

Satellite based precipitation estimation

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- The Hydroestimator
- Applications for Hydroestimator
- Summary and future work

1. Introduction

- Fourth meeting of the CBS-SWFDP Steering Group in Geneva, February 2012:
 - **Challenge for the SWFDP: “the need for very short-range forecasting tools, to address especially the rapid onset of localized severe thunderstorms which can produce heavy precipitation and strong wind, given the absence of adequate real-time observational networks, especially weather radar coverage.”**
 - The usefulness of EUMETSAT satellite based instability products, such as the Global Instability Index, for nowcasting purposes was recognized
 - Also agreed that real time satellite rainfall estimates have proven particularly useful in regions where rain gauges and radar coverage is sparse.
- Surface-based precipitation measurement systems in DC and LDC still needed to accurately measure and monitor precipitation amounts on the ground, to be incorporated into hydrological runoff models as well as aid in validation of other (satellite and model based) methodologies.

2. Measurement of precipitation

- Rain gauges:
 - provide a direct measurement of rainfall,
 - networks are far too coarse to capture all the rainfall, especially at smaller scales
 - unevenly distributed and,
 - most importantly, they provide point source data and not a representation of a spatial domain
- Radars rainfall:
 - an indirect measurement of rainfall,
 - radars need to cover the entire area of interest,
 - Well correlated and
 - have a good radar rainfall relationship.
- Satellite based estimates of rainfall:
 - not as accurate as gauges or radar,
 - major advantage is the high temporal resolution and coverage, even over oceans, in mountainous regions and sparsely populated areas where rainfall is not measured.

Sources of satellite QPE

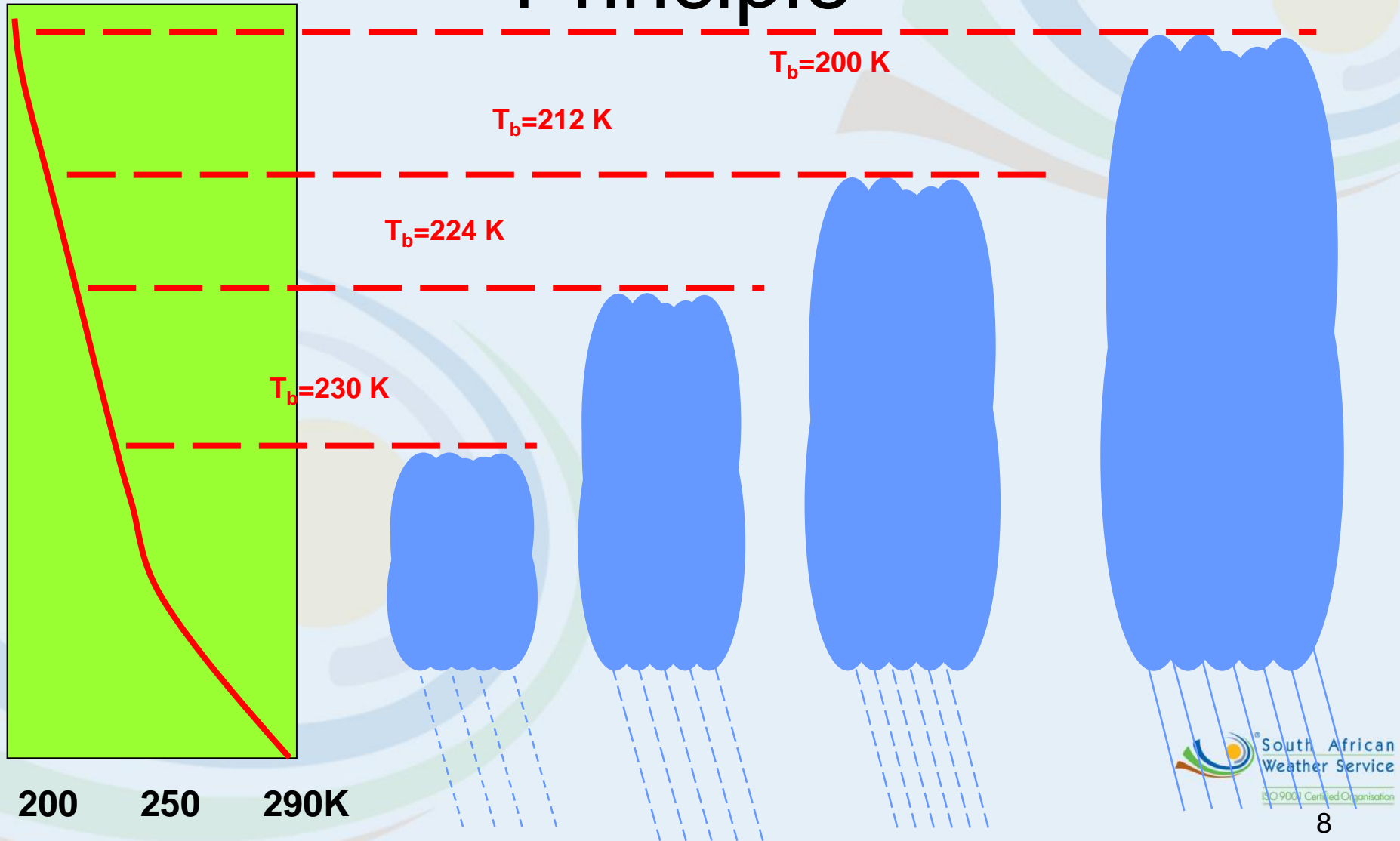
- Satellite rainfall can be derived from low earth orbiting (LEO) or geostationary satellites (GEO).
- LEO satellites:
 - advantage of high spatial resolution,
 - disadvantage is that the spatial coverage is in the form of narrow swaths at times which are not always coinciding with precipitating weather systems.
 - not useful for operational forecasting purposes, although the data can be utilized for other purposes, including data assimilation for numerical weather prediction (NWP).
 - the main advantage of LEO satellites is that the microwave sensors carried by these low orbiting satellites have a more direct link to precipitation than the instruments on board GEO satellites.

- GEO satellites:
 - are located much higher above the earth surface than the LEO satellites and thus have a coarser resolution.
 - major advantage that the data and images are available in near real-time for the entire footprint of the satellite.
 - operational forecasting requires frequent updates and near real-time availability. Forecasters who have to monitor and forecast the movement and changes in intensity of precipitating weather features, find GEO most useful
 - Hydroestimator is a GEO satellite based QPE

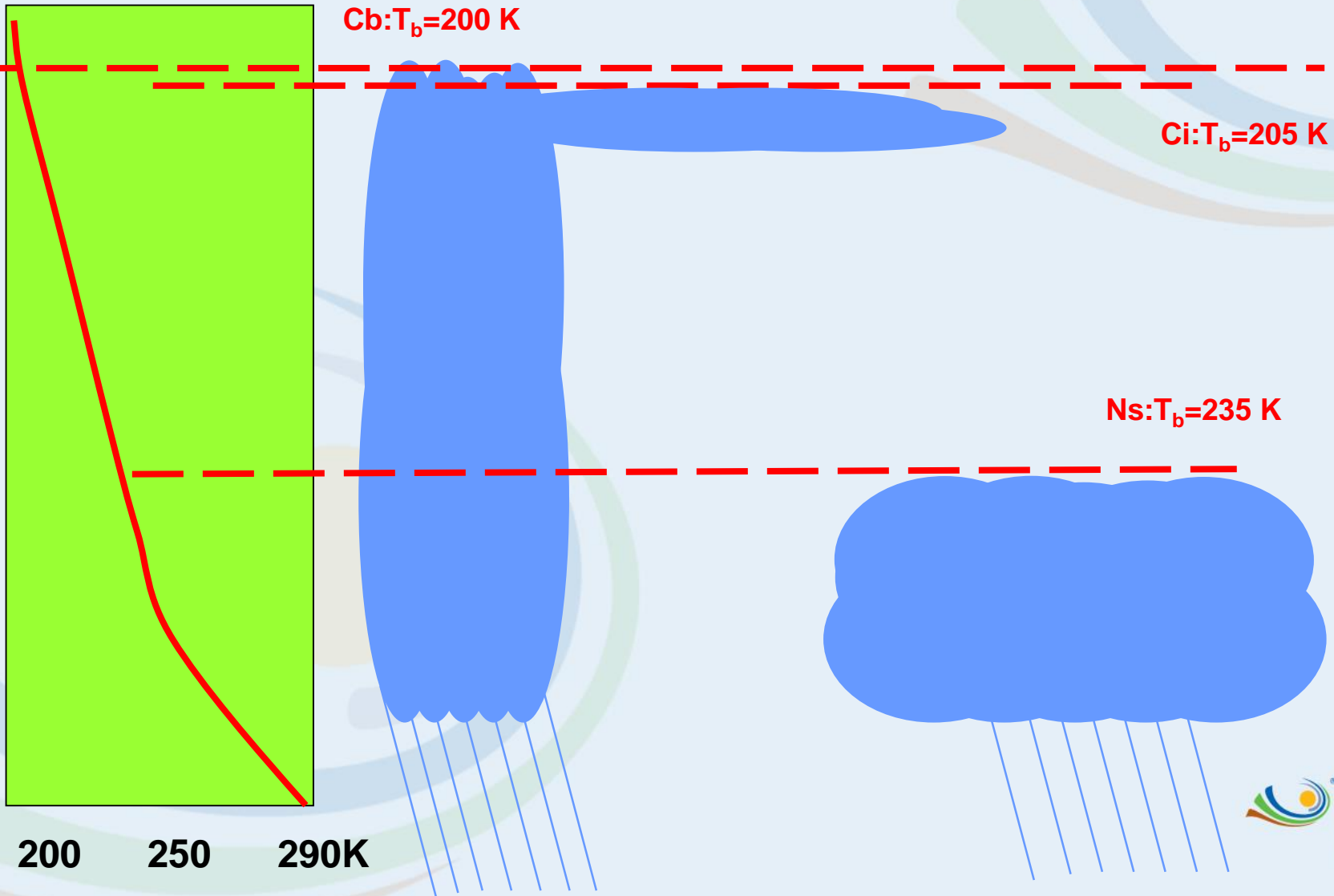
3. The Hydroestimator

- The National Environmental Satellite, Data and Information Service (NESDIS) developed an automated SPE algorithm for high-intensity rainfall called the Autoestimator (AE) using the GOES satellite (GEO)
- The original AE, developed by Vicente *et al.* (1998), computes rain rates from 10.7 μm brightness temperatures based on a curve that was derived from more than 6000 collocated radar and satellite pixels.
- The dependence of the initial AE on radar was a significant problem, because one of the advertised strengths of satellite QPE (Quantitative Precipitation Estimation) is its usefulness in regions for which radar and/or rain gauge coverage is unavailable.
- Another version of the AE, called the Hydroestimator (HE) has been developed which can be used outside of regions of radar coverage without compromising accuracy.

Cold Cloud Tops and Rain - Principle



Exceptions to the Rule



Hydroestimator

- Simple use of 10.8- μm brightness temperatures leads to missing of warm, stratiform rain and incorrect designation of cold cirrus as raining clouds
- Improvements to the HE considers the temperature relative to the surrounding pixels:
 - Pixels colder than their surroundings are assumed to be convective updrafts and hence producing rainfall
 - Pixels as warm as or warmer than their surroundings are presumed to be convectively inactive

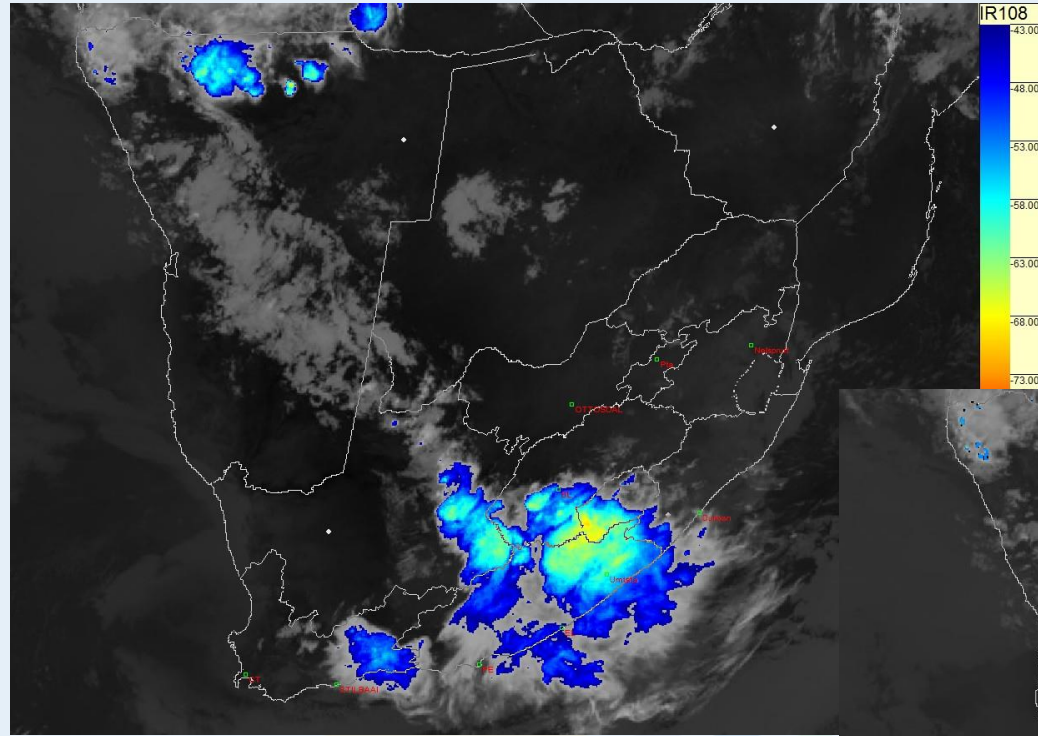
Hydroestimator

- Satellite imagery alone does not contain all the information needed for evaluating rainfall. Numerous processes occur below clouds e.g.:
 - evaporation of raindrops in dry air,
 - reduction or increase by terrain features
- Improvements to the HE considers some correction figures taken from numerical weather prediction models:
 - PW: rain is enhanced/reduced in high/low PW
 - RH: reduces rain in dry lower atmosphere
 - Actual level of neutral buoyancy is accounted for
 - 700 hPa wind field is interleaved with the topography

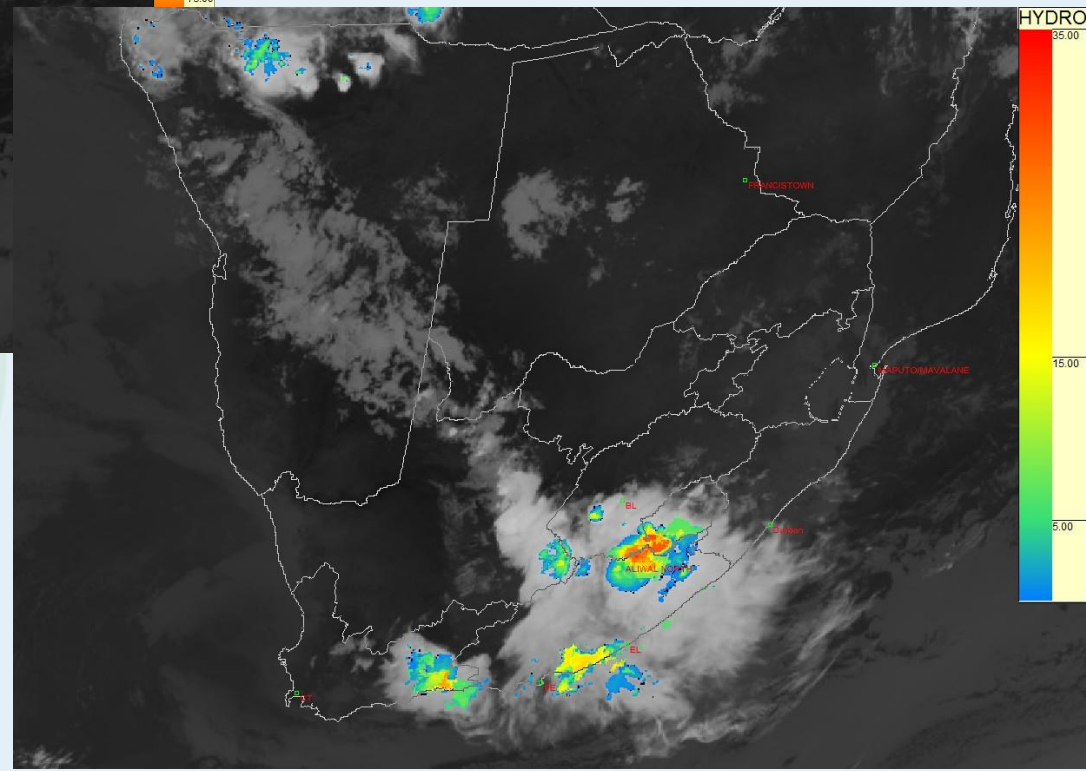
Hydroestimator vs IR108 on 29 Jan 2013



Hydroestimator



IR108 colour enhanced



HE for SADC region

- Code for HE was installed in SA in 2007, using NWP input from Unified Model, run in SA and MSG input (IR108)

Shortcomings of the HE

- The HE works best for **convective** events, stratiform events might be over/underestimated or missed.
- Very cold tops might be overestimated.
- Warm cloud tops are often underestimated/missed.

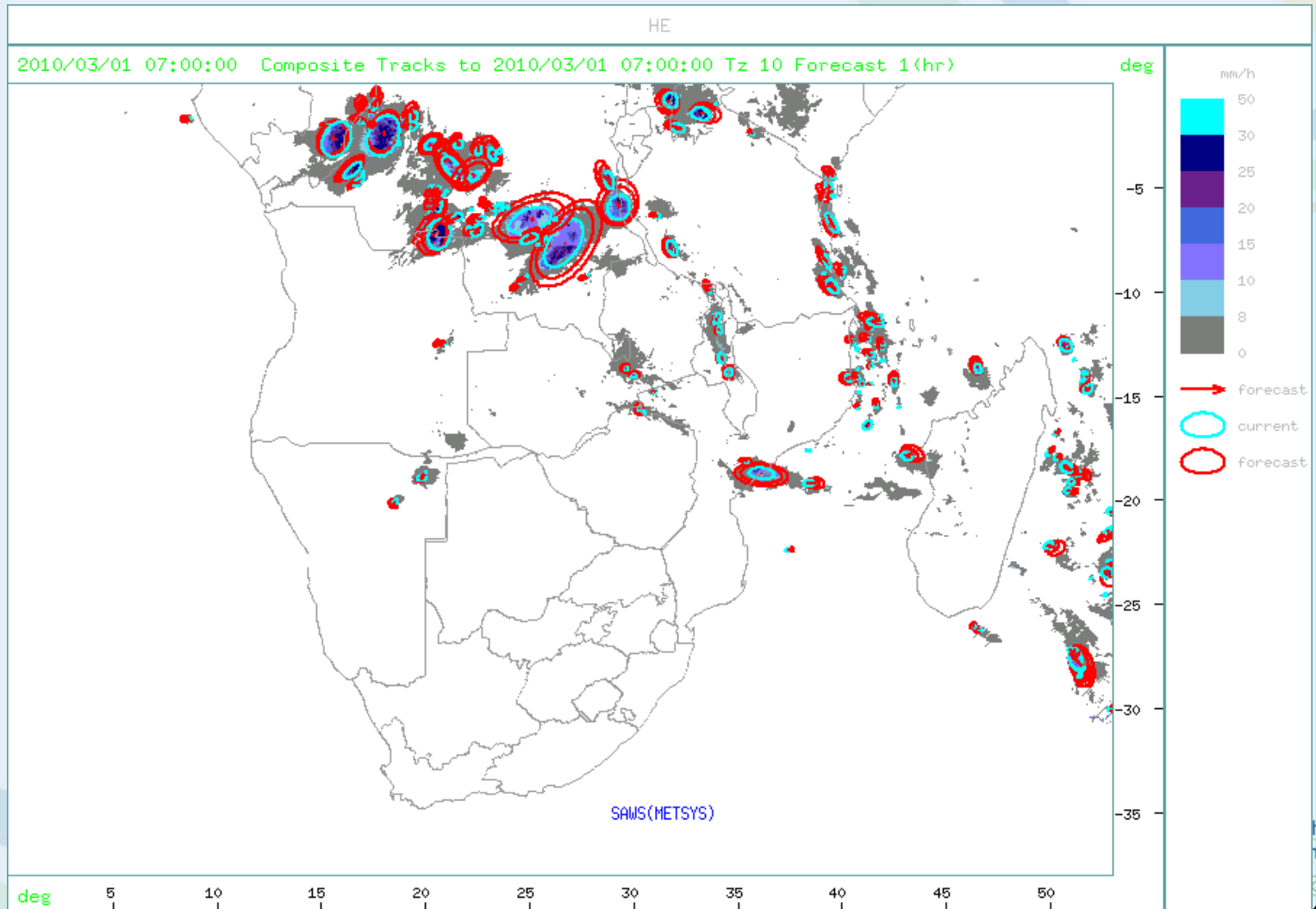
4. Applications of HE

- Tracking
- Accumulations
- Dissemination to SADC region via RSMC website
- SAFFG

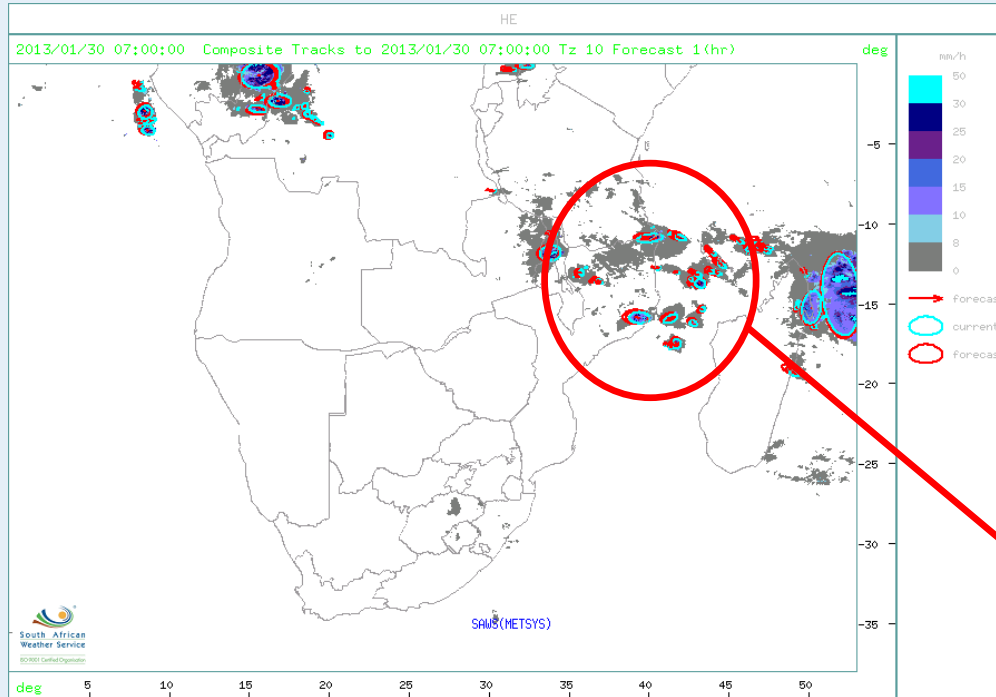
4.1 HE Tracking

- HE tracking done of the 10mm (~40 dBz core)
- Available on RSMC website:
<http://rsmc.weathersa.co.za/RSMC/login.php>
- Tracks storm direction for 30min and 60min forecasts.
- Growth and decay accounted for

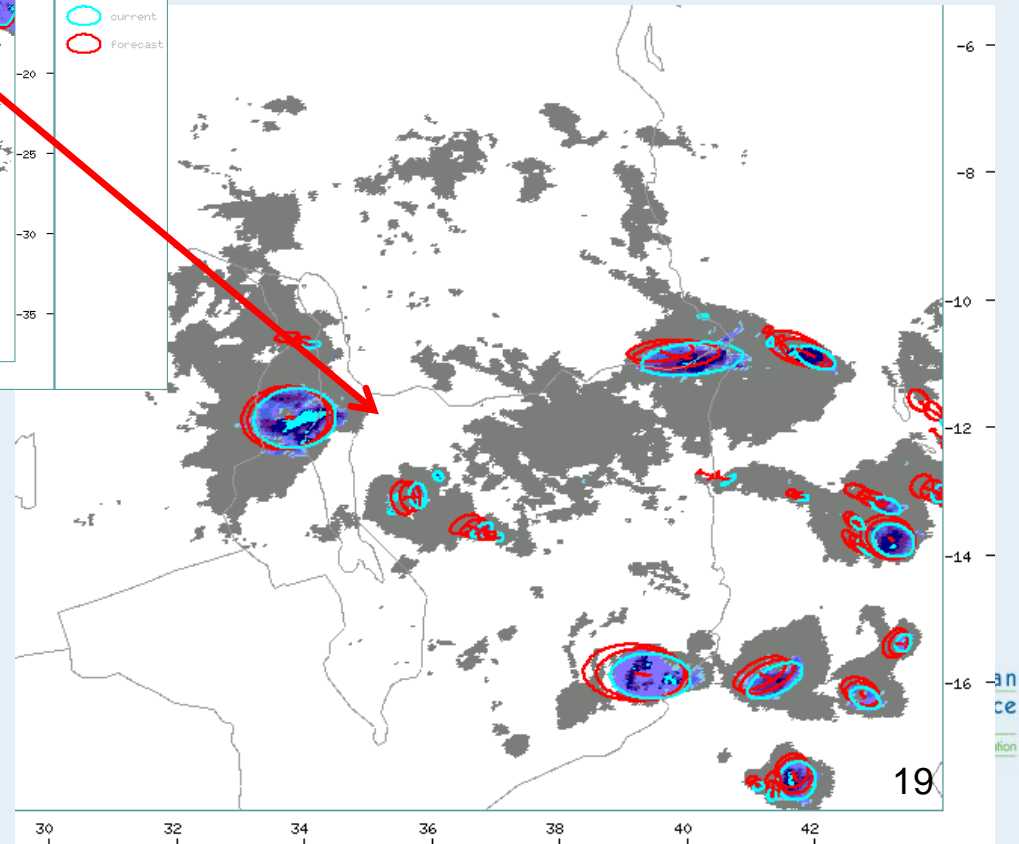
4.1 HE Tracking



4.1 HE Tracking



Blue is current and red is predicted 30/60 minutes





Guidance Products

NWP & EPS Products

Regional Models

- [UM SA12](#)
- [UM Africa LAM](#)
- [Aladin La Reunion](#)

Global Products

- [NOAA: GFS](#)
- [ECMWF: EPS](#)
- [Met Office: EPS](#)
- [NOAA: EPS](#)
- [SAWS: EPS \(SAWS\)](#)

Training Website

- [Met-eLearning](#)

RSMC Guidance Archive

Contact RSMC

Logout

Guidance Products

Short-range (1-2 Days)

- [Map Day 1](#)
- [Map Day 2](#)
- [Risk Tables](#)
- [Discussion](#)

Medium-range (3-5 Days)

- [Map Day 3](#)
- [Map Day 4](#)
- [Map Day 5](#)
- [Prob Tables](#)
- [Discussion](#)

SWFDP Evaluation Form

- [Click Here](#)

Regional and International Centers

- [ECMWF](#)
- [NCEP](#)
- [UK Met Office](#)
- [WMO](#)
- [RSMC - Reunion](#)
- [ACMAD](#)

SADC Countries

- [SADC Countries National Meteorological Services](#)

Other Services and Products

- [Short-range](#)
- [Long-range \(Seasonal\)](#)

Satellite-based 0-12 Hour Products

Satellite-Based Rainfall

Hydro-Estimator Rainfall Totals

- [1hr](#)
- [3hr](#)
- [6hr](#)
- [24hr](#)

Hydro-Estimator Rainfall Totals In Days

- [10 Days](#)
- [30 Days](#)
- [Description of Product](#)

Convective Thunderstorm Forecasts

Probability of Convective Thunderstorms

- [CII](#)
- [Description of Product](#)

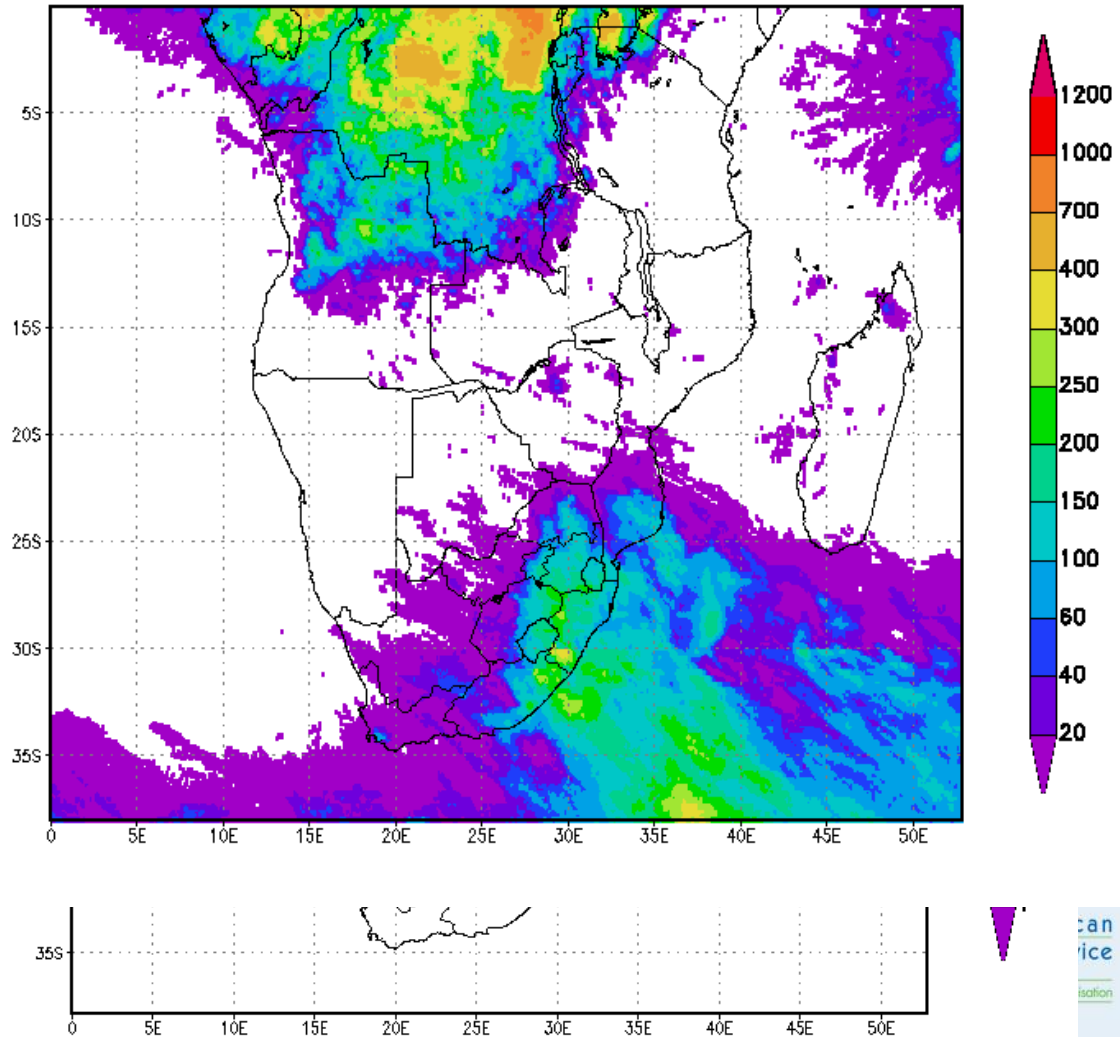
Hydro-estimator Storm Tracks

- [SADC](#)
- [SADC NW](#)
- [SADC NE](#)
- [SADC SW](#)
- [SADC SE](#)
- [Madagascar](#)
- [South Africa](#)

2. HE accumulations

- 1 hour, 3 hours
- 10 days
- 30 days

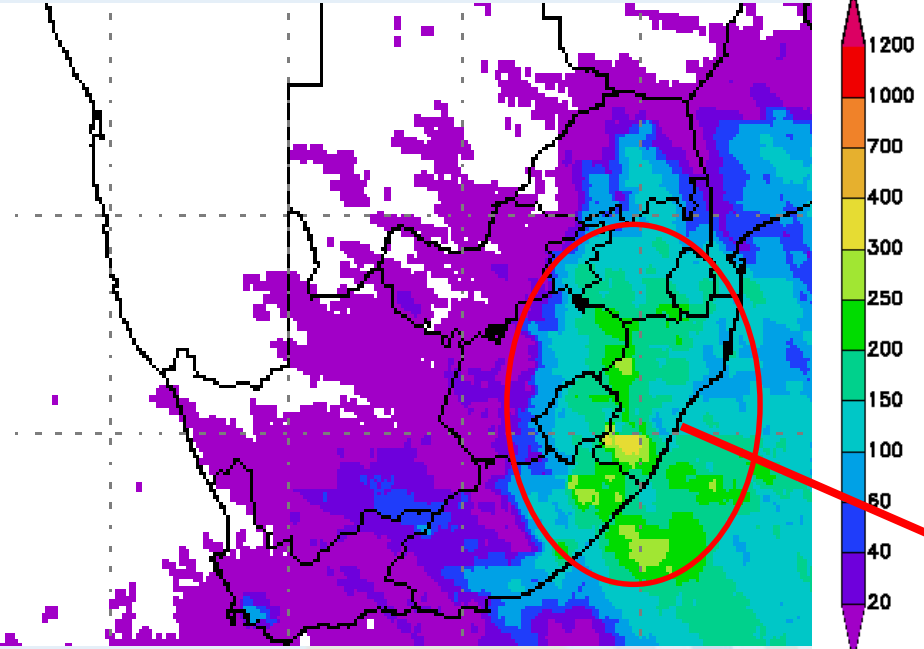
30 Day Hydro-Estimator Rainfall Total mm
20120901 06:00Z - 20121001 06:00Z



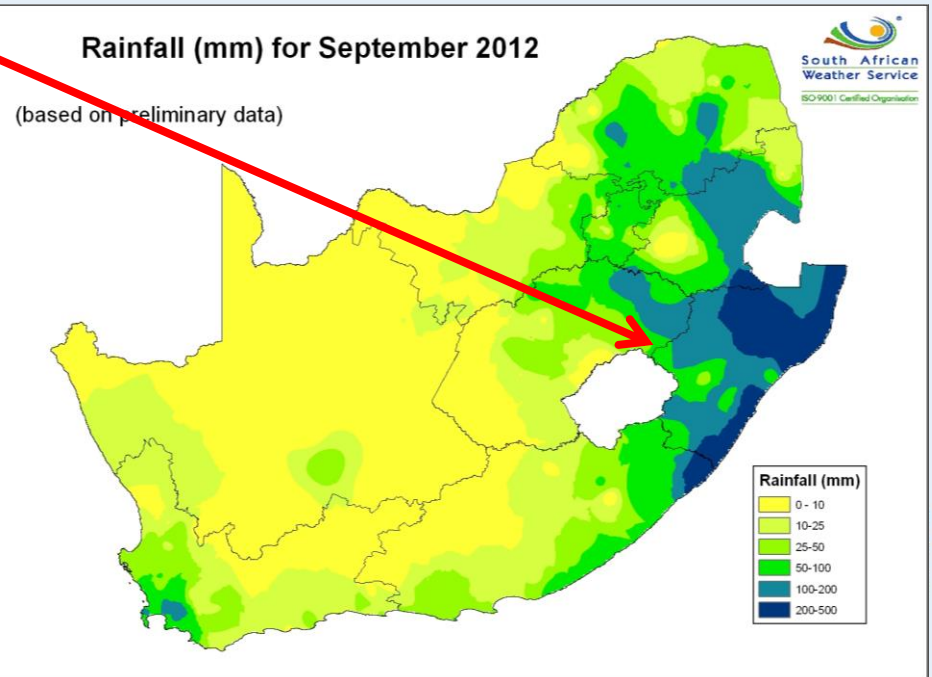
4.2 HE accumulations

30 day accumulation

Gauges:
Light blue 100-200mm
Darker blue 200-500 mm



Hydroestimator:
Most rain Eastern parts of SA >50mm (blue)
200 mm to 400mm in green/yellow



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Satellite-Based Rainfall

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Hydro-estimator Storm Tracks

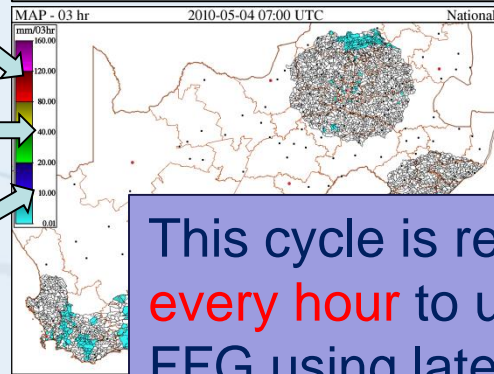
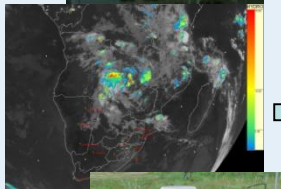
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- [SADC SW](#)
- [SADC SE](#)
- [Madagascar](#)
- [South Africa](#)

South Africa Flash Flood Guidance (SAFFG)

- Hydro-meteorological modelling system combining :
 - meteorological information, such as quantitative rainfall estimation from weather radars, satellite and rain gauges,
 - with hydrological modelling of the soil moisture conditions
- Result: flash flood potential in 5366 small river basins (on average 50 km²) in five flash flood prone regions over South Africa.
- The SAFFG uses the quantitative rainfall estimates of the previous hours from:
 - radar,
 - satellite and
 - rain gauges
- **Calculates the amount of rain needed over the basin that will lead to bankfull at the outlet of the river, i.e. start of flooding on an hourly basis.**
- The Flash Flood Guidance System (FFGS) is the intellectual property of the Hydrologic Research Center (HRC), a non-profit public-benefit corporation based in San Diego, USA. SARFFG was developed and implemented by HRC.

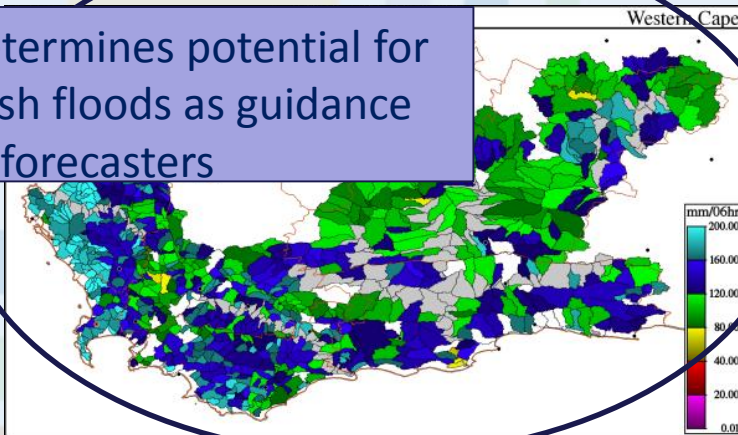
Flash Flood Guidance Process

Calculate from satellite & rain gauge info the averaged rainfall over small basins

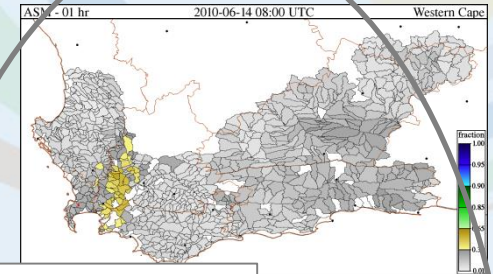


This cycle is repeated **every hour** to update FFG using latest rainfall information

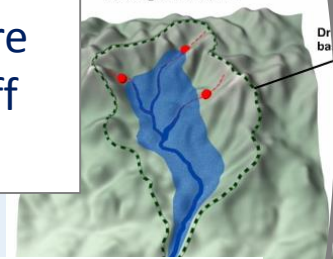
Determines potential for flash floods as guidance to forecasters



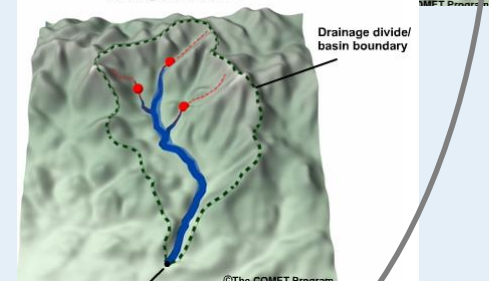
Hydrological models determine likely soil moisture and rainfall runoff for small basins



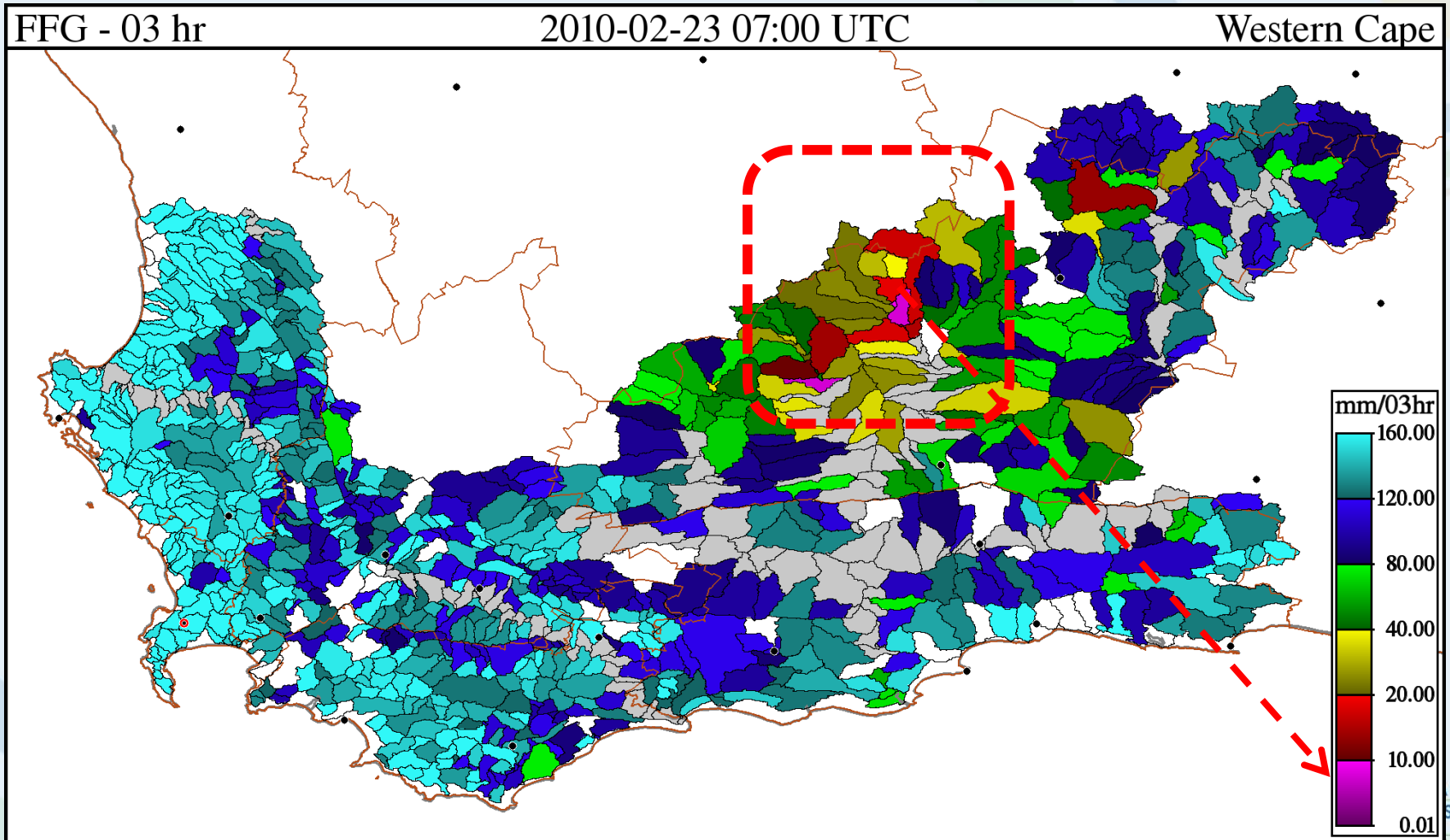
Drainage in a Basin



Drainage in a Basin



Example

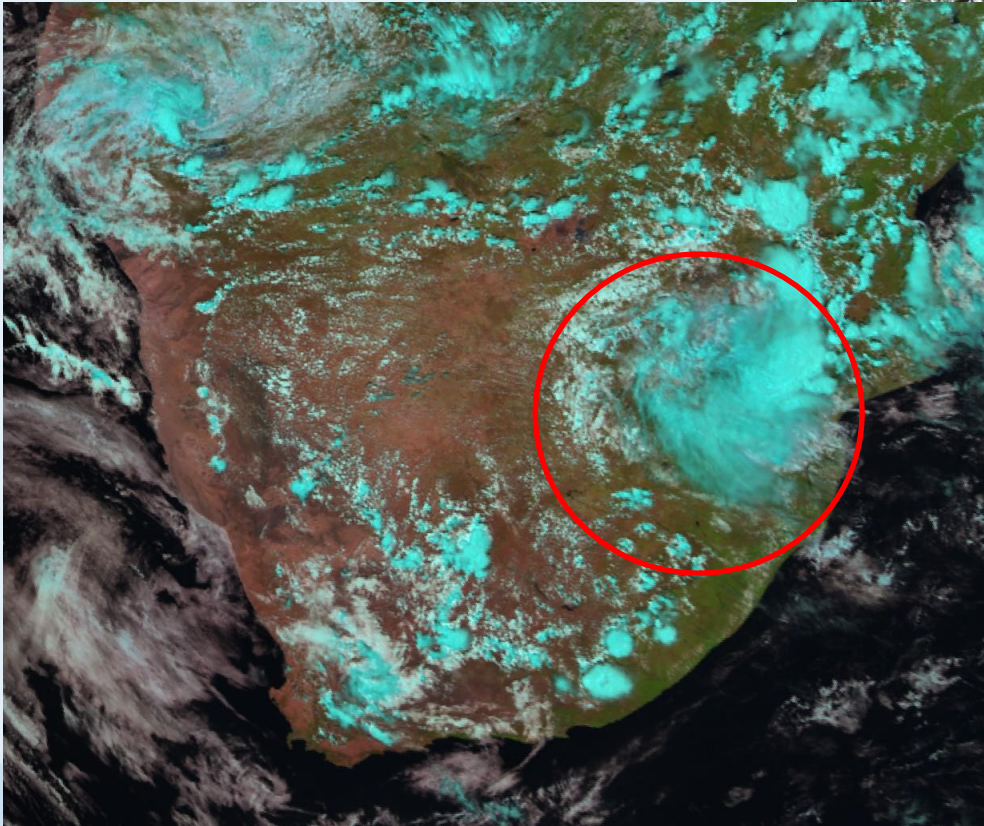


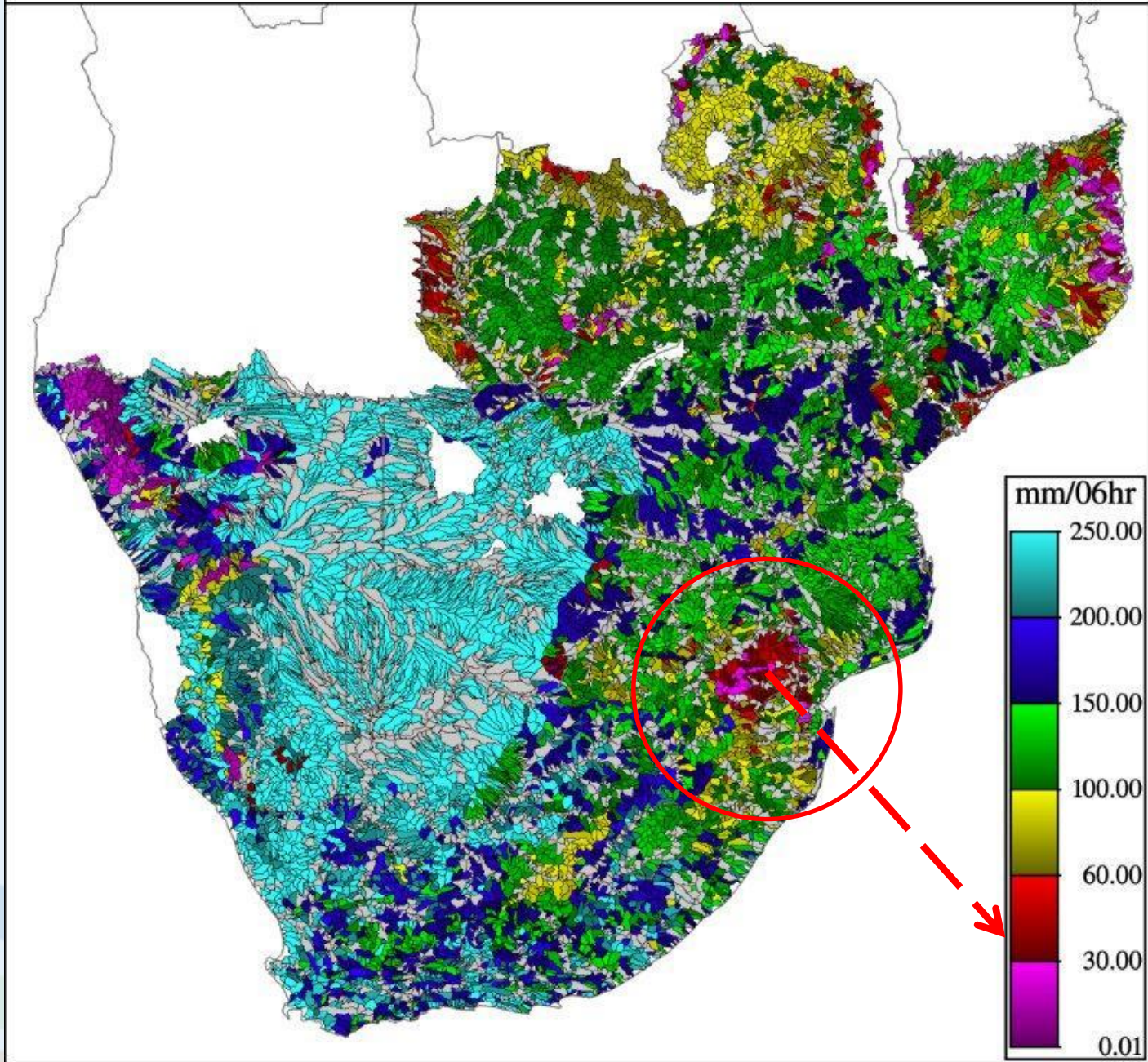
SAFFG for the rest of southern Africa (SARFFG)

- WMO - similar flash flood guidance system (called the SADC SARFFG) over seven southern African countries
- The SADC SARFFG system covers the rest of **South Africa and six other countries** where there are no radar coverage at the coarser 200km² resolution.
- SARFFG depends **primarily on satellite QPE** as precipitation input for modelling soil moisture and flash flood guidance over large parts of southern Africa.

Example Tropical Cyclone

Dando 18 January 2012





Summary and conclusion

- Accurate satellite rainfall estimation is crucial for good guidance in data sparse areas over Africa
- GEO satellite based QPE – great spatial coverage
- Hydroestimator – available every 15 minutes, as well as accumulation and tracking products
- SAFFG and SARFFG – guidance to forecasters for flash flood forecasting using Hydroestimator, radar rainfall (where possible) and gauges (where possible)

Coming soon...

- Archive of daily accumulations!
- Day totals (0600 – 0600UTC) for the past 35 days