P4.9 VERIFICATION OF NCEP ETA MODEL OVER EAST AND WEST AFRICA

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1. NCEP WORKSTATION ETA MODEL

The present paper is part of an ongoing and continual effort of documenting the verification of the Eta model forecast precipitation for all the regions of Africa and find ways to improve the forecasts through better data assimilation and improvements to the model physical processes including the convection parameterization. NCEP Workstation Eta model (NWEM) at Climate Prediction Center has been implemented initially in 2003 as part of monitoring short-term weather over Africa and later has been extended to cover other parts of the world including central America, Afghanistan and south Asia. Though the model has been operationally in existence since February 2003, starting with the forecasts for southern Africa, its stable performance has started only with the east Africa season of March-April-May 2003. Because of this and due to the limited amount of the available forecast data, southern Africa could not be included in our present forecast verification studies. However, it will be included in the future with the forthcoming season from November 2003 through March 2004. Before describing the methodology of forecast verification, a brief introduction to the model implementation at the Climate Prediction Center is given in the following paragraphs.

The present operational version of the workstation Eta model (Mesinger 1984) at CPC has a vertical resolution with 38 levels with a pressure level spacing of 25hpa from the surface to the top model atmospheric level of 25hpa and the convection parameterization scheme is that of Betts-Miller-Janjic (Betts, A.K., and M.J. Miller, 1986), though the choice is ad hoc and has no particular known advantage over the other well known convection parameterization scheme, namely, Kain-Fritsch (Kain, J. S., and J. M. Fritsch, 1990) for the east and west African domains. To avoid the complexity associated with the multiple compilations and the resulting executables, the model computational grid dimensions are kept constant for all the African domains. The forecast length has been chosen to be at least 72 hours and resolutions are chosen to optimize end user requirements and the computational resources and the desired quality of the forecast output. Another consideration in choosing the domain window is that the domain should be sufficiently large to allow the Eta model to capture smaller scale details that cannot be done by the coarser global model and yet the domain be small enough not to veer too much away from the general, large-scale features captured by the governing global model, which provides the Eta model with the initial and boundary conditions

Based on these considerations the following domains and resolutions have been implemented. For east Africa, the chosen model domain is 8°S-22°N, 9°E-58°E. For west Africa the model domain is chosen as 5°S-22°N, 24°W-21°E. The grid resolution is 0.154 degree in longitude and 0.141 degrees in latitude which approximately translates to a 22km horizontal grid. The time step required by the stability criterion for this resolution is set to 60 seconds as per NCEP guidelines. The input data for the model are derived from the NCEP-GFS 1-degree resolution, 3-hourly forecast data. This data is used to create the necessary initial and boundary conditions for the model runs. Surface input data include 4-minute land-sea mask, high resolution SST and other time-dependent fields such as vegetation, albedo and snow cover. The forecast output is stored at 6 hour intervals up to the forecast length of 72 hours. A post processor has been used to map the forecast output data from the native Eta grid to the latlon grid for use by the graphics package. A sample of operational forecast product involving the daily comparison of 24hr and 48hr forecast precipitation with CPC/FEWS-Net satellite precipitation estimates and GTS station precipitation analysis is shown in Figure 1.

2. MODEL VERIFICATION

The CPC generates daily global precipitation and temperature files for over 7000 world-wide locations using METAR and synoptic data. METAR (hourly data) and synoptic (6-hourly data with 3-hourly data used to

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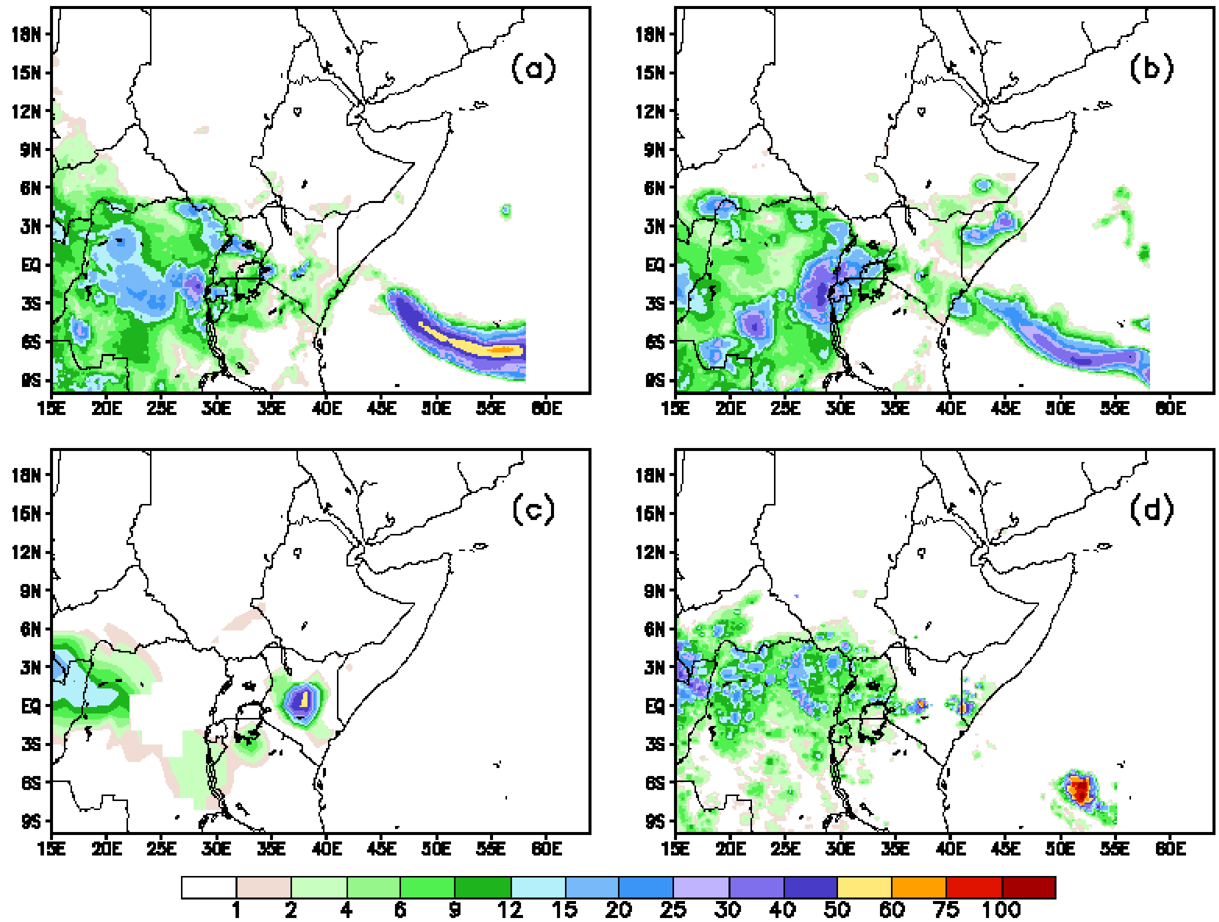

Figure 1. Comparison of 30hr and 54hr Forecast 24hr Accumulated Precipitation with the CPC 24hr Satellite Rainfall Estimates and analyzed GTS precipitation for 23-Oct-2003. (a) 24hr precipitation accumulation as 30hr forecast valid at 6Z 23-Oct-2003, (b) 24hr precipitation accumulation as 54hr forecast valid at 6Z 23-Oct-2003, (c) GTS reported 24hr precipitation accumulation ending at 6Z 23-Oct-2003, (d) CPC/RFE 24hr accumulated precipitation valid at 6Z 23-Oct-2003.

fill gaps) observations are collected both manually and through automated observing systems, then transmitted via the Global Telecommunications System (GTS) to NCEP in Camp Springs, MD. At the time of the analysis the west Africa forecast data period was not complete and the data was not processed. For this reason, only the results related to east Africa domain will be discussed in this paper.

To quantify the performance of the Workstation Eta Model, approximately 400 GTS surface stations over the East African domain (longitude - 9E-58E; latitude - 20N-10S) were selected for validation purposes. However, many of these stations are unreliable and incorrectly label missing values as zero rainfall, so it is necessary to only use stations that report daily rainfall. To resolve this quality control issue, for this research only the GTS stations that reported greater than 0 mm will be used in the comparisons. After each station was selected as having reported non-zero rainfall for the previous 24-hour period, the site is co-located by latitude and longitude to the nearest grid box of each Eta Model. This type of comparison is necessary because unfortunately, it is nearly impossible to construct a precipitation analysis due to the unreliability and coarse spatial resolution of the gauge data (1 gauge per 23000 sq. km) and lack of other useful remote sensors such as ground-based radar. In this point-to-grid box comparison, the stations are assumed to be “ground truth” for the forecast Eta validation. Each of the three forecast hours were compared to the station data and the corresponding daily biases are calculated. Figures 2 and 3 show the mean bias (GTS station data minus Eta forecast) and standard deviation of the mean difference, respectively.

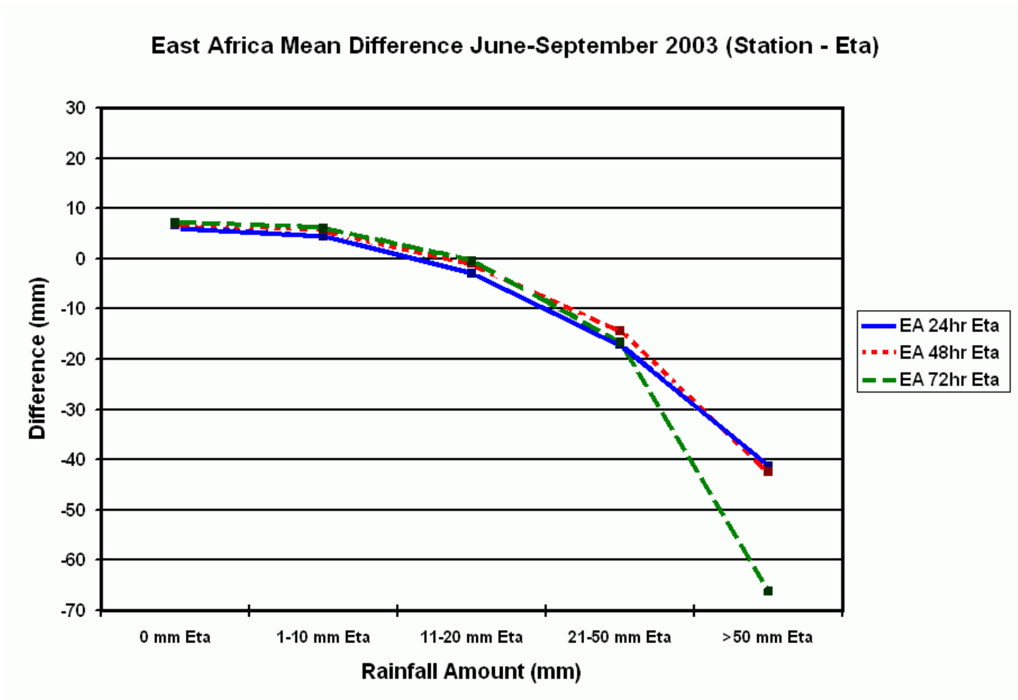

Figure 2. Mean difference of the 24, 48, and 72-hour forecast for the Workstation Eta Model over East Africa. The rain amounts (x-axis) represent the categorical amount of precipitation estimated by the Eta Model.

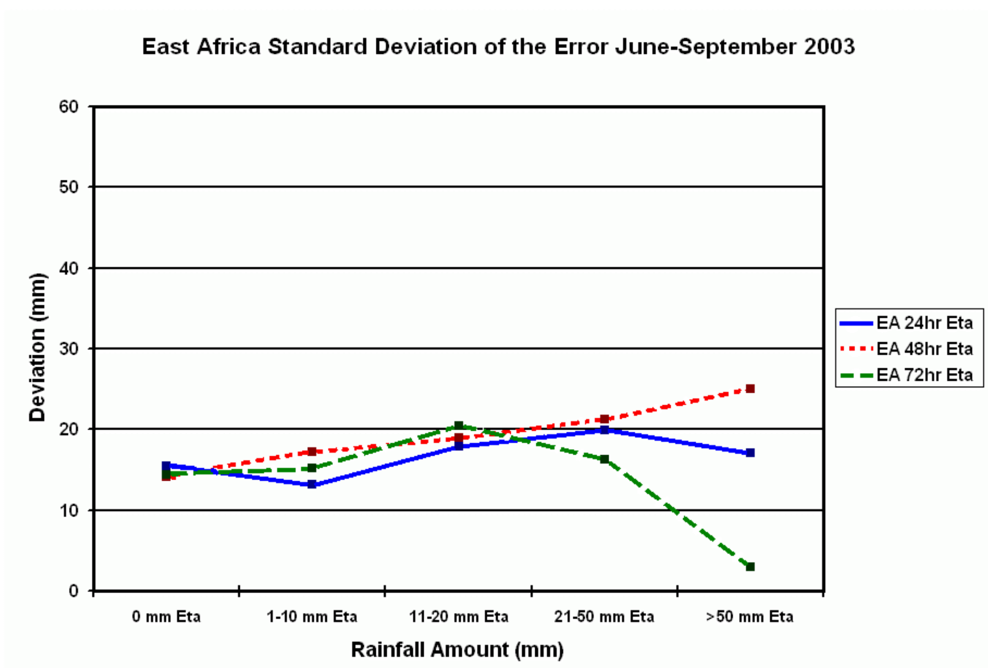

Figure 3. Similar to Figure 2, but showing the standard deviation of the mean difference.

The forecast products are compared from June through September 2003. Before June, the Workstation Eta Model experienced several major upgrades. The x-axis of both figures represents successive intervals in the amount of forecasted rainfall by the model. This was done to better determine the performance of the forecast data across the range of anticipated precipitation amounts.

The mean bias of the 24-hour forecast is represented by the blue (solid) line in Figure 2. The bias is around +8 mm (underestimate of the forecast) when the model predicts 0 mm of rainfall. A slight underestimate is shown for the two other forecast times within this same category (48-hour forecast, red short-dash; 72-hour, green long-dash), which is expected considering that for quality control purposes, all stations that contained a 0 mm report is removed from the GTS data set. As the Eta model forecast precipitation amounts increase (1-10 mm) all three forecast times continue to slightly underforecast (+4 to +5 mm) when compared to reported rainfall. This trend continues as the forecast rainfall amount increases. The 24, 48, and 72 hour forecasts show a mean bias of about 0 mm when the products forecast rainfall amounts between 11 and 20 mm. However, when the forecast amounts increase to between 21 and 50 mm, each time begins to overforecast to around -15 to -17 mm. When the Eta forecasts precipitation at amounts greater than 50 mm, all three forecasts, again, show a negative bias in rainfall. The 24 and 48 hour forecasts show the best performance (overestimate by -40 mm) when compared to the 72-hour (-68 mm). However, for this category the number of GTS station points is significantly lower than for lighter categories. It is interesting to note that for categories before the >50 mm bin, the three forecast times show very consistent biases as forecast time length increases.

Figure 3 represents the standard deviation of the mean bias. This was calculated to show the fluctuations of the differences between each forecast time period and the GTS station data. All three times show similar trends as the estimated rainfall amounts increase. Deviation amounts are not meaningful for the 0 mm because of the station quality control used. The standard deviation for the 24-hour forecast is slightly better (13 mm) than the 48 and 72 hour (18 and 16 mm, respectively) when the Eta model predicts rain amounts from 1-10 mm, and this trend continues in the 11-20 mm bin. Interestingly in the 21-50 mm category, the 72-hour forecast shows the least deviation (17 mm), while the deviations for the 24 and 48 hour forecasts increase slightly from earlier binned amounts. The trends increase to around a 25 mm deviation for the 48-hour forecast and somewhat lower (18 mm) for the 24-hour forecast. An even lower deviation (3 mm) is noted for forecast rainfall that is estimated by the model to be above 50 mm.

3. FUTURE VERIFICATION STUDIES

The present study is far from conclusive, due to lack of sufficient number of stations reporting precipitation in the areas of pre selected bin ranges. As an alternative satellite rainfall estimates for the African regions could be used to overcome this deficiency. Visiting scientists from Africa at the African Desk of the Climate Prediction Center would be encouraged to do some of the verification studies as they better understand their regional climatology. Also, efforts are underway to incorporate modern methodologies and incorporation of more number of relatively reliable stations which are not part of the GTS station network. On the other hand, the findings from the future verification studies could be used as a feedback for model developers to improve various physical parameterization schemes of the Eta model.

4. REFERENCES

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