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CLOUDS 1

FLOW VISUALIZATION: THE PHYSICS AND ART OF FLUID FLOW

Benjamin Ross Britton | Mechanical Engineering

Clouds are arguably the most commonly viewed fluid phenomena. Since the progression of weather detection systems it has become easy for many to take the sky for granted. Instead of analyzing patterns and shapes of clouds to determine weather, this information is found on the internet or the news. The purpose of this image was to grasp the beauty of the sky while describing the physics that create such clouds. This image demonstrates mountain wave clouds forming over the continental divide and continuing over the Front Range in Boulder, Colorado.

This particular photograph was taken from a viewing point on Flagstaff Mountain in Boulder, Colorado on January 18, 2010 at 5:08 pm. The camera was pointed North-West showing the continental divide being buried in clouds with Long's Peak on the right-hand side. The elevation was near 6,900 feet, which is almost near the 6,978 foot peak elevation. The camera was positioned on an adjustable tripod angled slightly upward (about 10˚) to fully capture the clouds above. The tripod was placed on some overhanging rocks protruding roughly 100 feet above ground. This made sure that no trees or unwanted objects were in the field of view.

There are two types of clouds shown in this photograph: mountain wave and foehn cloud wall. Mountain wave clouds form when stable wet air is pushed over a mountain face. The water condenses due to the decrease in temperature of the surrounding air and forms a cloud. The still stable air want to go back down to its original elevation and thus begins to drop after cresting the mountain. Momentum is gained and the stable air overshoots where it wants to be and bounces off of the ground to rise again. Once the air reaches its peak elevation the water condenses again and creates another cloud. This process can repeat itself over and over creating the 'wave' effect. This image shows two mountain waves that formed after the foehn cloud wall (furthest back). A foehn cloud wall occurs as moist air rises over a large peak (in this case the Continental Divide). Most of the moisture in the air condenses into a cloud on the rise and becomes quite dry near the summit. This creates warmer air at equal elevations on the lee side of the peak. With warm, dry air there is no moisture to condense which causes the cloud to cease as it reaches the summit, creating a 'wall'. Both of these cloud phenomena create standing clouds (do not move with respect to the ground), which was observed while taking this photograph. In an hour of time lapse, it appeared that they had not moved at all but rather changed shape slightly as new air moved in and condensed.

The surrounding sky was very clear with the exception of a few smaller, broken mountain wave clouds that formed further down the Front Range and over the plains. It was very windy, which would confirm the source of the mountain wave and foehn wall clouds. Figure 1 shows the skew-T plot for the

night of January 18, 2010 in Denver. The recorded CAPE was 0.00 and the slope of the parcel line indicates stable air, which is the other ingredient for mountain wave and foehn wall clouds.

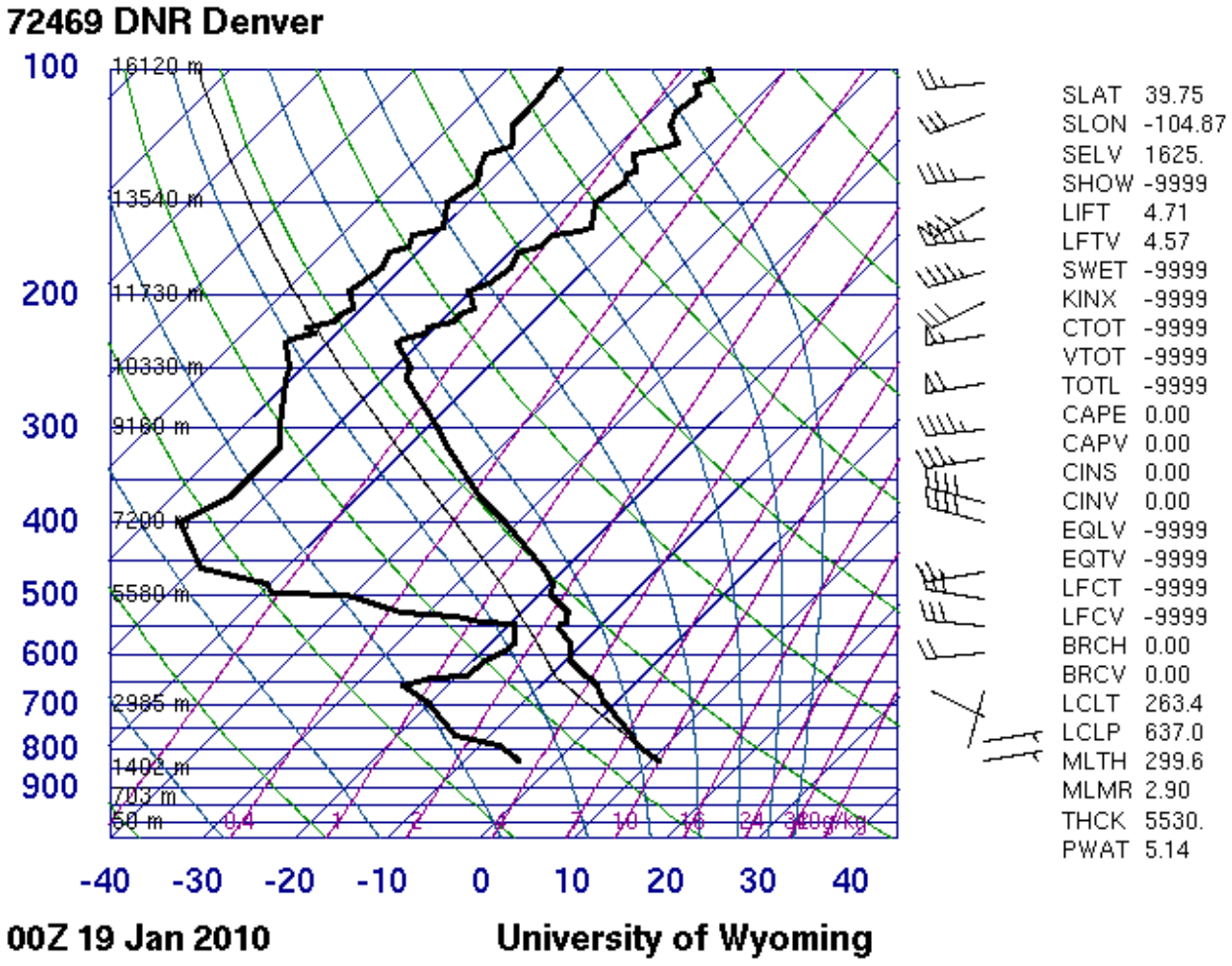

Figure 1: Skew-T for 00Z 19 Jan 2010

This photograph was taken to show great contrast between the clouds and the surrounding sky. The following information explains exactly what settings were used to take the picture:

Camera	Canon EOS Digital Rebel XT
Lens	Canon Zoom Lens EF 28-200mm 1 : 3.5 - 5.6 72mm ↔
Date	1/18/2010 @ 5:08PM
Shutter Speed	1/100 sec

Exposure Program	Normal Program
F-Stop	f/6.3
Aperture Value	f/6.3
ISO Speed Rating	800
Focal Length	50mm
Flash	Did not fire
	No Strobe Return Detection (0)
	Compulsory Flash Suppression (2)
	Flash Function Present
	No Red-Eye Reduction
Metering Mode	Average
Pixel Dimensions	3328 x 1717
Orientation	Normal
Resolution	72 dpi
Color Space	sRGB

After capturing this photograph a few manipulations were done in Photoshop. First the image was cropped to reduce the amount of land in the picture. This maintained the focus on the clouds and the distant peaks. Next the image was changed to black and white to improve the contrast and give the image a more powerful impact. The curves were auto-adjusted so that the lower mountains were full black and the clear sky was full white, which further enhanced the contrast. Finally, a micro-adjust in Photoshop's black and white mode changed the amount of color in the original image. This made the shadows in the clouds pop-out and further defined the image. Below is a copy of the original photograph:

This image reveals the true beauty of physics at work on a very large scale. I really like how parallel each set of clouds are with respect to the continental divide. I find patterns found in nature to be both interesting and beautiful. I dislike that this image was under exposed. If I could redo this picture I would send more light onto the sensor of the camera to pick up more contrast and detail. I would also like to know more about what is going on near Long's Peak. The foehn cloud wall breaks up here and appears to send clumps toward the long mountain wave cloud. I am sure there was some very interesting physics happening at this point and it would be fun to explore this in more detail.