<u>Cloud Project One:</u>

A Representation of the Kelvin-Helmholtz Instability

Figure 1: Final Photograph

Christopher McCray

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Clouds Project One

The purpose of this project was to photograph and analyze phenomena seen in our atmosphere, particularly focusing on clouds. The photograph I have selected represents a theory commonly known as the Kelvin-Helmholtz instability. Although this instability occurs daily in our atmosphere, it is difficult to photograph due to most of the fluids being transparent. The phenomenon is visible here due to a cloud being located at the location of the instability.

The image was taken in the late afternoon on February 27, 2006 in Boulder, Colorado. Taken from one of the neighboring Flatirons at roughly eight thousand feet above sea level, the picture shows the vertical profile of the cloud. The cloud was northwest of Boulder several miles and was roughly fifteen to twenty thousand feet above the city. At several thousand feet wide, the cloud is quite large and located at the ideal location where two wind streams are adjacent to one another.

The day of the photograph the atmospheric conditions were quite modest above Boulder. There was a severe wind coming off the top of the Flatirons, reaching nearly 50 knots at higher elevations. The wind in Boulder was mild, peaking at times to almost 10 knots. The atmosphere was moderately stable as well, creating the optimum scenario for the Kelvin-Helmholtz instability. This can be seen in the figure two, the SkewT plot for Feb. 27, 2006, by the velocity change at roughly twenty thousand feet above Boulder.

The photograph was taken with a Canon Rebel XT 8.0MP digital camera with a 17-85mm wide angle lens. The shooting information was as follows: the shutter speed was 1/400 second, the aperture value was 11.0, the ISO was 100, and the focal length was 78mm. The width of frame is roughly 10,000 feet taken from approximately 50,000 feet away. The photograph was taken late in the day so the light on the horizon was very dim. The original photograph had little contrast between the cloud and blue sky. I manipulated the color levels, brightness, as well as contrast and was able to achieve much greater contrast between the cloud and sky. The sky now a much deeper blue and the clouds are a more brilliant white.

This instability, again called the Kelvin-Helmholtz instability, is not only seen in the atmospheric gases but also in higher viscosity fluids such as liquid water and oils. The wave pattern is a result of two fluids flowing adjacent to one another along the medium of the two. The differences in velocity create a vertical shear stress instability within the fluids that creates the wave shaped features when below a critical value of the Richardson number. This number, which is a dimensionless ratio of the buoyant forces to the kinetic forces, shows the relationship of two fluids at a the edge of their medium. When the relative velocities between the two fluids increases to a certain state, the buoyant forces between the two are overpowered and the fluids begin to swirl as seen in the photograph. As the relative velocities increase, the instability becomes more and more prominent. If the relative velocities were below the state, the two fluids would have a less severe interaction. The Kelvin-Helmholtz instability can also be seen in day to day life. Common examples are cigarette smoke rising in the air and also wind formed waves on the surface of a lake or pond. Although the principle is very simple, the results are very beautiful and almost surreal.

I am very happy with the final photograph of this cloud. This is one of the better photographs I found of the instability and I think it does a very good job representing it. My main concern was the low light present when the photograph was taken. It did not produce much contrast and therefore needed to be manipulated to do so. I would like to explore the effects of larger velocity differences between shearing flows to view their interaction.

References

Figure 2: SkewT Plot for Denver, Colorado on February 27, 2005