HOW MUCH DOES A CLOUD WEIGH?

by
Mike Staudenmaier, Jr.

Question: How much does a 'typical' cumulus cloud weigh?

The mass of a differential volume element is simply the density times the volume of that element.

IF...

$$R_d = 287 \text{ J/K kg}$$

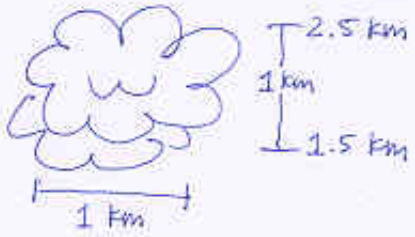
and

$$R_v = 461 \text{ J/K kg}$$

AND WE USE...

$$\rho = \frac{P}{(RT)} \qquad (the \quad ideal \quad gas \quad law)$$

Then, assume a 1 km X 1 km X 1 km cumulus cloud contains only water vapor and air molecules along with 0.5 g/m^3 of liquid water content in the form of cloud droplets (no ice or rain).



from the standard atmosphere:

$T_{2\,km} = 275.15\text{K}$

$P_{2\,km} = 79.495 \text{ Kpa}$

so for dry air...

$$\rho_d = \frac{79495 \quad Pa}{(287 \quad \frac{J}{K \quad kg}) \; (275.15K)} = 1.007 \quad \frac{kg}{m^3}$$

and for moist air...

$$\rho_m = \frac{79495\ Pa}{(461\ \frac{J}{K\ kg})\ (275.15K)} = 0.627\ \frac{kg}{m^3}$$

for the cloud droplets in the cloud...

$$\rho_{drop} = (\frac{0.5\ g}{m^3})\ (\frac{1\ kg}{1000\ g}) = \frac{.0005\ kg}{m^3}$$

The volume of the cloud itself is 1 km^3, so that the mass of the cloud is :

$$(1km^3)\ ((.627\ +\ .0005)\ \frac{kg}{m^3})\ (1000\ \frac{m^3}{km^3}) = 627{,}500{,}000\ kg = 1{,}380{,}500{,}000\ lbs$$

the mass of an equal volume of dry air would be :

$$(1km^3)\ (1.007\ \frac{kg}{m^3})\ (1000\ \frac{m^3}{km^3}) = 1{,}007{,}000{,}000\ kg = 2{,}215{,}400{,}000\ lbs$$

Answer: Thus, a 'typical' fair weather cumulus cloud "weighs" about 1 billion 400 million pounds, or about 800 million pounds less than dry air of equal volume. Thats a lot of weight!