Improving Weather Forecasts in West Africa Using WRF Model

Ibrah Seidou Sanda| Diane M. Laourou | Agossou Gadedjisso-Tossou | Mandela C. M. Houngnibo | Abdou Ali |

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CGIAR | AICCRA
Accelerating Impacts of CGIAR Climate Research for Africa

Key messages

- Enhancing the quality of weather forecasts in Africa is crucial for mitigating the risks associated with potential life and property losses;
- Accurate impact assessment and informed decision-making depend on locally produced weather forecasts and tailored products from global and regional climate centers, such as AGRHYMET Regional Center;
- The Weather Research and Forecasting Model (WRF), a widely utilized model globally, has demonstrated its effectiveness in providing weather forecasts;
- AGRHYMET has set up a WRF model specifically tailored for weather forecasts over West Africa and the Sahel region. This info note presents preliminary outputs from this model, reflecting ongoing testing efforts;
- To maximize the effectiveness of the WRF model in the region, ongoing efforts are needed to conduct further investigations and enhance the capacity of the model used by AGRHYMET. Continued research and development will contribute to refining the accuracy and reliability of weather forecasts for West Africa and the Sahel region.

Background

The lack of weather and climate information at appropriate scales is one of the major obstacles to disaster risk reduction in West Africa. The AGRHYMET Regional Climate Center for West Africa and its partners have undertaken to implement projects aimed at filling these gaps. It has equipped itself with the technical infrastructure and established the necessary expertise to produce Numerical Weather Prediction (NWP) with the Weather Research and Forecasting Model (WRF) model to provide NMHSs with information and tailored products for their operational activities.

Since 2021, AGRHYMET has been equipped with a high-performance computing facility and has started implementing the WRF model to make short and medium-range forecasts. Thus, there is a need to assess the accuracy of the outputs that have been obtained so far to facilitate the improvement of the whole WRF modeling process at AGRHYMET. In this info note, we have explored the methodology used to assess WRF outputs at AGRHYMET and presented some preliminary results.

Methodological Approach

The WRF model is set up to run four times per day at 12 km resolution over the entire West Africa, with GFS 0.25 boundary condition as indicated in Table 1 below.

Table 1. Daily WRF model initialization time and run

Cycle (Initialisation time)	Forecast length
00 h	240 h (10 days)
06 h	48 h
12 h	48 h
18 h	48 h

The WRF model is also set up to run in hindcast mode with a 16-members ensemble with different parameterizations. The rainfall of each member is evaluated against Satellite Rainfall estimates (CHIRPS) with the Model Evaluation Tools (MET). For now, only a limited subset of these hindcasts have been produced. They are not sufficient enough to

draw robust conclusions on the best parametrization for West Africa. The diagram below summarizes the different subsequent steps from model setup to WRF model output evaluation (Figure 1).

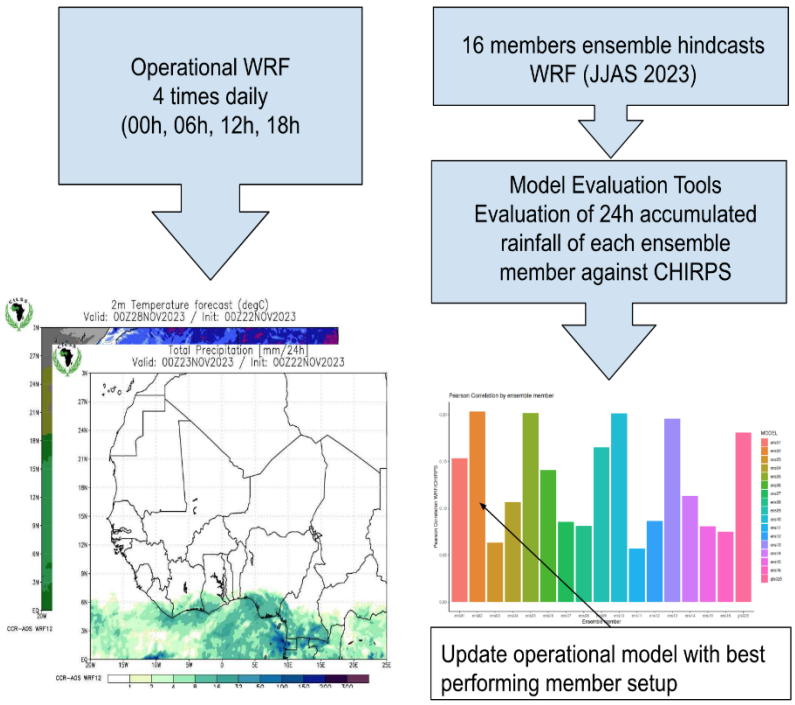

Figure 1. Workflow of the WRF modeling and evaluation process

Applications: Case study of West Africa and the Sahel (preliminary results)

The evaluation of the model against satellite rainfall estimates is still ongoing. As part of the capacity building, AGRHYMET has hosted staff of NMHS for short-term on-the-job training at its premises in Niamey on different thematics. From June to September 2023, AGRHYMET hosted Diane M. Laourou, a staff of Benin Meteo for on-the-job training on WRF modeling and Evaluation using Model Evaluation Tools (MET).

Figure 2 shows that WRF generally detects rain events but tends to overestimate them locally compared to observations. The rainfall forecasted over Senegal has not been observed. Conversely, observed rainfalls over the southern part of Chad have been missed by this configuration of the WRF model.

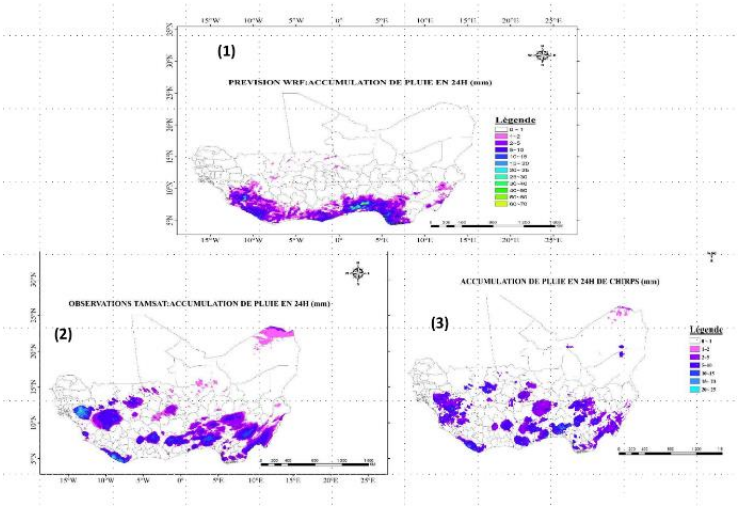

Figure 2. Total precipitation in 24 hours: (left) WRF forecast valid for 27/05/2023 at 06:00 UTC; (right) CHIRPS estimation for 26/05/2023.

The evaluation of the operational WRF model against precipitation observations collected from the GTS has been initiated. Sample preliminary results of the WRF outputs evaluation are presented in Figure 3 below.

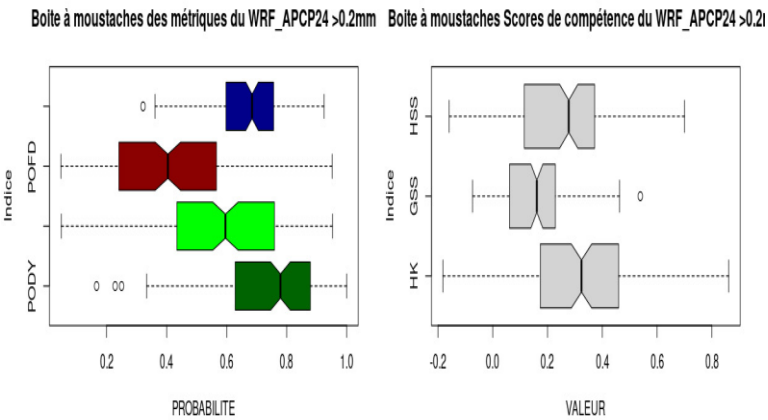

Figure 3. Boxplot of Hit Rate (deep green), Non-Event Ratio (light green), False Alarm Ratio (red), and Accuracy (blue), and three skill scores (Kuipers, Hanssen, Gilbert) of the WRF model vs Synoptic weather stations for detection of rainfall events (24-hour cumulative rain > 0.2 mm).

The model has better performance in forecasting low amounts of precipitation (Figure 4, left). This is because the forecasts deviate from the observations as the

quantities of rainfall increase. None of the extreme events that occurred at the Bamako, Cotonou, or Korhogo stations were predicted by the WRF (Figure 4, right).

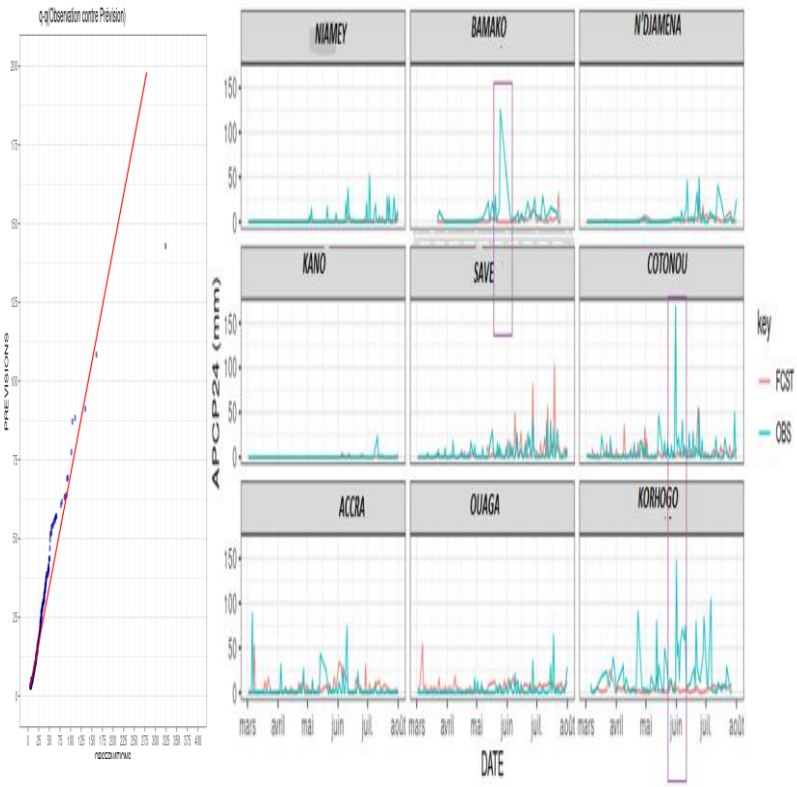

Figure 4. WRF evaluation results

Challenges, lessons learned, and perspectives

This exercise of evaluating the WRF model outputs has allowed us to constitute the observation database needed for that purpose. It also allowed us to get acquainted with the Model Evaluation tool (MET). The results obtained concern only a small sample of the output forecasts. The way forward of this work is to continue the evaluation focusing on several variables (precipitation, temperature, wind gusts, probabilistic forecasts) on the scale of a month and a season for robust conclusions. The main challenges encountered are the maintenance and the sustainability of the costly infrastructure of the HPC on which the model is run and where the outputs are stored.

References

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Accelerating Impacts of CGIAR Climate Research for Africa (AICCRA) is a project that helps deliver a climate-smart African future driven by science and innovation in agriculture. It is led by the Alliance of Bioversity International and CIAT and supported by a grant from the International Development Association (IDA) of the World Bank. Explore our work at **aiccra.cgiar.org**