WEATHERSMART

NEWS

Scientific meteorological and climatological news from the South African Weather Service

February 2021

CLIMATE EXTREMES AND RECORDS IN THE NON-STATIONARY CLIMATE OF SOUTH AFRICA

SOUTH AFRICAN WEATHER SERVICE LAUNCHES THE REGIONAL WMO INTEGRTED GLOBAL OBSERVING SYSTEM CENTRE (RWC-SA) ON 9 FEBRUARY 2021

AVIATION FORECASTS AS A RESULT OF TROPICAL CYCLONE GUAMBE

South African Weather Service®

WEATHERSMART

NEWS

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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

What the weather will be:
(Meteorological thresholds)
- 50mm in 24 hours - 35 knot winds

To

What the weather will do:
(Impact Warnings)
- Roads flooded - Communities cut off

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Message by the Acting Chief Executive Officer

This is the sixth year of the South African Weather Service producing the bi-annual WeatherSMART newsletter, having been incepted in 2016. We are extremely proud that this initiative is still continuing.

As World Meteorological Day is celebrated annually all over the world by countries forming part of the World Meteorological Organization (WMO), a Specialised Agency of the United Nations, I thought it appropriate to give a short background on this day.

The WMO was established by means of the United Nations Convention on the World Meteorological Organization in 1950, as the successor of the International Meteorological Organization, created in 1873. WMO's mission is to support the countries of the world in providing meteorological and hydrological services to protect life and property from natural disasters related to weather, climate and water, to safeguard the environment, and to contribute to sustainable development.

Each year, the World Meteorological Day celebrations focus on a theme of topical interest. The theme for 2021 - *The ocean, our climate and weather* – celebrates WMO's focus in connecting the ocean, climate and weather within the Earth System. It also marks the launch of the United Nations Decade of Ocean Science for Sustainable Development (2021-2030), which will enable us to better understand the link between ocean, climate and weather, in order to help us understand the world in which we live in, including the impacts of climate change, and strengthen our ability to protect lives and property, reduce the risk of disaster, and maintain viable economies.

The global oceans cover 70% of the earth. They carry 90% of world trade, constitute one of the world's largest food sources, and host 40% of world's population along their coastlines. The oceans drive our weather and climate, producing frontal systems, modulating precipitation, and influencing storm tracks and intensities. With the oceans having taken up over 90 % of human-induced excess heat, they are critical natural assets in the mitigation of global climate change. The South African Weather Service monitors and forecasts the coastal ocean conditions around South Africa. It also conducts research toward better understanding coastal ocean systems to aid short-term decision making and long-term change management.

With Climate Change occurring at a rapid pace, its influence on our local weather systems, as well as over larger areas, require the South African Weather Service to be at top performance in terms of its service delivery. This newsletter touches on our ocean meteorological activities; Climate Extremes and Records in the Non-Stationary Climate of South Africa as well as the in the oceans, as well as recent severe weather events.

I hope you find this edition of the WeatherSMART scientific newsletter informative and enjoyable.

Mnikeli Ndabambi
Acting Chief Executive Officer

Doing our part to sustain ocean observations globally

by Tamaryn Morris

"If you like your weather forecast, thank an oceanographer"

Ocean observations are critically important not only for the continuous monitoring of ocean health and the resultant implications of climate change on these vast bodies of water, but also for use in weather and climate forecasting systems. Every day, thousands of instruments deployed within the global oceans are collecting and transmitting data to land-based stations for processing and dissemination to the Global Telecommunications System (GTS), and are used by various research and forecasting groups to produce global numerical weather predictions. These ocean data come from instruments such as moored surface expression buoys close to coastlines transmitting automatic weather station (AWS) data, from tide gauges, and commercial, sailing and research vessels equipped with data acquisition systems, both atmospheric and oceanographic, which are transmitting continuously along major shipping routes. Less well-known ocean observing systems include drifting buoys (www.aoml.noaa.gov/phod/gdp), tethered by sea anchors to the upper 15 m of the water column, which collect barometric pressure and sea surface temperature, and have recently been improved to collect wind speed and direction and wave parameters. Similarly, Argo floats (www.argo.ucsd.edu), autonomous ocean robots which collect temperature, salinity and pressure, profile the water column every ten days from depths of 2000 m to the surface. These free-floating ocean observing systems are not constricted by shipping lanes for data acquisition, thereby increasing the availability of data across the world's oceans to the GTS system.

The Southern Hemisphere is severely understudied owing to the reduced landmass and greater oceanic expanse when compared to the Northern Hemisphere, and the concentration of observing capacity in the Northern Hemisphere, due to the abundance of highly developed industrialised nations. That being said, South Africa is uniquely placed globally between three major ocean systems (Indian, Atlantic and Southern Oceans) and on our doorstep is the gateway for warm salty Indian Ocean water entering the cold fresh South Atlantic. This transport of water is critical for the Northern Hemisphere climate, which brings warmer conditions to the United Kingdom and Europe, without which they would exist in an almost perpetual freeze. The SAWS Marine team members are strongly involved with a number of the ocean observing platforms and the international panels that monitor and encourage these continued deployments globally. As such, we are ideally placed to assist with deploying ocean observing systems as part of our take-over and research cruises.

Photo 1: Bosun assisting with the deployment of a SOLO II Argo float from the stern of the SA Agulhas II. Photo credit: Lauren Smith

SAWS is not in a position to procure satellite-tracked drifters or Argo floats, given not only the costs of the infrastructure itself but also the satellite data time required. However, excellent working relationships exist between our team and the National Oceanic and Atmospheric Administration (NOAA), SOFAR Ocean (www.sofarocean.com), the UK Met Office, Euro-Argo, Woods Hole Oceanographic Institute (WHOI) and the Federal Maritime and Hydrographic Agency of Germany, all of whom sent observing platforms to South Africa for deployment in our oceans. On the Gough (September 2020) take-over cruise, six Argo floats and four satellite tracked surface drifters were deployed as the SA Agulhas II transited to Gough Island. This vessel track is critical to our own weather predictions, given that weather systems impacting the Western and Northern Cape develop in the South Atlantic and Southern Ocean.

In December 2020, the SA Agulhas II left Cape Town for Antarctica on the SANAE take-over cruise with 28 Argo floats, six satellite-tracked surface drifters and 15 SOFAR Ocean Spotter surface buoys, which collected wave height, along with wind speed and direction data, over and above tracking surface currents. Roughly half of these instruments were deployed on the southward leg of the take-over cruise, with the rest scheduled for deployment as the vessel makes its way back to Cape Town at the end of February 2021. Arguably, weather systems directly south of South Africa will not impact our country directly. However, they impact Marion Island, and the valuable data these observations acquire close to the Marginal Sea Ice Zone, and severely understudied Southern Ocean, input to our forecasts with regards our MetArea VII obligations.

Photo 2: Lauren Smith (SAWS), Asavela Somaxaka (SAWS) and Zinhle Shongwe (DEFF/SAWS) preparing a satellite tracked surface drifter for deployment. Photo credit: Lauren Smith

Photo 3: Lauren Smith (SAWS) and Zinhle Shongwe (DEFF/SAWS) deploying the satellite tracked surface drifter from the stern of the vessel. Photo credit: Lauren Smith

Photo 4: Thando Mazomba (UCT), Menthiam Sebesho (SAWS) and Kelcey Maewashe (UCT) preparing an NKE Argo float for deployment. Photo credit: Kelcey Maewashe

Captain Craig McLean, NOAA's Acting Chief Scientist, said it best during his opening address at the OceanObs '19 conference, "If you like your weather forecast, thank an oceanographer". Understanding the oceans surrounding South Africa, and indeed the full extent of MetArea VII region which is our responsibility, is critical to the work we do at the SAWS. One of the ways in which we do this is to collaborate with international teams, along with DEFF Antarctica and Islands, to deploy ocean observing systems, as far and as wide as possible.

This work has been made possible with the deployment assistance of the scientific teams involved with the Gough 2020 and SANAE 2020/2021 teams, along with the Captain, officers and crew of the SA Agulhas II.

Climate Extremes and Records in the Non-Stationary Climate of South Africa

by Charlotte McBride and Andries Kruger

Department: Climate Service

1. Introduction

The Department: Climate Services recently embarked on detailed research on the prevalence and likelihood of new weather records, specifically daily maximum and minimum temperature and rainfall. This research was firstly triggered by the increasing number of enquiries with regards to the perceived increase in record-breaking temperatures and precipitation amounts measured by the SAWS observation network. An in-depth study of the perceived increase in climate records has not been conducted in South Africa and therefore a scientifically validated answer to these questions was not possible.

It is a well-established fact that global warming and associated climate change has had significant local effects in many regions of the world (IPCC, 2013). While most regions experienced significant warming since the Industrial Revolution due to the increased concentrations of greenhouse gases in the atmosphere, the warming atmosphere has also brought about observable changes in the mean state of other climate parameters, such as precipitation. Therefore, it can be accepted that the climate is in a non-stationary state, with associated changes in its mean state as well as an increase in the probabilities of extremes to occur. In a warming world it can be assumed that warm or hot extremes in surface temperature will become more frequent, while cool or cold extremes less so. The same argument applies to observed shifts in precipitation, where negative trends in precipitation could enhance the probability of increased frequencies of dry periods and prolonged droughts. Long-term increases in precipitation can have the opposite effect, where there can be an enhanced probability for floods to occur.

Most of the above observations have been well-researched and documented e.g. in the USA (Meehl et al. 2016 & Meehl et al. 2009), China (Zhang et al. 2016 & Pan et al. 2013) and Australia (Alexander & Arblaster 2017). However, trends in weather and climate extremes have not been properly investigated in South Africa. South Africa is in the fortunate position that it does have reliable observed data sets going back to the early 20th century and thus using these observed data could shed light on trends in extreme values. The ability to understand extremes and the implications of these in the future rest on our ability to document and understand these changes in extremes from direct observations (Zwiers et al 2013).

Cooley (2013) makes the point that changes in the mean temperature record do not show a linear pattern in the occurrence of extremes but rather have shown “periods of rapid increases followed by plateaus”. It would be important to determine if this holds true for South Africa and if the pattern is similar for both temperature and precipitation. This understanding of possible variability of the occurrence of extreme weather conditions over time is important to investigate, as society may find it more difficult to adapt to nonlinear trends rather than coping with just an altered mean condition (Rahmstorf & Coumou 2011).

One can show that the inclusion of a small number of new extremes or climate record-breaking values in a long-term climate series can change the estimated values of the associated extreme value distribution parameters. These will in some instances result in an appreciable broadening of the extreme tails of the distribution. Such changes, especially where they increasingly occur due to a non-stationary climate, enhance the theoretical probability of extreme values to occur. The application of extreme value distributions, used to estimate the probability of extremes over long time periods, are integral to long-term planning to adapt to and mitigate for extreme climate events e.g. design values for the built environment.

A better understanding of the possible long-term changes in the distribution parameters could assist the industry in adjusting to possible changes in occurrence and intensity of extreme events.

In addition to the above, there is not a coherent picture in terms of the seasonal distribution of changes in frequency and intensity of extreme events (Tabari & Willems 2018). Work by Sen Roy and Rouault in 2013 did consider the spatial patterns of season extreme hourly precipitation across South Africa but the data sets used were for a limited period of 1998 to 2007. The understanding from a seasonal point of view could also be explored from a spatial perspective as changes are in most cases region-specific. This spatial understanding is important when taking decisions and conducting risk assessments (AghaKouchak, Sellars & Sorooshian 2013).

In understanding changes or variability in extreme events policymakers, disaster managers, famers and developers of infrastructure, to name a few, can be in a better position to allocate resources to adapt and mitigate against the effect of these extremes on society. Up to now decisions made in understanding the effects of extremes have largely been made using historical data in a stable climate (Balov & Altunkaynak 2019). However, due to climate change the assumption of a stationary climate could lead to significant underestimations of risk. Thus, the main reason to study extremes is to understand them and then manage the consequent risks in order that adaptive strategies can be meaningful (Sura 2013).

Following on the above, it is widely acknowledged that adaptation measures to climate change should take into account the increase in climate extremes that could increasingly test the abilities of socio-economic sectors to absorb the impacts of climate and weather extremes. Therefore the research will assist to quantify the changes in the probabilities of extremes to occur, which will in turn assist the planning of adaptation measures to climate change.

2. Specific objectives of the research

The main objective of the research is to determine whether there are historical and projected changes in the occurrence of climate extremes and records and the probable effects of these changes on relevant socio-economic sectors. This objective can be subdivided into the following aims or research questions:

- Are there observed changes in climate extremes, and how do the definitions of climate extremes and climate extreme indices affect the assessment of climate change?
- Following on the above, are there any trends in new climate records?
- Are there any historical and future changes in the probabilities of extreme climate occurrences?
- Are there spatial differences in terms of the trends in frequency and intensity of extreme events considering South Africa's complex climatology and can these differences be regionalised?
- Are there possible effects of future changes in the prevalence of climate extremes to selected socio-economic sectors?

3. First results

The research commenced with the analysis of trends in daily maximum and minimum temperature records. We looked at the temporal and spatial distribution of the frequency of breaking highest and lowest daily maximum and minimum temperature records over the period of 1951 to 2019 for 25 weather stations over South Africa. In a climate that is stationary (non-changing over the long-term) we would expect the probability to measure a record temperature for a specific day in the year as $1/n$ where n is the year since recording began. It became apparent, especially in the last decade since 2010, that high temperature records were broken more frequently than expected, while low temperature records were broken less frequently. The ratio of highest maximum to lowest minimum temperature records was almost an equal 1:1 ratio near the start of the analysis period, but it increased substantially in the latter years at all the weather stations, as shown in Figure 1.

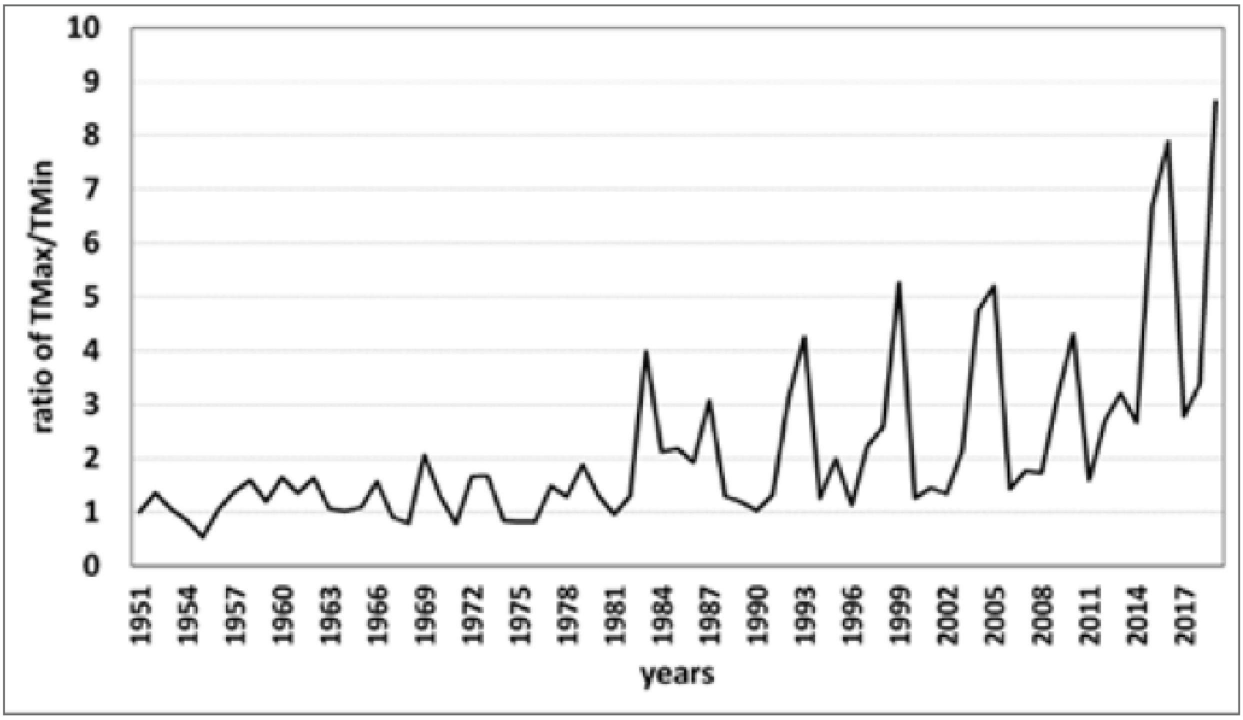

Figure 1: Ratio of high Tmax to low Tmin records for all 25 weather stations for the period 1951 to 2019.

Figure 2 presents the actual number of records for highest and lowest maximum and minimum temperatures compared to what is expected in a stationary climate.

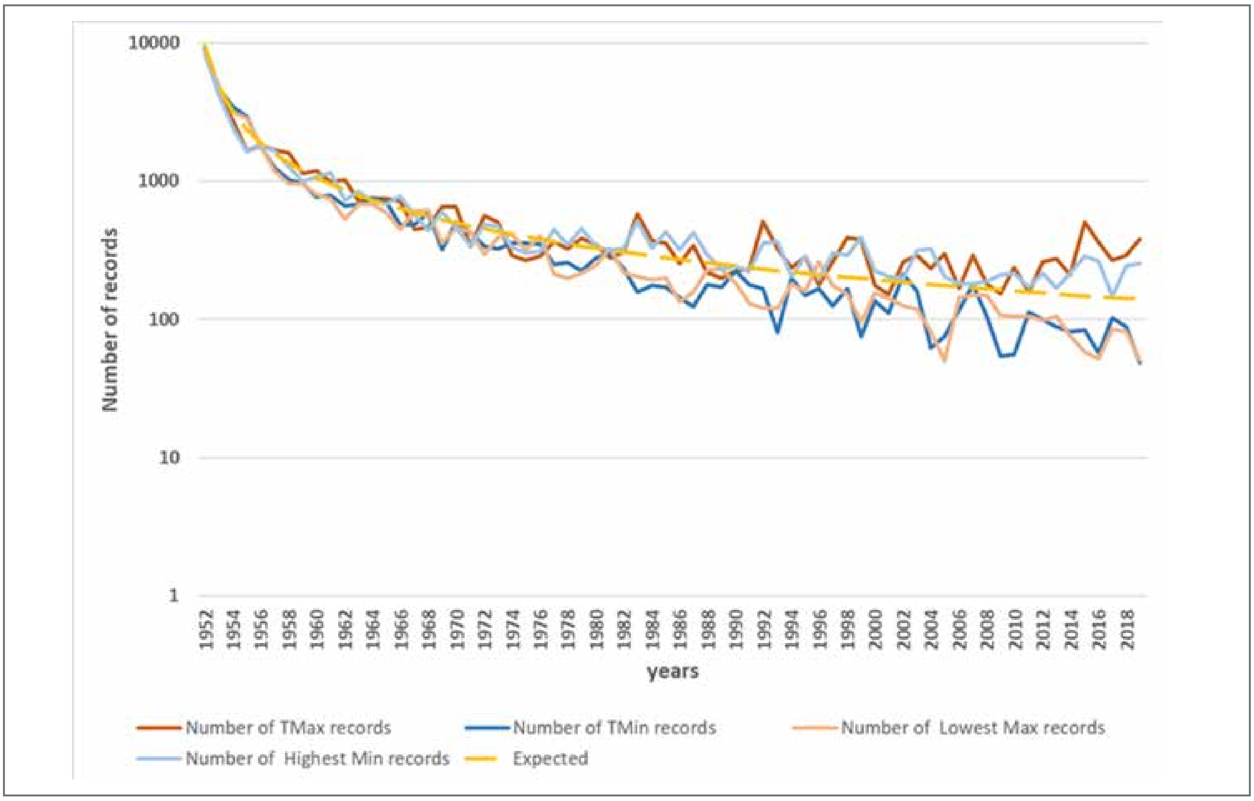

Figure 2. Temperature records for 25 stations over South Africa from 1951 to 2019. Yellow dashed line is the expected number of records 1/*n* in a stationary climate, high Tmax: dark orange, low Tmax: light orange, low Tmin: dark blue and high Tmin: light blue.

Previous researchers, e.g. Werner and Krug (2010) recognised that the estimation of the expected number of records should take into account the warming trend due to climate change. So, instead of an expected probability of $1/n$ in a stationary climate, the probability of measuring a temperature record takes into account the warming trend by the addition of a "warming term" as follows:

$$P_n \approx \frac{1}{n} + \frac{v}{\sigma}\frac{2\sqrt{\pi}}{e^2}\sqrt{\ln\left(\frac{n^2}{8\pi}\right)} \qquad (1)$$

where n is the number of years, v = mean temperature trend and σ = standard deviation, π = Pi and e = Euler–Mascheroni constant. The first term $1/n$ is the theoretical expected number of records in a stationary climate, the next expression after the addition sign is defined as the trend term or "warming term" (Wergen and Krug, 2010). When there is no trend (stationary climate) v = 0. We know that South Africa did not warm uniformly due to climate change and that some regions experienced more warming than others. Therefore, the "warming term" will be unique for a specific station. As an example, Figure 3 presents the expected number of daily maximum temperature records over the period 2010 to 2019. It is evident that more records are expected to occur over especially the central and western interior.

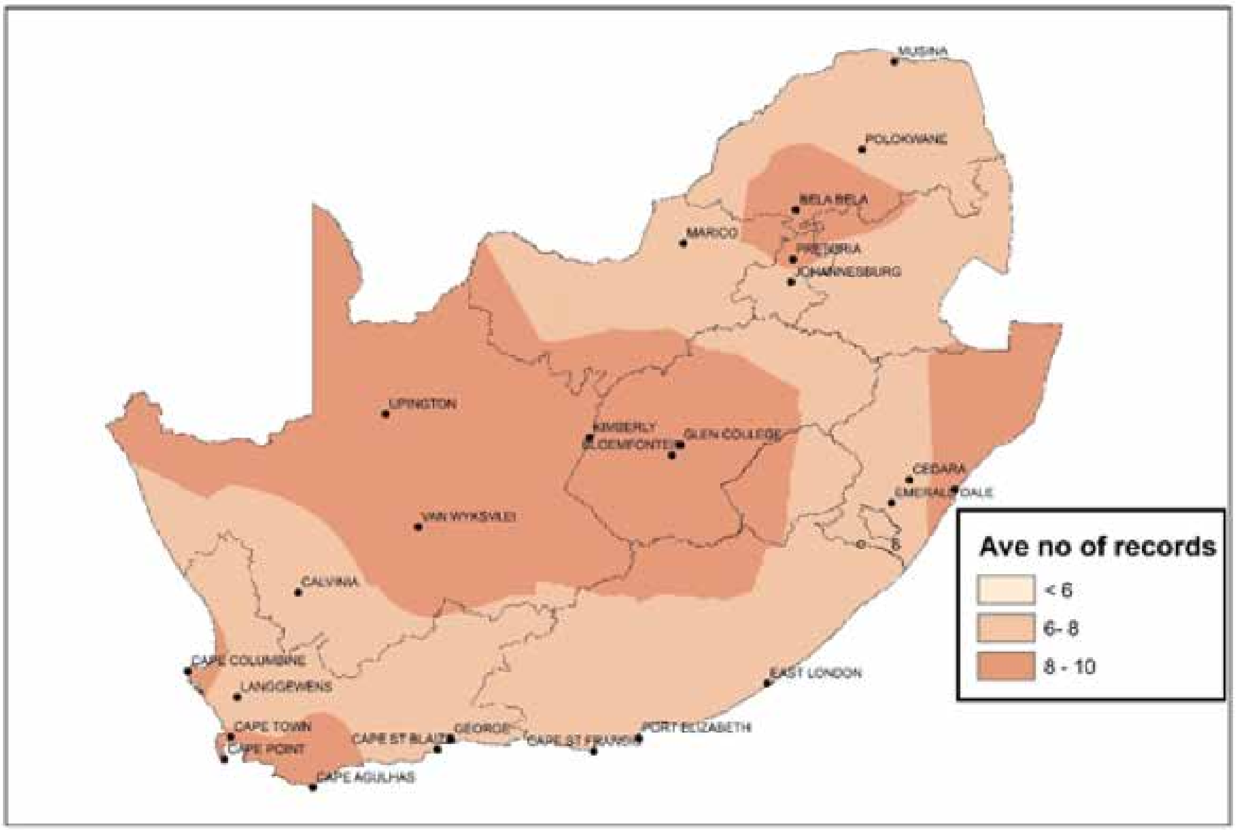

Figure 3: Spatial distribution of the annual average number of expected high daily maximum temperatures records with warming trend considered for period 2010 to 2019.

However, even taking the long-term increase in maximum temperatures into account, the observed number of records far exceed the expected. Figure 4 presents the actual average number of observed maximum temperature records per year for the period 2010 to 2019. Over the central interior, where eight to ten records are expected due to warming, more than 20 were recorded in places.

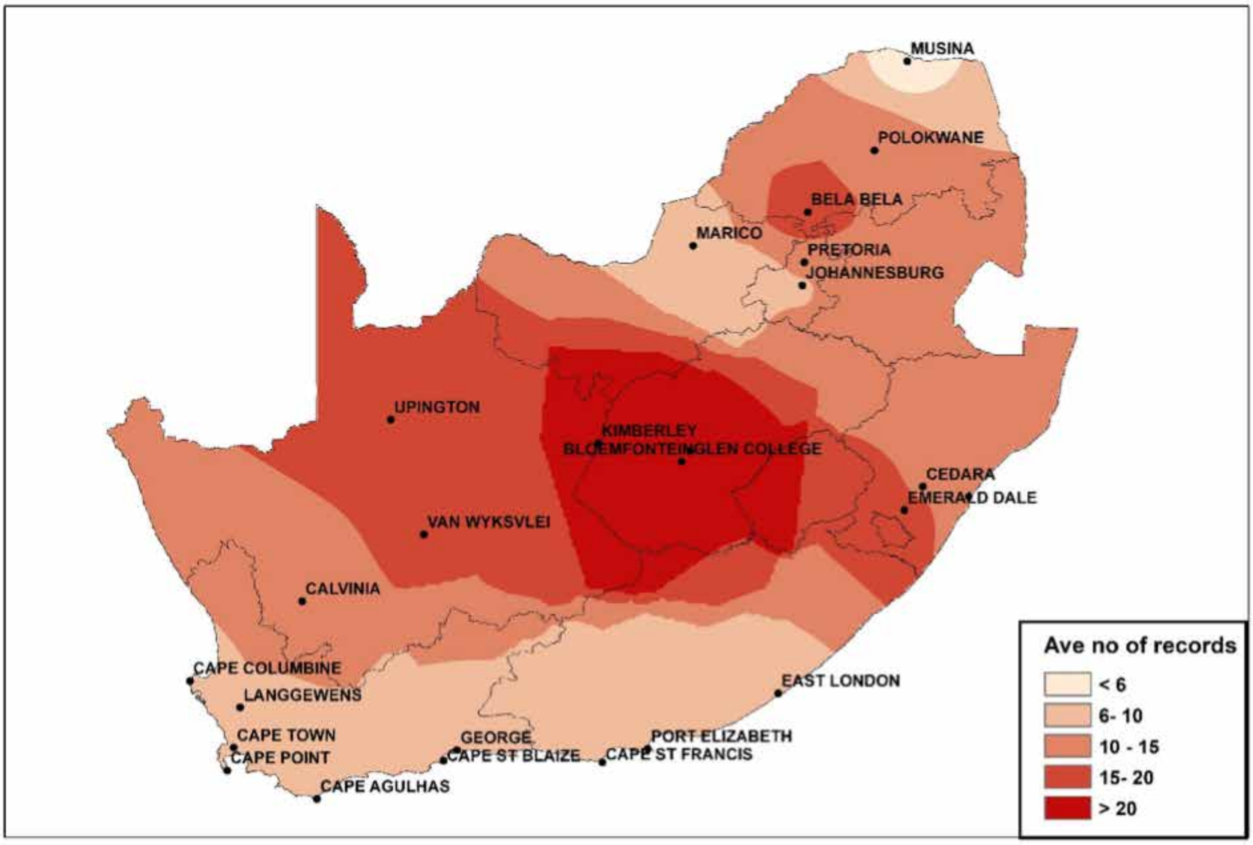

Figure 4: Spatial distribution of the annual average number of observed maximum temperature records for the period 2010 to 2019.

This observation that, even taking the long-term warming trend into account, the observed number of daily maximum temperature records far exceeded the expected, warranted further investigation. One of these were to investigate whether the increases in temperatures since 1951 were near-constant or accelerating. This research led to the conclusion that the higher-than expected number of records were indeed due to an increase in the warming trend (i.e. acceleration in warming). Figure 4 shows that the 30-year mean trend in the annual average maximum temperature has increased since 1951. The 1951 – 1980 trend was about 0.1 °C/decade and increased to more than 0.3°C/decade in the last decade. This will of course have a bearing on the validity of equation (1), which only considers the mean trend over the whole analysis period.

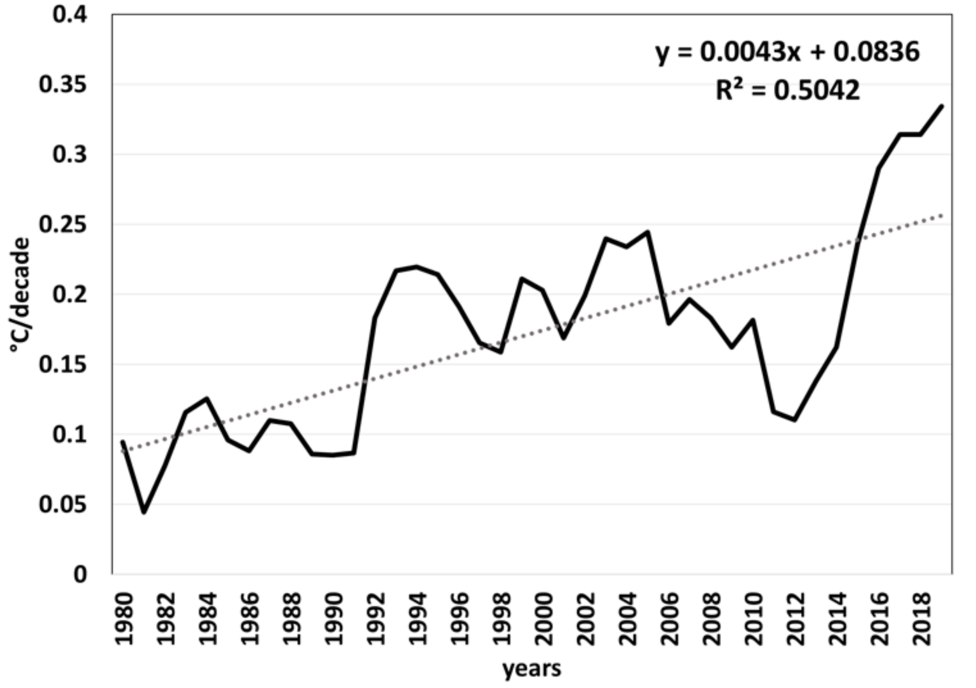

Figure 5: Linear trend of the 30-year trend of annual average maximum temperature with window centred on the 30 following years, e.g. the first value, for 1951, represents the linear trend over the period 1951 – 1980 and the last value for 1989, the linear trend over the period 1989 - 2019. An increase indicates acceleration in warming.

We therefore deduce that the higher than expected numbers of high maximum temperature records in the latter part of the analysis period were probably due to an acceleration of the general warming trend. An additional observation is that spikes in annual record counts mostly occurred in El Niño years, contributing to the occurrence of anomalously high numbers of maximum temperature records over South Africa. Figure 6 shows that during El Nino years, quite often a much higher number of maximum temperature records are broken. These record-breaking temperatures seem to clearly contribute to the general higher-than-expected frequencies of records since the mid-1980s.

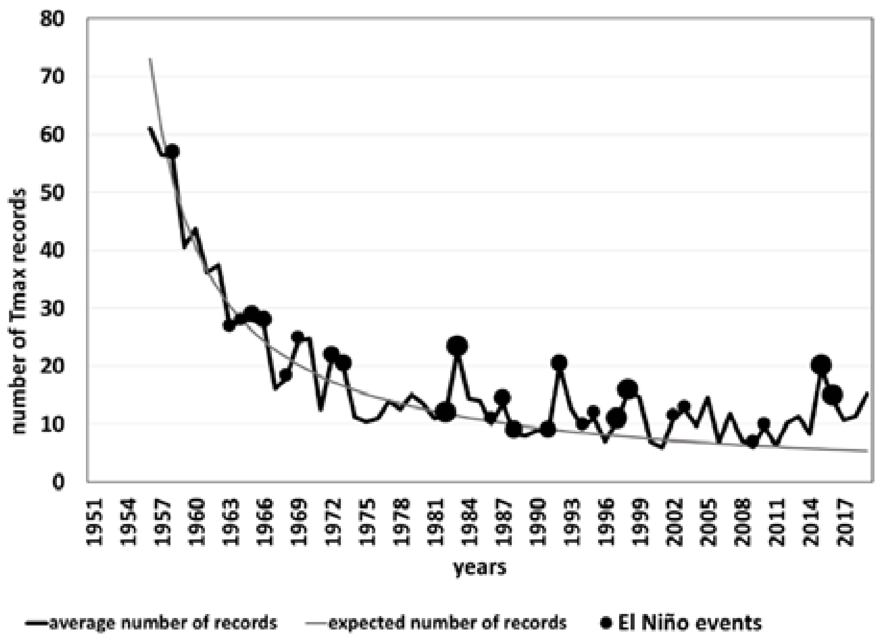

Figure 6: Average number of maximum temperature records for all stations per year for 1951 to 2019. The black line is the expected number of records in a non-stationary climate. Black dots indicate El Niño year (size of dot indicate strength of the event).

4. Conclusion and way forward

From the initial analysis it became evident that even taking the general warming into account due to climate change, many more temperature records are broken than expected. Warming over South Africa is accelerating and this means that, in all probability, high temperature records will be broken at a higher than expected rate. The results warrant an investigation into how El Niño events will contribute to high temperature records in future, what the temperature trends are predicted to be in the near and far future and what the effects of these relatively frequent record-breaking temperatures will be in relevant socio-economic sectors, e.g. health and agriculture.

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Determining the type of severe thunderstorm that developed north-west of Bram Fischer International Airport, Bloemfontein on 20 January 2021

by Elani Heyneke and Tshifhiwa Ravele

A severe thunderstorm is a thunderstorm that produces large hail or a large amount of small hail, tornadoes, strong, damaging winds and/or heavy downpours that lead to flooding. The impacts associated with severe thunderstorms can range from minor (localized damage) to significant (damage over a larger area/ urban area) and all depend on the size, region where it occurs, longevity and severity of the thunderstorm. Environmental factors associated with severe thunderstorms are: exceptional instability, sufficient moisture, unsaturated/dry air in the mid-levels, vertical wind shear and steep low-level lapse rate to name a few. Although severe thunderstorms are well-known and there is a broad knowledge of what causes and contributes to them forming, there are still types of severe thunderstorms that require further study. Pulse severe thunderstorms are one of these, therefore, this case study will be beneficial to the meteorology community of South Africa.

Classification of a severe thunderstorm

Severe thunderstorms can be classified as pulse severe and multicell thunderstorms, supercells, or a mesoscale convective system (MCS) which contains squall lines. The classification is determined by the size of the thunderstorm on radar as well as the shearing environment as seen in Figure 1. Supercells are thunderstorms that have a rotating updraft (mesocyclone) as well as a downdraft and the severe thunderstorm can sustain itself for hours, causing localized damage as it moves. Squall lines are well organised, connected thunderstorms that can have a large spatial scale and produces a gust front; therefore, this type of severe thunderstorms can cause widespread damage. Pulse severe and multicell thunderstorms are isolated thunderstorms that produce severe weather for a brief period of time, but since these types of severe thunderstorms are usually slow-moving or

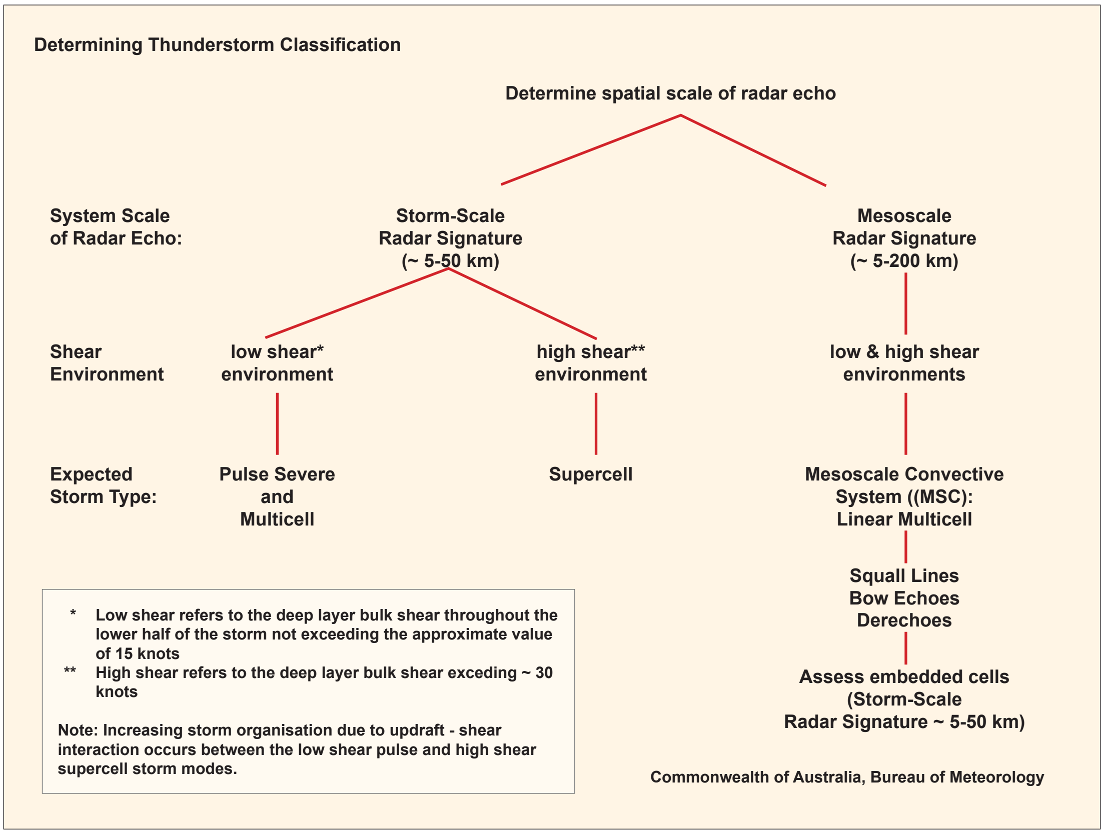

Figure 1: A decision tree to determine the classification of a thunderstorm. Source: MetEd

keep on redeveloping, localized damage could be caused. Weather forecasters look at the following atmospheric factors to determine whether there is a possibility of severe thunderstorms: Total of total values greater than 50; K-index values greater than 35; Showalter index less than –3; surface CAPE values greater than 250; directional and speed shearing; sufficient moisture throughout the atmosphere and a trigger mechanism. Supercells and squall lines usually develop in these types of atmospheric conditions. On the other hand, pulse severe thunderstorms are more difficult to forecast, because they develop in a weakly sheared environment and therefore do not meet the minimum requirements set out for forecasting severe thunderstorms.

Case study

During the afternoon of 20 January 2021, a severe thunderstorm developed north-west of the Bram Fischer International Airport, Bloemfontein. This thunderstorm resulted in damage to houses and caused trees to break and produced heavy downpour which led to localized flooding. The purpose of this case study is to determine the type of severe thunderstorm and the meteorological factors that contributed to its development. Further investigation will be done by making use of satellite and radar data, numerical model data, and synoptic data and well as the impacts that occurred.

Study Area

Bloemfontein is the capital of the Free State, which is the central province of South Africa, and is situated in the central parts as seen in Figure 2. The Free State is an agricultural province, but Bloemfontein is the exception, with a population of 567,000. Bram Fischer International Airport is situated west of Bloemfontein and the study area is north-east of the airport as seen in Figure 2.

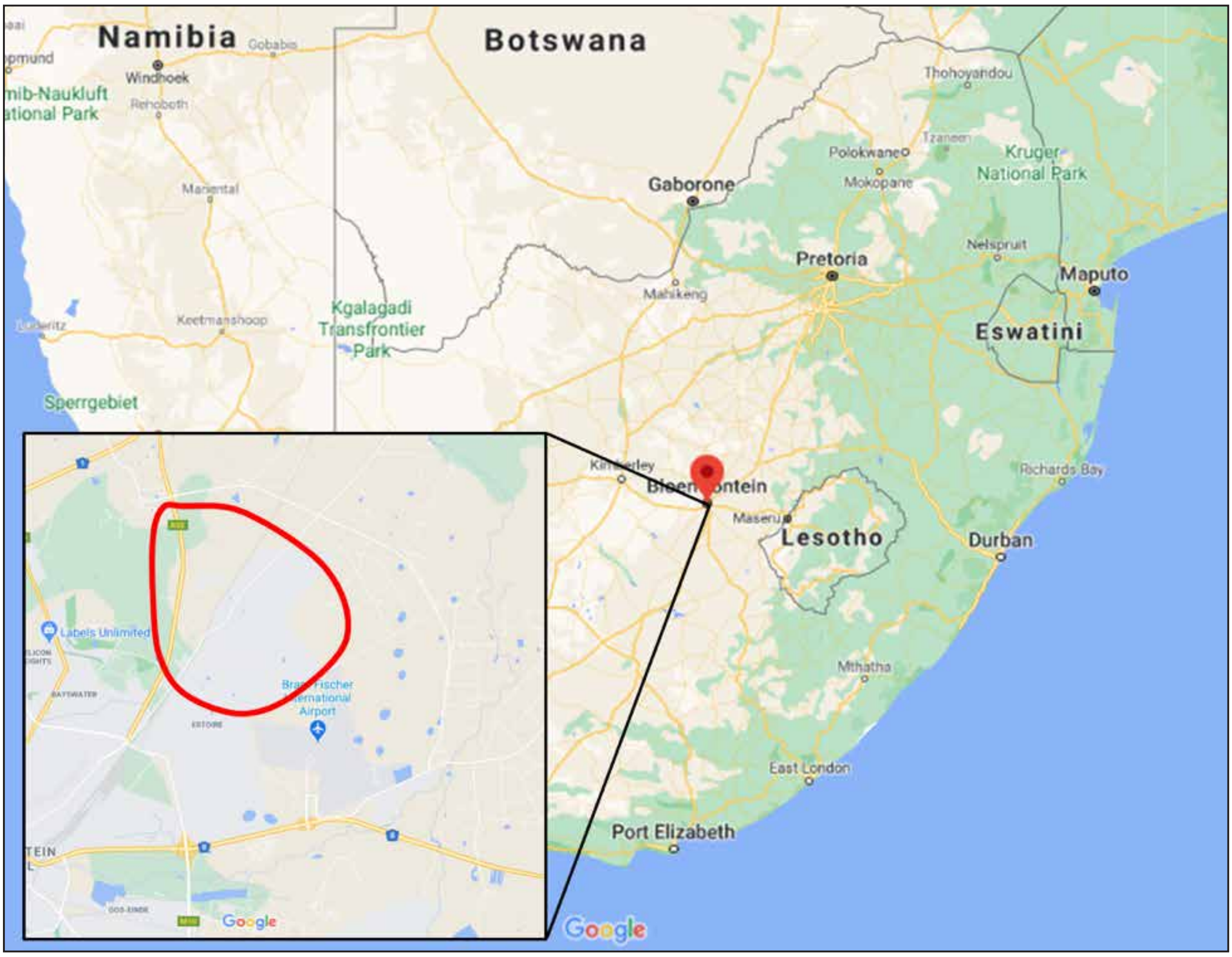

Figure 2: Location map of Bloemfontein, Free State with the focus area being Bram Fischer International Airport. Source: Google Maps.

Synoptic data

On 20 January 2021, there was a surface high pressure system over the eastern parts of South Africa as well as a surface trough over the western parts. Good surface convergence was present between the weather stations that are located at the city centre of Bloemfontein and at the Bram Fischer International Airport as seen in Figure 3.

Numerical model data

It is necessary to determine if the model data is evaluating well with the real-time data, which, in turn will determine if the model data can be trusted or not. Therefore, certain synoptic parameters were compared with that of the Unified Model SA4, which has a resolution of 4 km and is the numerical weather model that is run in-house at the South African Weather Service.

Comparing the 10 m winds at Bethlehem and at Bloemfontein by making use of Figure 3 and Figure 4, the winds over Bethlehem and Bloemfontein City evaluated well. Even though the 10 m winds at Bram Fischer International Airport do not seem to be reflected in the model data, which can be due to a local effect. But the model data can still be trusted and used for further investigation.

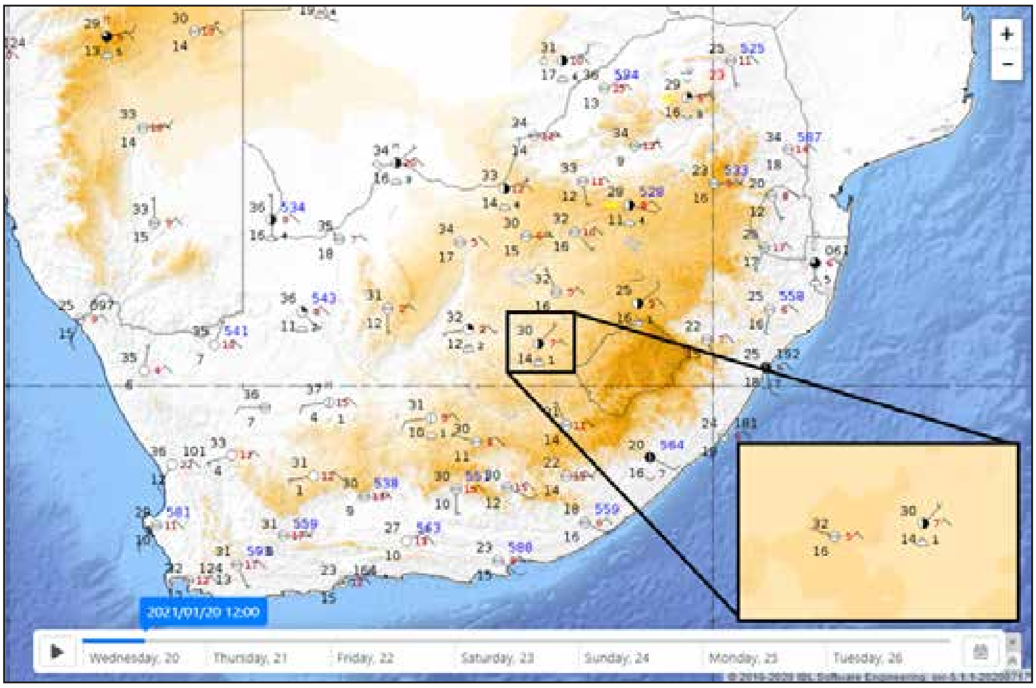

Figure 3: Synoptic chart of South Africa valid for 20 January 2021 at 12:00Z (+2 hours for SAST). Source: Eumetrain.

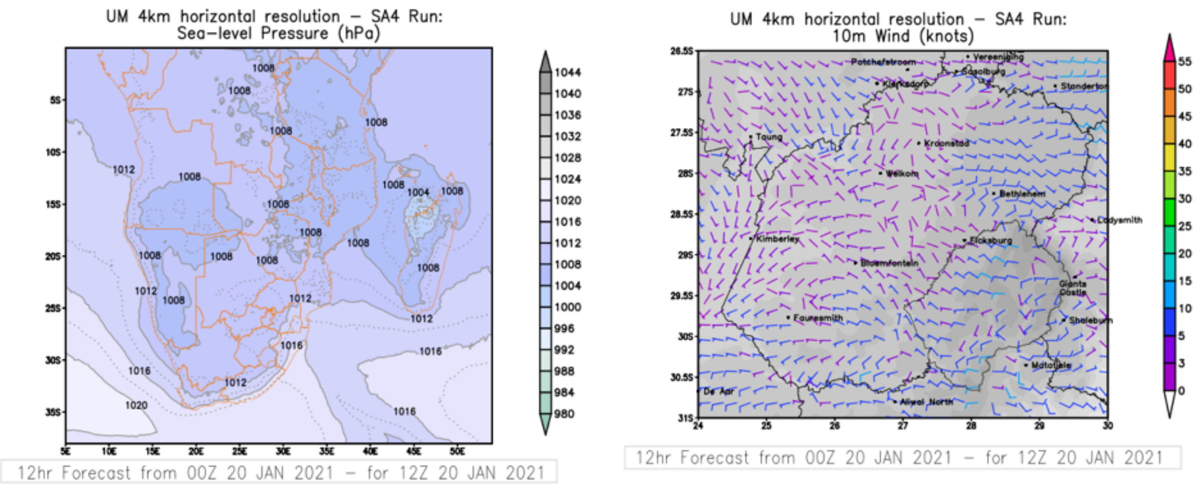

Figure 4: Sea-level Pressure (hPa) left and 10m wind (knots) right valid for 20 January 2021 at 12:00Z. Source: SAWS.

Instability is an important ingredient for thunderstorms to develop, therefore the following parameters were consulted: the K-index, the Total of Totals, the surface CAPE and the dryline, which will determine whether there was a trigger for the thunderstorms to develop which is another necessary ingredient. Referring to Figure 5, the K-index was above 40, the Total of Totals close to 50, the surface CAPE around about 400 and the dryline was situated west of Bloemfontein. These are all indications that there is a possibility of thunderstorms with some of the parameters having thresholds that can warrant severe thunderstorms.

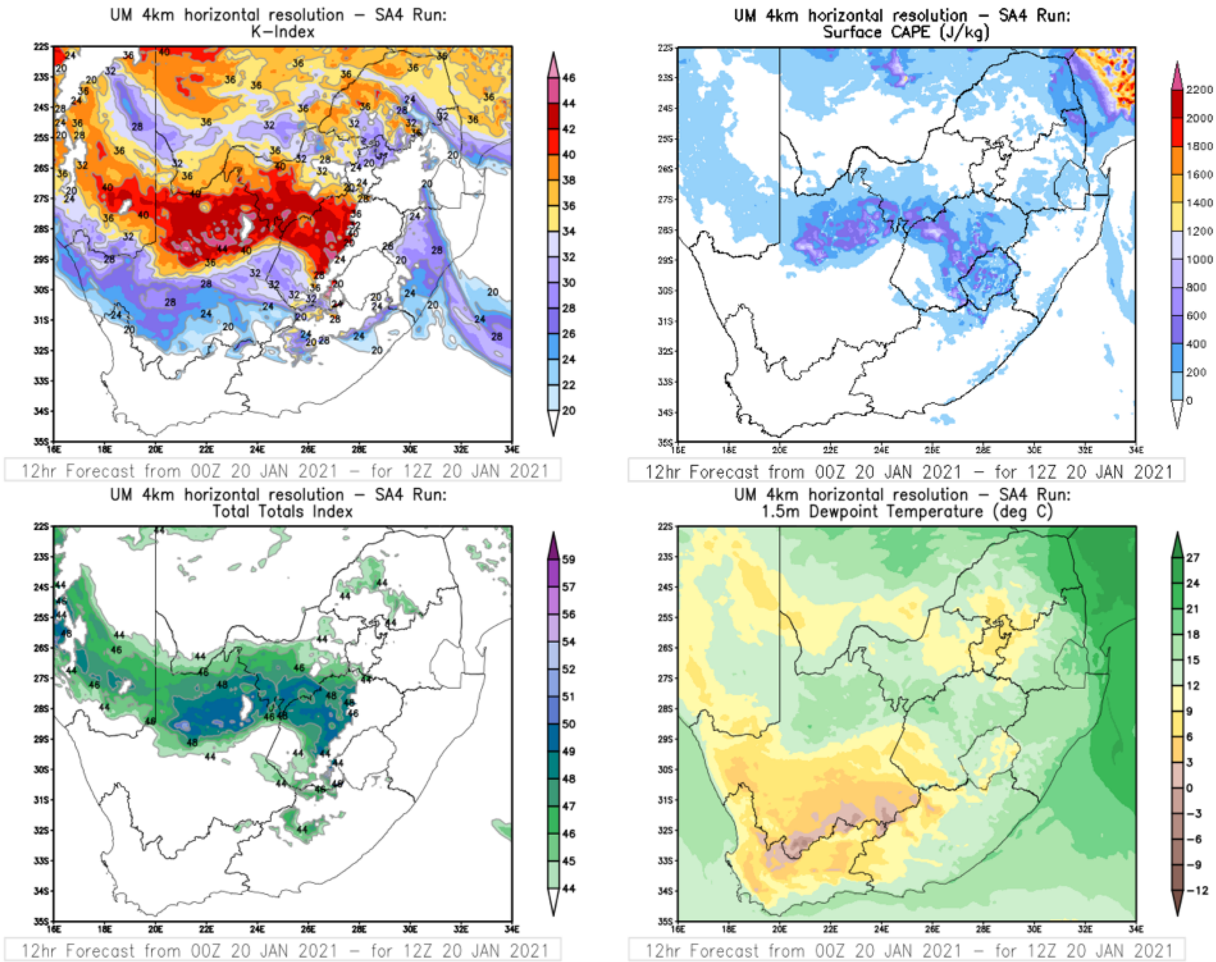

Figure 5: K-Index, surface CAPE, Total of Totals and Storm motion vector valid for 20 January 2021 at 12:00Z. Source: SAWS.

Thunderstorms cannot develop if there is not enough moisture in the lower, middle and upper levels of the atmosphere. Referring to Figure 6, there was enough moisture throughout the atmosphere to warrant a 30% chance of thunderstorms to develop near and east of Bloemfontein on 20 January 2021. The next step in forecasting thunderstorms is to determine if there is a possibility of severe thunderstorms.

A strong shearing environment is one of the atmospheric conditions that a weather forecaster looks at to determine if severe thunderstorms are possible. The ideal wind direction and speed at 850 hPa is a north-easterly wind of about 5 to 10 knots, a northerly wind of 15 to 20 knots at 700 hPa and, at 500 hPa, a north-westerly wind of 30 knots and stronger. Referring to Figure 7, there was weak speed shearing, but no directional shearing. Therefore, it was a weak shearing environment, rather than a strong one. The steering winds for the anticipated thunderstorms were also weak with a speed of 20 to 30 km/h, which is classified as slow-moving thunderstorms.

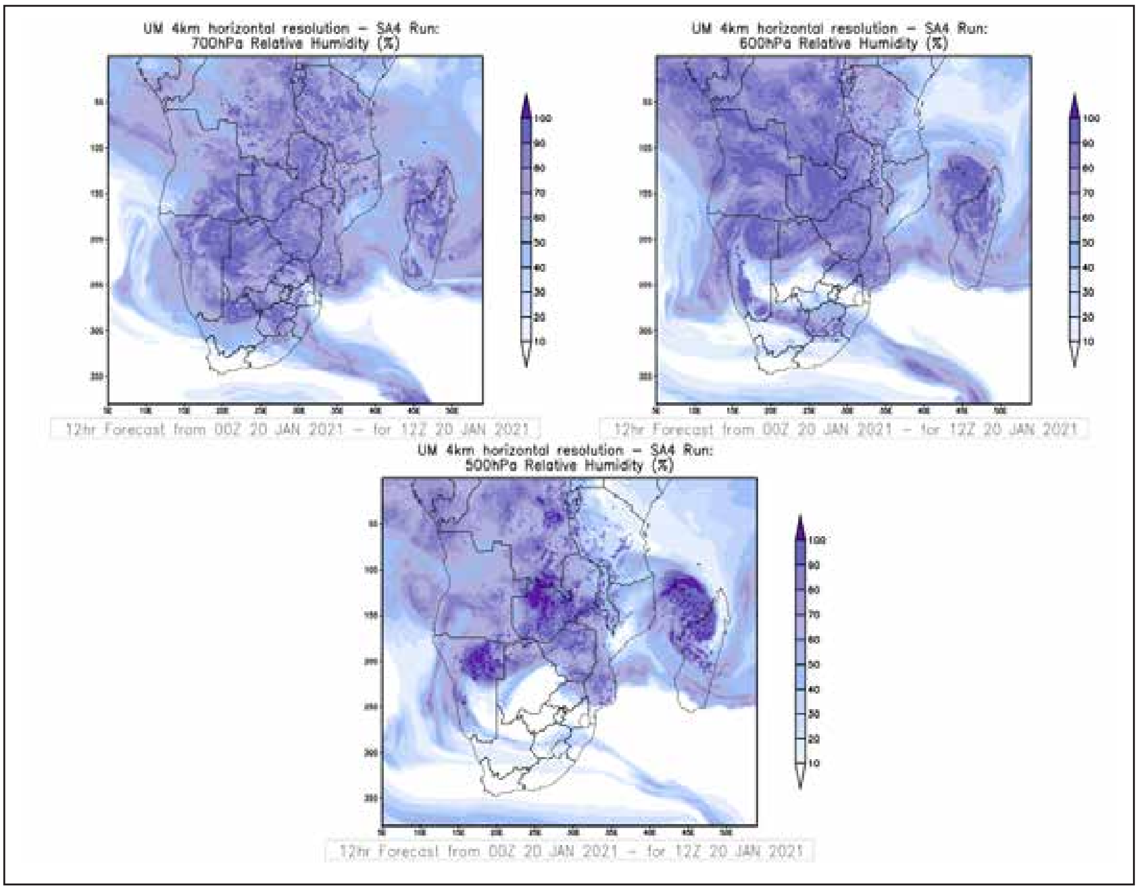

Figure 6: Relative humidity at 700, 600 and 500 hPa valid for 20 January 2021 at 12:00Z. Source: SAWS.

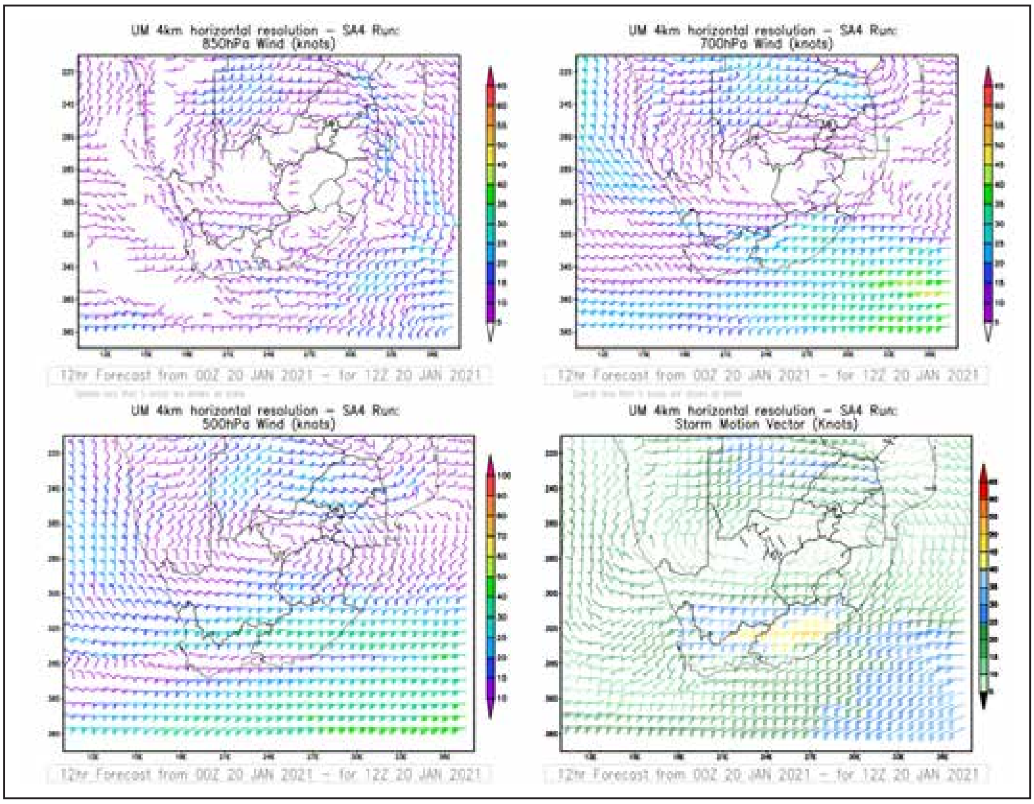

Figure 7: 850, 700 and 500 hPa winds as well as the storm motion vector (the speed and direction of the thunderstorm) valid for 20 January 2021 at 12:00Z. Source: SAWS.

Satellite and radar data

Radar is one of the tools used by weather forecasters to detect thunderstorms and their severity as well as their movement and speed. Satellite images are also useful for determining the severity of a thunderstorm, especially in regions where there is no radar coverage. It is also important to consider the type of shearing environment when a possible severe thunderstorm is spotted on the radar and satellite.

On 20 January 2021, around about 14:00Z, a thunderstorm was affecting the aerodrome of the Bram Fischer International Airport. An overshooting top can be seen on the radar cross section in Figure 8 as well as on the Overshooting Tops RGB. Since the shearing environment was weak, it could be either a pulse severe thunderstorm or a multicell. To spot a pulse severe thunderstorm on radar, one would look for high reflectivity of 50 dBZ and greater, a strong updraft, an overshooting top, and/or mid-altitude radial convergence that usually last for about 20 minutes. On satellite images, one would also look for a dome-like protrusion above the storm, using the visual channels, or by making use of the Overshooting Tops RGB where bright white areas within a thunderstorm are where the overshooting top would be located. This indicates that there is a strong updraft and can potentially be a severe thunderstorm developing. It is noteworthy to mention that there is a displacement issue with satellite images, the further the location is from the equator, due to the curvature of the earth. This is prominent on the Overshooting Tops RGB image in Figure 8 when comparing the position of the severe thunderstorm on the radar image with that on the satellite image.

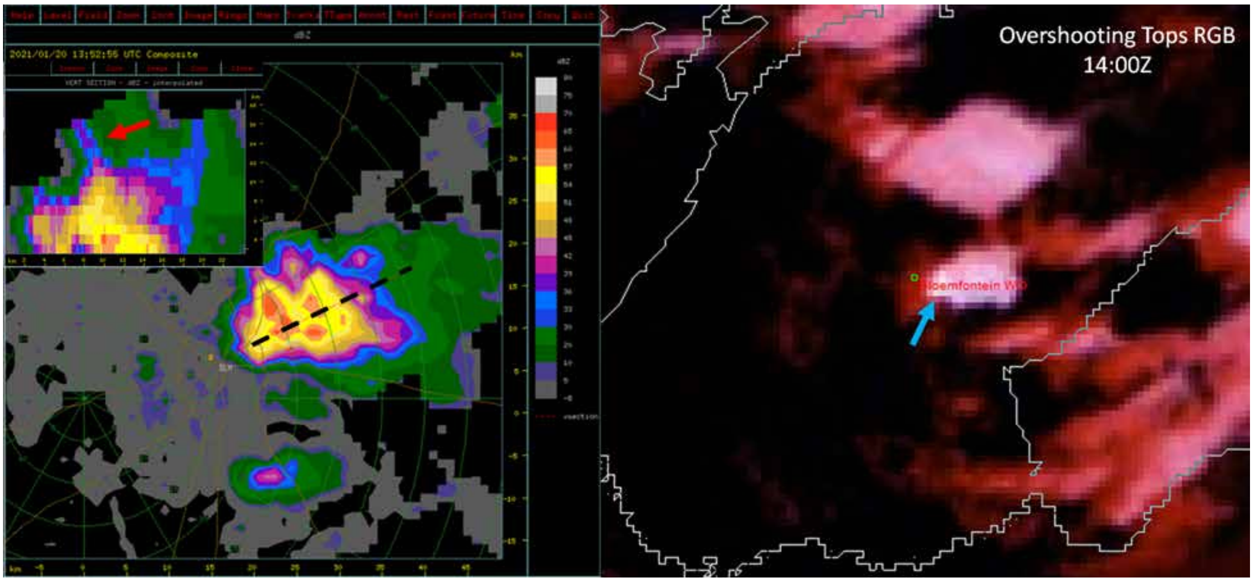

Figure 8: Radar image (left) valid for 20 January 2021 at 13:53Z showing a thunderstorm north-east of Bram Fischer International Airport. An overshooting top (red arrow) can be seen on the cross-section. The Overshooting Tops RGB (right) which is a satellite product also indicates the overshooting top (blue arrow) at 14:00Z. Source: SAWS.

This severe thunderstorm intensified quickly, had high dBZ values of above 65, lasted for about 20 minutes and was slow-moving as seen in Figure 9. Therefore, also considering the information above, it can be stated that it was a pulse severe thunderstorm. Since these types of severe thunderstorms do not last very long and form in a weak shearing environment, it is proven that these are some of the most difficult severe thunderstorms to forecast and are often missed.

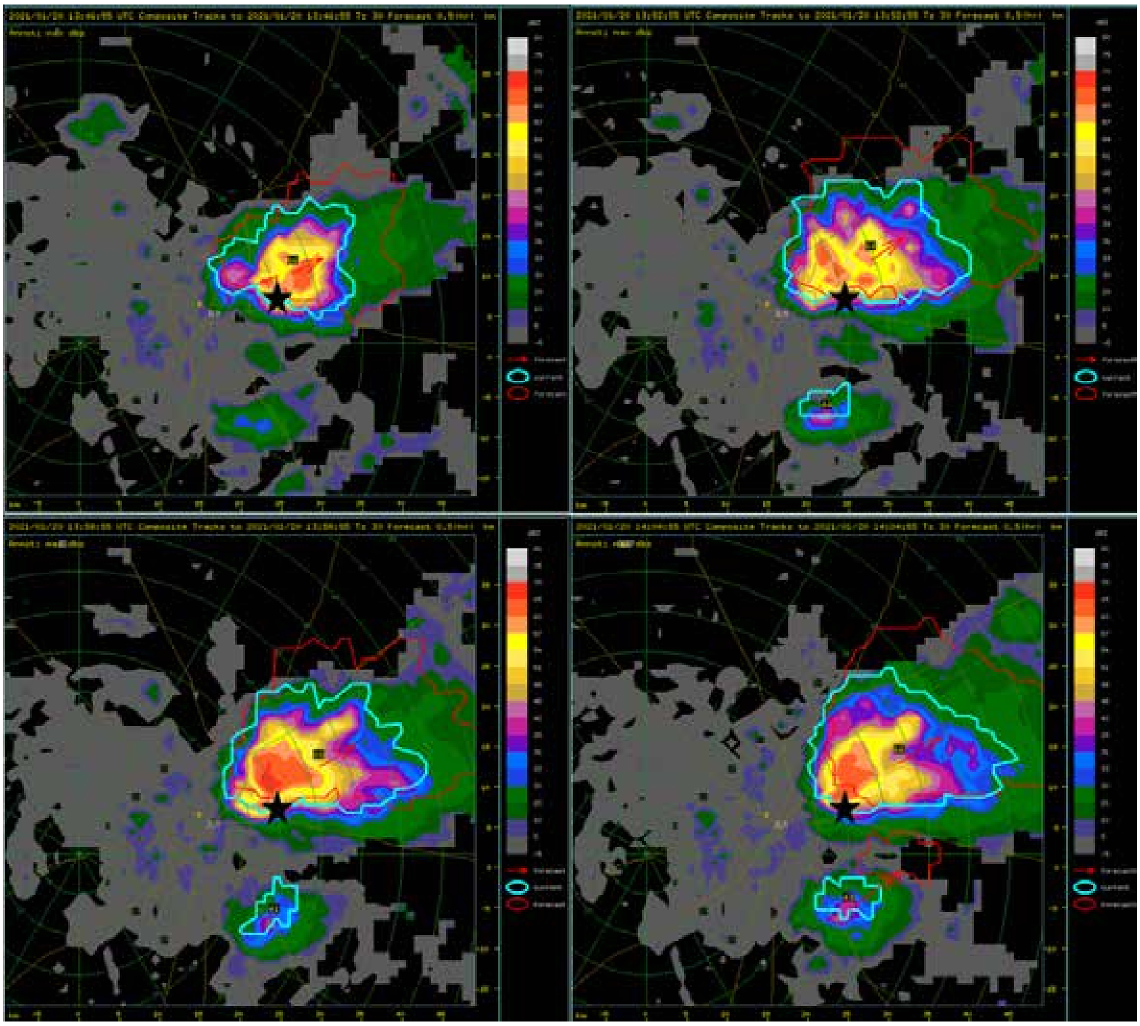

Figure 9: Radar images of the pulse severe thunderstorm that was situated north-east of Bram Fischer International Airport (location indicated by the start) on 20 January 2021; top left corner – 13:47Z, top right corner – 13:53Z, bottom left corner – 13:59Z, bottom right corner – 14:05Z. Source: SAWS.

Impacts

The pulse severe thunderstorm that formed north-east of the Bram Fischer International Airport resulted in heavy downpours, which led to localized flooding, hail as well as damaging winds. The Bloemfontein Courant reported that damages occurred in Estoire, Olive Hill and Ribblersdale and stated that 100 mm of rain was recorded, trees were uprooted, power surges occurred and the roof of a house was blown off. See Figure 10. The Bloemfontein Weather Office, which is situated at Bram Fischer International Airport, recorded 29 mm due to this thunderstorm. Seeing that the core of it was located north-east of the Bloemfontein Weather Office, it is possible that heavier rainfall occurred over the study area. Considering the types of damage that were reported, minor impacts occurred.

Conclusion

Against popular believe, a weak shearing environment can contribute to severe thunderstorms, namely pulse severe thunderstorms, as identified in this case study, when the necessary ingredients are met. Pulse severe thunderstorms are usually associated with heavy downpour, leading to localized flooding, large amounts of small hail and strong, gusty winds and, very seldom, weak tornadoes. Therefore, it is important to investigate further when dealing with a weak shearing environment to determine whether pulse severe thunderstorms could occur and to also keep a close eye on the radar and satellite data to detect as soon as one develops, so that a warning can be issued on time.

Figure 10: Impacts that occurred north-east of Bram Fischer International Airport, Bloemfontein on 20 January 2021 between 13:30Z and 14:40Z. Source: Bloemfontein Courant.

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Miller, P.W. and Mote, T.L., 2017. Standardizing the definition of a “pulse” thunderstorm. *Bulletin of the American Meteorological Society*, *98*(5), pp.905-913.

Sobash, R.A., Kain, J.S., Bright, D.R., Dean, A.R., Coniglio, M.C. and Weiss, S.J., 2011. Probabilistic forecast guidance for severe thunderstorms based on the identification of extreme phenomena in convection-allowing model forecasts. *Weather and Forecasting*, *26*(5), pp.714-728.

SOUTH AFRICAN WEATHER SERVICE LAUNCHES THE REGIONAL WMO INTEGRTED GLOBAL OBSERVING SYSTEM CENTRE (RWC-SA) ON 9 FEBRUARY 2021

by Francis Mosetlho

The official launch of the SADC WMO Regional WIGOS Centre took place via virtual platform on 9 February 2021. The launch was an outcome of the South African Weather Service's expression of interest, in May 2019, to host the Regional WIGOS Centre for SADC. This expression was supported by the Regional Association I (Africa) and endorsed by World Meteorological Organization (WMO).

Regional WIGOS centres (RWCs) were established as one of five priority areas for the WIGOS pre-operational phase, 2016-2019, to advance the implementation of WIGOS within WMO regions (or sub-regions), by providing regional coordination, technical guidance, assistance and advice to Members and Regional Associations. The RWCs work closely with the WMO Secretariat and their respective regional working bodies to ensure efficient and effective implementation of WIGOS. Furthermore, they work closely with data providers to facilitate regional WIGOS metadata management (OSCAR/Surface); regional WIGOS performance monitoring and incident management (WIGOS Data Quality Monitoring System).

The RWCs liaise with relevant existing WMO Centres, in particular with the Regional Instrument Centres (RICs), Regional Climate Centres (RCCs) and Regional Training Centres (RTCs) regarding all WIGOS related activities in the Region.

Virtual Training of SADC NMHSs Focal Points on WDQMS attached to RWC-SA was conducted by the WMO experts in October 2020, and thereafter the readiness of the South African Weather Service to was confirmed.

By hosting the RWC-SA, the South African Weather Service will further contribute to regional and national observing network management, support and build regional activities and assist with coordination of regional and sub-regional as well as national projects.

Aviation forecasts as a result of Tropical Cyclone Guambe

by Hetisani Oscar Shiviti - Forecaster: (Aviation Weather Center)

A tropical cyclone is defined as an intense low-pressure system, which typically moves from east to west following warm sea surface temperatures and occurs in areas with little or no wind shear. A tropical cyclone has a vertical structure with a clockwise rotation in the southern hemisphere that can easily be seen on satellite imagery.

There are certain conditions that are vital for the formation of a tropical cyclone, which include:

- Sea surface temperatures of at least 26.5 °C (needs to be throughout a depth of at least 50m)
- The atmosphere needs to be unstable
- A moist troposphere
- The development should be at least 500 km away from the equator
- There should be a pre-existing disturbance with sufficient rotation (vorticity) and inflow (convergence)
- There needs to be very little vertical wind shear

The formation or development of a tropical cyclone happens in four stages, which are named in relation to the development process occurring in each stage. These are: the Formative, Immature, Mature and Decaying (Dissipating) stages. Each stage has characteristics that define what type of development the tropical cyclone is undergoing.

In the Formative stage the development is disorganised and ill-defined, with the strongest winds occurring away from the centre with wind speeds less than gale force (gale force winds have speeds between 34 and 40 knots (KT)). In the Immature stage the convection becomes more organised, the surface pressure drops to below 1000 hPa and the centre becomes well-defined with the strongest winds found around the centre and wind speeds reaching storm force strength (storm force strength winds have speeds between 48 and 55 KT). In the Mature stage of development, a steady state is reached with only a few changes in the maximum wind speeds and pressure. Notably, at this stage of development a distinct eye is present. Finally, in the Decaying stage, the warm core of the tropical cyclone is destroyed, resulting in an increase in pressure and weakening of winds. It is at this stage that the clockwise rotation becomes disorganised. During the Decaying stage, there may be some heavy rain as well as low-level clouds remaining.

The tropical cyclones that typically affect South Africa develop in the south-west Indian Ocean. The Meteorological Watch Office (MWO) is responsible for issuing any warnings relating to tropical cyclones. In South Africa, the MWO is referred to as the Aviation Weather Centre (AWC) based at OR Tambo International Airport. For all warnings and forecasts for a tropical cyclone, the MWO should always consult the Tropical Cyclone Advisory Centre (TCAC) – based in La Reunion.

The role of the TCAC is to inform the MWO about specific attributes of the tropical cyclone, such as its location, movement, forecast position and time, speed, central pressure and maximum wind speed close to the centre of the tropical cyclone. Upon receiving this information from the TCAC, the MWO then uses this information to issue the necessary Significant Meteorological advisories/warnings (SIGMET).

Meteo-France is responsible for tropical cyclone forecasting and tracking over the South West Indian Ocean. Thus, making La Reunion - Tropical Cyclone Centre - a French branch of Meteo-France, responsible for forecasting tropical cyclones in areas affecting South Africa.

Tropical Cyclone forecasts can be displayed in the form of a significant weather chart or a Significant Meteorological Information warning (SIGMET) and the MWO is responsible for issuing aviation-related forecasts. Upon receiving a tropical cyclone advisory from the TCAC (La Reunion), the MWO needs to incorporate the information contained in the advisory into both the significant weather chart and the SIGMETs, provided that the tropical cyclone is within the area of responsibility for which the OR Tambo-based MWO is responsible.

Towards the end of February 2021 a tropical cyclone Guambe affected the south-eastern parts of Africa.

Subsequently, this system had an impact on the weather over the said region, thus influencing the aviation forecast. This tropical cyclone was active for a total of 5 days, from 17 to 21 February 2021. To forecast the tropical cyclone effectively, the MWO had to rely on La Reunion Tropical Cyclone Centre.

From 17 February 2021, the MWO started receiving advisories for a tropical cyclone called "Guambe". Accordingly, the MWO responsible for this area had to include tropical cyclone Guambe into the forecast, as it was within the forecast area. On 19 February 2021 tropical cyclone Guambe was located over the ocean to the east of southern Mozambique as can be seen on Figure 1, which clearly shows the cyclonic rotation of tropical cyclone Guambe with a well-defined eye around the centre of circulation. This is an indication that tropical cyclone had reached its Mature stage of development.

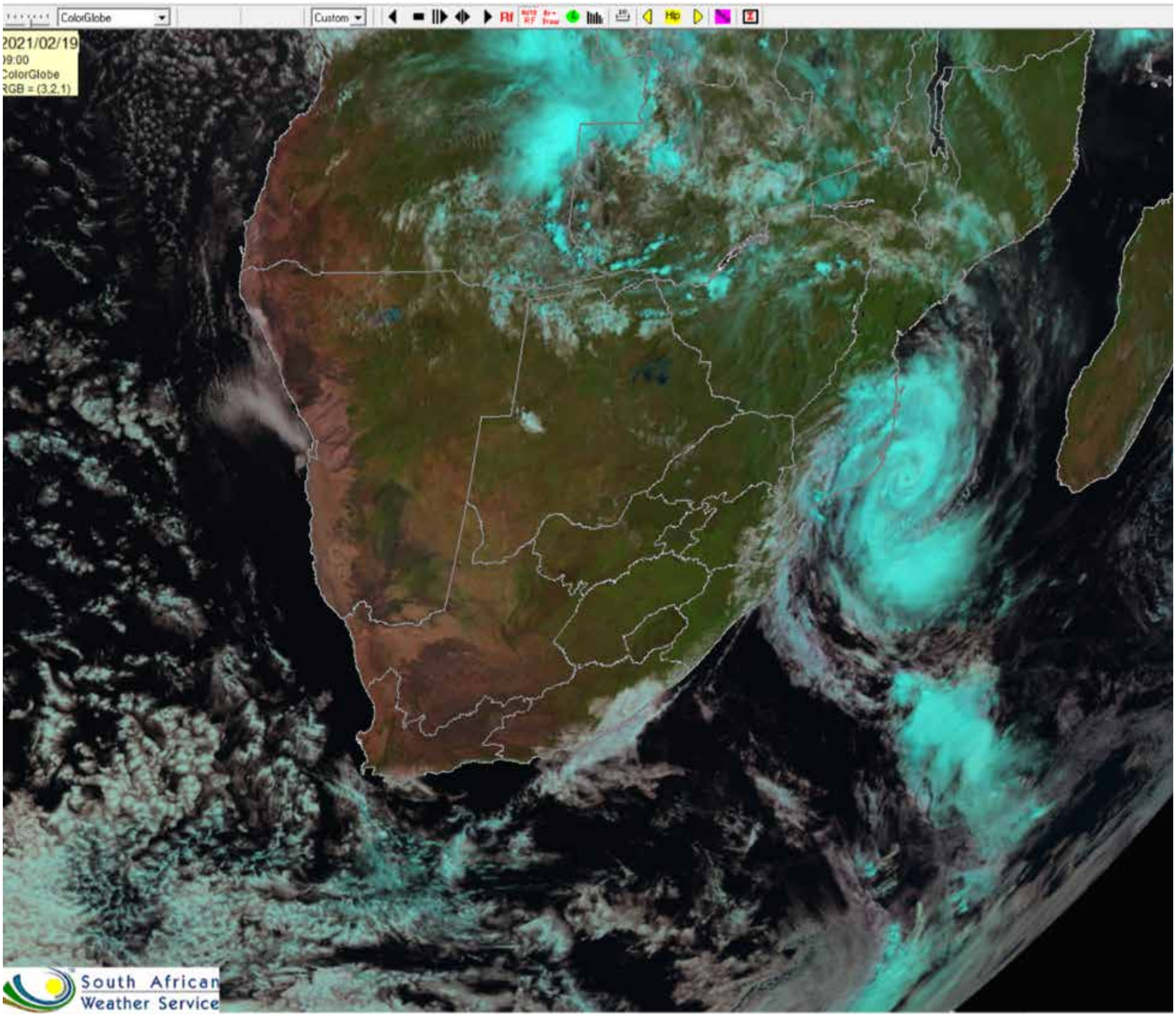

Figure 1: Tropical Cyclone Guambe and its circulation as seen on a Day Natural Colours (DNC) satellite image at 0900Z on 19-2/2021. (SAWS)

Furthermore, the TCAC also provides a useful forecasting tool in the form of an image. This image indicates the current position of the tropical cyclone as well as the expected projection of its movement throughout its development. See Figure 2 below.

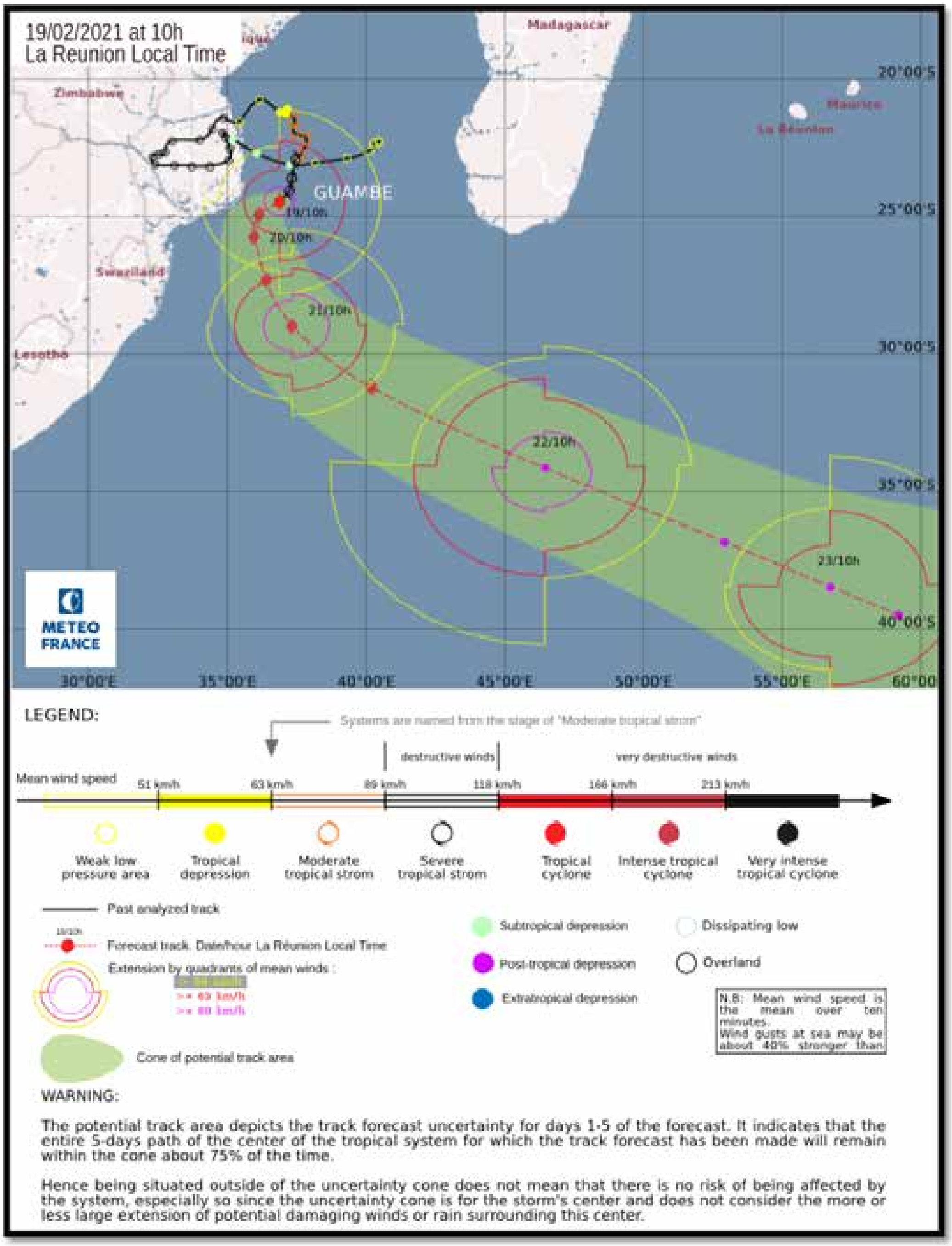

Figure 2: A visual display of the location of Tropical Cyclone Guambe as well as the projected trajectory throughout all its development stages, generated on 19 February 2021 at 10:00 am UTC La Reunion local time (08:00 am South African standard time). (www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/index.html)

On 19 February 2021 at 08:39 SAST, a tropical cyclone advisory was sent to the MWO which was incorporated into the significant weather forecast charts, as a result of the position of the tropical cyclone being expected to be within the significant weather chart domain (the domain for a significant weather chart is between longitudes 12.5E and 40E; and latitudes 15S and 37.5S). The tropical cyclone advisory received on 19 February can be seen in Figure 3 while the significant weather charts into which the advisory was incorporated can be seen in Figure 4.

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50 Boulevard du Chaudron
97490 Sainte-Clotilde
Tél : 0262 92 11 00
Fax Exploitation : 0262 92 11 48
Fax Direction : 0262 92 11 47

METEO FRANCE

FKIO20 FMEE 190639
TC ADVISORY
DTG: 20210219/0639Z
TCAC: REUNION
TC: GUAMBE
ADVISORY NR: 2021/08
OBS PSN: 19/0600Z S2426 E03651
CB: WI 180NM OF TC CENTRE TOP FL540

MOV: SW 05KT
INTST CHANGE: INTSF
C: 963HPA
MAX WIND: 75KT
FCST PSN +6 HR: 19/1200Z S2441 E03627
FCST MAX WIND +6 HR: 85KT
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FCST PSN +24 HR: 20/0600Z S2542 E03558
FCST MAX WIND +24 HR: 100KT
RMK: NIL
NXT MSG: 20210219/1200Z

Figure 3: Tropical Cyclone Advisory for TC Guambe issued at 0639Z (08:39 SAST) on 19 February 2021. (http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/activiteope/bulletins/avis/liste.html#)

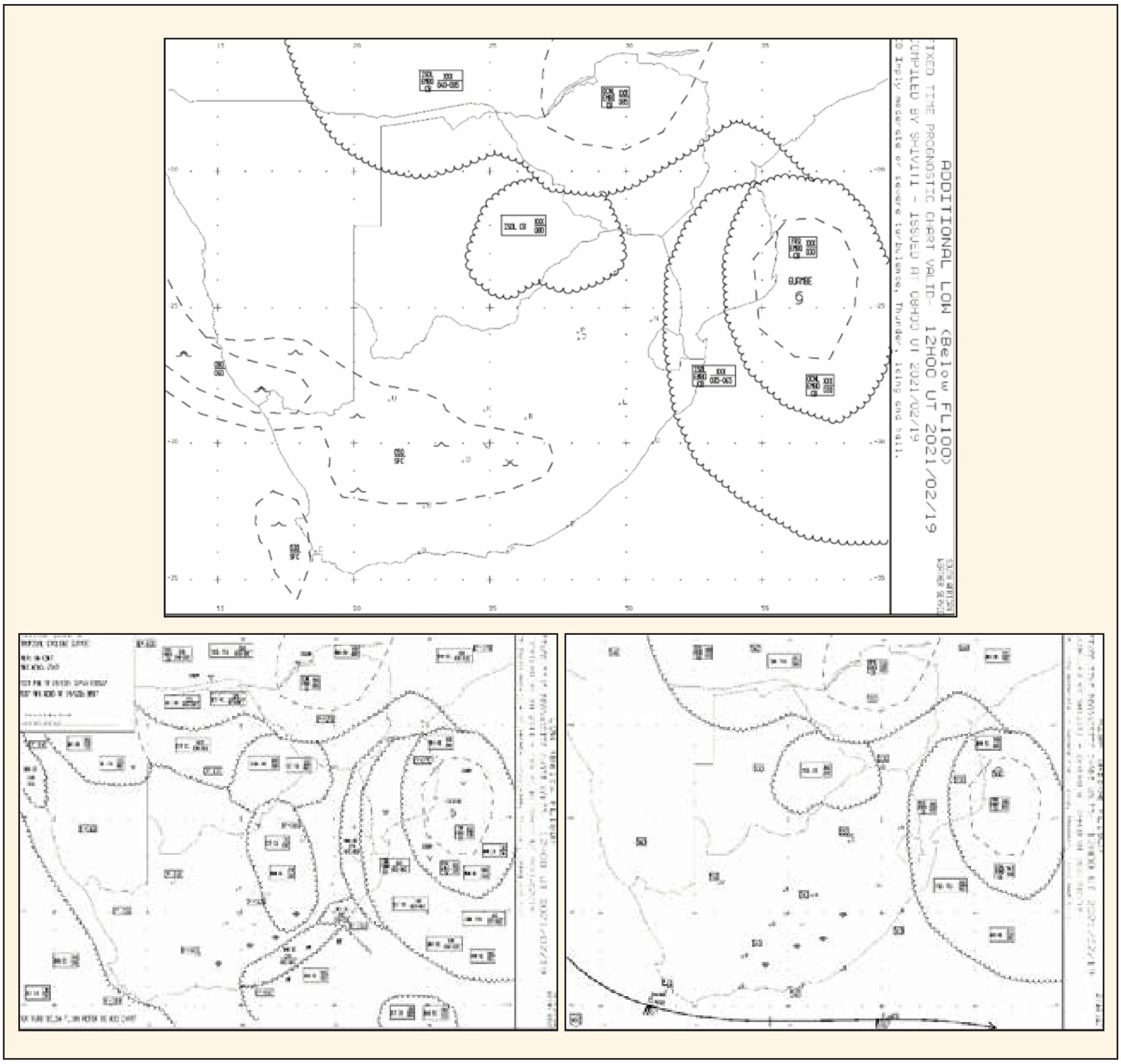

Figure 4: Significant weather charts (Additional, low and high Level) valid for 1200Z (14:00 SAST) issued on 19 February 2021. (SAWS)

On 21 February 2021, tropical cyclone Guambe had moved further south and had entered the Johannesburg Oceanic Flight Information Region (FIR), therefore, a SIGMET for it could be issued by the MWO (or rather AWC). The advisory received by the MWO which was then used to issue a TC SIGMET can be seen in Figure 5. The SIGMET issued as a result of the advisory can be seen in Figure 6.

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FKIO20 FMEE 211205
TC ADVISORY
DTG: 20210221/1205Z
TCAC: REUNION
TC: GUAMBE
ADVISORY NR: 2021/17
OBS PSN: 21/1200Z S3042 E03858
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C: 981HPA
MAX WIND: 50KT
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FCST PSN +24 HR: 22/1200Z S3637 E05124
FCST MAX WIND +24 HR: 50KT
RMK: NIL
NXT MSG: 20210221/1800Z

Figure 5: Tropical Cyclone Advisory for tropical cyclone (TC) Guambe issued at 1205Z (14:05 SAST) on 21 February 2021. (http://www.meteo.fr/temps/domtom/La_Reunion/webcmrs9.0/anglais/activiteope/bulletins/avis/liste.html#)

As stated earlier, tropical cyclone Guambe was active as for a total of five days but had no big impact on the weather of South Africa. The only impact of significance was on the aviation forecast. For the whole time that tropical cyclone Guambe was active, the MWO was constantly monitoring its movement as well as impact on the aviation forecast until it reached its Decaying stage and moved out of the MWO's forecast area of responsibility.

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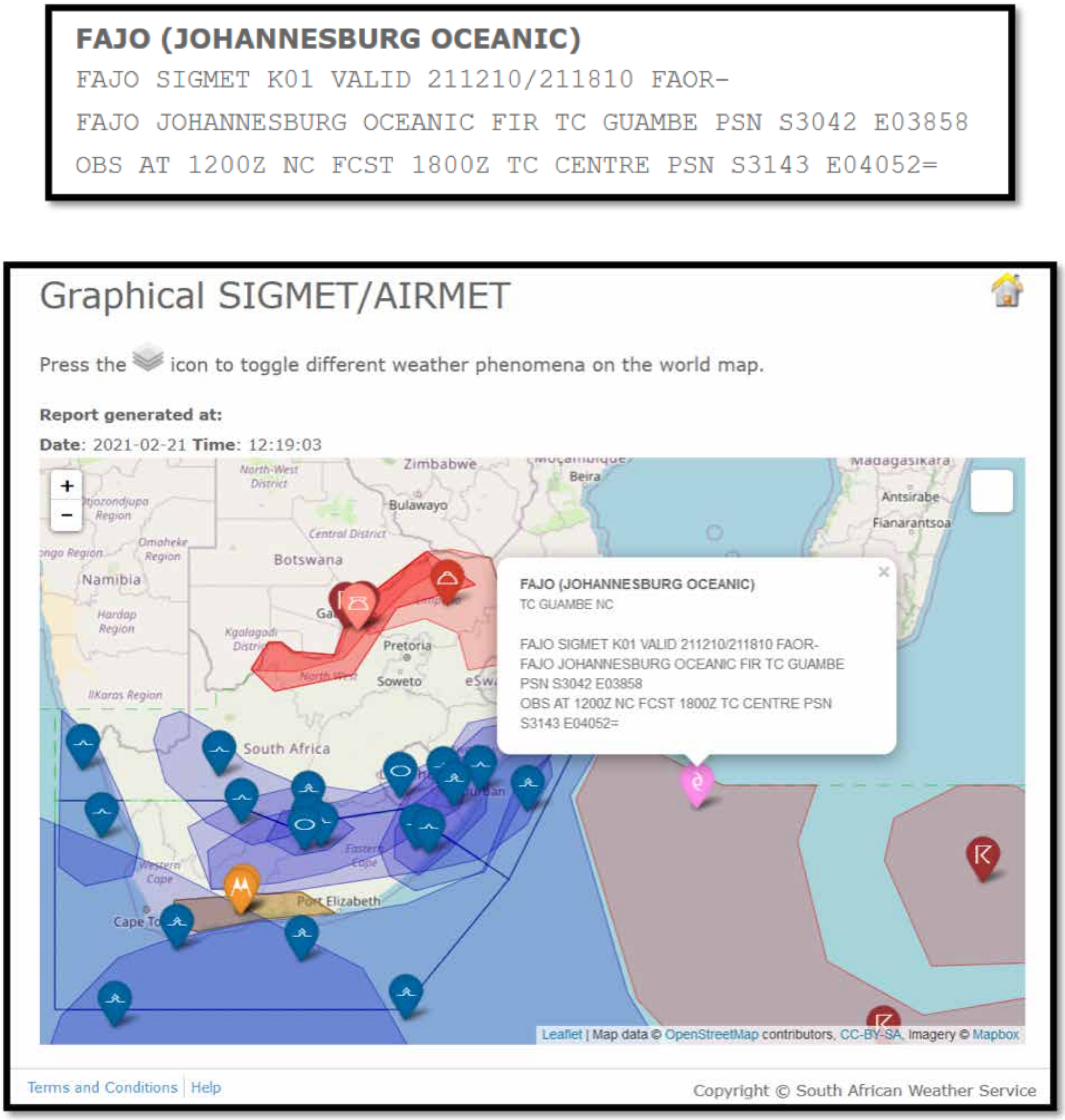

Figure 6: Tropical Cyclone Guambe SIGMET in both a text format (top) and a graphical format (bottom) issued on 21 February 2021. (SAWS)

Meet the Authors

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 writing 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, and assisting in the quality control of climate data.

In 2001, Dr Kruger obtained a PhD (Civil Engineering) degree at the University of Stellenbosch on the research topic "Wind Climatology and Statistics 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 has published papers both locally and internationally, and authored a SAWS series of publications on the general climate of South Africa. He is widely recognised, both nationally and internationally, for his research, which involves advanced statistical analyses and interpretation of historical climate data.

Ms Elani Heyneke

Elani Heyneke started her forecasting career at the South African Weather on the 5th of January 2017 after completing her B.Sc and B.Sc (Hons) in Meteorology as well as the post graduate certificate in Weather Forecasting at the University of Pretoria. She has a passion for severe weather forecasting, especially severe thunderstorms and is planning on completing her Masters and P.hD before she is 40. She is actively involved in creating a weather smart nation through writing short and informative pieces on weather related topics and sharing it with the media (RSG and MedFM). She loves briefing the public, the aviation and agricultural sector and various stakeholders to help with planning and preparing for significant weather events.

Ms Charlotte McBride

Charlotte McBride joined the then South African Weather Bureau in 1998 as a meteorologist focusing on the development of educational publications and assisting with the communication of weather related topics to various stakeholders. In 2010 she moved to be Manager of Climate Data in the Climate Services Department which involved quality controlling all climate data on the SAWS main climate database. This includes managing a team who are involved in data rescue activities, quality control of weather data, spatial checking of data and archiving of climate documents. Over a number of years she has co-author the SAWS inputs to the Bulletin of American Meteorological Society (BAMS) State of the Climate report. She is also involved with the work of the World Meteorological Organisational (WMO) as a co-chair of the Expert Team on Capacity Development for Climate Services under the Standing Committee on Climate Services. Charlotte holds a MSc in Science Education and is currently registered at University of Pretoria for a PhD in Geography.

Mr Francis Mosetlho

Gaobotse Francis Mosetlho, is currently the regional manager for the Free State and North-West. He joined the South African Weather Service in 1984 as a learner Meteorological Technician stationed at the Mahikeng Weather Office and led the former Bophuthatswana Meteorological Services after the departure of Ms Gaborekwe Khambule from the time of amalgamation of the weather services of TVBC State with the then South African Weather Bureau. He joined the Bloemfontein weather forecasting team in 1998 where served as a forecaster until 2005 when he joined management.

He represented the SAWS at various WMO sanctioned meetings. Currently he serves as the regional lead on Aircraft-based Meteorological Data Array (AMDAR) project and is the chairperson of the RA I Task Team on Aircraft-Based Observation (RA I-TT-ABO). Furthermore, he serves as the National Focal Point for the WMO Integrated Global Observing System (NFP-WIGOS) and is the lead of the Regional WIGOS Centre Southern Africa which was launched in 2021.

Trainer from 1999 to 2000.

Dr Tamaryn Morris

Tamaryn Morris is a Senior Scientist with the SAWS Marine Unit, based in Cape Town. She oversees the SAWS SANAP responsibilities and is heavily involved in ocean observing networks and deployment of instruments around South Africa.

Ms Tshifhiwa Ravele

Ms Tshifhiwa Ravele completed BSc Geography and Agrometeorology in 2016 at University of the Free State. In 2017 completed honors in Agrometeorology with the same university. Obtained forecasting certificate in 2020 through Regional training center (RTC). Currently doing forecasting internship in the Bloemfontein Office. She is fascinated by what is happening with the weather each day.

Mr Oscar Shiviti

Mr Hetisani Oscar Shiviti is a forecaster at the Aviation Weather Center (AWC) at OR Tambo International Airport. He completed both the BSc degree and BSc honours degree in Meteorology at the University of Pretoria. He also further completed the forecasting training provided by the South African Weather Service (SAWS) for a full year. Since his employment he has been a willing participant on SAWS outreach initiatives to educate the public on weather related issues."

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