Numerical Weather Prediction Models

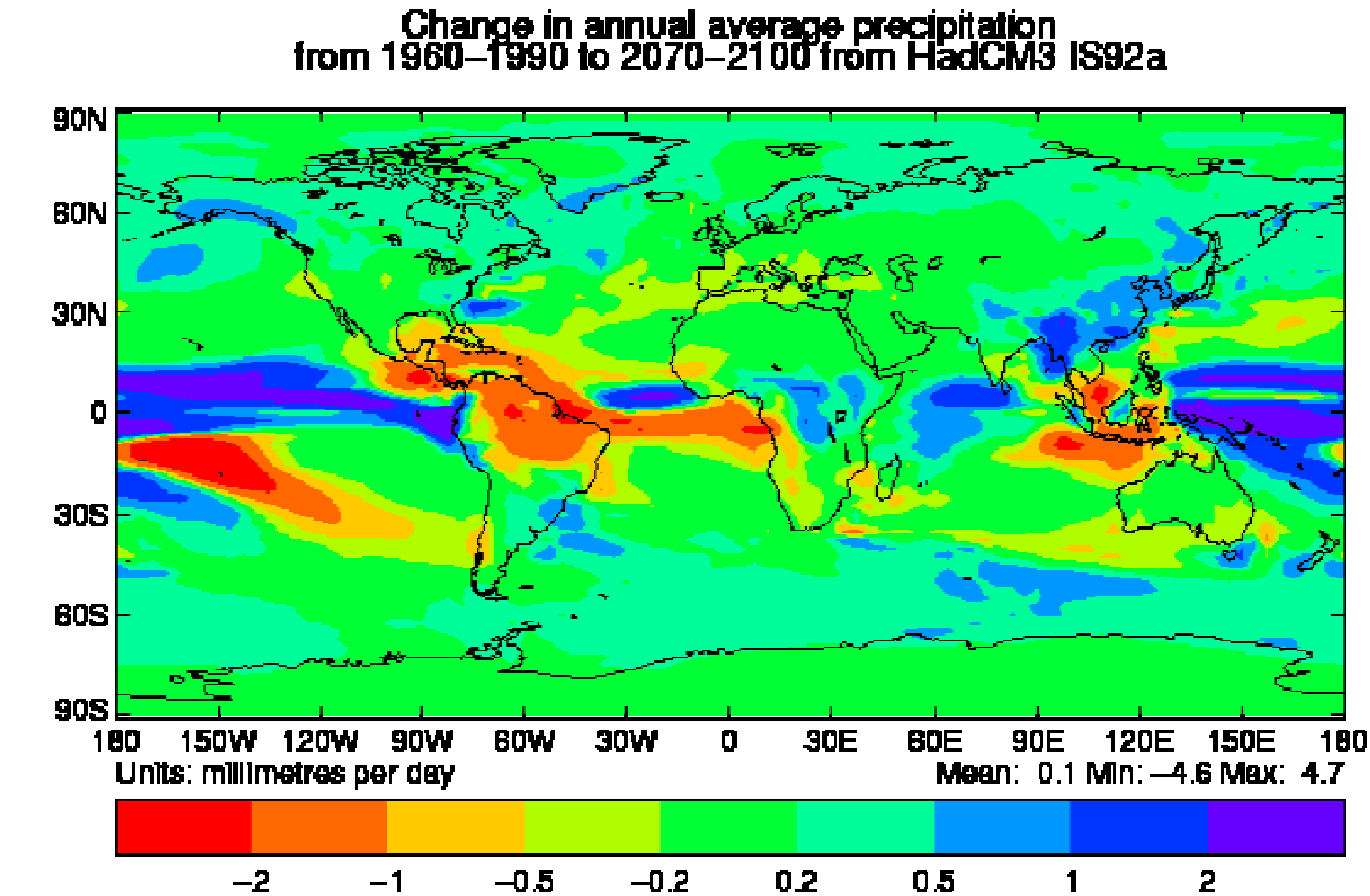
Adapted partly from Davies, 2012

NWP Model Formulation

- Different types of model
- Model Characteristics
- General strengths and weaknesses of NWP models

Types of atmospheric model

- Climatological
  - Global Climate Models (GCM's)
  - Hindcasts and Forecasts
  - Climate change – global warming
  - Non operation weather forecasting models



Hadley Centre for Climate Prediction and Research, The Met. Office

Types of atmospheric models

- Long-term and seasonal
  - Coupled ocean-atmosphere models
  - Aims to infer climate from indicators such as Sea Surface Temperature (El Niño)
  - Forecasts issued by ECMWF every month
  - Forecasts issued by SAWS (GPC)

  http://www.weathersa.co.za/web/index.php/forecasting?layout=edit&id=253

ECMWF Seasonal Forecast

Mean 2m temperature anomaly

Forecast start reference is 01/09/06

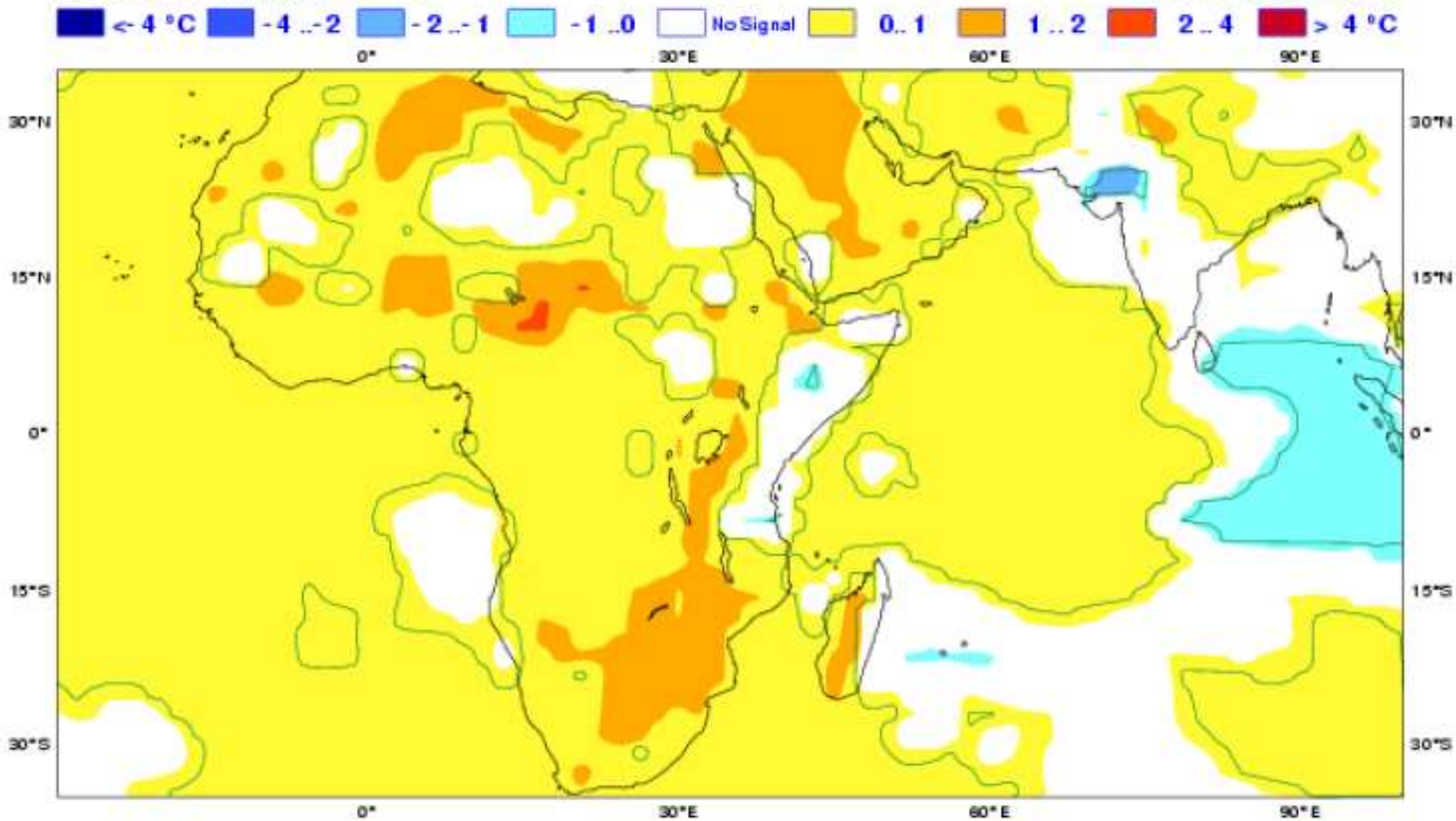
Ensemble size = 40, climate size = 75

System 2

OND 2006

Shaded areas significant at 10% level

Solid contour at 1% level



Forecast issue date: 15/09/2006

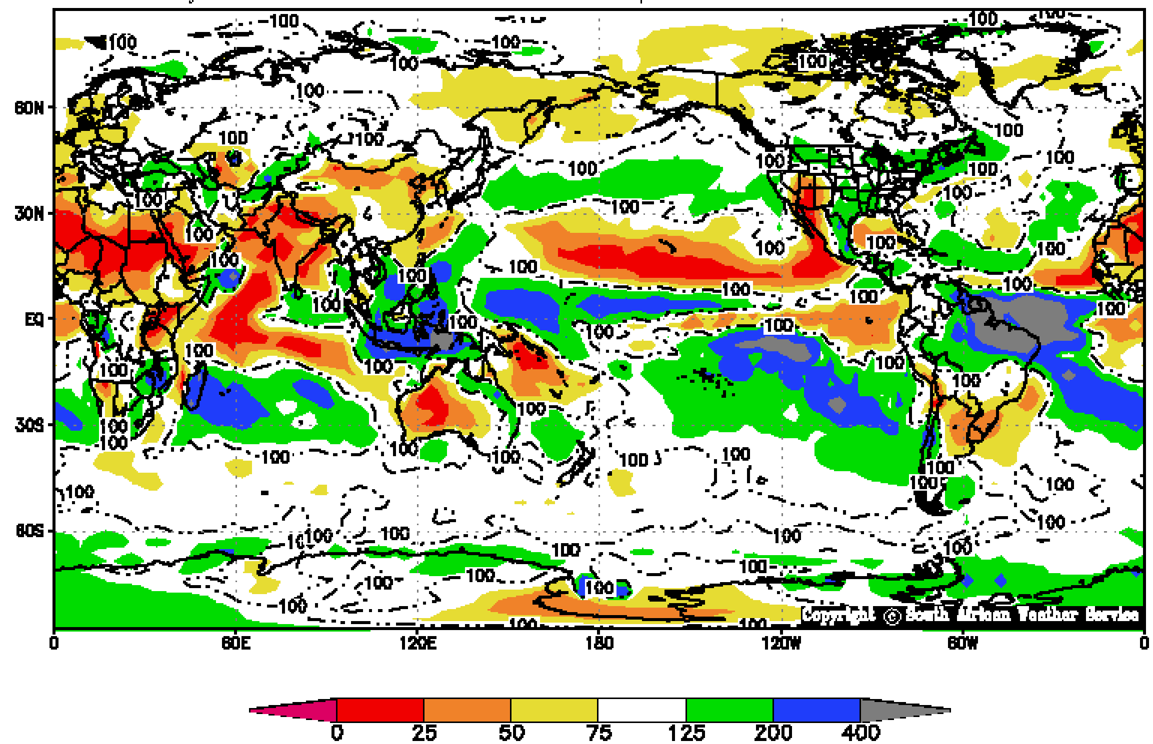
ECMWF

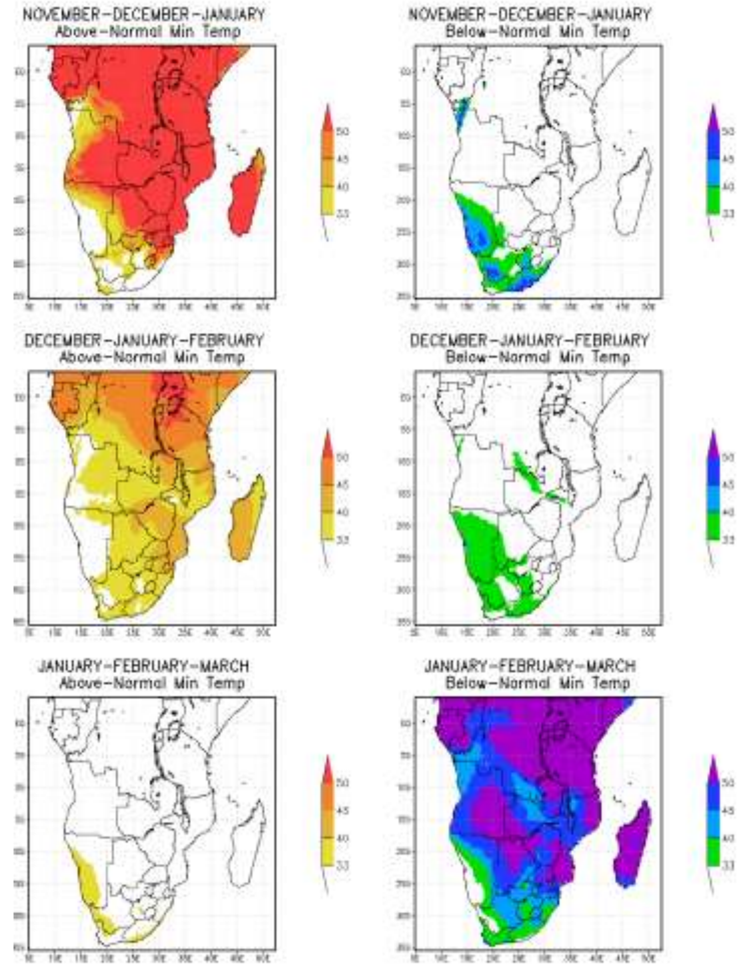
ECHAM4.5 GCM SEASONAL OUTLOOK

Rainfall as a Percentage of Normal

e.g. 50% indicates that half of the usual rainfall for the time of year is expected

Forecast Period: Aug 2013 – Oct 2013 Last Updated 17 Jul 2013





The International Research Institute for Climate and Society

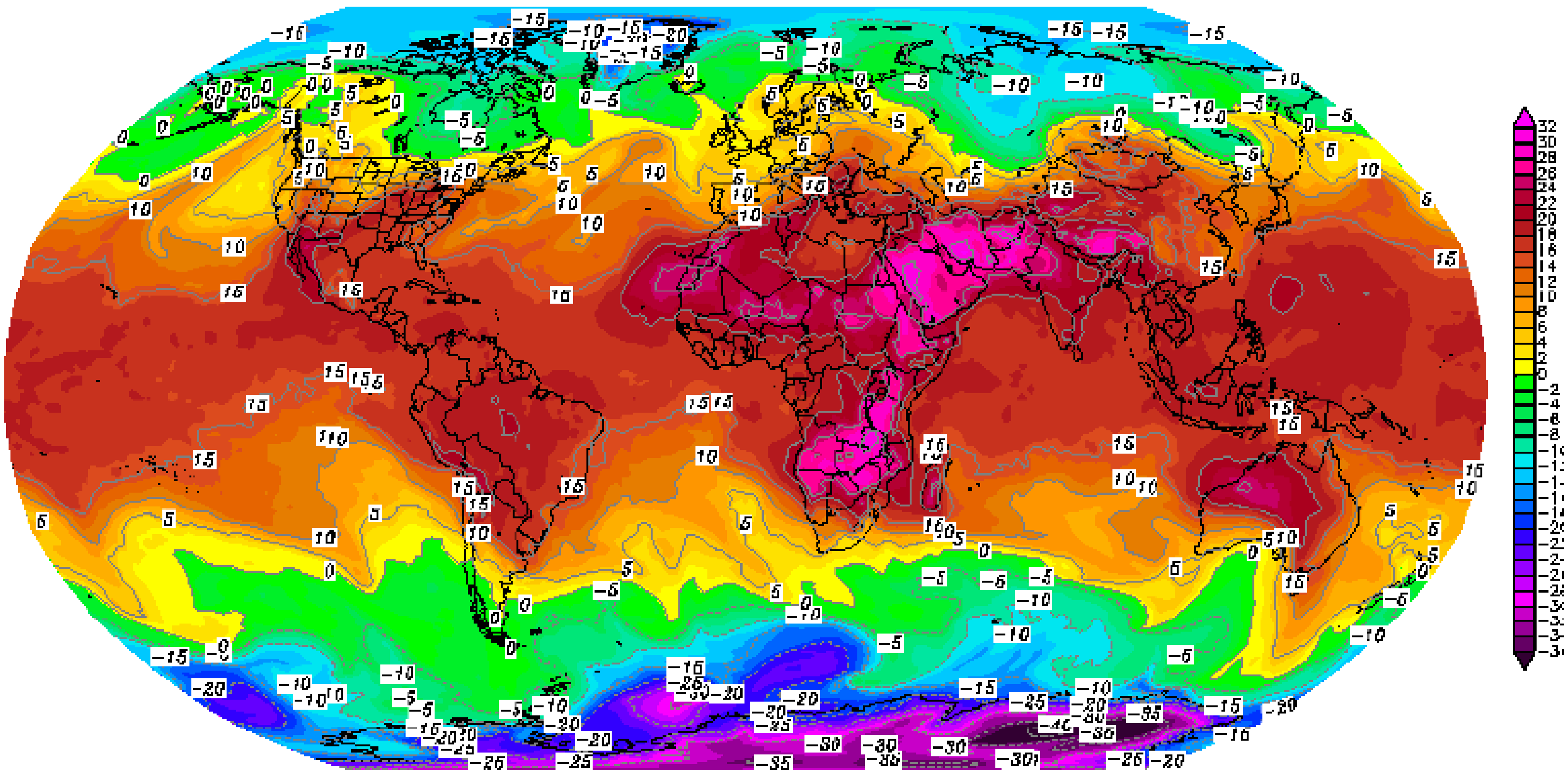
Types of atmospheric models

- Global NWP models
  - Operational forecasting models
  - Run twice to four times daily
  - Generally short to medium range (typically T+144)
  - Global coverage

Init : Wed,04OCT2006 06Z

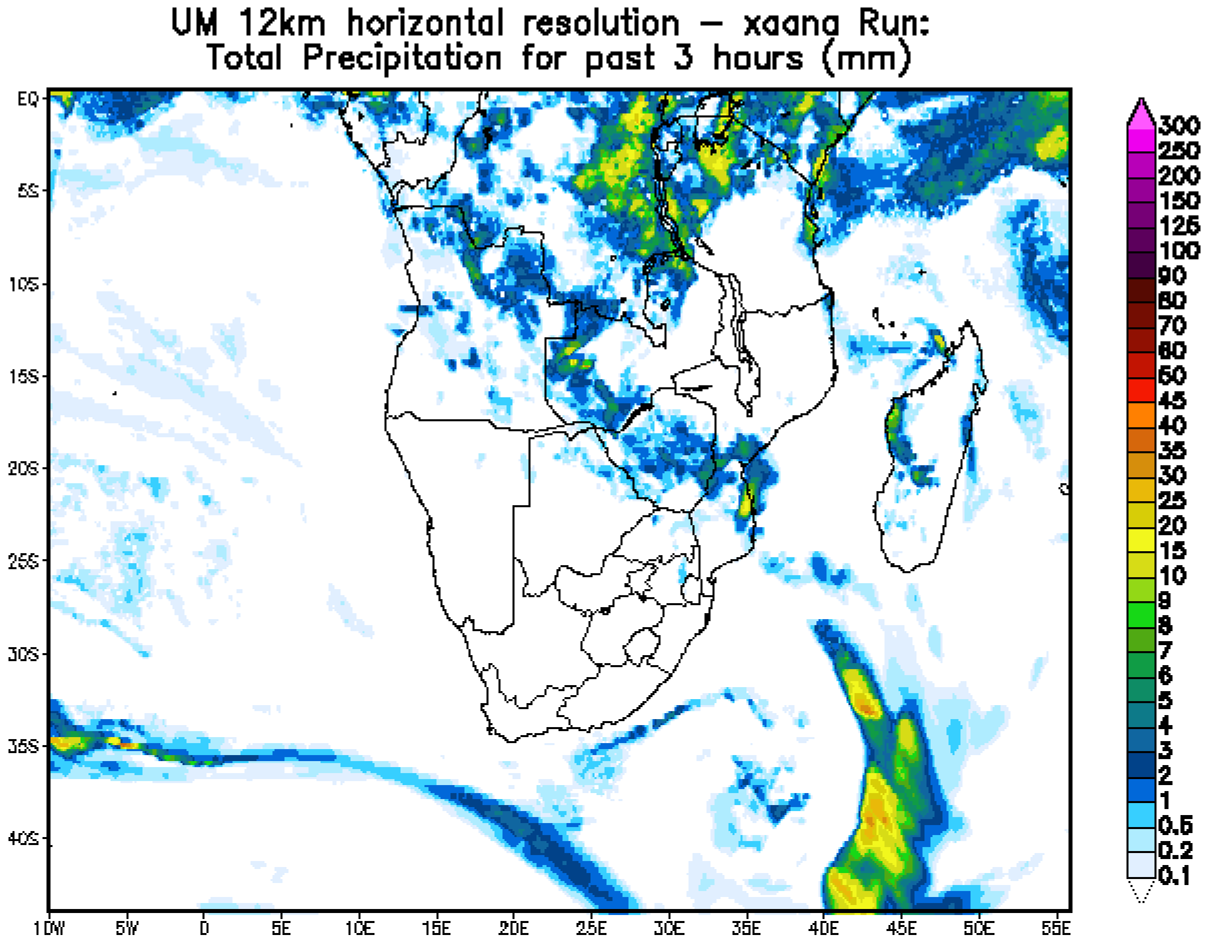
Valid: Wed,04OCT2006 12Z

850 hPa Temperatur (Grad C)



Types of atmospheric models

- Limited Area Models (Mesoscale/LAMs)
  - Add local detail to broad picture from global model
  - Take boundary conditions from global models
  - Higher resolution, so better representation of small scale events
  - Shorter forecast time (typically T+48)
  - Physics adjusted to domain of interest



Total precipitation of 06Z to 09Z, 08 NOV - Initiated 00Z 08 NOV 2013

Types of atmospheric models

- Nowcasting
  - Aim to give best forecast for time period of 0-6 hours ahead
  - Blend od model and observational data
  - i.e. Hydro-Estimator

Types of atmospheric models

- Specific Applications
  - Atmospheric Dispersion
  - Air Quality
  - Lee-wave forecasting models
  - Hydrology / flood forecasting (SARFFG)
  - Agriculture

Models

- ECMWF
  - Horizontal resolution of 16km, 91 vertical levels
  - 10 days ahead
  - 4-D VAR

  - EPS – Ensemble Prediction System
  - 32 km, 62 levels

Models

- NCEP
  - National Centre for Environmental Prediction (USA)
  - Known as GFS (Global Forecasting System)
  - AVN/MRF combined

  - Global Ensemble Forecasting System (GEFS)
  - 21 members per run
  - Runs 4 times daily

Models

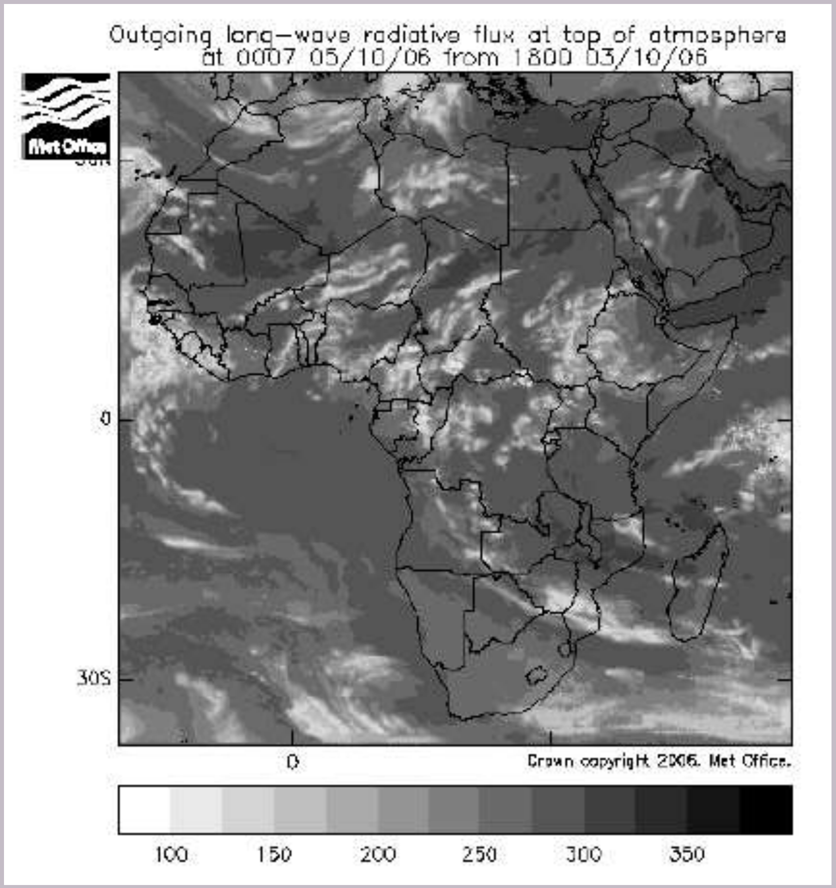
- UK Met Office
  - Horizontal resolution of 17 km and 70 vertical levels
  - 4 times daily
  - Run out to T+144
  - 4-D VAR

Models

- UK Met Office
  - Limited Area Models
  - UK Var
    - 1.5 km
    - 70 levels
    - Covers UK
    - Updates 8 times per day
    - T+36

Models

- Africa LAM discontinued

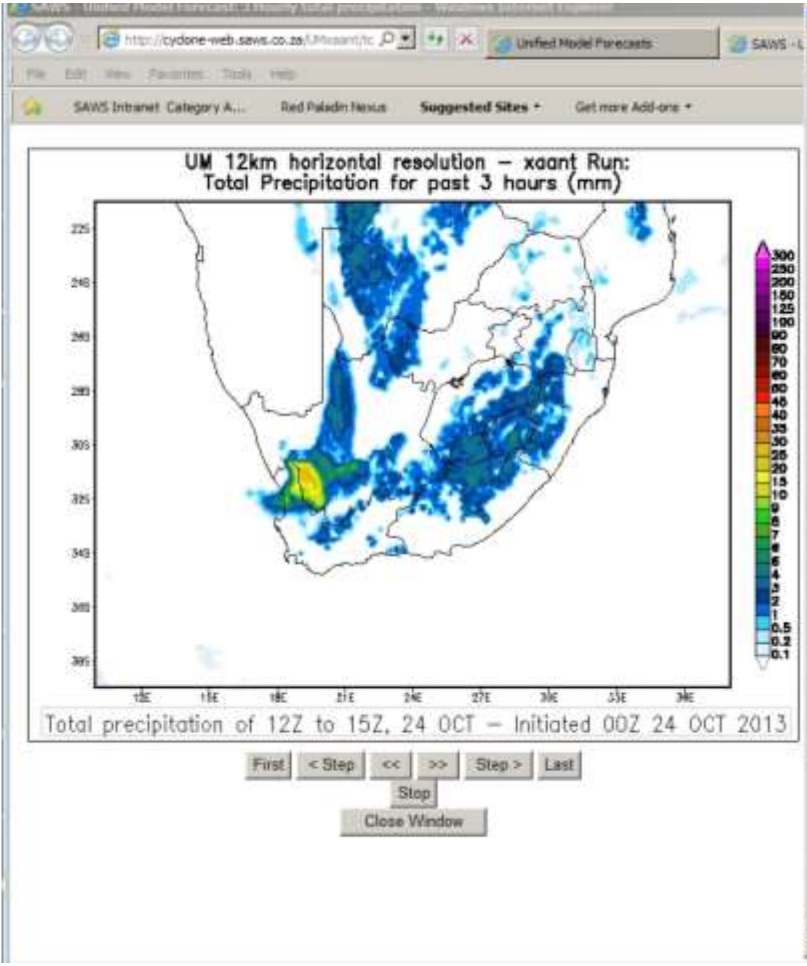


Strengths & Weaknesses of NWP models

- There are generic problems common to most NWP
- If we know about these we can account for them in our initial verification
- Most problems are related to resolution

Strengths & Weaknesses of NWP models

- STRENGHTS
  - Convection
    - General area of convection is well captured
  - Extra-tropical latitudes
    - Models is much better here
    - Frontal systems are well represented
    - Orographically enhanced rainfall better than Global Model


UM 12km horizontal resolution – xaant Run:
Total Precipitation for past 3 hours (mm)
Total precipitation of 12Z to 15Z, 24 OCT – Initiated 00Z 24 OCT 2013
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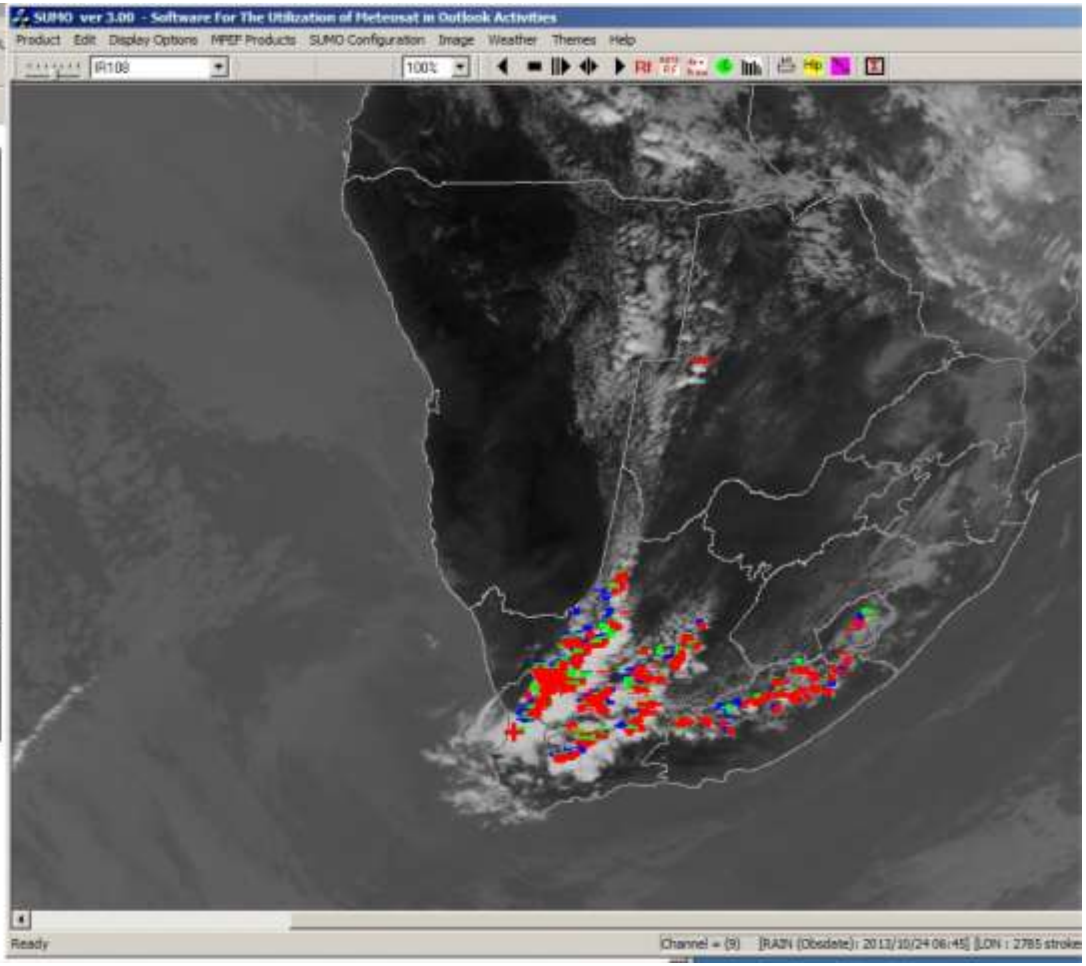
Step >
Last
Stop
Close Window


SUMO ver 3.00 - Software For The Utilization of Meteosat in Outlook Activities
Product Edit Display Options MPEF Products SUMO Configuration Image Weather Themes Help
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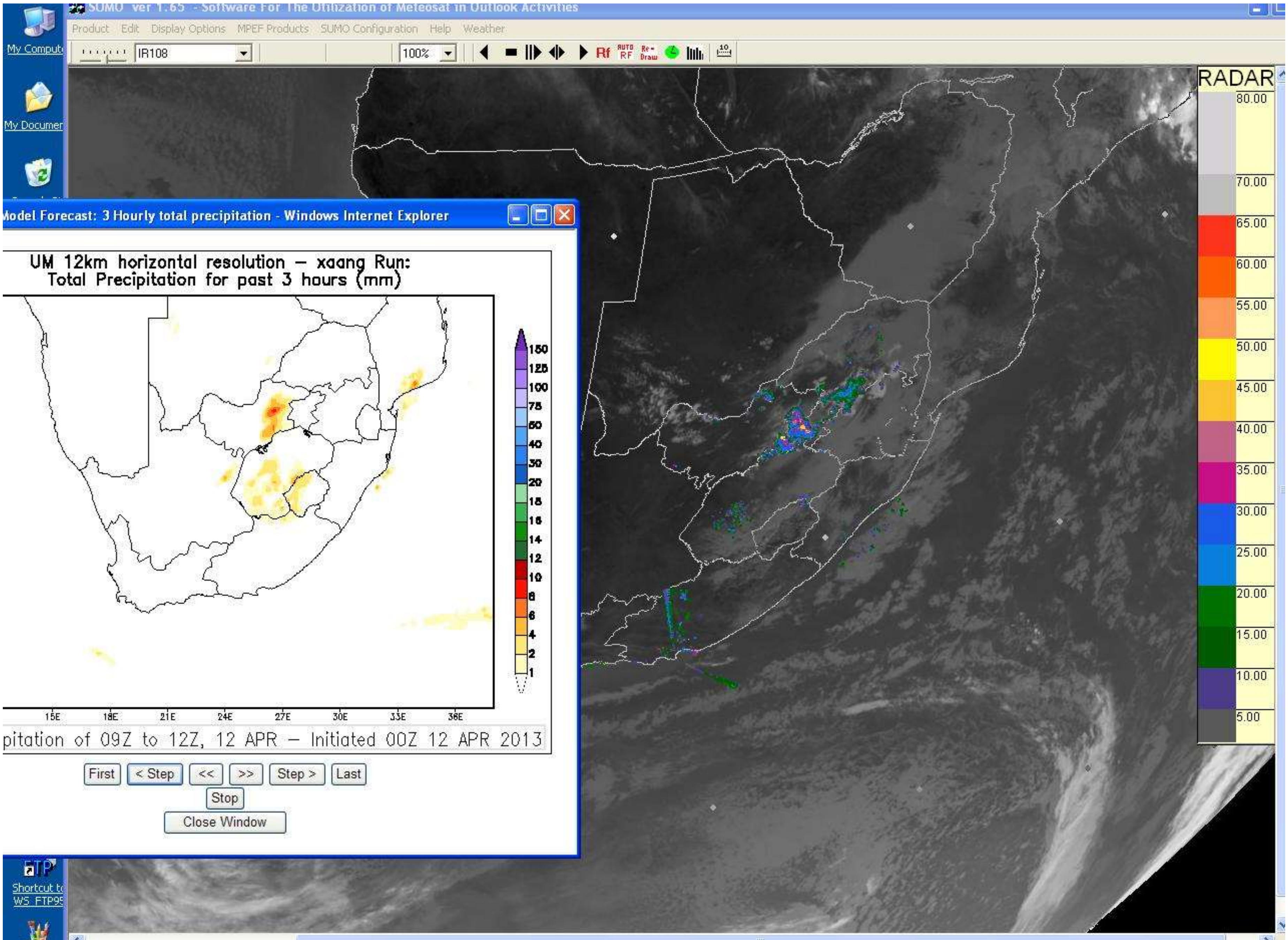

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Product Edit Display Options MPEF Products SUMO Configuration Help Weather
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Model Forecast: 3 Hourly total precipitation - Windows Internet Explorer
UM 12km horizontal resolution – xaang Run:
Total Precipitation for past 3 hours (mm)
150
125
100
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15E 18E 21E 24E 27E 30E 33E 36E
pitation of 09Z to 12Z, 12 APR – Initiated 00Z 12 APR 2013
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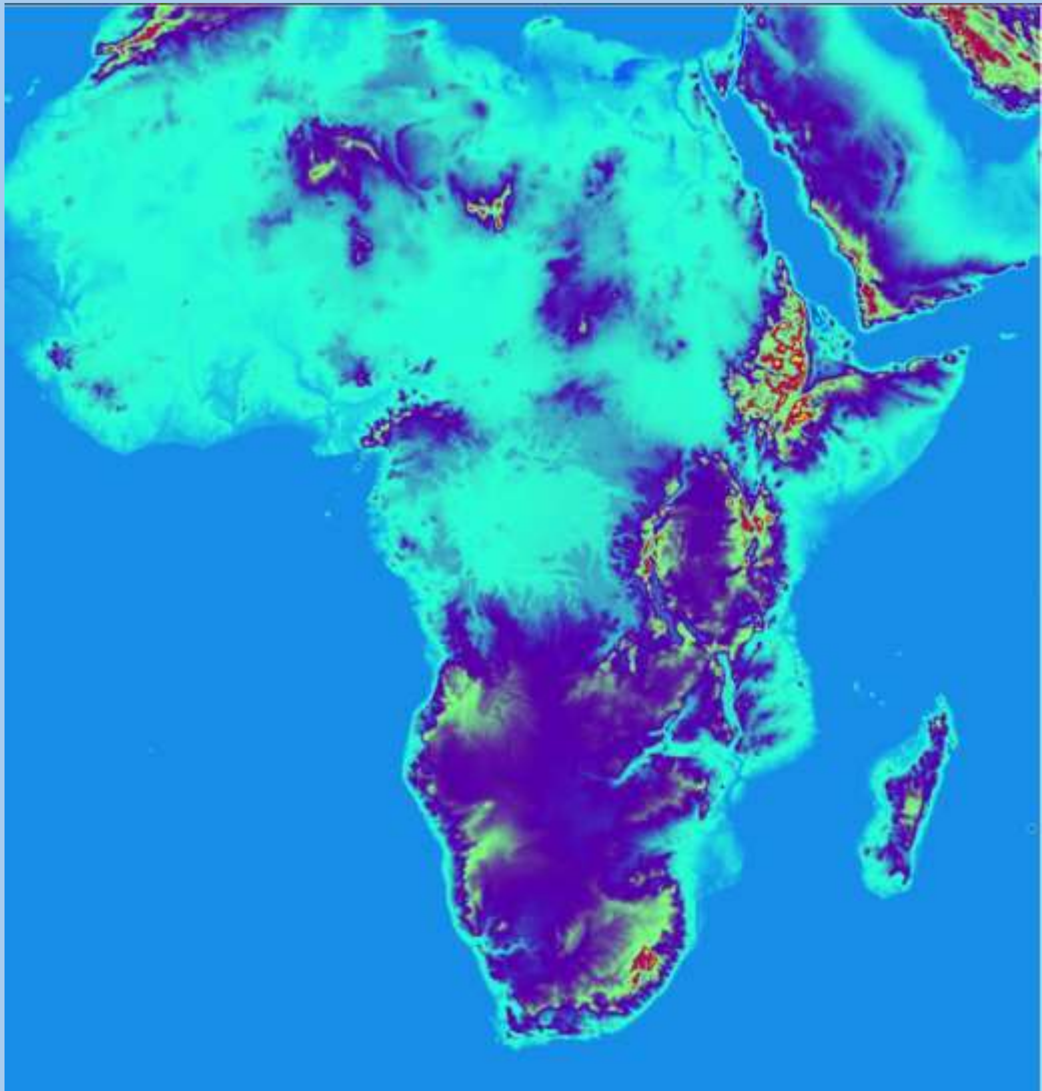
WS_FTP95

Strengths & Weaknesses of NWP models

- GENERIC PROBLEMS
  - Inaccurate Initial Conditions
    - Lack of data
    - Imperfect data assimilation
  - Resolution
    - Horizontal resolution may cause small scale features to be missed
    - Vertical profile may not capture full detail e.g. inversions, localized temperature advection

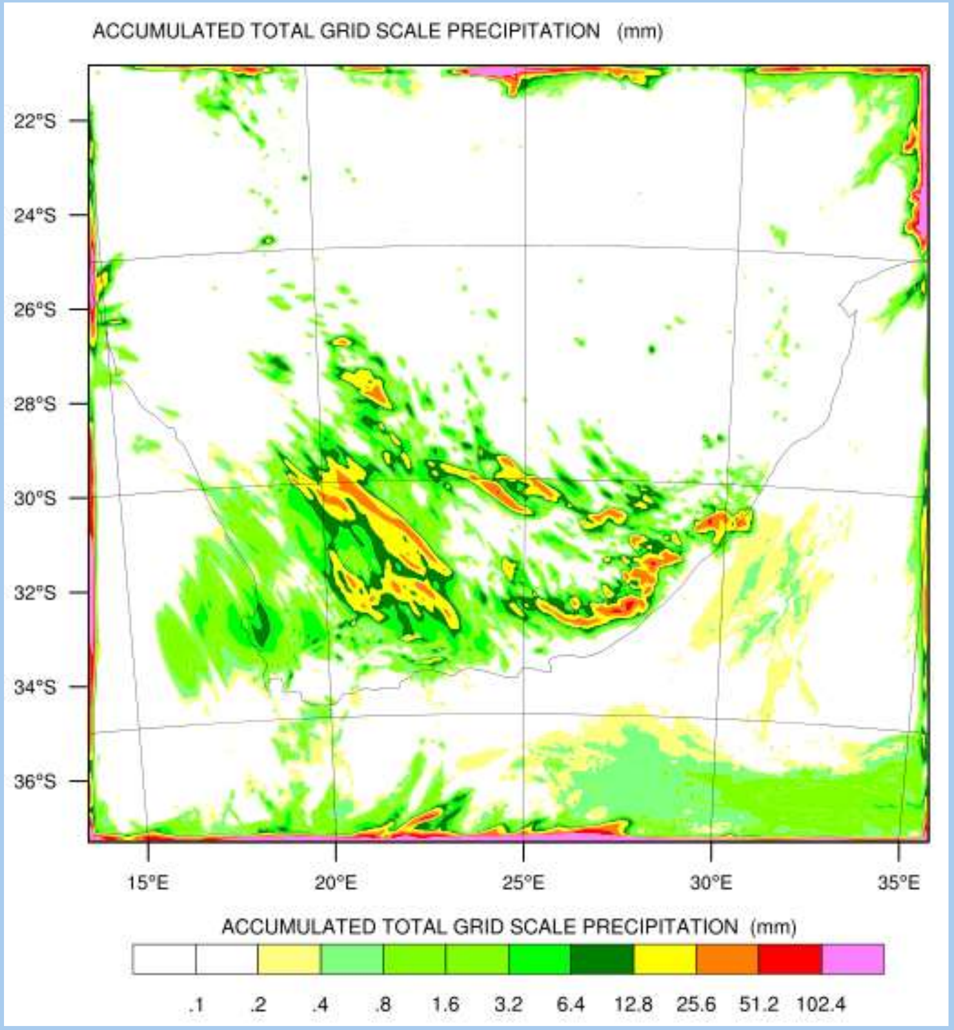
Strengths & Weaknesses of NWP models

- GENERIC PROBLEMS
  - OROGRAPHY
    - Generally flattened – less steep and less high
    - Some features completely omitted
    - Orography in LAMs is better than in global models but still not perfect



Strengths & Weaknesses of NWP models

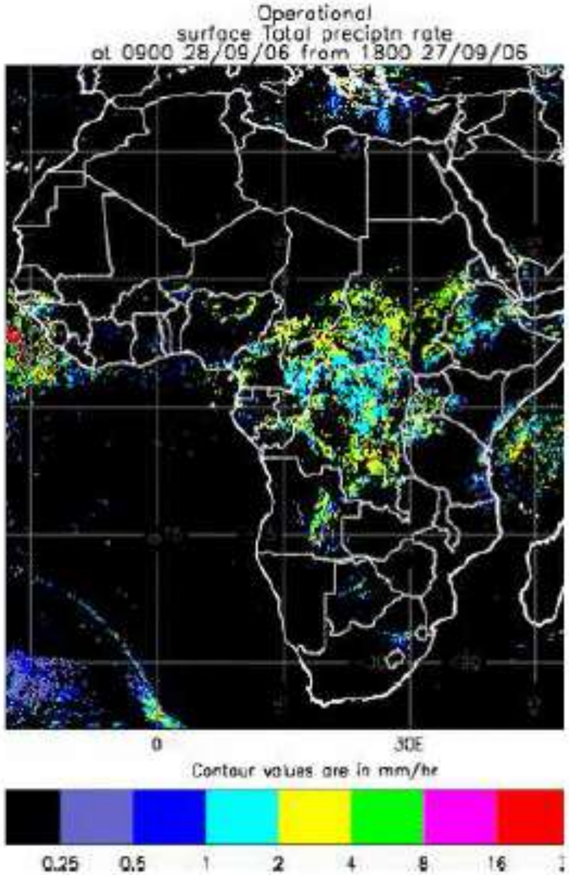
- GENERIC PROBLEMS
  - Lateral Boundary Conditions
    - Only a problem for LAMs
    - Spin up problems when transporting low resolution data onto high resolution grid
    - Potential problems at edge of domain

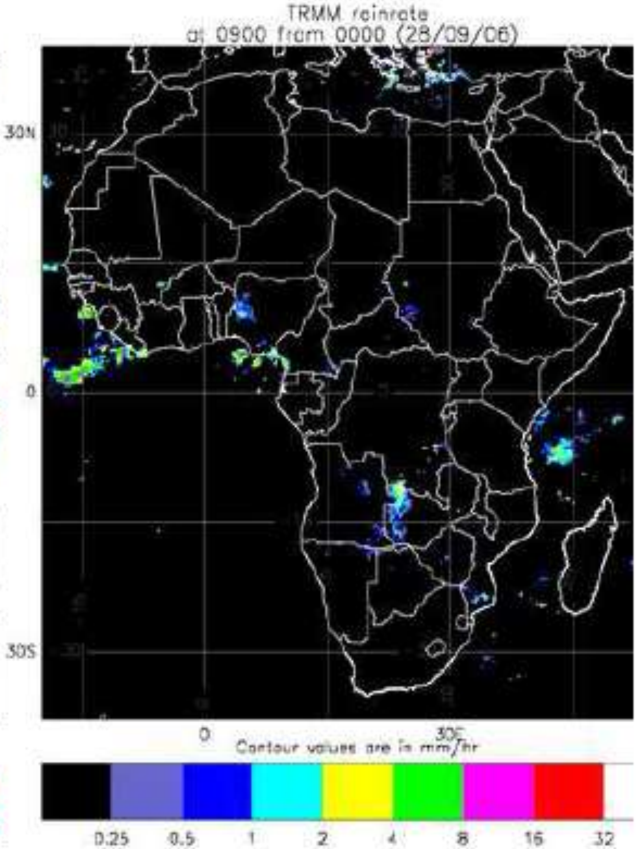


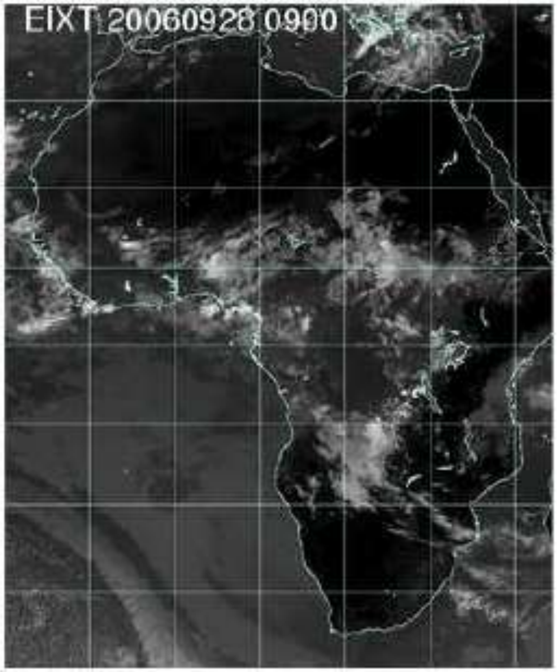
Strengths & Weaknesses of NWP models

- WEAKNESS:
  - Tropical Convection
    - Representation of diurnal cycle is poor
    - Convection initiated too early and is too widespread
    - 0600-1200 ppn accumulation frames contain spurious ppn but can indicate areas of activity
    - Fails to develop large scale, long-lived mesoscale convection systems

NWP convection switched on...

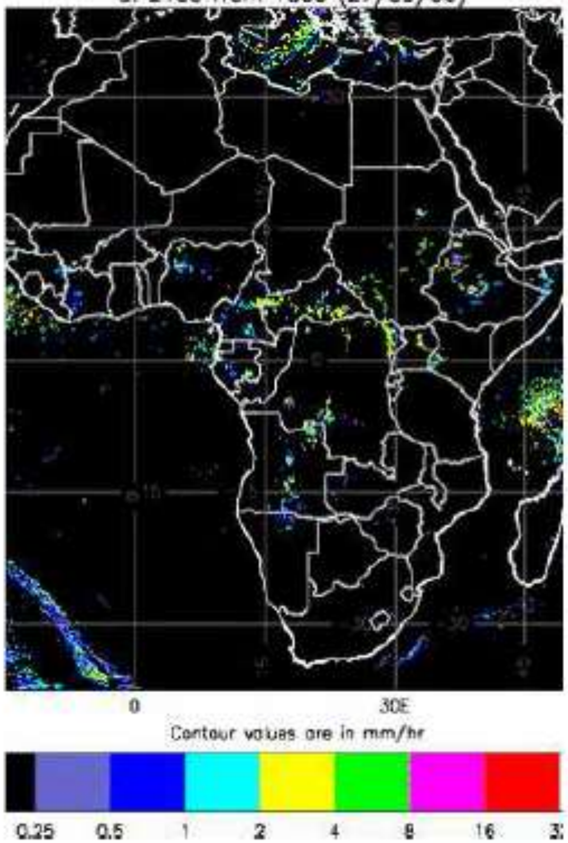




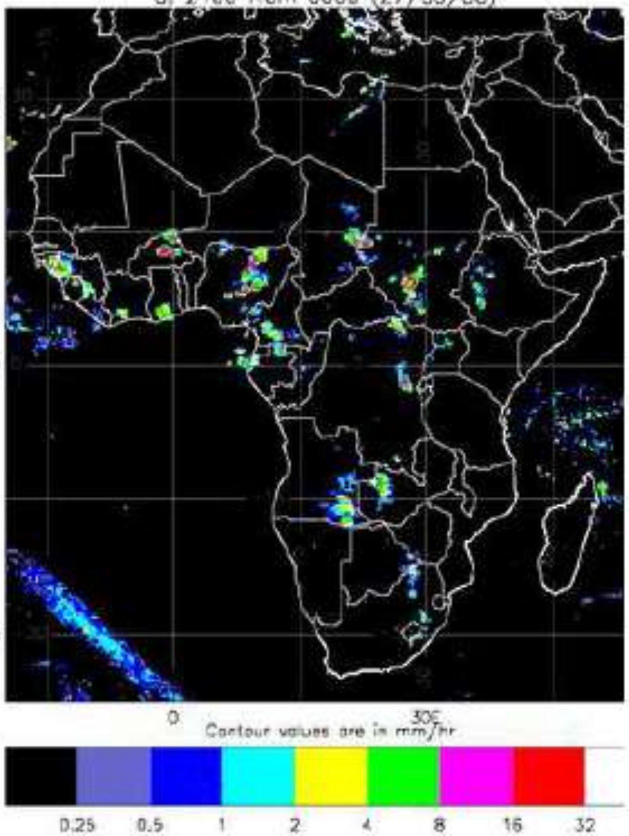


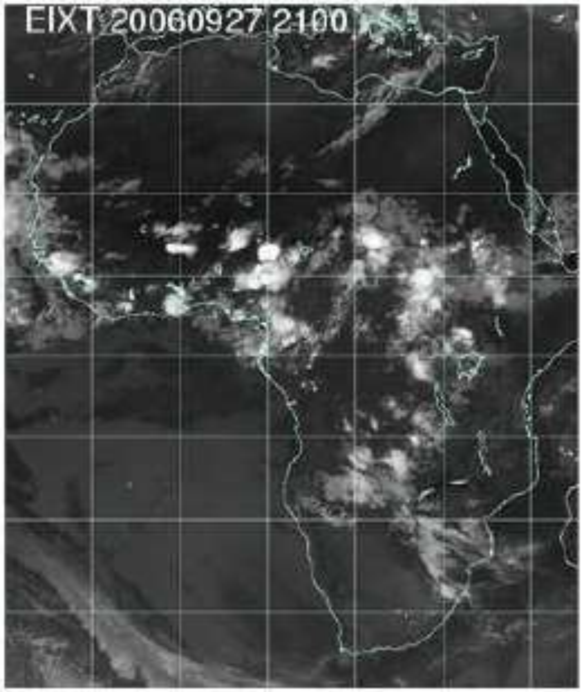
NWP convection switched off...

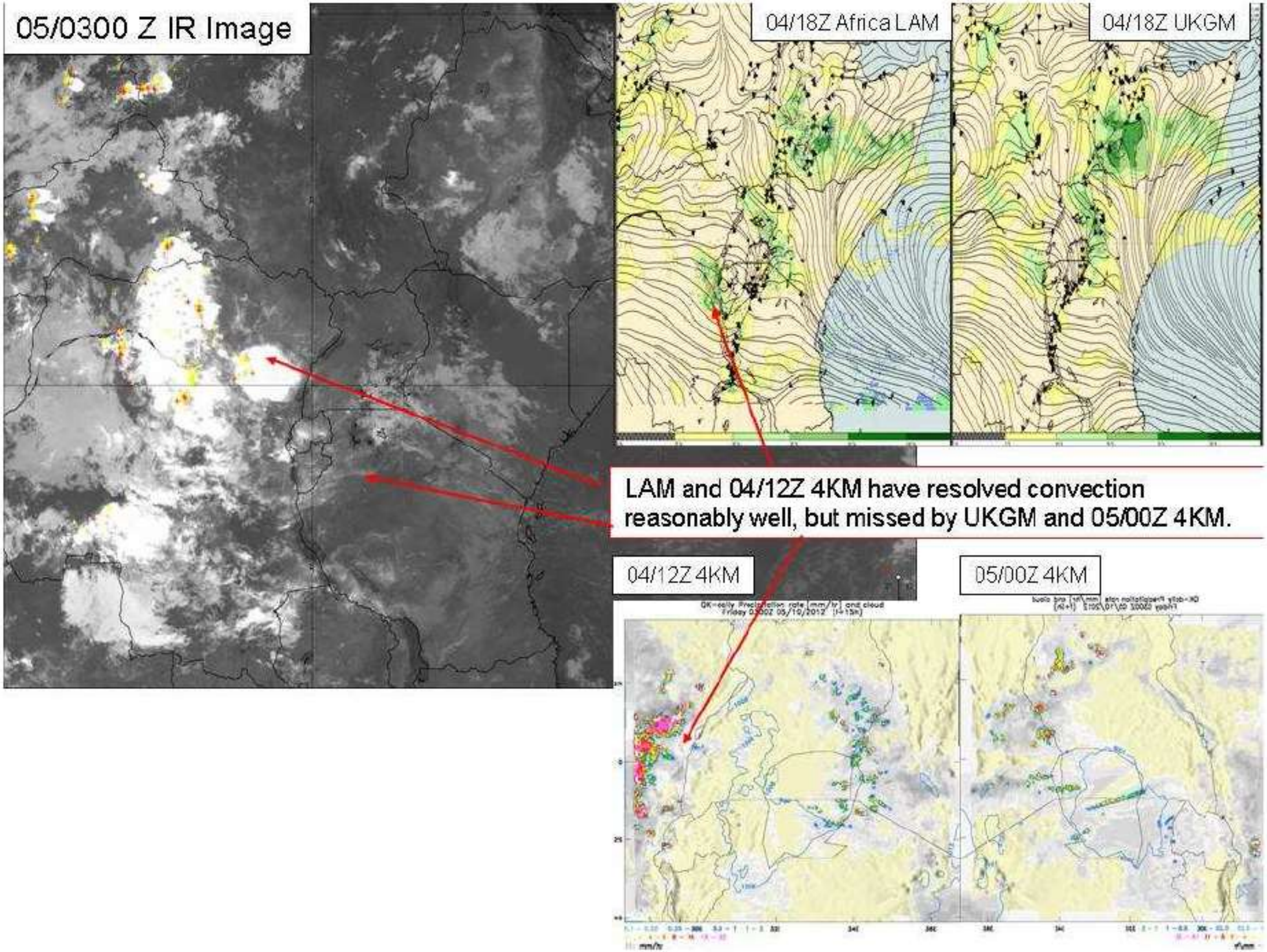
Operational
surface Total precip rate
at 2100 from 1800 (27/09/06)



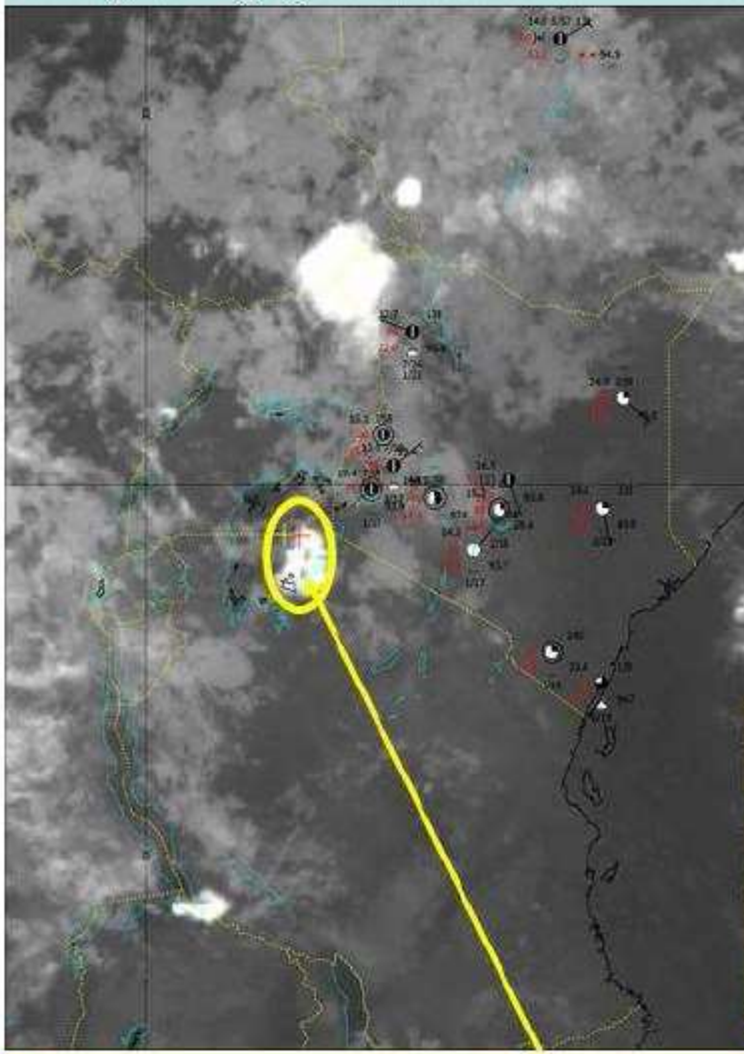
TRMM rainrate
at 2100 from 0000 (27/09/06)

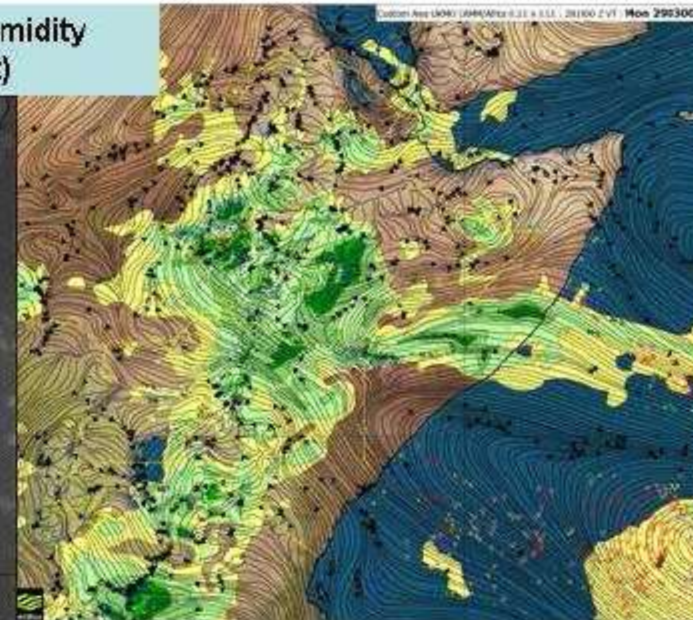


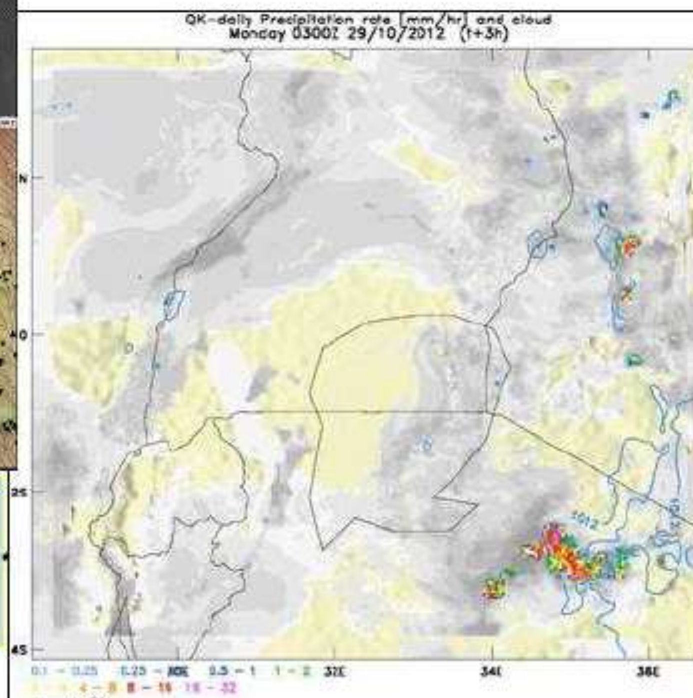



05/0300 Z IR Image
04/18Z Africa LAM
04/18Z UKGM
LAM and 04/12Z 4KM have resolved convection
reasonably well, but missed by UKGM and 05/00Z 4KM.
04/12Z 4KM
05/00Z 4KM

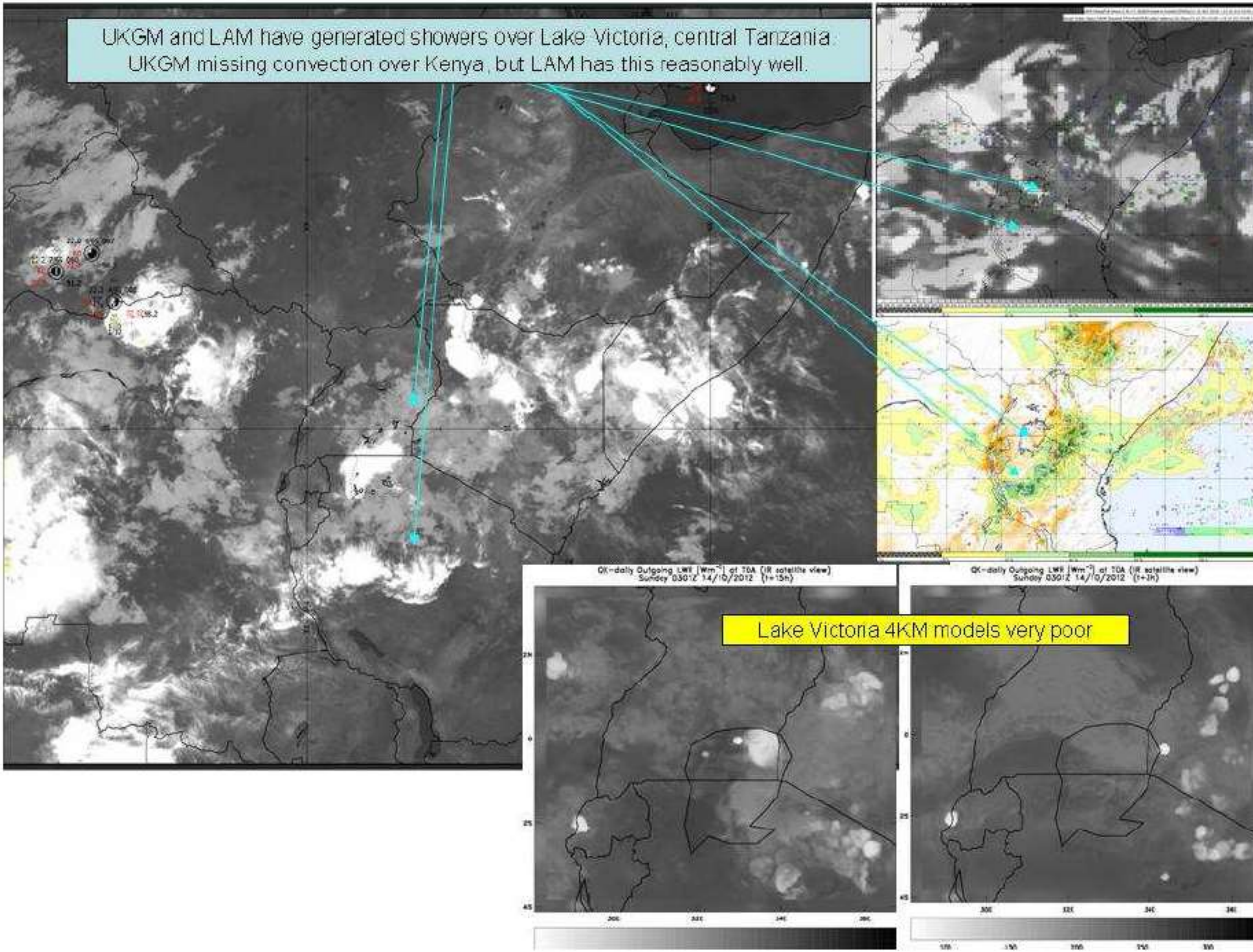
29/03Z IR image (below left), with 28/18Z Africa LAM T+9 ppn and 700hPa humidity fields (above right), and Lake Victoria 4KM model valid at 29/03Z (lower right)







Development commenced over the far SE corner of the Lake and the 4KM model does not verify well at this time. The corresponding signal From the Africa LAM is little better, despite this model having the requisite moisture fields in about the right location.


UKGM and LAM have generated showers over Lake Victoria, central Tanzania.
UKGM missing convection over Kenya, but LAM has this reasonably well.
Lake Victoria 4KM models very poor

The forecast process

- Convergence
- lake/sea breezes;
- orography;
- surface processes (soil moisture, vegetation, etc);
- diurnal cycle

- Most NWP Models may have difficulty predicting due to problems with initial conditions and convective parameterisation schemes.
- Therefore use NWP intelligently to predict:
  - Timing and location of convection initiation
  - Convective system evolution

The forecast process

- Look for favourable synoptic and mesoscale patterns in NWP products;
- Look for favourable conditions (instability on ascents, indices) for convection formation;
- Be alert for any known model biases in positioning/timing errors of synoptic systems;
- Watch for predictions of unrealistic looking precipitation due to convective parameterisation limitations.

Questions and Answers