

CLASS 16 HEAT BUDGET OF THE EARTH

Basic budget

Latitude variations

Surface temperatures

Sea ice

"HEAT BUDGET" -- Where does incoming solar radiation go?

Incoming Solar Energy can be:

- Reflected- bounced immediately back into space so there's no effect at all
- Absorbed (changed into heat)- warms the earth/atmosphere
- Absorbed and re-radiated out to space- incoming radiation warms the surface temporarily, but the energy is quickly lost again as infrared energy so it does not warm the earth

The balance or imbalance of these:

- Controls earth surface and atmosphere temperatures
- Drives ocean and atmosphere circulation

EARTH'S GLOBAL HEAT BUDGET

Let global average solar radiation = 100%

Reflection = 35% [31% by atm.; 4% by land & sea]

Absorption = 65% [17.5% in atm.; 47.5% by land & sea]

ABOUT HALF OF INCOMING ENERGY ABSORBED BY THE LAND AND SEA

Fate of energy absorbed by land & sea

Re-radiated (infrared) directly to space = 5.5%

Transferred to atm. = 42%

MOST OF THE SOLAR RADIATION ABSORBED BY LAND AND SEA IS TRANSFERRED BACK TO THE ATMOSPHERE

This transfer happens in two ways:

1) Evaporation and condensation of water.... 29.5% (out of the total 42%)

Heat uptake by evaporation -- cools surface

Energy transferred to molecule motions in water vapor

Later...heat released by condensation -- warms atm.

Mostly at higher latitude

WATER VAPOR VERY IMPORTANT carrier of energy on earth!!!!

2) Conduction and radiation- the obvious mechanisms- but ONLY 12.5%

-- Most infrared energy radiated by earth's surface is absorbed in the atmosphere by "greenhouse gases"

-- In absence of this greenhouse effect, the earth would be about -10°C!

Latitudinal variations in heat budget

Energy budget above applies to the earth as a whole, averaged over all places.
For any individual location on earth, the budget may not balance...

Solar energy influx depends on latitude- rays hitting at an angle less intense

- max. at Equator

- min. at poles

So... at any given latitude, energy input not necessarily equal to output

low latitudes: input > output

high latitudes: input < output

BUT...Global heat budget must be balanced overall, for the whole earth.

How can the budget balance if it is imbalanced at most latitudes?

Heat transfer from lower latitude to higher lat. by ocean and atm. currents

- Warm water/air currents: Equator --> poles

- Cool water/air currents: poles --> Equator

Convection, caused by the temperature differences, drives these currents

The heat they move from low lat. to high lat. balances the energy budget.

AND....most of the heat transport is actually transport of the "latent heat" locked up in water vapor

SURFACE TEMPERATURES on earth

1) Latitude "**belts**" of roughly constant Temp.

Ocean currents modify this

e.g., **Britain** is unusually warm for a place so far North

2) Seasonal temp. variations: Difference between winter lows and summer highs

- Continents -- large T range

- Oceans -- small T range

 - High heat capacity of water causes this

 - Oceans stabilize (moderate) the surface T of Earth

SEA ICE (not = icebergs)

Sea Ice = Layer of ice that forms annually at high lat.

- Near Antarctica

- In Arctic Ocean

Thickness of sea-ice limited...

- < 2 meters (single season), because...

- Ice acts as a blanket, slows loss of heat, slows formation of additional ice

Sea-ice formation:

Reminder: Ice formation --> high-S water.

This forms the densest and deepest water masses in the oceans.