An Evaluation of Met Office Unified Model forecasts of Orographic Rainfall over Sub-Saharan North Africa with Observational Data

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Introduction

Prediction of rainfall in Sub-Saharan North Africa is important for both regional agriculture and its influence on the global energy budget. Numerical weather prediction in North Africa is known to have rainfall biases which lead to an unrealistic view of soil moisture and total precipitation during the summer (Le Barbe, Lebel and Tapsoba 2002). Large orographic regions in the region are thought trigger mesoscale convective systems and have a significant impact on the monsoon rains (Semazzi and Sun 1997).

The study aims to highlight differences in rainfall predicted by the NWP version of the Met Office Unified Model and observed by the Tropical Rainfall Measuring Mission (TRMM) satellite.
We expect the model to predict the onset and peak rainfall too early in the day, predict too much light rainfall and miss major rainfall events.

Figure 1 shows the regions of interest for the study. There is a spread of different climatic regions from costal to desert. Niamey is used as a control region.

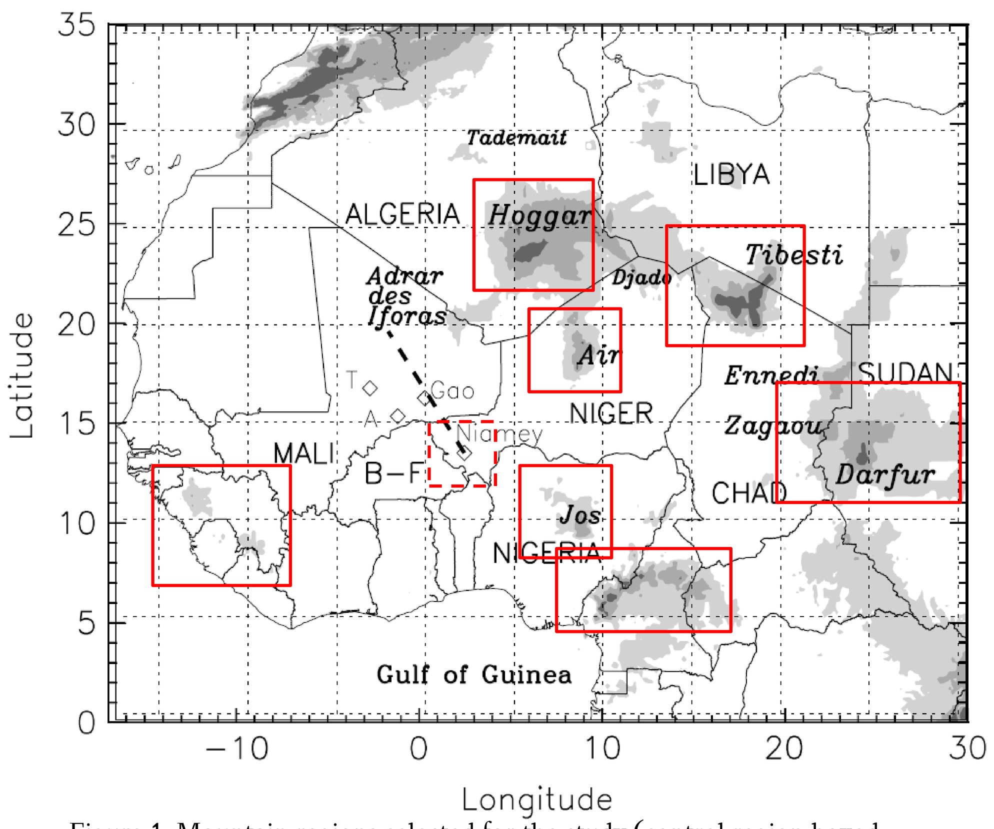
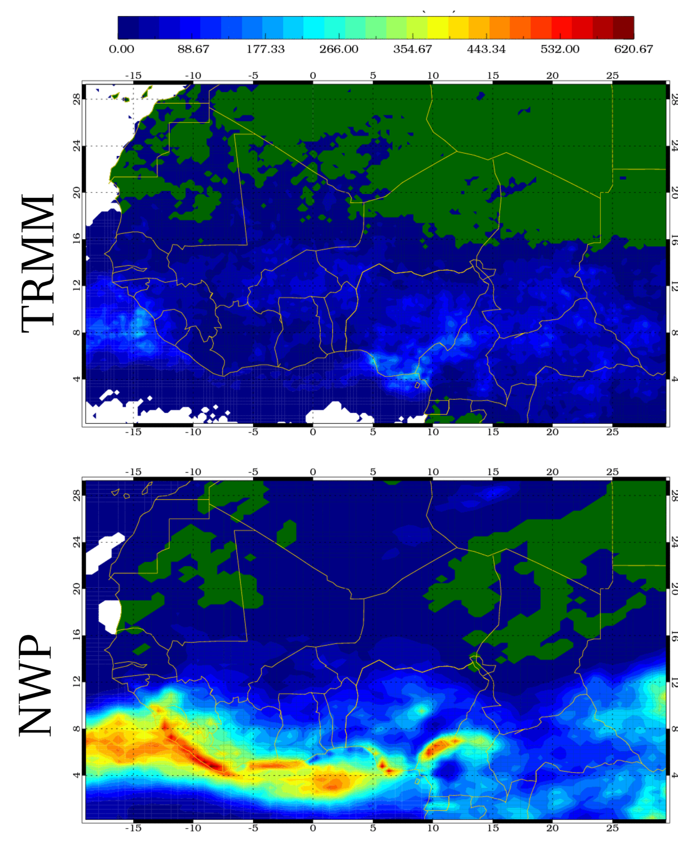


Figure 1. Mountain regions selected for the study (control region boxed with dashed lines). Courtesy of C. Birch, a modified version of Figure 1 in Flamant *et al.* (2007)

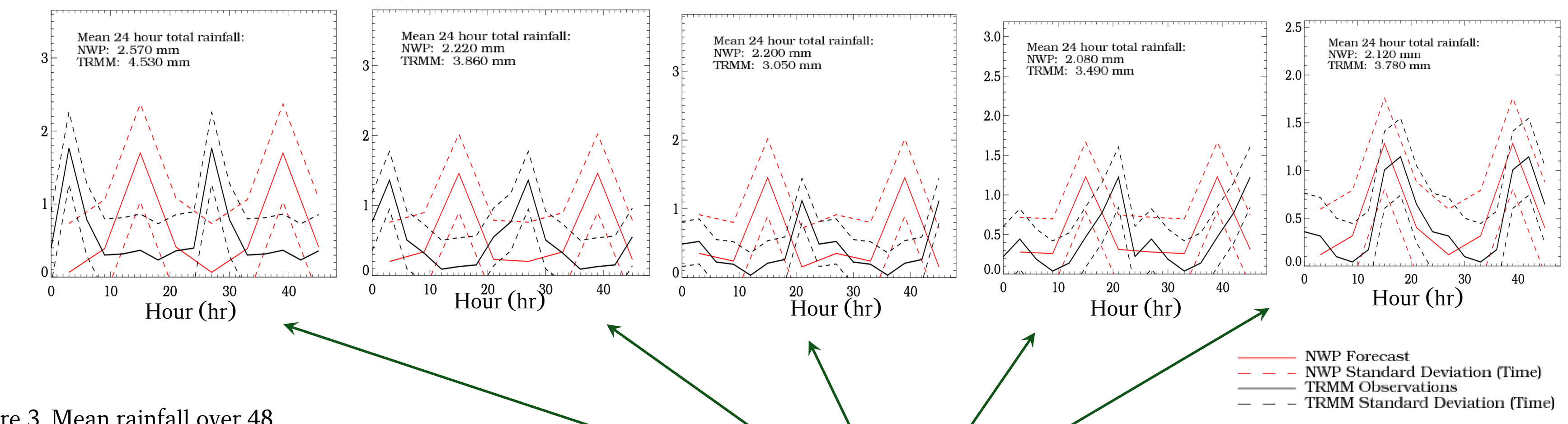


Mean rainfall for June 2006

Figure 2. Mean rainfall over the study area for June 2006. TRMM on top, NWP on bottom.

Time of peak rainfall:

TRMM	03:00	03:00	21:00	21:00	18:00
NWP	15:00	15:00	15:00	15:00	15:00



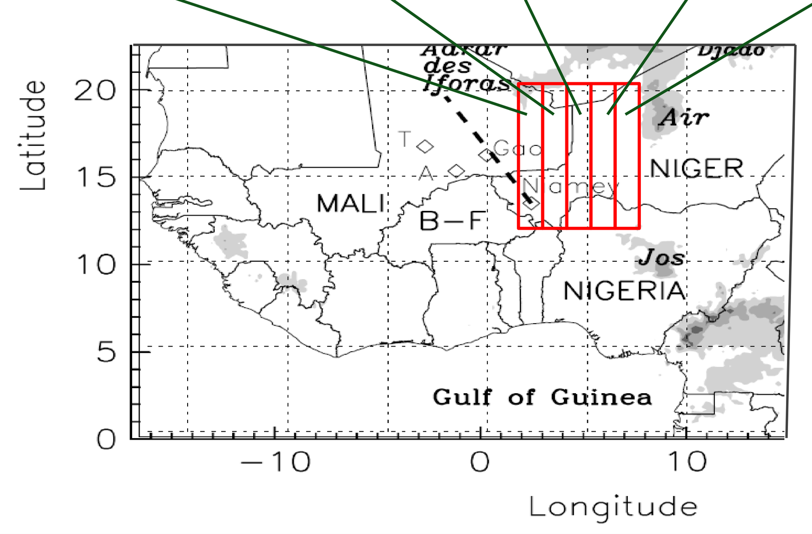


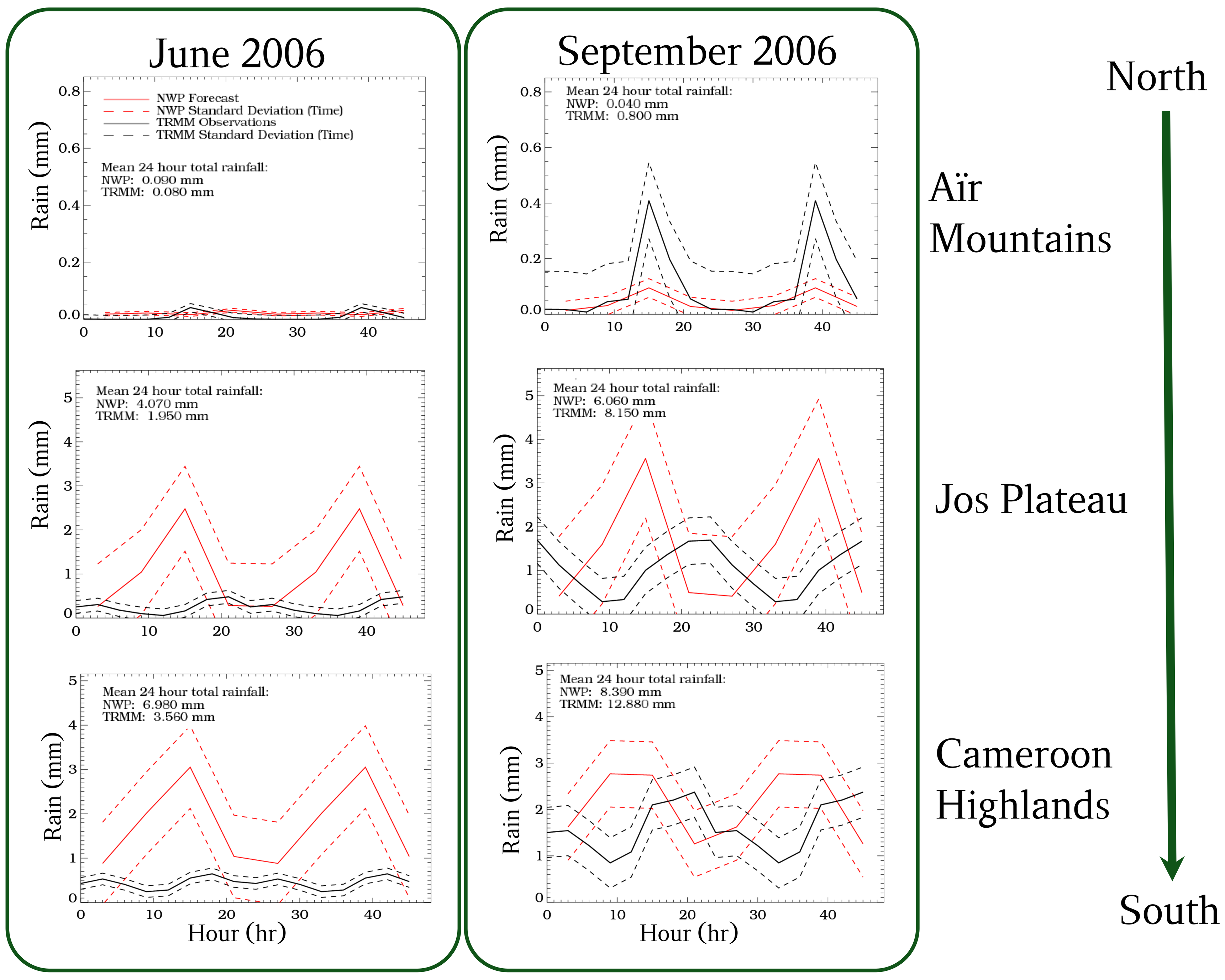
Figure 3. Mean rainfall over 48 hours in August 2006. Weather systems propagate from east to west. TRMM shows the peak rainfall getting later in the day (until it reaches early morning).

Figure 4 (right). Mean rainfall over 48 hours for Aïr Mountains (top), Jos Plateau (middle) and Cameroon Highlands (bottom) for early monsoon (June) and late monsoon (September)

Results - Propagation

Figure 2 shows the mean rainfall over the region in June 2006, NWP over predicts the intensity in the coastal regions by about a factor of five. Both TRMM and NWP show an increased amount of rainfall over the Cameroon Highlands. This is a typical situation for the study period (2006-2011, March-September).

Propagation of convective systems triggered by mountains, travelling east to west can be clearly seen in *figure 3*. The peak rainfall detected by TRMM starts at around 18:00 just past the Aïr Mountains and gets later in the day as you travel west, until a peak at 03:00 is detected near Niamey. NWP has the same peak rainfall time throughout the region (around 3 pm).



Results – Different Climates

There is distinct North/South variability in the region for both the monsoon onset and the end of the monsoon. The Aïr mountains do not receive as much rainfall as the other regions, as they are well into the Sahel region. NWP accurately predicts virtually no rainfall in June but does not predict the increase towards the end of the monsoon.

For June in both the Jos and Cameroon region, NWP over-predicts the rainfall by around a factor eight. The peak of the NWP rainfall is also too early, around 3pm, compared to the TRMM peak which is around 8pm. The later monsoon diurnal cycle for Jos shows NWP is still over predicting, although not by as much.

Both Cameroon TRMM rainfall graphs show evidence of a twin peak, possibly due to a sea breeze, as described by Duvel (1989). This is not captured by the NWP, although NWP does predicts similar amounts of rainfall in August, although the peak of rainfall is out of sync.

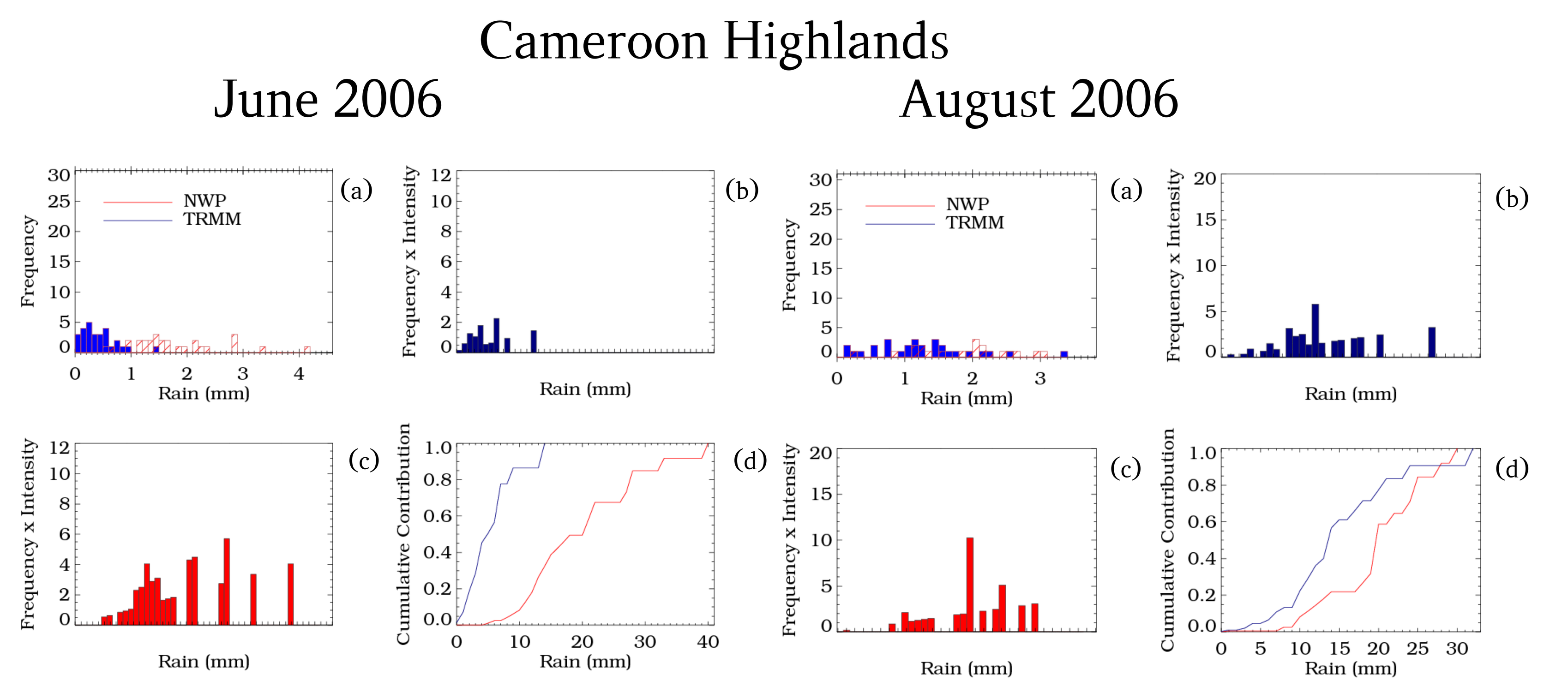


Figure 5. Histogram of daily rainfall (a), contribution of rainfall events for TRMM (b) and NWP (c) and the cumulative contribution (d)

Results – Distribution

Figure 5 shows the spread of rainfall events in the Cameroon Highlands in 2006 from their frequency (a), relative intensity (b) and (c), and their cumulative contribution (d). NWP over predicts the amount of large rainfall events in June, possibly predicting the monsoon earlier than reality where as the distribution is fairly even for August, well into the monsoon season; although NWP still gets most of the months rainfall from intense events, unlike TRMM, which detects a spread from lighter to heavier events.

Summary

Unlike we expected, NWP over predicts the total rainfall due to predicting large events that do not occur. A moving rainfall peak in the diurnal cycle is captured by TRMM but is not represented by NWP as a convective systems moves from east to west, from the Aïr mountains to Niamey.

References

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