Understanding the Onset and Demise of the West African Summer Monsoon

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Abstract

The West African Summer Monsoon (WASM), its onset, demise, and seasonal total rainfall has considerable societal and economic importance for West Africa (WA). It has significant impact on agriculture, which contributes to a large amount of the region's gross domestic product. Hence, the ability to anticipate the seasonal total rainfall of WASM could be extremely useful. In this study, we aim to estimate the onset, demise, seasonal length, and seasonal rainfall for 20 WASM seasons by using 20-year high-resolution Integrated Multi-satellitE Retrievals for Global Precipitation Mission version 6 (IMERG) rainfall data. This study found that an earlier onset date foretells a long WASM and above normal seasonal total rainfall, and a preceding or developing El Niño event may lead to a below normal WASM.

Data and Methodology

Data used

- 20-year (2001-2020) 10-km resolution IMERG (3.5 months latency) daily rainfall data used to obtain four features of WASM such as onset, demise, seasonal length, and seasonal total rainfall.
- Oceanic Niño Index (ONI) data from Climate Prediction Center (CPC) used to find the El Niño–Southern Oscillation - WASM rainfall relationship.

Methodology

- Estimated daily cumulative rainfall anomaly using;

$$P'_n(k) = \sum_{m=1}^{k} \left[P_n(m) - \overline{\overline{P}} \right]$$

$P_n(m)$ – area averaged daily rainfall for day m of year n averaged over terrestrial WA

$\overline{\overline{P}}$ – is the corresponding annual mean climatology of the rainfall.

- Minimum (maximum) of $P'_n(k)$ is considered as the onset (demise) of WASM.
- Days (cumulative rainfall) from onset to demise is the seasonal length (total rainfall).
- Pearson's correlation coefficient (CC) were used to estimate the CCs.

Results

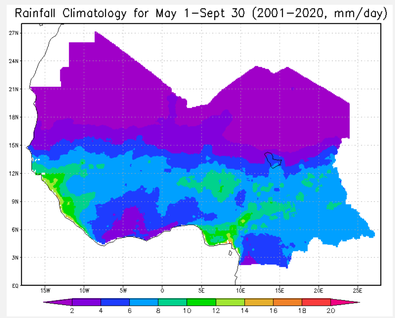

Figure 1: 20-year (2001-2020) May – September mean rainfall (mm/day) climatology over West Africa (WA).

- Maximum rainfall rainfall areas are located between 3°N and 10°N.

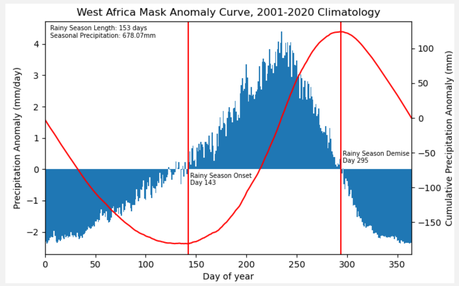

Figure 2: 20-year climatology daily rainfall anomalies (blue shades), cumulative anomaly curve (red curve), and onset and demise (red lines).

- Climatological onset (demise) date is 23 May (22 October).
- Climatological seasonal length (seasonal total rainfall) is 153 days (678.07 mm).

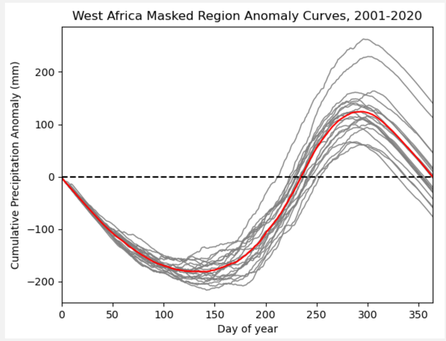

Figure 3. Cumulative rainfall anomaly curve for each year (2001-2020). 20-year climatology is shown in red color.

- Interannual variability of WASM demise dates are less than the onset dates.

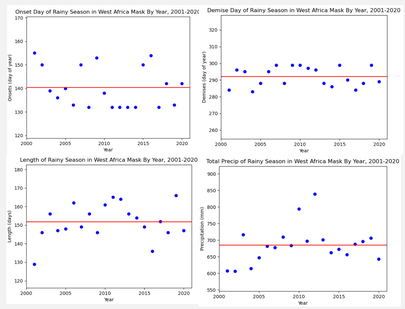

Figure 4: Scatter of WASM onset, demise, season length, and total seasonal rainfall. The standard deviation for onset (demise) is 8.4 (5.7) days.

	Onset Date	Demise Date	Season Length	Total Rainfall
Onset Date	1			
Demise Date	0.17	1		
Season Length	**-0.79**	**0.46**	1	
Total Rainfall	**-0.46**	**0.44**	**0.68**	1

Table 1: Correlation coefficients between the four features of WASM from 20-year data.

- Early onset leads to long WASM season and result in above normal seasonal total rainfall.

Results

Table 2: Correlation coefficients between ONI index for given season and WASM metrics.

Niño 3.4	Onset Date	Demise Date	Season Length	Total Rainfall
Dec-Feb	**0.32**	0.14	-0.22	**-0.33**
Jun-Sep	0.20	0.10	-0.12	-0.26
May-Oct	0.21	0.11	-0.12	-0.27

- There is a significant negative correlation between the Dec-Feb ONI and WASM onset and total rainfall.

Conclusion

- Climatological onset date, demise date, seasonal length and seasonal total rainfall are 23 May, 22 October, 153 days and 678.07 mm.
- Early onset of WASM onset result in longer season, above normal seasonal total rainfall
- Dec-Feb ONI has negative correlation to WASM onset and seasonal total rainfall.

Future Considerations

- Extend this analysis by using CPC rainfall data and CRU rainfall data for the longer time period and larger sample size.
- Use methodology in state-of-the-art climate models to obtain the projected future changes.

References

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