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Flow Visualization
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Clouds of the Front Range

Purpose

The purpose of this photograph is to capture and categorize a cloud formation. Cloud formations, like many other physical phenomena, have the ability to be both visually and scientifically appealing. Clouds are naturally beautiful. They can be viewed morning, afternoon, and evening. Clouds can be seen almost every day of the year, and yet a photograph of them can still be interesting both artistically and scientifically. The cloud photographed for this assignment will be identified and its formation and physical characteristics will be discussed. The photograph in this paper was taken in the morning facing NW, about 20 miles southeast of the Boulder, Colorado. The photograph is a panorama of the Front Range, with the flatirons at the center of the image.

Figure 1: Photograph of cirrocumulus stratiformis and altocumulus congestus cloud formations.

Cloud Classification

This image was chosen because it shows the cloud formations as they move over the mountains. It also shows two types of clouds at the same time. In addition to its atmospheric beauty, this image also shows wide open planes with the Rocky Mountains as the back drop. This beautiful scenery added aesthetic appeal as well as perspective to the image (figure 1). The first cloud formation that will be discussed is located in the upper right portion of the screen; these clouds are classified as cirrocumulus stratiformis. The second cloud formation in this image is located all along the top of the mountains, as well as in left portion of image; these clouds are classified as altocumulus congestus.

Cirrocumulus **s**tratiformis are a high level cloud formation at altitudes ranging from 20,000-40,000 ft above the ground. These cloud formations are semi-transparent,

meaning it is easy to see though them. This is evident in the image in figure 1 because the blue sky behind the clouds can be easily seen. These clouds are made of ice crystals high in the atmosphere [1], and they are sometimes so transparent that they can't be seen; the only evidence of them is in a halo around the sun or moon [2].

Altocumulus congestus are low level clouds with elevations raging from 0 – 10,000 ft above the ground. These clouds form because strong updrafts are caused by the rising of hot air and the falling of cold air, which results in convection in the atmosphere. This is what makes the clouds look like they are exploding upward. The mountains in the foreground are at an elevation of about 8000 ft, and the clouds in the photograph are just above them, so they are likely at an elevation around 10,000 ft (from sea level) [1].

The atmosphere on the day that the photograph was taken was classified as conditionally stable according to skew-T plot (figure 2). This means that (from figure 2) storms and clouds are a possible occurrence from an altitude of 1332m – 5580m, however the plot (and the conditionally stable atmosphere) does not guarantee that this is the case. Above 5580m, the stratosphere is stable. Looking at the dew point line on the skew-T, the line is horizontal at a height of about 6354m. This is likely to be the location where the cirrocumulus **s**tratiformis clouds have formed. The altocumulus congestus cloud formations are so low they may not appear on this plot, or there may not be evidence of them.

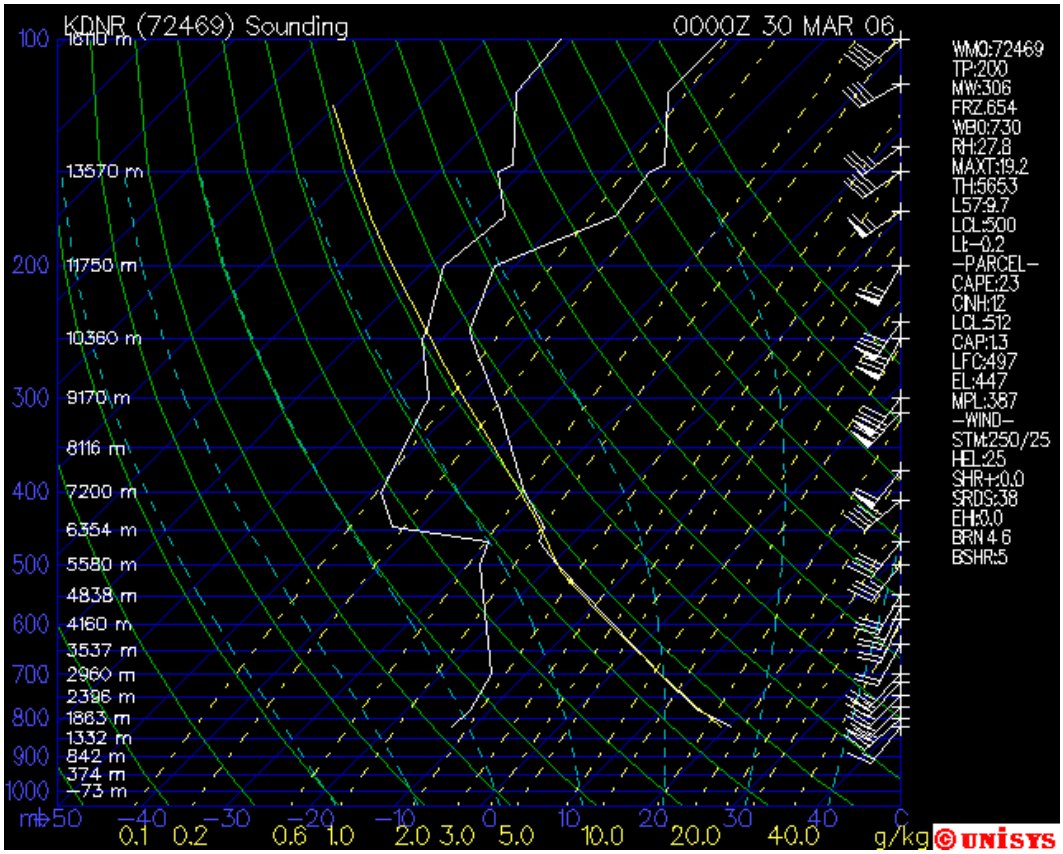

Figure 2: Skew-T plot of for the day that the photo was taken. [3]

Photographic Technique

This photograph was taken from a ridge outside Superior, Colorado about 20 mi SE of Boulder. It was taken on Wednesday March 30, 2006 at 10:59 AM on a warm day. The camera was facing northwest towards the flatirons. Because the photo was taken in the morning and the camera was facing west, the sun lights the clouds from behind the camera. The table below gives other pertinent information regarding camera settings (table 1). The spatial resolution for this photo was found to be 11.12 ft/pixel. Because of convection in the atmosphere, the clouds are moving within themselves, however, as these clouds are a long distance from the camera and moving relatively slowly, investigating the blur due to motion is not practical. It would also be difficult to estimate its speed, so no blur investigation was performed. The only light that is present in this picture is the light from the sun, no flash was used. This image consists of 5 separate photos that where merged in Photoshop to form this panorama. Photoshop was also used

to eliminate some distracting elements in the photograph; namely light poles and one small jet contrail. The color was also adjusted in Photoshop.

Table 1: Information regarding the photographic technique used for this photo

Photographic technique	**Value used**
Image height	~5-10 miles
Image width	20 miles
Field of View	150 mi^2
Distance from object to lens	30 mi
Lens focal length	8.0 mm
Type of camera	HP Photo Smart R717
-Aperture	f/4.8
-Shutter speed	1/750
-Film speed	ISO 50

Conclusion

This image shows the formation of cirrocumulus stratiformis and altocumulus congestus clouds with the flatirons in the foreground. Altocumulus congestus clouds are caused by hot air rising in the atmosphere. The intent of this project was to capture an image that is both aesthetically appealing and has some atmospheric significance. This image fulfills both of these objectives. There are no distracting elements or imperfections in this image. The scenery foreground adds beauty and perspective to the image, and the panorama gives a more complete picture of the cloud formation that day. I am happy with every aspect of this photograph.

References

[1] http://www.met.tamu.edu/class/Metr304/Exer10dir/highclouds.html
[2] http://ww2010.atmos.uiuc.edu/(Gl)/guides/mtr/cld/hgh/crss.rxml
[3] http://weather.unisys.com/upper_air/skew/skew_KDNR.html
[4] Cloud Dynamics. Robert A. Houze, Jr. Academic Press: 19-22