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Second Cloud Image

Figure 1: Cirrus Clouds Over Boulder, Colorado on November 8, 2016

Introduction

As it turns out, there are incredible representations of fluid dynamics all over the world every day. All you have to do is just step out your door and look up. Clouds are formed when the relative dew point is close to the relative temperature, at a given altitude. 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 second 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.

The image was taken outside of the Sustainability, Energy, and Environment Complex (SEEC) on the University of Colorado Boulder's East Campus on the evening of November 8th, 2016. In fact, the image was taken at 4:53 pm a few days after daylight saving's time was lifted. I was walking to a Tuesday evening class at the SEEC building, facing west towards the mountains. The sunset made everything strangely orange, which is captured well in the image.

Physics of the Present Clouds

As stated, I believe the clouds reflecting the sunset over the mountains on November 8, 2016, are mainly cirrus clouds because they formed in a stable environment at relatively high elevation. The formation is fairly condensed instead of being multiple smaller cumulus or altocumulus clouds scattered across the sky. I especially liked this image because the cirrus cloud on the right-hand side of the image looks like a feather, with the stem thicker stem and thin bristles coming off at an angle. These some of the only clouds in the visible sky that evening, as the sky cleared up over the plains. The Skew T diagram for Denver at 6 pm on November 8, 2016, courtesy of the University of Wyoming, can be seen below. Note that the timestamp of this Skew-T says 00Z on November 9, 2016, but that actually means sunset on November 8th.

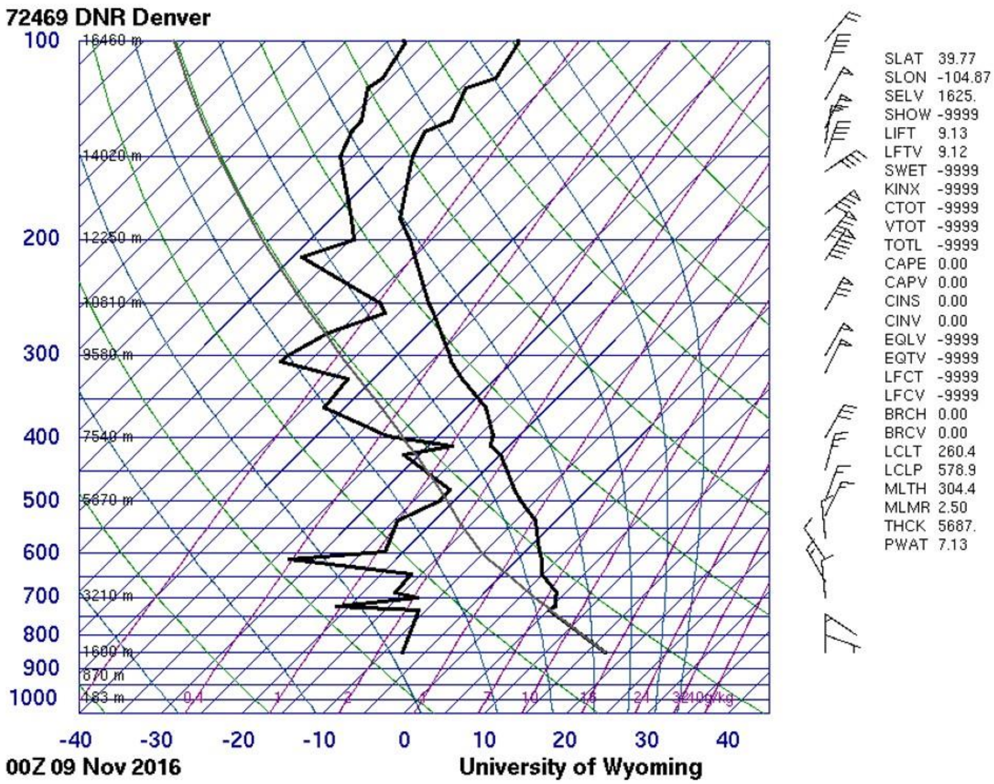

Figure 2: Skew-T from November 8, 2016

The CAPE is zero; thus the atmosphere was still stable in the evening. We were in the middle of an extremely mild November in Boulder, Colorado. According to AccuWeather, the high was 64°F on November 8th, and the low was in the high 30's. That was the case all week; having highs reach the 70's some days and the arid, dry days would end in the 30's at night. There was not a cold front moving through or anything strange. The temperature dropped rapidly as the sunset, making Tuesday a cold night. However, the Skew-T for the following morning shows that the atmosphere was still stable and the temperatures rose into the upper 70's at the University of Colorado.

According to this Skew T diagram, I would assume the cirrus clouds were building at an elevation around 25,000 feet above sea level, which results as about 20,000 feet above Boulder (Boulder is already 5,430 feet above sea level) or 15,000 feet above the flatirons. This means the clouds are a little less than three miles above the mountain shown in the bottom-left corner of the image. According to Gavin Pretor-Pinney, author of *The Cloudspotters Guide*, cirrostratus clouds tend to form between 20,000 to 25,000 feet above ground, often in a stable or mostly stable atmosphere. Cirrus clouds tend to form above 35,000 feet. This would be similar to my observations and the Skew-T, which seems to close the case; these were indeed cirrus on the far right and potentially a cirrostratus cloud centered in there as well. The depth of field is likely two to three miles in length, and four miles high (at the tallest cloud element). This means the cloud was likely of similar dimensions, maybe 2 miles by 1 mile each, by about a half mile tall.

The image also features a contrail cutting the sky in half. Contrails are clouds formed when water vapor condenses and freezes around small particles that exist in aircraft exhaust. Some of that water vapor comes from the air around the plane while the exhaust of the aircraft adds more. The exhaust of an aircraft contains both gas and solid particles. The altitude of the contrail is likely similar to the feather-like cirrus cloud, approximately 35,000 feet or higher.

Visualization and Photography Techniques

Believe it or not, this cloud image was taken with my Samsung Galaxy S5 smartphone. As previously stated, I was heading to class on CU's East Campus 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 November 8, 2016

Figure 3b: Edited Image on November 14, 2016

The aperture was set to an f-stop of f/2.2 and shutter speed was set to 1/184 sec to try to reduce the 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-40 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 posts and the smoke stacks on top of the Chemical and Biological Engineering Building. 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 November 8th, 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.

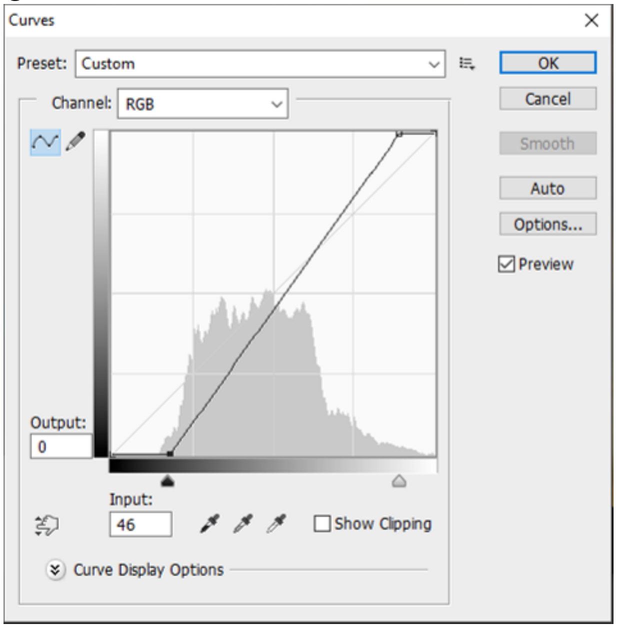

Figure 4: RGB Curve from Photoshop

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. The cirrus cloud on the right-hand side of the image looks like a feather. I also like the contrast in the image, composed from black mountains on the horizon to the bright cirrus and cirrostratus clouds in the 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’s East Campus. 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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