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Excellence in Agricultural Research and Development

# UMLINDI
## The Watchman

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INSTITUTE FOR SOIL, CLIMATE AND WATER

CONTENTS:



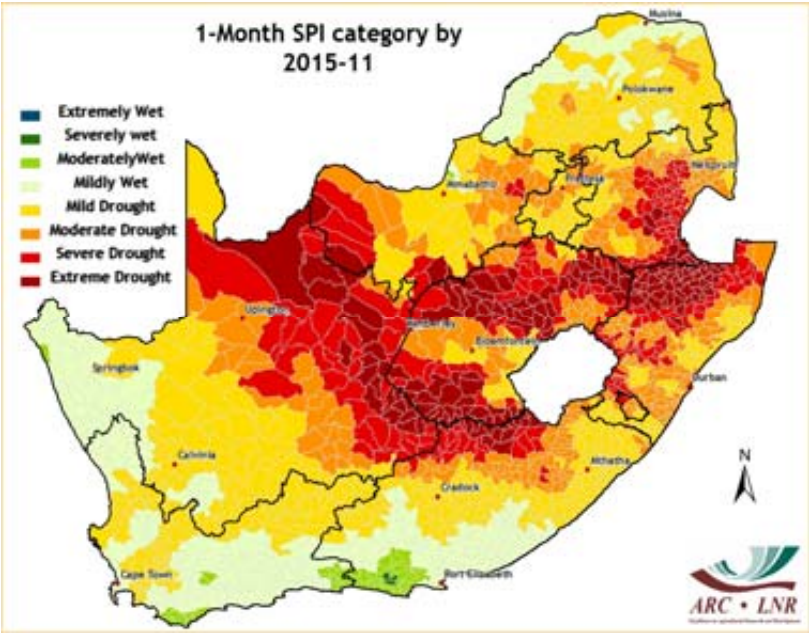
agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

South African Weather Service

AMESD

*138th Edition*

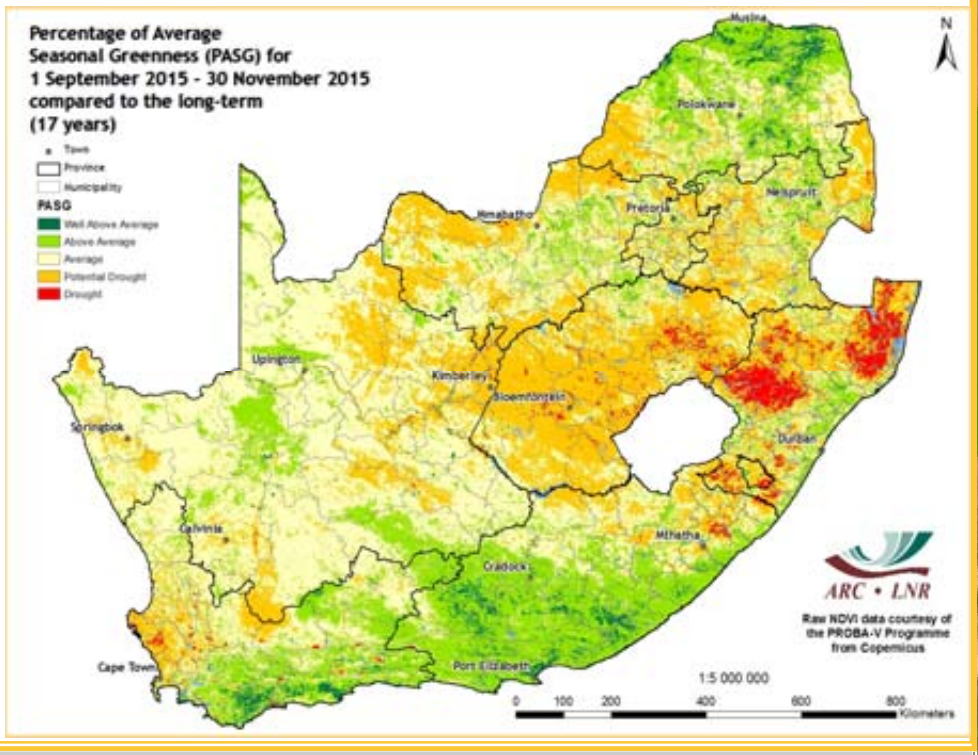
# Images of the Month




## Drought intensifies over parts of the summer rainfall region

Hot and dry conditions continued into November over large parts of the summer rainfall region. According to the Standardized Precipitation Index (SPI; top image), the month was extremely dry especially over the northern parts of KwaZulu-Natal through much of the Free State and into the northeastern parts of the Northern Cape. Dry conditions were accompanied by heatwave conditions especially during the first few days of the month and again around the 25th. Hot and dry spells also had a negative effect on planting in parts of the eastern maize production region, where the planting window has now come to an end.

The rainfall pattern, with the focus area of dry conditions from the Free State into the northern parts of KwaZulu-Natal, was a continuation of conditions that had been present during September and October. The persistence of drier conditions in the above-mentioned areas, with relatively wet conditions to the north over Limpopo and parts of North West as well as to the south over parts of the Cape provinces, is reflected in the 3-month Percentage of Average Seasonal Greenness (PASG; bottom image), with below-normal cumulative vegetation activity indicated especially over parts of the Free State and KwaZulu-Natal, while above-normal vegetation activity occurs over parts of Limpopo and North West as well as the southern parts of the country.




The Agricultural Research Council - Institute for Soil, Climate and Water (ARC-ISCW) collected the data, generated the products and compiled the information contained in this newsletter, as part of the Coarse Resolution Imagery Database (CRID) project that was funded by the Department of Agriculture and Department of Science and Technology at its inception and is currently funded by the Department of Agriculture, Forestry and Fisheries (DAFF).

# 1. Rainfall



***Overview:***

November 2015 was characterized by extremely hot conditions during the early part of the month over most of the interior as well as some significant thundershowers over the central to northeastern parts by the middle of the month, with dry conditions setting in once again after the 21st. Several thunderstorms, especially in the northeast, became severe with hail damage reported from several areas.

The month started out with an upper-air and surface low pressure system in the south and strong Atlantic Ocean anticyclone to the south resulting in widespread rain and cold conditions over the southern parts of the Cape provinces with heavy falls in places while hot and windy conditions occurred over the interior. The frontal system moved northwards, preceded by extremely hot conditions over the northern parts. By the 3rd, cold dry air had spread over much of the interior with light snow also observed over the KwaZulu-Natal Drakensberg while the rain in the south had cleared.

The unstable events at the beginning of the month were followed by a 10-day period of a slow build-up with increasing temperatures over the interior and very little precipitation. Weak frontal activity and surface onshore flows kept the southern parts relatively cool while upper-air anticyclonic circulation with gradual increases in especially maximum temperatures culminated in extremely hot conditions over the northern to northeastern parts between the 9th and 14th. Through this time also, a large area of anticyclonic circulation became established to the east/northeast of the subcontinent, strengthening towards the 14th and resulting in favourable large-scale circulation for the first outbreak of widespread significant thundershowers over the central to northeastern parts from the 14th to the 20th. These were also supported by an upper-air trough located over the central to western parts during this period. Conditions also favoured the development of thunderstorms into severe events, with hail damage over many areas. Some stations received 24-hour totals exceeding 50 mm, with totals for this period between 50 and 100 mm over many areas in the northeast.

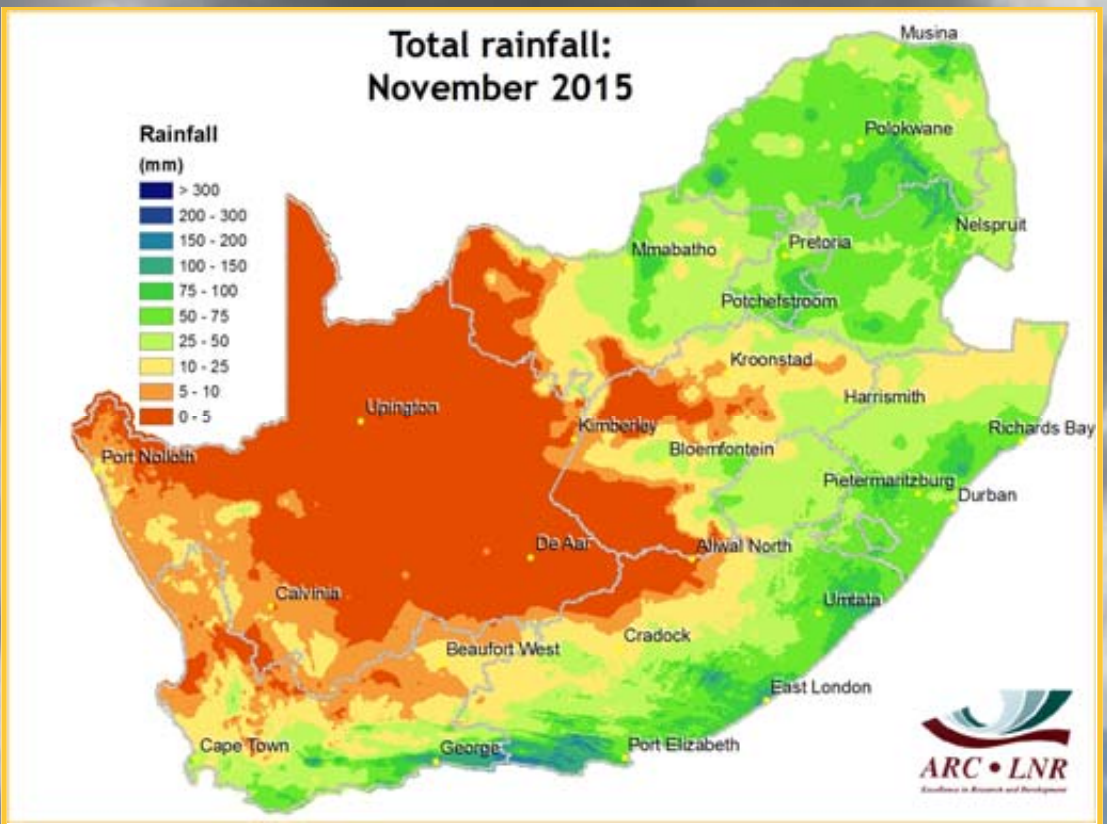
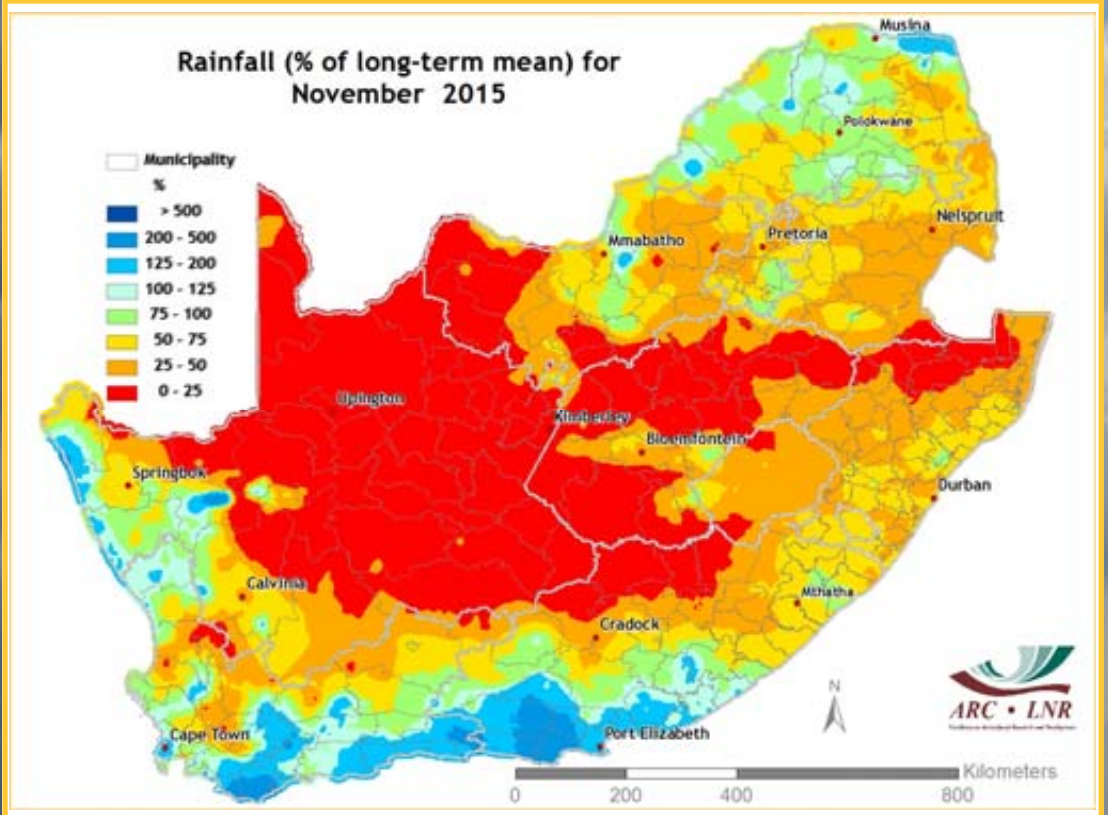



Figure 1

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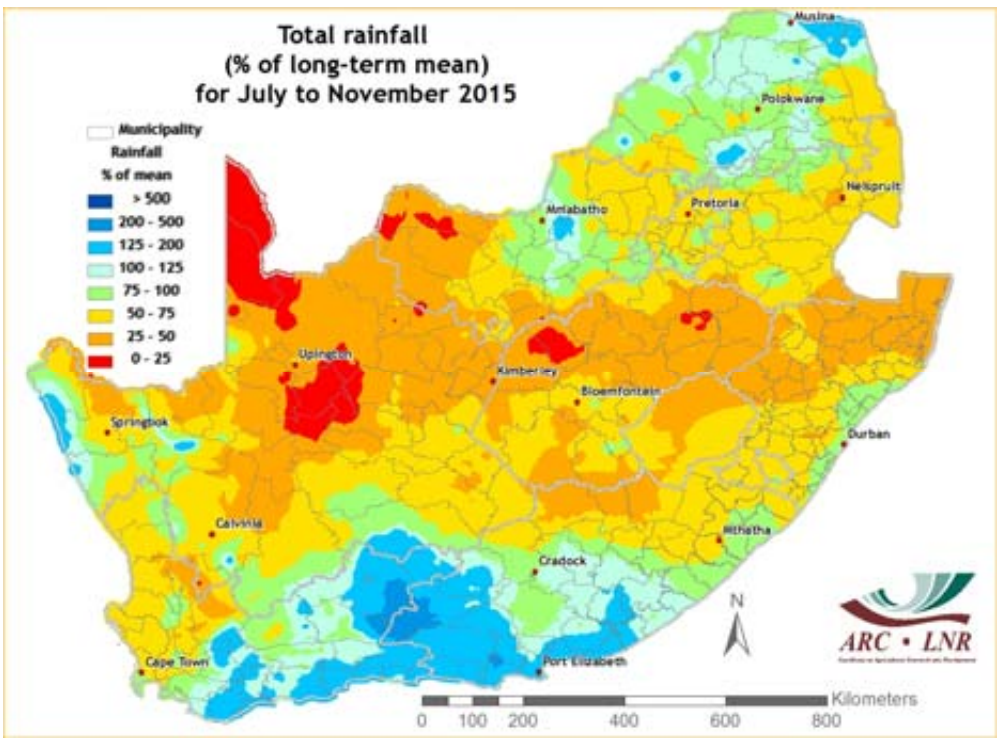


Figure 3

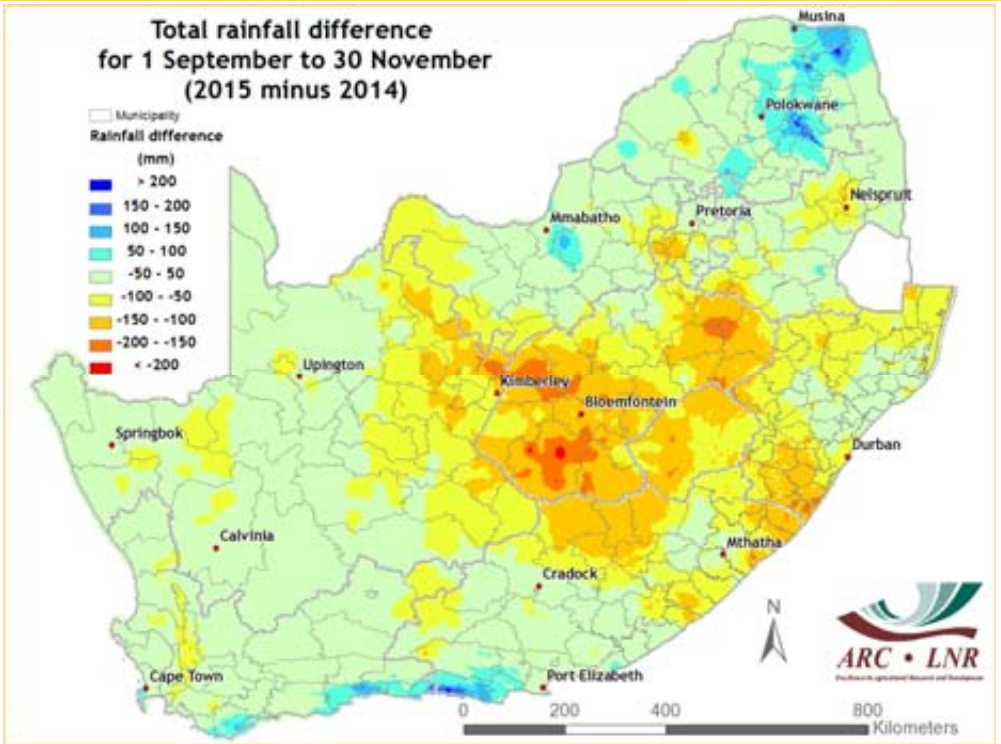


Figure 4

A cold front moved over the western parts by the 20th resulting in widespread light showers over much of the winter rainfall region. Dry air from the west pushed the system eastwards during the next 2 days, resulting in an abrupt end to the wetter conditions over the summer rainfall region. Temperatures started increasing again, especially firstly over the western parts, spreading to the northern and northeastern areas by the 25th. From the 27th, a strong ridge of the Atlantic Ocean anticyclone around the country resulted in isolated thundershowers over the central and northern parts, with scattered thundershowers over northern and eastern Limpopo on the 27th and 28th, as well as over central Botswana as cooler moist air invaded the country from the east, bringing some relief after another spell of high maximum temperatures.

**Figure 1:**
Much of the Northern Cape and adjacent parts of the provinces to the east received no rain during November. In contrast, the southern coastal areas and Garden Route received up to 150 mm while most of the northeastern and eastern summer rainfall region received between 50 and 100 mm. Almost all of the rainfall in the northeast occurred between the 14th and 21st while most of the rain in the south occurred during the first 2 days of the month. Very little rain occurred in the east-west band stretching from northern KwaZulu-Natal to northwestern Free State.

**Figure 2:**
Over the summer rainfall region, only parts of Limpopo and the central parts of North West received normal to above-normal rainfall. The rest of the summer rainfall region received less than 75% of the long-term mean, and less than 25% over much of the Free State and towards the west. Most of the all-year rainfall region in the south and much of the winter rainfall region in the southwest to west received normal to above-normal rainfall, especially along the Garden Route.

**Figure 3:**
Rainfall over the southern parts of the country, into the central parts of the Northern Cape, has been above normal since July. This also applies to the parts of Limpopo and central North West. Rainfall was below normal over the northern parts of KwaZulu-Natal, through the Free State and Northern Cape towards the western parts of the winter rainfall region.

**Figure 4:**
A northwest-southeast band covering western North West, the Free State and southern KwaZulu-Natal received much less rain during September-November this year than in 2014. The southern parts of the Cape provinces as well as parts of Limpopo and central North West received more rain than in 2014.

**Questions/Comments:**
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# 2. Standardized Precipitation Index



## Standardized Precipitation Index

The Standardized Precipitation Index (SPI - McKee *et al*., 1993) was developed to monitor the occurrence of droughts from rainfall data. The index quantifies precipitation deficits on different time scales and therefore also drought severity. It provides an indication of rainfall conditions per quaternary catchment (in this case) based on the historical distribution of rainfall.

REFERENCE:
McKee TB, Doesken NJ and Kliest J (1993) The relationship of drought frequency and duration to time scales. In: Proceedings of the 8th Conference on Applied Climatology, 17-22 January, Anaheim, CA. American Meteorological Society: Boston, MA; 179-184.

The current SPI maps (Figures 5-8) show that severe to extreme drought conditions occur at the shorter time scales over the central to eastern parts as well as the western parts of the winter rainfall region. At longer time scales, severe to extreme drought conditions are confined to the northern parts of KwaZulu-Natal, southern Mpumalanga and eastern parts of the Free State.

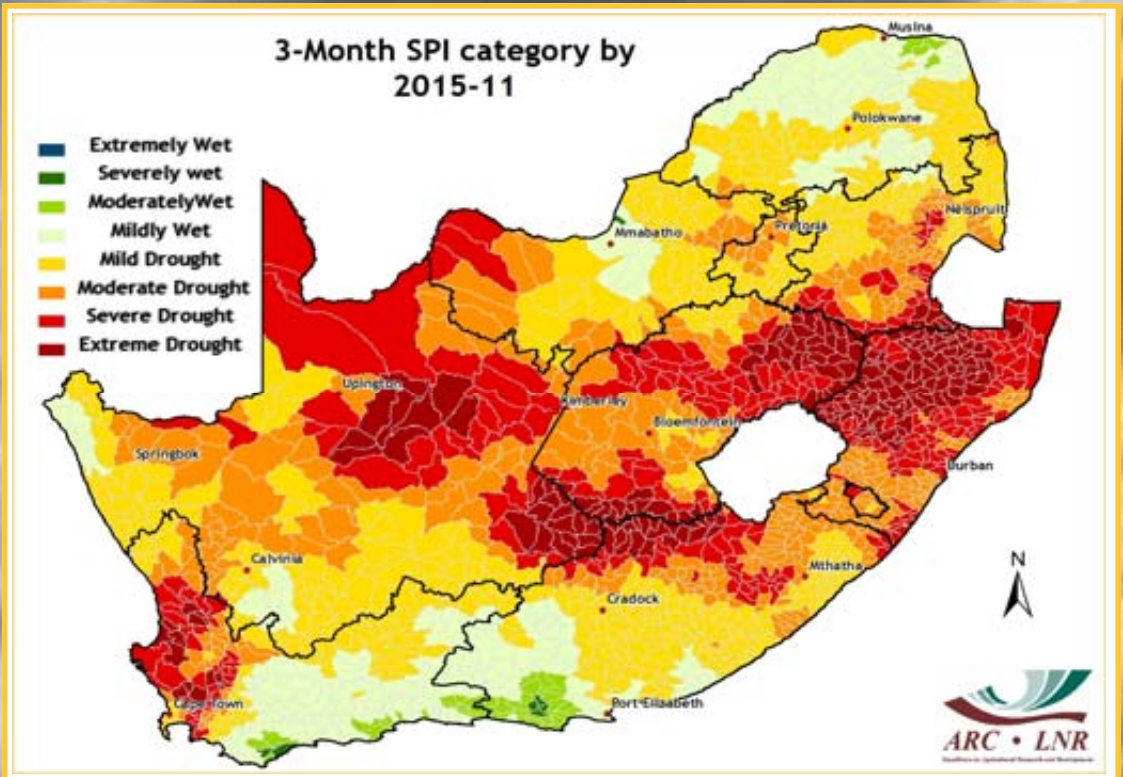


Figure 5

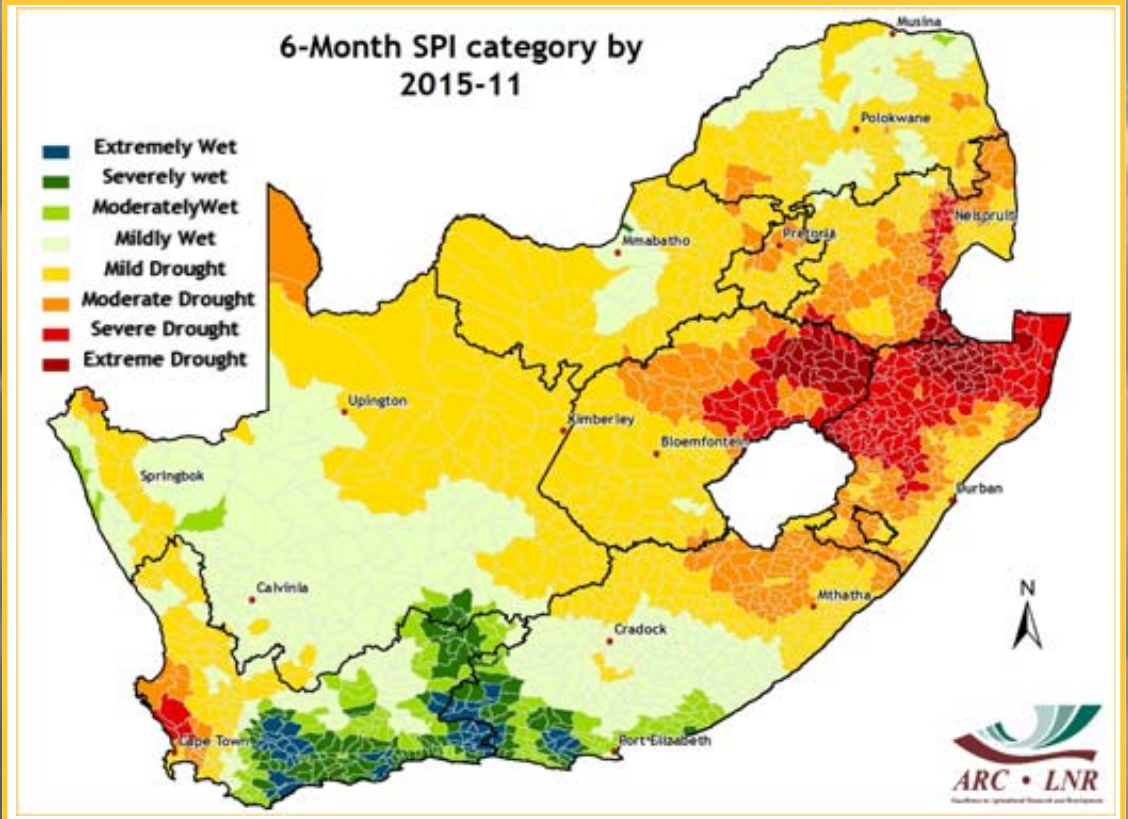


Figure 6

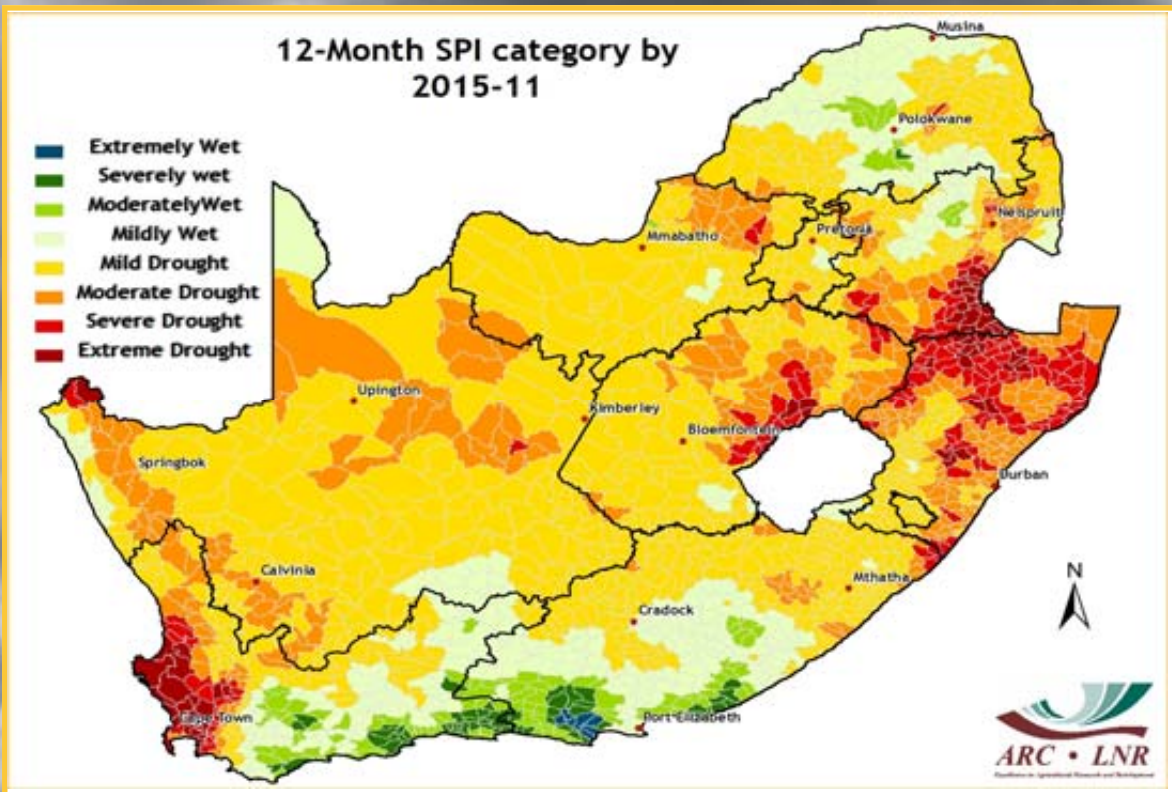


Figure 7

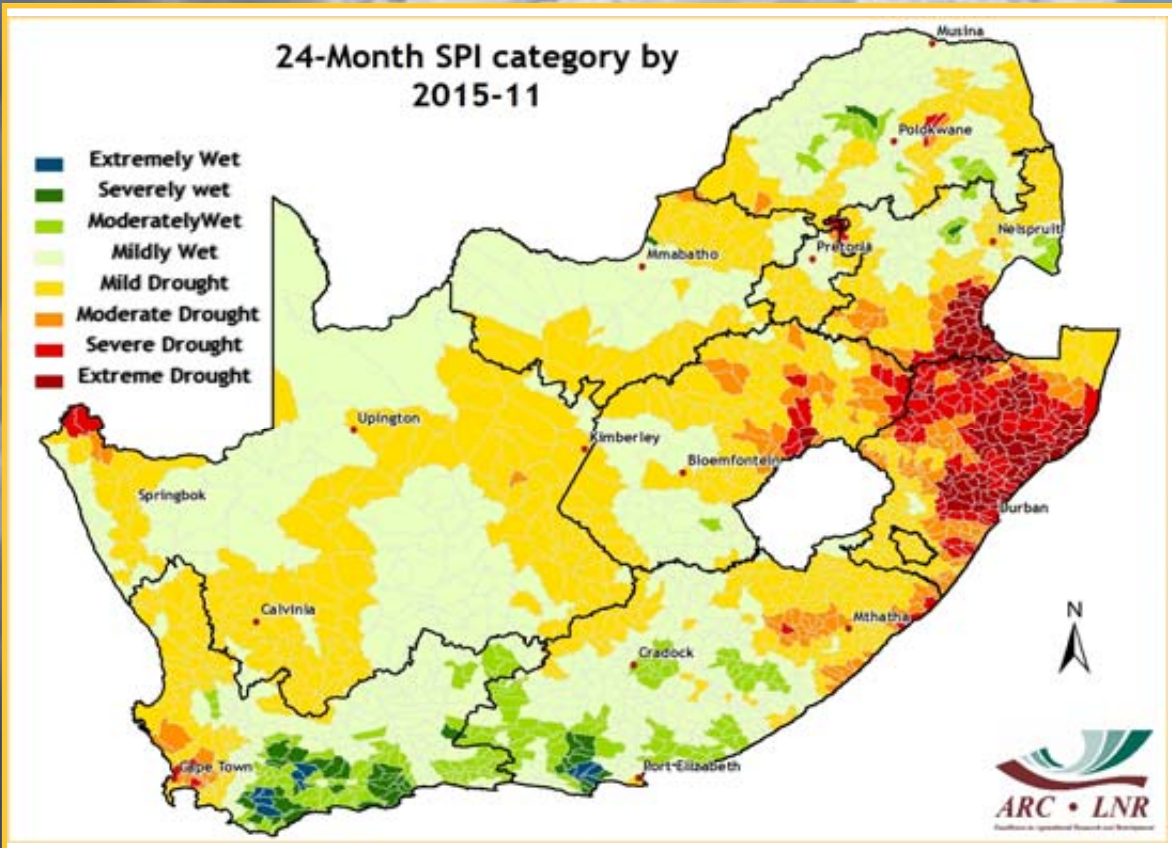


Figure 8

# 3. Rainfall Deciles



Deciles are used to express the ranking of rainfall for a specific period in terms of the historical time series. In the map, a value of 5 represents the median value for the time series. A value of 1 refers to the rainfall being as low or lower than experienced in the driest 10% of a particular month historically (even possibly the lowest on record for some areas), while a value of 10 represents rainfall as high as the value recorded only in the wettest 10% of the same period in the past (or even the highest on record). It therefore adds a measure of significance to the rainfall deviation.

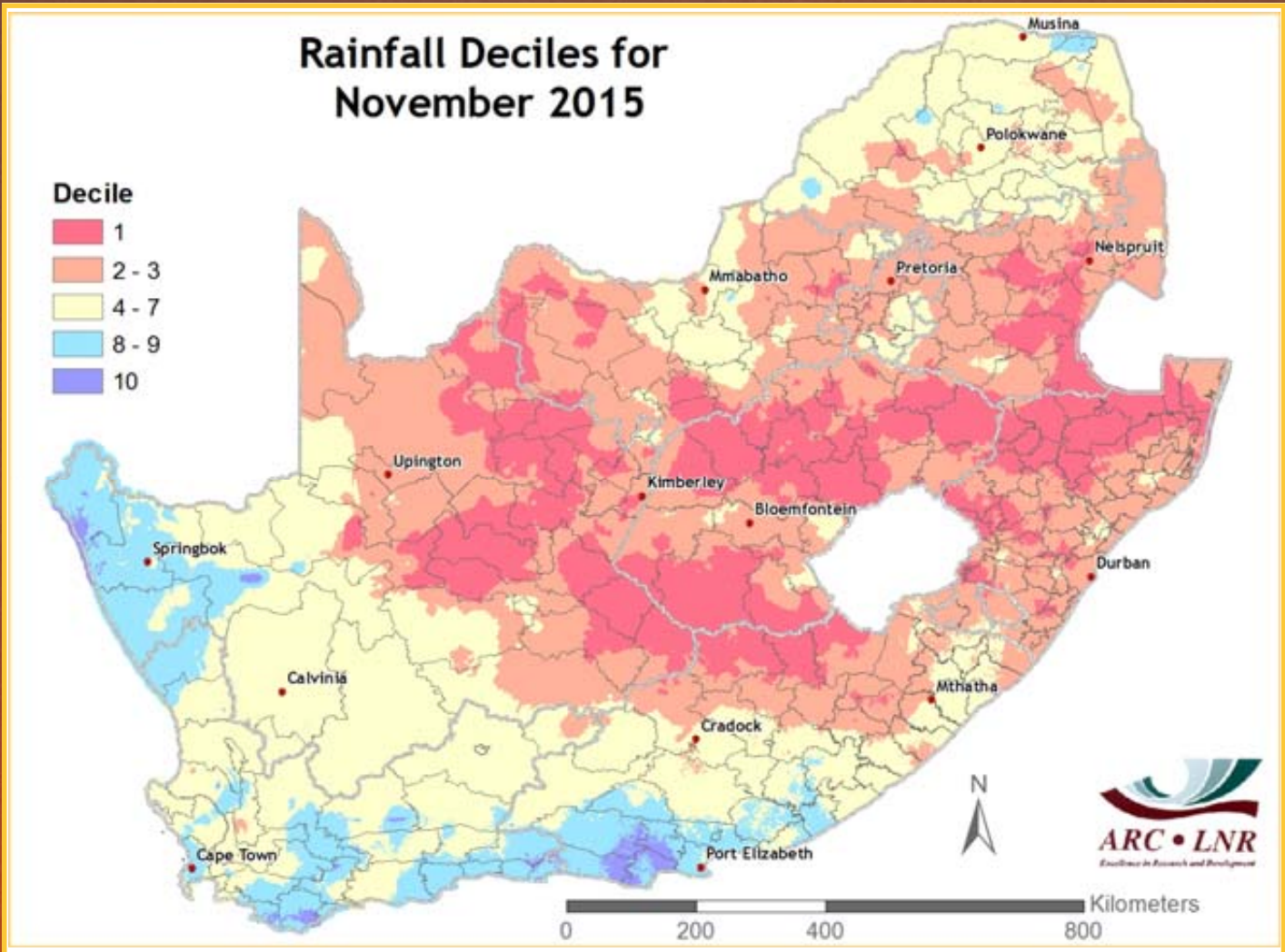


Figure 9

**Figure 9:**
The central to eastern parts of the country were exceptionally dry during November while the northeastern interior, winter rainfall region and southern parts received near-normal to above-normal rainfall.

**Questions/Comments:** *Johan@arc.agric.za*

# 4. Water Balance



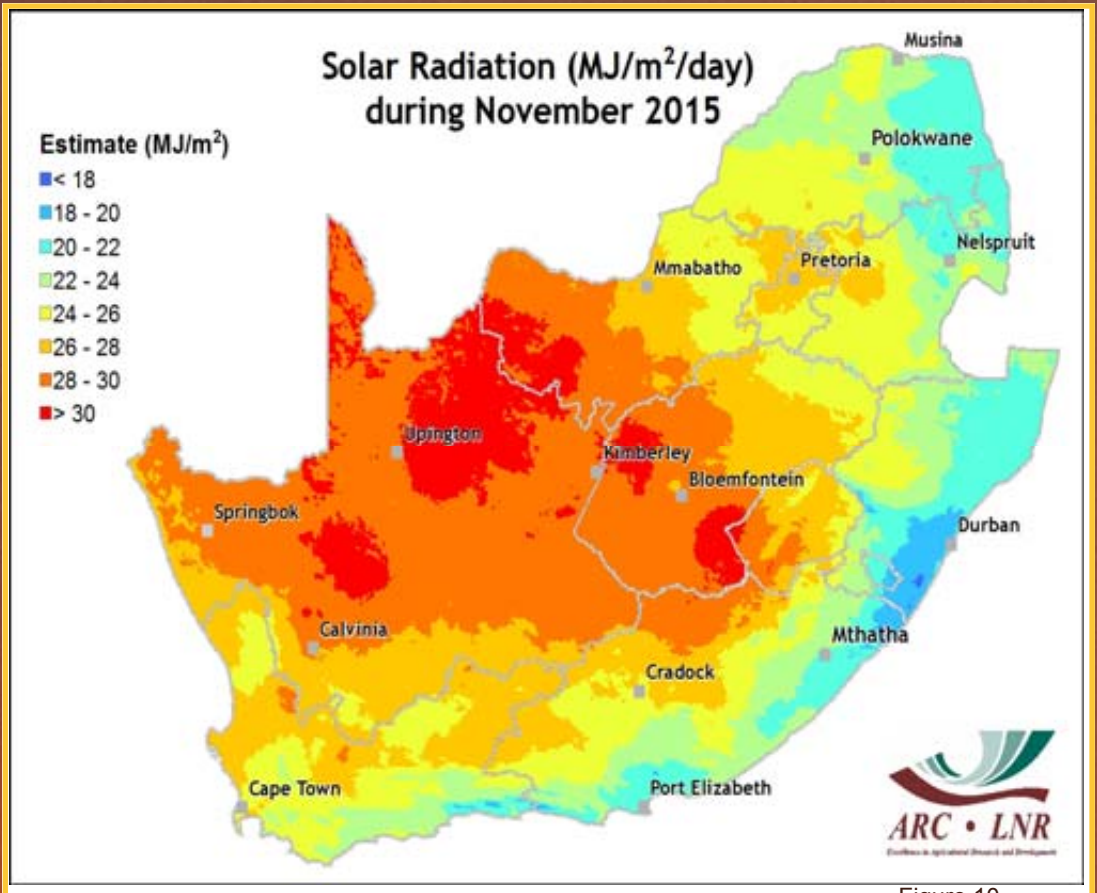


Figure 10

## Solar Radiation

Daily solar radiation surfaces are created for South Africa by combining *in situ* measurements from the ARC-ISCW automatic weather station network with 15-minute data from the Meteosat Second Generation satellite.

**Figure 10:**
Solar radiation estimates remained low over the southern to eastern coastal areas and Lowveld. Very high values are indicative of sunny conditions dominating the central interior.

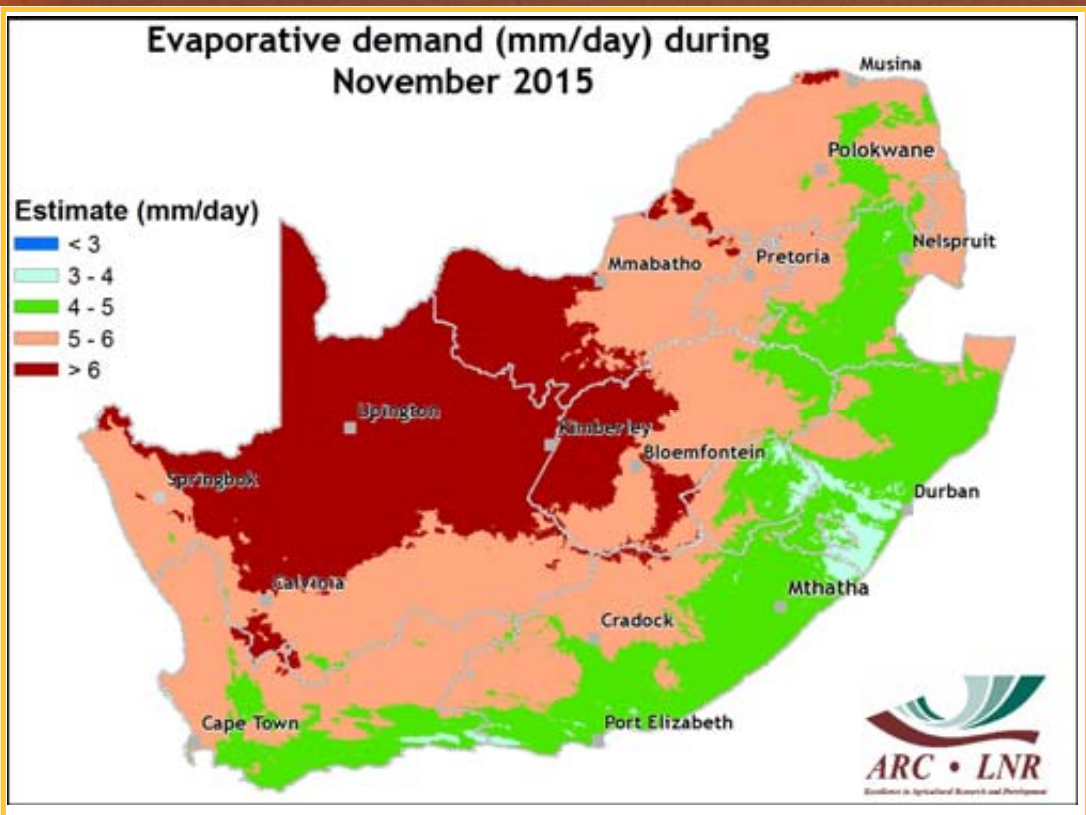


Figure 11

## Potential Evapotranspiration

Potential evapotranspiration (PET) for a reference crop is calculated at about 450 automatic weather stations of the ARC-ISCW located across South Africa. At these stations hourly measured temperature, humidity, wind and solar radiation values are combined to estimate the PET.

**Figure 11:**
Potential evapotranspiration remained low from the Escarpment towards the coast in the south and east, but exceeded 6 mm/day over the central to northern interior.

**Questions/Comments:**
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# 5. Vegetation Conditions



## Vegetation Mapping

The Normalized Difference Vegetation Index (NDVI) is computed from the equation:

NDVI=(IR-R)/(IR+R)

where:
IR = Infrared reflectance &
R = Red band

NDVI images describe the vegetation activity. A decadal NDVI image shows the highest possible "greenness" values that have been measured during a 10-day period.

Vegetated areas will generally yield high values because of their relatively high near infrared reflectance and low visible reflectance. For better interpretation and understanding of the NDVI images, a temporal image difference approach for change detection is used.

The Standardized Difference Vegetation Index (SDVI) is the standardized anomaly (according to the specific time of the year) of the NDVI.

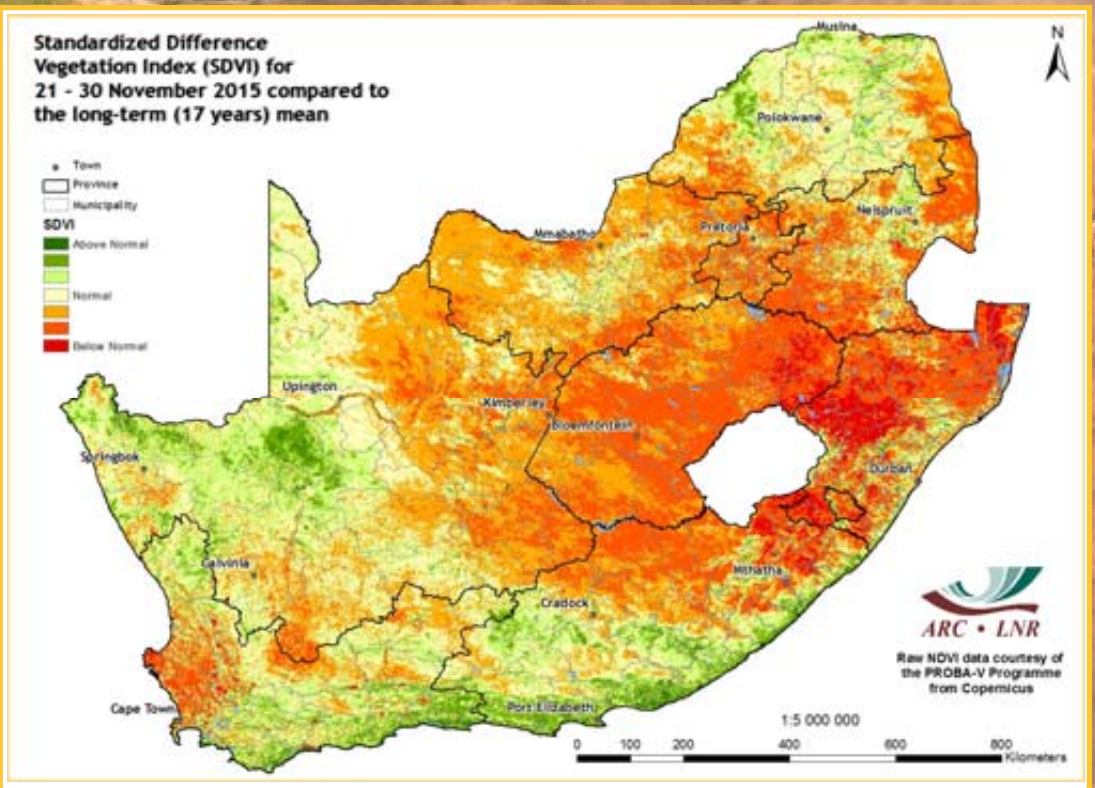


Figure 12

**Figure 12:**
The SDVI indicates drought stress over the northern parts of KwaZulu-Natal, central Free State and much of the surrounding interior together with the western parts of the winter rainfall region, focusing on the Swartland.

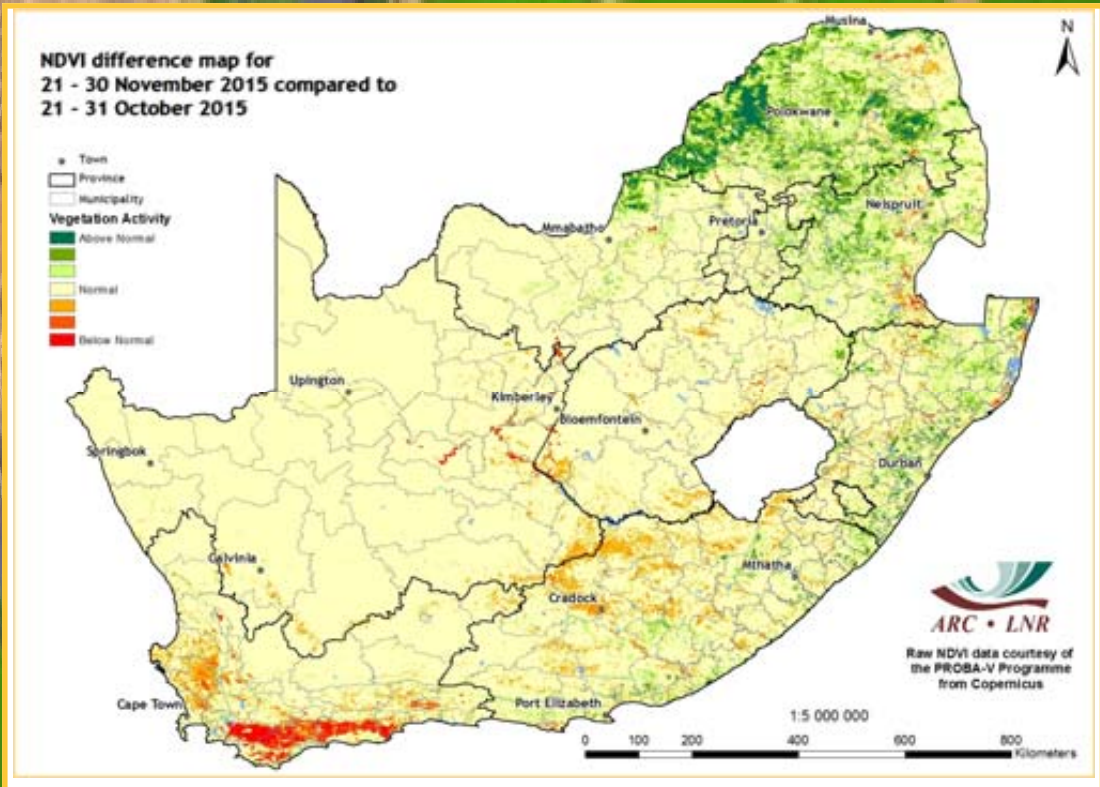


Figure 13

**Figure 13:**
Vegetation activity increased over the northeastern parts of the country due to widespread thundershowers during the middle of November over those areas. Decreasing activity is noticed over the winter rainfall region, associated with the ripening of grains (especially towards the south) or drought (especially towards the west).

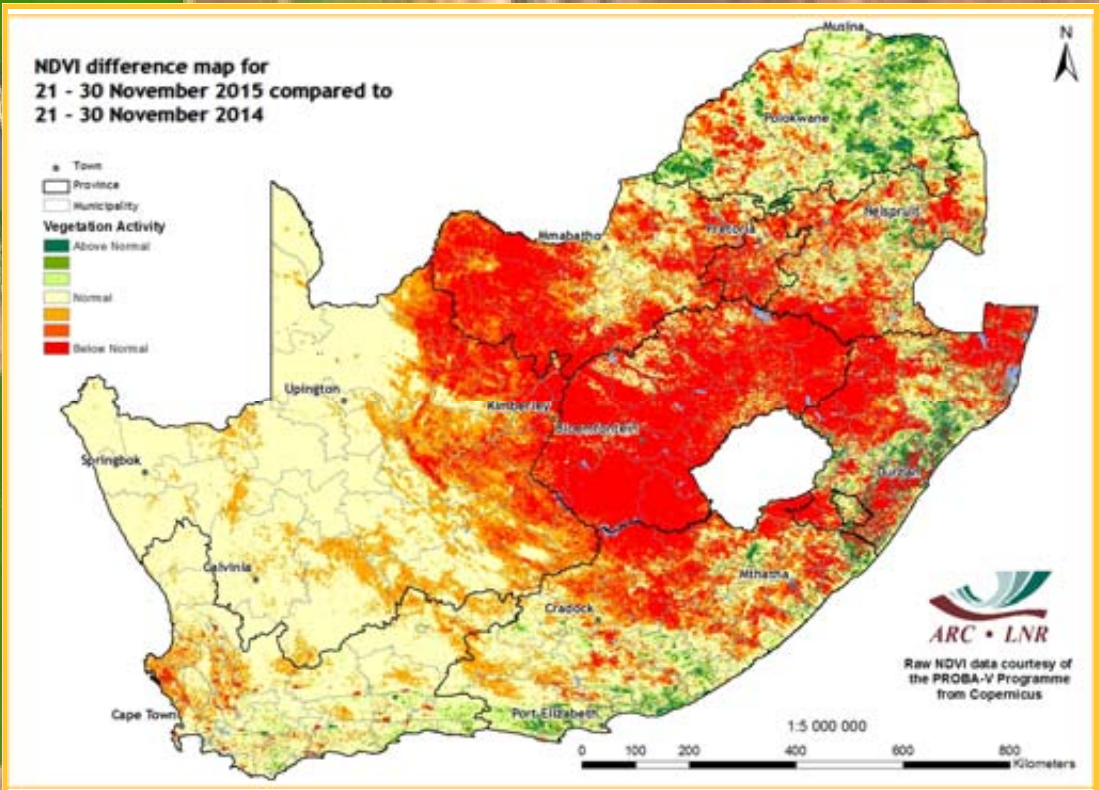


Figure 14

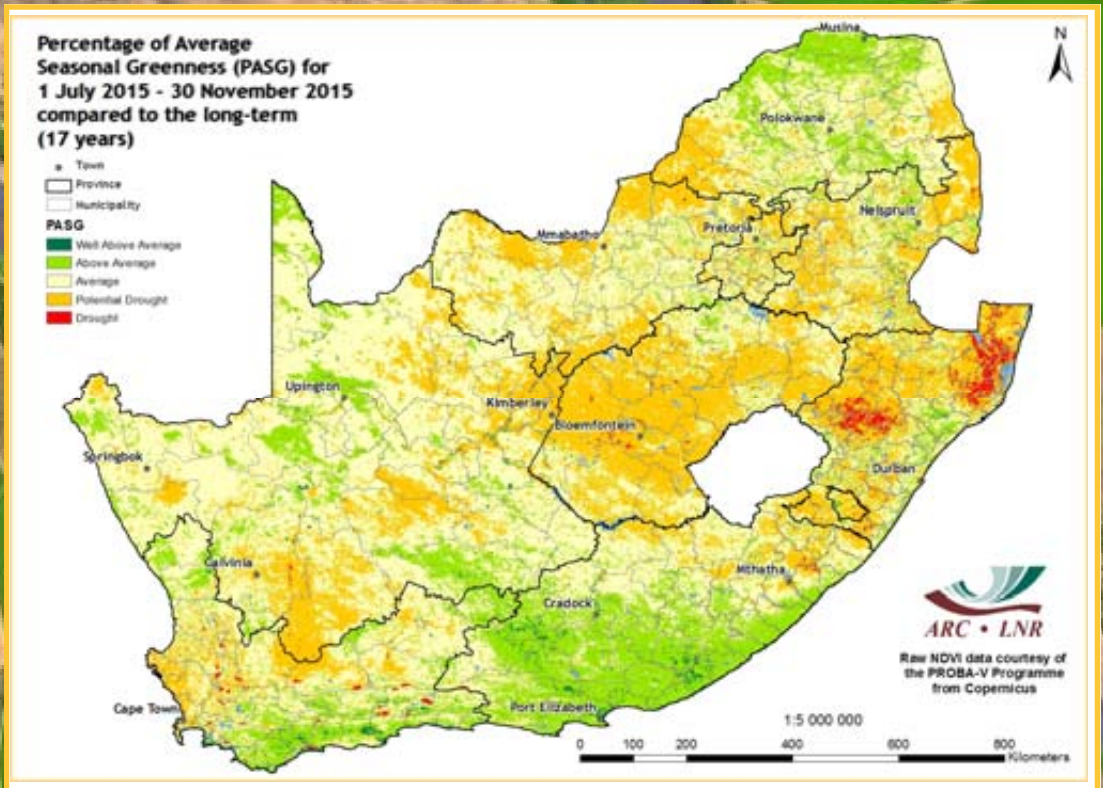


Figure 15

## Vegetation Mapping
*(continued from p. 8)*

### Interpretation of map legend

NDVI values range between 0 and 1. These values are incorporated in the legend of the difference maps, ranging from -1 (lower vegetation activity) to 1 (higher vegetation activity) with 0 indicating normal/the same vegetation activity or no significant difference between the images.

### Cumulative NDVI maps:

Two cumulative NDVI datasets have been created for drought monitoring purposes:

**Winter:** January to December
**Summer:** July to June

**Figure 14:**
Vegetation activity this year is higher over the southern and northeastern parts relative to last year but lower over the remainder of the summer rainfall region and western parts of the winter rainfall region.

**Figure 15:**
Cumulative vegetation activity is above normal over the southern and southeastern parts as well as parts of central to northwestern Northern Cape and central to northern Limpopo. Cumulative vegetation activity over the northern parts of the Western Cape into the western parts of the Northern Cape is below normal. Cumulative vegetation activity is below normal to well below normal over the central to eastern interior, stretching towards the north coast of KwaZulu-Natal.

**Questions/Comments:**
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# 6. Vegetation Condition Index



**Vegetation Condition Index (VCI)**

The VCI is an indicator of the vigour of the vegetation cover as a function of the NDVI minimum and maximum encountered for a specific pixel and for a specific period, calculated over many years.
The VCI normalizes the NDVI according to its changeability over many years and results in a consistent index for various land cover types. It is an effort to split the short-term weather-related signal from the long-term climatological signal as reflected by the vegetation. The VCI is a better indicator of water stress than the NDVI.

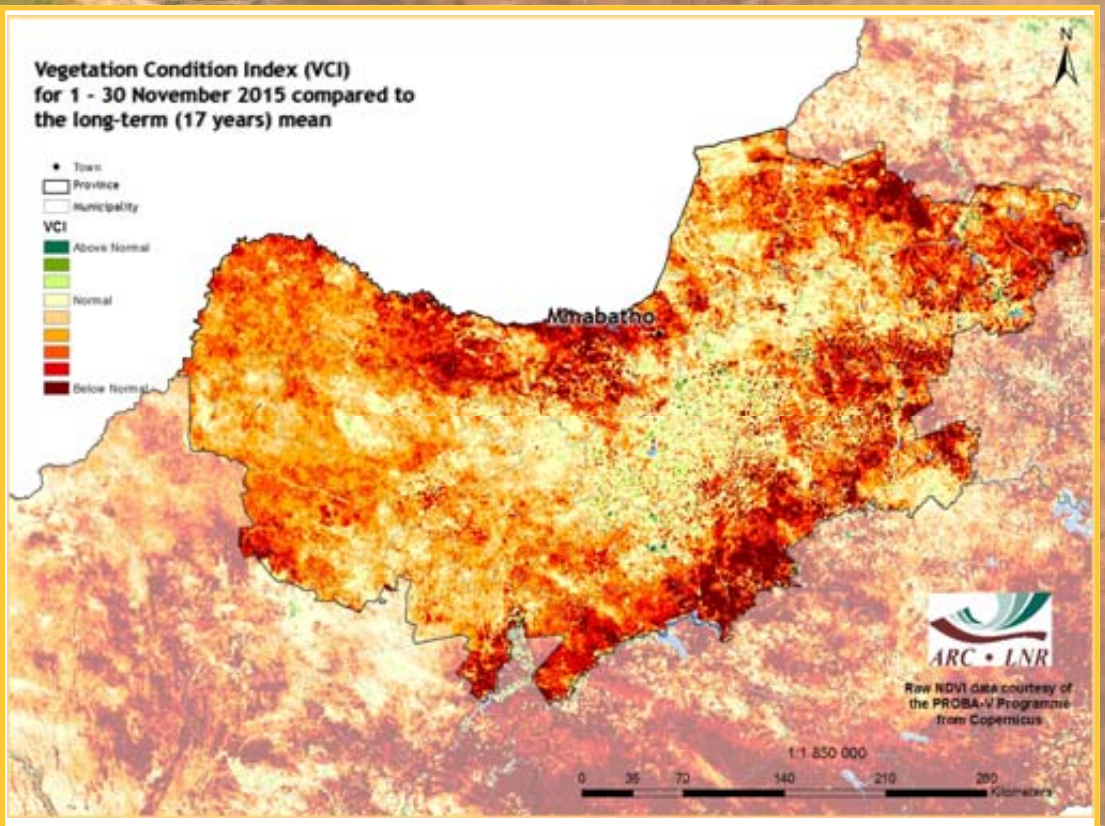



Figure 16

**Figure 16:**
The VCI map for November indicates below-normal vegetation activity over most of North West except for isolated areas in the interior.

**Figure 17:**
The VCI map for November indicates below-normal vegetation activity over the whole of the Free State.

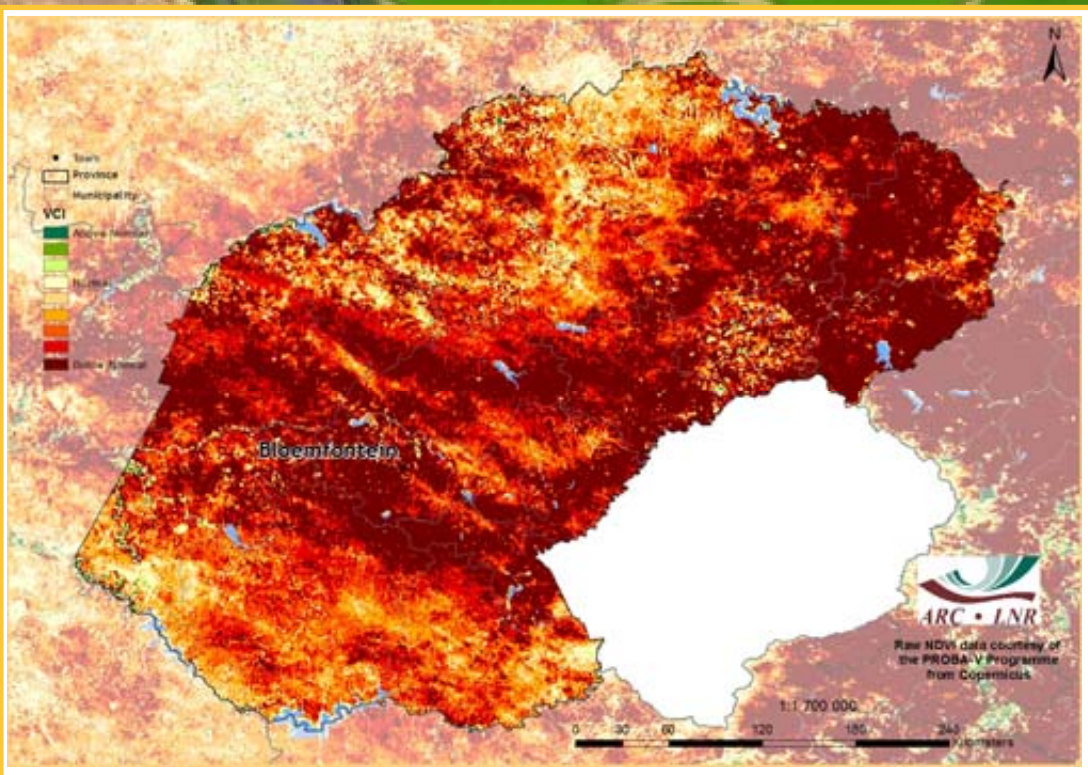



Figure 17

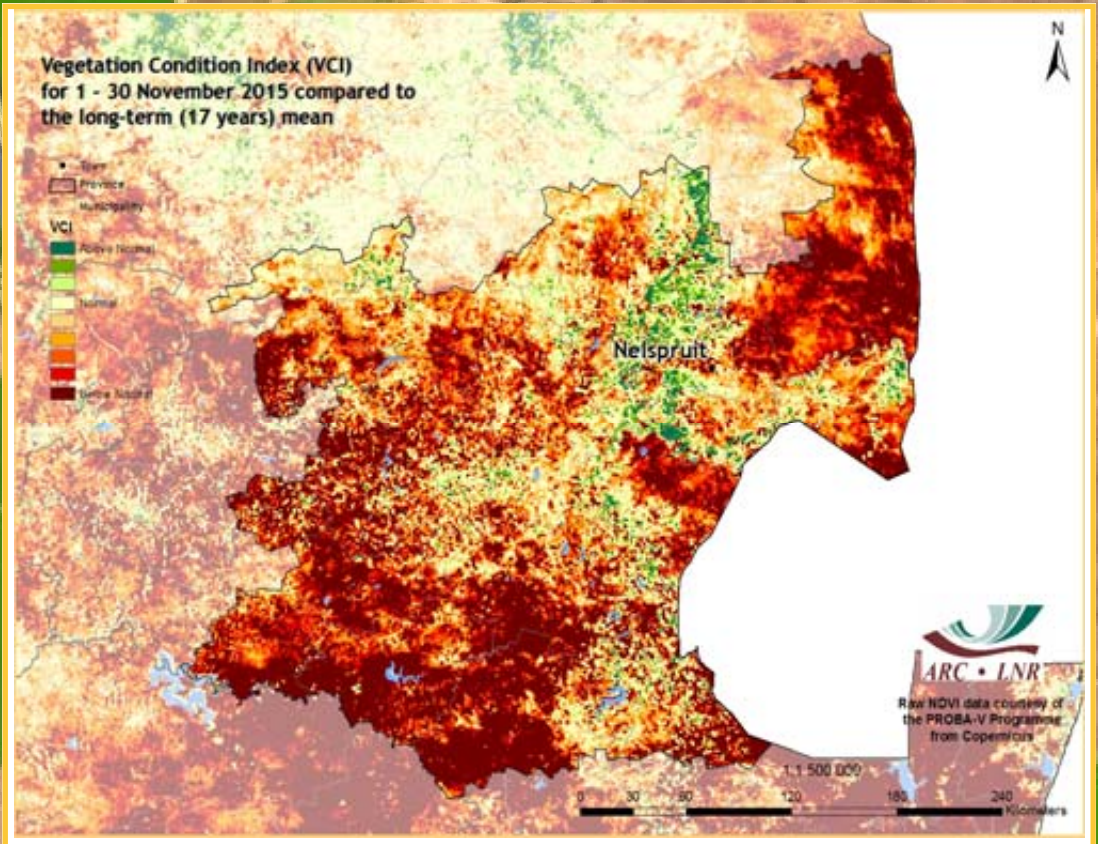



Figure 18

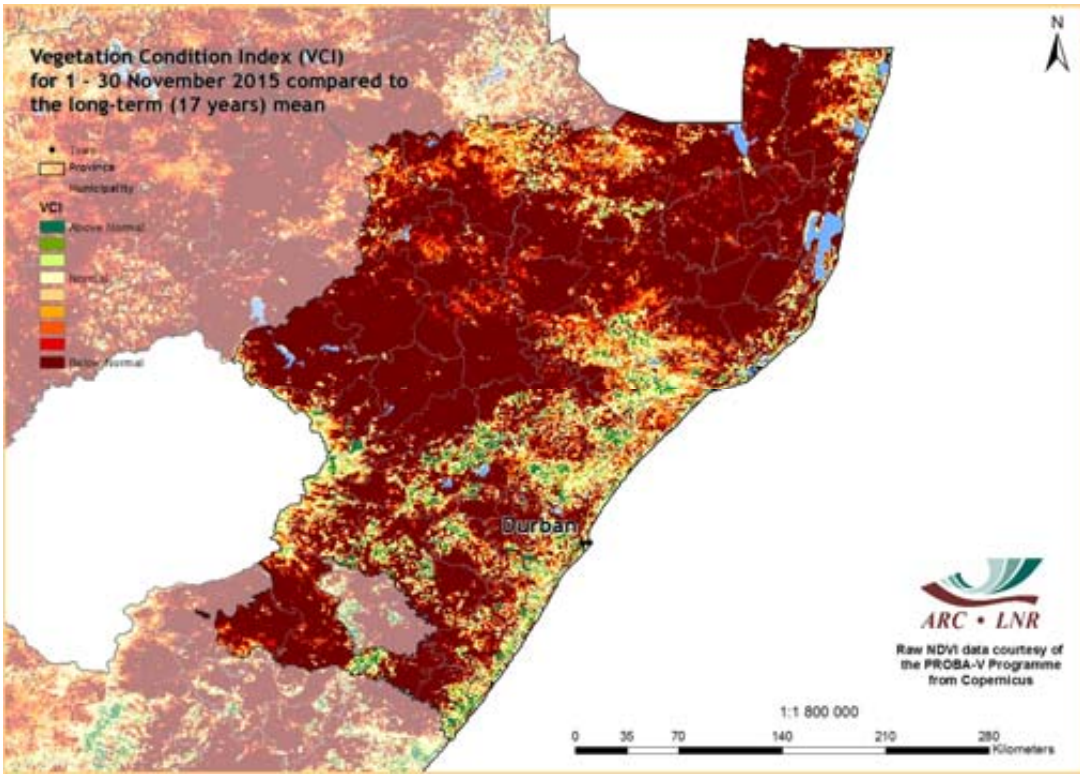



Figure 19

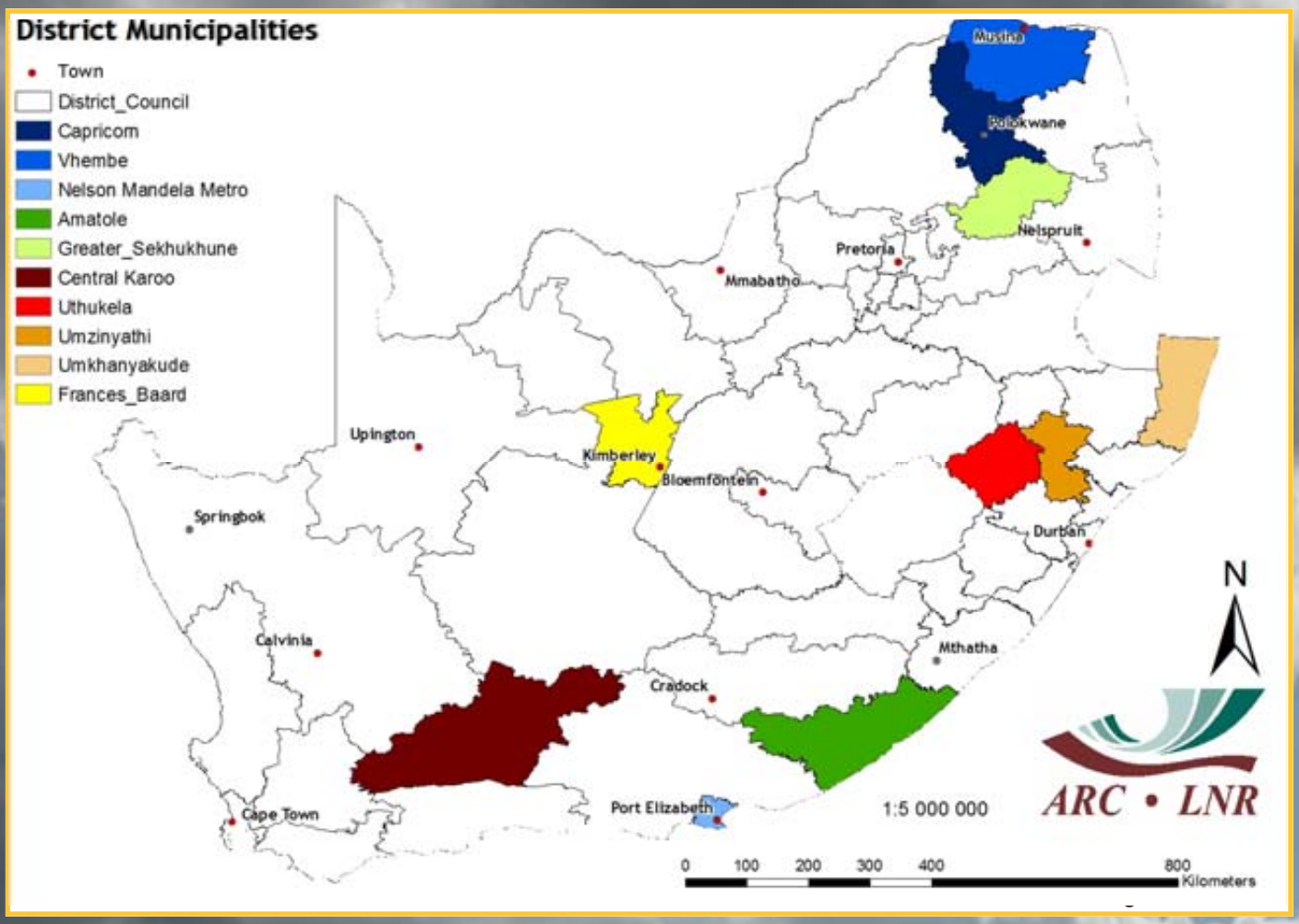
**Figure 18:**
The VCI map for November indicates below-normal vegetation activity over the southwestern parts of Mpumalanga and the Lowveld.

**Figure 19:**
The VCI map for November indicates below-normal vegetation activity over most of KwaZulu-Natal except for the central to southern coastal area and adjacent interior.

**Questions/Comments:**
*NkambuleV@arc.agric.za*

# 7. Vegetation Conditions & Rainfall



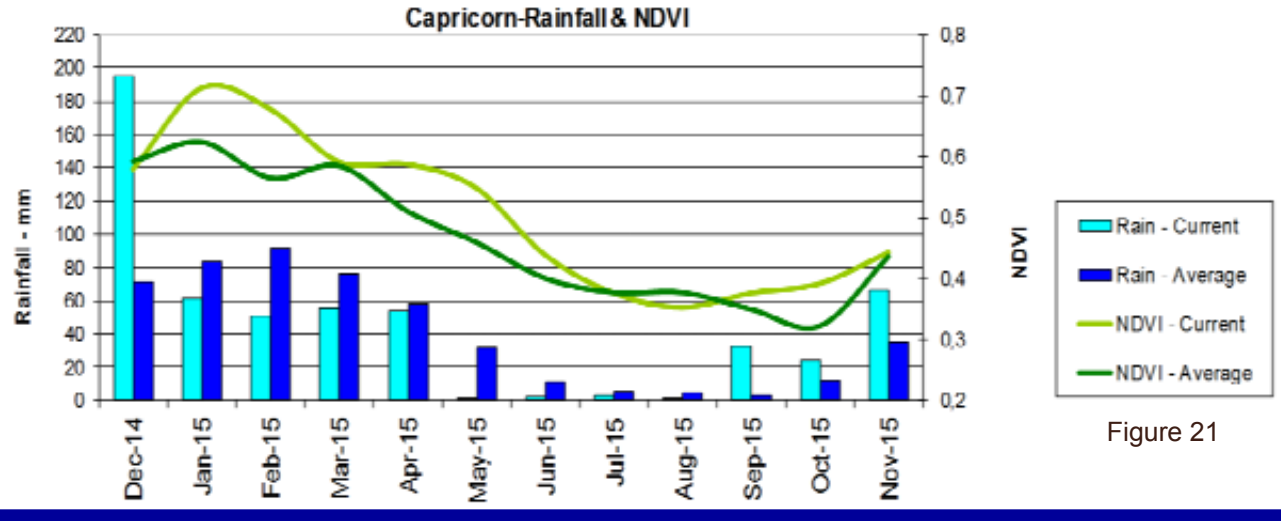



**NDVI and Rainfall Graphs**
**Figure 20:**
Orientation map showing the areas of interest for November 2015. The district colour matches the border of the corresponding graph.

**Questions/Comments:**
*Johan@arc.agric.za; NkambuleV@arc.agric.za*

**Figures 21-25:**
Indicate areas with higher cumulative vegetation activity for the last year.

**Figures 26-30:**
Indicate areas with lower cumulative vegetation activity for the last year.

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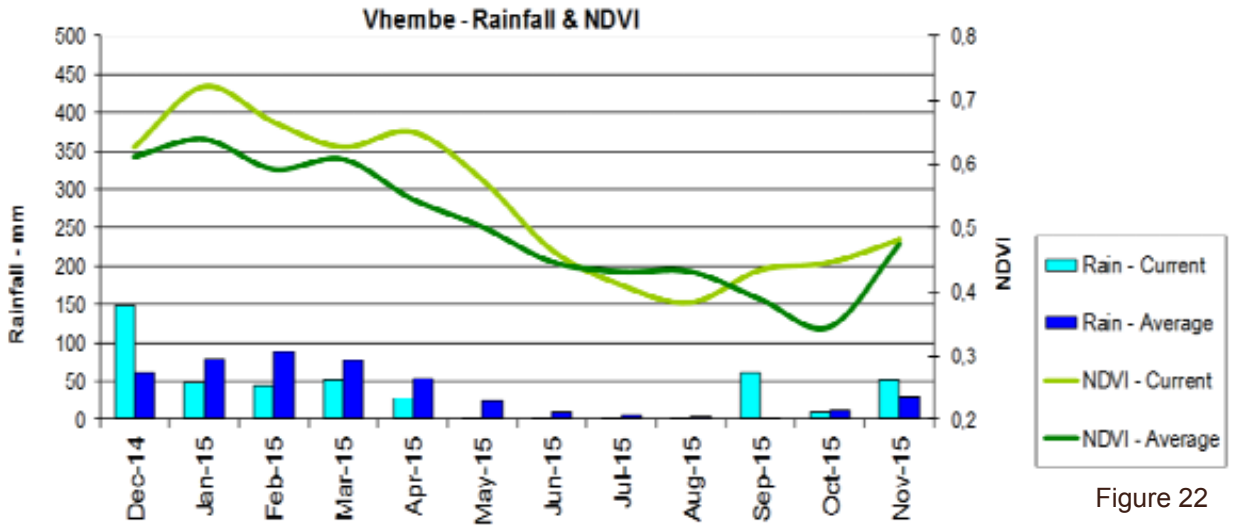


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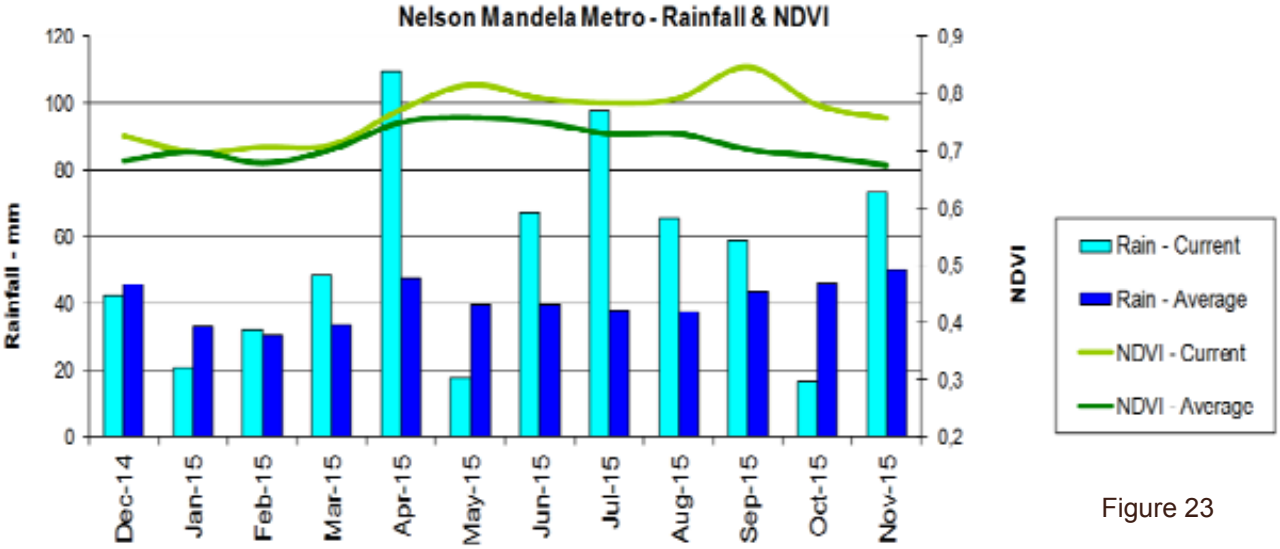


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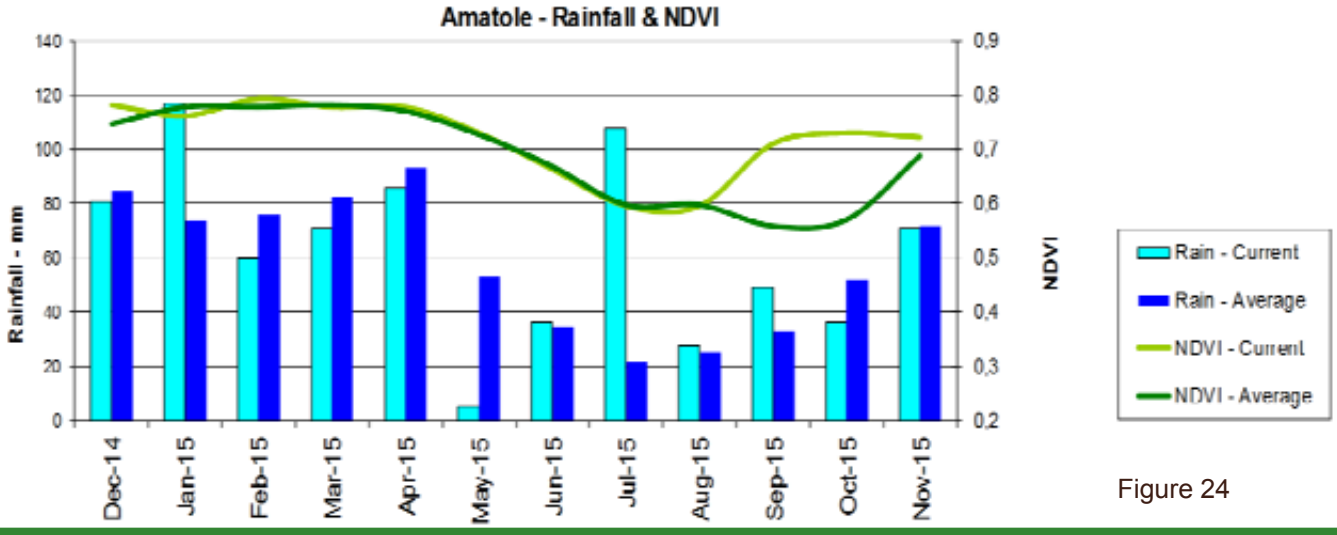



Figure 24

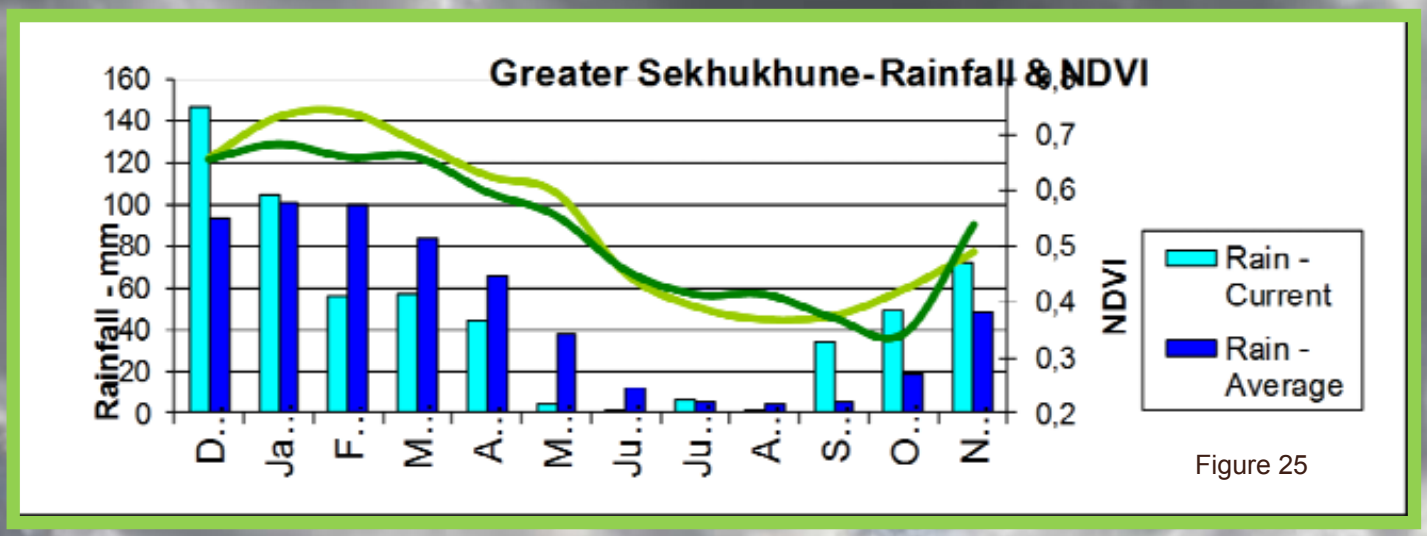



Figure 25

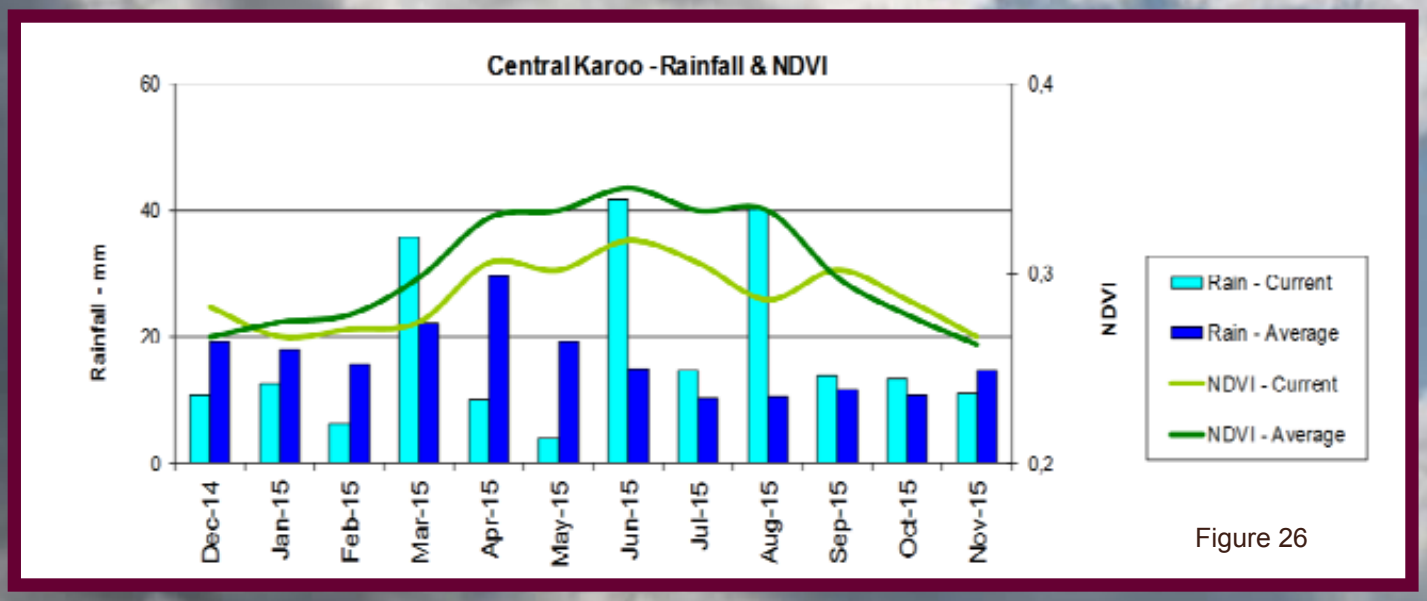
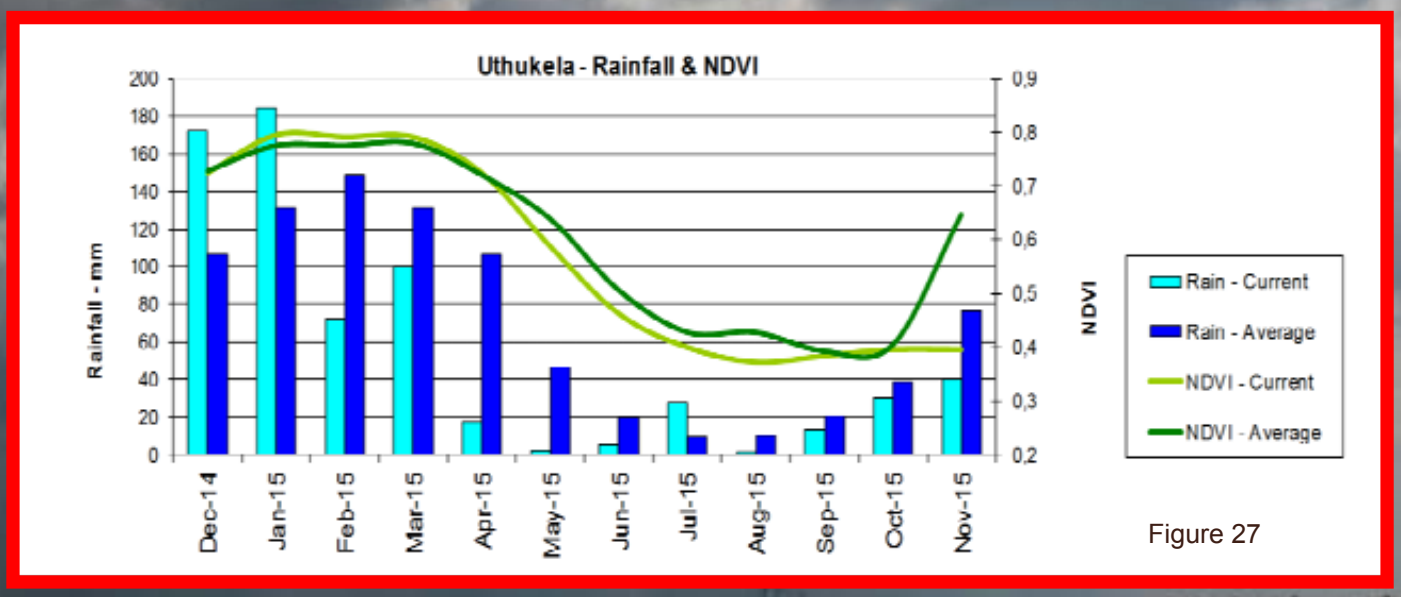



Figure 26

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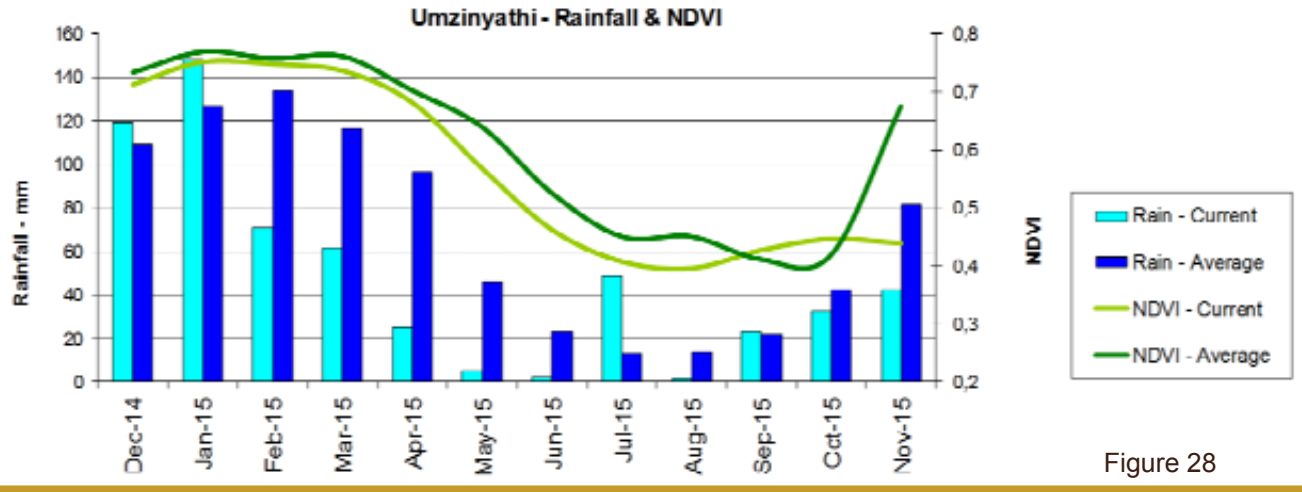


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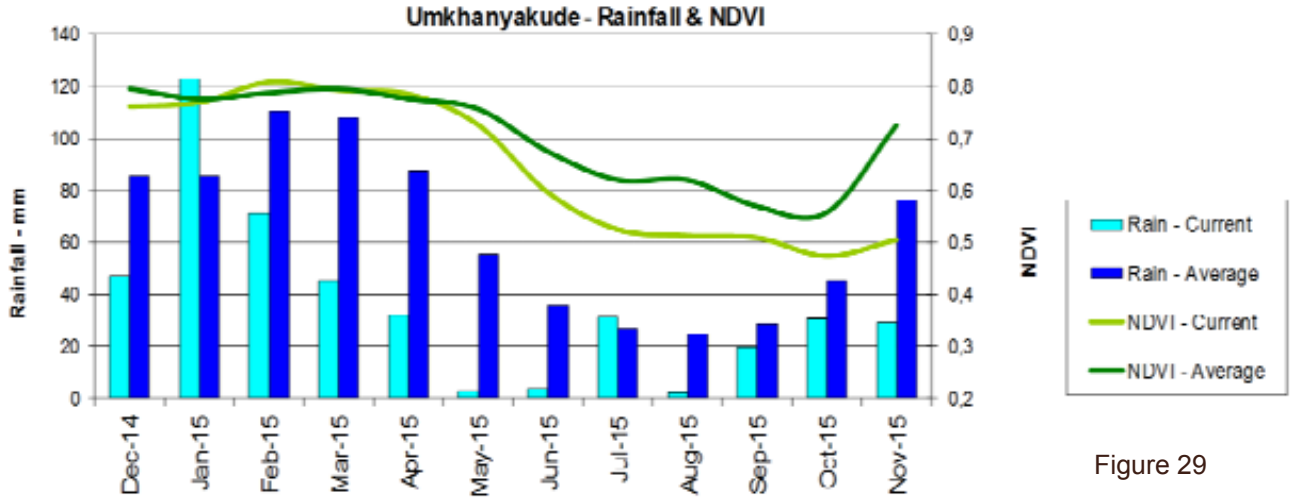


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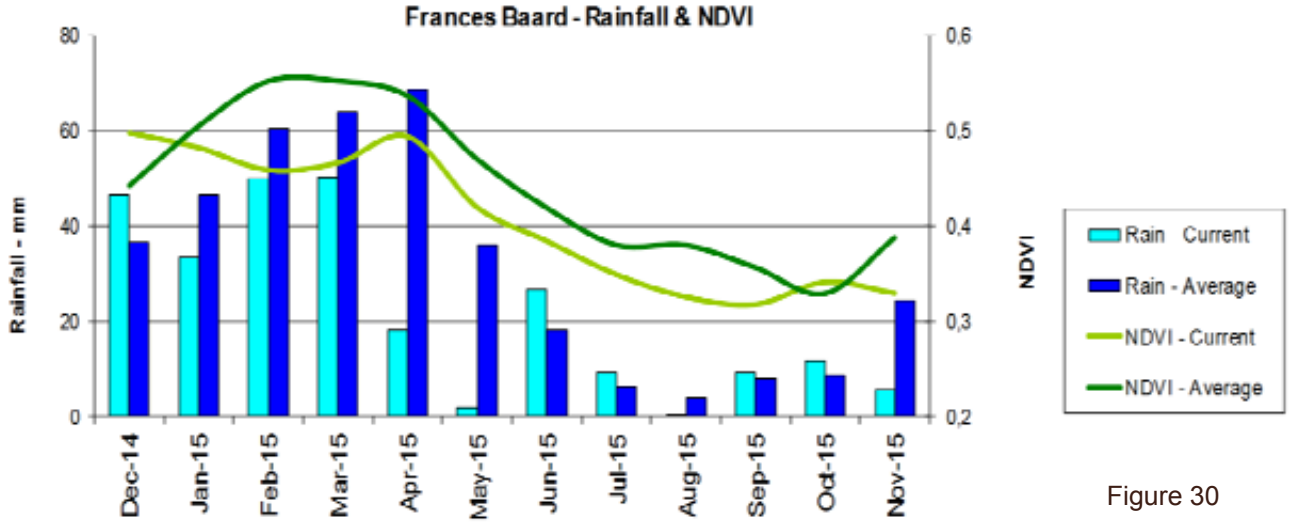


Figure 30

# 8. Soil Moisture

PAGE 16

**Countywide soil moisture modelling by the University of KwaZulu-Natal Satellite Applications and Hydrology Group (SAHG)**

Figure 31 shows the monthly averaged soil moisture conditions for November 2015. The colour scale ranging from brown to blue represents the Soil Saturation Index (SSI), defined as the percentage saturation of the soil store in the TOPKAPI hydrological model. The modelling is intended to represent the mean soil moisture state in the root zone. Figure 32 shows the SSI difference between November and October 2015, with the brown colours showing the drier and the green colours the wetter areas. Similarly, the year-on-year SSI difference for November is shown in Figure 33.

The anomalies concur with wetter conditions over the northeastern parts during mid-November as reported elsewhere in the newsletter.

*The SSI maps are produced at the ARC-ISCW in a collaborative effort with the University of KwaZulu-Natal Applications and Hydrology Group, made possible by the WMO.*

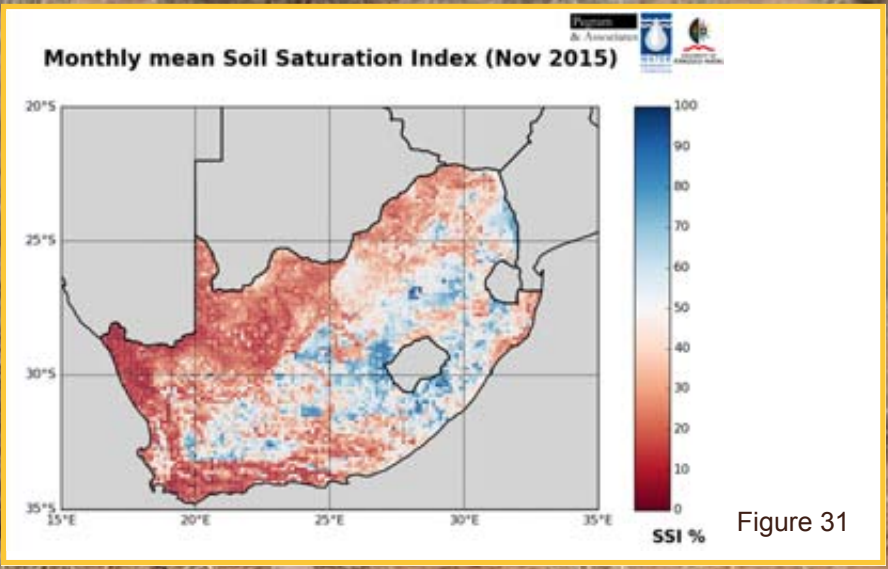


Figure 31

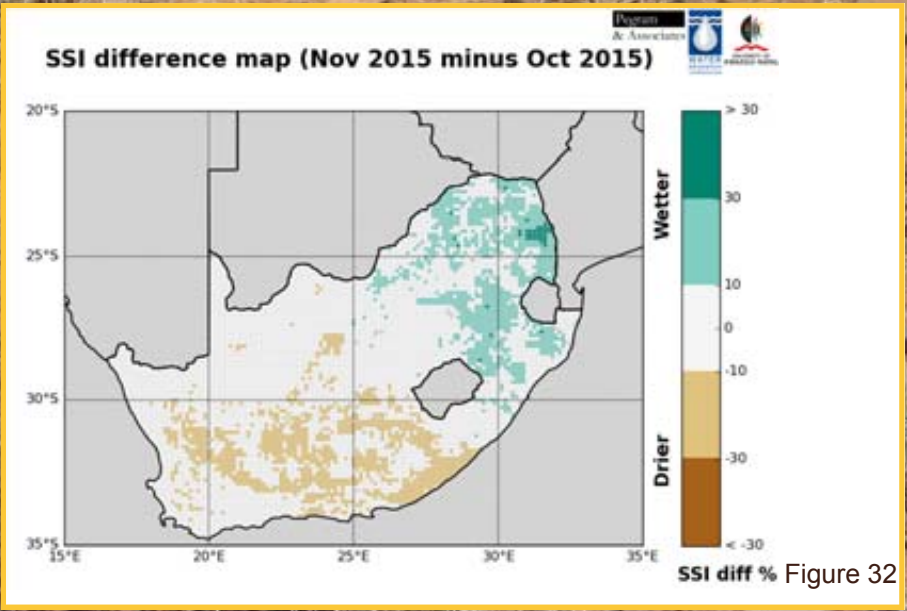


Figure 32

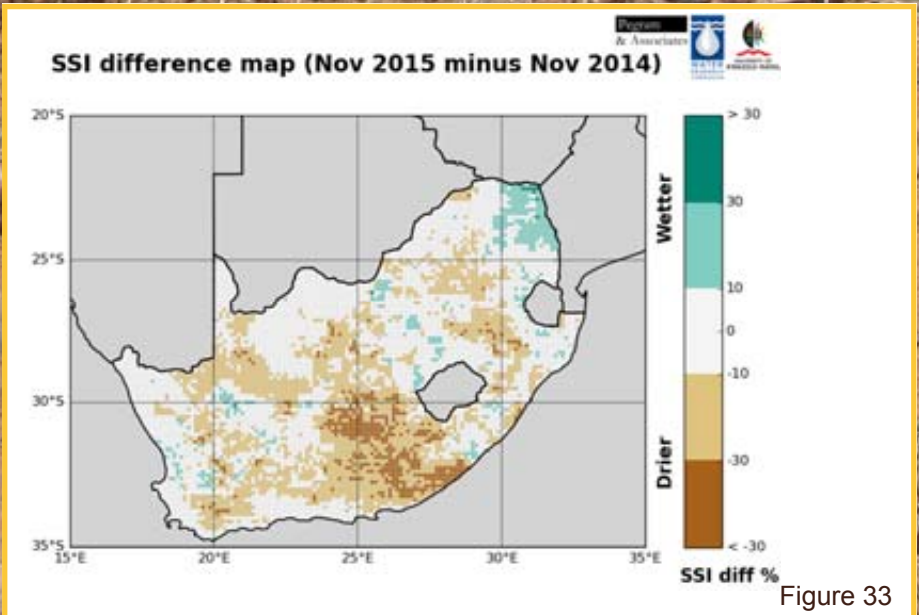


Figure 33

UNIVERSITY OF KWAZULU-NATAL

# 9. Fire Watch

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**Active Fires** *(Provided when data is available)*

Forest and vegetation fires have temperatures in the range of 500 K (Kelvin) to 1000 K. According to Wien's Displacement Law, the peak emission of radiance for blackbody surfaces of such temperatures is at around 4 µm. For an ambient temperature of 290 K, the peak of radiance emission is located at approximately 11 µm. Active fire detection algorithms from remote sensing use this behaviour to detect "hot spot" fires.

**Figure 34:**
The graph shows the total number of active fires detected during the month of November per province. Fire activity was higher in the Free State, Limpopo and North West compared to the average during the same period for the last 14 years.

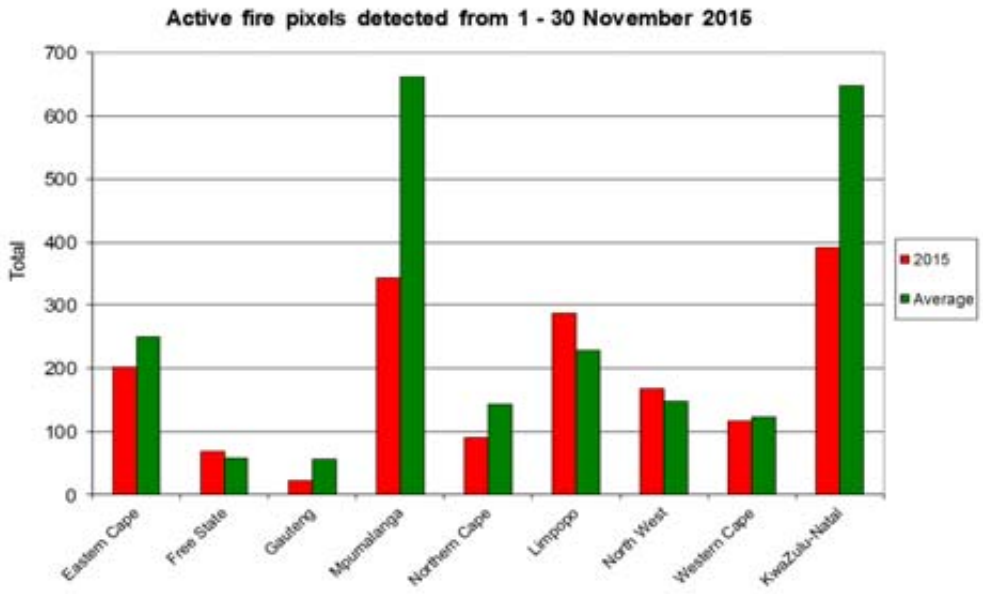


Figure 34

**Figure 35:**
The map shows the location of active fires detected between 1-30 November 2015.

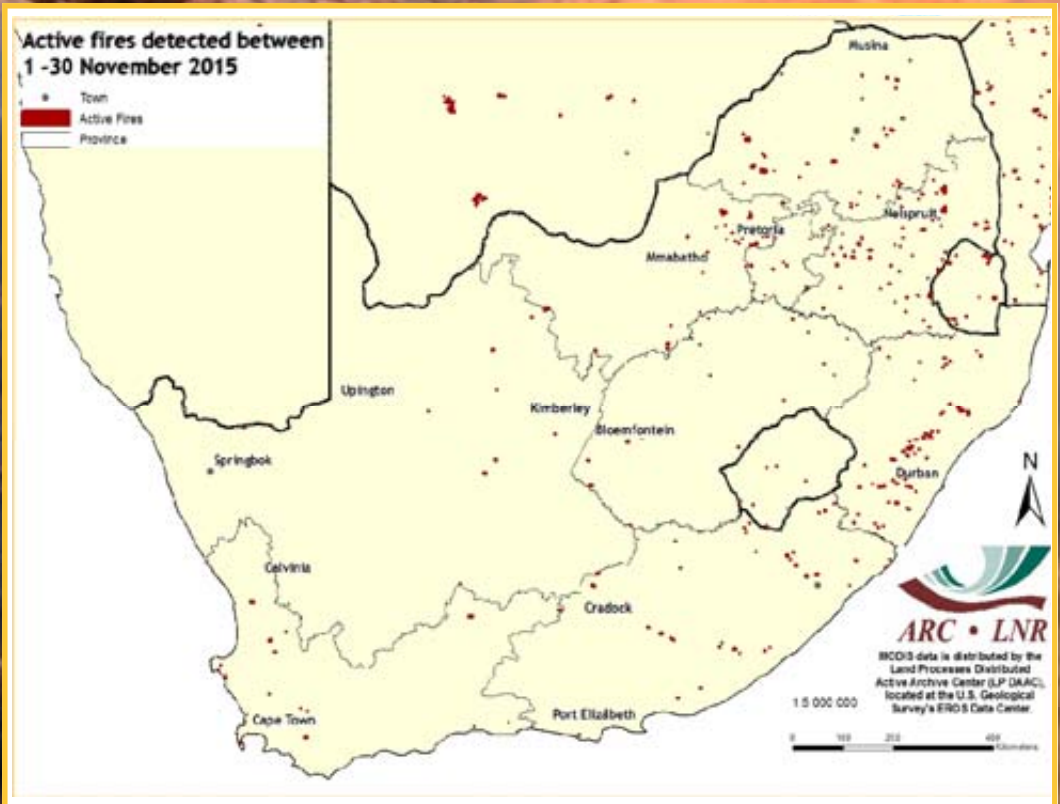


Figure 35

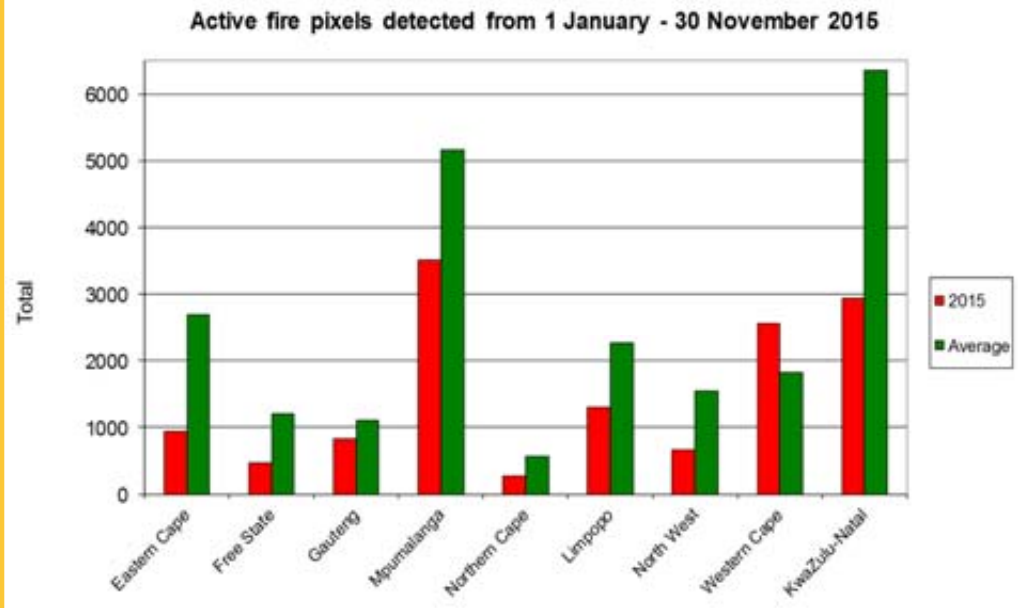


Figure 36

**Figure 36:**
The graph shows the total number of active fires detected between 1 January to 30 November 2015 per province. Fire activity was lower in all provinces except the Western Cape compared to the average during the same period for the last 14 years.

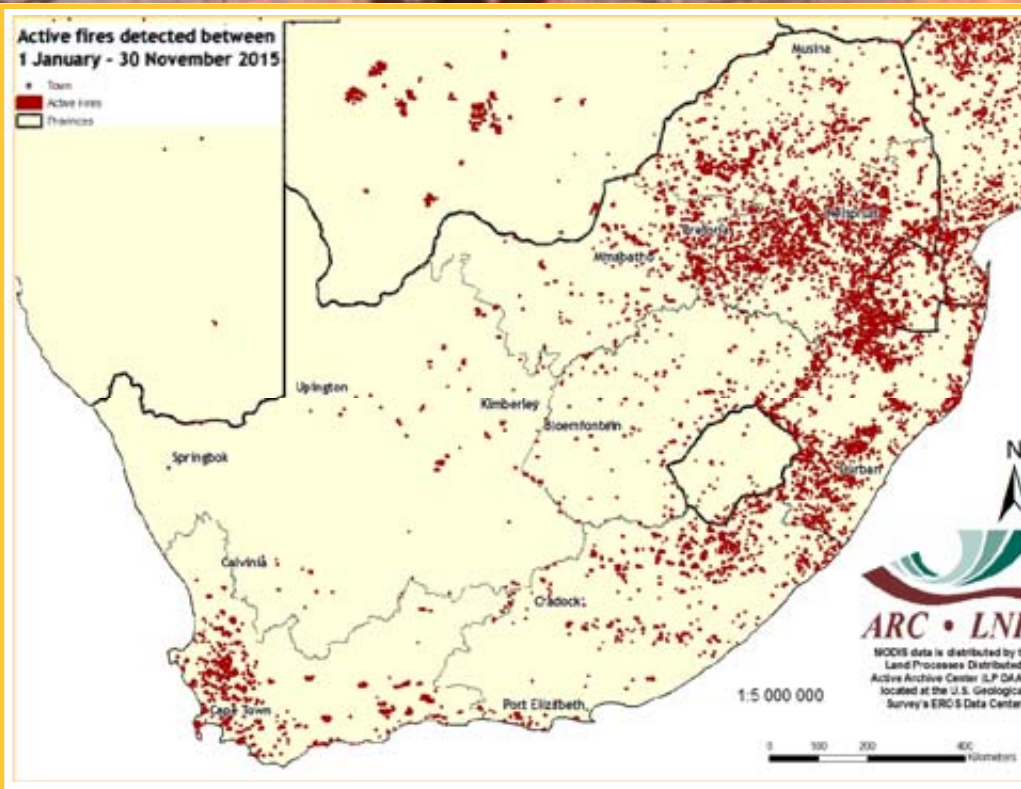


Figure 37

**Figure 37:**
The map shows the location of active fires detected between 1 January to 30 November 2015.

***Questions/Comments:***
*NkambuleV@arc.agric.za*

# ARC-INSTITUTE FOR SOIL, CLIMATE AND WATER

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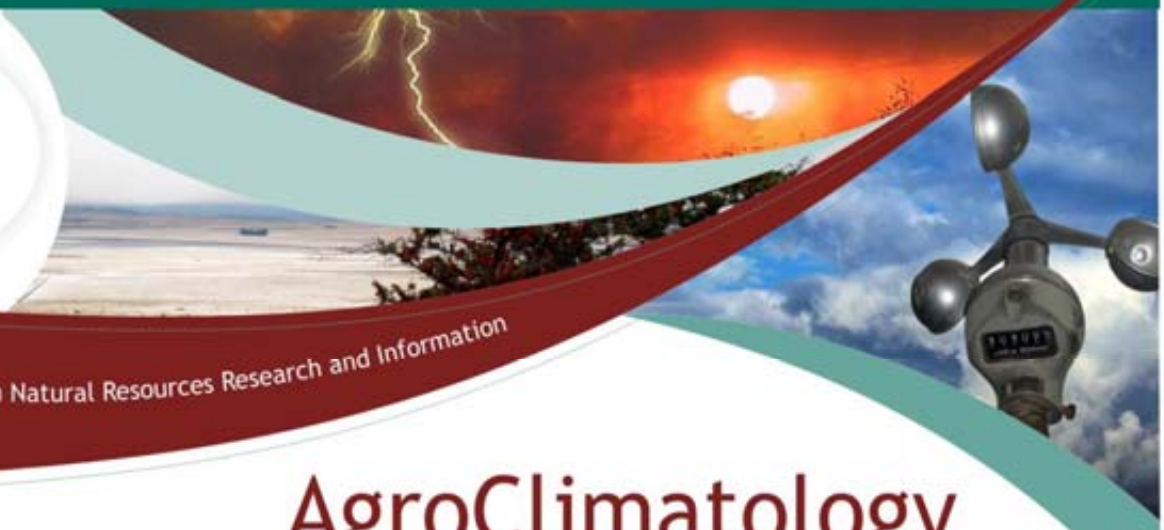

Your Partner in Natural Resources Research and Information

# AgroClimatology

The AgroClimatology Programme of the ARC-Institute for Soil, Climate and Water monitors South Africa's weather and supports the country's agricultural sector through timely provision of weather and climate information.

Since its inception at Bien Donné in the Western Cape in 1940, the Programme has evolved to become a leading arm of the ARC and currently has the capacity to maintain a large country-wide weather station network comprising over 500 automatic weather stations and a small number of mechanical weather stations. The data from all the stations is loaded onto a web-enabled databank from which various climate information products can be derived.

The weather station network and databank constitute a National Asset whose maintenance is largely funded by government through a parliamentary grant that is annually disbursed for this purpose.

## Products and Services

Climate-related services and information are available from the Institute's offices in Pretoria (Tel: 012 310 2500), Potchefstroom (Tel: 018 299 6349) and Stellenbosch (Tel: 021 809 3100).

From the web-enabled databank, hourly, daily, monthly, yearly or long-term data can be requested for the following measured elements:

- Temperature
- Rainfall
- Wind speed (including gusts) and direction
- Radiation
- Humidity

Value-added information on evapotranspiration, cold and heat units, and Powdery and Downy Mildew disease indicators is available and various spatial interpretations can be conducted for interested users upon request.

**For more information contact:**
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*E-mail: ChrisK@arc.agric.za*
*Tel: 012 310 2560*

# The Coarse Resolution Imagery Database (CRID)

### NOAA AVHRR

The ARC-ISCW has an archive of daily NOAA AVHRR data dating from 1985 to 2004. This database includes all 5 bands as well as the Normalized Difference Vegetation Index (NDVI), Active Fire and Land Surface Temperature (LST) images. The NOAA data are used, for example, for crop production and grazing capacity estimation.

### MODIS

MODIS data is distributed by the Land Processes Distributed Active Archive Center (LP DAAC), located at the U.S. Geological Survey's EROS Data Center. The MODIS sensor is more advanced than NOAA with regard to its high spatial (250 $m^2$ to 1 $km^2$) and spectral resolution. The ARC-ISCW has an archive of MODIS (version 4 and 5) data.

- MODIS v4 from 2000 to 2006
- MODIS v5 from 2000 to present

Datasets include:

- MOD09 (Surface Reflectance)
- MOD11 (Land Surface Temperature)
- MOD13 (Vegetation Products)
- MOD14 (Active Fire)
- MOD15 (Leaf Area Index & Fraction of Photosynthetically Active Radiation
- MOD17 (Gross Primary Productivity)
- MCD43 (Albedo & Nadir Reflectance)
- MCD45 (Burn Scar)

Coverage for version 5 includes South Africa, Namibia, Botswana, Zimbabwe and Mozambique.
More information:
**http://modis.gsfc.nasa.gov**

### VGT4AFRICA and GEOSUCCESS

SPOT NDVI data is provided courtesy of the VEGETATION Programme and the VGT4AFRICA project. The European Commission jointly developed the VEGETATION Programme. The VGT4AFRICA project disseminates VEGETATION products in Africa through GEONETCast.

ARC-ISCW has an archive of VEGETATION data dating from 1998 to the present. Other products distributed through VGT4AFRICA and GEOSUCCESS include Net Primary Productivity, Normalized Difference Wetness Index and Dry Matter Productivity data.

### Meteosat Second Generation (MSG)

The ARC-ISCW has an operational MSG receiving station. Data from April 2005 to the present have been archived. MSG produces data with a 15-minute temporal resolution for the entire African continent. Over South Africa the spatial resolution of the data is in the order of 3 km. The ARC-ISCW investigated the potential for the development of products for application in agriculture. NDVI, LST and cloud cover products were some of the initial products derived from the MSG SEVIRI data. Other products derived from MSG used weather station data, including air temperature, humidity and solar radiation.

### Rainfall maps

- Combined inputs from 450 automatic weather stations from the ARC-ISCW weather station network, 270 automatic rainfall recording stations from the SAWS, satellite rainfall estimates from the Famine Early Warning System Network: **http://earlywarning.usgs.gov** and long-term average climate surfaces developed at the ARC-ISCW.

### Solar Radiation and Evapotranspiration maps

- Combined inputs from 450 automatic weather stations from the ARC-ISCW weather station network.
- Data from the METEOSAT Second Generation (MSG) 3 satellite via GEONETCAST: **http://www.eumetsat.int/website/home/Data/DataDelivery/EUMETCast/GEONETCast/index.html**.

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**The operational Coarse Resolution Imagery Database (CRID) project of ARC-ISCW is funded by the National Department of Agriculture, Forestry and Fisheries. Development of the monitoring system was made possible in its inception through LEAD funding from the Department of Science and Technology.**

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To subscribe to the newsletter, please submit a request to:
**Johan@arc.agric.za**

**What does Umlindi mean?**
UMLINDI is the Zulu word for "the watchman".

**http://www.agis.agric.za**