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Interactive comment on "African Easterly Waves in an Idealized General Circulation Model: Instability and Wavepacket Diagnostics" *by* Joshua White and Anantha Aiyyer

Anonymous Referee #1

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Recent studies have suggested that African easterly waves are not sufficiently accelerated by baroclinic and barotropic instabilities to explain the amplitudes the waves achieve as they propagate along the African easterly jet. The previous works have shown that initial disturbance by forcing from extratropical waves or by bursts of convection initiate the waves. These authors argue, in contrast, that baroclinic and barotropic instabilities act along clusters of waves instead of just to amplify an individual wave. They suggest that group velocities of the waves, corrected for quasi Doppler shifting, can maintain wave packets in the jet for extended periods of time, thereby allowing these instabilities to contribute substantially to the wave amplitude. The authors use reanalysis data, presented in Figure 1, to motivate the argument that eddy dispersion

can move the clusters of waves eastward or westward within the jet domain, making room for their arguments. They argue that a wave packet that has net zero group velocity somewhere in the packet would allow the wave pack to exist in the same region for extended periods of time. They suggest that a slowly varying background flow would allow for slow adjustment between westward, eastward, and stationary group propagation that would yield periods of enhanced or reduced easterly wave activity.

I think their arguments are generally well-made, and their model analysis compelling. Their results generally support their conclusions. They also include important caveats, such as the relevance of moist processes or interactions with other modes, which their model experiments do not accommodate. My primary concern is that the authors apply similar caveats to their interpretation of Figure 1. Figure 1 is included as simple observational support for the idea that clusters of waves can move eastward, westward, or be stationary in the African easterly jet region. They infer from this figure that wave group velocities behave similarly. Although I agree from first principles that the authors' point is likely true (i.e., given that the jet is roughly 5 m/s westward, and that somewhat similar mixed Rossby gravity waves have an eastward group velocity around 5 m/s eastward, it is conceivable, as a back of the envelope estimate, that easterly wave packets could become trapped in the jet region). I refer here to MRG waves just as an illustration, since we have a better understanding of their fundamental group velocity characteristics. Since the time Wheeler and Kiladis (1999) showed that observed MRG waves do not conform to theoretical MRG wave group velocities, authors have continued to attempt to estimated group velocities from longitude time diagrams of observed data. The problem with attempting such estimation is that amplitude along an observed wave packet is impacted by many other mechanisms beyond group propagation. Consider the illustration of an MRG wave packet interacting with the MJO. The group velocity of mixed Rossby gravity (MRG) waves can be close to the phase speed of the MJO, but let's assume here that MRG wave group velocity is 1 m/s slower than the MJO phase speed. The MJO is well known to modulate the amplitude of MRG waves. Now, assume that the MJO is moving from east to west across the packet, transitioning from the active convective phase to the suppressed convective phase. Since the MJO, in this case, is faster than the MRG packet, but since the MJO will be preferentially amplifying the eastern side of the packet relative to the western side, interaction with the MJO will cause the wave to appear to disperse eastward more rapidly than would have been predicted in the absence of the MJO. Yet this signal is not true dispersion, but is a nonlinear process caused by the MJO modulation of the MRG convection, which, in turn, feeds back on MRG circulation. Interaction with other waves and changing base state signals would window activity in easterly waves in a manner that would mimic dispersion, even if easterly waves were not fundamentally dispersive (herein I'm not arguing that point is true). Further, we know that breaking extratropical waves can force new easterly waves. The longitude at which the extratropical waves break can adjust with time, eastward or westward, thereby making the resultant waves appear to have eastward or westward group velocities. I suggest, therefore, that the authors revise their discussion of Figure 1 to include these caveats. Their point is well taken that observations show the waves clustering sometimes toward the west and sometimes toward the east. It is just not clear from these figures that this outcome is consistent with the waves' actual group velocities. The authors' model experiments appear robust to these mechanisms, but they need to caveat that their results do not show how important the effects they demonstrate are in comparison to effects like the ones I describe above.

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