WEATHERSMART NEWS

Scientific meteorological and climatological news from the South Africa Weather Service

FEBRUARY 2019

- Thunderstorm forces diversions
- Sun City Flooding
- Reitz Free State veld fire
- Windstorm Research
- El Niño macroeconomics
- Temperature trends
- And more

South African Weather Service

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FEBRUARY 2019

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FOREWORD AND EDITORIAL COMMENT BY THE ACTING CHIEF EXECUTIVE OFFICER

Welcome to the WeatherSMART news edition of February 2019. This edition covers the scientific weather news of the past six months – a period that included severe weather, damage to property and warming temperatures.

The Aviation industry, one of the South African Weather Service's (SAWS') biggest clients, is very vulnerable to severe weather events and storms. For the safety of lives and property of passengers, being mindful of severe storms and other weather phenomena that can influence aviation safety, is crucial. A case in point is the dry microburst which occurred on 2 September 2018 at the Bloemfontein airport. The dusty, dry and windy conditions had some pilots in panic and led to flights having to be rerouted. Another severe weather incident, this time a supercell development south of OR Tambo International Airport on 17 January 2019, resulted in aircraft delays and also caused damage in neighbourhoods.

In an exciting development, staff from the South African Weather Service participated in the Weddell Sea Expedition, with a forecaster on board the *SA Agulhas II* which set out to Antarctica on 3 January 2019.

We take a glance at the ongoing research on several windstorms and report on a unique tornado forecast that was done in January 2019. The Sun City flooding incident of December 2018 is evaluated, and we look at measures to take in future to warn the public sooner about such imminent weather. In a similar vein, a veld fire north of Reitz, Free State on 5 September is investigated and the conditions that led to the veld fire are analysed and reported on, concluding that in spite of dramatically improved weather models, nature still has the upper hand – and we are painfully reminded that run-away veld fires can be extremely dangerous.

Concerning the gradual increases in temperatures in South Africa, we report on research that was done to determine how well climate models can simulate trends in climate. The conclusions reached are that models are not sufficiently robust yet and that more work will be required in this field.

Our publication concludes with an article on the macroeconomic effects of El Niño in South Africa with the stark conclusion that any occurrence of an El Niño event can add to economic misery in South Africa in the form of food and water shortages and job losses.

The weather and climate have become increasingly variable, and the contribution of humankind is increasingly confirmed. It is up to each South African to become environmentally aware of their own footprint and, most of all, be weather aware.

Mr Mnikeli Ndabambi
Acting Chief Executive Officer

DRY MICROBURSTS: BLOEMFONTEIN AIRPORT

By Tumi Phatudi

The aviation industry is known to be weather sensitive. Amongst others, microbursts either wet or dry can hinder flight operations. A dry microburst is defined as an intense micro-scale downdraft from a thunderstorm in the absence of rain. It results in straight strong winds at the surface resulting in dust in the lower atmosphere and low-level wind shear. Both these weather conditions can cause flight diversions and delays.

On the 2nd September 2018 a cut-off low system was dominant and situated to the west of Bloemfontein. The mid-day upper-air ascent known as Tphi-gram (Fig.1A) shows dry and windy conditions from the surface to mid-levels. Such an ascent used with other tools is a good indicator of dry microburst. Weather conditions reported on the day included windy conditions, reduced visibility due to dust (Fig.1B).

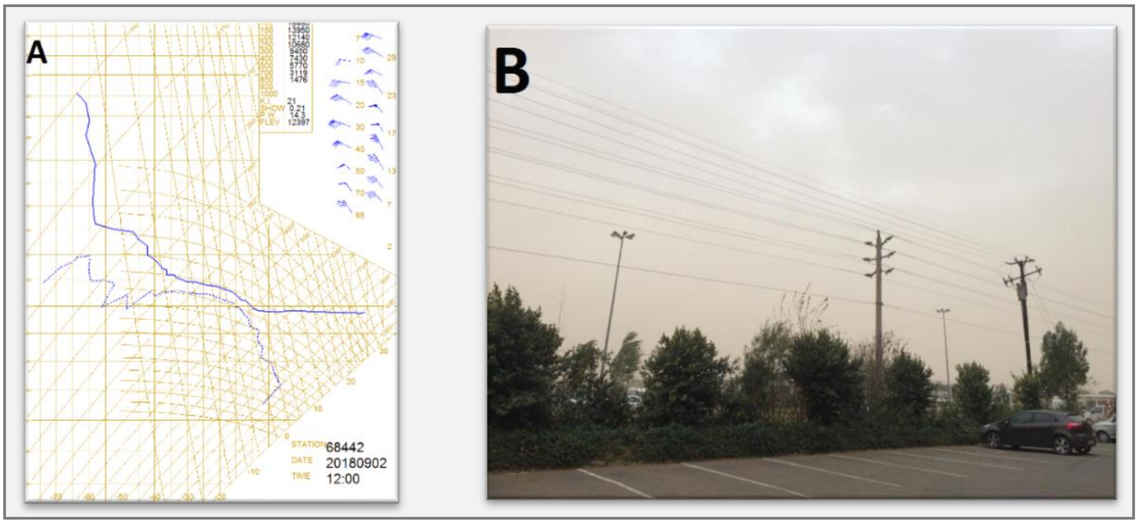

Figure 1: Bloemfontein midday upper air ascent (A) and observed dust in Bloemfontein (B).

A telephonic interview was held between the pilot and a forecaster for further interaction. The pilot stated that while descending (about 1500 feet above ground level) he saw red haze (dust) and feared to damage the aircraft. Unfamiliar with such weather conditions, the pilot panicked and was uncertain about landing after the first unsuccessful attempt, he explained. After consulting with ATNS (Air Traffic Navigation Service) and AMC (Airport Management Centre) a decision was made to land at OR Tambo international airport in Johannesburg which is about 430km away. The Boeing 737 was not the only one affected, visual flights were reported to have also struggled to land at the airport.

In another separate incident with similar weather/atmospheric conditions, a pilot encountered difficulties with landing and taking off at Bloemfontein airport on the 6 September 2018. Strong surface winds in excess of 50km/h were reported. Dry and windy conditions are common in the September/October months in Bloemfontein, hence there are various cases of poor visibility due to dust. Aircraft have filters that are designed to protect them from small particles to contaminate the engine. Thus poor visibility due to dust remains an obstacle in flight operations.

SEVERE THUNDERSTORM FORCES AIRCRAFT DIVERSIONS AWAY FROM ORTIA

By Hetisani Oscar Shiviti -Forecaster: (Aviation Weather Centre)

Thunderstorm activity usually occurs during summer seasons for South Africa, however, they can develop outside of the summer seasons depending on the conditions. Thunderstorms can cause notable disruptions for the transport industry, mainly because they can have considerable effects on visibility, surface and upper winds.

There are mainly three types of thunderstorms, namely a single cell thunderstorm, a multi-cell thunderstorm and a supercell thunderstorm. Severe weather associated with thunderstorms is usually characterised by severe turbulence within the storm, heavy rain, flooding (with possible flash flooding), strong damaging surface winds, tornadoes, large hail or large amounts of small hail and frequent lightning.

On 17 January 2019, a supercell development in the afternoon, south of OR Tambo International Airport (ORTIA), resulted in aircraft diversions and delays. Visibility reduction as low as 800 m along with strong surface winds up to 42KT (80 km/h) were observed - see Figure 1. A total of six diversions occurred between 16:00 to 18:00 on the day, where one aircraft had to be diverted to Gaborone, Botswana due to the adverse conditions.

These adverse conditions did not only affect the aviation industry but also lives and property. In Alberton, which is south of Johannesburg, a tree was uprooted due to the strong surface winds. There were reports of roofs being battered by the storm in Boksburg just east of ORTIA as seen in Figure 2.

Station: FAOR

Date: 2019-01-17

FAOR 171609Z 20024KT 170V230 3000 TSGRRA FEW028 SCT046 SCT050CB 19/13 Q1021 RETSRA TEMPO 2000 +TSRA=

FAOR 171614Z 20026G42KT 170V240 0800 R21L/P2000N R03L/2000D +TSRA SCT012 SCT040CB 14/13 Q1021 TEMPO 0500=

FAOR 171625Z 20020G32KT 3400 TSRA FEW010 BKN015 SCT040CB 14/13 Q1023 NOSIG=

FAOR 171642Z 20020KT 160V220 5000 TSRA BKN025 OVC047 SCT050CB 15/14 Q1021 NOSIG=

Figure 2: Aviation Special Weather Report (SPECI) detailing the surface changes at ORTIA during the Supercell thunderstorm.

Figure 3: Trees and roofs were uprooted by the storm. (Coutesy of ReenvalSA via Angie Del Castello and Storm Report SA via Jan de Lange as well as Tasha De Swardt)

Forecasters are well equipped in predicting and monitoring the onset, movement as well as duration of thunderstorms. One of the tools forecasters use in monitoring storms is the weather radar. With the radar, one can track the movement and intensity of a storm in real time by analyzing water content. Forecasters are able to tell the water content and phase using colour coding techniques. In Figure 4 the faint blue circle encloses ORTIA to a radius of 8km; the yellow to orange to red coloured cells are actually depictions of severity stages of a storm with the red colour indicating the most severe stage of this particular storm. It can be noted that between 16:10 and 16:16Z the water droplets were larger and also accompanied by ice particles. During this period, visibility was down to 800 m and small hail was reported.

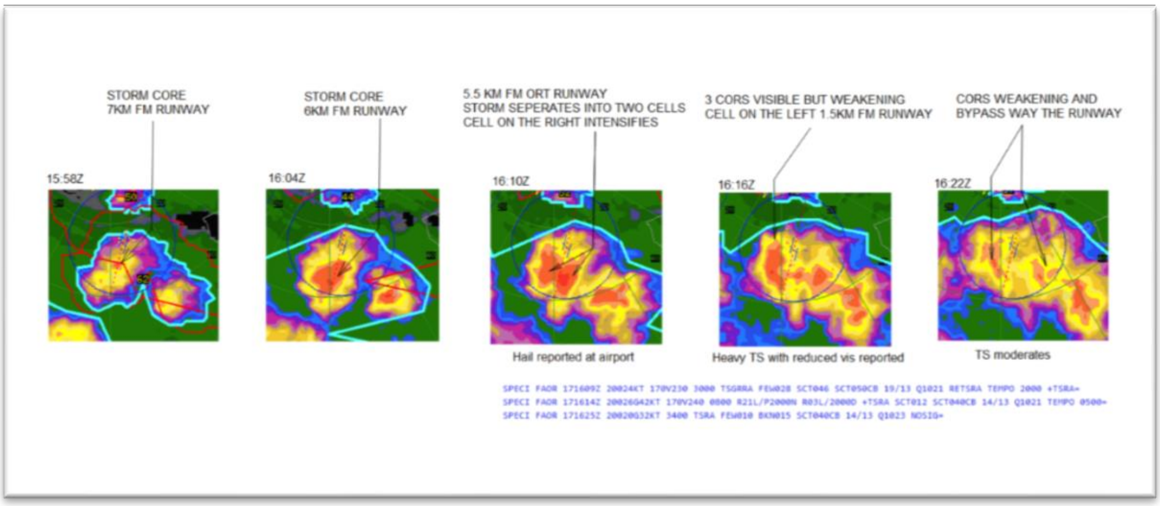

Figure 4: Radar image showing the movement of the storm over ORTIA on 17 January 2019.

Whenever there is a thunderstorm approaching within a radius of 8 km of ORTIA, the Aviation Weather Centre (AWC) sends out a thunderstorm warning to the industry for the said thunderstorm. For a particular thunderstorm, the AWC sends out one aerodrome warning which goes to the aviation website (http://aviation.weathersa.co.za); and one warning which is in the form of a short message system (SMS) that goes directly to the airlines. It is important to note that both these warnings contain the exact same information, just in different formats. The warning includes information on whether the thunderstorm is forecasted or observed; a forecasted thunderstorm warning simply means that the thunderstorm has not developed yet, however, is expected to develop, while an observed warning means the thunderstorm is already active at the time the warning is issued.

A total of three warnings were issued for ORTIA on this day. In Figure 5, an SMS warning that was issued on the day communicated that a thunderstorm with lightning and showers, reducing visibility, was forecasted to develop over ORTIA and was expected to last for 2 hours between 16:00 and 18:00.

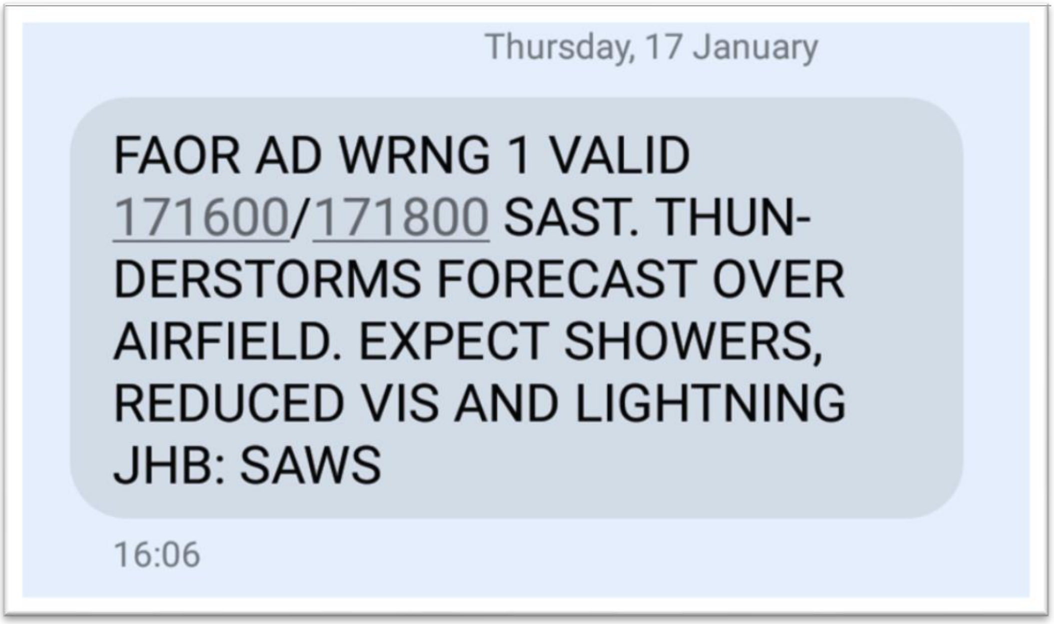

Figure 5: Short Message System (SMS) warning issued for ORTIA on 17 January 2019.

It is with the help of such warnings that the respective airlines make the decision to either cancel or delay a flight if the said flight has not yet taken off; or divert or loop a flight if the said flight has already taken off. As mentioned earlier, for this particular day, the airlines decided to divert the flights due to the severity and long duration of the storm as communicated to them via the warnings and telephonic briefing from AWC.

Surface wind speed and direction is particularly important for both take-off and landing of an aircraft. The runway change in airports is dependent on wind direction.

Thunderstorms have an unpredictable effect on the surface wind direction in particular. During a thunderstorm, winds can change direction frequently, making it extremely difficult for ATNS to plan a take-off or landing. It is for this reason that the forecaster provides information on how long the storm will last via a warning so they can make all the necessary preparations.

THE GREAT METEOROLOGY MOVEMENT: WEDDELL SEA EXPEDITION 2019

By Mmathapelo Makgabutlane, forecaster at Cape Town Weather Office and Riesna Audh, Oceanography MSc student at the University of Cape Town

Since the second half of the twentieth century, the field of meteorology has moved forward in giant strides. Notable steps include the development of operational weather radars post World War II; the first successful launch of a weather satellite in 1960, and an ever expanding global network of upper air, land and ocean surface observations. Never before had so much weather data been available. Considering rapid progress in research, as well as the numerical weather prediction explosion of the 1950s due to advances in computers, the latter 55 years of the century saw meteorology morph into something quite inconceivable from the days of Aristotle's theories in his pioneering piece, *Meteorology*.

THE FATE OF THE *ENDURANCE*

These advances may seemingly have come too late for Leonard Hussey, the meteorologist aboard the *Endurance*, the ill-fated vessel captained by Sir Ernest Shackleton during the 1914-1917 Imperial Trans-Antarctic Expedition. The aim of the expedition was to achieve the first land crossing of the Antarctic continent, but instead, turned out to be one of the grandest, albeit arduous, survival stories of the time. The vessel became trapped in sea ice in the Weddell Sea in December 1914, drifted with the ice for the rest of the summer and throughout the Antarctic winter, and eventually crushed in November 1915, where after it sank, never to be seen again. The crew camped on the ice for months, then made for Elephant Island, from where they were rescued after six of their members sailed to South Georgia, 1 300km away, to find help. Astonishingly, each member of the 28-person strong crew survived.

The Weddell Sea Expedition, a British-led add-on leg to the annual South African National Antarctic

Programme (SANAP) voyage of the *SA Agulhas II* vessel to the SANAE IV base in Antarctica, set out on 3 January 2019. The aim was to search for the wreck of the *Endurance* in the Weddell Sea, while conducting scientific research of the newly exposed face of the Larsen C ice shelf on the way. The SAWS is in the advantaged position to have been able to participate in this voyage to the Weddell Sea with a forecaster on board.

1914 VERSUS 2019

No doubt Mr. Leonard Hussey would have had measuring instruments, such as a barometer, anemometer and thermometer, as well as the official Observer's Handbook published in 1909. These, on their own, would have been scant providers of crucial information about the expected movement of weather systems or the sea ice conditions in the Weddell Sea. Although these instruments are still used, thankfully, the situation is quite different in 2019.

With the South African Weather Service meteorological measuring instruments conforming to the highest international standards, the *SA Agulhas II* vessel was able to accurately measure atmospheric parameters throughout the Weddell Sea Expedition. These measurements were supplemented with visual observations (such as weather, clouds, and sea state) done manually by the on board forecaster, giving a more complete picture of current weather conditions. Additionally, several weather balloons were released into the atmosphere (the highest reaching 22.6km – well into the tropopause at those latitudes) and drifting weather buoys deployed into the Weddell Sea. These observational data are of immeasurable value as Weddell Sea, which stretches to the Antarctic Peninsula in western Antarctica, is one of the most remote and under-researched parts of the world.

Meteorology wisdom reveals that a good forecast begins with good observations. Each day, the on board forecaster compiled three-day weather forecasts, with support from the marine forecasters at the National Forecasting Centre (NFC) in Centurion, using the observations, as well as internet-based numerical weather prediction models. The forecasts were useful for a number of operations on the ship, including the use of the autonomous underwater vehicles essential in the search for the *Endurance* shipwreck. The accuracy of these forecasts was a testament to the progress of meteorology, given the historic scarcity of surface observations in these parts.

A SEA ICE STORY

The true beauty of science is realised when one field elegantly merges with another. As the world gets smaller and more connected, this kind of cross-disciplinary collaboration has become more of an inevitability rather than a novelty. Throughout the Weddell Sea Expedition, the SAWS worked with the University of Cape Town's oceanography department to make detailed observations of the sea ice conditions in the region.

Sea ice characteristics that were observed include sea ice concentration (how much of the ocean surface is covered in ice), the type of sea ice (which is directly related to its method of formation), sea ice thickness (which speaks of its age), the topography of the sea ice, as well as snow cover. Certain meteorological elements, such as air temperature, wind speed, cloud cover and weather, were also recorded. These observations were done every hour while transiting through sea ice, following the criteria described in the Antarctic Sea Ice Process and Climate (ASPeCt) protocol. The observations were complemented by footage captured by action cameras mounted on the vessel recording time-lapse videos of the sea ice conditions.

The formation and growth of sea ice demonstrates the complex relationship that exists between the atmosphere and the ocean surface due to the influence each has on the other. Sea ice formation is primarily driven by thermodynamic processes, which are influenced by the temperature of both the sea surface and the atmosphere that is in direct contact with it. Weather systems and the precipitation of snow is one of the ways in which sea ice grows in thickness. The relationship between atmosphere and ocean is also seen in the interaction between surface winds and ocean surface currents as these are the main determining factors in the direction and speed of sea ice drift.

Polar-going vessels like the *SA Agulhas II* rely on passive microwave satellites for information about sea ice characteristics, particularly to monitor sea ice concentrations. The output of these satellites is not direct, but is a best estimation using empirical models that combine information about the resolution of the satellite instruments with observations. The observations done during the Weddell Sea Expedition are highly important as they will be used to validate these passive microwave satellite data, eventually helping to improve the accuracy of the satellite output.

A GLIMPSE INTO THE FUTURE

As was evident in the case of Shackleton's *Endurance*, sea ice impacts marine navigation to varying degrees. Even the *SA Agulhas II*, a class-leading ice-breaking vessel, has found herself in less than favourable situations as a result of poor sea ice conditions. With a greater understanding of meteorological and oceanographic processes in an Antarctic context, forecasting sea ice will become a widespread service provided by national weather offices responsible for the southern polar regions. This is a service already being offered for the Arctic region by various providers in the northern hemisphere. Indeed, part of the SAWS marine department Master Plan includes the eventual provision of a sea ice forecasting service. Considering the exciting growth of the SAWS marine division, the continued partnership with the University of Cape Town's oceanography department will prove invaluable in this journey.

With more observations from the furthest reaches of the world, research giving a fuller picture of our earth system, and computing power increasing at lightning speed, so meteorology continues its forward march with an ever increasing gait. Let the Weddell Sea Expedition of 2019 pay homage to the memory of the 1914 Imperial Trans-Antarctic Expedition by aiding in this endeavour. And let us as the SAWS and as people of South Africa be proud of our role in this story.

ON-GOING RESEARCH ON SEVERAL WINDSTORMS

By Puseletso Mofokeng

In January 2017, the International Council for Science (ICSU) reported that there were no current warning systems for tornadoes and hailstorms anywhere in Africa. This view has been reflected by many in literature for a long time, including in the Master of Science dissertation by Sarah White, seven years earlier.

In a first for South Africa, the South African Weather Service, on Saturday, 30 December 2017 forecasted and warned about a tornado to hit Protea Glen, Soweto, within 4 minutes of sending a warning message. As forecasting tornadoes can create panic, this was a first attempt at forecasting and warning for this event.

Since this historic day, more research is being done to improve the short time lead-time and sporadic real situation tests are done when the opportunity warrants. The first test came hot on the heels of a tornadic thunderstorm which battered Bhunya area in eSwatini on Tuesday, 4 December 2018. Soon after mid-night of Saturday, 5 January 2019, a test forecast (non-operational forecast) was recorded for the Mpumalanga escarpment and Lowveld (Figure 1 (a)), including the northern KwaZulu-Natal and eSwatini.

More than 13 hours later, a resident by the name of Tinus Joubert posted a photo to Twitter (at 14:05 SAST) of a funnel cloud lowering in the Lydenburg area along the northern Mpumalanga escarpment (Figure 1 (b)). During the same hour, another tornado (rope tornado), made a touchdown in Albert Luthuli local municipality, in Mpumalanga, at the Oshoek area, off the north-western border of eSwatini.

(a) (b) (c)

Satellite image at 14:00 SAST | Funnel cloud lingering | Rope tornado at Oshoek

Figure 1: Events of Saturday, 05 January 2019, in the early afternoon hours

In a clip which SAWS has seen, a resident could be heard praying loudly, probably to end the storm (Figure 1 (c)). Another evidence of this storm has been captured by the Moirs, according to the Getaway website.

The techniques for forecasting tornadoes are learned from countries such as the United States of America (USA), the United Kingdoms (UK), Europe, Australia and others.

Due diligence was ensured on Friday, 23 February 2019 when we issued a watch for severe thunderstorms for the next day for these areas: the north-eastern areas of the Eastern Cape, the interior of KwaZulu-Natal (KZN) as well as for the eastern high veld of Mpumalanga.

Further analyses of potential severe thunderstorms were done on the morning of Saturday, 24 February 2019. On these analyses, the Global Forecast System (GFS) maintained the suggestion of rapidly-gained extreme instability between 06:00 and 12:00 Universal Time Constant (UTC) (that is, 08:00 and 14:00 SAST, respectively). These instabilities were highlighted for the northern KZN, Mpumalanga escarpment areas, eSwatini and the extreme southern Mozambique. That is, Convective Available Potential Energy (CAPE) was suggested to grow from about 500 to just over 2 200 J/kg with Lifted Index (LI) at - 8 ^{O}C.

To gain better insight into the potential severe thunderstorms, the Unified Model (UM) was used. The model confirmed extreme instability with wet-bulb potential temperature rising from 20 to 26 °C and the response to this rise came in the form of CAPE values of more than 3 000 J/kg in the afternoon. Meanwhile, the LI dropped to - 11 °C; signifying exceptional unstable conditions. The UM also suggested significant vertical directional wind shear with wind speed shear in excess of 35 knots (65 km/h) between 850 and 600 mb. From these classic model outputs, the possibility of forecasting a tornado was discussed among forecasters, particularly for the northern KZN. This discussion was reflected in the daily inference with the forecasting office in KZN having to monitor the situation closely.

The difficulty associated with forecasting a tornado is twofold: First, it is almost impossible to pinpoint the exact location where a tornado will hit. Second, South Africa has not yet established a system of how to respond when a tornado warning is issued. History has shown that in cases where tornado hoaxes were released, the public panicked and reacted in a manner which led to severe traffic congestion, putting even more lives at danger. Earlier this year, Twitter users reportedly panicked after a possible tornado was mentioned on television.

The South African Weather Service will continue to do research on ways to warn about impending tornadoes and other severe weather phenomena, and ways to educate the public to react to such events.

A REVIEW OF THE SUN CITY FLOODING INCIDENT

By Puseletso Mofokeng

The countdown to 2018 Christmas was at 9 days 7 hours and 55 minutes; just from that moment, the Sun City Resort became heavily flooded. In a flash, social media trended this chaotic event which was characterised by localised flooding and accumulated hail. Due to the high popularity stakes of this holiday and entertainment destination, the mainstream media, in the form of television, radio, and online news articles, followed suit almost immediately, emphasising the angle relating to the inconvenience to the patrons. Soon enough, a few in the media broadened the news story with enquiries at the forecasting desk of the South African Weather Service (SAWS). The event was an isolated miss – this incident is something that no on-duty or even off-duty forecaster may wish for anywhere in Africa or in the world.

The profession of forecasting has been improved significantly over the past decade, following the dedicated collaborative efforts of researchers at SAWS and at domestic universities, including international partners. For example, the Unified Model (UM) has been set to work out the potential weather changes at every top of the hour, within at least 48 hours. This set up enables weather forecasters to pick up on the rapid rate of instability transformation over a period of 3 to 6 hours. Once this rapidness has been satisfactorily established, the issuing of weather alerts (i.e. watches and/ or warnings) for severe thunderstorms ensues. To mention a few, watches and warnings were sent out to disaster management and the public in South Africa, before the destructive windstorm in the eastern areas of Limpopo and Mpumalanga on 28 November 2018 and again on 4 December 2018. On the latter date, a tornado touch- down caused massive destruction to crop and property at Bhunya on the western areas of eSwatini.

However, the origin of the locally-limited flooding at Sun City has not yet been accommodated into Numerical Weather Prediction (NWP) models, in the country. In this event, two ordinary cells of thunderstorms had a displacement of roughly about 20 km - one was to the south-west of Sun City and the other to the north-west, in the North West province. These storms developed between 15:30 and 16:00 and drifted diagonally towards each other. During this window period, the records undoubtedly show that the forecasting team on the day focused on quality control of various weather services due for a number of stakeholders.

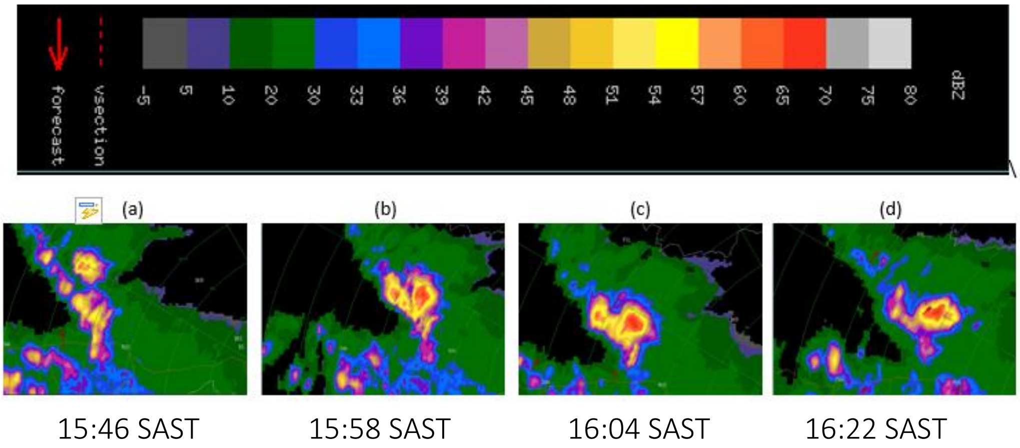

Figure 1: Merger of several thunderstorms one at a time, causing slow movement strong gusty winds, large hail, heavy rain which lead to localised flooding

The storms in question remained ordinary towards the end of the majority of the shifts. Moreover, a catch-22 situation came into being from pop-up calls, a little while after 16:00 SAST. These calls kept the attention of the lone forecaster away from the meteorological radar - a tool with which the development of severe thunderstorms are monitored and tracked.

According to the radar footage, the merger of these ordinary storms took place from about 16:00 South African Standard Time (SAST), while also drawing the energy of the nearby isolated thunderstorms. The impact of this amalgamation of energies led to a single massive thunderstorm which produced strong gusty winds, large amount of small hail as well as heavy rain which led to localised flooding.

It was interesting to learn of the view that this event happened due to the anger of the previous owners of the land on which Sun City Resort has been built.

To maintain a useful early warning system, a quicker solution could be to work on the development of an alarm system to detect ordinary thunderstorms, approaching one another or even clashing. Beefing up systems against the challenge of merging thunderstorms should involve a heightened research on NWP models.

Hail and Flooding (Source: Arrive Alive)

Inconvenienced patrons (Source: SA News, 2018)

Figure 2: Impact of on the ground from the merger of the thunderstorms

VELD FIRE NORTH OF REITZ, FREE SATE: 5 SEPTEMBER 2018

By Elani Heyneke and Tumi Phatudi

South Africa is situated at the southern tip of Africa in the Southern Hemisphere. The summer season is from December to February, winter from June to August, spring from September to November and autumn from March to May. South Africa has two fire seasons, namely the cool, dry winter fire season that affects the central and eastern parts of the country and the warm, dry summer fire season that affects the western and south-western parts of the country as seen in Figure 1. Within these two main fire seasons, there are four months that experience peaks in fire activity when referring to certain provinces in South Africa: Mpumalanga and KwaZulu-Natal in August; Western Cape in February; North-West Province, Free State, Gauteng and Eastern Cape in September; Northern Cape in November.

On 5 September 2018, there was a cold front with a secondary development behind, it situated over the south-western parts of the country, with a steep upper-air trough to the west. Usually, ahead of a cold front, the central interior of South Africa experiences warm to hot, windy and dry conditions which are favourable for possible run-away veld fires. September the 5th 2018 was no different. The South African Weather Service issued a warning for extremely high veld fire conditions that were expected over the north-eastern parts of the Free State as seen in Figure 2.

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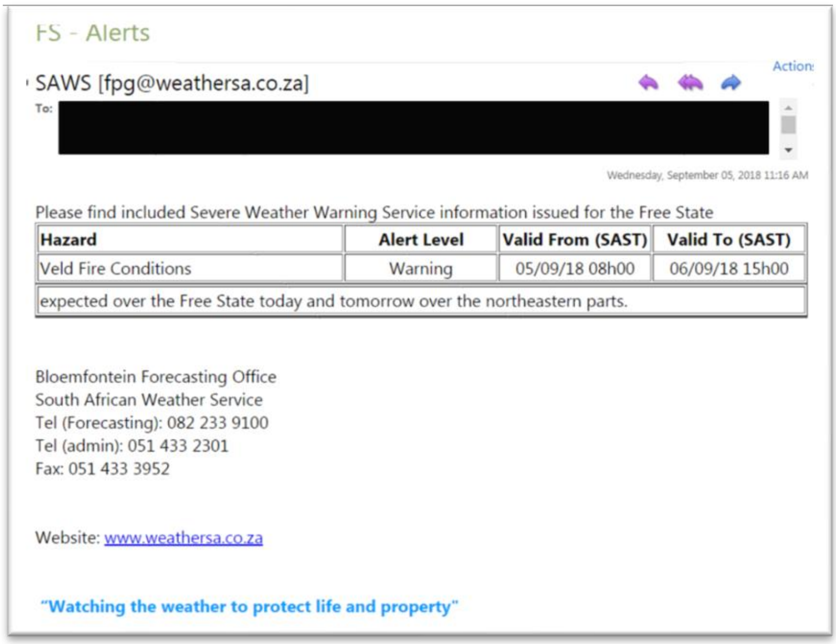
Figure 1: The fire seasons of South Africa



FS - Alerts

SAWS [fpg@weathersa.co.za]

Actions

To: [redacted]

Wednesday, September 05, 2018 11:16 AM

Please find included Severe Weather Warning Service information issued for the Free State

Hazard	Alert Level	Valid From (SAST)	Valid To (SAST)
Veld Fire Conditions	Warning	05/09/18 08h00	06/09/18 15h00
expected over the Free State today and tomorrow over the northeastern parts.			

Bloemfontein Forecasting Office
South African Weather Service
Tel (Forecasting): 082 233 9100
Tel (admin): 051 433 2301
Fax: 051 433 3952

Website: www.weathersa.co.za

"Watching the weather to protect life and property"

Figure 2: The email that was issued for extremely high veld fire conditions over the north-eastern parts of the Free State on 5 September 2018.

For the purpose of this article, Reitz will be our main focus. This is a small town between Frankfort and Bethlehem in the north-eastern corner of the Free State. Reitz is located about 70km south of Vaal Dam (see Figure 3). The fire broke on the farm Mara to the north of the town. A teenager got burned over 85% of his body (which sadly lead to his passing few months later) while his father sustained face burns while trying to extinguish the veld fire. According to a local news report, the father and his son got caught in the fire, because of a sudden change in wind direction. The purpose of this case study is to investigate this particular veld fire event and to establish if the wind changes could have been predicted and to investigate the development of flammagenitus.

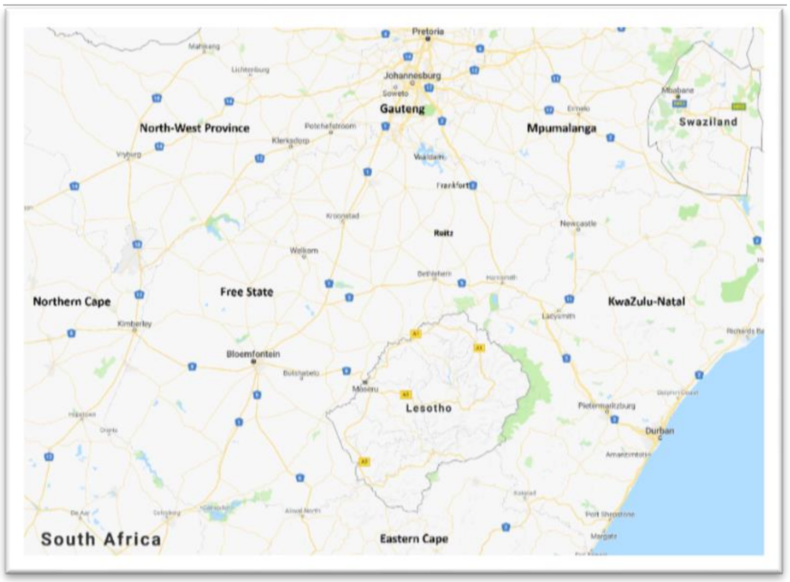


Figure 3: Map of the Free State

The midday satellite image (Figure 4) at 1000Z (+2 hours for SAST) showed the formation of a smoke plume which became more evident an hour later and throughout the afternoon. The development of the smoke plume was spreading south-eastwards as it formed a pyrocumulus cloud, indicating that the low level winds were from the north-west. Flammagenitus (more specifically, Cumulus flammagenitus, also known as Pyrocumulus due to its clumpy structure) are also observed within the smoke plume, underneath the source of the veld fire, which is an indication of the immense heat that was generated by this veld fire. From 1200Z, cumulus development could be seen to the west of the veld fire with the burn scar clearly visible at 1500Z.

In Figure 5 (A), active veld fires can be seen over the north-eastern parts of the Free State, using the Vaaldam as reference. The aftermath can be seen in Figure 5 (B), with the area where the veld fire occurred near farm Mara highlighted in red, showing the large surface area that got burned.

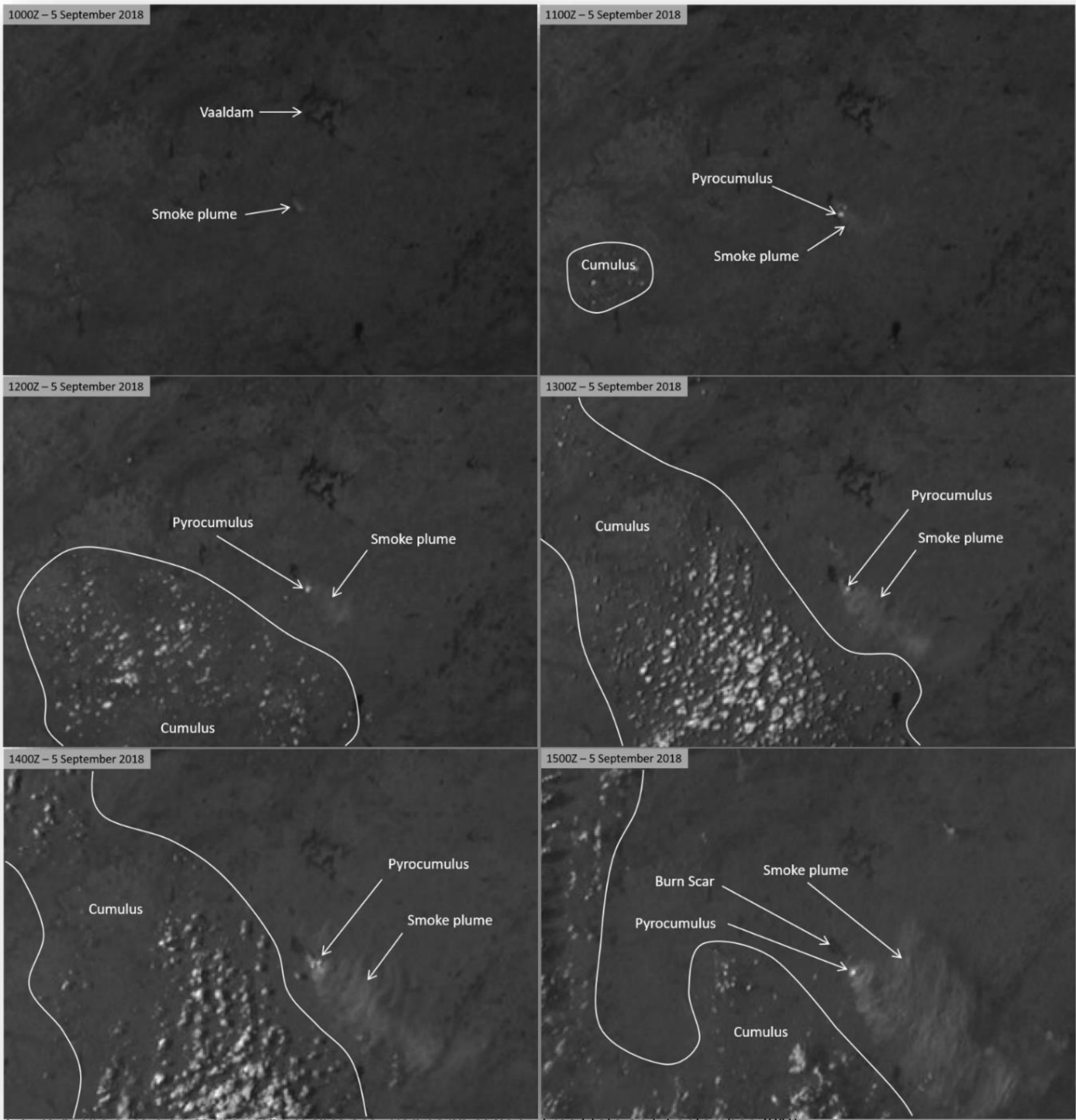


Figure 4: The evolution of the veld fire that occurred north of Reitz, Free State on 5 September 2018

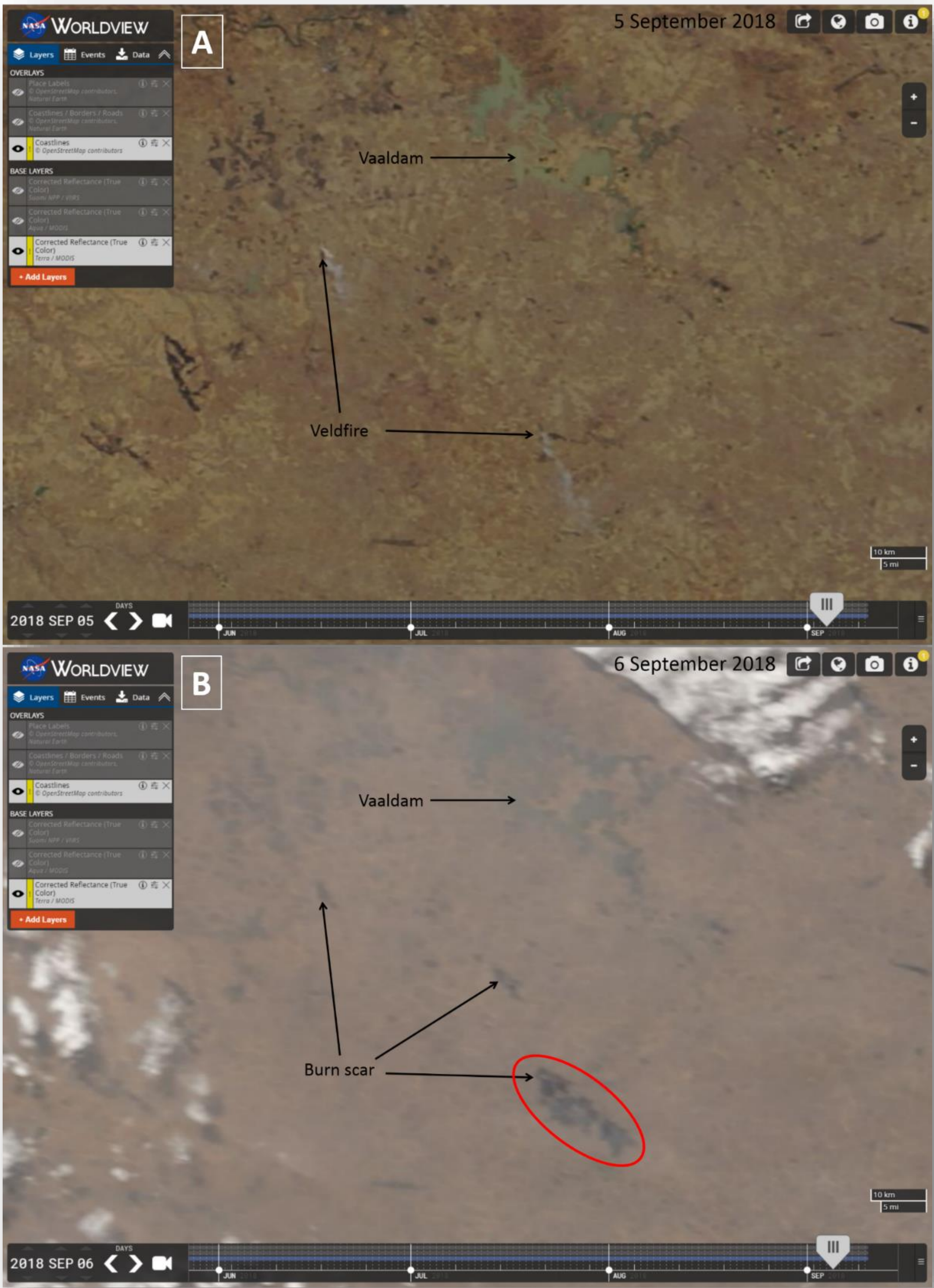


Figure 5: MODIS satellite images from the 5th (A) and 6th (B) of September 2018.

The smoke plume was so extensive that it was even visible on the radar image (Figure 6) when comparing the Day Natural Colours RGB (DNC) at 1300Z with that of the 1306Z radar image.

The burn scar was already visible at 1300Z with the smoke plume stretching kilometres to the south-east.

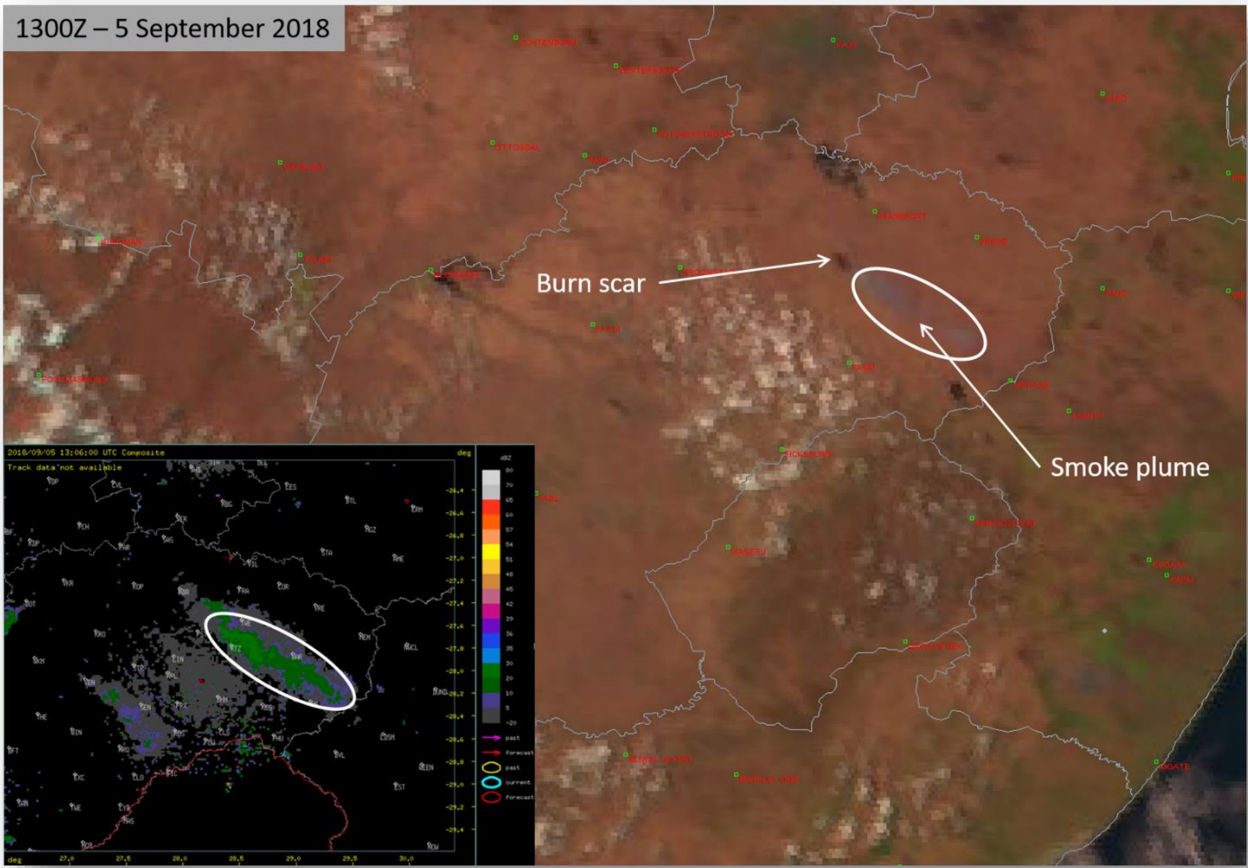


Figure 6: Comparing the Day Natural Colours RGB with that of the radar image around 1300Z

The smoke plume was still visible in the evening just before sunset and it even spread into KwaZulu-Natal. The burned scar on the surface was apparent from the farm Mara indicated by the black colour on the satellite image west of the smoke plume (Figure 7). Unfortunately, after sunset the smoke plume could not be tracked using the satellite anymore, because smoke plumes are only visible on solar channels, which gives an indication of the thickness of the cloud or in this case the smoke plume - the thicker the cloud/smoke plume, the brighter (whiter) it will appear. Smoke plumes are not visible when using infrared channels, because the temperature of the smoke plume will be very similar to that of the surrounding atmosphere, therefore it will look the same than the earth's surface. Luckily the radar could have been used to track the moving and dispersion of the smoke plume after sunset. The last radar image of the smoke plume was at 1600Z, after which it dissipated completely.

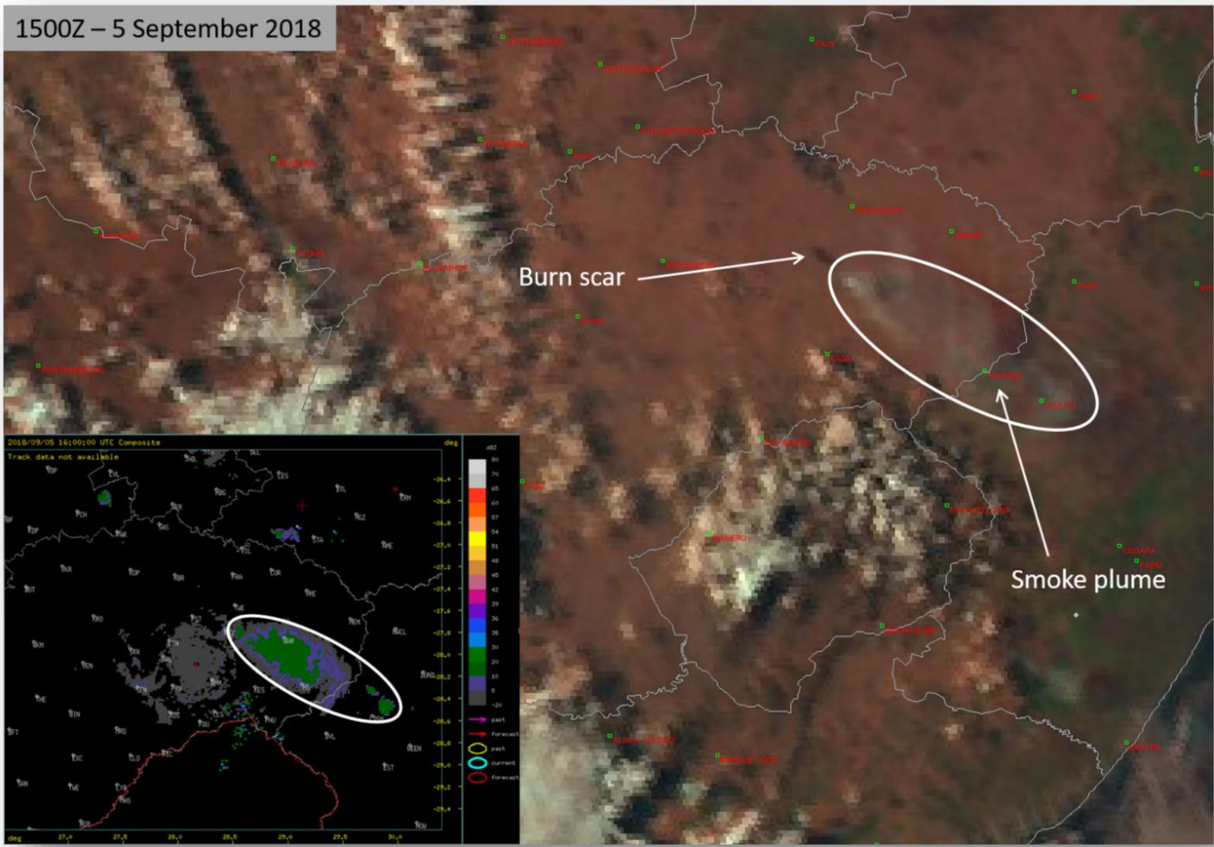


Figure 7: Comparing the Day Natural Colours RGB at 1500Z with that of the radar image 1600Z.

Table 1 below shows wind speed and direction as well as the gusts for the Kroonstad and Bethlehem stations between 15:00 and 16:15 where there was evidence of a sudden change in wind direction for a short period of time. It was a windy day with the direction changing by 30° at both stations in the afternoon. The wind at Kroonstad changed direction from north-north-westerly to north-westerly while at Bethlehem it changed from westerly to north-westerly. The wind speed and gusts were not strong enough for the forecaster to issue a special weather advisory for strong winds over the interior (issued when the wind speed is greater than 50 km/h and gusts greater than 90 km/h), because the wind speed measured was between 25 and 32 km/h and gusts of between 36 and 47 km/h.

Table 1: Wind speed, direction and gust over Kroonstad and Bethlehem weather station on the 5th of September 2018.

Station	Time (SAST)	Wind direction (º)	Wind speed (km/h)	Gust (km/h)
Kroonstad	16:05	340	27.36	43.56
	16:10	310	32.40	45.72
Bethlehem	15:15	280	30.96	47.16
	15:20	302	25.56	36
	15:25	310	24.48	39.6

In general the models gave no indication of a sudden change in wind direction (10 m above the ground), for example a gust front moving through, but looking closer at the 10 m wind model output, it seems like this model (Figure 8) gave some indication of a change in wind direction from 1300Z to 1400Z. Although the model showed a change in wind direction from north-westerly to northerly, in reality the winds changed from westerly and north-north-westerly to north-westerly.

Conclusion

Even though our weather models have improved dramatically over the past decade, they still cannot give a clear indication of sudden changes in wind direction (that last a few minutes) on a small scale. In an ideal world, it would be beneficial if our model forecasts could have 15-minute intervals, especially the wind output, instead of hourly. It should also be noted that local weather effects were probably also at play, which could have contributed to the sudden change in wind direction which tragically caused the loss of a teenager's life while trying to fight the fire. This is a painful reminder of how dangerous run-away veld fires can be. The public is encouraged to visit our website (www.weathersa.co.za) before starting an open fire, to see if there is a warning issued for extremely high veld fire conditions and also not to throw cigarette buds out of the vehicle or on an open field.

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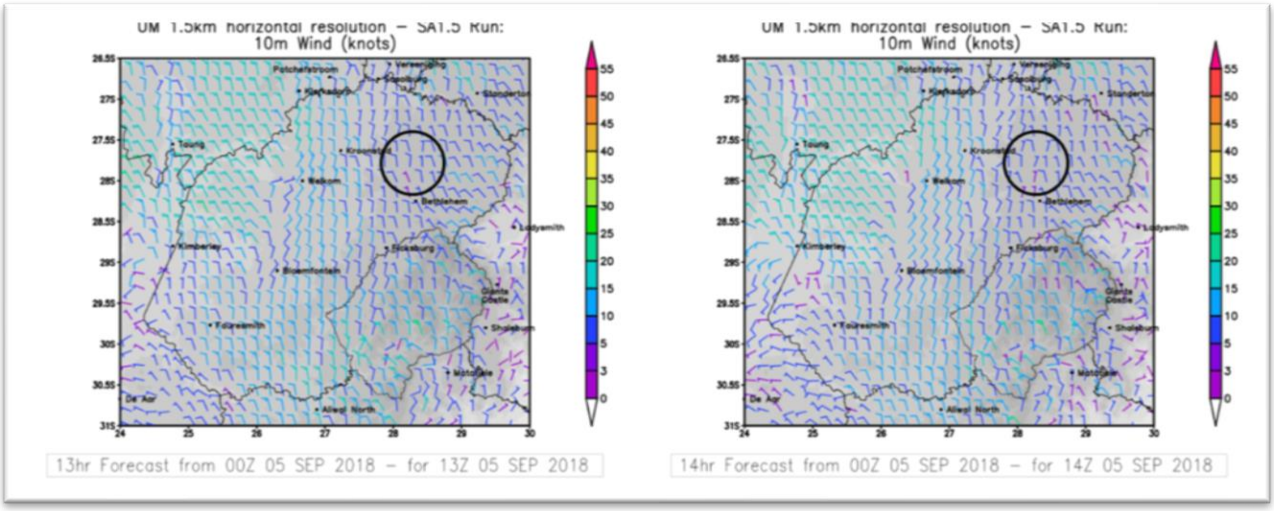


Figure 8: The 10m wind model output from 1300Z to 1400Z, the black circle highlights the area around Reitz.

HISTORICAL TEMPERATURE TRENDS FROM MEASUREMENTS AND MODEL SIMULATIONS

Andries Kruger, Sifiso Mbatha and Sandile Ngwenya – Climate Service
Hannes Rautenbach and Thabo Makgoale – Research

A question is often asked as to how well models are able to simulate the real climate. In the context of climate change this question can be extended to: How well are climate models able to simulate trends in the climate? Recently a research team consisting of colleagues from the Climate Service and Research departments at the South African Weather Service initiated a project to investigate how well climate models can represent observed trends from climate data sets considered to be reliable. The rationale behind the project was that, with the available data, there was an opportunity to validate the consistencies of model simulated trends against the associated observed trends. Such an analysis could create a better understanding of how to eventually interpret future projections. The first phase of the project focused on surface temperature, and the results were published in a research paper in press in the *South African Journal of Science*, in which more details of the research will be provided.

Regional Climate Model (RCM) outputs contain systematic errors (also known as biases) when compared to observations. It is therefore not advisable to use raw climate change projection data, but rather express change in terms of future anomalies relative to the historically simulated climate. Therefore, to study future climate change the actual values simulated by the RCM is not of the same significance than the changes that are predicted to occur. It follows then that it is imperative that the RCM is able to effectively simulate historical climate change over a sufficiently long period.

Recent studies of historical climate change in South Africa indicate a general, but spatially variable, warming over recent decades. Measurements show that historical trends in mean temperatures are less than 0.04 °C/decade for some stations in the interior, but higher than 0.20 °C/decade in the south-western and north-eastern parts of the country. Trends in temperature extremes confirm this warming, which is also stronger in the south-west and north-east of the country.

A number of modelling studies have already been conducted to identify the most possible future near-surface temperature scenarios over southern Africa, e.g. the Climate Change Reference Atlas produced in 2017 by the South African Weather Service, with support from the South African Water Research Commission (WRC) (available online at www.weathersa.co.za/climate/climate-change-reference-atlas). The latter is based on previous dynamical downscaling modelling done under the auspices of the Coordinated Regional-climate Downscaling Experiment (CORDEX). The simulations of nine coupled Atmosphere-Ocean General Circulation Models, which were included in the Inter-Governmental Panel on Climate Change (IPCC) Fifth Assessment Report, were used as inputs for a 1951 - 2095 simulation downscaled to a resolution of 0.4 ° x 0.4 ° using the Rossby Centre Regional Model Version 4 (RCA4) RCM. The main parts of the publication considered in this study were the future projections of the average near-surface temperature for two 30-year periods, i.e. 2036 – 2065 and 2066 – 2095, but first considered were the RCM simulations over the 1951 – 2005 historical period.

Historical comparisons

The historical trends simulated by the CORDEX models and observed daily maximum and minimum temperatures at 22 locations in South Africa were compared over the period 1951 – 2005. In this context it is important to acknowledge that there are inherent differences in the internal variability between model and observational data sets, which imply that there is not a chronological correspondence between modelled and observed values over a specific simulation period. It is therefore necessary that the period over which the comparisons are made is deemed sufficiently long to compare long-term trends, which over time will appear super-imposed over the shorter-term internal variability. Opinions about a sufficient period vary but it appears that as long as the simulation period is longer than 30 years, one should be able to statistically detect any possible background climate change signals from the simulated data sets. From the grid of the RCA4 model output, the values at the positions of the 22 observation stations were estimated using a trigonometrical estimation method, to coincide as closely as possible with the positions where the measurements were made.

It was established that on average, the RCMs underestimate the observed annual average minimum temperature trends by only about 0.05 °C/decade, compared to the observations. However, while the average RCM trends range from +0.10 to +0.16 °C/decade, the range in trends in the observed time series is much larger, ranging from insignificantly small to very large trends of more than +0.4 °C/decade. For the annual average maximum temperature there is on average little difference between the trends captured by the RCM (+0.12 °C/decade) and the observations (+0.14 °C/decade) but, on closer inspection, as with the minimum temperature, the range of the RCM average trend (+0.09 to +0.17 °C/decade) is much smaller than those of the observed trends (-0.12 to +0.36 °C/decade). In addition, no RCM ensemble member consistently simulates the observed trends better than others. It is also noteworthy that the RCM ensemble members are mostly unable to simulate strong observed warming trends. The models that in general simulate localized strong warming better, do not perform as well in those areas with less observed warming, e.g. the central interior of South Africa.

Trends in temperature extremes according to the indices developed by the WMO Expert Team on Climate Change Detection and Indices (WMO-ETCCDI) were also examined. For these index trends it was also apparent that the models were not able to effectively simulate very large positive or negative trends. A wide range of indices were tested, and a subset of the results discussed below.

Both the observations and model ensemble mean showed cold nights to decrease but evident from the observations were larger decreases along the coastal regions (mostly < -2.5%/decade) compared to the interior (mostly -1.5 to -0.5%/decade). With the exception of Calvinia (Western Cape Province), all observed cold night trends were significantly negative. The ensemble mean showed more consistent trends, at all locations in the range -1.5 to -0.5%/decade:

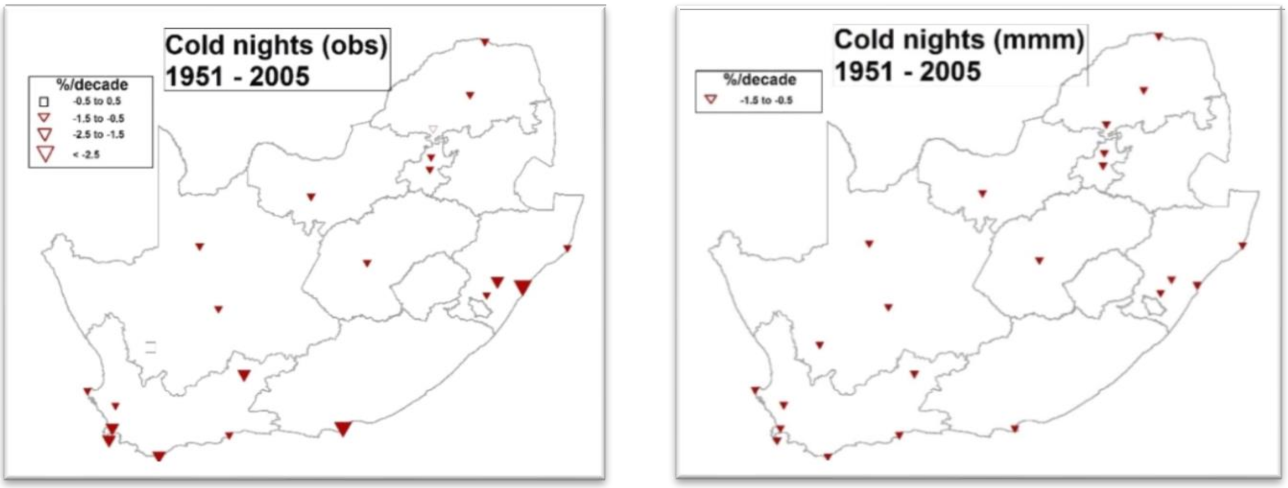


Figure 1: Trends in annual number of cold nights in % per decade, for the period 1951–2005 from the observations (obs) and multi-model mean (mmm) data sets. Filled triangles denote significant trends at the 5% level.

The trend results for hot days indicated general increases, but again the results from observations were spatially more variable, with trend magnitudes ranging from negative to greater than +2.5%/decade. For the ensemble mean, most locations showed statistically significant trends of +0.5 to +1.5%/decade:

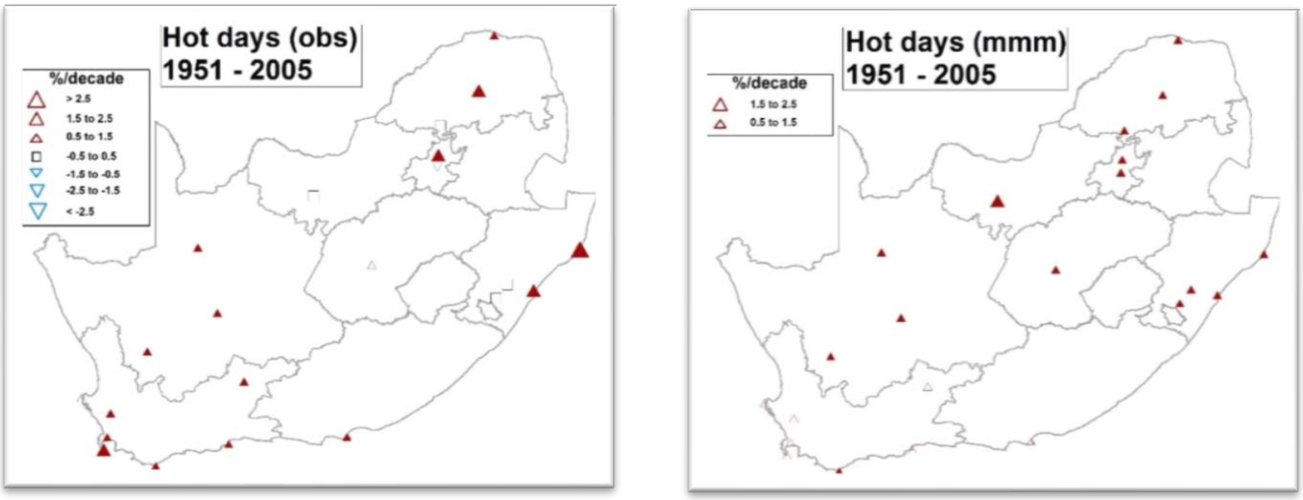


Figure 2: Trends in annual number of hot days in % per decade, for the period 1951–2005 from the observations (obs) and multi-model mean (mmm) data sets. Filled triangles denote significant trends at the 5% level.

The differences in the results for annual extreme temperatures were even more striking. For example, for the coldest night per year most coastal stations showed relatively large positive trends in their observational time series, mostly greater than +0.2 °C/decade. In contrast, all locations from the model ensemble results showed small non-significant trends of -0.1 to +0.1 °C/decade:

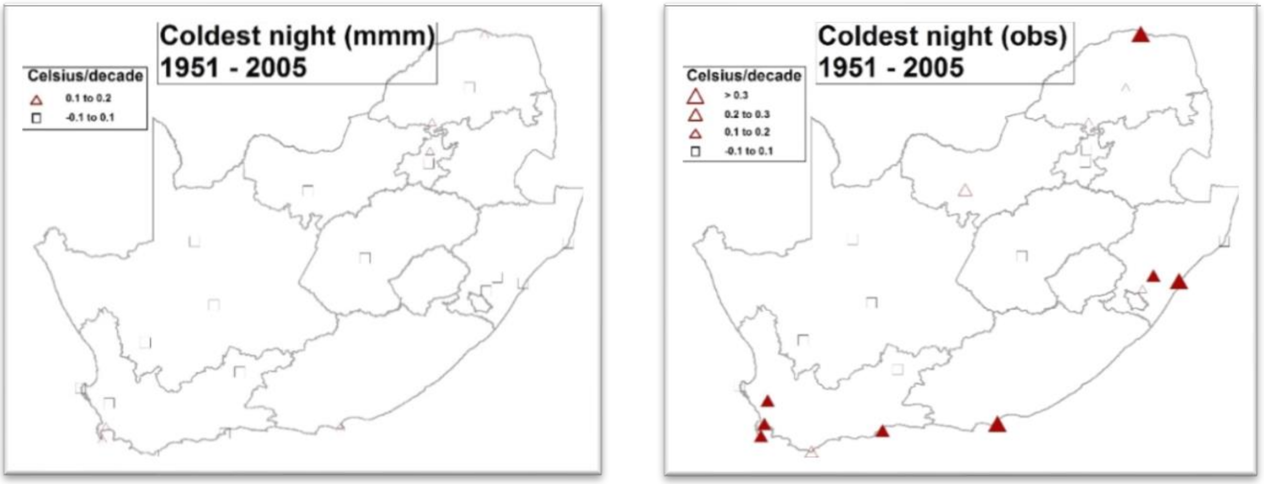


Figure 3: Trends in coldest nights per year in °C per decade, for the period 1951–2005 from the observations (obs) and multi-model mean (mmm) data sets. Filled triangles denote significant trends at the 5% level.

Future change

In the light of observed global warming due to increased concentrations of Greenhouse Gasses (GHGs), various future GHG concentration-based projections have been produced, known as Representative Concentration Pathways (RCPs). These RCPs have been defined according to the anthropogenic contribution to atmospheric radiative forcing projected for the year 2100 as a result of the projected increases in GHGs. The medium-to-low concentration RCP4.5 (a pathway that stabilizes radiative forcing at 4.5 $W.m^{-2}$ in 2100 without ever exceeding that value) and the high concentration RCP8.5 (which projects a radiative forcing of 8.5 $W.m^{-2}$ in 2100 - also known as “business as usual”) GHG projections are the most commonly used in climate change projections and also focused on in this study.

As expected, the trends under conditions of the RCP8.5 pathway showed stronger warming than under RCP4.5. Also, for both pathways the warming trends in extreme temperatures were on average stronger than the historical trends. It was also noted that under the RCP8.5 pathway an acceleration of trends was noticeable for all indices. For example, the ensemble mean projection of the warm nights index under the RCP8.5 for Cape Agulhas showed a clearly noticeable trend acceleration in the second half of the future period. In contrast, the trends under the RCP4.5 pathway showed more constancy:

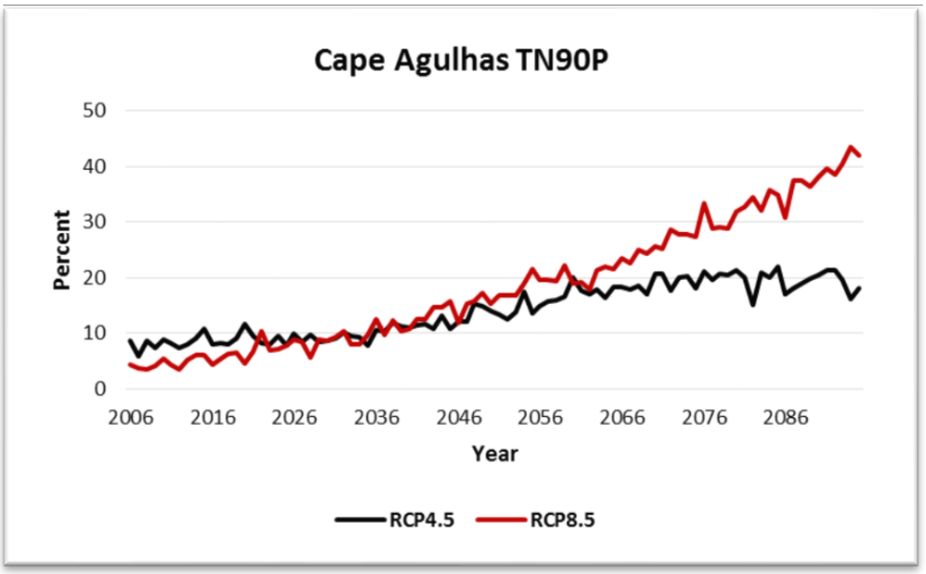


Figure 4: Ensemble mean simulation of warm nights in % (with basis period 2006 – 2035), under the RCP4.5 and RCP8.5 emission scenarios, as indicated

Conclusions

From the results it can be argued that in some, but not all of the cases of large warming, urbanization might have played a role, e.g. Pretoria. However, a general conclusion from this particular study is that the efficiency of models to simulate the trend in surface temperature over a large region cannot be translated to similar efficiencies over smaller areas where the role of the micro-climate at the local scale becomes increasingly important to consider. In addition, where observations show spatially coherent significant trends and they are not reflected as such in the model simulations, the models can be considered to be not sufficiently robust to simulate these trends. This is here especially the case for extreme temperatures.

We also found that the observational time series show in general more variance than the ensemble means. An example of these can be illustrated by the minimum temperature time series for Cape Town, where the annual averages of the ensemble mean show less variance and ultimately a flatter trend compared to the observations:

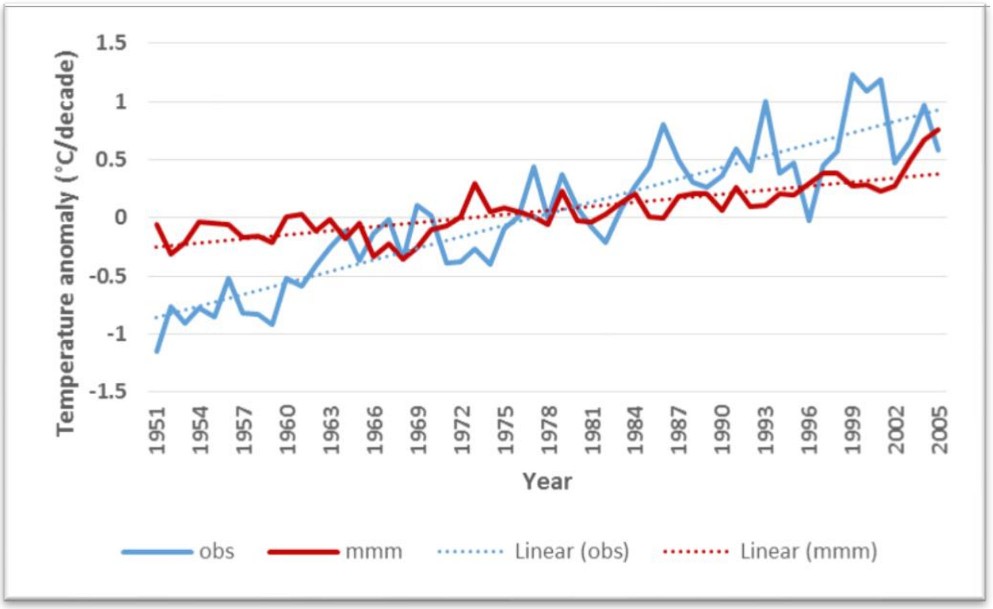


Figure 5: Annual anomalies of the annual mean minimum temperature (base period: 1961 – 1990) for Cape Town Weather Office for observations (obs) and the CORDEX downscaled multi-model mean (mmm), with linear trends shown as dotted lines.

The final inference we can make from the results is that incidents of extreme temperature events are probably much more likely than model projections suggest. This makes the projections of the characteristics of our future climate even more uncertain, and in turn makes adaptation planning for future climate change even more challenging than planning around the likely future mean climate would suggest.

THE MACROECONOMIC EFFECTS OF EL NIÑO IN SOUTH AFRICA

By Lesiba Seshoka

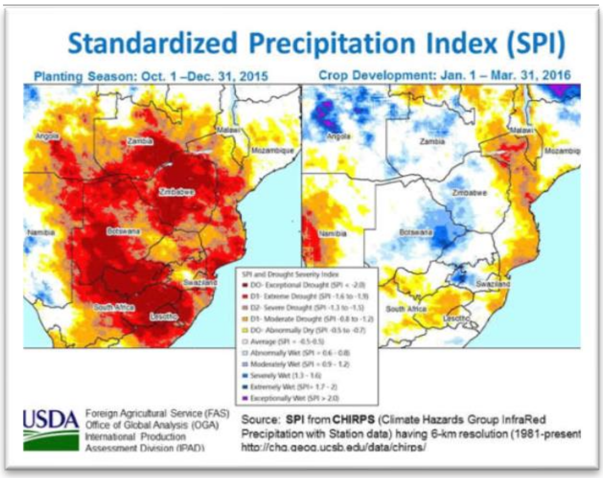
Introduction

The South African Weather Service had in late 2018 forecast an El Niño, a phenomenon accompanied by increased probability for below average rainfall and above average temperatures and which limits the amount of rainfall our country, South Africa and the SADC region receives. The forecast predicted that the phenomenon would not be as severe as the 2015 one. At the time WMO secretary-general Petteri Taalas said that 2018 "was on track to be one of the warmest on record", after especially high temperatures in July and August across several parts of the world.

The El Niño and the economy: A literature review

In their article titled *"What do we learn from the weather? The new climate-economy literature"*, the writers point to a growing body of research which applies panel methods to examine how temperature, precipitation, and windstorms influence economic outcomes. These growing body of research focus on changes in weather realizations over time within a given spatial area and demonstrate impacts on agricultural output, industrial output, labour productivity, energy demand, health, conflict, and economic growth amongst other outcomes, they argue.

A further review of the climate-macroeconomy literature reveals that El Niño impacts economies differently depending on the region where a particular country is located. In an International Monetary Fund (IMF) working paper published by an economist from Cambridge University and two from the IMF titled *"Fair weather or Foul? the Macroeconomic effects of El Niño"*, researchers note that in their study they exploited the "exogenous variation in El Niño weather events over time, and their impact on different regions cross-sectionally, to causatively identify the effects of El Niño shocks on growth, inflation, energy and non-fuel commodity prices". The results showed that there are considerable heterogeneities in the responses of different countries to El Niño shocks. While Australia, Chile, Indonesia, India, Japan, New Zealand and South Africa face a short-lived fall in economic activity in response to an El Niño shock, for other countries (including the United States and European region), an El Niño occurrence has a growth-enhancing effect. Furthermore, most countries in the sample experienced short-run inflationary pressures as both energy and non-fuel commodity prices increased.



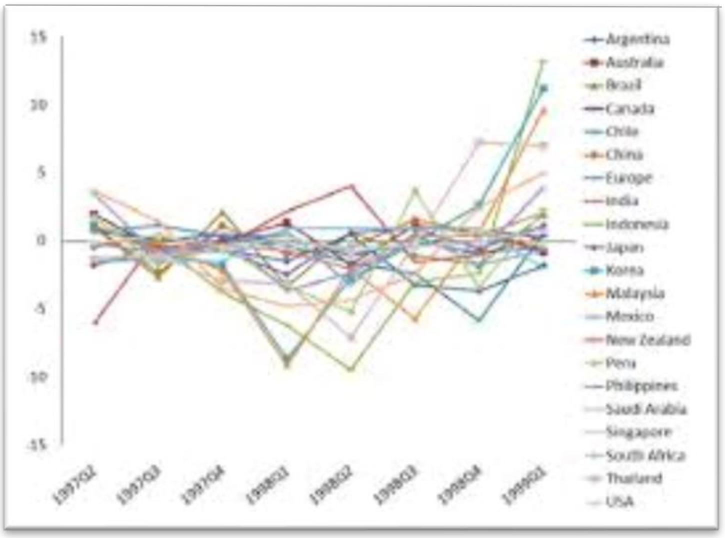


Figure 1. Growth Following the 1997/98 El Niño Episode

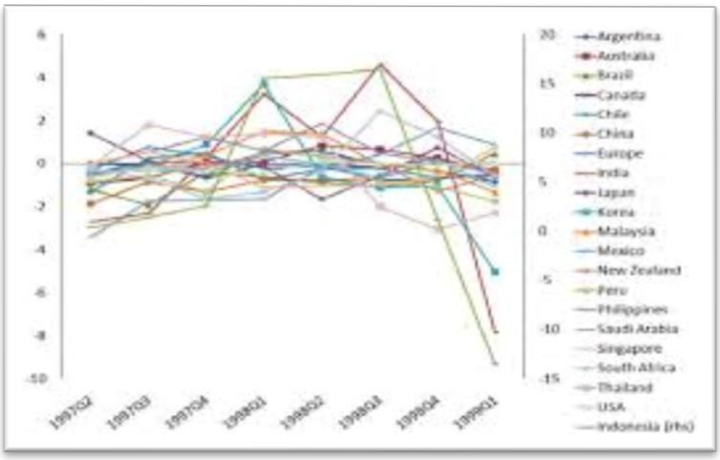


Figure 2: Inflation Following the 1997/98 El Niño Episode

South Africa

It is evident from various climate-macroeconomy studies that South Africa is amongst countries that faces a short-lived fall in economic activity in response to an El Niño shock.

Thus any present or future El Niño occurrence is likely to exacerbate the economic challenges that South Africa faces especially in the agricultural sector, a sector already impacted by high fuel prices and what pundits refer to as regulatory uncertainties brought by the land debate. In an International Monetary Fund working paper published by an economist from Cambridge University and two from the IMF titled “Fair weather or Foul? the Macroeconomic effects of El Niño”, researchers note that South Africa experiences hot and dry summers during an El Niño episode which has adverse effects on its agricultural production. On the economic front, empirical results suggest that South Africa always records a fall in GDP by 0:63% the third quarter after the El Niño. This is due to the impact of the El Niño on the primary sectors of agriculture, mining, forestry, fishing and quarrying. These sectors contribute about 10% to the economy from exports. As the export of these primary products is more than half the country ‘s general exports, the short-lived fall in economic activity due to El Niño immediately impacts negatively on the country ‘s balance of payments. These always has multiplier effects leading to higher inflation which then pushes interests rates up

South Africa experienced one of the worst occurrences of El Niño in 2015 when the United Nations Food Agency warned at the time that the phenomenon is “set to have a devastating impact on harvests and food security in Southern Africa”.

The World Meteorological Organization said in a statement that it does not expect the anticipated El Niño to be as powerful as the 2015-2016 event, but it will still have considerable impacts. In South Africa, the likely impact of the El Niño could be on food security and water collection amongst others with a rippling effect on the ailing economy as food inflation is likely to rocket. Though the current El-Niño is said to be not as severe as the previous one in 2015, its impact could also not be as short-lived as per usual due to an economy that is already in intensive care. The country experienced a technical recession in the second quarter of 2018 and still grapples with recovery.

In 2015 for example, El Niño brought on the worst drought to hit South Africa since 1982, with the government declaring five of the nine provinces drought disaster areas for agriculture.

In a separate study published in Geophysical Research Letters, a journal of the American Geophysical Union, researchers from the University of California, Santa Barbara found that the El Niño or its opposite would amplify changes to temperature, precipitation and wildfire risk. Thus in mid-July to August 2018, a series of large wildfires erupted across California, mostly in the northern part of the state, including the destructive Carr Fire and the Mendocino Complex Fire. In early August, a national disaster was declared in Northern California, due to the extensive wildfires burning there. These fires which were followed by the ones in early November became the most destructive and deadliest on record and claimed eighty-five lives and levelled over thirteen thousand residence

In Knysna, South Africa, fires which were fanned by 100 km winds, left several people dead, flattened over a thousand houses, destroyed plantations and burnt down over seventeen thousand hectares of fynbos and indigenous forests.

For a country with a massive unemployment rate of 26,7% and impending retrenchments at major parastatals such as Eskom, the SABC, the public service and elsewhere, the El Niño is likely to add fuel to our fire.

It is likely to also result in a job blood bath in the primary sectors which would compound the joblessness problem. Unemployment ticked up higher in the third quarter of 2018 according to Statistics South Africa, with export growth at its weakest.

Conclusion

From the macro-economic literature, it is evident that any future El Nino event would have a negative economic impact on the South African economy. These effects would differ from time to time depending on the prevailing economic circumstances at the time. As the adage puts it, Study the past if you will divine the future. The Mandarins and the population would benefit largely if such studies are taken into account for better future planning.

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FALLING ECONOMIES AND RISING TEMPERATURES

By Musiiwa Denga and Nokuthula Dhlamini

Both the South African Weather Service and the World Meteorological Organization agree on one thing: This period is likely to be the warmest on record. However, United States' withdrawal from the Paris agreement on climate change mitigation will in all likelihood have a major impact on temperatures across the globe.

There is strong scientific evidence that an increase in greenhouse gases, such as carbon dioxide and chlorofluorocarbons that are attributable to human activities, will result in global warming. According to the most recent temperature analysis by National Aeronautics and Space Administration (NASA)'s Goddard Institute for Space Studies, the global average temperature has increased by approximately 0.8 °C since the year 1880. The rate of warming since 1975 is almost double than that over the last 100 years (0.15 ± 0.03 °C vs 0.07 ± 0.02°C per decade). This is further supported by higher temperatures during 2015 and 2016, which set new global heat records since the start of regular measurements.

Further increases are projected during the end of the 21st century depending on plausible greenhouse gas concentrations, i.e. Representative Concentration Pathways. South Africa's average temperatures may plausibly be higher than the global average because temperatures are likely to rise at about 1.5 times the global rate of temperature increase.

Associated with change in global average temperature, is climate change that manifests itself by the change in duration, frequency, intensity, timing and spatial extent of weather and climate extremes. Weather and climate extremes can result in severe impacts on human and social systems that depend on the degree of exposure and vulnerability to that extreme. The Intergovernmental Panel on Climate Change places Africa among one of the most vulnerable continents in the world, mainly because African countries' economies strongly depend on climate sensitive sectors and the region has low technological capacity for adaptation to climate change.

The discussions on mitigating the effect of global warming and climate change through reducing the emission of greenhouse gases has been actively ongoing for the past three decades. The United Nations Framework Convention on Climate Change, in its first Conference of the Parties (COP) held in Berlin in 1995, introduced a tolerable global temperature window approach to limit global warming and climate change. The predefined threshold of 2 °C above the global average temperature during pre-industrial times attracted much attention and discussion at international climate conferences and negotiations aimed at avoiding dangerous climate change, and the Cancun Agreement was adopted in 2010 at the COP16. Half a decade later, a review progress was made towards a 2 °C target and the Paris Agreement, that was signed at the COP21, went further to strengthen the reduction of global warming by including the more ambitious 1.5 °C to ensure the risks and effects of global warming and climate change are reduced in the long term.

This agreement directs countries to plan and determine their means of mitigating global warming, with the developed countries such as Norway and Netherlands planning to ban new petrol and diesel cars by 2030 and requiring all cars to be emission-free by 2030. As an alternative, they are introducing electric trains. South Africa

towards the Paris Agreement in the Intended Nationally Determined Contribution (INDC). South Africa's footprint is visible in its dependence on coal-fired power plants and significant proportion of its liquid fuels generated from coal.

In light of the commitments made by South Africa in its INDC knowing that the Paris Agreement will be binding, fair, effective and incorporate a 'no-backsliding' to enhance climate change mitigation and adaptation implementation, one questions the commissioning of the Thabametsi and Khanyisa coal fire power stations.

Thabametsi (557 MW to be based near Lephalale, Limpopo) and Khanyisa (306 MW to be based near eMalahleni, Mpumalanga), which are set to be operational by December 2021, have been widely criticised for their contribution to greenhouse gas emissions. The Centre for Environmental Rights has indicated that the design of the power stations would result in greenhouse gas emissions 60% higher than that of Medupi and Kusile coal-powered stations, which are still under construction. This exacerbates the situation as South Africa is already one of the highest per capita greenhouse gas emitters in the world. South Africa's commitment under the Paris Agreement has thus been viewed as 'highly insufficient' to meet the global targets. Many have questioned the reasoning behind the commissioning of the power stations at a cost of R28 billion where alternative sources such as green electricity, solar energy, wind energy and ocean currents exist. These alternative sources will undoubtedly alleviate greenhouse gas emissions emitted by the country.
However, those in favour of the commissioning of the coal power stations have noted pertinent issues which cannot be overlooked. South Africa's INDCs must weigh development needs against climate change imperatives. South Africa faces the challenge of climate change as a developing country, with prevailing priorities to eliminate poverty and inequality. Eliminating poverty and inequalities requires job creation, sustainable economic growth, education, health and many other basic needs while taking into consideration South Africa's dependency on coal as well as aging and inefficient coal fire plants that are approaching the end of their life cycle. The commissioning of the two power stations with the latest technology is expected to inject R40 billion into the economy and create thousands of jobs.

As a developing country South Africa has an obligation to grow the economy and take full advantage of all opportunities to grow the economy whilst being cognisant of the terrible ramifications of political decision-making that is inconsistent with global aims of reducing emissions.

A strong balance is therefore required on the side of the political bureaucrats to ensure that the globe is less warm than expected and the economy is sound.

MEET THE AUTHORS

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Mr. Thabo Makgoale is a Research Scientist in the Climate Change and Variability research department at SAWS since 2015. His career involves exploring the theory of climate change and then goes into the question of predictability, cross scale relationships and feedbacks in the climate system, the tools and techniques of prediction, and translation of predictions into the user community including impacts and vulnerability analyses. He has been involved in national research projects focusing on impact of climate change on extreme weather events and water resources and participated in national and international science conferences. He has background in Climate Modelling, Climate Change & Predictability, Ocean Modelling, Ocean & Atmosphere Dynamics, and Marine Systems. He graduated with a BSc degree in Ocean and Atmospheric Sciences in 2012 at the University of Cape Town (UCT) and BSc (Hons) in Atmospheric Sciences in 2013 through Climate System Analysis Group – UCT. He is currently completing his MSc study at North West University (NWU) where he is focusing on investigating the sensitivity of southern Africa surface temperatures to aerosols using the NASA –GISS modelE and the CCAM GCM.

Dr. Andries Kruger

Dr. Andries Kruger is a Chief Scientist: Climate Data Analysis and Research in the Department: Climate Service of the South African Weather Service. His present and previous duties include the creation and writimg of general climate publications, climate change and variability research with historical data as input, ad hoc scientific projects of which the numbers have increased substantially in recent years, climate data and information requests, where advanced statistical analyses are required, drought monitoring, as well as assistance in the quality control of climate data. In 2001, Dr Kruger obtained a PhD (Civil Engineering) degree at the University of Stellenbosch, with research topic “Wind Climatology and Statitsics of South Africa relevant to the Design of the Build Environment”. Before that, he obtained an MSc (Environmental and Geographical Science) degree at the University of Cape Town. He published papers both locally and internationally, and authored a SAWS series of publications on the general climate of South Africa as well. He is widely recognised, both nationally and internationally, for his research, which mainly involves advanced statistical analyses and interpretation of historical climate data.

Ms. Mmathapelo Makgabutlane

Ms. Mmathapelo Makgabutlane is an operational weather forecaster. She completed her Honours in meteorology degree at the University of Pretoria in 2013, and has been based at the Cape Town Weather Office for 4 years. She has participated in a number of projects involving the training of others in various aspects of weather. Her particular area of interest is making weather information as accessible as possible to the people who need it, as well as presenting weather to users in a useful and practical way.

Mr. Sifiso Mbatha

Mr. Sifiso Mbatha is a Climate Service Scientist: Climate Data. He joined SAWS as an intern in 2015 and was employed in July 2016 under the same unit. He completed his BSC degree in Physics and Geography in 2013 and further obtained his Climatology Honors in 2014 from the University of Zululand. Sifiso is currently enrolled with the University of Venda for his Master's degree, modelling the variability of convective activity over East Rand South Africa.

Mr. Puseletso Mofokeng

Mr. Puseletso Mofokeng is a senior forecaster at the Disaster Risk Reduction Department of the South African Weather Service. His roles include overseeing the services which are being provided for the South African public and also generating extreme weather forecasts for all the 16 countries in the Southern Africa Development Community (SADC). Mr. Mofokeng enjoys writing and, in the recent past, he wrote about 40 columns and articles for various newspapers. Currently made a commitment to engage in rigorous masters' program at the University of Witwatersrand.

Mr. Sandile Ngwenya

Mr. Sandile Ngwenya is a Scientist in Climate Service: Climate Data at the South African Weather Service. He holds a BSc in Geography and Hydrology and a BSc Honors in Climatology. He is currently enrolled for MSc at the University of Venda. He joined the South African Weather Service in 2017. Before joining SAWS, he was a DST-NRF intern stationed at the University of Venda's Department of Geography and Geo-Information Sciences.

Ms. Tumi Phatudi

Ms. Phatudi is a Forecaster in the Aviation Weather Centre at OR Tambo International Airport. She studied BSc in Physics and Agrometeorology and BSc. Honours in Agrometeorology at the University of the Free State, Bloemfontein. She joined the South African Weather Service in 2015 as a forecasting student in the Regional Training Centre (RTC), Pretoria. She started working in Bloemfontein office in 2016 where she became an active supporter and contributor of SAWS social media.

Prof. Hannes Rautenbach

Prof. Hannes Rautenbach was appointed as Chief Scientist: Climate Change and Variability at SAWS in 2016. He graduated with a BSc degree in Meteorology in 1987 and obtained his PhD in Meteorology in 1999 at the University of Pretoria (UP). He served as a coordinator of the Meteorology Group at the University of Pretoria from 2003-2015, and became head of the Department of Geography, Geoinformatics and Meteorology (GGM) in 2006, a position that he held until 2014. During this period, he also served as Director: UP Water Institute between 2010-2014. Prof Rautenbach was also President of the South African Society for Atmospheric Sciences (SASAS) during 2005-2010, and still serves on the Board of the National Association of Clean Air (NACA). He served on various bodies that evaluate research and was leader of various research projects at, amongst others, the Water Research Commission (WRC) and the National Research Foundation (NRF). He has currently published more than 46 scientific papers in accredited science journals and presented more than 100 talks at national and international conferences. He is currently rated as a C2 scientist by the NRF. Prof. Rautenbach left the South African Weather Service at the end of 2018.

Mr. Lesiba Seshoka

Mr. Lesiba Seshoka is Senior Manager for Communications, Marketing and Stakeholder Relations at the South African Weather Service. He holds a Bachelor of Arts degree with majors in Communications and English, BA(HONS) in English Language and Literature and a Masters in Business Administration (MBA) in Marketing and Strategy from the University of South Africa. He is a final year Master of Laws (LLM) student at Nelson Mandela University and has edited and contributed extensively to dozens of publications including the accredited Nursing Research Journal Curationis, the Sunday Times, City Press as well as South Africa’s leading financial and investment magazine Finweek amongst others.

Mr. Hetisani Oscar Shiviti

Mr. Hetisani Oscar Shiviti is a junior forecaster at the Aviation Weather Center (AWC) at OR Tambo International Airport. He completed both his BSc and honours degrees in Meteorology at the University of Pretoria.

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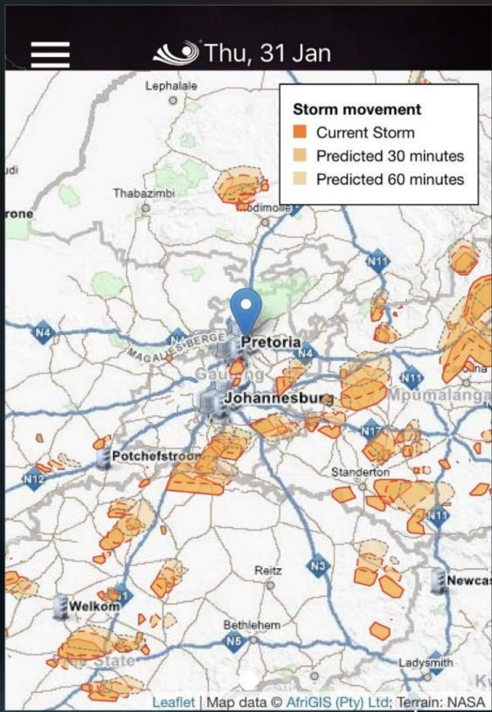

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Impact-Based Severe Weather Warning System

WHAT IS IMPACT-BASED FORECASTING?

Severe weather is a regular occurrence across South Africa which often negatively affects humans. Due to the vast distribution of vulnerabilities across the country, the same weather hazard can result in different impacts in two areas, depending on the specific vulnerability of the area.

Impact-Based warnings combine the level of impact the hazardous weather conditions expected with the level of likelihood of those impacts taking place

Moving from : → **To :**

What the weather will be: (Meteorological thresholds)	What the weather will do: (Impact Warnings)
- 50mm in 24 hours	- Roads flooded
- 35 knot winds	- Communities cut off

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