Ensemble forecasting at SAWS

RESEARCH AND DEVELOPMENT DEPARTMENT

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❑ Introduction

- ❖ SAWS produce daily weather forecasts to safeguard the nation from weather disasters as tasked by the SA government;
- ❖ Disasters includes: heavy rainfall, thunderstorms, floods, tropical cyclones and heatwaves.
- ❖ SAWS run a numerical weather prediction (NWP) model operationally to support the weather forecasters.
- ❖ However, it is well-known that NWP is a initial value problem, and the accuracy of the forecasts depends on initial conditions, i.e. Giorgi and Bi, 2000
- ❖ To improve numerical forecasts, SAWS applies ensemble forecasts and is implementing data assimilation (DA) to numerical forecasts.
- ❖ In DA, the latest observations are combined with previous forecasts to create an analysis (Barker et al.,2004; Barker et al.,2012; Clayton et al., 2013; Rabier, F., 2006)
- ❖ SAWS aims to apply convective-scale DA to improve forecast quality relative to Global and downscaler forecasts, over a lead time of 6-18 hours
- ❖ The DA process is applied in many meteorological centres, i.e. United Kingdom's Met Office (UKMO) Lorenc and Jardak, 2018), Meteo-France (Seity et al., 2011; Auger et al., 2015) and others
- ❖ Either 3-dimensional (3DVAR) or 4-dimensional (4DVAR) system will be applied.

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❑ Data and Methodology

- ❖ SAWS applies the Unified Model, developed by the UKMO for daily NWP purpose.
- ❖ The UM is a fully non-hydrostatic model, the UM version 11.4 is applied and is configured to run operationally as a regional model

- ❖ The UM is firstly run for the SADC:
  - ➢ horizontal resolution of 4.4 km,
  - ➢ stretches north-south (0^0 to 38^0S);
  - ➢ stretches west-east (50^0E to 54^0E).

- ❖ The UM is secondly run for the SA:
  - ➢ horizontal resolution of 1.5 km,
  - ➢ stretches north-south (20^0S to 36^0S);
  - ➢ stretches west-east (15^0E to 34^0E)

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❑ Data and Methodology

- ❖ **For the two UM deterministic downscalers, initial (IC) and boundary conditions (LBC) are obtained from the 10 km Global Atmosphere (GA) model,**
  - ➢ **IC and LBC's provided four times daily (00Z, 06Z, 12Z and 18Z) from the UKMO data server.**
  - ➢ **The GA forecasts support several regional models within the UM partnership.**

- ❖ **The SAWS UM convection permitting ensemble prediction system (CSEPS) has a horizontal resolution of 4.5 km,**
  - ➢ **Covers the SA domain and consist of 18 members.**
  - ➢ **This system runs with IC's and LBC's from the UKMO global ensemble prediction system (MOGREPS-G) (Hagelin et al., 2017)**

- ❖ **Also a multi-model ensemble (MMENS) prediction system was developed with a domain covering the SADC region (similar to the 4.4 km UM downscale).**

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❑ Data and Methodology

- ❖ **The system combines forecasts from different global and regional model configurations:**
  - ➢ **SAWS-SADC configuration (4.4 km),**
  - ➢ **German Weather Service's (DWD) ICON (13 km),**
  - ➢ **NCEP Global Forecast System (GFS, 25 km) and**
  - ➢ **UKMO Global Atmosphere (GA, 10km).**

- ❖ **All four ensemble members are rescaled to a corresponding horizontal resolution of 6 km.**
- ❖ **To achieve an ensemble size of 12 members, a pseudo-ensemble method (Theis et al., 2005) is performed on each model to obtain six additional members.**
- ❖ **The MMENS produces forecasts with a lead time of 48 hours once a day at 00Z.**

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❑ Results

- ❖ We present the results for the case studies from:
  - (i) deterministic downscaler forecasts,
  - (ii) SAWS multi-model ensemble forecasts and
  - (iii) CSEPS forecasts.

- ❖ A case study of a tornado event over the Kwazulu-Natal Province of South Africa.
- ❖ Tornado occurrences are common over the north-eastern parts of South Africa/highveld, with an average of 7 events per year.
- ❖ During November 2019, three tornado events (12, 22 and 23 November) occurred over KwaZulu-Natal.
- ❖ The late afternoon tornado event over the town of Hanover on 12 November 2019 is presented here.
- ❖ Two fatalities were reported, including several injuries and damages to houses, trees and vehicles.

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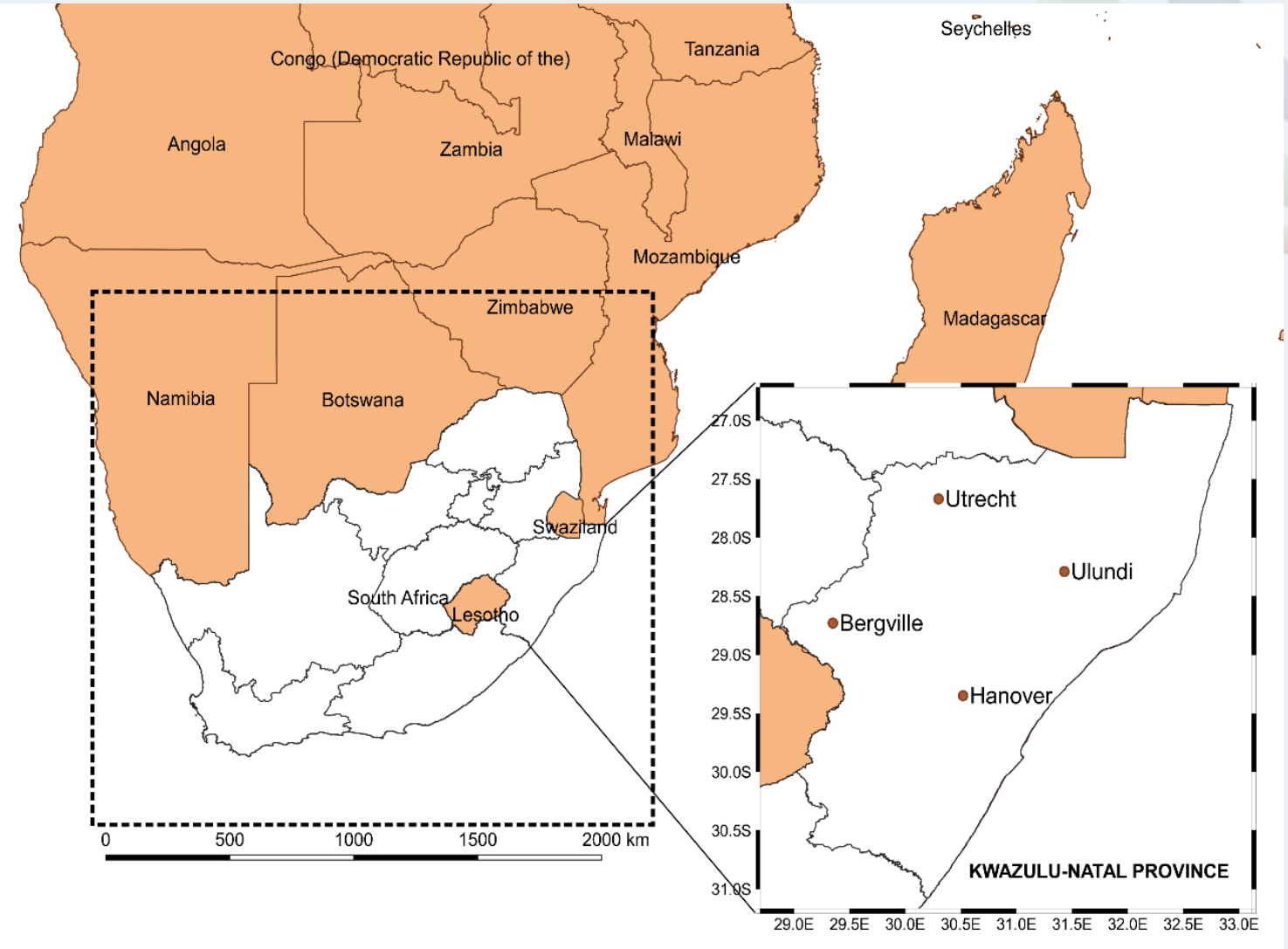
❑ Results



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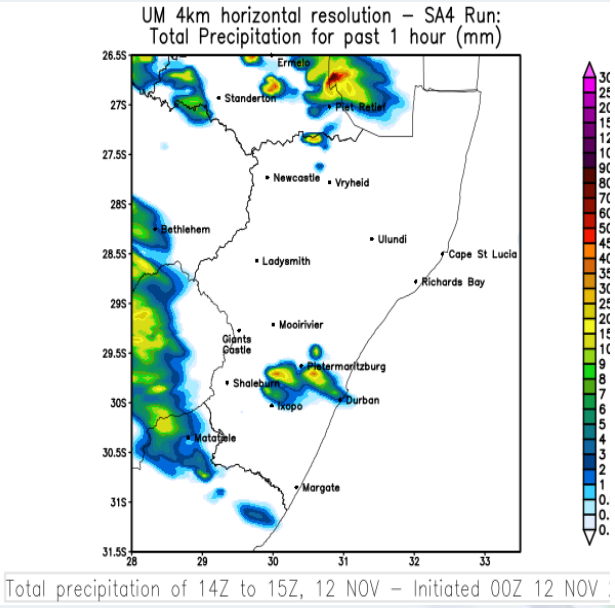
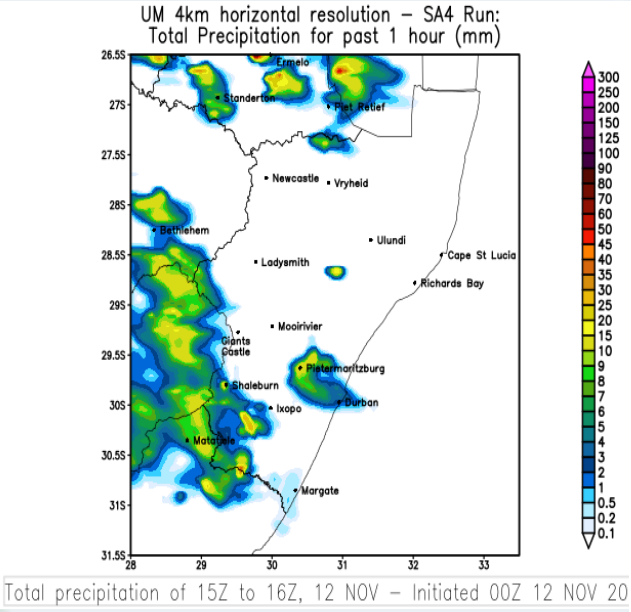
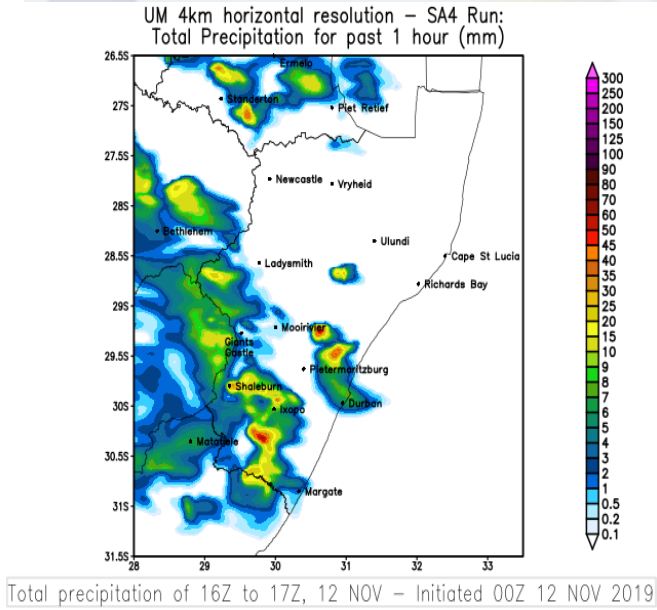
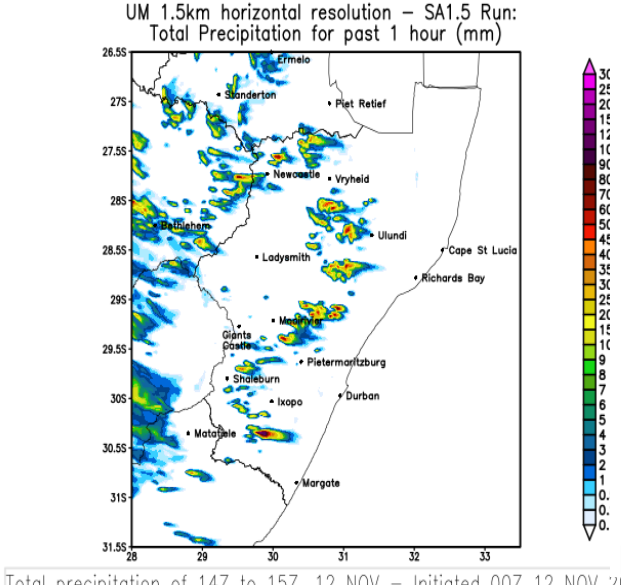
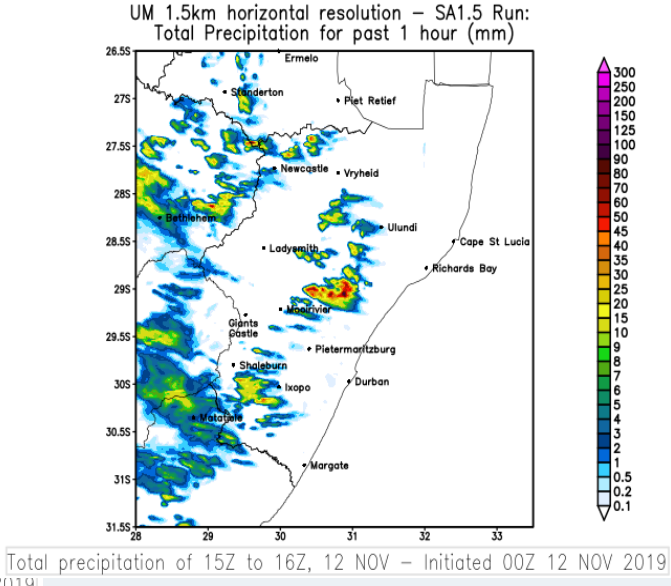
❑ Results: SA Downscalers

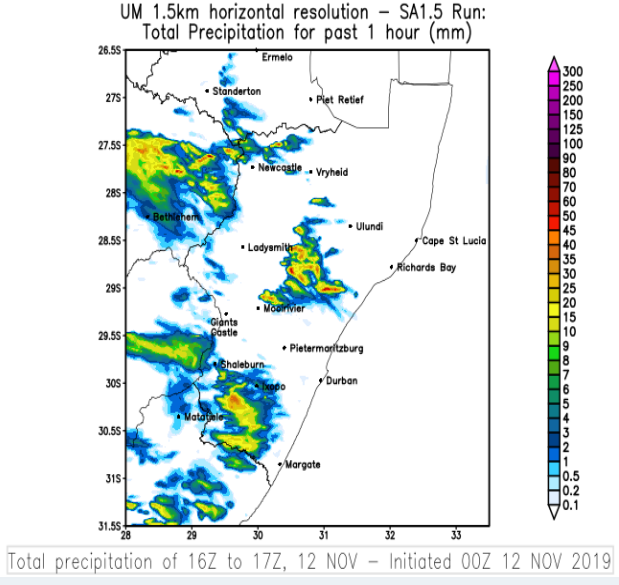












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❑ Results: SA Downscalers

- ❖ The SA 4 downscalers shows better spatial and temporal distribution of rainfall;
- ❖ This is not the case with SA 1.5 although they have better resolution, but it captures the rainfall intensity better than the SA4.
- ❖ However higher resolution provides more information/details

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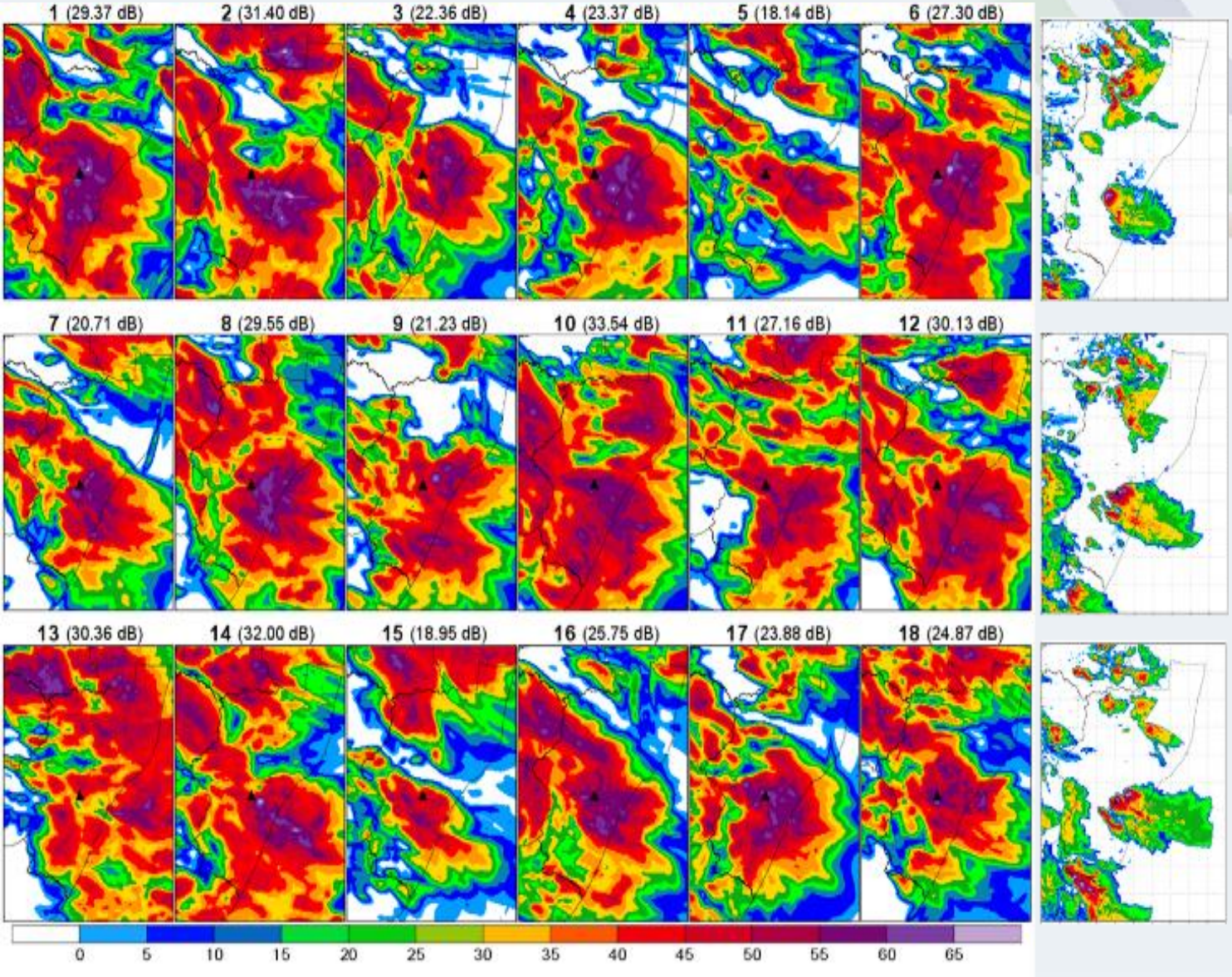
❑ Results

❖ **The CSEPS captured the spatial and temporal observed location of the storm.**



- **Postage stamps of the 18 members from the 18Z, 11 November 2019 forecast for the maximum reflectivity between 15–18 for 12 November 2019.**
- **Maps to the right are the maximum reflectivity observed for 15, 16 and 17Z.**
- **The black triangle is the location of the observed tornado at Hanover.**

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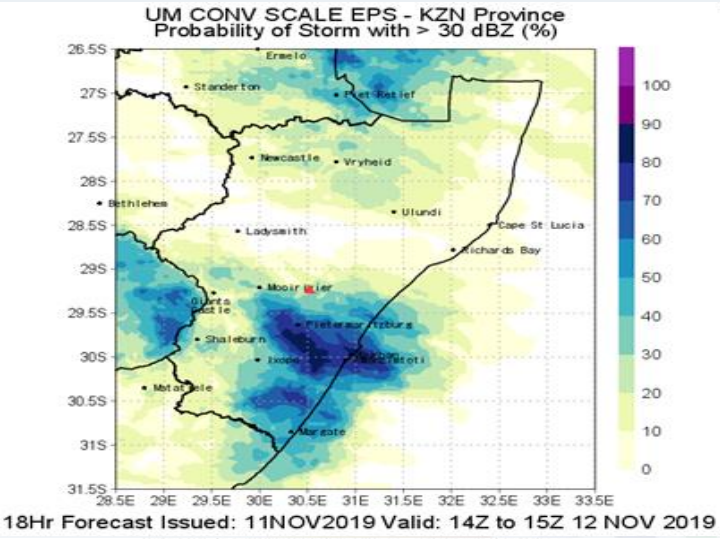
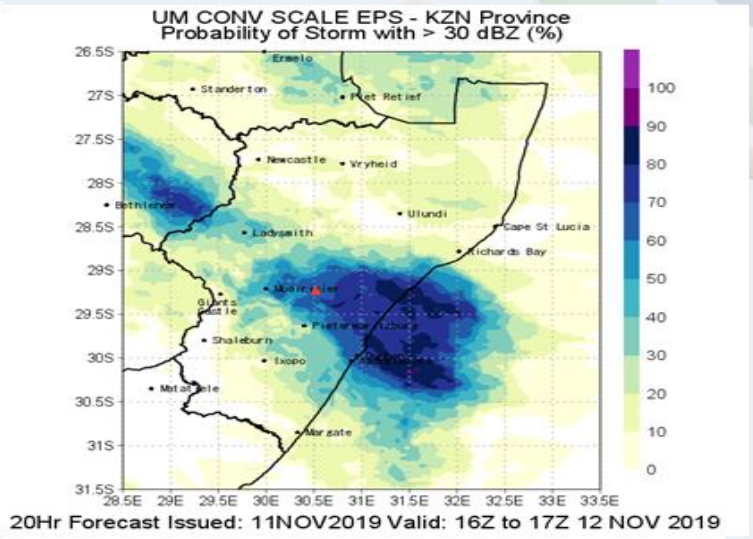
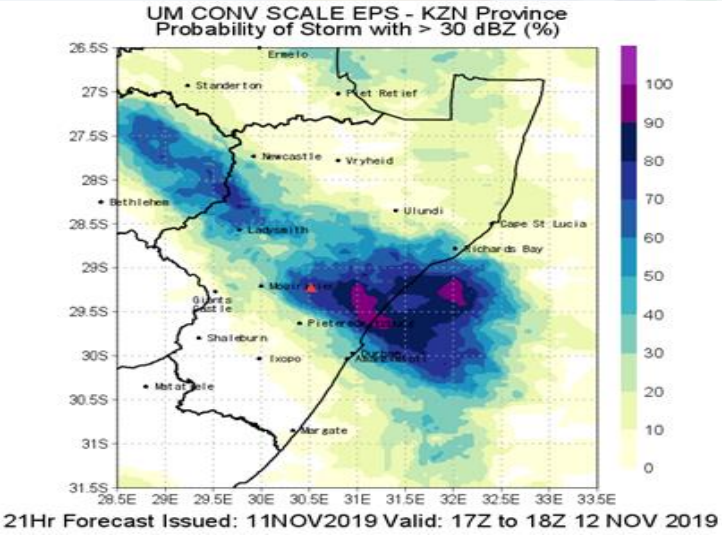
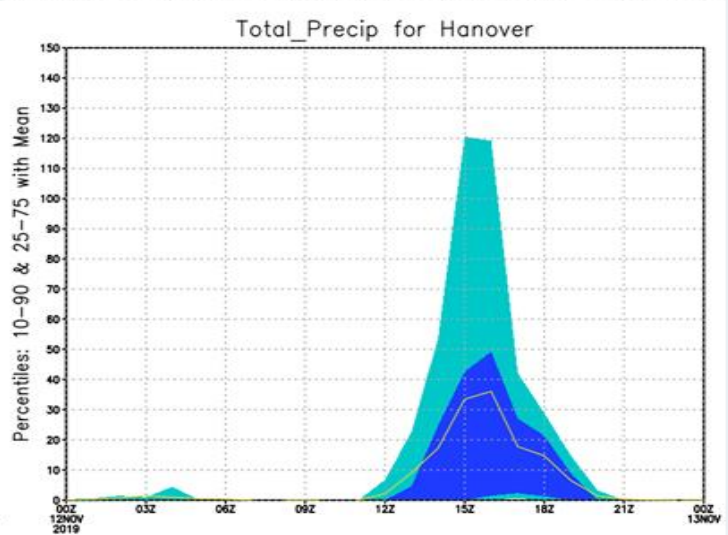
❑ Results

❖ **The probabilistic MMEPS forecast over Kwazulu-Natal also captured the areas of reflectivity higher than 30 dBz and the temporal distribution of wind speed**









- **The three hourly probabilistic forecasts for reflectivity exceeding 30 dBZ.**
- **The last image indicates the spread of the total rainfall for Hanover.**

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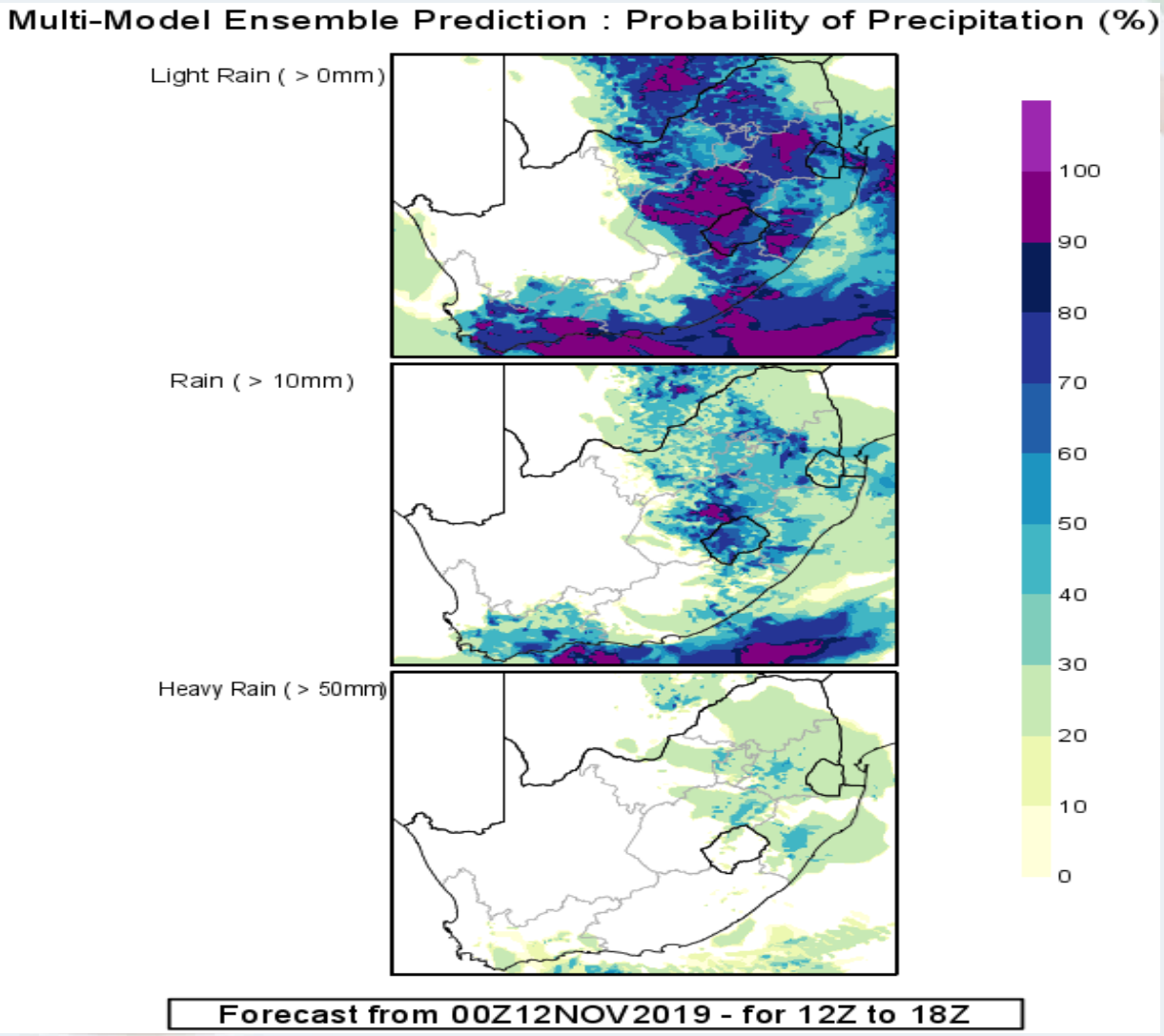
❑ Results

❖ The Multi-Model Ensembles for the 12Nov2019



- Higher probability for light rainfall
- Probability is reduced with increased rainfall intensity
- Better spatial distribution communicated as compared to deterministic downscalers
- More is better than one!!

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❑ SAWS Future DA Plans

- ❖ **SAWS is in the process of implementing the Convective-Scale Data Assimilation Common Test Framework (CSDA-CTF),**
- ❖ **This was originally developed as part of the SINGV project (a collaboration between the Met Office and Meteorological Service Singapore),**
- ❖ **The SINGV project provides UM partners with a portable way to run and validate regional DA configurations.**
- ❖ **A 4.5km resolution 3-hourly cycling 3D-Var configuration of CSDA-CTF has been setup, for research purpose on a CRAY (XC30) machine,**
- ❖ **Will be used to assimilate observations from:**
  - ➢ **The Met Office and**
  - ➢ **Will in future assimilate data from SAWS observation network.**

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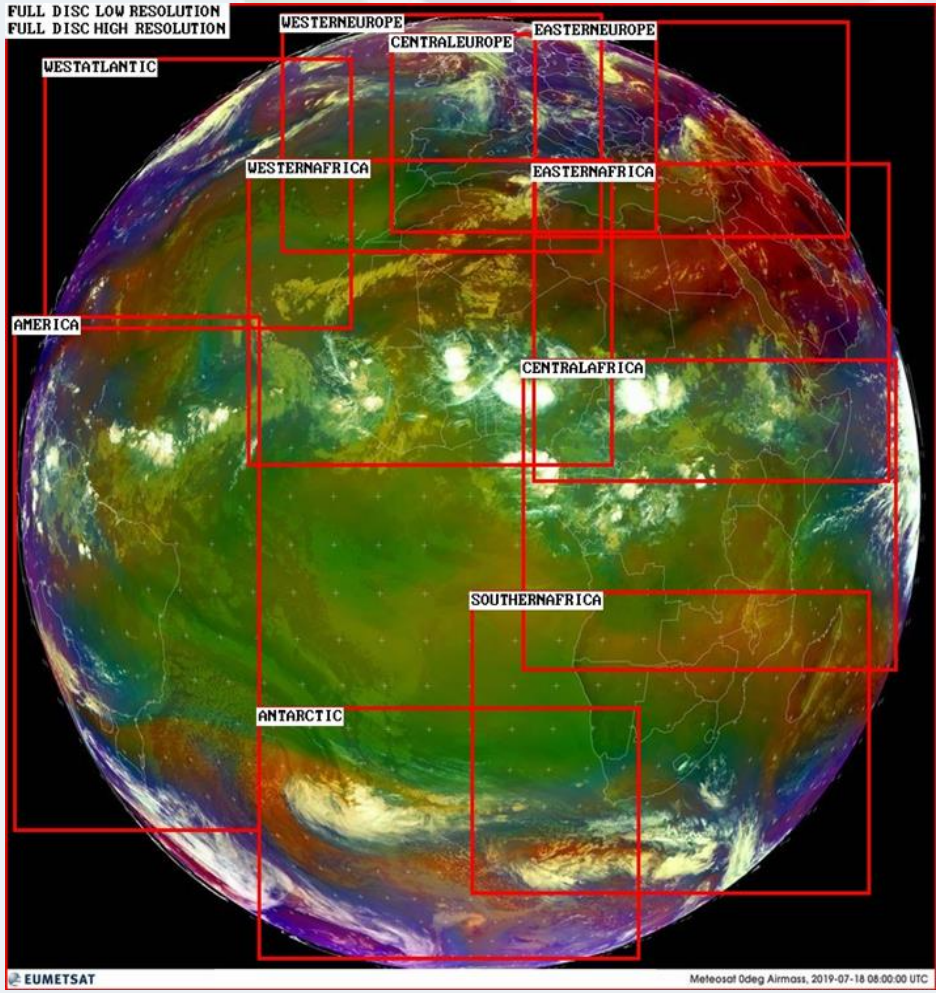
❖*Satellite data*

- ❑ SAWS receives real time satellite images from EUMETSAT every 15 minutes
- ❑ Meteosat Second Generation (MSG) satellite
- ❑ Information for up to 12 channels:
  - ➢ day natural colours
  - ➢ and infra-red imagery



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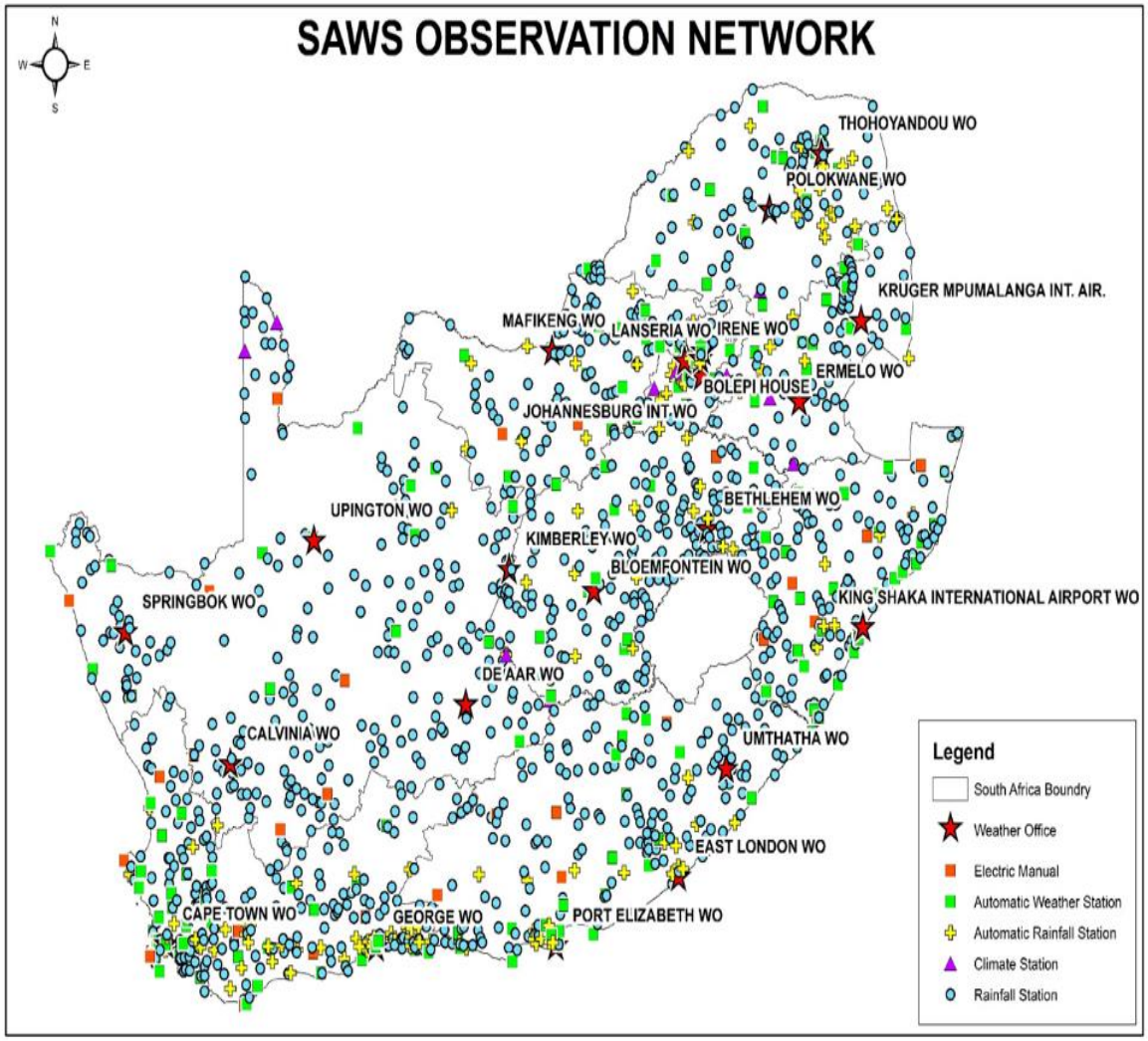
❑ *Surface observations*

- ❖ **SAWS operates a number of surface stations (station id: 68***);**
- ❖ **On average, there are 220 AWS, 151 ARS and 1074 manual rainfall stations,**



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❖ *Upper air soundings*

- ❑ **SAWS operates a limited number of upper air stations:**
  - ➢ **68842-Port Elizabeth,**
  - ➢ **68424-Upington**
  - ➢ **68263-Irene.**
- ❑ **Observations done 00Z and 12Z,**
- ❑ **Vertical levels (850, 700, 500 and 250 hPa) respectively.**
- ❑ **Variables measured include:**
  - ➢ **temperature,**
  - ➢ **dewpoint temperature,**
  - ➢ **pressure,**
  - ➢ **wind speed and direction**

❖ *Solar radiation stations*

- ❑ **SAWS operate a network of 13 solar radiation station:**
- ❑ **Variables measured:**
  - ➢ **global horizontal irradiance (GHI),**
  - ➢ **diffuse solar irradiance (DIF),**
  - ➢ **direct normal irradiance (DNI).**
- ❑ **In De Aar, - baseline solar radiation network (BSRN)- data sent to WMO monthly.**

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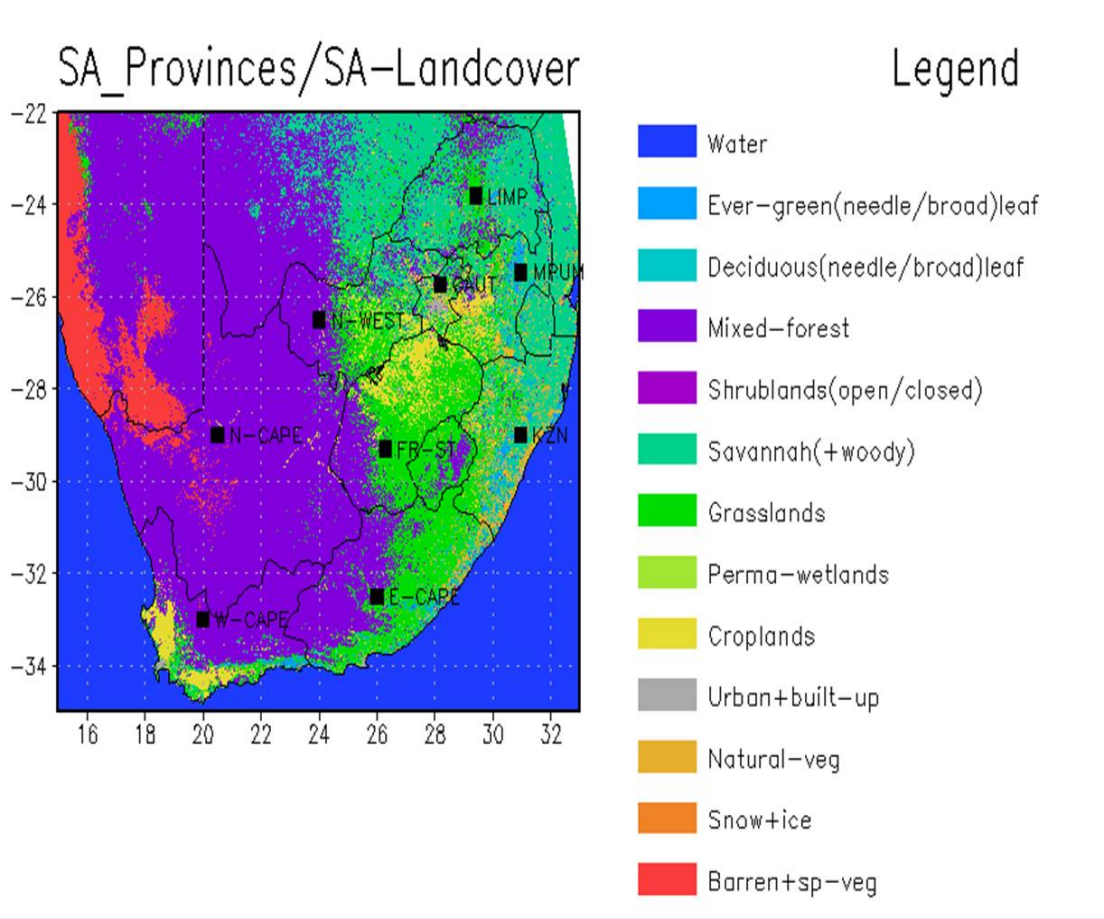
- ***Plans***
- ***To customise and use updated MODIS/SENTINEL landcover data on JULES/LIS***

➢ Spatial resolution of 300 meters

➢ Classify according to IGBP classes (currently used with 17 classes)

- ***Capable of simulating monthly/seasonal variations of vegetation;***
- ***Incorporate urban features, i.e. cities***
- ***Stream flow data-for hydrology/climate change studies***
- ***Plans to incorporate major stream over the country***
- ***Benefits to hydrology;***
- ***To be used for future projects (i.e. prediction of floods)***



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THANK YOU

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