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ARTF 5200
Clouds II

Introduction

For my second cloud image I had a number of images to choose from over the last month or so. I ended up using an image which I thought had both an interesting composition and set of clouds. The clouds themselves are extremely common for Boulder, showing a mountain wave formation. On this day the conditions generated two layers of mountain wave cloud. The image shows this depth framed by trees and a pedestrian sign and the corner of Folsom Field. Other images I took around the same time were pretty compelling including several of these formations as well as some looking to the east. In the end this image felt the most powerful to me.

Selected image. Layered mountain wave clouds over Boulder

Image Context

This image was taken looking west along Colorado Ave near Regent Dr on CU's campus. The road there is on a hill which put the trees to the west higher than me making it difficult to avoid. I estimate I was angling up at close to 45° to capture this image. It was taken on Friday March

15th at 4:15 in the afternoon. It had been a warm day with high winds, up to 26 mph around the time of the image [1].

Mountain waves taken facing east from selected image vantage.
How many do you count?

There are two layers of clouds featured in this image. I believe them both to be a mountain wave cloud at different heights. I would label the cloud in the foreground as a cumulus or an alto-cumulus formation. Being closer to the ground lends a bit of turbulence causing the shape to be somewhat irregular although mostly existing at the same height in a horizontal row along the front range of the mountains.   The second cloud behind and above the first is an altocumulus lenticularis, another type of mountain wave cloud.

The orographic lift caused by air moving east across the continental divide (which is only about 20 miles west of Boulder) creates clouds as moisture is pushed into colder temperatures at higher elevations. As it continues to the east and the mountains give way to the plains the air quickly descends which causes a bounce off the ground pushing it back up. This bouncing can continue for some time and depending on the temperature profile a number of mountain wave clouds can occur. The upper cloud here has the rounded top of one of these waves. Another image I took near the same time facing east shows at least four or five more wave clouds with similar "lens" shaped tops.

According to Weather Underground [2] data there was a high pressure system moving in from the south west of the state and a low pressure system which had moved out, on to the east.

The 00Z March 16 Skew-T plot [3] indicates a stable atmosphere. The high winds at all levels seem to correspond with the large number of wave clouds present on this day. The first layer of clouds I believe lies in the first region where the dew point index takes a sharp turn around 4500 meters and the second seems to be around 6000 meters in height. Based on my observations and estimated angle from the horizon this all seems reasonable.

Photographic Technique
My image was taken with a Nikon D-40 DSLR camera with the following settings:

Shutter Speed	F-stop	ISO	Focal Length
1/4000 sec.	f/7.1	800	50mm

For an estimated 45° angle above horizon and the estimated cloud heights of 4500 and 6000 meters the distance from the respective clouds can be estimated at 6364m and 8485m respectively. A rough approximation of the field of view at a depth somewhere in between the two clouds can calculated as follows:

$$2 * 7000 * \tan(19°) = 4820 \text{ m}$$

This assumes a 50mm focal length gives an angle of view of 38°. This calculation would be for the original image which was slightly cropped in the horizontal. The original image was 3008x2000 pixels while the edited image was 2676x1936 pixels. Cropping was done in Photoshop. Additional editing was done to bring out the depth of the image and some of the shadows in the clouds. I manually edited the RGB color curves separately trying to retain a natural color while significantly increasing the contrast. I wanted the foreground to become much darker than in the original image and this processing did the trick.

Conclusions
I really like that this image captures a couple different looks of the mountain wave cloud we see so often in Boulder. The second layer of cloud is a really nice example of a lenticular cloud shape. The layering and texture of these clouds I think makes this image powerful. Additionally, the context with the trees, sign and lights of Folsom Field has an immediate impact on me as being CU Boulder. Although, I do wish I had been able to find a slightly different vantage which captured these formations without the large tree in the center. I wish I had enough information and knowledge to further confirm the size of these clouds and their distance. I'm not 100% that I'm correctly interpreting the Skew-T plot. Because of the continuing shapes to the east I would have liked to find a way to create a sequence which some how showed this image as well as all its siblings in a cohesive fashion. Ultimately, I found the results to be a striking and powerful image which stands on its own without even knowing the context. This exercise has definitely given me a new appreciation for clouds.

[1] - http://weatherspark.com/

[2] - http://www.wunderground.com

[3] - http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2013&MONTH=03&FROM=1600&TO=1600&STNM=72469