Clouds Project #2

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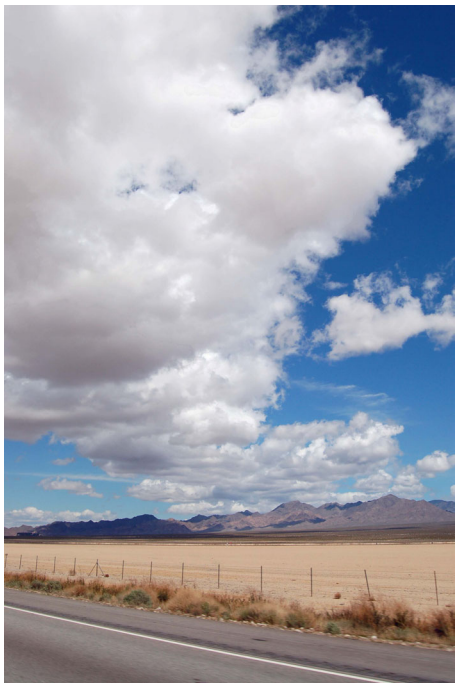
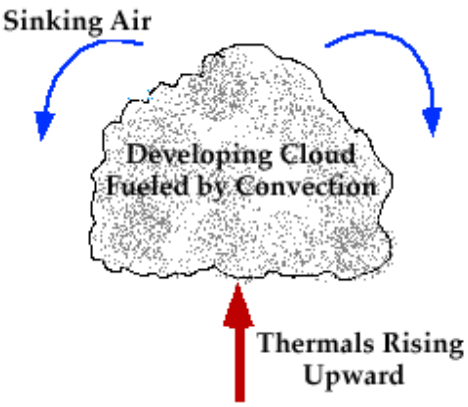


This is the second of the cloud projects completed for the Spring 2006 Flow Visualization class. The intent of this image is to contrast the harsh, barren landscape of the desert with a beautiful blue sky full of fair weather cumulus clouds. At the same time, the physics of such clouds will be explained.

The picture shown on the previous page was taken out the window of a car as it cruised by the Nevada desert south of Las Vegas at 75 miles per hour. The cloud formations shown are fair weather cumulus clouds created from convection currents, or thermals. The desert sun heats up the ground to a relatively high temperature. The air above this ground convects some of the heat away, raising the temperature of the air. As this happens, the air expands, making it rise. Due to the heat driven expansion and upward motion, these types of air masses are called thermals. When the ground temperature is very high, this process can happen very quickly. The expansion of the rising air currents pushes outward against nearby air masses, performing work on the atmosphere. This positive work reduces the total amount of energy in the thermal by the first law of thermodynamics, or conservation of energy. This loss in energy amounts to a loss of heat, and so the temperature of the air current decreases as it increases in altitude. Eventually, there is sufficient temperature drop within the thermal that the pressure of the air current reaches the saturation pressure for that temperature. At this point water molecules begin to condense onto particulate matter suspended in the air, causing what we see as clouds.



Once the thermal has lost too much of its heat energy, there is a loss of buoyant forces to continue rising, so the cold air begins to fall off to the sides of the cloud. This process is shown in the adjacent figure. Sinking air moves past rising air, creating shear. New clouds will have clearly defined, sharp edges. Older cumulus clouds, on the other hand, will appear more smudged out, as the shear layer pulls tufts of the cloud out from the edge, a process known as cloud erosion. The process that creates and sustains these fair weather clouds is generally a sign of an unstable atmosphere.

When a stable layer of air exists above the rising and falling currents, the cumulus clouds are not able to propagate vertically. This is why fair weather cumulus clouds look like white cotton balls, and are associated with good weather. If allowed to grow higher into the atmosphere, the cumulus clouds may become so saturated with water that rain will occur.

The visualization technique with clouds is particle tracking. We can see the light that is diffracted by the tiny water droplets. Lighting for the picture was provided by bright sunlight, without the flash from the camera.

The image was produced using a Nikon D50 digital camera with a resolution of 6.0 Megapixels. The exposure time was $1/500^{th}$ of a second, with an f-number of F/11 and a focal length of 20 mm. At this exposure, and the speed of the car, the picture moved a distance of 6.7 cm. Considering the immense size of the clouds, this is a very small distance. Therefore, the image is spatially resolved. Minimal Photoshop was techniques were utilized, such as increasing contrast and eliminating unused colors through manipulation of the levels.

The most appealing aspect of this picture to me is the straight road and flat desert, contrasted sharply with the white, cottony lumps of clouds. The blue sky and brilliant white also contrast well with the earth tones. I think this met my intent very well. What I do not understand about the fluid phenomenon is why there seems to only be one long line of clouds, rather than a sheet of cumulus clouds filling the sky. This made me believe that the clouds were formed by convergence, two air masses coming together and forcing each other upwards, but I decided this was not the case through further study of the characteristics of the clouds shown in my image versus those of cumulus clouds formed by convergence. In order to improve my understanding and ability to document this phenomenon, I would need to find a similar cloud formation in an area that has well documented archives of weather data. This remove section of Nevada had no SkewT plots for that particular day. I may have been able to take data from other days with similar data, but I was just passing through the area when I snapped my picture. It might be interesting to spend more time in a desert to better document the cloud patterns there. It may even be possible to gather data from personal radiosondes.