- Radiation of longwave from ground up to clouds/atmosphere and reflection back down

- **Incoming:**

$$100_{\text{In}} - (6+20+4)_{\text{refl}} - (16+3)_{\text{abs by atm}} - (51)_{\text{abs by surf}} = \textbf{zero}$$

- **Energy gained/lost by surface:**

$$+51_{\text{input}} - 6_{\text{loss}} = \mathbf{45}_{\textbf{emit by surf}}$$

- **Energy gained/lost by atmosphere:**

$$+(16+3)_{\text{input}} + 45_{\text{emit by surf}} - 64_{\text{loss}} = \textbf{zero}$$

- **Overall planetary net radiation:**

$$100_{\text{SWin}} - 30_{\text{SWrefl}} - 64_{\text{LWatm}} - 6_{\text{LWsurf}} = \textbf{zero}$$

-
  - Emitted by surface = moved away from the surface
  - 64% lost to space
- Energy received = Energy reemitted
  - Eventually, all of the energy that reaches the Earth's surface is reflected back

Greenhouse Effect:

- Greenhouse effect: barrier causes inflow of energy that outpaces the outflow → interior warms
- Warming effect due to atmospheric GHGs preventing heat emitted from surface from escaping into space
- Water vapor (most abundant), carbon dioxide (most abundant anthropogenic GHG), methane, and nitrous oxide (greatest effect on global warming in future)
- Absorb longwave radiation and reradiate it to surface (counter radiation)

How Do We Measure Global Climate?

- Weather stations recording temperature since 1714
- Instrumental period (1860) = current era, access to temperature readings taken directly with thermometers
- Satellites (1979) measure temperature from space using IR
- Comparing temperatures to fixed base period shows climate changing over time

Proxies:

- Collecting proxy data provides climate change information from ancient climates (paleoclimates) – less precise b/c uncertainty in relation btw proxy and climate
- Proxy: observable + measurable phenomenon, indirect indicator climate change
  - Must overlap with modern instruments to provide calibration
  - Proxy – measurement that stands in for paleoclimate variable when we can't measure it directly because it pre-dates the instrument record. An example is tree rings