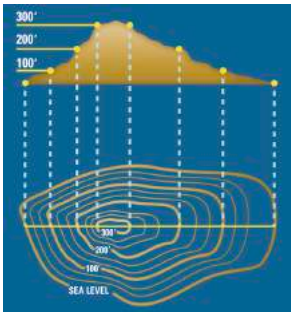
Augmented Reality Sandbox Model

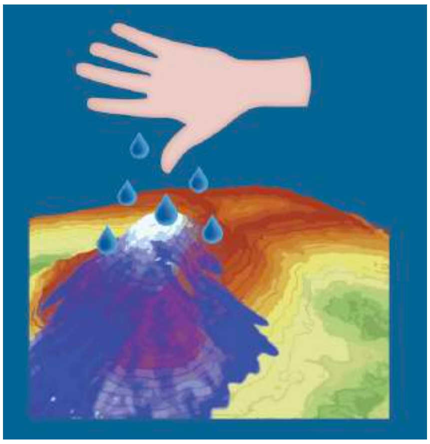
In this model, the different colours show the different height levels as on a topographic map. Contour lines join points which are all the same height, and the distance between the contour lines shows the gradient (steepness) of the slope. Close lines appear on steep slopes!

Contour lines are used on flat maps to represent the landscape, but using the sandbox, the contours are shown on the models of hills and valleys - a three-dimensional map which you can move around.



Make a variety of slopes to see how the contour lines and colours change.

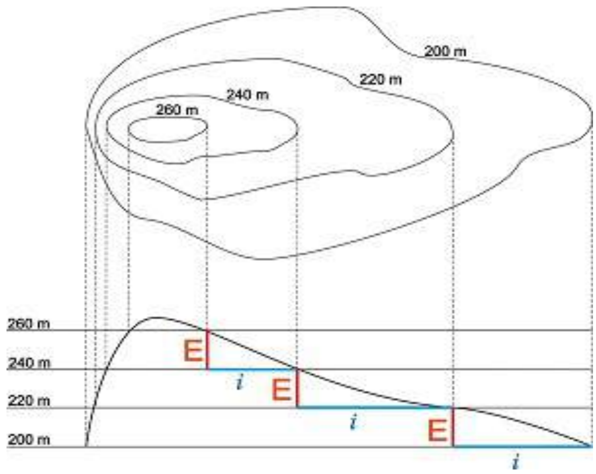
Using the hills and valleys you make, the model can show what happens when it ‘rains’ – where the water goes and how if flows down the hills until it gathers in a marsh area, pond, sea or lake.



Make it ‘rain’ and then using the ‘Drain’ button you can dry out the model and try another shape or landscape.

Topographic Maps

A **topographic map** is a type of map that shows heights that you can measure. A traditional topographic map will have all the same elements as a non-topographical map, such as scale, legend, and north arrow.



On a map, you are looking straight down, so it is difficult to see the change in elevation of the ground. As you can see in this image, a topographic map uses lines to determine the heights of features such as mountains and valleys. Topographic maps can show the heights of features a variety of ways, including contour lines, relief, and colour.

Contour Lines

The defining feature of a two-dimensional topographical map is its contour lines. A **contour line** is a line joining points of equal elevation on a surface. An easy way to imagine a contour line is to imagine walking around the shore of a lake. As you walk, you will always remain at the same elevation, and eventually you will return to your starting point. There are three rules for contour lines:

- Every point along a contour line is the exact same elevation
- Contour lines can never cross each other
- A contour line must close on itself

Some contour lines will have their elevation marked next to them, but not all. To calculate the height of any contour line, you need to know the contour interval.

Contour Interval

A topographical map will contain many contour lines, but the change in elevation between each line will remain the same; this is called a **contour interval**. By making the change in elevation between the lines equal, it is easy to calculate height by using multiplication.
The AR Sandbox demonstrates how these contours change as you change the gradient (steepness) of the slope.

An easy way to think about topographic maps is the distance between the lines is horizontal distance, while the values of the lines are the elevation. If the distance between the lines is very far apart, that indicates a gradual increase in elevation. If the lines are close together, the change in elevation happens very quickly, indicating a steep terrain.

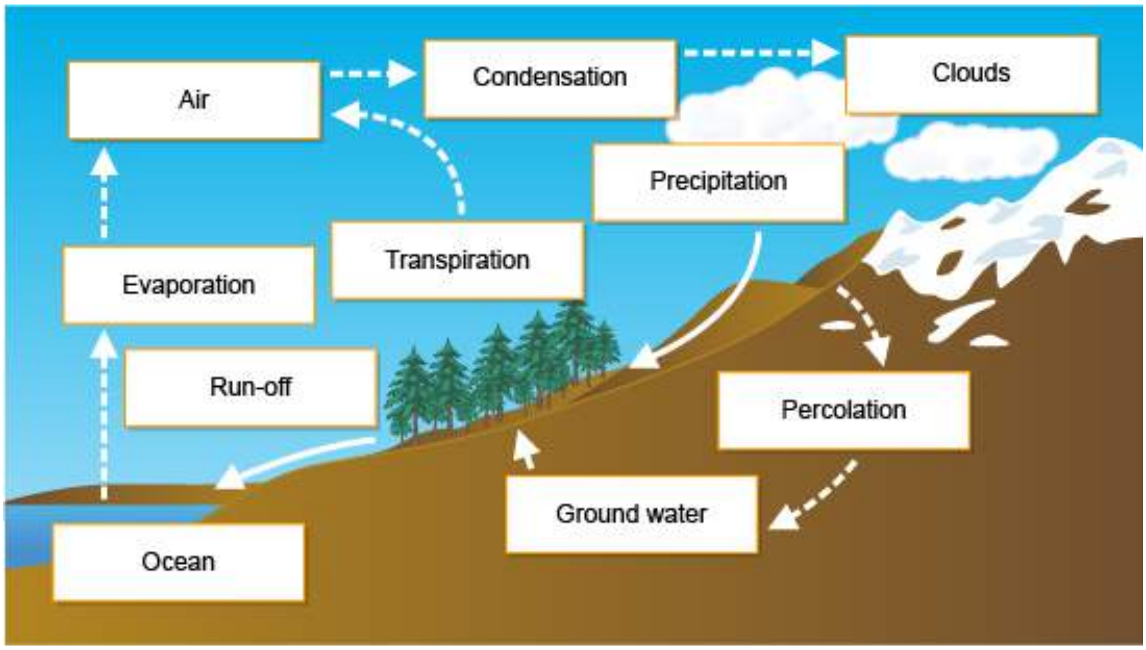
Relief Map

A **relief map** is a specific type of topographic map that uses colours and shading to show heights and features on the map. If you have ever felt bumps on a map or globe, you have used a topographic relief map. Shading on a topographic map is used to give it a more realistic view. You can see that on this map, the mountains look like mountains instead of just contour lines.

Using the Sandbox, you can see this colour change – the 'augmented reality' projected onto the sand – as well as the contour lines.

The hydrological cycle

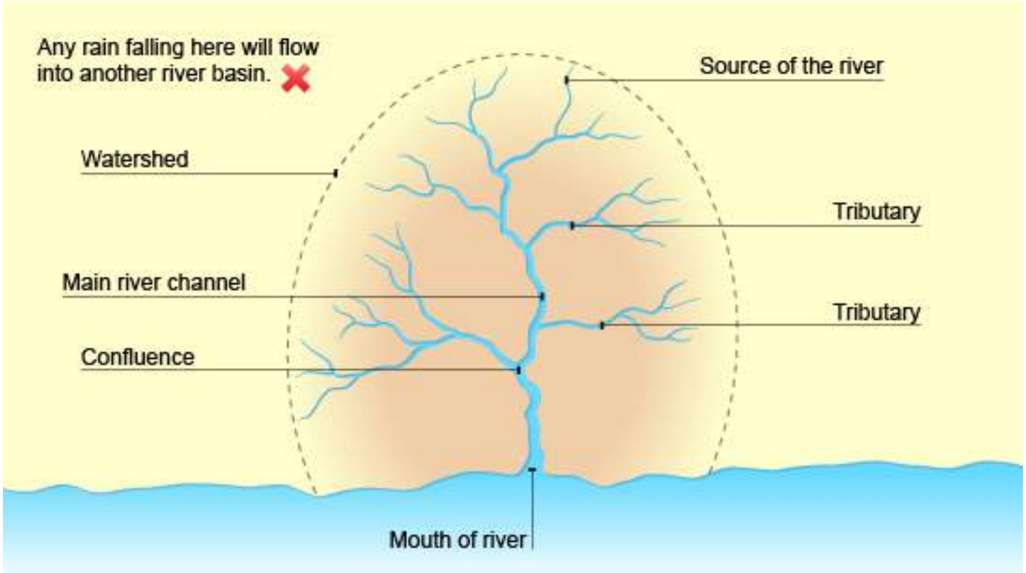
The hydrological cycle is also known as the **water cycle**.
Seas and oceans contain 97 per cent of the world's water, and ice holds 2 per cent. That leaves just 1 per cent of the world's water as fresh water on land or in the air. This water is recycled again and again through the process of *evaporation*, *condensation* and water transfers such as surface run-off.



The key stages in the hydrological cycle

The study of rivers

- **Drainage basin** - the area of land drained by a river.
- **Catchment area** - the area within the drainage basin.
- **Watershed** - the edge of highland surrounding a drainage basin. It marks the boundary between two drainage basins.
- **Source** - The beginning or start of a river.
- **Confluence** - the point at which two rivers or streams join.
- **Tributary** - a stream or smaller river which joins a larger stream or river.
- **Mouth** - the point where the river comes to the end, usually when entering a sea.



Key features of a river

Using the sandbox, you can see the effect of changes to the shape of the landscape (topology) affect the way water behaves

How does the Augmented Reality Sandbox work?

AR Sandbox uses a computer projector and a motion sensing input device (a Microsoft Kinect 3D camera) mounted above a box of sand. When you shape the sand in the sandbox, the Kinect detects the distance to the sand below, and a visualization an elevation model with contour lines and a colour map assigned by elevation is cast from an overhead projector onto the surface of the sand. Move the sand, and the Kinect perceives changes in the distance to the sand surface, and the projected colours and contour lines change accordingly. [1]

Using a 'make it rain' gesture above the surface of the sand, virtual rain appears as a blue, shimmering visualization on the surface below. The water appears to flow down the slopes to lower surfaces. The water flow simulation is based on real models of fluid dynamics (a depth integrated version of the Navier-Stokes equations).
Pressing and holding the button "Drain" dries out the virtual water.

This version of the sandbox uses a Microsoft Kinect camera, the same camera used in video games. The Kinect uses an infrared projector, camera and special microchip to track the movement of objects in 3D. This is then processed by the modelling program using a computer equipped with a powerful graphics card [2]. The resulting image is projected onto the sand with a short-range Promethean 35 projector.

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[1] *The original model for the **Augmented Reality Sandbox** was developed in 2012 by the UC Davis W.M. Keck Center for Active Visualization in the Earth Sciences (Keck Caves), using software made available by Dr Oliver Kreylos and is supported by the National Science Foundation under US Grant No. DRL 1114663. For more information, please visit https://arsandbox.ucdavis.edu.*

[2] For those interested, the computer uses an Asus B250 Pro motherboard, an Intel i5 7400 7th Generation (Kaby Lake) processor, and a Palit Nvidia Geforce GTX 1070 Game Rock Graphics processor.