

MPO 551 Comprehensive Exam Question Spring 2010

show: 1) symbolic logic; 2) that the units work out; 3) only then plug in numbers.

1. Show how the surface temperature relates to the Earth's mean temperature for a one-layer atmosphere in radiative equilibrium. Provide a numerical answer; the solar flux at the top of the Earth's atmosphere = 1370 W m^{-2} . Assume an atmosphere that is completely transparent to solar radiation, and completely opaque to infrared radiation. Stefan-Boltzmann's constant is $5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$

2. As shown in the figure below, the atmosphere is not entirely transparent to solar radiation. What is the average rate at which the atmosphere (including clouds) is heated by direct absorption of solar radiation? (express your answer in K/day)

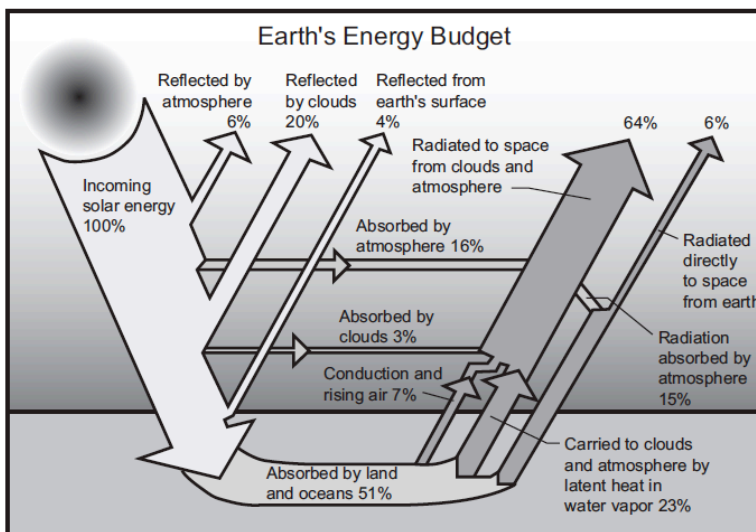


Fig. 1.2: Components of the globally averaged energy budget expressed as percentages of the incoming solar radiation. *Redrafted from an illustration by J.T. Kiehl and Kevin E. Trenberth.*

- Also based on the above figure, what is the average rate at which the atmosphere (including clouds) is radiatively cooled by infrared emission to space?
- To first-order, the Earth's atmosphere is understood to be in 'radiative-convective' equilibrium. Explain and relate your answer both to 2) and 3) (combined), and to the above figure.
- derive an expression for the rate of change in temperature with height of a parcel of air undergoing a saturated adiabatic process.
- The Venus atmosphere is approximately 95% CO_2 and 5% N_2 by volume. What does this imply for Venus' dry adiabatic lapse rate, assuming (incorrectly) that its gravitational constant is identical to Earth's?