5D.3a THE ROLE OF GUINEA HIGHLANDS CONVECTION ON TROPICAL CYCLOGENESIS

Michael J. Ventrice*
University at Albany, Albany, New York

1. Introduction

Previous work has suggested that potential vorticity (PV) generated by convection in the vicinity of the Guinea Highlands (GHs) is important for influencing the likelihood that an African easterly wave (AEW) will be associated with downstream tropical cyclogenesis (e.g., Berry and Thorncroft, 2005; Hopsch et al., 2010). The PV structure of AEWs is determined by a combination of processes that occur upstream over West Africa and those that occur in the vicinity of the GHs, especially those associated with the coherent diurnal cycle of convection. We will explore the interaction of this diurnal cycle with an approaching AEW. Tropical Storm Debby (2006), a weak AEW that surprisingly developed into a TC off the coast of West Africa during the 2006 NAMMA (NASA African Monsoon Multidisciplinary Analyses) period, is looked at as an ideal case of the merging of PV between the GHs and a weak approaching AEW. Interestingly this AEW interacted with a convectively-coupled atmosphere Kelvin wave during the time of tropical cyclogenesis. We will also compare the evolution of the Debby-precursor with an intense non-developing AEW in order to shed light on the processes that influence whether AEWs develop or not.

2. Diurnal Cycle

The diurnal cycle of the GHs is a complex but coherent process (Fig. 1). In the early morning hours (06-12Z), convection blows off the continent from the previous days convective bursts over the GHs, and new convection (immediately downstream of the GHs) begins to develop around 15Z. This convection intensifies at 16Z and a new convective burst can be seen to develop on the northwestern edge of the maximum elevation peaks of the GHs. These convective bursts intensify throughout 18Z. After 18Z, the convection south and west of the GHs begins to weaken, however north and west of the GHs, the convection continues to intensify. This convection continues to move northwest and eventually propagates off the coast of Senegal during the early morning hours.

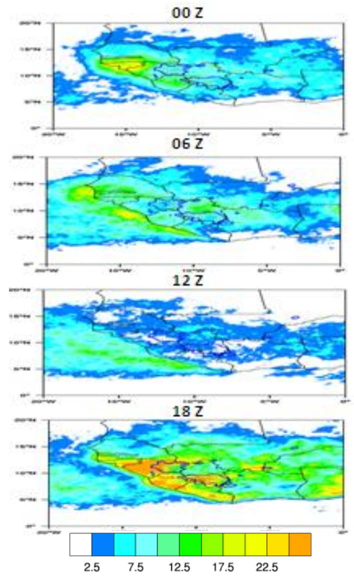

Fig.1. 2004-2008 Climatology of Sept. 233K Exceedence Frequency. Shading represents the percentage of time a cloud is precipitating (Courtesy M. Janiga).

3. Case Study of Tropical Storm Debby (2006)

The phasing between the diurnal cycle of the GHs and an AEW may promote tropical cyclogenesis near the coast of tropical West Africa, if the sea-surface temperatures are sufficiently warm in the eastern tropical Atlantic. Tropical Storm Debby (2006) is an ideal case highlighting the direct phasing between the GHs diurnal cycle and an AEW resulting in tropical cyclogenesis directly off the coast of West Africa.

i) The AEW that seeded Tropical Storm Debby

The AEW that seeded Tropical Storm Debby in 2006 was a weak AEW over tropical West Africa on 00Z August 19th (Fig. 2). The low level wind circulation associated with this AEW was weak, consistent with the weak 650 hPa PV strip.

* *Corresponding Author Address:* Michael J. Ventrice, Univ. at Albany, Dept. of Atmos. and Env. Science, Albany, NY 12222; email: MV945965@albany.edu

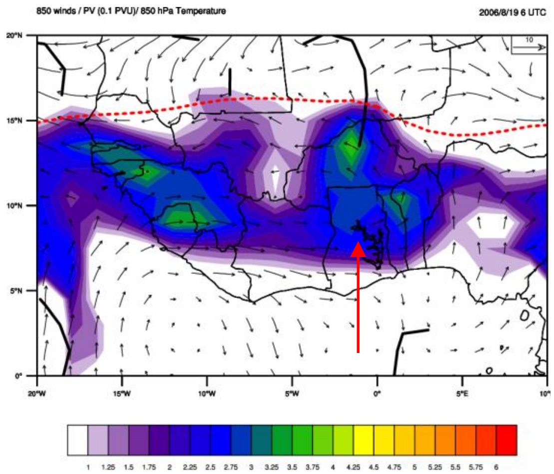

Fig. 2. 06Z August 19th - 650 hPa PV (shaded), 850 hPa Winds (vectors), AEJ (red dashed line), and AEW trough axis (black line). The red arrow points to the AEW of interest.

ii) Interaction with the GHs diurnal cycle

The developing convection over the GHs on August 20th follows the pattern of the composited diurnal cycle of the GHs (Fig. 3). During the morning hours (06-12Z), convection forms directly off the coast and grows northward. This is followed by early afternoon (15-18Z) convective bursts along the coastal terrain, downstream of the GHs. This convection is seen to propagate towards the northwest, consistent with the GHs diurnal cycle.

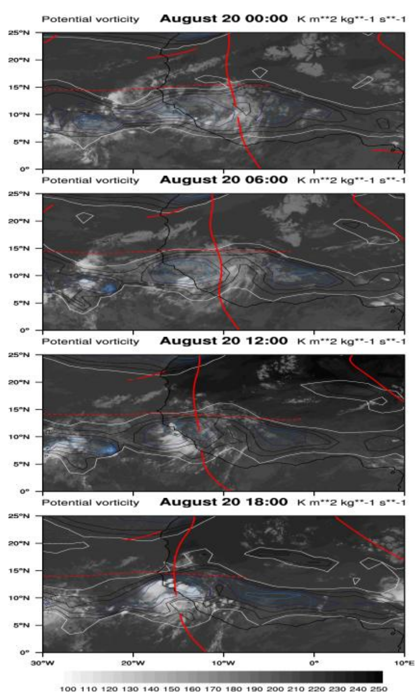

Fig. 3. Brightness temperature representing convection (shaded) for 6 hour intervals on August 20th, AEW trough axis (red solid line) associated with Debby, and AEJ (red dashed line). The convection is consistent with the diurnal cycle composites (c.f., Fig. 1)

iii) Interaction with a convectively-coupled Kelvin wave

A convectively-coupled atmospheric Kelvin wave phased with the developing Debby after moving into the eastern tropical Atlantic on August 21st (Fig. 4).

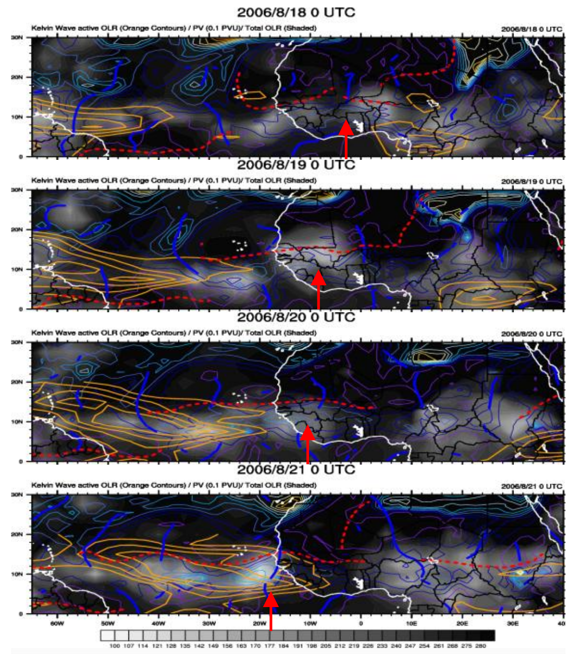

Fig. 4. Grey shading is total outgoing long-wave radiation (OLR). Orange contours are Kelvin wave active filtered OLR. Blue lines are AEW trough axis. Red dashed lines are AEJ location. The red arrows are pointing the AEW trough axis associated with Debby.

The phasing between the AEW and active OLR phase of the Kelvin wave enhanced deep convection in the core of Debby, as well as moistening a region of the troposphere over the tropical Atlantic, downstream of Debby (Fig. 5).

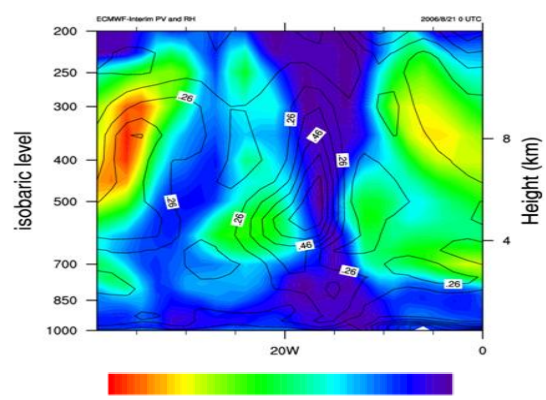

Fig. 5. Cross section (along 10°N) through the AEW that seeded Debby on 00Z August 21st at the time of the Kelvin wave interaction. Color shading is Relative Humidity (%) and contours are PV.

The enhancement of the convection in the core of Debby acted to intensify the low and mid-level PV, and saturated the column. We argue the Kelvin wave played a key role in catalyzing the tropical cyclogenesis of Debby.

3. Case Study of an Intense non-Developing AEW

An intense non-developing AEW in early August (1996) is explored. Over the tropical West Africa, the intense non-developing AEW PV structure is much stronger when compared to Debby (Fig. 6). Also, the cyclonic low-level wind circulation can be seen to be well defined. This AEW moved over the GHs at a time where the AEW phased with the GHs diurnal cycle, which intensified the wave at the coast (not shown)

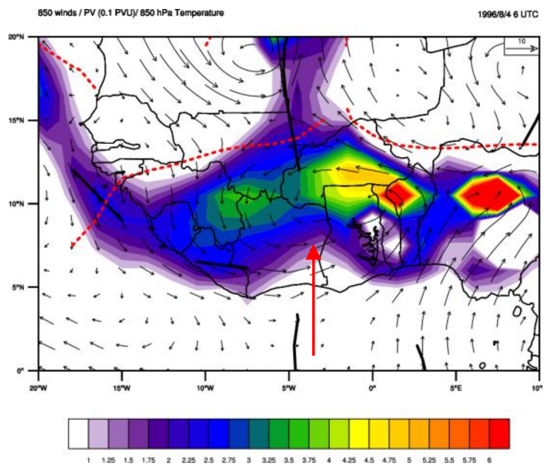

Fig. 6. 06Z August 04th - 650 hPa PV (shaded), 850 hPa Winds (vectors), AEJ (red dashed line), and AEW trough axis (black line). The red arrow points to the AEW of interest.

However, as the non-developing AEW moved out over the tropical Atlantic, very dry air was seen to be downstream of the wave on August 6th, this dry air was advected into the wave at below 850 hPa and above 400 hPa, ultimately acting to suppress the deep convection processes needed for tropical cyclogenesis (Fig. 7).

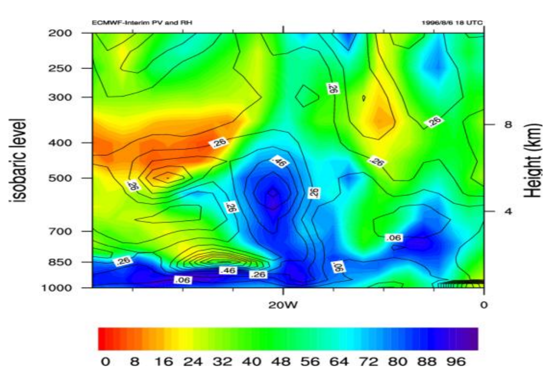

Fig. 7. Cross section (along 15°N) through the intense non-developing AEW directly off the coast of West Africa on 18Z August 6th. Color shading is Relative Humidity (%) and contours are PV.

More importantly, the AEW never interacted with a convectively-coupled atmospheric Kelvin wave over the tropical Atlantic (not shown). This suggests that Kelvin waves may play an important role with enhancing deep convection inside a developing AEW, as well as moistening the troposphere downstream of the wave. A moister troposphere ahead of the wave will lower the likelihood of dry air being advected into the developing AEW.

This talk will aim to stress the importance of the processes that pertain to the GHs, a region not heavily studied. The correct phasing between an active phase of a convectively-coupled atmospheric Kelvin wave, diurnal cycle over the GHs, and AEW passage may promote tropical cyclogenesis in the eastern tropical Atlantic.

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