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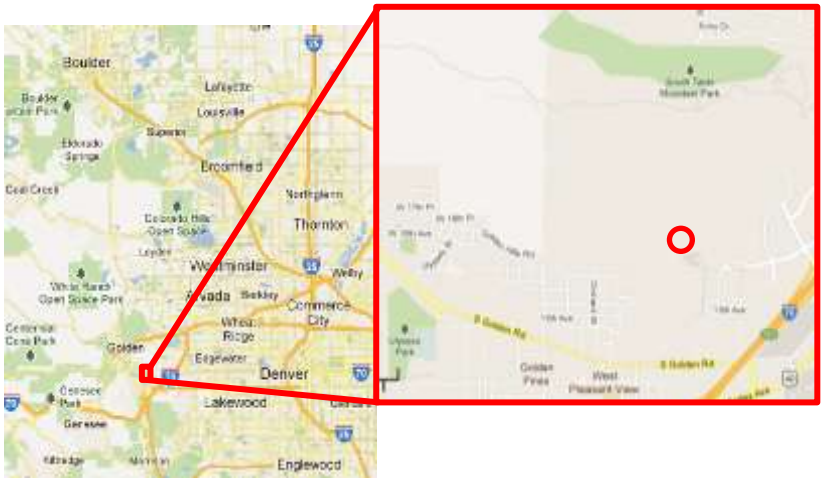
Cloud Image Report #1

2/25/2012

Context and Purpose of Image:

The cloud image above was taken to fulfill the requirements of the first cloud picture. I was simply trying to capture the beauty of the Colorado sky, which I think many people take for granted. I am originally from North Dakota, which has a different kind of beauty, but really good clouds are slightly more rare. Here in Colorado I am almost daily blown away by the "ephemeral beauty" of "Nature's poetry" [1]: clouds. I also work in a very scenic location (Golden, CO), and so I had taken several shots at different times of day. Originally, I had picked out a stratus cloud that looked like a whale, but I think this shot captured the stunning diversity



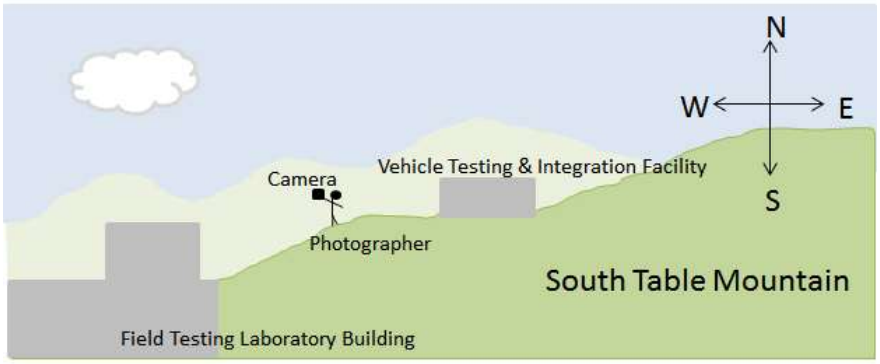
of the sky.

Image Circumstances:

This photo was taken on the campus of the National Renewable Energy Laboratory in Golden, Colorado. See **Figure 1** for the location.

Figure 1 (right): A map of the location of where the image was taken. The red circle shows specifically where on the site of the South Table Mountain where the picture was captured.

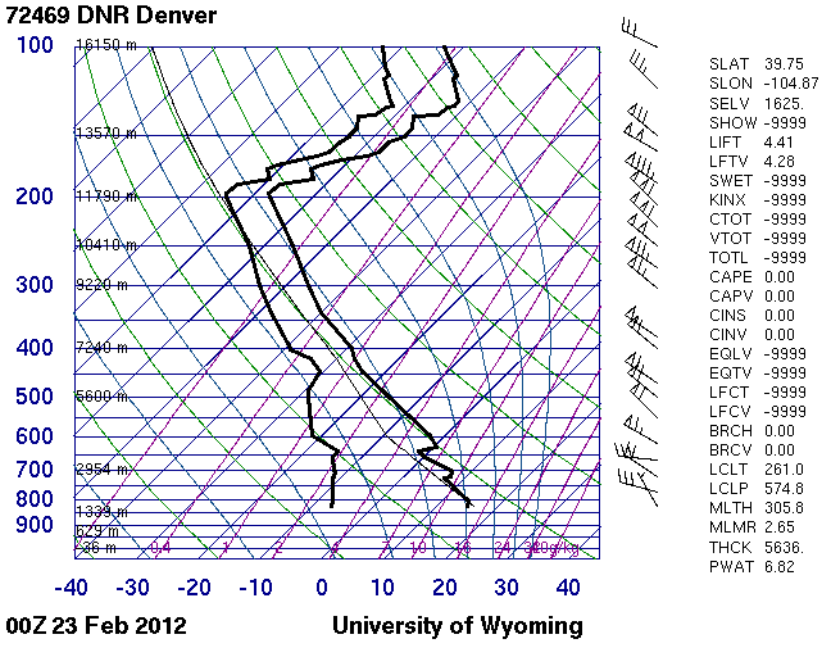
This photo was taken near the Vehicle Testing and Integration Facility (VTIF) on the NREL STM (South Table Mountain Campus) facing northwest. The elevation is 5862 feet above sea level, and of higher prominence than most of the region immediately northwest allowing for the elimination of distracting elements near the horizon. The camera was held approximately in line with the horizontal. See **Figure 2 (right)** for a schematic of camera position and height with respect to the prominent topography.



The picture was taken at 2:30 in the afternoon on Wednesday, February 22, 2012.

Statement of Clouds:

Analyzing the Skew-T plot of the atmosphere is helpful in understanding the types of clouds depicted in the image. **Figure 3 (right)** shows the Skew-T[2] plot for Denver, Colorado for 6 pm on February 22, 2012. On this particular day, it is important to notice the wind indicators near the right side of the Skew-T diagram. More "lines" and



“flags” on the indicators show stronger wind speeds. Throughout the atmosphere there are very high wind speeds, from about 40 knots up through 100 knots (on the indicators where you see 2 “flags). This corresponds to wind speeds of 46 mph to 115 mph. Clearly, the wind was one of the most outstanding weather features of the day. Next, we can analyze the stability of the atmosphere by looking at the temperature plots compared to the dry adiabats (in green). Near the surface, we see some layers of stability alternating with layers of instability. This could partially explain the diversity of the clouds in the image. Generally, where the two black lines touch (the dew point temperature on the left and the atmospheric temperature on the right) we can expect to find a cloud. The two temperature lines do not touch. However, there were clearly clouds in the sky on the date that the photo was taken. This could be explained several ways. First of all, the plot is for 6 pm, and the photo was taken at 2:30. The atmosphere can change dramatically in this region, especially in the afternoon. Additionally, this Skew-T plot was for the Denver area, which is near to Golden, but does not have the same topographical conditions seen in Golden. Additionally, research suggests that the atmospheric temperature does not always appear to be less than the dew-point temperature [3]. For instance, a concept called the *cloud virtual temperature* can at least partially explain why clouds can form at temperatures higher than the dew point [3]. The virtual temperature is the temperature at which dry air would have the same density as the cloud air [3]. The virtual temperature is usually 1-2°C less than the temperature indicated on the diagram [3].

Now that the Skew-T diagram has shed some light on the meteorological situation, let’s analyze the types of clouds visible in the image. First off, it should be noted that Golden is situated in the foothills of the Rocky Mountains, meaning that some or most of these clouds are the result of *orographic lift* which occurs when air must pass over an obstruction (such as the Rocky Mountains). Mountains and topography have a very distinct impact on cloud physics, since they are a physical barrier for moving air [4]. Not only is the atmosphere cooler at higher elevations, but there is also simply *l*ess air. As warm moist air encounters a mountain, the air parcel will tend to swell as air pressure drops and water contained in the air tends to condense and form clouds [4]. We see this clearly occurring in this photo. Near the right side of the image, we see a cloud with a very distinct boundary low in the horizon. This is likely a stratus cloud. If we follow the horizon to the left, we see a very stratified

smooth cloud with distinct laminae. This is called an altocumulus lenticularis, or "lennie".[1] Although it is hard to tell from the perspective, I believe this is the highest cloud. We are also seeing some stratocumulus fractus on the left side of the image – a stratocumulus cloud that is in the process of being ripped to shreds after reaching the end of its life. The stratocumulus fractus may also be causing the interesting iridescence that's exhibited at the top of the photo where the sun is peeking through. Most of the physics can be explained by the cold front that was moving through on this day, which resulted in snow later on in the evening. The movement of the air over the mountains and then back "down" on the other side led to the fascinating dynamics seen here.

Photographic Technique

This photograph was taken with a Nikon D40 DSLR. It's hard to predict the width of the image and the depth of field, but I estimate that the entire image encompasses approximately 50 miles across. The bulk of the clouds are within 20 miles from me, the viewer. The image is 2992 by 1768 pixels in size. The ISO was 1300 and the shutter speed was 1/200 s, at F 5.6. Only marginal post-processing was done on the image. A few lens scratches were removed in Photoshop, and the colors were adjusted slightly. See **Figure 4 (above)** for the original photo. The contrast was slightly increased and the brightness of the sunspot was repaired slightly.

Conclusions

Overall, I enjoy this picture because of the incredible diversity of the cloud types. I think I am lucky to live in such a beautiful place. On top of that, I think I am lucky to live in a place with such beautiful cloud physics. I think this picture might have been even better if I could have

climbed higher onto the mesa to capture an even larger view. However, I was still able to capture a portion of the incredibly dynamic conditions that were occurring on that day.

References:

1. Pretor-Pinney, Gavin. The Cloudspotters Guide: The Science, History, and Culture of Clouds. PERIGREE: 2006.
2. University of Wyoming, College of Engineering. Weather Soundings. Accessed: 25 February 2012. <http://weather.uwyo.edu/upperair/sounding.html>.
3. Whiton, Roger C and the U.S. Air Force. "*The Use of the Skew-T Log-P Diagram in Analysis and Forecasting."* December 1979. Accessed: May 2012 at <http://wx.erau.edu/reference/text/Tr79-006.pdf>.
4. Orville, H.D. "Ambient Wind Effects on the Initiation and Development of Cumulus Clouds over Mountains*." Journal of Atmospheric Science* 25 (1968): 385-203.