



feature

Aquifers Can't Hide from Satellites

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*With a dwindling freshwater supply and an ever-increasing demand, it is important to keep track of our aquifers. On the **DEMUWA project**, scientists are testing out their theory that they can monitor aquifers via satellite.*



or the DEMUWA (DEtection and Monitoring of Underground WATER) project, Prof. Sebastiano D'Amico and his colleagues in the Department of Geosciences at the University

of Malta are attempting to monitor aquifers from space. These fast-depleting sources of precious freshwater are currently difficult to monitor at a large scale. How can satellite images reveal information about processes happening underground? Before we dig that deep, let's scratch the surface for some background information.

AQUIFERS IN MALTA

Malta's tap water comes from desalination of seawater and from aquifers. Of the total potable water produced, around 36% came from aquifers (through groundwater) in 2022. There are two types of aquifers nestled between the layers of rock that make up the islands. The one we get our potable water from is the 'mean sea level' aquifer, and as the name implies, its vertical location is at about sea-level. This aquifer, sometimes also called the lower water table, consists of freshwater that percolates down through fissures and porous rocks and settles in the Lower Coralline Limestone (locally known as; *Żonqor*). Since it is at sea level, sea water enters this aquifer and sits at the bottom, below the freshwater due to the fact that seawater is denser than freshwater.

The second type of aquifer is the 'perched' aquifer, or the upper water table. This aquifer is above sea level and occurs in areas where the outcrop is Upper Coralline Limestone (*Qawwi ta' Fuq*) with Blue Clay (*Tafal*) beneath. Rain percolates through the Upper Coralline Limestone and Greensand (*Ġebbla s-Safra*) layers until it reaches the blue clay (Note: The porous Greensand is not always found between the blue clay and the upper coralline limestone layers. Often it is only about 1 metre thick.). Clay is impermeable, which means that water cannot pass through it, so instead, it

collects on top of it. The water pumped out of perched aquifers (sometimes via windmills) is used for agriculture and not for drinking.

The levels of water in the aquifers vary, depending on how fast they refill. The rate of refill, in turn, depends on the weather and on the extraction rate. Rainfall helps to refill the aquifers, but very heavy rainfall might mean that there is not enough time for the water to be absorbed, percolate through the rocks, and reach the water table. In intense storms, a lot of rainwater tends to be lost as runoff. The extraction rate depends on how much water we take out of the aquifers, but this can also vary with the weather, because hot, dry weather usually means that more water is needed.

As one can reasonably expect, aquifers are impacted by climate change. The increased temperatures and the increasing frequency of droughts put a lot of pressure on available fresh water. Furthermore, although total precipitation might increase due to climate change, this will mostly be in the form of heavy rainfall and floods, which do not effectively replenish the aquifers. Another climate change impact is the rising sea level, which might result in too much saline water entering the sea-level aquifer.

In Malta, the large proportion of paved surfaces and built-up areas can exacerbate the effects of climate change because these surfaces are not capable of absorbing water. Therefore they decrease the amount of rainwater directed into aquifers and increase the amount that is wasted as runoff. All this has resulted in aquifers being in a critically low state worldwide, especially in semi-arid regions like Malta, where weather and climate change intersect with a high demand for water.

HOW CAN SATELLITE DATA HELP?

Scientists working on the DEMUWA project are attempting to find a way to monitor the upper water table (perched aquifers) in the long term ➔

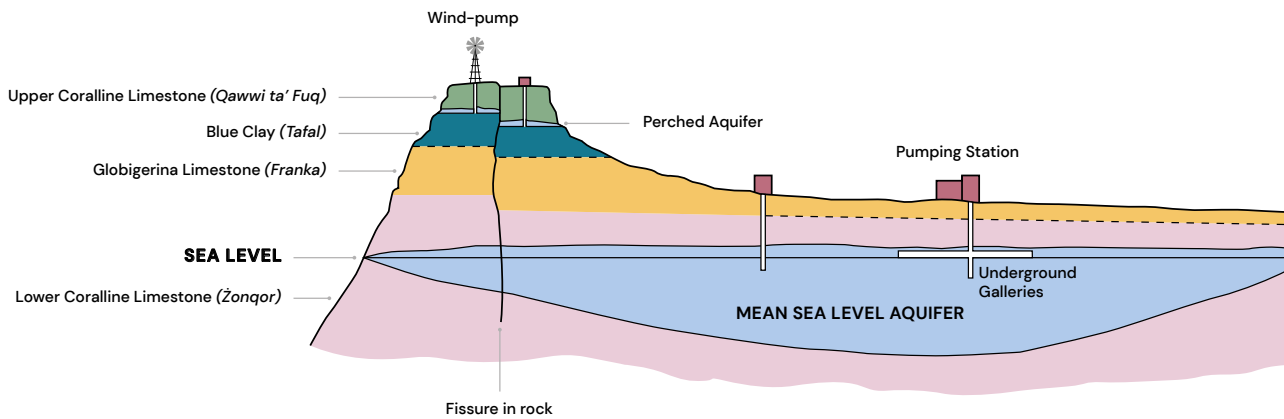


Illustration adapted for **THINK Magazine** from teleskola.mt/sources-of-water-in-the-maltese-islands

and in a cost-effective way. Traditional aquifer monitoring methods can be quite cumbersome, requiring the hauling of equipment to areas that might be difficult to access. The project is a proof-of-concept, meaning it aims to demonstrate the feasibility of their proposed method. If feasible, this method would allow for more consistent monitoring of perched aquifers across larger areas.

The way that D'Amico and his colleagues think perched aquifers can be monitored from space is by measuring the gradual vertical movement of the ground above them. As freshwater makes its way into aquifers, the ground above bulges a little. On the other hand, when the aquifer is emptied, the ground constricts. This slow and barely perceptible vertical movement of the ground, at a scale of centimetres, might reveal the level of water in the aquifer. To detect this movement, scientists can't use regular satellite photos; interferograms are needed. Interferograms are photos produced by an interferometer. Interferometers take extremely precise measurements by superimposing waves in a way that causes interference, hence the name. Satellites scan the same place over and over again as they make their orbit around the earth. Therefore, different interferograms of the same place taken at different times can be combined to map the motion of the surface. Combining interferograms can reveal differences in millimetres, and therefore, it is entirely plausible that this method can be used to detect small changes in the ground caused by the dynamics in perched aquifers. Combining interferograms over a long time period can reveal the seasonality of perched aquifers and variations and trends over time. Eventually, these detected changes can be correlated with climate, weather, and other factors that impact perched aquifers.

One problem that the scientists foresee is differentiating small changes in ground elevation caused by perched aquifers from other, larger ground movements. Subsidence (vertical movement of the ground caused by natural or man-made processes), for example, could mask the smaller movement that the scientists are interested in.

Since subsidence is mostly a vertical movement and not a sloping one, it could easily obscure the movement caused by perched aquifers. As D'Amico puts it, 'hearing a small noise in a church is easy but trying to hear that same noise in a bar would be much more difficult.' To avoid such sources of error and to verify the information gleaned from interferograms, the project also includes ground-truthing the data. This involves using drones and traditional aquifer monitoring methods to compare the data collected by the satellite.

DEMUWA is currently half way through, and scientists have high hopes that the project will find a way to consistently monitor perched aquifers at a large scale, producing a lot of useful data along the way. This will help authorities make more informed water management choices and could also be of help to the agriculture sector. In science, proof-of-concept projects like this one could result in previously unforeseen uses of the same method, opening new, exciting avenues of research. **T**

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Further Reading

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