Visual Analysis and Appreciation of Clouds

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Table of Contents

Table of Figures

Introduction

Cloud formations are one of the most difficult scientific phenomenon to classify due to the numerous shapes they can take in addition to the various factors that affect their formation. The following photograph was taken of a cloud in Louisville, CO for the purposes of classifying and identifying the cloud type and the various factors associated with that type's formation. Although the original intent was to provide a sharp contrast between the cloud and the blue sky, the transparency as well as lighting of the photograph created a deceiving cloud line, making it difficult to distinguish the outline of the cloud from the sky itself. The following paper describes the experimental setup, technique, weather, and cloud analysis involved in the production of the photograph seen below in Figure 1.

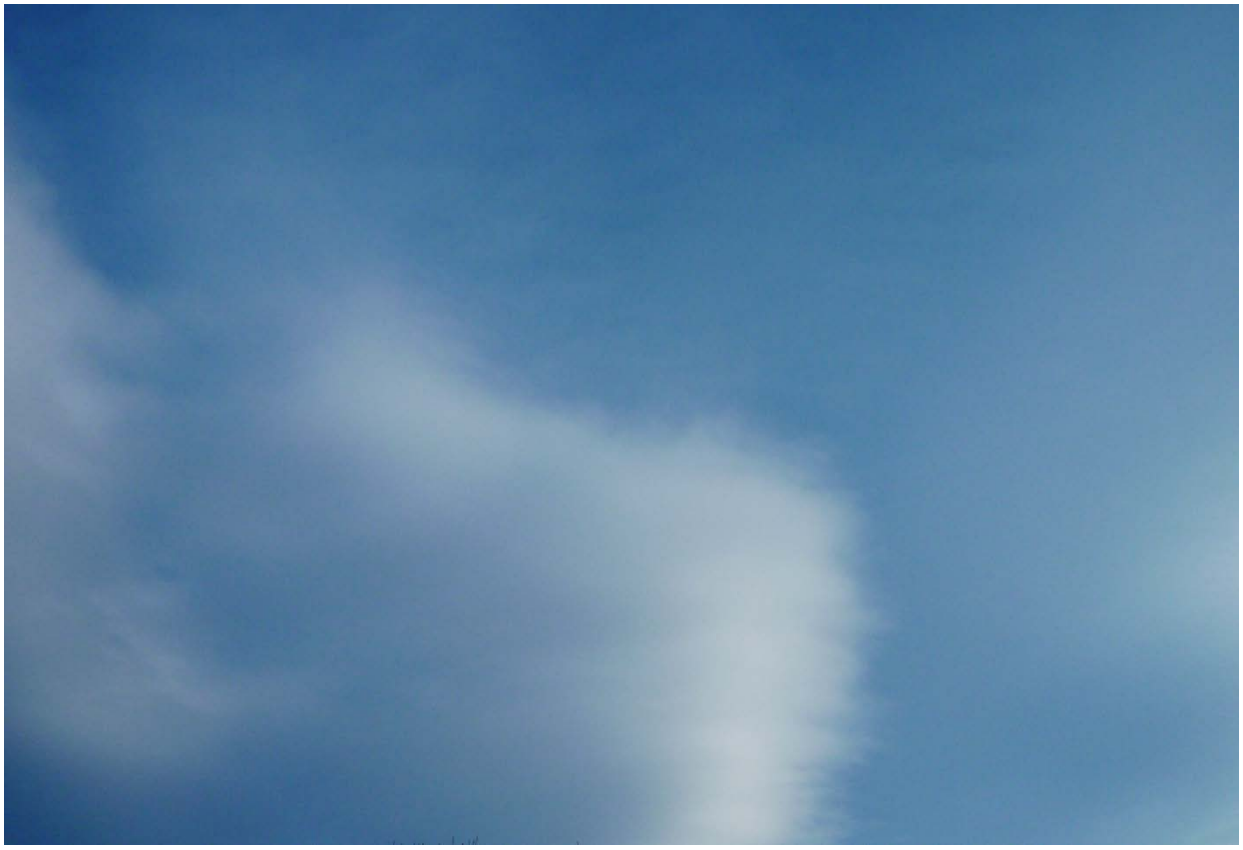

Figure 1- Possible Alto Cumulus or Alto Stratus Cloud captured in Louisville, CO

Circumstances and Weather Conditions

The photograph in Figure 1 was taken in Louisville, CO on the porch of my house. Although it has been cropped out of the photograph, the clouds were slightly above a tree, which created a better focusing point. The directionality of the camera during the taking of this photograph was exactly northwest at an angle of precisely 72.4^{o} above the horizontal point

according to the tripod utilized. Note however that my porch is not perfectly vertical (it appears to be so), suggesting that this may be off by 0.5^{o} (as an approximate). During the days leading up to the taking of this photograph, weather conditions in Louisville, CO were snowy with slight rain precipitation throughout the day. These conditions began approximately two weeks before the date of the photograph and lasted up until the day of the photograph itself, which was February 12th, 2014. As a result, the photograph was taken at a sort of aftermath, where the storm had completed its run. The time of the photograph was approximately 6:29 PM.

Identification Cloud and Influencing Factors

Due to the removal of certain aspects of the photograph, it is difficult to visualize the surrounding conditions during the photo session. Consequently, Figure 2 below is the original photograph, unmodified.

Figure 2-Original Cloud photo with no modifications to contrast or cropping

As stated earlier, the tree line was used as a focusing point in order to capture the cloud's contrast with the sky and surrounding objects as clearly as possible. Despite the somewhat dark color of the internal area of the cloud, the camera's capture of the color created a unclear cloud

line towards the left hand side of the photograph. The entire left side of the photo is a single cloud, yet certain colorations at the center of the cloud give the illusion that there are gaps within the cloud itself. This will be discussed in further detail below. For computational and weather data, Figure 3 below is the Temperature, Pressure, Wind Speed, and Wind Direction for the day of the photograph [1]. Note also that conditions leading up to this point were clear until approximately 4:55 PM when scattered clouds appeared.

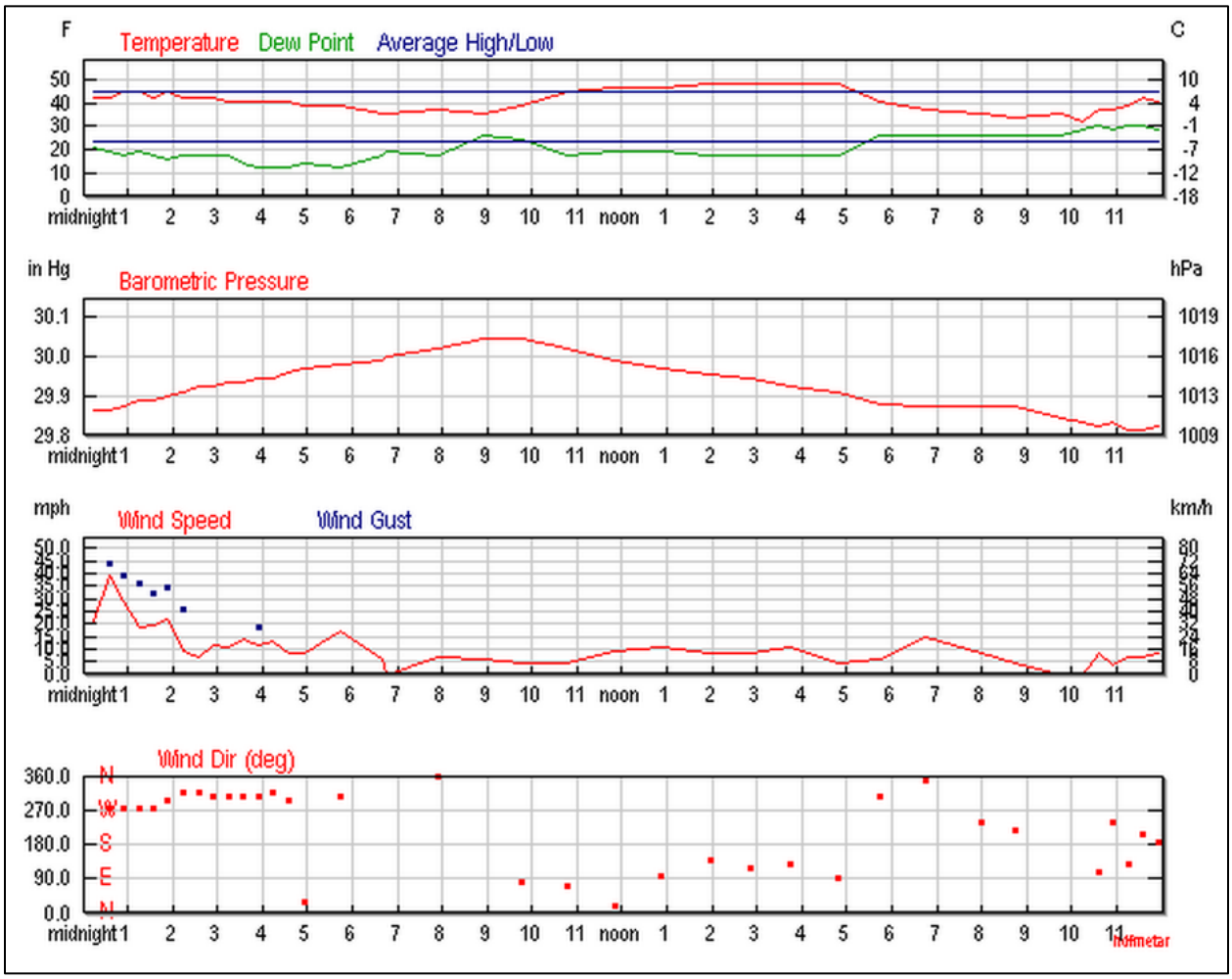

Figure 3-Temperature, Pressure, Windspeed, and Wind Direction for February 12th, 2014

From Figure 3, the general atmospheric conditions around 6:30PM exhibited a lowering of temperature, pressure, and a slight jump in wind speed. Furthermore, according to the hourly weather history and observations, there was cloud cover over Louisville, CO until about 10:15 PM. Wind Speed was also increasing slightly during this time, but not by a significant degree as indicated by the Wind Speed graph in Figure 3. Through examination of the nation's weather map during this time, the storm front mentioned earlier exhibited movement away from Colorado [2]. The weather map is shown below in Figure 4.

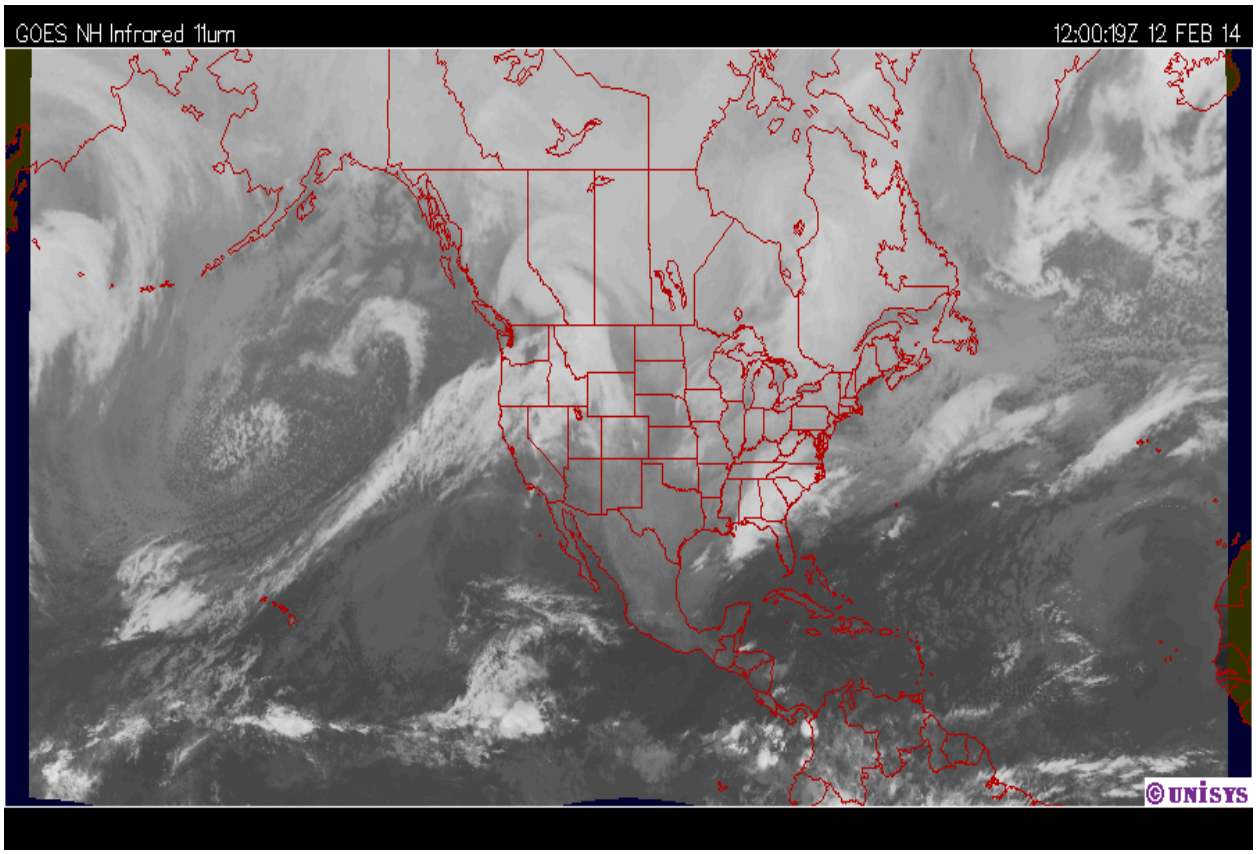

Figure 4-Weather Map of the Continental US on February 12th, 2014

Additionally, the weather leading up to the date of the photograph was scattered to overcast in terms of cloud cover, with 51 mph winds during the hours of 8:00 PM to 2:00 AM [1]. I also remember that it was difficult to take a cloud photo in the days leading up to February 12th due to the continuous cloud cover during all the periods I attempted to take a photo. However, prior to the photo, there was no snow and only slight winds (defined as calm) [1].

In general, the cloud heights that I expected were generally low altitude clouds due to the weather front's final passing. Based on general estimations of the associated altitudes with certain cloud types, I would expect the cloud to be anywhere from below 6,000 ft to 20,000 ft, depending on the actual type of cloud observed [3]. Additionally, from what I understand, general cloud altitude estimations can be calculated based on both the temperature as well as the dewpoint. This calculation is normally performed through an algorithm. As a result, based on the temperature data provided in Figure 3, the approximate cloud altitude of the cloud in the photograph was 2727.3 ft [4].

Along with an analysis of the weather conditions, an examination of the Skew-T diagram was performed to determine the stability of the atmosphere. The Skew-T for the photograph above is displayed below in Figure 5 [5].

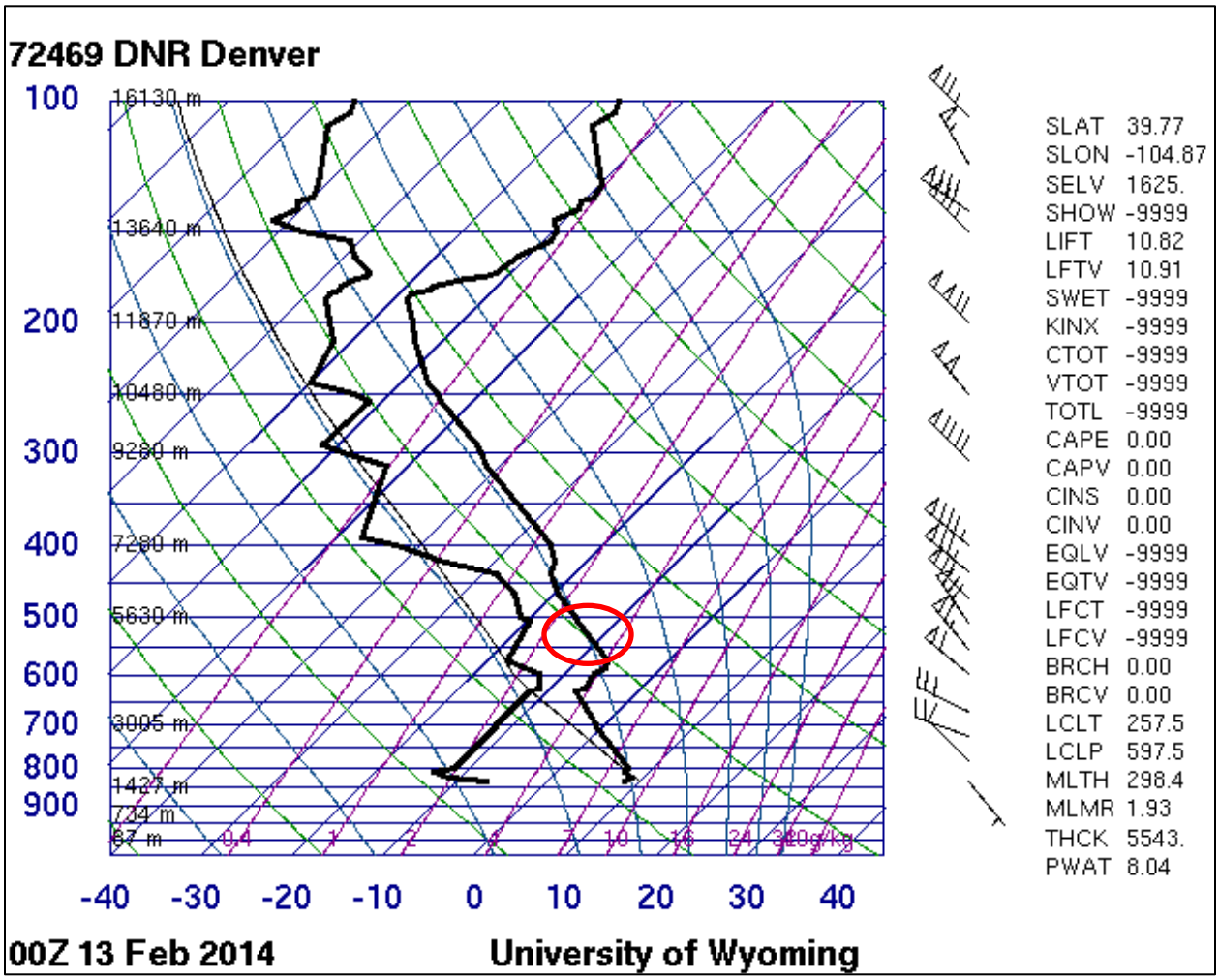

Figure 5-Skew-T of February 12, 2014 Weather over the general Denver, CO area

Analysis of the Skew-T diagram above for the given time suggests that the atmosphere was stable. Upon examination of the furthest left dark line, the curve's slope (or steepness), does not seem to exceed that of the green Dry Adiabat line, which is a general indication of stability. Note that the CAPE factor on the right of the diagram also reads as 0.00, which suggests that the atmosphere is stable, supporting the slope analysis associated with the Dry Adiabat line.

Based on the analysis from both the cloud elevation, the stability of the atmosphere, as well as visual observation, my guess would be that the cloud is stratocumulus. However, it is possible that the cloud is stratus as well, though I am leaning towards stratocumulus simply due to the almost cotton ball like structure that stratus does not appear to have. The physics behind stratocumulus also support the observation that the cloud in Figure 2 is stratocumulus as in general, stratocumulus clouds provide either no precipitation, or some extremely light snow or rain. Stratocumulus clouds are also cited to appear towards the end of storms or at the beginning [6]. These phenomenon are due to three factors, specifically "turbulence, convection in unstable air layers, which are limited by a strong inversion upward (on the Skew-T), or undulation in very damp air layers and usually at inversions" [6]. While the Skew-T does not indicate an inversion

or unstable air layers, I would not rule out that there exists some turbulence within the cloud formation. As to further refine the identification of the cloud in Figure 2, I would speculate that the cloud might be Stratocumulus Perlucidus as seen below in Figure 6 [6].

Figure 6-Strato Perlucidus captured in Goeppingen, Germany of August 2006

Overall, based on my understanding of the cloud elevation, weather data, and Skew-T, I believe that the characteristics of a stratocumulus were observed.

Photographic Technique and Artistic Approach

The image was captured using a Panasonic FS15 Digital Camera. Based on my measurements from the porch to the tree used for focusing, my distance from the lens was approximately 66-70 ft. However, in terms of the actual distance to the cloud itself, I am not sure I could provide a reasonable estimate. For this photograph, the lens focal length was 6mm with an aperture of 3.44, shutter speed of 1/640 sec, and an ISO setting of ISO 80. As seen through the comparison of Figure 1 and 2, a large majority of background objects were removed in order to emphasize the behavior of the clouds. Consequently, the final image was 3395x2094 pixels.

Additionally, based on the height of the tree in Figure 1 as well as the overall width of the shot, I would estimate that the field of view of the photograph was 30 ft x 55 ft, using the known height of the tree captured within the photograph. The only modifications to the photograph include a change in the contrast using the curve feature in Photoshop CS5, as well as some slight cropping and sharpening. As a result, the photograph in Figure 1 appears to be much brighter than that of Figure 2, helping to provide a somewhat artistic contrast between the sky and the cloud. Note however, that this increased the obscurity of the cloud line, which made identification of the cloud difficult.

Overall Summary

The cloud photo reveals the somewhat deceiving nature of the cloud coloration with that of the sky. Due to the slight bluish hue that appears in the center of the cloud, it looks as if there is a slight break in the darkness when in reality it is simply a coincidental matching of color. While for artistic reasons, I enjoyed this feature very much, when it came to the identification of the cloud, it became extremely difficult to classify the cloud type. Additionally, the physics of the cloud were very difficult to find due to the coloration of the cloud and its matching of the background sky. Consequently, a majority of the physics analysis was taken from the associated data, with very little dependence on the photograph taken, which disappointed me a little bit. My major question would be how I could visually resolve the break outline in the cloud such that I could get a better contrast between the cloud and the sky itself. Overall, I fulfilled my artistic intent, but I failed to meet the scientific intent I had originally wanted. Due to this, I would have liked to take a different cloud photo with a more clear-cut contrast in order to visually resolve the flow physics and to add a more scientific spin on my analysis that would extend beyond simple number crunching and graphical analysis. With this in mind, I plan to attempt to take a photo at sunset such that I have a great color contrast with the orange glow, and furthermore, have a much more visually striking method of analyzing the flow physics associated with cloud formation.

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