MCEN 5228-Flow Visualization

“Skiing with Clouds”

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Assignment: Clouds 1

Professor Hertzberg

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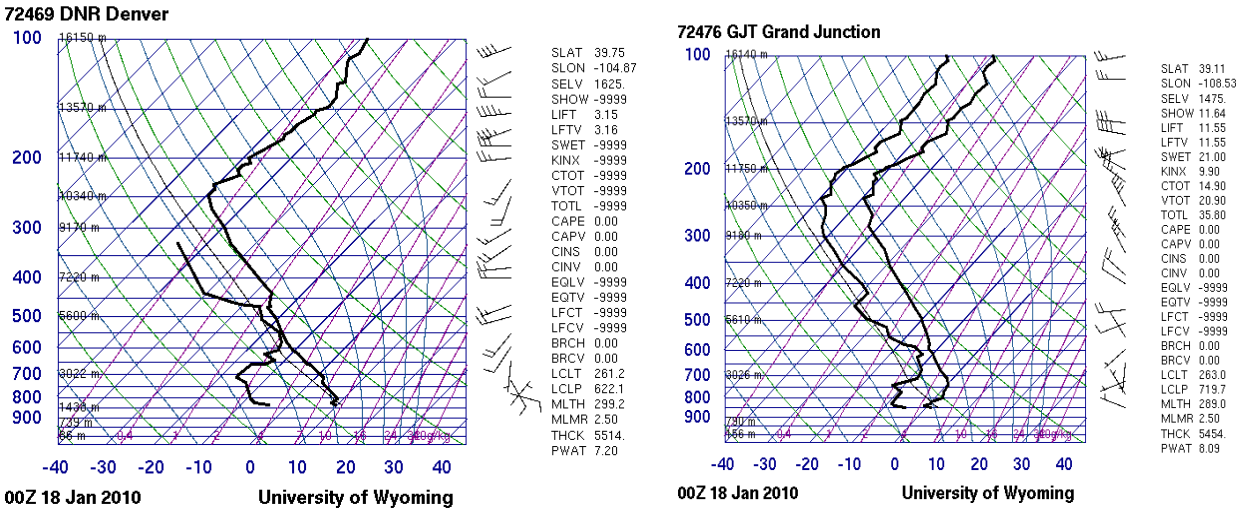
Clouds are a magnificent and elusive part of Mother Nature's artistic masterpiece. "Nature is a mutable cloud which is always and never the same", as Ralph Waldo Emerson describes the nature of clouds their uniqueness in nature (Emerson). Just like snowflakes, all clouds embody similar characteristics and variety that continuously captures the human mind and imagination. The artist took the picture during the middle of a ski trip at a lodge in Vail, CO trying to capture the beautiful scene created by the mountains and the clouds. The picture was taken spontaneously as one of many pictures taken throughout the day. The picture was taken for the Clouds 1 Flow Visualization project instructed by Professor Hertzberg at the University of Colorado at Boulder. The artist's goal in taking the picture was to capture the unique effect that the mountains have on cloud formation and movement. The clouds observed in this picture are stratocumulus and alto-cumulus clouds.

As mentioned above, the picture was taken on top of China Bowl in the Gore Range in Vail, CO. The picture was taken around 1:30 pm on January 17, 2010 and the lighting was somewhat "dull" due to the clouds and snow. The top of the mountain is at 12,250' and the valley is at about 10,400' above sea level (Vail). The angle of the camera was between 0 and 5 degrees above the horizontal, with the clouds being about 4 miles from the photographer. The temperature was 35 degrees Fahrenheit.

The interesting flow effects that make the cloud originate from the turbulent nature of the wind blowing over the mountains. Normally, air travels across a flat surface (such as the plains), and yields fairly laminar and consistent fluid. However the mountains create a large amount of disruptions in the air to cause it to flow in both laminar turbulent fashions, depending on the geography of the area. For example, air flowing through a valley may be more or less laminar since all the air is being forced through a tunneling system which streamlines the air. In comparison, air may also be flowing over peaks or simply hitting the side of the mountain, causing air to be redirected and become turbulent. This picture incorporates both elements of flow since there is a large valley (please refer to original in Appendix B) channeling some of the air and also obstructions that make the air turbulent (Memarian et al).

The cloud can be classified as a stratocumulus and alto-cumulus clouds. A stratocumulus cloud has characteristic properties that include it being low to the ground, producing a gray layer of cloud, and also being near the edge of a frontal system. This can be seen by the higher likelihood of the cloud releasing precipitation, as can be seen by the clouds in the right side of the picture. The release of precipitation indicates that the air was highly saturated and above the dew point. The cloud also has varying density and is spread more horizontally than vertically (NOAA). Stratocumulus clouds also have characteristics of having low-lying clouds close to the surface. Alto-cumulus clouds are characterized by being fluffy with

large and grayish portions. There are some stratocumulus clouds on the top part of the picture.



The atmosphere's condition can be visualized and quantified by a Skew-T plot, like the two above (University of Wyoming). Normally weather balloons are released at 6 am and 6 pm MST, which translate to 0000 the following day & 1200 the current day Zulu time at major cities all over the country. Since the picture was taken at Vail (between Denver and Grand Junction in Colorado) and at 1 pm MST (or 1900 zulu), there was no exact Skew-T available for the exact time and/or place of the picture. However, the two Skew-T plots from Denver and the two Skew-T plots from Grand Junction were used in interpolating the atmospheric condition when the picture was captured (see Appendix A). The Skew-T plot provides a lot of data, but the most important data is the CAPE value. When the CAPE value close to or equal to zero, it indicates that the atmosphere is stable. When the CAPE value is large, it indicates that the atmosphere is very unstable and that air is constantly circulating in the atmosphere. For both Denver and Grand Junction, the CAPE was zero, indicating that the atmosphere was stable. It is also important to notice that the data shows the air is close to dew point at around a mile above the ground (for Denver and Grand Junction). This indicates cloud cover and maybe a release of precipitation. However, this data isn't very good to interpret for this picture since the Skew-T plots are only for Denver and Grand Junction, not Vail.

The basic theory behind the stability of the atmosphere depends on how a sample of air (or parcel) would behave with respect to the rest the environment. The parcel of air travels up through the atmosphere at a linear rate. The information obtained by the weather balloon shows a slope greater than that of the parcel, meaning that if a force were exerted on the parcel that the air would sink back down. This shows that the atmosphere is stable (cold air on the bottom, hot air on top). Conversely, the atmosphere is unstable when there is hot air on

the bottom of the atmosphere and cold air on top. This causes the air to circulate and be unstable. The picture captures clouds in a stable atmosphere.

The camera used in this shot was a simple 10 Mega pixel Digital Elf by Canon. The shutter speed was 1/400 sec and aperture was f/8. For more camera information, please see Table 1 below.

Table 1: Camera Data

Camera Data 1		
Make:	Canon	
Model:	Canon PowerShot SD850 IS	
Date Time:	1/17/2010 – 1:22:08 PM	
Shutter Speed:	1/400 sec	
Exposure Program:		
F-Stop:	f/8	
Aperture Value:	f/8	
Max Aperture Value:	f/2.7	
ISO Speed Ratings:	80	
Focal Length:	5.8 mm	
Lens:		
Flash:	Did not fire	
	No strobe return detection (0)	
	Auto mode (3)	
	Flash function present	
	No red-eye reduction	
Metering Mode:	Pattern	
Camera Data 2		
Pixel Dimension X:	3264	Y: 2448
Orientation:	Normal	
Resolution X:	180	Y: 180
Resolution Unit:	Inch	
Compressed Bits per Pixel:	1	
Color Space:	sRGB	
Light Source:		
File Source:	DSC	

My intent was recognized well in this picture. I tried to capture the flow of the clouds over the mountains. The clouds give the viewer of feeling of grandeur for nature and its power. The clouds showed both the beauty of the cloud precipitating onto the mountains, and also is vast size on the same size or great than with the mountain. I particularly like the mix of the cloud and its activity over the mountain. I also really like the depth of field of the cloud over the mountain. I would like to improve this picture by increasing the exposure and collecting more light from the clouds. However, this would be difficult as the snow reflects too much light and could overexpose the picture. If I would change something about the picture, I'd increase the contrast a little more and try to brighten the image without saturating the already white parts of the picture. The overall picture successfully captured the cloud, fluid flow and beauty of the mountains.

References:

Emerson, Ralph Waldo.
http://www.brainyquote.com/quotes/quotes/r/ralphwaldo165480.html (2/25/2010)

How Stuff Works. http://home.howstuffworks.com/weather-activities-for-kids1.htm

Vail Resorts. http://web.vail.net/local/resort.info.cfm?info_id=1 (2/25/2010)

Skew-T Plots. http://weather.uwyo.edu/upperair/sounding.html (2/25/2010)

Memarian, M.H., Kozhoevnikov, V.N., Dmitrieva-Arrago, L.R. "Wave Clouds over Mountains". Russian Meeorology and Hydrology, Vol 39. September 2009.

University of Wyoming. Department of Atmospheric Science. "Skew-t archive."
http://weather.uwyo.edu. 2009

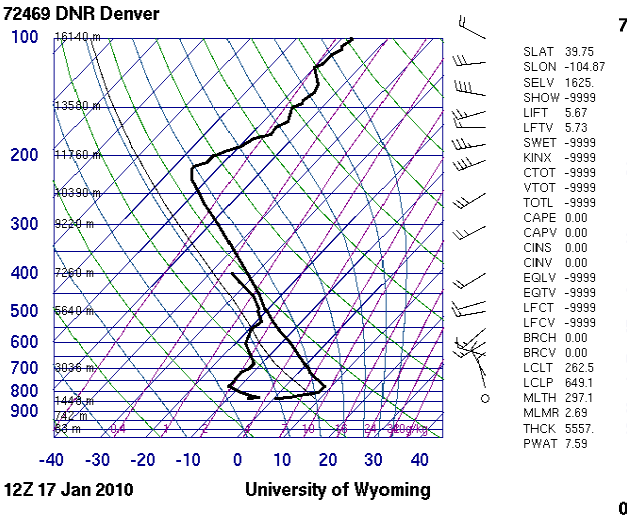
Eckermann, Dornbrack, Vosper, Flentje, Mahoney, Bui, Carslaw. "Mountain wave-induced polar stratospheric cloud forecasts for aircraft science flights during SOLVE/THESO 2000". Weather and Forecasting, Vol 21. Feb 2006

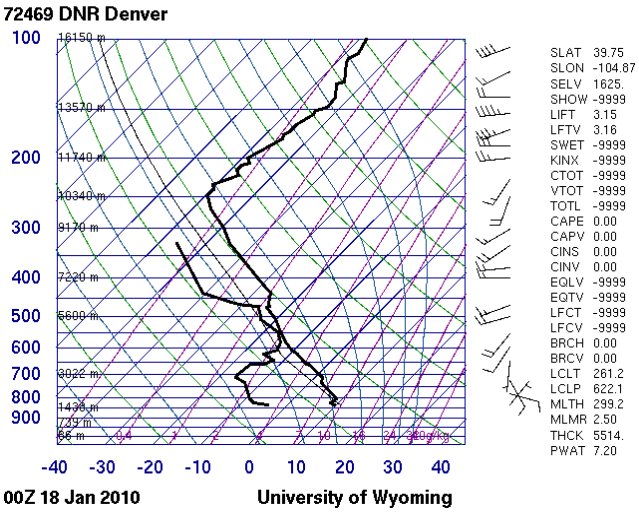
NOAA: http://www.crh.noaa.gov/lmk/soo/docu/cloudchart.pdf

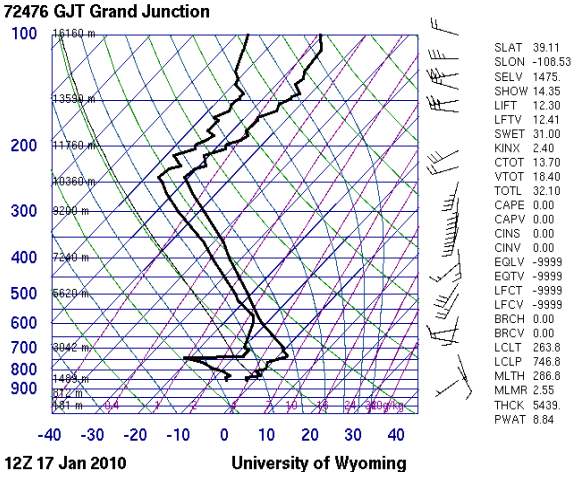
Kundu, Cohen. Fluid Mechanics, 4th ed. Academic Press, November 2008.

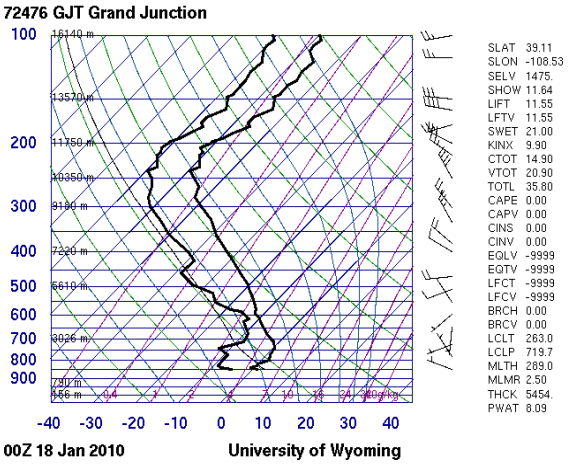
Appendix A:

Additional Skew-T Plots









Appendix B:

Original Image