Clouds 1

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"Superior" View

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Background

While we enjoy the numerous types of clouds that fill the sky, it is not often we explore the physics involving the formation of these clouds. This project not only involves the photography of clouds but also the physics behind the cloud formation as well as the cloud identification. While I would have loved to photograph a rare cloud formation, the word rare implies being somewhere at the right time and right place and unfortunately, this did not occur. With that in mind, my goals for an image were to create an image that would not only capture intriguing clouds but also capture cloud formations involving the mountains. Having taken images from multiple places, including Interstate 36, the Flatirons in Boulder, and Lookout Mountain, the final image used was from Interstate 36 right before the descent into Boulder, Colorado. The clouds shown in the image are classified as Orographic (Altocumulus) clouds and will be discussed in more detail later.

I debated whether or not to include the mountains in the final image because the focus should be on the clouds, not on the surroundings. However, surroundings, especially mountains, can significantly impact the formation of these clouds. For this reason, I decided to include the mountains. Using Adobe Photoshop, I believe I was able to edit the image to ensure the clouds remained the main focus.

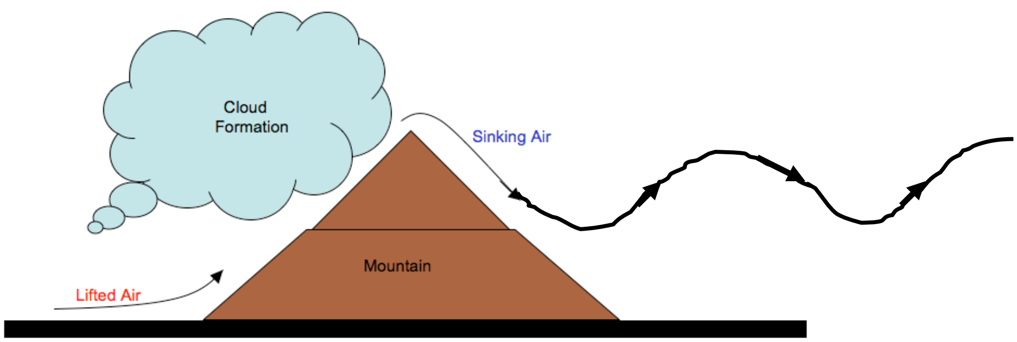
I also believe the image became much more aesthetically pleasing by combining the original image with three colored images. This will also be discussed in more detail later.

Orographic Clouds

Orographic clouds include Altocumulus clouds, Cumulus clouds, and Stratocumulus clouds. The final image is composed of Altocumulus clouds and they occur between 2400 and 12000 meters depending on their classification within Altocumulus. With regards to the final image, I believe it is Altocumulus castellanus, which occur between 2400 and 6000 meters.

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



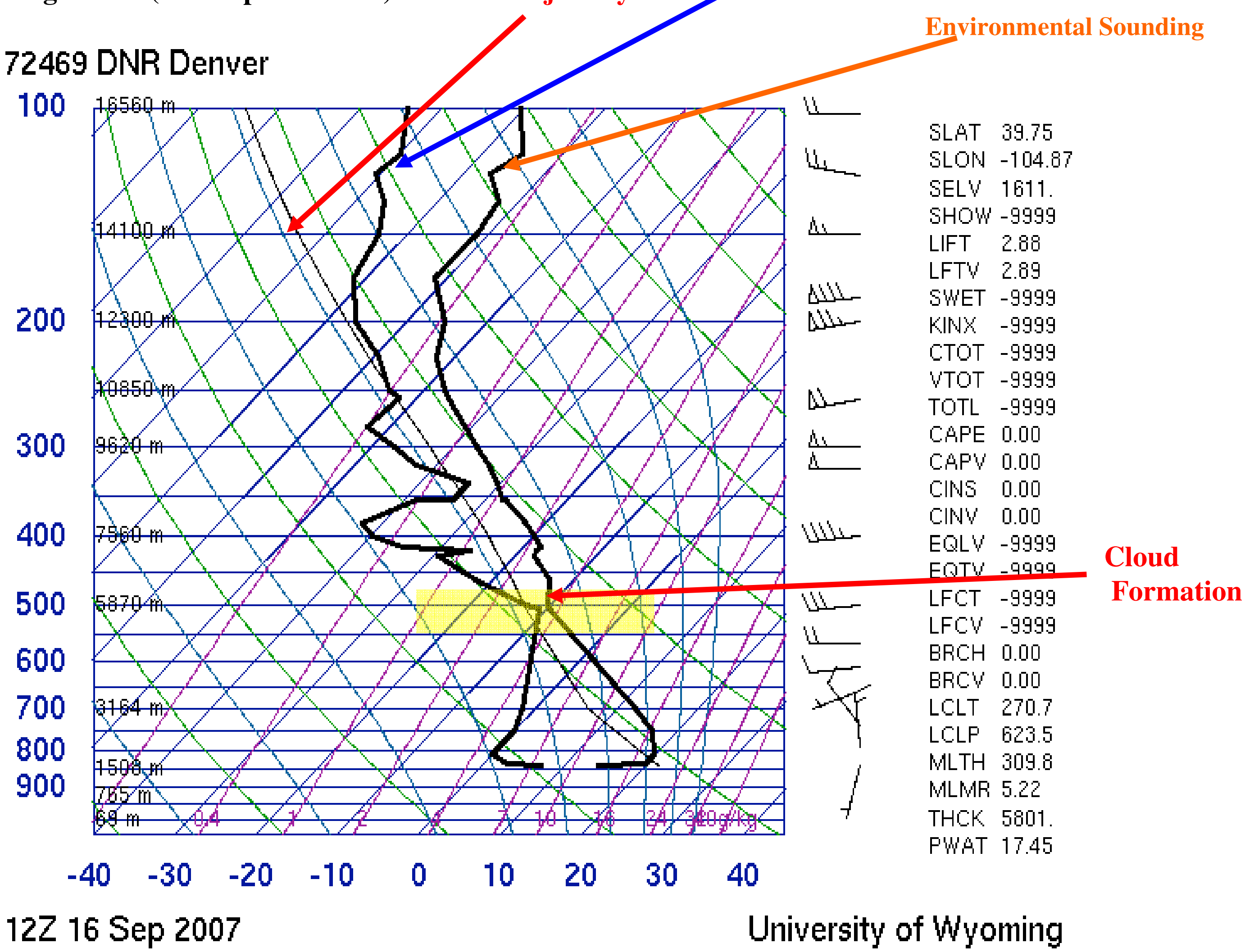
Sounding Data

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

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 the relationship between the parcel temperature and the temperature of the environment. The stability can be determined by using the dry adiabatic lapse rate and moist adiabatic lapse rate. If we lift a parcel of dry air and follow the dry adiabatic lapse rate and it's final temperature is less than that of the surrounding environment, the parcel would want to sink back to its original position. The environment is therefore stable. However, the environment is unstable if the parcel finds itself warmer after being lifted because it would continue to rise. Another way to determine stability is to compare slopes of the parcel trajectory and the temperature profile. Using both of these methods to verify if the environment is stable or not, it is evident that is stable.

Classifying the clouds relates directly to their height above the surface and when analyzing the skew-T plot, shown in Figure 1.2, the dew point line and temperature line come close to each other around 5870 meters. There is also a noticeable change in wind speed and direction that helps the formation of clouds. Therefore, this is most likely where the cloud formation took place and can be classified as Altocumulus castellanus clouds. This classification becomes tricky when calling the environment stable because castellanus can represent instability. However, if you analyze the moist adiabatic lapse rate as well as a lifting parcel around 5870 meters, it seems there could exist a small region of instability.

Figure 1.2 (12Z September 16)



Reynold's Number

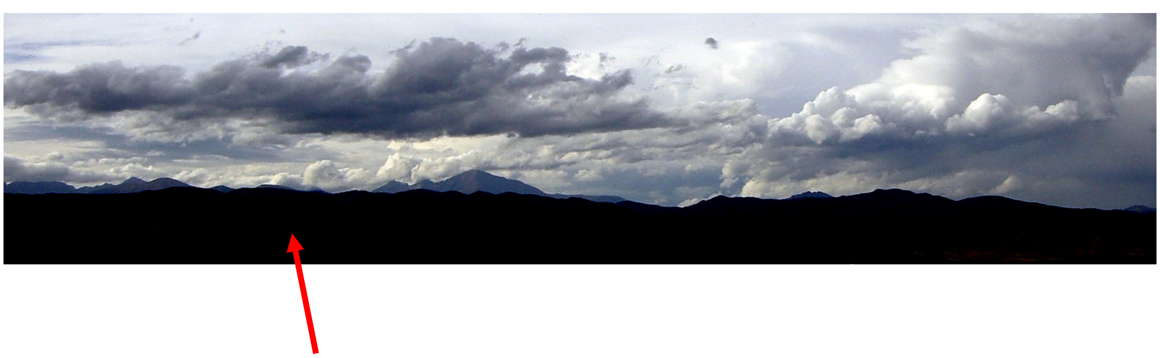
For Stratocumulus clouds, the Reynolds number is most likely turbulent and this explains their random structure. For example, for a kinematic viscosity of 10^{-5} m^2/s[1], a velocity of 10 m/s, and a length of 500 ft, $Re=5*10^8$. This number definitely falls into the turbulent region.

Adobe Photoshop

For the final image, I cropped it down from 3072 X 2304 pixels to 1766 X 350 pixels. In addition to cropping the original image, I also edited the RGB values to ensure the focus was on the clouds and not the mountain range. As one can see from the image, the mountain range is outlined to let viewers know mountains are there, but blacks out the details of the mountain. This is pointed out in Figure 1.2.

To create a more artistic image, I then edited the original image into 3 new images by changing the RGB curves.

Figure 1.3



Blacked Out Mountain Range

Photographic Technique

Focal Length	6.20 mm
Size of the Field of View	~ 10 miles
Distance from Object to Lens	~16000 ft.
Type of Camera Digital Width X Height (Original) Width X Height (Cropped)	 Casio Exilim EX-Z700 3072 X 2304 1766 X 350
Exposure Specs Shutter Speed Aperture ISO	 1/800 4.3 400

Final Thoughts

While I am happy with my picture, I would have enjoyed capturing an image that is rare to see. However, like I mentioned earlier, that involves a lot of time and being in the right place at the right time. I believe I was able to capture an exciting image and with the help of Adobe Photoshop, create a more artistic image,

This project has been exciting not only because have I been able to capture awesome cloud images but also because I can now explain the physics behind the cloud formation. In addition to that, I have found great online resources for what is occurring in atmosphere. This is not only nice to know for academic reasons but also for personal outdoor adventures! While I thought I learned a lot on the Get Wet project, I have learned even more on the Clouds project.

References

1.) http://www.princeton.edu/~asmits/Bicycle_web/transition.html
2.) http://weather.uwyo.edu/upperair/sounding.html
3.) http://ww2010.atmos.uiuc.edu/(Gh)/guides/mtr/cld/cldtyp/oth/org.rxml
4.) http://www.atmos.millersville.edu/~lead/SkewT_Home.html
5.) http://www.theweatherprediction.com/thermo/skewt/
6.) http://www.uwsp.edu/geo/faculty/ritter/geog101/textbook/atmospheric_moisture/lapse_rates_2.html
7.) aurora.aos.wisc.edu/~lazear/101lec_svrwx_**stability**.ppt