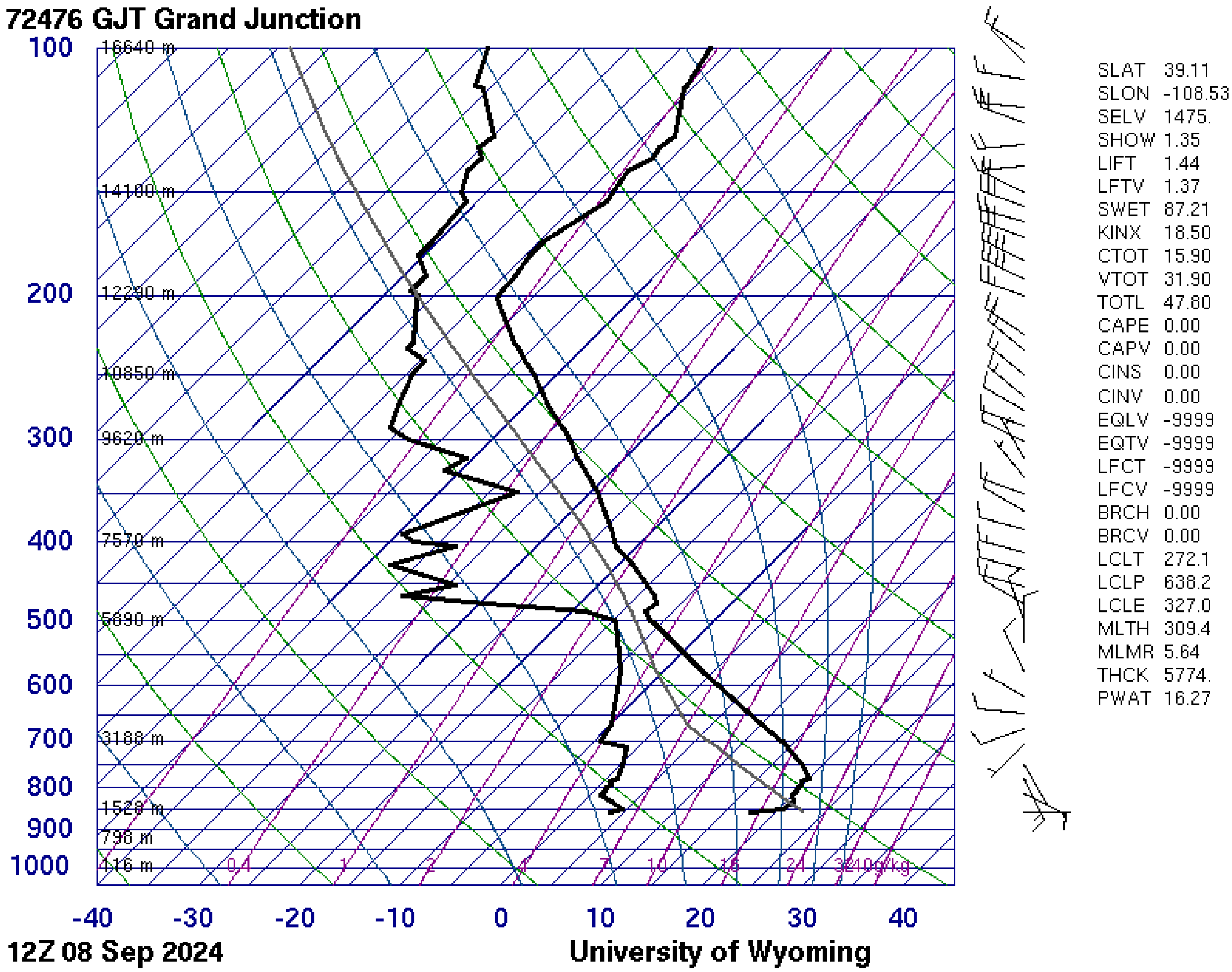

Figure 3.0.1: Grand Junction, CO Skew-T diagram for September 8th, 2024

represent cool moist air moving in from the north west; the system did eventually form thicker stratocumulus/nimbostratus clouds that precipitated over much of the central Front Range, including around Denver and Boulder.

4 Conclusion: Revelations

There are few flows so beautiful and easily viewed as cloud formations. Clouds inspire aw and terror, mark the passing of time, and bring both life and destruction to the places we live. I made a conscious decision not to bring my DSLR up the mountain they day I took this photo. Although I am happy with how my phone handled the view, I would like to know what it would have looked like in a full frame sensor. Modern phones do an impressive job at capturing believable photos, but it is hard to know what is real and what is generated automatically by the phone in order to boost the relative quality of the image. In the future I would love to capture a time lapse of the late summer clouds up in the mountains; the image presented in this report only shows one moment in a day long journey from perfectly clear skies to thundering rain clouds that happens nearly every day in the Rockies here in Colorado.

5 Acknowledgements

References

[1] Jim W. Lee. *Cloud Chart*. https://www.weather.gov/key/cloudchart.

[2] Google/Landsat-Copernicus/Airbus/SIO/NOAA/U.S. Navy/NGA/GEBCO. *Huron Peak*. https://earth.google.com/web/search/3857'9.4154"+N+10626'51.6095"+W/@38.95037234,-106.44181044,3874.90429164a,2509.98660113d,35y,117.69665795h,79.58634408t,360r.