Altocumulus Undulatus

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Clouds Second
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Overview:
This image was taken for the second clouds assignment for the Flow Visualization course at CU Boulder. The intent of the image was to capture the short wavelength rows of clouds and the gradient of definition from the cloud mass in the bottom right corner to the tight, defined rows in the middle, to the gaps and open space at the top left.

Circumstances:
This image was taken at 3:03 P.M. on November 23, 2022 in Denver, Colorado around GPS coordinates 39.824805, -104.982342. The elevation angle of the image was about to 45°. These clouds were fairly thick in the easterly direction, while the sky was clear to the west.

Cloud Analysis:

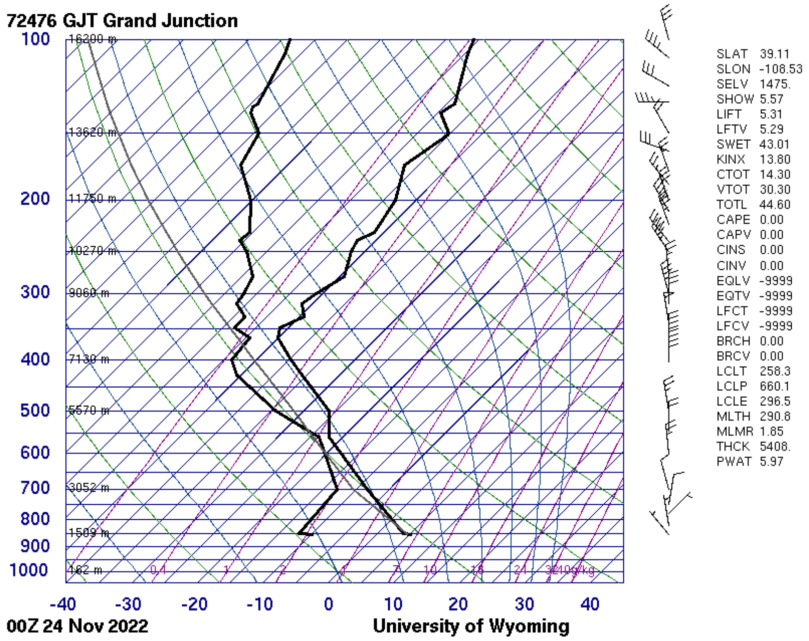

Figure 1: Skew-T diagram for 6pm November 23, 2022 in Grand Junction, CO

Figure 1 shows that the dewpoint and actual temperature are closest at about 4,500m, so clouds are most likely to form at this height. The CAPE value is 0.00, indicating that the atmosphere is stable. The wind speed increases quickly as the elevation increases around the height of the clouds, meaning the wind above the clouds is much stronger than the wind below them. These conditions, in addition to the fact that the clouds form distinct, puffy rows rather than a continuous undulating sheet, confirm that this image shows Altocumulus undulatus clouds.

Undulatus clouds form due to wind shear, or sharp increases in wind as height also increases, such as in Figure 1. This difference causes the air in between the high and low velocity areas to “ruffle” and bunch up into rises and dips. When clouds are present, they allow us to see these patterns in the flow of air. The rows of undulatus clouds form perpendicularly to the flow of wind, as opposed to cloud sheets, which form in parallel [1].

Photographic Technique:
This photo was taken on iPhone SE second generation, with automatic settings of f-stop = 1.8, focal length = 28 mm, ISO = 20, and shutter speed = 1/1675s. Because the image was taken at about 3pm and the camera was pointing northeast, the sun lights the clouds from above and to the left, creating shadows on the right-undersides of the clouds. The original image (Figure 2) was 4032 X 3024 pixels and the final image is 2895 X 1534 pixels. During post-processing, the image was cropped to draw focus to the clouds and remove the fence and concrete, the RGB curve was edited to a very slight s-curve, the contrast and saturation were increased, and the brightness was slightly decreased. The image was also rotated counterclockwise by a few degrees in order to emphasize the diagonal line of the rows.

Figure 2: Unedited Image

Conclusion:
I caught these clouds from the passenger seat of a car, and I'm very glad I did. The formation of these rows is such an interesting phenomenon. It is also more revealing of the invisible dynamics occurring above our heads than most clouds I typically see, since the wind shear effect causes such dramatic undulation.

References:
[1] Kizer Whitt, K. (2022). *Undulatus Clouds Look Like Wavy Rows*. EarthSky. Retrieved from https://earthsky.org/earth/undulatus-clouds-wavy-rows/