Tim Read
Clouds 2
April 19, 2006

The purpose of this photograph is to provide a means of showing mountain wave clouds in a vast and beautiful context. The photo was taken on January 30, 2006 at approximately 5:00 in the afternoon with the intent of using it for any one of the number of cloud assignments for Flow Visualization. On this particular day I saw these interestingly shaped clouds above the foothills continually forming and changing shapes for nearly the entire afternoon. I drove up onto Flagstaff Mountain just west of Boulder and selected this photo from among about 50 others that I took at nearly the same time and location. It is taken looking to the north.

The clouds seen just to the right of the tree in the photograph are vertically propagating mountain wave clouds. You can also see just to the lower left of the tree a Foehn cloud wall. The lenticular wave clouds are caused by standing waves in the airflow on the leeward side of a mountain. As the air begins to rise within this standing wave, it undergoes adiabatic cooling and will drop below the dew point. The moisture in the air then condenses to form the cloud. This condensed air will continue to travel along the path of the wave, and will eventually begin to descend where it will undergo adiabatic heating and eventually rise back above the dew point, causing the cloud to disappear. The Foehn cloud wall is formed by a similar process, but on a much larger scale in which the entire body of air is forced up to higher elevations due to a mountain range, not a standing wave as is the case with the mountain wave clouds. The weather data for this day states that ground-level temperatures were around 30 degrees Fahrenheit (www.9news.com). Winds were approximately 24 mph out of the west (which is moving

from the left to the right in this photo). I calculate the Reynolds number (assuming the mountains are modeled as a 500m pipe) to be approximately 3.39 x 10^8 (www.efunda.com). This is fully turbulent and thus very unpredictable on a small scale, but from a macroscopic point of view the clouds follow a fairly easily traceable streamline. The ragged edges most likely show up as they do because of the turbulence and extreme wind levels at the given elevation.

The photo was taken using a Canon Digital Rebel XT (8.2 mega pixels). The focal length was 18mm. I used such a wide angle because I wanted to include the tree in the photograph, as well as to provide as sweeping a view as possible of the mountains in the lower half of the photo. I estimate the field of view to be around 10 miles from left to right, giving us a spatial resolution of approximately 15 ft., which is impressive for a field of view so large! Lens aperture was set at F/16 in order to obtain a large depth of focus. The shutter speed was 1/100 sec and the camera automatically set the ISO at 3616 (time resolution for this shutter speed is 4.5 inches, but since the flow is so far away from the camera the time resolution for a cloud photo is insignificant.). I used the aperture-priority setting on the camera, which may help explain the strange ISO number. Post editing was done in Photoshop where I increased the saturation slightly as well as added a slight orange hue to my eye's preference for what I felt the colors should be.

I especially enjoy these types of mountain wave clouds because the shift and change so often. You can get an entirely new cloudscape if you just wait for five minutes. If I could go back and redo this photo I would probably try to frame it a little bit better than I did, however I did not want to crop it because I feel like you lose some of the vast feelings that the photo invokes when you crop certain parts out of it. As I said for my last

clouds assignment, I would still like to develop this idea of photographing mountain wave clouds a little bit further by doing a time lapse series of photos or video so that you can easily see how the clouds move and form and change by simply speeding up the footage. I just haven't been able to find the time for such a project yet.

References

www.efunda.com/formulae/fluids/calc_reynolds.cfm#calc
www.9news.com
www.wunderground.com/US/CO/boulder.html