WEATHERSMART NEWS

Scientific meteorological and climatological news from the South African Weather Service

MARCH 2024

- How will the climate change by 2050 in South Africa?
- BIANKA - South African, Chilenean and German scientists joining forces for balloon experiments
- Bad weather caused plane diversion from OR Tambo Airport
- Attributes of numerical weather prediction models
- Relocation of the South African Weather Service Head Office and its High-Performance Computer
- Was December 2023 windier over the Cape Peninsula than usual?

South African Weather Service

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FOREWORD
Chief Executive Officer

Welcome to the March 2024 edition of the WeatherSMART NEWS. The work of the South African Weather Service provides valuable input to many sectors in the South African economy as well as academia and research. By publishing these articles, we aim to create a WeatherSMART nation which is well informed about the plethora of meteorological phenomena observed in the country.

This edition addresses several important meteorological and climatological issues such as what weather and climate could be expected by 2050. By referencing the International Panel on Climate Change (IPCC)'s sixth assessment report, we read about two scenarios, offered by the IPCC, namely Representative Concentration Pathways (RCP) 4.5 and RCP 8.5, both of which predict an increase in greenhouse gas emissions until the mid-century, but then they diverge thereafter. RCP 4.5 sees a stabilisation and decrease of emissions, while RCP 8.5 continues with high emissions throughout the century. Despite these differences, both scenarios show similar climate projections until 2050. Climate change is projected to have a drastic impact in South Africa, particularly under the RCP 8.5 "business as usual" scenario, which assumes a low mitigation. Of significance is that temperatures are projected to increase at probably twice the rate of global temperatures. As South Africa is susceptible to flooding and drought extremes, we can expect many impacts on our economy, water security, food security and health, among others.

Once again scientists from South Africa and Germany combined forces to probe the atmosphere over the Karoo. A tri-lateral campaign with scientists from the SAWS, Forschungszentrum Juelich, Germany and Universidad Technica Federico Santa Maria, Chile, measured atmospheric phenomena over the South American and African continents in a campaign called BIANKA (**BI**modal **AN**des **KA**roo). Amongst others, the atmospheric composition over South America and Southern Africa was measured in as near real-time as possible, and our scientists played a crucial role in this regard.

The diversion of planes at OR Tambo International Airport on February 20, 2024, due to thunderstorms, emphasises the dynamic challenges posed by adverse weather conditions in the aviation industry and the importance of providing proactive safety measures, effective communication, and collaborative efforts among stakeholders to ensure the well-being of passengers and the continued efficiency of airport operations. Airports and airlines need to be well-prepared for adverse weather conditions, and advanced weather monitoring systems contribute to effective response measures.

Numerical Weather Prediction (NWP) models are techniques that use a set of physics and dynamic equations as well as current observations to predict the future state of the atmosphere (Lions et al., 1992). More light is shed on the use of these models by our researcher, Ms Patience Mulovhedzi. The SAWS uses High-Performance Computing (HPC) architecture for the processing of NWP models, which form a critical component of the forecasting operations. These models simulate atmospheric processes to generate weather forecasts by using complex algorithms and computational power. The relocation of our HPC system was therefore of crucial importance during our relocation in November 2023, and I am glad to report that this operation went well.

I want to encourage you to read till the end, as our last article addresses the question whether Cape Town was windier than normal during December 2023. Read for yourself why the observed stilling of the wind at the Cape Town Royal Yacht Club over the last 20 years points to the effects of climate change, but that there was indeed more wind during the month mentioned.

I hope you find this edition insightful and enjoyable.

Ishaam Abader
Chief Executive Officer

HOW WILL THE CLIMATE CHANGE BY 2050 IN SOUTH AFRICA?

Nosipho Zwane, Siyabonga Nozwane, Aphinda Jabe, Andries Kruger, Katlego Ncongwane

Introduction

According to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6), the global surface temperatures during the first two decades of the 21st century (2001 – 2020) were about 1°C higher than pre-industrial (1850 – 1900). Notably, since 1970, the increase in global surface temperatures has been more rapid than in other 50-year periods over the preceding two millennia. This increase in average temperature has been linked to intensified extreme weather events such as heat waves, veld fires and droughts (Field and Barros, 2014). Specifically in South Africa, studies have observed an increase in minimum and maximum temperatures (Mbokodo et al., 2020 and Engelbrecht et al., 2015), as well as record-high temperatures consistent with global warming (McBride et al., 2021). The occurrence of these climate-related hazards leads to loss of life, social disruption, and economic hardships as indicated in Ihinegbu (2021). A case in point occurred in January 2023, when several news outlets in South Africa reported a severe heat wave in the Northern Cape, with temperatures reaching 41°C over a wide area, resulting in heatstroke-related deaths of seven farm workers. Additionally, the country faces highly variable rainfall patterns and more severe storms (Tarmizi, 2019). The findings of IPPC AR6, together with Tarmizi (2019), have associated climate change with a decrease in the likelihood of rainfall and a rise in its intensity, leading to an increased frequency of flooding, posing a significant threat to South Africa's food and water security, human health, economy, society, and environment (Kwame et al., 2022).

Modelling Approach

The projected temperature and rainfall presented in this article are based on the Coupled Model Intercomparison Project Phase 5 (CMIP 5) Global Climate Models (GCMs), with specific focus on the selected projected greenhouse gas concentration pathways, also used as basis in the SAWS Climate Change Atlas (https://www.weathersa.co.za/home/climatechangeatlas). The model outputs are based on the IPCC "Representative Concentration Pathways (RCPs)". Only two RCP scenarios were considered in this article, the RCP 4.5 "moderate scenario" and RCP 8.5 "business as usual scenario" (where no significant action is taken to curb greenhouse gas emissions), also defined as the addition of 4.5 W/m^2 and 8.5 W/m^2 radiative forcing in the atmosphere by the year 2100.

The analysis utilises historical and projected simulations from nine GCMs, as listed in Table 1. Note that the output from these GCMs is in a relatively coarse resolution. To refine to a higher resolution, dynamical downscaling was employed, achieving a finer resolution of 0.44°×0.44° (± 50km x 50km) using the Rossby Centre Regional Atmospheric Model (known as the RCA4 model) from the Swedish Meteorological and Hydrological Institute (SMHI). Simply put, the nine GCMs in Table 1 provided boundary input to the RCA4 (SAWS atlas, 2017).

Table 1: CMIP5 GCMs used as boundary conditions for high resolution simulations of approximately 0.44° × 0.44° using the RCA4 Regional Climate Model (RCM)

Model name	Institute/Country	Resolution	Literature
CanESM2m	CCCMa (Canada)	2.8° × 2.8°	Arora *et al.*, (2011)
CNRM-CM5	CNRM-CERFACS (France)	1.4° × 1.4°	Voldoire *et al.*, (2013)
CSIRO-MK3	CSIRO-QCCCE (Australia)	1.9° × 1.9°	Rotstayn *et al.*, (2013)
IPSL-CM5A-MR	IPSL (France)	1.9° × 3.8°	Hourdin *et al.*, (2013)
MIROC5	AORI-NIES-JAMSTEC (Japan)	1.4° × 1.4°	Watanabe *et al.*, (2011)
HadGEM2-ES	Hadley Centre (UK)	1.8° × 1.2°	Collins *et al.*, (2011)
MPI-ESM-LR	MPI – M (Germany)	1.9° × 1.9°	Ilyina *et al.*, (2013)
NorESMI-M	NCC (Norway)	1.9° × 2.5°	Tjiputra *et al.*, (2013)
GFDL-ESM2M	GFDL (USA)	2.0° × 2.5°	Dunne *et al.*, (2012)

Model Verification against Observations

The temperature and rainfall climate projections shown in this article were generated after verification of the model output. This is when the model performance in simulating the climate system is assessed. Historical ensemble mean simulations spanning from 1979 to 2005, derived from the nine RCA4 Regional Climate Model (RCM) members were compared with observational data from the Global Precipitation Climatology Centre (GPCC) (Schneider et al., 2011. SAWS, 2017) for precipitation and the NOAA GHCN_CAMS Land Temperature Analysis for observed temperature (Fan and van den Dool, 2008. SAWS, 2017). Figures 1 and 2 show that the model accurately captured the spatial distribution of rainfall and temperature.

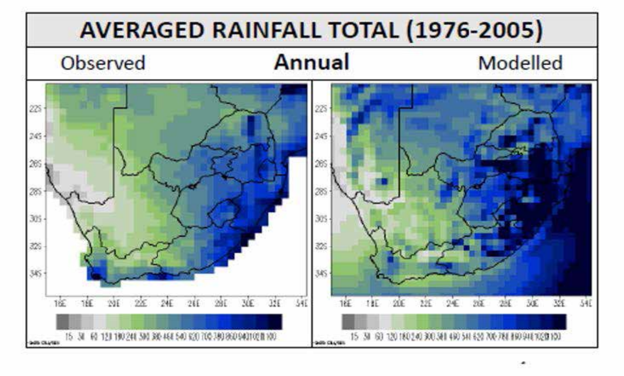

Figure 1: Average of observed annual total rainfall (mm.year-), from the Global Precipitation Climatology Centre (GPCC) (left), compared to the associated nine-member ensemble mean rainfall as simulated by the RCA4 RCM (right), for the period 1976-2005

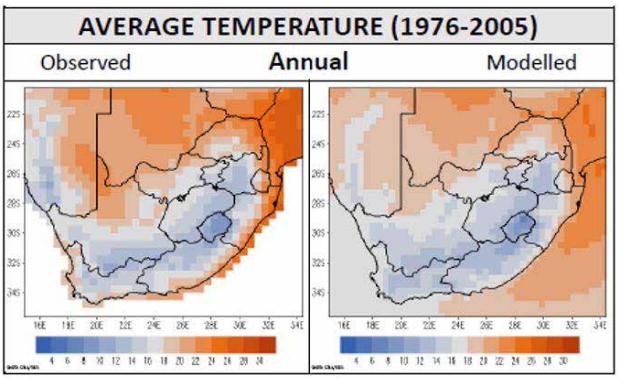

Figure 2: Average of observed annual mean temperature (°C), from the NOAA GHCN_CAMS Land Temperature Analysis (left), compared to the associated nine-member ensemble mean temperature as simulated by the RCA4 RCM (right), for the period 1976-2005

Temperature projections for year 2050

Figure 3 below shows the annual projected temperature change for the year 2050 for both RCP 4.5 and RCP 8.5 scenarios. Under the RCP 4.5 scenario, increasing temperatures are projected across the northern and north-eastern parts of South Africa, and cooler conditions are expected in the Lesotho highlands. On the other hand, the RCP8.5 scenario suggests warmer conditions extending further southward and along the coast of South Africa. However, there is a minor difference between the two scenarios for this near-future outlook, suggesting that, regardless of moderate actions to curb greenhouse gas emissions, the country is locked in for significant warming for the foreseeable future. This increase in temperatures could have significant impacts as demonstrated in studies by Botai et al. (2019 and 2020), which investigated drought characteristics over the Western Cape and drought risk in the Eastern Cape, respectively. Meanwhile, Nhemachena et al. (2020) investigated the impact of water scarcity on the agricultural sector and observed a reduction in crop yield and the survival of livestock, which are likely to exacerbate financial constraints already experienced in the country. Tourism, one of the essential economic sectors (Sifolo and Henama, 2017), may experience negative effects due to some changes in the ecosystem, weather conditions, infrastructure and tourist attraction landscapes, water shortage, food availability and the spread of vector diseases such as malaria (Pandy and Rogerson, 2021). Moreover, increases in temperatures adversely affect human health by contributing to heat-related illnesses. (Wright et al., 2021), reinforcing the need for comprehensive and urgent actions to mitigate its effects.

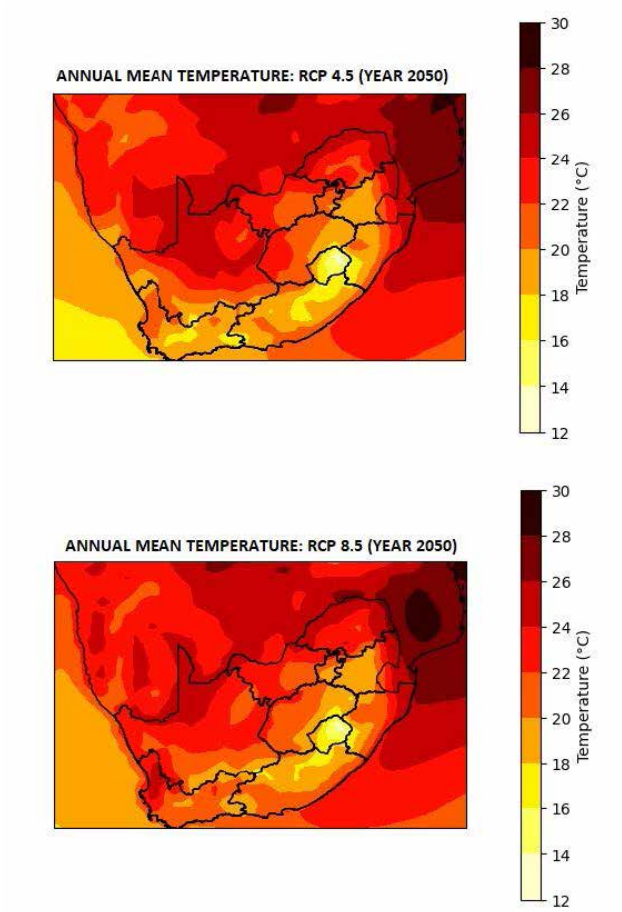

Figure 3: Annual mean near-surface temperature (°C) projected for 2050 relative to reference period (1976-2005), under the RCP 4.5 and the RCP 8.5

Figures 4 and 5 present seasonal projections for the period December – February (2049-2050), March – May 2050, June – August 2050 and September – November 2050. As clearly indicated under the moderate mitigation scenario (RCP 4.5), the projected temperature increase is about 1,2ºC particularly for the northern regions of the country during December – February and March – May seasons. Further warming for the business-as-usual scenario (RCP 8.5) between 1,2-1,6ºC is observed for the same months. In winter an increase of 0,6ºC and 0,8ºC is demonstrated for RCP 4.5 and RCP 8.5 respectively.

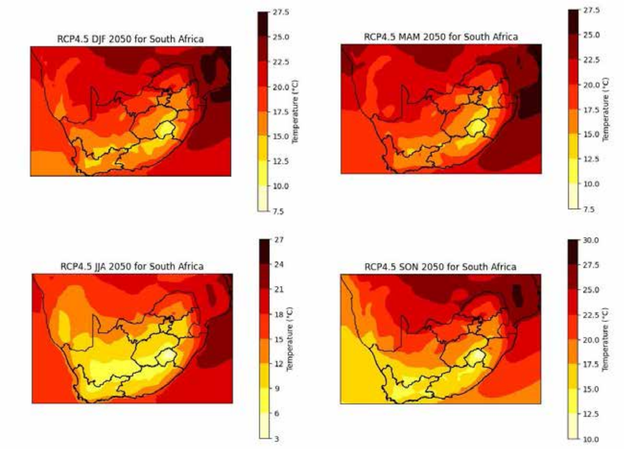

Figure 4: Seasonal mean near-surface temperature (0C) projected for 2050 relative to reference period (1976-2005), under the RCP 4.5

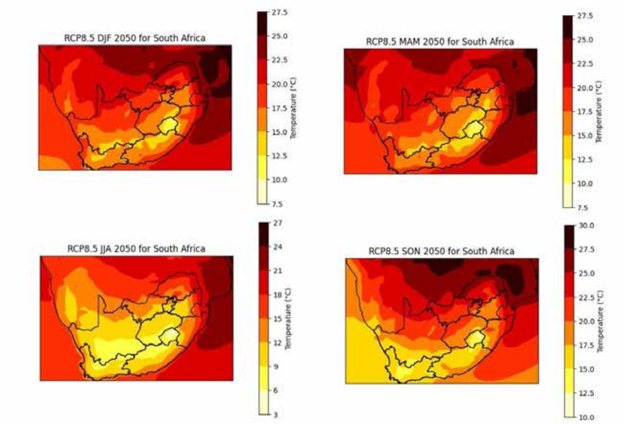

Figure 5: Seasonal mean near-surface temperature (°C) projected for 2050 relative to reference period (1976-2005), under the RCP 8.5

Rainfall projections for year 2050

Rainfall is a more variable climate parameter, compared to temperature. The RCP 4.5 scenario indicates a general decrease in precipitation rates across most of South Africa, but especially in the west and extreme north. However, the north-eastern regions of the country may experience relatively higher precipitation rates. This observation is emphasised in the RCP 8.5 scenario, which shows higher precipitation rates in regions of KwaZulu-Natal (KZN), Mpumalanga, and across eSwatini.

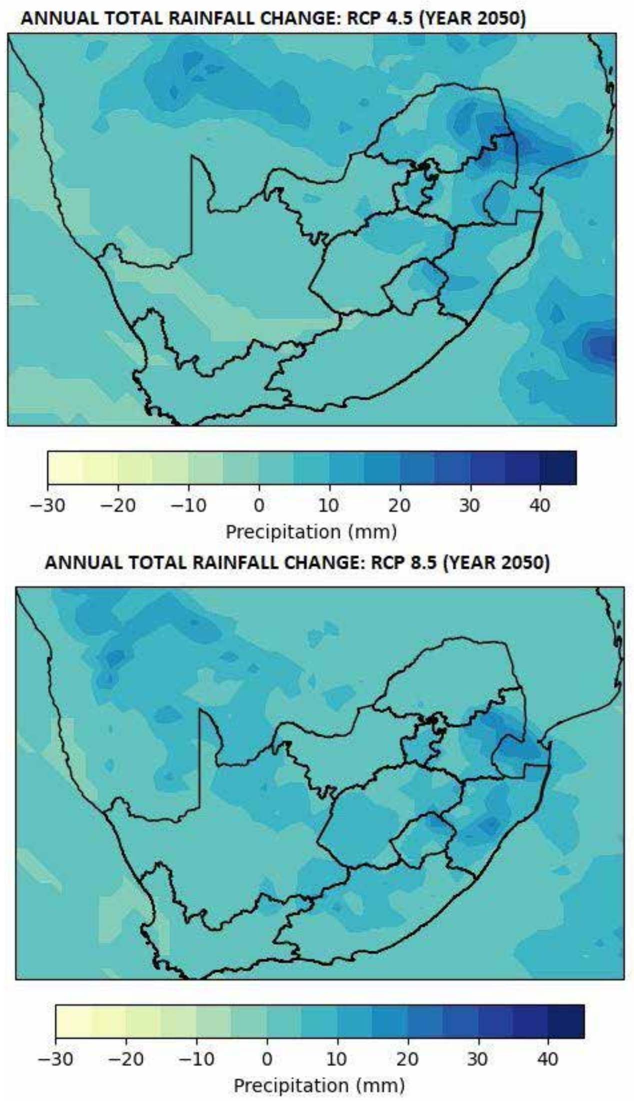

Figure 6: Annual total rainfall change (mm) projected for 2050 relative to reference period (1976-2005), under the RCP 4.5 and the RCP8.5

Figures 7 and 8 illustrate the seasonal projected rainfall change. Both scenarios show relatively similar spatial changes, with summer months projected to have an increase in rainfall along the north-eastern part of the country, including Lesotho. Meanwhile, a decrease in rainfall along the western part of the country is projected for the winter season, with the exception of the Cape Town region, which illustrates a higher rainfall simulation.

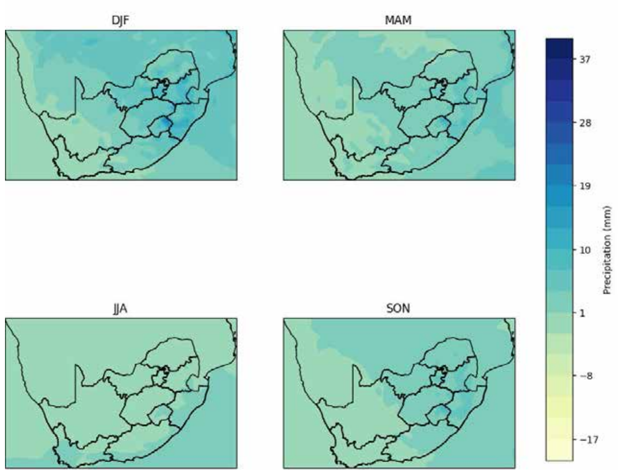

Figure 7: Seasonal total rainfall change (mm) projected for 2050 relative to reference period (1976-2005), under the RCP 4.5

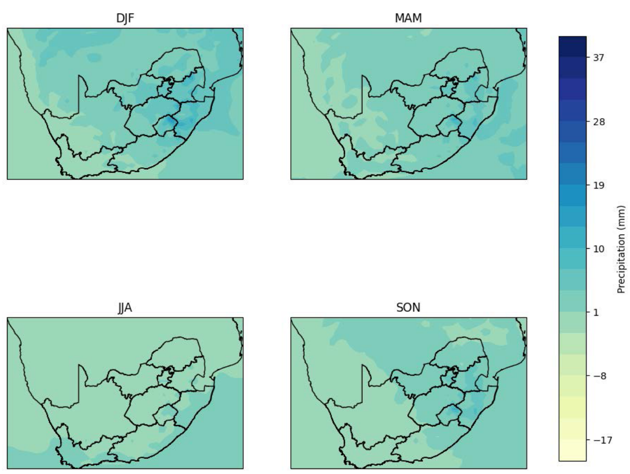

Figure 8: Seasonal total rainfall change (mm) projected for 2050 relative to reference period (1976-2005), under the RCP 8.5

Conclusion

The AR6 report highlighted that both the RCP 4.5 and RCP 8.5 scenarios predict an increase in greenhouse gas emissions until the mid-century, but then they diverge thereafter. RCP 4.5 stabilizes and decreases emissions, and RCP 8.5 continues with high emissions throughout the century. Despite these differences, both scenarios show similar climate projections until 2050. Climate change is projected to have a drastic impact in South Africa, particularly under the RCP 8.5 “business as usual” scenario, which assumes a low mitigation. Temperatures are projected to increase probably twice the rate of global temperatures. South Africa is projected to become drier under the business-as-usual scenario, however, when it rains, the intensity of rainfall will increase, as observed for the eastern part of the country in summer. Overall, the South Africa is susceptible to both extremes (flooding and drought). The changes in climate will have an impact on the country's economy, water security, food security and health, among others.

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BIANKA - South African, Chilean, and German scientists joining forces for balloon experiments

Casper Labuschagne and Markus Geldenhuys

*Recently scientists from South Africa and Germany combined forces (yet again!) to probe the atmosphere over the Karoo. This year, the campaign was a tri-lateral campaign where scientists from the South African Weather Service, Forschungszentrum Juelich, Germany and Universidad Technica Federico Santa Maria, Chile combined forces to measure atmospheric phenomena over the South American and African continents in a campaign called BIANKA (***BI***modal* ***AN****des* ***KA****roo). BIANKA amongst others aimed at measuring the atmospheric composition over South America and Southern Africa in as near real-time as possible (aiming at sampling the same high altitude airmasses as they move from South America over South Africa).*

Some objectives of BIANKA campaign were to:

- Take high resolution photos of individual ice crystals inside clouds with the brand new NIXE instrument
- Detection of traces of Hunga-Tonga Ha'apai volcanic plume that is still in the stratosphere more than two years after its eruption
- Capture small air samples up to 32km with AIRCOREs
- Characterise different types of aerosols from air pollution and wildfires
- Measure different atmospheric trace gases like ozone, water vapor, etc with the MOSES payload.

Briefly – Once a suitable event has been identified, Dr Markus Geldenhuys, a SAWS forecaster, will run a series of balloon ascent and descent simulations. This is done using sophisticated tracking software, to determine if a suitable landing site can be identified (i.e., not against or atop of a mountain range; or proximity to some farm dirt roads for example). A 1500g or 3000g helium-filled balloon is prepared and the instrument payload is connected with some radiosonde and GPS trackers and released. After an ascent to the ~30km altitude range the balloon bursts and the payload descends back to earth using a parachute, to be collected by the ground team who has the final landing co-ordinates from the flight.

Figure 1: Launch preparation in daytime (left) and during night-time hours (03h00) (right).

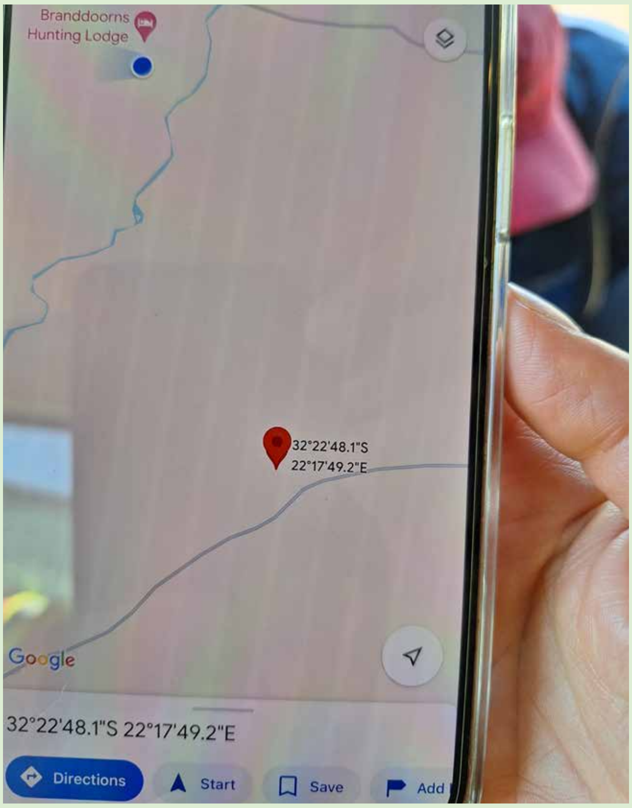

Figure 2: Left - Using cell phone technology to locate the fallen payloads.
Right – Casper Labuschagne locating a payload "in the middle of nowhere".

Instruments

This year, there were quite a few new, additional instruments called "payloads" since the last campaign. This is an indication of the success of the first campaign and the subsequent scientific interest that it has sparked.

One example is the light-weight aerosol counter (LOAC), which helps the team to study the evolution of the aerosols following the strongest volcanic eruption of the past few decades (the Hunga Tonga- Ha'apai eruption). The measurements of this and other campaigns are valuable to subsequently determine the climate impact of such an event.

Figure 3: Instrument payload with NIXE (balloon) - a cirrus cloud ice particle imager on the far right of the image, UCASS (aerosol counter) in the middle of the image, CFH – Cryogenic Frost point Hygrometer (in light blue cover), ozone sonde with Vaisala radiosonde (top left box), LOAC – aerosol counter (in the middle of the table).

Figure 4: Left: Photo directly after launch showing the launching team. The camera is attached to the bottom of the first payload. Right: Photo from higher up showing the landscape and a 20m line where the next instrument attaches.

For the South African leg of the campaign, the SAWS and Juelich scientists set up camp on a farm in the Beaufort West vicinity. They converted a hunting lodge into a temporary laboratory and balloon launch pad. The area is ideally situated for these types of campaigns due to its wide, open plains, low mountain ranges and sparsely populated areas, all making successful balloon payload recoveries possible.

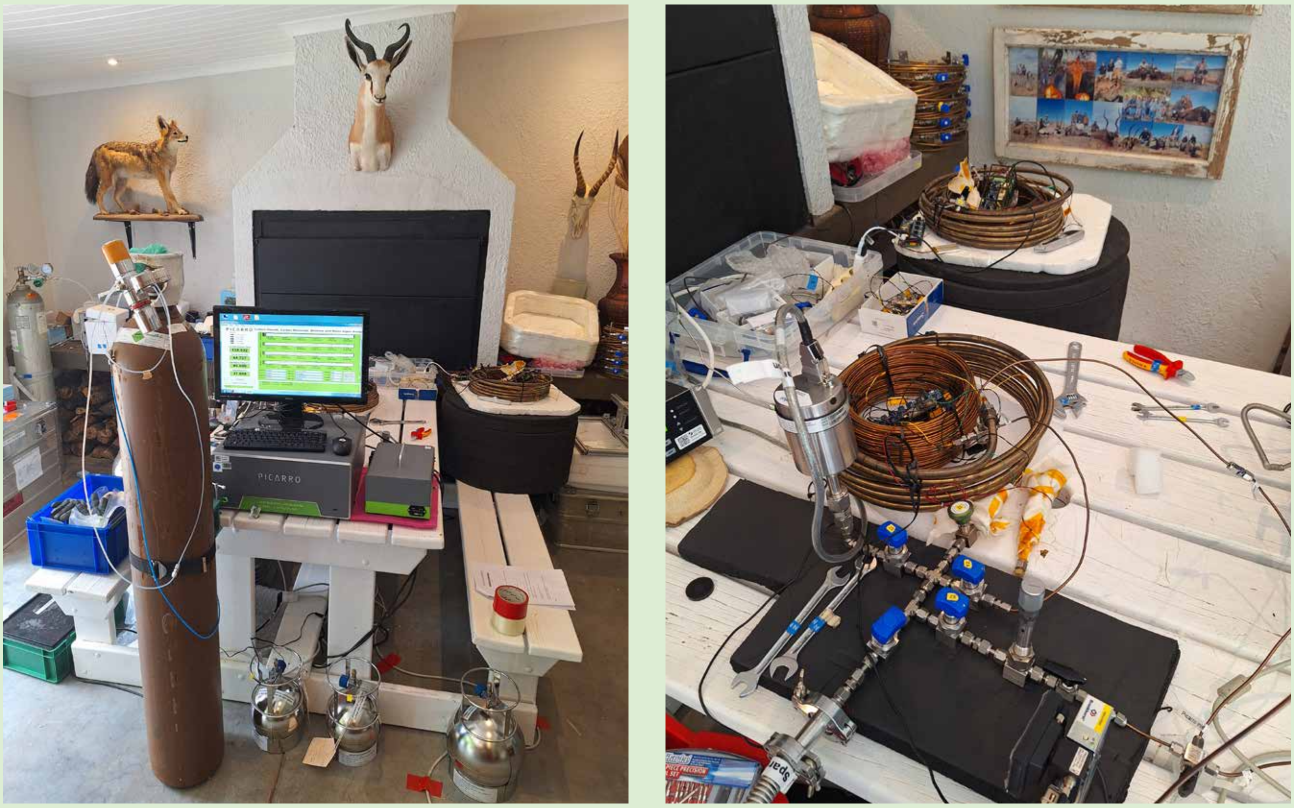

Figure 5: Temporary laboratory constructed inside Branddoorns Hunting Lodge, Beaufort West. Right depicts an AIRCORE atmospheric sample (coiled tube) pushed into a Picarro instrument shown on left side picture to quantify greenhouse gases such as carbon dioxide and methane.

The results of this campaign (and combined with the one from 2023) will be published as various research articles in scientific journals and at international conferences. A recent example was the European Geoscience Union General Assembly which took place from 14 – 19 April 2024, where the team presented its first results. We would like to thank everyone who contributed to make the campaign a success, especially the farmers of the Karoo who always welcomed us so warmly!

Campaign contributors:

Markus Geldenhuys (SAWS), Casper Labuschagne (SAWS), Tshidi Machinini (SAWS), Pieter Labuschagne (SAWS)

Johannes Laube (IEK-7 Juelich), Armin Afchine (IEK-7 Juelich), Corinna Kloss (IEK-7 Juelich), Kyriaki Blazaki (IEK-7 Juelich), Wilhelm Steffes (IEK-7 Juelich)

Bad weather caused plane diversion from OR Tambo Airport on 20 February 2024

Xolani Matlou and Welheminah Seleka

1. INTRODUCTION

Bad weather conditions can significantly disrupt air travel, leading to delays, diversions, and inconvenience for both passengers and airlines. This case study explores the specific incident at OR Tambo International Airport on February 20, 2024, where adverse weather conditions resulted in diversion or delays. OR Tambo International Airport, situated in Johannesburg, South Africa, stands as one of the continent's key aviation hubs, serving as a gateway for both domestic and international flights. Handling millions of passengers annually, the airport is critical to the region's air transportation network, connecting travellers to various destinations worldwide.

While airports are designed to operate seamlessly, they are susceptible to disruptions caused by external factors, such as adverse weather conditions. The incident on February 20, 2024, provides a unique case study to explore how important airport like OR Tambo International Airport copes with the challenges imposed by severe weather, showcasing the balance between ensuring safety and minimizing disruptions to passengers. Weather conditions have an impact on aviation operations, influencing flight schedules, safety protocols, and ground operations. Understanding the specific meteorological challenges faced by airports is crucial for devising effective strategies to mitigate the impact of adverse weather events.

Objective of the Case Study:

The objective of this case study is to provide a meteorological analysis of the incident at OR Tambo International Airport on February 20, 2024, where severe weather conditions necessitated planes to be temporarily diverted away from the airport causing delays.

2. DESCRIPTION OF THE STUDY AREA

OR Tambo International Airport is located in Kempton Park, Ekurhuleni, Gauteng, South Africa. Its geographical coordinates are approximately 26.1392° S latitude and 28.2460° E longitude. The airport is situated near the city of Johannesburg, South Africa's largest city and a major economic and cultural hub.

Size and Infrastructure: The airport covers a vast area, with multiple runways, taxiways, and terminal buildings. It spans over 4,500 hectares and has undergone significant expansions and improvements over the years to accommodate the growing air traffic demand. The infrastructure includes modern terminals, cargo facilities, and maintenance areas.

Figure 1: OR Tambo international Airport (source: https://en.wikipedia.org/wiki/O._R._Tambo_International_Airport)

3. METEOROGICAL ANALYSIS

3.1 Satellite Images

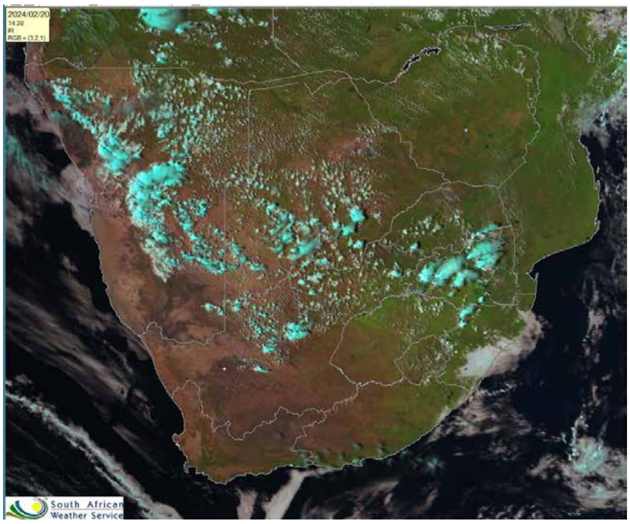

Figure 2: Day natural colour image indicating thunderstorms development over the OR Tambo International Airport (red circle) on the 20 February 2024 at 1430Z. Courtesy: EUMETRAIN, 2024

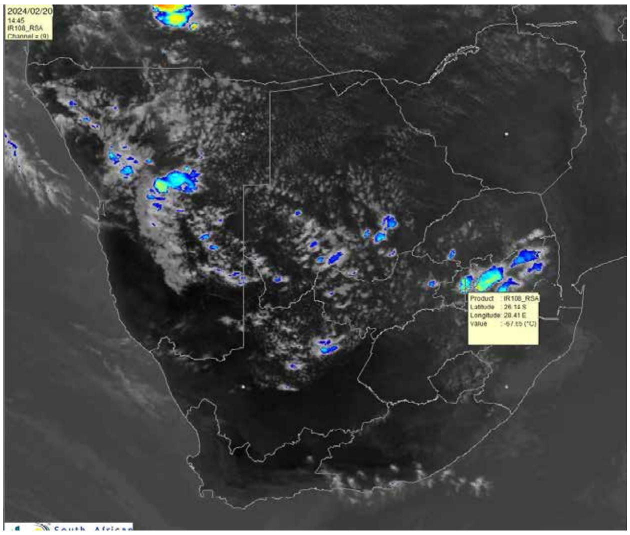

Figure 3: Infrared satellite image (IR imagery) overlayed with cloud top temperatures on the 20 February 2024 at 1445Z. Courtesy: EUMETRAIN, 2024

The satellite images shown in Figure 2 and 3 depict the presence of thunderstorms over the OR Tambo International Airport on the 20 February 2024. Mature thunderstorms typically exhibit very cold cloud tops. In IR imagery (Figure 2), colder temperatures are represented by brighter shades, such as white or light grey, indicating strong updraft. Mature thunderstorms often produce anvil-shaped clouds at the top of the storm system. These anvil clouds, visible in the day natural colour image (Figure 1), result from the spreading of the upper portion of the thunderstorm in the upper atmosphere. Mature thunderstorms are also known for producing intense lightning, which poses a potential danger to aircraft during flights, and both commercial and general aviation take precautions to minimize the risks associated with lightning strikes.

3.2 Radar images

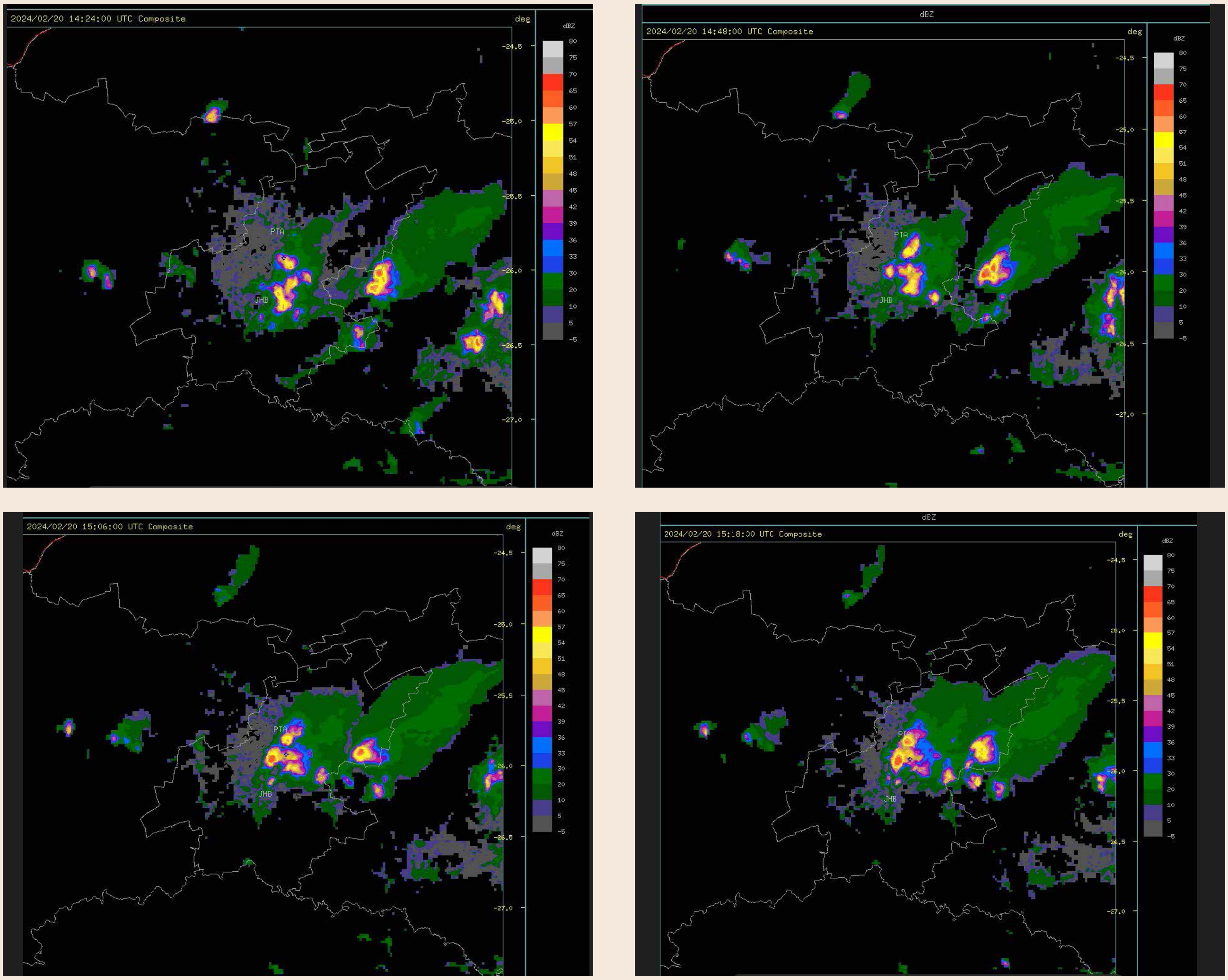

Figure 4: Irene radar images from 14:24Z to 15:18Z on 20 February 2024

Meteorological radar systems are critical tools for monitoring and assessing severe thunderstorms. These radar systems provide valuable real-time information about the structure, intensity, and movement of storms. Meteorologists use radar data to forecast and track severe weather, enabling airlines to adjust flight plans and routes to avoid hazardous conditions. Pilots receive real-time radar updates during flights, allowing them to navigate around or above developing storms to minimize turbulence and ensure passenger safety. Thunderstorms typically exhibit areas of high reflectivity on radar images, indicating the presence of intense precipitation which can be seen on figure 2.

3.3 Meteorological Aerodrome Reports (METARS)

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METAR FAOR 201430Z 15030G40KT 1200 0550E R03R/0550D R03L/1900D +TSRA BKN040 FEW045CB 17/16 Q1023 BECMG 5000 TSRA=

SPECI FAOR 201437Z 16017G33KT 120V190 2000 R03R/0550N R03L/P2000N +TSRA FEW005 SCT023 OVC043 18/17 Q1023 BECMG 5000 TSRA=

SPECI FAOR 201440Z 14023G40KT 100V170 0750 0450 R21L/1600D R03L/1700D +TSRA BKN040 FEW045CB 17/16 Q1023 BECMG 5000 TSRA=

SPECI FAOR 201450Z 04010KT 340V090 2600 0600E TSRA BKN040 FEW045CB 18/16 Q1022 BECMG 5000 TSRA=

SPECI FAOR 201455Z 03010KT 340V090 3100 0900E TSRA BKN040 FEW045CB 19/15 Q1022 BECMG 9999 NSW=

METAR COR FAOR 201500Z 03010KT 340V090 4000 0900N TSRA BKN040 FEW045CB 19/15 Q1022 BECMG 9999 NSW=
```

Figure 5: METAR observation for OR Tambo International Airport (FAOR) between 1430Z and 1500Z on the 20 February 2024

METARs (Meteorological Aerodrome Reports) are standardised aviation weather reports that provide concise information about the current weather conditions at an airport or aerodrome. These reports are essential for pilots, air traffic controllers, and meteorologists to assess the weather at a specific location. METARs provides information on wind, visibility, sky conditions, temperature, dew point, altimeter setting, and other details. In Figure 4, The visibility over the OR Tambo International Airport dropped significantly due to heavy thunderstorms and rain, dropping as low as 750 m at 1440Z. Reduced visibility can make it challenging for pilots to navigate visually, especially in areas without well-defined landmarks. This can be particularly problematic during visual approaches and departures. Pilots and air traffic controllers may need to implement special procedures, such as low-visibility departures and approaches. These procedures are designed to enhance safety in adverse weather conditions.

3.4 Terminal Aerodrome forecast (TAF)

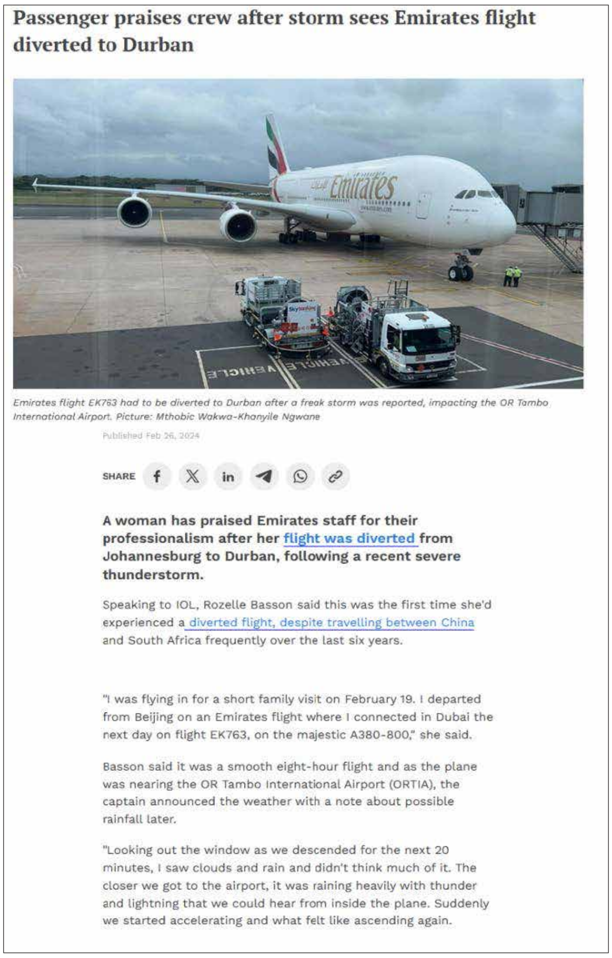
```
FAOR 201000Z 2012/2118 29010KT 9999 SCT030 TX30/2013Z TN18/2104Z PROB30 TEMPO
2012/2020 -TSRA FEW035CB BECMG 2017/2019 VRB03KT BECMG 2021/2023 30010KT BECMG
2115/2117 36010KT=
```

Figure 6: TAF for OR Tambo International Airport (FAOR) issued at 10Z on the 20 February 2024

A Terminal Aerodrome Forecast (TAF) is a weather forecast specifically designed for aviation purposes. It provides detailed information about expected weather conditions at an airport or aerodrome for a specified period, typically covering a 24- or 30-hour period. In Figure 5, the red circle show that Thundershowers and rain were forecasted to occur between 1200Z and 2000Z.

4. DISCUSSION AND CONCLUSION

Thunderstorms are atmospheric disturbances involving cumulonimbus clouds, often associated with heavy rain, lightning, strong winds, and turbulence. These conditions can significantly impact aviation operations, necessitating precautionary measures and sometimes leading to the diversion of flights. In response to the adverse weather conditions, the airport and airlines prioritise safety. If the conditions at OR Tambo International Airport become unsafe for landing or taking off due to thunderstorms, flights may be diverted to alternative airports with more favourable weather. An article below from Independent Online (IOL) depicts an Emirates flight diverted to Durban due to bad weather over OR Tambo International Airport on the 20 February 2024. The article also mentions that two more flights had to be diverted away from the Airport during the period of the bad weather.



Passenger praises crew after storm sees Emirates flight diverted to Durban

Emirates flight EK763 had to be diverted to Durban after a freak storm was reported, impacting the OR Tambo International Airport. Picture: Mthobic Wakwa-Khanyile Ngwane

Published Feb 26, 2024

SHARE

A woman has praised Emirates staff for their professionalism after her flight was diverted from Johannesburg to Durban, following a recent severe thunderstorm.

Speaking to IOL, Rozelle Basson said this was the first time she'd experienced a diverted flight, despite travelling between China and South Africa frequently over the last six years.

"I was flying in for a short family visit on February 19. I departed from Beijing on an Emirates flight where I connected in Dubai the next day on flight EK763, on the majestic A380-800," she said.

Basson said it was a smooth eight-hour flight and as the plane was nearing the OR Tambo International Airport (ORTIA), the captain announced the weather with a note about possible rainfall later.

"Looking out the window as we descended for the next 20 minutes, I saw clouds and rain and didn't think much of it. The closer we got to the airport, it was raining heavily with thunder and lightning that we could hear from inside the plane. Suddenly we started accelerating and what felt like ascending again.

Figure 5: Independent online (IOL) reporting about Emirates flight diverted to Durban due to bad weather over OR Tambo International Airport on the 20 February 2024

The diversion of planes at OR Tambo International Airport on 20 February 2024, due to thunderstorms, emphasises the dynamic challenges posed by adverse weather conditions in the aviation industry. The incident underscores the need for proactive safety measures, effective communication, and collaborative efforts among stakeholders to ensure the well-being of passengers and the continued efficiency of airport operations.

5. LESSONS LEARNED

The incident highlights the importance of airports and airlines being well-prepared for adverse weather conditions. Regular training, updated procedures, and advanced weather monitoring systems contribute to effective response measures. Investing in advanced meteorological technology allows airports to predict and respond to severe weather conditions more accurately, aiding in decision-making and reducing disruptions.

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Attributes of numerical weather prediction models

Patience Mulovhedzi

Numerical Weather Prediction (NWP) models are techniques that use a set of physics and dynamical equations as well as current observations to predict the future state of the atmosphere (Lions et al., 1992). The equations use basic conservation laws that include the momentum equations:

$$\frac{du}{dt} - fv = -\frac{\partial ø}{\partial x}$$

$$\frac{dv}{dt} + fu = \frac{\partial ø}{\partial y};$$

the hydrostatic equation:

$$\frac{dp}{dz} = -pg;$$

the continuity equation:

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} + \frac{\partial \omega}{dz} = 0;$$

the thermodynamic equation:

$c_p dT/dt - \alpha\, dp/dt = 0$; and

the equation of state:

$$p = \rho RT.$$

Observations, also referred to as initial conditions, used to initialise NWP models, include in-situ/ground observations and remote sense data from weather balloons, weather radar and satellites (Pu and Kalnay, 2018). NWP models divide the atmosphere into a three-dimensional grid, with each grid cell representing a specific geographical location and altitude (see Figure 1). These models are written in the form of computer programmes that represent physical processes (such as convection, tornadoes, etc.) at each grid point and are often run on supercomputers. Improved observational networks, advances in computer technology and resources, and developments in methods for representing physical processes are amongst the reasons NWP models have improved their performance in recent years (Joe et al., 2022).

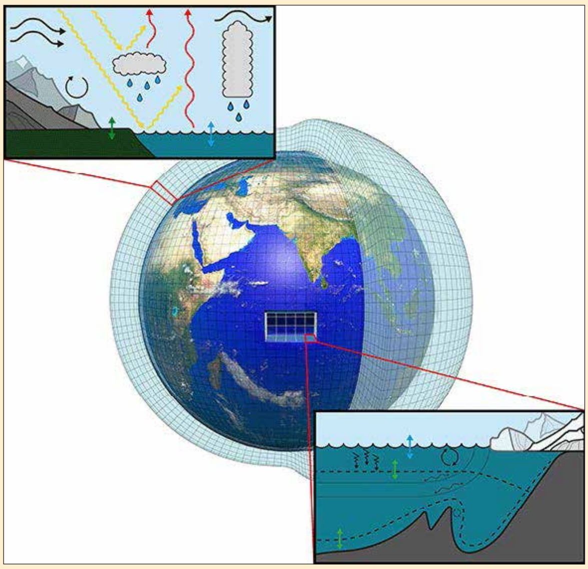

Figure 1: NWP for every point on earth, for horizontal and vertical grids (Christensen and Zanna, 2022)

High-performing NWP models are critical for issuing timely and accurate weather and climate forecasts and data. This is critical for the South African Weather Service, as the voice of weather for the country and the Southern African Development Community (SADC) at large. Furthermore, NWP models are critical to help combat the impacts of climate change: application of timely and accurate NWP models competency in issuing forecasts and warnings for severe weather events. Benefits of this will be experienced by many, including general citizens, agriculture, health, water, and energy sectors, as timely and accurate weather and climate forecasts support informed decision-making, reducing risks, and contribute to the overall resilience and well-being of communities, amongst others (Agyekum et al. 2022).

Moreover, in light of climate change, most parts of sub-Saharan Africa were projected to suffer from the consequences of climate change. This includes an increase in severity and/or frequency of severe weather events, such as droughts, extreme heat events, and heavy rainfall/flash-flooding/flooding events. This may result in an increase in undernutrition and infectious diseases, food and water security risk and human health and safety risk, amongst others. According to the UN Sustainable Development Goals (SDGs) outlined in the Paris Agreement, strategies for dealing with the impacts of climate change are now mainly focused on developing plans and systems for adaptation, to reduce vulnerability, build adaptive capacity and build resilience to climate change on vulnerable communities. Additionally, the South African government has committed to this agreement by running different projects to help combat the impacts of climate change, of which one involves improving timeliness and accuracy in issuing forecasts and warnings for severe weather events. This is possible through the application of NWP models.

Typically, NWP models comprise two components, namely, dynamical core and physical parameterizations (Gross et al., 2018). The dynamical core simulates resolved processes using primitive equations listed above. However, even the finest NWP models run at resolutions where some processes may be too small-scale to be resolved and are rather simulated through physical parameterization schemes. Furthermore, benefits of parameterization schemes are evident in how model forecasts increase in accuracy, skill and the ability to produce features that closely resemble what has actually been observed in the atmosphere. These parameterization schemes include (as shown in Figure 2):

- Planetary boundary layer schemes, which represent the turbulent processes near the Earth's surface. They generally determine surface fluxes of momentum, heat and moisture; vertical profiles of the turbulent fluxes within the boundary layer; height of the boundary layer; and vertical velocity at the top of the boundary layer (Bhumralkar, 1979). Formulation for boundary layer schemes is generally based on surface layer, bulk PBL similarity theory, eddy-coefficient approximations and/or simplified forms of higher-order-closure turbulence formulations (Sommeria, 1988).

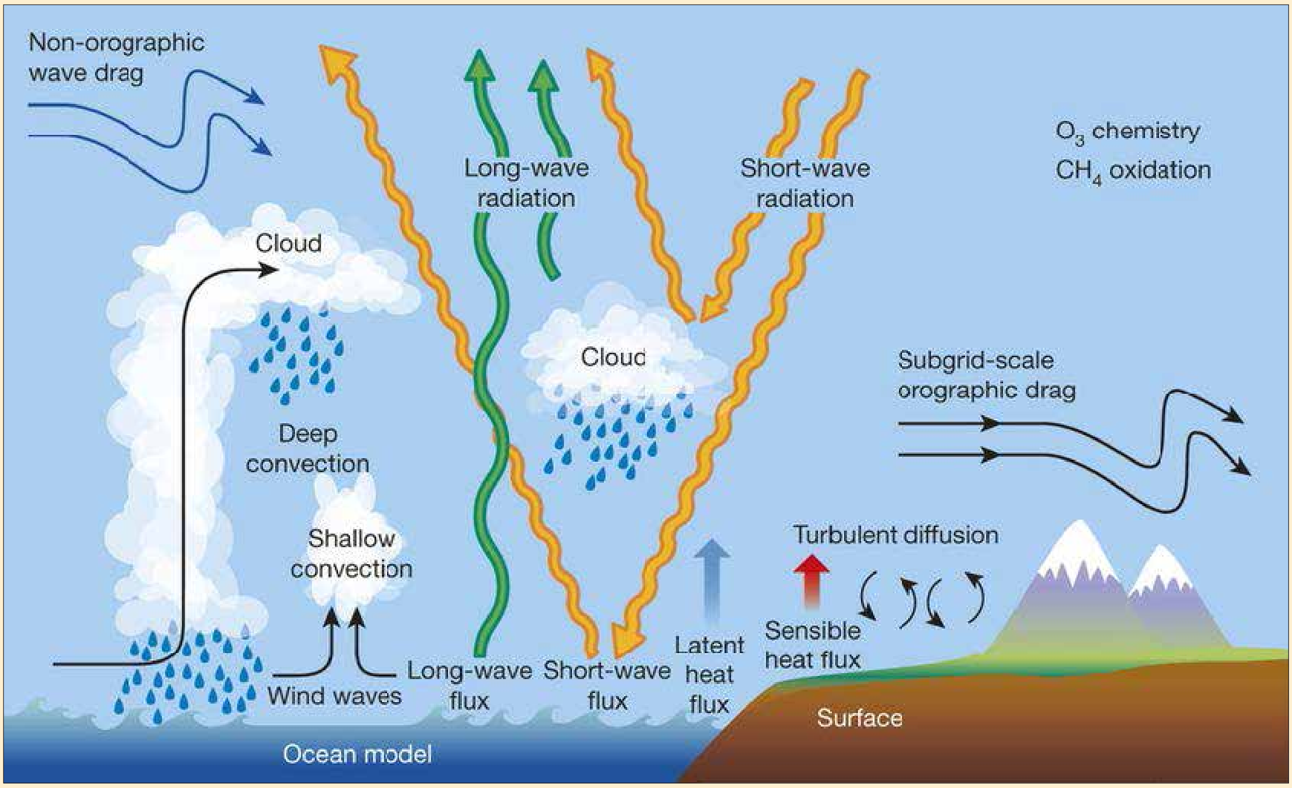

Figure 2: Atmospheric processes that are not explicitly resolved in NWP models / by the model dynamics. These processes are rather resolved through parameterization schemes (Bauer et al., 2015)

- Radiation Parameterization schemes represent the transfer of solar and thermal radiation. The scheme is formulated to compute radiative fluxes at a specific grid point on the surface, at the Top of Atmosphere, and within the vertical atmospheric column. Precisely, the scheme represents the transmission/absorption of short-wave and long-wave radiation scattering of short-wave radiation emission of long-wave radiation.
- Cloud microphysics schemes represent small-scale processes and properties of cloud particles within atmospheric clouds, i.e. the formation, growth, and interactions of individual cloud droplets, ice crystals, and other microscale constituents within clouds (Morrison et al., 2010). These processes occur at micro-scale. The ultimate goal of these is to improve how the model simulates precipitation.

- Convection parameterization schemes represent the physical processes and transports of combination of individual convective clouds on the large-scale system/environment. Physical processes and transports represented include entrainment, updrafts, downdrafts, detrainment, subsidence, vertical transport of heat, moisture, and momentum associated with convective processes. Figure 3 depicts some of the processes and transports represented in convection parameterization schemes. Parameterization schemes may be formulated for shallow convection with a small vertical extent, resulting in light-to-no precipitation, and deep convection with a large vertical extent, which may result in heavy rainfall associated with lightning and tornadoes. The ultimate goal is for NWP models to simulate rainfall at the right place and time, and to capture the correct amount of rainfall.

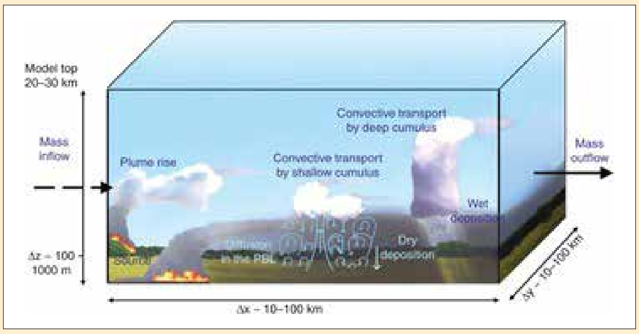

Figure 3: A schematic presentation showing some sub-grid processes and transports associated with convection (Brasseur and Jacob, 2017)

In addition to these basic components of NWP models, other aspects may be incorporated to a model to improve its performance:

- Ensemble forecasting
- Data assimilation
- Coupled atmosphere-ocean-land modelling
- Unified/seamless modelling

NWP models are generally developed in the global north. However, the South African Weather Service has recently embarked on a model development project, which allowed scientists to contribute towards the development of the Conformal Cubic Atmospheric Model (CCAM).

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Relocation of the South African Weather Service Head Office and its High-Performance Computer

Stephanie Landman

The South African Weather Service (SAWS) is pivotal in safeguarding lives, property, and the economy by providing essential weather forecasts and warnings under a government mandate (South African Weather Service Act, 2001 (Act No. 8 of 2001 as amended). The SAWS fulfils this mandate through timely forecasts of impending severe weather, allowing for necessary precautions, evacuation, and actions to mitigate potential damage to life and property. To provide these services sufficiently, the SAWS operates 24/7 year-round, collecting vast amounts of real-time meteorological data from various sources, including satellites, weather stations, automatic observation stations, a radar network, a lightning detection network and waverider buoys.

An invaluable resource that the SAWS uses to issue forecasts is High-Performance Computing (HPC) architecture for the operations of Numerical Weather Prediction (NWP) models, which form a critical component of the forecasting operations. NWP models simulate atmospheric processes to generate weather forecasts, leveraging complex algorithms and computational power. HPC systems are crucial for running these models efficiently due to their ability to handle large datasets and perform complex calculations rapidly, which is essential for an operational organisation. However, maintaining such infrastructure is expensive and requires substantial investment in both hardware and expertise.

The SAWS has operated HPC and NWP systems for more than four decades. These NWP models provide high-resolution atmospheric simulations to better guide forecasters for approaching severe weather events. The current operational NWP configurations cover a) the Southern African Development Community (SADC) region (from 45° S to 0° and 5° E to 53° E) with a horizontal grid spacing of 4,4 km and b) the South African domain (35° S - 20° S and 16° E to 34° E) with a horizontal grid spacing of 1,5 km (*shown in Figure 1, including the difference of resolution*). Both model configurations run on the HPC system concurrently four times daily, providing hourly forecasts for two to three days. These forecasts guide the SAWS' forecasting offices, including Disaster Risk Reduction, Aviation and Marine forecasters and services. In addition, the model outputs provide data support to various clients and stakeholders requiring real-time feeds to support their operations.

The recent relocation of the head office to a new facility necessitated the migration of its critical infrastructure, which included the HPC and other operational systems (e.g., real-time meteorological satellite data). In preparation for this move, several backup and failover systems were implemented and tested, and communication with stakeholders was initiated. The criteria for success included the ability to implement backup and failover systems effectively, maintaining continuous operational capability, and the timely resolution of issues that may arise.

The transition involved meticulous planning and coordination between various teams within the SAWS and the invaluable support of the Centre for High-Performance Computing (CHPC) in Cape Town. The SAWS and the CHPC have a formal arrangement through a Memorandum of Agreement (MoA) which governs the relationship between the entities in case the SAWS requires additional computational resources, as well as a backup service in the case of the malfunctioning of its HPC system. The CHPC facility, being a research-driven entity assisting research institutions to run computationally intensive simulations, is the only facility of its kind in South Africa that can assist the SAWS in case of an HPC-system breakdown. A duplicate of the SAWS NWP SADC 4,4 km domain configuration is available on the CHPC's Lengau system In addition to running the model, the accompanying model output post-processing facilitates the all the necessary user distribution feeds with minimum impact on users, e,g., aviation and marine. This capacity and capability played a pivotal role in ensuring a smooth changeover, allowing the SAWS to maintain the continuous public service it is committed to. The seamless cooperation demonstrates the effectiveness of the partnership between these two national entities.

Overall, the business continuity test was considered a success. The operational systems were transitioned with minimal disruptions, and the backup and failover systems proved effective. While minor issues were encountered, the NWP team resolved them swiftly, ensuring minimal impact on services. The operational systems were successfully maintained throughout the relocation process. The issues identified during the test have provided valuable insights for future operations. These include refining communication protocols, enhancing documentation, and optimising certain procedures to streamline the continuity process further.

Given the SAWS' critical service, all supporting systems and infrastructure need to be robust and resilient. Backup systems and redundancy are therefore essential to ensure seamless and continuous operations, even during hardware failures or natural disasters. Any disruption in weather forecasting capabilities could have far-reaching consequences, underscoring the importance of investing in these systems' resilience.

Figure 1: SAWS limited-area operational NWP a) domain configurations with examples of the horizontal grid spacings of b) 4,4 km and c) 1,5 km, respectively, over Cape Town.

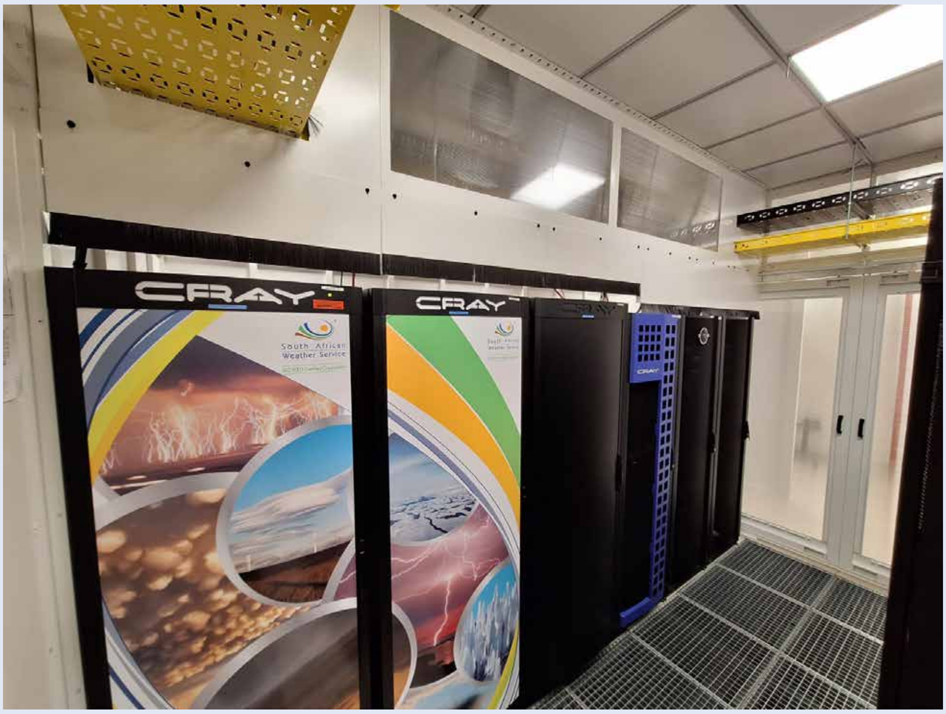

Figure 2: The Cray XC30 High-Performance Computer assembled at the new data centre.

Was December 2023 windier over the Cape Peninsula than usual?

Andries Kruger, Kanyisa Makubalo and Elani Heyneke

The Cape is known for its dry and windy summers due to its Mediterranean climate. Often, the dominant South Atlantic High-Pressure System over the ocean, together with a surface trough (an extension of a Low-Pressure System) over the western parts of the country, result in very tight isobaric gradients as seen in figure 1. This in turn leads to strong winds along the coastline, especially along the south-west coast of the Western Cape. Depending on the positioning and the strengths of the systems, they can result in warning-worthy and impactful winds especially over the Cape Peninsula. In this case, the Cape Peninsula includes Cape Point, Kommetjie, Cape Town City, Robben Island and the Cape Flats (Cape Town International Airport). Climatological records indicate that the months with the strongest winds in summer over the Cape Peninsula are December and January.

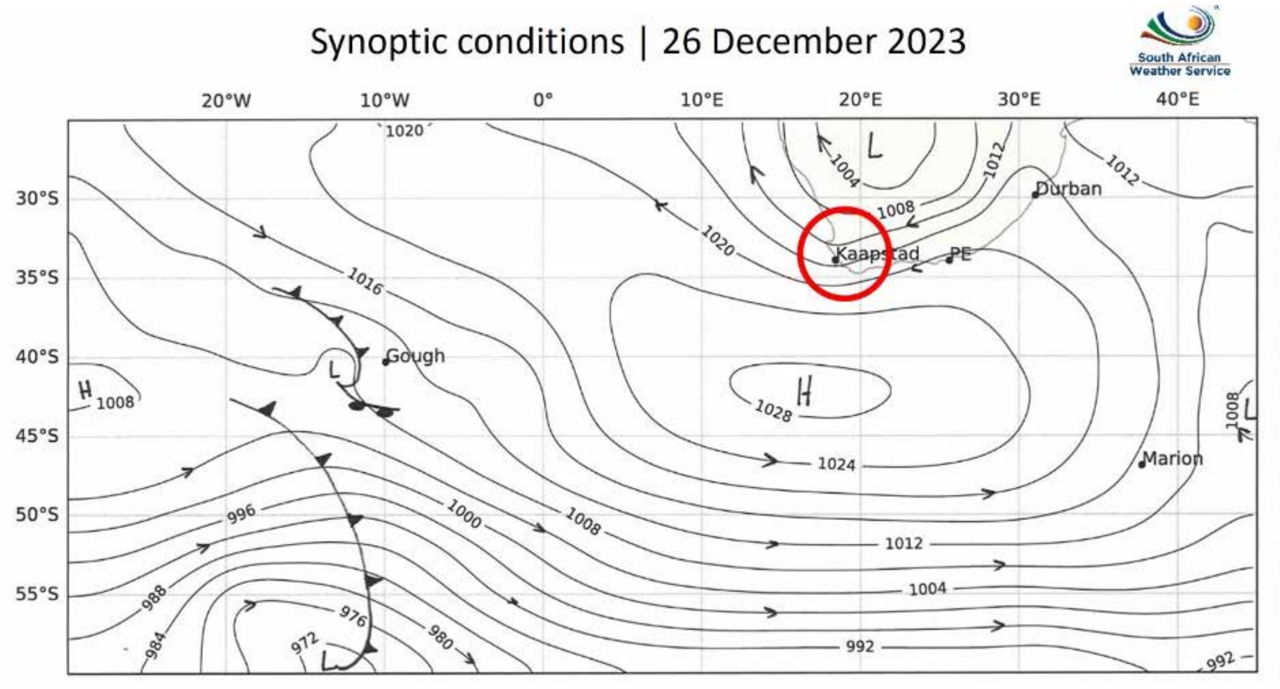

Figure 1: This is an example of the typical synoptic conditions that are dominant during summer over South Africa with the South Atlantic High-Pressure System south of the country accompanied by a surface trough over the western interior. The tight isobaric gradients over the south-western parts are shown by the red circle (Source: SAWS).

The South African Weather Service (SAWS) received a public query from Mr. Charles Scheltema in January 2024 where he highlighted that he had been living in Green Point for almost 45 years and it seemed to him that this summer, particularly December 2023 had been windier than ever before. This query prompted SAWS to investigate this matter. The closest WMO (World Meteorological Organization) weather station to Green Point is located at the Cape Town Royal Yacht Club.

An analysis of the average wind direction at the Cape Town Royal Yacht Club during December 2023 shown that the surface wind had a more southerly component (figure 2a), compared to the long-term average (LTA) wind direction for December (2003-2022), which is generally south-easterly as seen in figure 2b. According to the Cape Town Royal Yacht Club wind rose (Figure 2a), for December 2003-2022, the southerly wind occurred about 16% of the period where 5% of that was a strong southerly wind of greater than 10.7 m/s (~40 km/h). On the other hand, the Cape Town Royal Yacht Club wind rose (Figure 2b), for December 2023, the southerly wind occurred about 34% of the period where 8% of that was a strong southerly wind of greater than 10.7 m/s (~40 km/h). The southerly fetch of the winds encounters little friction as it moves towards the Cape Flats while the typical south-easterly wind direction faces more terrain friction, thereafter, reducing the speed of the surface winds over the same region as seen in figure 3.

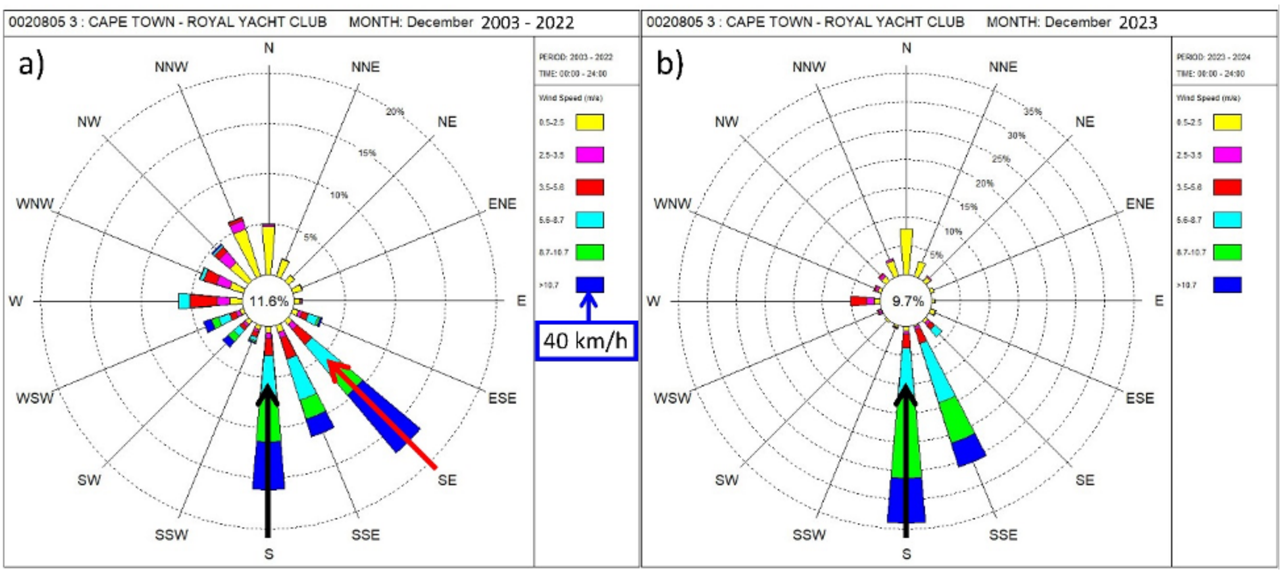

Figure 2: The wind roses for the Cape Town Royal Yacht Club station for a) December 2003-2022 and b) December 2023, respectively. The black arrow indicates the southerly wind direction and the red arrow the south-easterly wind direction (Source: SAWS).

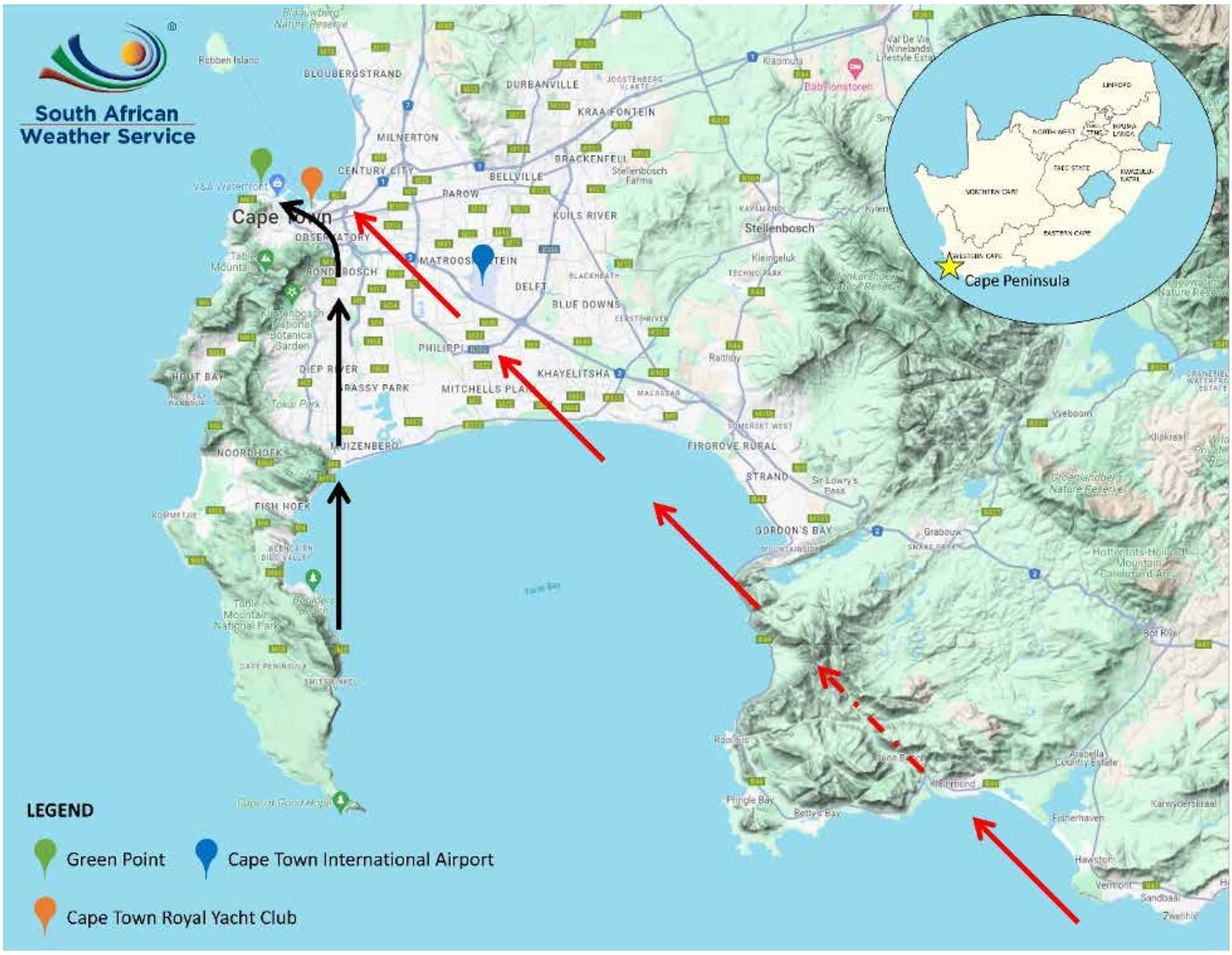

Figure 3: The trajectory of the southerly wind (black arrow) compared to the south-easterly wind (red arrow) over the Cape Peninsula, Western Cape. The location of Green Point is highlighted in green, the Cape Town Royal Yacht Club in orange and the Cape Town International Airport in blue (Source: Google Maps and Wikipedia; Modified: SAWS).

The other factor that may play a role is the fact that according to the LTA, there is usually a persistent strong south-easterly wind (figure 2a). The dominant wind during December at the Cape Town Royal Club is a strong southerly wind (17%) with the strong south-easter only being recorded 8% of the time. However, during December 2023, the strong south-easterly wind was almost non-existent, since this wind speed and direction was recorded at the station less than 5% of the time. The question is - may it be that the locals are not use to a dominant southerly wind direction, compared to the usual strong south-easter; therefore, it seemed odd and out of place? Or was it indeed windier than usual?

Long-term trends

Quite often queries like the above allude to a possible change in the climate, where a client enquires whether a specific day, month or season's temperature, wind or rainfall (or possibly another weather variable) is unusual or unprecedented. While the above enquiry was successfully handled with, it is sometimes possible that the public can extrapolate or generalize such incidents or events to assume that the anomaly observed represents a feature of a long-term trend. Such perceptions can lead to erroneous assumptions, e.g. an abnormally cold winter perceived to contradict long-term warming of the atmosphere, or that a specific wet season in the west of South Africa invalidates the long-term trend and projections of progressive drying and desiccation in the region.

To test whether the windier than usual December in 2023 at Green Point is representative of a long-term trend, it is necessary to compare the average wind speed of December 2023 with available long-term data. Examining the available data for the Cape Town Royal Yacht Club in Figure 4, it is apparent that December 2023 was indeed windier than the December months in the recent past. The average wind speed in December 2023 at 6,1 m/s (22 km/h) was the highest since 2017 and of the highest since 2011. However, the trend over the near-continuous period of 2003 – 2023 shows a declining trend, due to the relatively high wind speeds up to 2010. This observation accentuates the fact that lay observers of the weather and climate most often vividly remember only the very recent past and therefore long-term observational data is needed to place a specific weather or climate event in perspective.

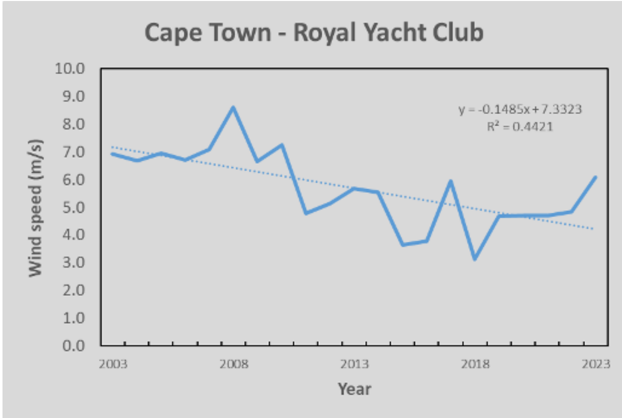

Figure 4: Average wind speed (m/s) in December at the Cape Town Royal Yacht Club (2003 – 2023) (Source: SAWS).

The trendline in Figure 4 presents the interesting observation that there was a significant stilling of the wind in December at the Cape Town Royal Yacht Club over the last 20 years. To further explore whether this observation could be representative of a real long-term trend of the wind in December in Cape Town, Figure 5 presents the average wind speed in December at the Cape Town International Airport and Robben Island, over the longer period of 1993 – 2023. These two weather stations have the longest automatic weather station records in the Cape Town metropole, stretching over a period which is now longer than 30 years. From the data of these two weather stations it is clear that December 2023 was a month with relatively higher wind speeds than usual. For Cape Town it was the highest on record, and for Robben Island the second-highest, after 2010.

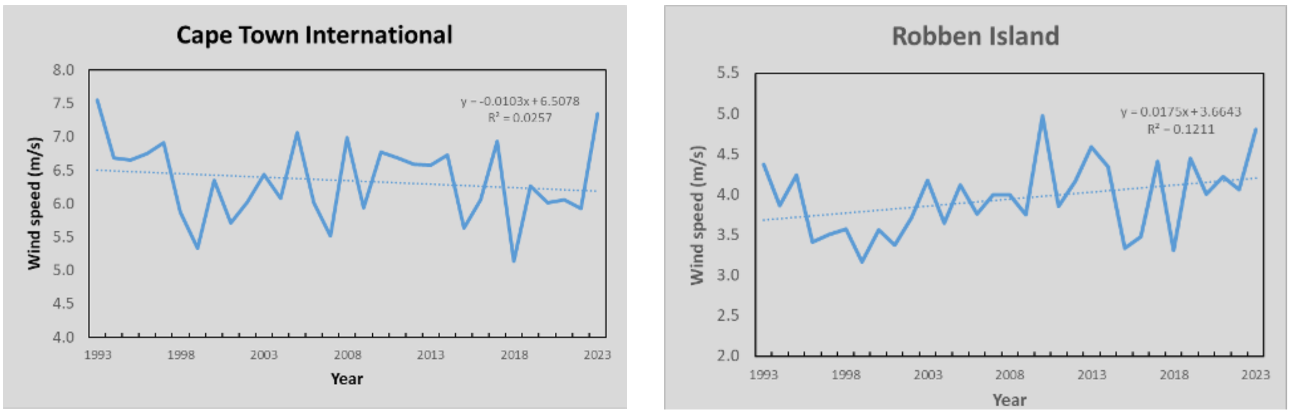

Figure 5: Average wind speed in December at the Cape Town International Airport and Robben Island (1993 – 2023) (Source: SAWS).

However, examining the long-term trend from the analysis of these two weather stations, one can assume that over the recent climatological period the average wind speed over the metropole in December seems to have been quite stable, and no consistent trend among wind observations can be inferred.

Following on the above, it should be mentioned that it is expected among a significant number of climatologists that the wind in the extreme south of South Africa, particularly the winter rainfall region that experiences high wind speeds due to the passage of strong cold fronts, will experience a general stilling of wind speeds over time. This deduction is primarily motivated by the expectation that due to global warming the subtropical High-Pressure Systems will become more dominant over time across the region. While in winter all circulation features are situated more to the north, with the effect that the westerlies influence the weather of the southern part of the subcontinent, cold fronts will be restricted more southwards, with their areas of maximum wind speed more often having a lesser impact on the subcontinent, especially over the south-western parts of the country. In this regard, further research is therefore needed to establish whether wind speed trends to confirm this are already evident from the SAWS observational data.

Meet the authors

Patience Tlangelani Mulovhedzi

Ms Patience Tlangelani Mulovhedzi *is a scientist under model development, Research department. She has vast experience in numerical weather prediction and model development. She is passionate about numerical modelling and coding/programming. She is currently enrolled for a PhD that focuses on the development of a cumulus convection scheme, model development.*

Dr Markus Geldenhuys

Dr Markus Geldenhuys *is a forecaster in the Gqeberha (Port Elizabeth) 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.

Xolani Matlou

Mr Xolani Matlou *is a forecaster at the Aviation Weather Center (AWC) at OR Tambo International Airport since 2020. He first started working at the Cape Town Weather Office also as a forecaster in 2022, where he was specialising in public, marine and aviation forecasting. He completed both the BSc degree and BSc honours degree in Meteorology at the University of Pretoria in 2017 and 2018 respectively. He also further completed the forecasting training provided by the South African Weather Service (SAWS) for a full year in 2019.*

Welheminah Seleka

Ms Welheminah Seleka *was recently promoted as a Senior forecaster at Aviation Weather Centre. She joined South African Weather Service in January 2011. She studied BSc and BSc (Hons) Chemistry from North-West University and obtained BSc (Hons) in Meteorology at the university of Pretoria.*

With thirteen years of experience in Aviation, has dedicated her career to understanding and predicting the complex weather patterns that impact flight safety and operations.

She has sharpened her skills in forecasting severe weather events including thunderstorms, severe turbulence, fog, low clouds and poor visibility that affect flight routes and schedules.

She has a passion for uncovering the details of weather systems that ground flights, and has developed expertise in analysing and communicating critical weather information to aviation professionals (Airport Management Company (AMC), ATNS's Central Airspace Management Unit (CAMU).

Welheminah's fascination with weather-related flight disruptions drives their ongoing pursuit of knowledge and improvement in aviation weather forecasting. They remain at the forefront of industry developments, collaborating with colleagues and contributing to the advancement of aviation weather forecasting. Their expertise has helped airlines, airports, and pilots make informed decisions, ensuring the safety of passengers and crew.

She hopes to find a solution by pursuing further education, and one of her areas of interest is addressing the chaotic weather systems that result in aircraft delays.

Siyabonga Hlumelo Nozwane

Mr Siyabonga Hlumelo Nozwane *is a scientist specializing in Climate Change and Variability under the Research and Development department. He holds an Honours degree in Geography with a specialisation in GIS & Remote Sensing and is deeply committed to climate change and environmental sustainability. Siyabonga's research interests include studying climate extremes and employing climate modelling to analyse trends such as temperature variations and precipitation patterns. His work aims to understand the impacts of climate change on communities and ecosystems, contributing to strategies for both mitigation and adaptation. Siyabonga effectively communicates his findings through insightful reports and engaging presentations.*

Ms Nosipho Zwane

Ms Nosipho Zwane *is a lead scientist in the Research and Development Department, Climate Change and Variability. Her research interests include climate modelling, climate extremes and the impact of climate change on climate sensitive sectors. She joined the SAWS in 2014 as an intern under the Research Climate Change and Variability unit and was later absorbed in the same unit specializing on climate change modelling, prediction and looking at climate change impact on hydrological resources. Upon the birth of the Research Applications, she expanded her expertise and worked under the Weather/ Climate & Energy Applications where her focus was on developing applications by pulling Numerical Weather Prediction data into services for the energy industry and forecasting renewable energy.*

Nosipho Zwane has BSc with double major in Environmental & Geographical Science and Ocean & Atmosphere Science, BSc Honors in Ocean & Atmosphere Science both from the University of Cape Town. MSc Meteorology from the University of Pretoria and National Certificate in Generic Management. She is currently enrolled for PhD Meteorology.

Throughout her career at SAWS, she has been involved in a number of revenue generating projects, contributed to various publications and positioned SAWS to various stakeholders both nationally and internationally.

Aphinda Jabe

Ms Aphinda Jabe *is an Intern in the Climate Change and Variability unit under the Research and Development Department since January 2024. She earned a Bachelor of Science degree in Applied Statistics and Chemistry from the University of Cape Town in 2022. Aphinda is particularly interested in applying statistical methods to climate change research, where she leverages her academic background to contribute to the understanding of climate variability and mitigation of its impacts.*

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.

Dr Katlego Ncongwane

Dr Katlego Ncongwane *is a Senior Manager leading the Research & Development Department at the South African Weather Service. She has over 15 years of experience in weather and climate research. Katlego holds a Ph.D. in Geography and Environmental Science and an MSc in Physics, both from the University of KwaZulu-Natal, as well as an MPhil in Sustainable Development Planning and Management with a focus on Renewable Energy Application from the University of Stellenbosch. She actively participates in various national and international committees within the meteorology and climate research field.*

Stephanie Landman

Ms Stephanie Landman *has been a Meteorologist for almost 20 years, 16 of which are at SAWS.*

She is the Lead Scientist for Post-Processing, Verification and Ensembles in the Research and Innovation department.

She leads the team responsible for the crucial task of implementing and operationalising SAWS' short—to medium-range numerical forecasting systems. The team also ensures the development of post-processing techniques to optimise forecasts and observations in product development and harness model output for accurate, useable, and valuable service delivery.

Her main area of interest is researching the sources of uncertainty in weather forecasts and observations, particularly in the application of forecast evaluation and verification.

She completed her MSc (Meteorology) degree at the University of Pretoria in 2012. Her research topic was focused on determining the skill in multi-model short-range ensemble prediction systems over South Africa. In addition to her academic pursuits, she also lectures part-time at the University of Pretoria, teaching a BSc(Honours) Meteorology course in applications of NWP systems and co-supervising MSc students. She has authored and co-authored research papers and scientific guidelines with local and international scientists on topics covering short-range numerical weather forecasting and verification. She is currently the vice-chair of a WMO-led expert team on "Operational Weather Forecasting Systems" that focuses on the implementation and use of operational NWP systems, verification systems, and the use of ensemble prediction products.

She is currently enrolled for a PhD in Meteorology at UP.

Kanyisa Makubalo

Ms Kanyisa Makubalo *is a hard working young scientist who enjoys being in spaces that seem greater than her, to rapidly grow and develop herself. She has been with SAWS for nearly 2 years and has already learnt so much and worked with great many scientists. She is grateful for every opportunity and is always welcoming for more opportunities and any extra work to further develop herself and assist her team of colleagues. Talk about a true young black excellence representative.*

Elani Heyneke

Ms Elani Heyneke *is a senior weather forecaster and is based at the Cape Town Weather Office. However, she started her forecasting career at the Bloemfontein Weather Office at the beginning of 2017. During her initial years as a weather forecaster, she studied the development of severe thunderstorms, in particular squall lines. There was a noteworthy case at the end of January 2018 that contributed to nearly 900 miners being trapped at a mine near Welkom, Free State that encouraged her to broaden her knowledge on squall lines over the central interior of South Africa. She is also passionate about real-time observations, severe weather forecasting, agrometeorology and most of all creating a WeatherSMART nation. is a senior weather forecaster and is based at the Cape Town Weather Office. However, she started her forecasting career at the Bloemfontein Weather Office at the beginning of 2017. During her initial years as a weather forecaster, she studied the development of severe thunderstorms, in particular squall lines. There was a noteworthy case at the end of January 2018 that contributed to nearly 900 miners being trapped at a mine near Welkom, Free State that encouraged her to broaden her knowledge on squall lines over the central interior of South Africa. She is also passionate about real-time observations, severe weather forecasting, agrometeorology and most of all creating a WeatherSMART nation.*

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