Supplementary Information for “The Potential Vorticity Structure and Dynamics of African Easterly Waves”

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1 Quasi-balanced Circulation Associated with the AEW

A coherent circulation associated with the AEW-scale PV is evident in the longitude-pressure cross-section of PV and meridional winds (Figure 4g–l in the main text). At nearly all levels, meridional winds are in quadrature with the PV anomalies for both AEW tracks, indicating a potentially balanced circulation that spans a deep column. Figure 1 shows composite average AEW-scale PV at 650 hPa (the level of peak anomalous winds) in ERAI. Shown in vectors is the composite average AEW-scale rotational wind (Figures 1a–c) and divergent winds (Figures 1d–f) at each base point. The rotational component of the flow is much stronger than the divergent component. Further, the rotational flow closely matches PV contours as expected from a balanced response to the PV anomalies. The result is the same for CFSR (not shown). A question that arises from these observations then is what sort of balance is appropriate? For small Rossby number flows, geostrophic balance is usually appropriate but as discussed in Raymond et al. (2015), nonlinear balance is more applicable to low-latitude disturbances. PV inversion studies of AEWs may be able to shed more light on this.

2 The PV Budget with CFSR

In these supplemental materials, we show corresponding figures to those shown in the text using ERAI, but using CFSR. Figure 2 shows the AEW structure for composite waves in CFSR (corresponding to Figure 4 in the text). The structure of the AEW-scale PV and flow are qualitatively similar to those in ERAI. Figures 3, 4, and 5 show the PV budget for the AEW for composite waves in CFSR (corresponding to Figures 6, 7, and 8 for ERAI in the main text). The structure of all PV budget terms shown here are qualitatively similar to those in ERAI with the exception of the AEW-scale diabatic heating over West Africa (Figure 4). The difference here is discussed in the main text but is due to the difference in the vertical structure of AEW-scale diabatic heating between the two. Nonetheless, there are no key qualitative differences in the conclusions.

References

Figure 1: Composite average AEWs in ERAI showing the 650-hPa AEW-scale PV (PVU; shaded) with a,b,c) rotational and d,e,f) divergent wind vectors (ms$^{-1}$). Base points are a,d) Atlantic, b,e) West Africa, and c,f) East Africa.
Figure 2: As in Figure 4 in the main text but using CFSR.
Figure 3: Longitude-height cross-sections through composite ERAI AEWs averaged between 5-15°N showing AEW-scale PV tendency (PVU/day; shades) and $-\nabla \cdot \nabla P_w$ (PVU/day contours).
Figure 4: As in Figure 7 but for CFSR. Also the diabatic heating rates are $H$ instead of $Q_1$. 
Figure 5: Horizontal cross-sections through composite CFSR AEWs showing 800-550hPa averaged AEW-scale PV (shades, PVU) and $-\mathbf{V}_w \cdot \nabla P$. a) and d) are for the Atlantic base point, b) and e) are for the West base point, and c) and f) are for the East base point. a,b,c) show ERAI and d,e,f) show CFSR.