MCEN-4228-010

Flow Visualization

Clouds Report 2

By

Kane Chinnel

Section Instructor: Jean R. Hertzberg

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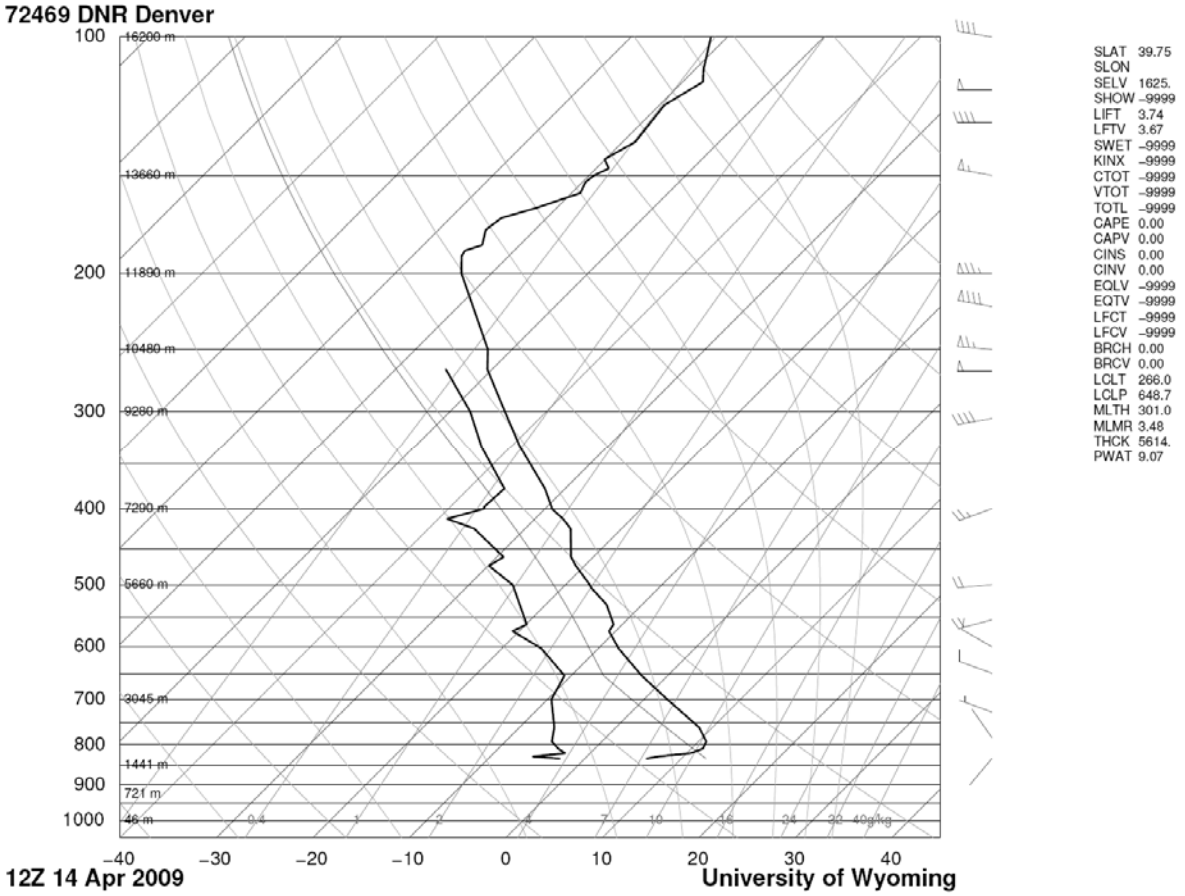
Introduction

The purpose of the assignment is to photograph and categorize a cloud formation. Cloud formations, like many other physical phenomena, have the ability to be both visually and scientifically appealing. The physics behind the study are physical processes that lead to the formation, growth and precipitation of clouds. The cloud photographed for this assignment will be identified and its formation and physical characteristics will be discussed thoroughly. The photograph for this paper was taken in the late afternoon facing westward towards the full mountain range of the Rockies.

Flow Apparatus

The apparatus for this experiment is the warm, Colorado sky during the spring. The image taken at approximately 4:30 PM on April 14, 2009, from the top of the 436 parking garage on the main campus of the University of Colorado at Boulder. The local Boulder temperature was a mild 64 degree Fahrenheit. The camera was held in place and directed west toward the front range of the Rocky Mountains. Figure 1 is the Skew-T data plot for Denver, CO in the afternoon of April 14, 2009 at 6:00PM. The clouds were formed at the end of a very large mountain wave cloud that was lingering for most of the day.

Interpretation and Analysis



Analyzing the plot, dew point line (darkened left line), is separated from the temperature line (darkened right line) at lower altitudes. Using the figure, lower altitudes implies 7400 meters. However, above 7400 meters to 9800 meters, the two lines are only separated by 5 to 15 degrees centigrade, implying that clouds are very likely to be formed within this altitude range. Depending on the slope of each line, with reference to the horizontal isobar lines, the plot also provides a gauge for atmospheric stability. Below 7400 meters, the atmosphere can be interpreted as unstable, conversely, above the same height, the dew point and temperature lines have smaller slopes and are closer together.

The articulated information from of the Skew-T data plot, shows that the clouds in the photograph are most likely a hybrid of altocumulus clouds with the most noticeable being "…the undulatus cloud formation which only occurs in the early stages of destabilizing return flows" [1]. As the air rises on one side of a standing wave, then condenses water vapor into laminar, layered formations like the photograph shown, and then sinks on the other clouds. The clouds are at a high elevation in a very stable atmosphere, above 7400 meters. The image only provides a smaller, yet more interesting part of the formation. In the photograph, there are three visible layers that provide contrast to one another. The Skew-T plot wind barbs, along the right side of the graph, indicate wind speeds at the elevation to be between 36 to 40 knots, increasing with respect elevation. The Reynolds number is estimated with a 38 knot wind speed is calculated to be about 4.62*10^7, indicating very turbulent external flow.

wind speed =	38 knots =	19.55	m/s	[2]
air density =	at 7600 m =	0.469	kg/m^3	
section of cloud est. =		1000	m	
viscosity of air =	at 7600 m =	0.00001983	kg/m*s	[3]
Reynolds # =	462377711			

Visualization Technique

The clouds were first spotted around in the afternoon. At that time, the wind velocities near the foothills of Boulder were calmer when compared to the morning; however a low velocity breeze could be felt near ground level. The late day sun allowed for a light angle that lit

up the articulate structures and layers within the clouds. This can be seen in the photographs provided. The brighter could colors were near the bottom of the cloud, and darker near the top. Conversely, the clouds closer to the eye were also dimmer than those further away.

Photographic Technique

The image was taken with a 6.1 megapixel Pentax *ist DS SLR camera with a SMC Pentax-FA 28-80mm f3.5-4.7 lens. Using Adobe Photoshop's "EXIF" metadata option, the photographic data is as follows:

Make:	Pentax
Model:	*ist DS
Date Time:	10/16/09 - 4:30 PM
Shutter Speed:	1/3000 sec
Exposure Program:	Aperture priority
F-Stop:	f/4.5
Aperture Value:	f/4.4
Max Aperture Value:	
ISO Speed Ratings:	400
Focal Length:	48 mm
Lens:	smc Pentax-FA 28-80mm f3.5-4.7
Flash :	Did not fire
	No Strobe return detection (0)
	Compulsary flash suppression (2)
	Flash function present
	No red-eye reduction
Metering Mode:	Pattern

The field of view for this image is estimated to be 1 to 2.5 kilometers. The estimated cloud elevation is 7600 meters. The final image size, cropped from an original image of 3008 pixels by 2008 pixels to 2214 pixels by 1496 pixels. The cropping of the image was to eliminate the trees from the bottom of the photograph. Adobe Photoshop was used to increase sharpness

and vivid colors through the use of a modified, overlaid background image. A high pass filter was used to increase overall pixel size to 9.2 to the dramatic colors of the sky.

Revelation

The image reveals a clouds formed by a typical spring weather pattern in Colorado. The duplication of layers became visible because of the late day sun angle as the upper atmosphere becomes more laminar. Once the large mountain wave cloud moved over the city, the sun shine through and illuminated the smaller clouds behind the wave clouds. Another set of wave clouds was over the ridge and waiting to move in. I had read that this type of cloud formations precedes a cold front three to five days later; I hope I am incorrect in my assumption. Nevertheless, the scenery was no less than amazing.

Original image before Adobe Photoshop

References

[1] "altocumulus" Nation Master Encyclopedia. 2009. NationMaster. 14 Apr. 2009

http://www.nationmaster.com/encyclopedia/

[2] “ 38 knots in meters/sec.” www.Google.com. 14 Apr. 2009

,http://www.google.com/search?q=42+knots.

[3] “viscosity of air.” www.google.com. 14 Apr. 2009

<http://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html>