Cloud Image 1

Hamed Yazdi

MCEN 5151: Flow Visualization

Date of Image: 2/22/12

Purpose

This image was taken as a requirement for the flow visualization class at CU, Boulder. This assignment is the first cloud image and its purpose is to take a picture of a cloud. Although I took many pictures of clouds for this assignment, I chose this particular image because of the interesting structure of the cloud, as well as the overall composition of the image. In particular, I liked the different aspects of the clouds captured in the image, as well as the scalability of the clouds with respect to the mountains. I must admit, however, that the first images I took for this assignment were not useable because they were highly overexposed. The above image is from a series of cloud images I took after learning how to appropriately use my camera for this purpose.

Circumstances

This image was taken in Boulder, CO, facing southwest as I was on campus, standing just west of the Leeds Business School. The camera was pointed upward roughly at a 20 degree angle above the horizontal. The image was taken just after 2 PM on February 22, 2012. The cloud was quite large and extended far beyond the left border of this photograph.

Analysis

The weather was quite windy that day. In fact, it was very windy for the two days prior to the date of my image. According to weatherspark.com, there were winds of 32.2 mph to the West at the time of this image.[1] This can be inferred from my image as the cloud's front is heading west, toward the flatirons. The temperature was about 57 degrees F at the time of this image. The temperatures were lower the two days prior to the image and significantly lower (28 degrees) the day after. There was about 0.18 inches of precipitation that occurred within the 24 hours following that day, but no significant precipitation during the few days prior to that day.[2]

In order to obtain more specific information about the clouds in my image, a skew-t diagram should be observed. A skew-t diagram is a thermodynamic diagram that tilts the lines of constant temperature (isotherms) and compresses the pressure scale logarithmically.[3]

[1] http://weatherspark.com/#!dashboard;q=Boulder,+Colorado,+United+States
[2] http://atoc.colorado.edu/index.php?option=com_wrapper&view=wrapper&Itemid=99
[3] http://skew-t.com/skew-t.htm

The following is a Skew-T plot for 6 PM on February 22nd, just three hours after my image was taken:[4]

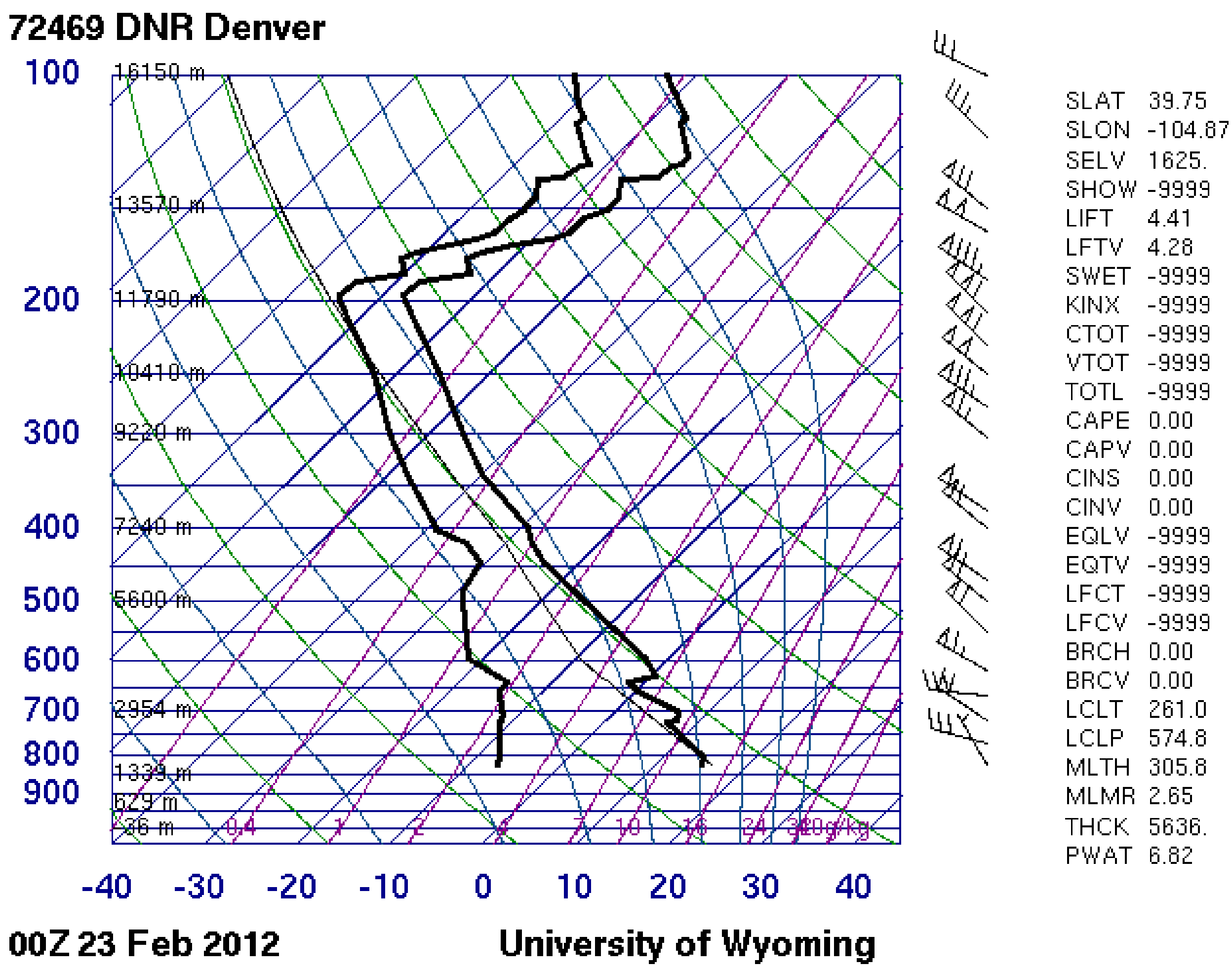


Figure 1: Skew-T Diagram for Denver, CO on 2/23
http://weather.uwyo.edu

In the skew-t diagram, the two black lines from right to left indicate the temperature and dew point for the atmosphere at various elevations, which can be read on the left vertical axis. Where the two lines come close is the elevation that has a high chance of forming a cloud, as the atmospheric temperature approaches the dew point at those locations. Based on the above image, there are two locations where clouds are likely to form: at the 6,500 m (21,450 ft.) and 12,150 m (40,095 ft.) elevations. It can be seen from my image that there may be two sets of clouds- one set closer to the ground and one set at a higher elevation. This is consistent with the information obtained from the skew-t diagram. The

[4] http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2012&MONTH=02&FROM=2300&TO=2300&STNM=72469

elevations given from the skew-t diagram are with reference to sea level, however, and thus at Boulder's altitude of 5,400 ft.[5], the clouds in my image are most likely at elevations of about 16,050 and 34,695 ft.

Another important feature of the skew-t diagram is the CAPE, which can be seen on the list of features to the right of the diagram, and reflects the stability of the atmosphere on the particular day. In this case, the CAPE has a value of 0, meaning that the atmosphere was very stable on that day. Stability of a cloud is the result of the air parcels within the cloud having temperatures that are less than the temperatures of the surrounding air masses. This makes the air parcels of the cloud denser than their surrounding air, and hence, they have a tendency to sink. Air parcels that have the tendency to sink are referred to as stable air.[6] The opposite of stable air is unstable air, in which the air parcels have a higher temperature (lower density) than their surrounding air masses and thus they tend to rise. Looking at my cloud image, one can verify that these clouds look rather stable, which is confirmed by the data given from the skew-t diagram in figure 1.

As we have determined that these clouds are stable, they are most likely among the stratus family.[7] Based on the image, the cloud with a higher elevation could very well be cirrostratus clouds. The one with a lower elevation is darker and most likely belongs to the altostratus family. As the sun can be seen through the higher cloud, it is a perlucidus variety. As for the lower cloud, the altostratus family can be further categorized into species and varieties. This altostratus cloud is most likely of the undulates variety because of its wave-like formation and the wind shear that it is subjected to on that windy day.[8] One way to confirm the identification of these clouds is that because the cloud at the higher elevation becomes brighter when it is thicker, it is most likely of a cirrus family. However, the cloud at the lower elevation gets darker as it gets thicker, so it is probably part of the alto family.[9] Thus, the cloud with a lower elevation is classified as an altostratus undulates, and the one at the higher elevation is a cirrostratus perlucidus.

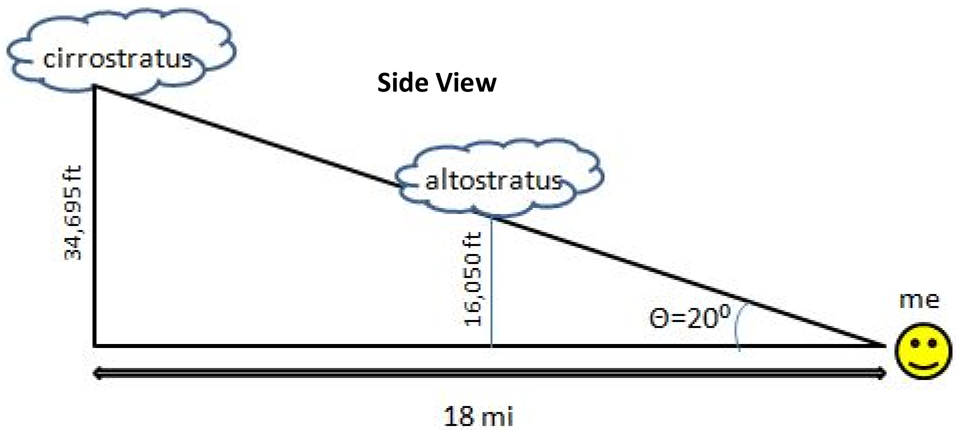
Imaging Techniques

The image was taken with a Canon EOS Digital Rebel XT. I took all photos using the manual program. In taking this photograph, I had to be very careful to not overexpose the image. Especially because the camera is pointed in the direction of the sun, it is very easy to overexpose the image (a case in which the image would look mostly white). Thus, although the cloud was moving very slowly, I had to make sure my shutter speed was very high to allow very little light to pass through the camera lens. The shutter speed used for this image was 1/4000 sec. One of the benefits of having a very abundant light source is that one can use a very low ISO, which makes the camera less sensitive and consequently gives the image a very high quality and minimal graininess. The ISO I used for this image was 100. The focal length

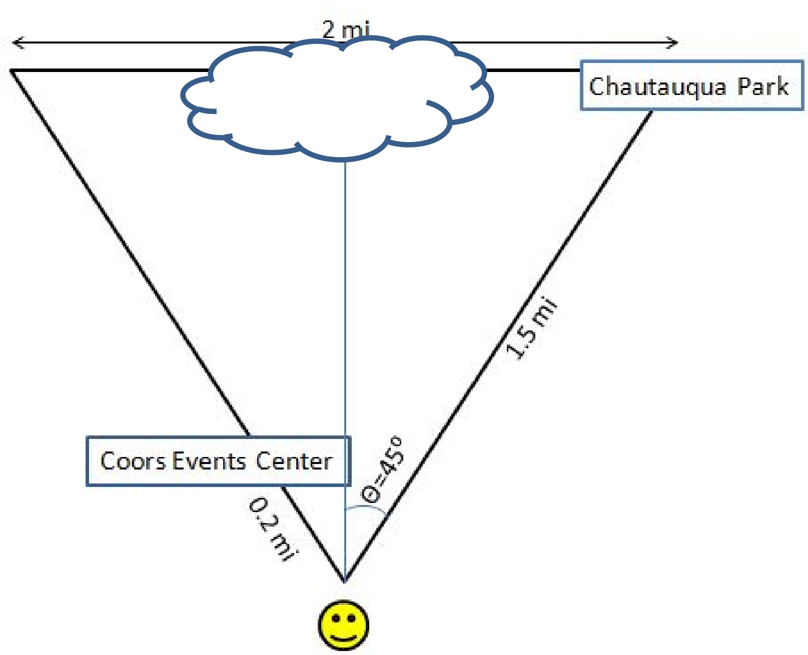
[5] http://www.normankoren.com/Boulder.html
[6] http://imnh.isu.edu/digitalatlas/clima/imaging/clddev.htm
[7] http://cloudappreciationsociety.org/collecting/
[8] http://namesofclouds.com/types-of-clouds/altostratus-clouds.html
[9] http://www.clouds-online.com/cloud_atlas/altostratus/altostratus.htm

and aperture for this image were 18 mm and f/5.0, respectively. The original and final images are both 1728 wide and 1152 pixels high.

The field of view is quite difficult to estimate in this image as it is such a large scale. However, based on my original estimate that the camera was pointed at a 20 degree angle, I can use the values of the elevations of the clouds with basic trigonometry to determine the horizontal distance from me to the clouds. The following is a schematic of the situation:



Top View:



The calculations associated with the above schematics are as follows:

$$tan\theta = \frac{elevation}{distance} => distance = \frac{elevation}{\tan(\theta)} => x = \frac{34{,}695ft}{\tan(20)} => x \approx 18\ mi,$$

$$\sin(\theta) = \frac{0.5 * width}{distance} => width = \frac{\sin(\theta) * distance}{0.5} => w = \frac{\sin(45) * 1.5\ mi}{0.5} => w \approx 2 \text{ mi},$$

And

$$\sin(\theta) = \frac{elevation}{direct\ distance} => direct\ distance = \frac{elevation}{\sin(\theta)} => d = \frac{34{,}695\ ft}{\sin(20)} => d \approx 19.2\ mi$$

Based on the above calculations, the field of view can be approximated to be about 2 mi wide x 6.6 mi high (34,695 ft), and the higher cloud could be somewhere about 18 miles away (horizontal distance) from where I was standing. The exact distance from my camera to the cirrostratus cloud is estimated to be 19.2 mi.

I did not manipulate this image very much, but I did use Photoshop for a few basic changes. First of all, I used the clone stamp tool to remove a light post from the left side of the photo. I also used the curves feature to increase the contrast between the light and dark colors to exaggerate the different shades of the clouds.

Personal Thoughts

This intent of this image was to capture an aesthetically-appealing cloud that clearly shows distinct characteristics of flow visualization. Personally, I like that the clouds look very calm and serene, yet massive and powerful at the same time. I especially like that the Flatiron Mountains are present in the image, which gives the viewer a better sense of direction and scale. One other thing I like about this image is that the sun is visible behind the clouds. Although I would have preferred that the part with sun don't get quite as overexposed, I still like the fact that it is there. The fluid physics are shown as the cloud is moving in waves, but it is not possible to see the top of the clouds to get a better idea of what exactly is going on.

It is not easy to capture exceptional cloud images. The hardest part is simply being at the right place at the right time. Overall, I believe I fulfilled my intent and I do enjoy looking at this image. I am curious to know the true size of these enormous clouds. In order to take this idea further, I could have stayed in the same place for some time and taken more pictures as the cloud moved. This would have certainly given me a better understanding of the fluid physics associated with the cloud, as well as a generally better understanding of its movement.