

HOW MUCH DOES A CLOUD WEIGH?

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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...

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

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:

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

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

so for dry air...

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

and for moist air...

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

for the cloud droplets in the cloud...

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

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

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

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

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

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!