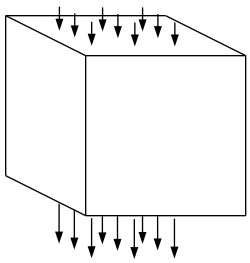
Flux in the Earth's atmosphere



By the definition of flux,

$$\Phi = \Phi_{\text{through top}} + \Phi_{\text{through bottom}} + \Phi_{\text{through sides}}.$$

Note that $\Phi_{\text{through top}}$ is negative — inward flux — because at the top surface $\vec{E}\cdot\hat{n} = -|\vec{E}|$. Note also that $\Phi_{\text{through sides}}$ is zero because on the sides $\vec{E}\cdot\hat{n} = 0$. Continuing,

$$\begin{aligned}\Phi &= \Phi_{\text{through top}} + \Phi_{\text{through bottom}} + \Phi_{\text{through sides}} \\ &= -(60.0 \text{ N/C})(10^4 \text{ m}^2) + (100 \text{ N/C})(10^4 \text{ m}^2) + 0 \\ &= 4.00 \times 10^5 \text{ Nm}^2/\text{C}.\end{aligned}$$

By Gauss's law

$$Q_{\text{inside}} = \epsilon_0\Phi = (8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2)(4.00 \times 10^5 \text{ Nm}^2/\text{C}) = 3.54 \times 10^{-6} \text{ C}.$$

So, here's the cute thing: We know the electric field only at the top and at the bottom, not the electric field within the interior. The electric field might increase linearly from 60 N/C to 100 N/C, or it might go from 60 N/C up to 250 N/C and then back down to 100 N/C. We don't know. But this doesn't matter to the total net charge enclosed... it will be the same in any case.

Grading: 2 points for sketch or something else to start up
2 points for figuring out that flux through sides is zero
2 points for finding total flux
2 points for finding total charge inside
2 points for three significant figures on total charge inside