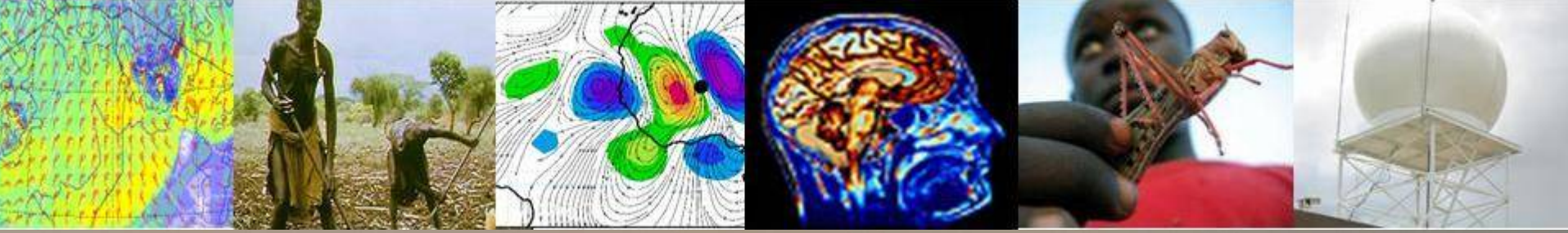


Opportunities and Challenges for Meteorology in Africa with a focus on West Africa: A Perspective from current ongoing UCAR projects

UNIDATA SEMINAR

15 October 2007

Boulder, CO

www.africa.ucar.edu

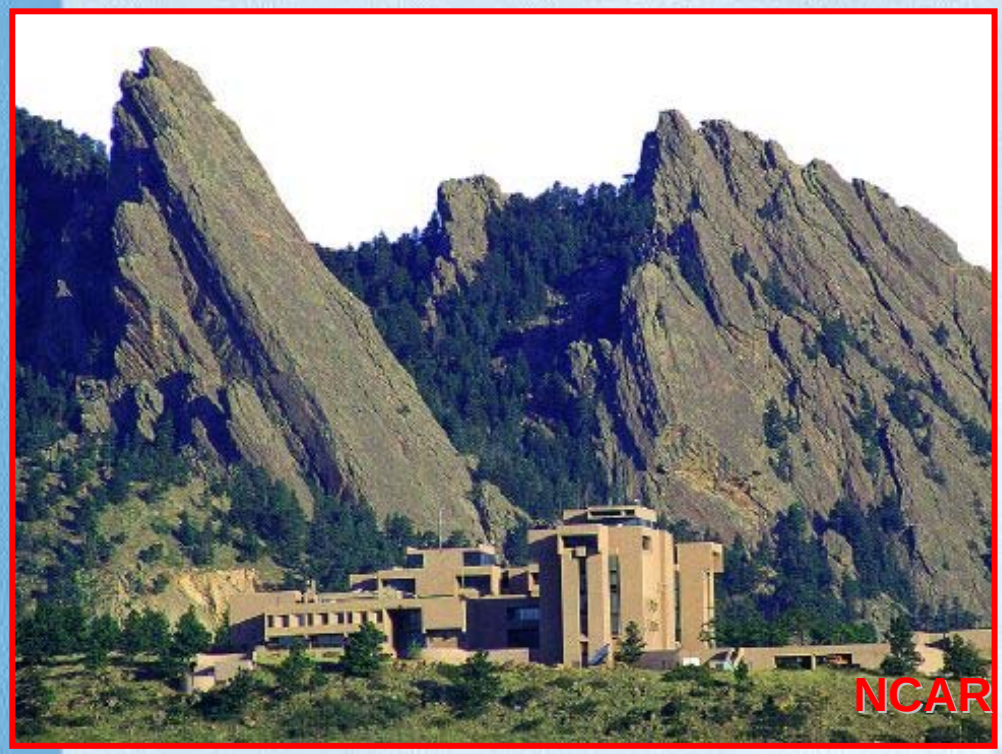
Africa Initiative Goal

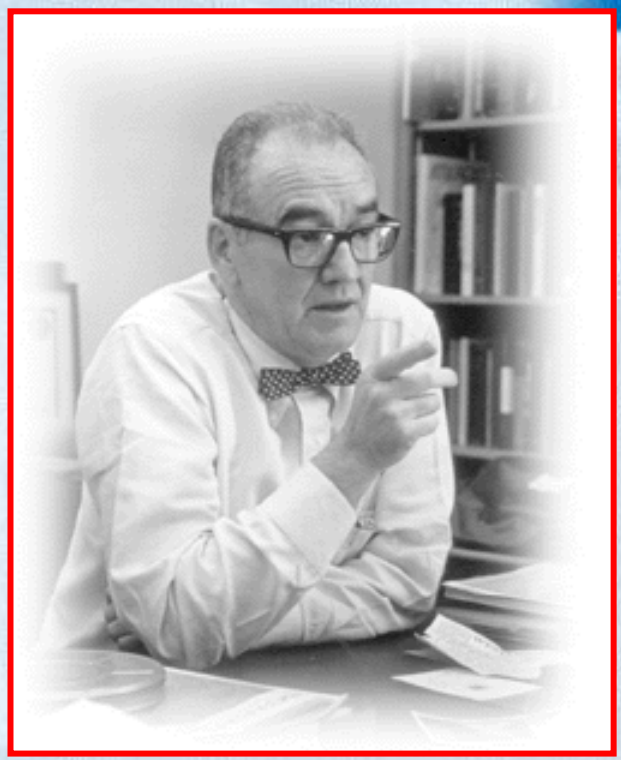
"African Solutions for African Problems"

An integrated end-to-end process, from research to impact

A partnership between Universities and UCAR for the benefit of the African people. The initiative envisioned will:

- Increase knowledge of the role of African weather, climate, and biogeochemical processes in the Earth system critical to Africa and important for the world
- Involve genuine collaboration with African institutions
- Develop research applications, operational systems, and dissemination strategies to improve lives in Africa
- **Enhance the capacity for atmospheric research in Africa by investing in sustainable infrastructure and education**
- Leverage the research infrastructure of NCAR/UCAR (and its partners) to add value to Africa research





“I have a very strong feeling that science exists to serve human welfare. It’s wonderful to have the opportunity given us by society to do basic research, but in return, we have a very important moral responsibility to apply that research to benefiting humanity.”

Walter Orr Roberts

Guiding Principles

- **Leveraging:** Focus on existing activities and coordinating pre-existing networks.
- **Develop research capacity while integrating research and education:** Contribute, in the long term, to developing local research capacity.
- **African Solutions for African Problems:** issues addressed should arise from an needs defined by local institutions, and focus on developing and enabling long-term strategies led by those institutions.

A very preliminary list of UCAR member universities with active atmospheric and related research in Africa

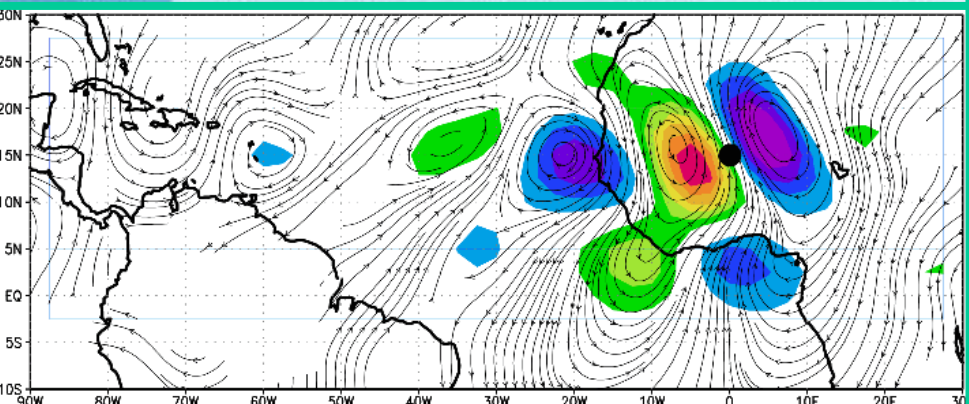
- Penn State (Many Researchers)
- Cornell (Kerry Cook)
- University at Albany - SUNY (Chris Thorncroft)
- Howard (Greg Jenkins)
- North Carolina State University (Fredrick Semazzi)
- Rutgers (Richard Anyah)
- Purdue (John Harbor)
- University of Illinois (Somnath Roy)
- University of Georgia (Carla Roncoli)
- Columbia University (Many Researchers, home of International Research Institute for Climate Prediction)

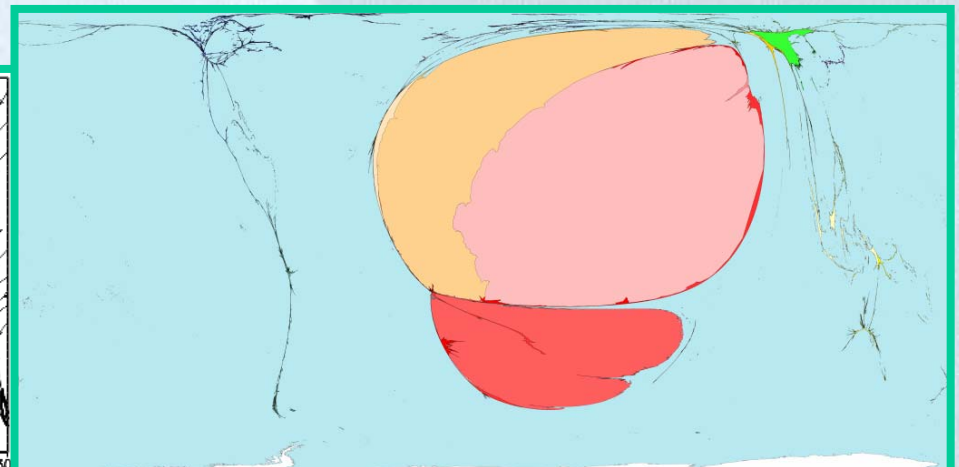
The importance of integration: Algerian Flood November 2001 : 737 Dead

“No warning to the population was raised and no measure taken to reduce the impact of the disaster, even though the meteorological office in Algiers announced two days earlier that a strong storm will arrive in Algeria on Friday night …”

Global and Local Impact

- African easterly waves (AEW) create 90% of intense Atlantic hurricanes
- AEW's originate from traveling low-pressure systems that deliver essential precipitation in the Sahel
- The Sahel is subject to poorly understood variability in seasonal rains and frequent drought.





A guiding strategy

“any solution proposed for Africa must be based on the continent's own perception of its needs, and on the dynamics of its own economic and political environment.”

David Dickson, Director
SciDev.Net

STEPS

- Identify and prioritize themes addressing local needs & global questions
- “Research for applications” around these priorities
- Integrate and coordinate existing activities to enhance collaboration and prevent overlap
- Broaden current activities to include regional and continental approaches
- Develop communities of practice with partners specializing in collaborating with stakeholders

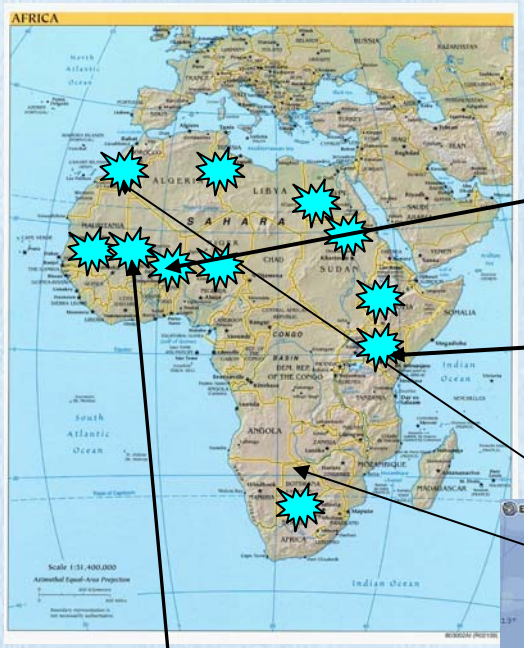
Pilot and planned activities

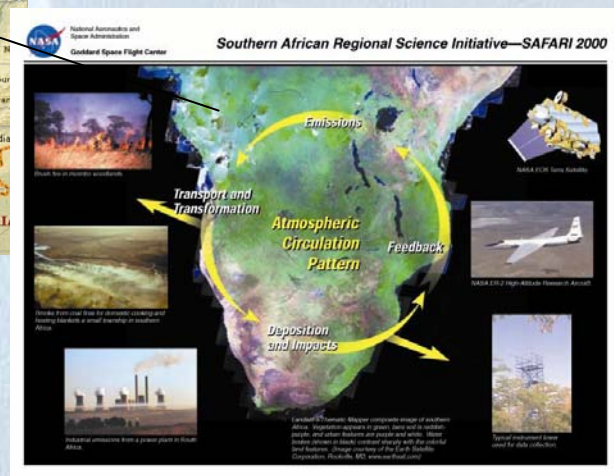
- *Internal priority for capacity-building activities, aligned with identified priorities and partners*
- *Pilot projects that enhance existing activities while allowing program development*

1. AAAS-UCAR African Scholars Program
2. Educational Opportunities: April workshop in Ouagadougou, Burkina Faso
3. Enhanced Observational Capacity: Radar network in West Africa
4. Enhanced Modeling Capacity: WRF in Ghana

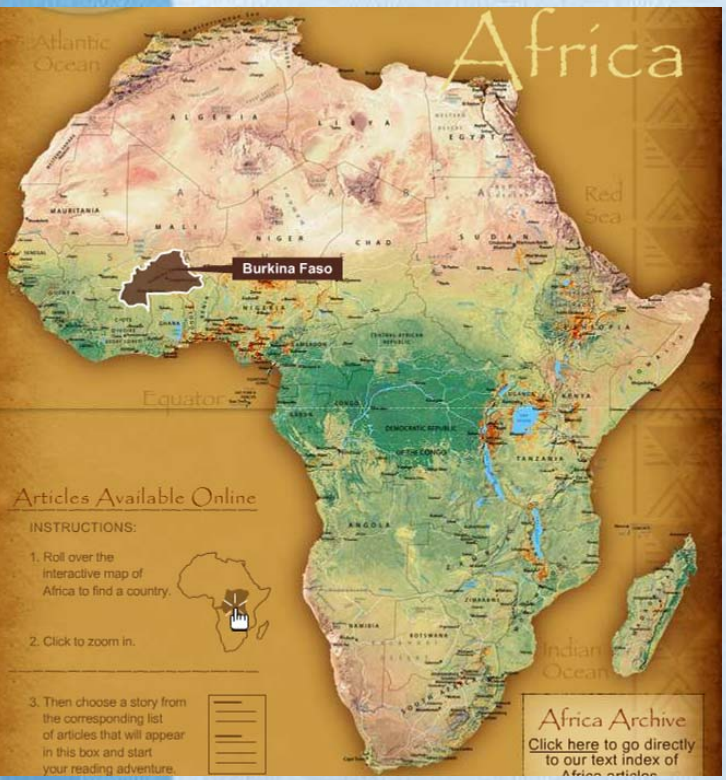
Africa Programs

NCAR





Supporting Capacity Building

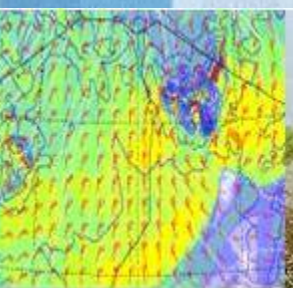


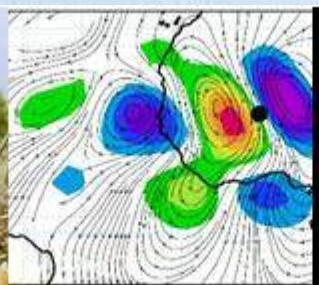
Sahel Conference 2007

2-6 April 2007

Ouagadougou, Burkina Faso

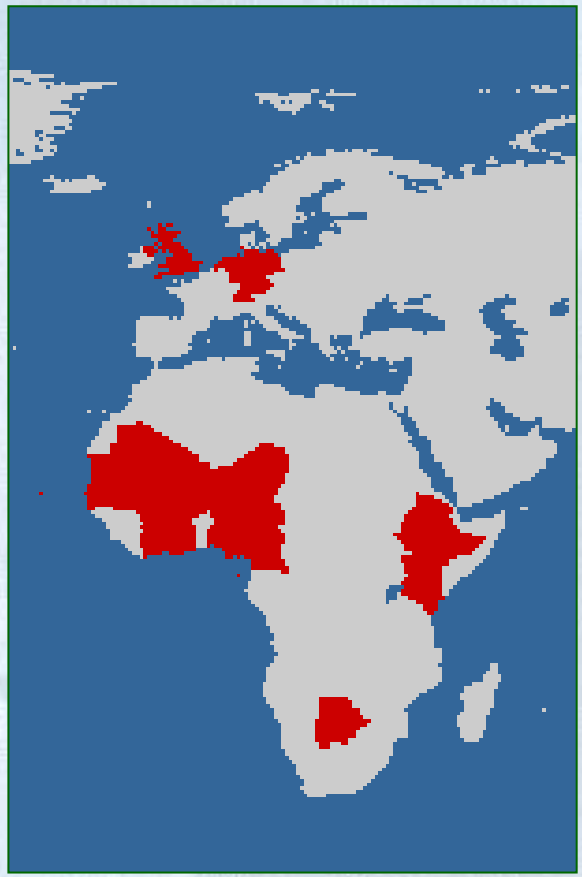
Co-hosted by CILLS, Programme SAAGA






Participants

- Over 80 Participants from 18 countries
- Several regional alliances
- 10 participants from UOP, NCAR, and UCAR
- Unique mix of operational meteorologists, researchers, university faculty, military personnel, and program leaders







Conference Consensus

- Fundamental importance of training and education
- Long-term investment in Infrastructure (telecom)
- Development of NWP research and operations capability
- Free and open data exchange
- Regional approaches are fundamental to success

Conference Structure

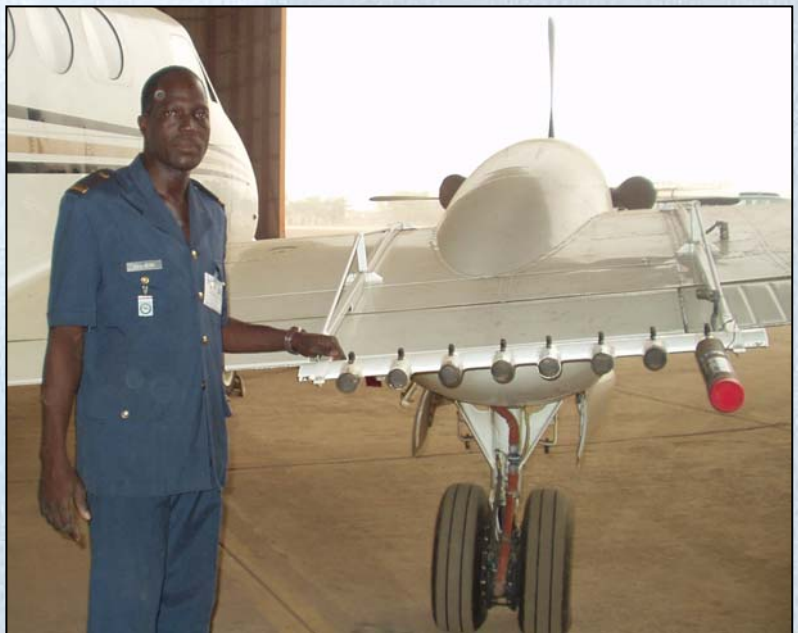
- Informal Interaction
- Morning Plenary Session
  - Talks from African and International Participants
- Afternoon Hands-On Workshops
  - Unidata, EUMETSAT, RAL Radar Modules
- Friday Working Groups
  - Data Sharing Infrastructure & Telecommunications
  - Satellite, Radar, Observation Networks and Integration
  - Cloud Seeding
  - Numerical Weather Prediction

Education and Training

We underline the fundamental importance of **training and education** for meteorological personal. Budgets for training and education are fundamental to long-term program success.

Infrastructure

We call out the need for **long-term investment in equipment and other infrastructure**. The recommendation is that planning for the long-term maintenance of infrastructure be included in planning process

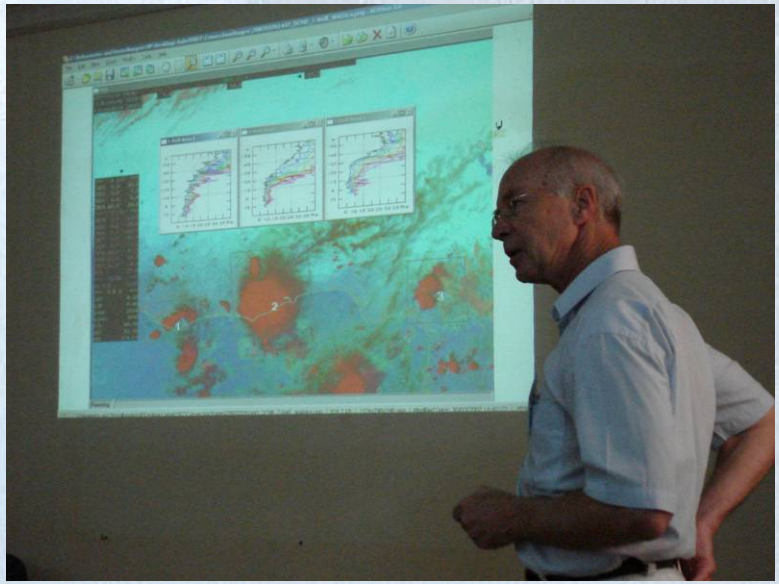


Weather Modification

- Controversial – A tentative consensus
  - Weather Modification should be accompanied by scientific research and optimization
  - Investment in rainfall enhancement capability produces other benefits

NWP

We propose the **development of numerical weather prediction research and operations capability**, and further recommend a **regional approach** that can extend the benefit of this capability to all Meteorological Services in the Sahel.



Sharing Data

We strongly endorse developing means to **share data freely** among all countries in West Africa, especially radar data, and for **developing a network of West African radars**

Potential Partnerships

- Unidata, EUMETSAT, African NMHS's collaborate to share and distribute products (e.g. composite rainfall from radar)
- Regional approaches to training, maintenance
- NWP with ACMAD, Senegal, Ghana, and Nigeria Weather Services
- Evaluation of Seeding
- CO_2 Monitoring in Kenya

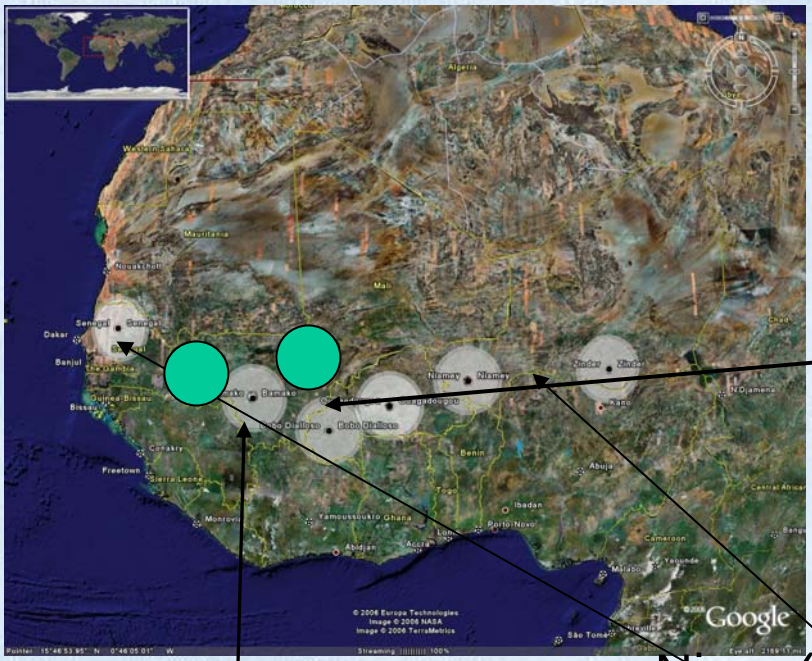
Regional Approaches

In overall terms, we support the **sustained collaboration** between the various West African Meteorological Services and with centers like ACMAD, ASECNA, CILSS, etc.

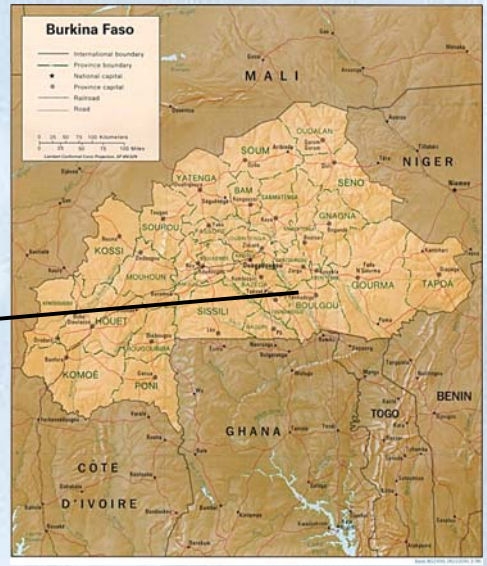
Participant Comments

- good discussions
- African co-leadership
- good mix of operational weather forecasters and scientists
- intensive interaction with other participations with diverse backgrounds and experience which resulted in common areas and new areas for research

West African Radars

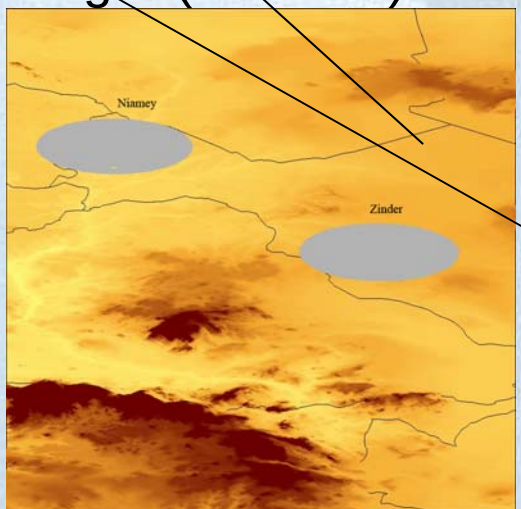


Burkina Faso (2 radars)



Mali (3 radars)

Niger (2 radars)



Senegal (one radar)

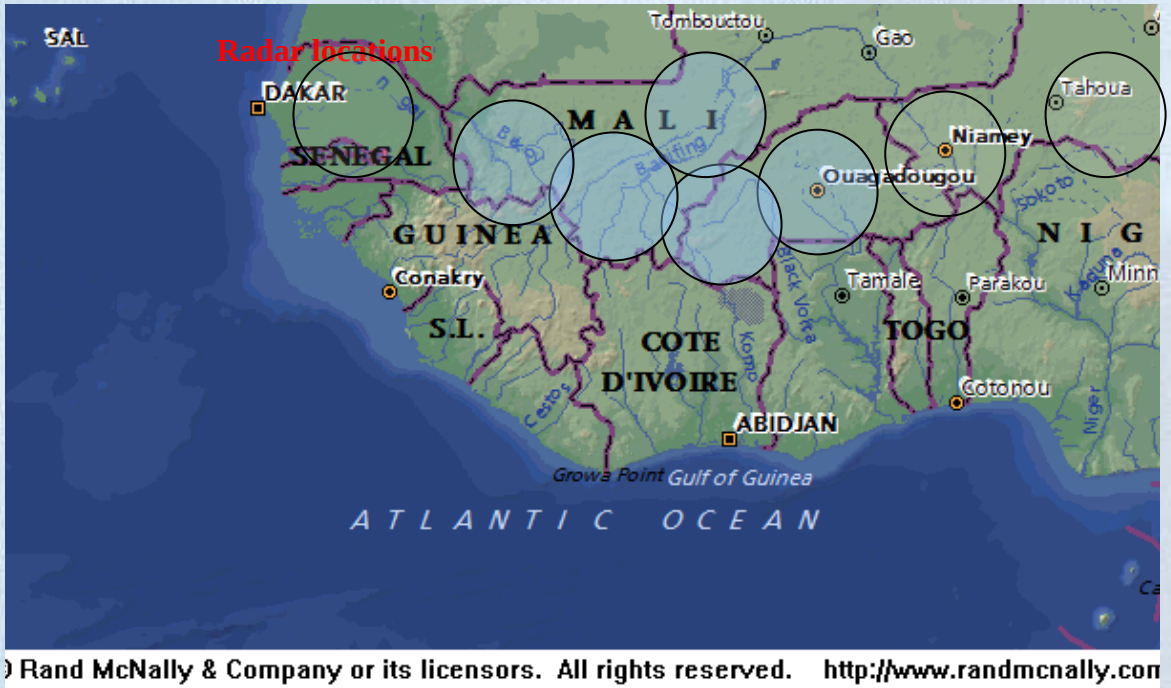
Burkina Faso infrastructure

Radar installations in Ouagadougou and Bobo Dialloso, Burkina Faso

Mali

Mali radar infrastructure
Bamako

Weather radar and project locations

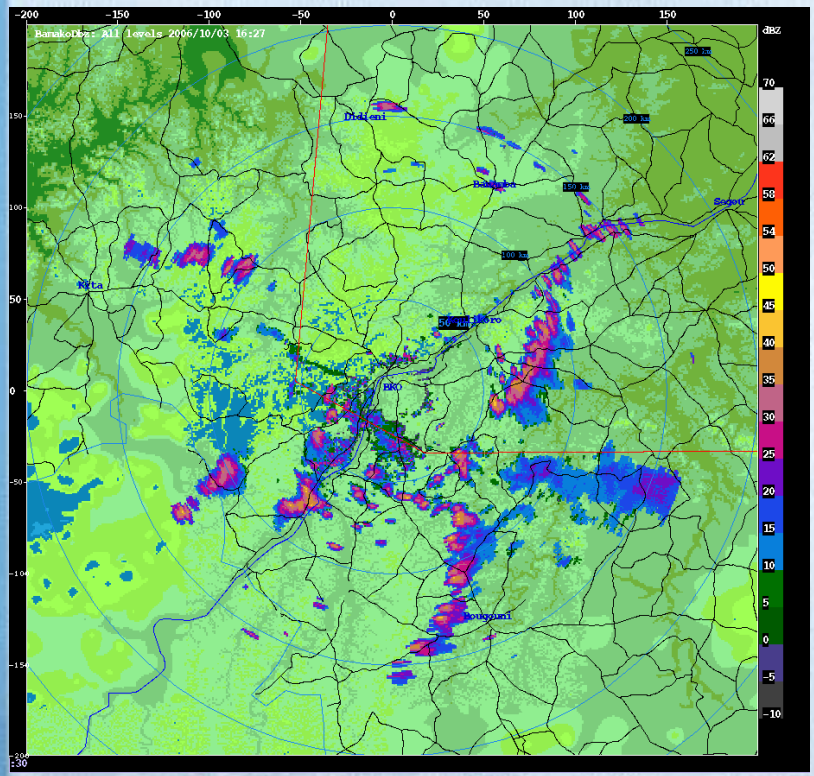


Burkina Faso, Mali (currently operational radars) and potential Senegal and Niger radar locations (not fully operational as yet).

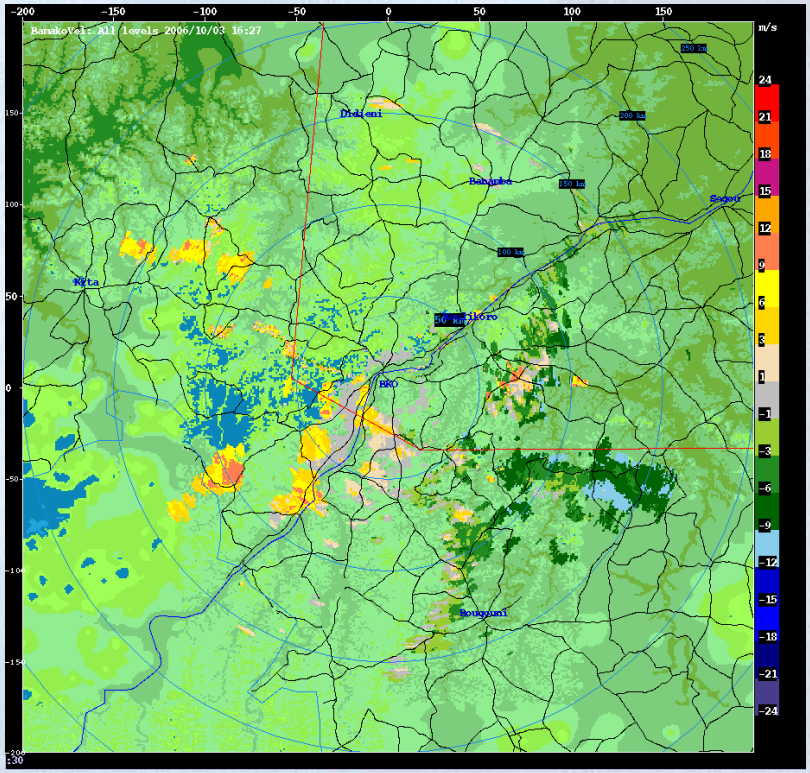
Real-time data
Bamako, Mali

http://www.rap.ucar.edu/projects/westafrica/bamakoradardata/index.php

Convective line of storms approaching Bamako



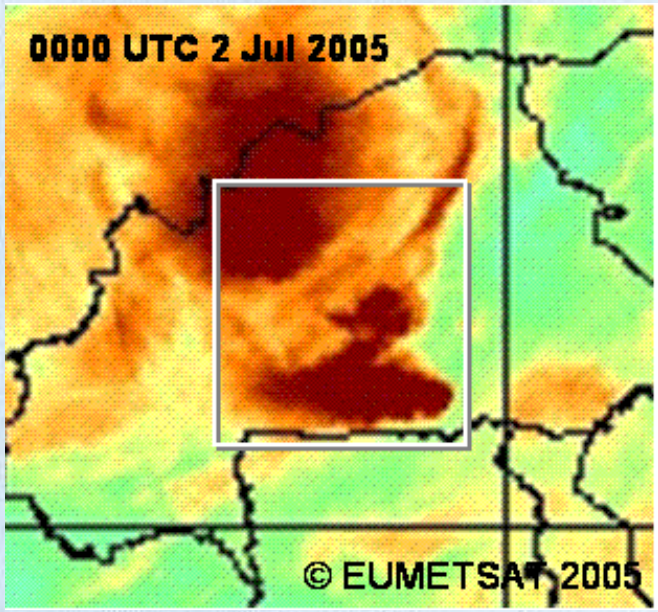
Reflectivity

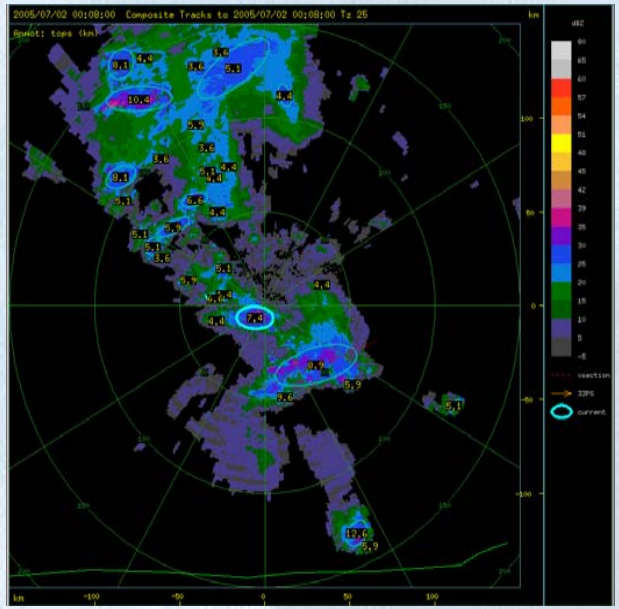


Radial Velocity

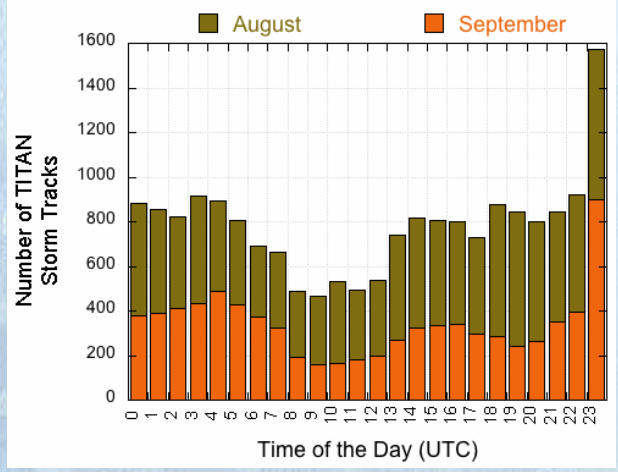
West Africa

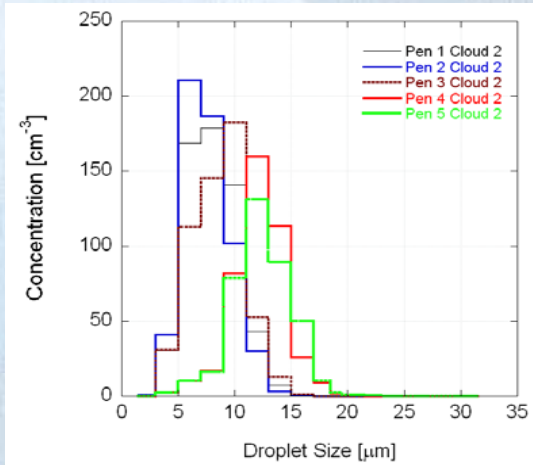
Satellite image and Ouagadougou radar





Bamako diurnal variation of radar echoes and cloud droplet spectra in clouds





Current West Africa Activities

- Conducted calibrations of radars and upgraded software
- Networked the Mali radars
- Quality control of data
- Network Mali and Burkina Faso radars
- Stream data to UNIDATA and provide UNIDATA products for West African countries and universities
- Coordinate with EUMETSAT to integrate radar and satellite data

Proposed Future Activities

- Enhance network of radars by networking all West Africa radars starting with Burkina Faso and Mali and including the Senegal and potentially upgraded Niger radars.
- **Education and training** (3 people from Burkina Faso and two from Mali visited NCAR for training in October 2006).
- Future training in the integration of radars with other sensors and uses for different applications including assessment of rainfall enhancement programs, weather forecasting and nowcasting, aviation weather, water resources management and agriculture
- Follow-up SAHEL Workshops to enhance share experiences and enhance future collaborations, and to provide for sustaining current infrastructure

Western Africa NWP: The model and initial results

Ben Lemptley

Model Configuration

- MM5-based Real-Time Four Dimensional Data Assimilation (RTFDDA) system
- "Standard" model physics are currently used
- 6-hour cycles with 24 - 36 hr forecasts in each cycle, depending on the grid.
- Observations: Standard GTS/WMO surface and upper-air stations, plus MADIS (mostly AMDAR) and QuikScat sea-surface winds

Computing Resources

- NCAR Director GAU Reserve

  7840 GAUs per month untill May 1
- CISL Lightning Linux-cluster

  18 dedicated dual-cpu nodes: 1 model master, 16 MPP and 1 spare
- Local post-processing and web service

  RAL PC clusters

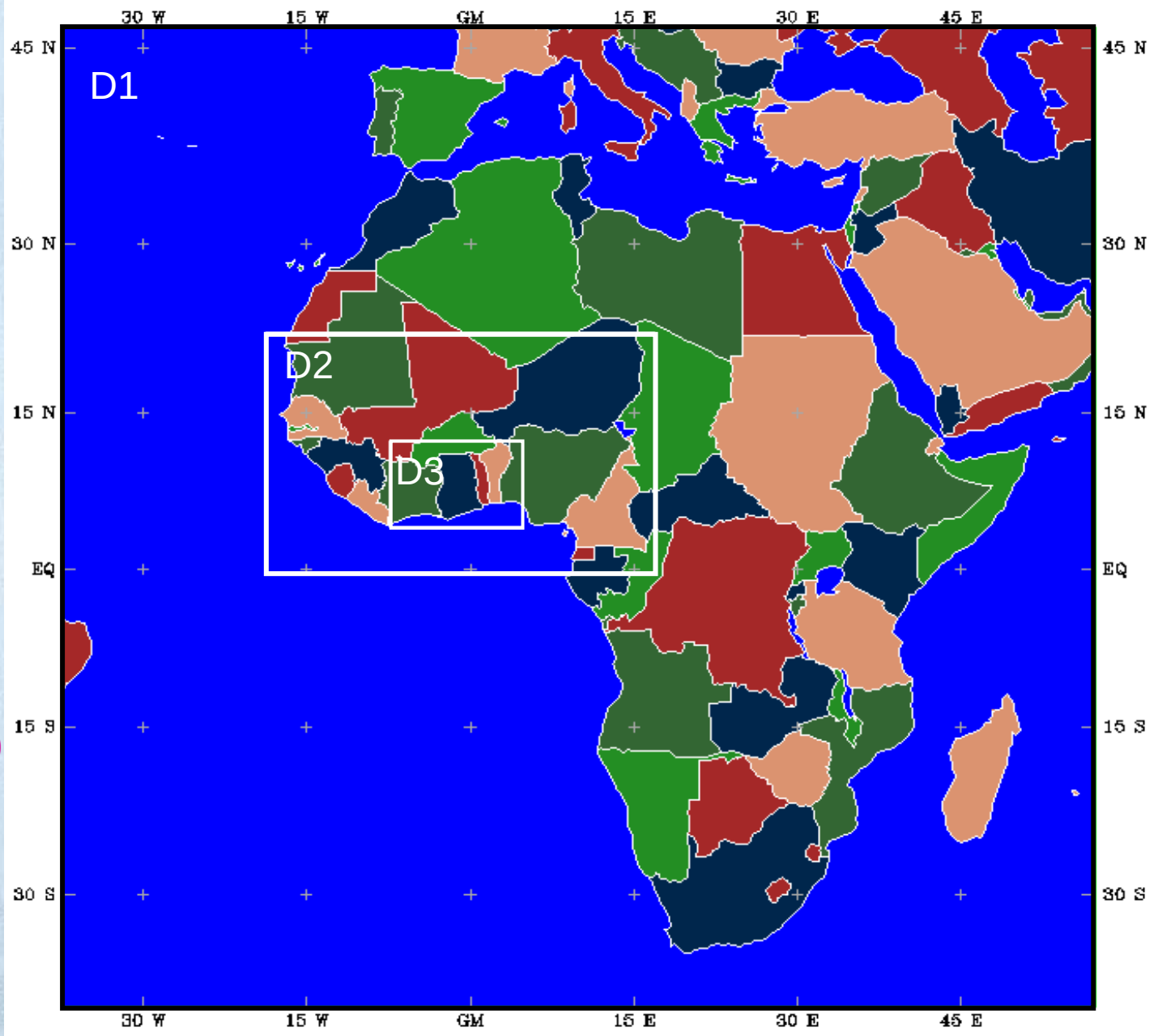
Domains

Three 2-way nested domains

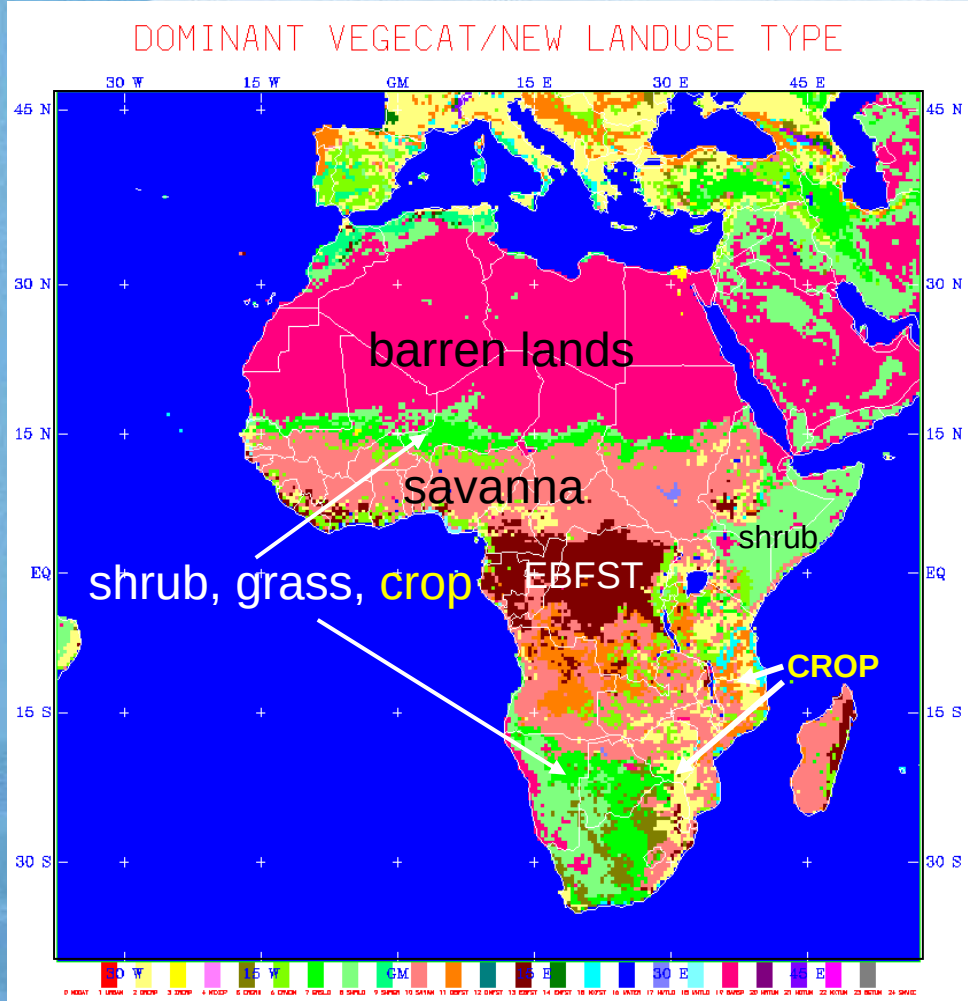
DX= 40.5/13.5/4.5 km

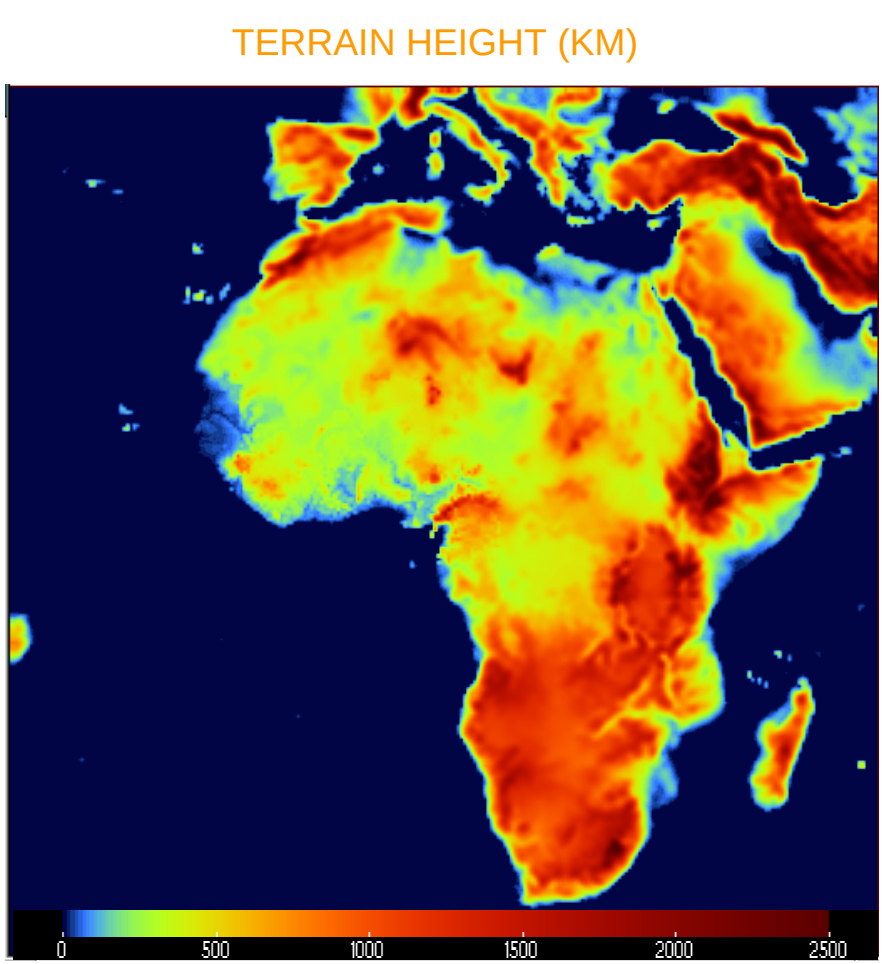
Dimensions
D1: 261x261x36
D2: 184x295x36
D3: 208x301x36

Sizes (km^2):
D1:10530x10530
D2: 3969x2592
D3: 1350x931

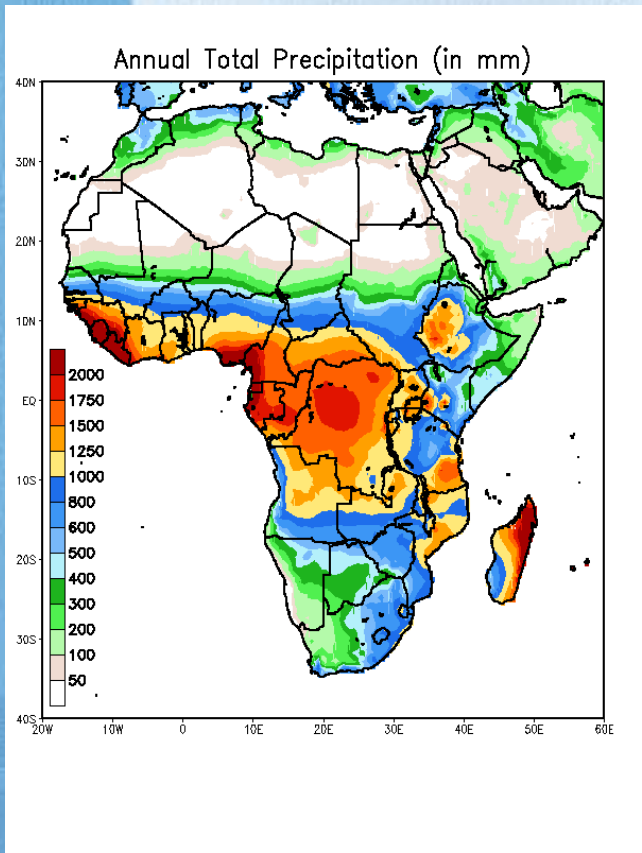


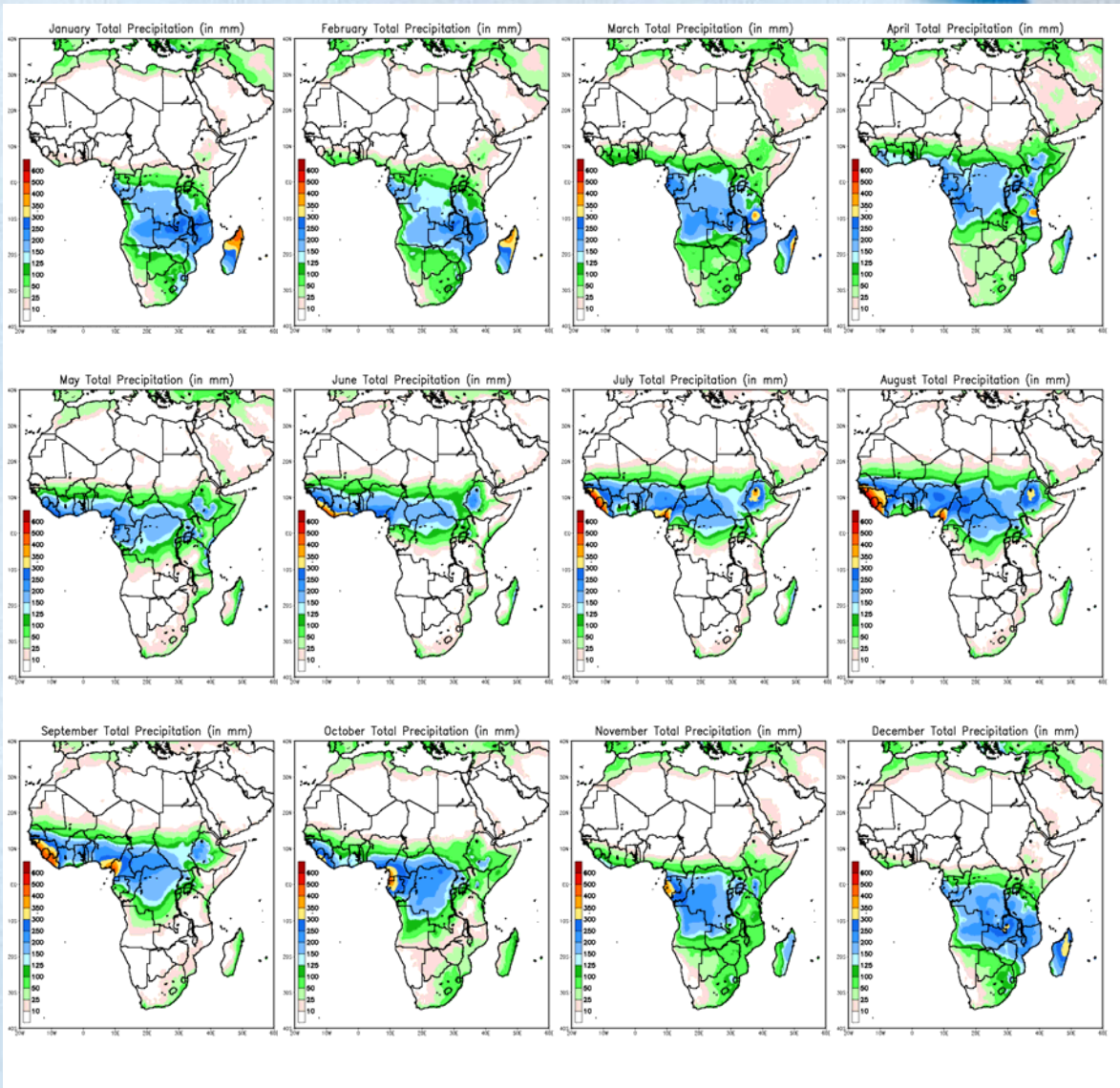
Land Use and Terrain Features





Precip. Climate
(From UK/CRU)

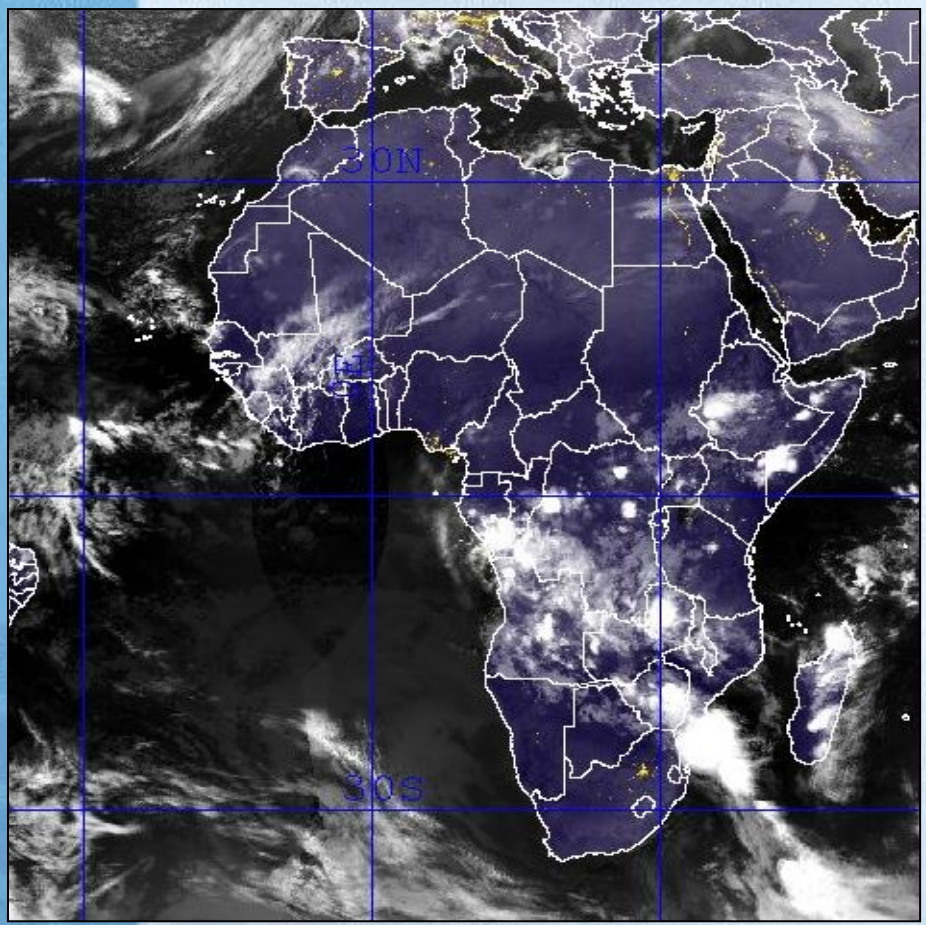




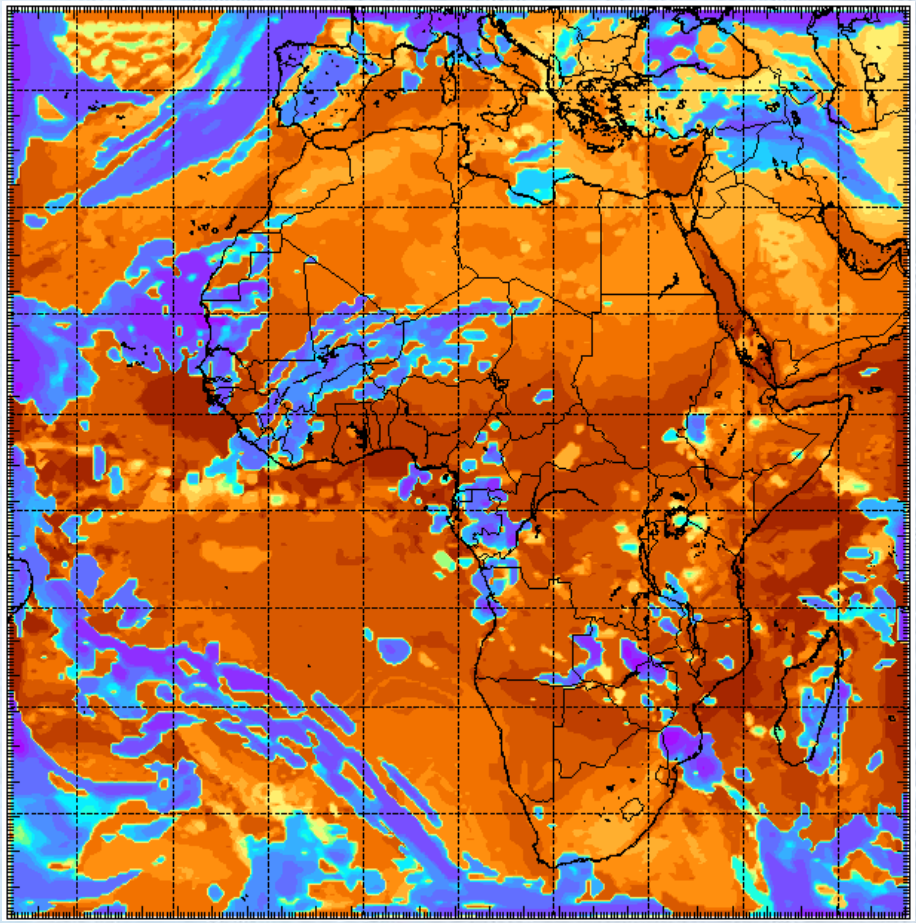
Verification of RTFDDA Forecasts of Cloud fields (Domain 1; valid at 00Z Dec. 5, 2006)

NCAR

NRL DAY/NGT VIS/IR



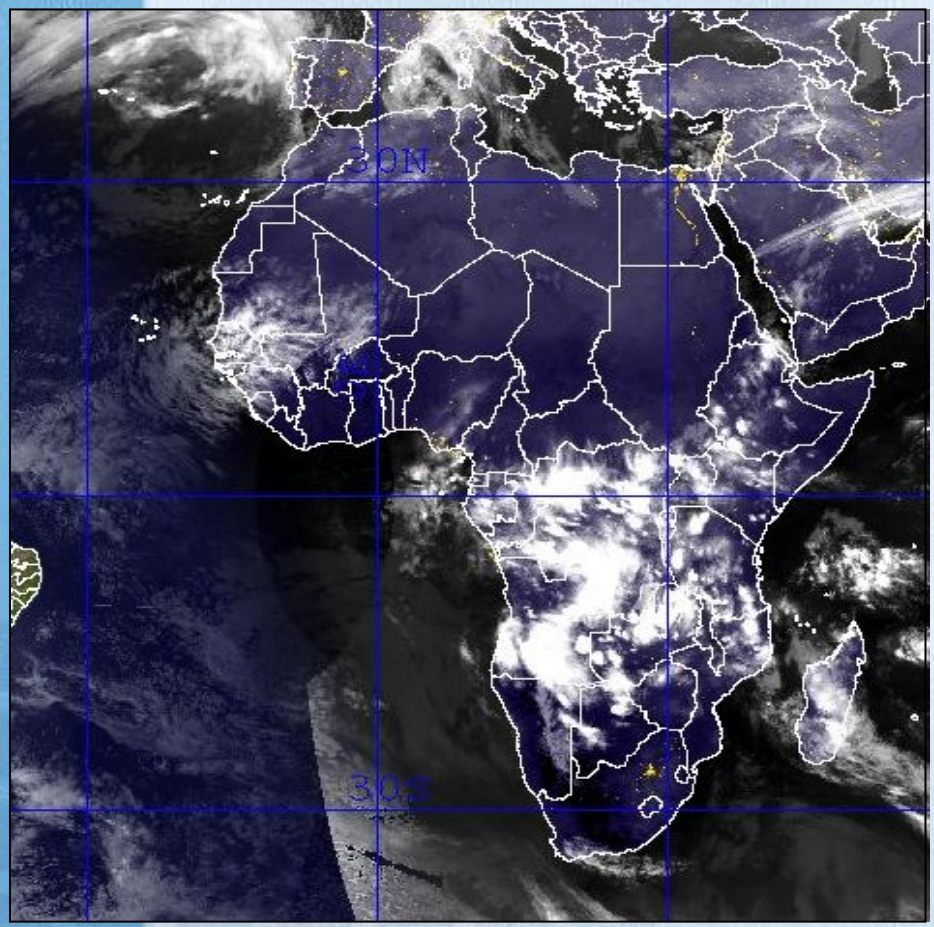
RTFDDA 6h FCST: Cloud Top T



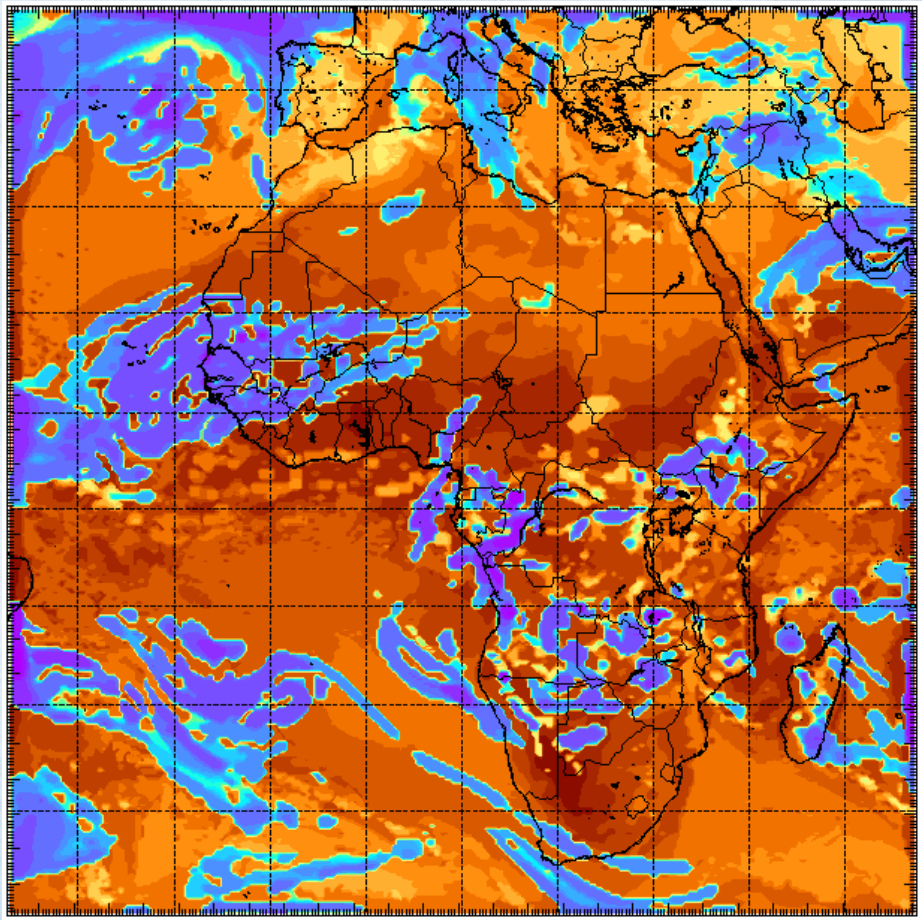
Verification of RTFDDA Forecasts of Cloud fields (Domain 1; valid at 18Z Dec. 6, 2006)

NCAR

NRL DAY/NGT VIS/IR

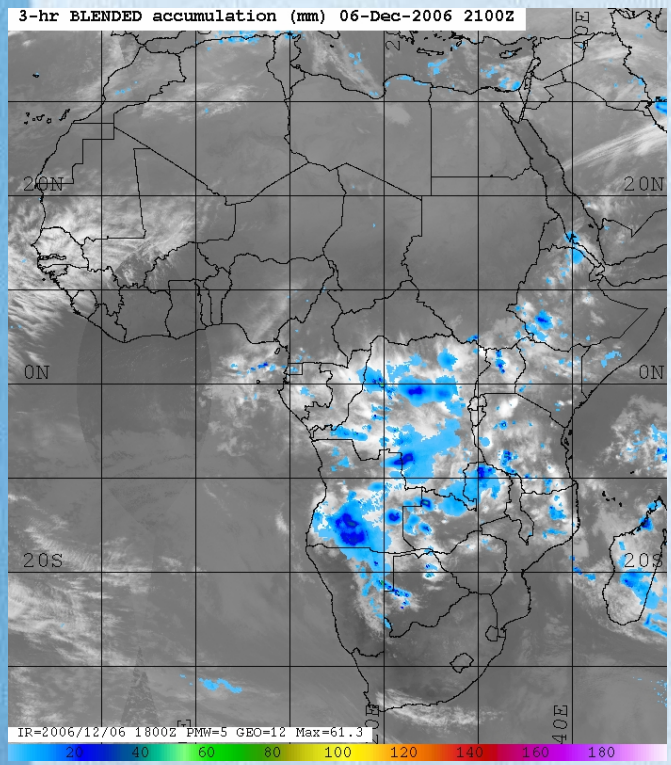


RTFDDA 18h FCST: Cloud Top T

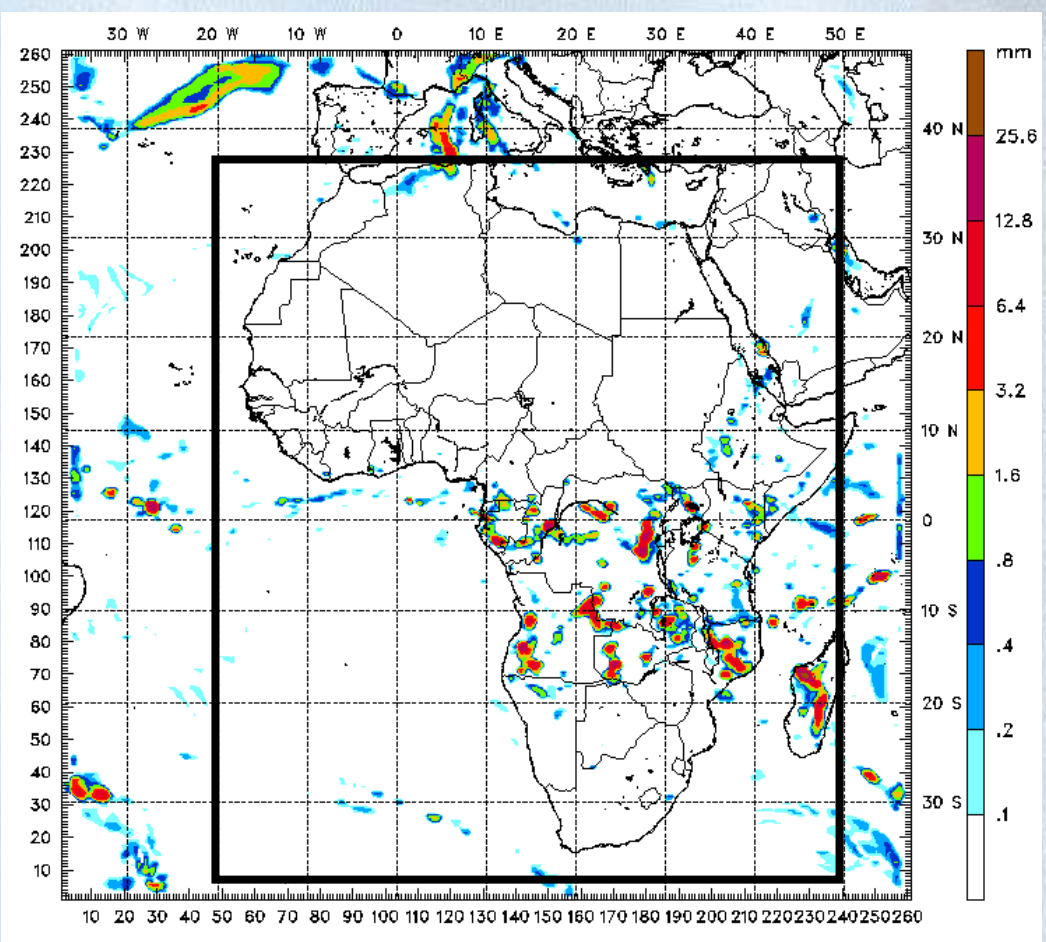


Verification of RTFDDA Forecasts of Precipitation (Domain 1; valid at 21Z Dec. 6, 2006)

NRL GEO-MV derived 3-h rain



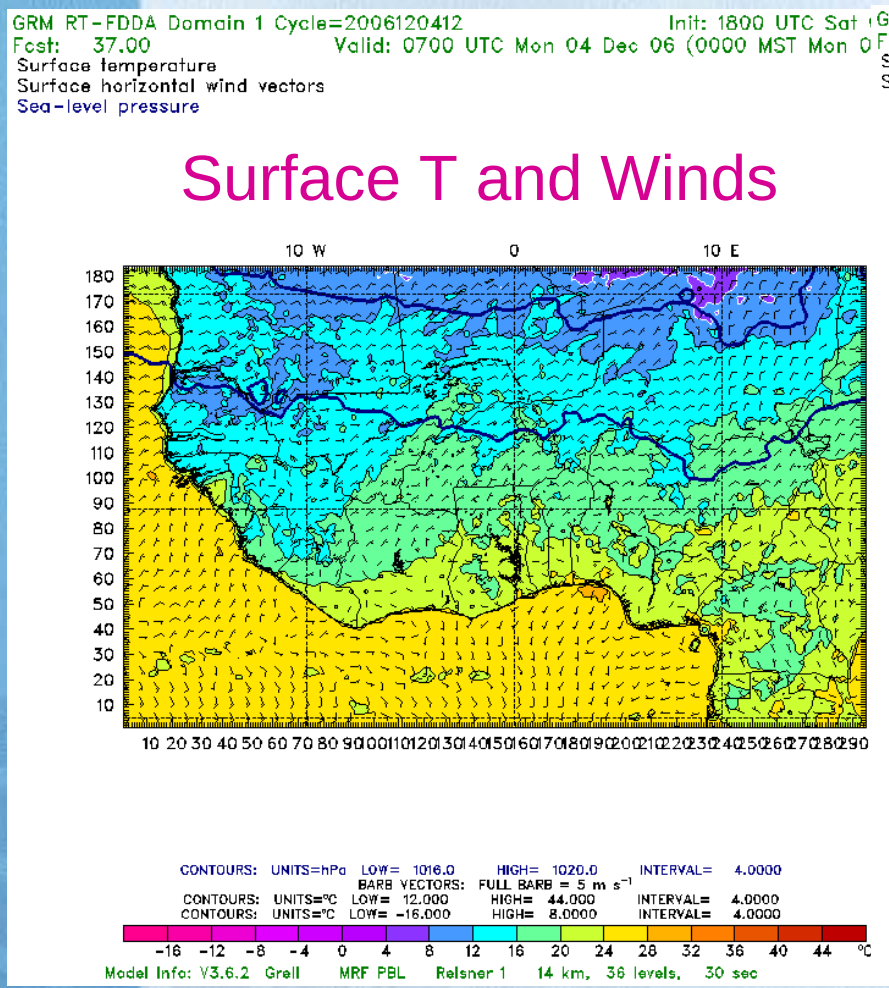
RTFDDA 3h FCST: 1h rain



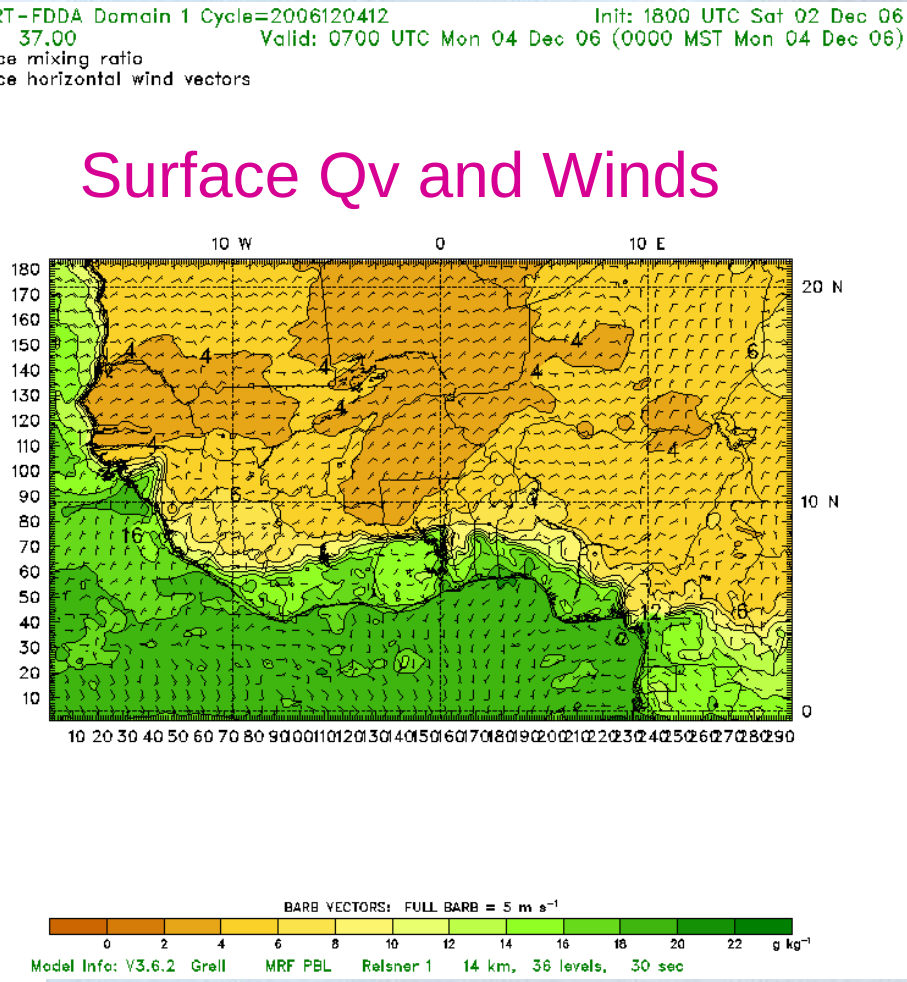
Domain 2

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

Surface T and Winds

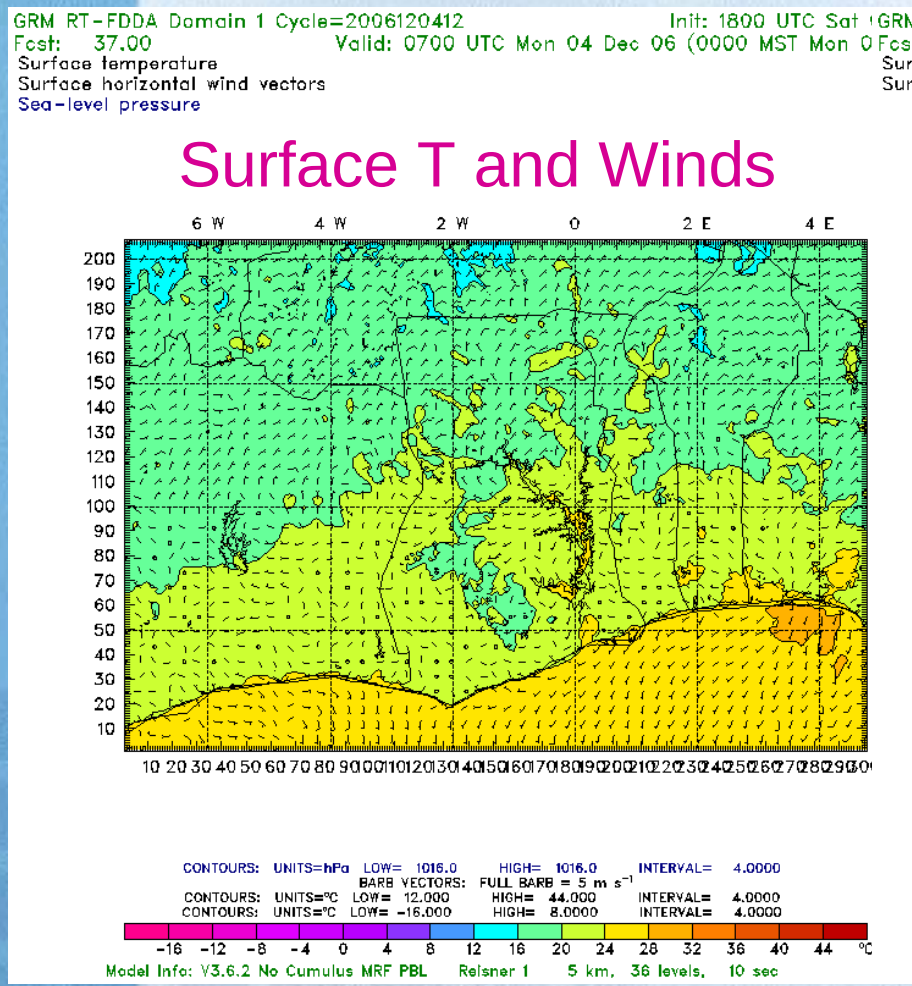


Surface Qv and Winds

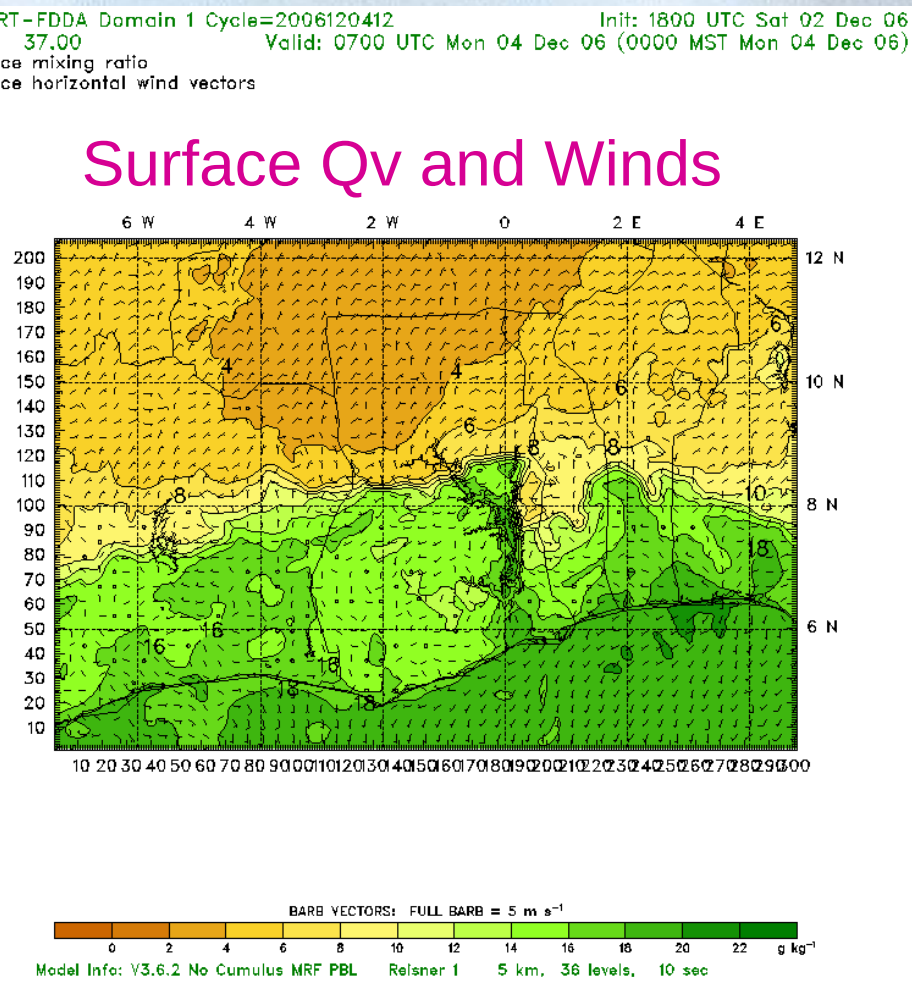


Domain 3

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



Surface T and Winds



Surface Qv and Winds

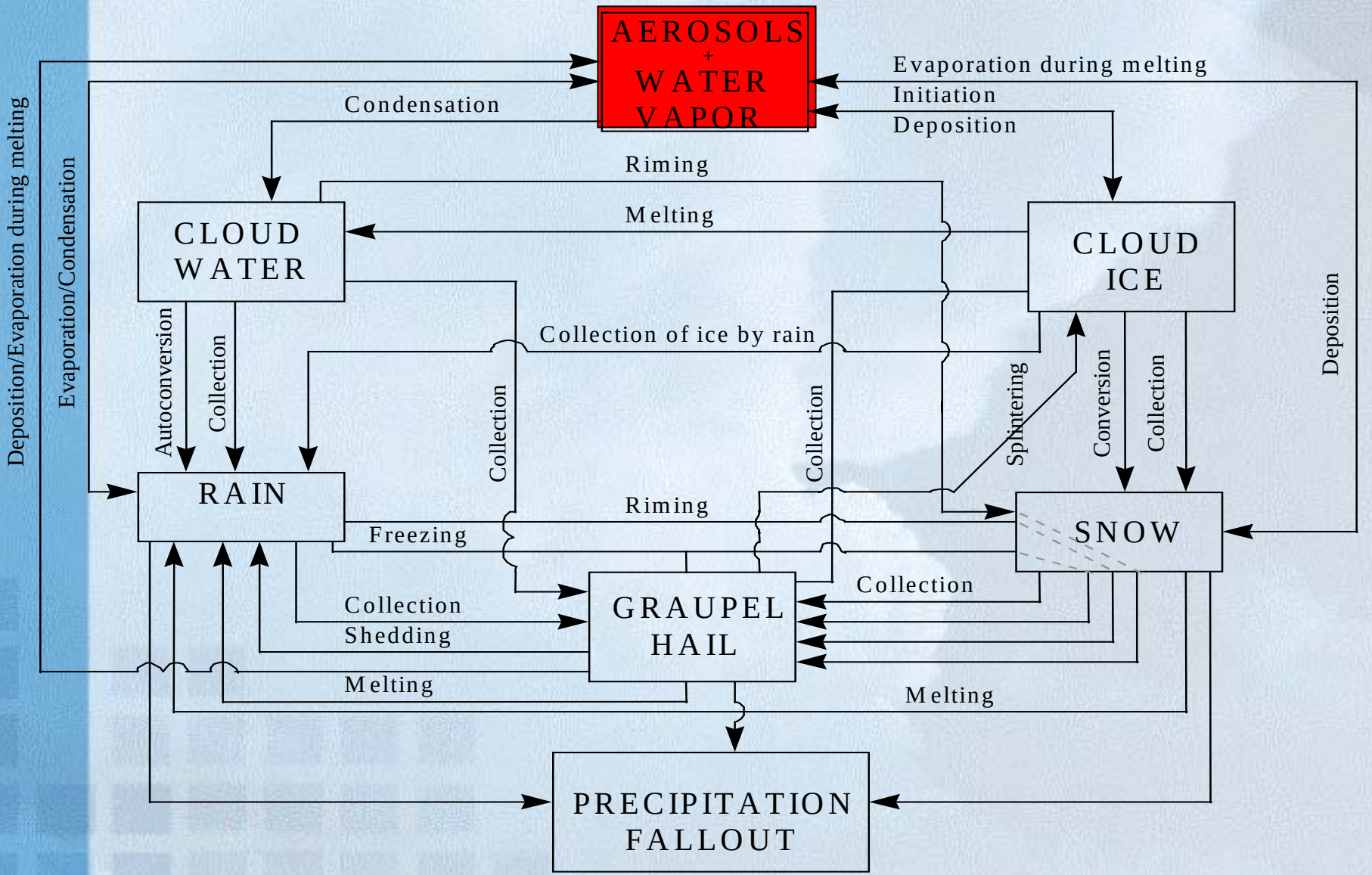
Summary

- A demonstration modeling system has been set up for Africa, to support NCAR/UCAR capacity-building on that continent.
- The system is running at CISL for the next 5 months, providing high-resolution mesoscale NWP for African forecasters and stakeholders.
- A first look at the model results for arbitrarily selected cases is encouraging.
- Next year this system will transition to one running on a dedicated PC cluster in RAL.
- Considerable work needs to be done to verify the model forecasts, and improve the physics where needed.

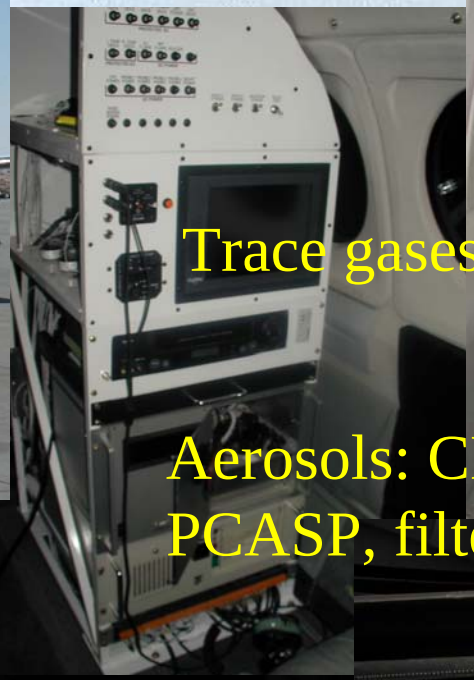
Weather Modification

- Controversial but consensus emerged
- Should be done very carefully
  - Controlled studies of effects
  - Quantification of conditions necessary for maximum effectiveness.
- Investment in rainfall enhancement capability produces other benefits
  - radars used to plan seeding can be used for civil aviation, agricultural planning, and even monitoring the movement of dust

Microphysical processes in precipitation development

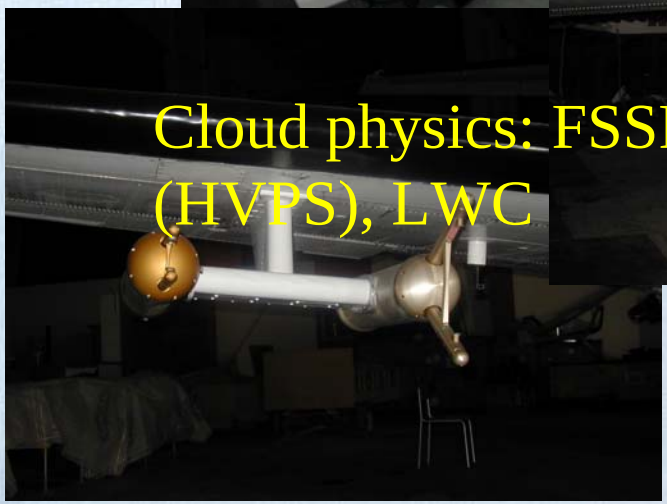


INSTRUMENTED RESEARCH AIRCRAFT



Trace gases: SO_2, O_3, $NO_{x/y}$

Aerosols: CN, CCN, PCASP, filter pack sampler

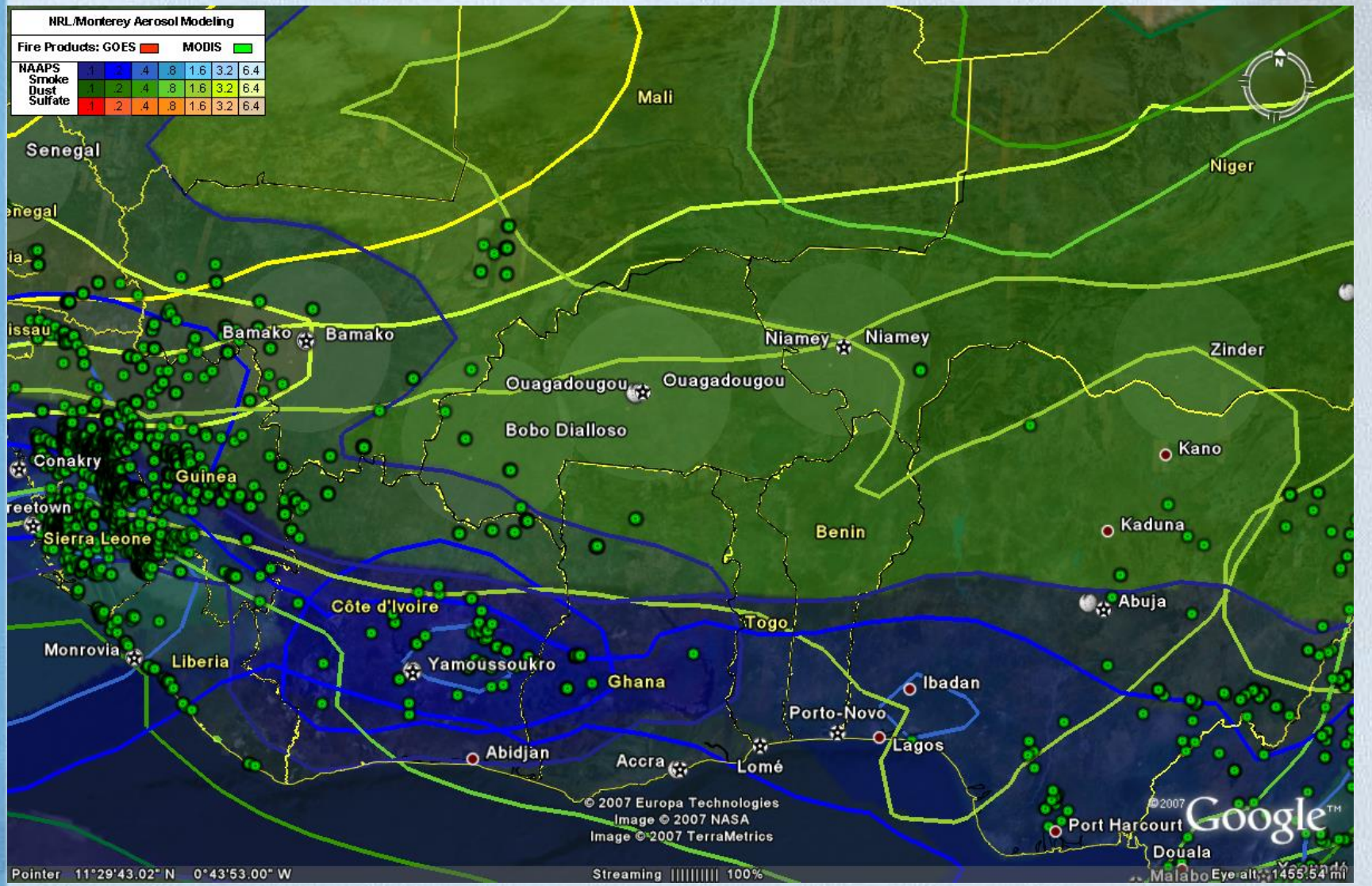


Cloud physics: FSSP, 2D-C, 2D-P, (HVPS), LWC

Missions: chemistry and aerosol mapping, cloud penetrations, seeding trials

State parameters: T, T_d, p, TAS, Hdg, GPS position, derived winds

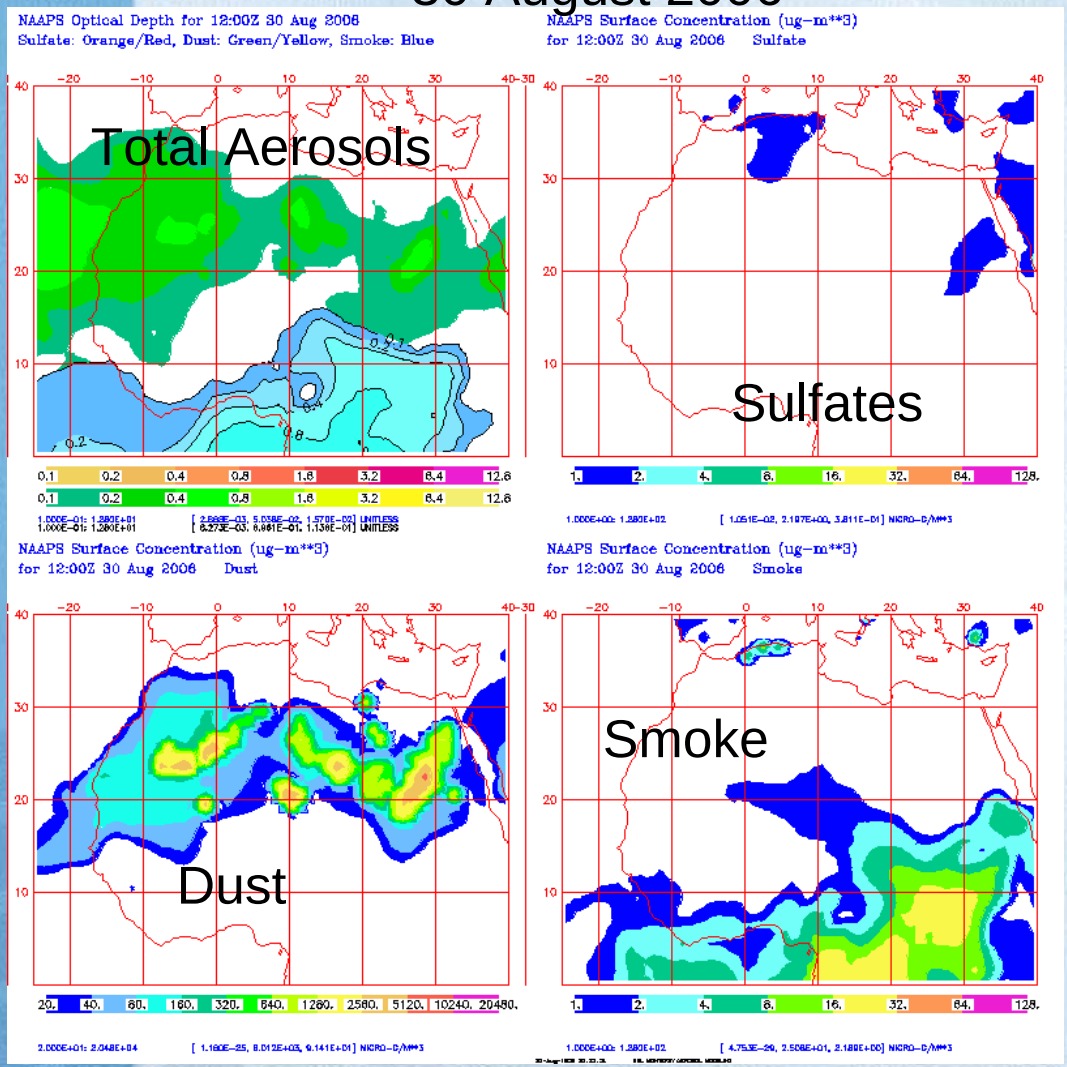
West Africa Aerosols

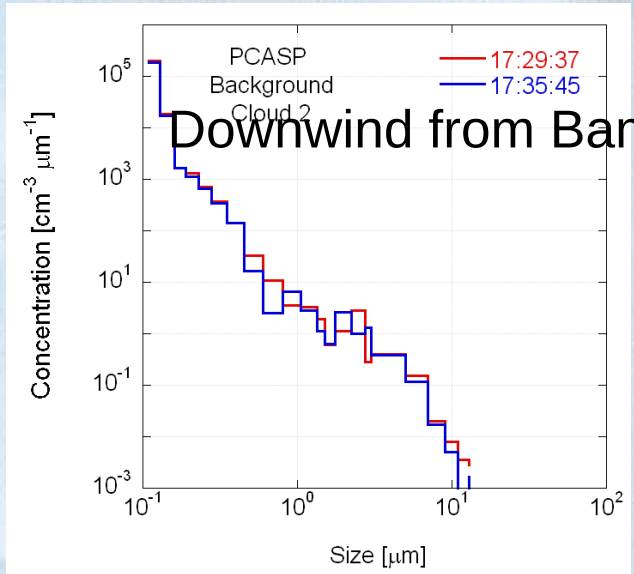


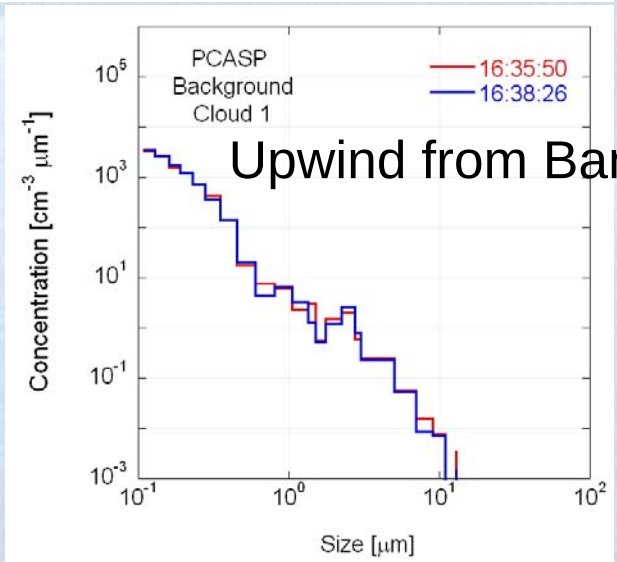
27 March 2007

Mali Aerosols Observations

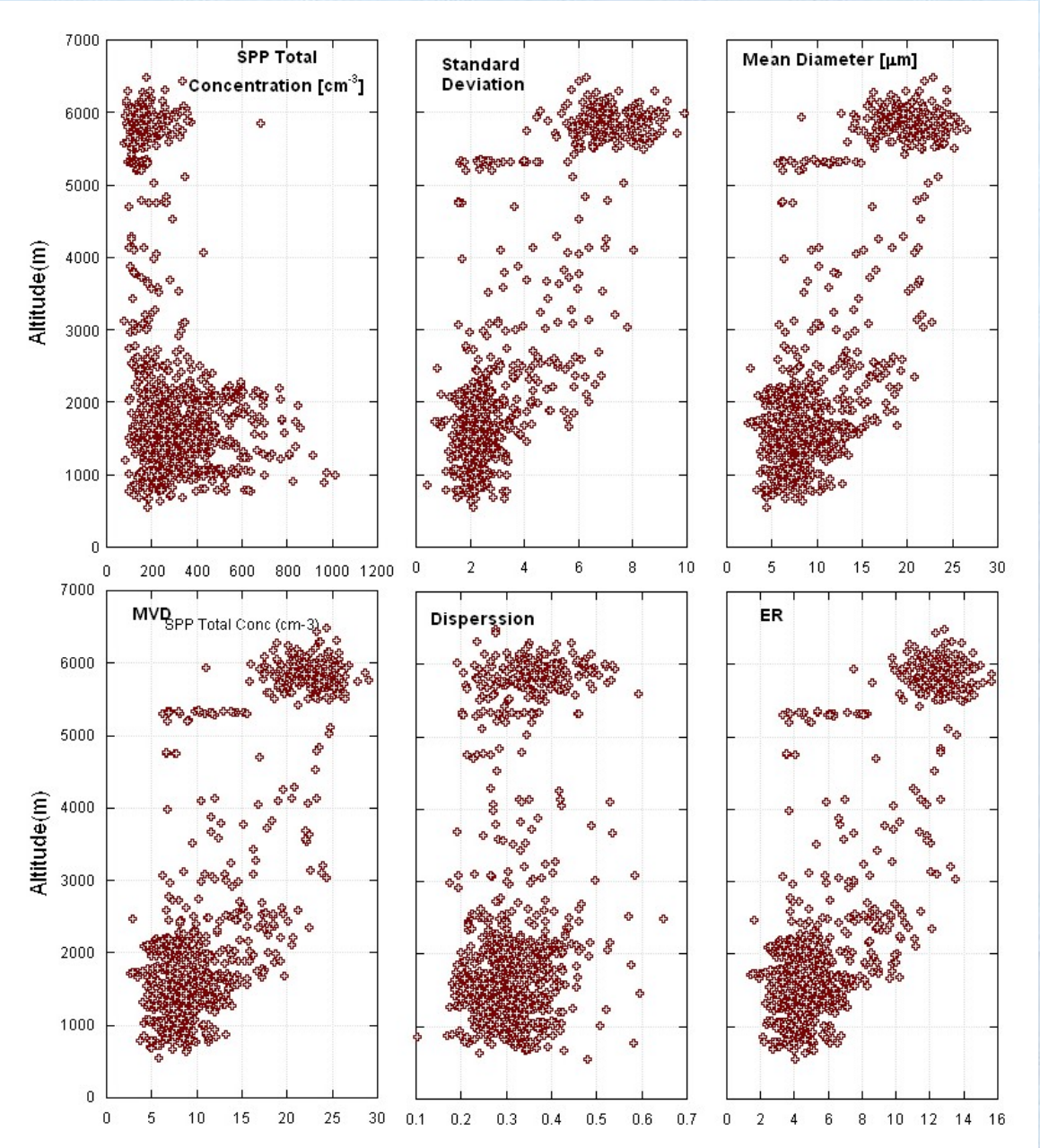
30 August 2006







Cloud parameters



Summary

- Spatial and temporal changes in natural concentration, sizes, and chemical composition of aerosols change microphysical and precipitation processes
- Affects of anthropogenic and active seeding and may widely differ from one situation to the other.
- These effects may mask seeding effects in the evaluation of experiments unless stratified by these conditions
- New tools available to stratify these results

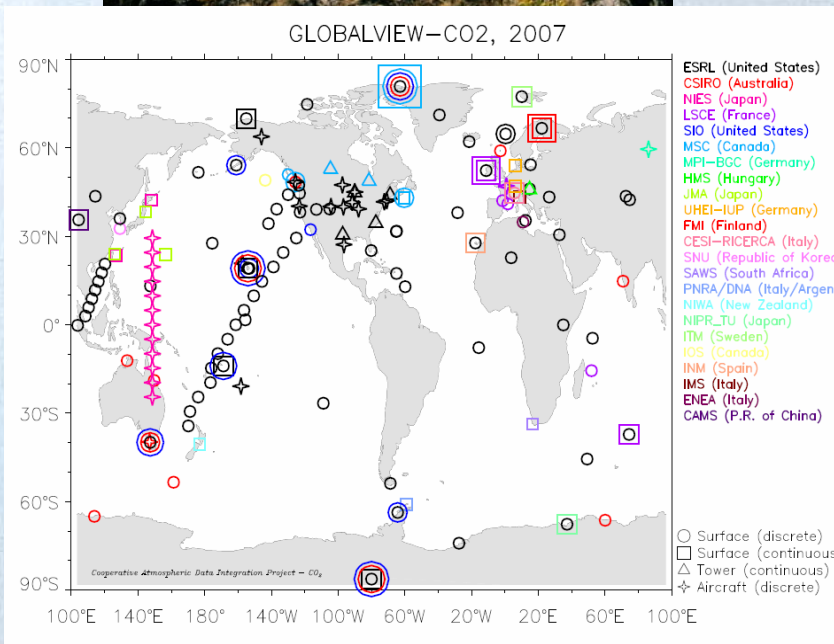
Improving regional-scale CO_2 flux estimates in Africa

Sherri Heck, University of Colorado, sherri.heck@colorado.edu
Britt Stephens, NCAR, stephens@ucar.edu

NCAR

- In cooperation with the University of Colorado, Kenya Meteorological Department and the University of Nairobi, Kenya
- Our CO_2 measurements will help to fill a key gap in available African CO_2 data
- CO_2 concentrations measured atop Mt. Kenya will use the AIRCOA (designed by Britt Stephens)
- Deployment in November 2007
- Estimation of regional-scale CO_2 surface fluxes will be determined using boundary layer techniques and by incorporating concentrations into inverse models
- These estimates can help improve African continental-scale and Indian Ocean fluxes

Mt. Kenya site



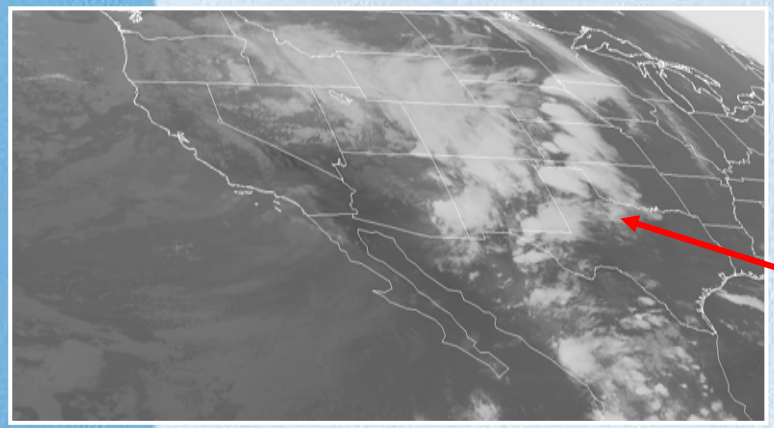
Improving regional-scale CO_2 flux estimates in Africa – Education and Outreach

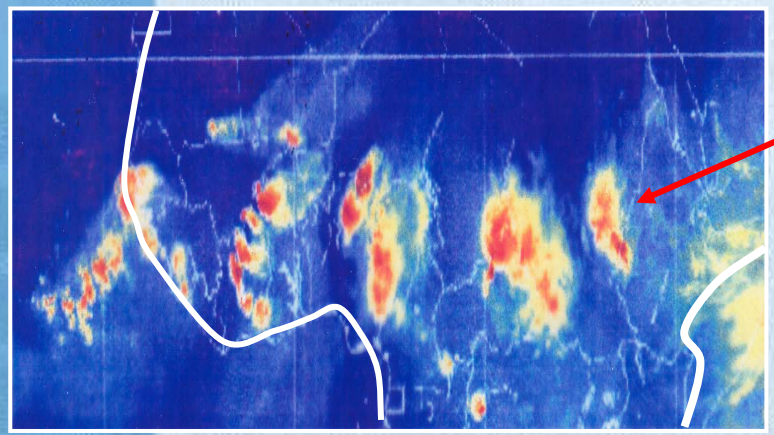
- Incorporating AIRCOA into Kenya Met Department/University of Nairobi Training Institute
- In cooperation with DLESE and Earth Exploration Toolbook, creating curriculum that utilizes CO_2 concentration data
- In conjunction with UCAR E&O and GLOBE, conducting physics and weather-related experiments in local schools and villages

Fine-scale prediction in West Africa

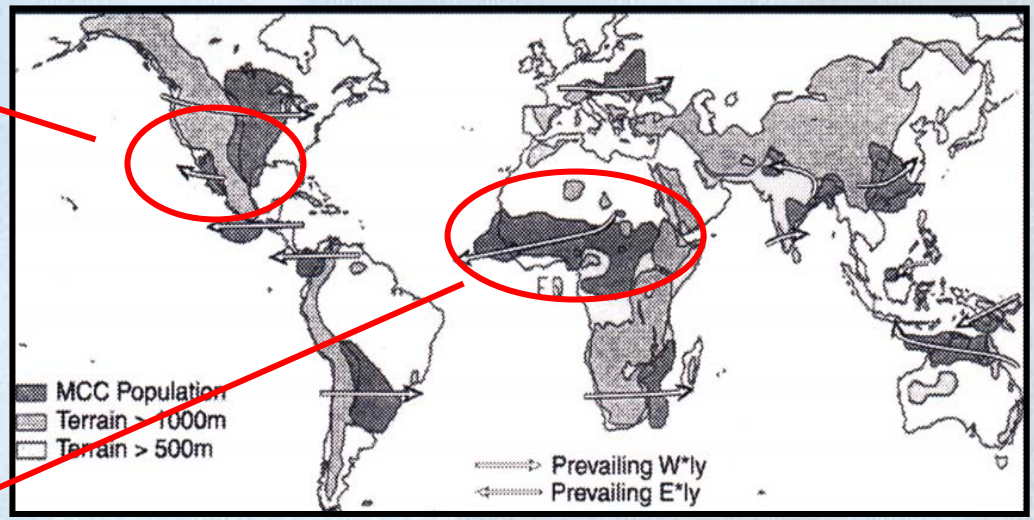
- Step 1: Radar observations, Networking capabilities, and Training in radar interpretation
- Step 2: Develop real-time forecasting and downscaling capacity at NCAR; planning and training in Africa
- Step 3: Regional WRF in Africa

Global context for W. African traveling precipitating systems





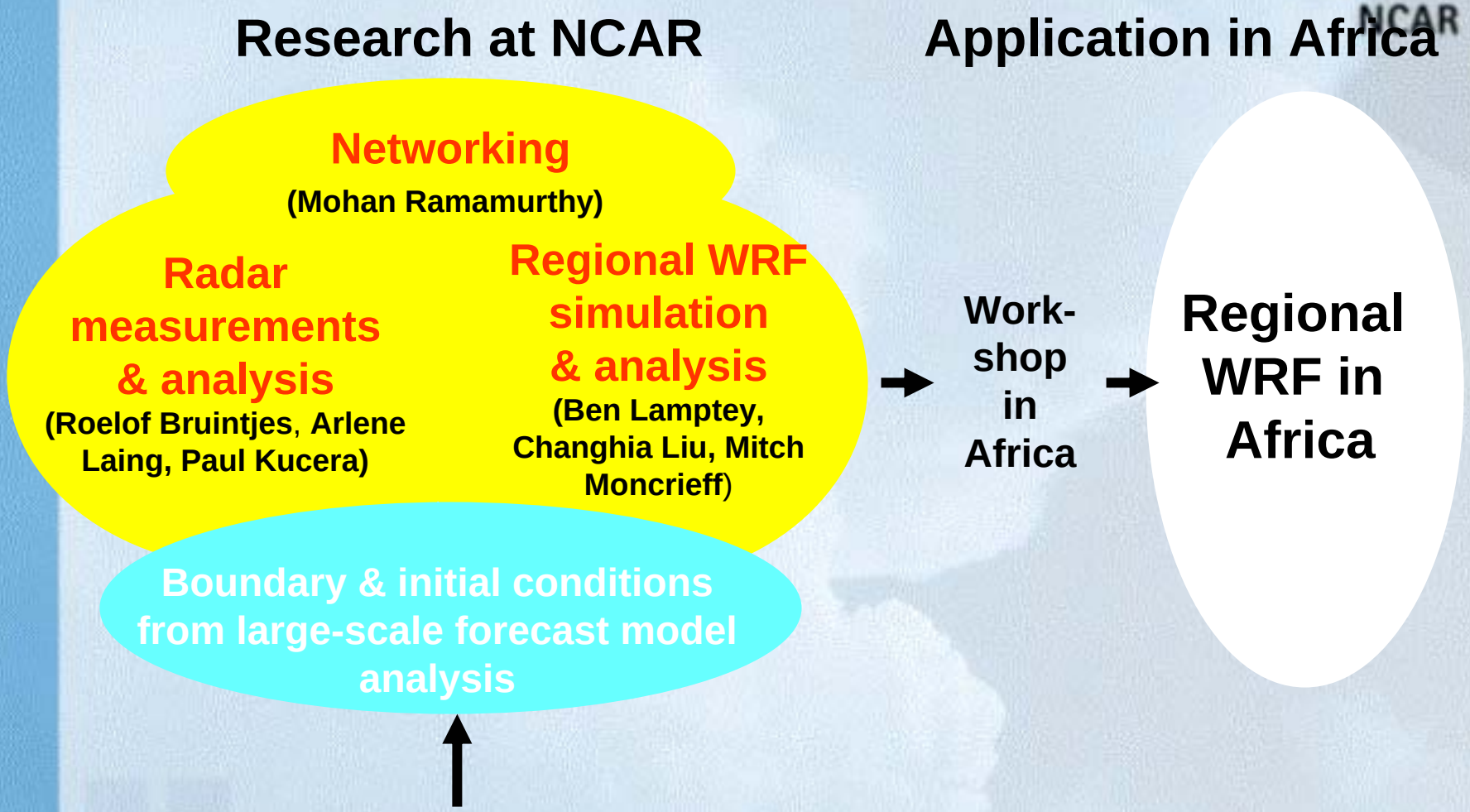
Laing & Fritsch (1997)



Connecting principle: dynamics of orogenic convective systems in sheared environments

(Moncrieff & Liu 2006)

Long-term plan for the African Initiative



Large-scale variability & teleconnection mechanisms

- Tropical easterly waves (~few days; AMMA Water Cycle Working Group)
- Planetary waves (week-2; THORPEX: TIGGE & Predictability & Dynamical Processes)

New integrated approach needed to study effects of aerosols on precipitation patterns

NCAR

- Combined observational, modeling and theoretical approach
- Observations: Surface and in-situ, satellites and multi-parameter radar
- Models: Two-way interactive development of pollution and natural aerosol transport, chemistry, physics, cloud microphysical and precipitation processes
- Theory: Aerosol physics and chemistry and interaction with cloud and precipitation processes.

ISSUE

The world is a complicated place. Take a look outside.

Other partnerships

- National academies
- US-AID
- Gates Foundation
- U.S. State Department

The US National Academies project, the African Science Academy Development Initiative (ASADI), is about to hold its third Annual Meeting in Dakar, Senegal, from November 12-14. The Meeting's theme is Water and Health in Africa and I am attaching the most recent agenda for the meeting. This broad topic is being parsed into themes:

- Access to Water. This includes the provision of water for drinking, sanitation, and hygiene, and includes presentations on the engineering aspects as well as the behavioral and cultural ones.
- Water and Diseases. This session includes talks on infamous water-related diseases such as malaria and diarrhea, and it elevates the topic of water quality and links it with diseases.
- Water-related disasters and catastrophes. This session discusses primarily floods and droughts and takes a specific, case study look at the devastating floods that hit South Africa, Mozambique, and Botswana in 2000.
- Water Resources Management and Governance. Presentations in this session relate to water allocation, uses of water, and ways to govern the administration of water resources at the regional and national levels.

Ouagadougou dust
April 2007

NCAR

Thank you