The wonder of the water cycle

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Climate change is a widely researched subject. Currently there is great concern about and a focus on climatic instability and water shortages. Several regions in the world, such as Southern Africa, are experiencing water constraints as well as severe and prolonged droughts.

Attention has mostly been focussed on the impact that climate change can have on the water cycle. In this article the focus will be on the water cycle and the effect of water on the local climate.

Different phases of water

There are around 1 400 million km^3 of water on earth. It is found in different environments and in three distinct phases. The next time you drink a glass of ice water, consider that you are experiencing water in all three its phases. The solid ice cools the liquid in your glass, and the air you are breathing is full of water vapour. This is possible because water can exist naturally in all three its phases in the temperature and pressure ranges that are common on earth.

Ice in the polar regions freezes and thaws with the seasons, and plays a key role in regulating the earth's climate. Water also has a remarkable ability to absorb and retain heat. The sun delivers a tremendous amount of energy to the earth every day, and the tropical oceans absorb much of that energy. In addition, a lot of it goes into creating water vapour, which is the source of all rain and snow. The 13 trillion tons of water in the atmosphere are responsible for absorbing approximately 70% of all atmospheric radiation from the sun.

Water's phase changes depend on temperature and pressure. During each phase change a specific amount of latent heat is either absorbed or released without the sensible temperature changing. These different processes are illustrated in *Figure 1*.

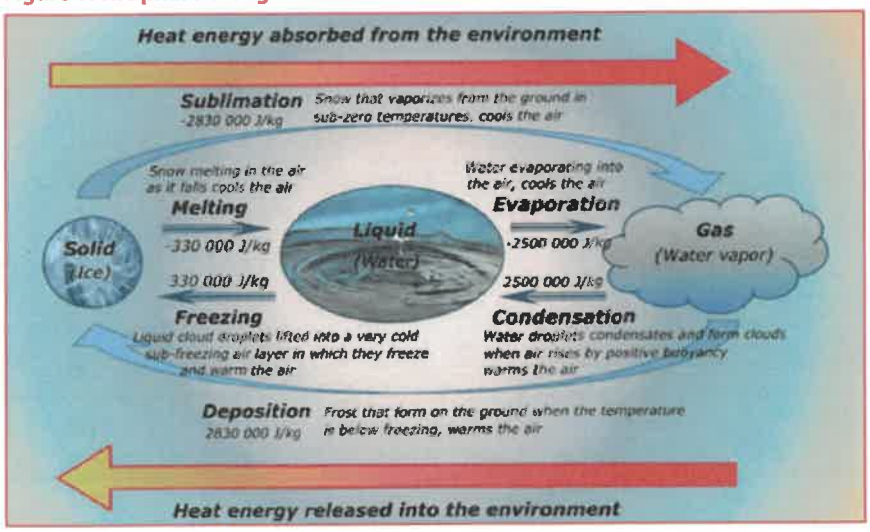
Water in the different environments

The oceans contain approximately 97,25% of the earth's total water volume and cover 70,8% of the planet's surface. The water in the oceans plays a key role in regulating global temperatures.

Water on land consists of the following:

- Snow and glaciers (70% of the world's fresh water), forming 2,05% of the volume of all water on earth.
- Rivers (0,0001%).
- Lakes and inland seas (0,01%).
- Groundwater (0,68%).
- Soil moisture (0,005%).

Figure 1: The phase changes of water.



The volume of water in the atmosphere is approximately ten times greater than the volume of water in all rivers. The water in the atmosphere plays a key role in regulating local temperatures.

Water in living organisms includes water in humans, animals and plants, and makes up approximately 0,00004% of the volume of all water on earth.

The regulating effect of water

Water plays a significant role in balancing temperature extremes between seasons, day and night, and different regions. Water vapour is the most abundant greenhouse gas in the atmosphere; its concentration in the atmosphere varies from 1 to 4%, while the average concentration of CO_2 is 0,0383%.

Where there is more water vapour present in the atmosphere, temperatures are moderated to a greater extent. Consequently, there are fewer extreme variations in the weather. Practical experience shows us that where water is lacking, extreme thermal conditions usually predominate, as experienced in the arid and desert regions.

Clouds play a crucial role in regulating the energy balance of the earth's solar radiation. Clouds usually shadow around half of the earth's surface at any given time. Low altitude clouds limit the entry of solar radiation into the atmosphere, which limits evaporation and thus the further formation of clouds.

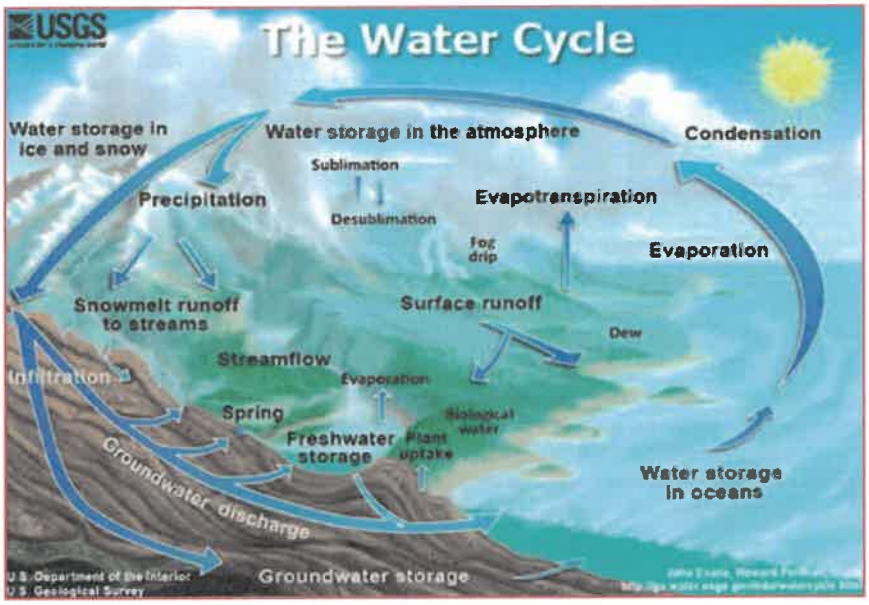
Thin, high-altitude clouds limit some of the longwave thermal radiation emitted from the surface of the earth into space. Thus, it prevents excessive cooling of the planet's surface.

The earth's water cycle

The sun provides the energy to facilitate the phase changes of water. The oceans, land and atmosphere store all the water on earth in an equilibrium of different phases and environments. This equilibrium is called the water cycle (*Figure 2*).

The ability of water to absorb and release a large amount of heat allows

Figure 2: The water cycle by John Evans and Howard Perlman. (Source: United States Geological Survey, USGS)

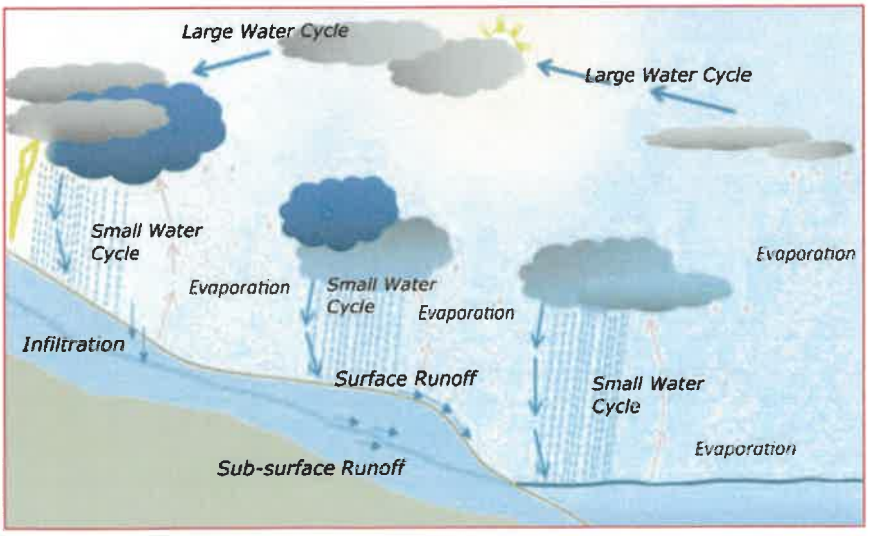


the earth's climate to be even-tempered, with an annual turnover of vast amounts of water in the water cycle. There are four main stages involved in the water cycle, namely evaporation, condensation, precipitation, and runoff.

When the sun shines, water evaporates. It turns into water vapour, goes into the atmosphere and turns into clouds. When clouds become dense, the water drops to earth in some form of precipitation such as rain, snow, hail, or sleet. Some of it infiltrates into the soil for use by plants or evaporates from the soil. Water that infiltrates deeper could emerge as springs at a lower elevation, whereas water that does not infiltrate into the soil concentrates on the soil surface. From here it evaporates or flows to the ocean, from where it evaporates again.

Throughout this continuous movement of water, it is purified, and it drives, cleans and regulates ecosystems. Two main components of the water cycle can be distinguished, namely the large and small water cycles (*Figure 3*).

Figure 3: A schematic representation of the large- and small water cycles.



The large water cycle: This is the exchange of water between oceans and land. Water vapour is carried high in the atmosphere inland from the ocean over great distances, as shown in *Figure 3*. This cycle contributes approximately 34% of inland precipitation.

The small water cycle: The small or local water cycle is a closed circulation of water on land or over the oceans. Water that has evaporated from an area falls as precipitation in more or less the same terrestrial area. This cycle contributes approximately 66% of inland precipitation.

Over the continents water is circulated in many small water cycles simultaneously, and water from the large water cycle is added to these small water cycles. Therefore, the moisture content of the soil in a region has an influence on the precipitation received in that respective area and its surroundings.

Disturbances in the cycle

Even relatively slight disturbances in the balance of this water system, especially over the long term and spread over many river catchments, could cause problems on land.

This typically occurs when the volume of rainwater that infiltrates into the soil is reduced. This will cause a gradual decrease in the potential volume of water available in the small water cycle over land. The resulting effect is a decrease in precipitation and increase in temperature in the respective area.

This global phenomenon has occurred throughout history and its cause can be attributed to several human activities. Over time the soil moisture content decreases, the subsurface water table declines, vegetation withers, and less evaporation takes place from the land.

However, it is possible, through deliberate conservation of water on the continents, to repair the functioning of the small water cycle. SF

For more information, the publication *Changing climate, the role of water and what you can do to drought-proof your land* is available from the ARC-Agricultural Engineering. Contact Elmarie Stoltz on 012 842 4017 or at StoltzE@arc.agric.za, or Fanie Vorster at vorsters@arc.agric.za