UNIVERSTIY OF COLORADO - BOULDER

Flow Visualization

Clouds 2

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MCEN 4151 – Professor Jean Hertzberg

The purpose of the "Clouds 2" assignment was to capture an image that revealed the physics of clouds as well as to learn how the conditions of the atmosphere determine the formation of specific clouds. The image was created for the Clouds 2 assignment in Professor Jean Hertzberg's flow visualization course at the University of Colorado in the spring of 2012. The original intent of the image was to capture an interesting cloud formation that was both intriguing and enjoyable to look at. Specifically, the image displays a cumulus fractus cloud as it propagates in front of the sun on a pleasant day in Boulder, Colorado. Ultimately, this revealed some iridescent colors at the fringes of the cloud as well as the shape of the sun in the middle of the cloud. The photo was captured spontaneously as one of many pictures taken over a two week period.

This image was taken on February 16, 2012 at 12:27 pm from the bus stop at Bear Creek apartments situated at 1650m (5400 ft) in Boulder, Colorado. This location was chosen because it faced south and allowed for an unobstructed view of passing clouds. The camera was oriented at approximately 45 degrees from the horizontal, facing south-west looking towards the southern part of the Flatirons.

The cloud photographed in the image is a cumulus fractus cloud. When the image was taken, no weather fronts were approaching and the rest of the sky showed the same type of fluffy stratocumulus or altocumulus clouds the remainder of the day. The weather was mild with a temperature of 41 degrees Fahrenheit and the winds were relatively calm with speeds reaching 3.4 miles per hour out of the north-east [2]. The previous day was a little cooler and not as cloudy; however, bands of mountain wave clouds were still present. The atmospheric conditions for this day can be obtained from a Skew-T plot. The corresponding Skew-T plot for the day, time, and nearest location is shown in Figure 1 below [1].

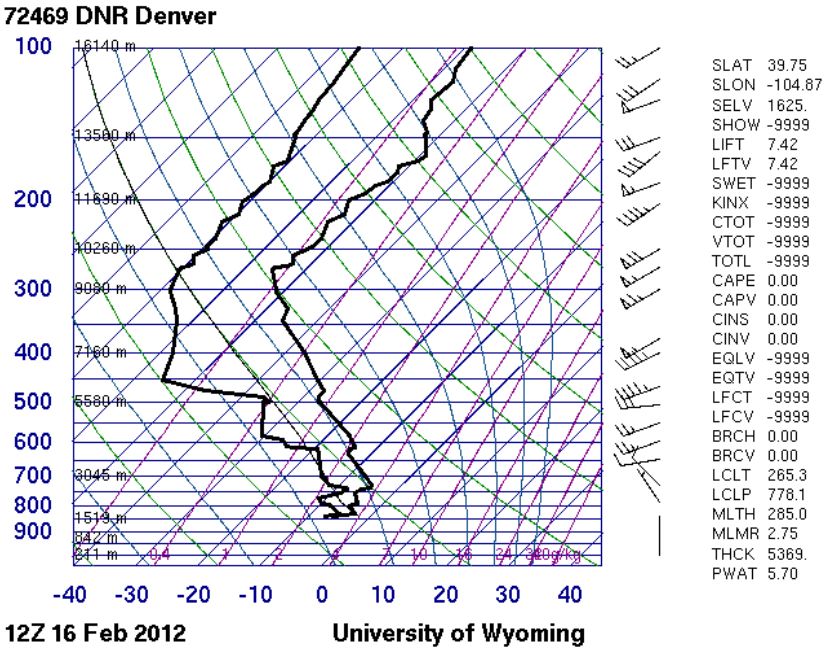

Figure 1: Skew- T plot for February 16, 2012 at 6pm in Boulder, Colorado

The Skew-T plot for 6am on February 16, 2012, indicated by 12Z 16 Feb 2012, shows that the clouds were located at an elevation of about 2600m, where the dew point (dark black line on left) is closest to the temperature (dark black line on right). The CAPE (Convective Available Potential Energy) value at this time was zero, which indicates that a stable atmosphere was present when the image was taken [3]. The expected cloud height obtained from the Skew-T plot agrees with the initial cloud type observation of a cumulus fractus cloud. Cumulus fractus clouds form from stratocumulus or cumulus clouds in stable atmospheres at an altitude of about 915-3000m [4]. The parent to the cumulus fractus cloud (stratocumulus or cumulus clouds) is very common in mountainous regions because as stable air is forced up and over the mountains, the water vapor in the air condenses to form a cloud. When the air then moves down the other side of the mountain to lower altitudes it warms up. Once this occurs, the water vapor in the cloud then turns to rise back up. When the warm air overshoots and rises to high, it begins to cool again. Over a range of mountains, the air will repeat this trend, ultimately creating long strings or clumps of lenticularis clouds as the air moves over each successive mountain peak [5]. Figure 2 illustrates this phenomenon.

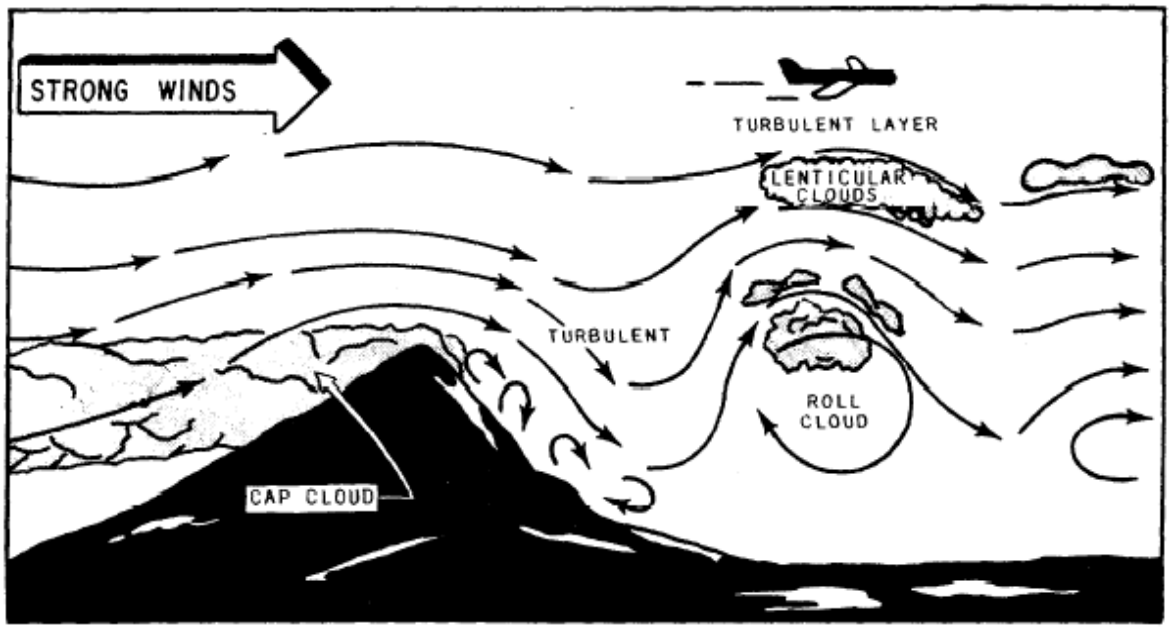

Figure 2: Mountain Wave Cloud Formation [6]

Fractus clouds are small fragments of this parent cloud type. They usually form when strong winds shear them off their parent cloud or they may form by simple dissipating from their larger parent cloud [7]. Additionally, the iridescent colors, seen in the fringe of the cloud, were created as the light from the sun was diffracted through the water droplets suspended in the cloud, revealing a beautiful array of colors. Boulder is located at 1650m (5400 ft), which means that the clouds would be located at about 950m (3100ft) above the ground. Since the clouds looked like they were hovering low, this seems like a reasonable cloud elevation estimate.

The photographer for this image was situated several thousand feet away from the cloud, making the field of view in the original image difficult to gauge. However, after viewing a wider angle photo of the same cloud the field of view in the original image was approximated to be 50 feet (wide) by 45 feet (height). A Canon PowerShot SX230 HS digital camera was held on a tripod to take this image. Assuming the camera was at an angle of 45 degrees from the horizontal and the cloud was at a height of 950m, then the cloud can be approximated to be at a distance of 1344m (≈4410ft) from object to lens. Along with the tripod, the camera had a built in image stability option that was used to reduce any motion blur caused by the wind. This orientation created an original image with pixel dimensions of 4000 x 3000. Since, the cloud had no distracting elements within it; there was no need to crop the original image. Due to this, the final pixel dimensions were 4000 x 3000. In order to clearly capture the stratocumulus cloud, the camera was placed in landscape mode and the settings were then adjusted to create the desired effect. The aperture was set to f/8 and a corresponding shutter speed of 1/3200 sec was chosen by the camera to allow a sufficient amount of light to enter the lens. Since, a sufficient amount of light was available from the sun; no external flash was used in producing the image. Additionally, the image was taken with an ISO setting of 100. Furthermore, the image was taken with the focal length of the lens being 17mm (35mm equivalent focal length = 96.9mm). The original image before being edited in Gimp can be seen in figure 3 below.

Figure 3: Original image before editing

After the original image was captured it was imported to Gimp and converted from JPG to a TIF file so that the image would maintain its format. The original image was then manipulated with the curves tool to darken the blue sky and the grays found in the cloud. The image was then enhanced with the unsharp mask tool to create a sharper overall image. The final edited image can be seen in figure 4 below.

Figure 4: Final edited image

Ultimately, the image reveals the majestic nature of a cumulus fractus cloud as it propagates in front of the sun on a beautiful day in Boulder, Colorado. I really like how the cloud was able to block out the majority of the sun's light, revealing some iridescent colors at the fringes of the cloud as well as the shape of the sun in the middle of the cloud. Additionally, the contrast between the white cloud and the brilliant blue sky adds a nice dimension to the image. By darkening the blue sky the physics of the stratocumulus cloud are intensified with all of the viewers focus going towards the center of the cloud, where the sun is, and then to the iridescent colors at the outer fringes of the cloud. Overall, the intent of capturing an interesting cloud that was both intriguing and enjoyable to look at was fulfilled. Moving forward, I would like to experiment more with various Photoshop effects, such as black and white as well as panoramic camera features. In the future, to develop this idea even further, I would present a sequence of photos that shows the variety of effects the sun has on the propagating cloud.

Works Cited:

[1] "Atmospheric Soundings." *Wyoming Weather Web*. 16 April. 2012. Web. 16 April. 2012. <http://weather.uwyo.edu/upperair/sounding.html>.

[2] *WeatherSpark*. Web. 16 April. 2012. <http://weatherspark.com/#!graphs;a=USA/CO/Boulder>.

[3] "SKEW-T BASICS." *WEATHER PREDICTION EDUCATION*. Web. 16 April. 2012. <http://www.theweatherprediction.com/thermo/skewt/>.

[4] "The Cloud Collector's Reference." *The Cloud Appreciation Society*. Web. 16 April. 2012. <http://cloudappreciationsociety.org/collecting/>.

[5] "Altocumulus Lenticularis Cloud." *Muriel Martin*. Web. 16 April. 2012. <http://mmem.spschools.org/grade5science/weather/altocumulusII.html>.

[6] *Large-Scale Vertical Waves (Mountain Waves)*. Digital image. *Repair and Maintenance Manuals*. Web. 16 April. 2012. <http://www.tpub.com/weather2/3-25.htm>.

[7] "Fractus Cloud." *Wikipedia*. Wikimedia Foundation, 24 Apr. 2012. Web. 01 May 2012. <http://en.wikipedia.org/wiki/Fractus_cloud>.