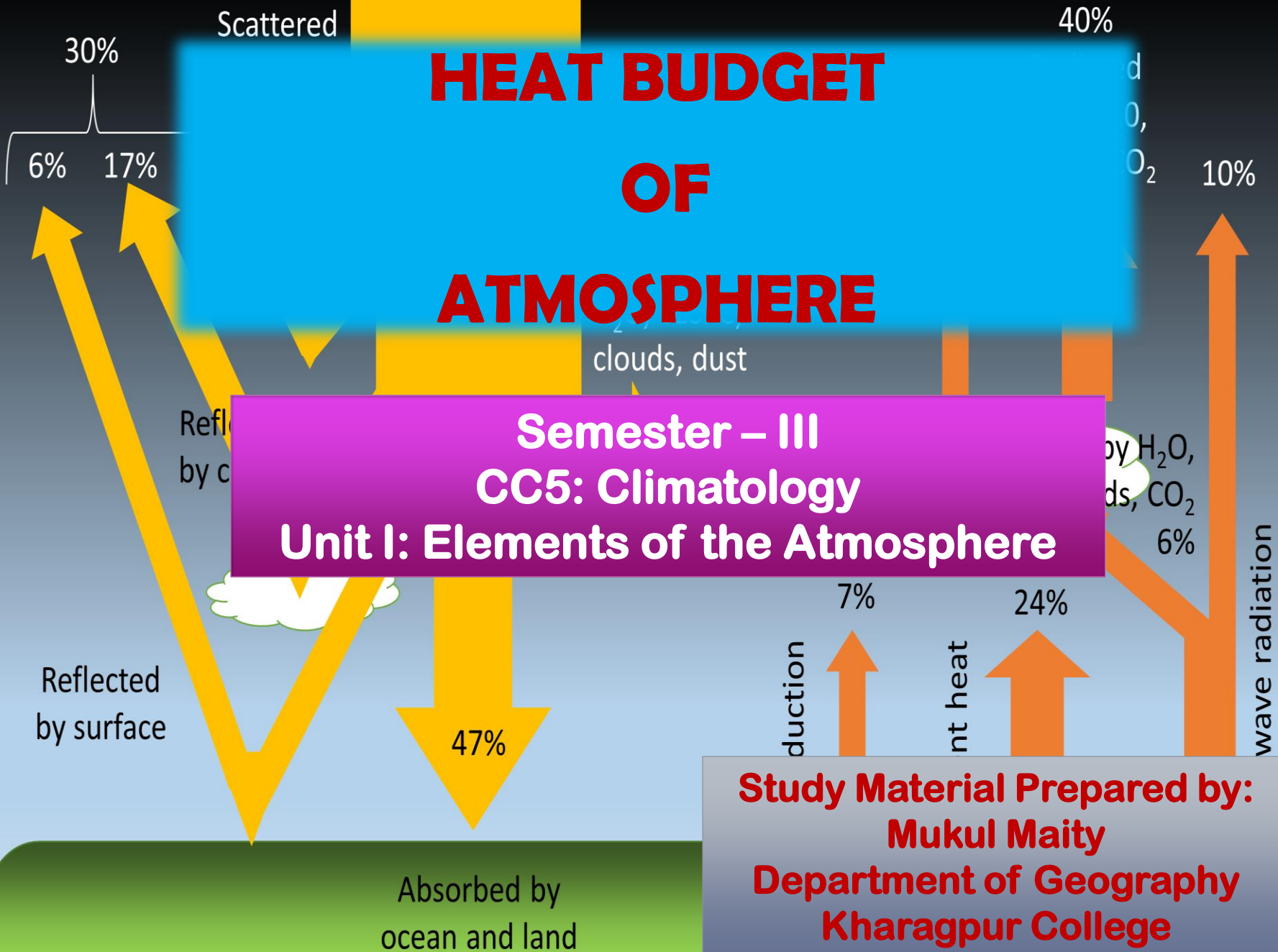


HEAT BUDGET OF ATMOSPHERE

Semester – III
CC5: Climatology
Unit I: Elements of the Atmosphere



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Radiation and Matter

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Absorption:

- Radiation is absorbed by matter (liquid and gases) in the atmosphere
- Leads to heating

Transmission:

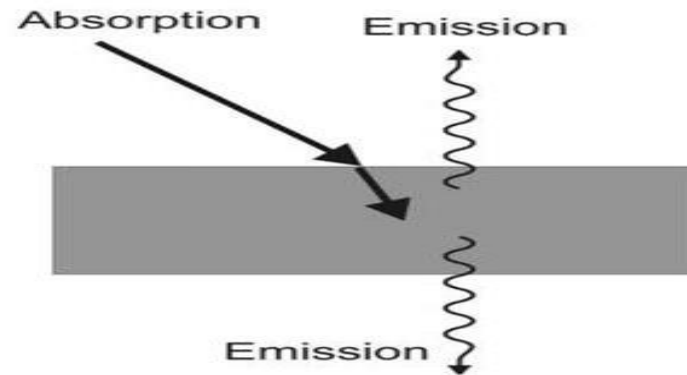
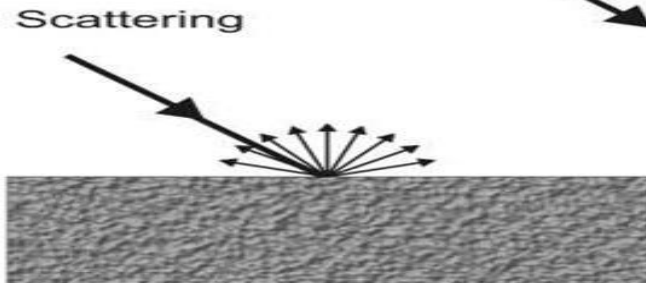
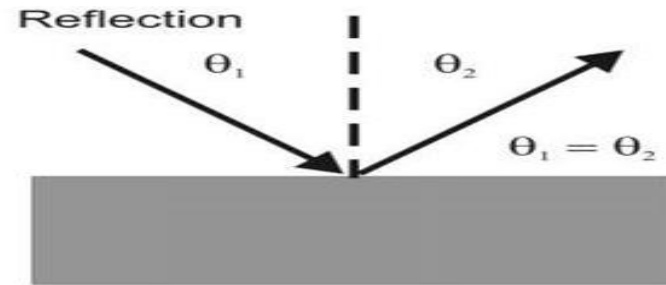
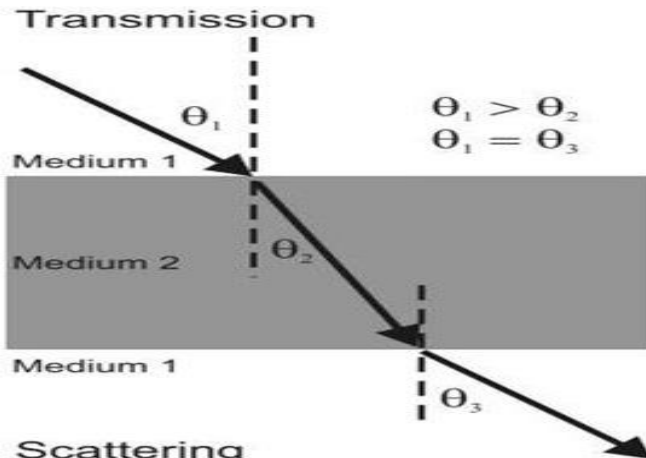
- Radiation passes through the atmosphere and does not interact with matter
- Does not affect the atmosphere

Scattering:

- Radiation is reflected and scattered by matter in the atmosphere, but is not absorbed.
- Also does not affect the atmosphere
- Results in a change of wavelength and/or direction of travel

Reflection:

- Reflection is the change in direction of a wave front at an interface between two different media so that the wave front returns into the medium from which it originated.



INTERACTIONS DEPEND ON WAVELENGTH AND TYPE OF MATTER

Incoming Solar Radiation

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- As the above example suggests, what happens to radiation depends on its wavelength

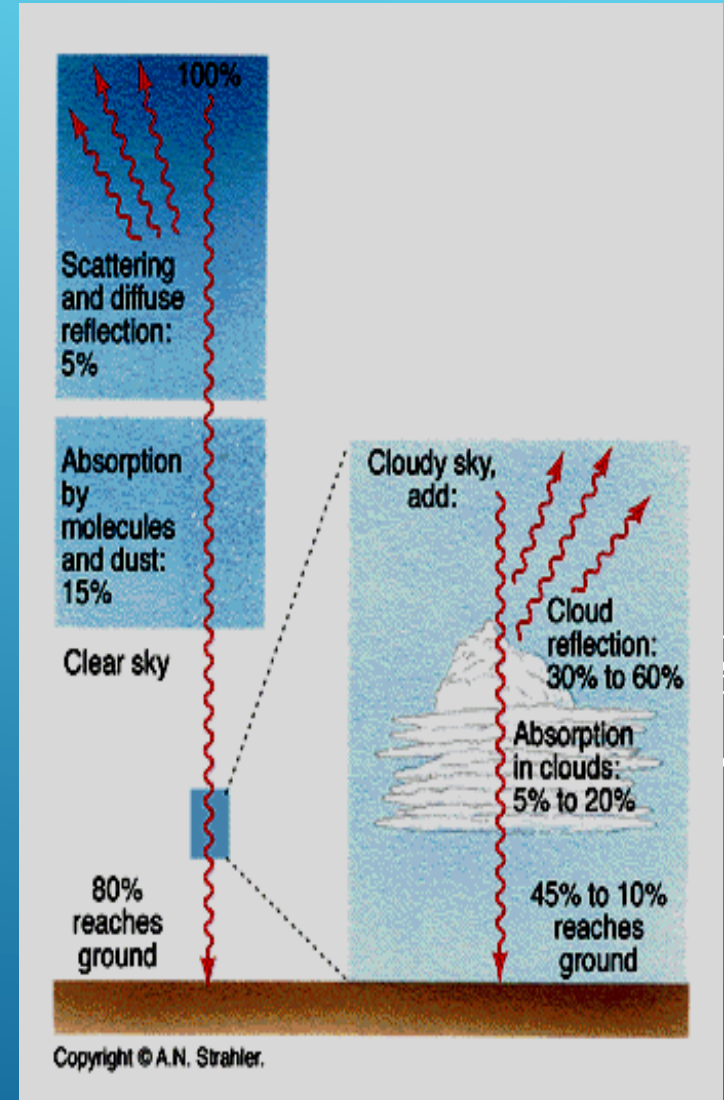
- Atmosphere is transparent to solar radiation (i.e. it reaches the surface and heats it)

- Atmosphere absorbs longwave radiation (i.e. it heats the atmosphere)

- It turns out that the clear atmosphere relatively transparent to solar radiation

- However, when we introduce clouds, we find that the transmission is cut down. In addition there is more reflection as well as more absorption in the atmosphere

- For right now though, we will just be considering average conditions



Shortwave Radiation Budget

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- Typically, to aid with discussion, we use 'dimensionless units' where 100 represents an amount equal to what comes from the sun

Reflection (Albedo):

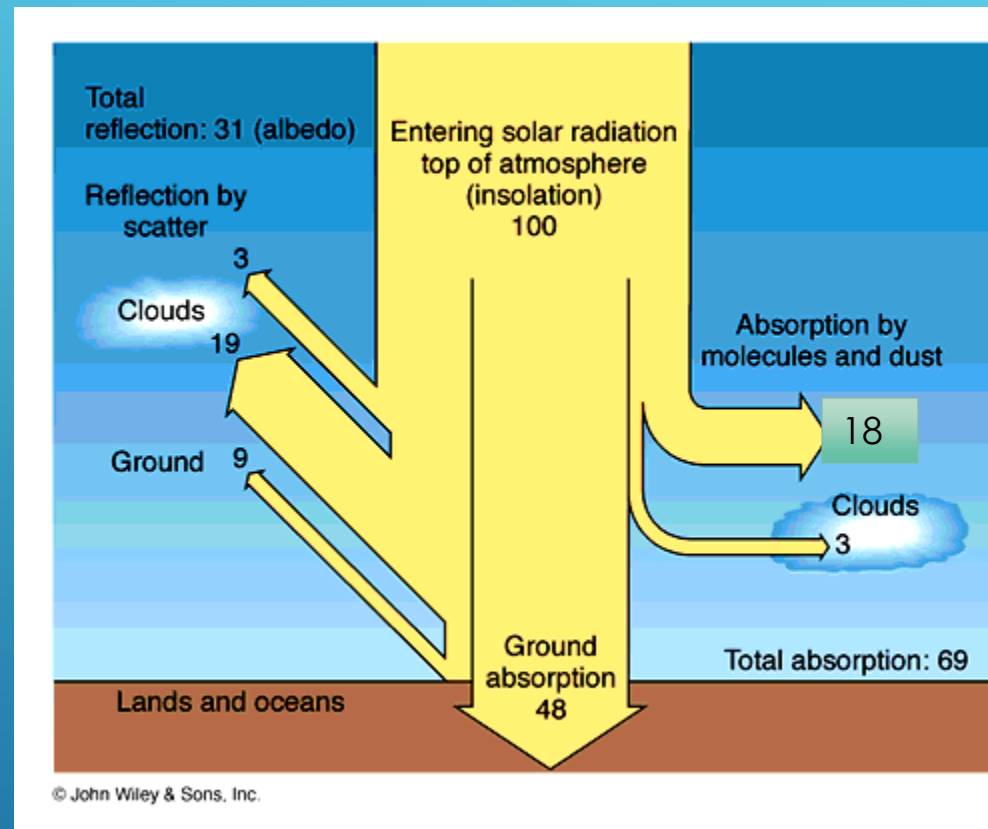
- 3% reflected to space by atmosphere
- 19% reflected by clouds
- 9% reflected by the surface

Absorption in the atmosphere:

- 18% absorbed by atmosphere
- 3% absorbed by clouds

Absorption by the surface:

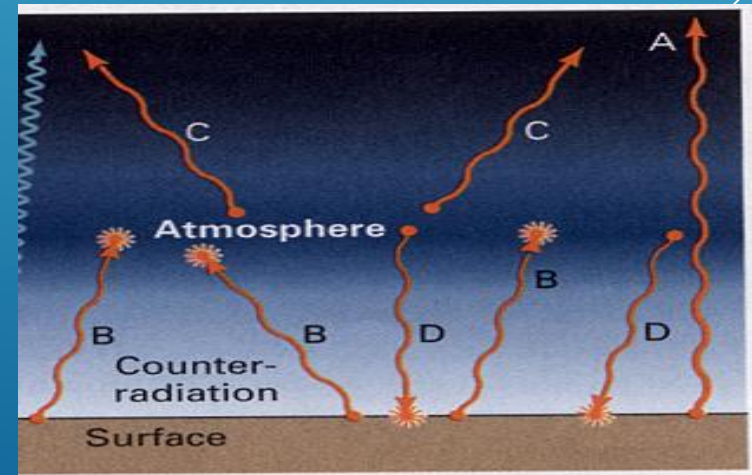
- 48% absorbed at the surface
- This radiation is absorbed, heats the surface and is converted to
 - Longwave radiation
 - Sensible and latent heat



Longwave Radiation

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- The surface emits longwave radiation (A and B), some of which escapes to the free space (A)
- As opposed to solar radiation, the atmosphere is strongly absorptive to longwave radiation
- Hence, the atmosphere “traps” outgoing longwave flux emitted by the surface (B)
- This absorbed long-wave radiation goes to heating the gas molecules in the atmosphere
- In turn, the atmosphere emits longwave radiation
 - Some of this radiation is emitted to space (C)
 - But some of it is also emitted back towards the earth (D)
- Hence emission of longwave radiation from the atmosphere back to the surface represents another form of radiative heating of the surface



Longwave Radiation Budget

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- We will continue use the dimensional units

From surface:

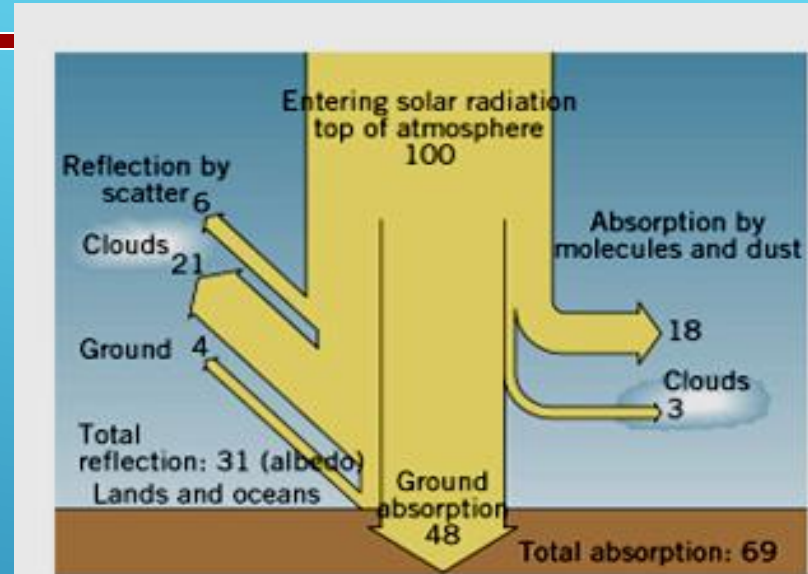
- 6% escapes to space
- 107% is radiated by surface and absorbed by atmosphere

From Atmosphere:

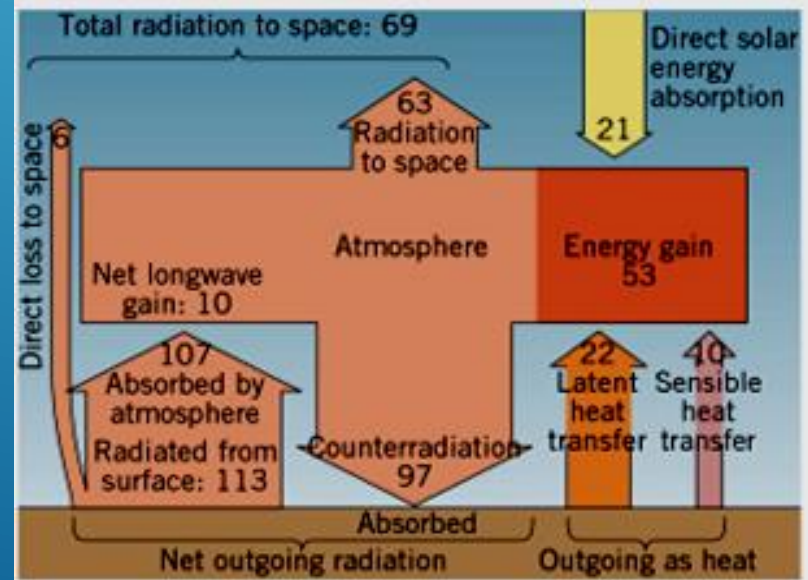
- 97% is re-radiated by atmosphere and is absorbed by the surface
- 63% is re-radiated to atmosphere and escapes

Why is more radiation emitted from the surface of the earth than is absorbed through solar radiation?

Because of the "Natural Greenhouse Effect"



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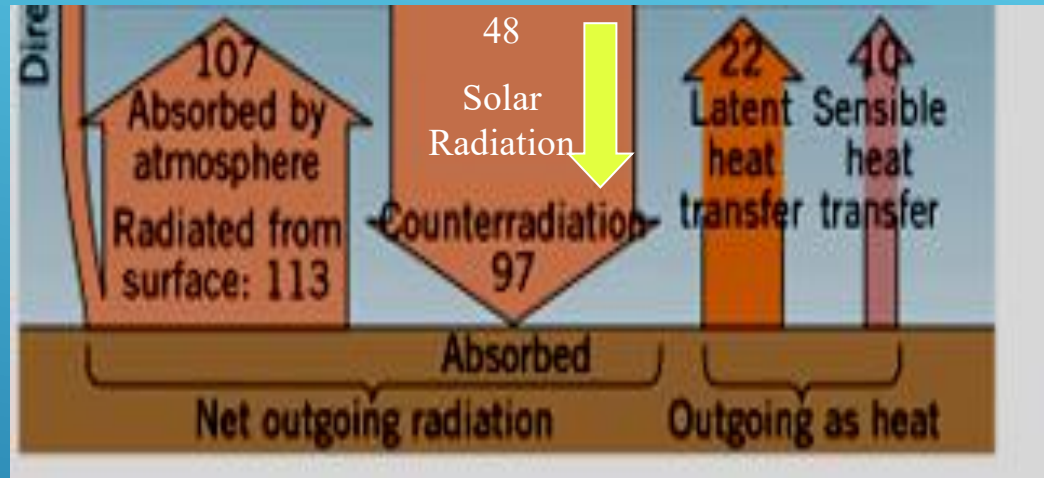
The Greenhouse Effect

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- Refers to the emission of longwave radiation by the surface, absorption by the atmosphere, and re-radiation back to the surface
- Because of the re-radiated longwave energy, the earth receives more than just energy from the sun
- Note that the earth receives more longwave energy from the atmosphere than it does directly from the sun
- Can consider this to be 'recycling' of energy within the earth system
- This is why the surface temperature of the earth is greater than 255K expected by simple radiation balance considerations

Surface Radiation Balance

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Heating

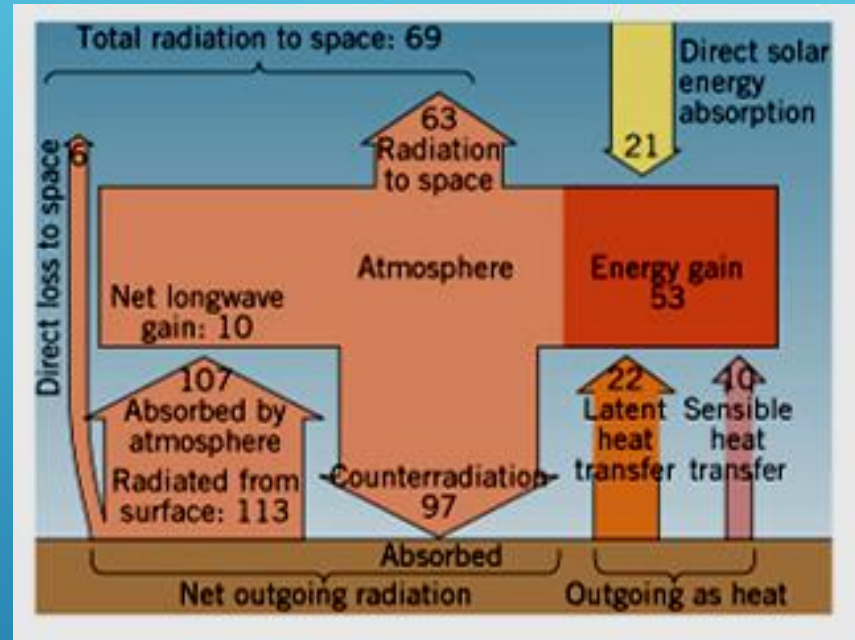
Incoming Solar Radiation	48
Incoming Longwave Radiation	97
Total	145

Cooling

Outgoing Longwave Radiation	113
Latent Heat	22
Sensible Heat	10
Total	145

Atmospheric Radiation Balance

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Heating

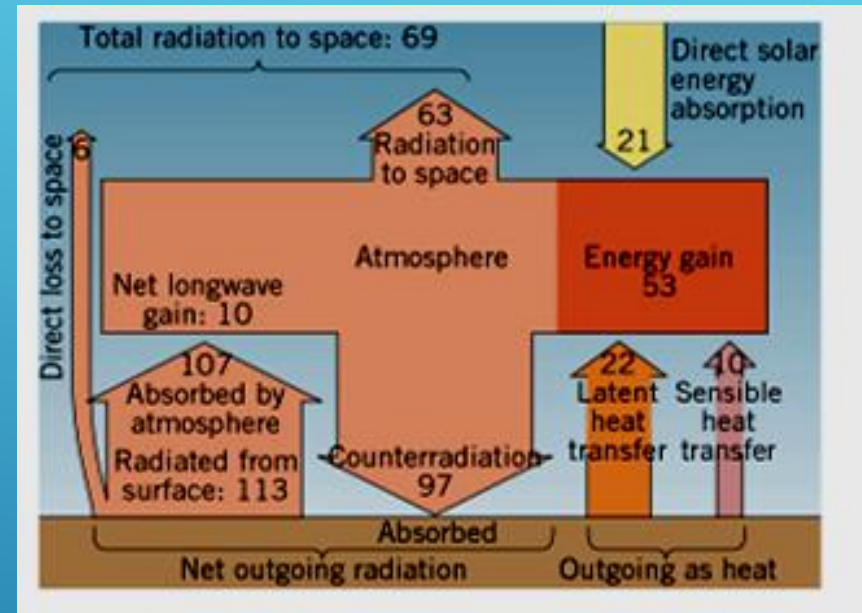
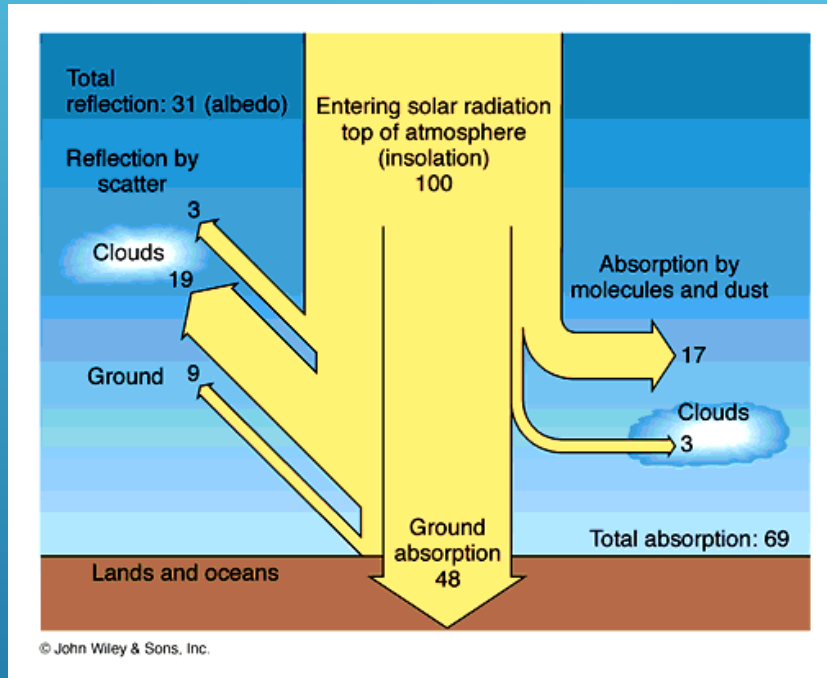
Incoming Solar Radiation	21
Incoming Longwave Radiation	107
Latent Heat	22
Sensible Heat	10
Total	160

Cooling

Outgoing Longwave Radiation (to space)	63
Outgoing Longwave Radiation (to Earth)	97
Total	160

Global Radiation Balance

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Incoming Solar Radiation 100

Reflected to space 31

Longwave Radiation from Earth 6

Longwave Radiation from Atmos. 63

Total 100

Total 100