Simulations of the COSMO model on the CHPC

CHPC Conference 2018

Patience T Mulovhedzi

Dr Mary-Jane Bopape

Gift Rambuwani

Model development

Weather Research

South African Weather Service

Pretoria

0001

Introduction

- The South African Weather Service (SAWS) is an authoritative voice for weather and climate forecasting
  - South Africa and SADC
- SAWS Services include:
  - Commercial (aviation, marine, etc.)
  - Public good (funded by government).
  - For protection of life, property and the environment.
- SAWS accomplishes its mandate, partially, through the use of weather forecast models.
- Provides numerical model forecasts through the Severe Weather Forecasting Demonstration Project (SWFDP) to the meteorological services of the 16 countries within the Southern Africa Developing Community (SADC).
- SAWS is a regional specialized meteorological center (RSMC) for SADC, therefore is a source of critical weather forecasting for the SADC region.
- It is, therefore, of great importance that the SAWS issues weather forecasts of high quality and value.

South African Weather Service

Introduction

- SAWS is conducting a business case to inform computational and modelling needs
  - Compare different numerical weather forecast models and identify the most suitable (skillful, valuable, accurate) one for SAWS.

South African Weather Service

Operational Numerical weather forecast (NWP) models at SAWS

- Unified model (UM) from the UK Metoffice serves as the main operational model.
  - Global model: 10km horizontal resolution (00Z & 12Z)
  - Convective Scale Models.
    - SA4(1250X1000) 4.4 km resolution (00Z & 12Z – 72hr; 06Z – 48hr and & 18Z – 60hr)
    - SA1p5(1408X1038) 1.5km resolution 36hr lead time (00Z, 06Z, 12Z & 18Z).

- Other models:
  - ECMWF (17Km)
  - NCEP (0.5x0.5 deg)
  - WRF (12Km and 15Km)

Aim

- To evaluate the capability of the **Consortium for Small-scale Modelling** (COSMO) model in predicting weather over the Southern African domain.
  - Vs observations
  - Vs 4.4km UM and 4.4km WRF

The COSMO model

- COSMO is a European limited area model
  - driven from Icosahedral Non-hydrostatic (ICON) global model: grid spacing of 13km globally
  - grid spacing of 4.4km
  - 40 vertical levels
- Allows for accurate numerical prediction of near-surface weather conditions
  - Clouds
  - Fog
  - frontal precipitation
- Allows for simulation of severe weather events triggered by deep moist convection
  - supercell thunderstorms
  - intense mesoscale convective complexes
  - prefrontal squallline storms
  - heavy snowfall from wintertime mesocyclones

South African Weather Service

COSMO model chain

13km ICON model data

- GRIB2 global coverage
- Provided by DWD via ftp

Int2lm

Output: 7km (40 levs)

- Preprocessing/ Interpolation of Global data

COSMO

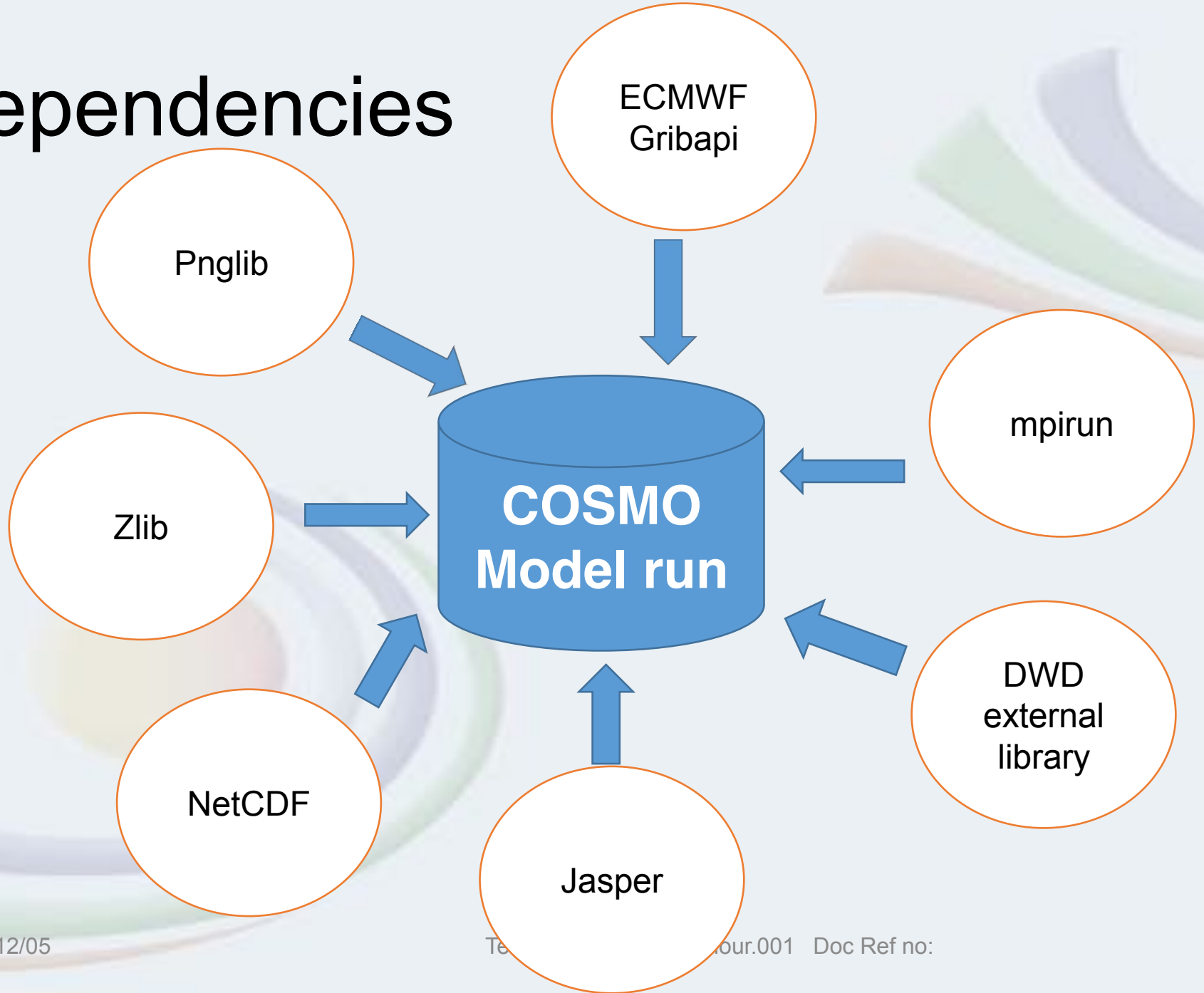
- Computation of weather forecast
- Output: 4.4km
- Grib1 over selected domain and forecast lead-time
- Output in p-levels and model levels
- Forecast variables=86

Post-processing

- Text output for Meteograms
- Image creation
- Statistical analysis

South African Weather Service

Dependencies



South African Weather Service

Model configuration and CHPC application

ICON: ICs and LBCs

- Domain: -41 °S to +1 °N and 4 °E to 56 °E.
- nx = 1301; ny = 1051
- GRIB2
- 13km resolution
- 90 vertical levels
- Initialized at 00Z
- 72-hour lead-time
- 3.8G

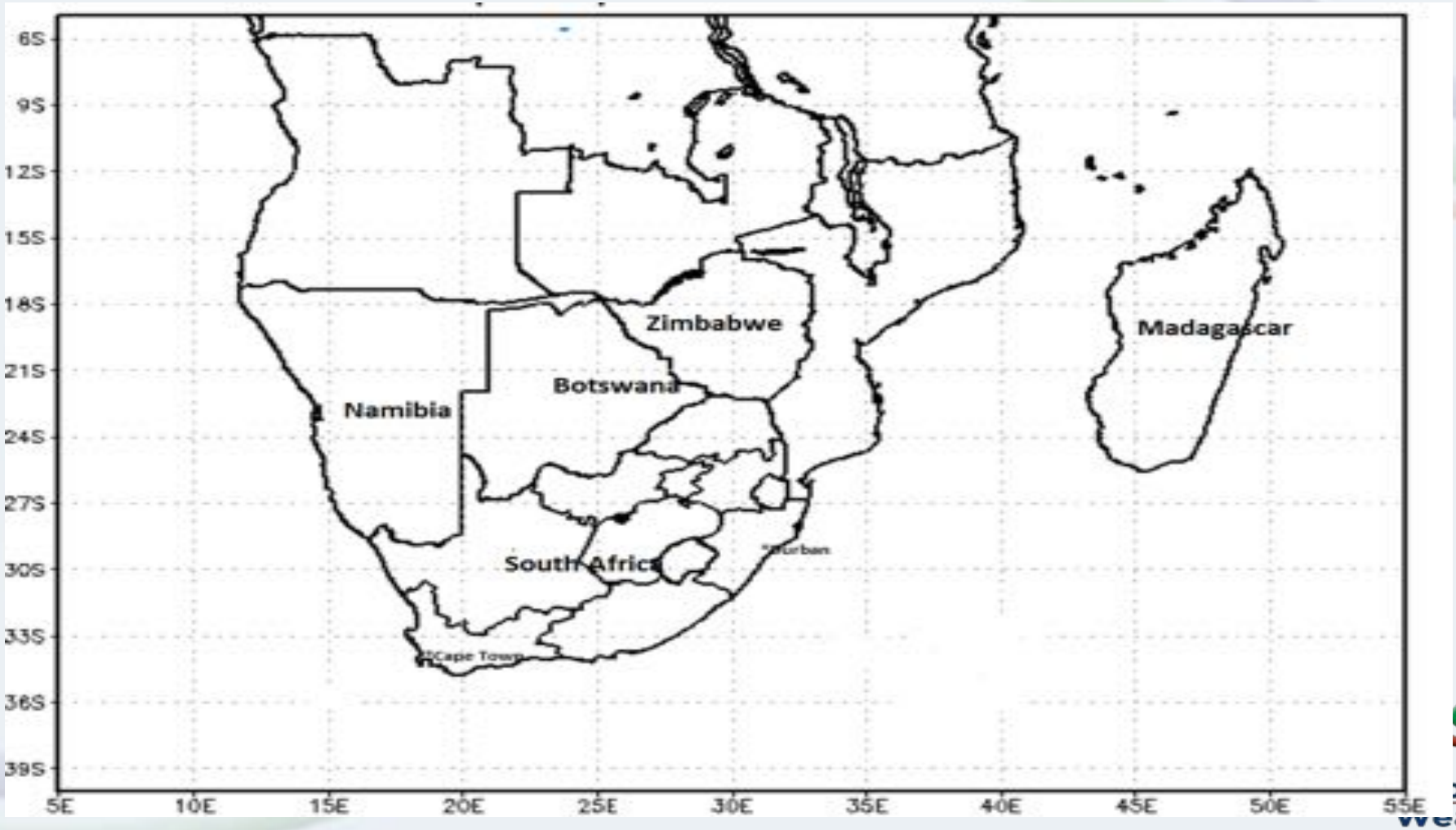
Int2lm: preprocessing

- 40 vertical levels
- 24-hour lead-time
- 16 nodes (with 20 cores each)
- Tstep=75s
- Nx=1274; ny=1024
- Output grid spacing=7km
- 17G

COSMO: model forecast

- 40 vertical levels
- 24-hour lead-time
- Default physics: mid-latitudes
- Tstep=30s
- Large queue: 1728 nodes
- Nx=1272; ny=1022
- grid spacing of 4.4km (dlat=dlon= 0.036°)
- SADC domain ranging from 5 – 56 °E and 40 – 5 °S
- GRIB1 data
- 76G

COSMO model forecast domain



Run time

Int2Im

- ~22minutes

Model forecast

- ~135 minutes (2hours, 15minutes)

Both the pre-processing and model run completed in +2.5 hours and the model output was in hourly intervals for 86 variables (80 in sigma coordinates and 6 in pressure coordinates).

South African Weather Service

Model evaluation

South African Weather Service

Data and Methods

- Parameters for evaluation
  - wind speed
  - surface temperature
  - total precipitation
  - Total cloud cover
  - Mean sea-level pressure
  - Surface pressure
  - Geopotential height
- Observations
  - Point observations from SAWS AWSs.
  - KNMI (EUMETSAT) satellite data
  - Global Precipitation Measurement (GPM) data
  - Convective Rainfall Rate (CRR) rainfall data

- Inter-comparison:
  - UM and WRF – 4.4km
- Eyeball verification:
  - Diurnal cycles (wind speed, surface temperature, total precipitation),
  - spatial distribution maps (wind speed, surface temperature, total precipitation, cloud cover and geopotential height)
- Categorical statistics:
  - Bias,
  - POD,
  - FAR,
  - CSI,
  - HK for total precipitation.
- Continuous methods:
  - RMSE,
  - correlation coefficient for surface temperature and total precipitation, and
  - percentage correct within 2 °C for surface temperature at over 200 point stations.

South African Weather Service

Results

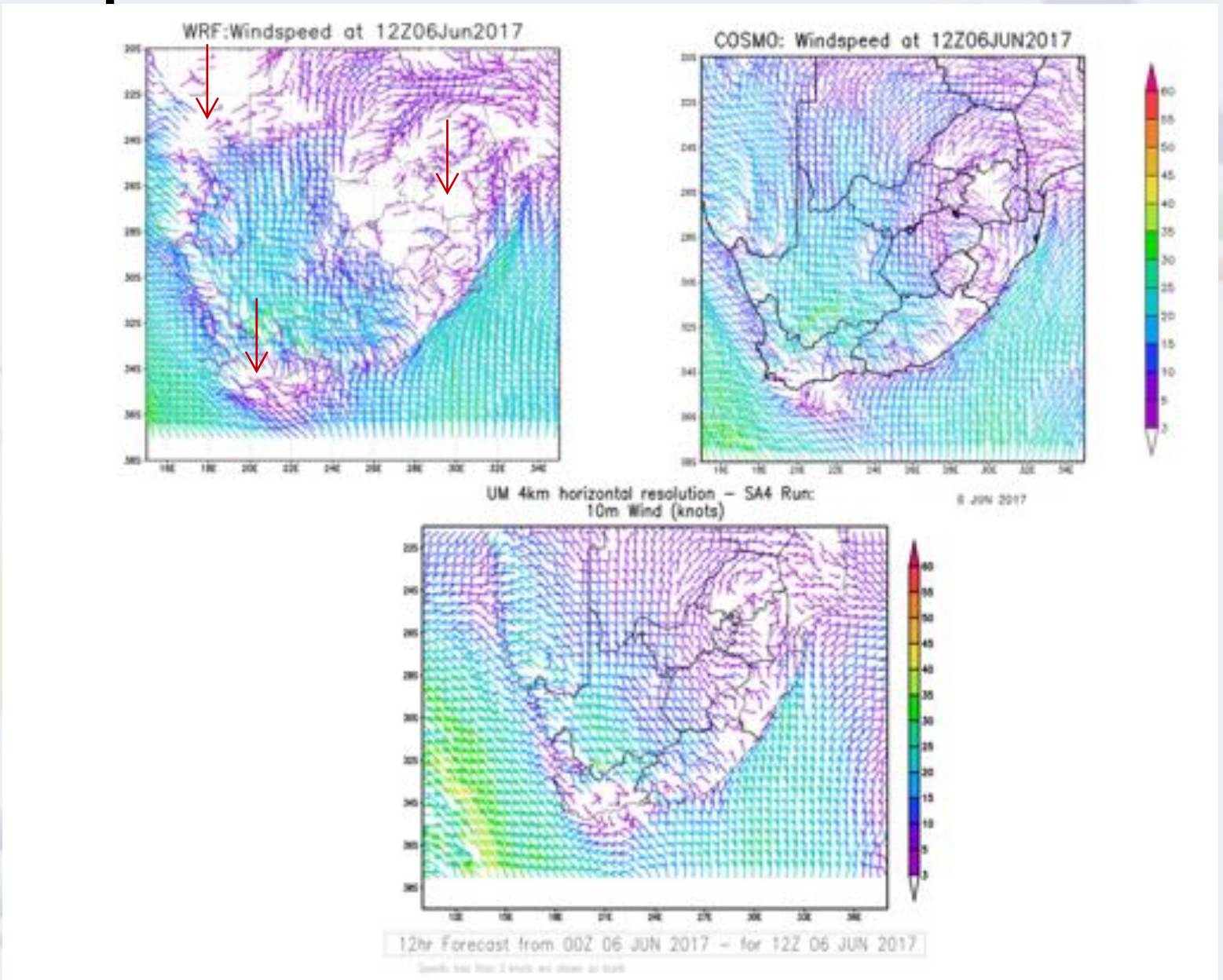
South African Weather Service

Case1: 6 June 2017

- On 6 June 2017, gale-force winds, storm and lightning were reported over parts of the Western Cape.
- Six deaths were reported while over 2 000 others were displaced from their homes and several others were injured.
- The weather conditions were caused by a severe cold front that landed on the country, specifically the Western Cape on the late hours of the 6th June 2017.

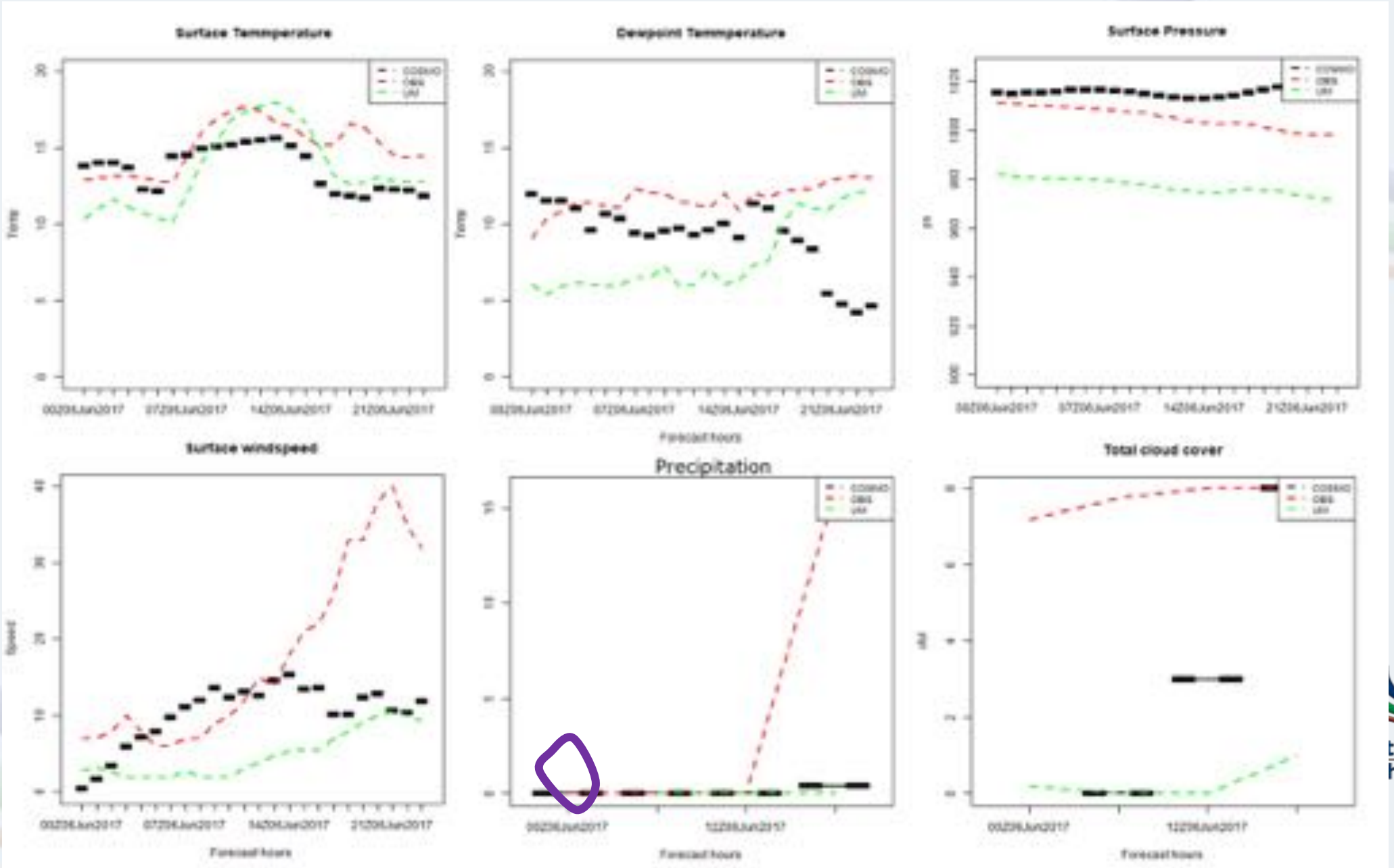
South African Weather Service

Wind speed



South African Weather Service

Diurnal cycles over Cape Town



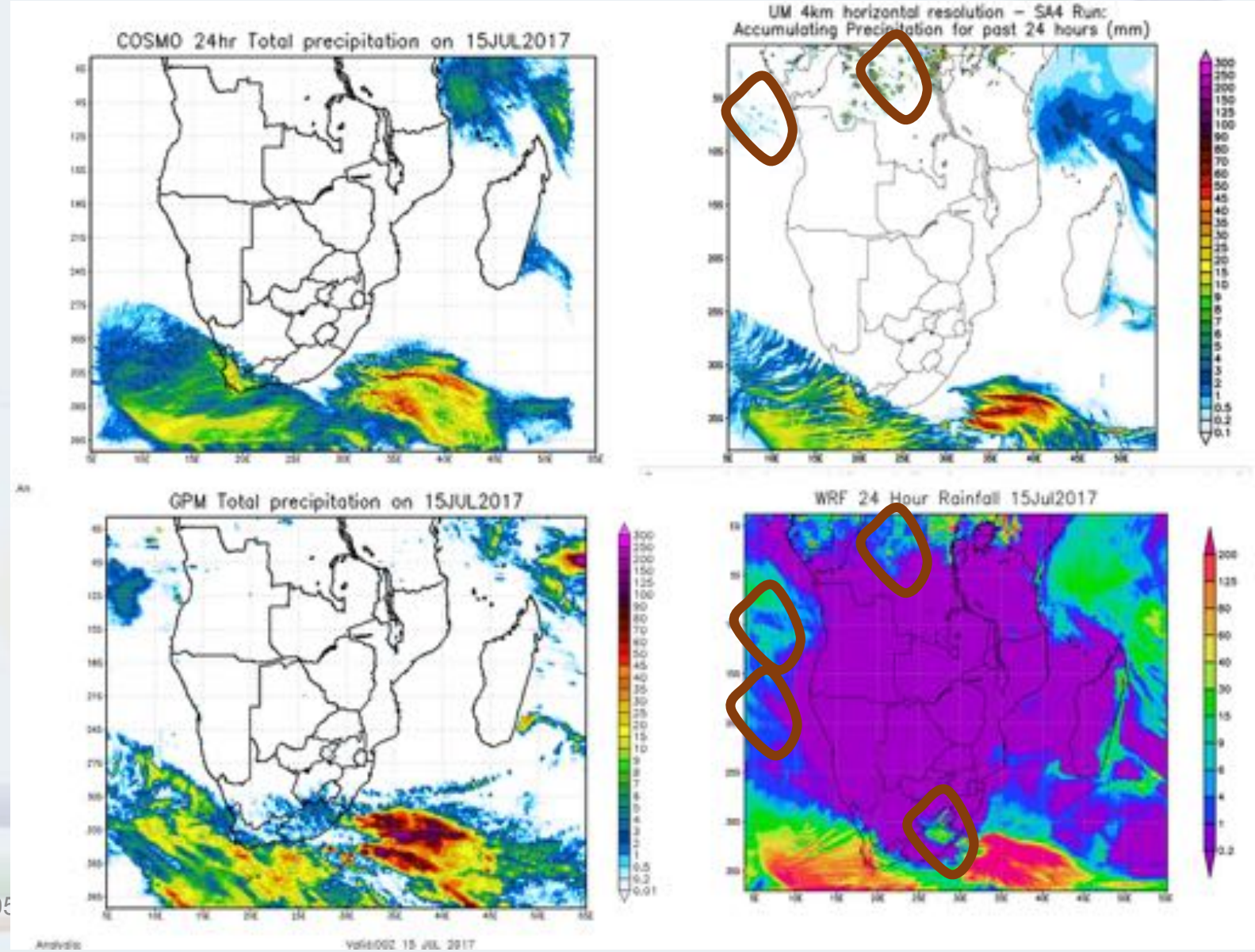
Case 2: 15 July 2017

- Wide spread showers, snow and rain were observed as a result of the cold front over the Western Cape, the Northern Cape and Eastern Cape. Parts of the Northern Cape were very hot.

- Snowfalls that were captured over parts of Sutherland, Northern Cape:

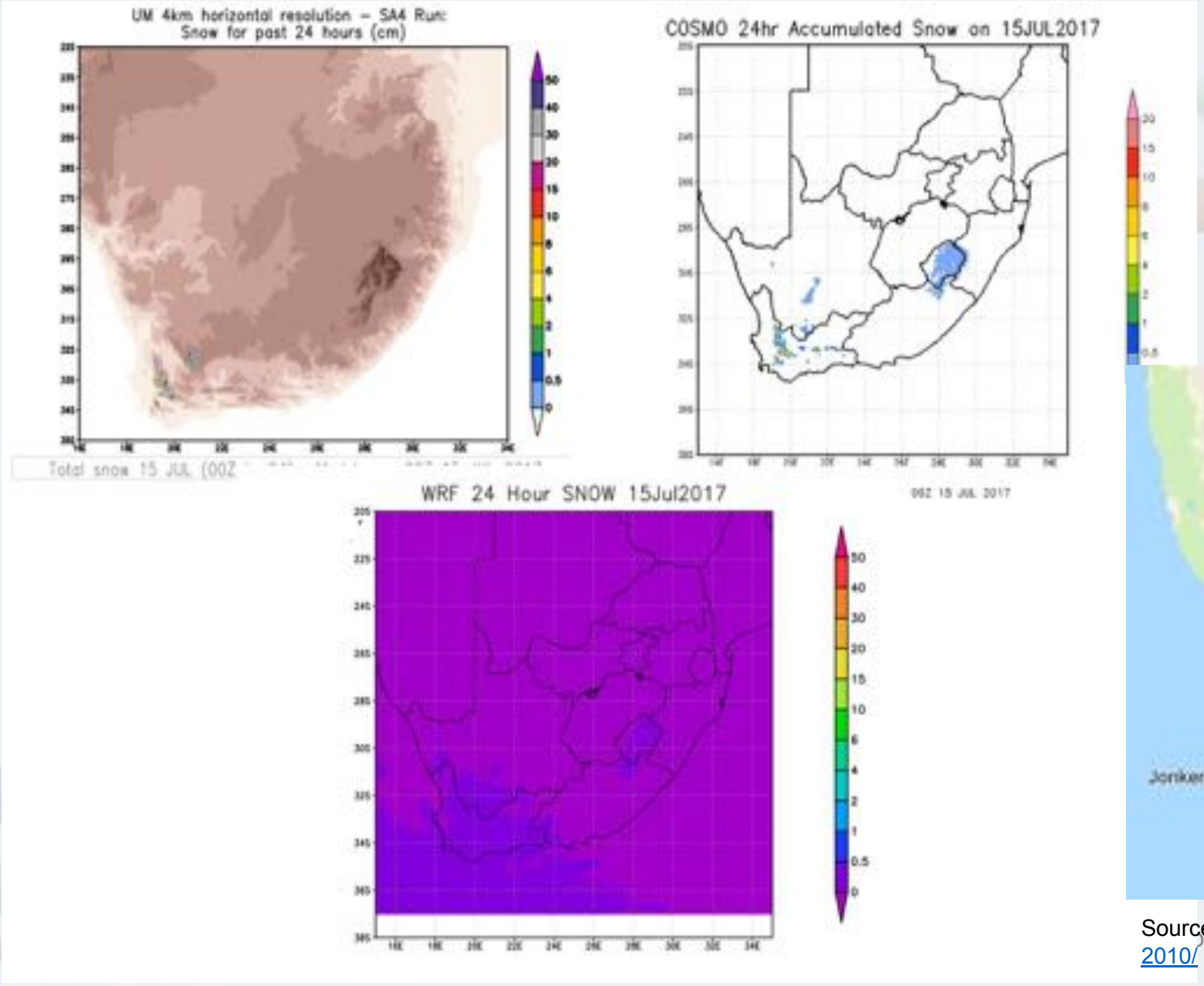
(Source: eNCA, 2017)

Accumulated rainfall



South African Weather Service

Snow



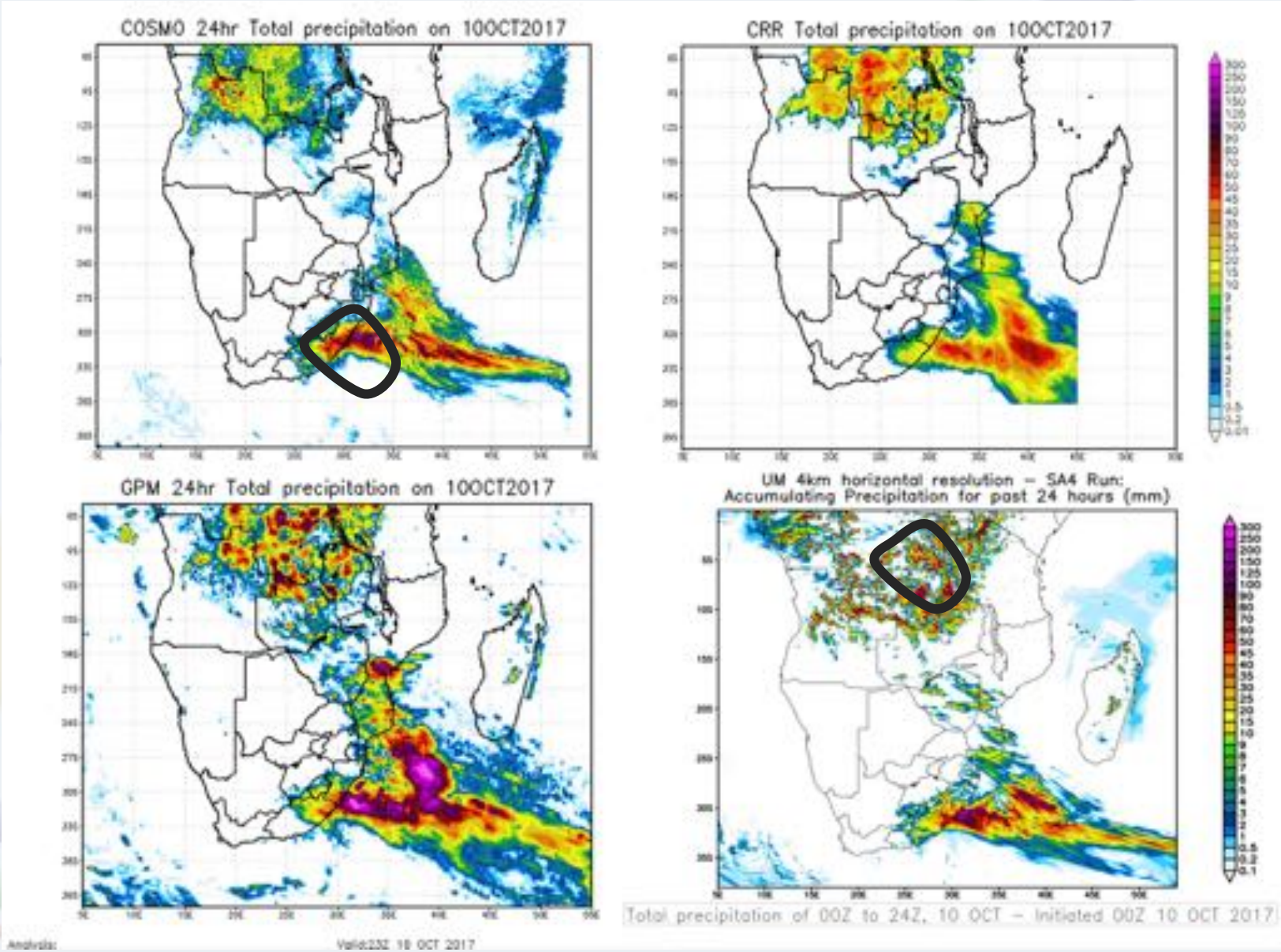
Source: http://snowreport.co.za/history-of-snow-in-south-africa-after-2010/

Case 3: 10 October 2017

- Floods were observed over parts of Kwa-Zulu Natal when severe thunderstorms, accompanied by heavy rains, strong winds and lightning hit the area on 10 October 2017.
- A number of fatalities were reported, schools and hospitals were closed.
- The weather was as a result of an upper-air cut-off-low that was situated south-east of the country with a high ridging over the south-eastern parts of the country.
- Record-breaking total daily rainfall amounts were observed in places including 108.2mm/day over Durban South Merebank.

South African Weather Service

Accumulated rainfall



South African Weather Service

Discussions and conclusions

- The COSMO model was run using default setting that were originally intended for the mid-latitudes.
- The model generally capture the general patterns of the observations, but not the quantity of parameters.
  - Winds, surface pressure and dew point deviate from early evening.
- Wind direction and strength for the three models has a good correlation over the sea.
  - UM and COSMO – resemblance over land.
  - WRF lighter over land
- Precipitation: WRF captures small-scale rainfall, but has a larger spatial coverage than the UM, COSMO and GPM.
  - COSMO – more precipitation than the UM.
- Snow: WRF has the highest snow coverage and quantity, followed by COSMO.

South African Weather Service

Way forward – validation!

- Re-run COSMO model using tropical and subtropical settings
- Collect more observations
- Evaluate more cases: difference weather systems
- Different vertical levels
- Longer lead-times

South African Weather Service

Acknowledments

- SAWS
- DWD
- CHPC

South African Weather Service

Thank you!!

South African Weather Service