WEATHERSMART NEWS

Scientific meteorological and climatological news from the South Africa Weather Services

August 2025

2024 the Hottest Year on Record Globally, with South Africa Also Significantly Impacted

Unveiling the Hidden Dangers of Mountain Waves Over the Tsitsikamma Mountains

An Overview of Impact-Based Forecasting Warnings, Alerts,and Advisories from 1 April 2024 to 31 March 2025

Excerpt from the SAWS Annual Report 2024/25

Peer Reviewed Articles Published by SAWS Scientists in Scientific Journals from 1 April 2024 to 31 March 2025

South African Weather Service

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South African Weather Service

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FOREWORD

CHIEF EXECUTIVE OFFICER

The 2025 edition of the WeatherSMART News comes in a year where the South African Weather Service has battled with the difficult consequences of a cyberattack earlier in the year which, among other things, also effectively prevented us from issuing an edition in March 2025. Swift and ongoing interdepartmental collaboration in the wake of the cyberattack experienced earlier this year, has however enabled us to compile this August 2025 issue of the WeatherSMART News. We have made significant gains in retrieving our data which is essential for the compilation of this vital publication.

This edition covers the scientific weather news in the last financial year, including important research by our climate scientists that contributes towards the South African Weather Service's mission to safeguard the lives and livelihoods of our citizens.

As we have seen all over the globe, incremental warming has resulted in several extreme weather events including thunderstorms, flooding, and heat waves, to name but a few. Over the past few months, many parts of the world were gripped by dire heat, which, for the northern hemisphere, has meant devastating incidences of extreme flooding. The study by our climatologists recounted in the first article of this edition, reporting that 2024 was globally the hottest year on record since 1951 – and this includes South Africa. The steady warming of the planet has occurred unequally, resulting in densely populated areas like Gauteng experiencing the brunt of the warming. Given this, the authors make a case for the introduction of adaptation strategies that take the regional variation of temperature increases into consideration.

The second engaging article discusses the hidden dangers that mountain waves pose for aviation safety in areas like the Tsitsikamma Mountains. Mountain waves are atmospheric oscillations that occur when stable air flows over mountain ranges and can lead to sudden changes in airspeed and altitude. This poses challenges for pilots and air traffic controllers. The authors believe that the findings from studying these phenomena are crucial for issuing timely warnings and advisories to pilots.

With our Annual Report for 2024/25 finalised, we thought it would be appropriate to also include an overview of the severe weather events for the period 1 April 202 to 31 March 2025. This serves as a valuable reference and shorthand for the extensive work contained in the report.

We conclude this edition with a list of research articles and conference papers that were published during the 2024/25 financial year, and we are proud of our scientific knowledge-

building efforts during this period. We hope that all you weather and climate enthusiasts find the content interesting, valuable, and thought provoking.

Ishaam Abader
Chief Executive Officer

2024 THE HOTTEST YEAR ON RECORD GLOBALLY, WITH SOUTH AFRICA ALSO SIGNIFICANTLY IMPACTED

Andries Kruger, Sandile Ngwenya and Sifiso Mbatha,
Department: Climate Service

In 2024 a global warming milestone was reached, being the first year to significantly exceed the 1,5°C climate target. Hotspots of concern include regions in Africa, with southern Africa having experienced particularly intense anomalies. Locally, South Africa saw its hottest year on record, marked by deadly wildfires, agricultural impacts, and heat stress across ecosystems and communities. These events reflect a broader pattern: warming is accelerating unevenly, pushing many regions into historic extremes.

The World Meteorological Organization (WMO) confirmed 2024 as the hottest year on record, with the global mean temperature about 1,55°C above the 1850–1900 pre-industrial baseline (WMO, 2025a). This new record was confirmed by six international data sets. Figure 1 presents the global mean temperature for the 1850–2024 period as anomalies from the 1850–1900 average from the HadCRUT5, NOAAGlobalTemp v6, GISSTEMP, Berkeley Earth, JRA-3Q and ERA5 data sets (WMO, 2025b).

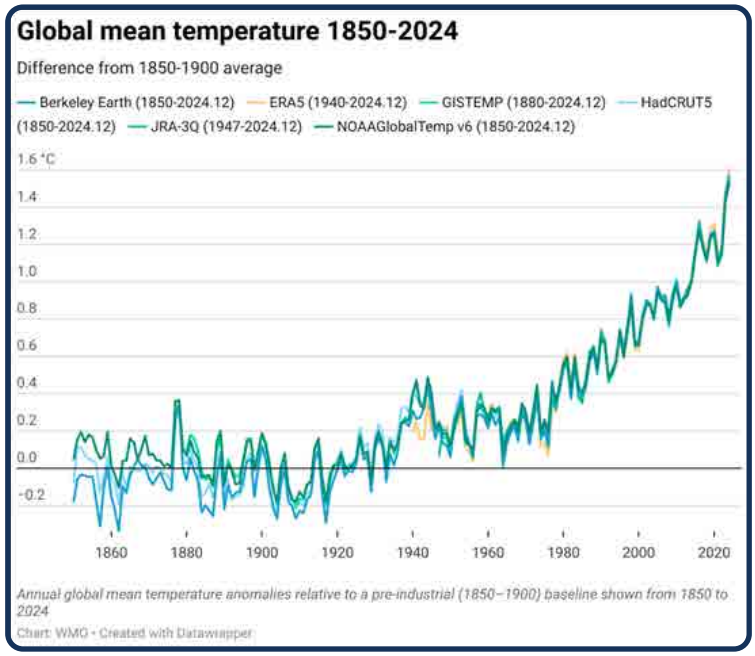

Figure 1: *Global mean temperature for the 1850–2024 period as anomalies from the 1850–1900 average from the HadCRUT5, NOAAGlobalTemp v6, GISSTEMP, Berkeley Earth, JRA-3Q and ERA5 data sets (WMO, 2025b)*

The highest ocean temperatures were also recorded during 2024. Both global sea surface temperature (SST) and upper 2000 m ocean heat content (OHC) reached unprecedented highs in the historical record (Cheng et al. 2024).

The most extreme surface temperature anomaly hot spots for 2024 include parts of North and South America, Northern Africa, Europe and Northern and Central Asia. While South Africa does not stand out as one of the regions with the largest temperature anomalies for 2024, the El Niño event of 2023/24 caused very large temperature anomalies in the northern parts of southern Africa in February, with 4–5°C above the normal temperatures (WMO, 2024).

Nonetheless, South Africa also recorded its warmest year since at least 1951 in 2024. Figure 2 presents the annual mean temperature anomalies for 1951–2024, based on the data of 26 climate stations, on average about 0,9ºC above that of the reference period (1991–2020). A warming trend of approximately 0,17 ºC per decade is indicated for the country over the period, statistically significant at the 95% level of confidence.

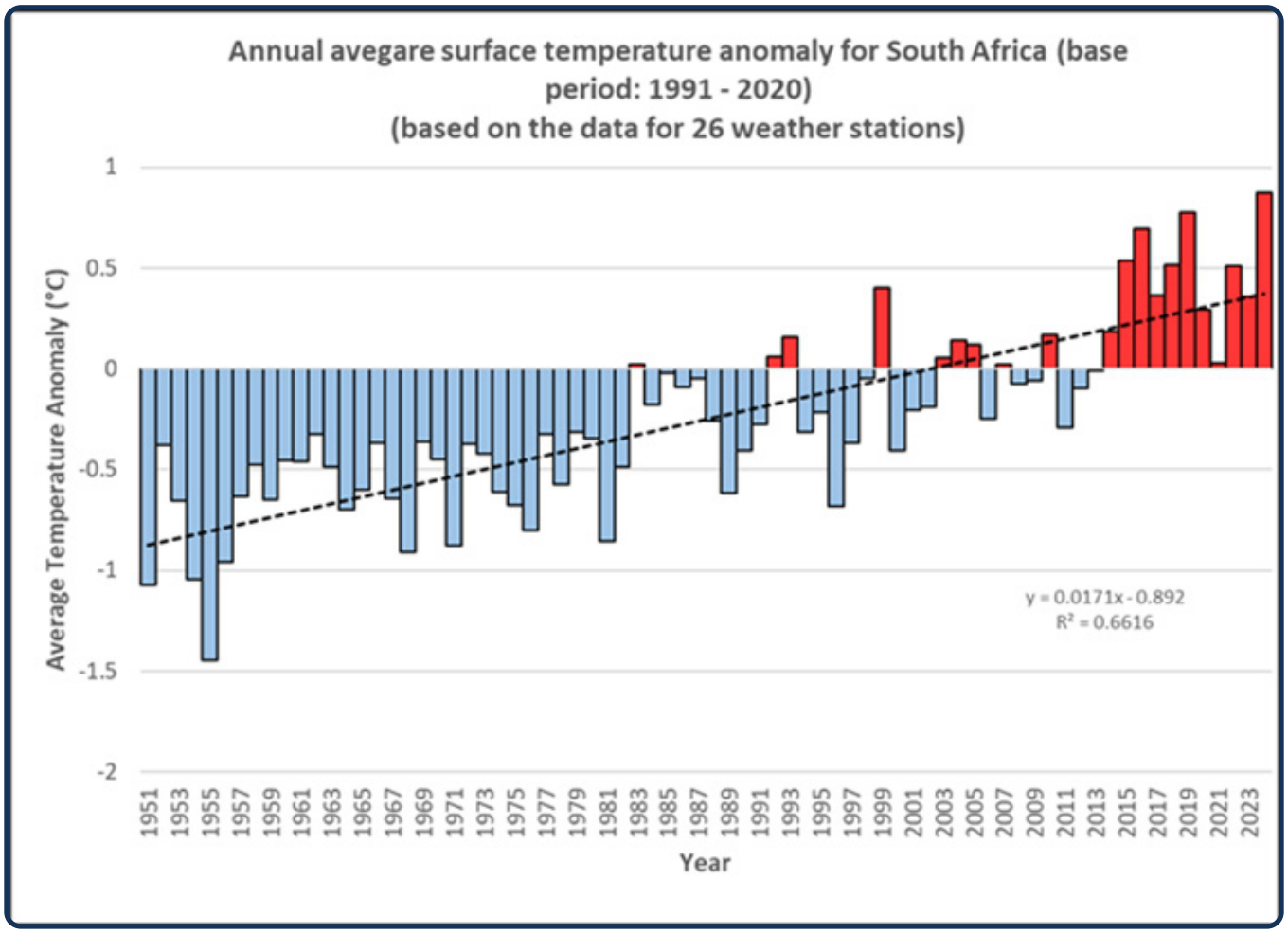

Figure 2: *Average surface temperature deviation over South Africa based on 26 climate stations: 1951–2023 (base period: 1991–2020). The linear trend is indicated (Source: South African Weather Service)*

On a regional basis, very hot conditions were experienced mainly in the central and northern interior. In the south, however, temperatures were closer to normal. Significantly hot months included January, which saw 2–3°C above normal in the west of the country. February and March were mostly dry, with maximum temperatures over the central parts 3–4°C above normal. During May dry conditions were experienced in the western and central interior and almost the whole country was abnormally hot, with maximum temperatures 3–4°C above normal, as presented in Figure 3.

During the winter months some parts in the north of the country experienced extremely hot conditions, continuing in a somewhat lesser degree into August. November and December saw large parts of the eastern half of South Africa enduring significantly above-normal temperatures. Many weather stations recorded their maximum temperatures for these months, with several warnings of hot days and heat waves issued.

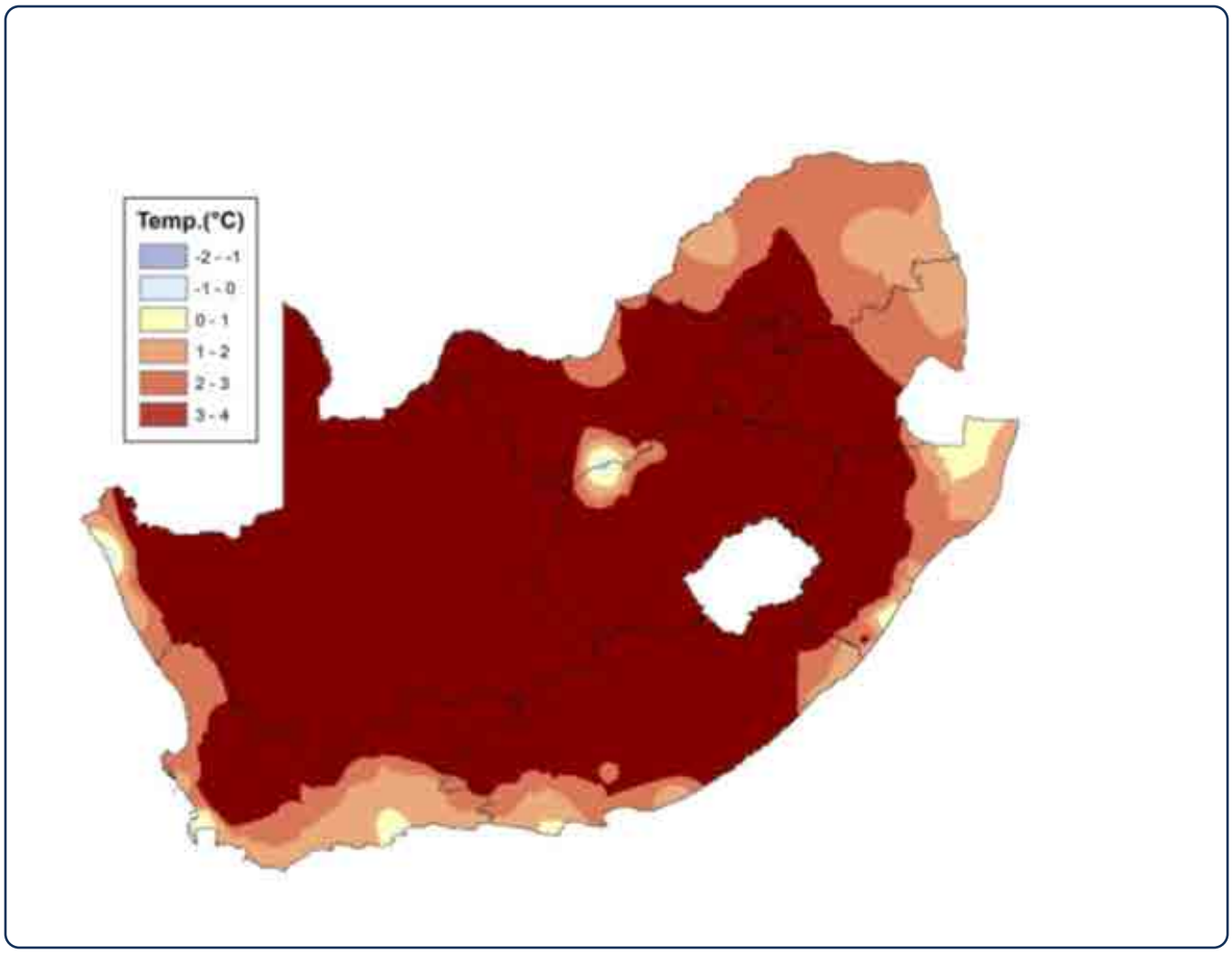

Figure 3: *Maximum temperature deviations from normal for May 2024 (Source: South African Weather Service)*

While it is imperative to consider general warming trends in policy and planning, the impact of the increase in surface temperatures will arguably mostly be felt through extreme temperatures and heat waves. Therefore, the South African Weather Service monitors the increases in relevant temperature extremes by analysing the time series of long-term temperature records. A wide range of extreme temperature indices was developed by the WMO Expert Team on Sector-Specific Climate Indices (WMO ET-SCI), of which the analysis of their trends can be done through the application of the sector-specific ClimPact software suite (Dunn et al. 2024). The following are spatial representations of the trends in a sample of the ET-SCI daily maximum temperature indices, calculated for 53 weather stations over the last 30 years. Figure 4 shows the trends in the annual percentage of hot days, where it is apparent that the northern parts and the extreme south of South Africa experienced stronger increases than the rest of the country.

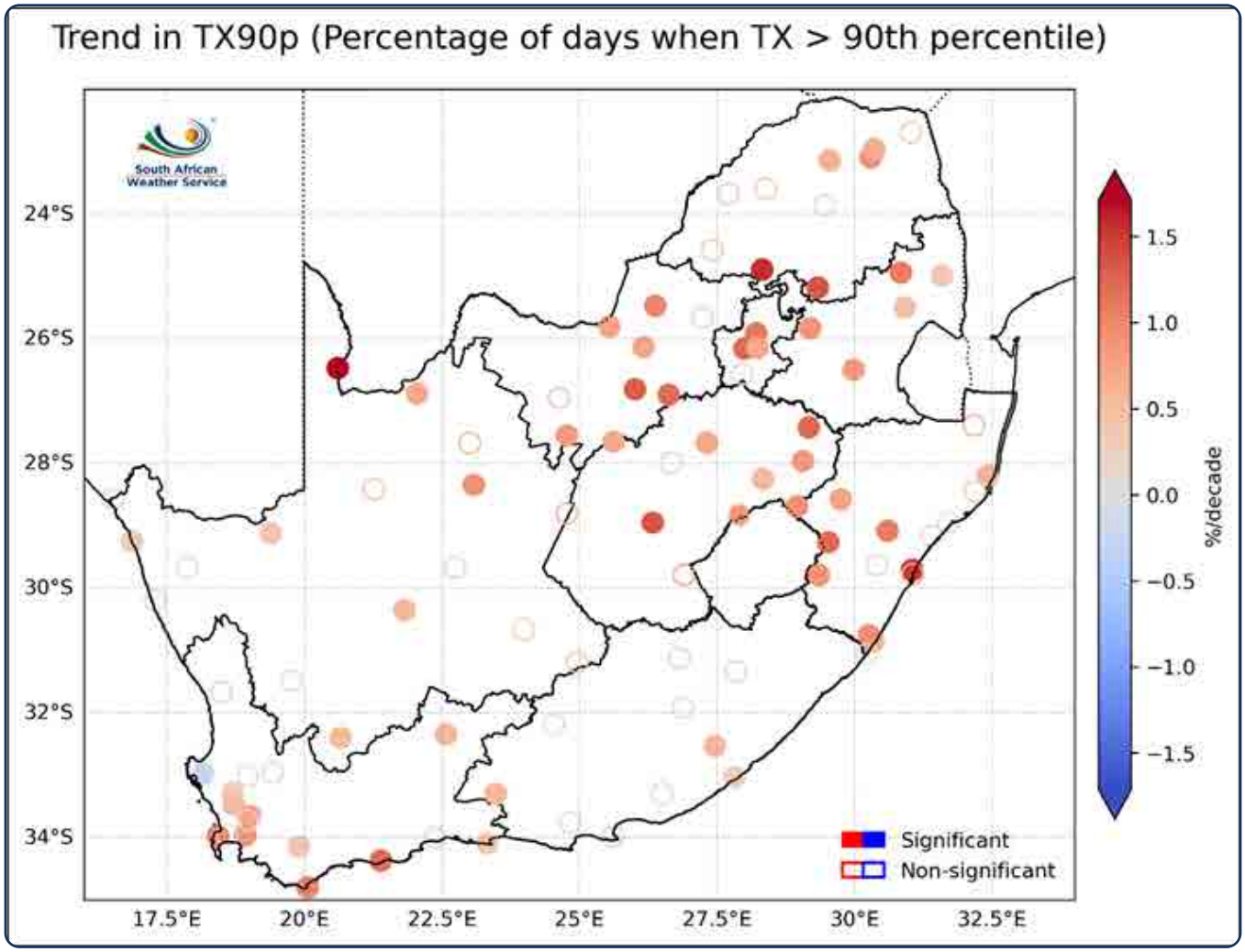

Figure 4: *Trends in TX90P, the percentage of hot days, per decade over the last 30 years. Filled circles indicate trends significant at the 95% level of confidence.*

Figure 5 presents the trend in the annual maximum temperature, TXx, where the northern and extreme southern parts experienced the strongest trends, with almost the same spatial pattern as in Figure 4 for the annual percentage of hot days. Strong positive trends in TXx have a direct bearing on the estimation of the return period of high extremes and the probability of experiencing unprecedented high temperatures.

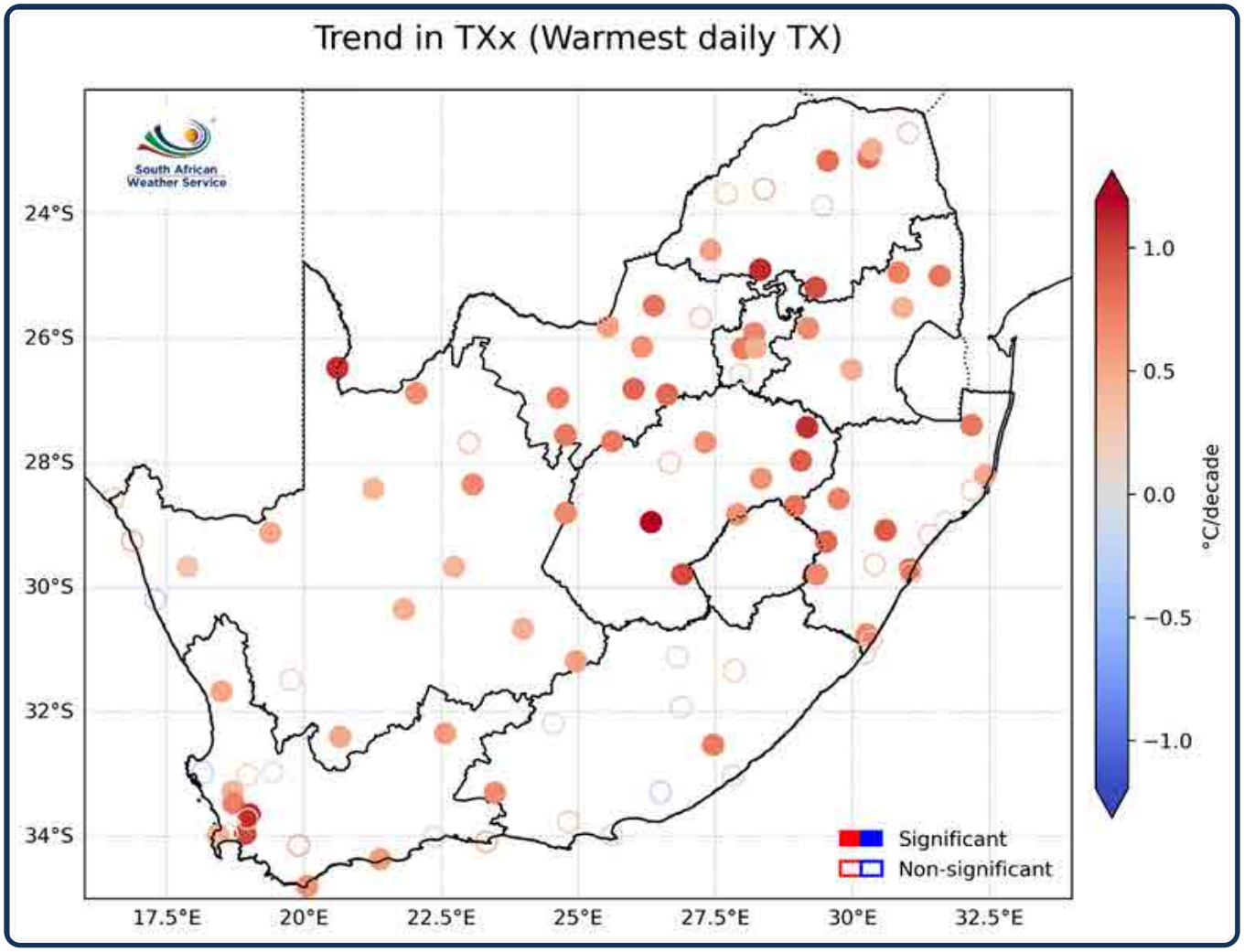

Figure 5: *Trends in TXx, the highest annual maximum temperature, per decade over the last 30 years. Filled circles indicate trends significant at the 95% level of confidence.*

The number of days contributing to warm spells that are at least three days long, i.e. three or longer consecutive hot days, have also increased over more or less the same regions as above. Over the central and northern parts of the country, extensive regions including Gauteng, have undergone increases of more than 10 days per decade contributing to 3-day warm spells.

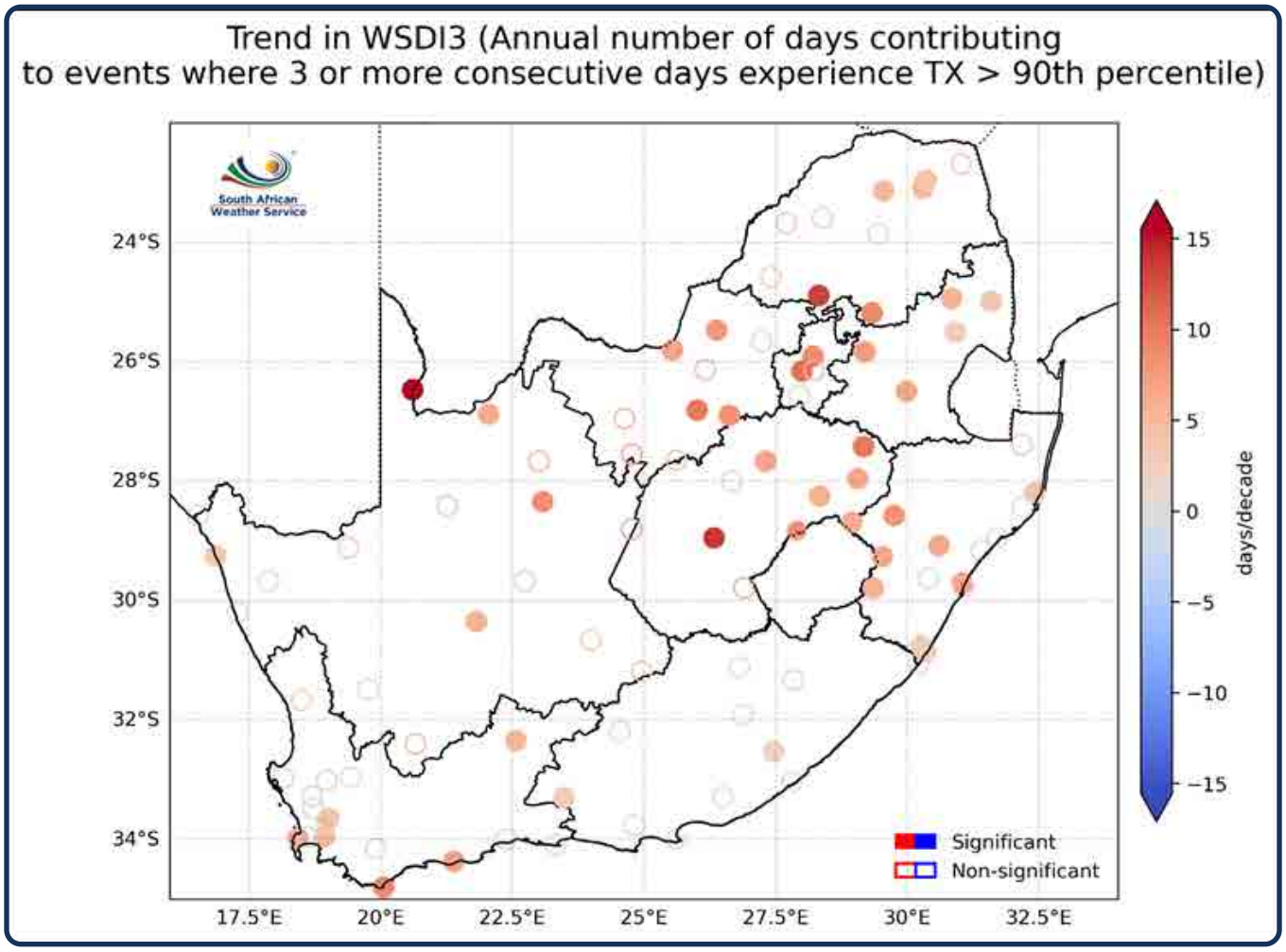

Figure 6: *Trends in WSDI3, the annual number of days contributing to warm spells which are at least three days long, per decade over the last 30 years. Filled circles indicate trends significant at the 95% level of confidence.*

In summary, South Africa experienced its hottest year in 2024 since at least 1951. This observation correlates with the global average surface temperature, which also indicates 2024 as the hottest year on record, but going back to 1850. Considering the general warming trends, it is also important to analyse which regions in the country experienced the strongest increases in temperature, especially high maximums. These "hot-spot" regions, which include the central and northern parts of the country as well as the extreme south, are more vulnerable to the impacts of temperature extremes. As some of the most densely populated areas, such as Gauteng, experienced the strongest warming in the country, it is even more important that adaptation strategies take the regional variation of temperature increases into consideration.

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UNVEILING THE HIDDEN DANGERS OF MOUNTAIN WAVES OVER THE TSITSIKAMMA MOUNTAINS

Dr Markus Geldenhuys and Mr Deon van der Mescht

South Africa's diverse topography presents unique challenges and opportunities for atmospheric research. Among these is the phenomenon of mountain waves – atmospheric oscillations that occur when stable air flows over mountain ranges. These waves can have significant implications for aviation safety, weather forecasting, and our understanding of atmospheric dynamics. Mountain waves can lead to sudden changes in airspeed and altitude, posing challenges for pilots and air traffic controllers. Understanding their formation and behaviour is crucial for issuing timely warnings and advising pilots.

The Tsitsikamma Mountains, located along the southern coast of the Eastern Cape, serve as a natural laboratory to study low-level mountain wave phenomena. The orientation, low-elevation and complexity of the mountains make this a unique and convenient (with suitable access roads) area to study these waves. The south-westerly wind patterns in the vicinity of cold fronts create conditions conducive to the formation of lee waves. These waves can manifest as lenticular clouds as well as rotors (Figure 1) and are often associated with turbulence, posing risks to aviation operations.

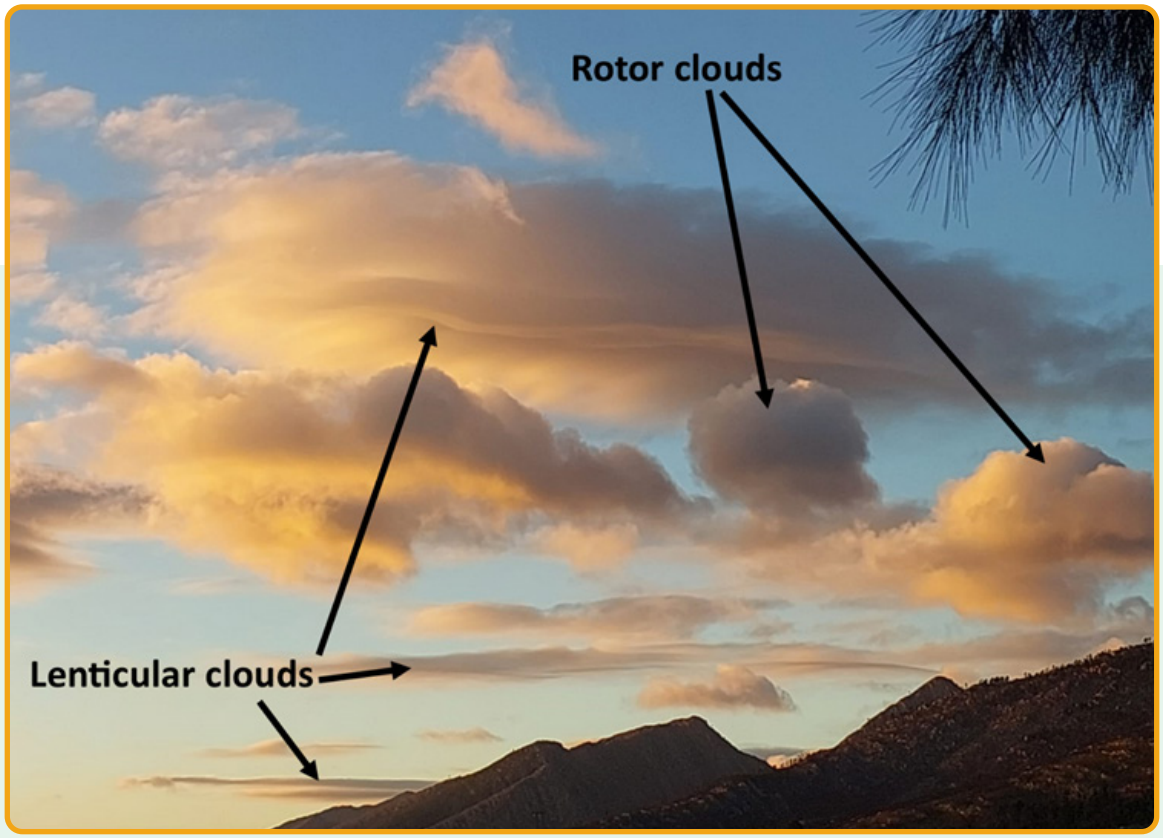

Figure 1: *Lenticular clouds and rotor clouds on 3 June 2025. Note how one can see the wind flow in the lenticular clouds.*

Observations from 3 June 2025

On 3 June 2025, a site visit revealed the presence of lenticular (resembling the lens of an eye) cloud formations downstream of the Tsitsikamma range, indicative of mountain wave activity (Figure 1). These waves were observed on satellite imagery and took on a classic interference pattern (Van der Mescht & Geldenhuys, 2019). A cold front tail (stretching WNW-ESE – Figure 2) can be seen south of the region, with south-westerly winds prevailing — a setup favourable for the development of lee waves (Geldenhuys et al., 2019). It is common to see gravity wave interference in this setting which results in a more chaotic wave compared to the typical linear gravity wave patterns. Figure 3 shows two photos taken 11 minutes apart. Note the dashed lines in the top photo showing the chaotic nature of these waves. The bottom photo looks dramatically different to the top photo, highlighting the fast-changing nature of this event. The top photo shows a very chaotic and interference type wave, while the bottom photo shows a more monochromatic, less turbulent and likely linear wave. In this case the monochromatic wave existed mostly over the ridge and quickly lost energy in the downwind direction (seen in the shortening of the wavelength). The atmospheric conditions and visual evidence on this day were very reminiscent of the 16 December 2015 aircraft crash in this region and underscore the importance of monitoring such meteorological conditions.

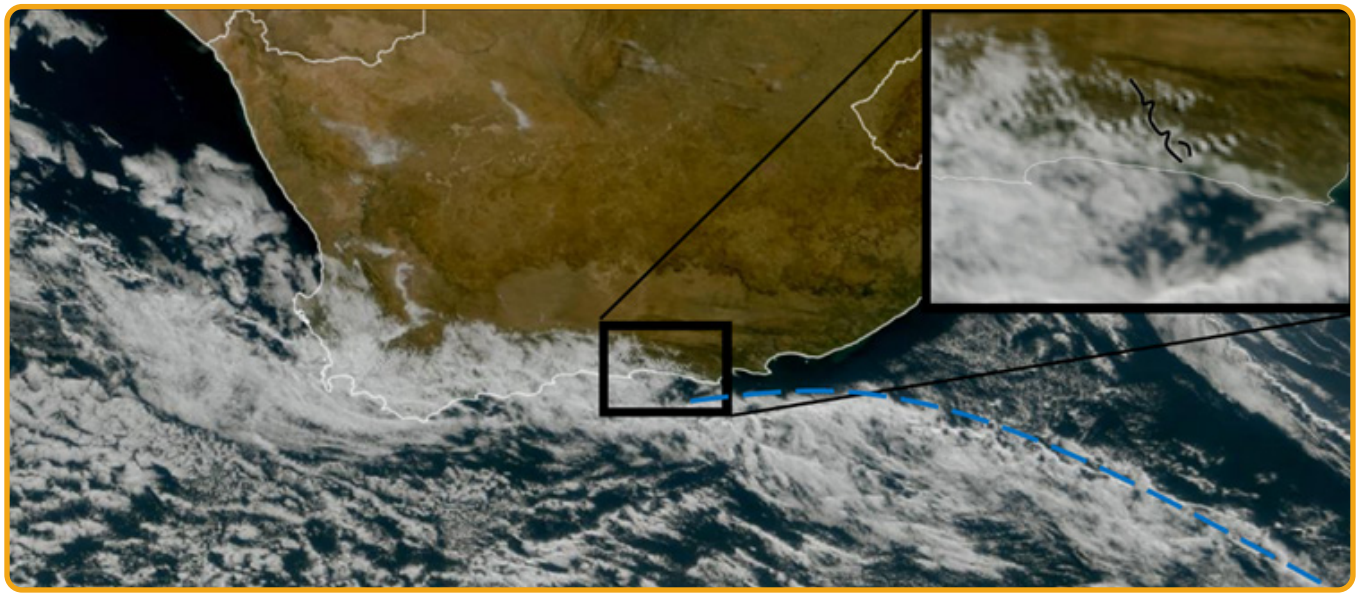

Figure 2: *Satellite image on 3 June 2025 at 08h30 UTC. The dashed blue line indicates the position of the cold front. The zoomed-in insert shows the irregular nature (interference pattern) of the waves. Source: Eumetsat, 2025.3*

Figure 3: *Top: The dashed lines indicate the wind flow as observed in the clouds and are numbered from closest to the camera to the furthest. Bottom: Photo from the same area, just 11 minutes later in the hike and slightly up the slope. Note how much the wavefield has changed in a very short time – indicating a rapidly changing environment.*

The site visit on 3 June 2025 was to install a CCTV camera on one of the prominent peaks of the region. This now allows for real-time wave monitoring and also assist in to detecting features that satellite images cannot resolve. During a previous site visit a weather station was installed on another prominent peak. Both these installations required the scientists to hike to the location for more than six hours, covering many kilometre and large elevation gains while carrying bulky and very sensitive electronic equipment. A second camera will soon be installed in the region to allow larger areal coverage. Further plans include doing weather balloon soundings and remote-controlled aircraft measurements.

Introducing a new PhD Research Project

In response to the need for a deeper understanding of mountain wave dynamics in South Africa, a new PhD research project has been initiated by Deon van der Mescht of the South African Weather Service. This study aims to:

- Analyse the frequency and intensity of mountain wave events over the Tsitsikamma Mountains.
- Investigate the atmospheric conditions that lead to the formation of interference patterns and other turbulent events.
- Assess the impact of these waves on aviation safety and weather patterns.
- Develop improved forecasting techniques to predict mountain waves and the associated turbulence occurrences.

By combining observational data, numerical modelling, and case studies, this research seeks to enhance our predictive capabilities and mitigating risks associated with mountain wave-induced turbulence.

Conclusion

The Tsitsikamma Mountains offer a unique opportunity to study mountain wave phenomena in the South African context. Through dedicated research and collaboration, we aim to unravel the complexities of these atmospheric waves, enhancing our forecasting abilities and ensuring safer skies for all.

Acknowledgement

The authors would like to thank all the pilots who have donated towards the equipment for this study. We would also like to acknowledge the help of the landowners. ChatGPT assisted in this article.

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AN OVERVIEW OF IMPACT-BASED FORECASTING WARNINGS, ALERTS, AND ADVISORIES FROM 1 APRIL 2024 TO 31 MARCH 2025

EXCERPT FROM THE SAWS ANNUAL REPORT 2024/25

The following is an excerpt taken from the 2024/25 Annual Report of the South African Weather Service (SAWS). It provides an overview of significant weather events that occurred from 1 April 2024 until 31 March 2025, and can be of value to weather enthusiasts and researchers.

From 1 April 2024 to 31 March 2025, the SAWS issued 140 warnings for disruptive rains that could lead to flooding events; 198 warnings for expected damaging winds that could impact infrastructure and communities; and 46 warnings for disruptive snow, leaving many people stranded and causing damage to crops. Advisories were mostly issued for heat related events, extreme heat and high discomfort indexes. The highest level of warnings was for a level 8, with two for the Western Cape (disruptive rain and damaging winds) and two for KwaZulu-Natal (disruptive rain and disruptive snow).

The weather for April to June 2024

A cut-off low developed along the west coast of South Africa on 6 April 2024 and deepened significantly as it moved relatively slowly over the western interior, eventually exiting along the south-east coast of the country on 9 April 2024. The SAWS issued several impact-based warnings for this system, including severe thunderstorms, disruptive rainfall, wind, and wave warnings, ranging from yellow to orange levels. A media release was issued on 4 April 2024 to warn the public and stakeholders of the impending weather event.

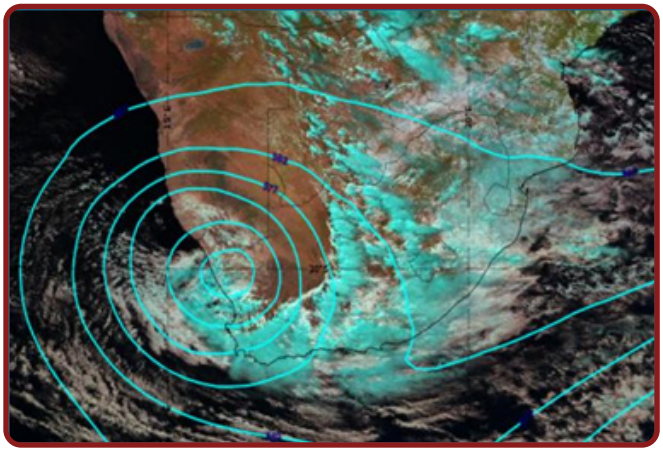

Figure 1: *The observed satellite image and the 500 hPa overlay indicating the cut-off low over the western parts of the country on 7 April 2024. (Source: EUMeTrain, 2024)*

A cut-off low developed along the country's west coast on 1 June 2024, ushering winter across the country during the first few days of the month. This system had a significant impact on parts of the Eastern Cape, Western Cape, and KwaZulu-Natal. Significant to severe flooding was observed in parts of the Eastern Cape and Western Cape, while severe thunderstorms resulted in tornadoes over parts of KwaZulu-Natal.

Heavy rain occurred over parts of the Eastern Cape on 1 and 2 June 2024, with torrential rain causing severe damage in Kariega (Uitenhage) during Saturday night, 1 June 2024, where 227 mm was recorded in a short period.

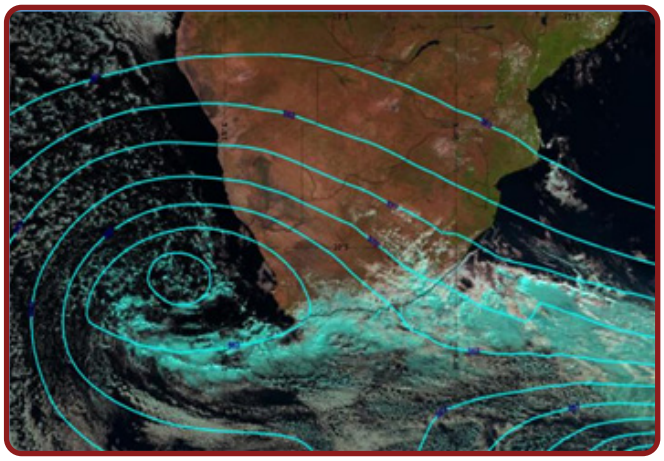

Figure 2: *The observed satellite image and the 500 hPa overlay indicate a cut-off low over the western parts of the country on 1 June 2024. (Source: EUMeTrain, 2024)*

Torrential rain severely damaged Uitenhage in the Eastern Cape on Saturday night, 1 June 2024. (Source: Smile FM, Daily Maverick, 2024)

Late on Monday morning, 3 June 2024, a line of thunderstorms developed along the border of the Free State and KwaZulu-Natal, ahead of a well-developed cut-off low-pressure system situated over the western interior of South Africa. Cold and dry air swept in from the western parts of the country to the central interior. In contrast, the eastern parts, particularly KwaZulu-Natal, experienced warm and moist atmospheric conditions, which aided in the development of severe thunderstorms where the cold and warm airmasses met. As a result, severe storms moved across parts of KwaZulu-Natal, with reports of at least two tornadoes sighted. The most severe tornado was reported in the oThongathi area.

Photos 1: *Images of the tornado captured near oThongathi (Tongaat) in KwaZulu-Natal on Monday afternoon, 3 June 2024. (Source: Facebook, Unknown)*

Photos 2: *Homes damaged by the tornado in the oThongathi area in KwaZulu-Natal on Monday afternoon, 3 June 2024. (Source: Reaction Unit South Africa, Facebook)*

The weather for July to September 2024

Above-normal rainfall was indeed experienced in the winter rainfall parts of the country. Several severe weather events occurred in the Western Cape, ranging from strong, damaging winds to flooding and snowfall.

The most significant weather event occurred from 19 to 22 September 2024, when a cut-off low-pressure system caused severe snowstorms over KwaZulu-Natal, Mpumalanga, the Free State and the Eastern Cape. Widespread snow resulted in many mountain passes being closed, which included the N3 national highway between KwaZulu-Natal and Gauteng. The impact of this weather system was accentuated, as it occurred during the school holidays, when many people were on the roads heading to their various holiday destinations. Ahead of this weather system, on 18 September 2024, the SAWS issued a media release, advising the public of the impending extreme weather conditions.

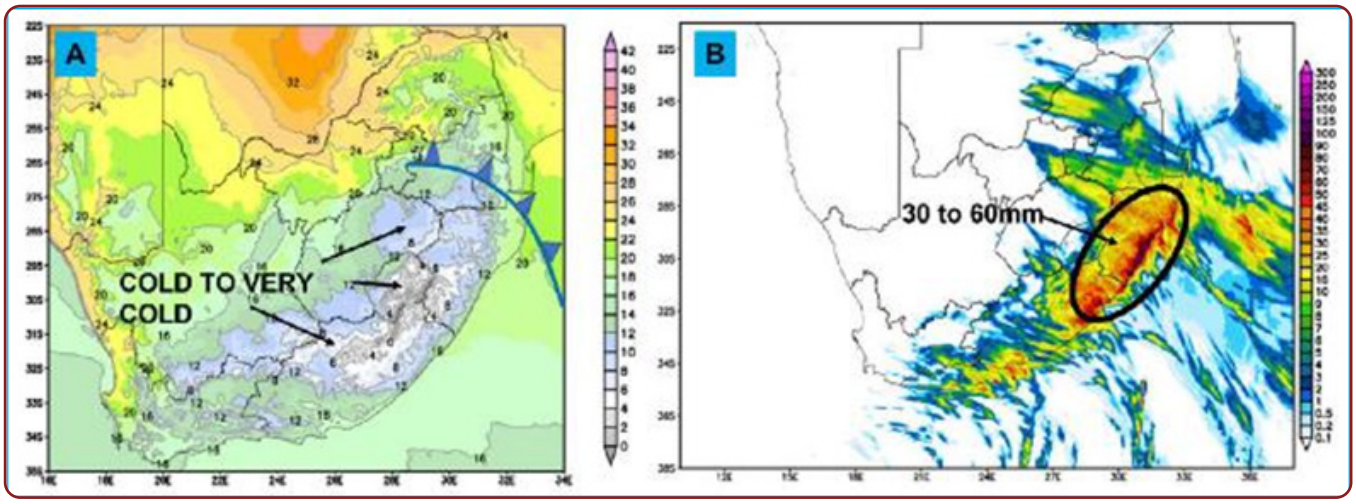

Figure 3: *Maximum temperatures (in °C) (left) and 24-hour rainfall accumulation (in mm) (right) for Friday, 20 September 2024, according to the Unified Model. (Source: SAWS, 2024)*

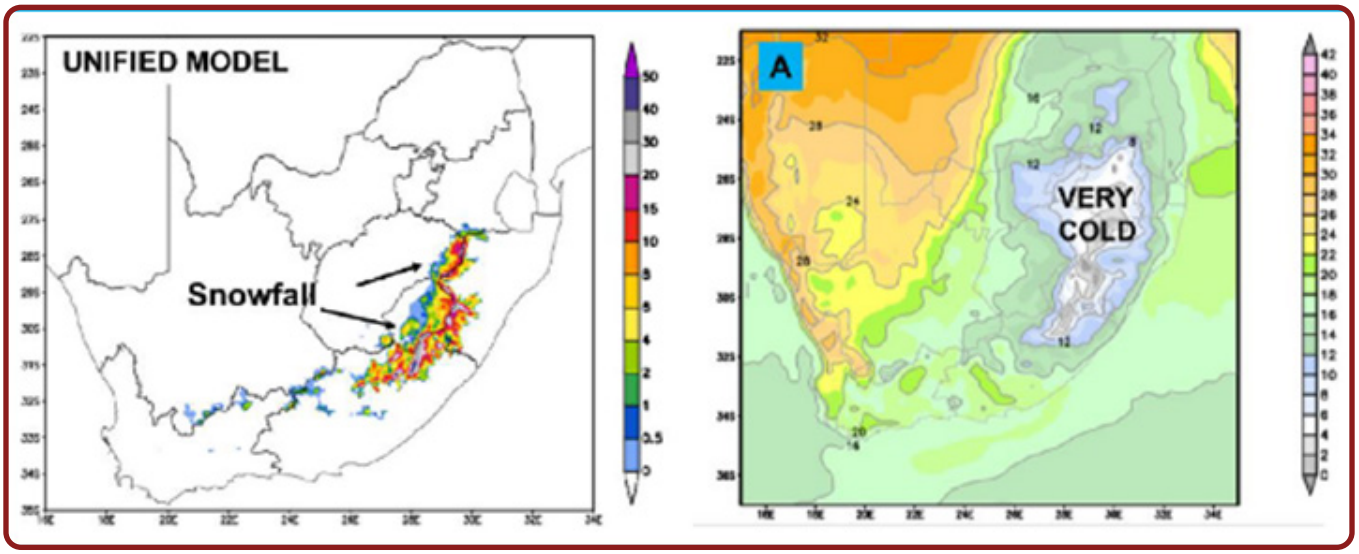

Figure 4: *Snowfall (in cm) according to the Unified Model (left) for Friday into Saturday (20 and 21 September) and the maximum forecasted temperatures (in °C) (right) according to the Global Forecast System (GFS). (Source: Global Forecast System (GFS), SAWS, 2024)*

Orange Level 6 warnings followed the media release on 18 September 2024, warning about the high likelihood of significant impacts from disruptive snow in the Eastern Cape, Free State, and KwaZulu-Natal, effective from 20 September 2024. The anticipated impacts included danger to life, loss of livestock and crops, road closures, and structural damage to infrastructure and settlements. On the morning of 21 September 2024, the warning for KwaZulu-Natal was elevated to an Orange Level 8, with a low likelihood of severe impacts. The expected extreme weather materialised and resulted in the unfortunate loss of a man's life due to hypothermia while he was in a taxi that was stuck on the N3 national road.

Photos3: *A, B and C. Vehicles are stuck on the N3. (Arrive Alive - Facebook)*

The weather for October to December 2024

This period signalled the start of the rainy season for the country's summer rainfall regions. The rainy season is also often characterised by extremely high temperatures and severe storms, which were experienced during this period and required numerous warnings and advisories from the SAWS.

Heat waves

Several heat waves were experienced, with the first occurring in a few districts between 4 and 6 October, followed by another between 10 and 14 October 2024, affecting nearly half of the country.

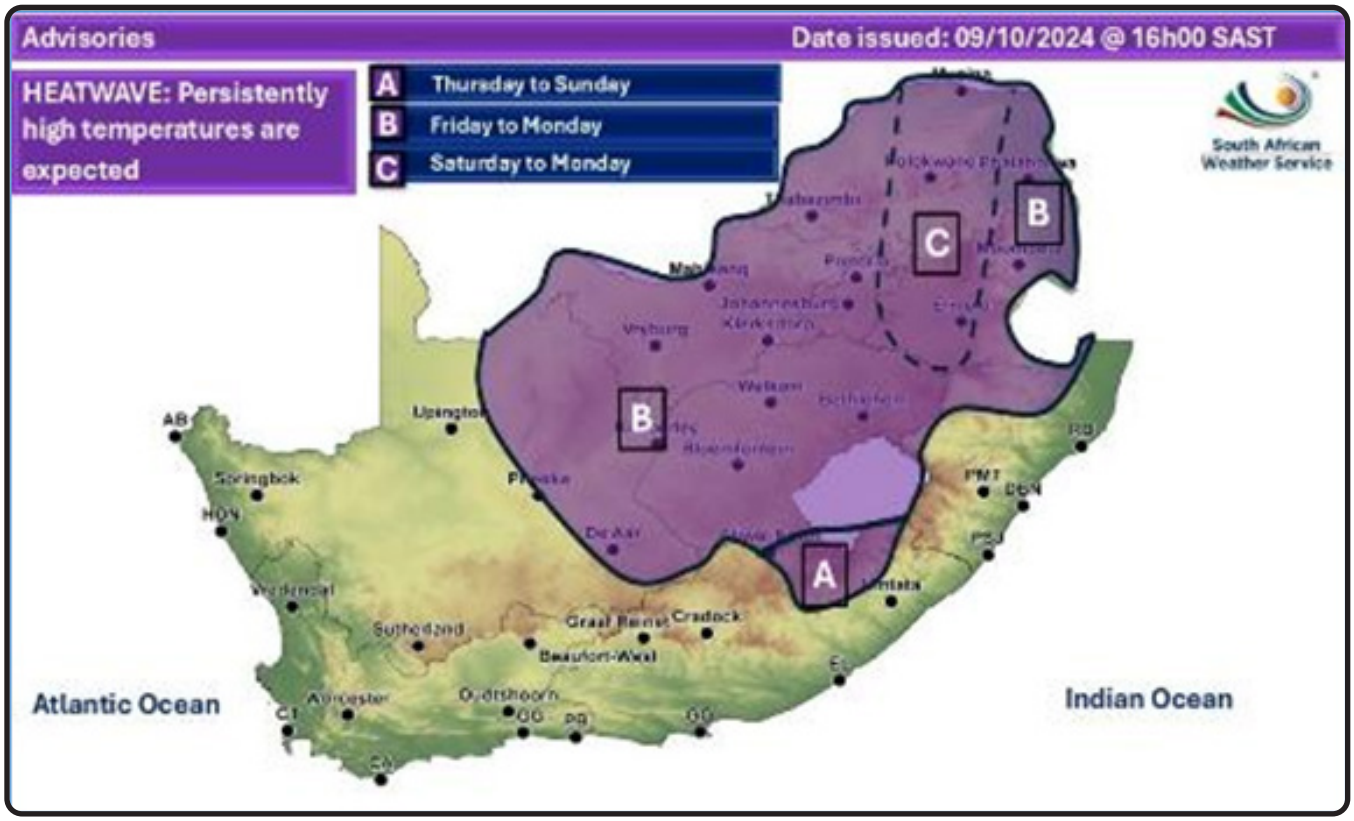

Figure 5: Heat wave advisory issued on 9 October 2024

The next heat wave, which lasted from 1 to 4 November 2024, affected half of the country. However, the worst was still in December 2024, with extremely hot conditions. A prolonged heat wave occurred from 1 to 7 December 2024 and produced several new temperature records, with the oldest record spanning over 40 years being surpassed. The last heat wave of 2024 was experienced between 11 and 14 December.

Table 1: *Temperature records on 11 December 2024 as extracted on 12 December 2024*

Criteria	Old value	Old Date	New Value	New Date	No. Years	Station
Highest Maximum	37,8	2017/12/28	38,5	2024/12/11	25	Wepener
Highest Maximum	39,3	2016/12/19	40,0	2024/12/11	30	Bloemfontein stad
Highest Maximum	39,4	1997/12/13	40,2	2024/12/11	62	Bloemfontein weather office
Highest Maximum	39,3	2016/12/19	40,1	2024/12/11	23	Fauresmith
Highest Maximum	39,7	2016/12/19	40,2	2024/12/11	21	Gariep Dam
Highest Maximum	42,3	2016/12/18	42,8	2024/12/11	31	Prieska
Highest Maximum	41,4	2016/12/19	41,7	2024/12/11	30	Orania AWS
Highest Maximum	35,7	2015/12/19	36,1	2024/12/11	34	Jamestown
Highest Maximum	39,7	2015/12/24	40,6	2024/12/11	26	Newcastle
Highest Maximum	40	2023/12/21	40,9	2024/12/11	31	Postmasburg
Highest Maximum	40,1	2018/12/23	43,0	2024/12/11	11	Vaalharts AWS
Highest Maximum	45,4	1981/12/05	45,9	2024/12/11	64	Twee Rivieren

Severe thunderstorms

A cut-off low-pressure system induced the first severe thunderstorm between 20 and 22 October 2024. The SAWS issued a media release on 19 October 2024, ahead of the event, warning of heavy rains and flooding, followed by a range of warnings for the districts that were to be affected. Although this event caused significant damage to human settlements and other infrastructure, it also relieved certain areas that had been experiencing long-term droughts, such as the Nelson Mandela Bay Metropolitan, which saw all its supplying dams fill to capacity.

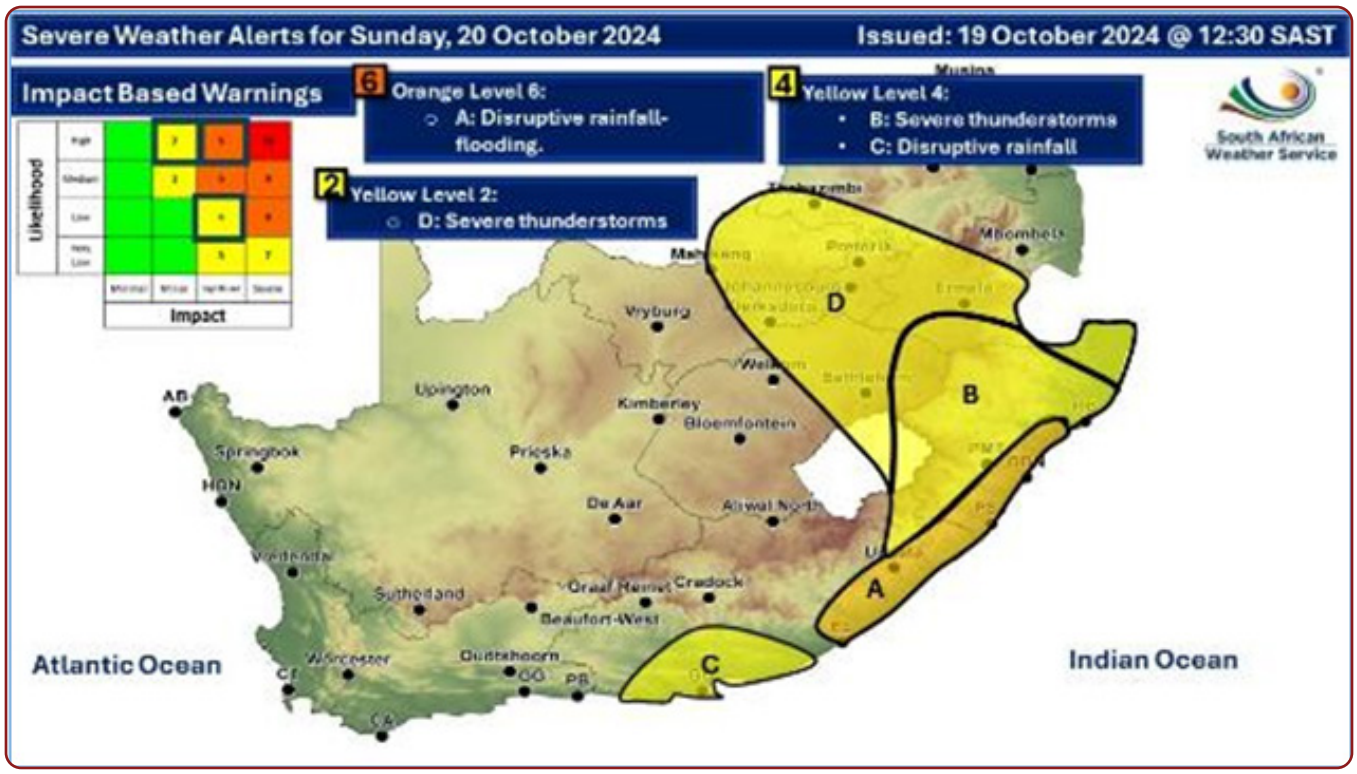

Figure 6: *Warnings issued on 19 October 2024*

Following the last heat waves in mid-December, conditions became very favourable for rain and thunderstorms over the country's eastern half. This brought cooler temperatures and a much-needed increase in water capacity, notwithstanding the severe weather events that also increased during the second half of the month. Several warnings were issued for flooding, strong and damaging winds, excessive lightning, and hail throughout the second half of December 2024.

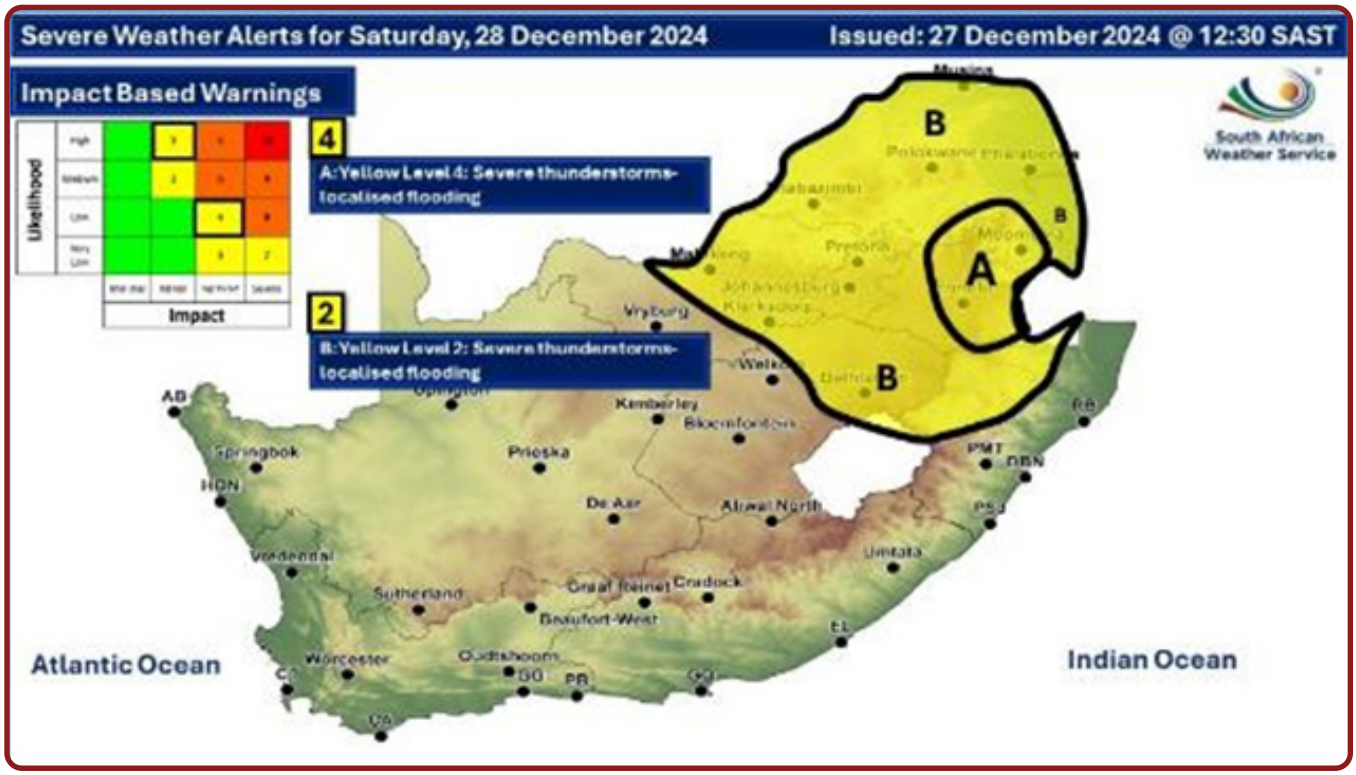

Figure 7: Warnings issued on 27 December 2024

The weather for January to March 2025

In December 2024, a significant shift occurred in the seasonal forecast, indicating above-normal rainfall for the remainder of the summer. One of the major climate drivers, the El Niño-Southern Oscillation (ENSO), was in a phase generally favourable for rainfall over the central and eastern parts of South Africa. Numerous warnings were issued to help safeguard life and property.

Heavy rainfall

A phenomenon referred to as “Africane”, a continental tropical low-pressure system, caused heavy rains with significant weather impacts over the north-eastern parts of the country from 16 to 20 February 2025. Ahead of “Africane”, the SAWS issued a media release on 16 February 2025 to alert the public of the impending severe weather. Heavy on-and-off showers were expected across North West and Gauteng, including the northern region of Free State, Highveld areas of Mpumalanga and southwestern Limpopo. The rainfall accumulation was expected to be in the region of 20 to 50 millimetres. The media release was followed by a series of warnings, which reached an Orange Level 6, indicating a high likelihood of significant impacts. The impacts were reported in North West, Gauteng, Mpumalanga, Limpopo and KwaZulu-Natal.

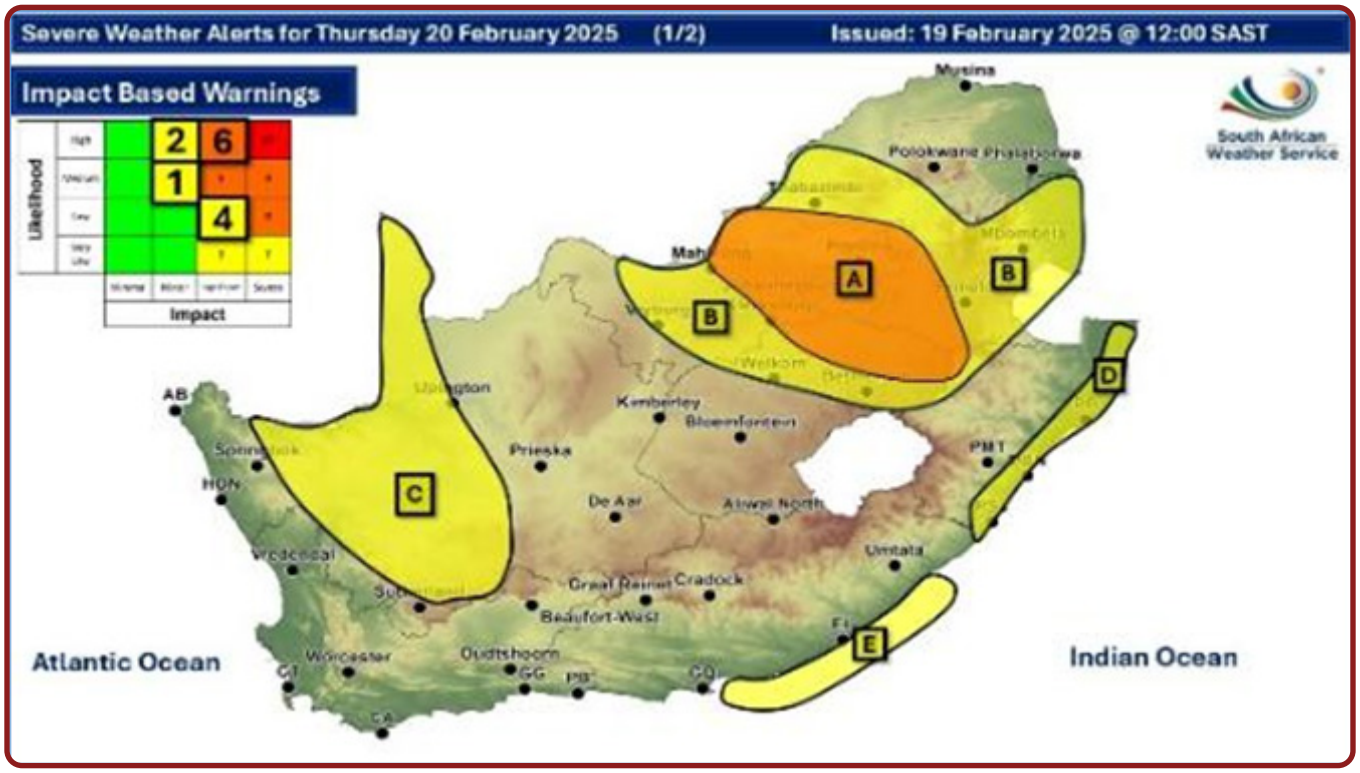

Figure 8: *Impact-based warnings for 20 February 2025, issued 19 February 2025*

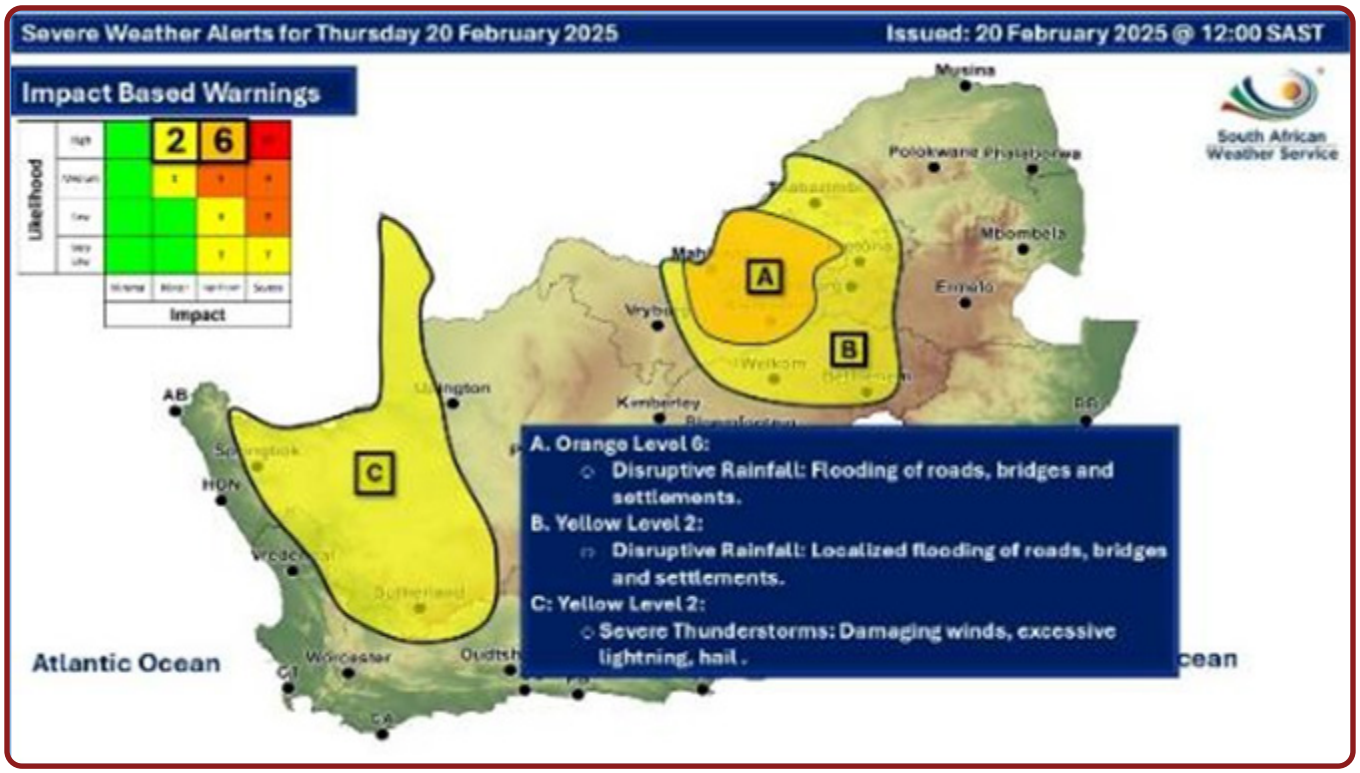

Figure 9: Impact-based warnings for 20 February 2025, issued 20 February 2025

One of the areas hardest hit was the Waterberg District of Limpopo, where severe flooding impacts were reported. The situation there was very likely accentuated by the opening of the sluice gates of several dams upstream of this district.

Photos 4: *A and B: Flooding over Limpopo, Thabazimbi. (Source: Facebook)*

On 2 March 2025, another severe weather event, caused by an upper trough, unfolded over the southeastern parts of the country. This was another instance of heavy rainfall that led to severe flooding, primarily in KwaZulu-Natal. Warnings were disseminated ahead of this weather system, with an Orange Level 6 issued for southern KwaZulu-Natal. The impacts reported included landslides in parts of the City of eThekwini.

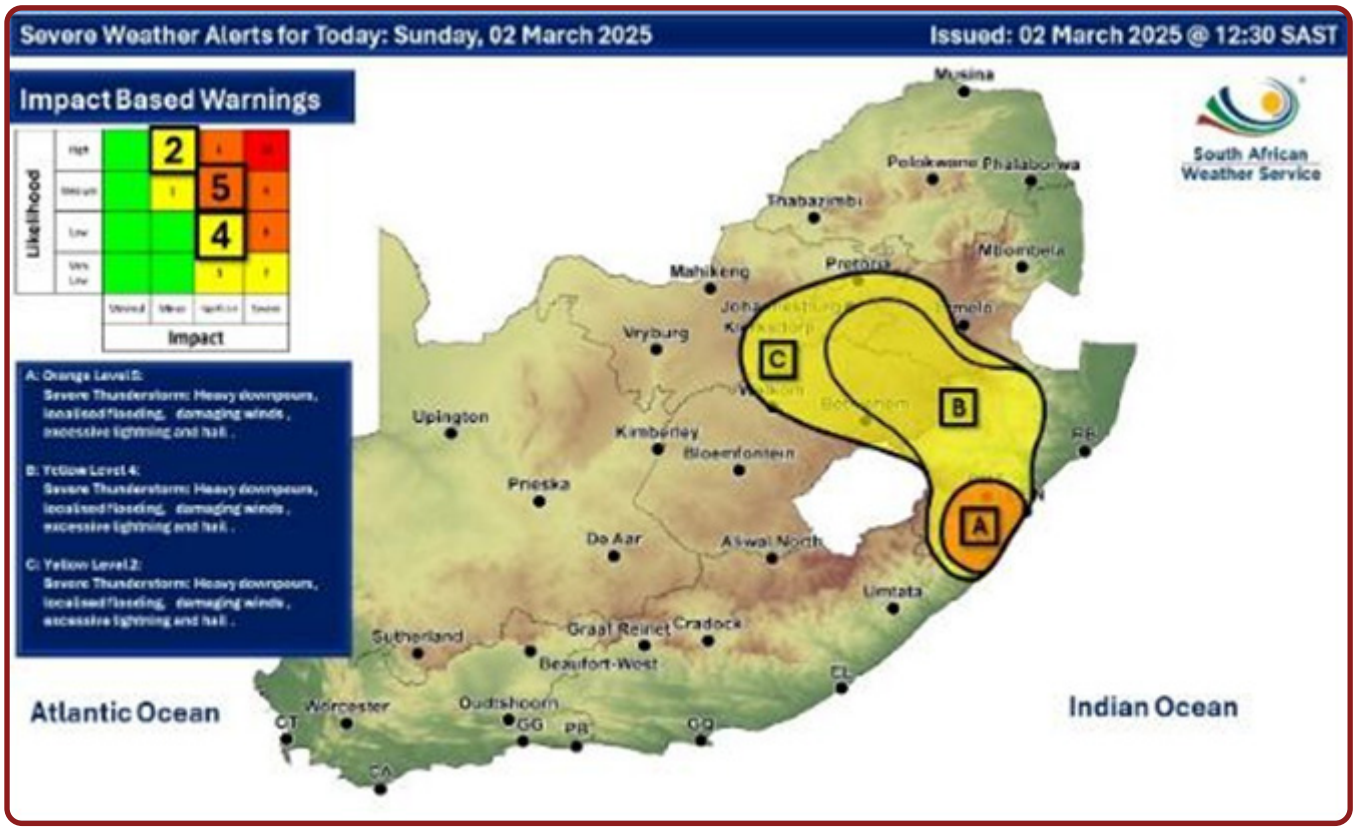

Figure 10: *Impact-based warnings for 2 March 2025*

As reflected above, a similar severe weather event unfolded on 13 and 14 March 2025, mainly affecting the City of eThekwini. Impact-based warnings, including those for severe thunderstorms, were issued before this event. Sadly, injuries and a regrettable loss of life in the Bojanala District of the North West were reported.

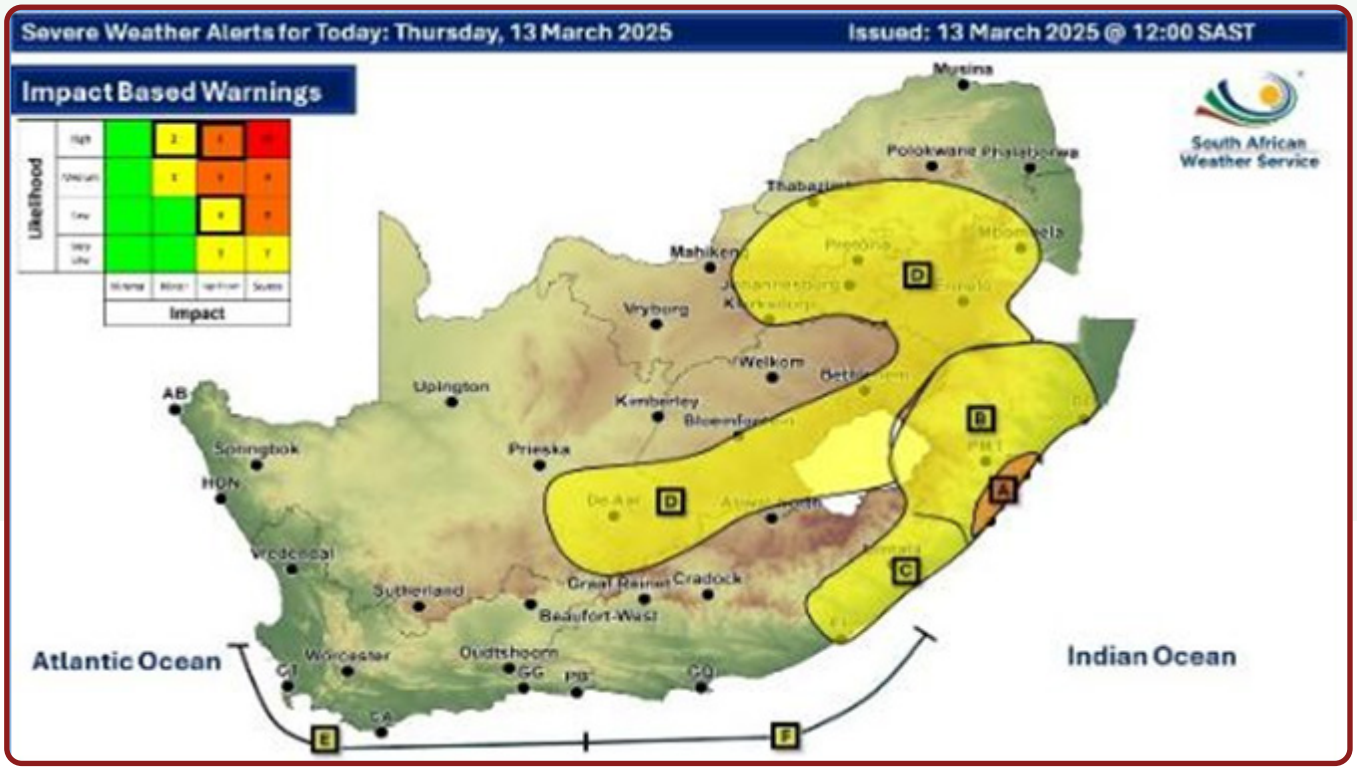

Figure 11: *Impact-based warnings for 13 March 2025*

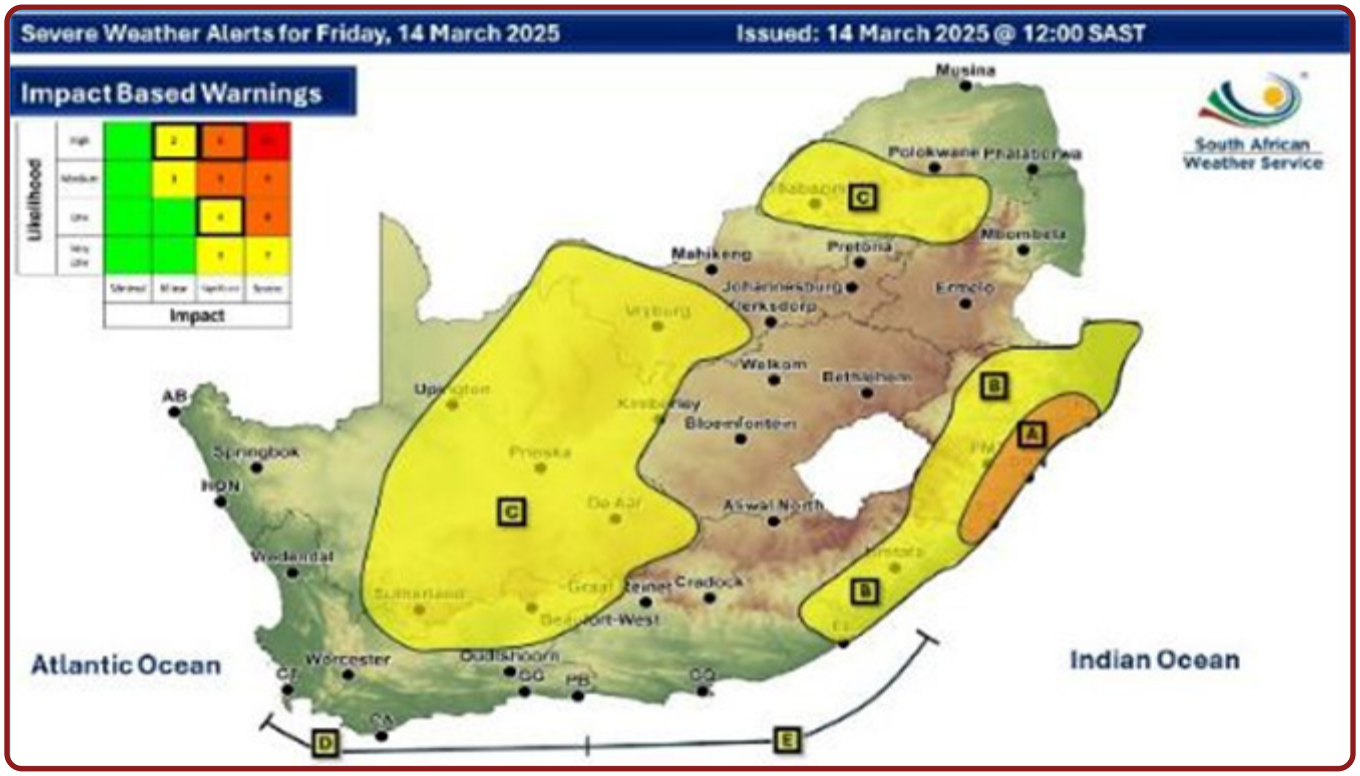

Figure 12: *Impact-based warnings for 14 March 2025*

PEER REVIEWED ARTICLES PUBLISHED BY SAWS SCIENTISTS IN SCIENTIFIC JOURNALS FROM 1 APRIL 2024 TO 31 MARCH 2025

The scientific research undertaken by the SAWS is captured in peer-reviewed articles, conference papers, book chapters and project reports which play an important role in advancing meteorological science and shaping the future of weather-related services and climate research. This article lists the 23 peer-reviewed scientific publications in local and international journals; 10 peer-reviewed conference papers included in official conference proceedings; one contribution to a book chapter and two peer-reviewed project reports that were published. These contributions can be made available on request.

Peer-reviewed scientific publications in local and international journals

1. BENCARDINO, M., D'AMORE, F., ANGOT, H., ANGIUL, L., BERTRAND, Y., CAIRNS, W., DIÉGUEZ, M.C., DOMMERGUE, A., EBINGHAUS, R., ESPOSITO, G., KOMÍNKOVÁ, K, **LABUSCHAGNE, C.,** MANNARINO, V., **MARTIN, L.,** MARTINO, M., NEVES, L.M., MASHYANOV, N., MAGAND, O., NELSON, P., NORSTROM, C., READ, K., SHOLUPOV, S., SKOV, H., TASSONE, A., VÍTKOVÁ, G., CINNIRELLA, S., SPROVIERI, F. AND PIRRONE, N. 2024. Patterns and Trends of Atmospheric Mercury in the GMOS Network: Insights Based on a Decade of Measurements. *Environmental Pollution*, **363**(Part 2), 15 Dec, 125104, 15 pp. https://doi.org/10.1016/j.envpol.2024.125104
2. **BOTAI, C.M.**, BOTAI, J.O., **TAZVINGA, H., MURAMBADORO, M.**, NHAMO, L., **NCONGWANE, K.P., MENGISTU, M.G., ZWANE, N.**, WAMITI, E., MPANDELI, S., MUTHONI, M. AND MABHAUDHI, T. 2024. Assessment of Rural Livelihoods, Health and Wellbeing in Vhembe District Municipality, South Africa and Narok County, Kenya: A Water-Energy-Food Nexus Perspective. *Environmental Science and Policy*, **159**, Sep., 103817. https://dx.doi.org/10.1016/j.envsci.2024.103817
3. **BOTAI, C.M., DE WIT, J.P.** AND BOTAI, J.O. 2024**.** Temporal Variability of Hydroclimatic Extremes: A Case Study of Vhembe, uMgungundlovu, and Lejweleputswa District Municipalities in South Africa. *Water*, **16**(20), 2924, 21 pp. https://doi.org/10.3390/w16202924
4. CHIKOORE, H., MBOKODO, I.L., SINGO, M.V., MOHOMI, T., MUNYAI, R.B., HAVENGA, H., **MAHLOBO, D.D.,** ENGELBRECHT, F.A., BOPAPE, M-J. M. AND NDARANA, T. 2024. Dynamics of an Extreme Low Temperature Event over South Africa amid a Warming Climate. Weather and Climate Extremes, 44, Jun., 100668. https://doi.org/10.1016/j.wace.2024.100668
5. GUSTIN, M.X., DUNHAM-CHEATHAM, S.M., LYMAN, S., HORVAT, M., GAY, D.A., GAČNIK, J., GRATZ, L., KEMPKES, G., KHALIZOV, A., LIN, C-J., LINDBERG, S.E., LOWN, L., **MARTIN, L.**, MASON, R.P., MacSWEEN, K., NAIR, S.V., NGUYEN, L.S.P., O'NEILL, T., SOMMAR, J., WEISS-PENZIAS, P., ZHANG, L. AND ŽIVKOVIĆ, I. 2024. Measurement of Atmospheric Mercury: Current Limitations and Suggestions for Paths Forward. *Environmental Science & Technology*, **58**(29), pp. 12853-12864. https://doi.org/10.1021/acs.est.4c06011. Published July 9, 2024
6. HOCKING, G., NEL, EMMA, MARKHAM, A., MUBAI, E., DUBA, T., ALI, S., MTHETHWA, H.S., **MATABANE, M.**, NDOU, N., SEBOGODI, K., AHMEDAI, S. AND FREEMAN, N. 2025. A Simple Model of the Draupner Wave Experiment. *Partial Differential Equations in Applied Mathematics*, **13**, Mar, 101085, 6 pp. https://doi.org/10.1016/j.padiff.2025.101085 (Published 15 Jan 2025)
7. **JACOBS, Q.** 2024. The Impact of Thunderstorms on Take-off Data in South Africa. *International Journal of Aviation, Aeronautics, and Aerospace, **11**(3), 12 pp* .https://commons.erau.edu/cgi/viewcontent.

cgi?article=1913&context=ijaaa

8. JOB, X.E.V., JAARS, K., VAN ZYL, P. G., MACSWEEN, K., BREDENKAMP, L., JOSIPOVIC, M., **MARTIN, L.G.,** VAKKARI, V., KULMALA, M. AND LAAKSO, L. 2025. Statistical Assessment of an Atmospheric Mercury Passive Sampler at a Regional Site in South Africa. *Environmental Science: Atmospheres*, 13pp. https://doi.org/10.1039/D4EA00071D (First published 3 Jan 2025)
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10. **KRUGER, A.C., McBRIDE, C**., ROBJHON, M. AND THIAW, W.M. 2024. Southern Africa [in "State of the Climate in 2023: Regional climates"]. *Bulletin of the American Meteorological Society*, **105** (8), pp. S416-S419. - https://doi.org/10.1175/2024BAMSStateoftheClimate.1
11. LUMBROSO, D., VINCENT, K., **MURAMBADORO, M**., STEYNOR, A., TSAROUCHI, G. AND NEZI, M. 2024. Current uses and potential future needs for climate services in South Africa. *Climate Services*, **36,** Dec, 100516, 10 pp. https://doi.org/10.1016/j.cliser.2024.100516 . Published 19 September 2024
12. MASHIFANE, T.B., BRABY, L., PIKISO, M., SUNNASSEE–TAUKOOR, S., **RAPOLAKI, R.S.** AND RAGOASHA, M.N. 2025. Machine Learning Algorithm Reveals Surface Deoxygenation in the Agulhas Current due to Warming. *Progress in Oceanography,* **231,** Feb, 103407. https://doi.org/10.1016/j.pocean.2024.103407 Available online 9 Dec 2024.
13. MASWANGANYI, C., TSHILONGO, J., MKHOHLAKALI, A., **MARTIN, L.**2024. Evaluation of Ambient NO2 and SO2 Concentrations at Lephalale, Polokwane, and Steelpoort Area in the Limpopo Province of South Africa. *Open Journal of Air Pollution*, **13**(4), Dec, pp. 111-126. https://doi.org/10.4236/ojap.2024.134007
14. **McBRIDE, C.M., KRUGER, A.C.,** JOHNSTON, C. AND DYSON, L. 2025. Projected Changes in Daily Temperature Extremes for Selected Locations over South Africa. *Weather and Climate Extremes,* **47,** Preproof, Mar, 100753,
15. MOHOMI, T., MBATHA, N.B., BOSHOFF, D.S., **MBOKODO, I.L**., NDARANA, T., BOPAPE, M-J. & CHIKOORE, H. 2024. Attributing Impacts of LULCC on the Boundary Layer Climate of South Africa's Eastern Escarpment. *Journal of Earth System Science*, **133**(4), Dec, 178, 24 pp. https://dx.doi.org/10.1007/s12040-024-02388-y . Published 9 September 2024
16. MOHOMI, T., MBATHA, N.B., BOSHOFF, D.S., **MBOKODO, I.L.,** NDARANA, T., BOPAPE, M-J. & CHIKOORE, H. 2024. Attributing Impacts of LULCC on the Boundary Layer Climate of South Africa's Eastern Escarpment. *Journal of Earth System Science*, **133**(4), Dec, 133 178, 24 pp. https://doi.org/10.1007/s12040-024-02388-y (published 9 September 2024)
17. **NTLEKO, T.** AND **MATLOU, X.** 2024. Exploring the Atmospheric and Weather Conditions for Hoar Frost Formation at OR Tambo International Airport: A Case Study of Ground Aircraft icing events for the period 2017-2023. *International Journal of Aviation, Aeronautics, and Aerospace*, **11**(3), MS1926. **https://dx.doi.org/10.58940/2374-6793.1926**
18. PERRY, Z., **RAPOLAKI, R.,** ROFFE, S. AND RAGOASHA, M. 2024.Analysing the Atmospheric-Oceanic Conditions Driving the Sustained Long Track and Intensity of Tropical Cyclone Freddy. *Tropical Cyclone Research and Review,* In Press, Journal Pre-proof. https://doi.org/10.1016/j.tcrr.2024.11.008
19. RAMSARUP, N., **MORRIS, T.,** HERMES, J. AND DICKEN, M. 2024. Long-term Interannual Temperature Variability across the KwaZulu-Natal Bight as a Technique for Monitoring the Complex uThukela Marine Protected Area, South Africa. *African Journal of Marine Science,* **46**(4), pp. 247-262. https://doi.org/10.2989/1814232X.2024.2405499
20. ROFFE, S., MYENI, L., **RAPOLAKI, R**., BELLO, Z., MOELETSI, M., MAZIBUKO, S. AND MALULEKE, P. 2024. Identifying Climatic Risks and Relevant Adaptation Strategies for Selected Smallholder Farming Regions, Limpopo Province, South Africa. *South African Geographical Journal,* Early view, 20 pp. https://doi.org/10.1080/03736245.2024.2398416. Published 3 September 2024
21. SEYMOUR, C.L., SEATON, D., KHATIEB, S., **LETSATSI, N.,** SKOWNO, A., TOKURA, W., VAN DER MERWE, S., VISSER, V. AND VON MALTITZ, G. 2025. Satellite-Derived Productivity Outputs for Land Degradation Assessment Vary with Biome and Rainfall. *Land Degradation & Development*, Early view, 15 pp. https://doi.org/10.1002/ldr.5541

22. **VERMEULEN, J.H.,** HEDDING, D.W. AND **LETSATSI, N.** 2024. Forecasting Extreme Hourly Rainfall in South Africa for Disaster Risk Reduction: Thresholds and Return Periods. *Water SA*, **50**(4), Oct, pp. 330-344. https://doi.org/10.17159/wsa/2024.v50.i4.4111
23. **ZWANE, N**., BOTAI, J.O., **BOTAI, C.M.** AND MABHAUDI, T. 2024. Sustainability of the Linkages Between Water–Energy–Food Resources Based on Structural Equation Modeling Under Changing Climate: A Case Study of Narok County (Kenya) and Vhembe District Municipality (South Africa). Sustainability, **16**(22), 9689, 15 pp. https://doi.org/10.3390/su16229689

Peer-reviewed conference papers included in official conference proceedings

1. **GELDENHUYS, M.**, BLAZAKI, K., AFCHINE, A., CERECEDA, F., GROOß, J-U., HEGGLIN, M.I., KLOSS, C., KUHN, T., L**ABUSCHAGNE, C., LABUSCHAGNE, P.,** LAUBE, J.C., **MACHININI, T., MKOLOLO, T.**, RENARD, J-B., ROLF, C., STEFFES, W., STOPFORD, C. AND RIESE, M. 2024. BIANKA: A Balloon Field Campaign to Study Climate Change Uncertainties, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 21-24. ISBN 978-1-0370-1666-0
2. **HEYNEKE, E.**, DYSON, L. AND VAN SCHALKWYK, L. 2024. The Importance of Understanding Mesoscale Weather Features to Assist Conservation Agriculture Practices in South Africa: a Case Study. *Proceedings of the 9th World Congress on Conservation Agriculture*, Cape Town, South Africa, July 2024, pp. 189-192. ISBN 978-1-0370-5134-0
3. **HEYNEKE, E.,** DYSON, L. AND VAN SCHALKWYL, L. 2024. Comparative Analysis of Two Squall Lines: A Case Study, in the 38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment", 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 32-36. ISBN 978-1-0370-1666-0
4. **JABE, A**., **NOZWANE, S.H., ZWANE, N**., **MURAMBADORO, M.** AND **SILWANYANA, Y.** 2024. Investigating Weather Forecast Accessibility in Vulnerable Communities of uMgungundlovu District Municipality, KwaZulu Natal: A Case study in Msunduzi Local Municipality, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 37-41. ISBN 978-1-0370-1666-0
5. **MASITHELA, T., MENGISTU, M., LANDMAN, S.** AND CLULOW, A. 2024. A Preliminary Evaluation of The Unified Model Soil Moisture Estimates Using In Situ TDR Measurements, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 46-49. ISBN 978-1-0370-1666-0
6. **MBOKODO, I.L.,** BURGER, R.P., BOPAPE, M-J.M. AND FRIEDLAND, A. 2024. Meteorological Characteristics of two High-Impact Squall Line Events over the South African Highveld, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 50-54. ISBN 978-1-0370-1666-0
7. **MUGERI, M.E**. AND GARLAND, R.M. 2024. Assessing the Ability of Global Modelling Products to Simulate Air Pollution Levels During a Cold Front Passage in Gauteng, South Africa, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 60-66. ISBN 978-1-0370-1666-0
8. **MURAMBADORO, M.D**. AND **SILWANYANA, Y.** 2024. Assessing the Early Warning and Weather Information Needs for Households with Persons with Disability to Support Disaster Preparedness and Risk Reduction in the uMgungundlovu District Municipality, South Africa, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 72-76. ISBN 978-1-0370-1666-0

9. **NKADIMENG, M**., **MABASA, B.** AND **TAZVINGA, H.** 2024. Minute, Hourly, Daily and Seasonal Characteristics of Surface Albedo at Irene Station in Pretoria, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, hosted by North-West University, Potchefstroom, pp. 77-83. ISBN 978-1-0370-1666-0
10. **VAN DER MESCHT, D**. AND **GELDENHUYS, M.** 2024. Trapped Mountain Waves Influenced by Small-Scale Topographic Features of the Tsitsikamma and Langkloof Mountains, in the *38th Annual Conference of the South African Society for Atmospheric Sciences: "Exploring the Novel Integration of Tools to Understand Our Changing Environment"*, 29-30 October 2024, North-West University, Potchefstroom, pp. 91-94. ISBN 978-1-0370-1666-0

Contribution to peer-reviewed book chapters

1. MANGANI, R., ARCHER, E., **ENGELBRECHT, C**., BELLOCCHI, G., MUKIIBI, A. AND CREUX, N.M. 2025. The Impact of Climate Change on Crop Production and Food Security: A South African Perspective, in FILHO, L.W., MATANDIROTYA, N., AYAL, Y.D., LUETZ, J.M. AND BORSARI, B. (Eds.) *Climate Change, Food Security, and Land Management*. Cham, Springer, pp. 1-28. https://doi.org/10.1007/978-3-031-71164-0_56-1

Peer-reviewed project reports

1. AGEET, S., PARKER, D., MSEMO, H., COLENBRANDER, W., DE CONING, E., **GIJBEN, M**., GONçALVES, J., GROVES, D., IMBWAE, F., JUHANKO, K., KIETH, G**., KROESE, N**., MARSHAM, J., MATAYA, D., MBULI, N., MONJANE, G., MONJANE, M., **MURAMBADORO, M**., PERRELS, A., ROBERTS, A., **SEBEGO, E., SEGALWE, O., STANDER, J., TAWANE**, T., TAYLOR, C., VINCENT, K. AND VOSLOO, C. 2024. Weather and Climate Information Services Early Warning for Southern Africa (WISER-EWSA) testbed 1. Report. University of Leeds. https://doi.org/10.48785/100/267
2. **MAISHA, T. R., MULOVHEDZI, P.T., RAMBUWANI, G. T., MAKGATI, L.N**., BARNES, M., LEKOLOANE, L., ENGELRECHT, F. A., NDARANA, T., **MBOKODO, I.L., XULU, N. G**. AND **BOPAPE, M.M**. 2025. *The Development of a Locally Based Weather and Climate Model in Southern Africa*. WRC Report no. 3181/1/24. Pretoria, Water Research Commission, 197 pp. ISBN 978-0-6392-0683-7. http://wrcwebsite.azurewebsites.net/wp-content/uploads/mdocs/3181%20final.pdf

MEET THE AUTHORS

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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 variability research with historical data as input, ad hoc scientific projects, climate data and information requests, where advanced statistical analyses are required, drought monitoring, and assisting in the quality control of climate data. Dr Kruger has a PhD (Civil Engineering) degree (University of Stellenbosch) on the research topic "Wind Climatology and Statistics of South Africa relevant to the Design of the Built Environment".

Before that, he obtained and 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 involved advanced statistical analyses and interpretation of historical climate data.

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Mr Sifiso **Mbatha**

Sifiso Mbatha is a Climate Service Scientist: Climate Data. He joined SAWS as an intern in 2015 and was employed in July 2016 in the same unit. He completed his BSc degree in Physics and Geography in 2013 and further obtained his Climatology Honours degree 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 the East Rand, South Africa.

Dr Markus **Geldenhuys**

Dr Markus Geldenhuys is a forecaster at the Gqeberha Weather Office. He has a wide interest in research and works on many topics ranging from building AWSs to marine to subseasonal predictions to climate change. In his MSc in Meteorology at the University of Pretoria where he studied low-level wind flow and turbulence in a mountaineous environment. During his PhD in Physics at the Bergische Universitaet of Wuppertal and at Forschungszentrum Juelich in Germany he studied gravity waves in the troposphere and stratosphere. He has a particular interest in field work and experiments. He has worked on fognets, AWS', radiosondes, Ozone-sondes, drones and a remote sensing limb imager aboard a research aircraft

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