MCEN 5151 Clouds 1 Report

Ryan Cameron
October 25^{th}, 2021
University of Colorado at Boulder

I. Purpose and Methodology

This is the first report on cloud formations for the fall 2021 semester, and was an attempt to capture mountain wave phenomena occurring over Boulder, CO. It was mostly captured out of luck one day, a few other cloud images had been captured but no clear phenomena was present, whereas in this image it showed behavior close to ideal mountain waves and thus was the image chosen to be presented.

This image was taken on Monday October 11th, 2021 at 12:37pm in Boulder, CO. It is taken from the South, pointing Northwards at approximately a 60 degree angle to the ground.

II. Cloud Details

First looking at the skew-T diagram shown in Fig. 1, the closest the two lines come are at about 5000m, which would indicated a mid-level of cloud.

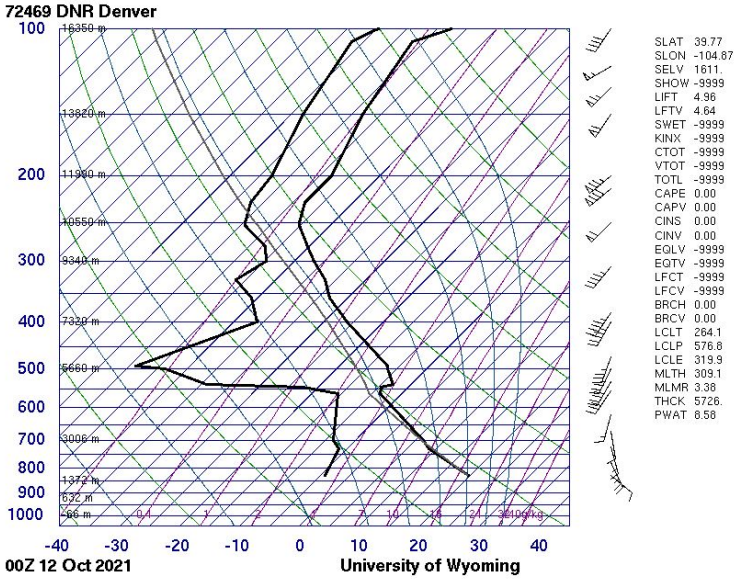

Figure 1. Skew-T diagram of Denver at 6:00pm on October 11, 2021

Then, based on the shape of them in the photograph, it appears that they are of cumulus species. This results in an estimate of an altocumulus cloud formation that was photographed. Around the sky though, there were no other clouds appearing and this one stood out in the sky. This is not surprising though as clouds of this type often precede larger weather patterns moving into the area, instead of being the large weather patter themselves. And in fact, the next day saw a large lighting storm move into the area, further confirming the cloud formation type.

Moving to talks of stability, the first thing to note is in Fig. 1 where it shows a CAPE value of 0.00, which generally indicates a stable atmosphere. This seems to directly interfere with the stipulation that this was a formation of mountain waves interacting with a cloud, since those waves are a form of instability. But, it must also be noted that the sounding the skew-T plot is showing was taken from Denver, CO, which is farther east and away from the mountains. That would mean there was plenty of space for the mountain wave instability to die out before it reached the balloon that collected data. Another possibility for the discrepancy is that the sounding is showing data collected at 6pm on October 11th, and the photo was taken at 12:30pm. This also provides plenty of time for the instability to

die out before the sounding took data and so it may not accurately reflect the smaller scale phenomena that the picture captures.

Visually though, we can compare this photo to others that exemplify more ideal situations of mountain waves like that shown in Fig. 2.

Figure 2. Ideal Mountain Waves [1]

As seen there, the altocumulus clouds are linearly separated in a periodic behavior that the mountain waves produce. In the submitted photo, Fig. 3, those separation lines can be seen but almost as if they are fanning out instead of coming from a straight line.

Figure 3. Submitted clouds image

This could be expected since according to the skew-T, the wind was coming from the southwest, which would make sense as to how the clouds are breaking off.

III. Image Details

Estimating some of the image parameters are a little harder here since the photo is looking at the sky, but a decent estimate of the field of view is probably around 3 miles across, then judging from the altitude of the clouds and the angle the photo was taken at, the clouds are approximately 6000m from the lens of the camera. Here it should be noted that this was taken with simply a Samsung Galaxy S8 camera. That means that the camera's settings were auto adjusted to an ISO of 50, aperture of $f/1.7$, shutter speed of $2736Hz$, and a focal length of $4mm$.

Then, there was a little bit of post-processing that was done in the photo. First, a gradient mask was applied to the bottom of the photo with a center right around the spot where the trees meet the sky. Then, a monochrome module was applied to that mask so that the bottom of the photo is slowly grayed out, accenting the sky. After that, the RGB curves were adjusted to bring out the blue of the sky on top, making sure that the eye is drawn towards the top third of the photo where teh cloud formation in question is.

IV. Results

Overall, the image is a nice portrait of a cloud formation over Boulder, CO, and could be a decent representation of mountain waves coming off of the flatirons and impacting this cloud. Since its not as clear as some other photographs of mountain waves though, some more verification would need to be done on actual velocity data of the winds at the altitude the clouds are at. Mining through that dataset could verify the existence of mountain waves for good, and could be a cool direction to go in next.

References

[1] S. Handley. The sky filled with ripples and waves over the mountains of mourne, northern ireland. https://cloudappreciationsociety.org/gallery/photo/photo-n-300389, 2018. Accessed: 2021-10-25.