Tropical thunder clouds

Shannon and Ian Jacobs

Giant anvil clouds (*cumulonimbus incus*) towering over sea or land are common in Thailand. They last for half a day and dump centimetres of rain over large areas. Just how large and how massive are these clouds?

Cumulonimbus incus over the inner Gulf of Thailand beyond islands that are 20 km off the coast has reached the tropopause somewhere about 15-18 thousand metres above the sea. Upward convection has ceased and the expanding top of the cloud has become cirrocumulus. These clouds appear mid morning and are fully developed by mid afternoon when this image was taken from a balcony 40 metres above the beach in Jomtien. To estimate the size of a cloud like this we first have to estimate both its height and its distance.

A smaller cloud (*cumulonimbus calvus*) for which we can make estimates.

This cloud has not reached the tropopause and does not have a flat cirrus top. The height can be tentatively put as somewhere around 10,000 metres. The island in the foreground (Ko Lin) is 22 km off the coast and 1.2 km long. The cloud appears in the image to be about 2 km high which places it (using similar triangles) at ~110 km, close to the province of Pranburi on the other side of the gulf. These estimates are not unreasonable and close enough for our purpose. The rain area under this cloud is likely to be circular with a diameter of ~5 km. If a thunder storm dropped 2 cm of rain over this area the mass m of water deposited in metric tonnes would be ….

$m \sim 3.14x2500x2500/50$ … which is ~250,000 tons!

If half the water in the cloud fell as rain this puts the mass of the cloud at ~500,000 metric tonnes, a remarkable number. Could a mass of half a million metric tonnes be the right *order of magnitude* for this cloud?

Appendix

A calculator on the web gives the distance to the horizon from 40 metres above a beach (from where the photograph was taken) at 22.6 km which confirms the distance estimate from the map we used.

The density of fluffy white cumulus clouds is estimated to be 0.5 g per cubic metre. You could search for that. Using this estimate and the volume of a cylinder 10 km high and 5 km in diameter gives ....

$$m \sim 3.14 \text{x} 2500 \text{x} 2500 \text{x} 10{,}000 \text{x} 0.0005/1000 = \sim 100{,}000 \text{ tonnes}$$

Cumulonimbus clouds contain more water per cubic metre. The upper estimate we find on the web for huge cumulonimbus clouds is 3 g/m^3. A value of 3 increases the value above to close to our rain-based estimate.

Searching the web for estimates for the mass of huge cumulonimbus clouds gives values from half to one million tonnes, in the same range.

Note: *We have not referenced our sources because a reader is better served by searching for the latest estimates.*

Given these enormous numbers why do clouds float?

The simple answer is they don't, they fall. Clouds are made up of tiny independent droplets that fall slowly because of air resistance. As the droplets gradually aggregate and become larger and heavier they fall faster and collect more tiny droplets on the way down. Updrafts within the clouds my keep these falling drops of rain cycling up and down for long enough and high enough to become hail which falls from the sky as chunks of ice. This can happen even in Bangkok (about once in 20 years).

Nimbus (rain) clouds have larger droplets and appear to be darker than common white cumulus clouds. Pileus (skull cap) clouds that form in wind layers of humid air above rising cumulus are made up of very tiny droplets that diffract sunlight as it passes through then giving strange colours. More of all this follows in articles to come.