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Excellence in Agricultural Research and Development

UMLINDI
The Watchman

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INSTITUTE FOR SOIL, CLIMATE AND WATER

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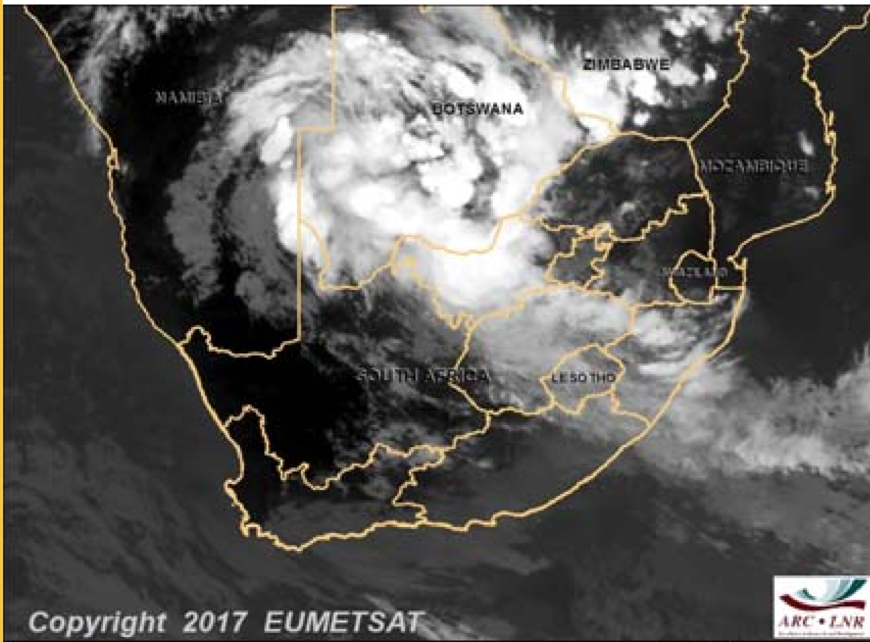
agriculture, forestry & fisheries
Department: Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

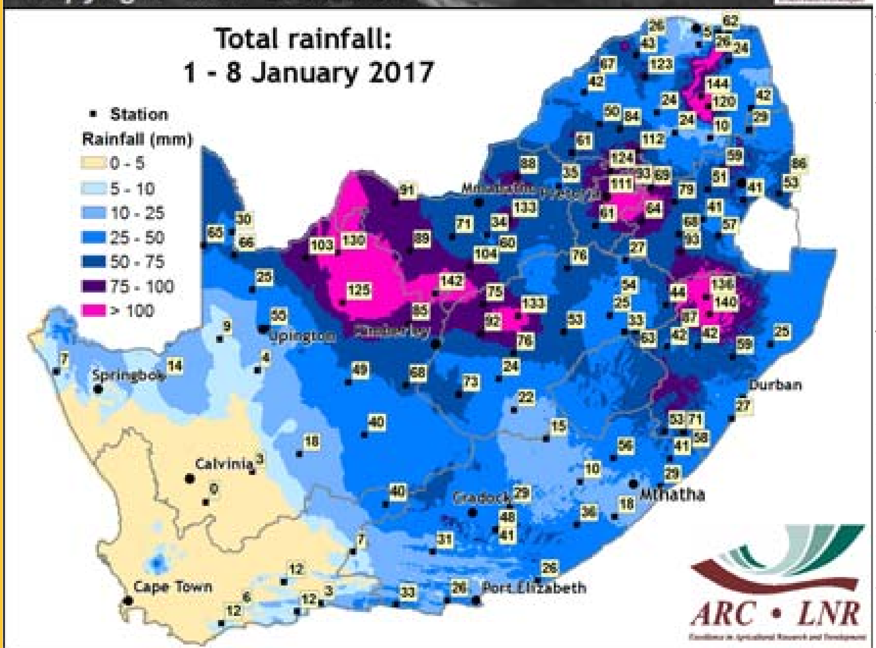
South African Weather Service

AMESD

151st Edition

Images of the Month





Widespread rain in early January

Significant rain occurred over much of the summer rainfall region during the first few days of January 2017. Some of the highest totals occurred in areas over the centre of South Africa where the drought situation was becoming critical. Rainfall totals recorded over the western parts of the North West and north-eastern Northern Cape already exceed the long-term average for January.

A tropical low-pressure system over Botswana was to a large degree responsible for the widespread rainfall especially over the northern parts of South Africa. Since the beginning of the month, scattered to widespread thundershowers occurred over the central parts while the low was situated over north-west Botswana. As the system moved towards south-eastern Botswana by the 6th, rain shifted to north-eastern South Africa. Several stations recorded daily totals in excess of 50 mm and dam levels over the summer rainfall region generally increased during and following the wet spell. The Thermal Band image of MSG3 at 17:00 SAST on Friday 6 January (top) shows the spiralling cloud mass associated with the tropical low over Botswana, with moisture flowing southeastwards across the north-eastern parts. Such systems are more prevalent over the area during years with above-normal summer rainfall.

The rainfall map (below) shows the total rainfall for the first 8 days of January 2017. It is an interpolation of rainfall data recorded by 450 automatic stations of the ARC-ISCW. The rainfall totals for a selected number of stations are also indicated.

Dear Reader

It's been a privilege to be part of the Umlindi team since the first newsletter. I hope the products and newsletter will remain an important contributor to the monitoring effort in South Africa. I am now based at the CSIR – my new email address is: Jmalherbe@csir.co.za

Johan Malherbe

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:

Weather conditions during December 2016 were such that the north-eastern parts of the country experienced favourable rainfall while much of the western interior experienced for the most part dry and warm weather. Unseasonal frontal activity kept the south-western winter rainfall region cooler with normal to above-normal precipitation.

Maximum temperatures over the western interior remained above 35°C almost throughout the month, with the hottest conditions, when maxima exceeded 40°C especially over the north-western parts, concentrated around the 4th, 18th and again by the end of the month. Over the eastern and north-eastern summer rainfall region, the highest maximum temperatures occurred in the beginning of the month and again around the 23rd while relatively mild conditions occurred during the rest of the month.

Over the winter rainfall region, lower temperatures and significant rainfall concentrated around the 8th and the 23rd – associated with frontal activity. An influx of dry air associated with these systems was partly responsible for the dry conditions over the western interior.

The month started out dry with precipitation confined to the east of the escarpment. Anticyclonic upper-air conditions were in place, but gave way to unstable conditions with scattered thundershowers from the 4th. From the 4th to the 15th, the interaction between a tropical low towards the north, ridging anticyclones and upper-air troughs in the westerlies moving across the southern parts of the country, maintained scattered to widespread thundershowers over the interior. Significant falls were recorded between the 10th and 14th in the north-east along the escarpment and the Lowveld, especially due to large amounts of moisture associated with the tropical system towards the north. A frontal system resulted in some rain over the winter rainfall region around the 10th.

Conditions then cleared, with only isolated to scattered thundershowers mostly over the Highveld as dry air spread into the western parts and upper-air anticyclonic flow dominated between the 15th and 23rd.

A frontal system moved into the south-western parts by the 23rd. An upper-air trough accompanying the system became established in the south-west while the anticyclonic flow over the interior weakened. By the 24th, the tropical low that had been present to the north moved southward into central to southern Botswana and was to a large degree responsible for the scattered to widespread thundershowers that occurred especially over the north-eastern summer rainfall region from the 23rd to the 29th. An influx of cooler moist air into the eastern interior by the 24th and 25th resulted in fairly general rain over the eastern parts of North West, Gauteng and Mpumalanga. Large amounts of moisture remained in place until the 29th, with scattered thundershowers over most areas. Extensive cloud cover kept maximum temperatures relatively low.

The low over Botswana was displaced north-westwards by the end of the

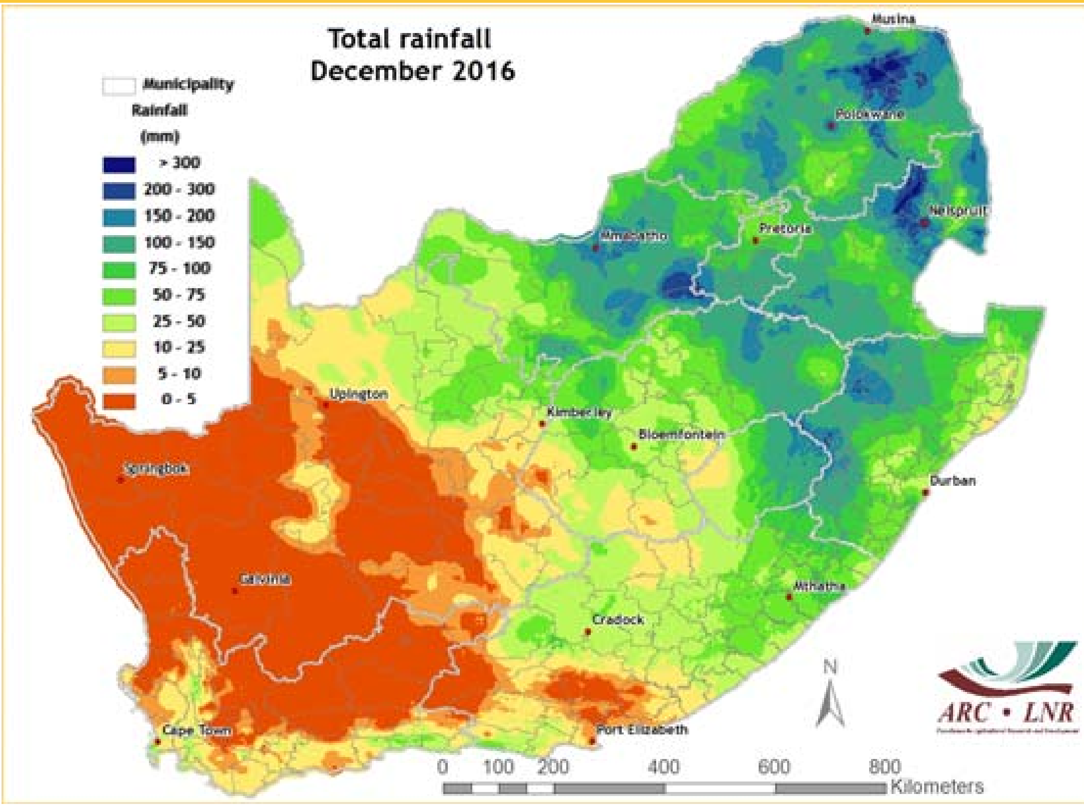
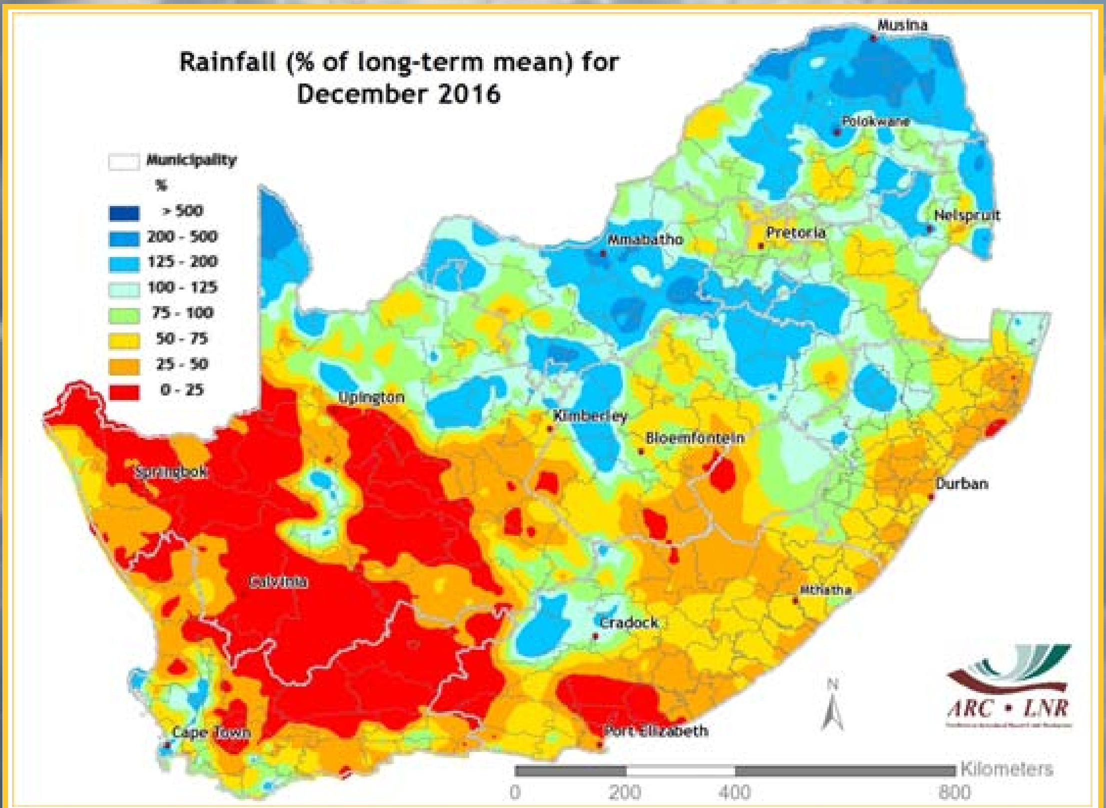


Figure 1



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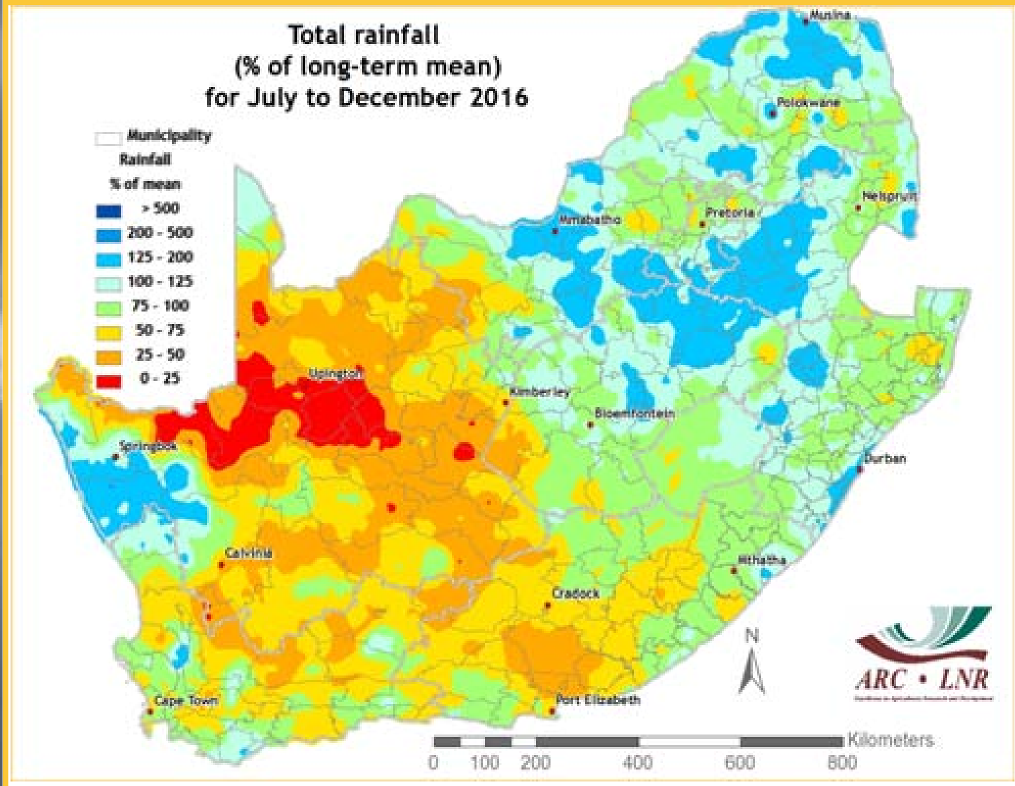

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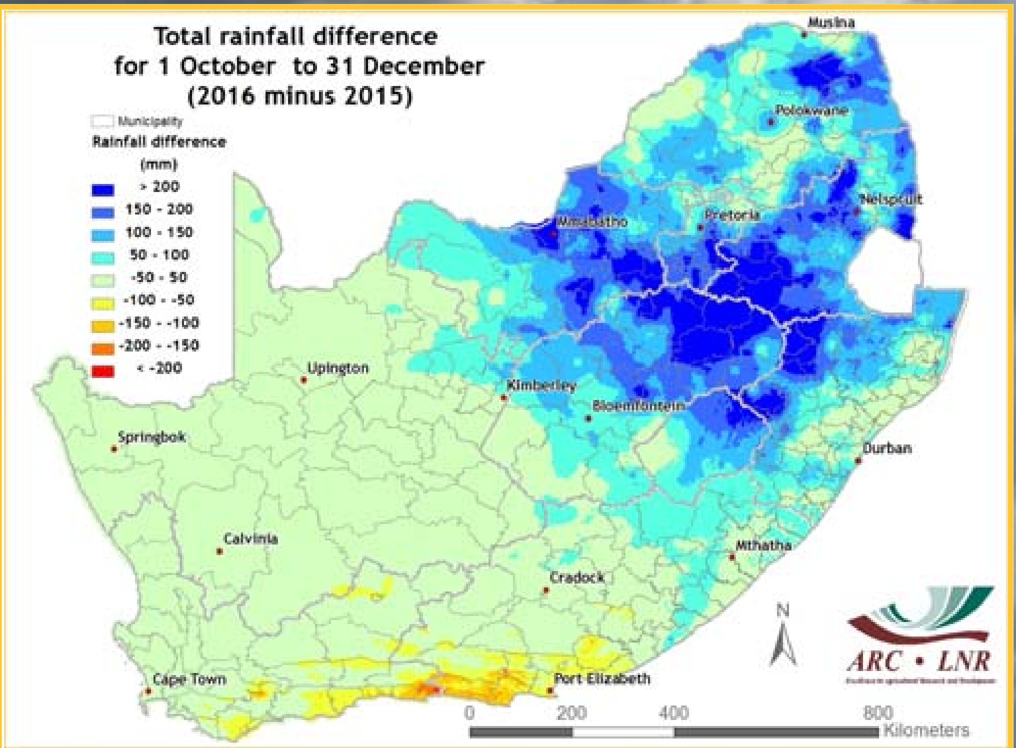

Figure 4

Figure 1:
The north-eastern half of the country received rain during December, with totals generally increasing in a north-easterly direction. Highest totals were recorded along the escarpment. Very little rain occurred over the western parts while some rain was recorded over the winter rainfall region and along the Garden Route.

Figure 2:
Large parts of the north-eastern and northern interior together with the south-western parts of the winter rainfall region received above-normal rainfall during December. Generally, the south-western interior and the south-eastern to eastern coastal areas and adjacent interior received below-normal rainfall.

Figure 3:
Since July, rainfall over the eastern half of the country was mostly normal to above normal. Below-normal rainfall occurred over the western interior. Much of the winter rainfall region, especially along the West Coast, also received above-normal rainfall.

Figure 4:
Much of the eastern summer rainfall region received significantly more rain during October to December 2016 compared to the previous year. The southern parts received less rain.

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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 (Figure 5-8) show that severe to extreme drought conditions occur at the longer time scales over some of the eastern parts, and at the short time scales over the southern to western parts. At short time scales, the eastern parts of the country are relatively wet.

Questions/Comments:
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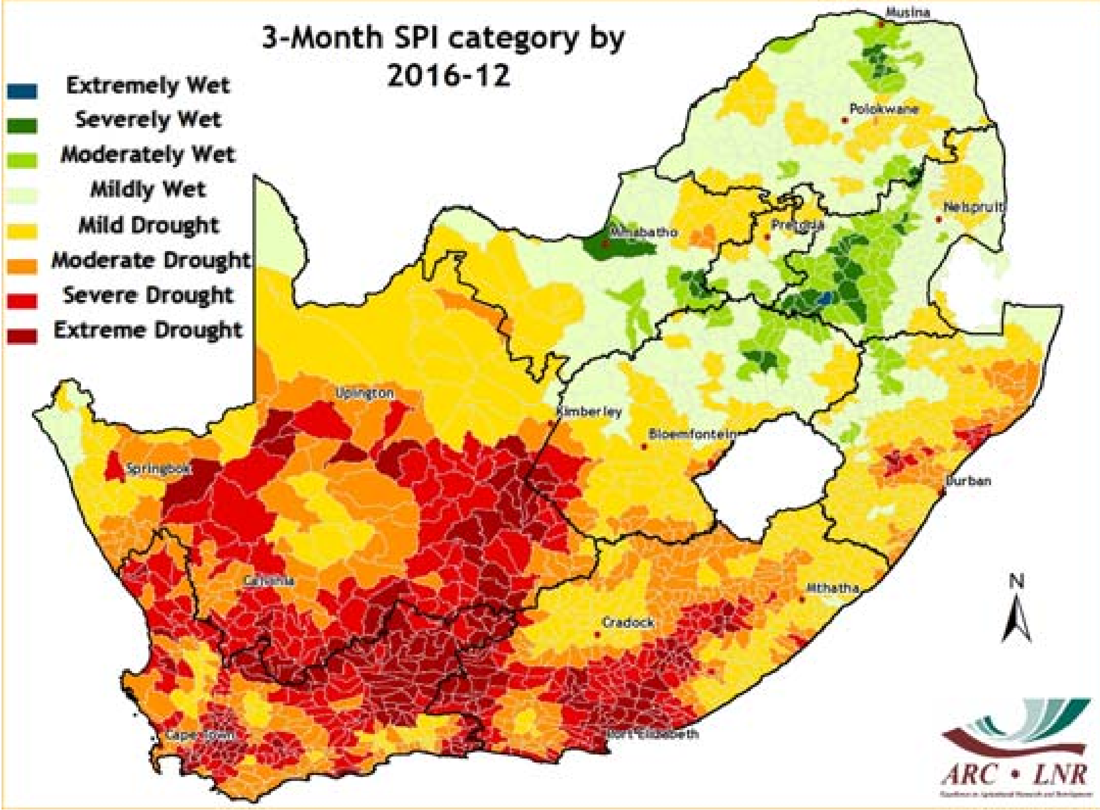
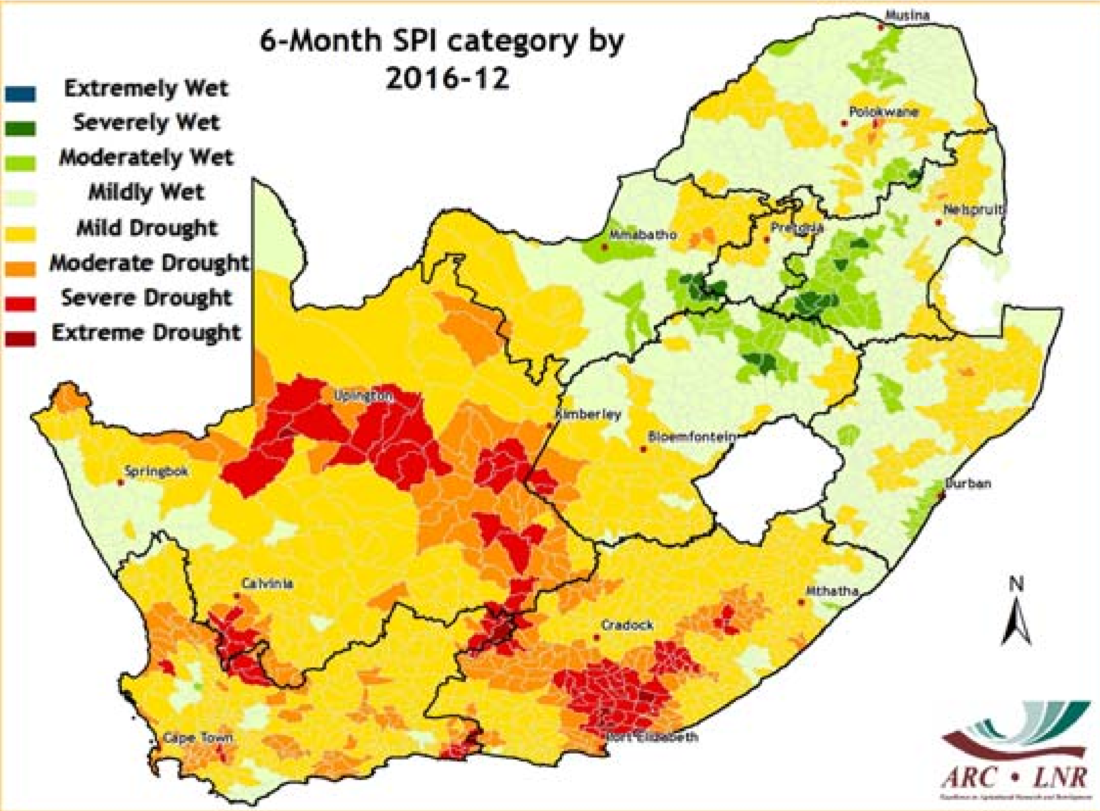


Figure 5



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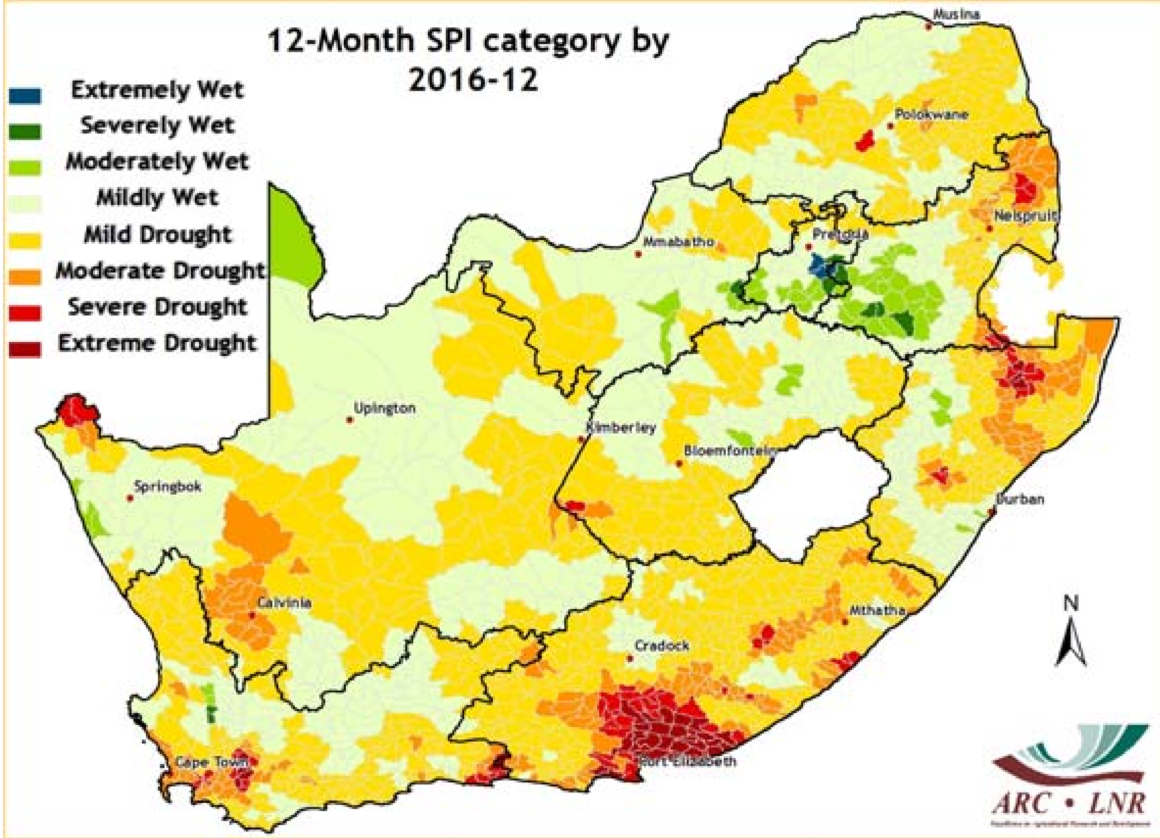

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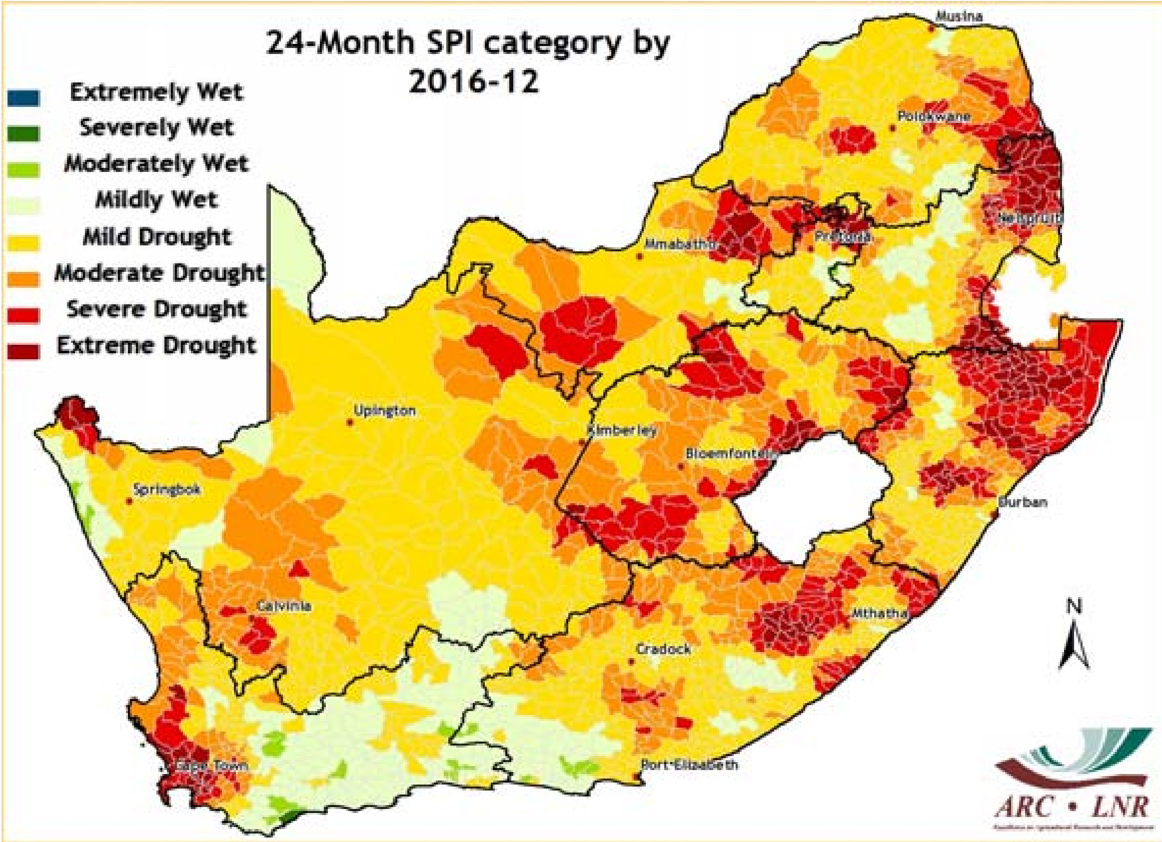

Figure 8

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.

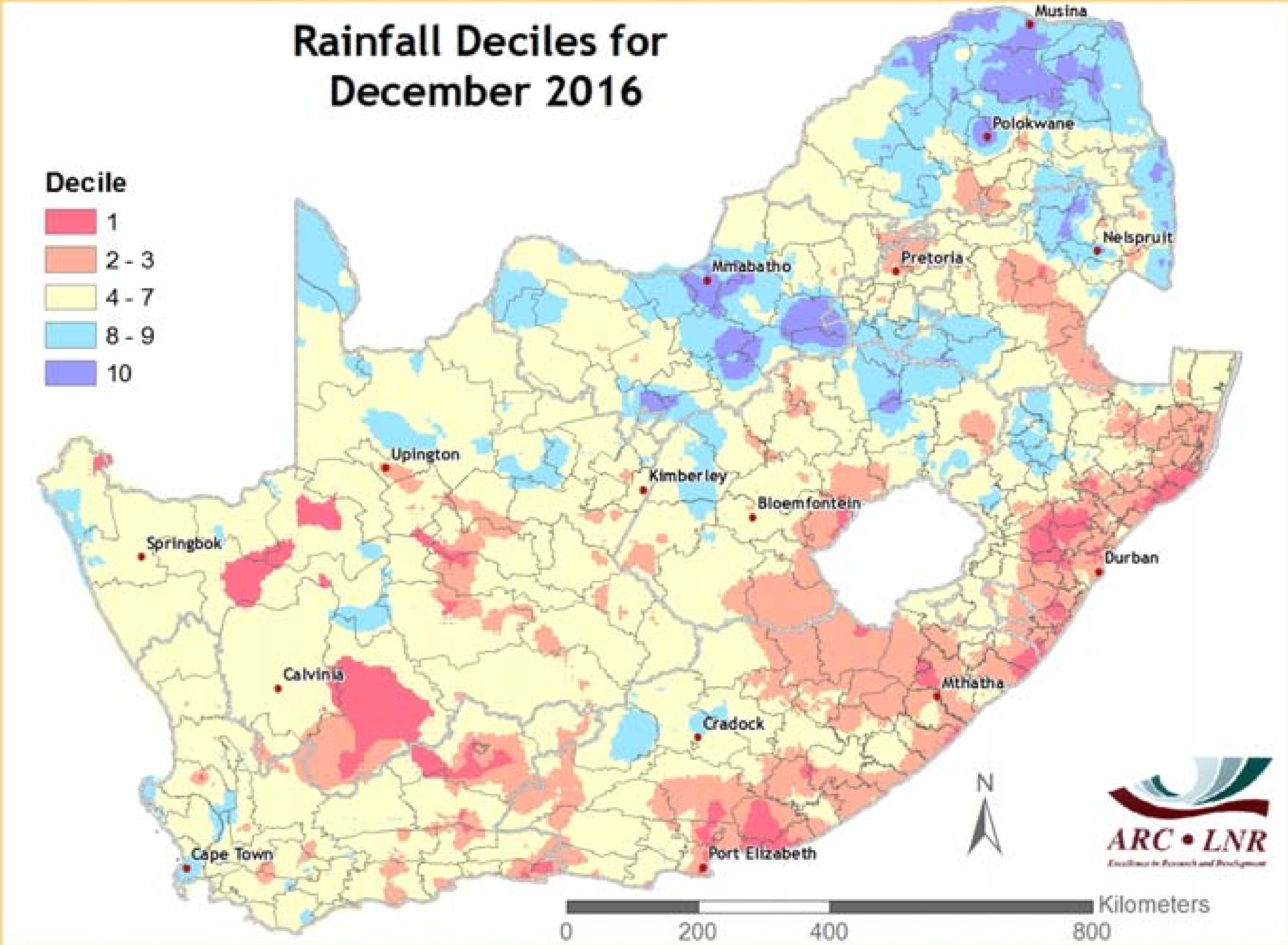

Figure 9

Figure 9:
Parts of North West and Limpopo were exceptionally wet during December while some parts of the coastal region in the south-east and east, together with isolated areas in the western interior, were exceptionally dry.

Questions/Comments: *JMalherbe@csir.co.za*

4. Water Balance

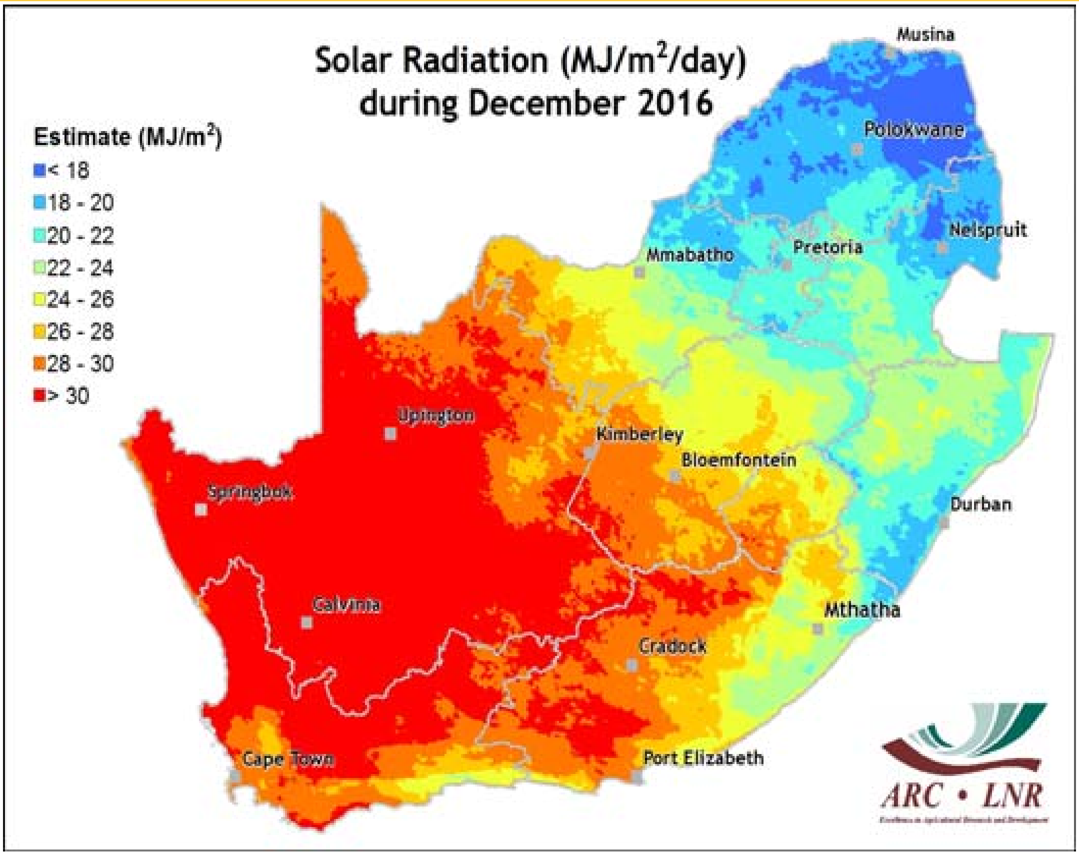

Figure 10

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:
Sunny conditions over much of the western interior during December are reflected in the very high values of average daily solar radiation. Further east and northeast, values were significantly lower due to regular cloud cover there.

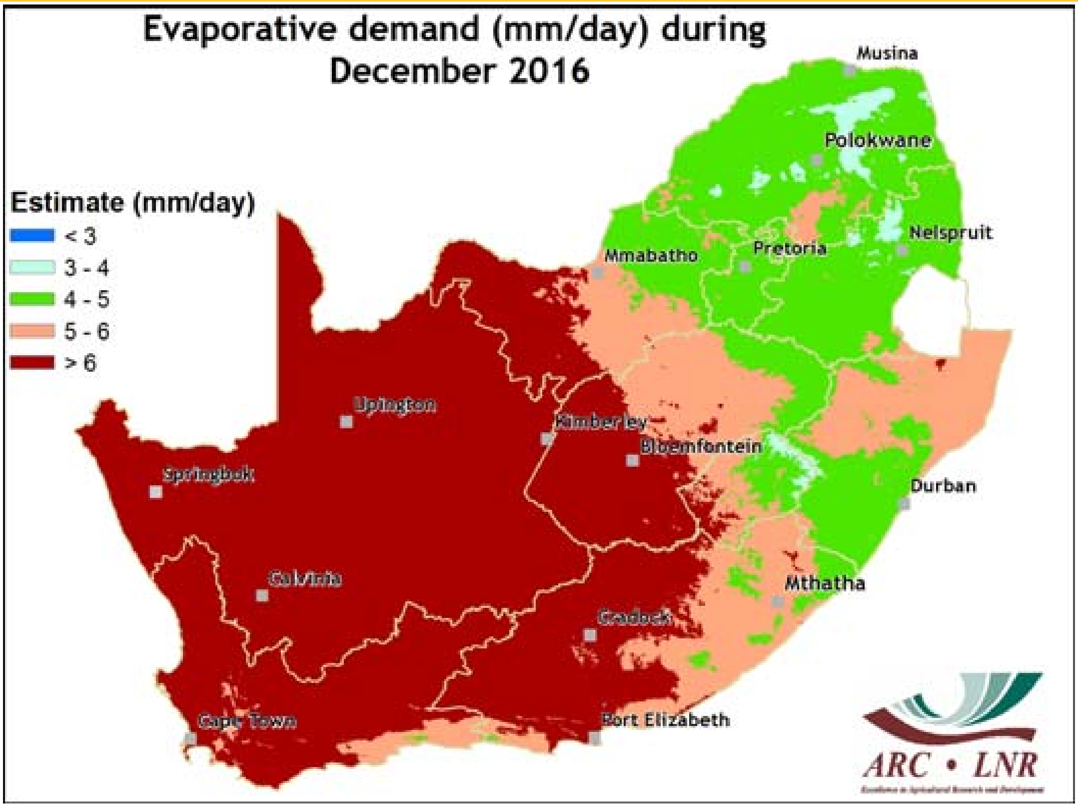

Figure 11

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:
Daily potential evapotranspiration values also increased further with high values over the central to western parts. Values in the northeast were relatively low.

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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.

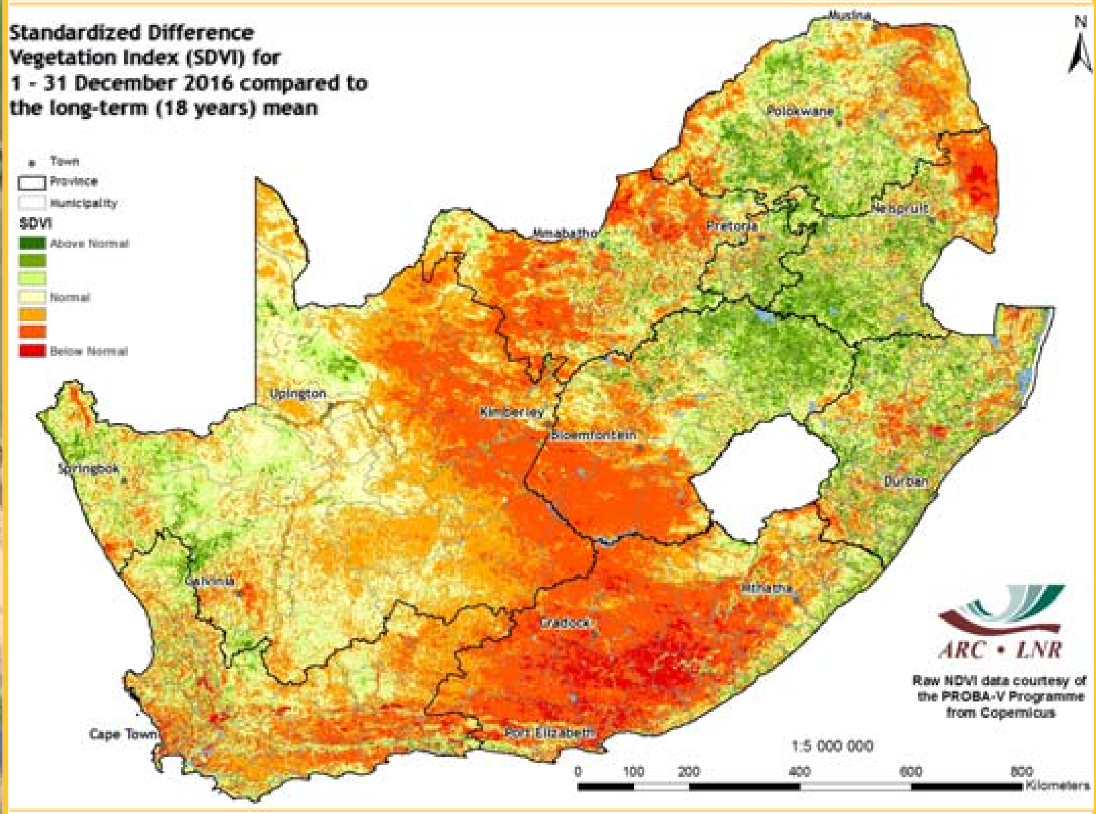

Figure 12

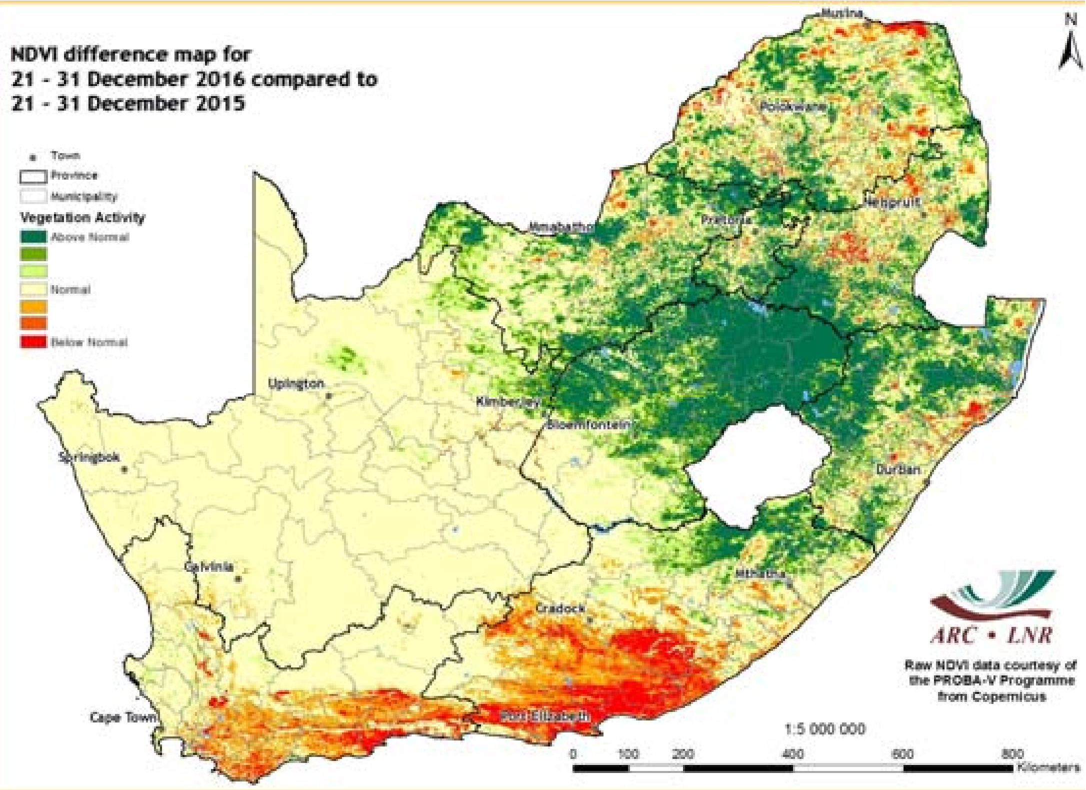

Figure 13

Figure 12:
Vegetation activity during December was above normal over the interior to the northern parts of the summer rainfall regions. Negative anomalies continued to increase in a diagonal band from western North West towards the Eastern Cape. Vegetation stress was experienced in isolated areas in the north-east, including much of the Lowveld.

Figure 13:
Vegetation activity was higher than in December 2015 over much of the summer rainfall region while the southern parts experienced more vegetation stress than a year before.

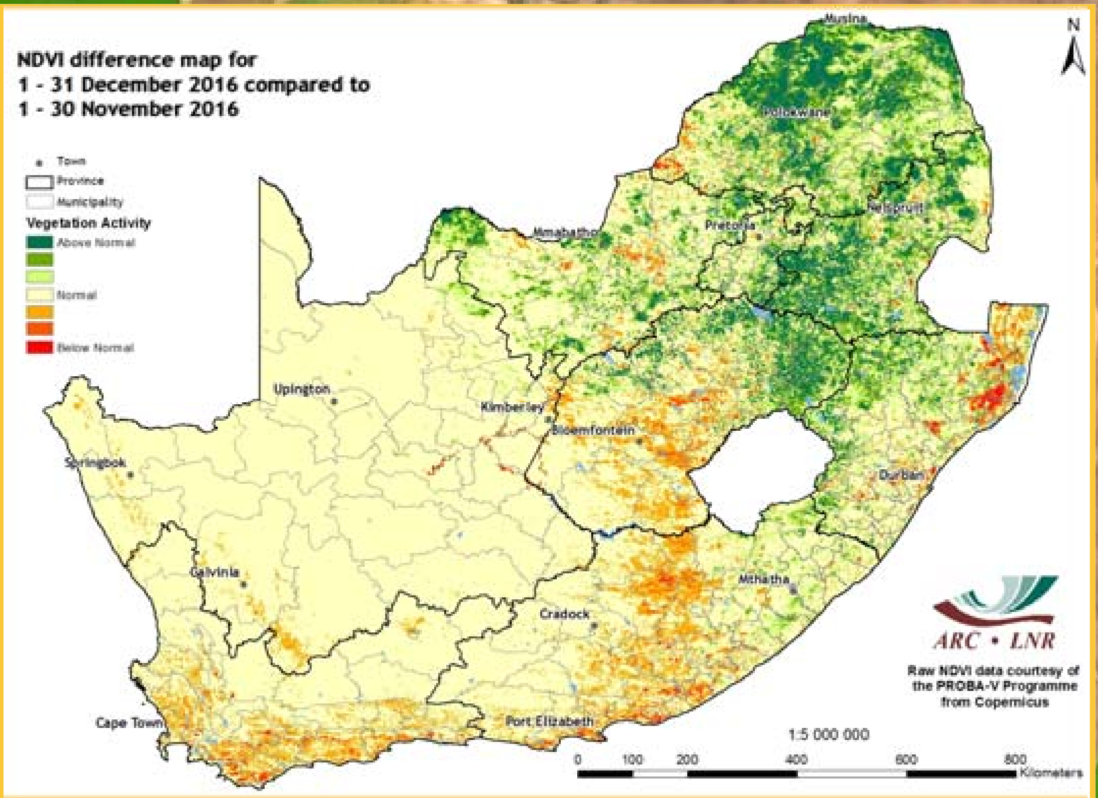

Figure 14

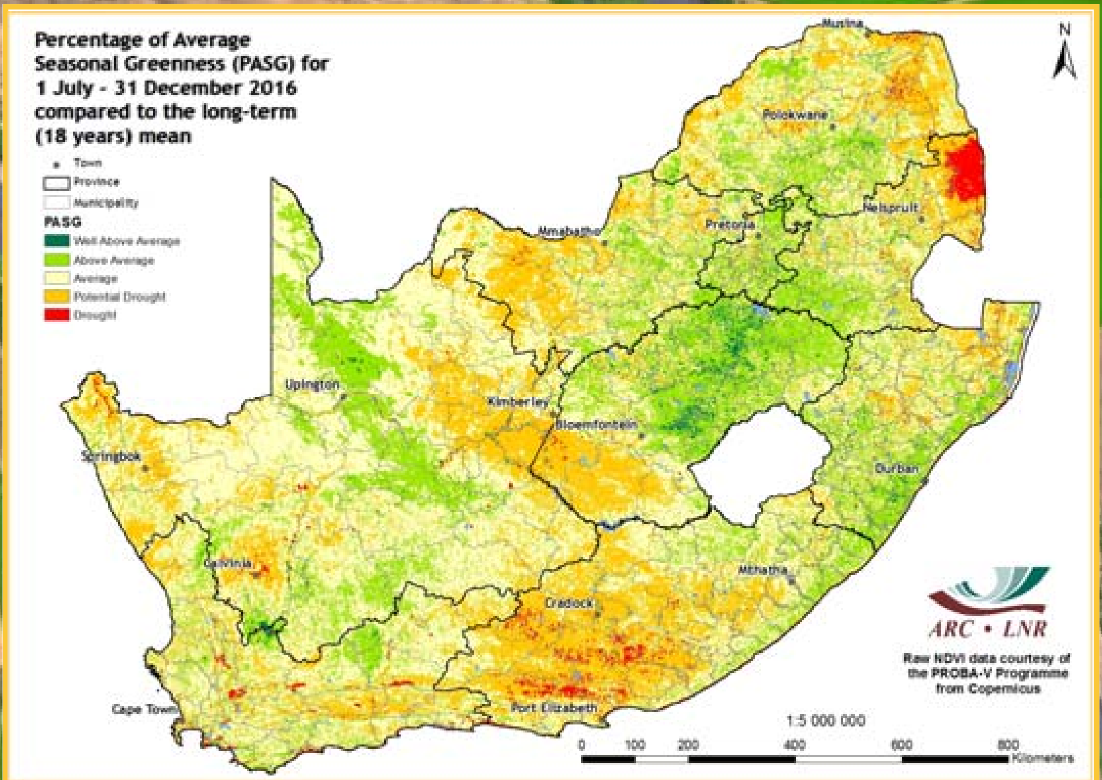

Figure 15

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 decreased over the western parts of the country but increased over much of the north-eastern summer rainfall region.

Figure 15:
The cumulative vegetation activity was above normal over the eastern coastal belt, Highveld and the central part of the Northern Cape. The PASG still indicates drought over parts of the Lowveld by December as well as over some of the central parts of the country.

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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.

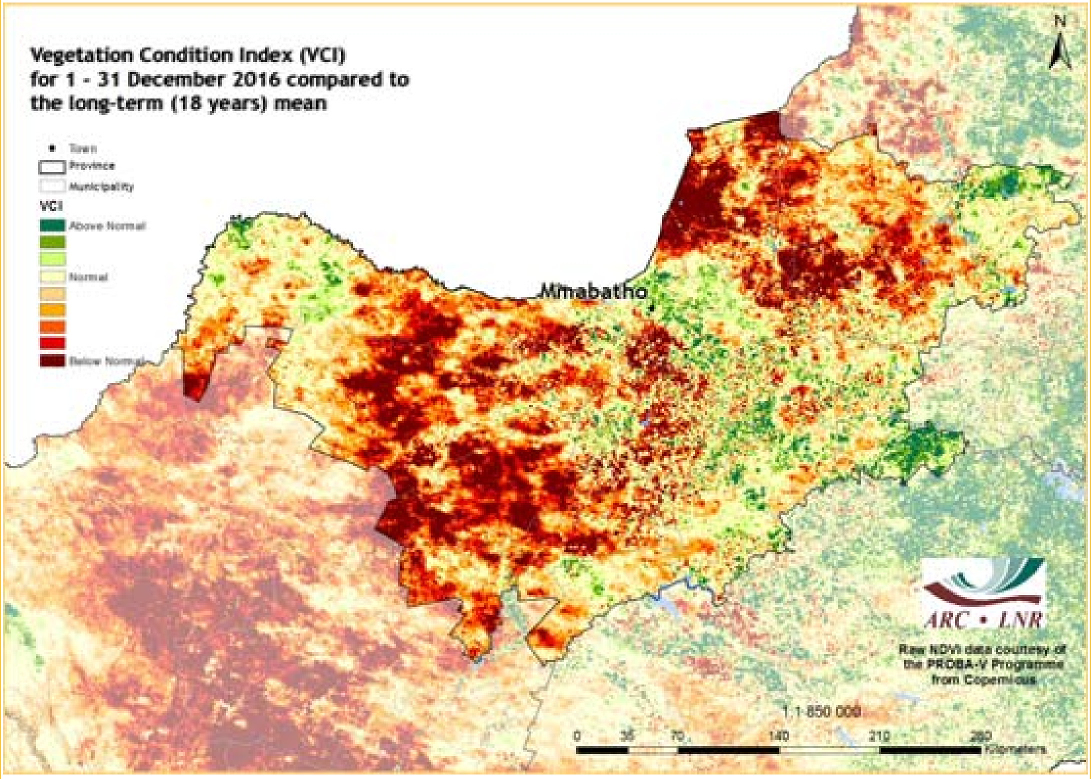


Figure 16

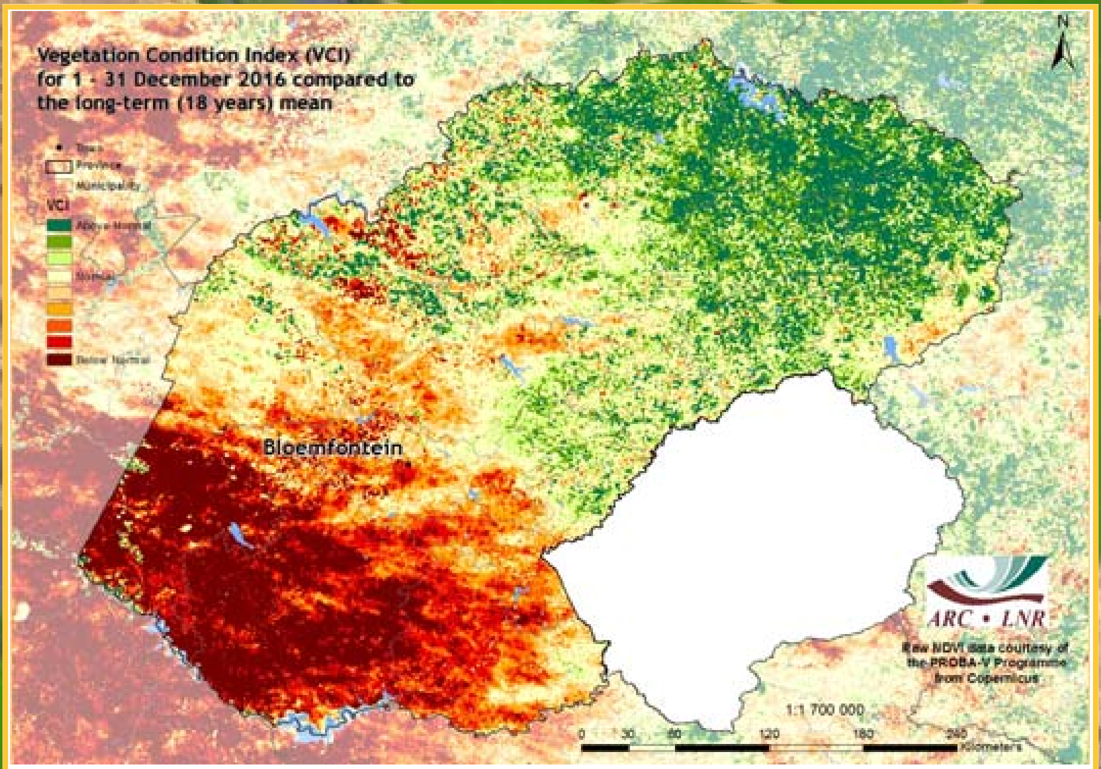


Figure 17

Figure 16:
The VCI map for December indicates below-normal vegetation activity over most of North West except over some of the eastern parts.

Figure 17:
The VCI map for December indicates below-normal vegetation activity over the southwestern parts of the Free State.

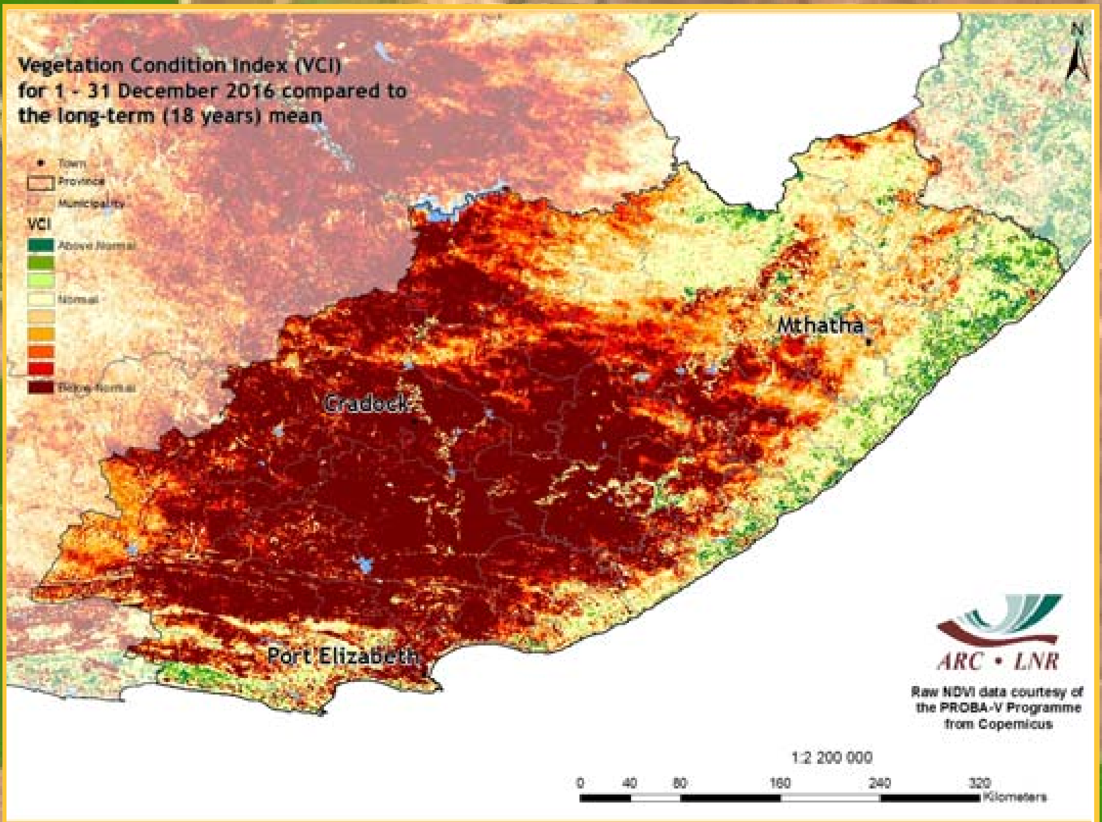


Figure 18

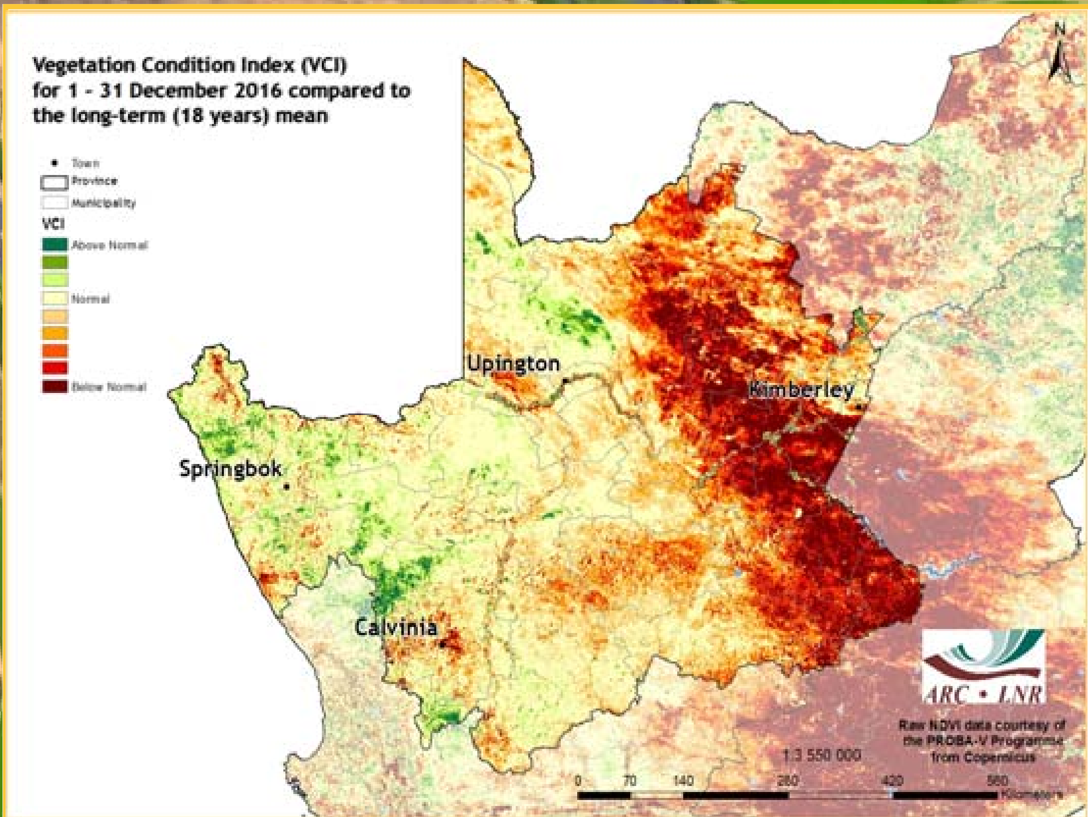


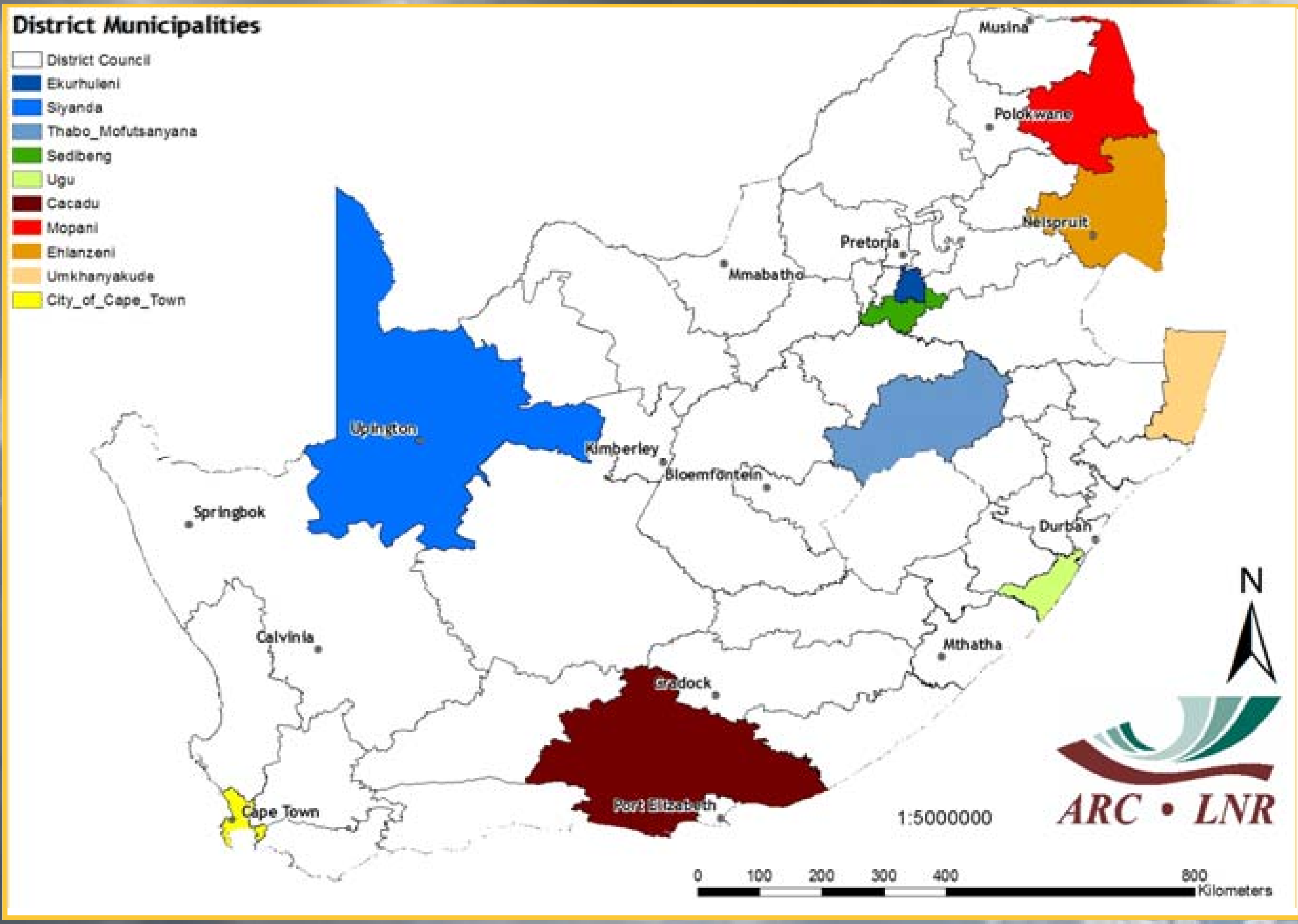
Figure 19

Figure 18:
The VCI map for December indicates below-normal vegetation activity over the central to western parts of the Eastern Cape.

Figure 19:
The VCI map for December indicates below-normal vegetation activity over the eastern parts of the Northern Cape.

Questions/Comments:
NkambuleV@arc.agric.za

7. Vegetation Conditions & Rainfall



NDVI and Rainfall Graphs
Figure 20:
Orientation map showing the areas of interest for December 2016. The district colour matches the border of the corresponding graph.

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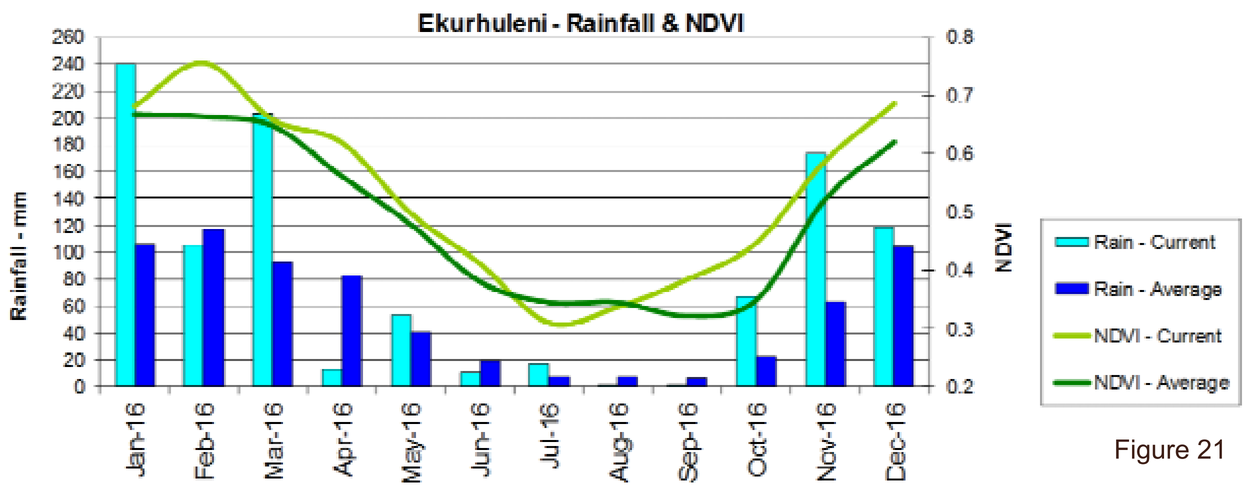
Figures 21-25:
Indicate areas with higher cumulative vegetation activity for the last year.

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



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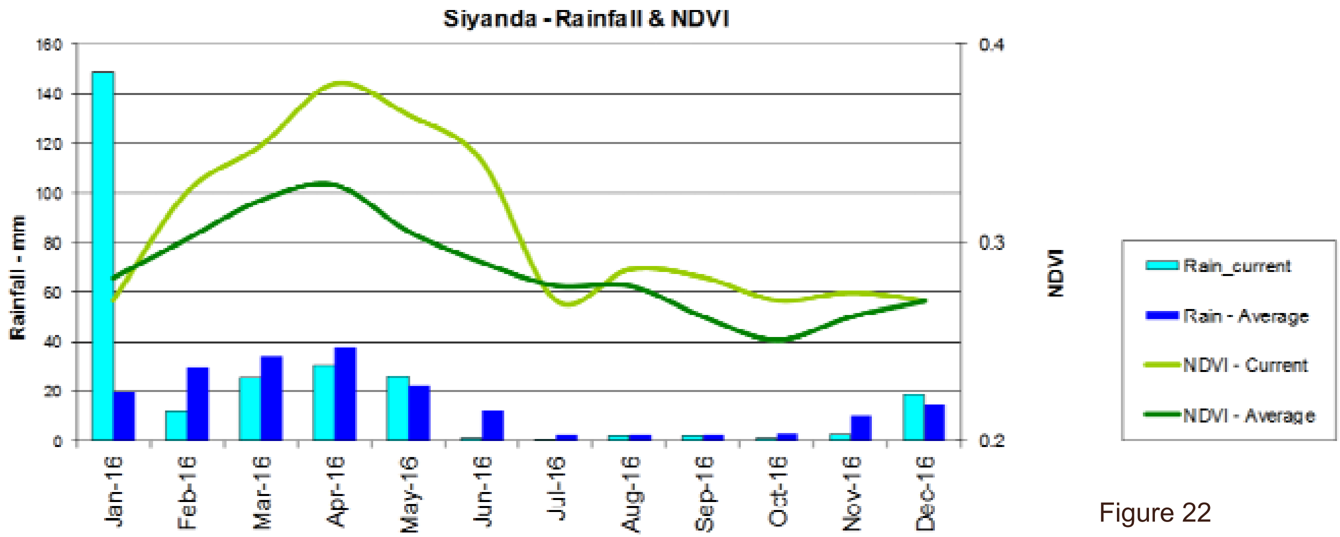

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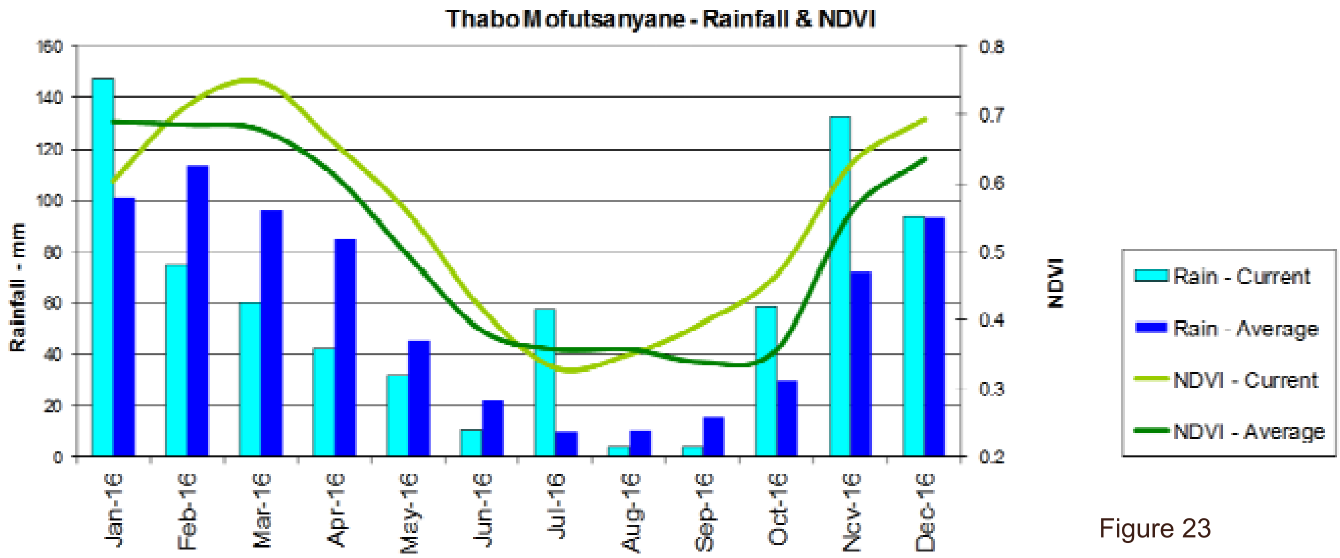

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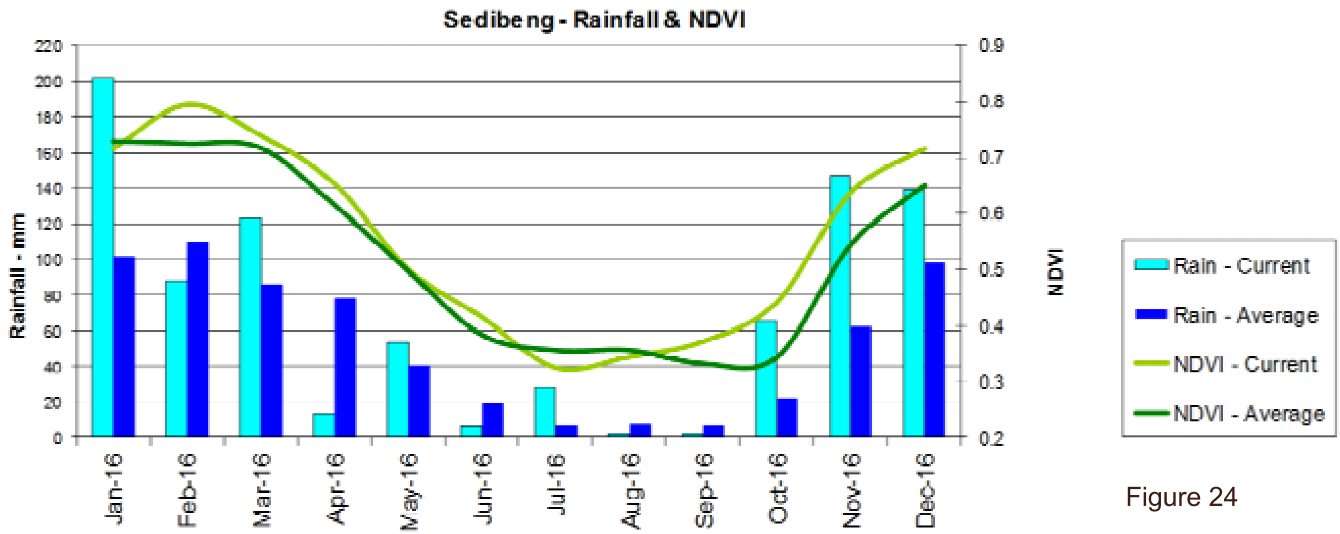

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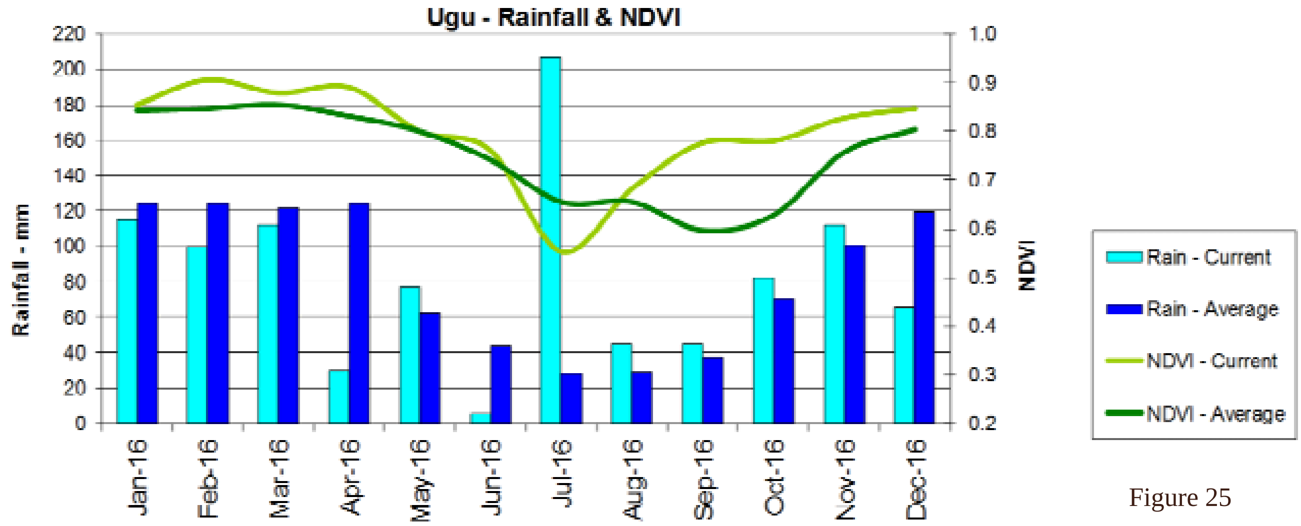

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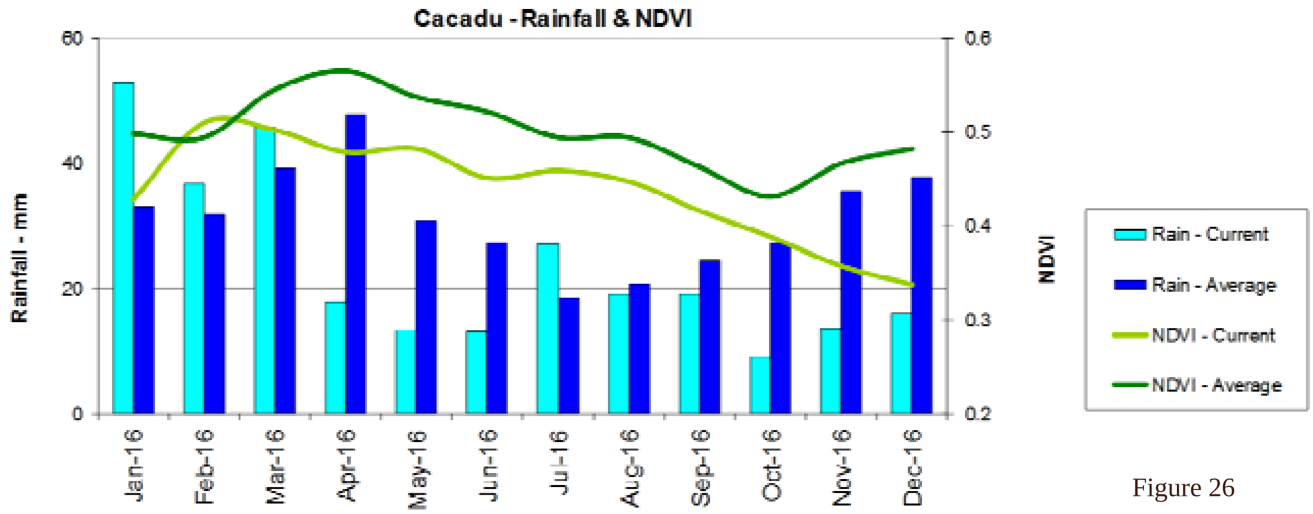

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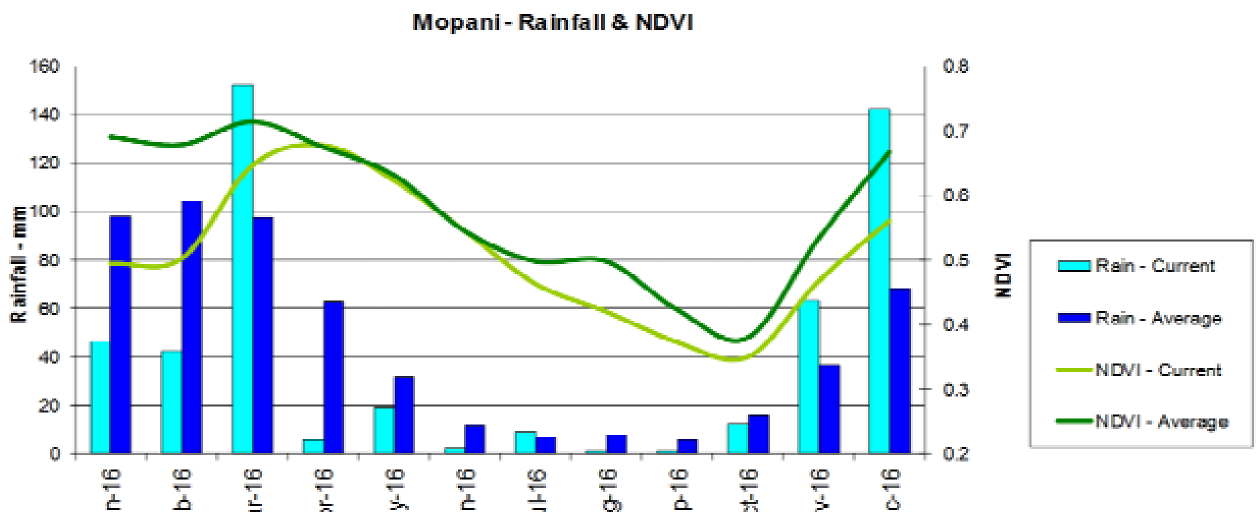

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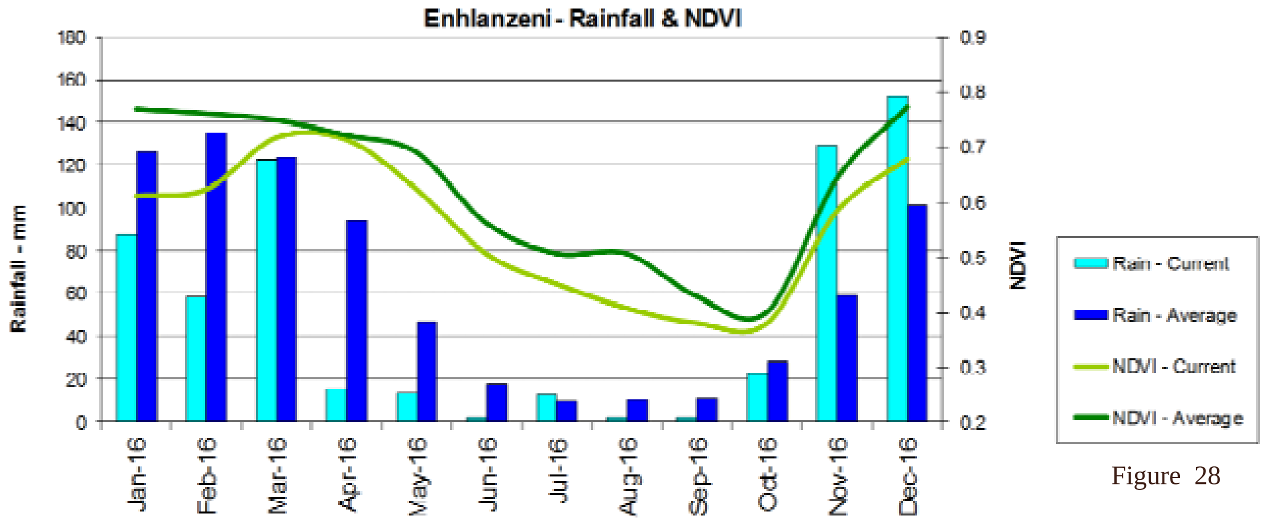

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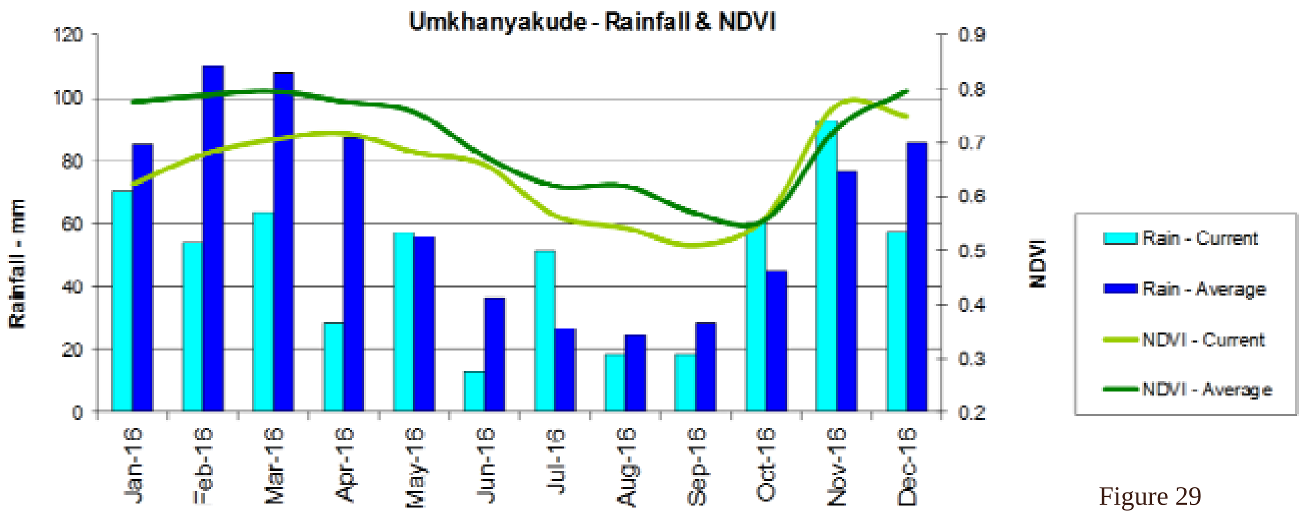

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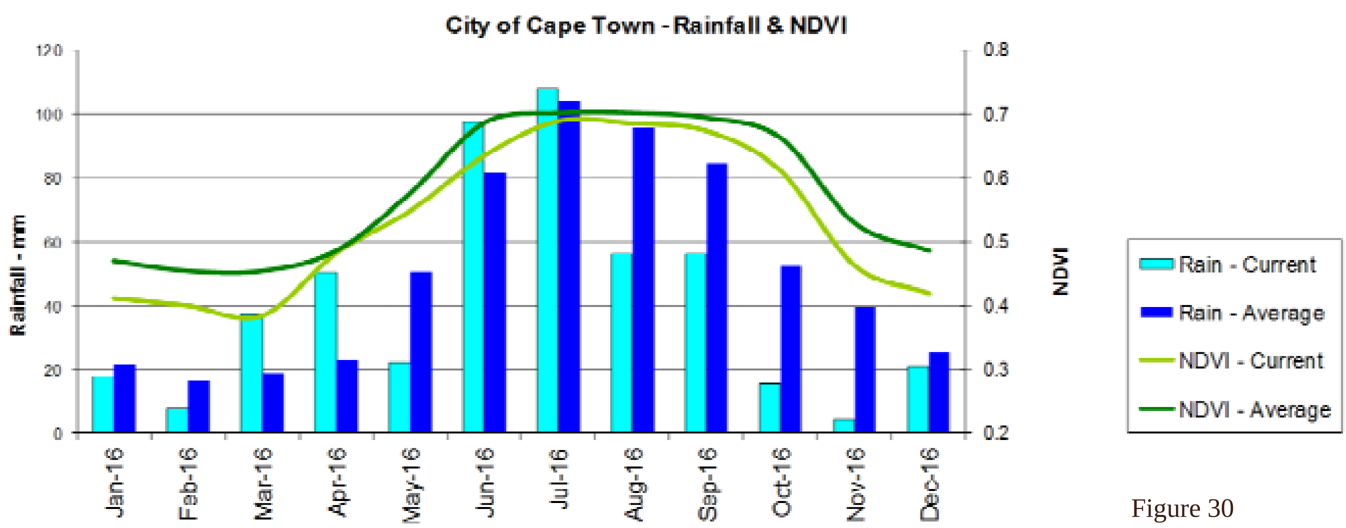

Figure 30

8. Soil Moisture

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 December 2016. 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 December and November with brown colours showing the drier and green colours the wetter areas. Similarly, the year-on-year SSI difference for December is shown in Figure 33.

The year-on-year and month-on-month SSI differences are in agreement with rainfall and vegetation trends observed 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.

Questions/Comments:
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UNIVERSITY OF KWAZULU-NATAL

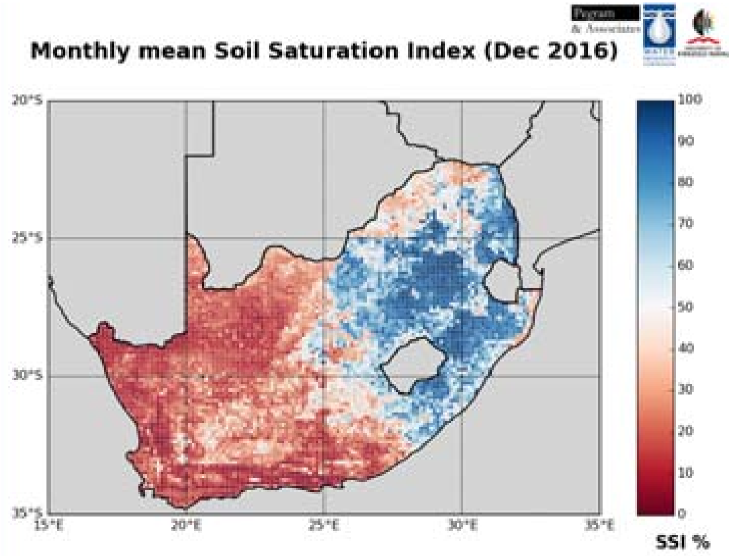

Figure 31

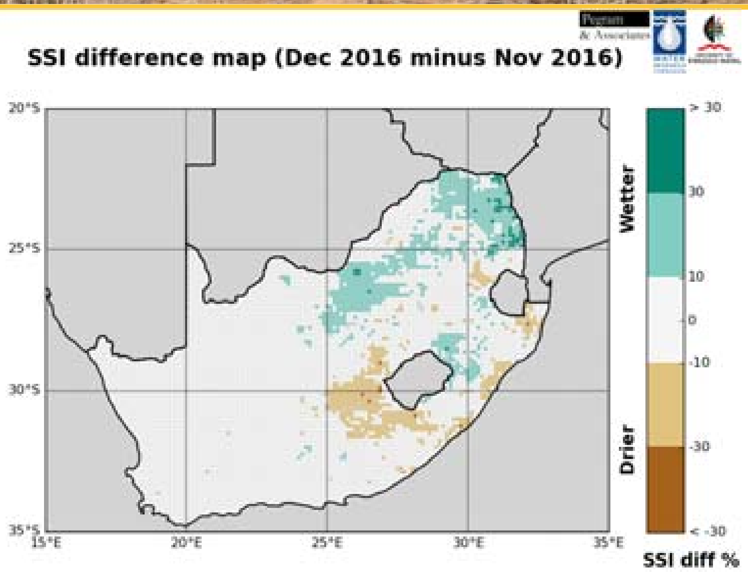

Figure 32

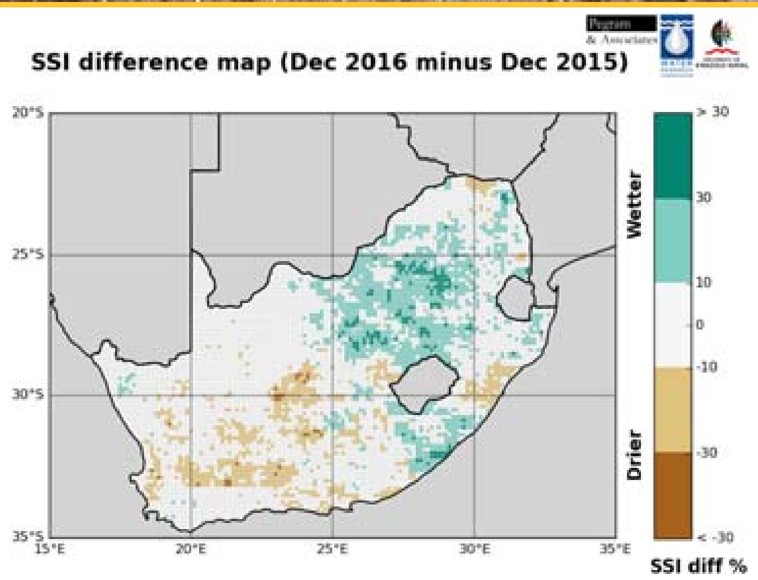

Figure 33

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 December per province. Fire activity was higher in Eastern Cape, Gauteng, Northern Cape, Limpopo, Western Cape and KwaZulu-Natal compared to the average during the same peri-

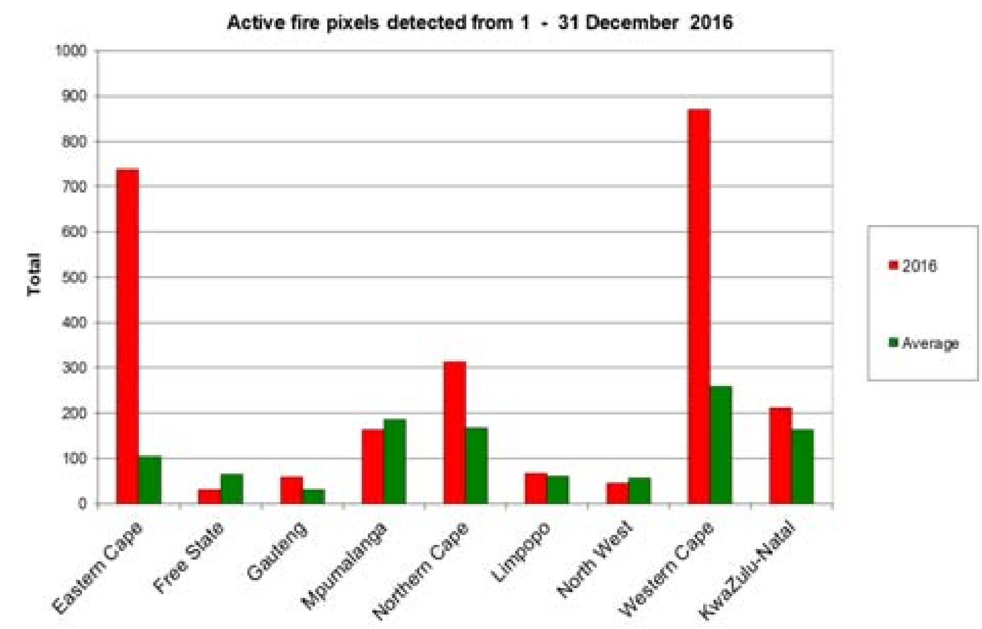

Figure 34

Figure 35:
The map shows the location of active fires detected between 1– 31 December 2016.

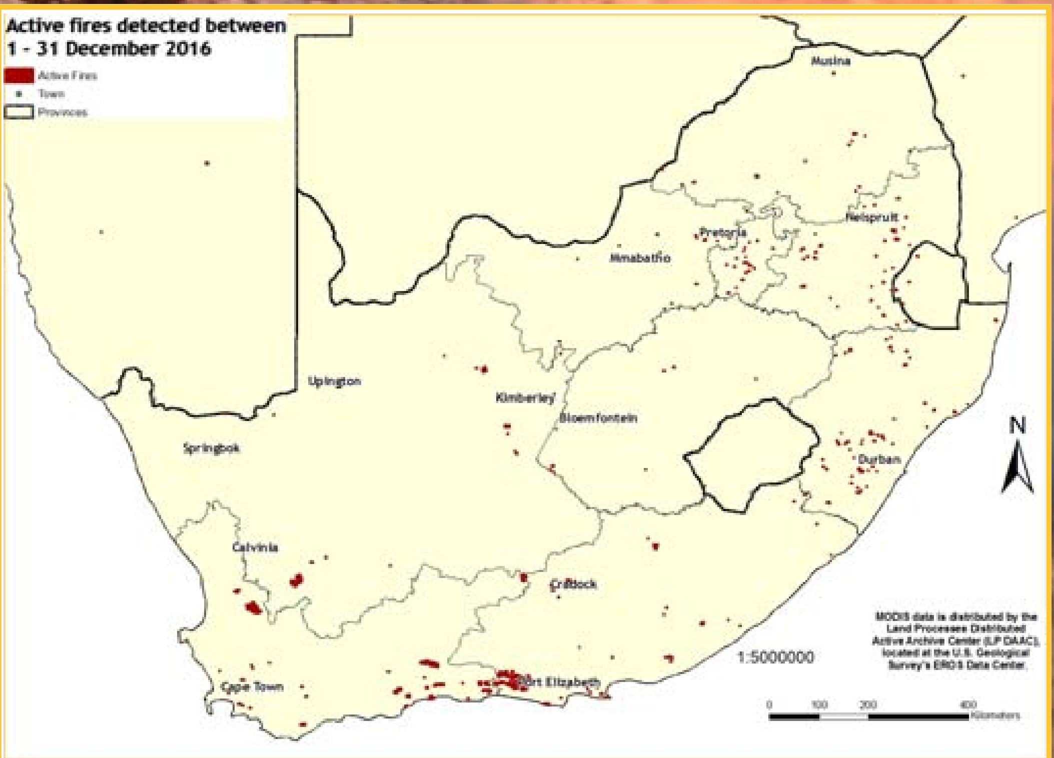

Figure 35

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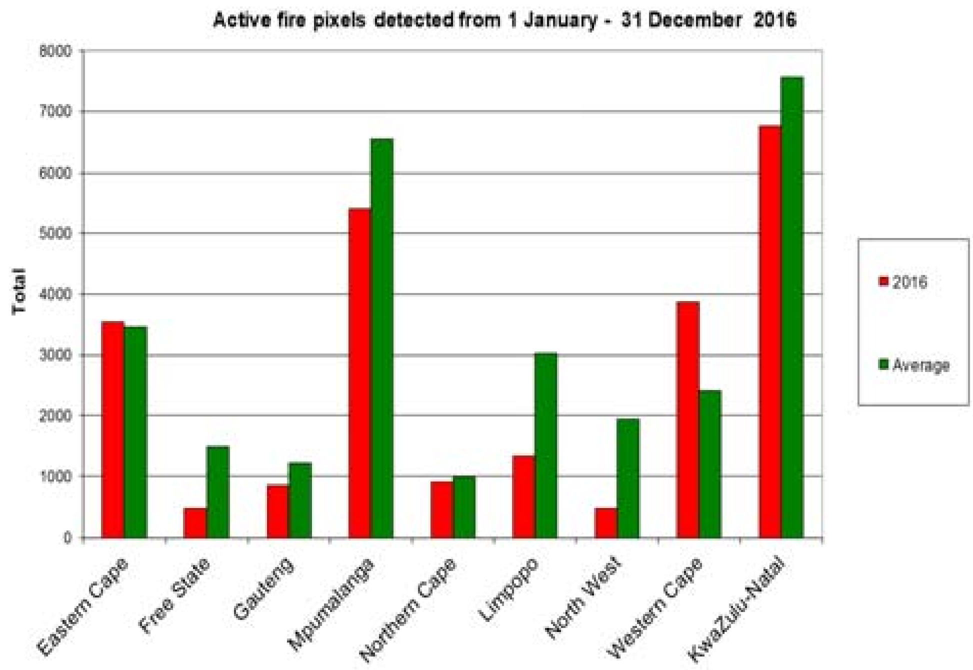

Figure 36

Figure 36:
The graph shows the total number of active fires detected from 1 January - 31 December 2016 per province. Fire activity was higher in Eastern Cape and Western Cape compared to the average during the same

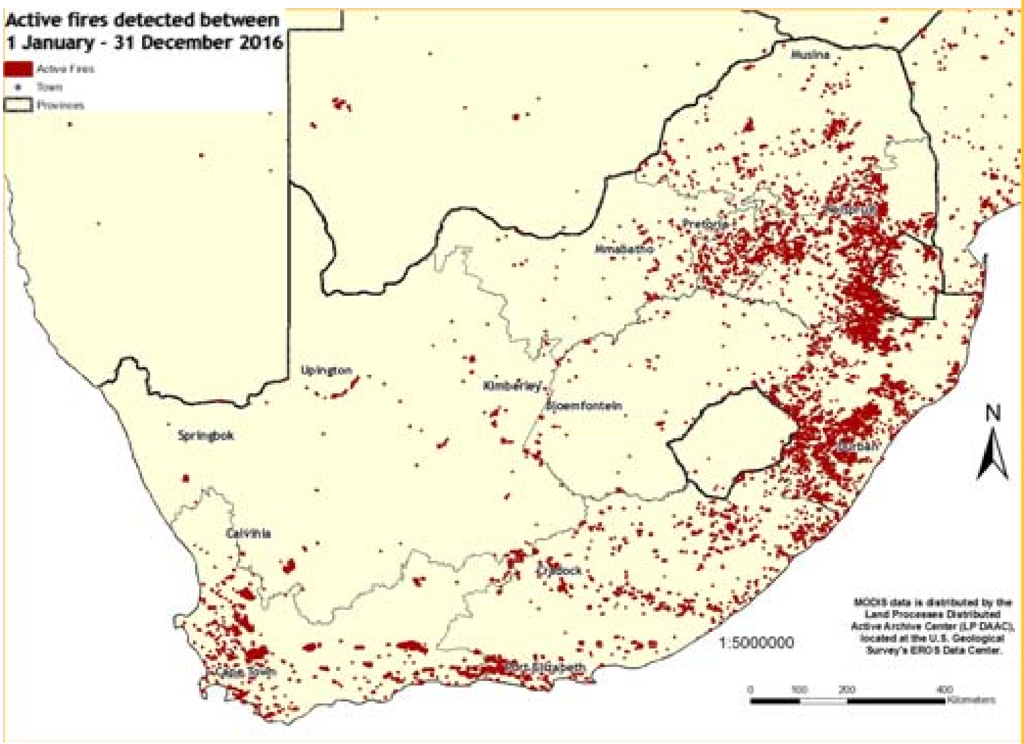

Figure 37

Figure 37:
The map shows the location of active fires detected between 1 January - 31 December 2016.

Questions/Comments:
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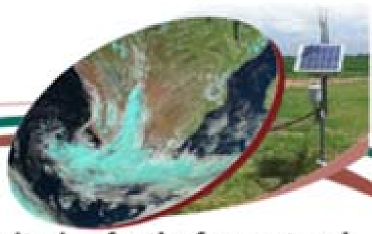
Agrometeorology



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The programme focuses on the use of weather and climate information and monitoring for the forecast and prediction of the weather elements that have direct relevance on agricultural planning and the protection of crop, forest and livestock. The Agro-Climate Network & Databank is maintained as a national asset.

FOCUS AREAS

Climate Monitoring, Analysis & Modelling

- Analysis of climate variability and climate model simulation
- Use of crop modelling to assess the impact of climate on agriculture
- Development of decision support tools for farmers

Climate Change Adaptation & Mitigation

- National greenhouse gas inventory in the agricultural sector
- Improvement of agricultural production technologies under climate change
- Adaptation and mitigation initiatives, e.g. biogas production in small-scale farming communities

Climate Information Dissemination

- Communication to farmers for alleviating weather-related disasters such as droughts
- Dissemination of information collected from weather stations
- Climate change awareness campaigns in farming communities

Contact Person:
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Geoinformation Science

ARC • LNR

The programme focuses on applied Geographical Information Systems (GIS) and Earth Observation (EO)/Remote Sensing research and provides leadership in applied GIS products, solutions, and decision support systems for agriculture and natural resources management. The Coarse Resolution Satellite Image Archive and Information Database is maintained as a national asset.

FOCUS AREAS

Decision Support Systems

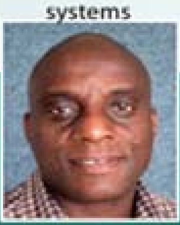
- Spatially explicit information dissemination systems, e.g. Umlindi newsletter
- Crop and land suitability modelling/assessments
- Disease and pest outbreaks and distribution modelling
- Precision agriculture information systems

Early Warning & Food Security

- Drought and vegetation production monitoring
- Crop estimates and yield modelling
- Animal biomass and grazing capacity mapping
- Global and local agricultural outlook forecasts
- Disaster monitoring for agricultural systems

Natural Resources Monitoring

- Land use/cover mapping
- Invasive species distribution
- Applications of GIS and EO on land degradation/erosion, desertification, hydrology and catchment areas
- Rangeland health assessments
- Carbon inventory monitoring



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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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Excellence in Agricultural Research and Development

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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 at its inception through LEAD funding from the Department of Science and Technology.

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What does Umlindi mean?
UMLINDI is the Zulu word for “the watchman”.

http://www.agis.agric.za