Flow Visualization

Clouds 1

Written By:

John Goblirsch

3/ 02/ 2011

The *Clouds 1* image assignment was designed for students to look for and photograph clouds which displayed particularly interesting fluid flow physics or were especially visually appealing in some way. There are many different classifications of clouds which vary tremendously in size and shape; and students are supposed to gain a greater appreciation for the complexity and beauty of different cloud formations throughout this course. After dozens of images taken over several weeks, I decided to choose this image for its aesthetic appeal over the fluid physics involved. The Flatirons are a gorgeous backdrop and give a very nice radial appearance; the clouds seem to spread and dissipate rather uniformly from the center peak. The sun was also directly above and, as you can see, it was only partly cloudy that day so there was plenty of lighting to display a deep blue sky contrast with the clouds (with the aid of Photoshop, of course).

This image was taken at 11:50 AM on Tuesday, February 15 in Boulder, CO. I took this picture on top of the Engineering Center parking garage facing west south west, looking at the southern portion of the Flatirons. The camera used was a *Cannon Powershot G12* set to all auto mode. There was plenty of lighting from the overhead sun, and the final image was cropped with adjusted contrast settings using *Adobe Photoshop CS5*. The Data for the finalized image is shown in Figure 1.

Shutter Speed	1/1250 sec
F-Stop	f/4.5
Max Aperture Value	f/3.2
ISO Speed Ratings	100
Focal Length	8.1 mm
Pixel Resolution (Pre-crop)	3648 x 2736
Pixel Resolution (Post-crop)	2784 x 2268

Figure 1: Camera Specifications

The clouds displayed in this image can be classified under the genus of cirrus, and more specifically of the species cirrus fibratus. Fibratus clouds gain their form from wind passing through clouds stretches them into long, fine filaments in the upper troposphere[1]**.** These clouds also resemble characteristics of cirrus radiatus clouds, which are clouds that extend in "long lines that stretch off to the

horizon," caused by clouds forming parallel to the wind direction of high wind jet streams in the top of the troposphere[2]. However, this is not as obvious a species to classify these clouds, it is just interesting to observe the visual appearance of the clouds radiating outward from the Flatirons.

Cirrus clouds are clouds that form high in the troposphere, typically in the range of 20,000 to 40,000 feet in elevation. Figure 2 shows the 10 main cloud types and their approximate elevations. Due to the high elevation, cirrus clouds consist almost entirely of ice particles. These particles can range from as small as 10 µm long to several thousand µm, and average at about 250 µm in lenth[6]. Many individual particles in cirrus clouds are sufficiently large, and the saturation vapor pressure of ice is sufficiently low, that the particles composing the clouds evaporate slowly, allowing for the wind to draw out the clouds into their characteristic stringy appearance[7]. The ice crystals in cirrus clouds can have various shapes as well, including columns, bullets, bullet-rosettes, and plates[7].

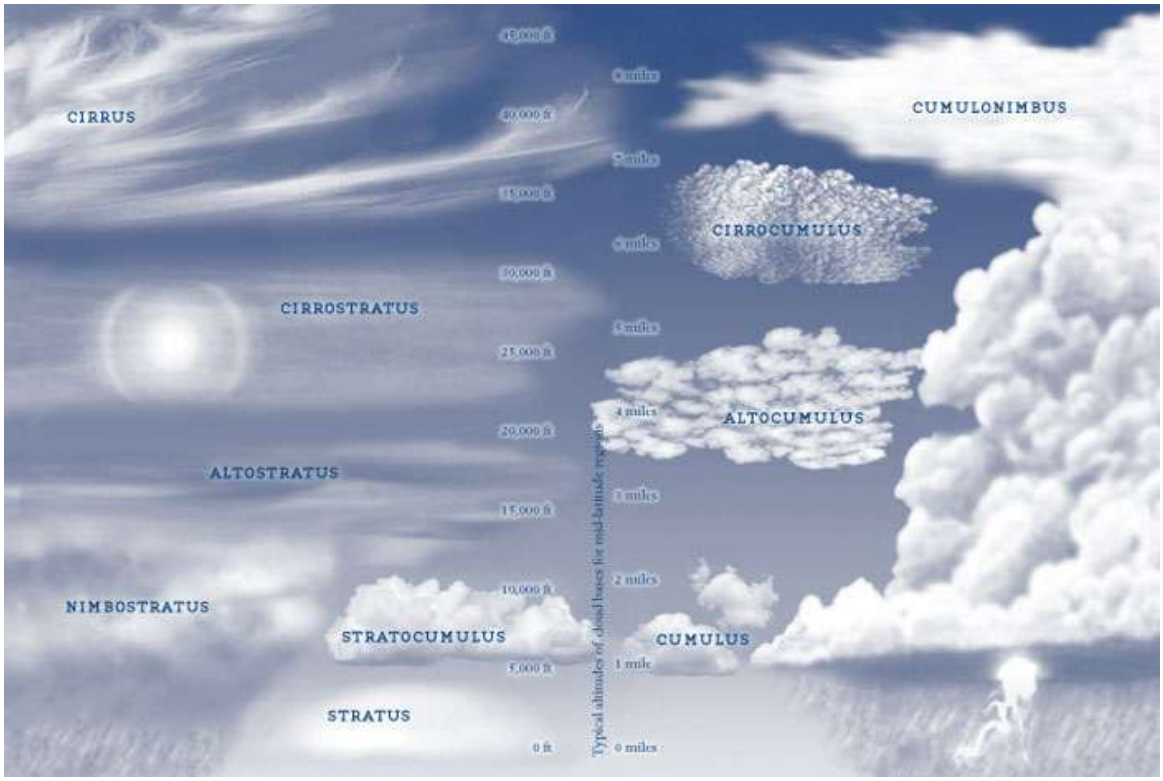

Figure 2: The ten main cloud types[3]

Cirrus clouds are formed by the uplift of warm, moist air usually traveling at about 0.1-0.2 m/s for the fibratus clouds I observed[7]. This air is moving along an incline of cooler air ahead of a warmer front, and typically indicate a storm front moving in over the next few days[7]. Looking at the SKEW-T diagrams for Denver on February 15th will show us the general atmospheric stability and cloud levels for that day. Below are the SKEW-T charts from DIA obtained at 6AM and 6PM on February 15th[4].

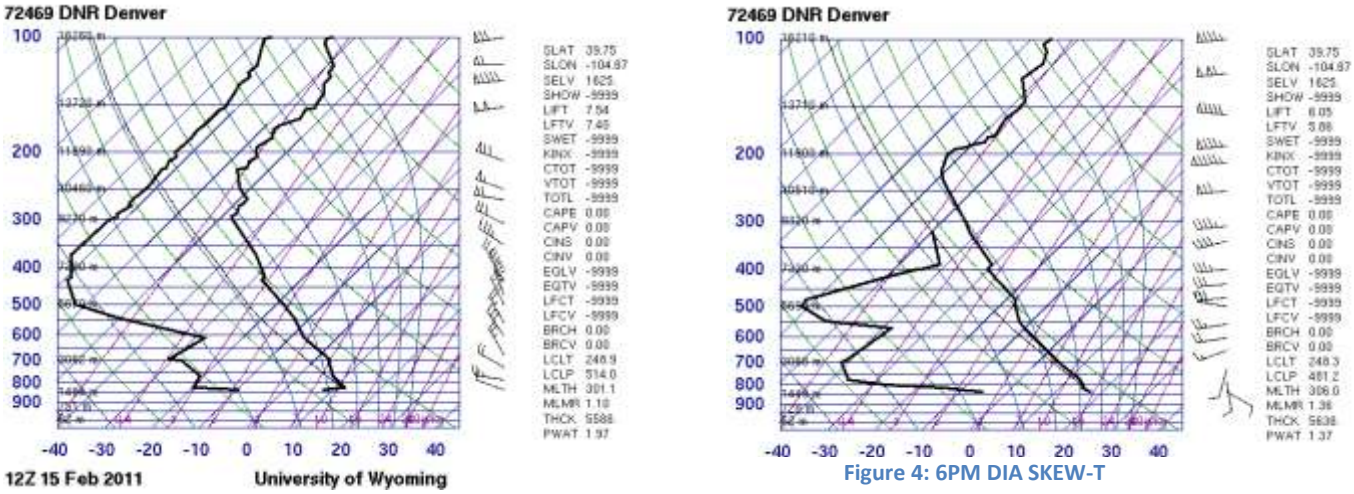

Figure 4: 6PM DIA SKEW-T

The figures above show that the atmosphere in Denver was completely stable throughout the day, noticing that the CAPE values are 0.00. It also appears that there was not a whole lot of cloud activity in the upper atmosphere taking place on that day. For more information on SKEW-T charts, please refer to [5]. One interesting observation is that the wind appears to shift from moving from the northwest to southeast in the morning to straight west to east in the afternoon. However, it is apparent from the picture that the wind is moving from the southwest to the northeast because of how the fibers stretch outward from the clouds in that direction. This is a good example of why it is important to note where and when your atmospheric data is taken; the above charts are from Denver International Airport at 6AM and 6PM, while the picture was taken at noon in Boulder.

With cirrus cloud formations, we expect there to be an impending storm front on the horizon. Looking at the forecast data for the week of February 13th from *Weather Underground*, we see that, although the weather was relatively nice throughout the week, there was a small surge later in the week on Thursday, where we can see that the temperature and barometric pressure drop while the wind speed and frequency increase considerably. A drop in barometric pressure indicates that a low pressure

system is moving in, indicating that low-pressure air is rising and will begin to cool[6]. If this warm, rising air is moist, it will condense into liquid droplets which form cumulus clouds. Low pressure storms often lead to rain or snow depending on the amount of moisture in the air and the atmospheric instability; however, this particular storm did not bring any precipitation, just more wind.

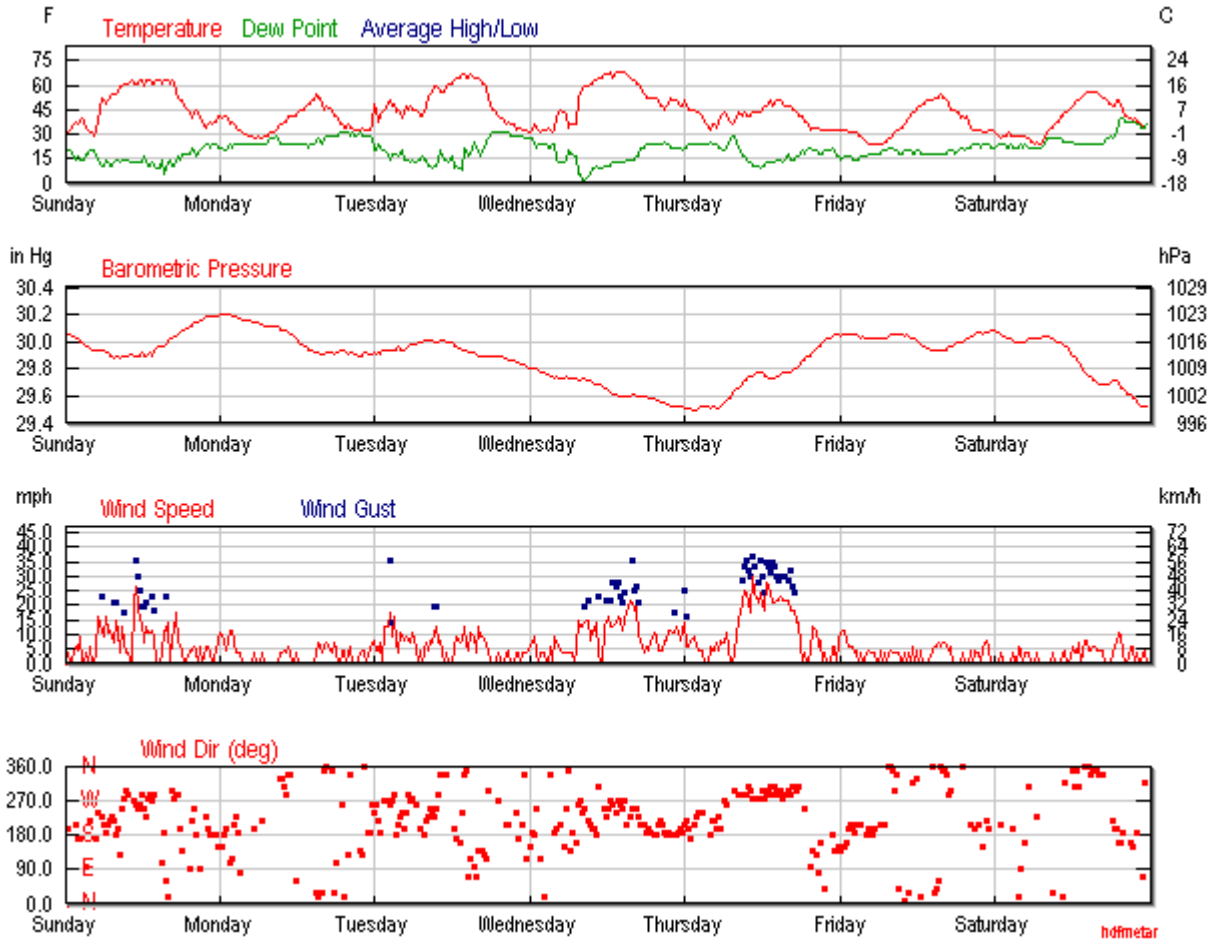

Figure 3: Atmospheric Data from Feb 13 - Feb 20[8]

References

1. Bluemel, A. "Cirrus Fibratus," *The Cloud Collector's Reference,* http://cloudappreciationsociety.org/collecting/andrew-bluemel/.

2.Chudleigh, B. "Cirrus Radiatus," *The Cloud Collector's Reference,* http://cloudappreciationsociety.org/collecting/brian-chudleigh/

3. Haythornthwaite, A. "The ten main cloud types," *The Cloud Collector's Reference,* http://cloudappreciationsociety.org/collecting/

4. University of Wyoming College of Engineering, Department of Atmospheric Science, "DNR Denver SKEW-T," 00Z 16 Feb 2011, http://weather.uwyo.edu/upperair/sounding.html

5. Haby, J. "SKEW-T Basics," *theweatherprediction.com,* http://www.theweatherprediction.com/thermo/skewt

6. "Cirrus Cloud," *Wikepedia, the Free Encyclopedia,* March 02, 2011, <http://en.wikipedia.org/wiki/Cirrus_cloud>

7. Houze R, *Cloud Dynamics*, Academic Press, 1993.

8. "History : Weather Underground." *Welcome to Weather Underground : Weather Underground*. Web. 03 Mar. 2011. <http://www.wunderground.com/history/airport/KEIK/2011/2/14/WeeklyHistory.html>.