Mountain Wave over the Flatirons

Report for “Clouds 1” assignment

MCEN 5228: Flow Visualization

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3/1/10

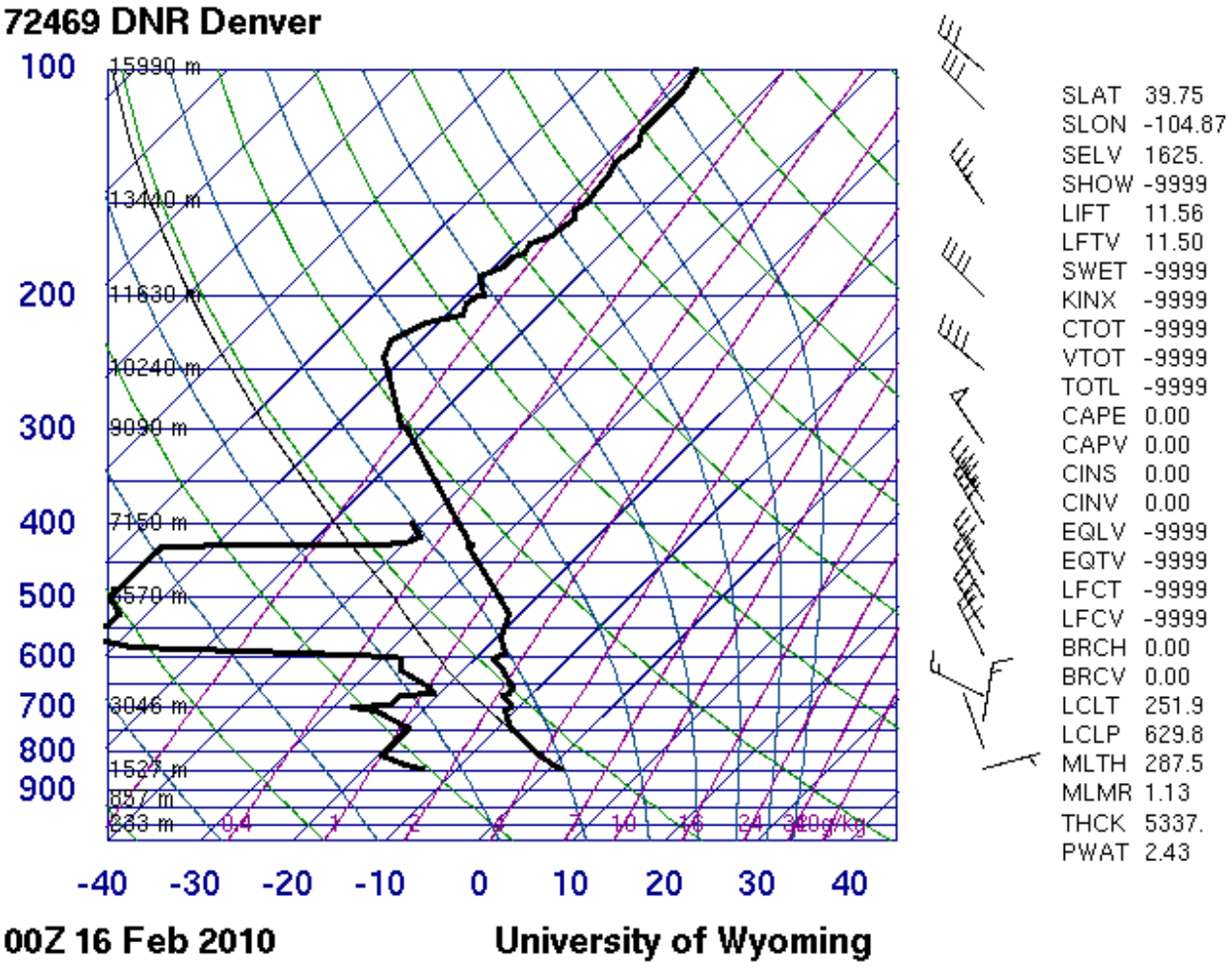
Clouds provide one of the most obvious ways of visualizing air currents in the atmosphere. Without special set ups or lighting, a trained eye can interpret these manifestations. Some, like stratus, simply languish in a featureless layer. Others, like cumulus, are atmospheric convulsions, changing almost by the minute. The more dramatic flow patterns often result in more dramatic views as the clouds take on very definitive and often ominous shapes and colors but sometimes even the simpler looking clouds represent the most amusing flow patterns. Thus, in the early afternoon of February 15th, 2010 I was fortunate to notice a phenomenon that might be described as nature's rollercoaster. Looking southwest from my location, I noticed a picture perfect set of mountain wave clouds hovering over the Flatirons. I moved a bit further west to gain a less obstructed view and the final image was taken from the intersection of Valmont and 55th street .

The photograph was taken using a Canon PowerShot SX120IS digital camera set for 1/1250 sec exposure time and F/5.6 aperture. Short exposure was necessary due to the image being taken in the direction of 260 degree azimuth while the sun was at approximately 220 degree azimuth. This also had the effect of placing the Flatirons in the shade. Focal length was set at 168mm (35mm equivalent) to limit future cropping of the image and improve resolution. The resulting image has a 5km vertical field of view at 35km. Assuming that the first visible wave is located in the vicinity of the Front Range, this correlates reasonably well with its placement in the photograph. The image was processed in PhotoShop. It was cropped to 3648 x 2142 pixels, brightness and contrast were adjusted and colors were adjusted to emphasize the blue of the sky. A light pole was also digitally removed. Slight haze made for unsuccessful attempts to remove the contrail digitally.

Mountain wave clouds, a subset of "lee waves" can form in an otherwise stable atmosphere when unsaturated air is forced up by changing terrain beyond the lifting condensation level where the resulting adiabatic expansion causes it to cool below its dew point. A fairly stable lenticular cloud can form over the ridge, sometimes followed by a series of clouds that form as the flow plunges down on the lee side of the range, overshoots the stable altitude and bounces back up above its dewpoint. The skew T diagram from the Denver International airport from about 4 hours after the photograph (shown below) depicts a highly stable atmosphere. The diagram gives a solid clue to the altitude of the clouds since air flow must be within 30 degrees of perpendicular to the Front Range which generally extends from north to south. There appears to be a single, fairly narrow band of west-northwesterly wind at approximately 3,500 m coinciding with the orientation of the cloud bands. A relative peak in the wet bulb temperature (with only a narrow gap to the parcel line) suggests fairly high relative humidity. These two factors make it reasonable to assume that the clouds are at that altitude.

As is often the case, timing is critical in cloud photography. Not only are some clouds short lived, modern aviation makes it challenging to capture an image unspoiled by contrails. This was unfortunately the case here as well. By the time I gained the perfect vantage point, there was a

large contrail above the clouds but with several more aircraft approaching there was no opportunity to wait for it to dissipate. Nonetheless, I am quite happy with the resulting image. While mountain wave clouds may lack the drama of cumulonimbus, they certainly provide a clear illustration of physical phenomenon that is quite appealing to the left brained. This exercise has certainly left me looking up, always wondering what I might discern from those puffy things floating above.



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