Water cycle in forest ecosystem

- ✓ The water cycle, also known as the hydrologic cycle or the H_2O cycle, describes the continuous movement of water on, above and below the surface of the Earth.

- ✓ The mass water on Earth remains fairly constant over time but the partitioning of the water into the major reservoirs of ice, fresh water, saline water and atmospheric water is variable depending on a wide range of climatic variables.

- ✓ The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of **evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow**.

- ✓ In so doing, the water goes through different phases: **liquid, solid (ice), and gas (vapor).**
- ✓ The water cycle involves the exchange of energy, which leads to temperature changes.

- ✓ For instance, when water **evaporates**, it takes up energy from its surroundings and cools the environment.
- ✓ When it **condenses**, it releases energy and warms the environment.
- ✓ These heat exchanges influence climate.

- ✓ The evaporative phase of the cycle purifies water which then replenishes the land with freshwater.
- ✓ The flow of liquid water and ice transports minerals across the globe.

- ✓ It is also involved in reshaping the geological features of the Earth, through processes including **erosion** and **sedimentation.**
- ✓ The water cycle is also essential for the maintenance of most life and ecosystems on the planet.

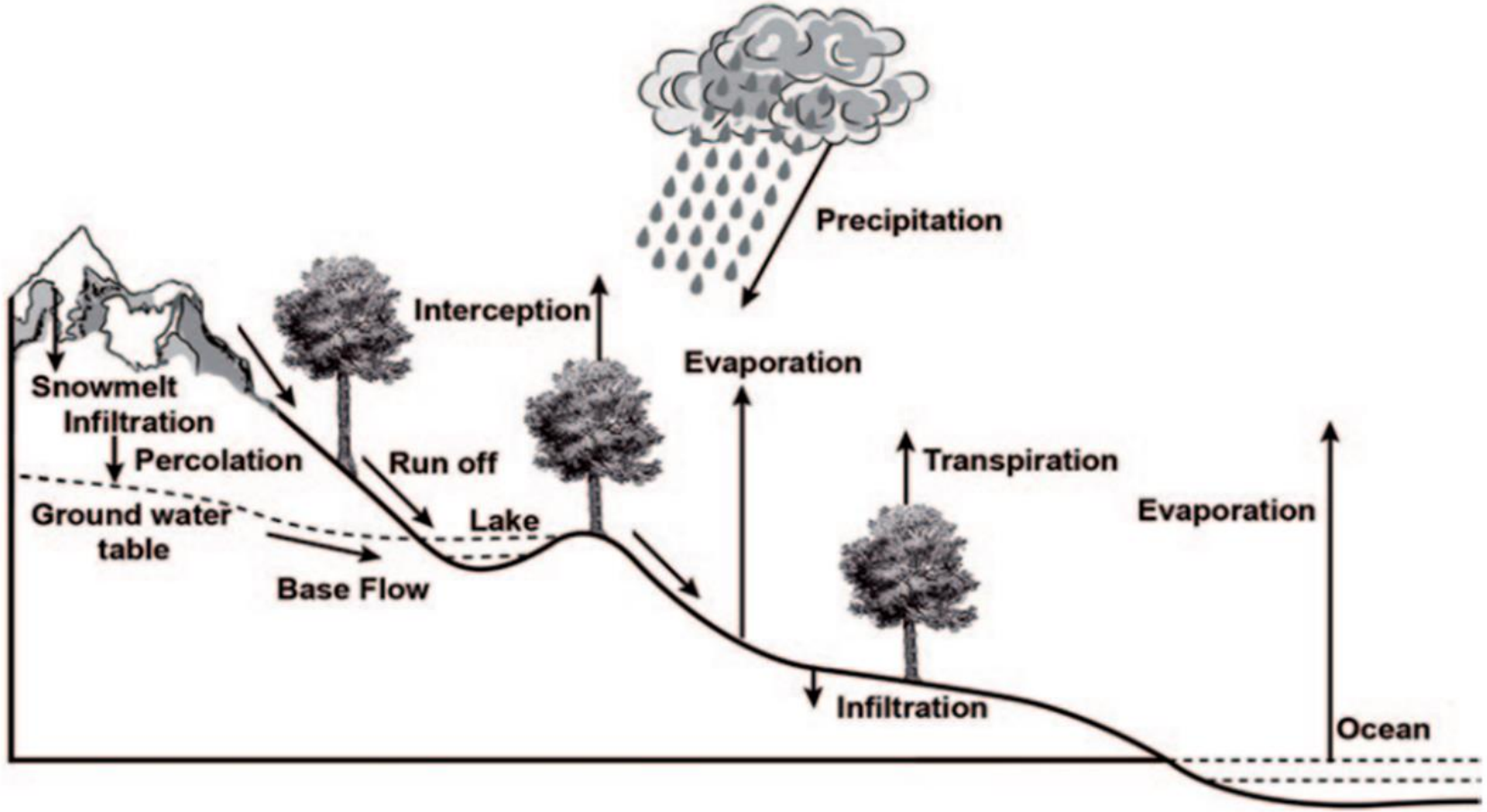
- ✓ The hydrologic cycle is an important feature of all ecosystems, and particularly forests, which generally grow in climates where precipitation provides more water than the vegetation can use or soils can store.

- ✓ The excess water contributes to stream flow, which provides for irrigation and urban needs far from the source of precipitation.

- ✓ Vegetation is a major factor in the hydrologic cycle. Before precipitation reaches the soil, water is intercepted and evaporated from the surface of vegetation and the litter layer.

- ✓ The rate at which water infiltrates into the soil, runs off the surface, or percolates through to the water table is affected by the density and depth of root channels and organic residue incorporated into the soil.

Fig. 2.4 The hydrologic cycle



Energy and Water

- ✓ Water and solar energy are essential for the functioning of the Earth System.
- ✓ Since neither is distributed evenly around the globe, the mechanisms by which they are redistributed (the global hydrologic cycle and energy budget) are important.
- ✓ These processes are so tightly intertwined that they cannot be treated separately.
- ✓ Solar energy drives the hydrologic cycle through the vertical transfer of water from Earth to the atmosphere via evapotranspiration, the sum of evaporation from surfaces and transpiration, which is the water loss from plants.
- ✓ Conversely, evapotranspiration accounts for 75% of the turbulent energy transfer from Earth to the atmosphere and is therefore a key process in Earth's energy budget .
- ✓ The hydrologic cycle also controls Earths biogeochemical cycles by influencing all biotic processes, dissolving nutrients, and transferring them within and among ecosystems.
- ✓ These nutrients provide the resources that support growth of organisms. The movement of materials that are dissolved and suspended in water links ecosystems within a landscape.

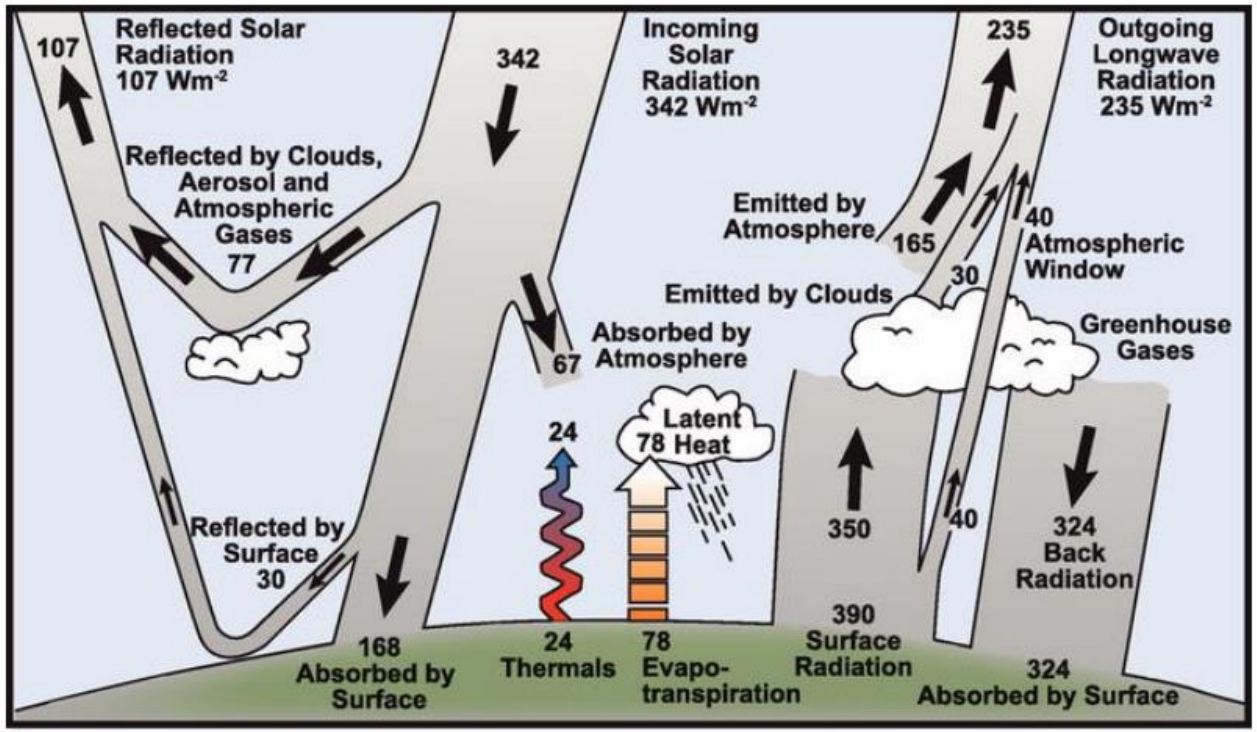


Figure 4.1: Estimate of the Earth's annual and global mean energy balance. Over the long term, the amount of incoming solar radiation absorbed by the Earth and atmosphere is balanced by the Earth and atmosphere releasing the same amount of outgoing longwave radiation. About half of the incoming solar radiation is absorbed by the Earth's surface. This energy is transferred to the atmosphere by warming the air in contact with the surface (thermals), by evapotranspiration and by longwave radiation that is absorbed by clouds and greenhouse gases. The atmosphere in turn radiates longwave energy back to Earth as well as out to space. IPCC (2007). Units are $W.m^{-2}$. Source: Kiehl and Trenberth (1997).

- ✓ The Sun can with high accuracy be described as a black body emitting energy at 5800 K (5530 °C) with a maximum at a wavelength of 0.5 µm (see Fig. 4.1).

- ✓ Averaged over the year and all surfaces of the Earth this amounts to 342 w m_2 As this shortwave radiation hits the Earth's atmosphere, 77 W.m_2 (23%) is directly reflected back into space, 67 W.m $_2$ (20%) is absorbed by molecules in the atmosphere, heating it.

- ✓ The remaining part is partly reflected (30 W.m_2 or 9%) and partly absorbed (168 W.m $_2$ or 49%) by the Earth's surface (see Fig. 4.1).

- ✓ The gross photosynthesis on Earth is 220 Pg (C) yr-1 .

- ✓ The heat of combustion of 1 g in the form of glucose (C) is 38.9 kJ and the gross photosynthesis corresponds to 7.84 x 1021 J. The solar energy trapped in photosynthesis is thus a negligible component (3%) in the Earth's energy budget.

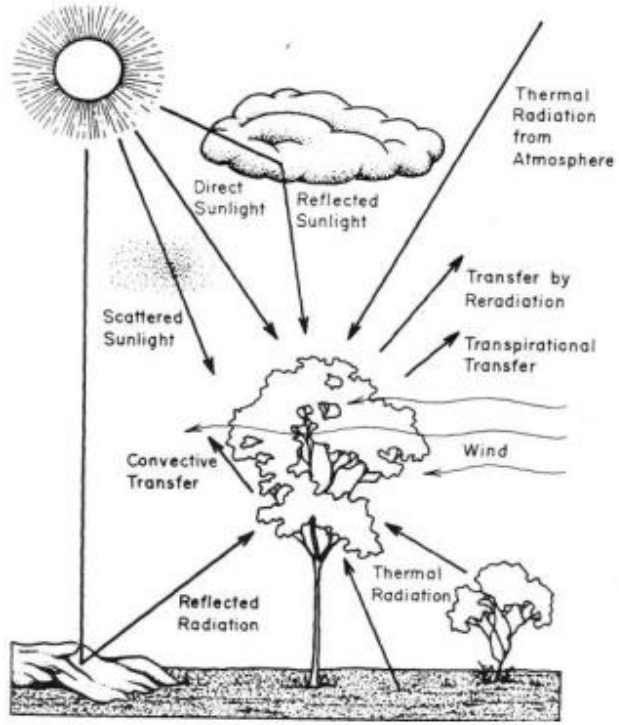


Figure 4.2: Energy exchange between vegetation and the environment involves a number of processes. Solar radiation reaches plant canopies as direct, scattered, and reflected sunlight, all of which contain some short-wave components important for photosynthesis. On partly cloudy days, reflection from clouds can increase incident short-wave radiation at the ground surface by as much as 30%. On clear days, less than 10% of the short-wave radiation is scattered by the atmosphere; on overcast days, incident short-wave radiation is reduced and diffuse, casting no shadows. Plant and other surfaces absorb and reflect short-wave and long-wave radiation, and they emit thermal radiation as a function of their absolute (Kelvin) temperature. The bulk of the heat load on plants is reradiated; evaporative cooling by transpiration and heat transfer by convection and wind (advection) remove the rest. Some heat is stored temporarily in the soil and plant tissue, which is later reradiated. (Gates 1980; Waring, Running 1996).

Table 4.1. Typical values of albedo of major surface types on earth (Chapin et al. 2002).

Surface type	Albedo
Oceans and lakes	0.03–0.10[a]
Sea ice	0.30–0.45
Snow	
Fresh	0.75–0.95
Old	0.40–0.70
Arctic tundra	0.15–0.20
Conifer forest	0.09–0.15
Broadleaf forest	0.15–0.20
Agricultural crops	0.18–0.25
Grassland	0.16–0.26
Savanna	0.18–0.23
Desert	0.20–0.45
Bare soil	
Wet, dark	0.05
Dry, dark	0.13
Dry, light	0.40

[a] Albedo of water increases greatly (from 0.1 to 1.0) at solar angles <30°.

Data from Oke (1987), Sturman and Tapper (1996), and Eugster et al. (2000).

Main components of water balance

Storage - water in soil and aboveground and belowground biomass.

Inputs - Precipitation, Interception, Throughfall, Stemflow, Infiltration, Percolation, Underground water.

Outputs - Transpiration, Evaporation Surface Runoff, Base Flow.

Precipitation - Condensed water vapor that falls to the Earth's surface . Most precipitation occurs as rain, but also includes snow, hail, fog drip, graupel, and sleet.

Canopy interception - The precipitation that is intercepted by plant foliage, eventually evaporates back to the atmosphere rather than falling to the ground.

Snowmelt - The runoff produced by melting snow.

Runoff - The variety of ways by which water moves across the land. This includes both surface runoff and channel runoff. As it flows, the water may seep into the ground, evaporate into the air, become stored in lakes or reservoirs, or be extracted for agricultural or other human uses.

Infiltration - The flow of water from the ground surface into the ground. Once infiltrated, the water becomes soil moisture or groundwater.

Subsurface flow - The flow of water underground, in the vadose zone and aquifers. Subsurface water may return to the surface (e.g. as a spring or by being pumped) or eventually seep into the oceans. Water returns to the land surface at lower elevation than where it infiltrated, under the force of gravity or gravity induced pressures. Groundwater tends to move slowly, and is replenished slowly, so it can remain in aquifers for thousands of years.

Evaporation - The transformation of water from liquid to gas phases as it moves from the ground or bodies of water into the overlying atmosphere. The source of energy for evaporation is primarily solar radiation. Evaporation often implicitly includes transpiration from plants, though together they are specifically referred to as evapotranspiration.

Sublimation - The state change directly from solid water (snow or ice) to water vapor.

Deposition - This refers to changing of water vapor directly to ice.

Advection - The movement of water in solid, liquid, or vapor states through the atmosphere. Without advection, water that evaporated over the oceans could not precipitate over land.

Condensation - The transformation of water vapor to liquid water droplets in the air, creating clouds and fog.

Transpiration - The release of water vapor from plants and soil into the air. Water vapor is a gas that cannot be seen.

Percolation - Water flows horizontally through the soil and rocks under the influence of gravity.

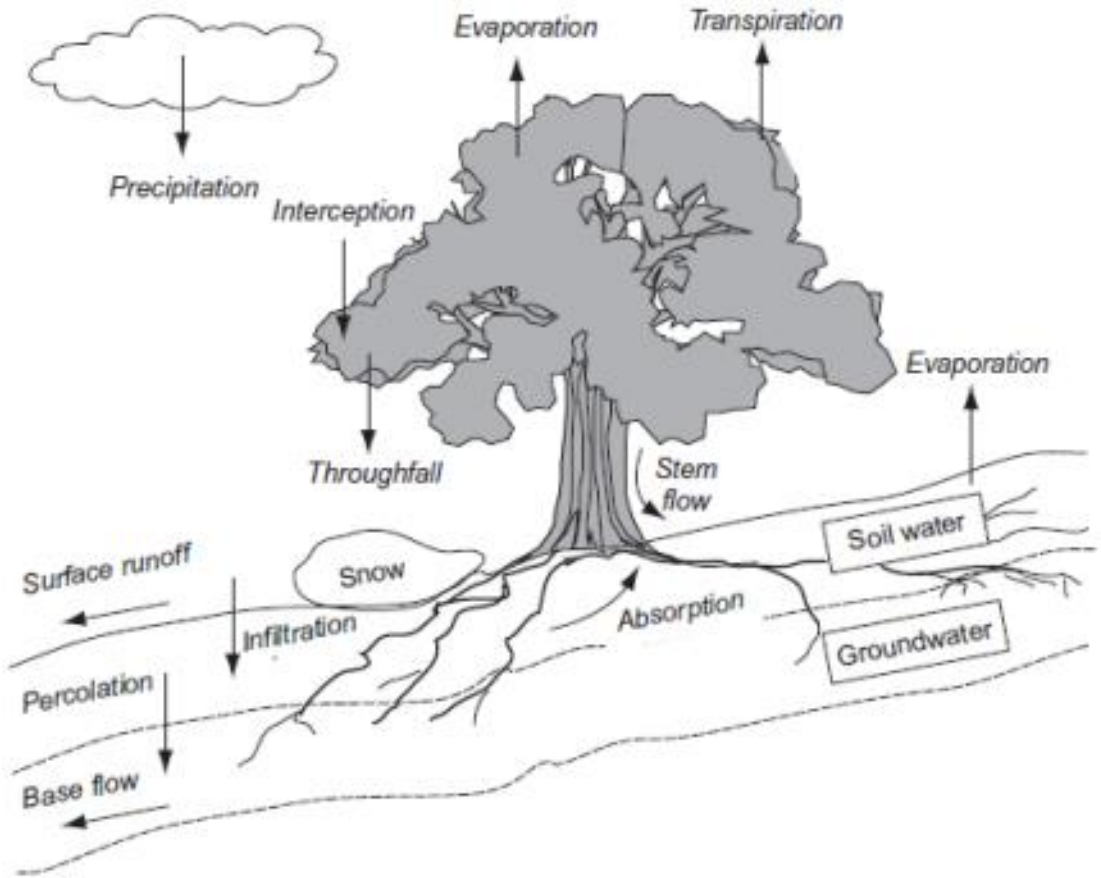


Figure 4.3. Water balance of an ecosystem (Waring and Running 1998).