

21 FEB 07

HINTS ON THE

FATE OF THE EARTH

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HUGH WILLOUGHBY

- HOW TO CALCULATE THE ALTITUDE WHERE A GIVEN TEMPERATURE IS FOUND IN THE STANDARD ATMOSPHERE:

$$\text{TEMP AT SURFACE} = 288 \text{ K}$$

$$\text{LAPSE RATE} = 6.5^\circ \text{C/km}$$

TEMPERATURE AS A FUNCTION OF HEIGHT, z .

$$T(z) = T_{\text{surf}} - \gamma z$$

$$= 288 - 6.5z$$

FOR EXAMPLE HOW HIGH TO YOU HAVE TO GO TO FIND $T = 0^\circ \text{C} = 273 \text{ K}$, THE FREEZING POINT

$$273 = 288 - 6.5z$$

OR

$$z = \frac{288 - 273 \text{ K}}{6.5 \text{ K/km}} = \frac{15 \text{ K}}{6.5 \text{ K/km}} = 2.3 \text{ km}$$

- HOW TO CALCULATE BLACKBODY TEMP USING THE STEFAN-BOLTZMANN LAW

ONE BILLION YEARS AGO THE SOLAR CONSTANT WAS 1241 W m^{-2}

THE AVERAGE INSOLATION IS 25% OF THIS NUMBER (BECAUSE OF THE GEOMETRIC FACTOR) TIMES $1 - \text{ALBEDO} (=30\%) = 70\%$

$$\text{AVE SOLAR HEATING} = 0.25 \cdot 0.70 \cdot 1241 = 217 \text{ W m}^{-2}$$

BLACKBODY TEMP

$$217 \text{ W/m}^2 = 5.67 \times 10^{-8} T_{\text{BB}}^4$$

$$T_{\text{BB}} = \sqrt[4]{\frac{217 \text{ W/m}^2}{5.67 \times 10^{-8} \text{ W/m}^2 \text{K}^4}} = 100 \sqrt[4]{\frac{217}{5.67}} \text{ K} = 248.7$$

ADDING 33°C TEMP DIFFERENCE BETWEEN BLACKBODY TEMP & SURFACE GIVES 281.7

OR 7°C COOLER THAN NOW



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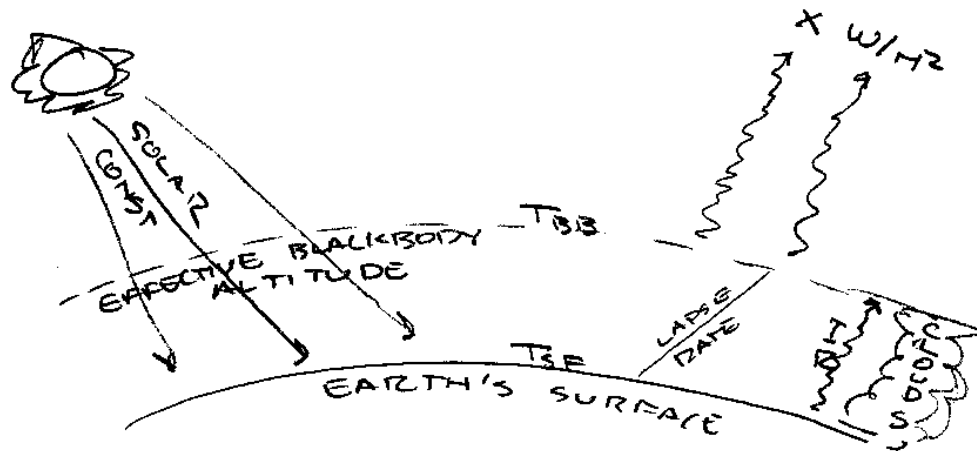
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• PHILOSOPHY BEHIND THIS PROBLEM



SUNLIGHT WARMS THE PLANET

CONVECTION WITH IR RADIATION FROM SURFACE
BOTH DRY AND MOIST
COMBINE TO MOVE HEAT VERTICALLY
TO AN EFFECTIVE ALTITUDE WHERE

IT IS RADIATED BACK TO SPACE BY
THE UPPER ATMOSPHERE.

THE BLACKBODY TEMPERATURE IS
DETERMINED ONLY BY THE SOLAR
CONSTANT, ALBEDO, AND 25% GEOMETRIC
FACTOR. BECAUSE IT HAS TO RADIATE THE
SAME AMOUNT OF HEAT THAT IS ABSORBED.

WE ASSUME (RASHLY) THAT THE LAPSE

RATE AND ALTITUDE WHERE WE

FIND THE BLACKBODY TEMPERATURE

ARE FIXED. THIS IS EQUIVALENT TO

A FIXED DIFFERENCE OF 32-33K BETWEEN
THE BLACKBODY AND SURFACE TEMPERATURES.

AS THE SOLAR CONSTANT INCREASES, THE
ONLY WAY TO GET A HIGHER
BLACKBODY TEMP IS TO RAISE THE SURFACE
TEMP. THAT'S WHAT I WANT YOU
TO CALCULATE.

