Forecasting Heavy Rainfall Using a High-Resolution Regional Model Over West Africa for Operational Application.

Eniola A. Olaniyan, Carlo Cafaro, Imoleayo E. Gbode, Juliane Schwendike, Kamoru A. Lawal

Background/Introduction

The frequency of flash floods resulting from heavy rainfall, over west Africa, is increasing with serious socio-economic consequences.
The need for a reliable weather forecasts from numerical weather prediction(NWP) models, specifically for heavy rainfall, is also rising in many meteorological operational centres in West Africa. Therefore,
For six different High Impact Weather (HIW) from 2015 to 2020, this study investigates across West-Africa;
•Major atmospheric dynamics in operational practice.
•Their individual and collective teleconnection in modulating areas of heavy rainfall
Also, it assesses
•the performance of COSMO-Model in predicting areas of heavy rainfall and
•the associated atmospheric dynamics with the aim of reducing the model's inherent biases as a deterministic model.

Model.

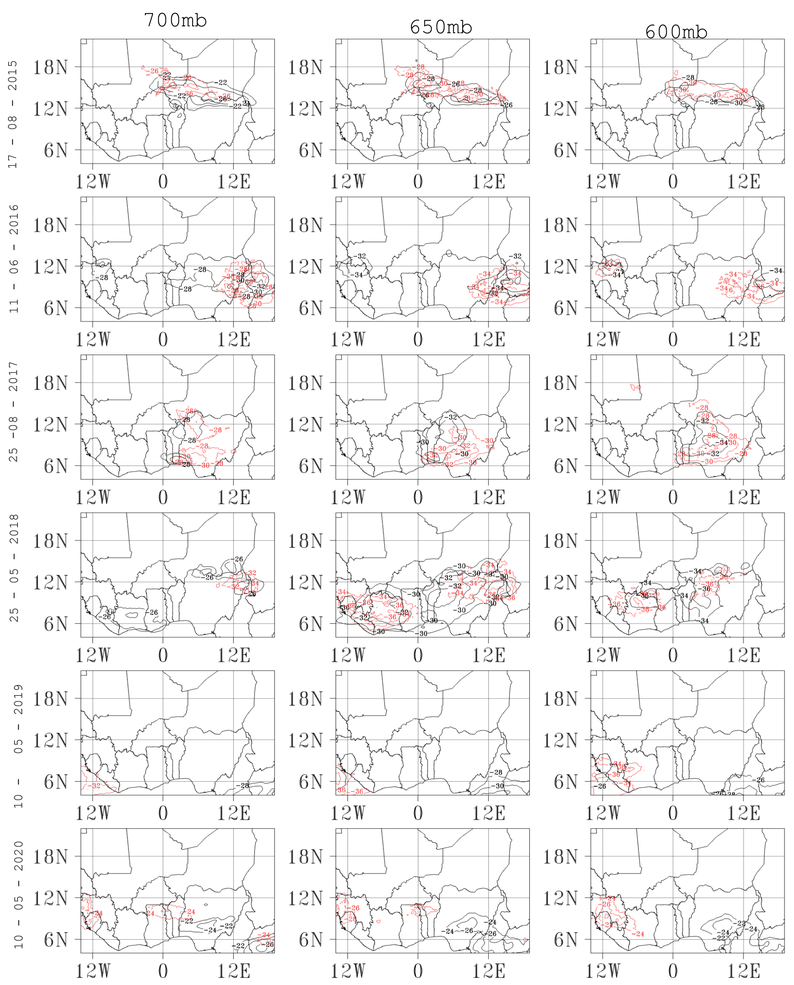
COSMO-Model grid size of 529 X 305 grid points at 7 km res. Drive by ICON daily . Simulated hr = 60 Tstep = 3hours.

Data.

1. Satellite derived observed daily rainfall data from the Integrated Multi-satellite Retrieval for Global Precipitation Measurement (GPM-IMERG).
2. Uwind, Vwind(700, 650, 600mb), CAPE , PMSL from ECMWF Era-5, and
3. COSMO-FCT data

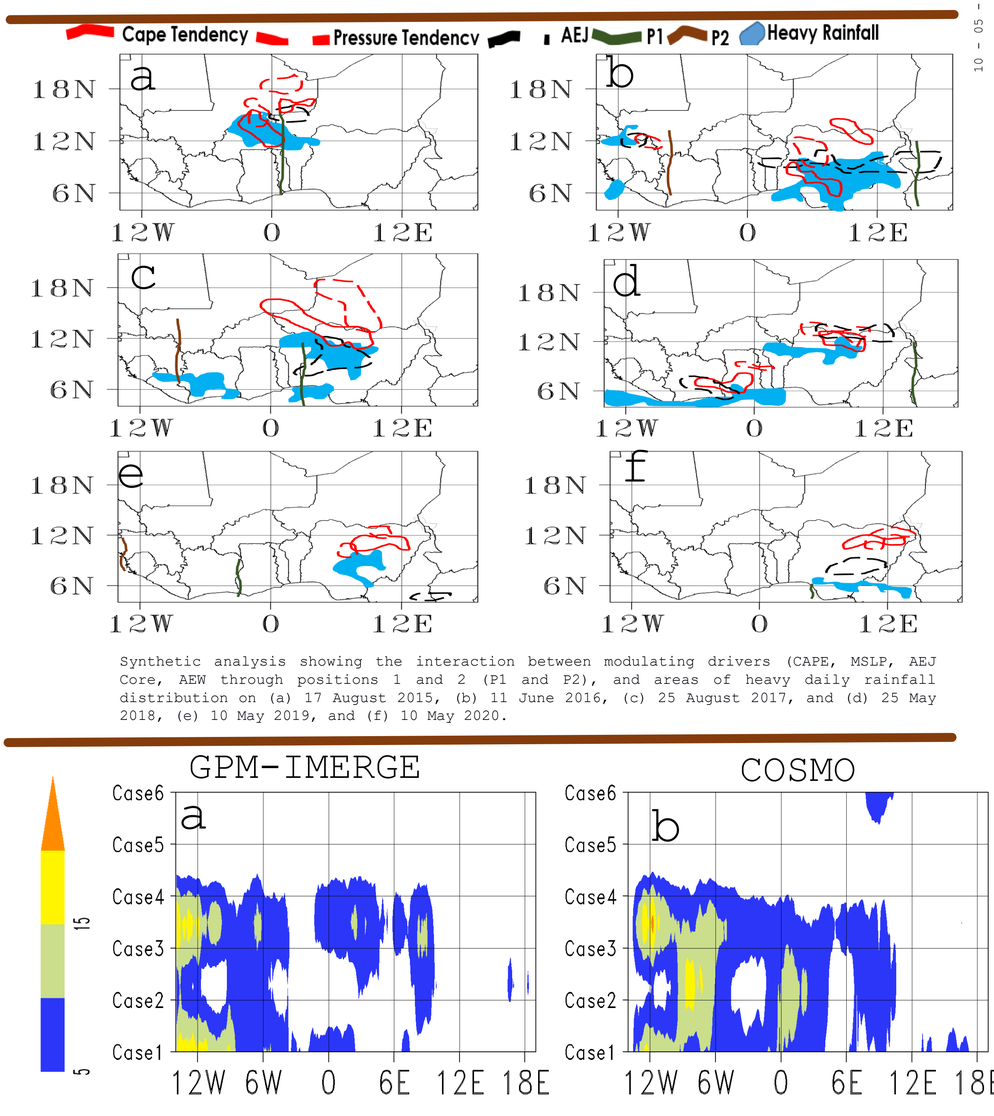
Methods

Daily rainfall accumulation, Daily CAPE tendency , and Pressure tendency. Zonal wind is used to determine AEJ position and meridonal is use to determine AEW position.
A Threshold of 30mm is used as heavy rainfall. It coincides with the 95th percentile of the rainfall distribution.
Linear-Correlation, Phase Composite, Bias, Contingency and, Fractions Skill Score(FSS; using 10th, 25th, 50th, 75th, and 90th percentile) are the statistical metrics used.

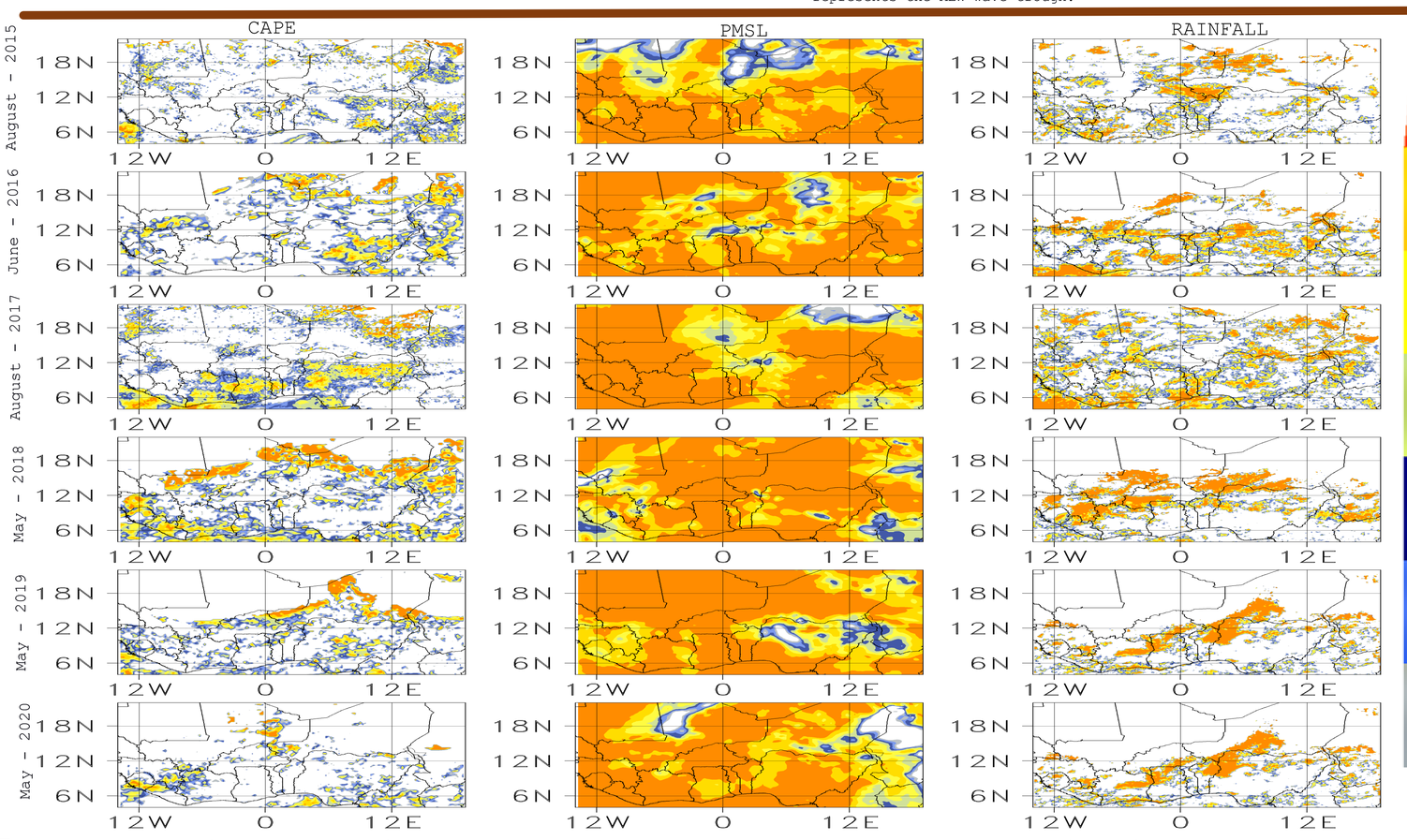


Spatial position of the AEJ core (zonal wind, knots) at 700, 650, and 600mb levels based on ERA-5 in black contour and from daily simulation of COSMO-Model in red contour.

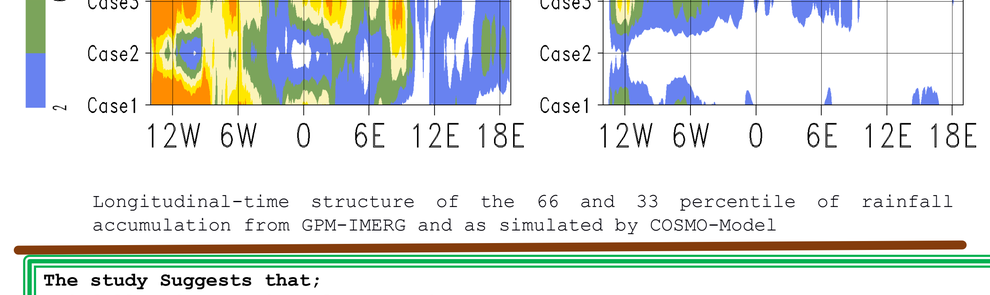
Longitudinal-time structure of 700-hPa AEW based on ERA-5, and as simulated daily by COSMO. The green coloured lines are 0.0 knots that represents the AEW wave trough.



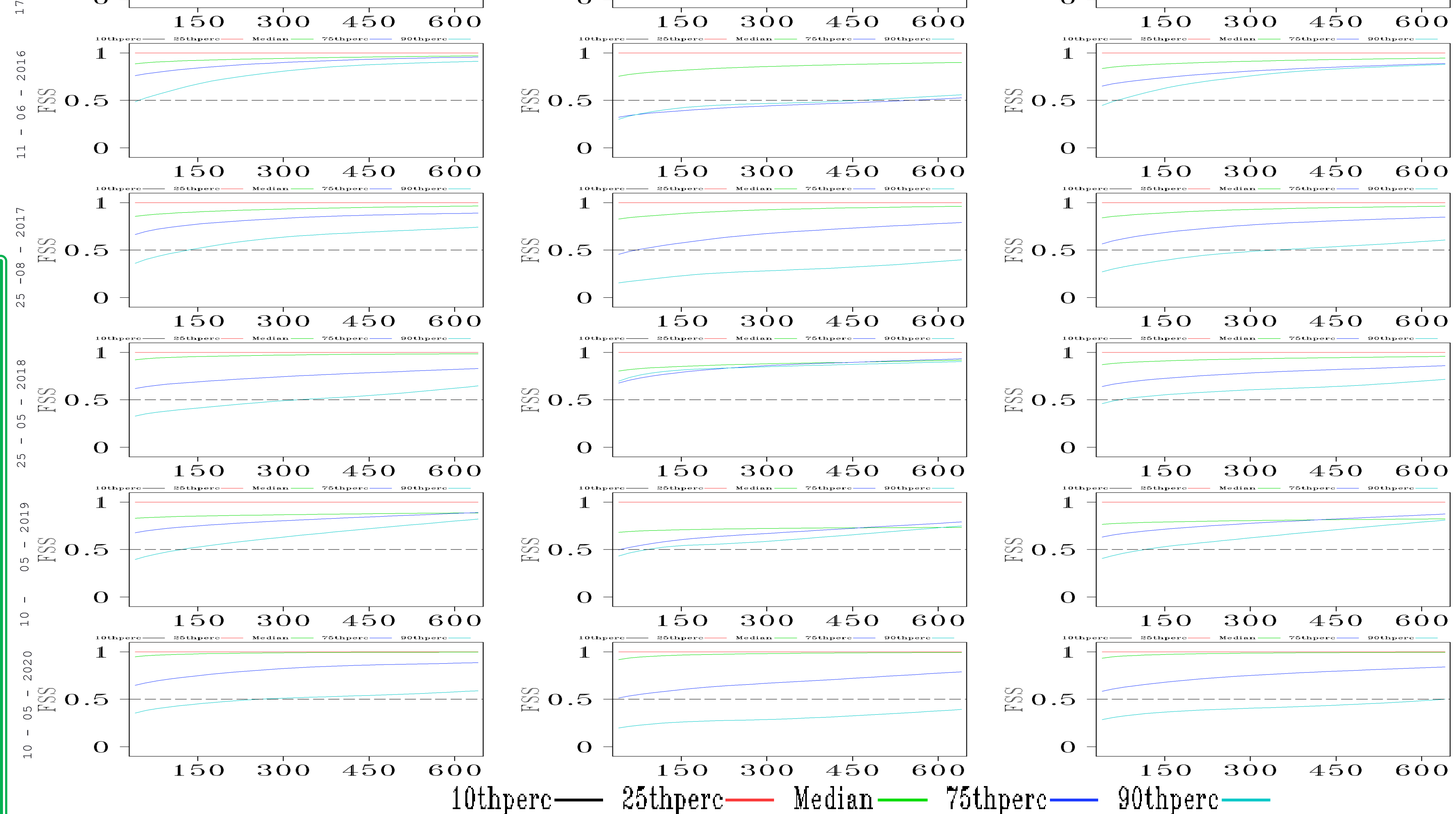
Synthetic analysis showing the interaction between modulating drivers (CAPE, MSLP, AEJ Core, AEW through positions 1 and 2 (P1 and P2), and areas of heavy daily rainfall distribution on (a) 17 August 2015, (b) 11 June 2016, (c) 25 August 2017, and (d) 25 May 2018, (e) 10 May 2019, and (f) 10 May 2020.



Map showing the correlation between COSMO and ERA-5 CAPE, ERA-5 MSLP, and GPM-IMERG daily rainfall accumulation from 17 to 22 August 2015, 11 to 16 June 2016, 21 to 27 August 2017, 22 to 26 May 2018, 7 to 12 May 2019 (m – o), and 5 to 10 May 2020.



Longitudinal-time structure of the 66 and 33 percentile of rainfall accumulation from GPM-IMERG and as simulated by COSMO-Model



The fractions skill score (FSS) based on the 10 (black line), 25th (red line), 50th (green line) 75th (blue line), and 90th (cyan line) percentile, over East of Meridian, the West of Meridian, and West Africa on 17 to 22 August 2015, 11 to 16 June 2016, 21 to 27 August 2017, 22 to 26 May 2018, 7 to 12 May 2019, and 5 to 10 May 2020.

The study Suggests that;

Rainfall and Synoptic Teleconnection

1. all modulating rainfall dynamics move in concert but ahead of the AEW trough.
2. The position of other drivers considered ahead of the AEW trough are sequential in order of pressure, CAPE and AEJ.
3. areas of heavy rainfall are often associated with areas where falling pressure coincides rising CAPE.
4. They are often found south of the AEJ core (entrance, exit or direct) ahead of the AEW trough that precedes it.
5. while areas of heavy rainfall east of the prime meridian are mostly associated with combined interaction of most atmospheric dynamics.
6. The AEW trough appears to be a distinct atmospheric dynamic associated with areas of heavy rainfall west of the prime meridian.

In assessing the model's skill in simulating rainfall and modulating drivers.

COSMO-Model exhibits distinct characteristics in West-Africa

1. Although skill decreases as rainfall tends to be heavy (30mm and above), COSMO adequately simulates the spatio-temporal variability of rainfall distribution over West Africa, albeit with inherent biases.
2. Despite the spatio-temporal biases, the model have a correlation skill greater than 0.5 in most places.
3. COSMO can reproduce the atmospheric dynamics modulating daily rainfall variability with a few kilometer spatial lag, in addition to capturing the daily propagation of the AEW trough and the core of the AEJ.
4. While the model correlation skill in predicting CAPE is good and consistent over Nigeria, it explicitly predicts the spatio-temporal evolution of the MSLP and the Pressure tendency with correlation skill greater than 0.85 in most places.
5. As the neighbourhood size increases there is a significant improvement in both the forecast fraction and the fractions skill score (FSS).

Implications/Conclusion

The reproducibility skill of the model in predicting atmospheric dynamics may not transform into the predictive skill of the model in producing rainfall. Nevertheless,

1. Operational forecasters may be able to determine likely areas of heavy rainfall by estimating the position of the AEJ core based on the position of areas of the least falling pressure from COSMO.
2. The incorporation of the fractions skill score metric based on the neighbourhood approach could also assist operational forecasters to decide at which scale a severe weather alert can be issued.

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