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MCEN 5151 Flow Visualization

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Cloud Second Report: Altocumulus Lenticularis

I. Context & Purpose

Flow visualization is an observation technique that makes transparent fluid flow patterns more visible by using auxiliary methods such as optical methods or dye tracers. As a result, flow visualization is not only widely used in scientific analysis, but is also important in the artistic field. In the Cloud Second Assignment, students will photograph and analyze clouds that interest them. On an ordinary afternoon on November 1, I went to the balcony of the dormitory to get some fresh air. I noticed a series of frisbee-like clouds over the beautiful Rocky Mountains. I watched them for a few minutes and noticed that they were evolving but not dissipating. I found these clouds very interesting and decided to record them as a research object for this assignment.

II. Basic Information

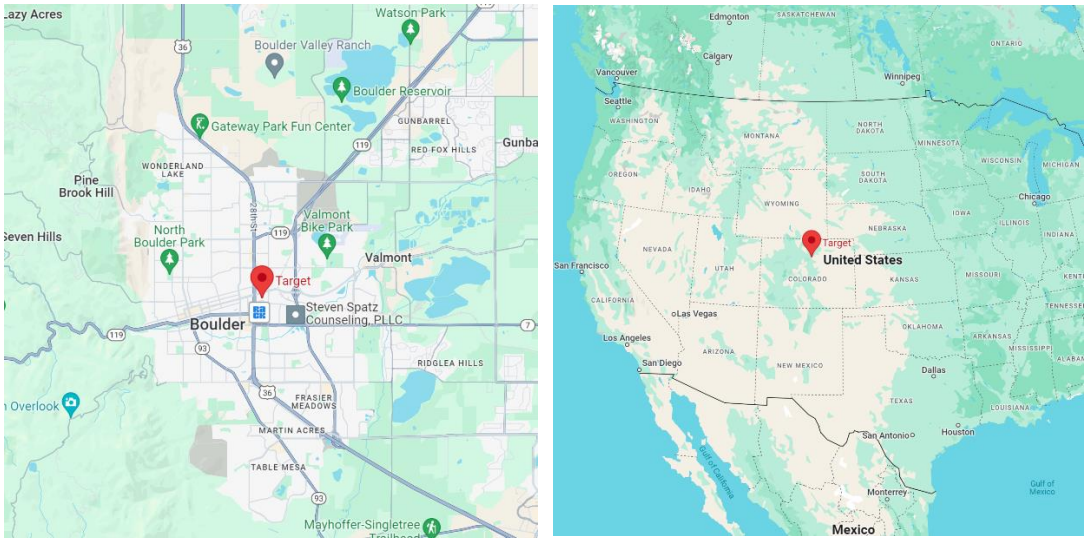

Figure 1. Location

The photo was taken at the center of the Boulder city, Colorado. The time was November 11, 2023 from 16:35 pm to 17:31 pm MDT. The camera has an elevation of about 5 degrees and an direction of about 190 degrees (south-southwest).

III. Atmospheric research

Figure 2. Photo of the clouds

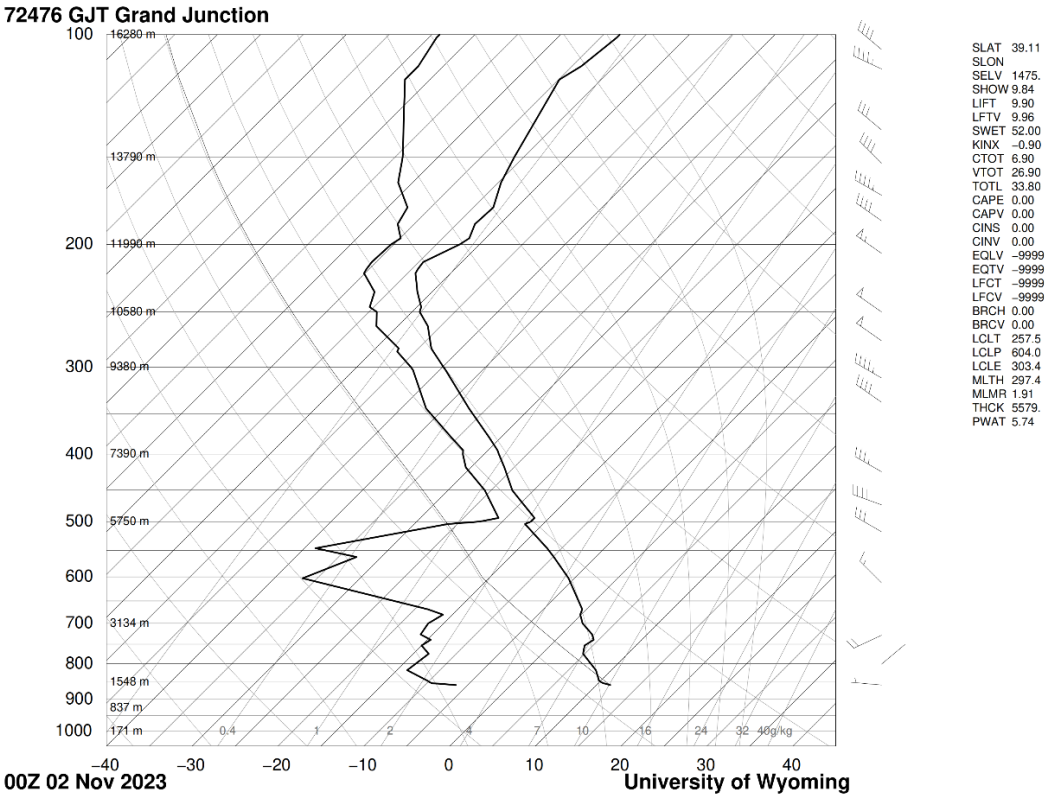

Figure 3. Skew-T diagram of Grand Junction

Figure 2 shows the clouds I captured at that time. There were thick clouds at the top of the photo, and in the lower part of these clouds, there were some distinct frisbee-shaped structures. These clouds were recognized as characteristic of lenticularis after comparison[1].

The Skew-T diagram for Grand Junction that night, shown in Figure 3, shows the two bold black lines, the dew point line on the left and the temperature line on the right, close to each other at an altitude of about 5750 m to 11000 m. This means that clouds are likely to form here because the dew point temperature of the rising air is close to the atmospheric temperature. This is consistent with the characteristics of altocumulus that they are typically form at 2000 - 7000 m[2]. And in combination with the above analysis of the cloud shapes, these clouds can be identified as altocumulus lenticularis.

On the day of the filming, the weather was mostly cloudy with occasional sunshine. Although the cloud cover was dense, there was no drastic weather or precipitation occurring. The weather records[3] also shows that there was no dramatic weather activity or precipitation on either of the two days before or after. The Boulder was under constantly cloudy or sunny skies during this period. The Skew-T diagram also shows that the slope of the black bold temperature line on the right side is steeper than both the dry adiabatic line and the moist adiabatic line, and the value of the CPAE is 0. This suggests that the atmosphere was stable during this period. This is consistent with observations of the absence of dramatic weather activity and precipitation.

In addition, according to the Skew-T diagram, there was a western wind of about 40-50 knots at that altitude. And the wind speeds at this altitude are much higher than at ground level. This may explain how these altocumulus lenticularis form: As strong western winds fly through

the Rocky Mountain, they are lifted by the mountains and create turbulence, and these flows descend again after being lifted, so that they form the shape of a peak, as shown in Figure 4. The moisture in the air then condenses at the highest point of the flow and forms the frisbee-shaped structures around the peak[4][5].

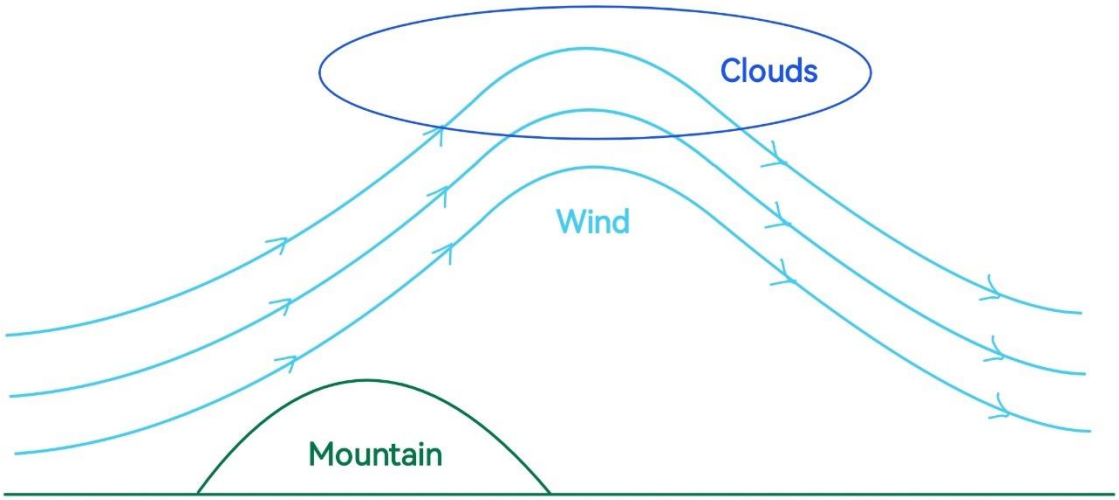

Figure 4. The principle of formation of altocumulus lenticularis

IV. Photographic Technique

Assuming that the height of the cloud estimated in the previous section is correct, the distance between the cloud and the lens can be calculated from the known altitude angle:

$$D = \frac{h_c - h_g}{\sin \alpha} = \frac{5.7\ km - 1.6\ km}{\sin 5°} \approx 47\ km$$

Where h_c is height of clouds, h_g is altitude of grounds, α is elevation angle. In addition, the width of the field of view can be estimated as about 12 km based on the height, while the frisbee-shaped structures of the altocumulus lenticularis extend about 4-6 km.

The lens used was the Tamron 18-300mm F/3.5-6.3, an all-in-one lens that covers a wide range of focal lengths and fields of view from wide-angle to ultra-telephoto. The camera used

was Sony's ZVE-10 mirrorless digital camera with 6000×4000 pixel high-resolution photography capability. Time-lapse video is an excellent method for recording the evolution of clouds. Therefore, the camera was set to take 6000×4000 pixels of high-resolution photos at a rate of one per second. More than 3,000 photos were taken in the whole process, which means that nearly an hour of cloud evolution was recorded. These photos were then stitched together in Adobe Premiere and played back at 60 frames per second, resulting in approximately 50 seconds of video. The focal length of the lens was 78mm, and due to the smaller APS-C size of the camera's sensor, the 35mm equivalent focal length was 117mm. To minimize noise, the aperture was set to its maximum value at that focal length, f/5, and the ISO was set to its minimum value, 100. The shutter speed was automatically adjusted by the camera's intelligent algorithm from 1/640s at the beginning of the recording to 1/320s at the end, as the sky was getting darker.

V. Result

In this assignment, some magical altocumulus lenticularis were captured. Weather patterns are complex and unpredictable, so beautiful clouds are often precious and fleeting. In this assignment, the video clearly shows the interesting structure of altocumulus lenticularis, how these clouds evolved, and how the wind flow passed over them. The report combines information from skew-T images, weather history records, and photographs to analyze important information such as the stability of the atmosphere, the height of the clouds, the direction of the winds, etc. The random beauty of the sky and the process of analysis and validation are fascinating.

The altocumulus lenticularis is not common in many places, However, the Boulder is close to the magnificent Rocky Mountains, so this peculiar cloud is not so rare for Boulder. This makes for great observing opportunities. I will continue to pursue this type of cloud in the future. I believe that this more in-depth research has helped me understand more about atmospheric science.

References

[1] *Altocumulus Lenticularis*, WMO, cloudatlas.wmo.int/en/species-altocumulus-lenticularis-ac-len.html. Accessed 15 Dec. 2023.

[2] *Altocumulus Cloud*, Wikimedia Foundation, 20 Aug. 2023, en.wikipedia.org/wiki/Altocumulus_cloud.

[3] *Past Weather in Boulder*, Time and Date, www.timeanddate.com/weather/usa/boulder/historic?month=11&year=2023. Accessed 15 Dec. 2023.

[4] *Learn about Lenticular Clouds: Lens-Shaped, UFO-Like*, whatsthiscloud, 16 May 2023, whatsthiscloud.com/cloud-species/lenticularis/.

[5] *Lenticular Clouds Big Island 11/25/2003*, NOAA, 29 Dec. 2018, www.weather.gov/hfo/lenticular.

The background music for the video is *No.9_Esther's Waltz* by Esther Abrami. The music was published by the author on YouTube Audio Library. YouTube Audio Library is a free music library that specializes in providing creators with royalty-free music. Therefore, my using this music for the video does not create a risk of copyright violations.