Due: 9 Oct 2024

Energy: Science, Technology, and Society

Homework Set 3

1. Venusian Climate

The planet Venus is in many respects Earth like, with mass ($M_V = 4.87 \cdot 10^{24}$kg) and

radius (R_V = 6,052 km) similar to those of Earth, but it orbits the Sun with a mean orbital radius of only $R_{SV} = 1.082 \cdot 10^8$ km. Like Earth, Venus has a near-circular orbit but a shorter year (225 Earth days).

Venus' climate is significantly influenced by its large albedo (a_V = 0.76) and the (extremely corrosive) atmosphere consisting largely of sulfuric acid vapors (and dust) leading to substantial greenhouse effects.

a) Use the model for evaluating the radiative balance of Earth introduced in class and calculate the solar constant S_V for Venus and its equilibrium surface temperature T_0 without an atmospheric greenhouse effect.

b) Given the measured surface temperature of T_{SV} = 730 K for Venus, what temperature T_{Vat} would the Venusian troposphere have to have, assuming it to be a layer with a large temperature laps rate $\Delta T/m - Altitude$?

2. Consequential Climate Trends

The Greenland glacier (latitude 69° 38' 7.50" N) covers an area of $A = 1.7 \cdot 10^6$ km^2 and has a total volume of approximately $V = 2.85 \cdot 10^6$ km^3. According to current observations, the glacier is melting at a slightly faster rate than its accumulation gain from the annual precipitation.

a) Estimate the total weight of the glacier in metric tons.

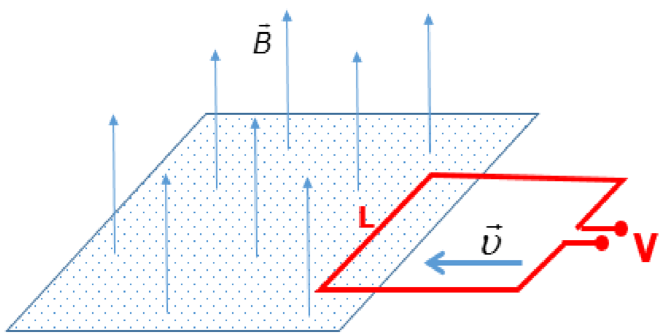
b) Calculate by how much the global sea level would rise if the glacier would melt completely. (Neglect a possible rise of the land.)

c) Calculate the total energy that the melting process in b) would require.

d) Given the mean solar insolation, roughly estimate the number of arctic summer seasons (June-August in every year) the process would require. (Neglect winter accumulation through precipitation.)

{**Useful information**: The latent heat of melting ice is ΔH = 334 kJ/kg.}

3. Mechanical Energy-to-Electricity Conversion



Consider a spatial domain filled with a uniform magnetic field $\vec{B}(\vec{r}) = B_0 \cdot \vec{k}$ aligned with the z direction, defined by the unit vector $\vec{k}$. As illustrated in the sketch, an open quadratic wire loop with side length L is moved with a constant velocity $\vec{\upsilon} = -\upsilon \cdot \hat{i}$, from the outside into that domain, in negative x-direction and perpendicular to the field.

a) Use Faraday's Law to derive a relation between the *emf* (= voltage *V*) induced at the ends of the loop, the field strength B_0, length and the speed υ of the wire loop.

b) Consider a quadratic wire coil of inside area $A=L^2=0.1\text{m}^2$ rotating at f= 60Hz in a magnetic field of strength B=0.5 T. How many turns must the coil have to generate an electric current of 1000A for an Ohm resistance of $R = 1\ \Omega$ of the coil?