Re: Does electrostatic charge keep a cloud up?

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- *From*: "Szczepan Bialek" <sz.bialek@xxxxx>
- *Date*: Mon, 13 Aug 2007 09:50:53 +0200

"Falk Tannhäuser" <tannhauser86549spam@xxxxxxx> schrieb
news:46bf9562$0$422$426a74cc@xxxxxxxxxxxxxxx

> Szczepan Bialek schrieb:
>
>> "Falk Tannhäuser" <tannhauser86549spam@xxxxxxx>wrote
>> news:46bf47c7$0$427$426a74cc@xxxxxxxxxxxxxxx
>>
>>> Due to electrostatic induction, the area on the ground lying
>>> directly
>>> below the negatively−charged cloud gets positively charged,
>>> leading to a
>>> reversal of the usual fair−weather field.
>>
>> Are you sure? It would mean that the technical grounding is not zero
>> under a cloud. When electrons are in clouds the field is reversal.
>
> Yep − that's <http://en.wikipedia.org/wiki/Electrostatic_induction>. It
> occurs because the Earth is quite a good conductor.

It should be measured and calculated. I bet that under a cloud is more
electrons (on the surface of the ground) then under the clear sky.

> I found some interesting web sites about thunderstorm charge distribution:
> <http://www.britannica.com/eb/art−19731/Electrical−charge−distribution−in−a−thunderstorm−When−the−ele
> or <http://minilien.fr/a0khcv> (one can see that ground charge is negative
> under the small centre of positive charge at the rain cloud base and
> positive under the (negatively charged) remaining part of the cloud base −
> the negative ground charge in fair−weather conditions is not depicted.
> <http://scf−cfs.rncan−nrcan.gc.ca/index/lightning−faq/3> shows a similar
> picture and even gives examples of observed electrical charges:
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>
> "The three centres of accumulated charge are commonly labeled p, N, and P.
> The upper positive centre, P, occupies the top half of the cloud. The

negative charge region, N, is located in the middle of the cloud. The lowest centre, p, is a weak, positively charged center at the cloud base. The N and the P regions have approximately the same charge, creating the positive dipole. Malan (1963) documented charges and altitudes above ground level for the p, N, and P regions of a typical South African thundercloud (1.8 km above sea level) as +10 coulombs (C) at 2 km, −40 C at 5 km, and +40 C at 10 km. These are representative of values that can vary considerably with geography and from cloud to cloud."

> Hence the negative C−G lightning actually increases the net negative
> charge of the earth. Thunderstorms effectively act as generators −
> without them, fair−weather current would soon make disappear the
> difference of potential between ground and atmosphere.
> Note that positive C−G lightning also occurs, but is considerably rarer
> than negative one.

I have read that they start from place where the normal lightning has stroke (in the same moment) . So they are C−C.

C−C between the positive anvil and negative cloud centre as well as the negative cloud centre and the positive rain base do happen, of course. However, positive C−G can occur independently.

They dont use term "voltage". Each drop has volume and charge. V = Q/C (Voltage = Charge/Capacitance). Normally each drop which hang has excess of electrons and proper voltage. Nomally because during lighning (which is an oscillate phenomenon) the deficit appears periodically. So positive C−G can not occur independently.

> Typically it originates from the cloud's anvil and strikes a place on
> the ground that is peripheral to the thunderstorm (and thus negatively
> charged). It is more often found during dissipating storms (where the
> lower cloud parts often disappear first) or in winter thunderstorms
> (when the cloud summits are lower).

Typical field strengths are on the order of magnitude of E = 10 kV/m
between ground and cloud, and 100 kV/m within the cloud. For comparison,
fair−weather field strength is about 0.15 kV/m near to ground level.

Concerning gravitational and electrostatic forces:
Consider a spheric rain droplet of a mass of m = 1 mg.
(It has a volume of V = 1 mm^3 and hence a diameter of 1.24 mm, since V
= 4/3*pi*r^3 − not an unreasonable size).
Its weight (force exercised by gravitation) is m*g = 9.81*10^−6 N
(with g = 9.81 m/s^2).
The electrostatic force equals q*E where q is the charge of the droplet.
If electrostatic force is supposed to prevent our droplet from falling
down, it has to compensate the gravitational force. Then we can
calculate the charge needed for this. If we set E = 100 kV/m = 100 kN/C,
we obtain that our droplet has to have a charge of 9.81*10^−11 C.
This would mean 1.02*10^10 such droplets (corresponding to 10.2 m^3 of
water) would carry an aggregate charge of 1 Coulomb.
Now we let's consider that we may find about 100000 m^3 of water in a
small thunderstorm cloud (just to get an idea of the order of
magnitude − this would correspond to 10 mm of precipitation over 10
km^2, note however that only a part of the water in the cloud finally
makes it to the earth as precipitation). The aggregate charge of this
mass of water would then equal to 10000 C − a value that seems much to
high to me! Average lightnings transport a charge of less than 10 C −
furthermore, a punctual charge of Q = 10000 C would produce a field of
about
E = 10 MV/m at a distance of d = 3 km
(E = Q / (d^2 * 4*pi*eps_0)
eps_0 being the vacuum permittivity of 8.8541878176*10^−12 F/m)
− which is stronger by a factor of 100 than the values actually observed
in thunderstorm clouds.

> > > Excelent job. Calculate now how many of the water particles ($H2O$) can one electron lift when E = 0.15 kV/m. It will be something as cross−examining.
> > > Not the all electrons fall down in form of lightnings. The most as the normal electric current.

> > Water has a molar mass of 18 g/mol and with the Avogadro constant of 6.022*10^23/mol we obtain the molecule's mass of 2.99*10^−26 kg and a weight of 2.93*10^−25 N.
> > OTOH an electron has a charge of 1.602*10^−19 C and experiences an electrostatic force of 2.403*10^−17 N in a field of 150 V/m. That's the weight of 82 million water molecules!

82*10^6 near to ground level. The higher the smoler number.

> > However, 100 C gives only 6.24*10^20 electrons while in 100000 m^3 of water there are 3.34*10^33 molecules − a ratio of 5.35*10^12

> > > > As a conclusion, I believe that electrostatic force can be
> > > > neglected
> > > > when compared to gravity, and even more the vertical winds
> > > > in a
> > > > cumulonimbus, where updrafts commonly reach 30 m/s and
> > > > more.

> > > Here is not place for "believe". The calculations should be done.

> > Well, when I wrote "believe", it was because I based myself on simplifying assumptions (punctual charge at a distance of 3 km, instead of charge continuously distributed within the cloud as in reality) and guesstimating (quantity of water in the cloud). And of course, all clouds are different!
> > A better model for charge distribution between the negative cloud centre and the positive anvil would perhaps have been a plate capacitor. However, as the text form the website I cited above shows, my estimation was not that far from the truth − typical charges in a cumulonimbus are of an order of magnitude closer to 100 C rather than 10000 C.

The estimate of the total charge in a cloud is impossible. The single drop should be observed like in Millican's experiment.

− Split this charge among droplets (or calculate the ratio

> of water molecules per electron), and you'll see that resulting electrostatic force is pretty weak compared to gravity.

Yes. For this reason large drops fall down (but the fine hang pretty well).

Dave " ..did some searching and it is said that warm rising air keeps clouds up. Is it possible the static
charge in the clouds could also have an effect?"
I have never seen textbook on meteorology. There should be something about it. In textbook on electrostatic are two pages about Absolute Earth Potential and Atmospheric Electricity. In the Fluid Dynamics by Prantl are many pages about atmosphere but nothing about charged fluids.
Weatherlawyer wrote: "It is a mystery why the clouds of vapour don't condense though. It is as if some magical force is holding them apart" and "It doesn't make sense that they don't fall to earth". This "magical force" works in each atmospherical conditions. We have XXI century. In my opinion in XIX century people have known what that was. In the XX all worked on details and forgot about fundamentals.
S*

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