Orographic Clouds at Base of the Mountains

Figure 1. Orographic Clouds at the Base of the Mountains final image.

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Clouds Second Report

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Introduction

The Orographic Clouds at the Base of the Mountains image was captured for the second of two cloud photography assignments in a Flow Visualization course. The goal of the image is to capture cloud formation that is caused by the topography of the ground below. The scientific intent behind the image is to identify atmospheric phenomena that are occurring due to this topography and atmospheric conditions, and identify cloud types seen in the image. The artistic intent behind the image was to capture dark and ominous looking clouds, highlight the crisp edge of the cloud front, and image the contrasting colors of the foreground below. I spent several weeks throughout the fall photographing interesting looking clouds with my phone, but this image proves to demonstrate the most interesting atmospheric phenomena. The final image captured shows fascinating cloud development due to the topography of the ground.

Image Context

The image was taken in Boulder just north and below the NCAR research facility south of Chautauqua park at the base of the flatiron mountains. The image was taken on the ground at approximately 5,906 feet in elevation. I was facing Northwest when I took this image, and was pointing the camera approximately 30 degrees up from horizonal.

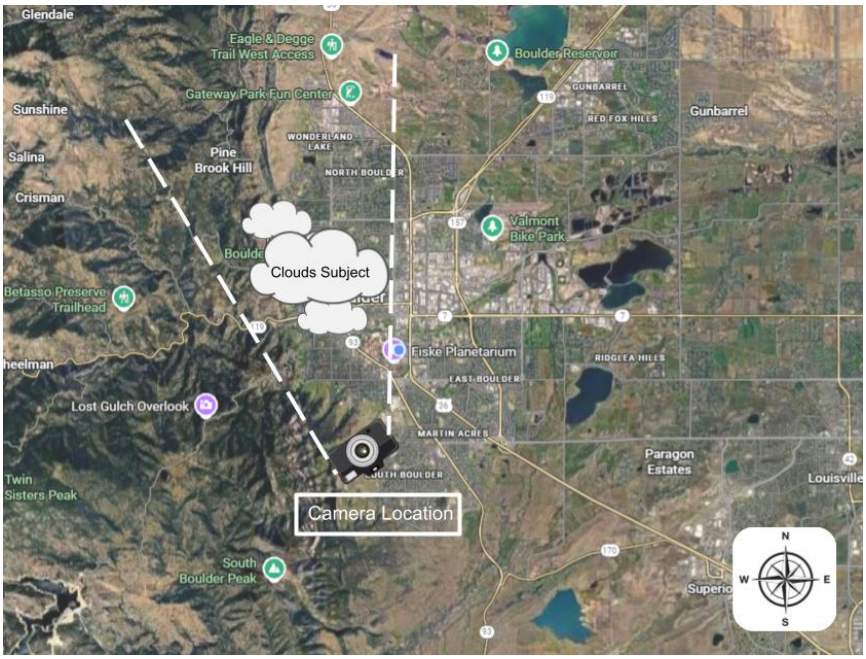

Figure 2. Location approximation for context of image.

The location and orientation shown in Figure 2 shows how the clouds photographed were occurring right at the edge of the front range of mountains in a uniform manner. This phenomenon

will be explored in later sections. The image was taken at 10:26 AM, on Sunday October 26th, 2025. The weather throughout the day was cloudy and cold, with cloud cover lasting all day.

Cloud Identification and Atmospheric Context

The clouds in the image can be identified as orographic clouds. This identification can be made because of their geographic location. As described above in Figure 2, the clouds are occurring specifically on the leeward (downwind) edge of the front range of the Rocky Mountains. In general, orographic clouds form when air is forced over mountains causing air to cool and condense. Orographic cloud literature that analyzes mountain-wave dynamics shows that when stable air flows over a ridge, oscillations form downstream and produce leeward cloud decks.[1] In the case of this image, the ridge is the flatirons at the downstream area would be over Boulder, which is often the leeward side of the Rockies.

When this image was taken, the rest of the sky eastward was completely covered in clouds, while the sky beyond the edge of the mountains (west) was completely free of any clouds. Images of clouds in days prior to this cloud image show very similar looking sheet-like cloud formations low in the sky. There had not been any precipitation the entire day of this photograph, and there was little to no wind throughout the day. Reviewing a Skew-T sounding from the nearest station reveals more about the atmospheric conditions on this day.

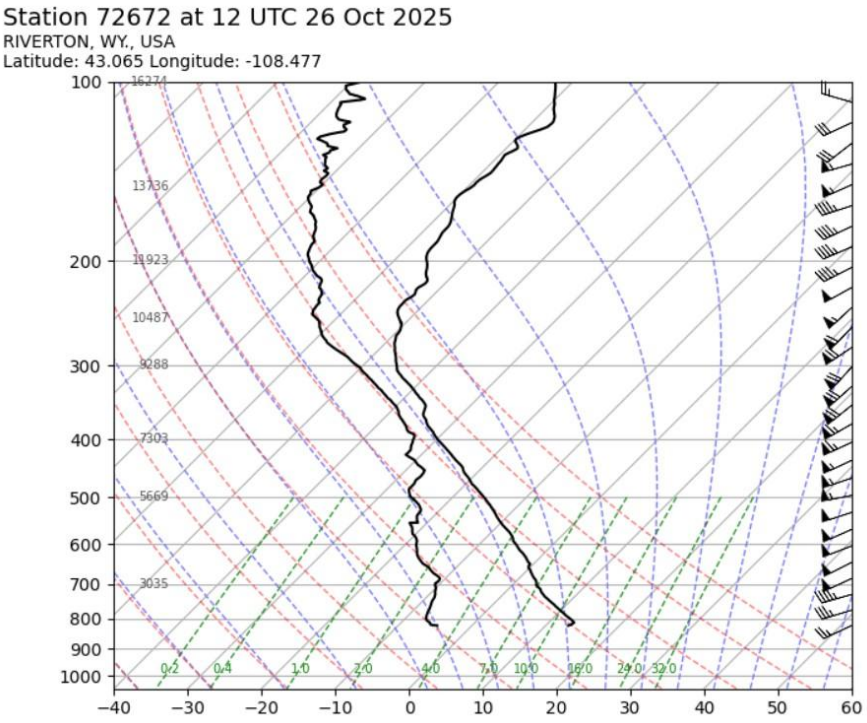

Figure 3. Skew-T Diagram from University of Wyoming database.[2]

The skew-T sounding is from Riverton, Wyoming at 12 UTC on October 26th, 2025, which is the closest in location and time to the location and time of the photograph. The diagram shows a deep mid-tropospheric layer that is almost saturated between 650 and 500 mb, so the height of this cloud layer can be approximated in the range from 11,500 feet to 20,000 feet (3.5 kilometers to 6 kilometers). According to a cloud dynamics text, altostratus commonly develop in broad, moist and stable mid-level layers. The moist-adiabatic lapse rates do not promote convective acceleration but rather horizonal cloud sheets instead of vertical cumuliform clouds.[3] The skew-T diagram and agrees with this literature since it shows a moist, stable, mid-level layer. The cloud dynamics literature, skew-T diagram, and observations of deep gray sheets that cover the sky indicate these orographic clouds can be classified as altostratus.

To verify the classification of these clouds as orographic altostratus a third piece of literature can be conferred. A literature piece on orographic precipitation explains that leeward cloud formation is common when mid-tropospheric moisture is sufficient and the stratification is stable.[4] Given the skew-T diagram findings and relevant literature, the observed clouds are consistent with mountain-wave induced (orographic) altostratus formed in a stable mid-layer.

Photography and Post-Processing

The Orographic Clouds at Base of the Mountains image was taken using the back facing camera of an iPhone 12 Pro. A phone camera was used to take this picture because I was on a hike and did not have my digital camera when I spotted this fascinating cloud formation. Only natural lighting was used for this image.

Photo Spec	Value
Camera	iPhone 12 Pro
Camera Type	Wide Camera
Focal Length	33 mm
Aperture	F1.6
Shutter Speed	1/3509 s
ISO Setting	ISO 32

Table 1. Camera settings for the Orographic Cloud image

For this image it can be assumed that the movement of the clouds is time resolved. The shutter speed is extremely fast and several orders of magnitude faster than the movement of low clouds that drift slowly relative to the location of the camera on the ground. With this difference in the order of magnitudes, there is negligible movement of the clouds during the exposure of the image.

Several post processing methods were employed to enhance the cloud formation and the foreground in the image. All post processing was done in Darktable. First the image was cropped vertically and horizontally to focus the image on the crisp edge of the cloud on the left hand side

of the image. The crop performed also allows the left hand side of the image to follow the rule of thirds, where the bottom third is the foreground of dry grass, the middle third is the blue sky, and the upper third of the image consists of the cloud. The size of the original image is 4,032 by 3,024 pixels in size, and the final cropped image is 1,300 by 822 pixels in size.

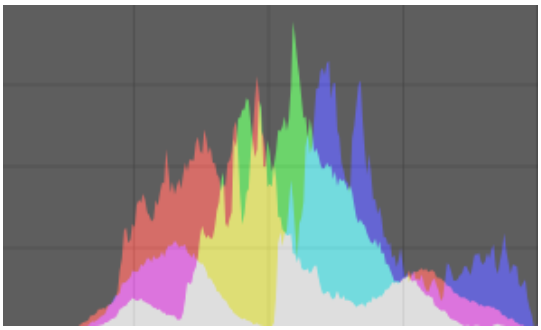

Figure 4. Image histogram after post processing

Other post processing techniques performed involve adjusting the coloring of the photo. The color zones tool was used to increase chroma yellow in color zones which helped enhance the color of the dry grass in the foreground, which was washed out in the original image. The color zones tool was also used to slightly decrease the chroma blue which made the grey clouds above more emphasized in color. The final color editing performed was to increase the blue-yellow contrast value to 1.21. The adjustment in contrast made both the sky and the dry grass pop and differentiate themselves in color, instead of being washed out. Figure 4 shows the final histogram of the image after post processing. A histogram shows the distribution of brightness and color values in the image, with the horizontal axis representing pixel brightness levels, where black is on the left and white is on the right The original and final edited image can be seen below.

Figure 5. Side by side of unedited image (left), and final image (right)

The final edited image clearly depicts the orographic cloud formation and enhanced the foreground which improves the overall color grade of the image. The post-processing performed enhances the contrast between the deep grey clouds and the bright blue sky, while keeping all characteristics of the cloud similar to the original image.

Conclusion

In conclusion, the Orographic Clouds at Base of the Mountains image clearly reveals interesting atmospheric phenomena due to the topography of the mountains. The image also shows the deep dark grey colors of the bottom of the altostratus clouds compared to the bright blue sky and foreground. One thing I enjoy about this image is the crisp line between the cloud and the blue sky, which really emphasizes why the cloud is being formed due to the end of the mountainous topography. One thing I dislike about this image is that it does not include the mountains in the frame. Since the atmospheric phenomenon being captured depends on the topography of the ground below the clouds, it would be informative for the viewer to show the topography that is causing the phenomena seen in the image. Future work of photographing orographic clouds could be to take a timelapse video of the clouds over time to show that they are being produced due to the topography and not infringing on the mountain edge. Overall, this image fulfills its scientific and artistic intent, and shows interesting low level cloud orographic formation occurring at the base of the Rocky Mountains.

References

[1] Smith, Ronald B. "Orographic Precipitation and Airflow over Mountains." *Annual Review of Fluid Mechanics* 15, no. 1 (1982): 75–102.

[2] University of Wyoming. 2025. "Station 72672 at 12 UTC 26 Oct 2025 (Riverton, WY) — Skew-T Plot." *Weather-UWYO*, 26 October 2025. Accessed via URL: http://weather.uwyo.edu/wsgi/sounding?datetime=2025-10-26%2012:00:00&id=72672&src=BUFR&type=PNG:SKEWT.

[3] Houze, Robert A. *Cloud Dynamics*. 2nd ed. Oxford: Academic Press, 2014.

[4] Roe, Gerard H. "Orographic Precipitation." Annual Review of Earth and Planetary Sciences 33 (2005): 645–671.