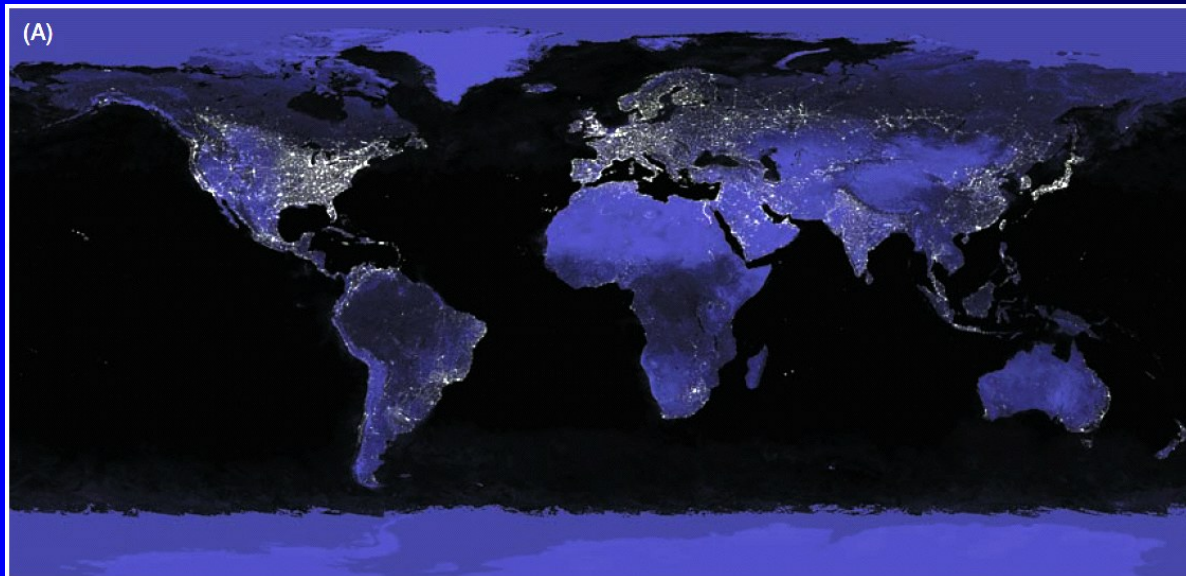


The Earth System



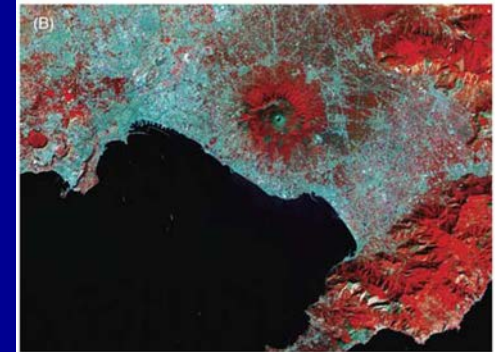
Earth System Science

Earth system science is the new holistic approach to studying the Earth as a whole system of many interacting parts

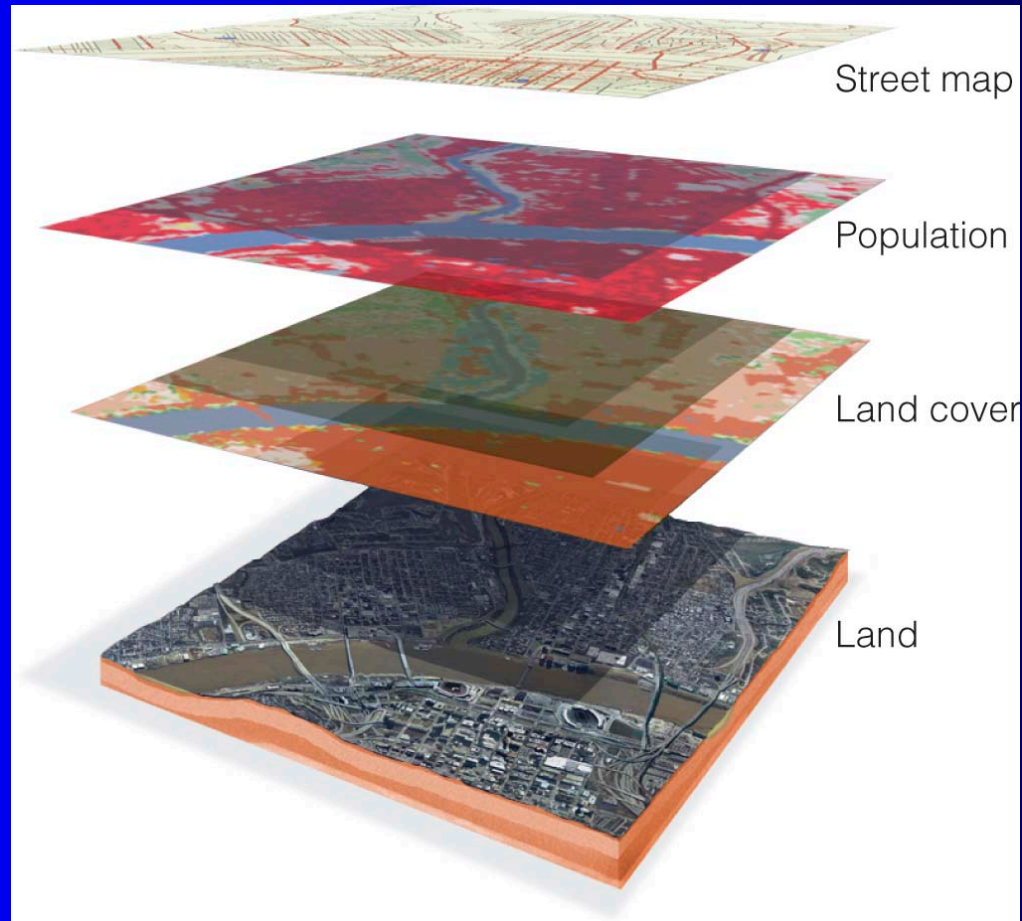
- The ocean
 - The atmosphere
 - The continents
 - Lakes and rivers
- Soils
 - Plants
 - Animals

Studying the Earth System

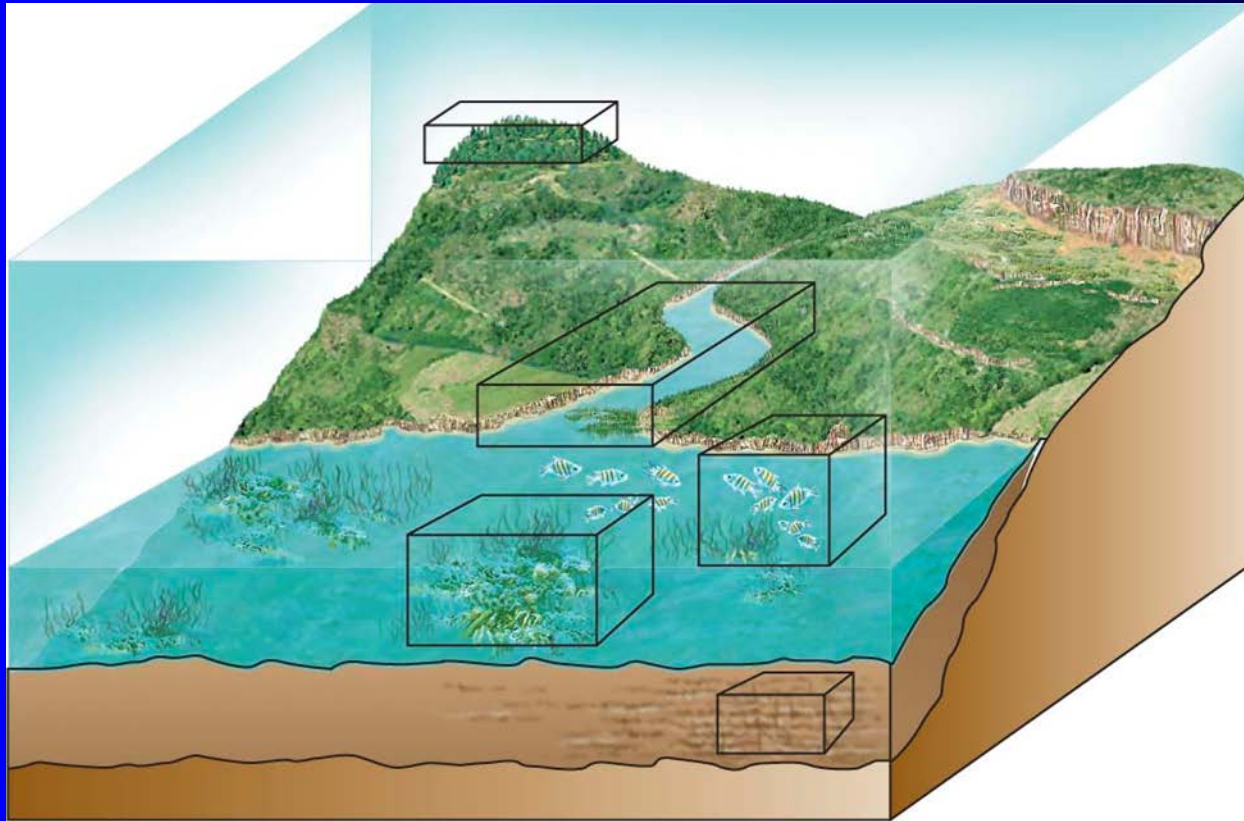
- Requires observations of the Earth at various scales
- The quintessential tool for making these observations is remote sensing with satellites



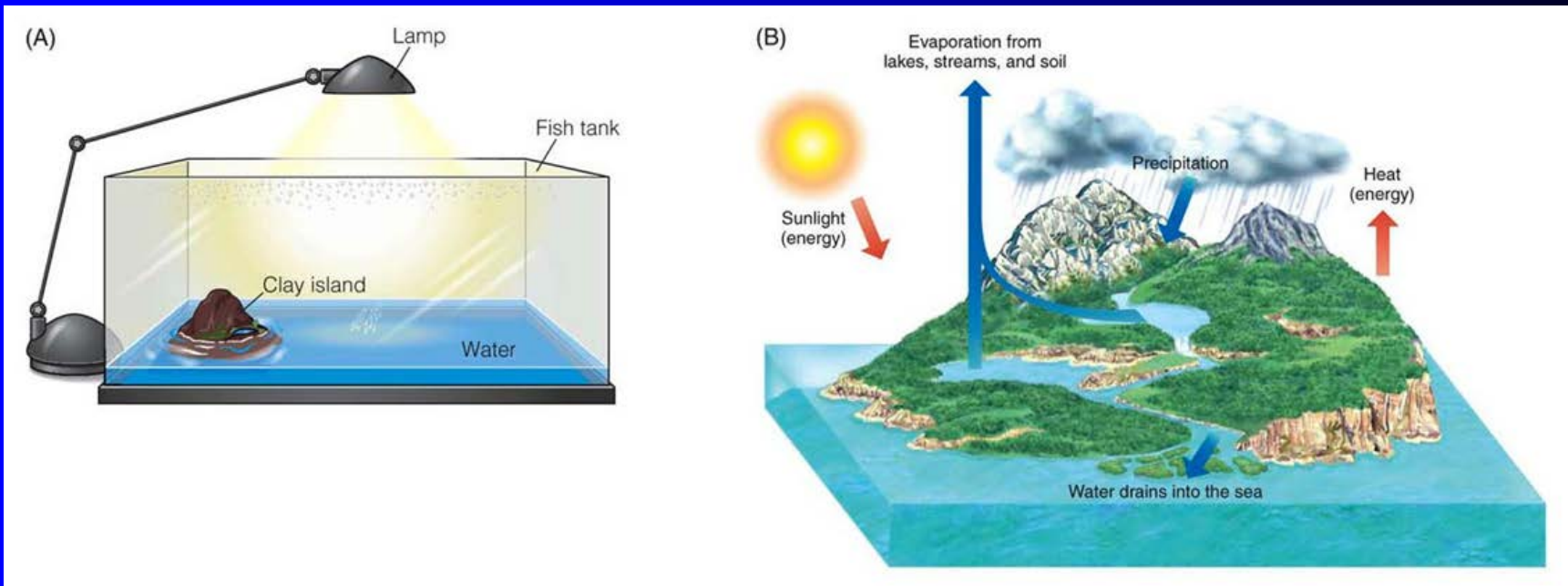
Geographic Information Systems provide ways for scientists to store and analyze vast amounts of data



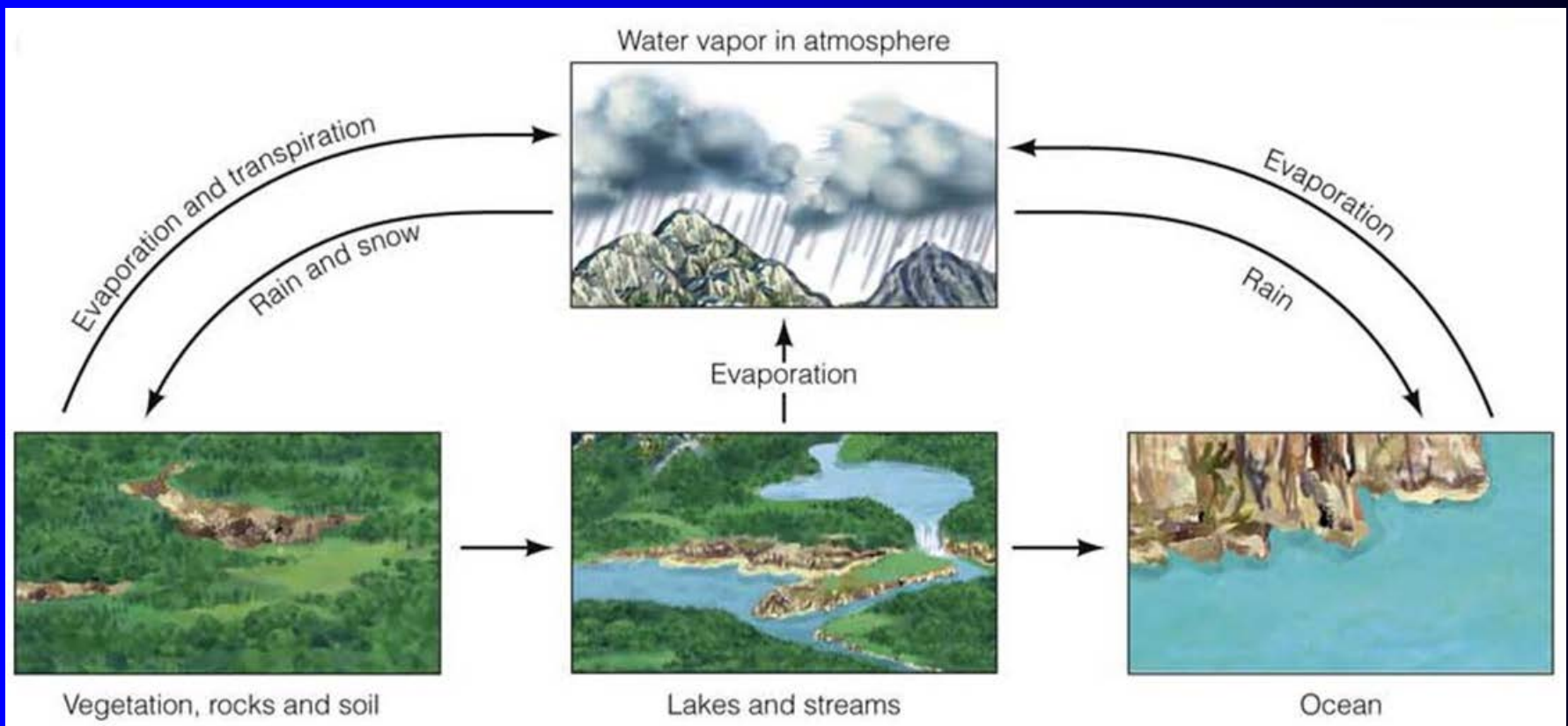
- A **system** is any portion of the universe that can be isolated from the rest for the purpose of observing and measuring changes
- By observing and measuring changes, systems can be used to study complex problems



- A **model** is a representation of something, typically a simplification of a complex original
- We can build models of processes, which can represent some of Earth's systems

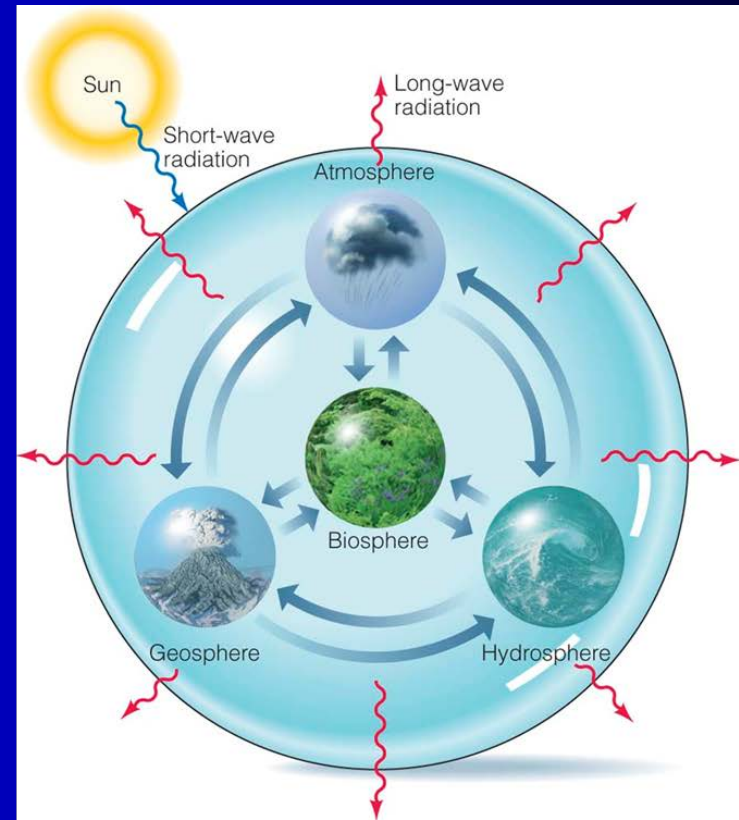
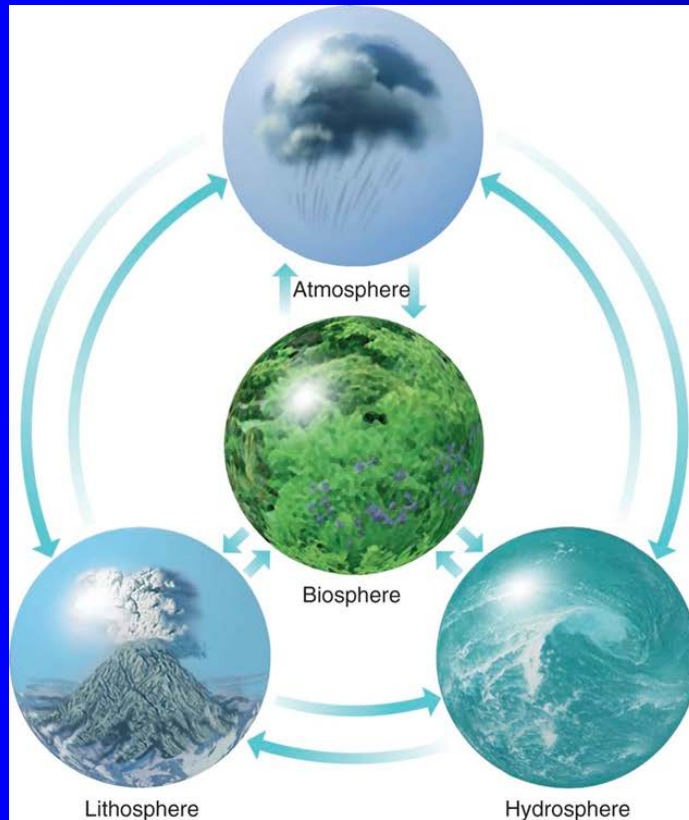


- A **box model** is a simple graphical representation of a system
- **Flux**
- **Reservoirs**
 - **Sink**
 - **Source**
- **Residence time** and **sequestration**



The Earth consists of four vast reservoirs with constant flows of energy and matter between them

Atmosphere Hydrosphere
Biosphere Geosphere

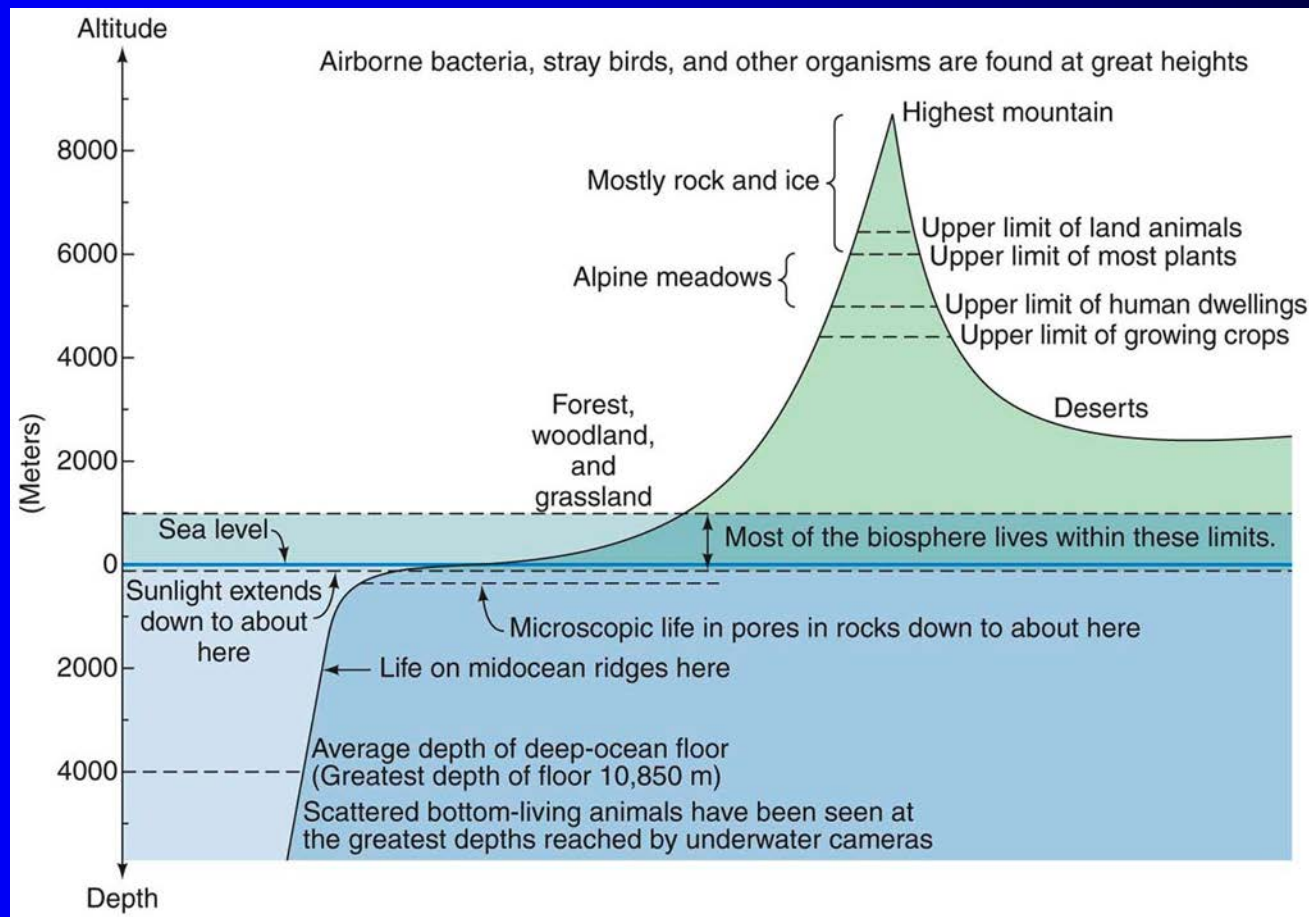


As a whole, Earth is essentially a **closed system**

Two important implications of Earth being a closed system are

1. The amount of matter in a closed system is fixed and finite
2. If changes are made in one part of a closed system, the results of those changes eventually will affect other parts of the system

- The place where Earth's four reservoirs interact most intensively is a narrow zone called the life zone
- Conditions favorable for life are created by interactions between the lithosphere, hydrosphere and atmosphere, and modified by the biosphere



Earth System Reservoirs

- **The Geosphere**
 - Is the solid earth
 - Composed mainly of rock and regolith
 - Where energy that comes into the Earth system from outside sources meets energy that comes from within the planet
 - Energy sources combine and compete to build up and wear down the materials of Earth's surface

Earth System Reservoirs

- **The Hydrosphere**
 - The totality of Earth's water
 - Includes oceans, lakes, streams, underground water, and all snow and ice
 - The perennially frozen parts of the hydrosphere are collectively the cryosphere
 - The hydrosphere and the atmosphere store, purify, and continually redistribute water

Earth System Reservoirs

- **The Atmosphere**
 - The mixture of gases that surrounds Earth
 - Predominantly N₂, O₂, Ar, CO₂, and H₂O
 - In the context of the planet it is a very very thin layer, but it protects life from damaging solar radiation, is the reservoir for oxygen and carbon dioxide
 - It is the outer boundary of the Earth system

Earth System Reservoirs

- **The Biosphere**
 - Includes all of Earth's organisms and matter that has not yet decomposed
 - The biosphere greatly affects every other of Earth's systems
 - Photosynthesis
 - Oxygen as a highly reactive gas

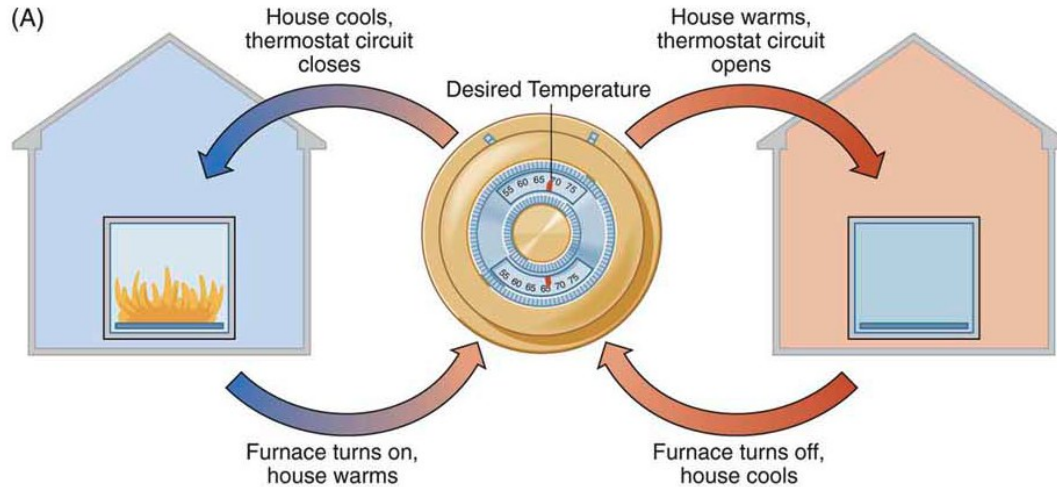
Earth System Reservoirs

- **The Anthroposphere**
 - The “human sphere”
 - Comprises people, their interests, and their impacts on the Earth system
 - The part of the natural system that has been modified by humans
 - Includes the **technosphere**, specifically to technology, machines, and the built environment

Dynamic Interactions Among Reservoirs

- Because energy flows freely into and out of systems, all systems respond to inputs and, as a result, have outputs
- A special kind of response, **feedback**, occurs when the output of the system also serves as an input
 - **Negative feedback**: the system's response is in the opposite direction of initial input
 - Often self-limiting or self-regulating
 - **Positive feedback**: an increase in output leads to a further increase in output
 - Vicious cycle
 - Destabilizing

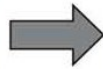
Negative Feedback



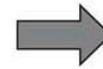
(B)



Child having a tantrum



Childs hand holding candy

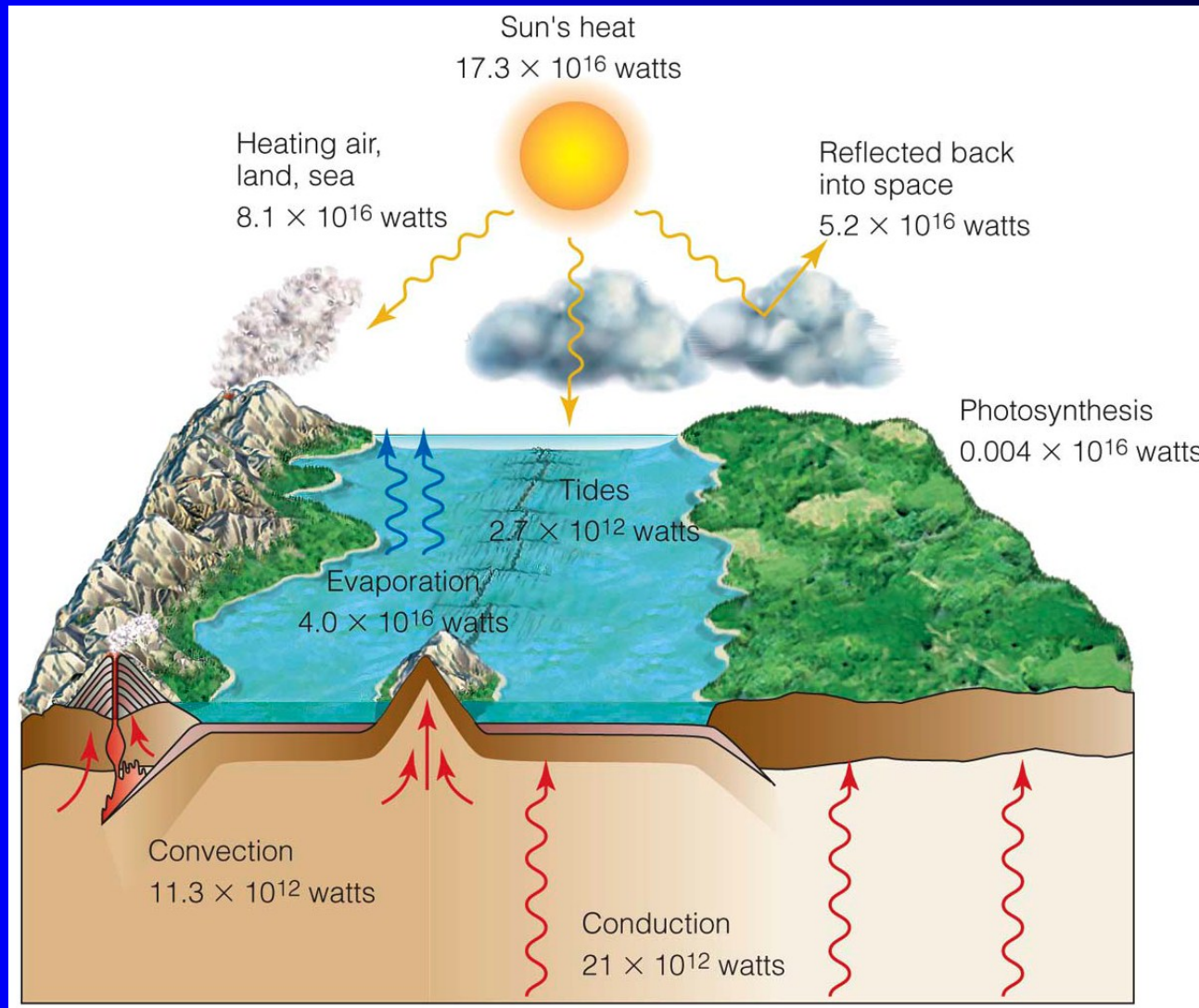


Child having another tantrum

Positive Feedback

- The constant movement of material from one reservoir to another is called a **cycle**
- Natural cycles are not simple, and exist in a state of **dynamic equilibrium**
- There are many important **Earth cycles**
 - The Hydrologic Cycle
 - The Energy Cycle
 - The Rock Cycle
 - The Tectonic Cycle
 - Biogeochemical Cycles

The Energy Cycle



- Humans involve or affect natural cycles
- Significant changes are now taking place in many Earth reservoirs, as a result, many are changing in unexpected ways
- Scientists have coined a term to describe changes produced in the Earth system as a result of human activities: **global change**