Cloud First Report **Jessica Holmes**

MCEN 5151 – Flow Visualization Oct. 30, 2023

Pictured above are two altocumulus standing lenticular clouds accompanied by altostratus clouds above. This photo was taken during the solar eclipse, which darkened the surrounding sky. The solar eclipse along with the backlit clouds were intended to create a gloomy, spooky feeling as we approach Halloween. Notice there is a slight iridescence at the bottom interface of the lower lenticular cloud.

Quick Image Circumstance

This image was taken 2 miles directly north of the CU Boulder campus, at approximately 4pm on Oct. 14, 2023, at a 45-degree angle facing west.

Cloud Formation and Physics

Altocumulus standing lenticularis are stationary clouds resembling lentils (hence the name) or flying saucers because of their smooth interface and oblong shape. Lenticular clouds usually form near natural obstructions, such as hills or mountains; the clouds above are oriented directly east of the Flatirons. The mountains disrupt the passing air, creating areas of turbulence on the leeward side of the mountain. As moist, stable air continues to flow over the previously present vortices, large standing waves are formed. A lenticular cloud is formed when the temperature at the crest of the wave drops below the dewpoint, creating trapped condensation.

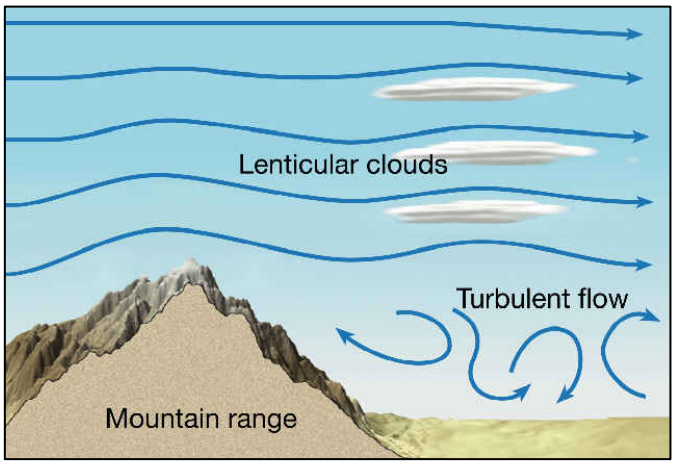

Figure 1: Diagram of lenticular cloud formation mechanism provided by (Tangren, 2013).

The lenticular clouds in the final image are categorized as altocumulus because of their estimated altitude: 3 kilometers (just above the height of the Flatirons). Figure 2 is atmospheric sounding data from the University of Wyoming database at the closest time and location to where my photo was taken; Grand Junction Airport at 00Z Oct 15, 2023 (6pm MST Oct 14, 2023). The circled areas on the heavy black temperature line (on the right) call attention altitudes for which the dew point is close to the local temperature, where it is easier to reach the maximum water saturation needed to condense into a visible cloud. The areas of inversion (i.e., areas where the local temperature is closer in slope to an isotherm) illustrate the thermal energy from the condensation process (Flow Visualization Guidebook, 2023).

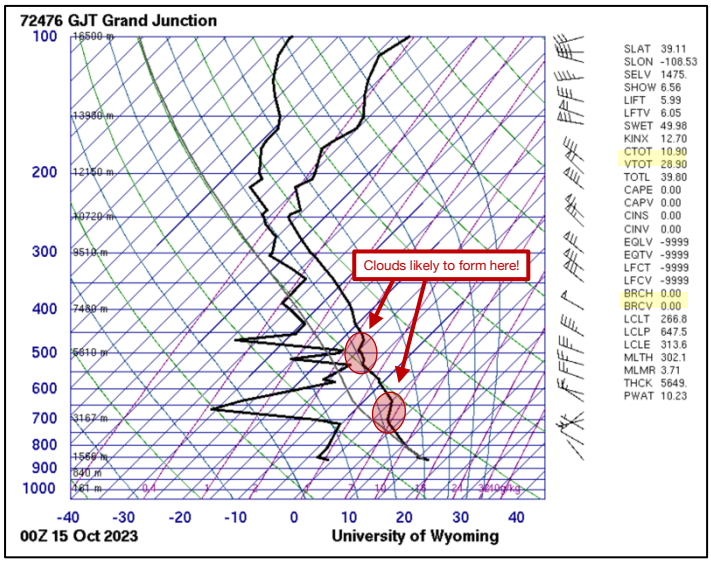

Figure 2: A Skew-T plot (UW Radiosonde Data, 2023) illustrating atmospheric conditions at the Grand Junction Airport at 00Z Oct 15, 2023 (6pm MST Oct 14, 2023); the closest spatially and temporally to when the project image was taken.

These inversions happen around 3 km and 5 km, which is consistent with the expected height of stratocumulus/altocumulus standing lenticular clouds[1] as well as altostratus clouds, a combination of wispy and clumpy, thin clouds sitting just above the lenticularis. At the lower inversion the wind is scattered in different directions, but at a lower speed of approximately 5 knots, while the higher inversion experiences fast winds of 25+ knots from the west. The associated CAPE of zero indicates the atmosphere is stable through the whole column of the troposphere (Flow Visualization Guidebook, 2023). The LCLP is the pressure at which the atmospheric level where a dry adiabat becomes saturated leading to condensation (National Weather Science, 2023). The LCLP in this case is 647.5 mb, which is consistent with the first inversion as well has the height of the pictured lenticular clouds.

Photographic Technique

As suggested by (Ibrahim, 2023), we can estimate the dimensions of the field of view to be,

$$\boldsymbol{FOV} = 2\ arctan\left(26.82mm\ /\ (2 \cdot 32mm)\right) \approx 45.47\ degrees,$$

where the diagonal length of the camera's sensor is 26.82mm and the focal length is 32mm. The estimated distance from the cloud to the lens is approximately 3 km. The photo was taken with a DSLR Canon Rebel 3Ti with the following specs and settings:

Shutter Speed:	1/400	**ISO:**	100
F Number:	11	**Aperture:**	7
Focal Length:	32	**Flash:**	No

Post Processing Procedure

Below is a comparison of the original photo to the edited version. I removed the trees lining the bottom of the original image using a retouch tool in Adobe Photoshop. To add more definition to the photo, I increased the vibrance and saturation by ~10%.

[1] Notice, the height of the obstruction, which may result in the formation of a lenticular cloud, sets a lower bound for which altitudes the cloud can form. Thus, if the lenticular cloud flows from a mountain 5km tall, it can likely be categorized as altocumulus.

Reflection

The most striking feature of the image are the smooth ripples on the underbelly, well as the iridescent interface at the rim, of the lenticular clouds. We transition from a dense object to fluffy, bulbous clouds, then to wispy clouds, as we increase in altitude. I still feel as though I could've captured more detail if I had lowered the aperture and slowed the shutter speed, which would've increased the depth of field and possibly would've resolved the texture of the clouds better. However, I do feel the level clarity is enough to see the phenomena, and inherent characteristics about it. I was lucky enough to be able to capture on of my favorite cloud types during a solar eclipse.

References

Flow Visualization Guidebook, "Clouds 3: Skew - T and Instability." Accessed October 30, 2023. https://www.flowvis.org/Flow Vis Guide/clouds-3-skew-t/.

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National Weather Science, "Skew-T Parameters and Indices." National Weather Science, Accessed October 30, 2023. https://www.weather.gov/source/zhu/ZHU_Training_Page/convective_parameters/skewt/skewtinfo.html.

Tangren, Jerry. "Stacked Lenticular East of the Cascades." *Community Cloud Atlas* (blog), April 29, 2023. https://communitycloudatlas.wordpress.com/2014/07/13/stacked-lenticular-east-of-the-cascades/.

University of Wyoming (UW) Radiosonde Data, "72476 GJT Grand Junction Sounding." Accessed October 30, 2023. https://weather.uwyo.edu/upperair/sounding.html