Clouds 2: Kevin-Helmholtz Instability

MCEN 4228: Flow Visualization
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Figure 1: Kevin-Helmholtz Instability Cloud

As an extension of the first cloud assignment, I continued to explore the skies for interesting and new cloud formations. Throughout the semester I was very intent on photographing a cloud that displayed the phenomena associated with the theory known as Kevin-Helmholtz instability. I was doubtful at first considering their rarity; however I happened to be in the right place at the right time and captured the image as seen in Figure 1. I have classified this cloud as Cirrus Kelvin-Helmholtz Colombia.

My image was taken mid-afternoon on the 21st of October in southeast Boulder, Colorado. I tried to take most of my pictures either during the early morning or early evening so that the

atmospheric conditions present would most closely match that of the sounding data collected at the Denver weather-balloon site. I captured the photograph from a stair landing at my apartment complex. The clouds were located high in the south-western portion of the sky just past the southernmost flatiron. I estimate that the elevation of the clouds between 5000 and 6000 meters.

The weather on this day was particularly windy. This was especially true for the early morning which had mild to extreme gusts. As the day progressed, the winds slowly tapered down. According to the skewT plot seen in Figure 2, the atmosphere was stable from ground level to 5650 meters. From 5650 meters to roughly 9000 meters the atmosphere changes to an unstable condition. As we continue in elevation from this point the conditions demonstrate generally stable conditions.

The skewT experimental data appears to be consistent with the formation of Kelvin-Helmholtz instability clouds. Kevin-Helmholtz instabilities occur when velocity shear is present within a continuous fluid or when there is sufficient velocity difference across the interface between two fluids. I believe that what we are observing in my photograph is the result of a significant velocity difference across the clouds interface. With reference to the skewT plot, there is a substantial velocity difference between roughly 4800 and 5650 meters. This is a good indication that this is the location of the cloud formation and the driving force behind the repeating wave-like structure. Kevin-Helmholtz instabilities also tend to form in stable atmosphere conditions. As stated earlier, the elevation that I assume this cloud to be at is under stable conditions. In addition to cloud shapes in the sky, the Kelvin-Helmholtz instability can be observed in sand dunes, rising cigarette smoke, and water waves.

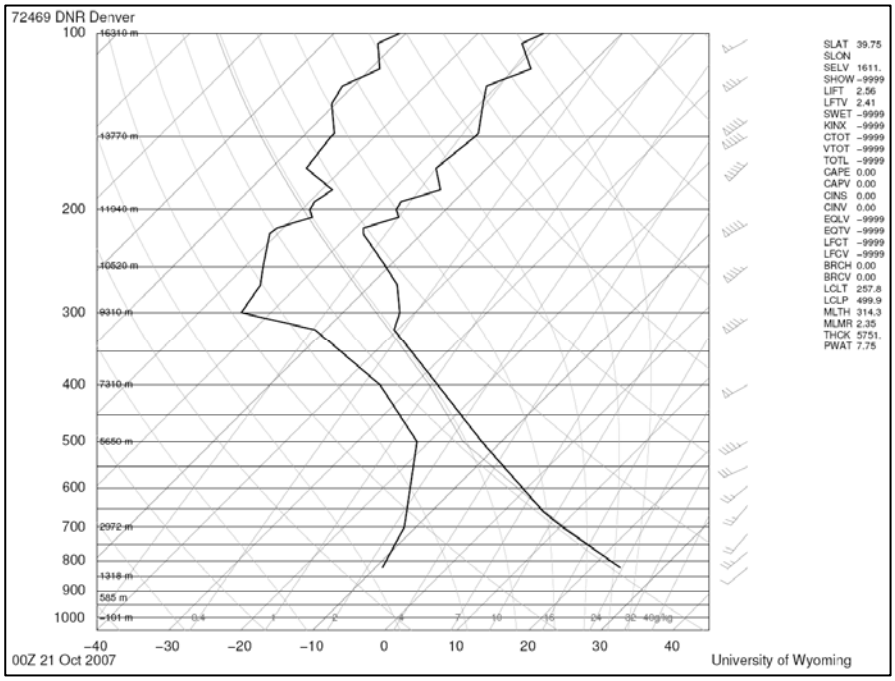

Figure 2: Sounding Data Skew-T Plot

All of the important image properties can be seen in Table 1. All other settings were automatically chosen by my cameras outdoor setting. That said, my photographic technique was relatively straightforward; simply a point and shoot process. The automatic outdoor feature seemed to produce high quality pictures. The only Photoshop techniques applied to this photo was an adjustment in the Levels. This really helped bring out the details in the Kevin-Helmholtz waves, enhanced the whiteness of the clouds, and modified the sky to a deeper, richer blue. The final image size is 3072 by 2048 pixels.

Table 1: Image Properties

Photographic Technique	**Value**
Size of field of view	Unknown
Lens focal length	55 mm
Type of Camera	Canon EOS Digital Rebel (6.3 megapixel)
Aperture	f/14
Shutter speed	1/400 sec
ISO setting	100

I am personally pleased with the final photo that I have selected. I feel like I was able to capture a relatively rare phenomenon and produce a quality end product. For me, Kevin-Helmholtz clouds represent a mysterious beauty that has fascinated people for ages. Even Vincent Van Gogh shows his curiosity in his painting "La Nuit Etoilee." I would say that my photograph lacks the more laminar and defined Kevin-Helmholtz waves as compared to other Kevin-Helmholtz clouds I have seen produced on the internet. However, I can't control Mother Nature and feel fortunate enough to of captured something of resemblance in the first place.

1: "Computational Cloud Dynamics**."** FLUENT. November 29, 2007. http://www.fluent.com/about/news/newsletters/04v13i2/a6.htm

1: "Department of Atmospheric Sciences**."** University of Wyoming. November 29, 2007. http://weather.uwyo.edu/upperair/sounding.html