Sun Setting on the Last Day of September

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First Cloud Image

Figure 1: Stratocumulus Cloud Over Boulder, Colorado on September 30, 2016

Introduction

As it turns out, there are incredible representations of fluid dynamics all over the world almost every day, just step out the door and look up. Clouds are formed when the relative dew point is close to the relative temperature. The water molecules condense, forming the large beings that absorb and refract light different than the rest of the sky, making them visible to the naked eye. When the sun is low in the sky, even deeper colors are reflected as the sun's rays have to travel through more of the atmospheric gases. For the first cloud image of Fall 2016's Flow Visualization class, I took the above image, which captures the golds, yellows, and oranges in the evening sky over Boulder, Colorado, on my 23rd birthday.

The image was taken at Kittredge North field on the University of Colorado Boulder's main campus on the evening of September 30th, 2016. In fact, the image was taken at 6:41 pm. I was working a CU Men's Lacrosse Alumni Game that night at Kitt North, facing west towards the mountains. That morning was dreary and gray (which is unusual for Colorado), but the clouds split early in the afternoon. The result was a spectacular sun set on the stratocumulus clouds flowing over the canyon.

Physics of the Present Clouds

As stated, I believe the clouds reflecting the sunset over the mountains on September 30, 2016, are stratocumulus clouds because they formed in a slightly unstable environment at relatively low elevation. The formation is fairly condensed instead of being multiple smaller cumulus or altocumulus clouds scattered across the sky. In fact, this was one of the only clouds in the visible sky that evening as the sky had completely cleared up over the plains. The Skew T diagram for Denver at 6 pm on September 30, 2016, courtesy of the University of Wyoming, can be seen below. Note that the timestamp of this Skew-T says 00Z on October 1, 2016, but that actually means sunset on September 30th.

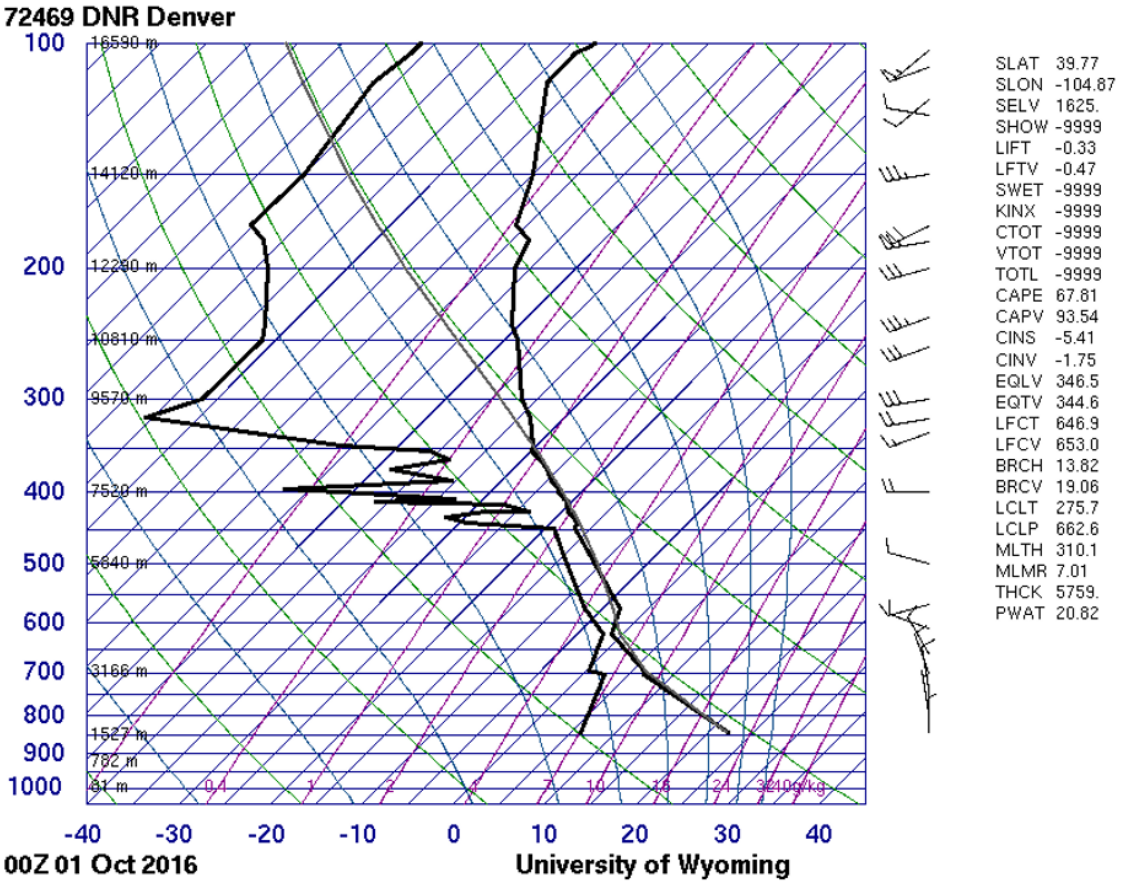

Figure 2: Skew-T from September 30, 2016

The CAPE is nonzero; thus the atmosphere was still unstable in the evening. However, the CAPE is only 67.81, which is slightly unstable as compared to potential values in the hundreds. A cold front had moved through on Wednesday, September 28th and Thursday, September 29th which made the front range and thus Boulder foggy and monotonous on Friday morning. The fog lifted early in the afternoon but the temperature did not rise greatly. The temperature dropped rapidly as the sun set, making Friday a cold night. However, the Skew-T for the following morning shows that the atmosphere was back to stable and the temperatures rose into the upper 70's for CU's midday football game against Oregon State on October 1st.

According to this Skew T diagram, I would assume the stratocumulus clouds were building at an elevation around 14,000 feet above sea level, which results as 8,500 feet above Boulder (which is already 5,430 feet above sea level) or 5,900 feet above the flatirons. This means the clouds are a little over a mile above the mountain shown in the bottom-left corner of the image. According to Gavin Pretor-Pinney, author of *The Cloudspotters Guide*, stratocumulus clouds tend to form between 5,000 to 10,000 feet above ground, often in a stable or mostly stable atmosphere. This would match my observations and the Skew-T perfectly, which closes the case; these were indeed stratocumulus clouds. The depth of field is likely two to three miles in length, and two miles high (at the tallest cloud element). This means the cloud was likely of similar dimensions, maybe 2 miles by 2 miles, by about a half mile tall.

Visualization and Photography Techniques

Believe it or not, this cloud image was taken with my Samsung Galaxy S5 smartphone. As previously stated, I was running game day operations for CU Men's Lacrosse so I did not have a chance to grab my camera to take the pictures. The resolution turned out better than I originally imagined. The original image, shown below next to the final edited image, had dimensions of 3264 pixels by 1836 pixels. The clouds were moving very slowly and sun still illuminating the sky bright enough, thus the resolution of the image was not jeopardized by any poor camera action of my smartphone.

Figure 3a: Original Image taken September 30, 2016

Figure 3b: Edited Image on October 5, 2016

The aperture was set to a f-stop of f/2.2 and shutter speed was set to 1/120 sec to try to reduce the amount of blur from my hands moving while holding the camera but allow more light to enter the camera since the sources of light were not bright compared to natural sunlight during the day. I did not have a tripod for capturing this image. The sensitivity was set to ISO-50 to reduce noise and any grain in the image as it was getting pretty dark outside.

Once the picture was taken, it was edited in Photoshop. First, the borders were cropped to center the fluid flow while limiting the distractions in the image. The color contrast was then edited using the curve adjustment tool. The dark end of the RGB color spectrum was brought in to fully utilize the entire range of contrasts and black out the mountains in the foreground. Then "Clone Stamp" was used to erase the light post. This tool worked better than I expected. It

is nearly impossible to find any ghost of the post in the edited image. Last, the sharpen tool was used to highlight the edges just slightly. Again, the original image snapped by the camera on the evening of September 30th, 2016 is shown in Figure 3a. The Photoshop color curve of the RGB color scale is shown in Figure 4. All of these edits result in the final image, again shown in Figure 1 on the first page and Figure 3b.

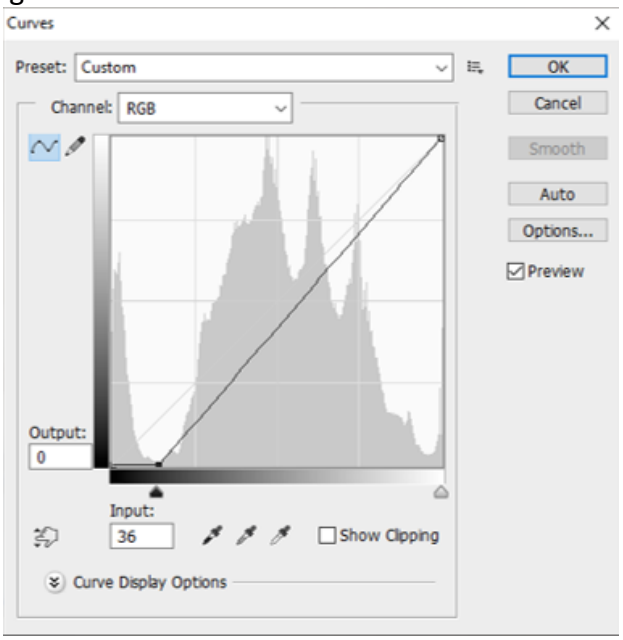

Figure 4: RGB Curve from Photoshop

Conclusion

In the end, the image reveals the true visual beauty in the sky that gets overlooked too often. I have a heightened appreciation for clouds and catch myself noticing and identifying them more often after learning about clouds in this Flow Visualization class. As for the image, I like the fact that it was already beautiful and required very little editing. I also like the contrast in the image, composed from black mountains and trees on the horizon to the bright sky, and from yellows and oranges to a deep blue sky at the top of the image. The intent of the image was fulfilled. And I really like that it was take from the University of Colorado Boulder on my birthday. Once again, I learned many lessons. I had to learn to take somewhat manual pictures using the automatic camera on my smartphone, then more specifically editing it using Photoshop and receiving critiques on the image and photography technique.

References

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