# **Clouds 2**

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## Background

For the Clouds Two Project, I not only wanted to explore a different classification of clouds from those investigated in Clouds One Project, but also ensure that my interpretations of skew-T plot were correct and accurate. With regards to creating an artistic image, I wanted to capture a colorful image and therefore focused on sunrises and sunsets. On October 19th, 2007 around 6:43 PM, while in Westminster, CO, I captured multiple images of the sunset and was able to capture not only a Cirrus cloud formation but also an Altocumulus cloud formation. This sunset in particular caught my attention because of how the light aided in distinguishing the height level of the two different cloud formations.

While it may appear that I used four different images in the final image, all four images are from one single image. Due to obstructions in the image, I had to crop out sections of the image; however, the picture still flows top to bottom and left to right as the original image. The final image consists of Altocumulus castellanus, Cirrostratus, and Cirrocumulus clouds.

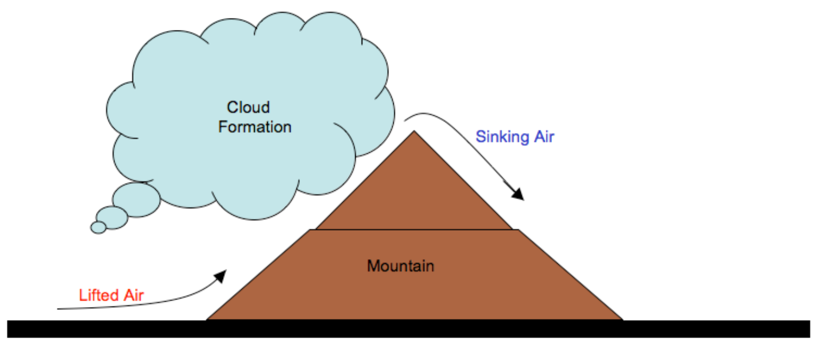
This rest of this report will cover a general description of cloud formation, a description of how Orographic clouds form, as presented in Clouds One, and finally focus on the stability of the atmosphere and the cloud heights using a slew-T plot.

## Cloud Formation

Evaporating water from Earth's surface plays a critical role in the formation of clouds. When warm air rises, it expands, cools, and as a result is unable to hold as much water vapor as the warm air. Consequently, some of this water vapor condenses into tiny pieces of dust floating in the air. Condensation also occurs when warm and cold air collide such as warm air cooling as it ascends a mountain and warm air flowing over a colder region of air. For the Front Range Mountains, Orographic clouds can describe the atmospheric activity.

In most cases, it is stable air that approaches a mountain and is forced upward. As a result, the air expands and the temperature cools down. When the air cools to its saturation temperature, a visible cloud is created because the water vapor in this air condenses (if the air is dry, a cloud will not form). However, once this air reaches the top of the mountain, it is heavier than the surrounding air and will fall back down. As it falls, the air will contract and become warm again. However, since this air has momentum, it will not stop once reaching its original height and will continue to fall. It will therefore become warmer than the surrounding air and will then try to rise back toward its original height. The cycle now repeats itself. This cycle is shown in Figure 1.1.

**Figure 1.1**




## Sounding Data

### I.) Stability

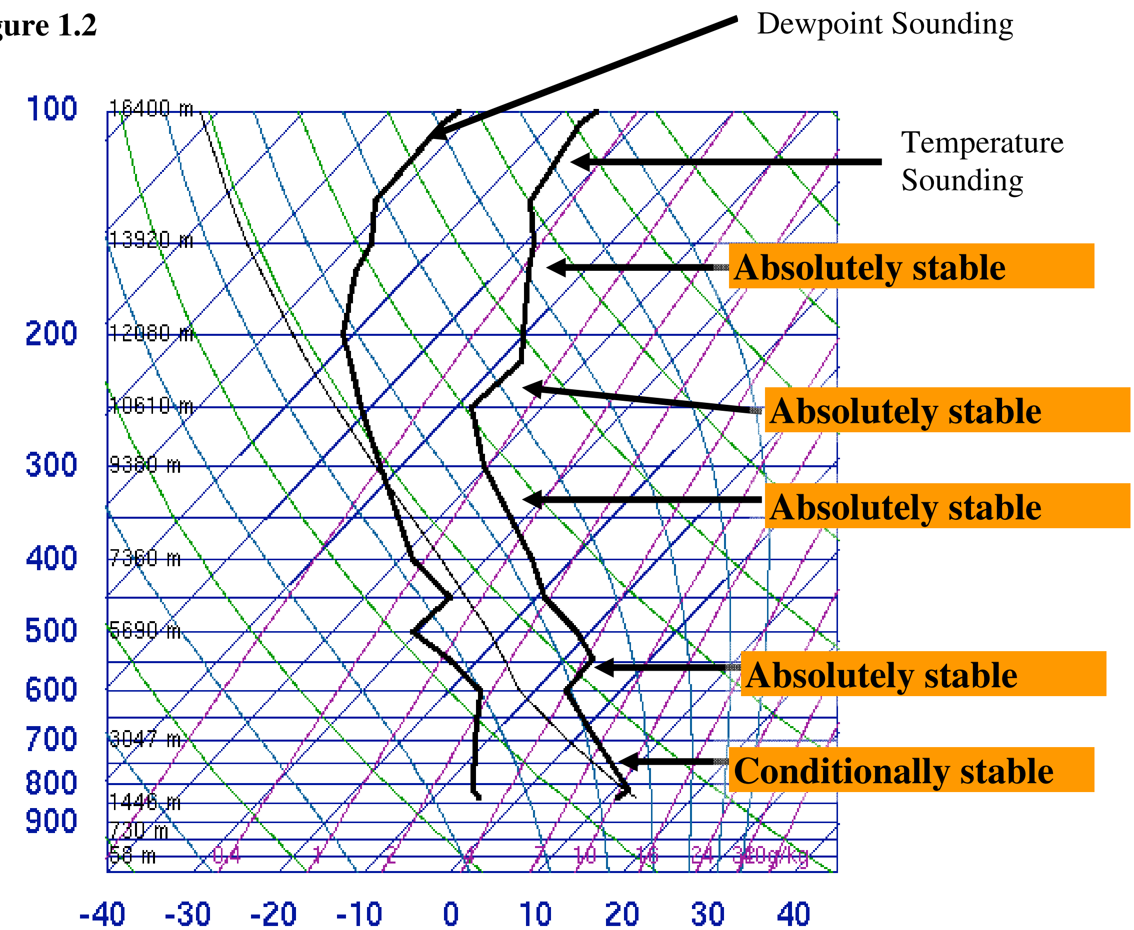
A skew-T plot helps determine how an atmosphere is behaving with a dew point line, a temperature profile, dry adiabatic lines, saturation adiabatic lines, and mixing ratio lines. Atmosphere stability and cloud formation are two of many conclusions that can be reached from the sounding data.

The stability of an atmosphere relies on the air molecules resistance to movement. For a stable atmosphere, an air molecule that rises will want to return to its original position. In an unstable atmosphere, that same air molecule lifted will continue to rise. The reason for these different behaviors is atmospheric thermodynamics and the relationship between a parcel of air temperature and the temperature of the environment. A quick and effective method of determining an atmosphere's stability can be determined by comparing the slopes of the temperature data, dry adiabatic lines, and the saturated adiabatic lines on a skew-T plot. This method is based on how the slope is measured and for my image, the slope was measured counter clockwise from the isobars to a section of the T curve.  Using this measurement system, the follow parameters determine whether or not the atmosphere is stable:

- Absolutely Stable:  Slope of temperature curve is less than saturation adiabatic line and slope of dry adiabatic line
- Absolutely Unstable: Slope of temperature curve is greater than saturation adiabatic line and dry adiabatic line
- Conditionally Unstable/Stable: Slope of temperature curve is less than dry adiabatic line but greater than the saturation adiabatic line
- Neutrally Stable: Slope of temperature curve is parallel to saturated or dry adiabatic line

Following these parameters and choosing numerous areas to analyze, Figure 1.2 shows a skew-T plot of stability regions.

**Figure 1.2**



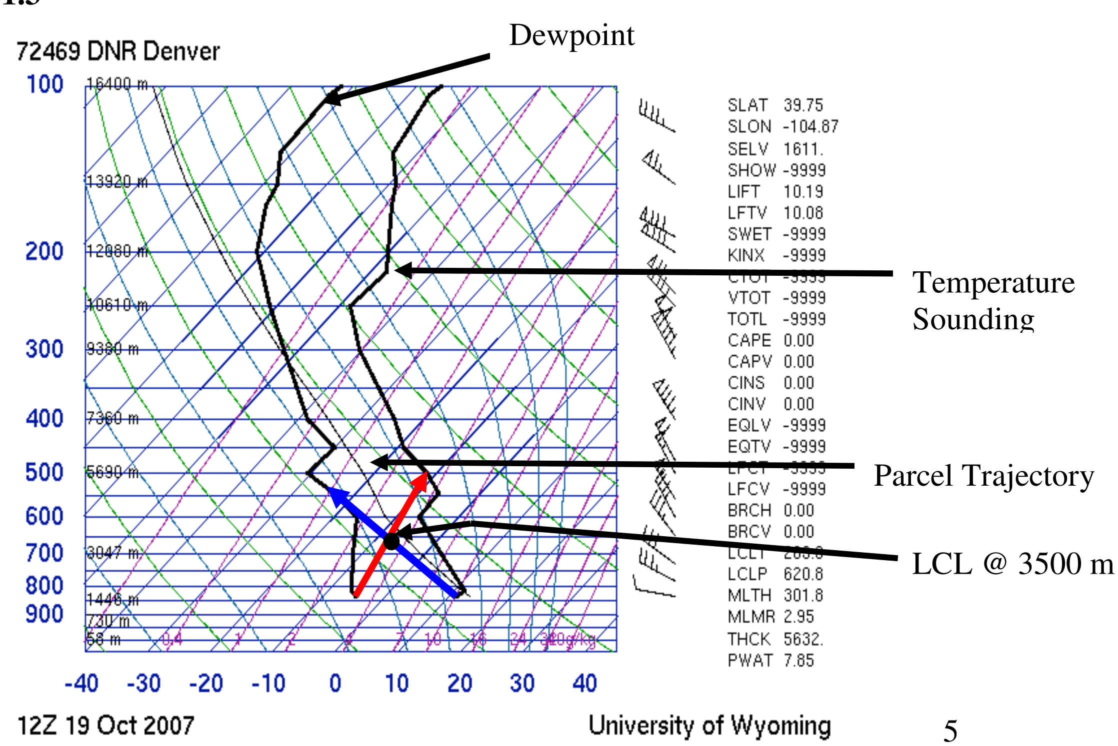
The conclusion reached from the skew-T plot in Figure 1.2 is that the atmosphere was stable and the final image agrees with this conclusion. The final image has very few low lying clouds and this makes sense because if we had a large instability region in the skew-T plot shown in Figure 1.2, we would have also expected more cumulus clouds than shown in the final image. However, there were some Altocumulus castellanus clouds hovering in the sky and since these clouds usually develop with instabilities, it shows that the skew-T plot cannot accurately depict the constantly changing atmosphere.

The stability of the atmosphere also agrees with the formation of both Cirrostratus and Cirrocumulus clouds.

## II.) Cloud Height

To determine an approximate base height of the lower cloud formation in the final image, the Lifted Condensation Level (LCL) must be determined. The LCL is established using the dry adiabatic lines, temperature sounding, dew point sounding, and the mixing ratio lines. The first step is to draw a line, starting from the base of the temperature sounding, parallel to the dry adiabatic lines. Next, starting from the base of the dewpoint sounding, is to draw a parallel line to the mixing ratio lines. The point at which these two lines intersect is considered the LCL and this is where condensation, as well as cumulus clouds, begin to form. The LCL is shown in Figure 1.3.

**Figure 1.3**



Therefore, the base height of the low cloud formation is 3500 meters (~ 11500 feet). This height agrees with the classification of Altocumulus castellanus. As for the cirrus cloud formations, I do not believe the skew-T obtained accurately depicts the time at which the image was taken. The reason is that the dewpoint line and temperature line never come in a close proximity to one another. For that reason I am unable to give an approximate height of the cirrus clouds but just a general height of being above 6000 meters (20000 feet).

**Photograph Information**

| | |
|---|---|
| Focal Length | ∞ |
| Size of the Field of View | ~ 10 miles |
| Distance from Object to Lens | ~16000 ft. |
| Type of Camera | |
| Digital | Casio Exilim EX-Z700 |
| Width X Height (Original) | 2304 X 3072 |
| Width X Height (Cropped) | 2000 X 1850 |
| Exposure Specs | |
| Shutter Speed | 1/100 |
| Aperture | 2.6 |
| ISO | 400 |

**Adobe Photoshop**

For the final image, due to obstructions within the image, I had to crop out four separate images from the single image and reconstruct it into a collage. However, the final image still flows top to bottom and left to right in the same manner as the original image.

In addition to removing the obstructions, I edited the contrast of the image to bring out the variation of colors from the sunset.

**Final Thoughts**

Clouds Two Project gave me the opportunity to learn more about skew-T plots and the abundant information one can obtain from it. In addition to that, I was pleased with obtaining a sunset image that highlighted two different types of cloud formations. If I were to redo anything, it would be to obtain that same image from a higher elevation in order to eliminate the ground in the picture as well as the obstructions I had to remove. Overall, I am happy with the image produced for Clouds Two Project.