The Sky's Natural Designs

Orographic Altocumulus Lenticularis Opacus
&
Cirrus Fibratus Raditatus

Daniela Molina
Flow Visualization
Professor Jean Hertzberg
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I. Objective

This image was captured for the Flow Visualization course's first "Cloud" project, at the University of Colorado at Boulder with the objective of exemplifying an atmospheric condition via the detailed observation of clouds. At an elevation of approximately 10,000 ft above sea level with extensive clear views was a perfect scenery to accomplish this assignment. This clouds image was captured atop the Indian Peaks on a sunny day with nearly stable weather conditions. The photograph illustrates a clear altocumulus Lenticularis cloud formation due to an orographic lift of winds flowing east accompanied by some Cirrus Fibratus formations possibly created by aircraft contrails. These cloud classifications and the atmospheric effects creating these formations will be investigated and discussed throughout this report to explain the conditions and dynamics of the image.

II. Discussion

This image was taken atop the Indian Peaks, facing southwest across the Red Rock Lake at about 1:30pm on February 12, 2011. Based on the 12Z sounding data in the Skew-T plot from Denver, CO (Figure 1)[1] the classification of the cloud in the image can be explained. Even though the dewpoint profile indicates a very stable atmosphere with mostly clear skies, it also measures, in concurrence with the temperature profiles, the probability of any cloud formations, most likely occurring between 15,000 and 16,500 ft above sea level. Thus, due to this measured altitude, the visible cloud formations fall into the middle level Altocumulus genera[2]. This image exemplifies these atmospheric conditions and also captures other cloud formations of the higher levels (20,000-40,000 ft) that fall into the Cirrus genera[2].

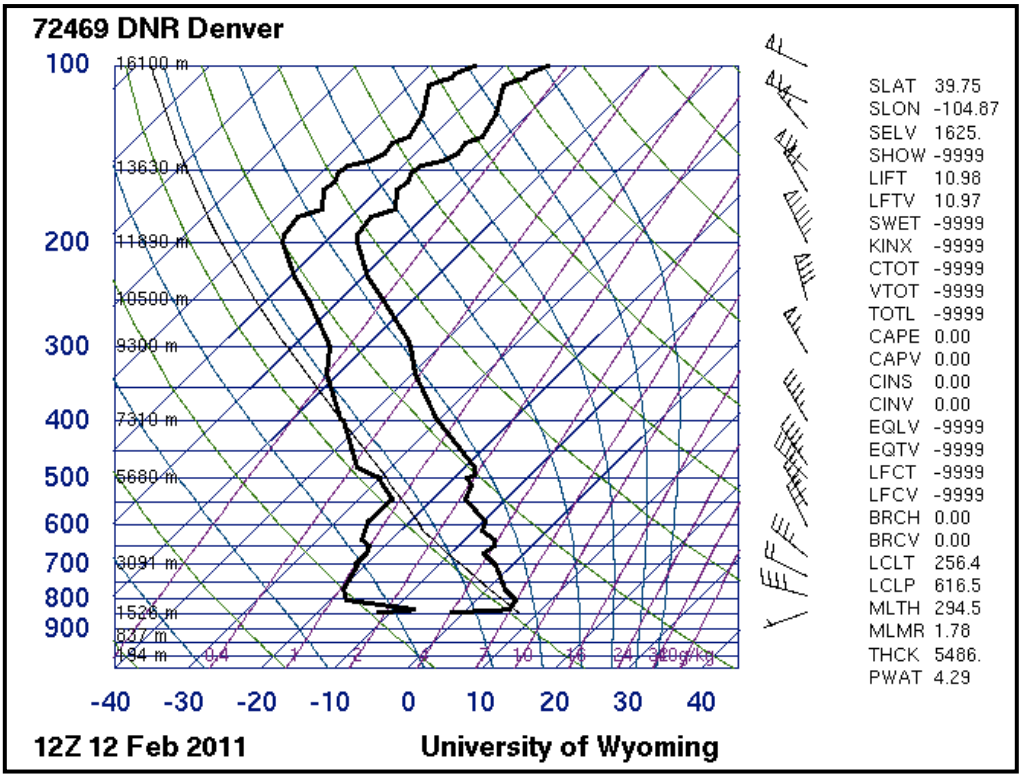

Figure 1: Skew-T Plot for Denver, CO on February 12, 2011. Skew-T plot was recorded at 12:00pm of that day (1.5 hrs before image was taken[1].

The latter, seen at the top right of the image, are the highest of the cloud types and due to their exposed straight and distinct filament (hair-like) features these can be further classified as Fibratus species[3]. The dewpoint stable (vertical slopes) profile depicted on the Skew-T plot (Figure 1) do not show any evidence

of high cloud formations for the day this image was created, but there may be other reasons why these formations could have happened. There are two pieces of evidence that may explain these high type cloud formations on that particular day: (i) the reminiscences of a passing cold front from the day before as depicted by the yellow dotted line in Figure 2[4] and/or (ii) the broadening of contrails (condensation trail) into Cirrus formations initially produced by an aircraft's engine exhaust.

Moreover, this Cirrus Fibratus configuration of discontinuous structure and limited horizontal extent are even further typified in the variety spectrum of Radiatus clouds. This variety of clouds is usually arranged in parallel bands as seen in the image. Owing to the effect of perspective, these bands seem to converge towards a point, or two (radiation points) on the horizon[1]. Thus, these clouds captured at the top right of this image can be referred to as Cirrus Fibratus Radiatus.

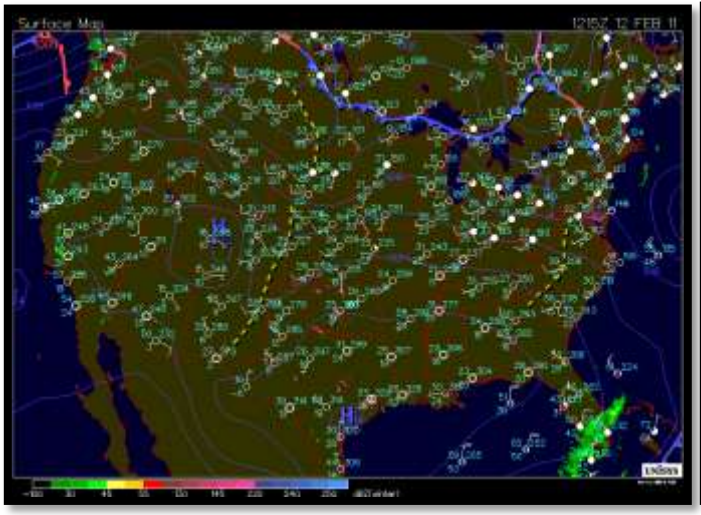

Figure 2: Surface Map of N. America portray the relatively low atmospheric trough (dashed yellow line) associated with the cold fronts moving through the country. At this time the cold front was barely still in CO[4].

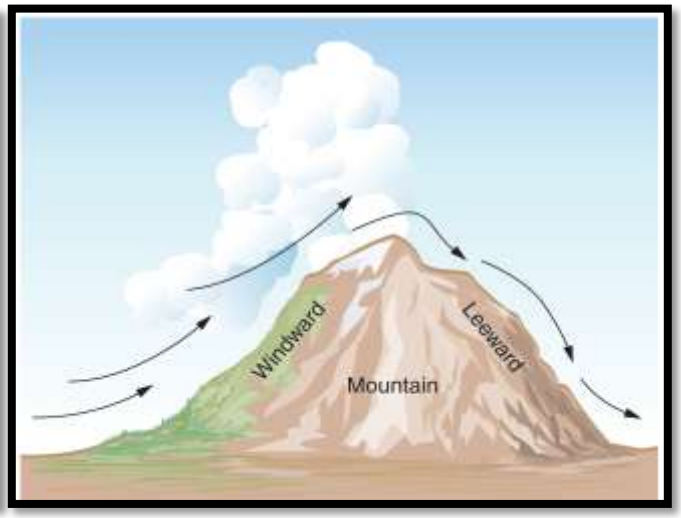

Figure 3: Schematic of an orographic uplift or most commonly known as a mountain wave effect.

The aforementioned Altocumulus cloud formations captured to the left of this image are peculiar in shape, placing them in the Lenticularis species. Altocumulus Lenticularis clouds are named for their smooth, round, lens-like shape (lenticular means lens or lentil-like). This species of clouds are usually very elongated and have well-defined outlines as seen in the image. The distinct outline and occurrence of coronae and irisation in this species of clouds are due to their consistent major composition of small water droplets. These nearly uniform micron size droplets craft this optical diffraction phenomenon when irradiated by the sun and then diffracting these light rays. These clouds are white and/or gray in color and they generally have shadowed parts; two characteristics represented in this image.

Altocumulus Lenticularis clouds appear most often in cloud formations of orographic origin, but may also occur in regions without any marked orography. In this case, with windward speeds (depicted by the barbs on the Skew-T plot) at a height of about 4,000 ft, ranging from 3-7 knots and flowing SE at leeward the formation of the Altocumulus Lenticularis cloud is originated due to the orography. Orographic clouds are formed by the forced uplift of air over a high ground (Figure 3). When wind blows across a mountain range, it tends to form airwaves on the leeward side of the mountains. This process, known as the mountain wave effect, is usually invisible, but when moisture is present at the top of these waves, Lenticular clouds form where the wind rises and dissipates where it falls. The reduction of pressure within the rising air mass produces adiabatic cooling and condensation if the air is sufficiently moist[2]. Also, another common attribute to an orographic cloud is slow motion across the sky even in the presence of high wind speeds. With high SE winds of ~40knots at the altitude of these formations (Reynolds number ≈ 30,000), these orographic clouds seemed static.

The Orographic Altocumulus Lenticularis cloud architecture can be further typified in the variety spectrum of Opacus clouds. This particular variety of cloud formations is usually characterized as extensive patches, sheets or layers that are sufficiently opaque to mask the sun or moon[3]. In this case, this is a perfect personification of the previously described characteristics. Thus, this cloud, giving the sense of overtaking the rest of the image with its uplifted flow can be classified as an Orographic Altocumulus Lenticularis Opacus.

III. Photography

The photograph of the cloud formations was collected using a Canon EOS Rebel T1i, digital SLR, with a final image resolution of pixel dimension [X: 4752, Y: 3114]. The field of view of the clouds composition is in the order of 12,500ft x 8,400ft giving a spatial resolution of approximately 2.6ft/pixel. The closest clouds at the elevation the image was taken were roughly 10,000ft from the lens. The camera was set to manual operation to appropriately adjust the exposure, shutter speed, and aperture accordingly to what was needed for the image. The lens focal length used was 18 mm, the minimal value to prevent granulation from any magnification and to be able to capture as much of the cloud formations for the respective field of view. The image was exposed with an aperture value of f/16, a shutter speed of 1/4000sec, and a maximum ISO speed rating of 3200 without the having the flash fired. The original image was exposed enough and lit enough that not many adjustments or editing were done. Some cropping was done to the image to remove some of the tree boundary from the bottom of the image. The contrast was adjusted to bring out the details of the clouds and the image was minimally saturated for better color exposure. All these adjustments were made using Photoshop.

IV. Conclusion

After closely analyzing the atmospheric condition readings and weather dynamics for the specific day this image was captured, it was concluded that the subject cloud formations can be classified as Orographic Altocumulus Lenticularis Opacus (left of image) and Cirrus Fibratus Radiatus (right) probably created by the contrails, also depicted in the image.

Having taken this image was an eye opening experience. In my perspective, it has always been fascinating to photograph clouds, and capture their looks under a sunrise or sunset, but never had I experience having to analyze these natural designs. This image captured more than one physical atmospheric occurrence at a snapshot of time that is revealed through these great sky configurations. The asymmetric balance of the image also brings another dimension and feel to the dynamic of what was captured, and the lighting of the sun gave it the final touch to help highlight important details of the clouds.

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[1] AMS Glossary. American Meteorolgy Society. Web. 26 Feb. 2010. <http://amsglossary.allenpress.com/glossary/search?id=mountain-wave-cloud1>.

[2] Met Office, National Meteorological Library and Archive, Clouds 1 (2007).

[3] Gavin Pretor-Pinney, Cloud Spotter's Guide, The Science History and Culture of Clouds, (2006).

[4] Unisys Weather, Image and Map Archive. 12 Feb. 2011 <http://weather.unisys.com/archive/index.php>