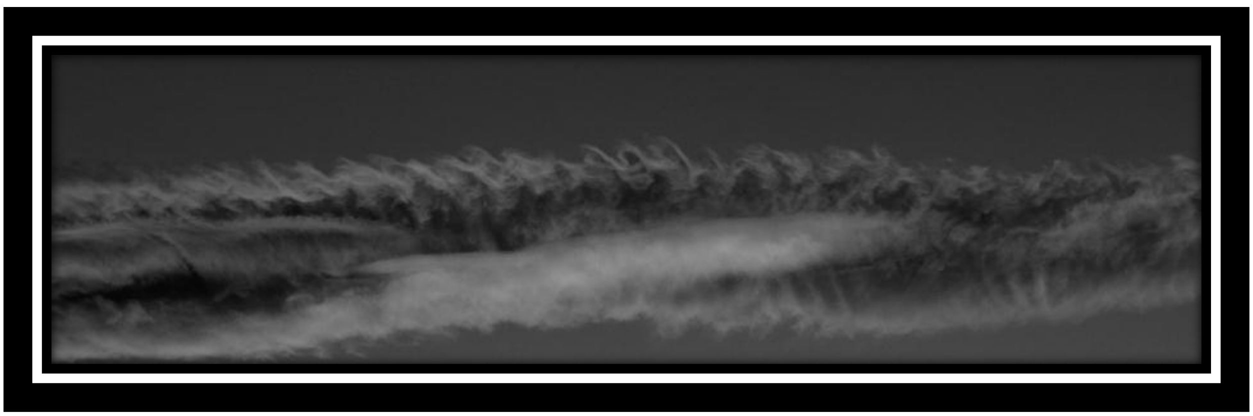
Flow Visualization
MCEN 5151

Spring | 2012

Scotty Hamilton



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Introduction:

If you have not experienced a sunset in Boulder, you have no idea the amazing skies that can be seen. Clouds and colors define Colorado sunsets, creating beautiful portraits not seen anywhere else. These sunsets provide perfect opportunities for pictures and that is what I achieved on a beautiful March sunset.

Image:

This image was taken March 3rd 2012 at 6:30 PM Mountain Standard Time. It was taken between Foothills Parkway and Baseline. The photo was taken facing west or a 270° azimuth. The sun was setting behind the mountains also at a 270° azimuth. This allowed the clouds to have a nice backlit look. Unfortunately the ISO on the camera was high, resulting in a grainy image. This is my only opposition to the picture. This image was chosen do to the unique vortices at the top of the cloud. These vortices are a common instability called the Kelvin-Helmholtz instability. The Kelvin-Helmholtz instability occurs when two parallel fluids travel at different speeds, causing the shear to develop between them and cause vortices (Figure 1). The onset of these vortices relies on the Richardson number to be less than .25. The Richardson number compares the potential energy in the air to the kinetic energy and is commonly used in aviation to determine turbulence.[7]

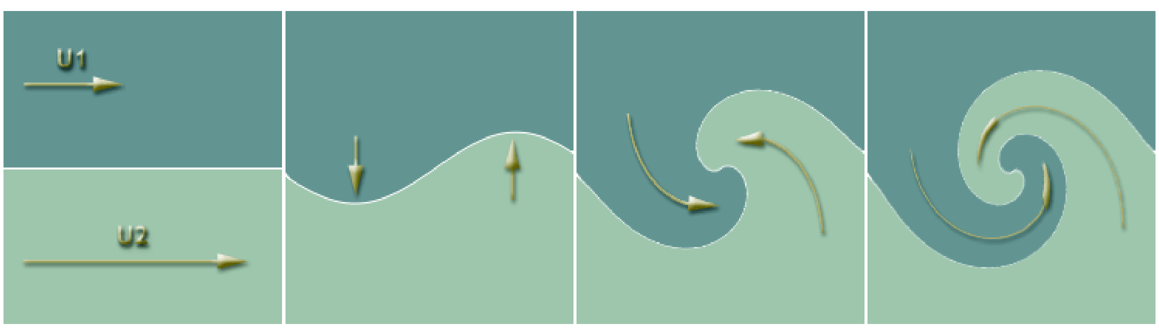


Figure 1 Example of Kelvin-Helmholtz instability[6]

Cloud Physics:

The cloud in the image is called a stratocumulus lenticularis, also known as a "mountain wave cloud". [1] These types of clouds are very familiar to the Boulder area and are seen quite often. Stratocumulus clouds have a common altitude between 2000-6500 feet.[1] The altitude of the cloud in the image was approximately 6000 feet, solidifying the fact that it was a stratocumulus lenticularis. These sorts of clouds are associated with a moist airstream that forms into a cloud to pass over a mountain.[1] Stratocumulus clouds tend to have a wide variety of shades ranging from bright white to a dark grey. This can be seen in my image as the top of the clouds are lighter while the bottom is dramatically darker.

The following figure (Figure 2) is a skew-t plot of the weather on March 3rd. As you may notice, the skew-t plot says March 4th, this is because it was measured on the Zulu time zone. Therefore the Mountain Standard Time is 7 hours behind. This skew-t plot was taken in Denver, 30 miles away and shows an accurate description of many factors occurring in the air. The left line on the plot is the dewpoint curve. The right line shows the temperature with respect to altitude. Stability is a result of a constant or inversion of temperature as altitude is increased. This figure shows that the air was stable that day.[2] The weather around March 3rd was very warm in relation to the other temperatures that week.

In the image the Kelvin-Helmholtz instability is easily seen from the vortices in the clouds this usually means there is instability in the air.[5] This is different than the skew-t plot referenced and the vortices could be a result of unique wind patterns present at the time.

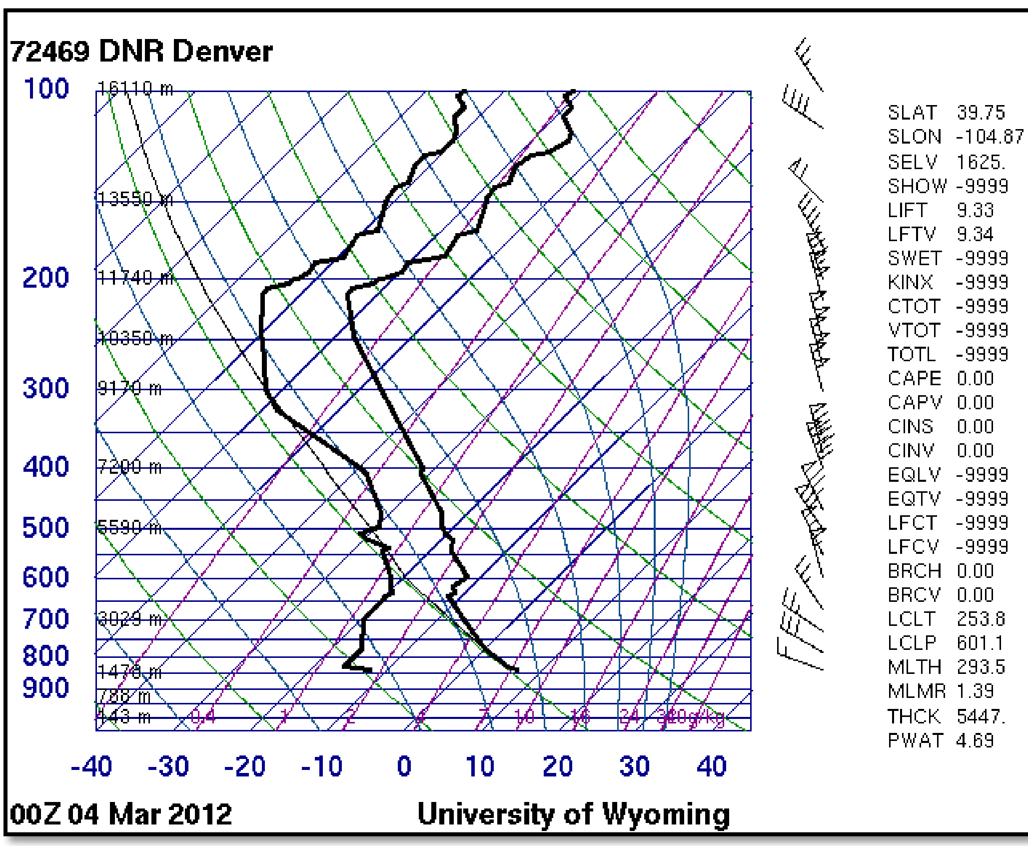


Figure 2 Skew-T plot for March 3rd 2012 [3]

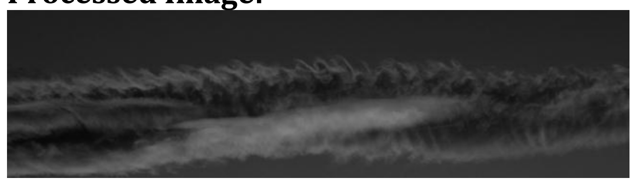
Photographic Technique:

The following is a list of the camera settings used to take the photo.

- Estimated cloud height 6000 feet
- Lens focal length: 55 mm
- Type of camera: NIKON D5000
  Original (4288 x 2848)
  Edited (4288 x 1152)
- Exposure Specs: Aperture: f/9
  Shutter Speed: 1/320
  ISO 400

Original Image:

Processed Image:



The original image showed the beautiful colors associated with it. It was converted to black and white because it added more contrast, which I liked. The image was then cropped down to focus more on the clouds.

Commentary:

In the past, clouds have never been a focus of mine. Now I always look to the sky to see unique shapes and patterns. Seeing a Kelvin-Helmholtz instability inspires me to continue to view the sky for any other unique phenomena. Cloud photography requires one to be prepared at all times in case of an extraordinary photo opportunity. If I was more prepared a time lapse of this phenomena would have been interesting and could have important documentation on the formation of this cloud.

References:

1. Pretor-Pinney, Gavin. *The Cloudspotter's Guide*. New York: Penguin Group, 2006. 91-109. Print.

2. "UNDERSTANDING A SOUNDING/SKEW-T." *Lead to Learn*. N.p., n.d. Web. 1 Mar 2012. <http://www.atmos.millersville.edu/~lead/SkewT_HowTo.html>.

3. Oolman, Larry. "Upper Air." *Department of Atmospheric Science*. N.p., n.d. Web. 19 Feb 2012. <http://weather.uwyo.edu/upperair/sounding.html>

4. "Boulder Weather Graph." *WeatherSpark*. N.p., n.d. Web. 3 Mar 2012. <http://weatherspark.com/

5. Oblack, Rachelle. *Kelvin Helmholtz Clouds.* 16 Apr 2012. <http://weather.about.com/od/cloudsandprecipitation/p/KelvinHelmholtz.htm>

6. (Figure 1 Image) <http://www.brockmann-consult.de/CloudStructures/kelvin-helmholtz-instability-description.htm>

7. http://en.wikipedia.org/wiki/Richardson_number