Cloud Assignment 2

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This report describes the second cloud assignment, including the possible physics behind the cloud captured, location, and photographic techniques used to take the photograph. For the first cloud assignment, my goal was to capture a mountain wave cloud, or Altocumulus Lenticularis because these clouds were new to me having never experienced them growing up on the west coast. For the second cloud assignment, I set out to take many pictures of clouds over many days to capture many different types of clouds and pick the most striking. I found that the most striking photos that I encountered were always mountain wave clouds in the Boulder,CO area over the assigned period, and I did not want to repeat the same cloud for the second cloud assignment. This led me to bring my camera while on vacation in Arches National Park in Moab, UT, and in hopes to capture a different variety of clouds.

This cloud image was captured on Friday, March 30, 2012, at roughly 12:00pm MST at the entrance to the Devil's Garden Trailhead in Arches National Park. The camera was facing west at about 60 degrees above the horizon line. All the clouds captured in my photographs that day were high wispy cirrus clouds, figure 1, but this cloud particularly caught my attention because its distinct spiral shape. I first looked around the sky to see if the cloud was part of a contrail that was breaking up, but there was no other evidence that a jet had recently passed through the area. Since the clouds dominating the sky this particular day were cirrus clouds it is highly likely that the image shows an example of a Kelvin Helmholtz cloud where high wind shear can occur and ice particles from the cirrus clouds fall over large distances in altitude.

Figure 1. Example of Clouds in Sky on 3/30/12 in Arches NP

Kelvin Helmholtz clouds are caused by instability of the same name and occur when there is a velocity shear present in a continuous fluid or when there is sufficient difference of velocity across the boundary of two fluids of different densities [1]. A turbulent layer forms when the faster moving top layer of fluid slides over the slower layer, dragging its surface along. If the difference between the top

and bottom layer velocities are big enough then waves can develop into the classic Kelvin Helmholtz shape[3]. The spirals shown in the cover photo are most likely caused by the difference in wind velocity in the different density layers the cloud occupied in the atmosphere, the higher altitude winds being greater than the lower altitude winds. Figure 2 shows another example of a Kelvin Helmholtz cloud [5] which has a similar shape to the one captured in the cover photo.

Figure 2. Example of a Kelvin Helmholtz Cloud [5]

Cirrus clouds can be identified by their bright white wispy appearance. Cirrus clouds are the highest of the common clouds seen forming at altitudes of 24,000 ft above the ground surface. They are composed entirely of ice crystals and are in fact precipitating clouds, however the clouds are too high and the precipitate evaporates before it hits the ground as it falls through warmer air masses. Cirrus clouds take on their wispy appearance due to the high wind speeds in the troposphere spreading the falling ice crystals over large distances. As the ice crystals fall to lower altitudes the winds generally decrease causing the falling ice to lag behind and create the streaking affect you see in many cirrus clouds [4].

The day before this image was taken there was a large layer of altostratus clouds formed up against the mountain range east of Arches National Park, but clear skies were seen above Arches itself. The day the image was taken winds were calm at 5 mph, but developed up to 30 mph the next day with a weather system moving in on Sunday. This would explain the appearance of cirrus clouds on Friday and Saturday since cirrus clouds usually precede a shift in weather [5].

A skew-T plot for both Salt Lake City, UT and Grand Junction, CO are shown in figure 3. The skew-T plots are for the morning 6 hours before the photograph was taken. Grand Junction is located 113 miles from Moab, UT, but is located slightly into the mountains so it was thought that Salt Lake City

might have more similar weather to Moab. It is my feeling that both these location are too far away or have different enough topography to not accurately show what was occurring in Moab. The Salt Lake City skew-T shows a better possibility of cirrus clouds starting at around 35,000 ft above sea level when the dew point line and the dry bulb temperature profiles approach each other. The Salt Lake City Skew-T also shows the formation of clouds at 11,000 ft above sea level, which would signify altostratus or stratocumulus clouds, however these types of clouds were not seen in the sky near Moab. Wind speeds barbs at cirrus cloud altitudes show roughly a wind speed differential of 10 knots between layers, but this might not be enough to cause a Kelvin Helmholtz instability. Due to the time the photograph was taken and the location, it is impossible to supply an accurate skew-T analysis and get a true sense of what the conditions were like in Moab at 12:00pm on March 30,2012.

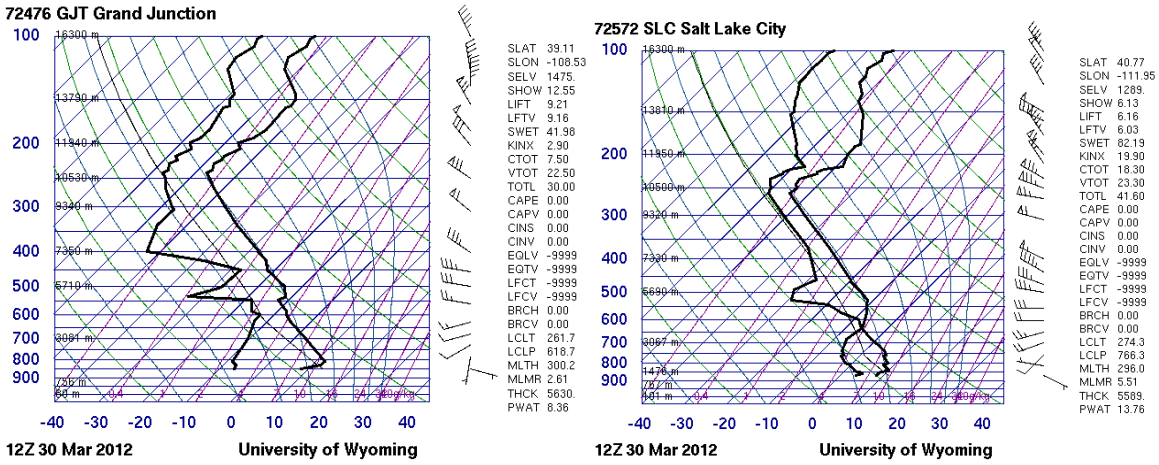

Figure 3 Skew-T Plot for Atmospheric Conditions on March 30, 2012 12pm MST

The photograph was taken with a D5100 Nikon DSLR camera. The only available lens was a VR 18-55mm F/3.5-5.6. Distance to the object was roughly 11 km with an estimated field of view of 100m. The focal length was 55 mm to cut down on later cropping out of the mountains. The ISO was set to 100 since the sun was almost directly overhead and to the south. Aperture was set to F/13 and the shutter speed was 1/200s because the bright noon sun required a faster shutter speed to decrease the brightness in the photo. The image size is 4928 x 3264 pixels and was edited in GIMP to increase the blue sky color, the red of the rocks, and white of the cloud to make the edges and lines stand out more. The original image is shown in Fig. 4. Most of the cloud was cropped out in order to focus more on the spiral section. I chose to leave the red rock in the photo because I thought it provided a nice contrast between the blue of the sky and the white cloud adding more dimension.

Figure 1 Original photograph of Kelvin Helmholtz Cloud

This photograph shows a probable Kelvin Helmholtz instability caused when wind of different speeds on a top and bottom layer of a cloud can shear the cloud creating wave patterns. A proper skew-T analysis cannot be performed since sounding data at the location and time the photograph was taken is not available. Given the definite presence of cirrus clouds with long wispy tails suggest that there were high winds of differing speeds in the atmosphere that day which are conditions needed to form a Kelvin Helmholtz cloud. I think a lens that was capable of zooming in on the cloud would have been helpful given the distance to the cloud. Greater detail of the spiral section could be nice, but overall I feel this photograph captured a beautiful and unique cloud. The landscape of Arches National Park provided an excellent backdrop to cloud photography.

References

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