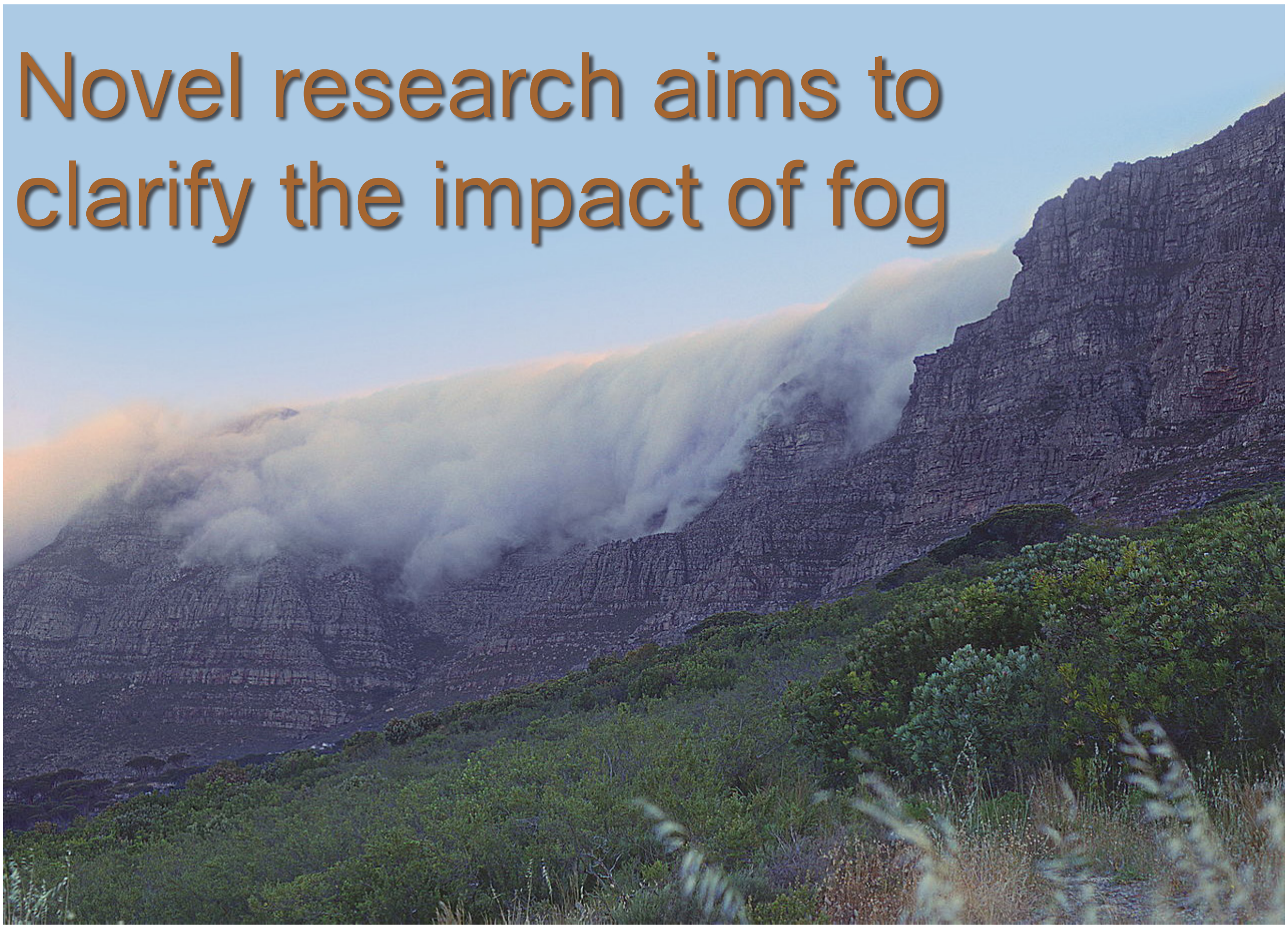
Novel research aims to clarify the impact of fog



Does fog contribute to the water flow in South African rivers? A new research project is trying to find out. Article by Petro Kotzé.

While fog is frequently experienced in South Africa, its influence on natural systems has not received much attention from local researchers, especially in comparison to most other freshwater sources. While ecologists, botanists and hydrologists seem to agree that its impact must be vital, there is still limited understanding of the ecological and hydrological impacts of fog precipitation in South Africa.

Yet, a number of places here record over ninety days of fog per annum, mostly along the West Coast and in mountainous regions. Along the West Coast, advection sea fog is common. This is formed when moist air from the South Atlantic Ocean passes over the cold Benguela Upwelling region and is cooled down. Along the mountains of the Eastern Escarpment and the Western Cape, the most frequent source of fog is orographic fog and stratus clouds. The first happens when low level onshore flow blows air up the escarpment, adiabatically cooling it as it rises, causing the moisture in it to condense.

The most iconic display of fog is probably the Table Cloth on Table Mountain, and it's also here that the basis was laid for some of the first scientific publications on fog precipitation, not only here, but also in the rest of the world. Renowned botanist, Dr Rudolph Marloth, probably best known for the mammoth six-volume *Flora of South Africa* (published between 1913 and 1932) was interested in the rainfall seasonality experienced by plants growing on the mountain, which prompted him to investigate what condition plants experience during fog events.

He put up the first pair of rainfall and fog collectors to compare the measurements during fog conditions. These were basically rain gauges with some reeds in them on which fog would condense as it blew over the gauge. He discovered that the fog gauge would fill up while the rain gauge recorded little precipitation.

He concluded that plants on Table Mountain do not experience a dry season that is nearly as severe as plants lower down. This is because of the South Easter fog which feeds the plants during summer months, when not much rain is experienced at the base of the mountain.

The specific topic has only received sporadic attention among researchers since then. For the last 30 years or so, most research focused on fog water harvesting for human consumption. The WRC has funded a number of these projects, due to the belief that it can provide clean drinking water of exceptional quality to communities where water treatment facilities might not be available. While the feasibility of the technique to augment domestic water supplies was investigated during the late 1960s, pilot fog collectors were later erected in various parts of South Africa. Yield from 1 m^2 nets ranged from 1 to 5 $ℓ/m^2$/day along the west coast, while in the mountainous regions, it exceeded 10 $ℓ/m^2$/day at elevations greater than 1 700 m. This success prompted the erection of larger systems, and with it, the harvesting of bigger amounts of water.

Yet, while it is now widely accepted that fog can contribute substantially to potable water supplies, and early studies showed that it can contribute much water to an ecosystem, there is still a limited understanding of the ecological and hydrological impacts of fog precipitation in South Africa.

A relatively new project now aims to shed light on these questions, though starting with some basic data collecting first. Under the helm of the SAEON Fynbos Node, the project started in 2013 (SAEON is part of the National Research Foundation and funded by the Department of Science and Technology). "Our first aims are to collect baseline data in order to shed some light on fog precipitation quantities, seasonality, elevation and associated wind direction," explains Abri de Buys, Technical Officer at the SAEON Fynbos Node. They hope to have some of these results published in the first half of 2016. These first few years of their research will serve to inform them how their fog monitoring network should be adapted in order to tackle longer term trends and more sophisticated questions.

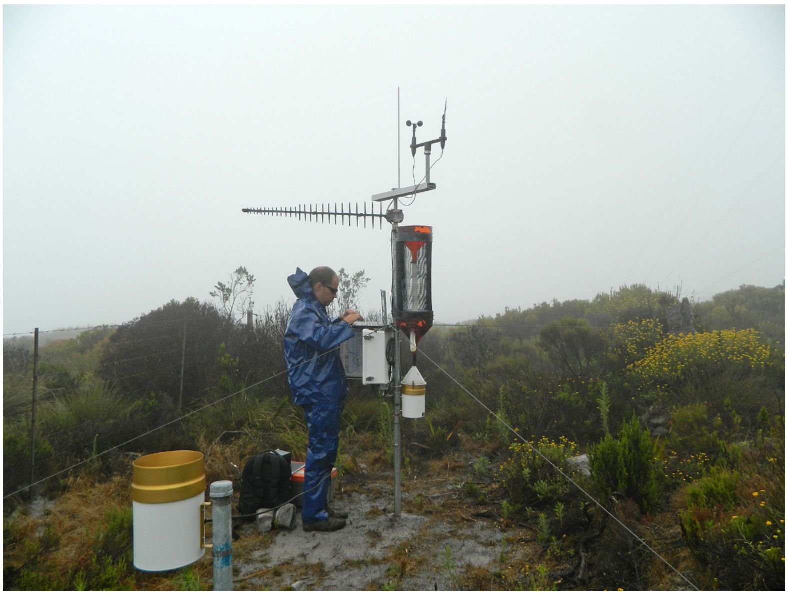
SAEON TAKES THE LEAD

To start with, a testing fog collector was first erected on Constantiaberg Peak in Table Mountain National Park at the beginning of 2013. The first fully functional fog collector with a weather station followed in the Cape Nature managed Jonkershoek Nature Reserve in March 2013.

Over the study period of about a year, fog precipitation at both the Constantiaberg and Jonkershoek high elevation site (Dwarsberg) averaged about 100 mm per month. During some dry months fog precipitation was shown to be the dominant form of precipitation that was measured with up to 86%

__Left:__ The fog collector used at Dwarsberg weather station, Jonkershoek is based on a design used by other fog researchers in North and Central America.

__Below:__ Constantiaberg weather station – configuring the data logger in some wet weather.



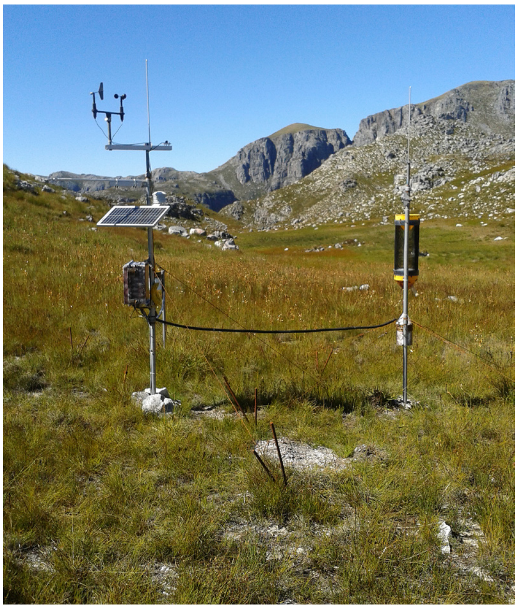
(153 mm) of total precipitation being fog. This precipitation is not measured by standard rain gauges and occurs to a lesser or greater extent, largely unmeasured, across many of our mountain catchments that experience fog, says de Buys. Their measurements show that this is a notable amount of precipitation. "While our Jonkershoek high elevation site recorded just over 3560 mm of rain over the study period thus far, the fog collector measured 1234 mm in the absence of rainfall."

The researchers have also quantified associations with trade winds. "We know that the South Easter which is responsible for the Table Cloth on Table Mountain also often results in cloud cover at Jonkershoek and Constantiaberg". Fog is also associated with the North Westerly winds that occur mostly in winter when frontal systems arrive at our study sites. These two trade winds occur during conditions that result in different cloud formations which both contribute fog."

Eventually this data will lay the cornerstones of more complex questions to be answered. These include how fog precipitation influences stream flow in one of their study catchments. They also aim to test methods of measuring how much fog moisture makes it into the soil.

According to de Buys "the simplest way is to monitor fog and stream flow concurrently and look for increases in stream flow when you've measured fog." Streamflow records at their study sites all show daily fluctuations that are due to changes in how much water evaporates from the catchment. "As transpiration from the vegetation reduces towards nightfall with the decrease in light and temperature, this causes stream levels to increase slightly but measurably. During days with high humidity and cloud cover one can see less of a reduction in stream levels as a result of evapotranspiration, meaning plants don't have to suck up as much water which leads to higher stream levels. When a significant fog event occurs one may be able to detect an increase in stream levels due to water collecting on the plants and dripping to the soil."

He further adds that another way would be by looking at the isotope signatures of rain and fog, and comparing these to that found in stream and ground water samples in order to identify the likely source.



Above: *Stratus clouds hiding the peaks in Jonkershoek valley. Lower elevation sites experience fog less frequently than the higher peaks .*

Right: *Dwarsberg weather station on a brilliantly clear day.*

THE VALUE OF FOG

While this project will only focus on fynbos, it will start to fill the gap that currently exists in the evidence necessary to support assumptions that fog plays an important role in botany, ecology and hydrology.

This assumption is already substantiated by work that has been done by researchers in other parts of the world, since the early work took place in South Africa decades ago.

In the Californian redwood forests for example, researchers have measured how much fog precipitation occurs seasonally, how much of it gets into the soil underneath trees and how this happens, says de Buys. They have found that fog collects on the

THE TALLEST TREE ON EARTH DRINKS FOG

The coast redwood (*Sequoia sempervirens)* is earth's tallest tree, reaching higher than a 30 floor skyscraper (around 100 m), while their trunks can grow almost eight metres wide. It is reported that they can live for more than 2 000 years. During California's rainless summers, the trees depend on fog for survival, which they can absorb through their leaves as well.

Studies have found that other plants in the coast redwood ecosystem also have the ability to take water in through their leaves, like **western sword fern** (*Polystichum munitum*), salal (*Gualtheria shallon*), madrone (*Arbutus menziesii*), tanoak (*Notholithocarpus densiflorus*), Douglas fir (Pseudotsuga menziesii), California huckleberry (*Vaccinium ovatum*) and California polypody (*Polypodium californicum*). The potential impact of climate change to these plants is a question that numerous researchers have investigated.

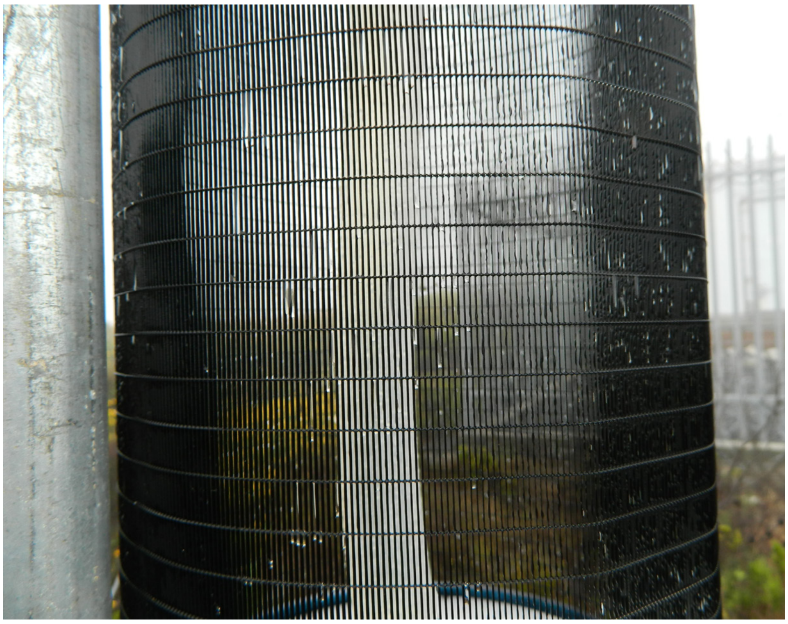
Source: www.savetheredwoods.org

leaves and branches and drips down or flows down the stems, contributing to the water available to the roots. In areas where there are no trees, fog blows over the site and not as much of it is "harvested" by the vegetation. They have also discovered that several plant species absorb fog water directly through their leaves, supplementing the water supply they get from the root systems. This foliar absorption reduces the need of plants to pull water from the soil. "We have yet to test whether or to what extent these same mechanisms and interactions occur in mountain fynbos," he says.

Additionally, there is also a social angle that makes this research interesting. "Most of our water comes from mountain catchments. In the Western Cape, many of these mountains receive fog precipitation. Our preliminary research has shown that over the period of a year there is a lot of fog, as much as a quarter of total precipitation at one site that we've investigated for a full year, that potentially can contribute to the water coming from these catchments. As a result of the fact that standard rain gauges don't measure fog input, we are missing a significant piece of the puzzle in terms of how our catchments function."

This might have some relevance for future water security. "Elsewhere in the world it has been shown that fog precipitation is influenced by climate change," says de Buys. Regional changes in sea surface temperature and also changes in land cover can influence the height at which fog forms, essentially reducing the area of mountains that comes into contact with fog. "This has implications for catchments and potentially for the water yield that we rely on given changes in climate. In order for us to know whether or to what extent we are experiencing similar climate change effects, and to plan accordingly, we need to first know what our current status is."

News of the project has been greeted with much interest by researchers that have been involved with fog harvesting research projects over many years. Prof Jana Olivier (University of Pretoria professor extraordinaire, UNISA emeritus professor) described the SAEON project as "fantastic work" and that she looks forward to potential collaboration in order to pool existing knowledge. ❑



A close up of the special louvered shade screen that the fog collector is made of.