Cloud First

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Purpose

The purpose of this image was to capture an aesthetically pleasing image of a cloud for submission for the University of Colorado at Boulder's Flow Visualization class's Cloud 1 assignment. The hope was to capture an image that not only was beautiful, but could also be used in discussing and gathering knowledge about atmospheric conditions using weather-sounding data. My specific hope was to capture some of the interesting cloud formations caused by the proximity of the Flat Irons to Boulder and to do so at a time when the lighting conditions would really help accentuate the impact of the image.

Circumstance

The image was taken on September 17th, 2015 at about 7:23 PM. The image was taken looking in a west-northwesterly direction from near Valmont Bike Park (40.030655 N, 105.229161 W) at about the standard elevation of Boulder, CO (~5,430 ft.).

Discussion

There are definitely two types of clouds displayed in the image. The ones in the foreground are significantly lower to the ground and are in thick, fluffy, groups, while the ones in the background are most likely about twice as elevated and appear much thinner and wispier. This obviously means that we have two definite cloud types, one being in the cumulus family and one being in the stratus family. To get more specific than this, we can turn to the skew-T diagram from that day. This can be seen in Figure 1 below.

Looking at the skew-T, it is quite clear that the atmosphere was in a conditionally stable state. The measured temperature plot actually follows a significant portion of the adiabat, but it does cross it from time to time leading to a low CAPE of about 11. Because of this, we know that there was a low chance of rain, but more importantly that perturbations in the atmosphere caused by the mountains would be made visible by the cloud formations. This result can be seen in the lower clouds. Based on the skew-T and the image, the lower clouds are about 1-2 miles above ground level, and after adding all this information together, we end up with the exact cloud type being stratocumulus lenticularis undulatus. This is distinguishable because we can see the recurring lines parallel to the mountain range getting weaker towards us, in relatively big puffy groupings [1,2].

When looking for information about the higher clouds, though, it is a little tougher to tell exactly what type they are since not all the details are available to us. Judging by the skew-T diagram and the picture, we can guess that they are somewhere between 3 and 5 miles above the surface putting them into the range to be altostratus. Towards the edge of the upper clouds, though, we can see some very high frequency perturbation shaping the cloud. This leads at least that section to be altostratus undulatus, if not the rest with the undulations just not completely visible. Based on the direction of the clouds corresponding to the east-northeast wind direction, it makes sense to attribute these undulations to a possible shear layer developing into a Kelvin-Helmholtz instability because the wind becomes significantly stronger in that layer of the atmosphere, creating conditions that

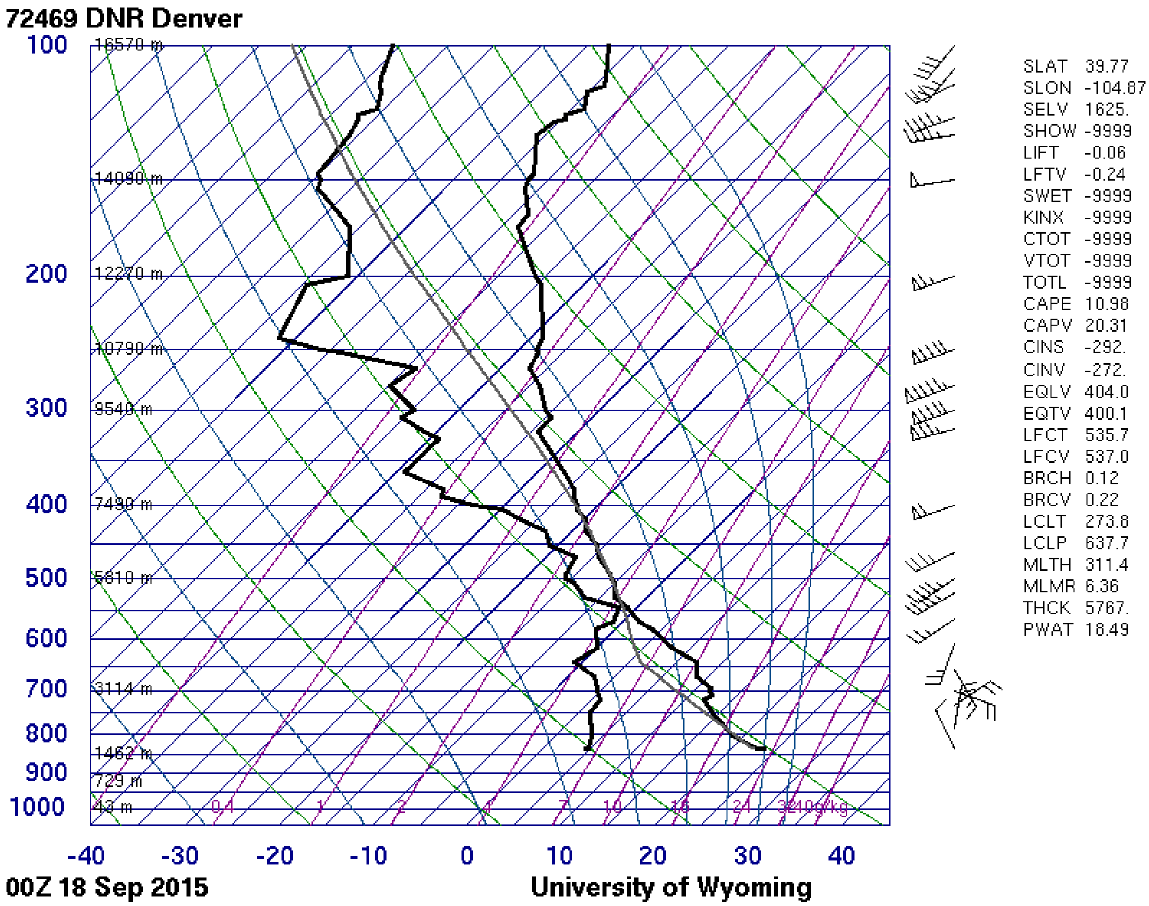

Figure 1: Skew-T diagram corresponding to 6 PM MST

would allow for such a shear to develop. In the end though, this is just speculation and does not have ample enough empirical evidence to fully support the claim [1,2].

Photographic Technique

This photograph was taken using a Sony Cybershot DSC-H90 digital point and shoot camera. Though, manual operations were originally used, the best image, which was the one chosen for submission, was obtained using automatic exposure settings. The image was taken with a resolution of 4608 x 3456 with an ISO of 100, focal length of 11.09mm, f/ of 4.5, and a shutter speed of 1/60 of a second. The main object was about 4-5 miles away based on the distance from the location where the photograph was taken to the base of the Flat Irons. With all of this information, we can then estimate the size of the field of view being approximately 1 mile in width based upon some simple trigonometric relationships from the focal length. To edit the image, a small portion was cropped out, putting the resolution down to 4592 x 2000 pixels. The only other adjustments were a modification of the overall channel using the curves tool in GIMP to make the curve essentially look like half of a parabola to allow more dynamic range in the darks and a very minor increase in the saturation level to really make all of the colors pop that extra little bit. These differences can be seen below in Figure 2. In the end, these changes were all made to have the final image more accurately represent the entirety of the sunset as viewed with the naked eye.

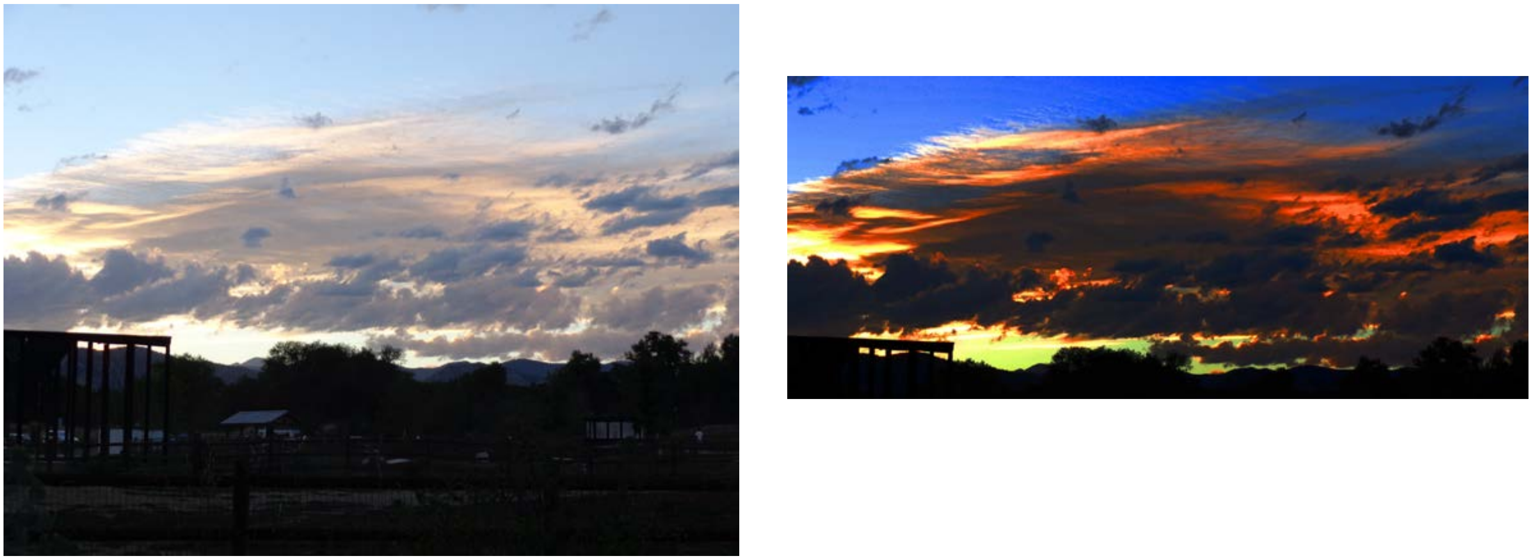

Figure 2: The original image (left), and the final image (right) for the purpose of comparing before and after editing.

Conclusion

The image manages to capture two very interesting and yet different cloud formations. The perfect parallel lines of the mountain clouds that were formed was a great sight to be able to capture and the high frequency clouds in the upper atmosphere give a good comparison point. The coloring of the image ended up being incredible with just some minor adjustments using GIMP, and overall I am very pleased with the final result. The only thing I wish I could improve upon, is finding out all the information leading to upper cloud. I would really be interested in finding out if it was truly developed by a Kelvin-Helmholtz instability or if it was some other governing mechanism. Unfortunately, I am not sure if there is a way to ever find out this information.

Bibliography

[1] G. Pretor-Pinney, *The Cloudspotter's Guide: The Science, History, and Culture of Clouds* (Berkley Publishing Group, 2007), p. 320.

[2] D. of A. S. University of Wyoming, (n.d.).