WEATHERSMART

NEWS

Scientific meteorological and climatological news from the South African Weather Service

AUGUST 2019

- Severe weather in April 2019
- AgriCloud: A digital APP
- Air pollution: a modern-day curse
- The new Human-biometeorological Network
- Drought Monitoring by the SAWS
- And more

South African Weather Service

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FOREWORD AND EDITORIAL COMMENT

BY THE ACTING CHIEF EXECUTIVE OFFICER

Welcome to the WeatherSMART news edition of August 2019. This edition covers the scientific weather news of the past six months – a period that included severe weather, damage to property and warming temperatures. A wealth of scientific knowledge is once again shared with our readers, in an effort to nurture a WeatherSMART nation, which is Safe, More informed. Agile, Resilient and can act Timeously on all forms of weather threats.

We look at severe thunderstorm events, where some led to the unfortunate loss of life and damage, especially the collapsing of a church wall in the Empangeni area.

A report on all four seasons in one day shares an interesting perspective on the weather changes in one day in Port Elizabeth and our contribution to the Agricloud agricultural app is discussed extensively. AgriCloud was developed to assist small farmer with day to day decision making and it is one way a farmer can increase yield and income.

The modern day curse of air pollution is discussed as an invisible killer that leads to an annual death rate of 7 million people per year, according to the World Health Organization (WHO). The vulnerability of the elderly and the young is highlighted, and mention is made of about 600,000 children that died from acute respiratory infected caused by polluted air in 2016.

An article on fog observed at OR Tambo International Airport (ORTIA) on the morning of the 14th of June 2019, which resulted in aircraft delays and diversions, demonstrates the importance of our aviation weather forecasts to ensure the safety of aviation operations. Improvements in predicting the likelihood of severe weather events as well as a discussion on the new human-biometeorological network at the South African Weather Service is discussed. The implementation of the Unified Model convective-scale ensemble prediction system (CSEPS) with a 4.5 km horizontal resolution is discussed as well as the results and improvements to our forecasting systems.

The importance of maintaining our remote sensing technology such as radar and our lightning detection network is highlighted, while the publication concludes with an article on the drought monitoring activities of the South African Weather Service.

I hope you enjoy these articles and find it a valuable learning experience.

Mr Mnikeli Ndababmbi

Acting Chief Executive Officer

SEVERE WEATHER IN APRIL 2019

– article by Thandiwe Gumede and Wiseman Dlamini, Wisani Maluleke and Mbavhi Maliage

Severe thunderstorm: 18 April 2019

On 18 April 2019 prior to the development of the cut off low, there was a steep upper-air trough situated to the west of the country and an upper-air high to the northwestern parts of Limpopo. This meant that provinces like the North West, Free State and KwaZulu Natal (KZN) fell on the area that was on the periphery of a high. At the surface, a deep surface trough had developed over the western interior of the country. Instability indices like the K index, Total totals index and Lifted index were all indicating values favourable for severe thunderstorm development. Furthermore, models indicated wind shear.

The severe storms were associated with excessive lightning, heavy downpours and strong winds. The area received a total of 40 mm of rain within 2 hours, the image of the storm as viewed from the RADAR displayed as figure 1(a). There was a drastic change in the wind speed and direction during the passage of the storm. The damage from the storm resulted in 13 people losing their lives and several other members of the church injured. The severe thunderstorms affected areas along the KZN north coast and resulted in a church wall collapsing in the Empangeni area as depicted by figure 1(b).

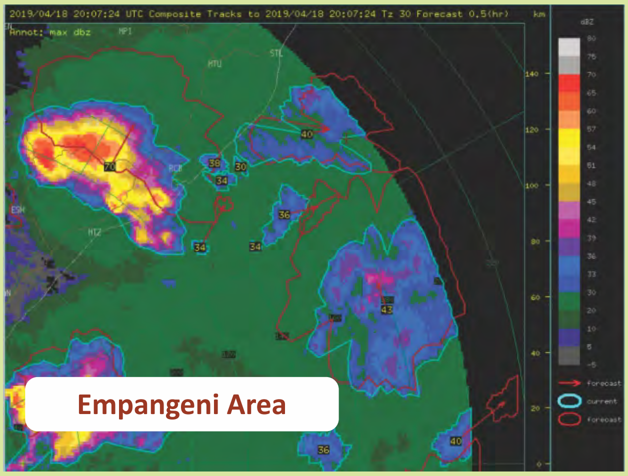


Figure 1: Images depicting (a) Radar imagery that depicts the storm that passed over the Empangeni, (b) image of the collapsed wall of the Pentecostal Holiness Church in the Empangeni area.

Heavy rain and flooding due to cut-off low: 21 – 24 April 2019

The Easter long weekend of 2019 ended on a low note for residents from the south-eastern parts of KwaZulu-Natal and the coastal regions of the Eastern Cape as major towns and cities received heavy rains that lead to flooding. This event resulted in some communities being displaced, settlements, both formal and informal, being destroyed, mudslides, several vehicle accidents and loss of lives (reportedly more than 70 people).

In this article, the weather systems that produced the severe weather that resulted in extensive damage are discussed. An analyses of the forecast and impact-based alerts issued prior to the event happening is provided. Furthermore, the impacts of severe weather will be evaluated through media reports and images captured by the public during and after the event.

System analysis and forecast

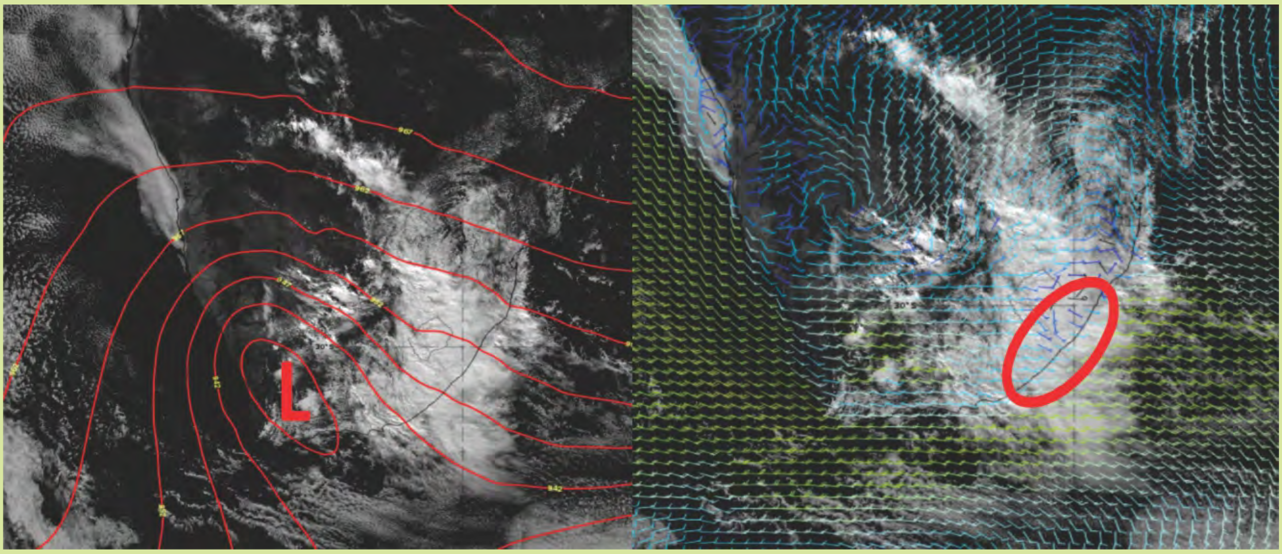


Figure 2: A high resolution Visible satellite image overlaid with geopotential height at 300 hPa indicating where the cut-off low was (right). The satellite image is overlaid with 10m winds. The red circle indicates roughly where the strongest onshore flow was, which coincides with the highest rainfall amounts recorded for some stations (left). (Source: Eumetsat)

The extensive flooding was due to a cut-off low system that was situated over the western interior of the country as depicted by figure 2. The position of the cut-off low and the surface systems created conditions that were favourable for heavy rain over the southern parts of KwaZulu-Natal and Eastern Cape for 22 to 23 April. The Unified Model forecasted a significant amount of rainfall along the south east coast line and adjacent interior, with up to 200m expected for areas in the extreme south coast of KZN as shown in figure 3. The highest amounts of precipitation (rainfall) were expected to be confined over the south-eastern parts of KZN including areas along the coast extending up to Cape St. Lucia.

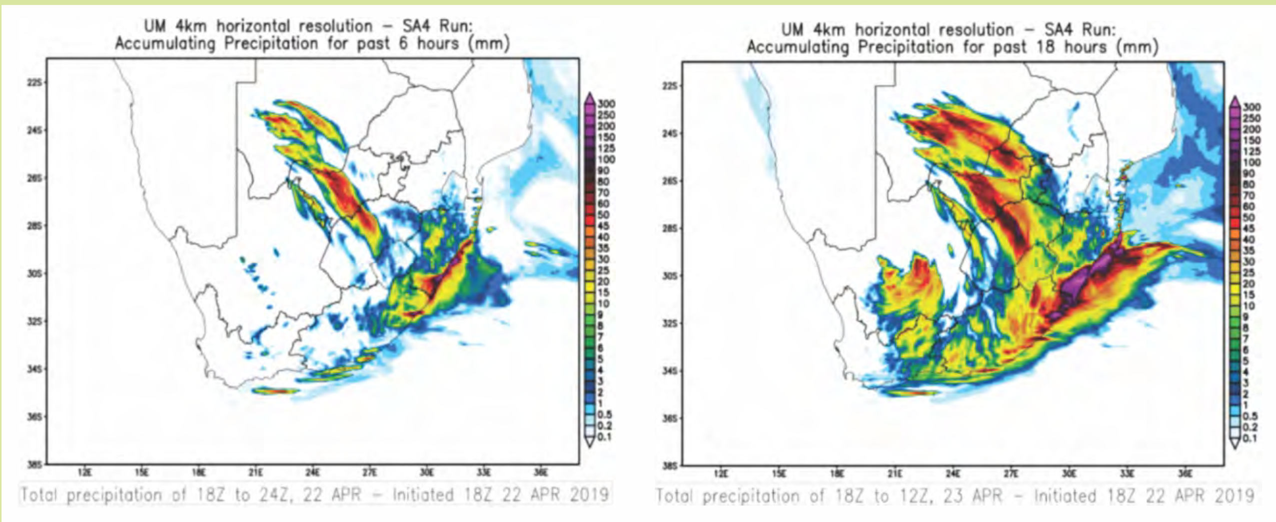
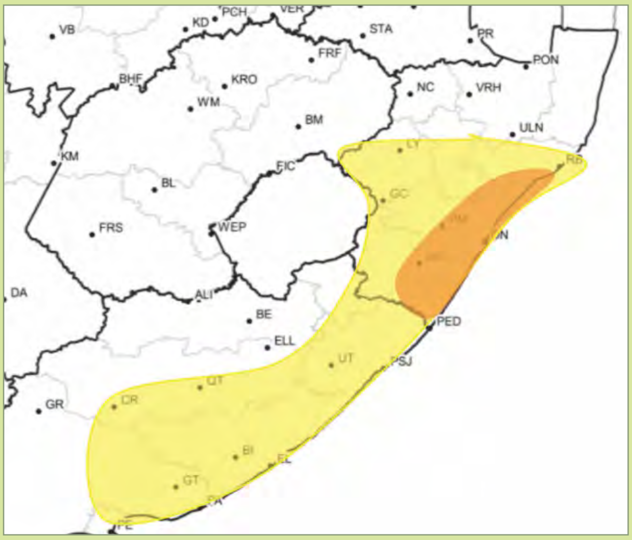


Figure 3: Unified model 4.4km output depicting the rainfall accumulation for 22 April for the past 6 hours (left) and accumulated rainfall for the past 18 hours (right) on 23 April 2019.

The cut-off low developed on Sunday 21 April, and by Monday, 22 April, the system had become a well-defined closed low in the middle and upper troposphere over the western interior. The surface high pressure began ridging in south of the country on Sunday morning. By Monday, the high pressure had strengthened, advecting more low-level moisture into south-eastern and eastern parts of the country. South-east of the upper-air system, in areas like the wild coast of the Eastern Cape, rainfall began to exceed 50 mm from Monday. Coffee Bay received over 117 mm by the end of the day, with Port St. Johns exceeding 200 mm. The south coast of KwaZulu-Natal also started receiving high amounts of rainfall, and Port Edward and Margate received just over 200 mm by the end of Monday.

Impact-based forecast (IBF) alerts

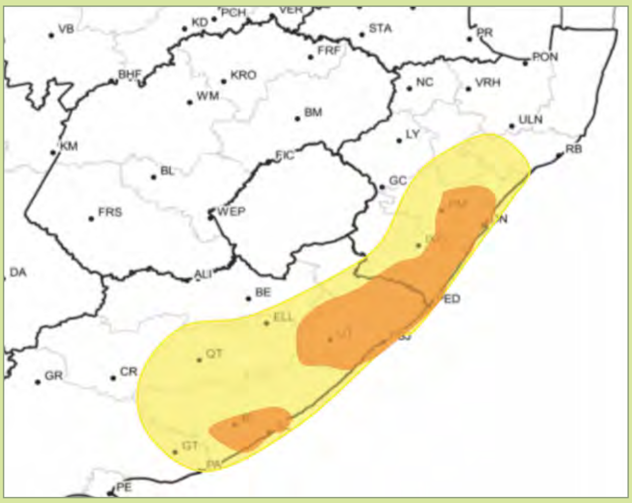
Impact-based alerts were issued on 19 and 20 April for both KwaZulu-Natal and the Eastern Cape coastal regions. Even though the event was days away, the system was expected to affect more people as it was Easter weekend. Most people would be either away from home or on the roads. The Durban office decided to include an area for significant impacts (orange warning) for the south coast as models were indicating higher amounts of rainfall accumulation in that region. This also meant that from as early as 19 April, the Durban weather office communicated with Disaster Management to confirm the alert. The areas around the orange area were marked as yellow (level 4), which implies significant impact of low likelihood for KwaZulu-Natal, but minor impacts with high likelihood for the Eastern Cape, refer to figure 4.



IBF issued 19 (KZN) and 20 (PE) April valid for 22 April 2019

Expected impacts:

- The major impact is the possibility of flash flooding due high rainfall intensity and sudden onset of storms.
- Roads becoming flooded rather quickly as drainage may not handle high volumes of water.
- Small Streams and rivers may also rise sharply, with low-lying bridges over-flowing may pose danger to life.
- Damage to mud-based houses/structures is also possible due to heavy falls.
- Mudslides are a possibility along embankments. There is greater risk to the general public and drivers on the roads as people will be travelling back from Easter weekend.



Upgraded IBF issued on 22 and 23 April 2019:

Expected impacts:

- Flooding of roads and settlements both formal and informal.
- Some communities may become displaced and inaccessible.
- Roads may be subjected to mudslides and some other damages which will in turn result in major traffic, road accidents and some roads being closed off.
- Water and electricity disruptions are possible for some communities.

Figure 4: Map of IBF alerts for heavy rain issued on the morning of 23 April valid for 23 April 2019 as well as the expected impacts.

Rainfall accumulation and damages

The daily rainfall accumulation for stations along the south coast and adjacent interior of KZN are displayed in figure 5. The table depicts that most of the stations received most rain between 22 and 23 April. Areas in the extreme south coast received significant amounts of rainfall from as early as 21 April, due to the thunderstorm band that had affected this area on the same day. Paddock and Port Edward were relatively consistent with rainfall amounts received on both 22 and 23 April. The stations that recorded the highest rainfall of above 100 mm were in the Ugu district and significant impacts were around the eThekwini District.

24 Rainfall (21 April 0600Z to 22 April 0600Z)

	Station Name	24 hr rainfall (mm)
KwaZulu-Natal	Margate	239,0
	Port Edward	201,4
	Paddock	178,4
	Pennington South	102,6
Eastern Cape	Port St. Johns	212,8
	Coffee Bay	117,2
	Dwesa Nature Reserve	104,0

24 Rainfall (22 April 0600Z to 23 April 0600Z)

	Station Name	24 hr rainfall (mm)
KwaZulu-Natal	Port Edward	176,6
	Paddock	143,2
	Virginia Airport AWS	126,0
	Kwamashu W/W ARS	114,0
	Mount Edgecombe	112,2
	Virginia	110,0

Rainfall in KwaZulu-Natal and Eastern Cape between 21 and 23 April 2019

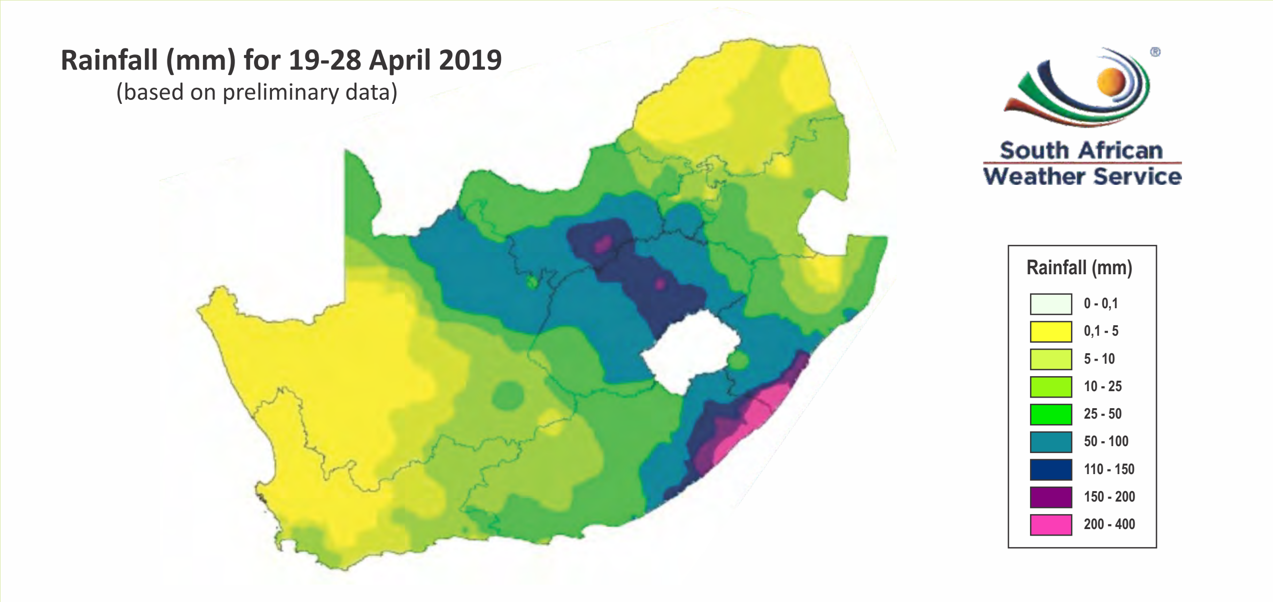


Figure 5: Rainfall accumulation from 19 to 28 April 2019.

The heavy rains that resulted in flooding wrecked eThekwini and Ugu districts especially over the southern parts of Durban as well as over the extreme south coast of KZN. The damage from the storms resulted in communities displaced in areas like Reservoir Hills and UMlazi. The heavy rains also resulted in about 70 lives being lost, due to drownings, mudslides, collapsing of houses and other structures. Furthermore, there were several road and bridge closures, mudslides, disruption of water and electricity supply by the municipality as well some closure of garages as water seeped into some petrol tanks.

Sink holes occurred over Amanzimtoti, rock falls were reported on some major routes like the N3 and some trains were suspended. Schools and universities closed on Tuesday, 23 April over most parts of eThekwini. Figure 6 depicts some of the damage reported by various media platforms. In the Eastern Cape, most damage was a result of flooding. Flash floods affected the low-lying areas as the major Mzimvubu River burst its banks, displacing just over 300 people. Green Farm in Port St Johns was one of the worst hit areas, where flooding damaged several homes and other infrastructure.

Figure 6: Collapsed house along the KZN coast and on the left an aerial view of flooded Amanzimtoti on 23 April (source: News24).

THE FOUR SEASONS OF PORT ELIZABETH

– article by Lulama Nhlapho

On 30 April 2019, a coastal low-pressure system (CL) was moving along the south coast of South Africa, ahead of the approaching cold front. Ahead of this particular CL were berg wind conditions of fine and calm weather. Temperatures over the Eastern Cape were generally warm but hot in places in the western half. These conditions changed drastically in a split second.

At 11h14 UTC (13h14 SAST), the south westerly winds at the Port Elizabeth aerodrome sharply picked up from an average of 10 knots, reaching an average wind of 35 knots, gusting at 45 knots within seconds. Figure 1 and 2 below show the Port Elizabeth aerodrome detecting the rapid increase in average winds and wind gusts respectively.

Figure 1 : Graph showing average wind speed over the Port Elizabeth aerodrome on 30 April 2019 (Source: copyright @SAWS2019)

Figure 2 : Graph showing wind gusts over the Port Elizabeth aerodrome on 30 April 2019 (Source: copyright @SAWS2019)

In addition to these gusts, the Port Elizabeth aerodrome experienced blowing dust, which reduced visibility to 5000 m. Subsequently, temperatures at the aerodrome drastically dropped from 35 degrees Celsius to 22 degrees Celsius by 11h35 UTC (13h35 SAST). Figure 3 below shows the drastic drop in temperature mentioned.

Figure 3 : Graph showing surface temperatures over the Port Elizabeth aerodrome on 30 April 2019 (Source: copyright @SAWS2019)

Within the hour, conditions went from CAVOK (CAVOK is defined in this article as no cloud below 5000 feet and visibility being 10 km or more) to broken cloud at 1000 feet above mean sea level by 12h00 UTC (14h00 SAST). Conditions returned to CAVOK for FAPE by 16h15 UTC (18h15 SAST) with the gusts and average wind subsiding. Later, at 20h00 UTC (22h00 SAST), thunderstorms moved in over the aerodrome, accompanied by light thunder-showers and rain, then cleared rapidly. CAVOK conditions were immediately reported at the aerodrome at 22h00 UTC (00h00 SAST).

Ultimately, on the last day of the April, all four seasons were experienced over the aerodrome and surrounding areas, the "clear and warm, cool windy and dusty and cloudy with rain" day. Consequently, the ground staff had to vacate the airbase several times as conditions made it difficult to do their day-to-day jobs, and planes that operate under visual flight rules could not fly under these conditions.

Fortunately, an aerodrome warning was issued for the wind gusts by the forecasters on duty. In addition, the weather office team worked well together in issuing the various products that needed to be sent out.

AgriCloud: A DIGITAL APP WITH WEATHER RELATED ADVISORIES FOR SMALL SCALE FARMERS – article by Nico Kroese

Farm management for small scale farmers poses unique challenges and risks to make a living. No matter how large or small, a farmer needs to use sound management principles. Many of a farmer's decisions are based on information that is not readily available. The digital platform "AgriCloud" was developed to assist small-scale farmers with day-to-day decision making.

The Rain 4 Africa Project

In order to address the need for decision-making weather information in the agricultural sector, South African entities, the Agricultural Research Council: Soil Climate and Water (SCW) and the South African Weather Service (SAWS)) collaborated with Dutch partners in a project called "Rain for Africa" (R4A). The R4A project has a strong agricultural focus and the aim is to impact on the agriculture sector through services to:

- **Farmers:** small scale farmers, commercial farmers and farmers' associations.
- **Agricultural service providers:** Agri-business, provincial departments of agriculture, cooperatives, NGO's, etc.
- **Agricultural Technical developer's:** IT application developers

"The Rain for Africa (R4A) project aims to provide agricultural advisory services to farmers based on the best available weather and climate information at their specific location."

The AgriCloud APP

The adoption of new technology is one of the ways a farmer can increase yields and income but usually these services come at a price. However this App translates the weather information into weather based agricultural advisories. AgriCloud is an online weather based agricultural advisory system that enriches weather and climate data with agricultural data and local knowledge and generates real-time personalised forecasts and warnings.

The "AgriCloud Portal" is a commercial service that helps agri-businesses, cooperatives and farmers to make well-informed farm management decisions in order to:

- optimise farm inputs
- reduce weather and climate related risks
- Improve food production in a sustainable manner

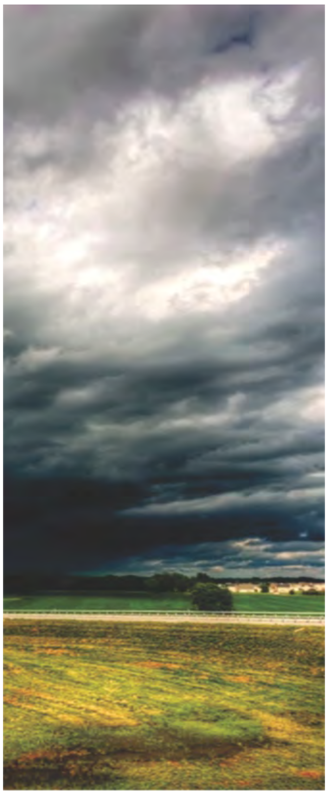
Contact the ARC, SAWS or visit the R4A web-site for more information on the above services.

The "AgriCloud" App is aimed specific-ally at small scale farmers. The following three services are provided for rain-fed crops:

- Planting advice
- Spraying advice-herbicides
- Spraying advice-pesticides

For small scale farmers the service is free and can be downloaded via a "smartphone"-application accessible via the Google Play Store for Android phones or a simple text message service (USSD / SMS). The APP was tested amongst a number of selected small scale farmers and extension practitioners across several provinces. Commentary from the users during the testing phase can be summarised as very positive.

"Many of the stakeholders are enthusiastic and impressed with AgriCloud as a useful tool to provide farmers with dynamic daily updated information in the local South African languages for their own farms."



How to register for the smart phone App:

– Go to Google Play Store

– Search for **AgriCloud**

– Download the AgriCloud App

– Follow the instructions

How to register for the AgriCloud USSD service:

– Dial *134*8383#

– Press the call button

– Wait for reply

– Follow instructions

Your own statistics (crowd sourcing):

– Help us to improve your information/ advisories by reporting weather observations on your farm

Benefits of reporting observations:

– More weather observations mean better information and statistics.

– Better statistics mean better farm management

– Better farm management means higher yields and lower input costs

Benefits of AgriCloud:

1. The AgriCloud App incorporates the latest weather information for farmer advisories
2. The advisories are location specific (specific farm)
3. The advisories are updated on a daily basis
4. The advisories are available in all the 11 official languages of South Africa
5. The information provided through AgriCloud is: • The right information • At the right time • At the right location • For the right purpose
6. The mobile AgriCloud APP is available"free"

AgriCloud App

AgriCloud is a "free" mobile APP for Android phones, downloadable from the Google Play Store. It provides guidance to farmers on the selection of planting dates for rain-fed maize for the specific location of their own farm. This information is based on the rainfall received over the previous 10 days together with the rainfall forecast for the next 10 days. It also gives advice on the weather conditions conducive for the spraying of herbicides and pesticides for the next 3 days. Extension practitioners, NGO's and others working with farmers can download the APP and register a number of farmers to assist them in obtaining the information. Similar information is also available for users of "simple phones" via a USSD service (*134*8383#)

Conclusion

Farmer must make a multitude of management decisions that address the risk factors they are exposed to. The management of risks, despite many aides and tools, cannot replace management skills obtained from knowledge, experience, initiative, discernment and wisdom. The AgriCloud APP is a tool that can assist and guide farmers to make better decisions.

For more information,

visit www.rain4africa.org

Contacts:

Prof Sue Walker: walkers@arc.agric.za

Principal Researcher: Agrometeorology

Agricultural Research Council – Soil, Climate and Water

Landline: +27 (0)12 310 2577

Nico Kroese: Nico.Kroese@weathersa.co.za

Manager: Research and Development

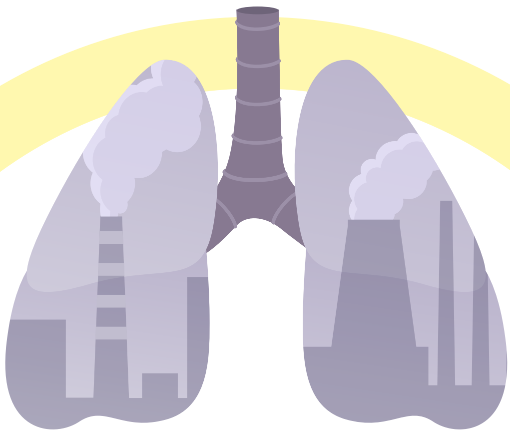
South African Weather Service

Landline: +27 (0)12 367 6000

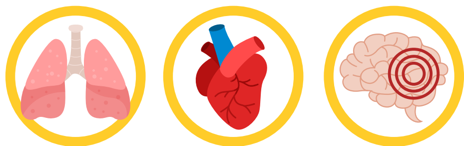
Air-pollution - a modern-day curse

– article by Lotta Mayana: Quality Manager Air Quality Services

With an already compromised health system, more people put strain on themselves because of exposure from the air pollution. Air pollution is all around us, preying on the young and old It is an invisible killer that has astonishingly earned the term “modern-day curse”, with a death rate of 7 million per year in accordance to the World Health Organization (WHO).



AIR POLLUTION



The elderly and the young are the most vulnerable groups. One reason why children are particularly vulnerable to the effects of air pollution is that they breathe faster than adults and so absorb more pollutants. They also live closer to the ground, where some pollutants reach peak concentrations – at a time when their brains and bodies are still developing. Newborns and young children are also more susceptible to household air pollution in homes that regularly use polluting fuels and technologies for cooking, heating and lighting.

In most cases, air pollution enters the body of a human being through the respiratory track and circulatory system. An adult person at rest takes about 12 to 20 breaths per minute. At complete rest and in a non-stressed state, an average person will therefore breathe in air at a rate of about 7.5 litres per minute. That gives a sum of about 11,000 liters of air per day.

Ambient air pollution alone imposes enormous costs on the global economy, amounting to more than 74 trillion rand in total welfare losses in 2013.

The lack of visible smog is no indication that the air is healthy. Across the world, in the cities and the country side, seeing toxic pollutants in the air exceed the average annual values recommended by WHO's air quality guidelines.

According the WHO every day around 93% of the world's children under the age of 15 years (1.8 billion children) breathe air that is so polluted that it puts their health and development at serious risk. Tragically, many of them die: In 2016 an estimated 600,000 children died from acute lower respiratory infections caused by polluted air.

Air pollution is hard to avoid, no matter how affluent the neighborhood you live in. It is all around us. Microscopic pollutants in the air can slip past our body's defense system, penetrating deep into our respiratory and circulatory system, damaging our lungs, heart and brain.

According to the U.S. Agency for International Development, air pollution is one of the leading threats to child health, accounting for almost 1 in 10 deaths in children under five years of age.

What must happen?

Implementation of policies to reduce air pollution

- All cities should work towards meeting the air quality guidelines to enhance the health and safety of children. To achieve this, governments should adopt measures such as reducing the over-dependence on fossil fuels in the global energy mix, investing in improvements in energy efficiency and facilitating the uptake of renewable energy sources.
- Better waste management can reduce the amount of waste that is burned by communities and thereby reduce 'community air pollution'.
- The exclusive use of clean technologies and fuels for household cooking, heating and lighting activities can drastically improve indoor air pollution and in the surrounding community.
- Steps to minimize children's exposure to polluted air: Schools and playgrounds should be located away from major sources of air pollution such as busy roads or intersections, factories and power plants.

FOG CAUSING DELAYS AT ORTIA

– article by Hetisani Oscar Shiviti and Tumi Phatudi - Forecasters: (Aviation Weather Center)

Fog is defined as the condition where the horizontal visibility is reduced to less than 1000 m (1 km) due to the presence of hydrometeors (water particles). The denseness of the fog reducing the visibility is influenced by a number of factors, namely the droplet size, amount of droplets, height above sea level, type of fog and the weather system responsible on the day.

Areas prone to fog formation have one of two dominating factors - either orographic or meteorological. Orographic factors include terrain, altitude, topography, slope and aspect of the area. Meteorological factors include the pressure, wind speed, low-level inversion, previous precipitation as well as the climatology of the area. In contrast, areas with strong wind speeds and warm surfaces are limiting factors for fog formation.

There are two common fog types, namely radiation fog and advection fog. Radiation fog usually occurs overnight when air near the ground cools down in calm wind conditions until it reaches saturation (usually after the presence of precipitation). Advection fog happens when moisture or already existing low cloud is pushed from one area to another. For the Oliver Tambo International Airport (ORTIA) the fog or low cloud is pushed from the east because of the presence of a ridging high-pressure system (i.e. moisture pushed from Mpumalanga to Gauteng).

A high-pressure system is a low-level system which has an anticlockwise flow of moisture around its center. When this moisture is pushed to a higher elevation area there has to be some type of mechanism that will trap the moisture in order to allow for fog formation - this mechanism is a low-level inversion (a situation where temperature increases with height in the low levels close to the surface).

On the morning of the 14th of June 2019 there was fog observed at ORTIA, which resulted in aircraft delays and diversions. The type of fog experienced on this day was advection fog, which is evident when looking at the Night Microphysical RGB satellite channel in figure 1: one is able to see the fog and low cloud along the east of the country which was advected into ORTIA.

From surface observations in the form of METARs done at the Aviation Weather Center (AWC), the fog was also reported. In figure 2 the METARs for ORTIA from 0300Z (05:00 am SAST) to 0800Z (10:00 am SAST) are shown, with visibility reductions and phenomena causing it highlighted in red. At 0300Z the horizontal visibility was 4500 m in mist (BR); at 0400Z and 0500Z the horizontal visibility was 0 m and the vertical visibility was 0 m in fog (FG); at 0600Z the horizontal visibility was 300 m and the vertical visibility was 100 m in fog (FG); at 0700Z the horizontal visibility was 500 m and the vertical visibility was 100 m in fog (FG); at 0800Z the fog had dissipated with only mist left reducing the horizontal visibility to 4000 m.

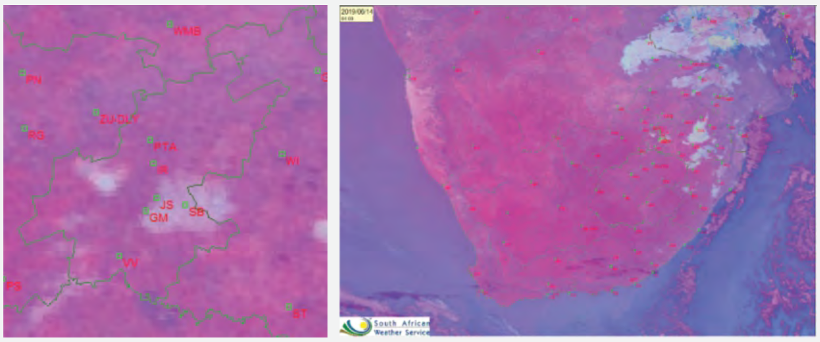


Figure 1: 0400Z (06:00 am SAST) Night Microphysical RGB satellite channel showing fog and low cloud in eastern parts of the country on 14 June 2019; at the top is a zoomed in image of Gauteng to clearly show the fog over OR Tambo International Airport.

Station: FAOR

Date: 2019-06-14

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FAOR 140300Z 07004KT 4500 BR SCT010 02/02 Q1033 NOSIG=
FAOR 140400Z 08005KT 0000 R03R/0500N R03L/0375D FG VV000 03/02 Q1034 NOSIG=
FAOR 140500Z 07005KT 0000 R03R/0350N R03L/0400N FG VV000 03/03 Q1034 BECMG
0300=
FAOR 140600Z 08003KT 0300 R21L/0250N R03L/0200N FG VV001 03/03 Q1035 BECMG
FM0700 3000 BR BKN005=
FAOR 140700Z 05003KT 020V090 0500 R21L/0225N R03L/0200N FG VV001 04/04 Q1035
BECMG 1000 BR BKN002=
FAOR 140800Z 02006KT 4000 BR BKN008 08/07 Q1035 BECMG 6000=
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Figure 2: 0300Z (05:00 am SAST) to 0800Z (10:00 am SAST) METARS at ORTIA for 14 June 2019 showing the effects of fog on the visibility.

Fog is difficult to forecast, however not impossible, and forecasters at the Aviation Weather Centre at ORTIA are well trained and equipped to deal with fog cases. It is for this reason that the fog that occurred on the 14th of June 2019 did not come as a surprise to the AWC; looking at the forecasts given on the previous day (13 June 2019), the forecasters had already indicated the possibility of fog occurrence for the 14th of June 2019 as seen on figure 3.

From the Terminal Aerodrome Forecast (TAF) that was issued at 1010Z (12:10 pm SAST) on the 13th of June 2019, it can be seen that fog was expected or forecasted for the 14th of June 2019 as seen on figure 3 by the highlighted red areas; the forecast had a 40% probability that ORTIA will experience fog between 0200Z and 0600Z with overcast low cloud expected at 100 ft above ground level (agl). The TAF that was issued later in the day at 1600Z (18:00 pm SAST) had an increased or rather maximum probability possible of fog to occur on 14 June 2019 between 0400Z and 0600Z with the low cloud still expected to be 100 ft agl.

On the 14th of June 2019 the TAF issued at 0506Z (07:06 am SAST) also still indicated that between 0600Z and 0700Z there was fog still expected to reduce horizontal visibility to 100 m as well as the vertical visibility to 0m; with the fog only expected to start dissipating by 0700Z where it would improve to mist with horizontal visibility at 3000 m and broken low cloud at 500 agl (as seen from the highlighted green areas).

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Date: 2019-06-13

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FAOR 131010Z 1312/1418 18007KT CAVOK
     TX16/1412Z TN04/1405Z
     FM132100 08007KT 9999 BKN008
     PROB40 TEMPO 1402/1406 0400 FG OVC001
     BECMG 1408/1410 28007KT CAVOK=

FAOR 131600Z 1318/1424 19005KT CAVOK
     TX16/1412Z TN03/1405Z
     BECMG 1318/1320 13010KT
     FM132300 07007KT 9999 BKN008
     PROB40 TEMPO 1402/1407 3000 BR OVC005
     TEMPO 1404/1406 0400 FG OVC001
     BECMG 1408/1410 28007KT CAVOK
     BECMG 1411/1413 VRB03KT=
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Date: 2019-06-14

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AMD FAOR 140506Z 1406/1512 09008KT 0100 FG VV000
    TX18/1512Z TN05/1505Z
    BECMG 1407/1409 3000 BR BKN005
    BECMG 1409/1411 32010KT CAVOK
    BECMG 1412/1414 VRB03KT
    BECMG 1505/1507 24006KT=
```

Figure 3: Terminal Aerodrome Forecasts (TAF) for ORTIA produced on the 13th of June 2019 valid until the 14th of June 2019; as well as TAFs issued on 14 June 2019 valid until 15 June 2019.

Doing an analysis for the day, it was noted that most of the conditions needed for fog occurrence were present on the day. On 14 June 2019, a surface ridging high pressure system was dominating (evident from the satellite image); from the METARs in figure 2 it can be seen that the surface winds were light; and from figure 4 it can be seen that there was a low-level inversion present. Figure 4 shows a tephi-gram (tephi), which is used to show how both the temperature and dew-point temperature react as the altitude increases. On a normal day what one expects to see from a tephi is for the temperature to be decreasing with height.

As mentioned earlier, a low-level inversion is a condition where in the low levels there is an increase in temperature with height. When a low-level inversion is present, it acts as a lid and traps all the moisture in the low levels. Therefore, if the surface winds are light, it allows for mixing of the moisture at high elevations such as ORTIA and thus fog is formed.

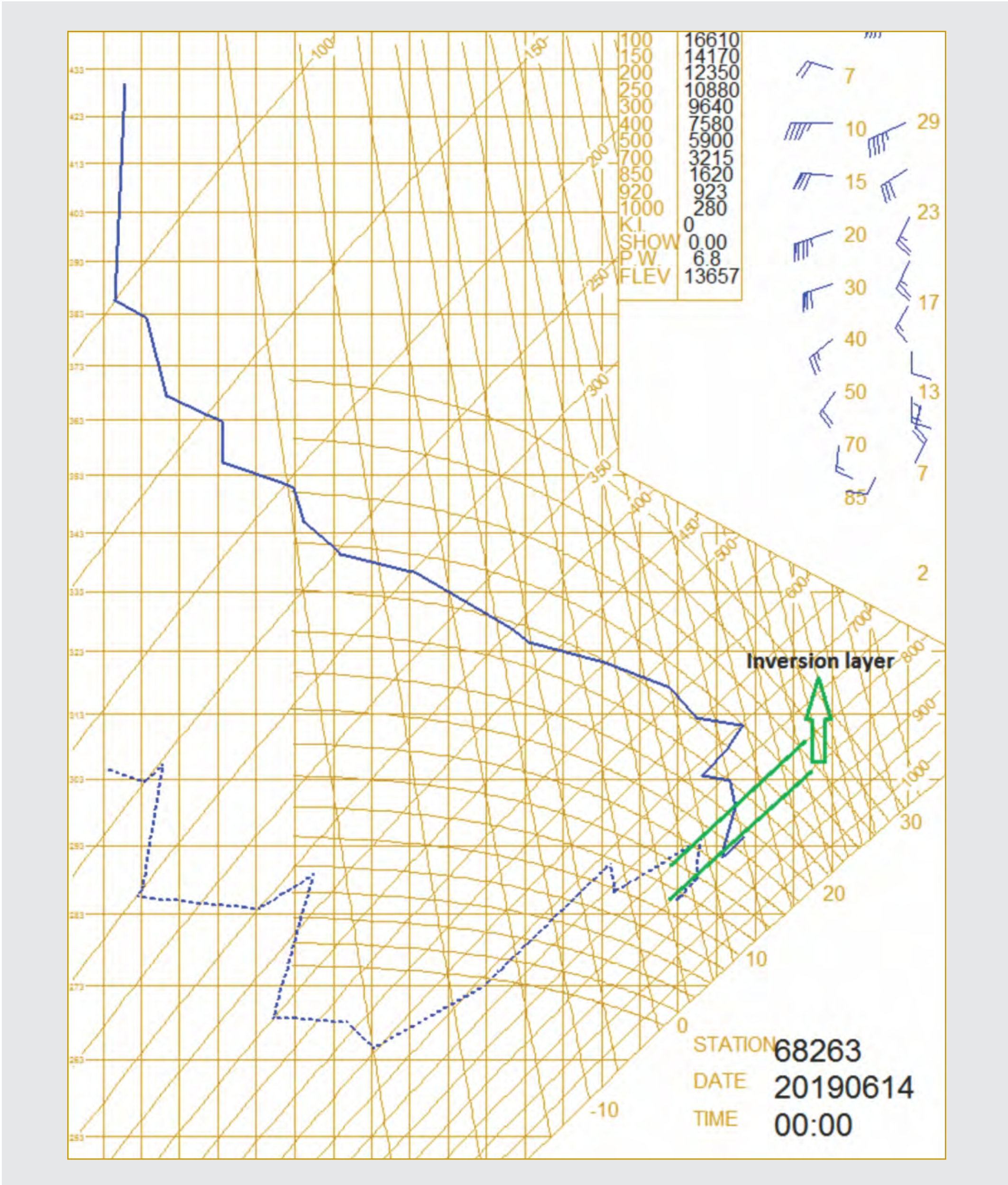


Figure 4: 0000Z Tephi-gram for Irene on the 14th of June 2019. The solid blue line shows the temperature change and the dotted blue line shows the dew-point temperature change with height.

Because of the presence of fog, aircraft had to delay taking off to ORTIA, or in the case where they had already taken off, they had to divert away from ORTIA or create a loop trajectory in the sky in the hope that the fog will dissipate and thus would allow for landing to be possible. In figure 5, the trajectories of different flights approaching ORTIA on 14 June 2019 can be seen - some of the measures they decided to take for dealing with the fog can also be seen.

It is important to note that no landing or take-off can be performed when fog is present, and it is for this reason that fog forecasts are crucial to the aviation industry.

Depending on how well airports can handle visibility reductions, airports are given categories. ORTIA is a Category 2 (CAT II) airport; meaning that when the cloud is less than 200 ft or runway visual range (RVR) is less than 600 m, Low Visibility Operations (LVO) are declared by the Air Traffic Controller (ATC). Under LVOs, aircraft are guided to land using the Instrument Landing System (ILS).

From figure 6 the change in visibility due to fog can be seen. The presence of fog can be seen to have had a drastic reduction in the visibility, which is one of the reasons why taking off or landing in fog is not permitted for ORTIA.

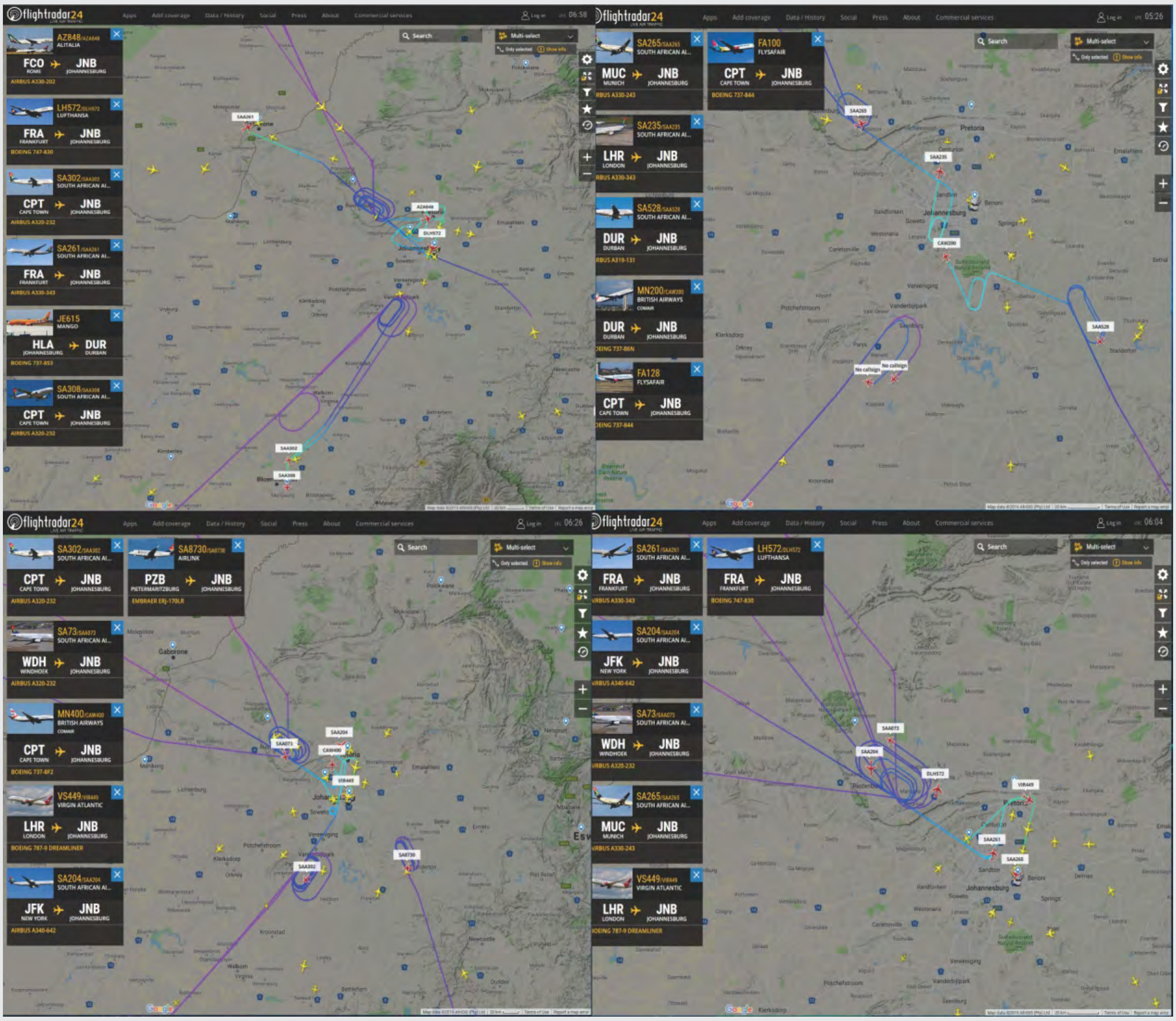


Figure 5: Screenshots of the Flightradar24 site on the morning of 14 June 2019; which was used to track the trajectory of planes making their way to ORTIA through the sky. (Courtesy of Flightradar24)blue line shows the dew-point temperature change with height.

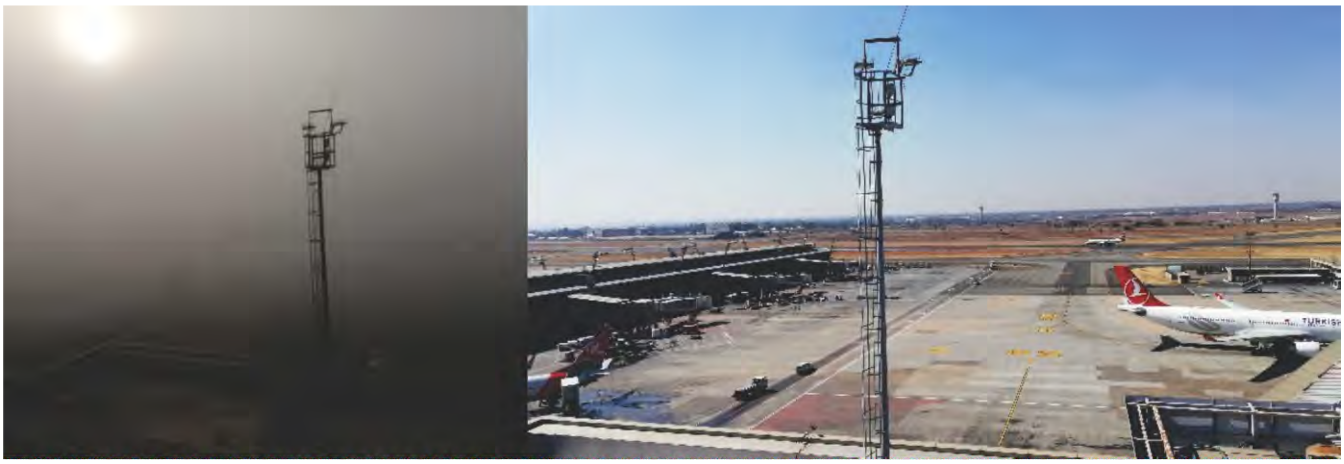


Figure 6: Visibility on a clear day (left) and on a fog day on the 14th of June 2019 (right).

IMPROVEMENTS IN PREDICTING THE LIKELIHOOD OF SEVERE EVENTS

Stephanie Landman - Lead Scientist: Post-Processing (Weather Research)
Estelle Marx – Senior Scientist: Post-Processing (Weather Research)
Elelwani Phaduli – Scientist: Post-Processing (Weather Research)
Louis van Hemert – Senior Scientist: Post-Processing (Weather Research)
Njabulo Mchunu – Scientist: Post-Processing (Weather Research)

Most Numerical Weather Prediction (NWP) systems provide a good enough representation of the predicted weather and they can be used to provide basic automated weather forecasts directly from the model output (although in general it is recommended that some post-processing should be used to calibrate automated forecasts). Any NWP process is dependent on the observations assimilated with the generation of the analysis (e.g., field representing the current state of the atmosphere). Due to this sensitivity to the initial conditions, any error can result in a large error in the forecast. Therefore, even with the best observations, a perfect analysis is not possible, and consequently, neither is a perfect forecast. An ensemble of forecasts addresses these weaknesses in NWP. The uncertainty in a weather forecast can vary widely from day to day according to the synoptic situation, and the ensemble approach provides an estimate of this day-to-day uncertainty. Convective instability adds a new scale of forecast uncertainty, which convective permitting ensemble systems will also address. The ensemble is designed to sample the spread of the forecast and results in probability forecasts to assess the likelihood that certain outcomes will occur.

An ensemble is attained by adding or subtracting small perturbations to the analysis field to attempt to address the uncertainty within the initial conditions. The resulting difference or size of the spread in the forecasts from the different initial conditions will either increase or decrease the confidence in the forecasts. Due to the computational costs of running an ensemble (multiple forecasts), the resolution of the ensemble members is generally double that of the deterministic (single) forecast. SAWS currently runs 4 km, and 1.5 km horizontal resolution models on the Unified Model.

During March 2019, a Unified Model convective-scale ensemble prediction system (CSEPS) with a 4.5 km horizontal resolution was implemented and had since been running regularly at SAWS for testing and verification. The ensemble covers the South African domain and consists of 12 members, each member receiving initial- and lateral boundary conditions from the United Kingdom Met Office's MOGREPS-G members. In addition to the UM CSEPS, a multi-model ensemble (MMENS) is also being developed, using the forecasts from several deterministic models. The models used are from the German Weather Service (DWD) ICON; the Met Office Global Atmosphere (GA); the Global Forecasting System (GFS); and the in-house UM SA4 deterministic run. All members are resampled to a common ~6 km horizontal grid, and additional members are achieved through pseudo-ensemble methods. The resulting ensemble also consists of 12 members.

Post-processing of any forecast is recommended to address issues of spatial uncertainty, and subsequently provide a more realistic spatial distribution of event probabilities. Different statistical methods may be necessary for different variables to take account of the relatively small ensemble size.

Numerous products are under development together with forecasters and disaster risk reduction scientists to fully present the output of the ensemble forecast. A list of products under consideration, but not limited to, is:

- Ensemble spread
- Basic probability products (threshold dependent)
- Quantiles
- Postage stamps
- Site-specific Meteograms

The KwaZulu-Natal (KZN) flood in April 2019 is used as a case study to evaluate the performance of both the CSEPS and MMENS. During the evening of 22 April and into the morning of 23 April, a significant amount of rain fell over the southern parts of the KZN coast. The rain was the result of a cut-off low which developed over the Eastern Cape Province coast but intensified along the KZN coast. The resulting floods and mudslides led to 68 fatalities, the displacement of ~1260 people and an estimated cost of R1 trillion in damages.

During the time of the event, operational forecasters had access to NWP guidance for issuing of warnings. However, in this case, we are looking into the spread of possibilities the two ensemble systems provided. In Figure 1, the CSEPS 00Z forecast from the 22nd shows the 12-member accumulated rainfall predicted for the 48 hours from midnight 22 April to midnight of the 24th of April 2019. All members indicate the high amounts of rain over the southern parts of the KZN coast, with member nr. 7 indicating the largest area expecting rainfall greater than 150 mm over the two days. The corresponding forecasts made by the members of the MMENS are shown in Figure 2. Due to the lower native horizontal resolution grids of the global NWP models contributing to the MMENS, the predicted rainfall areas are generally larger and less defined. It is also evident that more members are predicting larger areas of rainfall greater than 150 mm, than the members of the CSEPS.

The ensemble average of both systems was calculated and compared to the high-resolution deterministic SA4 forecast (Figure 3). The CSEPS average indicates the more distinct, concentrated region of significant rainfall over the southern KZN coast. The SA4 forecast is one of the members of the MMENS, but it is seen in the MMENS average rainfall that the other members of the ensemble lessen the intense rainfall predicted by SA4 along the KZN coast. Figure 4, in turn, indicates the actual rainfall observed by the automatic rainfall and weather stations over the KZN Province. The observations show that the highest amount of rainfall was concentrated from Durban southwards. As much as 163 mm was observed at Amanzimtoti during the 24 hours of 06Z 22 April to 06Z 23 April.

When comparing the average rainfall of the two ensemble systems, both forecasts have strengths and weaknesses. The CSEPS indicates more localised and concentrated regions of heavy rainfall than were observed, whereas the MMENS predicted the higher rainfall totals, but over a much larger area. However, both ensemble systems performed better than the single deterministic forecast. Since the ensemble of forecasts normally forms a good representation of the most likely expected weather, these ensemble systems may be used to provide reliable probabilistic forecasts of such weather.

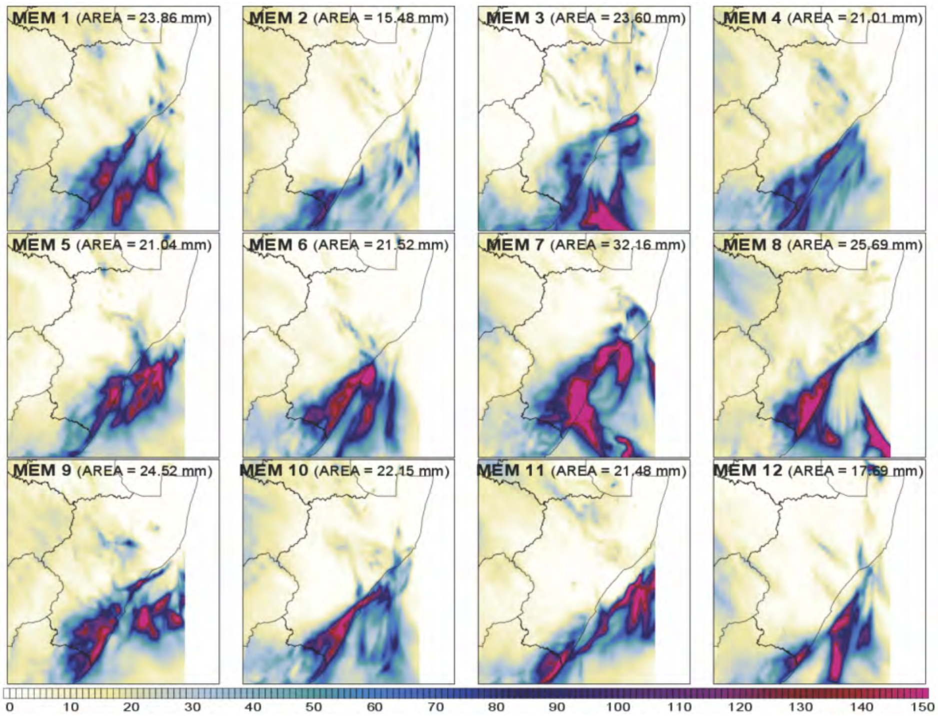


Figure 1: The 12 members of the CSEPS: total rainfall (mm) predicted for the 48-hour period of 00Z 22 April to 00Z 24 April 2019. Indicated is also the area average rainfall for the KwaZulu-Natal Province.

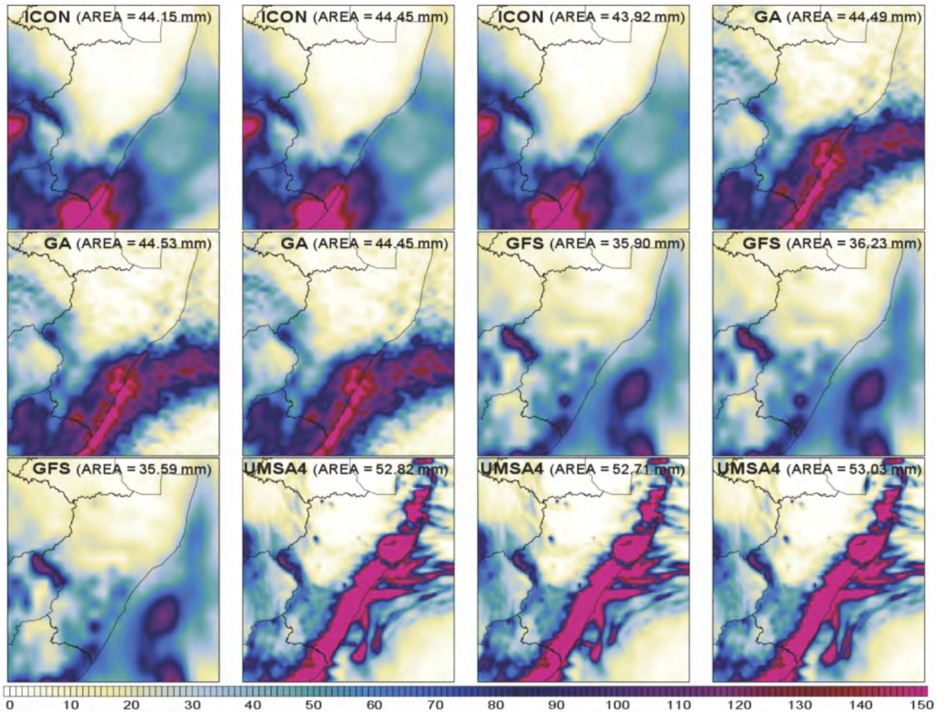


Figure 2: The 12 members of the MMENS: total rainfall (mm) predicted for the 48-hour period of 00Z 22 April to 00Z 24 April 2019. Indicated is also the area average rainfall for the KwaZulu-Natal Province.

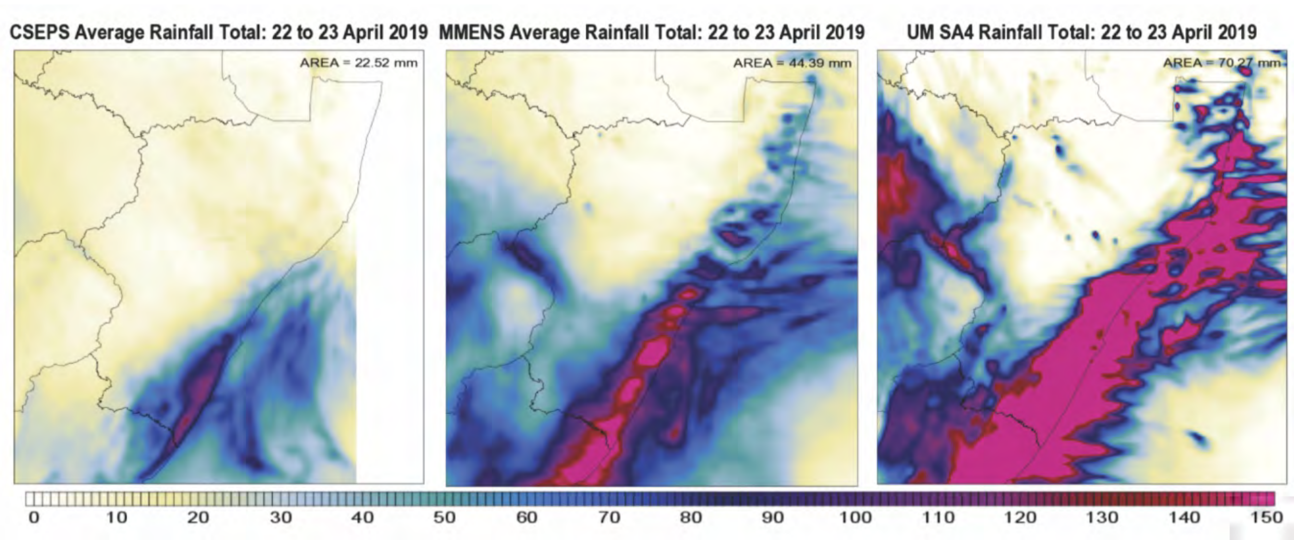


Figure 3: Ensemble averages for the CSEP and MMENS forecasts, including the single high-resolution forecast of UM SA4.

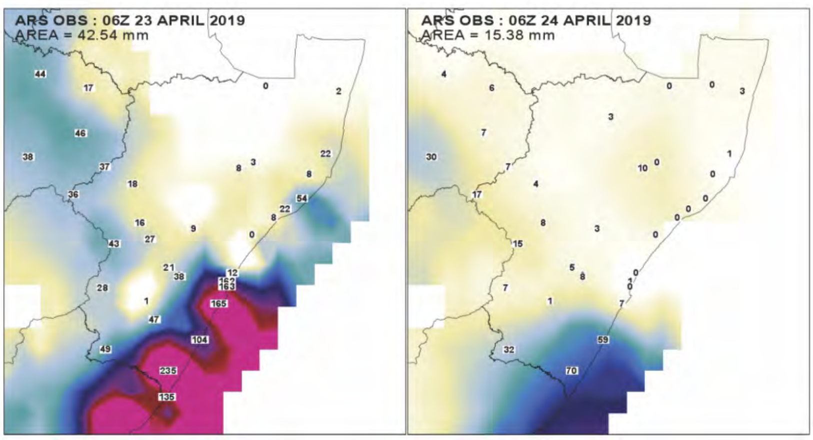


Figure 4: Gridded daily rainfall totals from the automatic rainfall stations in the KwaZulu-Natal Province, with observations from 06Z-06Z on 23 April and 06Z-06Z on 24 April 2019.

THE NEW HUMAN-BIOMETEOROLOGICAL NETWORK AT SAWS

– article by Katlego Ncongwane, Siphesihle Sithole and Dr Joël Botai

1. Introduction

There is a growing awareness of the linkages between human health, weather and climate. This view has compelled the scientific community and National Meteorological and Hydrological Services to invest in meteorological measurements in order to better understand weather conditions and climate change patterns and the associated health effects, thus leading to the effective allocation of technologies and resources to promote public awareness and resilience.

In addressing Programme 3 (Infrastructure and Information Systems) of the South African Weather Service's (SAWS) five-year strategic plan for the period 2019/20 – 2023/24, SAWS has procured a network of four human-biometeorological stations, three of which have since been deployed in Northern Cape (Keimoes), North West (Mahikeng) and Limpopo Provinces (Tshaulu). The fourth station will be installed at the University of Pretoria's Mamelodi Campus. For ad-hoc field campaigns and to accurately capture extreme events in real-time, SAWS has added a mobile human-biometeorological system hooked on a trailer. This biometeorological network will form part of data verification and re-analysis of the weather forecast, thus improving SAWS operations. At the national level, the new network responds to the call by the South African Climate Change Response Strategy and the National Climate Change & Health Adaptation Plan 2014-2019 (DOH, 2014; DEA, 2012) to tackle health effects of climate change. As widely documented in the literature, climate change has presented new and added health challenges to South Africans and many around the world, from increasing the risk of extreme heat events, heavy storms, severe drought and intense wildfires to increasing UV radiation levels and reduced air quality. These changes have resulted in direct and inherently complex indirect health implications to human health through a variety of pathways summarized in Figure 1.

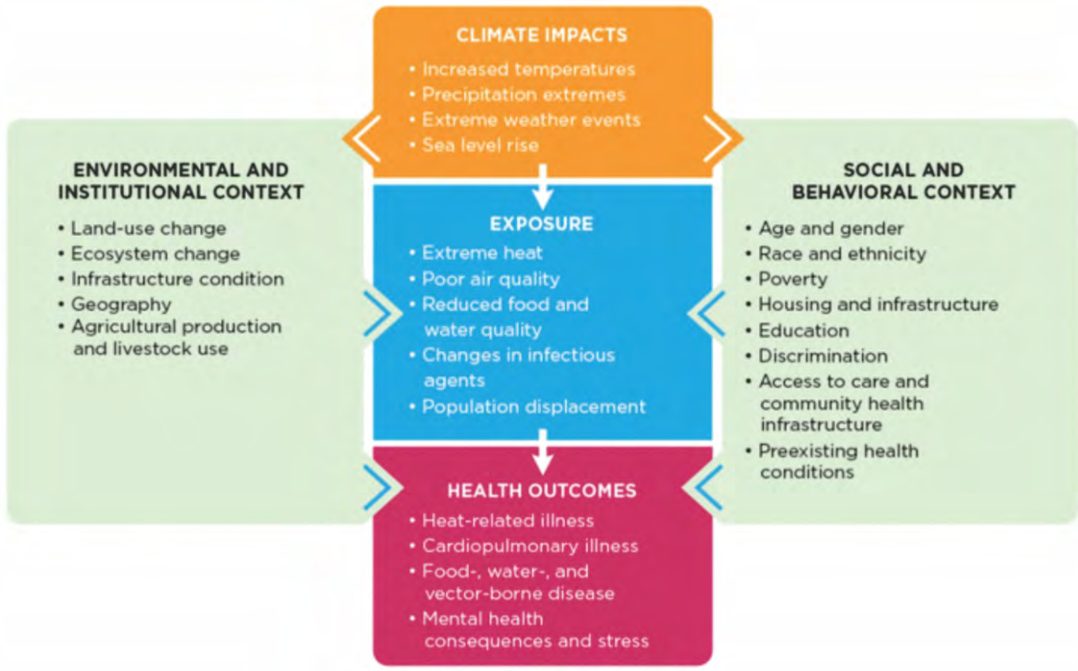


Figure 1 shows how climate change can affect people by changing their exposure to health threats (moving from top to bottom) and by influencing the environmental, institutional, social, and behavioural factors that affect a person's or community's health (moving through the boxes on the sides).

The human-biometeorological measurements are an integral part of the public health interventions to mitigate climate change health-related morbidity and mortality outcomes through the development of solutions and other application tools such as early warning systems that will ensure preparedness and timely response by the affected communities to minimize or mitigate health impacts of climate change. These will be based on environmental metrics from the new network, the existing network as well as other weather data sources.

2. The Human-biometeorological Station

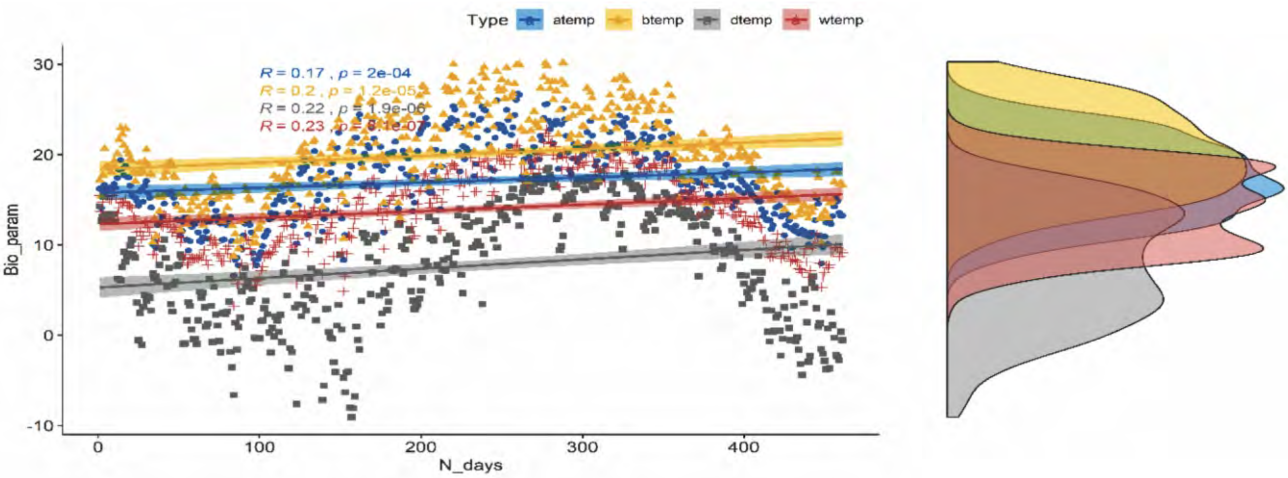
2.1 A suite of sensors forming the Human Biometeorological Station

A biometeorological station is a customized station consisting of Automatic Weather Station (AWS) standard sensors and additional suites of human-health sensors. The station measures air temperature (°C), relative humidity (%), wind speed (ms-1) and direction at 2 m above ground, rain (mm), solar radiation (Wm-2), erythemal irradiance (Wm-2) that measure ultraviolet radiation (UVB), as well as a black globe sensor that measure the globe temperature used in the assessment of heat stress. The station also consists of a Viasala air quality sensor-AQT 420 that measures air quality pollutants, including Nitrogen dioxide (NO_2), Sulphur dioxide (SO_2), Carbon monoxide (CO) and Ozone (O_3), and Particulate Matter (PM2.5 and PM10). Photographs of the human-biometeorological stations already installed and the installation team during installation are shown in Figure 2.

Figure 2: Human-biometeorological station and some of the installation team members.

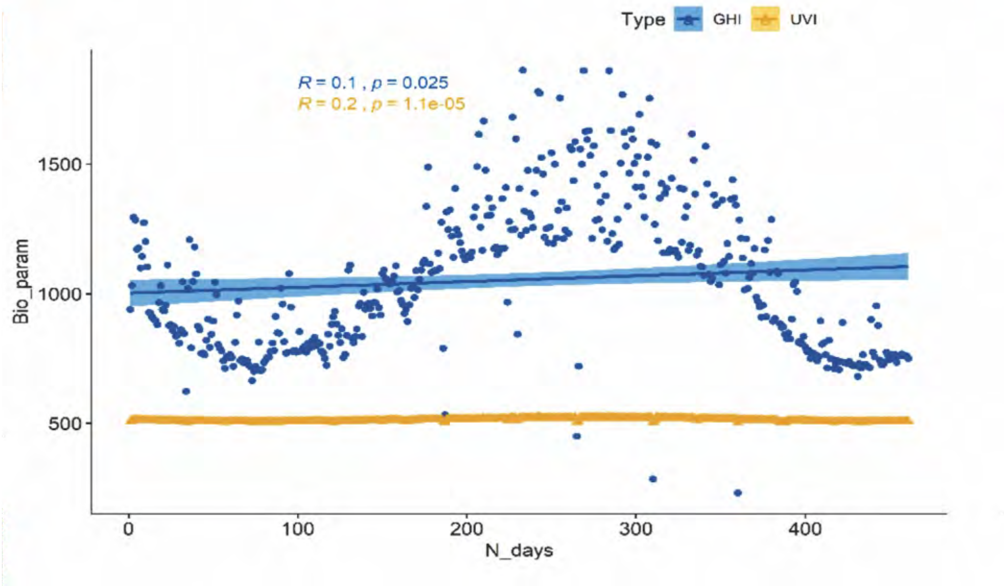
2.2 Sample results

A snapshot of some the readings from a typical Human-Biometeorological Station as given in Figures 3.



	Median	STD
atemp	16.85	4.37209950134138
btemp	19.88	4.86463020171471
dtemp	7.81	6.30280414871065
wtemp	14.14	4.24494426933049

Figure 3: One year of human-biometeorological station measurements and accompanying statistics of (a) atemp=Air Temperature, btemp=Black Globe Temperature, dtemp=Dew Point Temperature and wtemp= Wet bulb Temperature (b) mGHI=Global Horizontal Irradiance & mUVI= UV Index.



	Median	STD
mGHI	1020.655	284.412920781359
mUVI	11.13	5.98985608467586

3. Salient features of the human biometeorological network

3.1 Science with the community

The stations are located in community environments, thus bringing SAWS operations closer to the communities. This will raise public awareness on weather-related issues, minimize weather risks and importantly foster hands-on learning by students in those communities. By bringing this system to the communities, research scientists at SAWS will be able co-create and produce new knowledge by capturing the immediate microclimate conditions of those communities, observing their behaviour and by talking with the community, thus soliciting feedback which will feed back into our research cycle, bringing unprecedented benefits to the science and the community. All five human biometeorological stations will be up and running by the beginning of spring ready to capture weather extremes at new sites.

3.2 Science through partnerships

The project is anchored on solid internal and external partnership.

3.2.1 Internal collaborators

The in-house team responsible for the installation and maintenance of the human biometeorological network consists of Research and Development, Technical Service, Disaster Risk Reduction, ICT and regional offices. The combined knowledge, skills and experience will enable SAWS to efficiently and effectively achieve

3.2.2 External collaborators

SAWS sees value in collaborating with other organizations, hence the collaboration with various national and provincial entities of government, including the Department of Environment, Forestry and Fisheries (DEFF), National Department of Health (NDOH), South African Medical Research Council (SAMRC), the National Institute for Communicable Diseases (NICD). Higher education collaborator includes the University of KwaZulu Natal, the University of Pretoria and the Central University of Technology. Because of the uniqueness of the system, the network will provide insight into new research thus advancing the development of new scientific knowledge.

4. Conclusion

The human-biometeorological network will enable SAWS to measure human health parameters and also develop tools that will ensure public resilience in the changing climate through co-creation and co-generation of user-inspired health and weather/climate solutions.

WEATHER TECHNOLOGY: THE SOUTH AFRICAN WEATHER SERVICE NEAR-REAL-TIME REMOTE SENSING WEATHER PREDICTION AND MONITORING CAPABILITY – article by Rydall Jardine and Hannelee Doubell

Over the past decade, the South African Weather Service has improved its near-real-time remote sensing weather prediction and monitoring capability through its continued upgrades of radar and lightning detection technology.

Our Radar Network

A weather radar is a real-time observation instrument that sends out radio waves in a narrow beam, at a specific frequency. These radio waves continue to travel forward until they hit a desired object (precipitation forms in the case of weather observation) from where the waves are bounced back and received by the radar. The radio wave echoes are picked up by the radar's receiver and the echo intensity or reflectivity is displayed in dBZ. The radio waves sent out from weather radars are reflected by precipitation particles such as water and ice inside a cloud and the return echoes received by the radar have a specific intensity that distinguish various particles inside a cloud from each other.

A radar performs a 360-degree scan at multiple elevation levels, which ensures that a three-dimensional picture of a cloud is obtained. A radar can cover between 200 and 300 km from the radar and completes a scan every 5-10 minutes.

Radar information is extremely important to forecasters since it provides them with a detailed view of the structure of a cloud and the size and concentration of particles, over large distances, every 6 minutes. Capabilities such as Doppler detection and Dual-Polarization provide additional information on particle motion, phase and shape.

All these measurements allow forecasters to observe and track the movement of thunderstorms and severe thunderstorms, quantify rain rate and identify whether regions in the thunderstorm consist of hail, ice, snow, rain, etc. Various wind-related phenomena such as turbulence, wind shear, mesocyclones and microburst can also be identified using measurements from radar systems.

Other observation platforms such as satellites or lightning detection networks give forecasters a sense of the bigger picture of the current weather conditions, but radars provide the small scale, additional detail that is needed.

Radar information is used by weather forecasters to turn severe thunderstorm watches into warnings since it is the only tool that provides enough detail about thunderstorms. Various industries, such as the aviation, insurance, agriculture, hydrological and energy industries, make use of this information in their day-to-day

The Irene Radar is one of the ten S-band radars covering Gauteng, parts of Northwest, Mpumalanga, Limpopo and Free State with its coverage range of between 200 -300 km radius.

operations. Furthermore, radar has improved our weather knowledge by allowing for ground-breaking research to be performed and can play a large role in the improvement of numerical weather prediction models.

For radar to be useful, data needs to be available at all times and must be of high quality. The South African Weather Service operates and maintains a weather radar network as part of its mandate to protect life and property within South Africa. The current radar network consists of ten S-band radars and three C-band radars with the possible addition of two X-band radars in future. As any other infrastructure, weather radars can also be damaged by nature and a team of dedicated technical personnel ensure around the clock maintenance of our radars. The team is geared to improve overall radar availability, which will add value to the lives of all citizens, be they the general public or the South African working force.

Human life may be lost due to severe storms, flooding. Industries are affected due to them not being able to continue with their respective operations. The South African working force are impacted that they might not be able to get to their respective destination. The impact on the South African economy could have catastrophic consequences. The Aviation Industry depends on this critical information to secure their airport, aircrafts and even to be able to uphold their international status. The South African Power Generating Agency, ESKOM, requires the combination of the radar and lightning information to understand how best to manage its infrastructure and prevent millions of rands of damages annually.

Our Lightning Detection Network

The South African Weather Service remote sensing Lightning Detection Network (LDN) consists of 24 lightning detection sensors strategically positioned around the country to record lightning strokes within a 300 km radius. This technology, coupled with our radar capability provides effective lightning storm detection and tracking and provides useful information to the insurance industry, as well as around recreational areas such as golf courses; where the possibility of lightning can be detected early and suitable warnings could be sent out.

Our network of lightning detectors and radars are supported by a team of specialists, engineers, technologists and technicians strategically positioned around the country. This team ensures that the networks are maintained, available and effective. This included the maintenance of the peripheral equipment to ensure stable remote site power sourcing and stable communication from the site to the South African Weather Service Head Office in Centurion.

To ensure a stable power supply from the radar sites, we make use of the national Eskom electrical power grid, backed-up by diesel generators and dual redundancy Uninterrupted Power Supplies (UPSs). The LDN makes use of UPS's with 3 to 5-hour back-up power banks. Stable communication is provided through an outsourced process, which includes the required back-up communication solutions as prescribed by the South African Weather Service.

Lightning detectors form part of the SAWS Lightning Detection Network (LDN).

DROUGHT MONITORING BY THE SOUTH AFRICAN WEATHER SERVICE

– article by Sandile Ngwenya and Andries Kruger - Climate Services

Introduction

Drought is a period of abnormally dry weather sufficiently prolonged for the lack of rainfall to cause serious hydrological imbalance in the affected area. Droughts can occur at several timescales, ranging from mid-summer droughts to prolonged multi-year droughts. It is usually classified as meteorological, agricultural, hydrological, socio-economic and groundwater drought (Dracup et al. 1980; Wilhite and Glantz, 1985; Mishra and Singh 2010). Meteorological droughts are mostly defined over monthly and seasonal timescales (Byun and Wilhite 1999) resulting from extended periods of dry weather. A common time-scale for agricultural droughts is the season when deficiency in precipitation results in damage to crops. Hydrological drought is associated with precipitation shortage on a longer time scale (6 months to 2 years or more), as it takes longer for precipitation shortage to become evident in stream flow, ground-water and dam levels. It is therefore useful to track drought with an index that is capable of representing dry periods at different time scales, as the magnitude of drought is a combination of drought intensity and duration. The frequency and duration of dry spells in a season are critical for the development and propagation of a drought event (Hayes et al. 1996).

The South African Weather Service provides information on drought in the country on a monthly basis. These monthly updates can be found on our web site at (http://www.weathersa.co.za/Documents/Climate/CLS-CI-Drought%20Monitoring.pdf). As with many other countries, the Standardized Precipitation Index or SPI is used to track drought conditions, and is calculated for different timescales, i.e. at the 1-, 3-, 6-, 12- and 24-month scales. The analyses of the dry conditions at these different time scales make it possible to make a proper assessment of the duration and severity of particular dry spells.

The Standardized Precipitation Index or SPI

The SPI method was developed by McKee et al. (1993) to evaluate the spatial and temporal patterns and trends of droughts, characterizing them by their duration, frequency and severity. Different SPI timescales (ranging from e.g. 1 to 48 months) indicate the effect of drought on the availability of the different water resources. It provides a comparison of the precipitation over a specific period with the precipitation totals for the same period for all the years included in the historical record. Consequently, it facilitates the temporal analysis of wet and dry phenomena. Since rainfall does not follow the normal distribution, the long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero (Edwards and McKee 1997). Positive SPI values indicate greater than median precipitation and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way; thus, wet periods can also be monitored using the SPI.

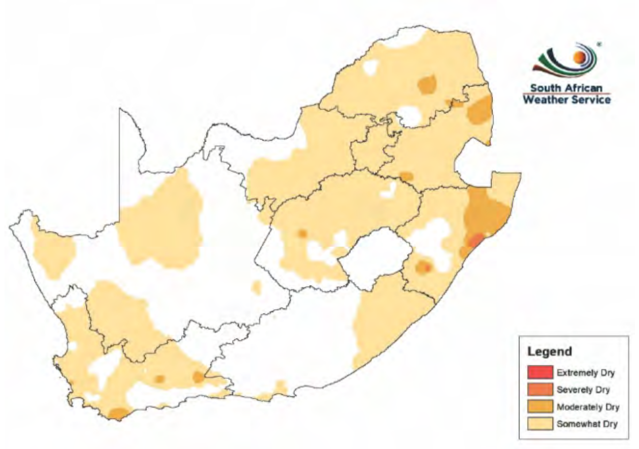
The classification system shown below is used to define drought intensities. A drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.0 or less. The event ends when the SPI becomes positive. Each drought event, therefore, has a duration defined by its beginning and end, and an intensity for each month that the event continues. The positive sum of the SPI for all the months within a drought event can be termed the drought's "magnitude".

SPI values	Category
2.0+	extremely wet
1.5 to 1.99	very wet
-0.99 to 0.99	near normal
1.0 to 1.49	moderately wet
-1.0 to -1.49	moderately dry
-1.5 to -1.99	severely dry
-2 and less	extremely dry

Interpretation of SPI values over different time periods

1-month SPI

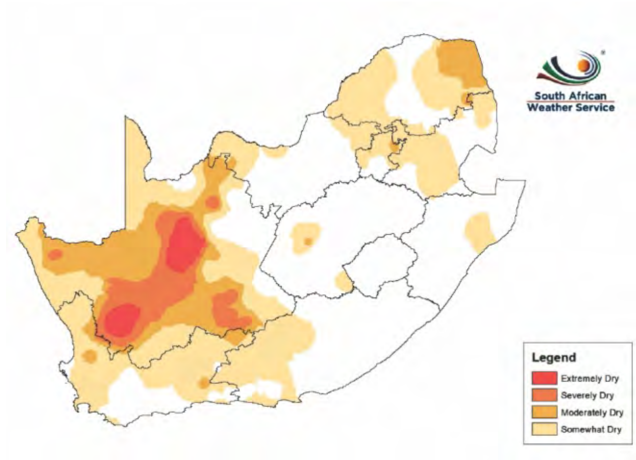
A 1-month SPI map is very similar to a map displaying the percentage of normal precipitation for a 30-day period. In fact, the derived SPI is a more accurate representation of monthly precipitation because the distribution has been normalized and it compares the precipitation total of that month with that of the previous years. Interpretation of the 1-month SPI may be misleading unless climatology is understood. In regions where rainfall is normally low during a month, large negative or positive SPIs may result even though the departure from the mean is relatively small. The 1-month SPI can also be misleading with precipitation values less than the normal in regions with a small normal precipitation total for a month. As with a percent of normal precipitation map, useful information is contained in the 1-month SPI maps, but caution must be observed when analyzing them.



1 month SPI map for May 2019

3-month SPI

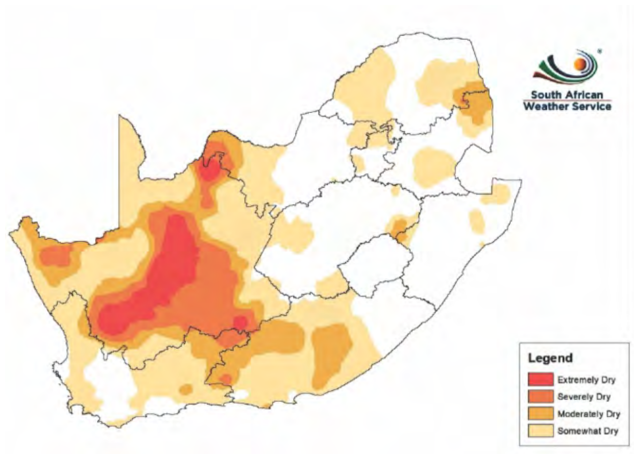
The 3-month SPI provides a comparison of the precipitation over a specific 3-month period with the precipitation totals from the same 3-month period for all the years included in the historical record. A 3-month SPI reflects short- and medium-term moisture conditions and provides a seasonal estimation of precipitation. In primary agricultural regions, a 3-month SPI might be more effective in highlighting available moisture conditions than the slow-responding Palmer Index or other currently available hydrological indices. It is important to compare the 3-month SPI with longer timescales. A relatively normal or even a wet 3-month period could occur in the middle of a longer-term drought that would only be visible over a long period. Looking at longer timescales can prevent misinterpretation, believing that a drought might be over when in fact it is just a temporary wet period. As with the 1-month SPI, the 3-month SPI may be misleading in regions where it is normally dry during any given 3-month period.



3 month SPI map for March to May 2019

6-month SPI

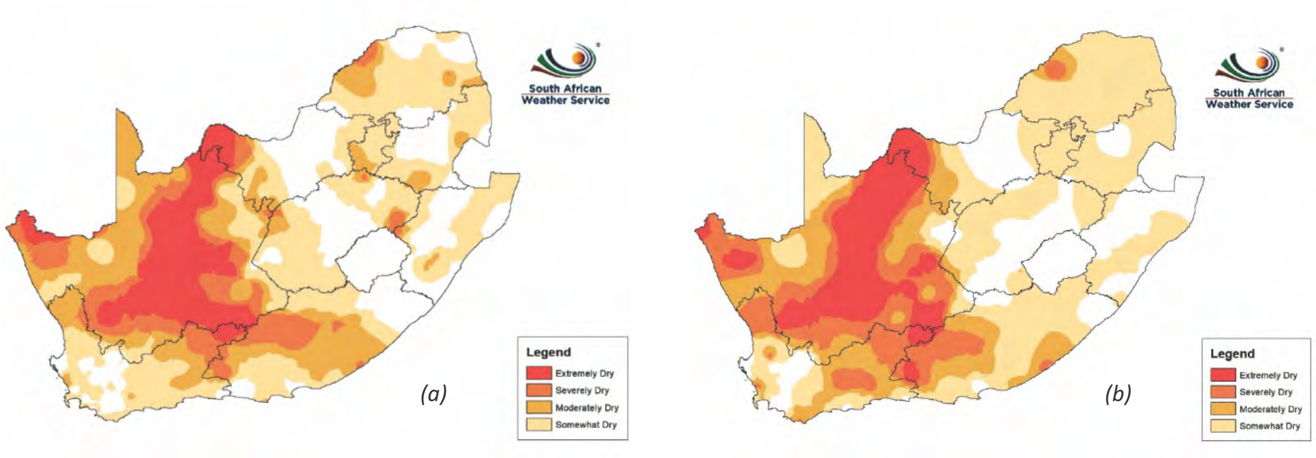
The 6-month SPI compares the precipitation for that period with the same 6-month period over the historical record. The 6-month SPI indicates seasonal to medium-term trends in precipitation. A 6-month SPI can be very effective in showing the precipitation over distinct seasons. Information from a 6-month SPI may also begin to be associated with anomalous stream flows and reservoir levels, depending on the region and time of year.



6 months SPI map for December 2018 to May 2019

12-month SPI and longer

The SPI at these timescales reflects long-term precipitation patterns. A 12-month SPI is a comparison of the precipitation for 12 consecutive months with that recorded in the same 12 consecutive months in all previous years of available data. Because these timescales are the cumulative result of shorter periods that may be above or below normal, the longer SPIs tend to gravitate toward zero unless a distinctive wet or dry trend is taking place. SPIs of these timescales are usually tied to stream flows, reservoir levels, and even groundwater levels at longer timescales.

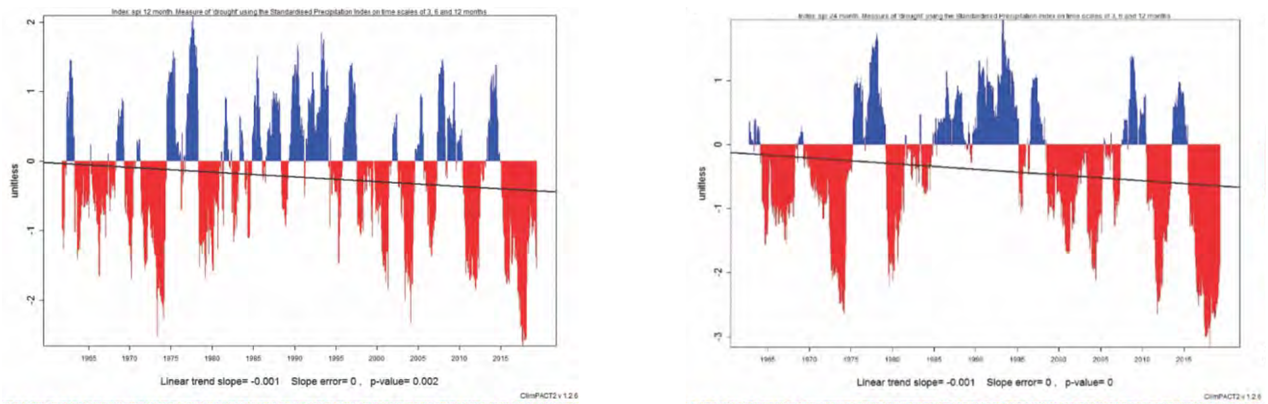


(a) 12 month SPI map for June 2018 to May 2019 and (b) 24 month SPI map for June 2017 to May 2019

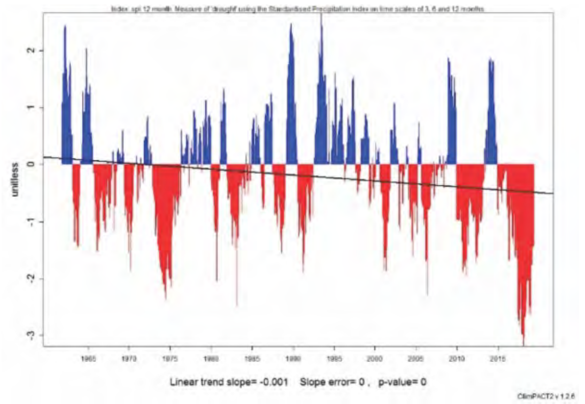
Tracking the SPI through time and the Western Cape drought of 2017-19

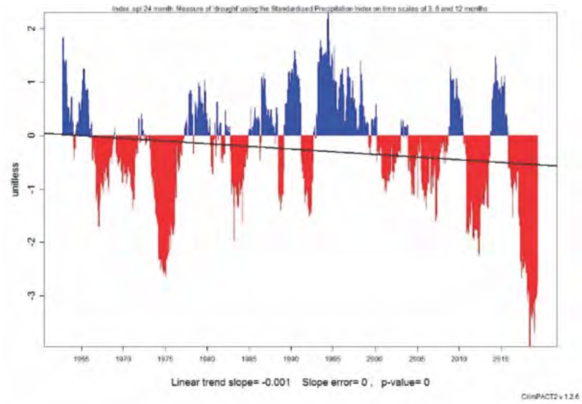
The SPI can be used to analyse the long-term variability of dry and wet conditions at specific locations. Such analyses can aid research in long-term trends of rainfall and droughts. Here we selected a limited set of long-term weather stations in the Western Cape Province to do a pilot study of the long-term trends in droughts which last for extended periods of time, in this case 12 and 24 months. Considering the 12- and 24-month SPI analysis of Cape Town, Cape Agulhas and Knysna below, it is apparent that there could be a widespread long-term increase in the occurrence of these droughts and that the most recent drought was the worst in the 1961 – 2019 period analysed. It is also apparent that the recent severe drought of 2016 - 18 commenced much earlier and became evident as early as 2015. The analysis also points to the possibility of statistically significant increases in the prevalence of long-term droughts in the Western Cape, but one should take into account the autocorrelation between subsequent monthly SPI values.

To investigate the long-term trends in prolonged droughts, the South African Weather Service's Climate Service department is currently busy with a thorough countrywide analysis which will consider, amongst others, seasonal rainfall trends, trends in the SPI drought index and the interpretation of these trend results.

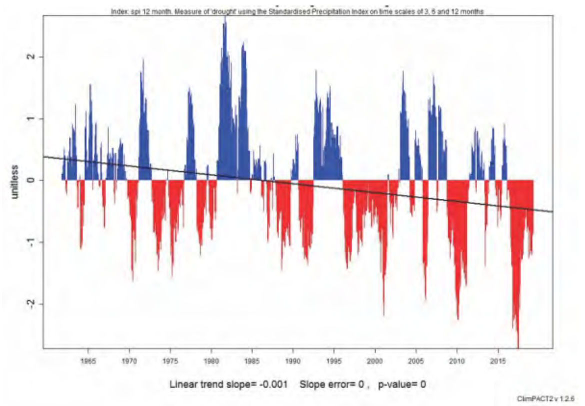


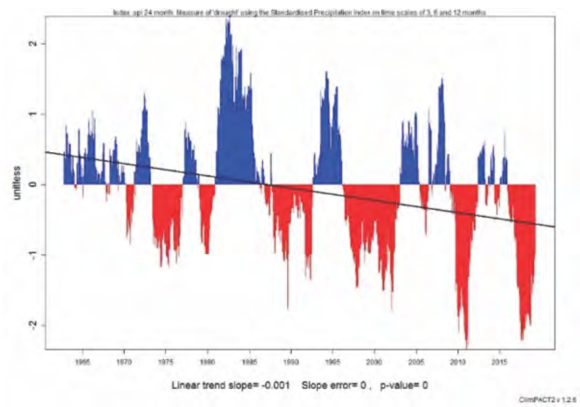
12- and 24-month SPI for Cape Town (1961 – 2019)





12- and 24-month SPI for Cape Agulhas (1961 – 2019)





12- and 24-month SPI for Knysna (1961 – 2019)

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Joël Botai

Dr. Joël Ondego Botai, PhD (Meteorology), MSc (Astrophysics), MSc (Space Engineering), BSc Hons (Eds.), Chief Scientist, Applications research, South African Weather Service.

Dr. Joël Botai is a chief scientist at the South African Weather Service leading a team of scientists undertaking research and developing weather and climate products and services in support of strategic sectors of the economy including water resources, agriculture, health, energy and socio-economic research applications.

Dr. Botai was awarded PhD (Meteorology) by University of Pretoria in 2011, MSc (Astrophysics) by Rhodes University in 2006, MSc. (Space Eng.) by Chalmers University, (Sweden) in 2005 and BSc (Hons) by Moi University (Kenya) in 1998. Dr. Botai has a multi-disciplinary academic background with a vast experience in cross-cutting research areas including earth and atmosphere sciences. Dr. Botai has been involved in various national and international research projects focusing on earth system sciences and geodynamic processes mimicking earth-atmosphere interactions and the resultant impacts to society and the environment. Further, Dr. Botai has authored and co-authored more than forty peer reviewed journal publications and presented at various national and international workshops, conferences, and acts as a reviewer of various national and international journals. Dr. Botai is also a member of various scientific organizations such as the American Geophysical Union and the African Association of Remote Sensing of the Environment. Prior to joining the South African Weather Service, Dr. Joël Botai was a senior remote sensing lecturer at the Department of Geography, Geoinformatics and Meteorology, University of Pretoria. Dr. Botai is also currently an extra-ordinary staff member of the University of Pretoria and honorary research fellow at the school of Agriculture earth and environmental sciences, University of KwaZulu-Natal. Dr Botai has been actively involved in capacity building especially supervision of MSc and PhD students. His current research interests include data science, advanced numerical and computational techniques as well the development of early warning systems. Lastly, Dr. Botai is a fervent Jazz and country music listener.

Wiseman Dlamini

Mr Wiseman Dlamini is a senior forecaster at Durban Weather office. He currently holds a BSc Honours degree in Meteorology. He joined SAWS in 2008 after successfully completing the training programme at the University of Pretoria.

Hannelee Doubell

Ms Hannelee Doubell is the communications manager at the South African Weather Service. She started working at the organisiation in August 1997, after several years at the then Department of Foreign Affairs. She formed part of the group that worked on the agentisation of the South African Weather Service in 2001 and played a key role in ensuring the promulgation of the first aviation cost recovery tariffs for meteorological services. She is responsible for managing media and communications at the South African Weather Service.

Thandiwe Gumede

Ms Thandiwe Gumede is a senior weather forecaster based at the Durban office. She joined the organisation as a forecaster in December 2014 after completing the forecasting training course that same year. She has an Honors Degree in Meteorology, which she obtained in 2013 from the University of Pretoria.

Louis van Hemert

Mr Louis van Hemert is a Senior Scientist at SAWS in the Research department. He obtained a BSc degree in Meteorology in 1981, joined SAWS in 1982 and has since then worked for SAWS in various departments, including Research, Climate data, Forecasting and Numerical Weather Prediction. He has been active in computer programming, data processing and archiving, operational forecast model maintenance, products development, computer training, and maintaining model data streams to clients. He is currently in the model Post-processing section of the Research Department of SAWS where he is still involved in all of the above-mentioned activities.

Rydall Jardine

Mr Rydall B. Jardine, was born and raised in Cape Town and completed his National Diploma in Electrical Engineering at the Cape Peninsula University of Technology. He started working for the South African Weather Service in January 1998. He also holds a bachelor's in electrical engineering through Tshwane University of Technology. He has over 20 years of experience within the Meteorological Infrastructure maintenance working on weather radars, high frequency transmitters, lightning detection infrastructure, manual and automated weather systems, as well as aviation weather observation and monitoring infrastructure.

He was tasked by the South African Weather Service to lead the deployment of Automated Weather Systems into the larger African Continent, where he ensured the successful deployment into Tanzania, Swaziland, Lesotho, Namibia and Zambia. He is currently the Manager: Infrastructure Availability within the company overseeing the Radar and Lightning Detection Networks; and is currently also fully the role of Acting Senior Manager: Technical Service overseeing all the company's weather observation infrastructure supported by a team of technicians, technologist, specialist and engineers.

Nico Kroese

Mr Nico Kroese has 34 years of experience in the South African Weather Service and started his career as a forecaster in the Central Forecasting Office. He transferred to the Research Department in 1990 where he was involved in working on cloud and meso-scale modeling before joining the Bethlehem Precipitation Research group that conducted research on rainfall enhancement in 1993. In Bethlehem he was involved in field work through the implementation of observation networks, radar and aircraft operations during field campaigns that were conducted in Bethlehem, Tzaneen and Polokwane.

He moved from the scientific environment into management being responsible for managing the Bethlehem Research Facility. He was responsible for the implementation of the Meteosat Second Generation (MSG) satellite system at SAWS trough participation in the continental wide PUMA project where he was the project leader for the developing of satellite applications in the SADC region. He was also project leader during the follow-on AMESD project. In 2010 he re-located to Pretoria after the closing of the research facility in Bethlehem and became manager of the Prediction Research group responsible for research on the forecasting of weather over timescales including nowcasting, short, medium and seasonal time scales. Nico is also involved in WMO activities through the RA1 Dissemination Expert Group (RAIDEG) for satellite data and products on the African continent. He participated in various local and international projects, the latest being the Rain for Africa Project (R4A) partnering with the Agricultural Research Council (ARC) and institutions from the Netherlands. He obtained a BSc Hons. (Meteorology) degree at the University of the Pretoria.

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.

Stephanie Landman

Ms Stephanie Landman has been working as a Meteorologist for almost 18 years. She started her career as a weather observer at the Bethlehem Weather Office (METSYS) after which she joined the short-term insurance industry for several years. Returning to atmospheric sciences, she became a Scientific Consultant in Air Quality at Bohlweki Environmental before she re-joined the South African Weather Service in 2008 and is currently a Lead Scientist in Weather Research.

She completed her MSc (Meteorology) degree at the University of Pretoria, researching the skill in multi-model short-range ensemble prediction systems over South Africa. Her areas of research interests are in forecast uncertainty and novel forecast verification methods. She also teaches a BSc (Honours) (Meteorology) course in applications of NWP at the University of Pretoria, supervises BSc (Honours) students with research projects on model evaluation issues as well as co-supervising MSc dissertations. At the Regional Training Centre (RTC) she trains the forecasting interns on the use of, and basic verification of NWP for practical forecasting.

Mbavhi Maliage

Ms Mbavhalelo Maliage is a Forecaster at the National Forecasting Centre (NFC). She completed her Honour's degree in Meteorology at the University of Pretoria in 2013, and went to complete her Diploma in Forecasting in 2014 at RTC. She has been working as a forecaster since December 2014.

Wisani Maluleke

Mr Wisani Malulee is a Senior Meteorologist at the South African Weather Service based in Durban Weather Office. He holds a BSc degree from the University of the North (now University of Limpopo). He further obtained BSc honours degree in Meteorology at the University of Pretoria.

Estelle Marx

Ms Estelle Marx is a Senior Scientist: Weather Research in the Department: Post-Processing of the South African Weather Service. Her present duties include upgrading, developing and verifying products derived from model data with the application of bias-correction techniques on raw model data. In 2008, she obtained a MSc (Meteorology) degree at the University of Pretoria, with research topic "The use of artificial neural networks to enhance numerical weather prediction model forecasts of temperature and rainfall".

Lotta Mayana

Mr Lotta Mayana is a chemist graduate by profession with more than ten (10) years of analytical laboratory experience. He has experience in mining, wherein he had to champion ISO 9001 and ISO 14000 certification. Moreover, He has more than ten (10) years of ISO 17025 experience and has championed four different quality management system of which all of them were subsequently accredited, as a result, a total of thirty-two (32) ambient air quality stations were SANAS accredited. He has further led accreditation efforts from both the private sector and government.

He is a member of the American Society for Testing and Materials (ASTM) international and South African National Standards Committee. Has participated in drafting of TR03 and championed the drafting of TR08 technical documents. He managed a network of capital investment of over R 20 million across the SADC region for clients including state agencies, parastatal, Provincial government, Municipalities, Petrochemical industries, and mining sector.

Njabulu Mchunu

Mr Njabulu Mchunu is a scientist at the South African Weather Service, a member of the post-processing group in the research department. He joined SAWS in 2015 as an intern. He holds a Bachelor of Science, Honours degree in Meteorology from the University of Pretoria and plans to commence with his MSc degree in 2020. His focus is on the maintenance and verification of the Numerical Weather Prediction (NWP) forecast models.

Katlego Ncongwane

Ms Katlego Ncongwane is a Lead Scientist in the Health Application Group within the Research Department. She is responsible for developing products and services such as early warning systems for infectious diseases (including Malaria, Pneumonia, Dengue fever and Cholera) and heat-health in support of communities. Ms Katlego Ncongwane has research experience in ozone, shortwave (solar) and UV radiation research and has managed the scientific aspects of SAWS UV, solar radiation and biometeorology networks.

Ms Katlego Ncongwane holds two Masters Degrees, an MSc in Physics from the University of Kwa-Zulu Natal (2015) and an MPhil in Sustainable Development Planning and Management (2010) from the University of Stellenbosch. Ms Katlego Ncongwane is currently pursuing her PhD in Environmental Science with the University of Kwa-Zulu Natal.

Sandile Ngwenya

Mr Sandile Ngwenya is a scientist in Climate Service: Climate Data, South African Weather Service. He holds a BSc in Geography and Hydrology and BSc Honours in climatology. He graduated with an MSc Environmental Sciences at the University of Venda in 2019. He joined the South African Weather Service in 2017. Before joining SAWS, he was a DST-NRF intern stationed at University of Venda, Department Geography and Geo-information Sciences.

Lulama Nhlapho

Ms Lulama Nhlapho is a junior forecaster at the Port Elizabeth weather office, who holds a BSc (Hons) in Meteorology from the University of Pretoria.

Thumi Phatudi

Ms Phatudi is a Forecaster in the Aviation Weather Centre at OR Tambo International Airport. She studied BSc in Physics and Agrometeorology and BSc. Honours in Agrometeorology at the University of the Free State, Bloemfontein. She started working in Bloemfontein office in 2016 where she became an active supporter and contributor of SAWS social media.

Elelwani Phaduli

Ms Elelwani Phaduli is a scientist working under the Weather Research subsection of research. Her day to day activities include verification of Numerical Weather prediction models for all models run at SAWS. Elelwani is currently involved in internal and external projects. In 2018 she graduated her Master of Science in Meteorology from the University of Pretoria, where she is also involved in the supervision of honours students.

Hetisani Oscar Shiviti

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

Siphesihle Sithole

Ms Siphesihle Sithole is a Research scientist in Health Applications at the South African Weather Service. She holds a BSc in Geography and Hydrology and BSc (Hons) in Hydrology that she obtained at the University of Zululand. She joined the South African Weather Service as an intern in 2018.

The

AUTHORS

Head Office

Centurion
Eco Glades
Block 1b, Eco Park
Cnr Olievenhoutbosch and
Ribbon Grass Streets
Centurion
0157

Regional Offices

Bloemfontein
Weather Office
Maselspoort Road
Bram Fisher International Airport
Private Bag X20562
Bloemfontein
9300
Tel: 051 433 3281

Cape Town International
Weather Office
ATNS Tower
Tower Street
Cape Town International Airport
PO Box 21
Cape Town International Airport
7525
Tel: 021 934 0749/0831

King Shaka International
Weather Office
Ground Floor
ATNS Building
King Shaka International Airport
PO Box 57733
King Shaka International Airport
4407
Tel: 032 436 3820/3812

OR Tambo International
Aviation Weather Centre
Room N161
3rd Floor
OR Tambo International Airport
PO Box 1194
Kempton Park
1627
Tel: 011 390 9329/9330

Port Elizabeth
Weather Office
Roof Top
Departures Hall
Port Elizabeth Airport
Private Bag X5991
Walmer
Port Elizabeth
6065
Tel: 041 581 0403/8587

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