

## ***Introduction***

This project was the second cloud assignment for the flow visualization course that takes place at CU Boulder during the Spring Semester and is taught by Professor Jean Hertzberg. The purpose of this report is to describe the clouds that were captured by explaining the background of when the image was taken, atmosphere when the image was taken, cloud type, physics, and photographic technique used. For this assignment, an image of a cloud or set of clouds was captured—between February 21<sup>st</sup> and April 8<sup>th</sup>—and documented. In the sections of the report following, the background information leading up to the final, edited image of the clouds captured is discussed. The final, edited image of the clouds can be seen in figure 1, below, and in figure 10 within the Photographic Technique section of the report.



Figure 1 - Final, edited image

## ***Image Background***

This image was captured on the CU Boulder Campus, between the Engineering Library and Cockerell Hall, on March 15<sup>th</sup>, 2013 at approximately 1:00pm. The elevation the photographer was at when the image was taken was estimated to be about 5,000 feet. The direction that the clouds were in the image was taken was roughly South.

## ***Atmosphere and Clouds***

There are two types of clouds in this image. The cloud in the background is a stratus cloud; the cloud in the foreground is a cumulus cloud. According to Russell et al, stratus clouds are “typical clouds

that result from fronts.”<sup>[1]</sup> Also according to Russell et al, cumulus clouds are formed due to “atmospheric convection” and rely on three “physical properties: radiation from the sun heats the surface of the planet; conduction of this energy to air parcels near the surface results in their warming; the heated air parcels become buoyant and rise while they remain warmer and less dense than their surroundings. .”<sup>[1]</sup> Based on the Skew-T plots and weather data seen below, the atmosphere was unstable at the end of the day, and the weather started becoming worse. This therefore confirms my hypothesis of the clouds that are visible. The weather in Boulder on March 15<sup>th</sup> for the last few years was very similar to the weather experienced this year. This is seen in figures 2, 3, 4, and 5 below—where figure 2 is the information from 2010, figure 3 from 2011, figure 4 from 2012, and figure 5 from 2013. As also seen in figure 5, there was no front coming through around that day, nor was there any rain/snow, however the cloud cover gradually increased during the day. The wind stayed below 15mph in the afternoon, though it increased as the elevation increased—seen in the skew-T plots of figure 6. <sup>[2][3]</sup>

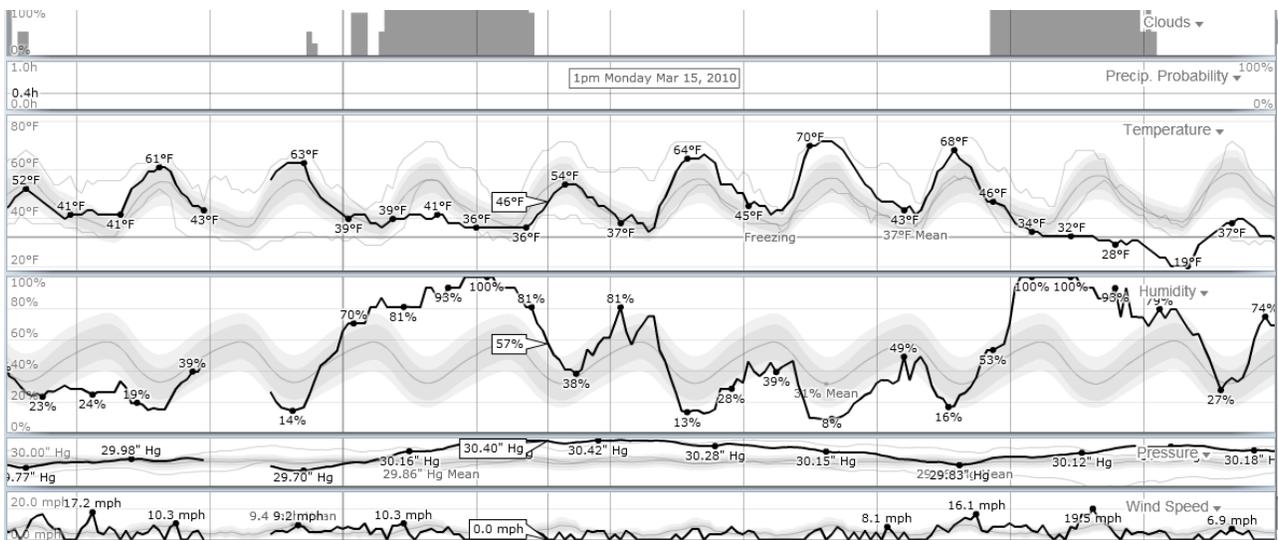


Figure 2 - Weather Data from March 15, 2010 (taken from [2])

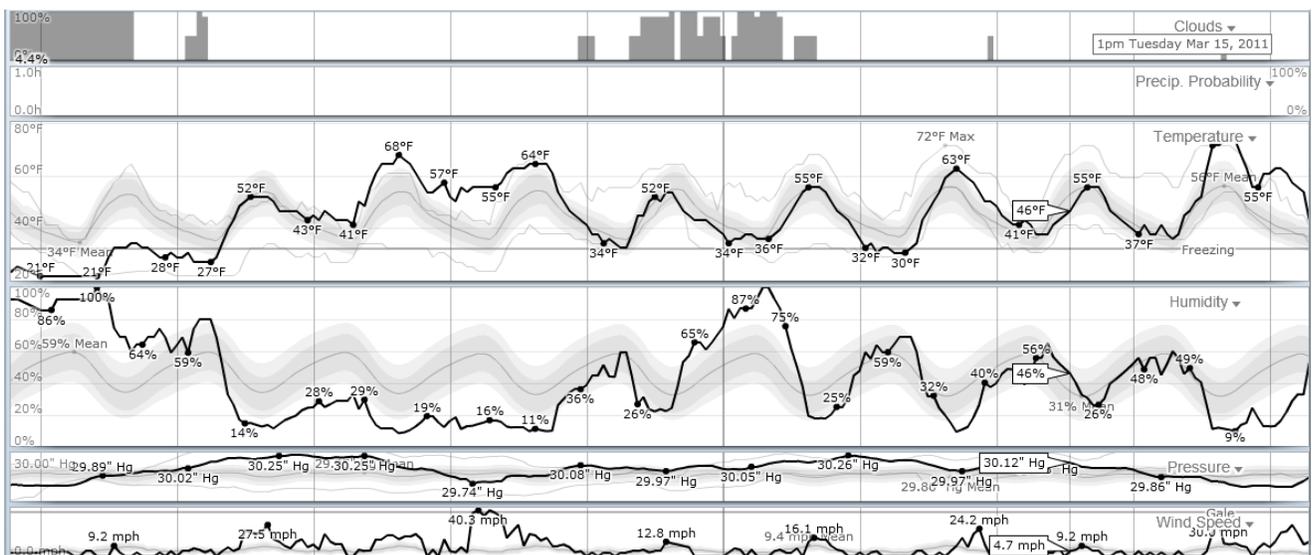


Figure 3 - Weather Data from March 15, 2011 (taken from [2])

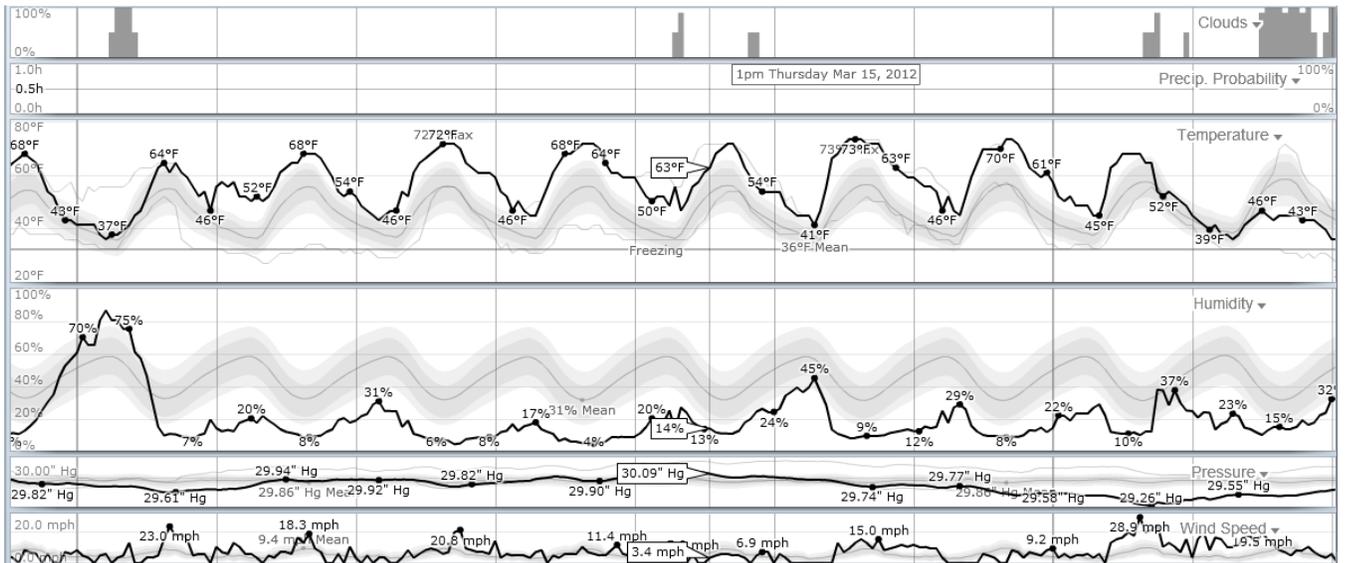


Figure 4 - Weather Data from March 15, 2012 (taken from [2])

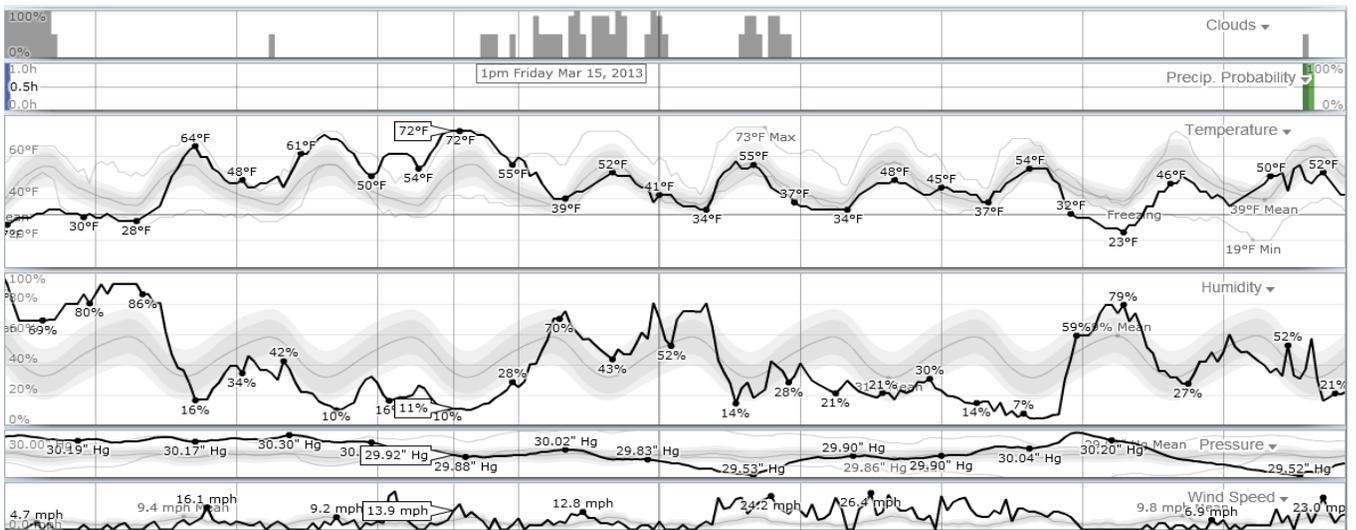


Figure 5 - Weather Data from March 15, 2013 (taken from [2])

Based on the skew-T plot, figure 6 below, the atmosphere was stable at 6am, but not at 6pm that day (though not very unstable). Judging from the image, the hypothesis is that the clouds were about 20,000 feet from sea level this is confirmed in the skew-T plots. Based on the skew-T plots for both the morning and the evening, the clouds were expected to form at an elevation above 6000m (or 19685 feet), since that's where the dew point line is nearest to the temperature line on the skew-T plots – even higher up than that for the evening skew-T plot. Although not shown with an image, there was no significant cloud ceiling during that time. The cloud types expected were mostly cumulus clouds (especially later in the day), in other words the cloud types expected were the cloud types that were observed.

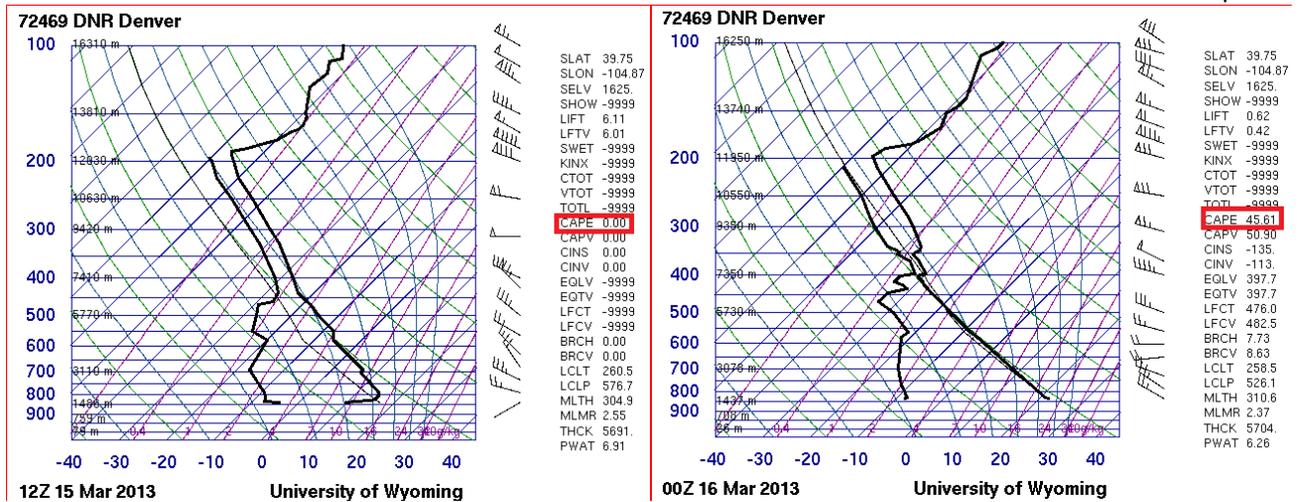


Figure 6 - Skew-T plot for 6am and 6pm on March 15, 2013 (taken from [3])

Gavin Pretor-Pinney does a good job at explaining the physics behind the stratus clouds and cumulus clouds. According to his book, stratus clouds are formed when “a large area cools, rather than individual pockets cooling as they rise in thermals.”<sup>[4]</sup> Furthermore, he defines stratus clouds as “grey layers or patches of cloud, with very diffuse edges” and states they generally form in “relatively stable air.”<sup>[4]</sup> In his book he also describes cumulus clouds and says that they are formed when heat rises into the air as water vapor- some of which is swept upwards by rising thermals. “As the thermal rises and cools, some of its water vapour condenses back into visible droplets and forms a cumulus cloud.” As the heat is released, the air becomes more buoyant and the cloud can form.<sup>[4]</sup> Pretor-Pinney defines cumulus clouds as “low, detached, puffy clouds....Their upper parts often resemble cauliflowers and they appear brilliant white when reflecting high sunlight, but can look dark when the sun is behind them.”<sup>[4]</sup> Two supporting images that can be used to further explain the formation of stratus clouds and cumulus clouds can be seen below in figures 7 and 8, respectively.<sup>[5][6]</sup>

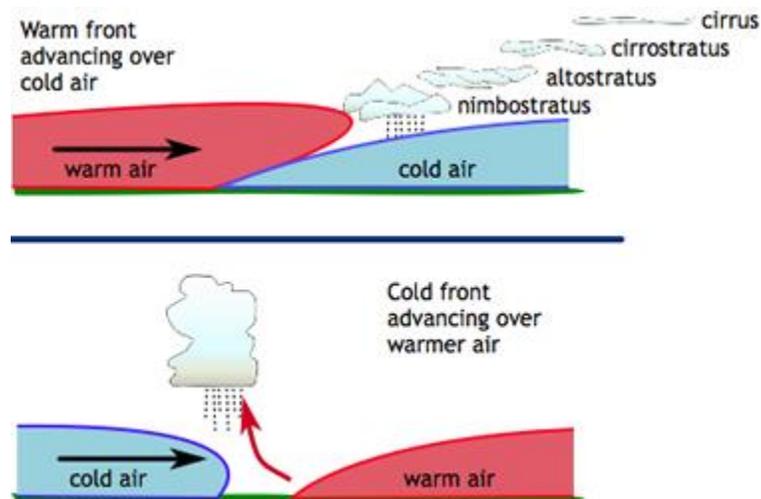


Figure 7 - Pictorial explanation of Stratus Formation (taken from [5])

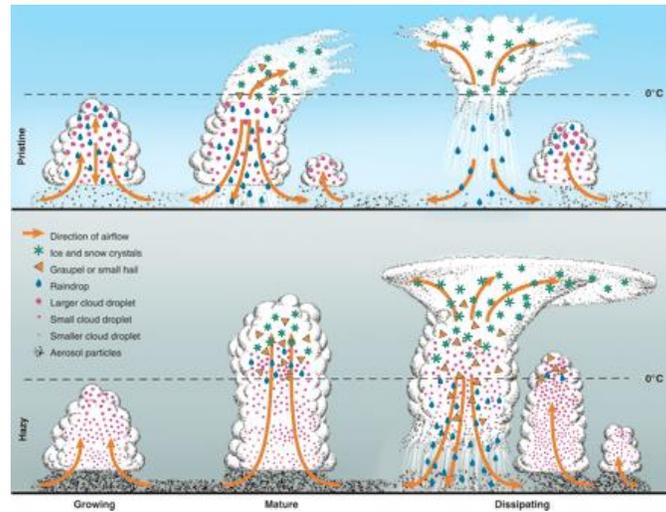


Figure 8 - Pictorial explanation of Cumulus Formation (taken from [6])

### ***Photographic Technique***

The camera used to capture this phenomenon was a Canon EOS Rebel T3 DSLR camera. The landscape setting on the camera was used, with the default settings selected. The size of the field of view of the original image where the cloud is located is approximately 4km tall by 6km wide. The clouds were located at least 2km away from the lens; however the width of the image where the building is located is closer to about 700 feet. The shutter speed, f-stop, aperture value, ISO speed, and focal length were 1/250 sec, f/16, f/16, 100, and 18mm, respectively. The original, unedited, image has pixel dimensions of 4272 pixels wide by 2848 pixels tall, and the final image has pixel dimensions of 3774 pixels wide by 2848 pixels tall. Refer to figure 9 for the original image and figure 10 (or figure 1) for the final image.

Adobe Photoshop CS2 was used to edit the original image. The tools used were: crop, spot healing brush, grayscale, and equalize. These edits produced the final image seen in figure 10.



Figure 9 - Original, unedited image



Figure 10 - Final, edited image

### ***Conclusion***

The image does a good job at showing both stratus clouds and cumulus clouds – with the cumulus clouds being much more predominant. I like the clouds presented and the fact that I chose to represent this image in black and white, I think it makes the image stand out a lot more and be much more striking. I actually dislike that the stratus clouds are there, because I think that the cumulus clouds are the focus and the stratus distracts a little bit from that, however I did not want to affect the quality of the image by removing the stratus clouds. I think that cloud and fluid physics are well defined and detailed in this image. My intent to show a gorgeous and striking cloud image that was different from my previous image was fully realized. To further develop this image, I would have removed the stratus cloud from the background, and had only the cumulus cloud there. While there is always room for improvement, I am very happy with the way that this image came out and the clouds that I managed to take a picture of.

## **References**

[1] Russell, Andrew, Hugo Ricketts, and Sylvia Knight. "Clouds." *Physics Education* 42.5 (2007): 457-65. Print.

[2] WeatherSpark Beta." *Beautiful Weather Graphs and Maps*. N.p., n.d. Web. 27 Feb. 2013. <<http://weatherspark.com/>>.

[3] "Atmospheric Soundings." *Atmospheric Soundings*. University of Wyoming, College of Engineering, n.d. Web. 27 Feb. 2013. <<http://weather.uwyo.edu/upperair/sounding.html>>.

[4] Pretor-Pinney, Gavin. *The Cloudspotter's Guide: The Science History, and Culture of Clouds*. London: Sceptre, 2006. Print.

[5] "Cloud Formation Due to Weather Fronts." *Cloud Formation and Weather Fronts*. Windows to the Universe, 21 May 2009. Web. 02 Apr. 2013. <[http://www.windows2universe.org/earth/Atmosphere/clouds/formation\\_fronts.html](http://www.windows2universe.org/earth/Atmosphere/clouds/formation_fronts.html)>.

[6] Rosenfeld, D., U. Lohmann, G. B. Raga, C. D. O'Dowd, M. Kulmala, S. Fuzzi, A. Reissell, and M. O. Andreae. "Flood or Drought: How Do Aerosols Affect Precipitation?" *Science* 321.5894 (2008): 1309-1313. Print.