Cloud Assignment #2

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The purpose of this assignment was to capture cloud formation and behavior for the second cloud assignment for the spring 2011 Flow Visualization class at CU Boulder. The time-lapse video was intended to visualize the formation of clouds as well as their behavior as they moved through the atmosphere.

The pictures were captured in Centennial, Colorado on April 9, 2011. The camera was placed on a rooftop approximately 20 feet above ground level facing SSW and at an upward angle of approximately 10 degrees from the horizon. One picture was taken every 10 seconds for a total of 3 hours and 48 minutes totaling 1156 pictures. The sequence begins at 11:29 am and ends at 3:21pm.

Several cloud types can be seen in the video. The primary clouds in the video are the formation of Cumulus Humulis clouds, which, due to high wind from the SW direction are quickly broken apart into Cumulus Fractus clouds as they move out of the frame. Another cloud type is visible at higher elevation above the cumulus clouds, which are likely Altostratus Undulatus due to their elevation and composition. There are also several jet contrails that can be seen passing through the frame during the video. In the video crepuscular rays can be seen as the clouds block the sunlight, contrasting with the scattered sunlight in the rest of the frame as seen in Figure 1.

Figure 1: Crepuscular rays visible as the atmosphere scatters the sunlight

It is likely that most of the clouds formed are due primarily to turbulent mechanical lift created by friction between the ground and the layers of the air containing the cloud. The air condenses as it is lifted, causing the clouds to form (1).

The Cumulus Humulis clouds could not be maintained in the stable atmosphere with such windy conditions, and quickly break up into Cumulus Fractus clouds and dissipate. The altostratus clouds likely formed as the stable air at mid-level altitudes became saturated. The undulatus characteristics can be seen in Figure 2 and were likely caused by wind shear, as the difference in wind speed between the layers of the atmosphere caused turbulence, forcing sections of the clouds up and down, causing the cloud to dissipate as it moves downward, and condense as it moves upward in a successive pattern (2) .

Figure 2: Undulations in the altostratus cloud are caused by a shear wave

The photographs were taken as a cold front was moving into the area, and the windy conditions were a precursor to the low pressure system that moved in early the next morning. The wind gusts were very strong, particularly during the last hour and a half of capturing time, with maximum sustained winds of around 30 mph at 3:21pm (2). There were similar conditions the day before with a stable atmosphere

and partial cloud cover, and a high temperature of 71°F. The temperature range while the pictures were taken was 59°F at 11:00am rising to the high temperature for the day at 72°F by 3:00pm. The atmosphere was very stable with a CAPE value on the skew-t plot taken at Denver International Airport of 0.00 (3). By the next sounding at 6:00am on April 10, the atmosphere was less stable with a CAPE value of 6.95 and there were fluctuations in the dew point accompanied by light rain.

Although the photos were taken in between the 6:00am and 6:00pm atmospheric soundings, the estimated elevation of the clouds based on the skew-t plots as seen in Figure 3 and Figure 4 is around 12,000ft, which would agree with the elevation of the Cumulus Humulis clouds seen in the image sequence. The elevation of the altostratus clouds cannot be accounted for in the skew-t diagram, and since they seemed to occur in small amounts in the middle of the video may not have been present at the time of the atmospheric soundings at DIA.

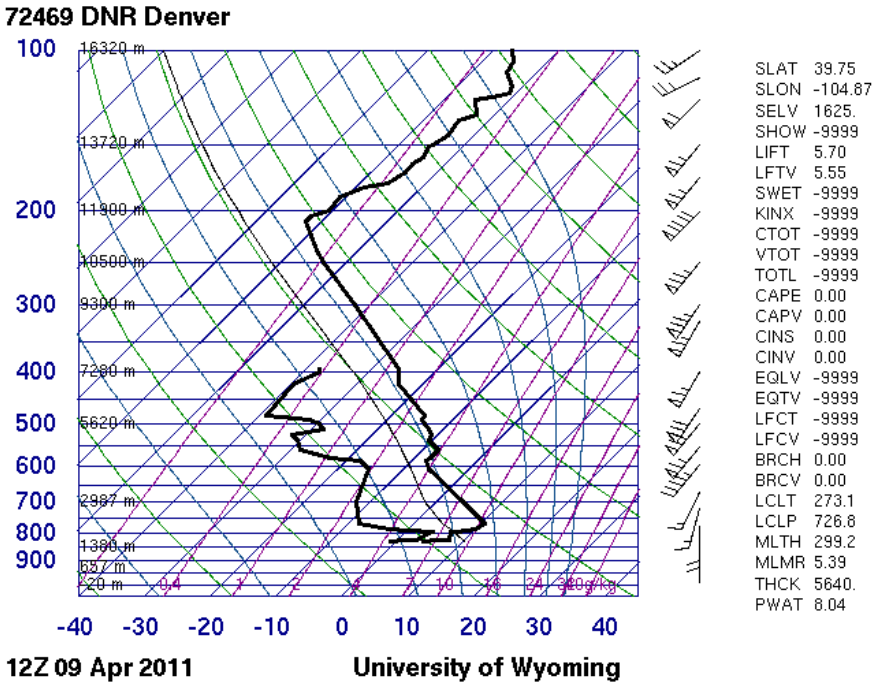

Figure 3: The Skew-T plot for Denver on April 9th 2011 at 6:00am

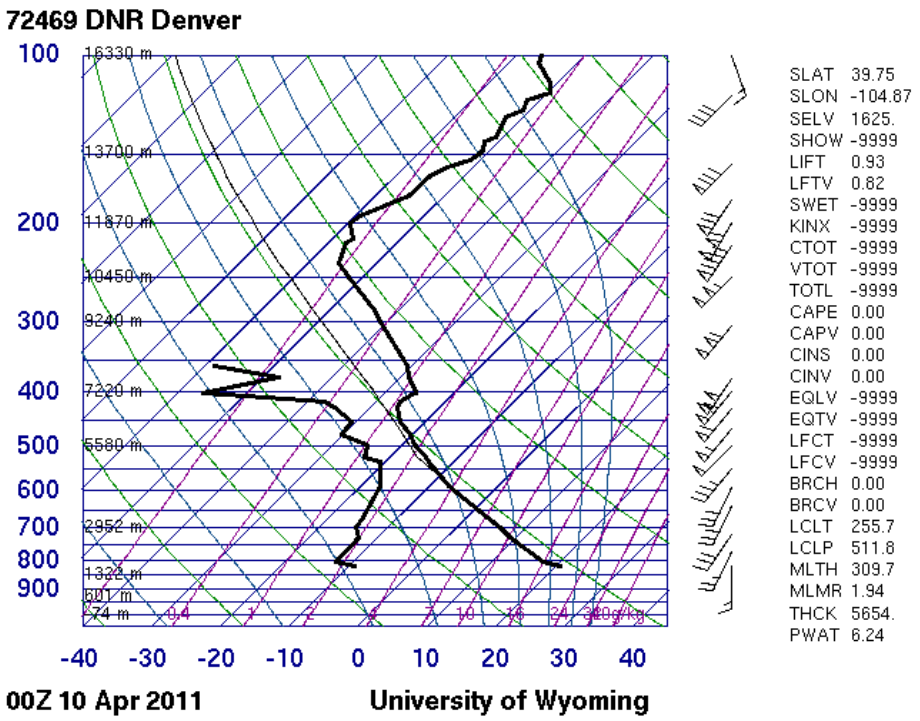

Figure 4: The Skew-T plot for Denver on April 9th, 2011 at 6:00pm

The focal length of the lens was 18mm, set for a wide angle to capture as much of the sky as possible for the image sequence. The lens was a Canon EF-S 18-55mm lens, and the camera was a Canon Rebel T1-I 15.1 MP DSLR. Since the lighting conditions weren't static and the camera was taking pictures over such a long time period, the camera was set to AUTO mode so that any lighting condition or change in cloud speed could be accounted for without having to adjust the camera settings. The range of exposure times was between 1/250 sec to 1/400 sec. The ISO speed remained constant at 100. The range of F-stop values was F10 to F13. The focus was set to manual to prevent the camera from focusing on different portions of the images. The size of each frame in the video was 4762 x 3168 pixels.

The time-lapse was created by using an automatic remote control which activated the camera and took one photo per 10 seconds. This time was chosen to find a balance between the time lapse video length, the memory card size, and the change in position of the clouds between frames. The speed of the clouds can be seen to change throughout the video as the wind speeds increased over the course of the video from nearly calm at the beginning of the video to over 30 mph sustained winds at the end (3).

The images were loaded as an image sequence with the animation codec into Apple QuickTime Pro. The image sequence was then exported as an avi file with some post-processing done to the image. The frame rate was set to 15 fps, and the contrast was increased, as well as the saturation. This was done to highlight the crepuscular rays apparent throughout the video.

Overall the time lapse was a great success. The formation and dissipation of the clouds within the frame was very interesting, and led to a great view of the atmospheric conditions on that day. If the setup were repeated it would have been advantageous to have taken pictures with less time in between each photo to eliminate the slight choppiness of the video, but overall the quality of the video was good. Also, since QuickTime cannot accept raw images, the video could have been made longer by only capturing the jpeg images rather than both the jpeg and raw images. This would have allowed for many more pictures to be taken over a longer period of time. A longer focal length would have shown more detail in the clouds, although it would not have captured as many due to the more limited field of view, but could be tried in the future if there is a greater certainty about the location of cloud formations. Making a time-lapse video instead of a still image was very rewarding in that it allowed the visualization of so many phenomenon involved in the cloud behavior and the results are beyond expectation.

Bibliography

1. Aerographer/Meteorology. *Integrated Publishing.* [Online] [Cited: April 17, 2011.] www.tpub.com/content/aerographer/14269/css/14269_16.htm.

2. Altostratus Undulatus, Excerpt from the book "Weather". *theairlinepilots.com.* [Online] [Cited: April 17, 2011.] http://www.theairlinepilots.com/met/altostratusundulatus.htm.

3. Centennial, CO 80112, USA. *Weather Spark.* [Online] [Cited: April 19, 2011.] http://weatherspark.com/#!graphs;a=USA/CO_80112/Centennial.

4. 72469 DNR Denver. *University of Wyoming College of Engineering Department of Atmospheric Science.* [Online] [Cited: April 19, 2011.] http://weather.uwyo.edu/cgi-bin/sounding?region=naconf&TYPE=GIF%3ASKEWT&YEAR=2011&MONTH=04&FROM=0812&TO=1100&STNM=72469.