Analysis of TRMM-identified Extreme Precipitation Systems in Africa: Storm Characteristics and Contributions to the Total Rainfall

Alexandria C. Gingrey, Manuel D. Zuluaga, Kristen L. Rasmussen, and Robert A. Houze Jr.

★ *Department of Atmospheric Sciences, University of Washington, Seattle, WA* ★

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Motivation & Background

- The African Easterly Jet (AEJ) is a product of the temperature and moisture gradients between the Sahara and the Gulf of Guinea.
- Synoptic disturbances in the form of African Easterly Waves (AEW) modulate heavy precipitation and deep convection across the Sahel region, in the Northern Hemisphere summer (Fortune 1980).

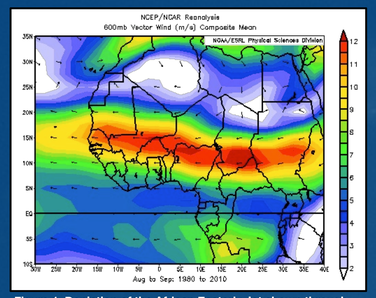

Figure 1. Depiction of the African Easterly Jet shown through averaged vector wind composite from 1980-2010 (NCEP/NCAR)

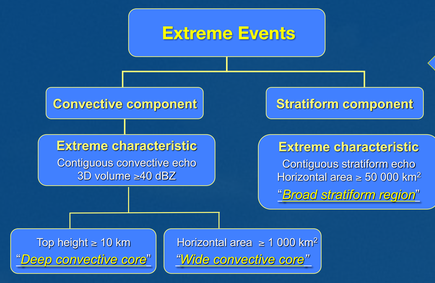

Figure 2. UW methodology used to separate TRMM Precipitation Radar (PR) echoes into different storm types (Houze et al. 2007)

Classification Technique

Extreme echoes were characterized in to four differing event types: *Deep Convective Core (DCC), Deep Wide Convective Core (DWCC)*, Wide Convective Core (WCC), and Broad Stratiform Region (BSR)*

*Deep-Wide Convective Cores are classified as events that share both DCC and WCC characteristics

Characteristics of Extreme Events

	West Sahel	Central Sahel	East Sahel
DCC	0.194	0.453	0.336
DWCC	0.093	0.219	0.099
WCC	0.681	1.017	0.431
BSR	0.097	0.109	0.037

Table 1. Annual frequency ratio of extreme echoes to the total amount of rainfall events displayed as a percentage

- The occurrence of extreme echo events is quite rare
- *Wide convective cores* are the most frequent, making up ~ 1% of the total raining events in the Central Sahel

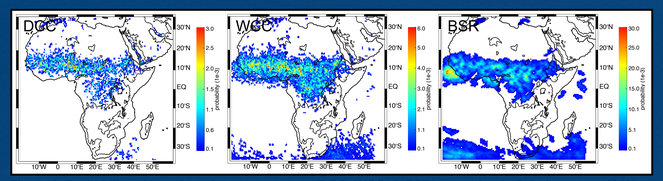

Figure 3. Probability of location of extreme events (DCC, WCC, & BSR) occurring in Sahel summer (JJA), derived from TRMM PR data (Zuluaga & Houze 2014)

Event evolution:

- Lifecycle of mesoscale convective systems (MCSs) is approximated through TRMM-identified storms
- *Deep* and *wide convective cores* initiate along the Sahel band within AEW troughs
- Some convective elements decay and develop into *broad stratiform regions*
- Increased core frequency and intensity near additional sources of moisture (i.e. Central Sahel region and Tropical Rainforest)

TRMM Precipitation Bias

- Our goal is to understand the rainfall from extreme convective storms globally
- TRMM PR rainfall algorithm underestimates precipitation from deep convection over land (Iguchi et al. 2009)
- To mitigate this bias we used a traditional Z-R method for calculating rainfall totals (Rasmussen et al. 2013)

Climatological Rainfall Contribution

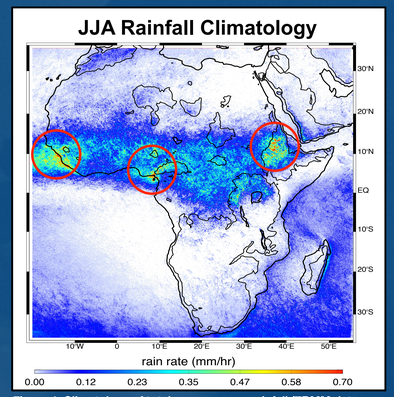

Figure 4. Climatology of total warm season rainfall (TRMM data 1999-2012)

- A quantitative approach is employed to investigate the role of the most extreme precipitating systems on the hydrological cycle in Africa
- Hotspots of total precipitation present near water bodies (Red Sea and Atlantic Ocean) may indicate sea breeze and monsoonal influences in enhanced precipitation rates
- Bulk of warm season rainfall located along AEJ, just south of the ITCZ locale for the Northern Hemisphere summer

- Sahel region receives majority of warm season precipitation
- Clear AEW/AEJ influence on extreme storm intensity and location
- Significant dominance of *wide convective* events in frequency and rain contribution

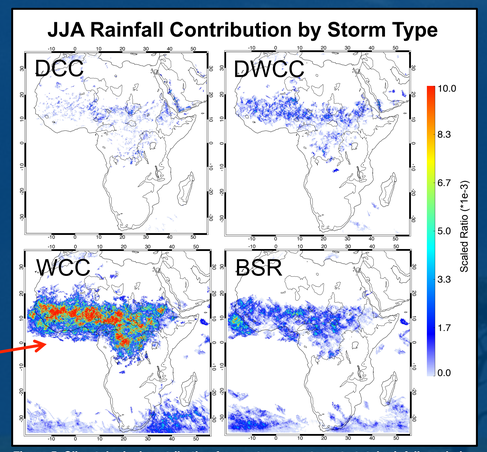

Figure 5. Climatological contribution from extreme systems to total rainfall, scaled by the TRMM-pixel count (TRMM data from 1999-2012)

★ *Wide convective cores* dominate the frequency and rain contribution of extreme events ★

- In the Sahel band, *deep convective* storms provide the largest rain contribution in the East Sahel as a product of direct topographical forcing
- Accumulated contribution from extreme echo rainfall maximizes in the Central Sahel
- *Wide convective* events maintain strongest influence in all regions

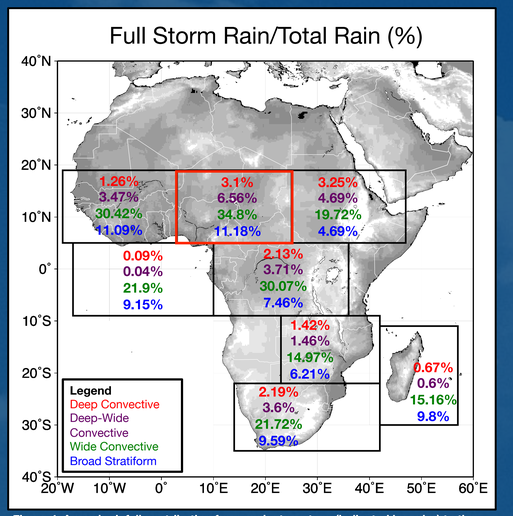

Figure 4. Annual rainfall contribution from each storm type (indicated by color) to the total precipitation in each region, expressed as a percentage. This calculation used the precipitation total from the full system in which the identified cores were imbedded.

For the Central Sahel (red region):

→Contribution of convective precipitation to the total annual rainfall: ~45%

→Including BSR precipitation, all extreme echo types contribute ~56% of the total annual rainfall in the Central Sahel

Conclusions

- Extreme echoes are dependent on warm season and AEJ/AEW influence for formation and intensification
- *Wide convective cores* are the most frequent and contribute the most rainfall of the four extreme categories
- The occurrence of TRMM-identified extreme storms accounts for < 2% of the total raining systems, yet they contribute significantly to the total precipitation
- Extreme echoes have prominent precipitation contribution in the African Sahel → ~ 45-55% of the total rain in the West Sahel and Central Sahel regions

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