Operational Forecasting in Africa: Advances, Challenges and Users

Aïda Diongue Niang
Senegal Meteorological Agency
Introduction

- Weather Forecasting is not a purely standardized process,
  It depends on Forecast Range, Region of interest, tools available, forecaster’s experience gained with day to day practice in a weather forecasting service, technical working environment

- However a standard succession of basic tasks can be drawn:
Weather Forecasting: Forcaster’s tasks

- Analysis of the current meteorological situation
- Examination of the Future Evolution of the atmosphere and choice of the most likely scenario
- Description of the evolution of the atmosphere and the expected weather
- Decision on issuing warning in case of severe weather
- Distribution of products to end-users
- Verification

- Observations
- Model analyses one or more Deterministic Models outputs: poor’s man ensemble
- Experience
- Ensemble prediction Systems, single or multi-model
Advances in Op. Weather Forecasting

- Tremendous advances have been achieved in operational Weather Forecasting thanks to:
  1. The development of NWP models, since the first operational numerical model in 1955 (Barotropic Model of Charney)
  2. The deployment of more observing systems and particularly development of satellite remote sense observations.
  3. Cooperation for operational activities coordinated by the World Meteorological Organization
Anomaly correlation of 500hPa height forecasts (ECMWF)

- Northern hemisphere
- Southern hemisphere

Day 3
Day 5
Day 7
Day 10

Year
Cooperation: Schematic view of WMO GTS and GDPFS

- Operational Weather forecasting needs rapid circulation of data in real to near-real-time:
  - Operational data to be made available to NWP centres to construct the initial state
  - Model outputs to be made available to forecasting services to perform operational forecasting or operational limited area modelling
GTS at Regional Level
Advances in Africa

- African National Met. Services have free access to some global model products through Eumetcast (e.g. ECMWF, UK) or Internet (e.g. GFS) to facilitate operational weather forecasting.

- Forecasters’ weather stations for receiving, processing and display (e.g. Messir. Com, MSG, Synergy)

- Regional and local modelling are performed in few NMS to take more account their regional/local characteristics, provide diagnostics needed, for applications (e.g. wave, air quality models)
  - Pioneers: South Africa and then Morroco
  - Less than ten countries running operational weather models
Challenges of Op. Weather Forecasting in Africa

Mainly related to:

- Poor observing network,
- Model performance,
- Gap in modelling and model use,
- Lack of training to catch-up with new tools (e.g GPS, EPS) and to update knowledge (interactions research-operational)
- Technical environment
- Lack of documentation (e.g Forecaster’s handbook) and systematic verification
Challenges in Weather Forecasting: Precipitation

Measures of Forecast Skill
Anomaly Correlation Coefficient
(over European Sector)

ACC for European $Z_{500}$ (top), $\theta_e$ (middle), PRECIP (bottom)

Potential Vorticity
500 hPa Heights
Precipitation

Z$_{500}$ & $\theta_e$ on 25° grid, 24h-PRECIP at SYNOP locations and divided by climatology

ECMWF

M. J. Rodwell
ACC Asian Monsoon Rainfall

ACC for Asian Monsoon $P_{p/c}$

$P_{p/c}$ is 24h precipitation at SYNOP locations and divided by climatology

Monotonic improvement in skill

12UTC deterministic forecasts are used. Approximately 180 SYNOP stations are used each day.
ACC North African Monsoon Rainfall

ACC for North African Monsoon \( P_{p/c} \)

\( P_{p/c} \) is 24h precipitation at SYNOP locations and divided by climatology

**70% Confidence Interval**

Little or no skill

12UTC deterministic forecasts are used. Approximately 20 SYNOP stations are used each day
Trends in 1-SEEPS (larger is better): a skill based on contingency tables and precipitation categories defined by the local climatological probabilities.
Model performance

Low model skill is linked to model errors

• Inaccuracy in the initial conditions used to initialize the forecast due to lack of observations or related to the data assimilation scheme
• Inaccurate representation of physical processes, such as cloud microphysics, convection, surface processes
• “Intrinsic” or residual uncertainty related to dynamical or thermodynamic perturbations on the subgrid-scale

The aim is to limit model errors to intrinsic errors
Challenges related to observing systems to construct initial conditions: surface observations

ECMWF Data Coverage (All obs DA) - Synop-Ship-Metar
20/Jul/2011; 00 UTC
Total number of obs = 31930
Statistics for synop reports
Challenges related to observing systems to construct initial conditions: RS

ECMWF Data Coverage (All obs DA) - Temp
20/Jul/2011; 00 UTC
Total number of obs = 645
Satellite data to overcome lack of in-situ data?

Low-level Humidity over land from Microwave observations

Karbou et al, 2009
Model *background* errors over Africa in NWP and Climate models (JJA)

Met Office, UK
Errors in the boundary layer temperature and Humidity

- Temperature offset consistent with timing
- Temperature gradient weaker in 5 day forecast
- Without sondes boundary layer analysis too moist
- Worse in 5 day forecast
Model errors in “dynamic” fields: AEJ in the framework of JET2000
Limited area model to add value to global model forecasts?
Eta Desktop Weather-Forecast System at Senegal Met. Service

- Automated Run for batch mode access to US NWS global NWP model output for: atmospheric initial conditions, initial soil wetness, snow depth, surface boundary conditions and lbcs

- Automated linkage to a desktop display program (GrADS) to visualize results of forecast with a GUI.

- Webpage to enable model output fields to be exploited outside the Met Service and by neighbouring countries: [http://213.154.77.58/PrevisionNumerique/](http://213.154.77.58/PrevisionNumerique/)
Experimental design

• Daily run from May 1\textsuperscript{st} to October 31\textsuperscript{st} 2006
  • Initialization Base 12 Z
  • Forecast Range 72 h

• Sensitivity studies
  • Controle: Kain-Frtisch scheme (mass flux type with updrafts and downdraughts entrainment and detrainment)
  • BMJ: Betts Miller Janjic scheme (adjustment type scheme with no explicit updraft or downdraft)

Parameters

○ Rainfall:
  
  \textbf{Observation}: Fews 24hr accumulated (mm/day) from 06Z to 06Z
  
  \textbf{Models}: 18hr-42hr lead-time
MJJASO Rainfall

2006 season
Seasonal Sum of Daily Satellite Estimated (FEWS) Rainfall

2006 season
Seasonal Sum of Daily Eta (KF) Forecast Rainfall

2006 season
Seasonal Sum of Daily Satellite Estimated (GPCP) Rainfall

2006 season
Seasonal Sum of Daily GFS Forecast Rainfall

FEWS

10km → 1deg

ETA

20km → 1deg

GPCP

1deg

NCEP

50km → 1deg
From 12N: meridional and zonal variability rather well captured

Eta BMJ:

- Better representation of rainfall north of 20N but with smoothed field
- Overestimation of rainfall even worse
ECMWF data does not represent the precipitation far north.
Lower values in the Sahelian region.
Better job in the Gulf of Guinea.
Monsoon onset on Sahelian region:

Captured by Fews data
Depicted rather well in Eta Model (decoupling)
Less good representation in NCEP GFS
Hovmuller of Daily Rainfall [-10, 10]

Monsoon onset on Sahelian region:

ECMWF: too small values, not far north, decoupling between guinean and soudano-sahelian less obvious
DAILY RAINFALL ANALYSIS DURING 2006: MJJAS and JAS

Networks of stations used to validate the models simulations
• Dots have data in JAS only
• Blue square have data in MJJASO
Moist convection over Mali and Senegal on 02-03 September 2008
1 Day Accumulated Rainfall  09020600-09030600

09020600-09030600
3-hourly TMPA-RT 062002Sep2008-062030Sep2008
Accumulated Rainfall [mm]

09030600-09040600
3-hourly TMPA-RT 062030Sep2008-062045Sep2008
Accumulated Rainfall [mm]

062020September2008 - 062030September2008
24h-Sum of Convective precipitation [kg/m²]

062030September2008 - 062045September2008
24h-Sum of Convective Precipitation [kg/m²]
June 11-12 Case study: test with WRF

- **ECMWF analyses**
  - 1200 UTC: Strong ECMWF Trough at 0°W
  - Convection initiation over Nigeria and Togo early afternoon
  - MCS moving eastward from Togo

- **Configuration with WRFEMS, version 3 COMET**
  - Domain: 0-20°N/15°W-15°E
  - resolution: 14km
  - Initialization: 11 June 00Z with GFS analyses
  - convection (Grell-Devenyi)
Forecast precipitation for 48 hours
24-hr Accumulated rainfall for 11 Juin 2006
Towards nested N-H operational cloud resolving model: Niger Aug, 1992 case
Users

- **Traditional**
  - Aviation
  - Marine activities
  - Agriculture / Water resources
    - Mainly short range to complement seasonal forecast for daily activities and water resources management
    - High demand for Medium range to Intraseasonal

- **Emerging**
  - Health: air quality, water-borne disease, meningitis?
  - Energy

- **Growing**
  - **Civil protection against high-impact weather:**
    - Flooding, dust, high wind, heat waves, marine hazards, etc
    - Need of medium-range and probabilistic forecast from EPS for better preparedness
Natural catastrophes in Africa 1980 – 2009
Number of events

- Climatological events (Extreme temperature, drought, forest fire)
- Hydrological events (Flood, mass movement)
- Meteorological events (Storm)
- Geophysical events (Earthquake, tsunami, volcanic eruption)

MunichRE
From Guillaume Nacoulma,
Lamin Touray,
From Charles Yorke,

700,000 affected persons
60 dead,
40% agriculture land destroyed (source HCR, BENIN government)
Floods in Kilosa, Tanzania, Dec 2009

Camp for Flood Victims

From Franklin Opijah
APRIL 2011 NAMIBIA FLOODING

60 deaths
Over 20,000 people displaced
Millions of dollars of damage to roads, bridges and crop (Government source)
Estimated damage :$620 million, nearly 10 percent of gross domestic product (world Bank source)
SWFDP in Southern Africa

Concept of Cascading Information

Global NWP centres to provide available NWP and EPS products, including in the form of probabilities;

Regional centre interprets information from global centres, Prepare guidance forecasts for NMHSs, run limited-area model to refine products

NMHSs issue alerts and warnings to Disaster Management and public

Courtesy of E. Poolman
Impact of Tropical Cyclone Favio
20-24 Feb 2007

- The model guidance correctly indicated landfall 5 days in advance where, and movement towards Zimbabwe
- Both Mozambique and Zimbabwe’s NMCs issued warnings 5 days in advance to disaster management departments

Following the success of SWFDP in Southern Africa
Another SWFDP have been initiated for East Africa. Further EPS products are being developed and tested in the framework of THORPEX/TIGGE.

Courtesy of E. Poolman
Thanks for your attention