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http://www.humboldt.edu/~geology/courses/geology531/531_handouts/earth_solar_energy_budget.pdf

THE EARTH'S SOLAR ENERGY BUDGET

The sun is the main source of energy for the earth. On the average, each square centimeter of the earth's surface receives 2 calories of heat and light energy every minute; i.e., the solar constant (influx of solar energy) is 0.033 cal/cm^2-sec.

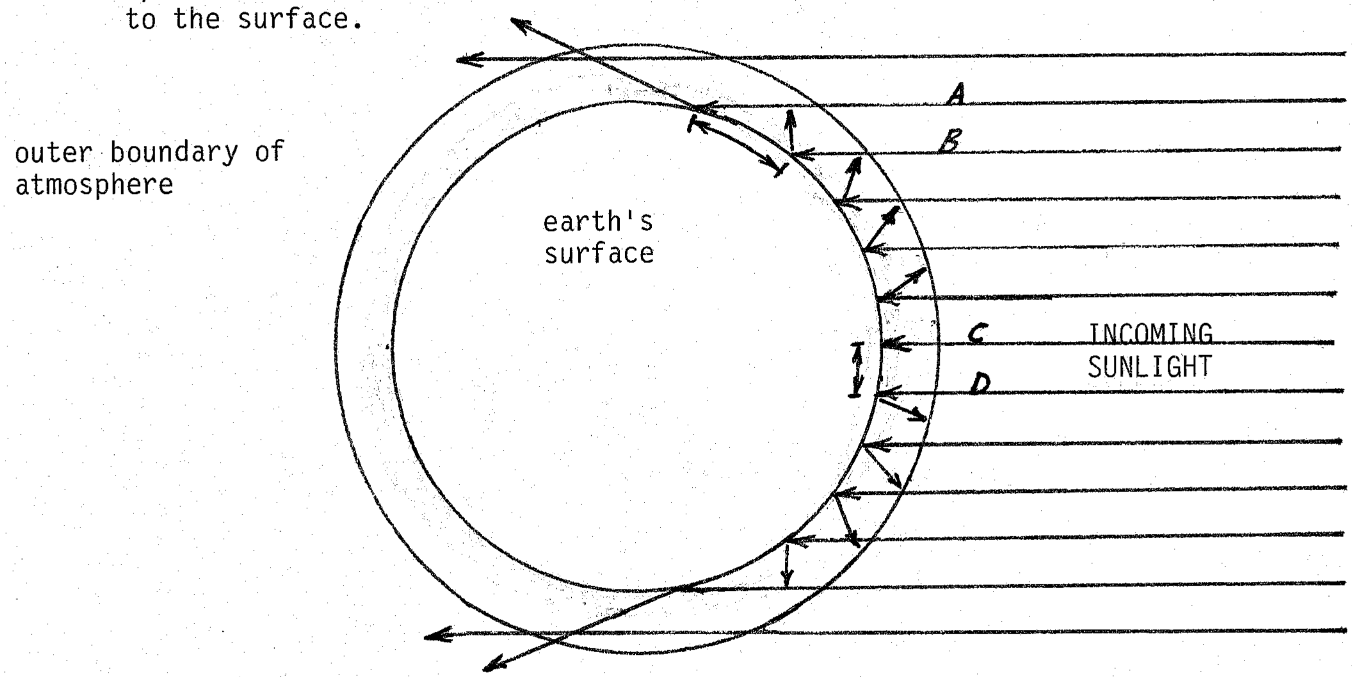
a. this corresponds to a total yearly input of 1.34×10^{32} cal/year

b. note that this heat is, in actuality, distributed inequally over the earth's surface; the equator gets approximately 2.4 times as much heat as the poles. There are three reasons for this:

1. since the rays are coming in parallel, 1 sq. meter of ground at the equator receives more rays than 1 sq. meter at the poles (see sketch)

2. rays near the poles come in at a low angle and thus more energy is reflected

3. the rays near the poles have to pass through a greater thickness of atmosphere and thus more heat is absorbed by the atmosphere and less gets to the surface.



a. note that the distance on the earth's surface between rays A and B is greater than that between rays C and D; thus the same amount of incoming energy must be spread over a larger area near the poles and hence the area must be cooler.

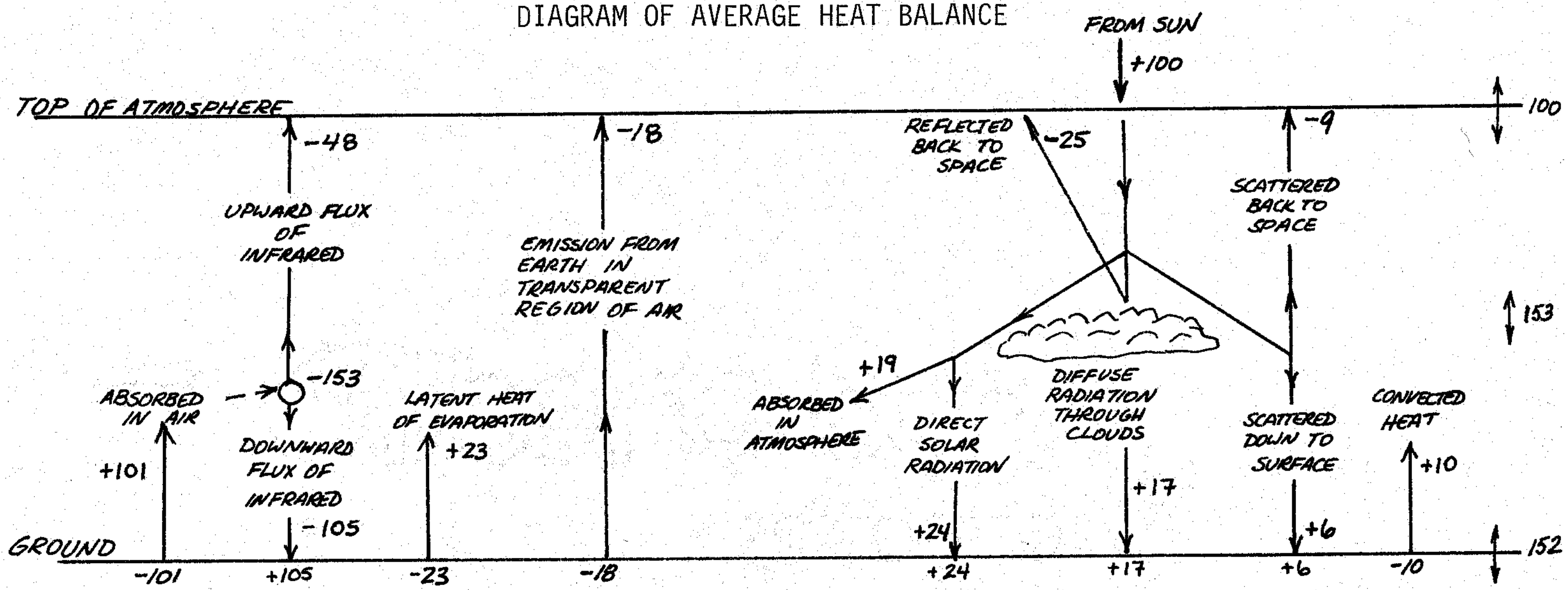
b. note greater distance of travel through atmosphere for ray A compared to ray C

c. note that ray A strikes surface nearly parallel so that there is lots of oblique reflection, while ray C strikes the surface at right angles.

We know that the earth's temperature has been essentially similar to that of today for at least the past 2 billion years. Our evidence for this is that 2 b.y. old sedimentary rocks indicate the presence of liquid H_2O, and hence temperature must have been between o° and 100° C. Algae in these rocks indicate that temperatures must have been in the middle of this range if they were to have been able to live and grow.

Since the earth's surface has not been getting significantly warmer or cooler for the past 2 b.y., as much heat must be being lost each year as is coming in; (if income were larger than outgo, the earth would be heating up; if outgo were greater than income, it would cool down). Thus there is an equilibrium between heat losses and gains.

DIAGRAM OF AVERAGE HEAT BALANCE



arrows ending at a boundary indicate energy transfer to that medium
arrows ending in mid-air indicate energy transfer to atmosphere

budget for top of atmosphere: incoming = 100%
outgoing = (-25%)+(-9%)+(-48%)+(-18%) = -100%

budget for atmosphere: incoming = (+19%)+(+23%)+(+10%)+(+101%) = +153%
outgoing = (-48%)+(-105%) = -153%

budget for earth's surface: incoming = (+24%)+(+17%)+(+6%)+(+105%) = +152%
outgoing = (-23%)+(-18%)+(-10%)+(-101%) = -152%

The wind and weather systems of the atmosphere, together with the ocean currents, act to transfer heat from the areas of excess (equator) to the areas of deficiency (poles). It is the difference in heat that drives these systems. Solar energy , mediated through the hydrologic cycle, is the chief driving force of surface processes on the earth.