Numerical Weather Prediction Models

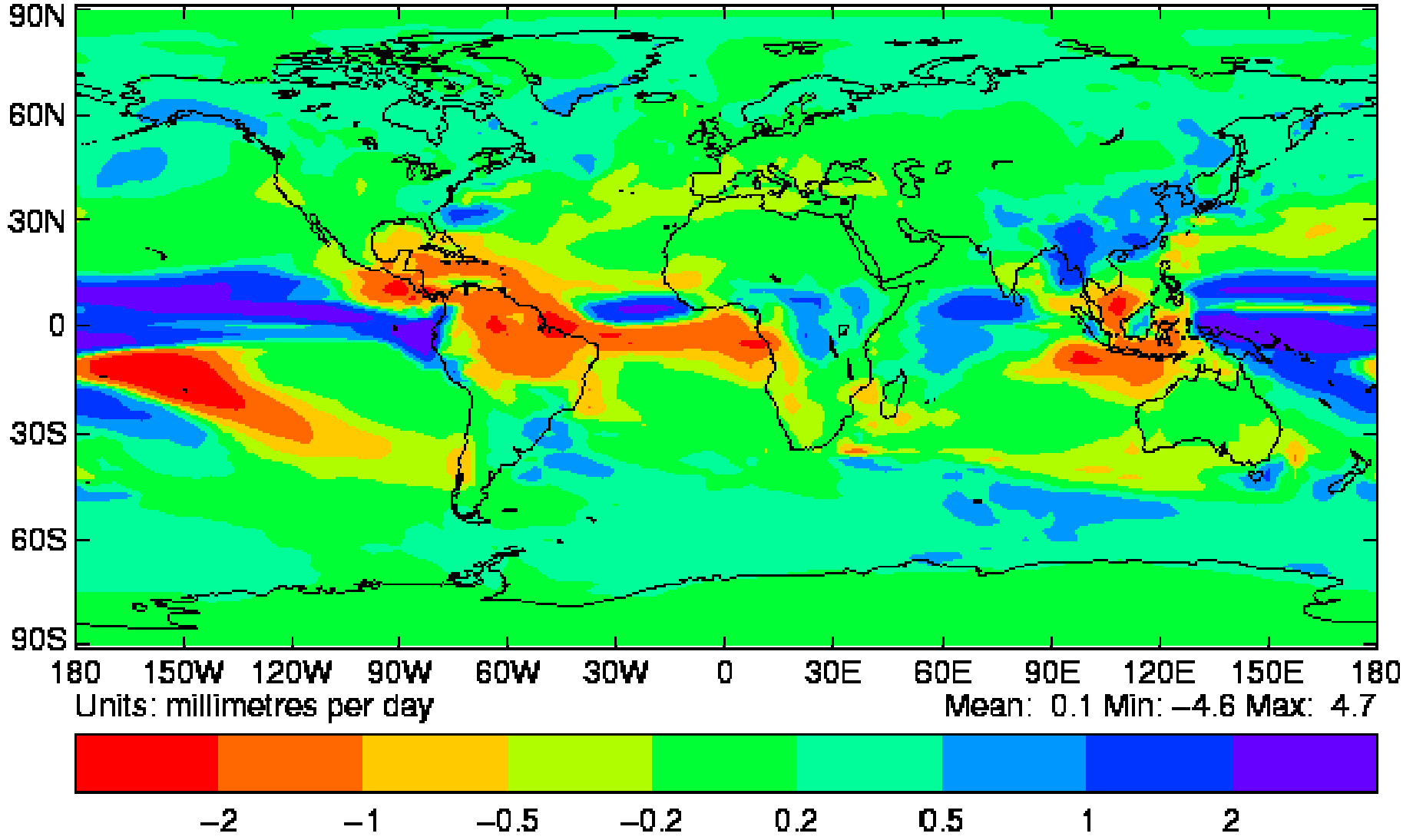
NWP Model Formulation

1. Different types of model
2. Model Characteristics
3. 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 operational weather forecasting models

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



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

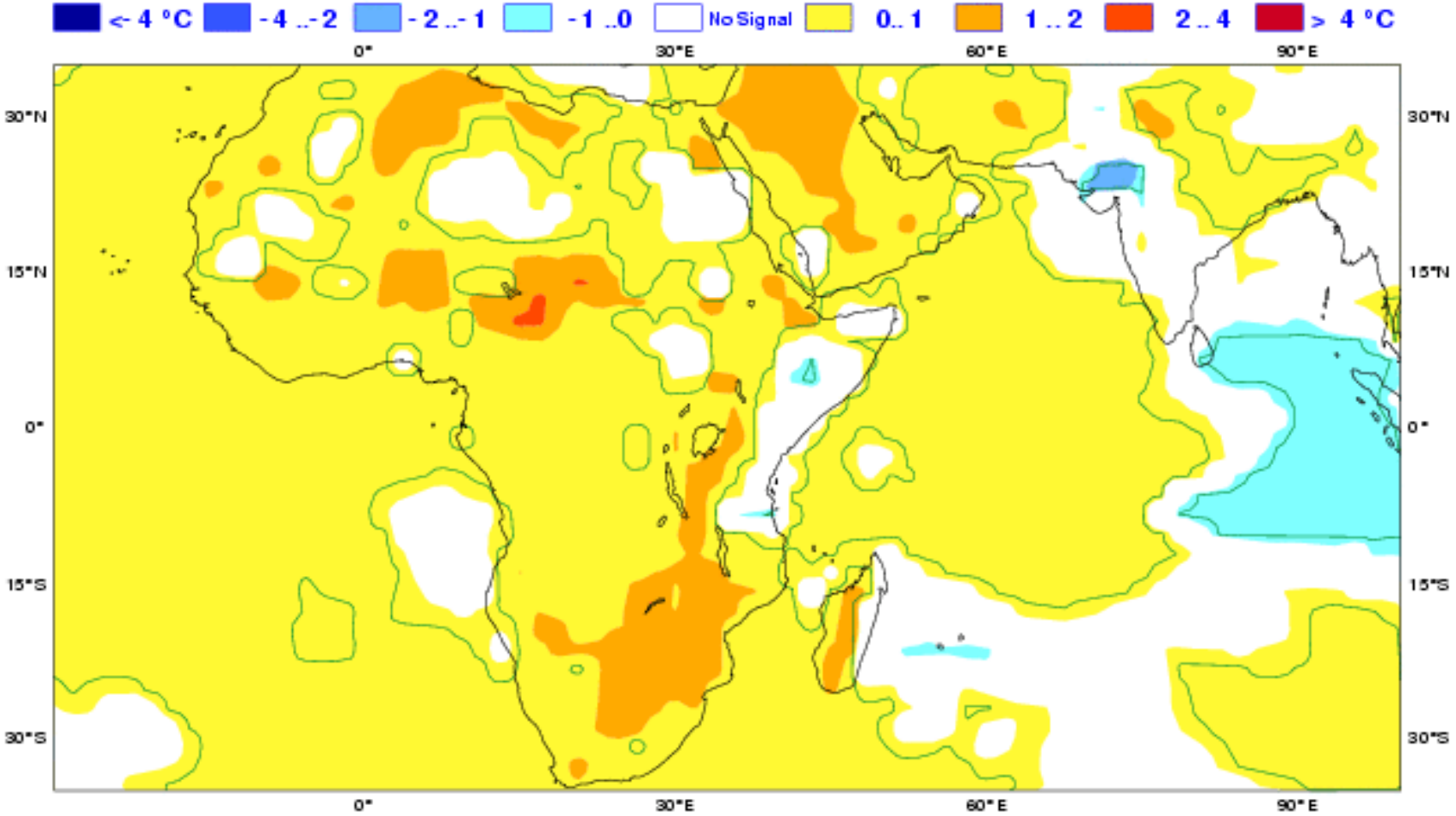
Types of atmospheric model

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

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

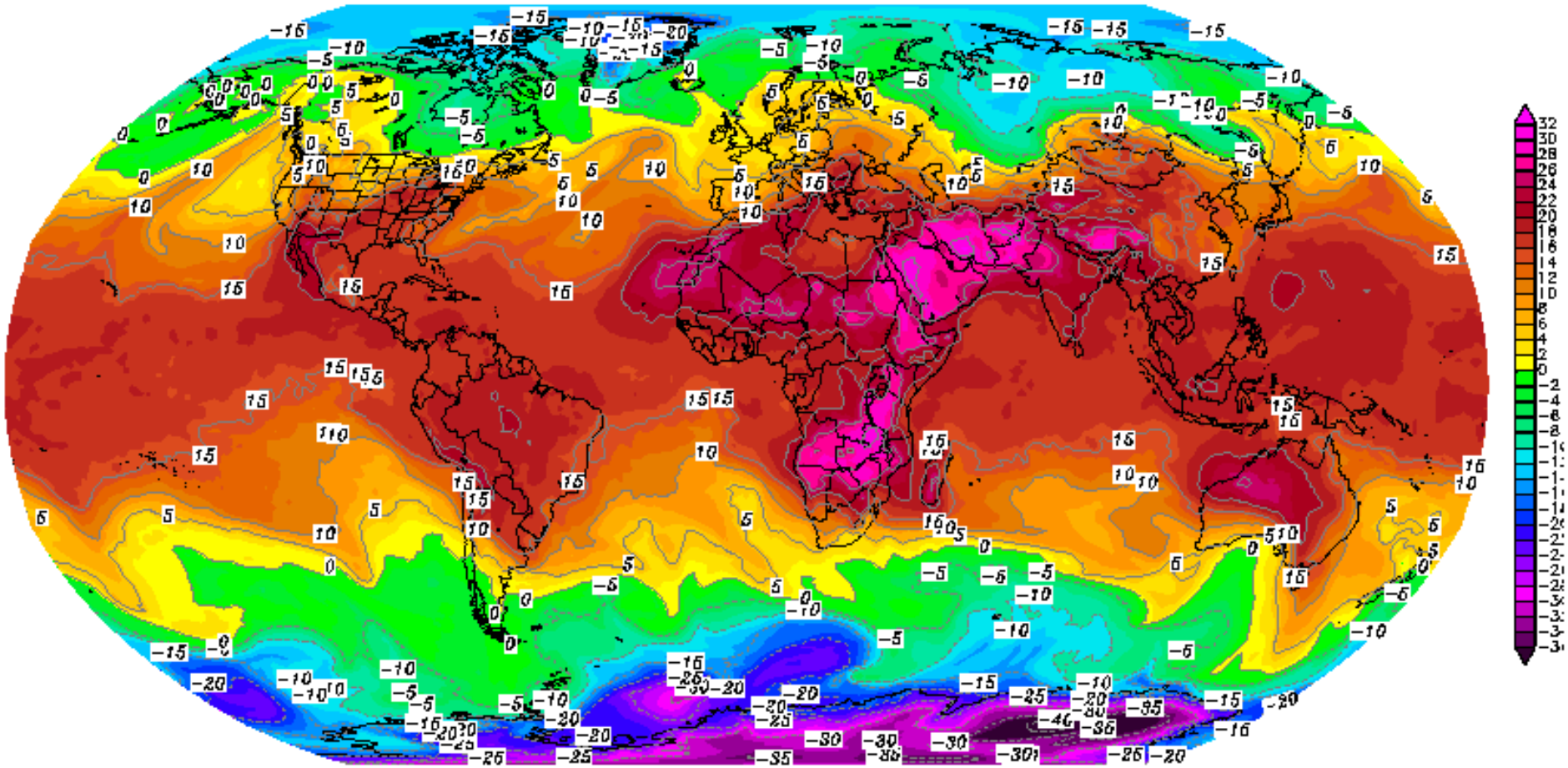
Types of atmospheric model

- 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

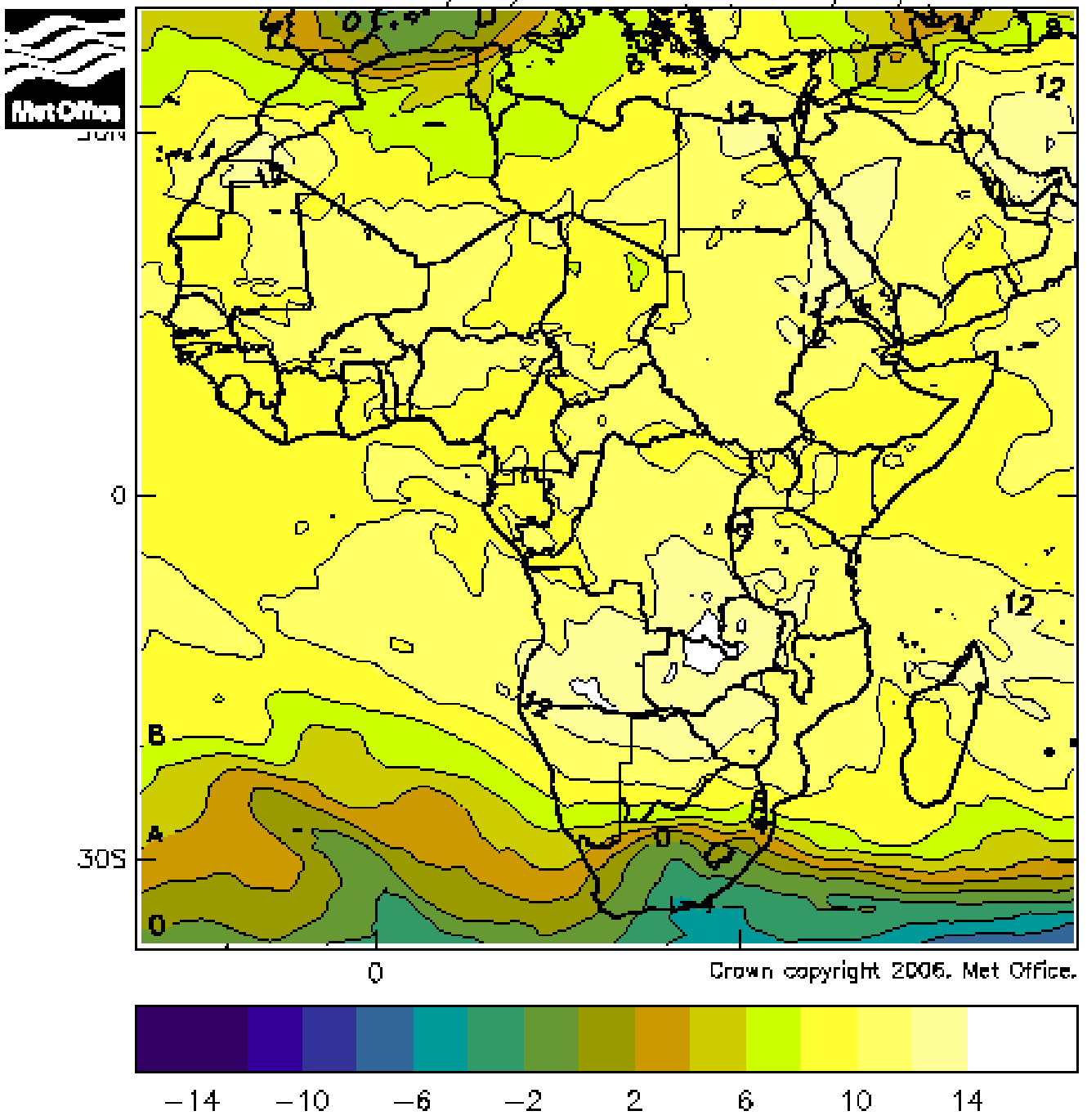
Valid: Wed,04OCT2006 12Z

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)


Temperature on pressure levels (°C) at 700.0 hPa
at 0000 05/10/06 from 1800 03/10/06
Met Office
0
30S
0
Crown copyright 2006. Met Office.
−14
−10
−6
−2
2
6
10
14

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 uses the NIMROD system
- Specific applications
  - Atmospheric Dispersion
  - Air quality
  - Lee-wave forecasting models

Models

ECMWF

- Horizontal resolution of T799 (16km), 91 vertical levels
- 10 days ahead
- 4-D VAR

- EPS – Ensemble Prediction System
- T399 (50km), 62 levels

NCEP

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

UK Met Office

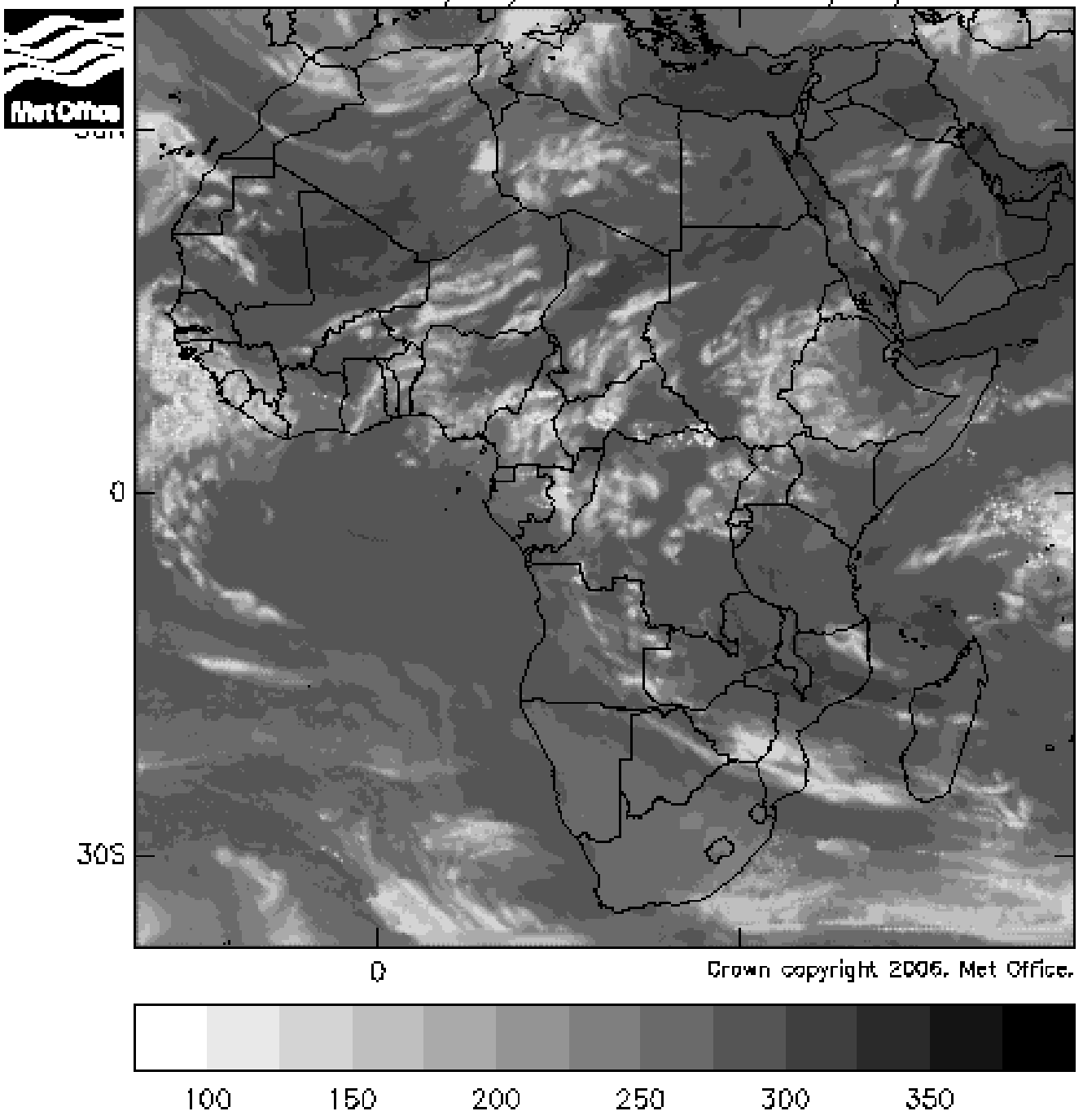
- Global model
- Horizontal resolution of 25 km and 70 vertical levels
- 4 times daily
- Run out to T+144
- 4DVar

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

UK Met Office

- Africa LAM
- 12 km horizontal resolution, 38 vertical levels
- Available via password protected website http://www.metoffice.gov.uk/weather/africa/lam/
- Username is afr_nms and password is uk_alam
- Intermittent data assimilation
- Run to T+48


Outgoing long-wave radiative flux at top of atmosphere
at 0007 05/10/06 from 1800 03/10/06
Met Office
0
30S
0
Crown copyright 2006. Met Office.
100
150
200
250
300
350

Strengths & Weaknesses of NWP models

Strengths & Weaknesses

- 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

NWP Strengths

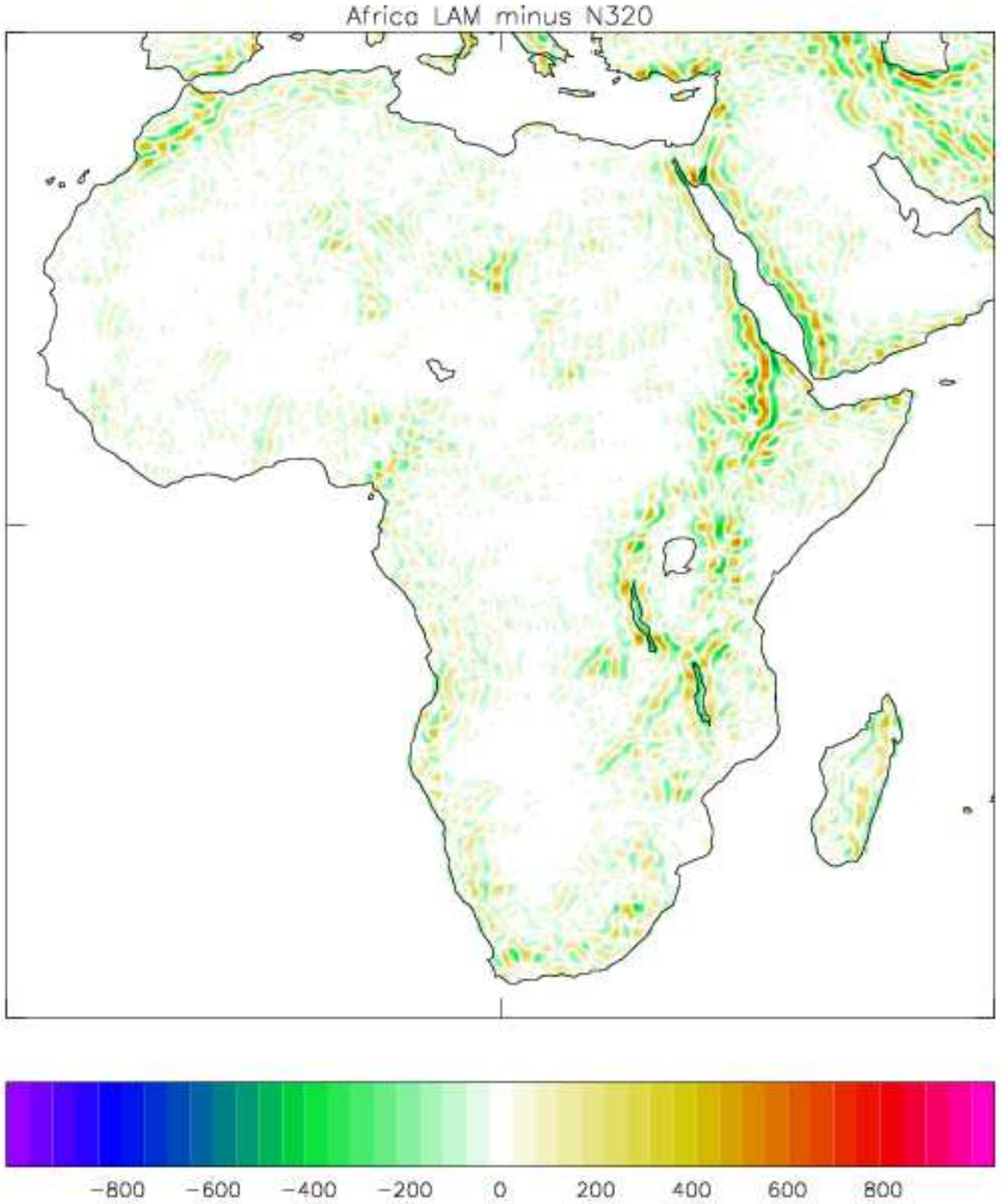
- Convection
  - General area of convection is well captured
- Extra-tropical latitudes
  - Model is much better here
  - Frontal systems are well represented
  - Orographically enhanced rainfall better than Global Model

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, localised temperature advection

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


Africa LAM minus N320
−800
−600
−400
−200
0
200
400
600
800

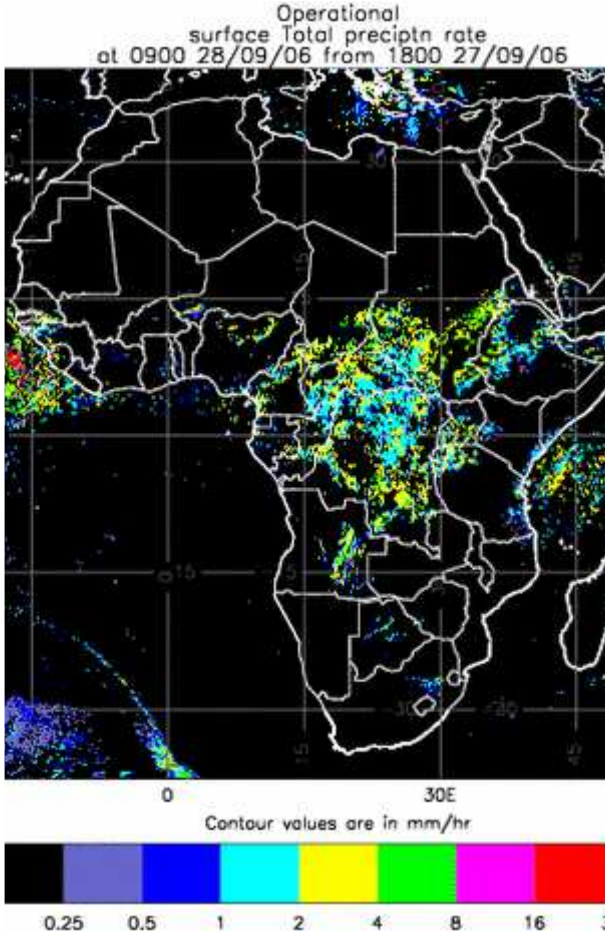
Generic Problems

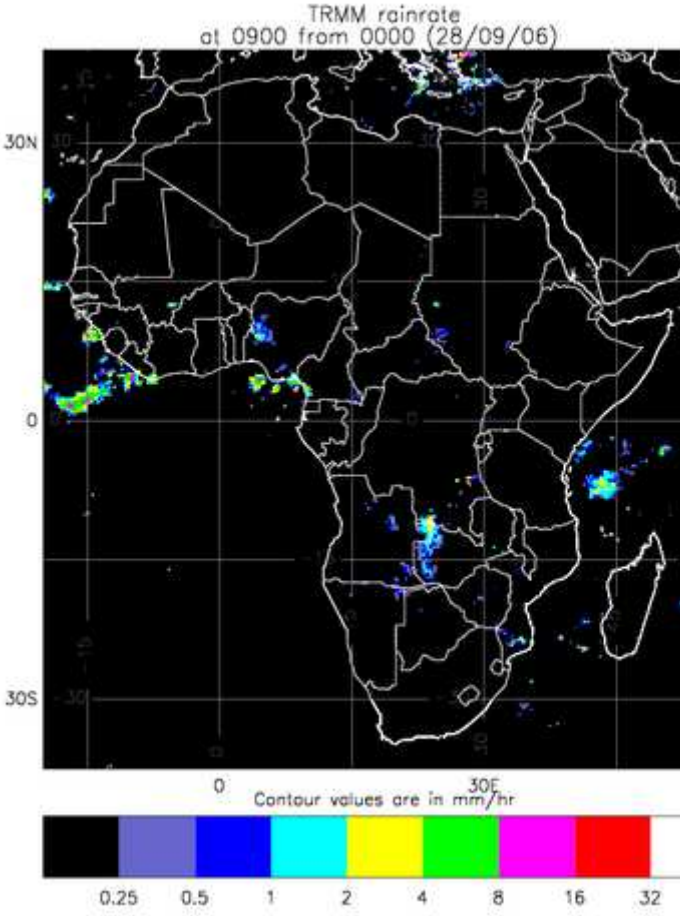
- Lateral Boundary Conditions
  - Only a problem for LAM’s
  - Spin up problems when transposing low resolution data onto a high resolution grid
  - Potential problems at edge of domain

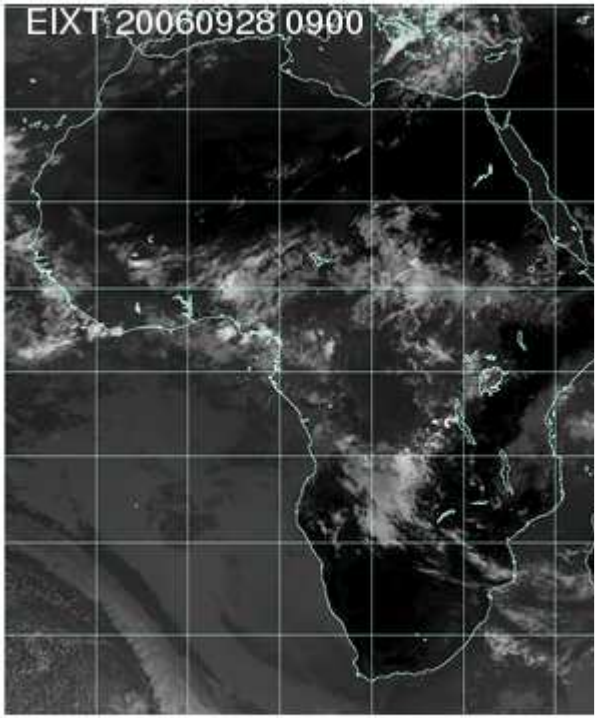
NWP Weaknesses

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

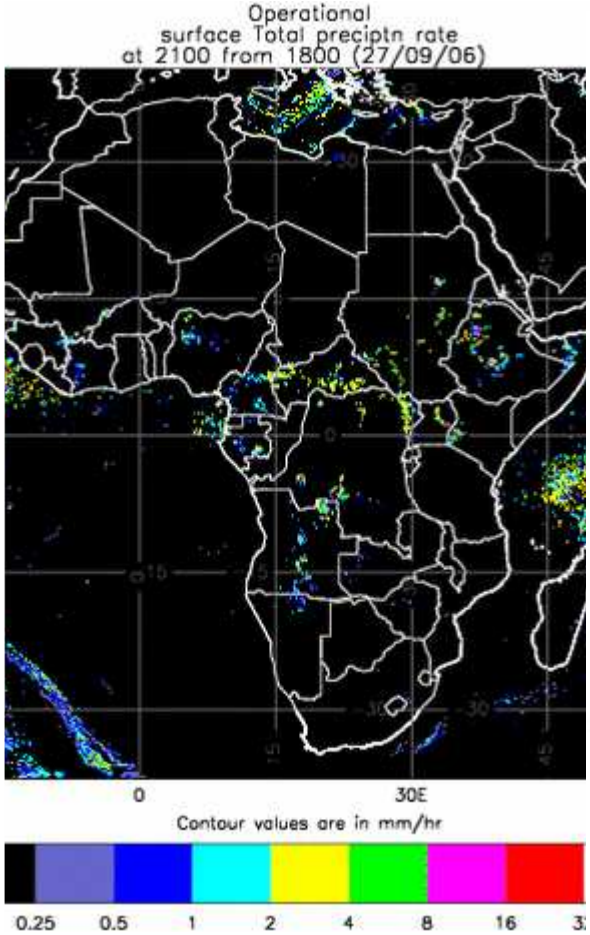
NWP convection switched on….

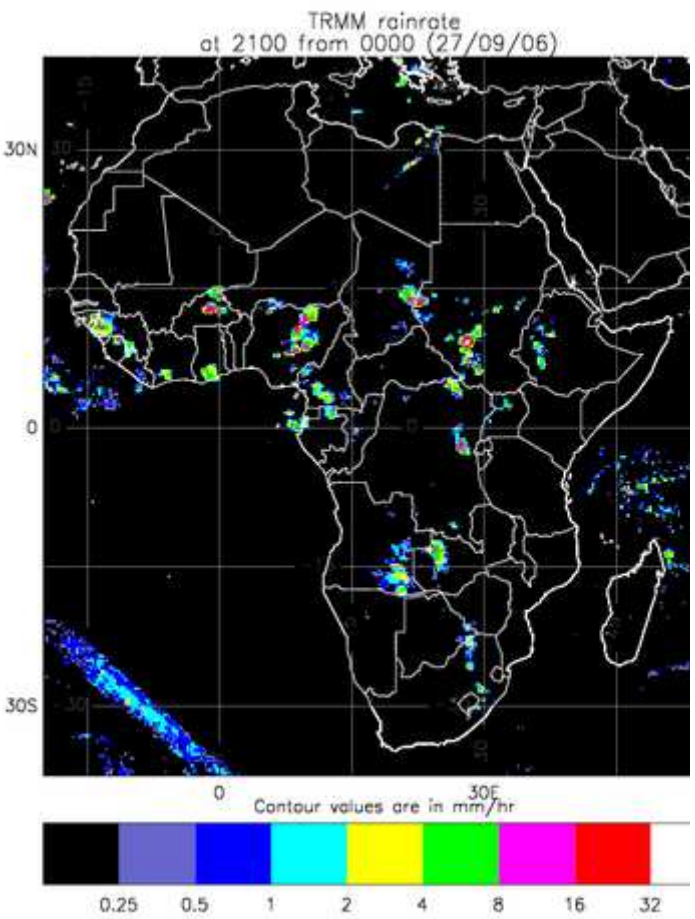


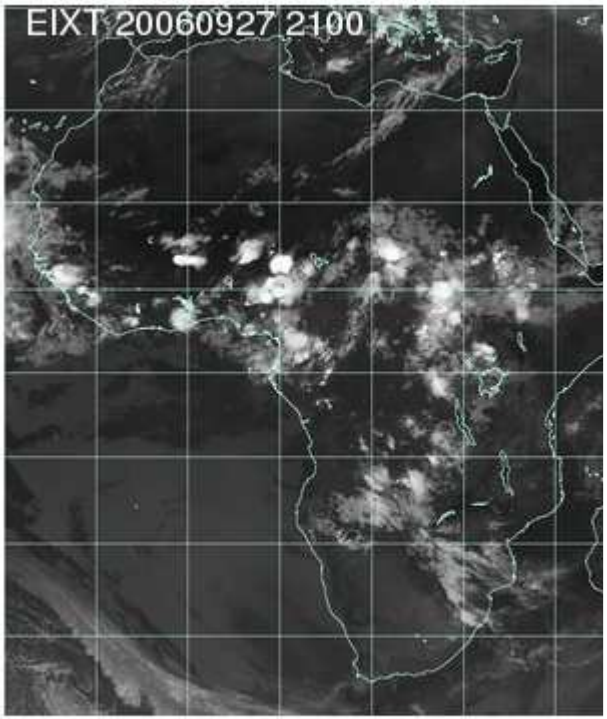


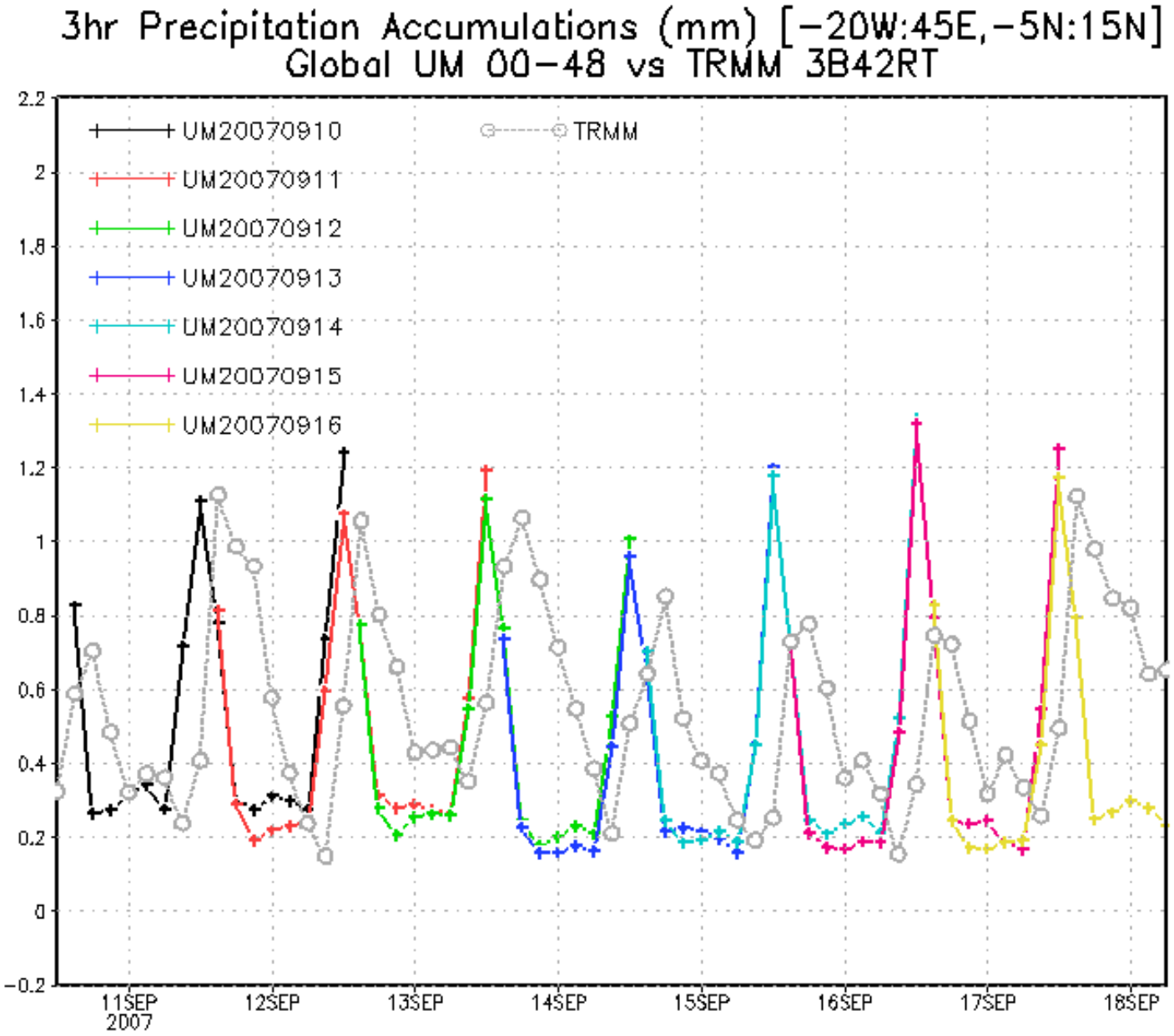


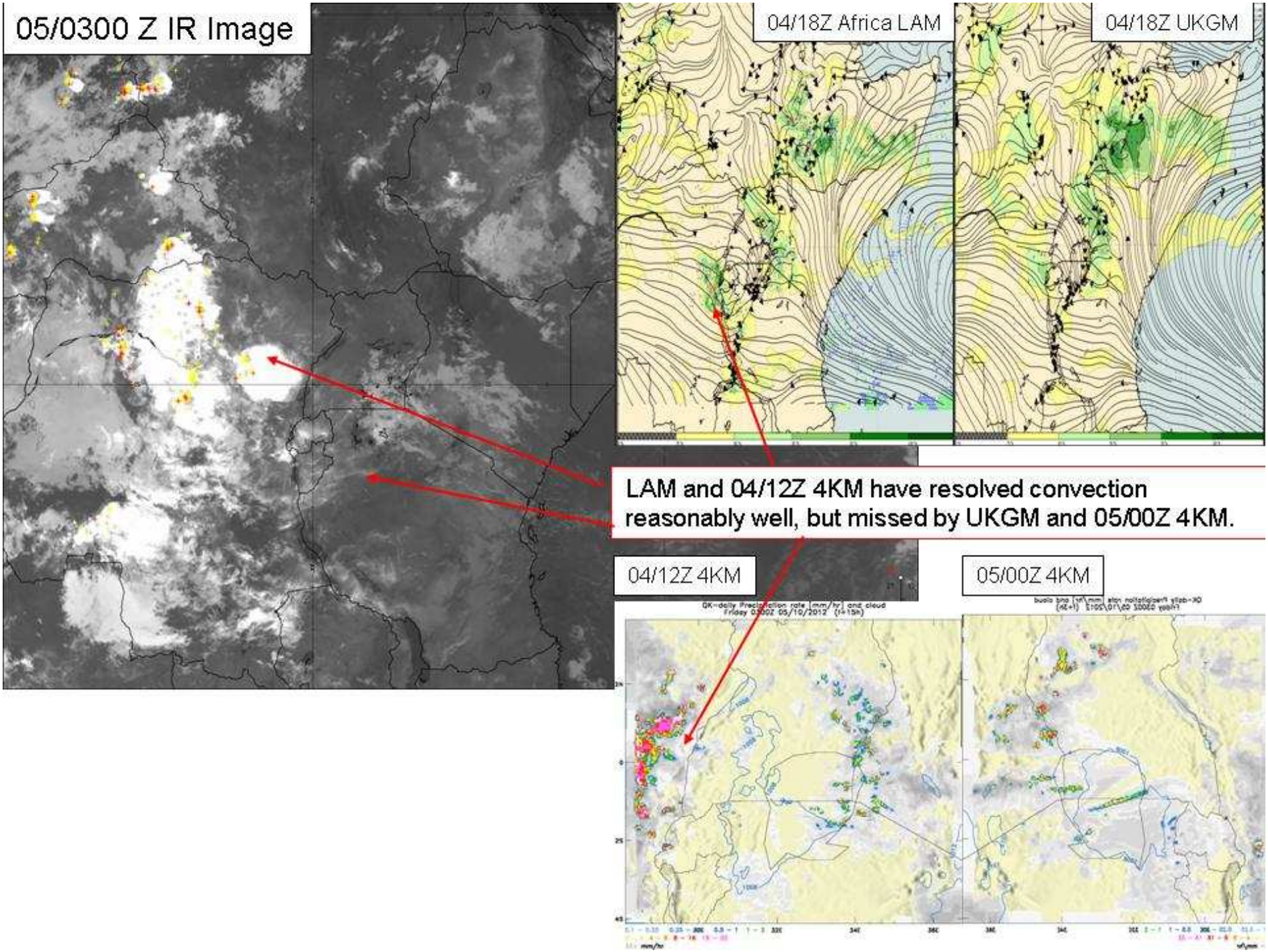
NWP convection switched off….



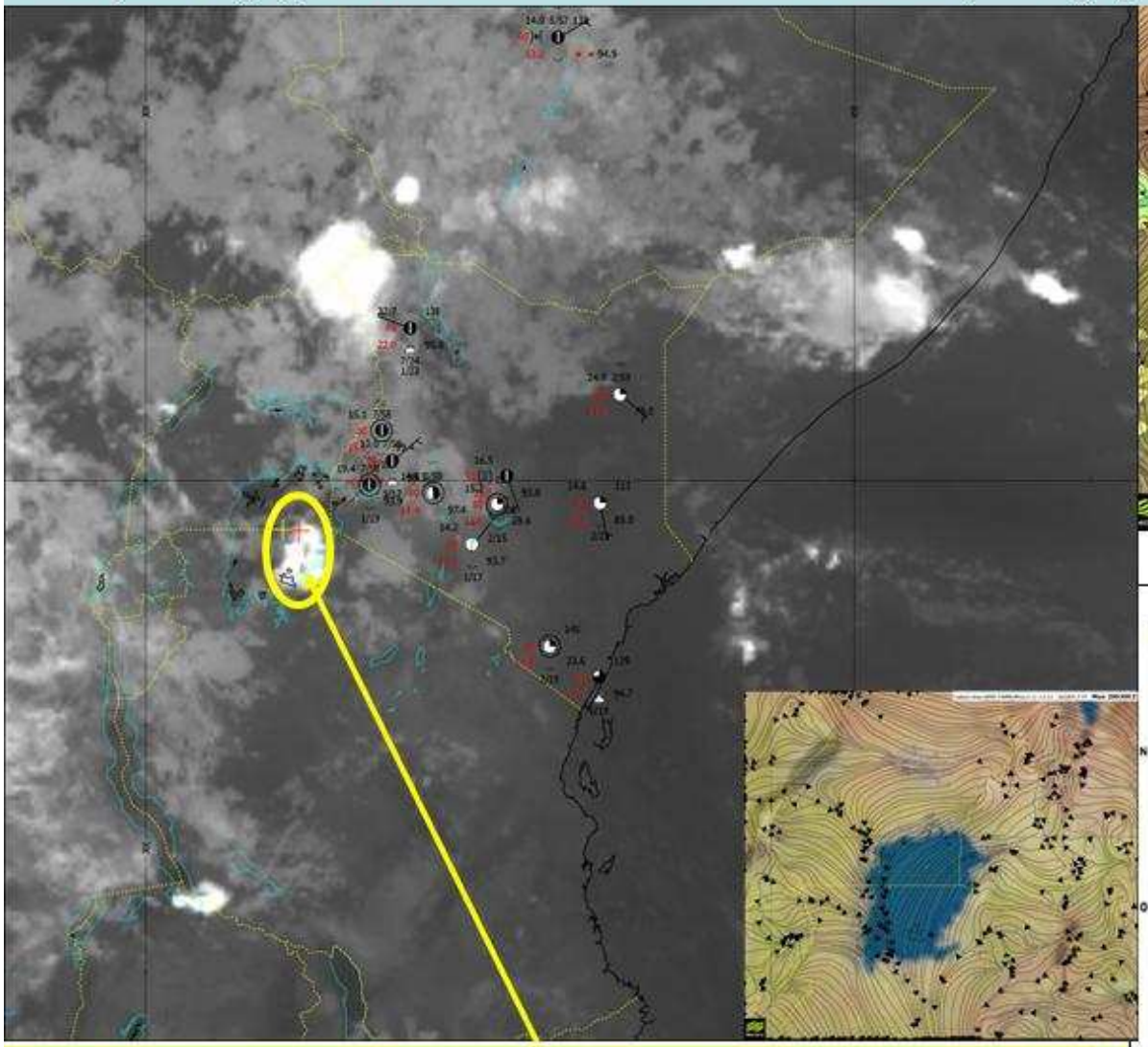


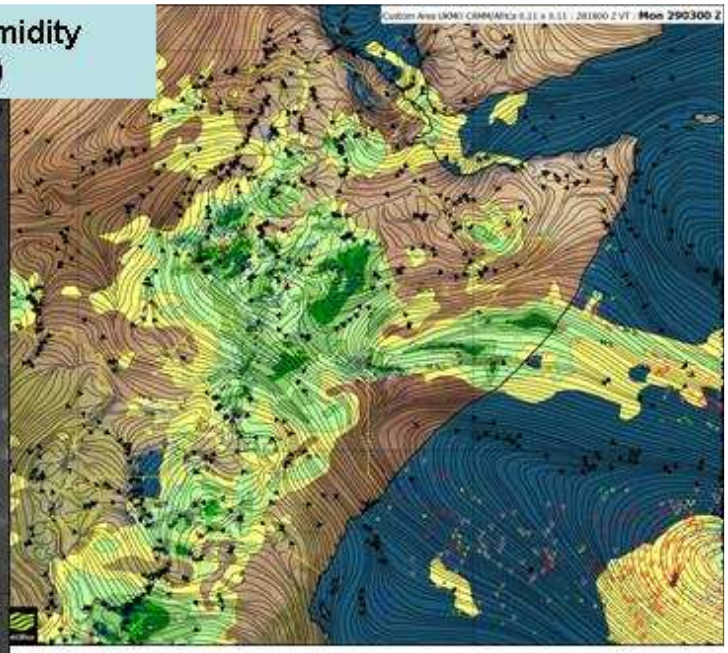


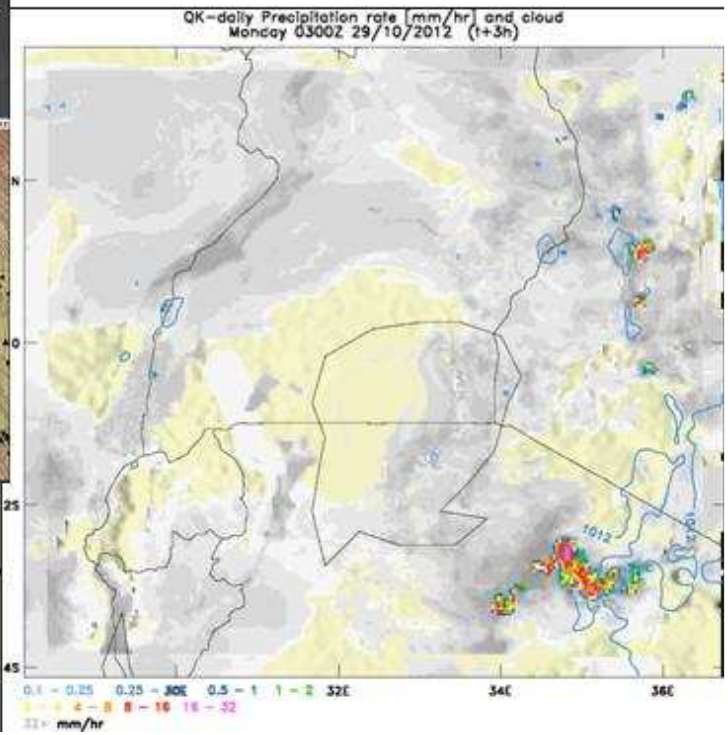

3hr Precipitation Accumulations (mm) [-20W:45E,-5N:15N]
Global UM 00-48 vs TRMM 3B42RT
UM20070910
UM20070911
UM20070912
UM20070913
UM20070914
UM20070915
UM20070916
TRMM
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
11SEP
2007
12SEP
13SEP
14SEP
15SEP
16SEP
17SEP
18SEP


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

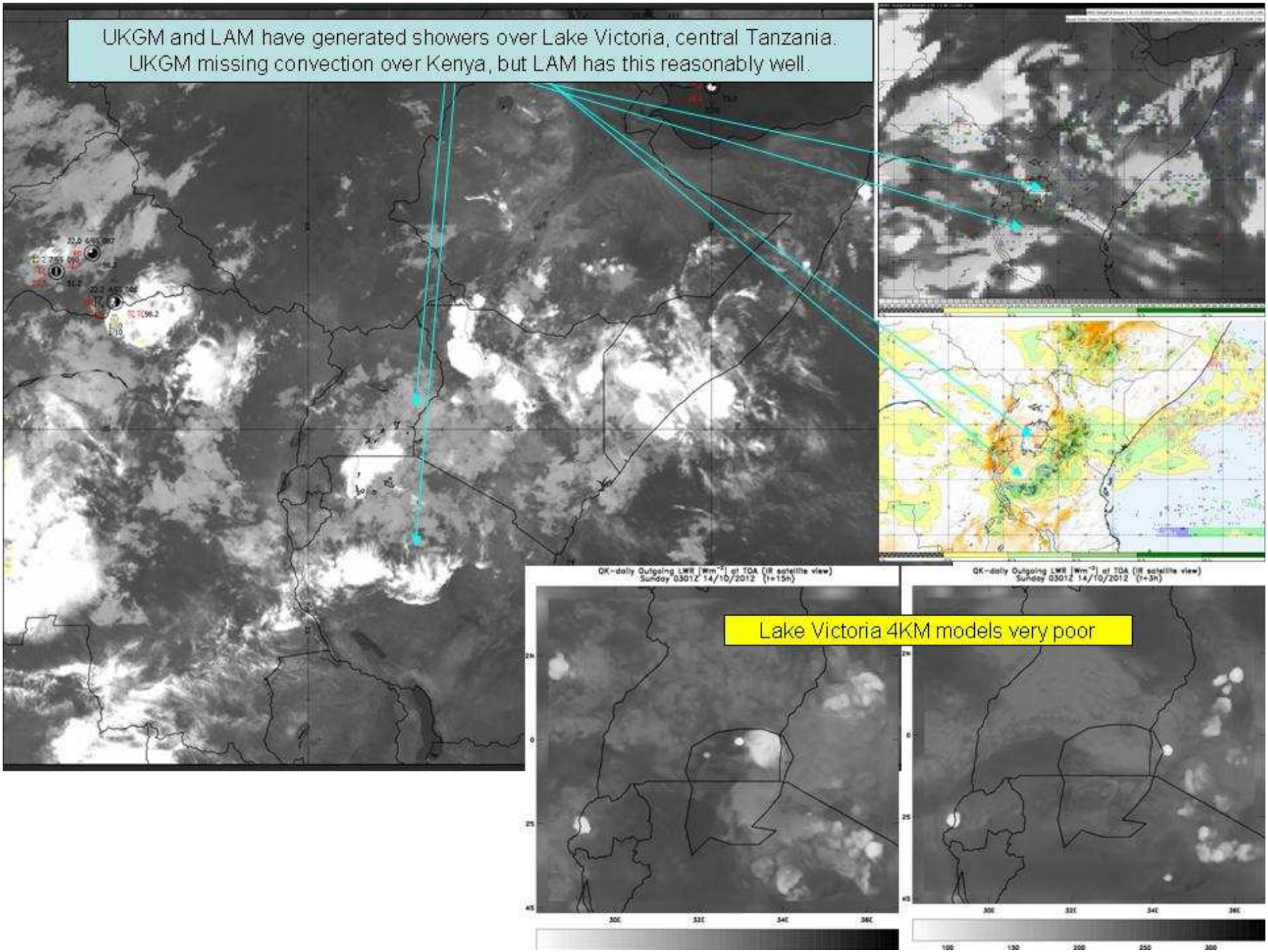
29/03Z IR image (below left), with 28/18Z Africa LAM T+9 ppn and 700hPa humidity fields (above right), and Lake Victoria 4KM model valid at 29/03Z (lower right)







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

Questions & Answers