

WRF (Weather Research and Forecast) Modeling in Ghana

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Motivation

- **A high-resolution regional weather analysis and forecasting system for Africa based on WRF model**
- **Capacity building**
 - **The modeling system will be transferred to Ghana.**
 - **This is an inclusive effort not exclusive. Will work with existing modeling groups**
 - **Desire to utilize the multi-purpose and community-based nature of WRF with data assimilation enhancement**
- **A tool for cooperation among local universities, government agencies and the private sector regarding weather information.**

Benefits of the System

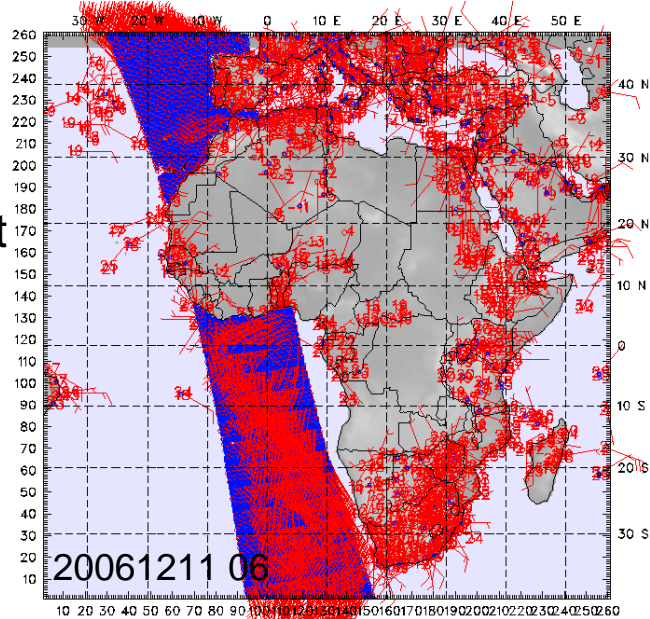
- **Operations - real-time forecast for public safety and planning by Africans**
- **Research opportunities: (i) for weather research at all time-scales (including diurnal processes); (ii) to develop a model with parameterizations that properly reflect African conditions; (iii) to incorporate standard and non-standard Africa observations into the model system to produce best possible current analyses and “spun-up” short-term forecasts.**
- **Applications – used as input to application models (e.g. agricultural, water, health, energy and economic models) that currently use GCM output or statistics.**

An Initial Modeling System

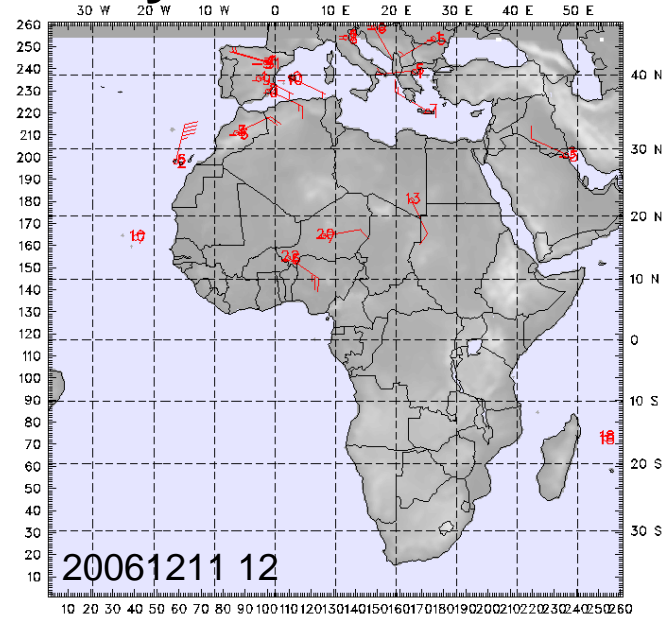
- **WRF-based RTFDDA model running at 40.5 km over Africa and 13.5 km and 4.5 km over West Africa (for a start) in real-time**
- **Cycles at 6 hourly time window with 4-D continuous data assimilation using all observations up to now (the more observations the better model performance).**
- **Generate up to 3 day forecast in each cycle**
- **Products to be made available to weather forecasters in the region via the Internet**
- **Objective and subjective verification**

Typical Distribution of Currently Available Observations

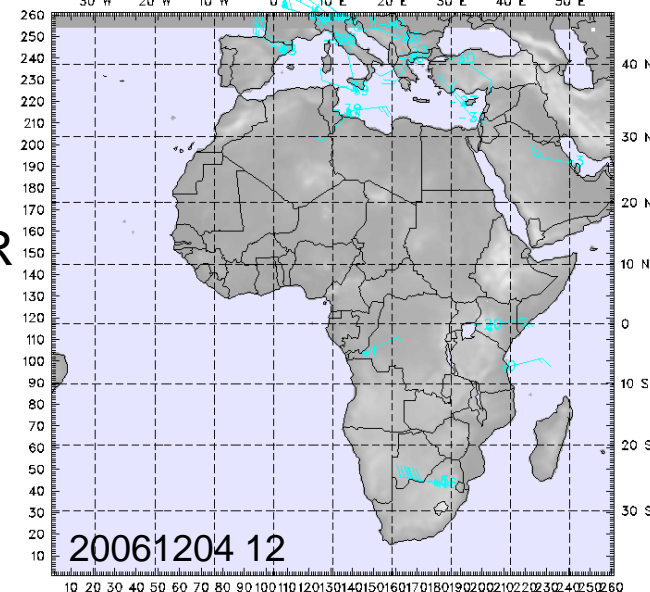
QuikScat
&
SFC



ROAB



AMDAR



Currently available obs:

Sfc: mostly at 00, 03 ... 21Z

Raob: 00 and 12Z. Some at 06
and 18Z

QuikScat: twice a day

AMDAR: vary diurnally. Significant

**More (local) observation should
be collected and assimilated into
the system in future!**

A Two-phase Development Plan

- **Phase – I**
 - **Establish an operational mesoscale forecasting system at NCAR (using modest computer), and provide products to African weather services. Focus first on West Africa.**
 - **Improve model (forecast quality) and graphical interface based on feedback from African forecasters.**
 - **Conduct a workshop for forecasters, in Accra, on “effective use of high-resolution meteorological-model products”.**
 - **A Quasi-operational system started in late November, 2006 and is currently running in real-time**

Phase-I Model Configuration

- **Started with the MM5-based RTFDDA**
- **“Standard” model physics as used in the NCAR/ATEC RTFDDA systems**
- **6-hour cycles with 24 - 36 hr forecasts in each cycle.**
- **Observations:**

Standard GTS/WMO surface and upper-air stations, plus MADIS (mostly AMDAR) and QuikScat (NASA satellite) sea surface winds

Phase-1 Computing Resources

- **CISL “lightning” Linux-cluster**
 - 18 dedicated dual-cpu nodes: 1 master, 16 MPP and 1 spare
- **Local post-procs and web server**
 - dev-c1 and atec-server
- **Real-time data transfer**
 - lightning – das-input1
 - lightning – dev-c1

Domains

Three 2-way
nested domains

DX=
40.5/13.5/4.5 km

Dimensions

D1: 261x261x36

D2: 184x295x36

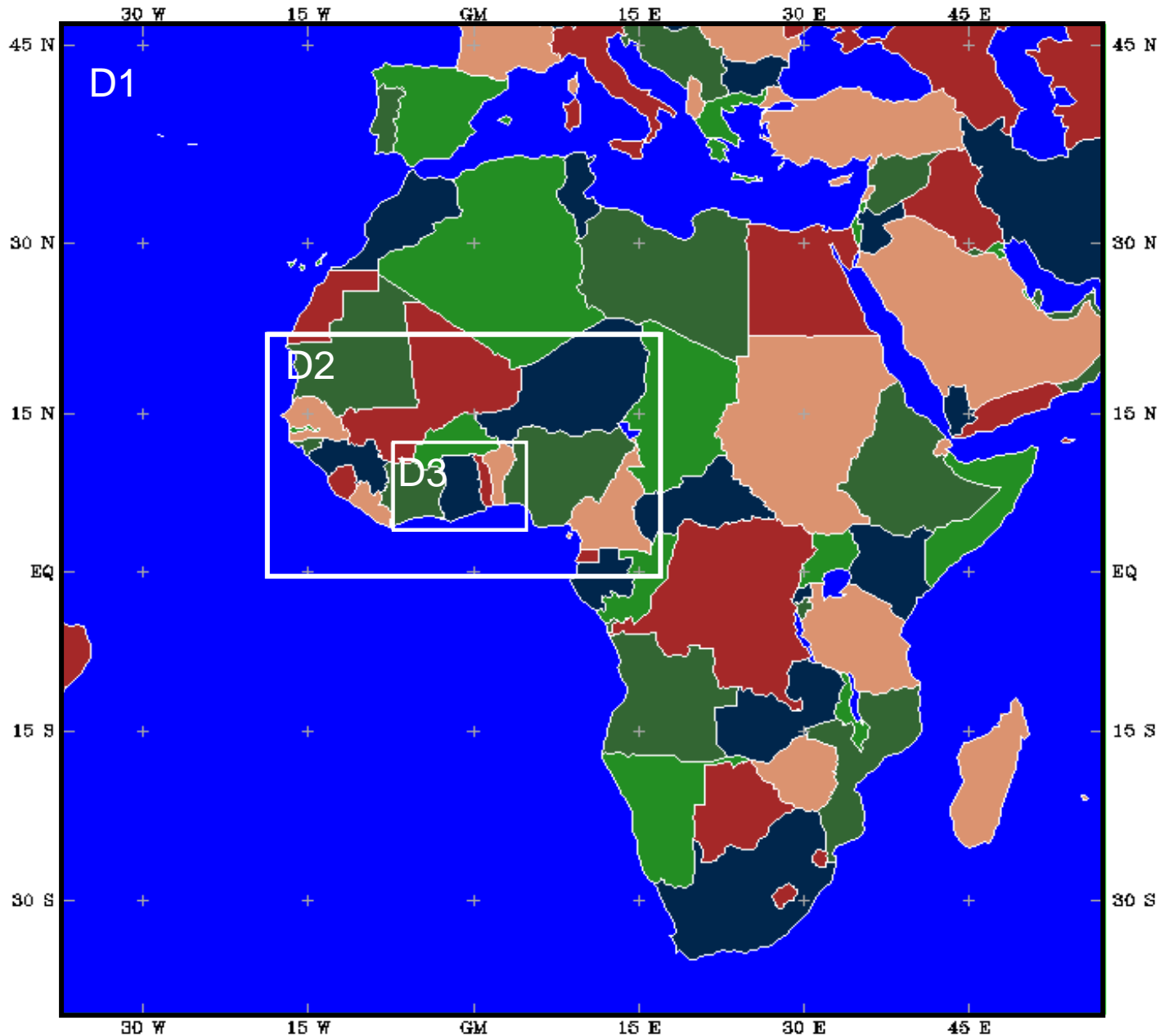
D3: 208x301x36

Sizes (km²):

D1: 10530x10530

D2: 3969x2592

D3: 1350x931



A Two-phase Development Plan

- **Phase – II**
 - **Expand area coverage of model high-resolution weather products using larger computer.**
 - **Expand educational component – Work with African universities and meteorological services to improve knowledge of numerical weather prediction and mesoscale meteorology.**
 - **Develop partnerships with African stakeholders (agriculture, water, etc.) to adapt weather products to special needs – e.g., coupled weather/agricultural models, dust-storm models, etc.**
 - **Funding will be needed**

Phase II system

- **A single dedicated linux-cluster**
- **1 node for model master, post-processing and web-server (Dell1950s dual-core 4cpu node)**
- **4 to 6 nodes needed for model execution**
- **System to start April 15, 2007.**

Early Partners

- **Ghana Meteorological Agency**
- **Nigeria Meteorological Agency (through Ernest Afesimama)**
- **University of Ghana – Legon, Ghana**
- **Kwame Nkrumah University of Science and Technology - Kumasi, Ghana**
- **Federal University of Technology, Akure, Nigeria (through Adebayo)**
- **Private sector (ZedX Inc., coupling weather models with agricultural models, etc.)**

Model Web sites

□ **Real-Time Demonstration home page**

<http://www.ral.ucar.edu/projects/wafrica>

4DWX home page

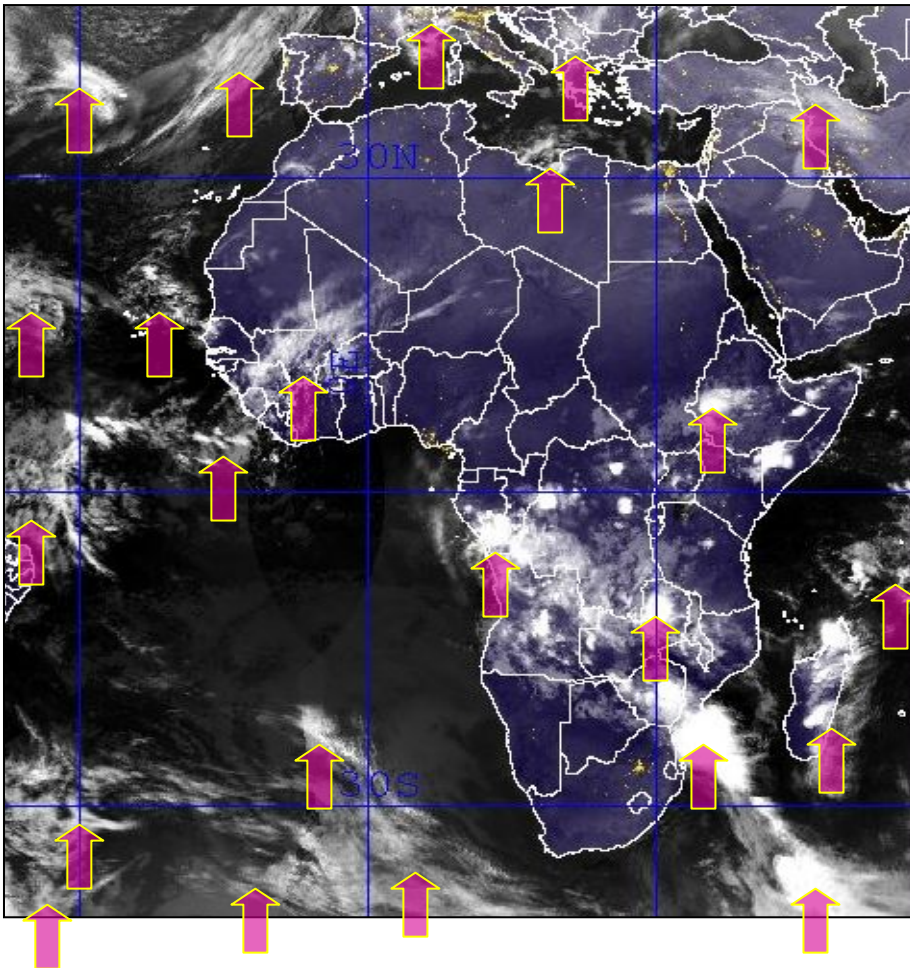
<http://www.rap.ucar.edu/projects/4DWX>

References page

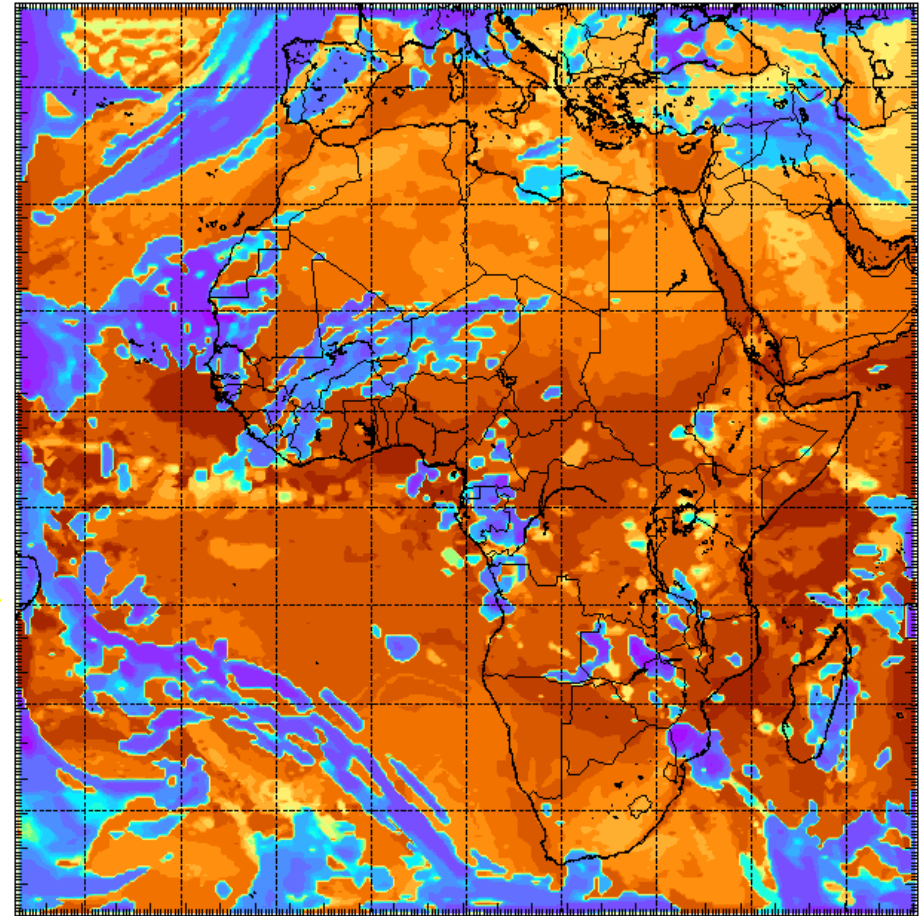
<http://www.rap.ucar.edu/projects/armyrange/references.html>

Verification of RTFDAA Forecasts of Cloud fields (Domain 1; valid at 00Z Dec. 5, 2006)

NRL DAY/NGT VIS/IR



RTFDAA 6h FCST: Cloud Top T



Sea Breeze in Domain 2

(Animated hourly, 07Z Dec. 4 – 18Z Dec. 5 2006)

GRM RT-FDDA Domain 1 Cycle=2006120412

Fcst: 37.00
 Surface temperature
 Surface horizontal wind vectors
 Sea-level pressure

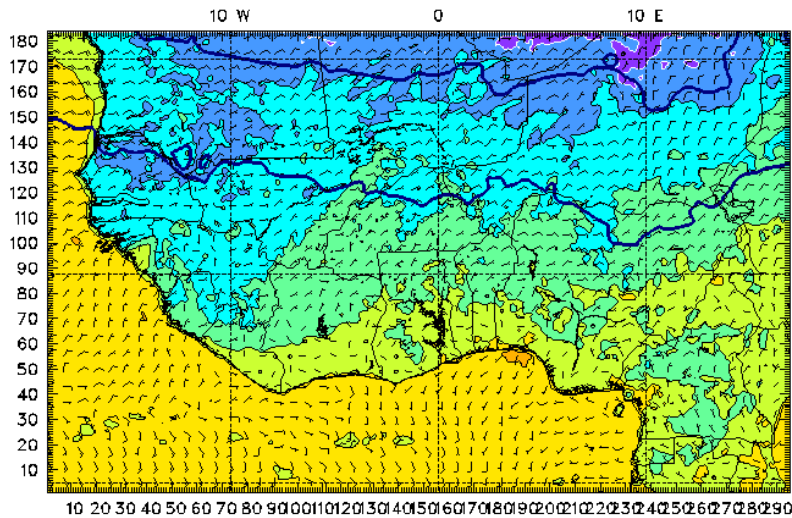
Init: 1800 UTC Sat 02 Dec 06 GRM RT-FDDA Domain 1 Cycle=2006120412

Valid: 0700 UTC Mon 04 Dec 06 (0000 MST Mon 04 Dec 06)
 Surface mixing ratio
 Surface horizontal wind vectors

Init: 1800 UTC Sat 02 Dec 06

Valid: 0700 UTC Mon 04 Dec 06 (0000 MST Mon 04 Dec 06)

Surface T and Winds

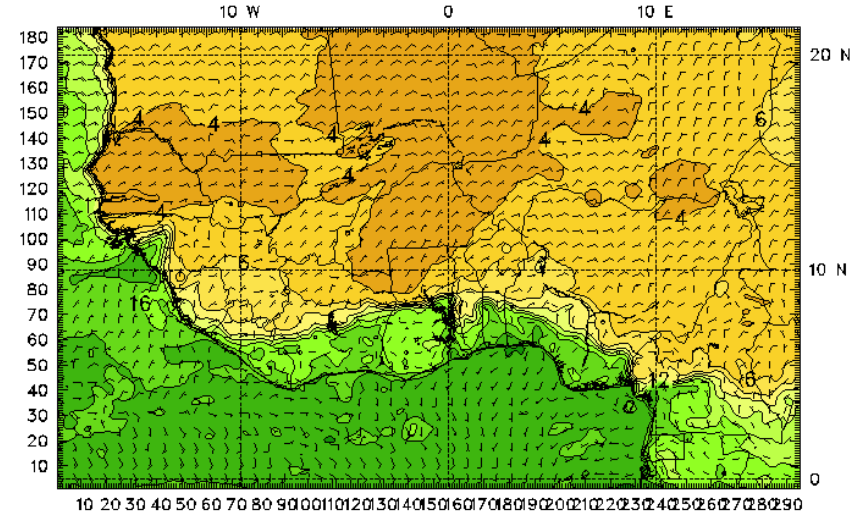


CONTOURS: UNITS=hPa LOW= 1016.0 HIGH= 1020.0 INTERVAL= 4.0000
 CONTOURS: UNITS=°C LOW= 12.000 HIGH= 44.000 INTERVAL= 4.0000
 CONTOURS: UNITS=°C LOW= -16.000 HIGH= 8.0000 INTERVAL= 4.0000



Model Info: V3.6.2 Grell MRF PBL Ralsner 1 14 km, 36 levels, 30 sec

Surface Qv and Winds



BARB VECTORS: FULL BARB = 5 m s⁻¹



Model Info: V3.6.2 Grell MRF PBL Ralsner 1 14 km, 36 levels, 30 sec

Sea Breezes in Domain 3 (Animated hourly, 07Z Dec. 4 – 18Z Dec. 5 2006)

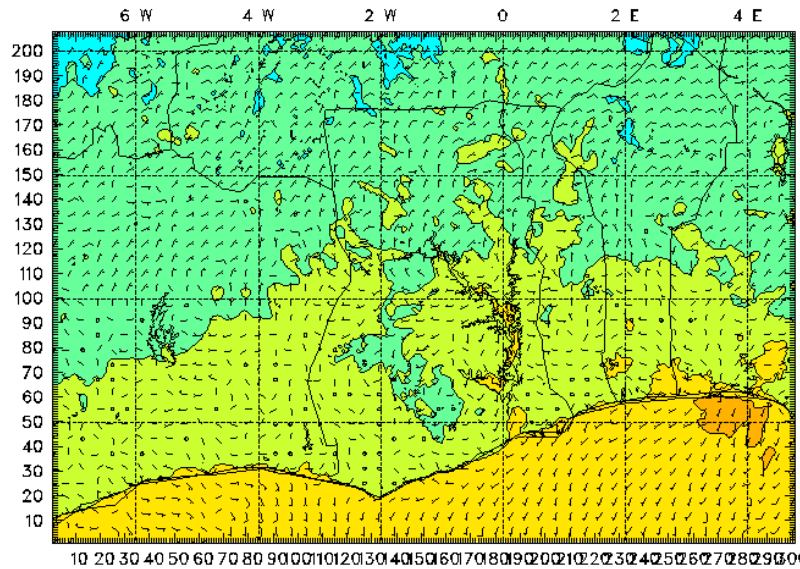
GRM RT-FDDA Domain 1 Cycle=2006120412
 Fcst: 37.00
 Surface temperature
 Surface horizontal wind vectors
 Sea-level pressure

Init: 1800 UTC Sat 1 GRM RT-FDDA Domain 1 Cycle=2006120412
 Valid: 0700 UTC Mon 04 Dec 06 (0000 MST Mon 04 Dec 06)

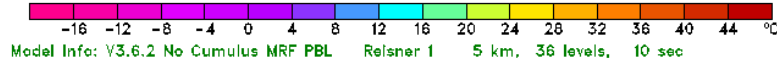
Surface mixing ratio
 Surface horizontal wind vectors

Init: 1800 UTC Sat 02 Dec 06
 Valid: 0700 UTC Mon 04 Dec 06 (0000 MST Mon 04 Dec 06)

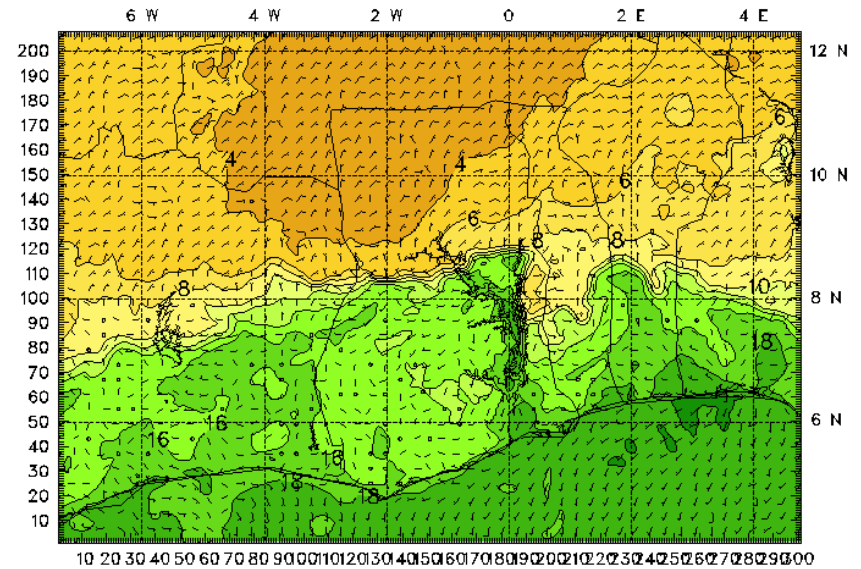
Surface T and Winds



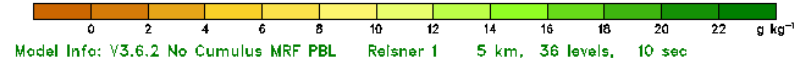
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Surface Qv and Winds



BARB VECTORS: FULL BARB = 5 m s⁻¹



Summary

- **A demonstration RTFDDA system has been started for Africa to support the “NCAR/UCAR Capacity Building in Africa”**
- **The Phase-I system is currently running at NCAR and will run until the end of April 2007**
- **A first look at the model results of arbitrarily selected cases showed encouraging modeling capabilities**
- **Continued R&D are conducted to improve the system performance**
- **Phase-II system is under development. NCAR seeks collaboration from Africa people and community for better understanding the needs, regional observations and weather wisdoms to advance the capability of the modeling system.**

Conclusion

- **This is an opportunity to develop local modeling capability for operations, research and applications**
- **A capability to influence decision-making at the relevant scales since very high resolution simulations can be achieved**
- **An offshoot of this system will be regional climate simulation capabilities**
- **In a long-term, an ensemble-based forecasting system can be planned.**