The Potential Vorticity Structure and Dynamics of African Easterly Waves

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1. Motivation & Background

African Easterly Wave (AEW) Structure

The kinematic and thermodynamic properties of AEWs have previously been documented in detail. What does Potential Vorticity (PV) look like in AEWs?

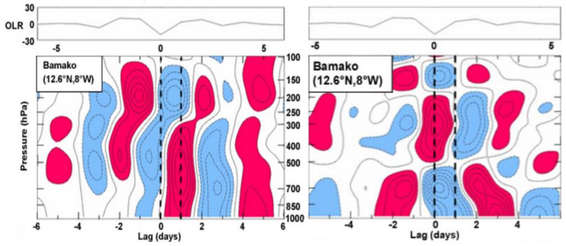


Figure 1: V-Wind and Temperature regressed onto OLR from Kiladis et al. (2006)

What propagates, maintains, and grows AEWs?

Burpee (1972) showed that the AEJ meets the Charney-Stern criterion for a barotropically and baroclinically unstable jet. However, Hall et al. (2006) showed that dry dynamics alone cannot explain the observed AEWs. What is the role of convection?

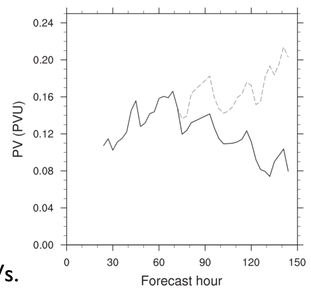


Figure 2: PV in a moist (dashed) and dry (solid) AEW from Berry and Thorncroft (2012).

Aims & Goals

1. Document the PV Structure of AEWs.
2. Examine how AEWs grow, maintain, and propagate.

2. Methods

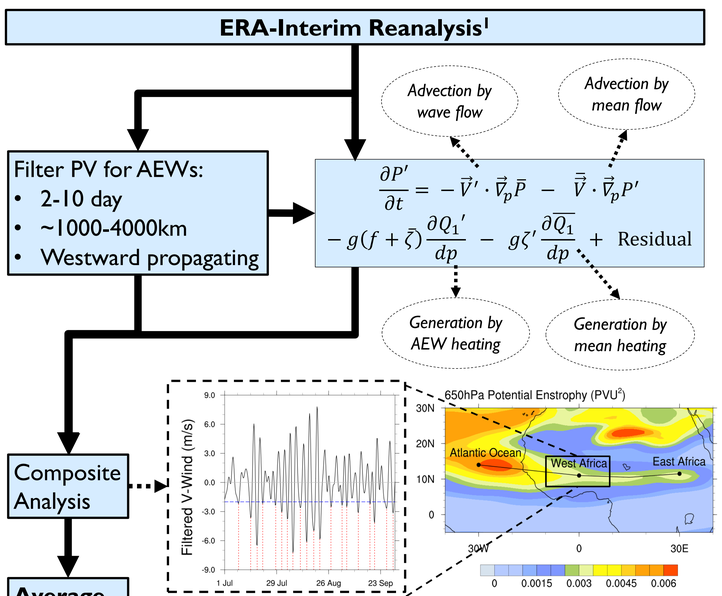


Figure 3: Diagram depicting the compositing method. Blue line is a threshold and red lines indicate AEW passages.

3. Structure

Key Points

- PV contours align with perturbation horizontal flow with few exceptions.
- Baroclinic and barotropic structures; prominent over West Africa.

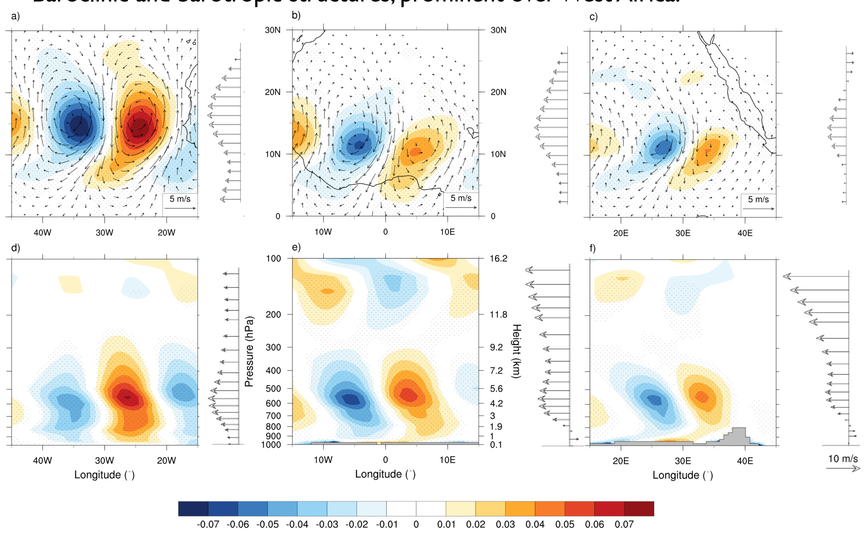


Figure 4: a,b,c) Horizontal (650hPa) and d,e,f) vertical (averaged over 8-14N) cross-sections of PV anomalies through the composite average AEWs. Composite average horizontal winds are overlayed. Corresponding time-averaged wind profiles along right side.

4. Advective PV Tendency

Key Points

- Advection by African Easterly Jet (AEJ) accounts for majority of the local PV tendency.

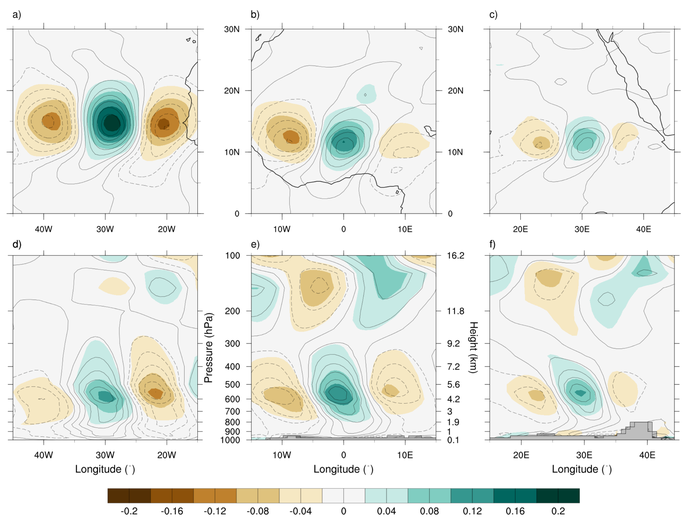


Figure 4: Horizontal and vertical cross-sections as in Figure 3 but for the 2nd term ($-\bar{\vec{V}} \cdot \vec{\nabla}_p P'$) in the perturbation PV budget (filled) and with $\frac{\partial P'}{\partial t}$ overlayed (contours).

While advection of AEW PV by the AEJ dominates the AEW propagation, it **cannot account for the growth of the AEW**

Lagrangian perspective required to examine growth of AEW PV

$$\left(\frac{\partial P'}{\partial t}\right)_L = \frac{\partial P'}{\partial t} - \bar{\vec{V}} \cdot \vec{\nabla}_p P'$$

5. Quasi-Lagrangian Perspective

Advective contributions

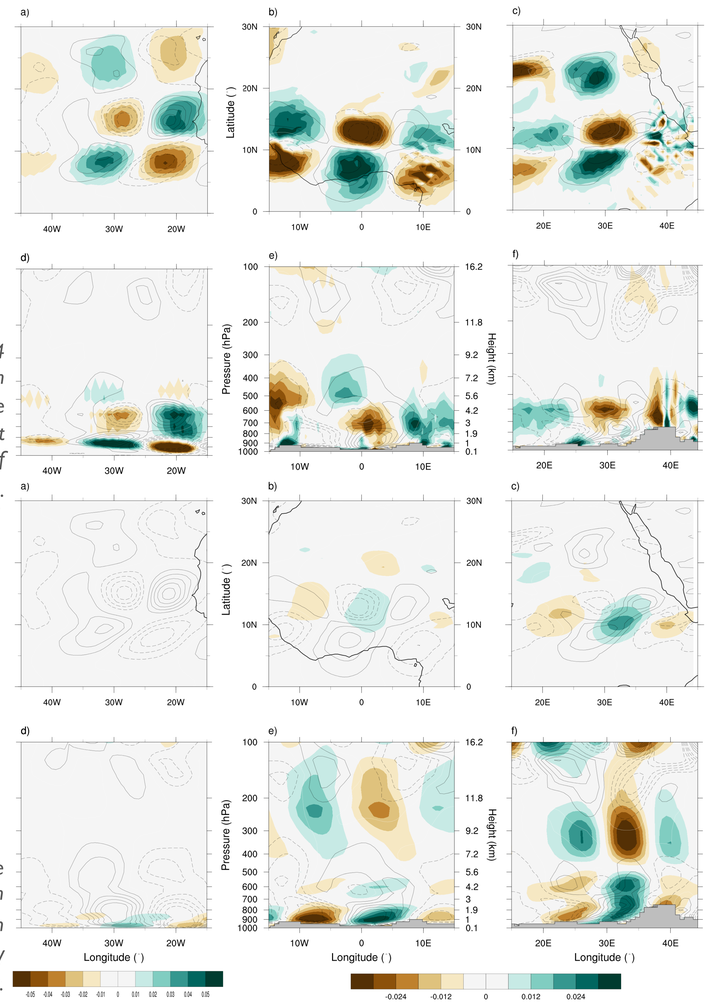
- Weak during early stages of AEW.
- Promotes growth of PV on southern edge of AEW.
- Dominant over Atlantic.

Figure 5: As in Figure 4 but for the 1st term ($-\vec{V}' \cdot \vec{\nabla}_p \bar{P}$) in the perturbation PV budget and with contours of $\frac{\partial P'}{\partial t}_L$.

Diabatic contributions

- Dominant during early stages of AEW.
- Promote deepening of AEW through PV generation in low-levels.
- Weak over Atlantic.

Figure 6: As in Figure 5 but for the 3rd term ($-g(f+\bar{\zeta})\frac{\partial Q_1{}'}{dp}$) in the perturbation PV budget.



6. Summary and Conclusions

- AEW PV is characterized by deep and tilted columns of PV with characteristic baroclinic and barotropic structures.
- Advection of AEW PV by the AEJ dominates the propagation of AEW PV.
- Diabatic processes associated with the AEW deepen and grow the AEW during early- to mid-stages after which advective processes begin to dominate.

Future Work

- High resolution WRF sensitivity studies will investigate the role of convection.

7. Acknowledgements & References

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References

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