Clouds 2

Mountain Wave Clouds Above Boulder, CO

Carl Marvin – April 15th, 2014

Introduction

These time lapses were taken as an assignment for a course called “Flow Visualization” at CU Boulder. The intent of the course is to visualize flows through photographic and videographic mediums in an artistically beautifully and scientifically significant way. Time lapses are a great way to expose motion that is too slow for the human eye to perceive. While mountain wave clouds are beautiful to look at, they also reveal the interesting atmospheric dynamics that arise above mountain ranges and their intersection with plains.

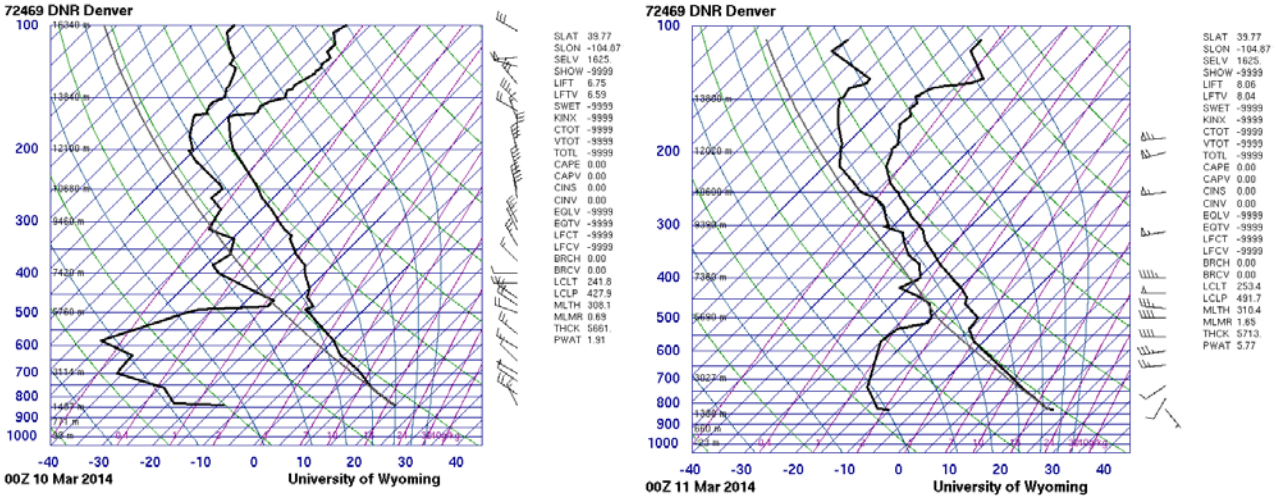
Image Circumstances

The first two time-lapses were taken during sunset on the evening of March 9th, 2014, and the last was taken on March 10th 2014 from on top of the roof of my house at 1200 Holly Place in Boulder Colorado. The first time lapse was taken from 6-7 pm, the second time lapse was taken from 7pm – 8pm, and the last time lapse was taken from 7-8pm. Both series of images were taken from an elevation of 5313 feet above sea level. The first image was taken at a heading of 270 degrees, with a camera elevation of 3 degrees above horizontal. The second image was taken at a heading of 250 degrees with a camera elevation of 5 degrees below horizontal. The final time lapse was taken at a heading of 350 degrees, with a camera elevation of 20 degrees above horizontal [calculated using Google Earth].

The image was taken from Google Earth while the heading and elevation calculations were being made.

Atmospheric Conditions

The atmosphere was stable when the time-lapses were being taken. This is known by looking at the Skew-T diagram from the nights of March 9th and10th. The following Skew-T diagram is from Denver, CO, and the atmospheric sounding was taken at 6pm.[Image from University of Wyoming atmospheric sounding archive]

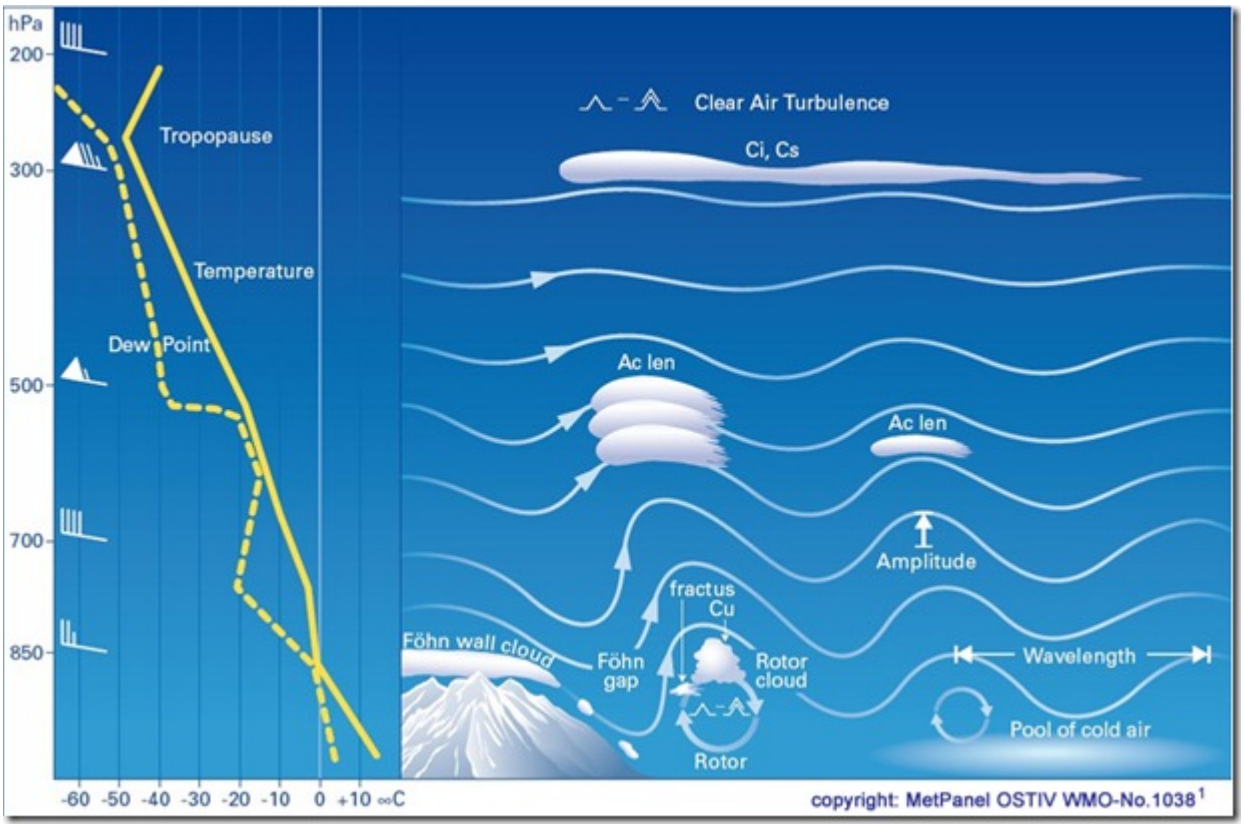


SkewT diagrams from 6pm on the nights of March 9th and 10th

As mentioned before, the atmosphere was stable at the time the image was taken. This is known from the "CAPE" value on the right hand side, which in this instance is 0. The CAPE value is the integral of the area between the dew point and the temperature profile of the sounding. In this case, the dew point profile is left of the temperature profile throughout the atmosphere, indicating a stable atmosphere. Interestingly, though, the dew point profile approaches the temperature profile around 6000m on both diagrams. This is the approximate height of the cloud formations.

Fohn Wall Clouds and Mountain Wave Clouds

The three time lapses highlight the three parts of mountain wave cloud dynamics: The Fohn wall cloud, the rotary fractus cumulus cloud, and the altocumulus lenticular cloud. The Fohn wave cloud forms over the mountain range that is generating the wave clouds, the rotary fractus cumulus clouds form low in the atmosphere, while the lenticular clouds form higher where the air isn't as turbulent.[1] This is all visualized in the image below.



Parts of the mountain wave cloud phenomenon
Source: http://wxbrad.com/wp-content/uploads/2011/04/OSTIV_MWP_Wave_thumb.jpg

The first time lapse focuses on the rotary fractus cumulus cloud that forms low and close to the mountain range. The second time lapse focuses on the Fohn wall cloud, which is behind the mountain range slightly. The third and final time lapse focuses on the altocumulus lenticular cloud, which is characterized by smoother edges than the rotor cloud.[2]

Imaging Details

All three timelapses were taken with a Canon Rebel T2i Camera and a Canon 50mm 1.8 prime lens. The exposure was set slightly overexposed at the beginning of each time lapse, as the sun was setting, and it balanced out the fading light for the longest video possible. Also, scenes with similar color pallets were selected for artistic homogeny through the time lapse set. The first time lapse was created from a series of 523 images, the second time lapse was created from a series of 1246 images, and the third time lapse was created from a series of 848 images. For each timelapse series, image data is shown below:

TIME LAPSE SERIES 1	
Exposure Time	1/100 Second
Aperture	4.0
ISO	200
Focal Length	50mm
Image Delay	4 Seconds

TIME LAPSE SERIES 2	
Exposure Time	1 Second
Aperture	2.5
ISO	800
Focal Length	50mm
Image Delay	4 Seconds

TIME LAPSE SERIES 3	
Exposure Time	6 Seconds
Aperture	2.5
ISO	100
Focal Length	50mm
Image Delay	2 Seconds

Raw, unedited stills from each series was edited using batch processing in Photoshop CS5 to increase contrast, correct white balance, and bring out detail in the shadows. Next, the images were spliced into an uncompressed AVI file using VirtualDub at a frame rate of 24fps. The uncompressed AVI was then processed through adobe premiere elements 9 to add titles and music. The music is of my own composition, and was composed, produced, and mixed in Ableton live 9. Raw unedited photos can be found in the appendix, figures 1 and 2.

Works Cited

1 Doyle, James D., and Dale R. Durran. "The dynamics of mountain-wave-induced rotors." *Journal of the atmospheric sciences* 59.2 (2002).

2 Worthington, R. M. "Lenticular wave cloud above the convective boundary layer of the Rocky Mountains." *Weather* 57.3 (2002): 87-90.

Appendix

Figure 1

Figure 2

Figure 3