

Numerical Weather Prediction Models

Adapted from Davies, 2012

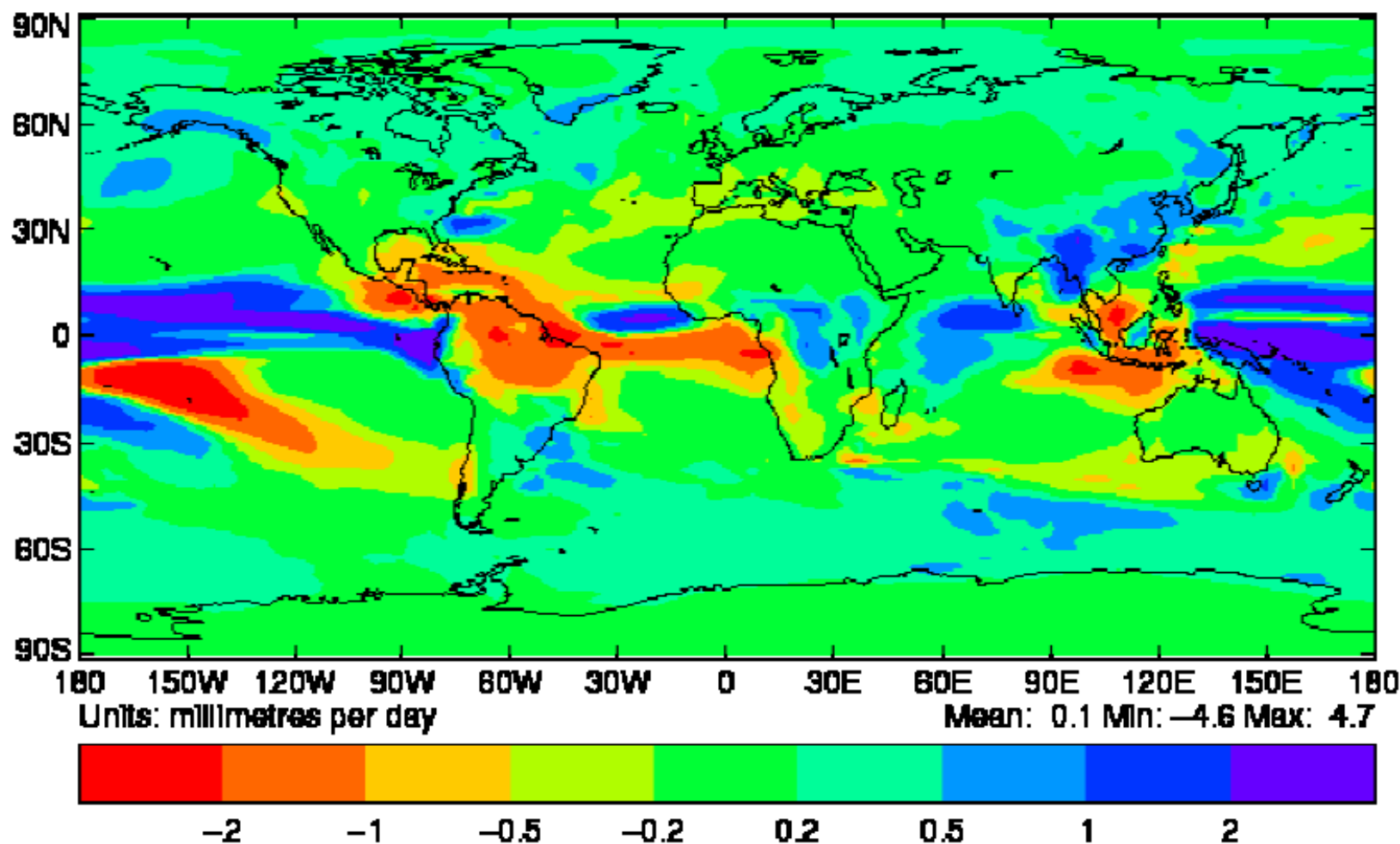
NWP Model Formulation

- 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

**Change in annual average precipitation
from 1960–1990 to 2070–2100 from HadCM3 IS92a**



Types of atmospheric model

- Long-term and seasonal
 - Couples 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

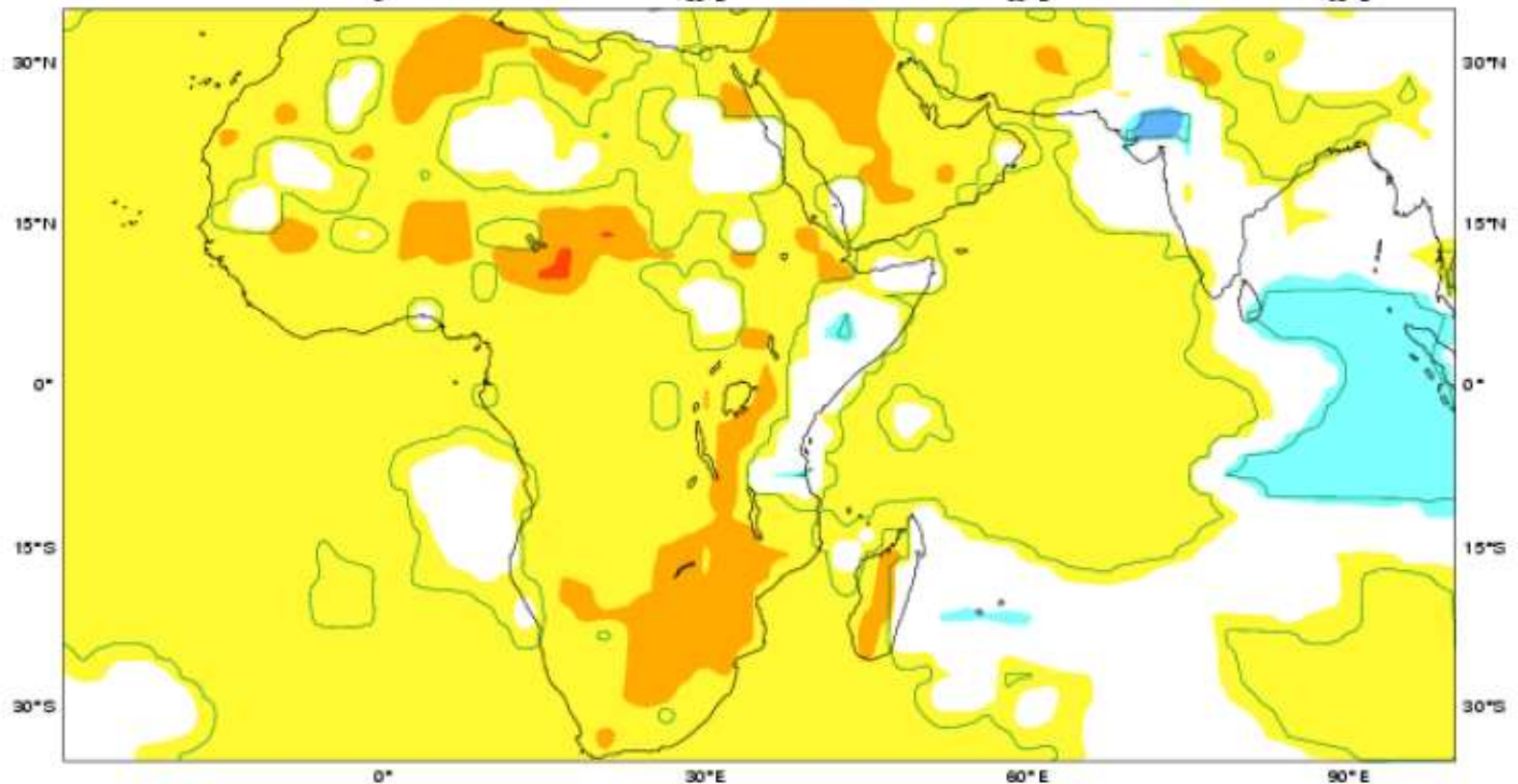
Forecast start reference is 01/09/08

Ensemble size = 40, climate size = 75

System 2 OND 2006

Shaded areas significant at 10% level

Solid contour at 1% level



Forecast issue date: 15/09/2008

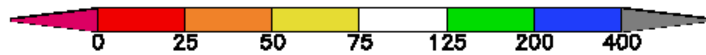
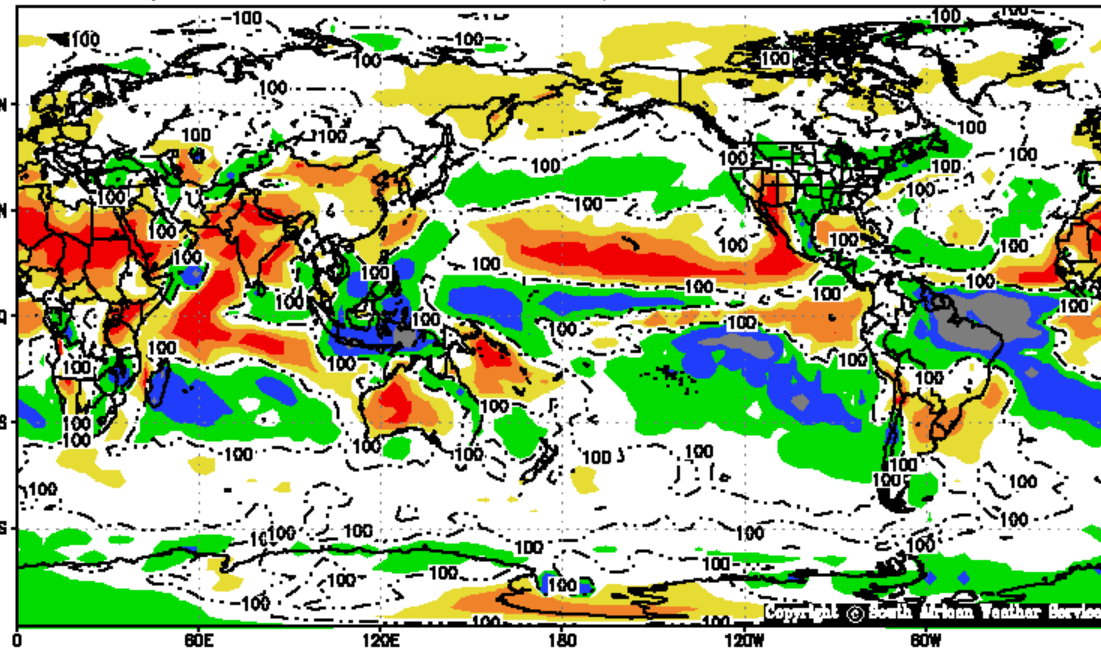
ECHAM4.5 GCM SEASONAL OUTLOOK

Rainfall as a Percentage of Normal

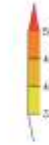
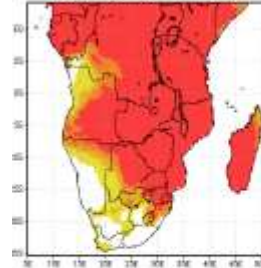
e.g. 50% indicates that half of the usual rainfall for the time of year is expected

Forecast Period: Aug 2013 – Oct 2013

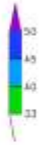
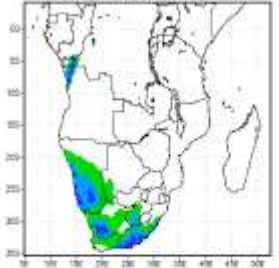
Last Updated 17 Jul 2013



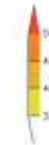
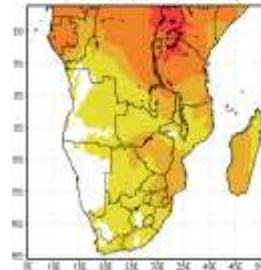
NOVEMBER–DECEMBER–JANUARY
Above–Normal Min Temp



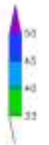
NOVEMBER–DECEMBER–JANUARY
Below–Normal Min Temp



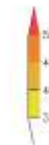
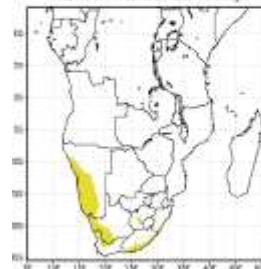
DECEMBER–JANUARY–FEBRUARY
Above–Normal Min Temp



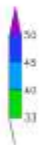
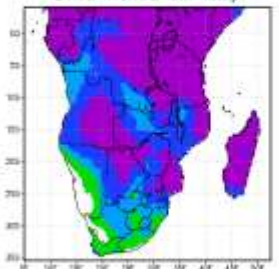
DECEMBER–JANUARY–FEBRUARY
Below–Normal Min Temp



JANUARY–FEBRUARY–MARCH
Above–Normal Min Temp



JANUARY–FEBRUARY–MARCH
Below–Normal Min Temp



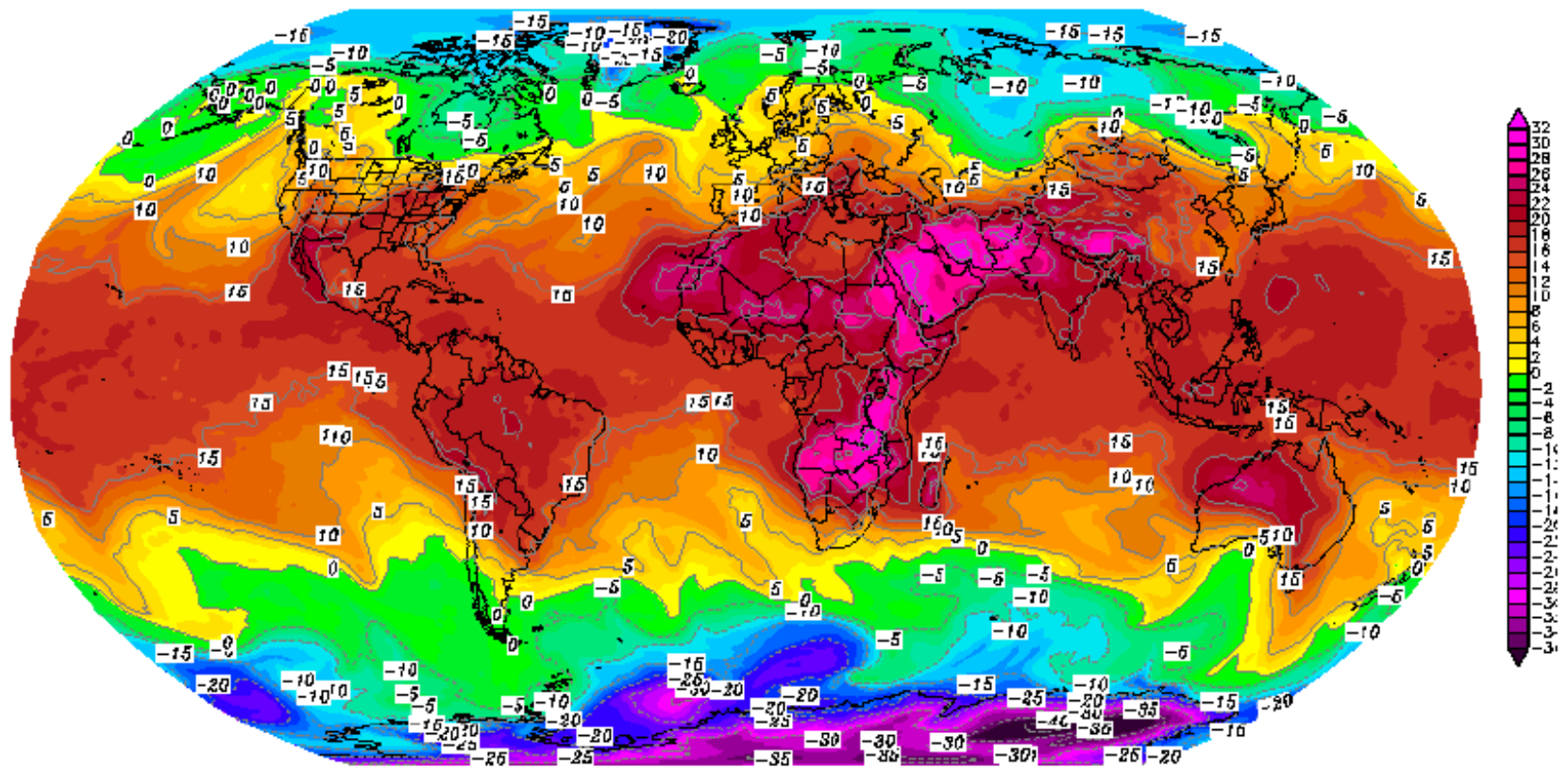
Types of atmospheric model

- 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

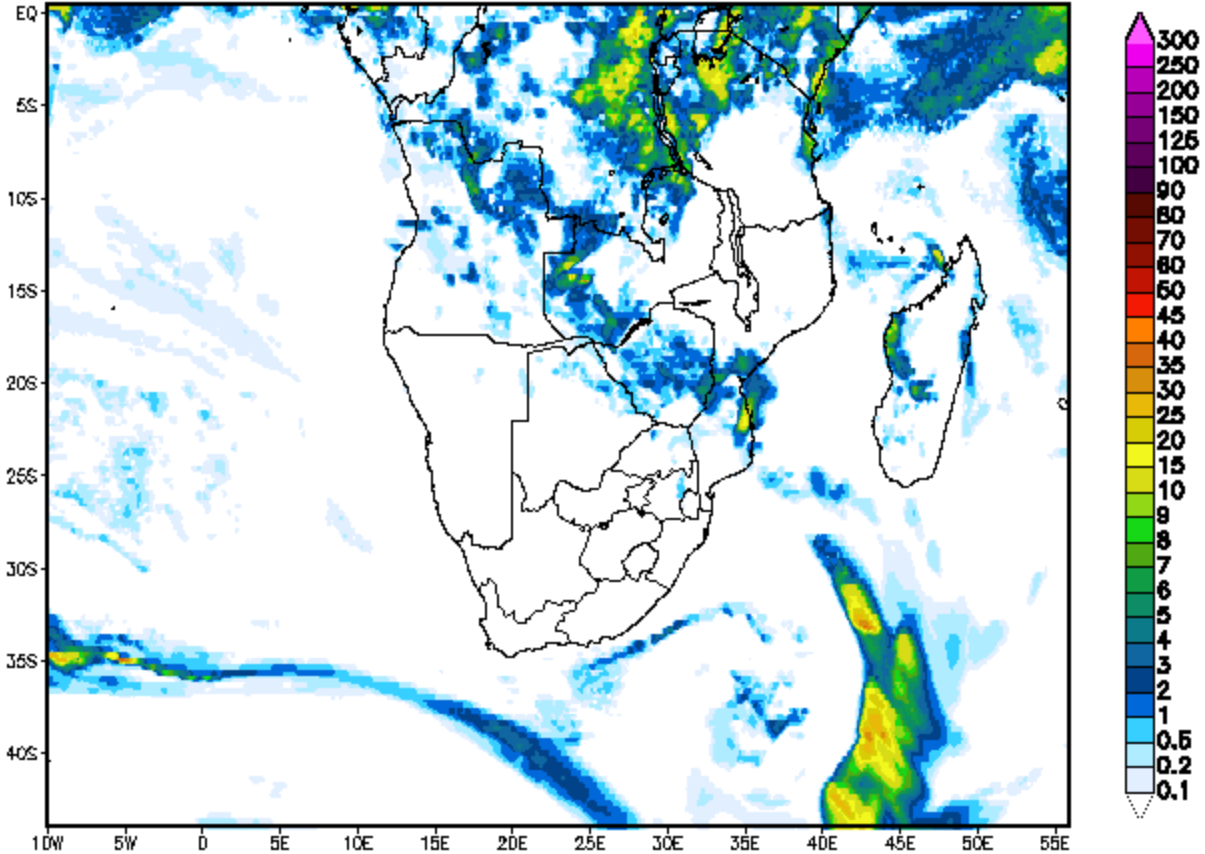
850 hPa Temperatur (Grad C)



Types of atmospheric model

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

UM 12km horizontal resolution – xaana Run:
Total Precipitation for past 3 hours (mm)



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

Types of atmospheric model

- Nowcasting
 - Aim to give best forecast for time period of 0-6 hours ahead
 - Blend of model and observational data
 - UK Met Office used the NIMROD system
- Specific Applications
 - Atmospheric Dispersion
 - Air Quality
 - Lee-wave forecasting models

Models

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

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

Models

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

Models

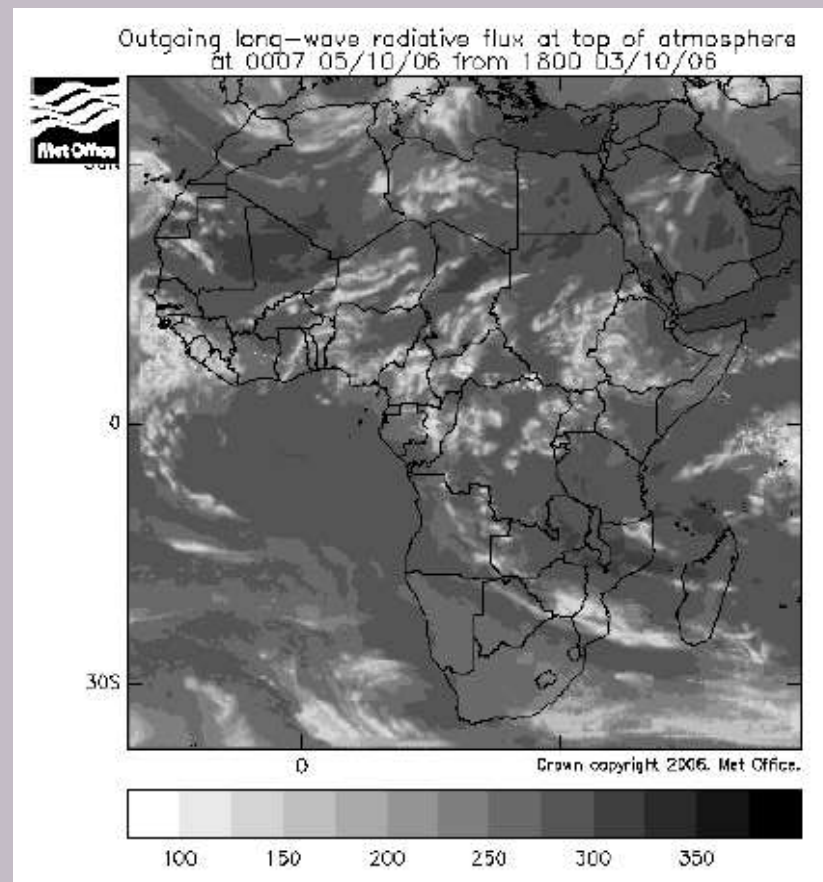
- UK Met Office
 - Horizontal resolution of 25 km and 70 vertical levels
 - 4 times daily
 - Run out to T+144
 - 4-D VAR

Models

- UK Met Office
 - Limited Area Models
 - North Atlantic European (NAE)
 - 12 km horizontal resolution, 70 vertical levels
 - Stretches from Newfoundland to Eastern Mediterranean and Northern Scandinavia to North Africa
 - Four times daily to T+48

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

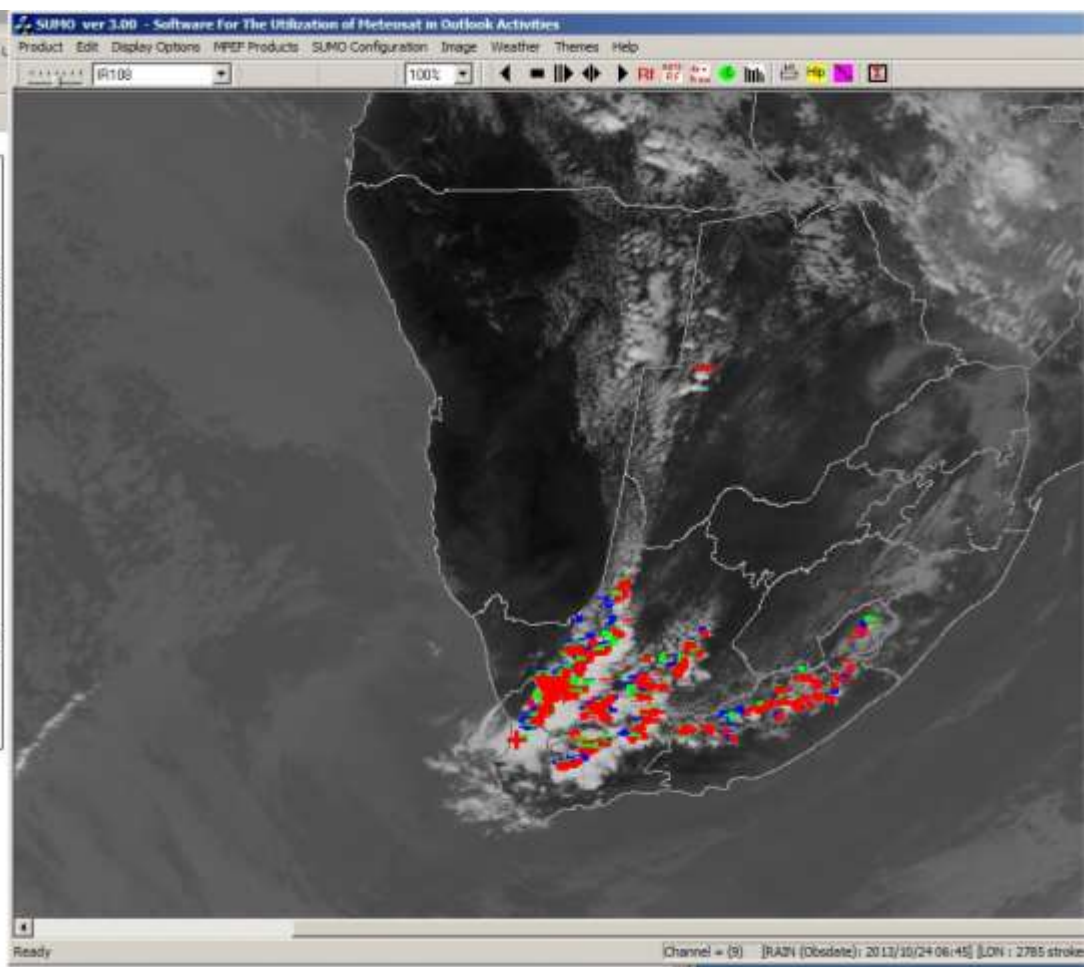
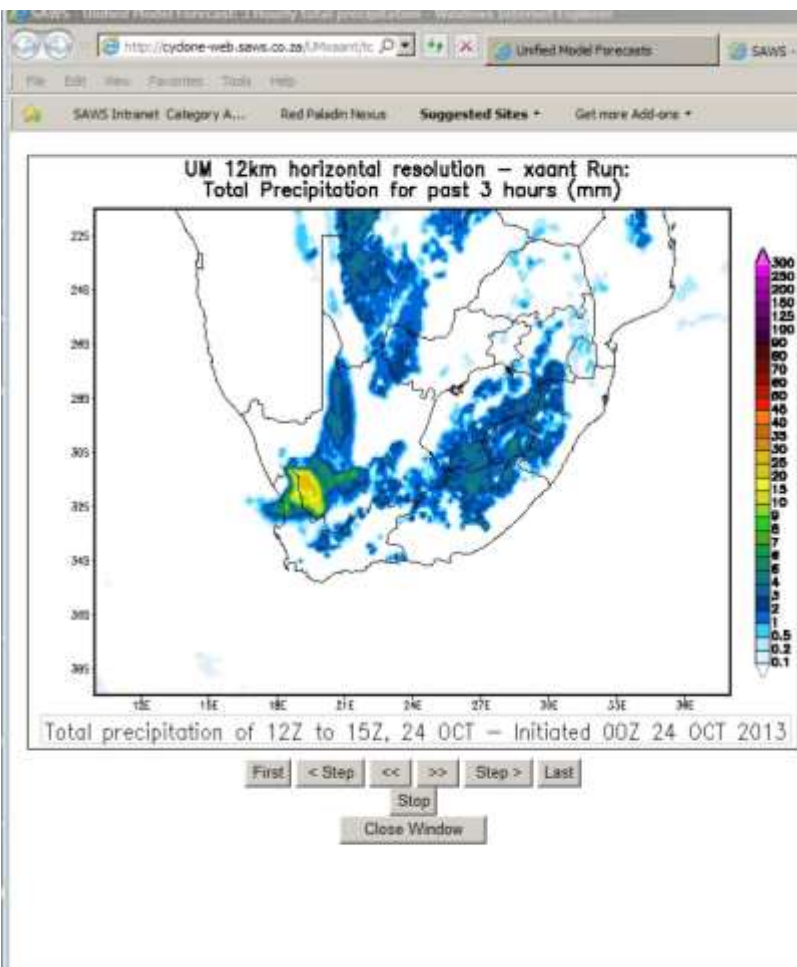
- STRENGTHS

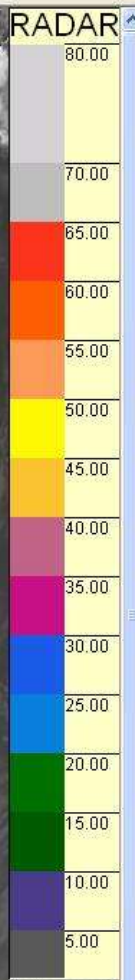
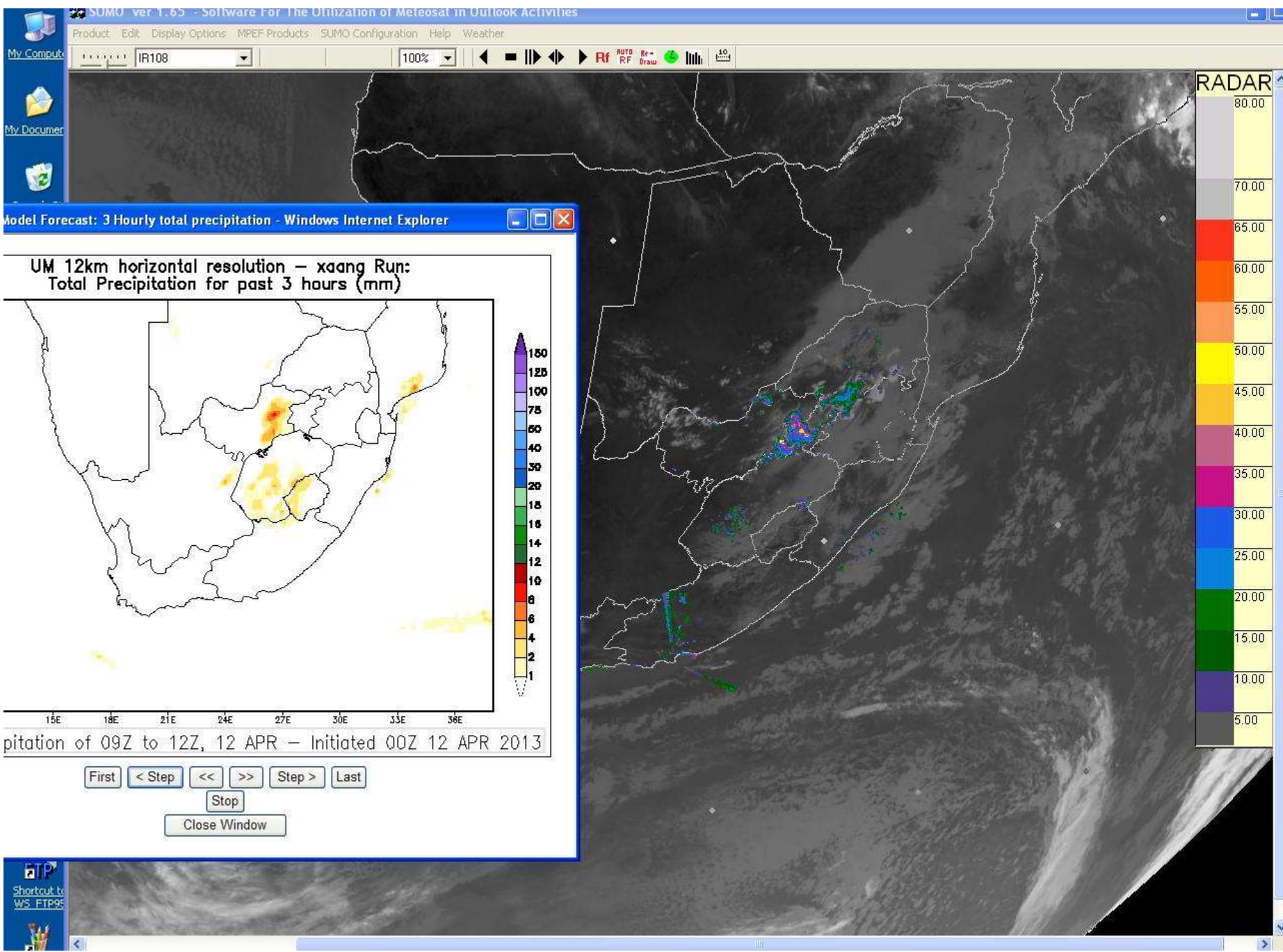
- Convection

- General area of convection is well captured

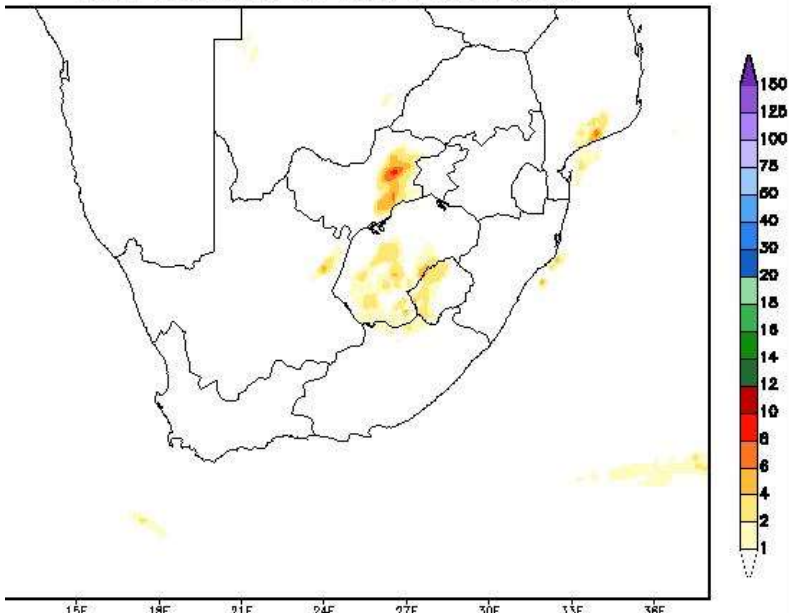
- Extra-tropical latitudes

- Models is much better here
 - Frontal systems are well represented
 - Orographically enhanced rainfall better than Global Model





UM 12km horizontal resolution - xaang Run:
Total Precipitation for past 3 hours (mm)



Total Precipitation of 09Z to 12Z, 12 APR - Initiated 00Z 12 APR 2013

First < Step << >> Step > Last
Stop
Close Window

Strengths & Weaknesses of NWP models

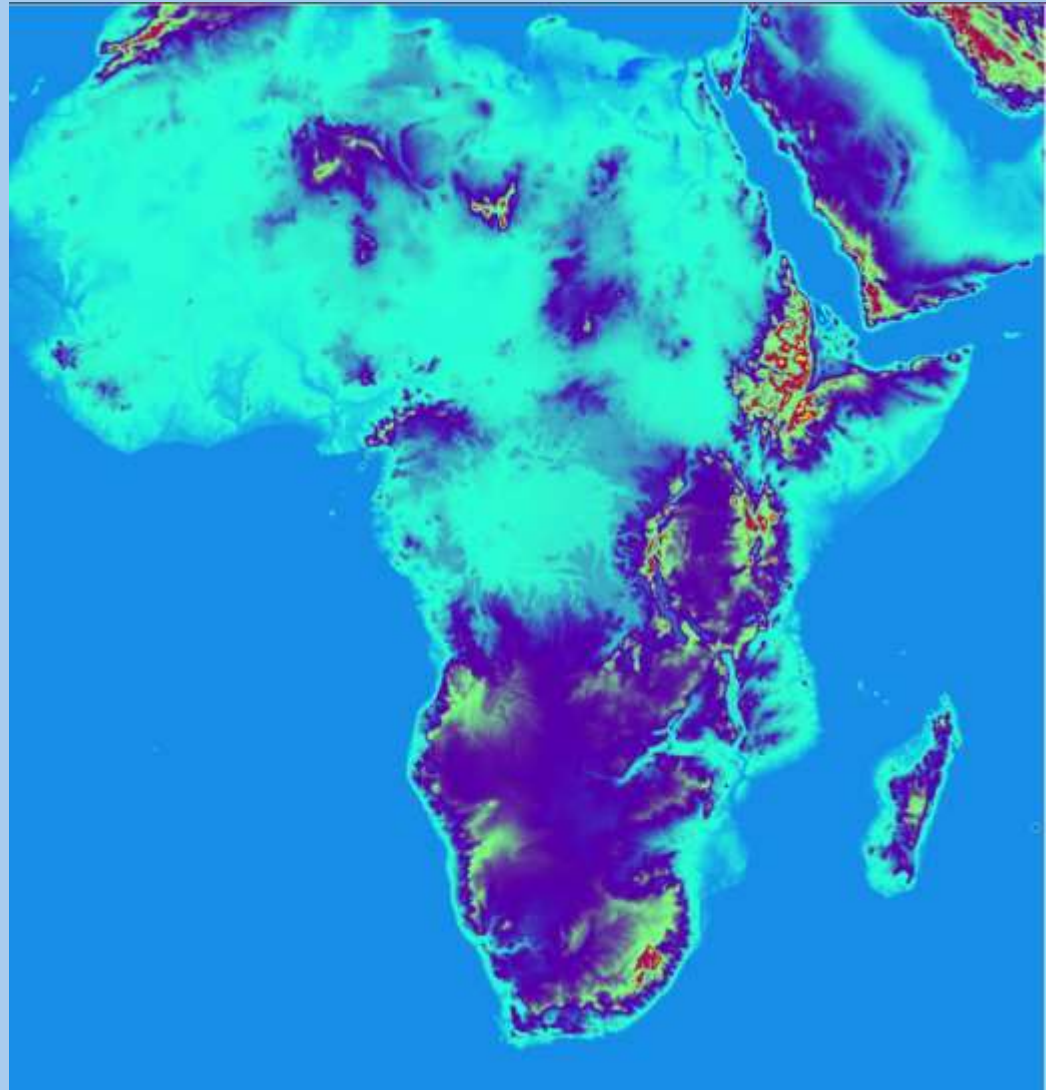
- **GENERIC PROBLEMS**
 - Inaccurate Initial Conditions
 - Lack of data
 - Imperfect data assimilation
 - Resolution
 - Horizontal resolution may cause small scale features to be missed
 - Vertical profile may not capture full detail e.g. inversions, localized temperature advection

Strengths & Weaknesses of NWP models

- **GENERIC PROBLEMS**

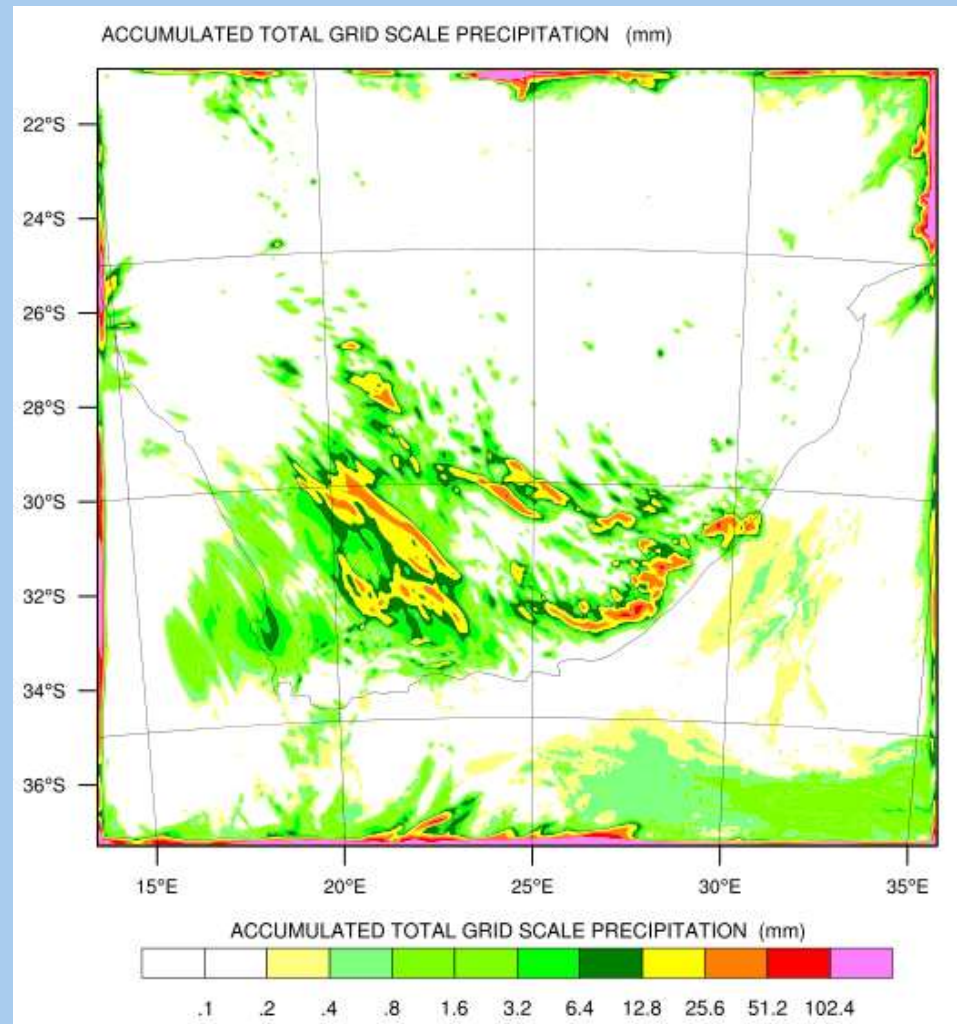
- **OROGRAPHY**

- 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

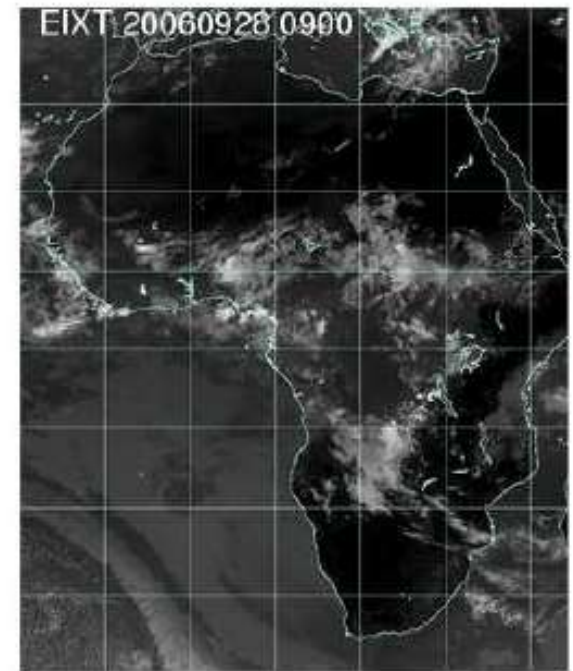
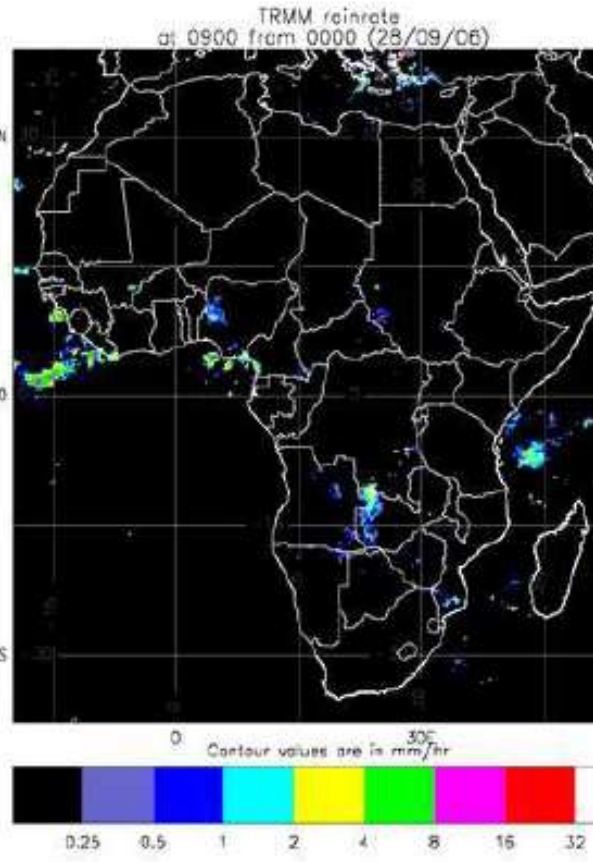
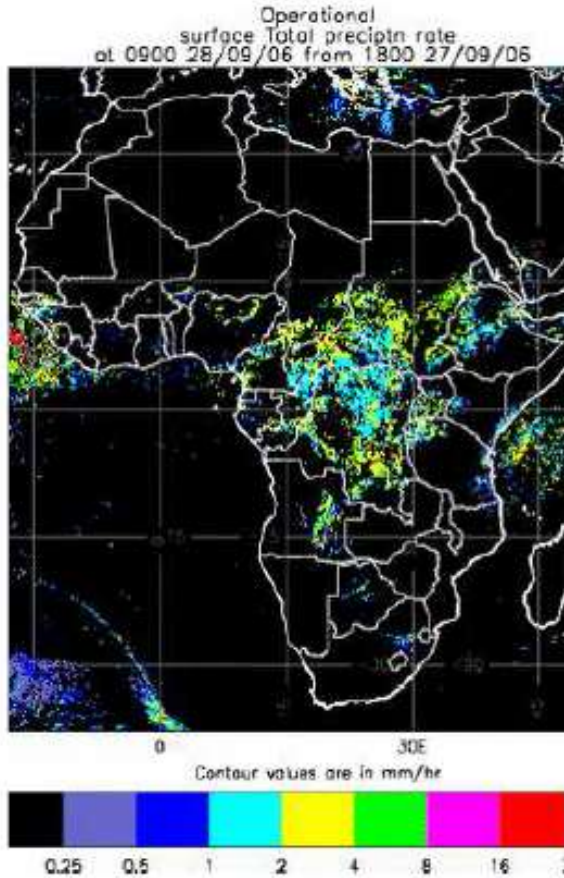
- **GENERIC PROBLEMS**
 - Lateral Boundary Conditions
 - Only a problem for LAMs
 - Spin up problems when transporting low resolution data onto high resolution grid
 - Potential problems at edge of domain



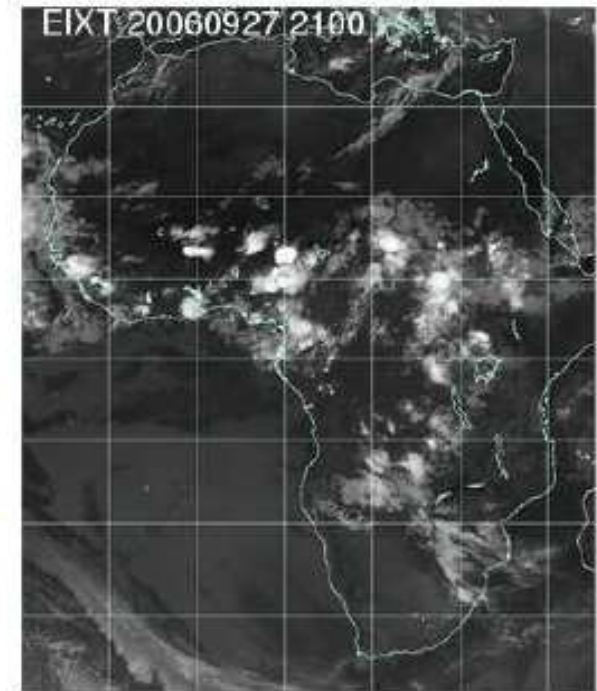
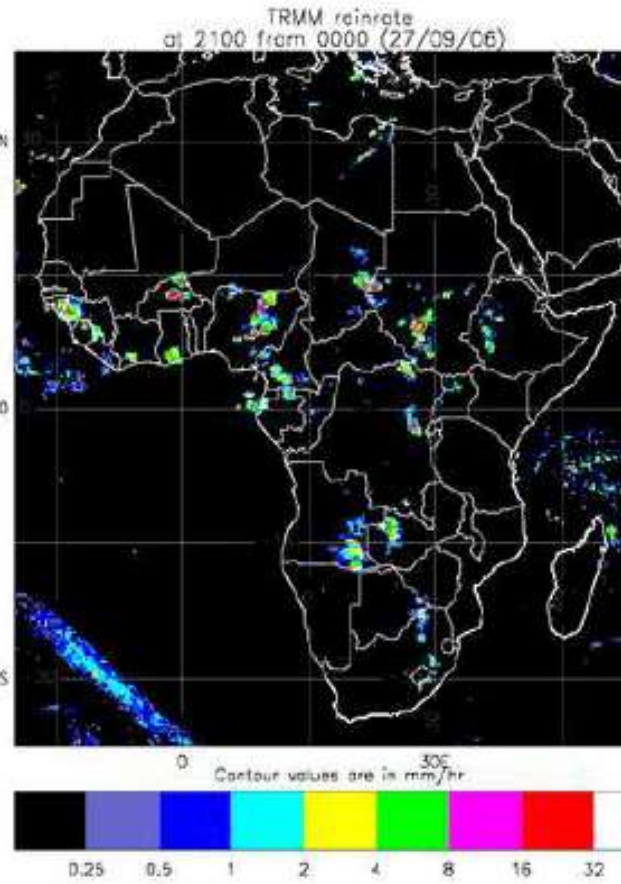
Strengths & Weaknesses of NWP models

- 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

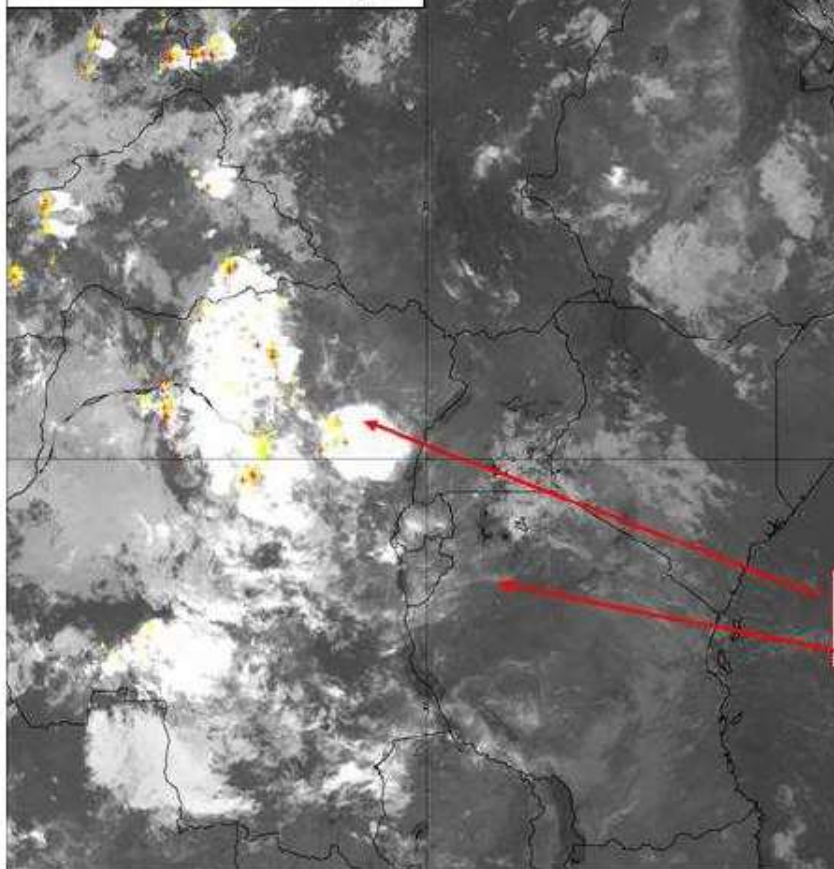
NWP convection switched on...



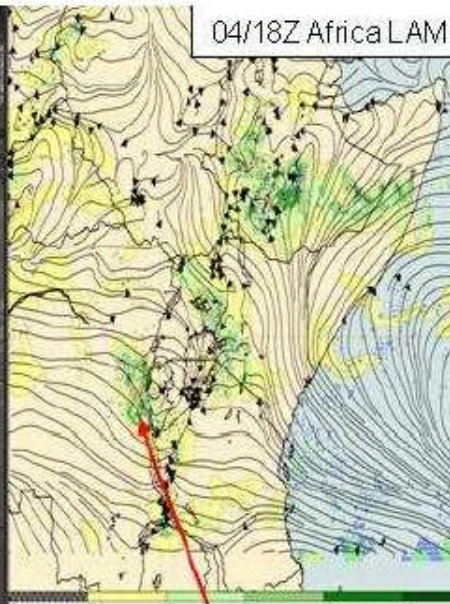
NWP convection switched off...



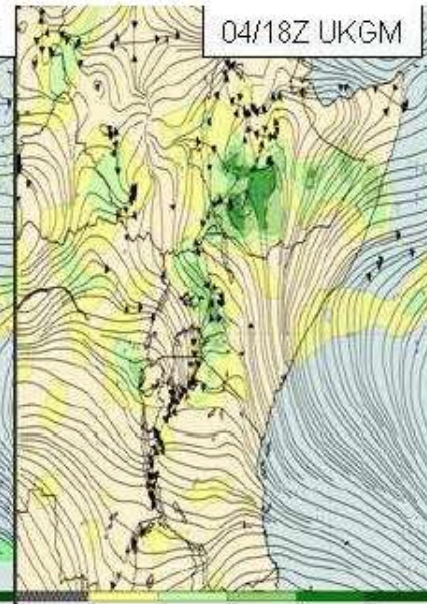
05/0300 Z IR Image



04/18Z Africa LAM



04/18Z UKGM

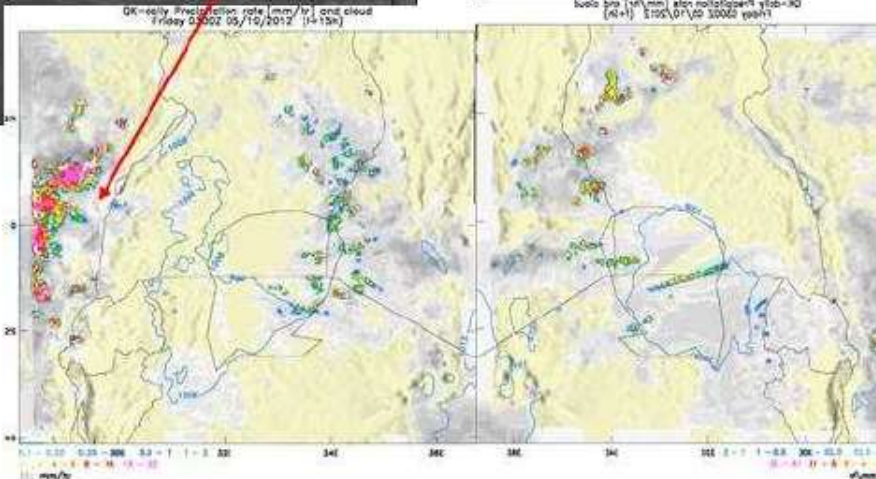
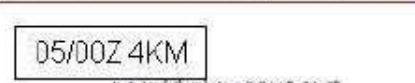


LAM and 04/12Z 4KM have resolved convection reasonably well, but missed by UKGM and 05/00Z 4KM.

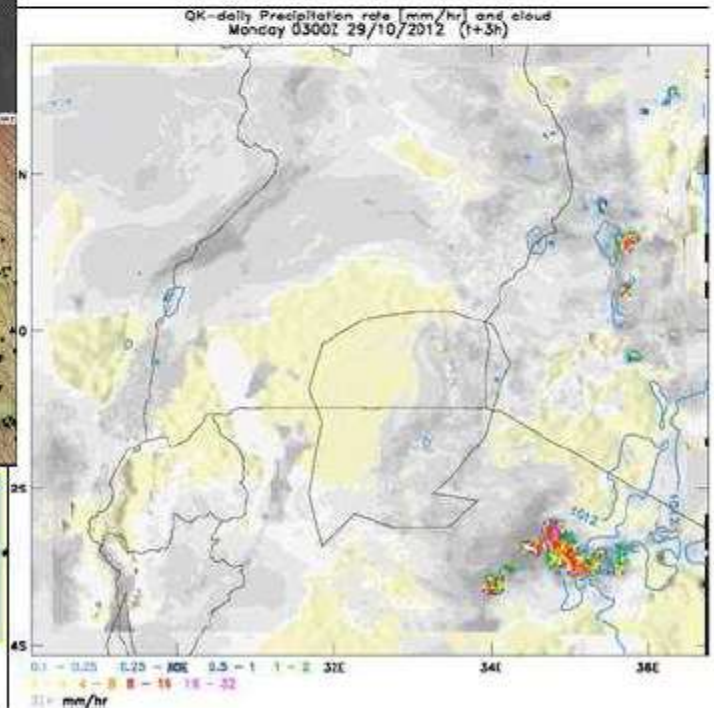
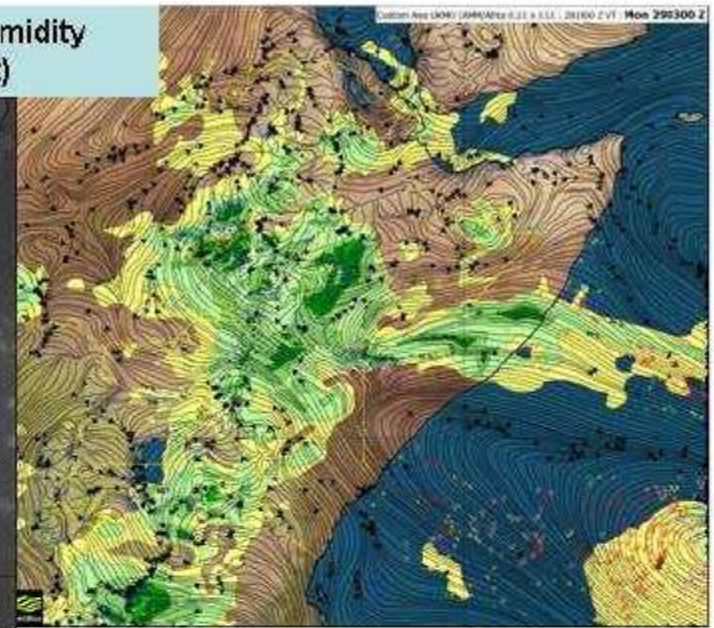
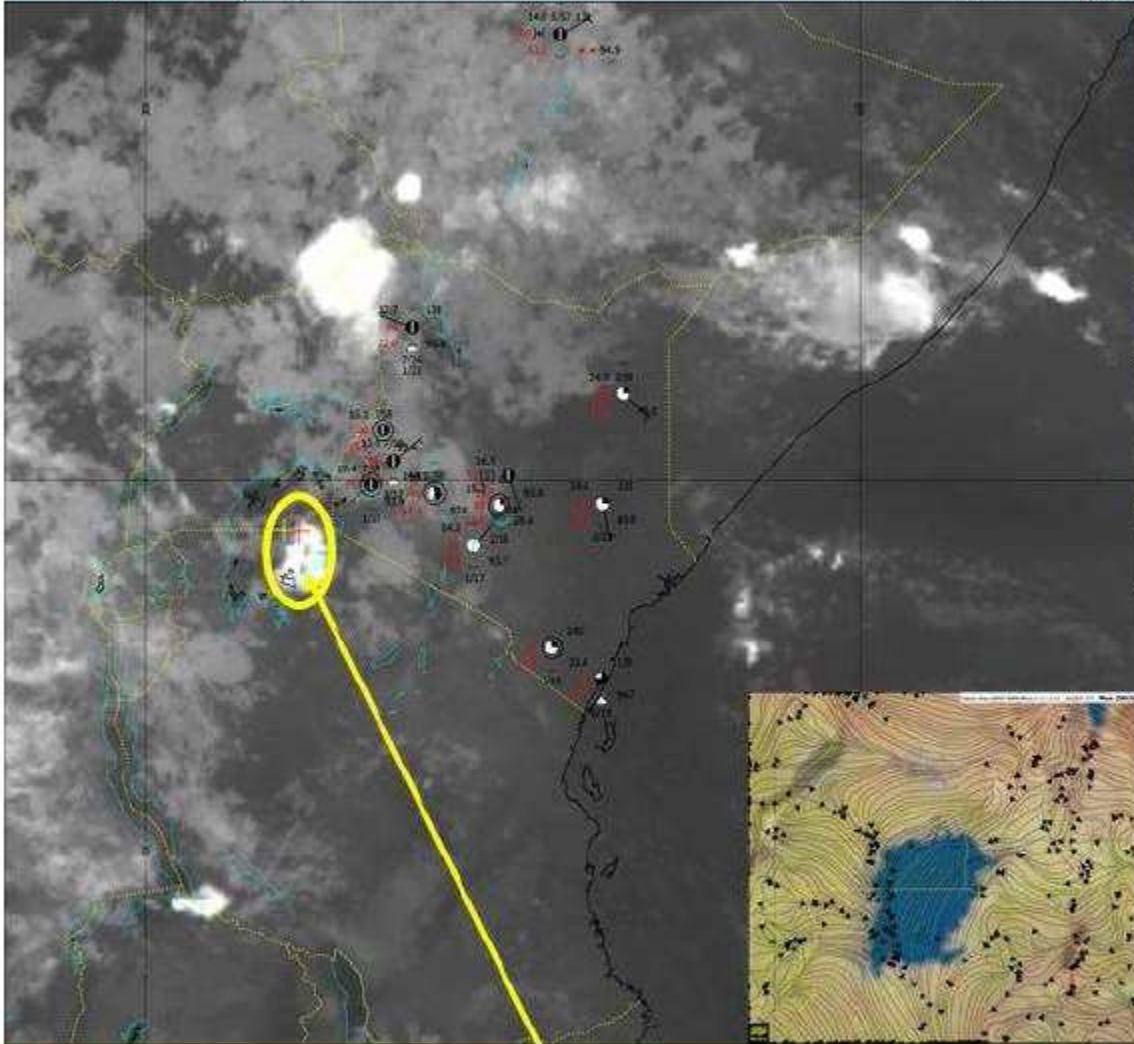
04/12Z 4KM



05/00Z 4KM

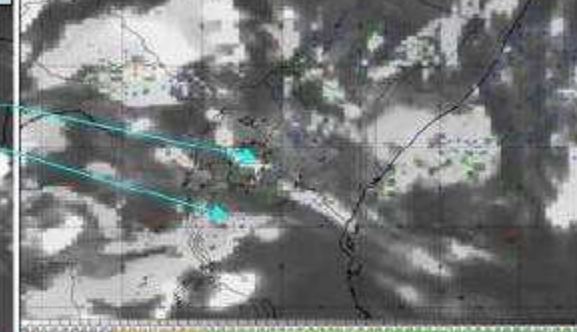
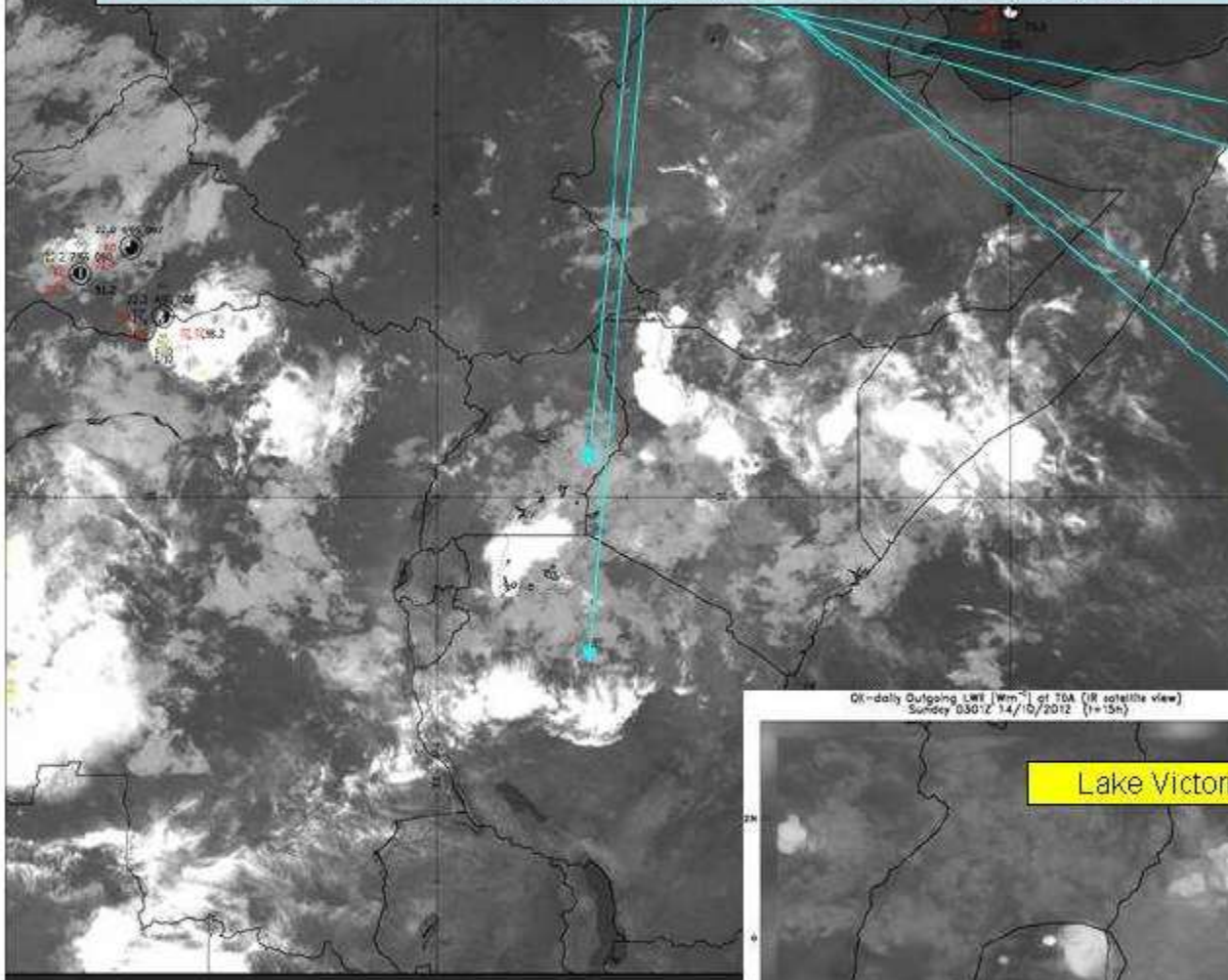


29/03Z IR image (below left), with 28/18Z Africa LAM T+9 ppn and 700hPa humidity fields (above right), and Lake Victoria 4KM model valid at 29/03Z (lower right)



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.



0K-daily Outgoing LWR [Wm^{-2}] at TOA (IR satellite view)
Sunday 0301Z 14/10/2012 (t+15h)

0K-daily Outgoing LWR [Wm^{-2}] at TOA (IR satellite view)
Sunday 0301Z 14/10/2012 (t+1h)

Lake Victoria 4KM models very poor

