Variability of African Easterly Waves and their relationship with Atlantic Tropical Cyclones

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Variability of African Easterly Waves

(1) Background

(2) Variability in AEW Structures and their relationship to tropical cyclones

(3) Intraseasonal Variability of AEW-activity and its relationship to tropical cyclones

(4) Summary
The Coupled Monsoon System

Key features of the WAM Climate System during Boreal summer

- SAL
- Heat Low
- AEJ
- ITCZ
- Cold Tongue
Key Weather Systems

- AEWs
- MCSs
- SAL
- TC

Diagram showing the distribution of these weather systems over a geographic area.
Bonnie (05)

Charlie (05)

Frances (05)

Ivan (05)

Ivan close to the Yucatan

courtesy A. Aiyyer
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m$^2$) at 10°N, 10°W for June-September 1979-1993

Day 0

Streamfunction (contours 1 X 10$^5$ m$^2$ s$^{-1}$)

Wind (vectors, largest around 2 m s$^{-1}$)

OLR (shading starts at +/- 6 W s$^{-2}$), negative blue

Kiladis, Thorncroft, Hall (2006)
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m$^2$) at 10$^\circ$N, 10$^\circ$W for June-September 1979-1993

Day-4

Streamfunction (contours 1 X 10$^5$ m$^2$ s$^{-1}$)

Wind (vectors, largest around 2 m s$^{-1}$)

OLR (shading starts at +/- 6 W s$^{-2}$), negative blue

Kiladis, Thorncroft, Hall (2006)
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m$^2$) at 10°N, 10°W for June-September 1979-1993

Day-3

Streamfunction (contours 1 X 10$^5$ m$^2$ s$^{-1}$)
Wind (vectors, largest around 2 m s$^{-1}$)
OLR (shading starts at +/- 6 W s$^{-2}$), negative blue

Kiladis, Thorncroft, Hall (2006)
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m$^2$) at 10°N, 10°W for June-September 1979-1993

Streamfunction (contours 1 X 10$^5$ m$^2$ s$^{-1}$)
Wind (vectors, largest around 2 m s$^{-1}$)
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Kiladis, Thornicroft, Hall (2006)
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m\(^2\)) at 10°N, 10°W for June-September 1979-1993

Day-1

Streamfunction (contours 1 X 10^5 m\(^2\) s\(^{-1}\))

Wind (vectors, largest around 2 m s\(^{-1}\))

OLR (shading starts at +/- 6 W s\(^{-2}\)), negative blue

Kiladis, Thorncroft, Hall (2006)
OLR and 850 hPa Flow Regressed against TD-filtered OLR (scaled -20 W m²) at 10°N, 10°W for June-September 1979-1993

Day 0
Streamfunction (contours 1 X 10⁵ m² s⁻¹)
Wind (vectors, largest around 2 m s⁻¹)
OLR (shading starts at +/- 6 W s⁻²), negative blue

Kiladis, Thorncroft, Hall (2006)
Importance of Guinea Highlands

- Marked transition takes place close to Guinea Highlands and Coastal region

- AEWs are often invigorated as they pass these regions – especially at low-levels

- May influence tropical cyclogenesis probabilities

Fouta Djallon Highlands ~914m

The Nambia Range ~460m
Composites of East Atlantic Developing and Non-Developing AEWs (1979-2001)

Importance of Guinea Highlands

Developing (33)  Non-Developing (512)

Hopsch, Thorncroft and Tyle 2009
Composites of East Atlantic Developing and Non-Developing AEWs (1979-2001)

Importance of Guinea Highlands

Hopsch, Thornicroft and Tyle 2009
Developers  Non-Developers

Day -2

850hPa Rel. Vort. [10^{-5}s^{-1}]

925hPa Streamlines (Grey)

700hPa Streamlines (Black)

Objective Mean Trough Locations (Thick Black Contours)

Brammer and Thorncroft (2014)
Day 0
Developing Non-developing

850hPa Rel. Vort

850hPa q [g/kg]
Wave Relative flow

Brammer and Thorncroft (2014)
3. Variability in African Easterly Wave Activity
Approach taken here is to consider impact of known phenomena on AEW-activity.

MJO has a coherent relationship with AEW-activity (measured by EKE):
  Ventrice, Thorncroft and Roundy, 2012
  Alaka and Maloney, 2013

Convectively Coupled Kelvin Waves can impact convection and AEWs:
  Ventrice, Thorncroft and Roundy, 2012
  Ventrice and Thorncroft, 2013
Variability in African Easterly Wave Activity - MJO

Ventricce et al, 2012
Variability in African Easterly Wave Activity - MJO

RMM Phase 1

RMM Phase 2

RMM Phase 3

RMM Phase 4

RMM Phase 5

RMM Phase 6

RMM Phase 7

RMM Phase 8
Unfiltered OLR, Kelvin-filtered OLR and 850 hPa wind anomalies

Key:

• Unfiltered total OLR field (Shaded)
• Kelvin filtered OLR (Contours) are contoured if statistically different than zero at the 95% level
• Positive (Negative) Kelvin filtered OLR anomalies 850 hPa wind anomalies (Vectors)
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Unfiltered total OLR field (Shaded)

Kelvin filtered OLR (Contours) are contoured if statistically different than zero at the 95% level

Positive (Negative) Kelvin filtered OLR anomalies

850 hPa wind anomalies (Vectors)
Unfiltered OLR, Kelvin-filtered OLR and 850hPa wind anomalies

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Variability in African Easterly Wave Activity - CCKWs

Shading: Kelvin filtered brightness temperature (Tb) anomalies

Contours: Tropical Depression type wave filtered Tb anomalies

- AEW wave train develops after the passage of convectively active phase of a CCKW.
- AEWs initiate (or amplify) east of one another

from Mekonnen et al. 2008
Shading: 700 hPa EKE anomalies (contoured if statistically different than zero at the 90% level)

**Bold Black Contours**: Kelvin filtered OLR anomalies (dashed if negative)
Tropical cyclogenesis relative to the Kelvin wave

AEW-CCKW-TC Relationships
Regional Variations in AEW Structure

- There are marked variations in AEW structures as they propagate between the African continent and the ocean.

- AEWs intensify and develop low level circulations as they pass the Guinea Highlands and coastal region.

- Variability in these processes likely impacts probability of tropical cyclogenesis.

- The most important differentiator between favorable AEWs that develop and those that do not is the presence (or not) of moist air at low-levels ahead of the AEW.
Variability in AEW Activity

• There is marked sub-seasonal variability in AEW activity.

• The MJO influences AEW-activity.

• This talk has highlighted the role of Convectively Coupled Kelvin Waves in generating such variability.

• CCKW-AEW interactions can influence the probability of rainfall over the African continent and tropical cyclogenesis in the tropical Atlantic.
Favourable characteristic based on wave climatology
CFSR 1979-2012

**Top 33%**

**Mid 33%**

**Bottom 33%**

PW - Precipitable Water
W  - Vertical Velocity (700-400hPa)
RV  - Relative Vorticity (900-600hPa)
EA  - Eastern Atlantic Precipitable Water

Brammer and Thorncroft (2014)
Monitoring AEW-quality in Real-Time

Based on Wave climatology

Top 33%
Mid 33%
Bottom 33%

Trough scale diagnostic

Trough + Environmental Diagnostic

Brammer and Thorncroft (2014)
Wave characteristics vary a lot during the season.

Brammer and Thorncroft (2014)