MCEN-4228-010

Flow Visualization

Clouds Report 1

By

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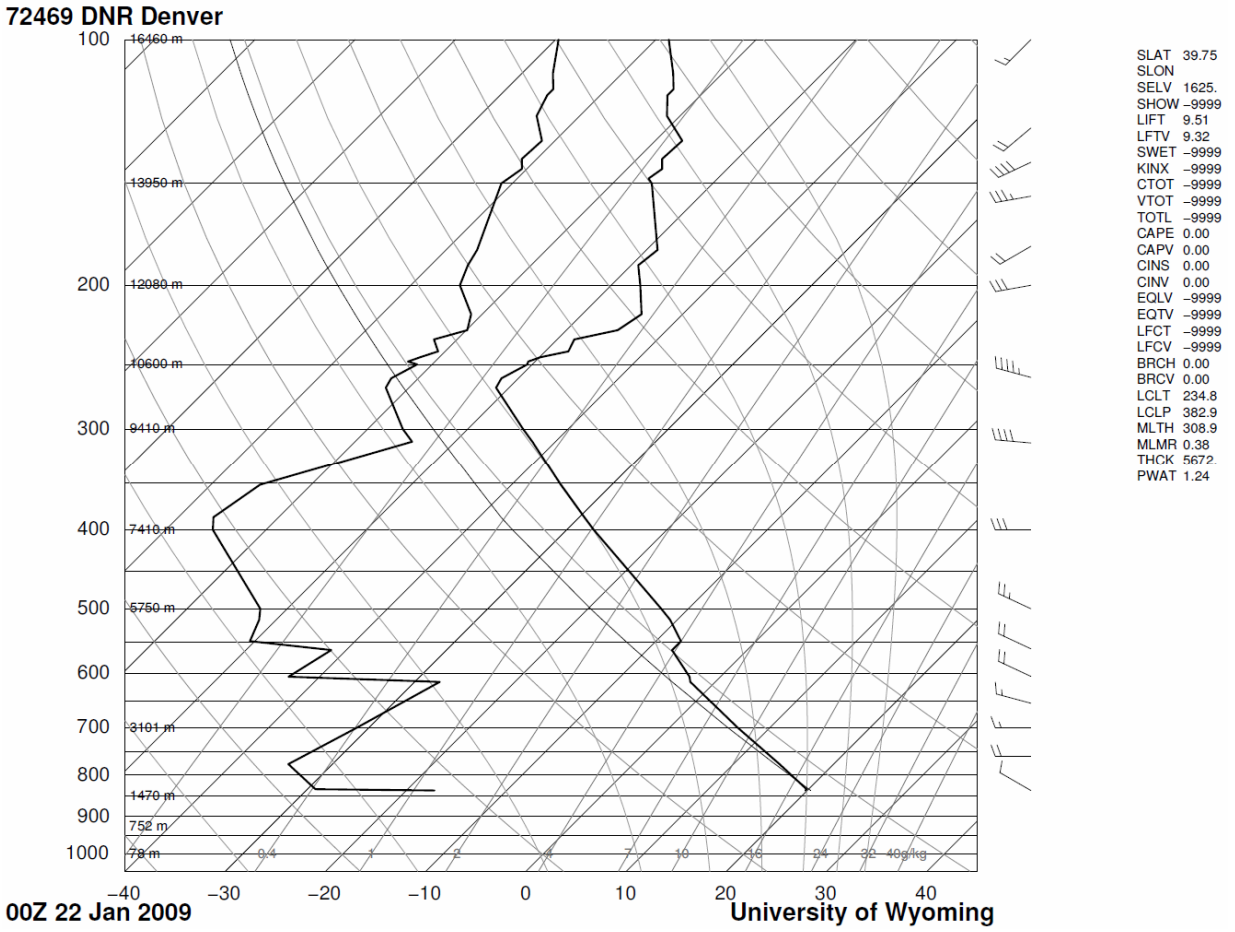
Introduction

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 southwest towards the flatirons.

Flow Apparatus

The apparatus for this experiment is the cooler January, Colorado Sky. The image taken at approximately 5:00PM on January 21, 2009, from the corner of 2922 Baseline Road in Boulder, CO 80303. The local Boulder temperature was a mild 52 degree Fahrenheit. The camera was held in place and pointed in a southwest direction. Figure 1 is the Skew-T data plot for Denver, CO in the afternoon of January 21st, 2009 at 6:00PM.

Interpretation and Analysis



Analyzing the plot, dew point line (darkened left line), is separated from the temperature line (darkened right line) at lower altitudes, below 9400 meters. However, above 9400 meters, the two lines are only separated by roughly 10 degrees centigrade, implying that clouds could be formed above 9400 meters. Depending on the slope of each line, with reference to the horizontal isobar lines, the plot also provides a gauge for atmospheric stability. Below 10200 meters, the atmosphere can be interpreted as unstable, conversely, above the same height, the dew point and temperature lines have smaller slopes.

The articulated information from of the Skew-T data plot, shows that the cloud in the photograph is most likely the altocumulus lenticularis cloud formation which only occur between

6000 meters to 12000 meters. The cloud formation is likely related to a cold front moving in westward from the mountains and pushing out the warm air from previous days. As the air rushes over the Rockies, it rolls, forming stacks of standing waves over one another. 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 9000 meters. The image only provides a smaller, yet more interesting part of the formation. The range of the cloud formation stretched over a large portion of the Rockies. The clouds stretched north and south of Boulder along the Front Range, easily covering a length of 10 kilometers. 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 32 to 52 knots, increasing with respect elevation. The Reynolds number is estimated with a 42 knot wind speed is calculated to be about 60000, indicating turbulent flow. However, most altocumulus lenticularis cloud formations are characterized by "…stable moist air flows over a mountain or a range of mountains, a series of large-scale standing waves may form on the downwind side" [1].

wind speed =	42 knots =	21.61	m/s	[2]
air density =	at 10000 m =	0.4127	kg/m^3	[3]
	section of cloud est. =	0.1	m	
viscosity of air	at 10000 m =	0.00001488	kg/m*s	[4]

Reynolds # = 59935.79973

Visualization Technique

The clouds were first spotted around mid afternoon. At that time, the wind velocities near the foothills of Boulder began to calm down. The layers of clouds and separation between layers were not visible. The late day sun allowed for a light angle that lit up the articulate structures and layers within the clouds.

Photographic Technique

The image was taken with a 3.2 megapixel Sony Ericsson camera phone. Using Adobe Photoshop's "EXIF" metadata option, the photographic data is as follows:

Make:	Sony Ericsson
Model:	K810i
Date Time:	01/21/2009 - 5:00:08PM
Shutter Speed:	1/640 sec
Exposure Program:	
F-Stop:	f/2.8
Aperture Value:	
Max Aperture Value:	
ISO Speed Rating:	80
Focal Length:	
Lens:	
Flash:	Did not fire
	No strobe return detection
	Auto Mode (3)
	Flash Function present
	No red-eye reduction
Metering Mode:	Center weighted average

The field of view for this image is estimated to be 2.5 to 4 kilometers. The estimated cloud elevation is 9500 meters. The final image size, cropped from an original image of 800 pixels by 600 pixels to 800 pixels by 555 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, overlayed background image. A high pass filter was used to increase overall pixel size, and hard lighting was decrease to 69% to capture the dramatic colors of the sky.

Revelation

The image reveals a clouds formed by a typical winter weather pattern in Colorado. The duplication of layers became visible because of the late day sun angle as the upper atmosphere becomes more laminar. I like that this image opened my eyes to weather patterns and other clouds for days and even weeks after the image was made. I am now realizing that this exact cloud will never be seen again, and this report is the only documentation of it.

Original image before Adobe Photoshop

References

[1] "altocumulus lenticularis." Nation Master Encyclopedia. 2009. NationMaster. 20 Feb. 2009 http://www.nationmaster.com/encyclopedia/Lenticular-cloud

[2] " 42 knots in meters/sec." www.Google.com. 20 Feb. 2009 ,http://www.google.com/search?q=42+knots.

[3] Collinson, R. P. G. "Introduction to Avionics Systems". Kluwer Academic Publishers. Circuits and Devices Magazine**,** Volume: 20, Issue: 4. July 2004.

[4] "viscosity of air." www.google.com. 20 Feb. 2009 <http://www.engineeringtoolbox.com/air-absolute-kinematic-viscosity-d_601.html>