

Key Ideas -- Energy and the Environment

The Sun is the ultimate source of almost all energy for the Earth System. Small amounts also come from **radioactivity** and **geothermal** sources.

Solar energy is created by **nuclear fusion**, which basically involves changing some of the mass in atoms of hydrogen into pure **electromagnetic energy**.

Energy can be **transferred** from an energy source to an energy sink through **radiation, convection, or conduction**.

Energy reaching any substance may be **transmitted** through it, **reflected** off it, or **absorbed** by it. **Insolation (Incoming Solar Radiation)** consists of energy in many electromagnetic wavelength zones, but especially **visible light** and lesser amount of **ultraviolet (UV)** and **infrared (IR or heat)** energy.

When insolation reaches the surface, about one-third immediately returns back to space by reflection off atmospheric gases, clouds, and surface materials. This is called the **albedo**. About 17% is absorbed by atmospheric gases and clouds. Only about half of the insolation reaching the top of the atmosphere is absorbed by surface materials. Shorter wavelength visible light absorbed at the surface is transformed into longer-wavelength infrared (heat) energy. This heat warms surface materials and creates the **density-driven atmosphere and ocean systems**. Eventually, the heat returns to space by **terrestrial re-radiation**. **Earth's energy balance** includes all these incoming and outgoing processes.

Water, carbon dioxide, methane, and other atmospheric gases "trap" (absorb) some of heat energy re-radiated from Earth's surface, making our planet much warmer than it would otherwise be. This **Greenhouse effect** has created conditions that enabled Life to form and survive in suitable conditions. In recent years, human release of carbon dioxide and other **greenhouse gases** has accelerated, leading to **anthropogenic climate change** that poses significant challenges for the future Earth System.

The atmosphere is **unevenly heated** and, as a result, **weather** serves as the main **energy transfer system** on our planet.

Equatorial and tropical regions receive the most amount of energy, and **polar regions** the least.

Seasonal shifts caused by Earth-Sun positioning produce **annual cyclical patterns**.

Short-term changes in energy transfer can produce events such as **El Nino-La Nina events**.

Longer-term changes in Earth-Sun relationships produce **natural climate changes** on the scale of centuries or millennia.

Surface materials affect local energy balances, producing such phenomena as **sea breezes** and **land breezes, mountain winds, and monsoons**.