Cirrus Fibratus

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Flow Visualization

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Project #2 (Clouds 1)

Due 10/11/07

Purpose:

This is the second project of the semester, and it entails the photography of clouds. The main objective of this project is to understand some of the underlying fundamental principles of cloud physics using photographic technique, and presenting something that is aesthetically pleasing. The idealistic goal of this project is to capture a nice photograph of one or two types of clouds, and be able to describe what kind of clouds they are from a scientific/atmospheric standpoint. The photograph specific to this paper is trying to visualize some really high elevation fibrous clouds, otherwise referred to as Cirrus Fibratus. It also reveals the formation of cloud-like trails that develop as a result of jet fuel combustion.

Taking the Photograph:

The image was captured on 9/27/07 in the parking lot just east of the Duane Physics building at the University of Colorado, Boulder. It was early evening/late afternoon, approximately around 4:45pm. The sun was still high in the sky above the western mountains. A miniature tripod was used to stabilize the camera while sitting on a structure in the parking lot. The photograph actually captured two types of clouds. The first type, Cirrus Fibratus, was located at an elevation of roughly 25k-30k feet. The second type, a contrail, was located at an elevation of roughly 10k feet. The clouds were photographed in the western sky and the final photograph (Figure 1) is shown below.

Figure 1: Cirrus Fibratus Clouds with a Contrail Streak

Physics:

The fundamental idea behind cloud formation is quite simple. As air in the atmosphere rises, it undergoes adiabatic cooling. Once the air is cool enough to condense the moisture retained within it, liquid droplets form in the atmosphere, and can be viewed as clouds. Since there are two different types of clouds in this picture, there are two different formations to discuss. The first cloud, which sort of pops out at the viewer, is nothing more than a condensation trail left from a commercial aircraft. The resulting cloud seemed to have been there for a while, and so this shows characteristics of the atmosphere being sufficiently cold and humid where the aircraft was flying. According to the International Cloud Atlas[1] packet provided by Prof. Jean Hertzberg in class, the contrails may remain intact for several hours when Cirrus or Cirrostratus clouds are present. This reinforces the observation of our particular contrail in the picture. When jet fuel goes through the combustion process, water is one of the main byproducts, and this leaves a trail of condensation behind the aircraft resembling a cloud. The main type of cloud in the photograph (Figure 1), which can be viewed behind the contrail, is known as Cirrus Fibratus. Cirrus clouds are made up of ice crystals. They resemble thin curvy strands, as in fibers or filaments. In the photograph (Figure 1), the viewer can see how this characterization fits the description. They are usually formed from the upper parts of the virga created from Cirrocumulus or Altocumulus clouds. Virga are vertical trails of precipitation that do not actually hit the earth's surface. So most of the time, the upper parts of these pre-existing precipitation trails evolve into fibrous Cirrus clouds, going through a phase change from liquid to ice as the moisture rises to much higher and colder elevations.

Sounding Data:

Sounding data[2] of the atmosphere was saved for 9/27/07 to try and relate what was seen in the photograph with the stability of the atmosphere. It is better to describe the contrail formation through fundamental principles, rather than try and relate it completely to the sounding data shown below (Figure 2). The combustion of jet fuel leaves a trail of water vapor that quickly condenses, thus forming a "cloud". How long it stays in the atmosphere retaining the cloud appearance has to do with how cold it is at that specific elevation. If it isn't sufficiently cold, the water vapor will most likely condense and then evaporate quickly, causing the contrail to disappear. Looking at the sounding data below (Figure 2), the surrounding temperature at 10k feet (3k meters) was around 5°C. That is sufficiently cold, and the primary reason for the persistence of the contrail. Looking further up, specifically around 24k-25k feet (8k meters), we can see that the theoretical air parcel passes the dew point line, and clouds form. The temperature at this elevation was around -40°C, which is why we have ice crystals

forming. This is consistent with the Cirrus Fibratus clouds in the photograph. Below that elevation, it is shown by the sounding data that the atmosphere is stable.

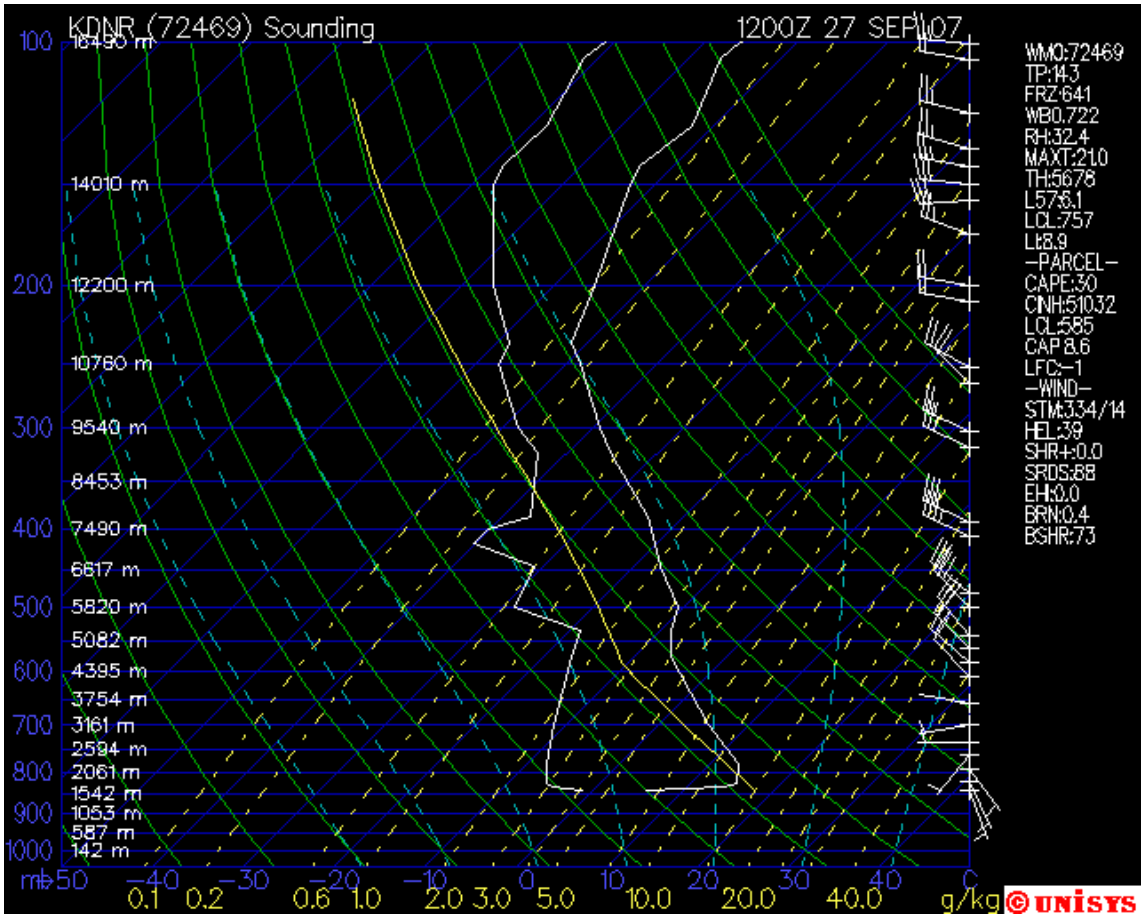

Figure 2: Sounding Data for 9/27/07

Photographic Technique:

The resolution wasn't a particular concern for this photograph, both spatially and temporally. The reason being the fact that the picture was taken anywhere from 25k-30k feet away, and fast movements of the clouds would result in relatively small movements to the observer. Also, the illumination was provided by the neighboring sun, and no other visualization techniques were used.

- Make/Model: Panasonic Lumix DMC-FX7 2560 X 1920 Pixels
- 35mm equivalent, 5.8mm – 17.4mm focal length range, 2.8 – 5.0 F-Stop range
- Actual specs for cloud photo: 10.1mm focal length, 7.5 F-Stop
- Field of View: ~10k-20k feet
- Exposure Specs: 1/500 sec exposure, max aperture value of 3.0, ISO speed rating of 80

There were a couple of Adobe Photoshop adjustments made to the original photograph to bring out the contrast of the clouds with the sky a little more. The contrast was raised some, and the brightness was lowered. Then the blue was strengthened in the photograph using the color balance option under image adjustments. This proved to give a better overall image. The image was also cropped to remove all of the unnecessary information. The two photos are given below in Figure 3 to show the comparison.

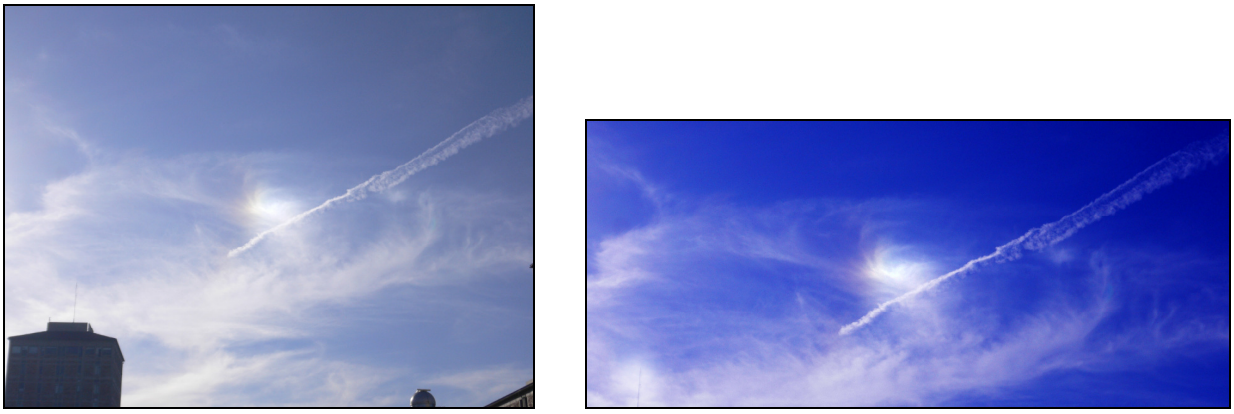

Figure 3: Comparison Between Original and Final Image

The Image:

The image is actually really interesting, as well as aesthetically pleasing. The science is beautifully portrayed, shown by the wispy strand like fibrous clouds, typical of Cirrus Fibratus. The contrail can resemble other clouds because of its similarity in formation. There are a couple things to note when analyzing the aesthetic value of the photo. The contrail can either be aesthetically pleasing or displeasing depending on who you talk to. By observance, it seems like the contrail is shooting right through the wispy Cirrus Fibratus cloud in the middle. It is definitely interesting either way you look at it. There are two other nice touches to the image. If the observer looks closely enough, they'll notice the optical effect in the middle cloud. This effect is known as a sundog, or Parhelia[3]. The other effect apparent is the resemblance of a mare's tail from the formation of the Cirrus Fibratus. This project was highly enjoyable and will be a good preface for the next cloud assignment to come.

References:

[1] Abridged Atlas. *International Cloud Atlas.* World Meteorological Organization. 1956. Reprinted in 1969. Provided in class by Prof. Jean Hertzberg.

[2] Sounding Data. Available online: http://weather.unisys.com/upper_air/skew/skew_KDNR.html

[3] Cloud Appreciation Society. Available online: http://www.cloudappreciationsociety.org/