

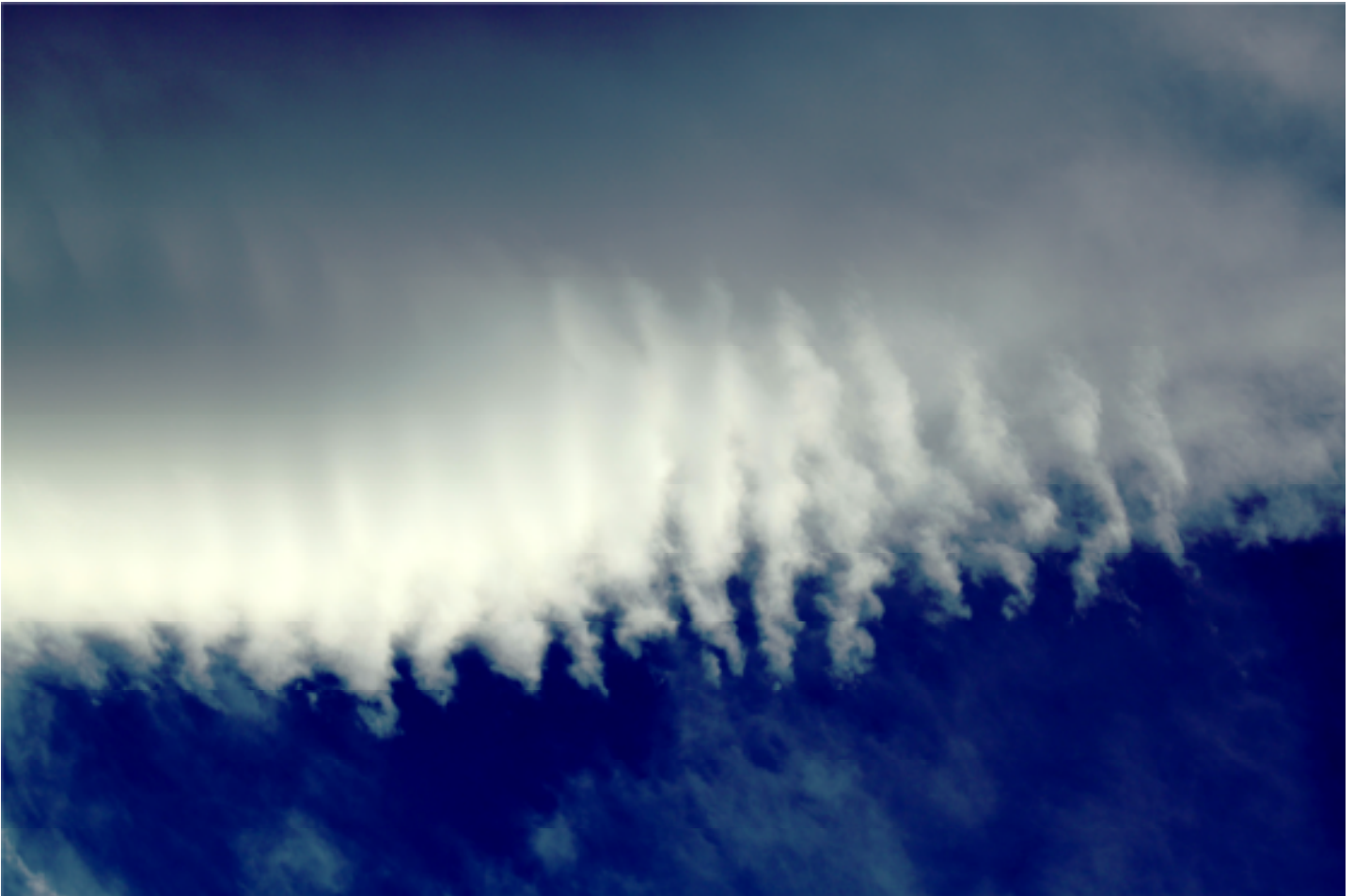
Cloud Image Project 1

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Flow Visualization

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The intent of this cloud photograph is to observe and capture the dynamics of a cloud formation as a fluid flow, and to categorize it to determine the atmospheric conditions present that allowed its formation. There are many varieties of clouds and cloud formations, and successfully capturing a cloud formation that was interesting, unusual, as well as a good photograph proved to be quite a challenge. There was no specific cloud that was the target for this assignment, but when this cloud formation was spotted it stood out as an excellent candidate for investigation.

This cloud formation was spotted over Centennial, Colorado on January 16, 2011 at approximately 5:10pm MST. The weather was cold (approximately 5°C) but not windy, and the clouds were moving slowly. The cloud in the image was located southwest of the camera, at an angle of approximately 70 degrees above the horizon. Only the tip of the cloud was photographed where the undulating waves on the underside of the cloud are clearly visible. The entire cloud was a long, flat spear-shaped cloud that extended for several miles in the south-southeastern direction from the camera's position. There was another similar cloud directly adjacent to the cloud which ran parallel to the cloud in the south-southeastern direction from the camera's vantage point.

After inspection and investigation, it is determined that this cloud is of the variety *Alto cumulus Lenticularis Undulatus*. *Alto cumulus* clouds are mid-level clouds which typically form between 2,000 and 7,000 meters above ground level in the atmosphere. The cloud species *Lenticularis* typically forms in stable atmospheric conditions and have a notably smooth round top (1). The variety *Undulatus* refers to the parallel rows of cloud that can be seen in the photograph.

The Skew-t plot is a plot which shows data about the atmosphere at different altitudes including temperature, pressure, dew point, and humidity was consulted for this day in Denver, and can be seen in figure 1 (3). Since the location is reasonably close to the location of the weather balloon used to gather the data and the time of the readings, it is reasonable to assume that the skew-t plot data closely represents the conditions seen at the location where the picture was taken.

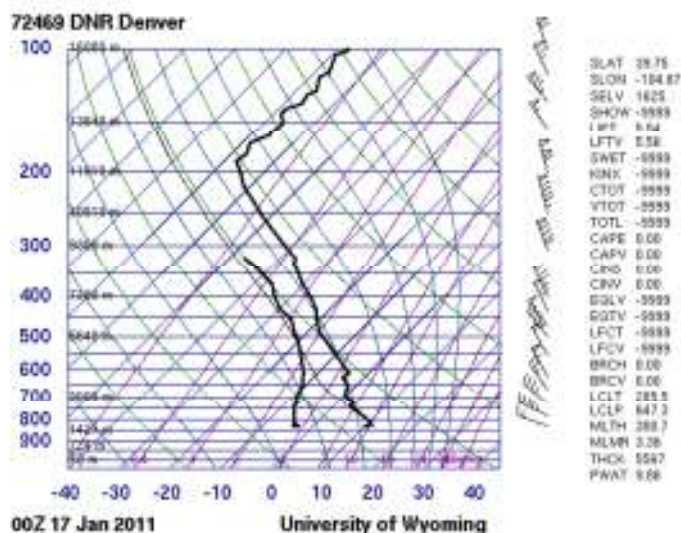


Figure 1: The skew-t plot for Denver on January 16, 2011 at 6:00pm

It was found from the skew-t plot that the atmosphere was very stable on this day around 6 pm, and it also shows that the expected cloud altitude was around 5,640 meters, which would agree with the region where the observed cloud genus Altocumulus typically forms.

Since the atmosphere was so stable, the undulating portion of this cloud was likely a gravity wave rather than a shear wave. A gravity wave is formed when a disturbance in a fluid causes the fluid to displace to a fluid surrounding it with a different density. Gravity then tries to restore the fluid to equilibrium, causing the fluid to oscillate around the equilibrium state (2). In this case, the cloud is formed as the air is displaced upward and the water vapor in the air condenses, and the gaps between the clouds are the regions where the air is travelling downward and the cloud evaporates. The final effect is the washboard appearance of the cloud formation seen in the image.

In addition to the altocumulus clouds present there were also cirrocumulus clouds at higher levels within the atmosphere.

Since the cloud was at an approximate angle of 70 degrees above the horizon at an estimated altitude of 5,640 meters, the estimated distance of the cloud to the camera is about 6,100 meters. With the lens focal length of 55mm, the approximate field of view is 730 meters wide by 550 meters high. The shot was taken by hand so no tripod was used, and the only lighting is natural solar light. The specific camera and settings used for the photo can be seen in Figure 2.

The photograph was processed using GIMP photo editing software. The only editing done to the photograph was an adjustment of the color and contrast curves to heighten the contrast of the picture. This was done to slightly increase the saturation of blue color in the sky and have it better contrast the lighter shades of the clouds.

Camera Type	Canon EOS Rebel Ti1 DSLR (15.1 Megapixel)
Focal Length	55mm
Aperture	f/13
Shutter Speed	1/125
Sensitivity	ISO 100
Field of View	Approx. 730m x 550m (4752 x 3168 pixels)
Distance from camera to object	Approx. 20,000 feet

Figure 2: The specifications of the camera used to capture the cloud image

Overall the photograph was a successful capture of an unusual and interesting cloud formation. The image clearly shows the undulation of the clouds, and the formation of the clouds was simple to confirm using the atmospheric data. It would be interesting to be able to observe this same cloud formation on a larger scale or in other situations to see any differences between this cloud formation and others of the same cloud variety. The picture could have benefited from the use of a filter to enhance the image and capture interesting lighting and coloring effects, and in the future additional post-processing effects

could be explored in order to obtain a more interesting photograph artistically. One alternate photograph that was considered was processed using GIMP and is shown in figure 3. This image was produced by inverting the colors of the photograph. Additional effort could be made to explore this technique further. The original unedited photograph is shown in figure 4.

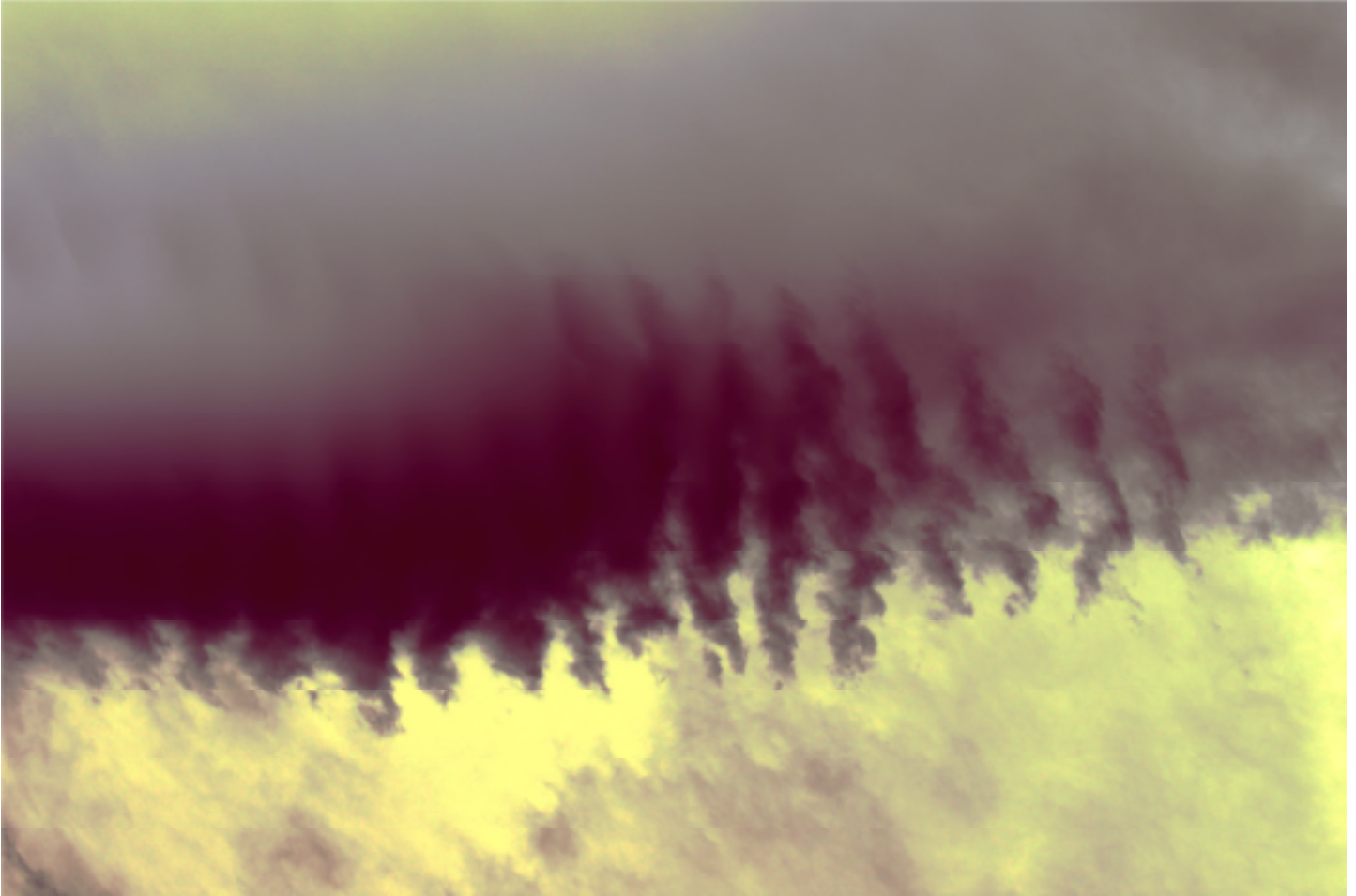


Figure 3: An alternate inverted-color version of the photograph created using GIMP



Figure 4: The original unedited photograph of the cloud formation

References

- 1) *Cloud Variety*. (n.d.). Retrieved February 22, 2011, from Integrated Publishing:
http://www.tpub.com/content/aerographer/14269/css/14269_18.htm
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http://en.wikipedia.org/wiki/Gravity_wave
- 3) *Weather*. (n.d.). Retrieved February 18, 2011, from University of Wyoming College of Engineering Department of Atmospheric Science: <http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2011&MONTH=01&FROM=1700&TO=1700&STNM=72469>