

Ask Dr. SOO: What Are Clouds Made of?

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Hello Dr. SOO! My question is: What are clouds made of, and how can they be different colors, and what keeps them from falling to the ground? Thank-you. --Woody in Plentywood.

Hello Woody. Most clouds you see are made up of water droplets; however, a cloud can be made up of a large number of small particles of different kinds suspended in the air, such as smoke particles (bits of partially burned material), particles of ice, particles of dust or dirt, or even large numbers of insects. Actually, the requirement that the particles be “small” can probably be relaxed as, when seen from a distance, collections of large objects can constitute a cloud; an extreme example would be the Milky Way, that band of whitish cloud you see in the sky at night, is actually made up of billions of stars thousands of light years away.

However, the vast majority of clouds you see everyday are made up of astronomical numbers of tiny water droplets, or, for cold conditions, ice particles. The particles are so small that a coffee cup, if filled with typical cloud, would hold around 100,000 droplets. If all 100,000 of those droplets floating around in your cup of cloud were to coalesce onto the sides of the cup, they would barely get the cup wet. So clouds are mostly empty air, with some water in the form of tiny droplets.

So the question arises as to why you can see clouds at all, since they are mostly plain air (which is transparent) plus water droplets (which are also transparent). The short answer is that water droplets scatter light in all directions because of their spherical shape. If you could shrink yourself down to a size where water droplets were as big as your hand, you could examine a water droplet in sunlight, and you would see that light is bent and distorted as it passes through it, much like looking through a magnifying glass. If you shine light on a cloud of water droplets, each droplet scatters a little light in lots of different directions. If all you had was one droplet, you would probably not notice the tiny glint of light from that one droplet. However, if you have a vast number of droplets in a cloud, then the combined effect of bits of light scattered from each droplet is for the cloud to be visible, and to appear the color of the light used to illuminate it.

On a clear day, light from the sun is white. The sun only appears red or orange near sunrise or sunset because the light at those times has to pass mostly through the lowest level of the atmosphere which is filled with dust, dirt and of course air molecules, which scatter and absorb blue light, leaving red to see. When the sun is above the horizon, its light is nearly pure white, and this is why clouds appear white when illuminated by sunshine. Clouds will appear darker, however, if they are in shadow (as might occur if another cloud is in front of the sun). In fact, if a cloud is so dense that it blots out the sun altogether, then it can appear black. Probably the densest clouds are those associated with thunderstorms. If a thunderstorm is between you and the sun, it will appear dark as it blots out the sun; however, if that same thunderstorm is being directly illuminated by the sun rather than blotting out the sun, it will appear brilliantly white, as the relatively dense droplets scatter and reflect a lot of sunlight.



This cloud of a developing thunderstorm appears bright white in parts directly illuminated by the sun, and dark and menacing in areas shadowed from the sun.

At sunrise or sunset, when sunlight is orange to red, you can get orange to red clouds when this light shines on the clouds. Another color for clouds that is somewhat rarer is green or aqua-blue. The only time this is observed is with very heavy thunderstorms, and it is not entirely known why they appear that way. Green thunderstorms are correlated with observations of very heavy rainfall or heavy hail. The big hailstorm that tore through northeast Montana in June of 2007 appeared green at times.



This storm cloud appears orange because it is illuminated at sunset, when the sun's light is orange.

Now, Woody, the last part of your question was what keeps clouds from falling to the ground. That's an interesting question. Actually, all water droplets or ice particles that make-up most clouds are heavier than air and do fall towards the ground, they just do so slowly. Because of the way friction with the air works on the surface of an object falling in air, smaller object fall more slowly than larger ones. Cloud droplets are so small, that it takes a long time to fall to the ground. Throw a person out of an airplane and it will take him 30 seconds to fall 1 mile. Throw a tiny cloud droplet out of an airplane, and it will take 143 hours to fall a mile. So a cloud of droplets stays in the air a long time, despite the fact that each particle is falling. Also, the air is often rising a little in clouds, which will hold the slowly falling drops up, and even cause them to rise.

Now, what you've probably thought of by now is that maybe some of these droplets get bigger, begin to fall faster, eventually getting big enough to fall to the ground as rain; and you'd be right. Rain drops are basically overgrown cloud droplets. But what causes them to grow? The main mechanism producing large rain drops from tiny cloud droplets is collision. The droplets in a cloud are all slightly different in size, and so fall at slightly different speeds. A slightly larger droplet can overtake smaller ones, collide with them, and coalesce with them to produce a single, larger droplet. This larger droplet will now fall faster and capture more small droplets, and continue to grow. If this droplet becomes big enough, it becomes a drop and can fall out of the cloud, eventually reaching the ground as rain. Some clouds, like fair weather cumulus clouds, are not very dense and this collision/coalescence mechanism never gets very far and rain never forms.

So clouds are made of tiny bits of liquid water or ice which practically float in the air. And while that is true, the explanation does not meet the aesthetic brilliance of Shelley's famous soliloquy:

From **The Cloud**

By Percy Bysshe Shelley

I am the daughter of Earth and Water,
 And the nursling of the Sky;
I pass through the pores of the ocean and shores;
 I change, but I cannot die.
For after the rain when with never a stain
 The pavilion of Heaven is bare,
And the winds and sunbeams with their convex gleams
 Build up the blue dome of air,
I silently laugh at my own cenotaph,
 And out of the caverns of rain,
Like a child from the womb, like a ghost from the tomb,
 I arise and unbuild it again.