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Cloud Photography Project #2

This was the second cloud image project for the Flow Visualization class at the University of Colorado. The goal of this image was to give a fresh perspective on a relatively common sight over the Flat Iron Mountains near Boulder, CO of a Foehn wall. While there are many images of these cloud formations, this particular image also includes secondary layering of a mountain wave cloud as well as a tertiary higher cloud structure.

As mentioned this image was taken over the Flat Iron Mountains near Boulder, Colorado. The original image was taken at 5:40PM on February 22nd 2012. The direction of the camera was facing northwest toward the Flat Iron Mountains from Broomfield, Colorado which is about 12 miles from the Flat Iron Mountains. Being that Broomfield is located near the Federal Heights neighborhood, it is fairly close to the same elevation as Boulder. Therefore, the image was captured at a relatively low camera angle of about ten degrees from horizontal. The atmosphere was clear and dry except for the clouds seen in the image, and the sun had set behind these ominous looking clouds.

It is believed that the cloud structures in this image are a combination of three distinct structures all caused by similar atmospheric phenomena. First, there is the ominous Foehn (Fohn) wall looming just above the mountains. Their elevation would be around 14,000 feet since that is the maximum height that the surrounding mountains reach. This was the original name given to the phenomenon of Foehn winds which were studied in the European Alps, but has taken on many regional names such as Chinook winds in the Rocky Mountains of North America, but it is also known as Bergwind, Diablo wind, or Nor'wester depending on the region it occurs at [1][4]. Foehn winds are the descending warm dry air over a mountain range [2]. When moist air ascends the windward side of a mountain it cools and condenses the moisture out into clouds or precipitation [2]. The cloud wall that forms marks the upper limit of the precipitation of the air on the windward side of the mountain before the warmer dry air begins to descend the leeward side of the mountain [1]. The result is warm dry winds on the plains after the leeward dry air descends and adiabatically warms further [2][3]. On the windward side the moist air undergoes a process called orthographic lift, which is adiabatic cooling of the moist air as it is forced up the windward side of the mountain face [4]. A similar class of winds caused by orthographic lifting is the Sirocco, the Bora, or the Santa Ana winds, which are also created by adiabatic, or compression heating [4].

The second cloud structure that can be seen in the image is above the Foehn wall and is believed to be a wave cloud. This formation is again caused by the raising of an air mass by a mountain, but in the wave cloud internal atmospheric waves are raised by the mountains [5]. When a stable air mass then passes through the waves it is continually lifted and dropped causing the waves [5]. Alternatively, simple convection near the summit of the mountain can cause the wave clouds as the summit forces the wave cloud into the more stable air above the summit of the mountain [5]. Wave clouds are also known as a type of lee cloud, named for the location of their formation near or above the leeward side of the mountains they are passing [6].

The third formation seen in the image is a higher cloud formation than the previous two. It is believed to be an altostratus or cirrostratus cloud formation due to it's much more wispy

appearance and apparent elevation. The Skew-T sounding data from the day the photo was taken seems to confirm this assumption as the lines seem to get extremely close together at around 12,000 meters above sea level as seen in figure 1. The classification seems to be confirmed by the cloud collector's reference guide as well [7]. The air mass is stable for the day the picture was taken as seen by a CAPE reading of 0.00 in figure 1 as well [9]. The climate for the day was clear, yet slightly windy. There was no precipitation that day, but the ATOC data from the weather station on the boulder campus showed a slight amount of precipitation within 12 hours of when the image was taken [8]. Cloud formations of Foehn walls, and Chinook winds are relatively common in the boulder area, but not usually layered in such a dramatic fashion.

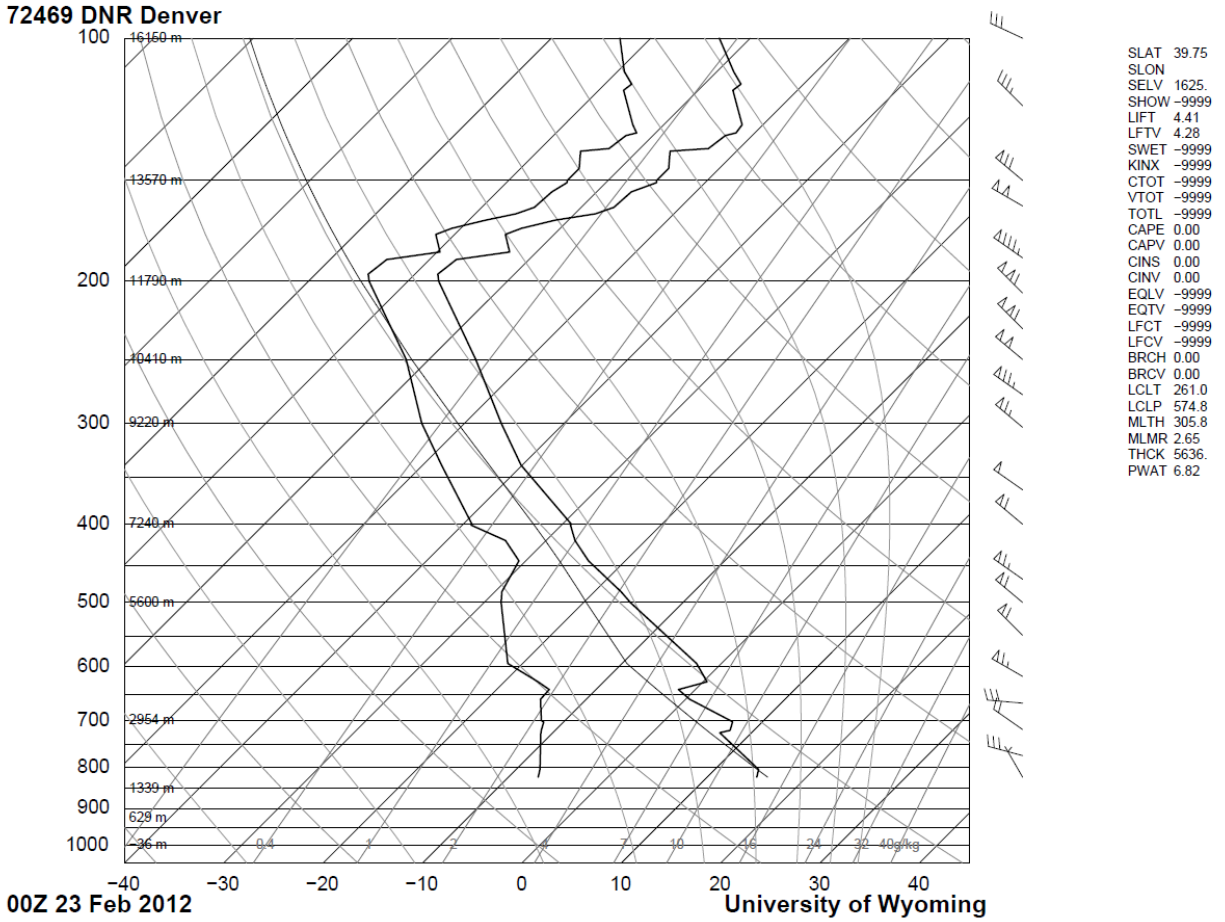

Figure 1: Sounding Data Feb.22, 2012

The photographic techniques used were not extremely complicated. The field of view is estimated to be about ten miles wide by about 5 miles tall given the sizes of the mountains in the fore ground for reference. As mentioned before the image was taken in Broomfield,

Colorado, so the distance to the cloud formations would be approximately 12 to 15 miles. The camera used was a Sony DSLR A-230 digital camera. The original image was 3872 pixels wide by 2176 pixels in height, as was the final image. The resolution the picture was taken was 350dpi, and uncompressed. The details of the camera settings were an F-stop of 4.5. The shutter speed was 1/200 seconds, and the ISO was 400. The focal length was 110mm, and the maximum aperture was 4.34. There was no flash used. The lens used was a Sony SAL55200-2 zoom lens. There was also some minor post processing done to the image to create a new perspective of the cloud structure. First, the image color and temperature was shifted strongly to the blue spectrum to increase the colors and contrast of the original image. The brightness and contrast were also adjusted to bring out the detail of the cloud formations in the image. Once that was accomplished the entire image color scale was inverted to give it the shades of red and pink that is seen in the final image. The image was not cropped at all.

This image reveals an excellent example of a Foehn wall, as well as a mountain wave together in unison above the Colorado Rockies. It reveals several types of fluid physics that occur during cloud formation all in one image. It also does this in a new light due to the post production, which is a refreshing change of pace from the everyday cloud image. The intent of the image was fulfilled in that it gave a breath of freshness to a somewhat common occurrence in Colorado, and demonstrated interesting fluid physics. It would also be interesting to get a similar image with more lighting on the details and more developed fluid flows in the future. Overall, it is an interesting and educational image demonstrating the weather patterns of Colorado.

References:

[1] http://www.britannica.com/EBchecked/topic/211886/foehn?anchor=ref49357

[2] http://www.hko.gov.hk/education/edu01met/wxphe/ele_foehn_e.htm

[3] http://en.wikipedia.org/wiki/Chinook_wind

[4] http://en.wikipedia.org/wiki/Orographic_lift

[5] http://en.wikipedia.org/wiki/Wave_cloud

[6] http://en.wikipedia.org/wiki/Lee_waves

[7] http://cloudappreciationsociety.org/collecting/

[8] http://atoc.colorado.edu/index.php?option=com_wrapper&view=wrapper&Itemid=99

[9] http://weather.uwyo.edu/upperair/sounding.html