

WATENV – Water, Soil and Vegetation

Lecture 1

1. Percentage of limnic systems in the water cycle

- The terrestrial and atmospheric percentages of the whole water cycle are presumed to be less than 4%.
- However, the very small percentage of 0.27 % of near-surface groundwater is essential for all limnic ecosystems

Marine, atmospheric and terrestrial percentages of the global water cycle

Segments of the water cycle	Configuration/ quality	Percentage [%]
Oceans and marginal seas	Salt water	> 96
atmosphere	Water vapor	0.001
glaciers	Ice and snow	2.0
Groundwater (total)	Freshwater (partly salt and brackish water)	1.69
Groundwater (surface-near)		0.27
Surface water (total)	Freshwater (partly salt and brackish water)	0.019
Limnic systems		<0.019
Stream systems		<0.0001

1.1. Water exchange

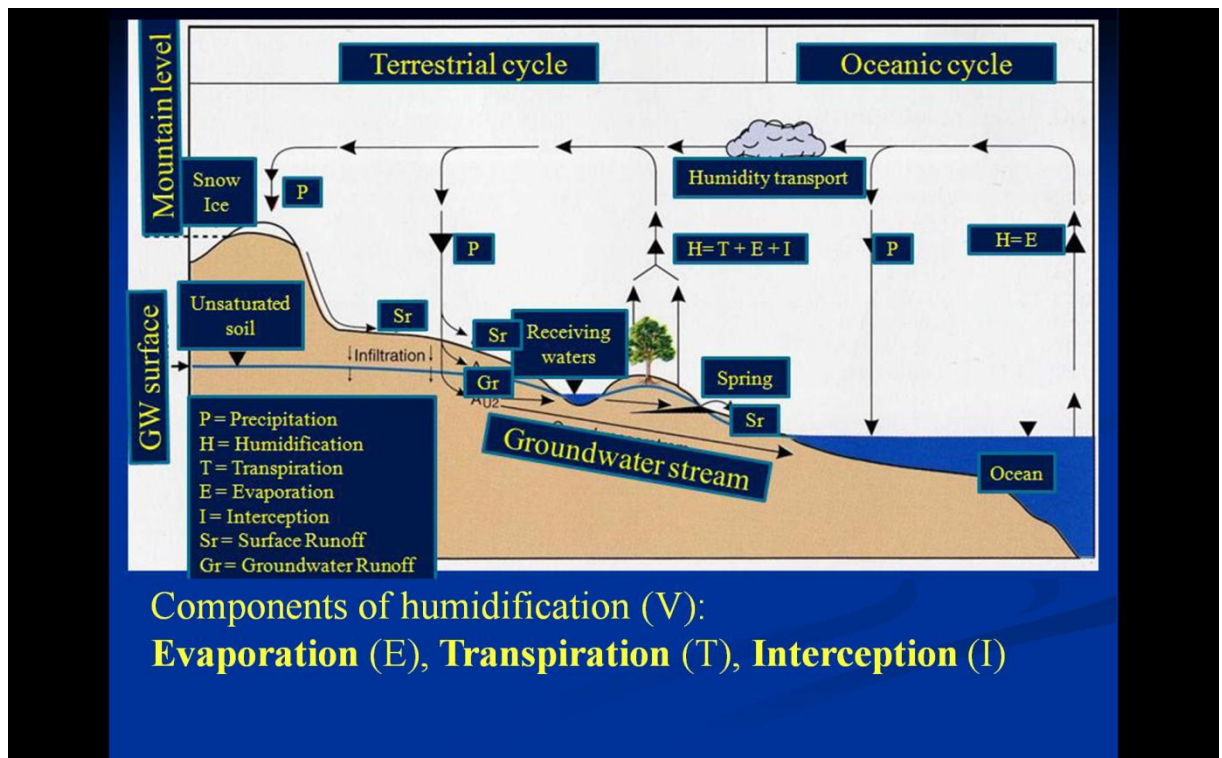
- The theoretical residence time of water can have an amount of several thousand years in oceans and the groundwater
- In flowing streams, it can be a matter of days

Inflow and outflow	Type of water	Residence time
Limnic systems with throughflow at the surface	Creek lake	Low to intermediate: 40 to 365 days
	River lake	Low: 5 to 40 days
Groundwater inflow and surface runoff	Overflowing lake	High; low low in spring basins
Groundwater inflow and sub-surface runoff	Closed limnic system	High, > 365 days

Residence time of water in limnic systems in relation to surface and sub-surface inflows and outflows

1.2. Water cycle

- The water cycle describes the permanent succession of changes in location and consistence of water
- Main components of the water cycle:
 - Precipitation (P),
 - Runoff (R),
 - Humidification (H),
 - Atmospheric water transport
- Hydrological main equation: $P = H + R$



- Precipitation surplus in Central Europe: Only 60 to 70 % of the annual precipitation return back into the atmosphere via **evaporation**
- The remaining percentage is **runoff (R)**.
- **Surface runoff** produced by springs reaches the seas via flowing streams
- **Sub-surface runoff** is seeped-away precipitation which leads to a recharge of groundwater by infiltration and can be stored in the underground.
- Time-delayed sub-surface runoff is called **base flow**, non-delayed is called **interflow**
- Base flow: the intermediate storage of precipitation in the underground leads to a decoupling precipitation events and flood runoffs, which can cause delayed flood events

1.3. Groundwater recharge

- Groundwater recharge is produced by the percentage of precipitation that seeps away in the underground
- In planar belts, this happens on a **big scale**
- In the more textured, colline and montane belts of Central Europe's solid rocks (in Germany about 53 % of the land surface) the recharge is strongly depending on topography
- **Infiltration** along the shores of lakes, mainly in the flood plains, the alluvials of mountain rivers plays a central role in groundwater recharge

1.4. Limnic systems in the water cycle

- **Limnic systems** are open ecosystems

- The boundary to the atmosphere is an important interchange zone: in temperate climates, precipitation outweighs the sum of the evaporation
- Permanent lakes in continental Central Europe underlay a dominant evaporation and are dependent on sufficient surface and sub-surface inflows
- On the southeast shore of the Neusiedler See in Austria, the strong evaporation leads to near-surface salt enrichments
- Due to drying up, the water of the Aral Sea (Kasachstan, Usbekistan) is 2.4 times as rich in salt as ocean water

1.5. Flowing streams in the water cycle

- Aquatic and terrestrial ecosystems are linked via the exchange of water and the substances which are transported by the global water cycle
- **Flowing streams** represent a major transport medium that diminishes water surpluses.
- They form essential components of successing erosional and accumulation processes.

1.5.1. Hydraulic potential gradient

- Due to the hydraulic potential gradient, flood discharge causes an effluent infiltration of surface water in the surrounding, mostly solid rock underground with an increase of the groundwater level in river valleys.
- Infiltration can only occur if the **interstitial space** (pore space of the riverbed or lakebed) is not impenetrable due to fine-grained particles
- At constant high groundwater levels or below-average channel flow, groundwater breaks the surface. This process is called **influent infiltration**.
- **Secondary channels** and **Oxbow lakes** are in permanent, periodic or episodic contact with the related river.
- Constant low groundwater levels in permeable layers lead to a permanent extraction of surface water.
- This water can accumulate in new streams.

2. Groundwater

- **Groundwater** is „sub-surface water completely filling pore spaces. Its movement is caused by gravity and its own force of friction“ (DIN 4049)
- **Technical terms:** Aquifer, unconfined aquifer, confined aquifer, aquitard, aquiclude, bore, artesian bore