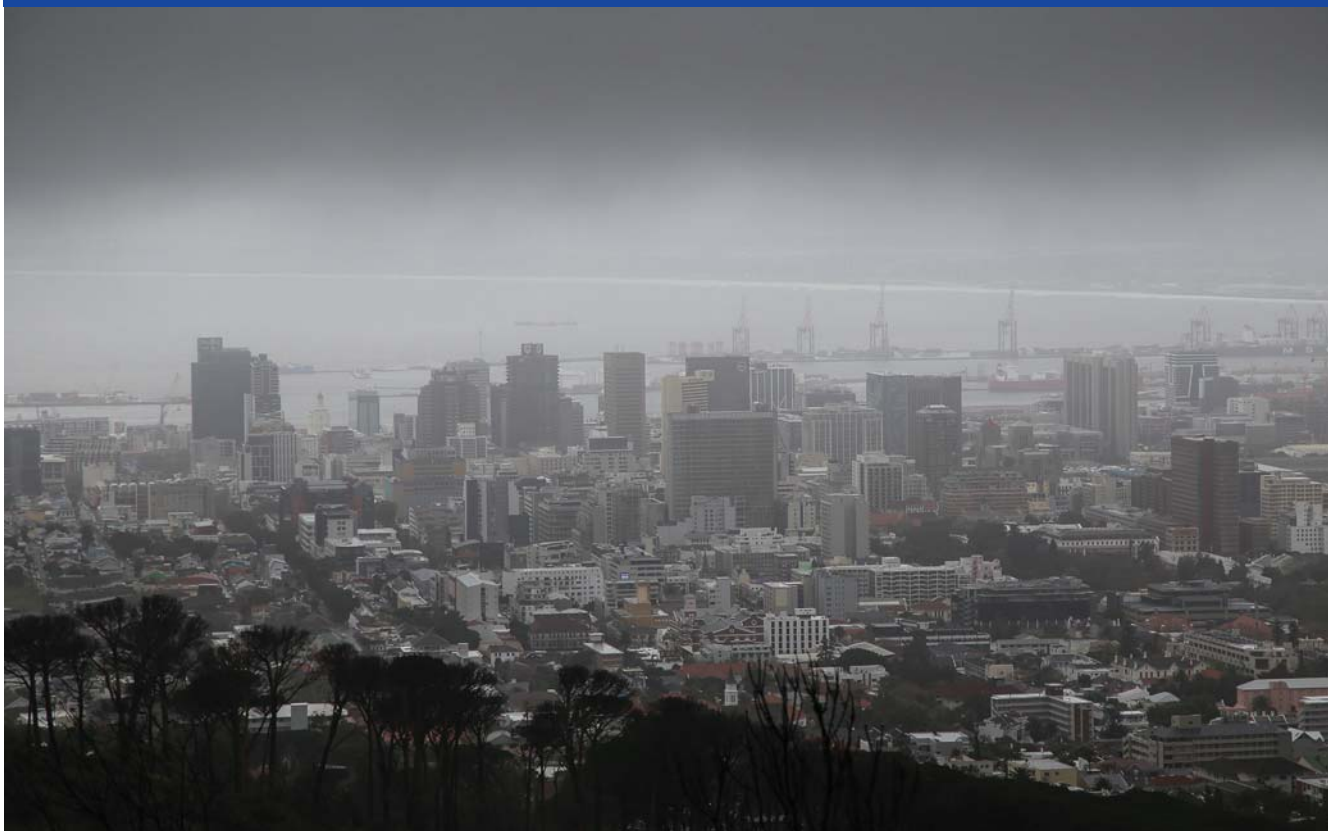
WEATHER FORECASTING

Improving extreme weather forecasts for South Africans

Petro Kotzé reports on the South African Weather Services's Impact-Based Severe Weather Warning System and what this means for disaster management in South Africa.

Petro Kotzé



Cold snaps and gale force winds might become more common to South Africans in future.

In mid-April, severe weather and flooding devastated parts of KwaZulu-Natal. Extreme rainfall and widespread flooding resulted in billions of Rand of damage across all economic sectors. The eThekwini Municipality announced an estimated R3.8 billion in damage caused by the floods to city infrastructure, excluding human settlements. Thousands were misplaced and had to seek shelter, food and health facilities as many parts of eThekwini were wrapped in darkness as power stations folded. At the time writing, 459 fatalities have been confirmed with dozens of people still missing.

Though the severity came as a surprise, the weather did not arrive unannounced. At least four days before the worst of the weather hit, a weather forecaster at the South African Weather Service (SAWS) head office in Johannesburg raised the alarm to provincial disaster risk management teams, who conducted their operation with hourly backups from the SAWS as the cut-off low system swept over South Africa's south-west coast.

Their collaboration was one of the results of the new severe weather warning service introduced across South Africa by the SAWS in 2020. It is known as the Impact-Based Severe Weather Warning System and entails a change from the previous threshold-based warnings to impact-based warnings. Impact-based forecasting combines hazard, exposure and vulnerability data to identify risk and support decision-making. In essence, it's

Lauren Dauphin/NASA Earth Observatory

Tropical cyclone Eloise, which hit the east coast of Southern Africa in January 2021. Leading up to, and during, the heavy rainfall caused by Tropical Storm Eloise, regular updates received from SAWS assisted disaster management in preparing in advance.

a change from communicating what the weather will be to what the weather will do. The ultimate objective is to encourage early action to reduce damage and death from natural hazards.

The change was in line with World Meteorological Organization (WMO) guidelines that have seen many National Meteorological and Hydrological Services agencies across the globe begin to explore impact-based forecasting and warnings as a means to communicate risks and impacts to the public and sector end-users. In South Africa, the project is carried out in collaboration with National Disaster Management Centre, a key element of its success. It also links the country to the first four of the Seven Global Targets of the Sendai Framework for Disaster Risk Reduction (2015 – 2030), to which South Africa is a signatory. The targets in question are to substantially reduce global disaster mortality and the number of affected people globally; reduce direct disaster economic loss; and substantially reduce disaster damage to critical infrastructure and disruption of basic services.

What is impact-based extreme weather forecasting?

Impact-based forecasting is a way of strengthening weather awareness amongst the public, says Hannelee Doubell, SAWS Communications Manager. In impact forecasting, hazard forecasts are translated into the impact they can potentially have on the ground. The decision on which impacts need to be communicated, and which ones not, are made in collaboration with emergency managers that are familiar with the situation as it is happening.

SAWS forecaster Elizabeth Viljoen, who started working on the development of the system at the SAWS in 2016, explains that the process still starts with a weather forecast based on a numerical weather prediction model. The forecaster, with support from the team on duty and in regional offices, decides if the forecast could result in anything that could cause an impact, such as disruptive rainfall, severe thunderstorms, damaging winds, disruptive snowfalls, reduced visibility, damaging waves and storm surges. If the answer is no, no warning is issued but if it is yes, a process kicks in that is vastly different from the previous SAWS approach.

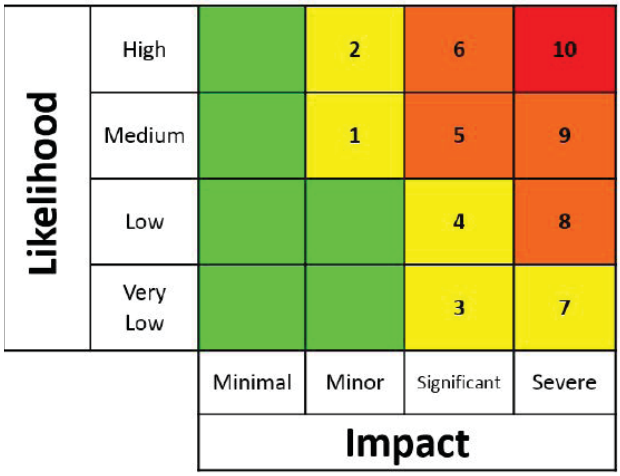
Rainfall impact table

Impact-Based Forecasting: RAINFALL Impact Table

Minimal	Minor	Significant	Severe
Business as usual	Localised Business as usual	Localised Short term strain on emergency personnel	Widespread Prolonged strain on emergency personnel
• Some **pooling** of water on roads or in formal/informal settlements • Day to day activities not disturbed • Wet roads and reduced visibility • Minimal traffic congestion • Isolated mudslides and rockfalls	• **Localised flooding** of susceptible formal/informal settlements or roads, low-lying areas and bridges • Major roads affected but can be used, increased travel times • Difficult driving conditions on dirt roads • Minor motor vehicle accidents due to slippery roads and/ reduced visibility • Closure of roads crossing low water bridges • Localised and short term disruption to essential services (water, electricity, hospitals, schools etc) • Localised mudslides, rockfalls and soil erosion • Localised disruption due to sinkholes/potholes/blocked drainage systems • Isolated cases of breakages of farm dam walls • Localised damage to mud-based/make-shift houses/structures • Localised disruption of access to drinking water and damage to crops	• **Flooding** of roads and settlements *(formal and informal)* • Danger to life (fast flowing streams / deep water) • Displacement of affected communities • Some communities temporarily not accessible/cut-off • Damage to property, infrastructure, loss of livelihood and livestock • Major disruption of traffic flow due to major roads being flooded or closed • Possible damage to roads and bridges • Disruption to essential services (water, electricity, comms, schools, etc) • Mudslides rockfalls and soil erosion • Disruption due to sinkholes/potholes/ blocked drainage systems • Isolated incidents of communicable diseases • Isolated cases of breakages of informal/farm dam walls • Damage to mud-based/make-shift houses/structures • Disruption of access to drinking water and damage to crops	• **Widespread flooding** of roads and settlements • Danger to life (fast flowing streams / deep water) • Large communities not accessible/cut-off for a prolonged period • Widespread displacement of affected communities • Widespread damage to property, buildings and loss of livelihoods and livestock • Widespread transport routes and travel services severely affected • Major roads and bridges damaged or washed away • Widespread, prolonged disruption to essential services (water, electricity, comms, schools, etc) • Widespread mudslides, rockfalls and soil erosion • Long term disruption due to sinkholes/potholes/ blocked drainage systems • Widespread incidents of communicable diseases • Breakage of dam walls • Widespread damage to mud-based/make-shift houses/structures • Widespread disruption of access to drinking water and damage to crops

The forecast impact level is first determined based on impact tables that were generated in collaboration with stakeholders, including disaster managers from each district across the country, in months of workshops as part of the years of preparation before the 2020 launch. "It's not something we did overnight," she says. "It has been a long process."

SAWS level of impact



Based on Impact Tables (above is an example for rainfall), the most appropriate impact level is identified for the region. Meteorological systems will aid the forecaster to determine the expected likelihood that these impacts could occur. From this, the appropriate warning risk level is established (below).

For yellow warnings, disaster management at the district or provincial level might be consulted, but not necessarily. This is a key difference from the previous system. "Our relationship with disaster management has changed," Viljoen says. "We are literally on first-name basis with them. We can phone them any time, and they are waiting for our calls." In return, it has made our work in disaster management easier by providing ready access to professionally-developed, relevant information which can guide effective decision-making," according to the Mopani Disaster Management Center (in written replies).

Previously, disaster management was never consulted, Viljoen says. "We just issued warnings." Once a yellow warning is issued, disaster management also has the power to negotiate a downgrade or upgrade of the warning depending on the situation in real-time. The disaster manager might phone and explain that the situation on the ground is such that the danger is not that serious, and request the warning to be lifted. "We can talk to each other," Viljoen says.

Any orange and red warnings are discussed with district disaster managers prior to their issuance, in order for the impacts to be verified and evaluated before they are published in media reports and on social media. Just this morning, she says, disaster managers in the Western Cape sent her photos of the informal settlements in the province in flood. "Our rain gauges can't tell us that," she says, "but now we know that if there is even more rain expected, we might need to adjust the warning levels." In this case, the impact of 50 mm of rain in the Western Cape will be very different than 50 mm of rain in the Northern Cape, and the new system allows for that to be reflected, she explains.

Doubell adds that that is the strength of the system, that they now talk about the impacts that are expected. "We try to make people aware of what kind of daily activities they should be careful of when certain weather is coming."

The Orange Level 9 warning for KwaZulu-Natal and parts of the Eastern Cape issued by the SAWS on 12 April, for example, warned that "disruptive rainfall leading to widespread flooding of settlements, schools, roads, bridges, sinkholes, mudslides, soil erosion and major disruption of traffic is expected over the extreme south-eastern parts of KwaZulu-Natal."

Weather forecasters have had ample opportunity to test the efficiency of the system. Numerous extreme weather events have plagued South Africa since the 2020 launch. In November of that year, a tornado tore through Mbolompo (northwest of Mthatha) as multicell thunderstorms ripped roofs off homes, uprooted trees and caused heavy downpours and flooding. In January 2021 Severe Tropical Storm Eloise devastated parts of the South-East Coast of Africa. In January 2022, record-breaking temperatures were recorded during a heat wave in the Western and Northern Cape. In February 2022, Tropical Cyclone Batsirai bore down on the African east coast and a month later, Tropical Storm Gobe swept over the Mozambique Channel. June of this year saw a series of cold fronts make landfall over the western parts of the country that resulted in strong winds, high waves, light snow, a significant drop in temperatures and the heavy rainfall that caused the flooding that was brought to Viljoen's attention that morning.

However, the new system has proved its worth. In reply to how the impact-based system has impacted their work, the Mopani Disaster Management Centre replied: "Leading up to, and during, the heavy rainfall caused by Tropical Storm Eloise, regular updates received from SAWS assisted us in preparing in advance and establishing a JOC for joint decision-making. Using the already established Mopani RIMS (Road Incident Management System) network, weather warnings and updates could also easily be disseminated to first responders on the ground. This gave services the opportunity to prepare in advance ahead of the arrival of Eloise, ensuring that equipment was ready and sufficient staff were available."

Furthermore, "a great example of how the weather warnings were used to good effect was in the case of the Sanral-appointed RRMs (Routine Road Maintenance) teams. The RRMs worked to protect Sanral road infrastructure by ensuring that potential problem areas were addressed and storm water drains were all clean, especially along the Escarpment areas where the heaviest rainfall was expected. There is no doubt in our mind that this pre-planning prevented damage to key road infrastructure which keeps the local economy running."

Surveys that Viljoen conducted as part of her PhD research have provided more input on the impact of the system. Asked if people took any action because of the weather warnings, many responded yes. These ranged from taking their animals to higher ground when floods were expected to stocking up on groceries ahead of potential bad weather. Other people selected to work from home, or chose safer roads for travelling. A farmer reported organising alternative transport for workers that had to cross a

low-water bridge flagged to be potentially affected by flooding. "We won't know for sure, but that could potentially have saved lives," Viljoen says.

Disaster managers, again, reported they kept equipment like chainsaws on standby due to the warnings. This could help them to quickly remove fallen trees blocking roads, for example, allowing emergency vehicles access to affected areas. "Those are the types of feedback we receive, and we feel that's exceptionally positive," Viljoen says. Still, she says, they are always trying to improve. Most of these efforts are geared towards better communicating the weather warnings and extending their reach.

On the ground during Cyclone Eloise

"We keep a careful watch on weather activity in the south-west Indian Ocean basin during the tropical cyclone season. Contact was established with SAWS a week before the onset of Eloise, which gave (disaster management) extra time to plan and prepare. As soon as SAWS confirmed that Eloise was going to track inland towards South Africa, those plans could be put into action and a Joint Operational Centre (JOC) was formally established. The JOC saw representation at management level from a variety of services and related departments or interested parties, including Disaster Management at local and district level, Mopani Fire & Rescue Services, Emergency Medical Services, South African Police Service, Traffic, the Kruger National Park, Department of Public Works, and Department of Water and Sanitation, Routine Road Maintenance (RRMs), among others. For the first time in our history, a virtual JOC had to be established due to the COVID-19 pandemic. Once established, the Mopani JOC joined the National JOC, which had been established by the National Disaster Management Centre, for presentations by national structures, including a crucial presentation from SAWS. Following this, a virtual meeting of Mopani JOC members was held to deliberate finer-detail planning specific to the Mopani District, with direct input from SAWS. Engagement was sought directly with managers before the establishment of the Mopani JOC to ensure full participation. The Mopani JOC and Mopani Roads Incidents Management System (RIMS) groups were then used jointly for the dissemination of further impact-based weather warnings and receipt of information related to incidents or flood damage. All flood-related incidents reported were captured in GIS. There was thus a continuous, uninterrupted flow of information up and down through various structures which facilitated a meaningful response, including the action taken by the RRMs to protect road infrastructure."

Source: Mopani Disaster Management Centre

Learning and improving

The SAWS remains a scientific organisation, Doubell says, and scientific organisations often struggle to communicate in simple language or to the media. "We're not really there for entertainment," Doubell says but she adds that they are also aware that they must lose a bit of their 'gravitas'. "It's a matter of obtaining a balance," she says. After all, she adds, "a large part of the system's success or failure is the public's capacity to receive and read it." The organisation is continuously trying different ways to do that better.

Some of the improvements SAWS has made since the launch of the new system are to use more graphics and less text in its warnings. Another potential improvement on the cards is voice messages translated into some of the country's eleven languages and sent directly to people's phones. The organisation is also conducting community outreaches and welcoming any traditional or technology-based communication channels. "We've heard that in certain villages in the Eastern Cape they use pots and pans to get the villager's attention, we can think we can even use that," Viljoen enthuses.

Timely warnings of extreme events will become even more important in future.

Cold snaps, rough seas and gale-force winds, bitterly cold weather, snowfall, flash flooding and thunderstorms are some of the many extreme weather terms that South African have already become familiar with and, it will likely increase. Following the April floods, the SAWS announced that as weather scientists, they cannot attribute individual weather events occurring on short timescales to longer-term events occurring over years or decades. However, they can state with confidence that globally, as a direct result of global warming and associated climate change, all forms of severe and extreme weather such as heatwaves, heavy rain, and coastal storm surge events are becoming more frequent and more extreme than in the recent past. "In other words, heavy rain events such as the current incident [in reference to the April KwaZulu-Natal floods] can rightfully be expected to recur in the future and with increasing frequency."

With more extreme weather in the pipeline, one has to remain on your toes, Doubell says. "You have to make sure that the information gets out there." We are entering uncharted territory when it comes to the anticipated impacts of climate change, the Mopani Disaster Management Centre representative adds but, "we do, however, believe that we are on the right track with the impact-based weather warning system and that this will grow and develop to keep pace with changes as they occur."