# P11.2 COLLAPSE OF TRANSITIONING MESOSCALE CONVECTIVE SYSTEMS OFF THE COAST OF AFRICA

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## 1. INTRODUCTION

It has been shown through previous studies from GATE and COPT81 that convection becomes disorganized as it transitions from land to ocean. While most MCSs dissipate upon approaching the coast and transitioning over the ocean, some strengthen, as in the 1999 case of Hurricane Cindy (Sall and Sauvageot 2005). A better understanding of how some systems decay will prove useful for identifying other MCSs that go on to play a role in tropical cyclogenesis (Zipser et al. 2009).

Hodges and Thorncroft (1997) suggested that MCSs tracking over the ocean have to adjust to a significantly different environment and may actually decay. The sustainability of MCSs is dependent upon the formation of new convective cells (Yuter and Houze 1998; Schumacher and Houze 2003; Houze 2004). Schumacher and Houze (2006) went on to show that while the stratiform portion of MCSs continues to be present over the eastern Atlantic, the convective rain rates decrease. More recently, Fuentes et al. (2008) found similar results, such as the reduced vertical extent for convective cells over the ocean, but similar stratiform rain region profiles when comparing MCSs over ocean and land. Shallow convection progressively becomes more common with proximity to the ocean and this is attributed to the significant reduction in the amount of CAPE available over the eastern Atlantic compared to the continental regions of West Africa. In their study of the diurnal cycle of the West African monsoon circulation, Parker et al. (2005) showed that MCSs normally occur under strong low-level wind shear, CAPE values greater than 2500 J $kg^{-1}$, and a strong African Easterly jet located at approximately 650 mb.

In contrast to these previous satellite studies that must make averages from single observations of MCSs, the stationary NASA Polarimetric (NPOL) ground-based radar was able to obtain with high temporal resolution (15 minute volumes) up to five hours of observations of several MCSs as they transitioned from land to the eastern Atlantic. This paper will show the transition of three such MCS cases (31 August, 2 September, and 11 September 2006) during the NASA African Monsoon Multidisciplinary Analyses (NAMMA) field campaign.

## 2. DATA & METHODOLOGY

The NPOL radar is an S-band radar that was located in Kawsara, Senegal (14.66° N, 17.10° E, 80.0 m ASL) during the NAMMA field campaign in August and September 2006. NPOL has a beamwidth of 1.4° and a gate spacing of 200 m. The unambiguous range for the radar was 157.8 km for volume scans with a corresponding Nyquist velocity of 25.4 m $s^{-1}$.

The REORDER software program (Mohr et al. 1986; Oye and Case 1995) was used to interpolate and grid edited radar data from its original spherical coordinates onto a Cartesian grid. The analysis domain was a 300 km by 300 km box ($-150.0 < x < 150.0$, $-150.0 < y < 150.0$, $0.0 < z < 18.0$) centered on the NPOL radar. For the 31 August and 2 September 2006 cases, the Cartesian grid was given a horizontal and vertical resolution of 1.0 km and 0.5 km, respectively. The horizontal radius of influence was set to 2.0 km, while the vertical radius of influence was set to 1.0 km. For the 11 September case, due to its increased distance from the radar, the horizontal and vertical resolution of the Cartesian grid was 2.0 km and 1.0 km, respectively. The horizontal radius of influence was increased to 3.2 km and the vertical radius of influence also

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increased to 2.0 km. A Barnes exponential weighting scheme (Barnes 1964) was used to interpolate the radar data onto the Cartesian grid.

Vertical cross-sections of radar reflectivity were taken along a storm motion vector during the time periods of interest for each case to allow the same frame of reference to show MCS evolution transition from land to ocean.

## 3. RESULTS & DISCUSSION

### 3.1 31 August 2006 MCS case

Figure 1 shows hourly cross-sections from 0700 to 1000 UTC for the 31 August 2006 MCS that crossed over the NPOL radar approaching from the northeast. At 0700 UTC, the horizontal cross-section at 4.0 km AGL suggests that the cells in the convective line over land are stronger than those that are part of the line already out over the ocean. Maximum reflectivity values of up to 55 dBZ were associated with portions of the line over land versus maximum reflectivity values of 42 dBZ over the ocean. The average storm motion vector was chosen to follow roughly the apex of the bowing MCS from land to the ocean. The horizontal cross-section an hour later at 0800 UTC depicts some disorganization already occurring along the convective line at the coast just before the entire MCS transitioned over the ocean. The vertical cross-section clearly shows the transition of 2 initiating cells with reflectivity values up to 56 dBZ along the leading convective line likely generated from the gust front. It also appears that there are three decaying cells along the storm motion vector that move rearward into the extensive stratiform region. At 0900 UTC, the 0 dBZ contour extended almost up to 18 km AGL. While the MCS extended farther vertically at this particular time along the storm motion vector, of particular note is the 6 dB decrease in maximum reflectivity. There is also a reflectivity minimum immediately behind the convective line as well as evidence of a developing bright band signature in the trailing stratiform rain region. At 1000 UTC, the convective region of the MCS exhibits substantial disorganization over the ocean. Although there appears to be a portion of the line with stronger reflectivity and organization to the north of the storm motion vector, a closer inspection revealed that this portion of the line only reached 8 km in altitude AGL (not shown), which is consistent with results for satellite climatologies of transitioning MCSs off the coast of West Africa (Schumacher and Houze 2006; Fuentes et al. 2008).

### 3.2 2 September 2006 MCS case

Figure 2 provides one of the best examples of MCS collapse off the coast of West Africa during the NAMMA field campaign. At 2300 UTC 1 September 2006, the MCS was just entering within range of the NPOL radar. The vertical cross-section along the east-west oriented storm motion vector showed the 30 dBZ contour reaching slightly above 15 km (not shown). At 0000 UTC, the MCS organized, although the leading convective region appears slightly separated from the trailing stratiform rain region. As the MCS approached the NPOL radar at 0100 UTC, disorganization appeared within the convective line even though not all of the MCS had transitioned out over the ocean by that time. At 0200 UTC, the MCS does show the convective portion of the leading line extending up to approximately 18.0 km. At 150.0 km distance along the vertical cross-section (the location of the NPOL radar), one can see evidence of the “cone of silence” due to a maximum scanning elevation angle of 33.0°. The final hour of analysis for this case is 0300 UTC, which clearly shows the collapse of the MCS as it transitioned out over the ocean. The horizontal cross-section at this time had to be reduced to 2.0 km AGL because *no* reflectivity echo, including portions of the convective line still within range of the NPOL radar, could be found at 4.0 km AGL.

### 3.3 11 September 2006 MCS case

Figure 3 shows the 11 September 2006 case that was associated with an AEW that formed Tropical Depression 8 the next day and eventually became Hurricane Helene. The 0900 UTC horizontal cross-section at 4.0 km AGL shows a convective leading line with a large region of reflectivity reaching up to 51dBZ. In the next hour, as the MCS exited the coast, the convective line surged ahead and separated from the trailing stratiform rain region. Although the vertical extent of the MCS remained nearly the same, the maximum reflectivity decreased by approximately 6 dB.

In the final hour (1100 UTC), the convective portion of the MCS appeared to have fully separated from the trailing stratiform region. While maximum reflectivity values within the convective region remained at approximately 42-45 dBZ, the reflectivity gradient within the convective region of the MCS increased significantly. Soundings taken at Kawsara, Senegal (location of the NPOL radar) showed a 50 knot African Easterly jet at 650 mb was associated with this case (not shown) and could possibly be related to the separation of convective and stratiform regions of this MCS. In addition, forecasting models that were used during the NAMMA field campaign underestimated when this system should have exited the coast by nearly 24 hours.

## 4. CONCLUSIONS

The 31 August and 2 September 2006 cases showed MCS collapse as transition over the ocean occurred. Unlike the previously mentioned cases, the 11 September 2006 case did not collapse, however maximum reflectivity values decreased by approximately 6 dB with transition over the ocean. The strong dynamic forcing from the associated AEW may partially explain why the convective portion of the MCS surged ahead and separated from the trailing stratiform rain region. A current hypothesis is that MCS collapse is governed by changes in cold pool outflow and storm inflow after transition from land to ocean. Future work involves validation of this hypothesis using high-resolution 1 km WRF model runs.

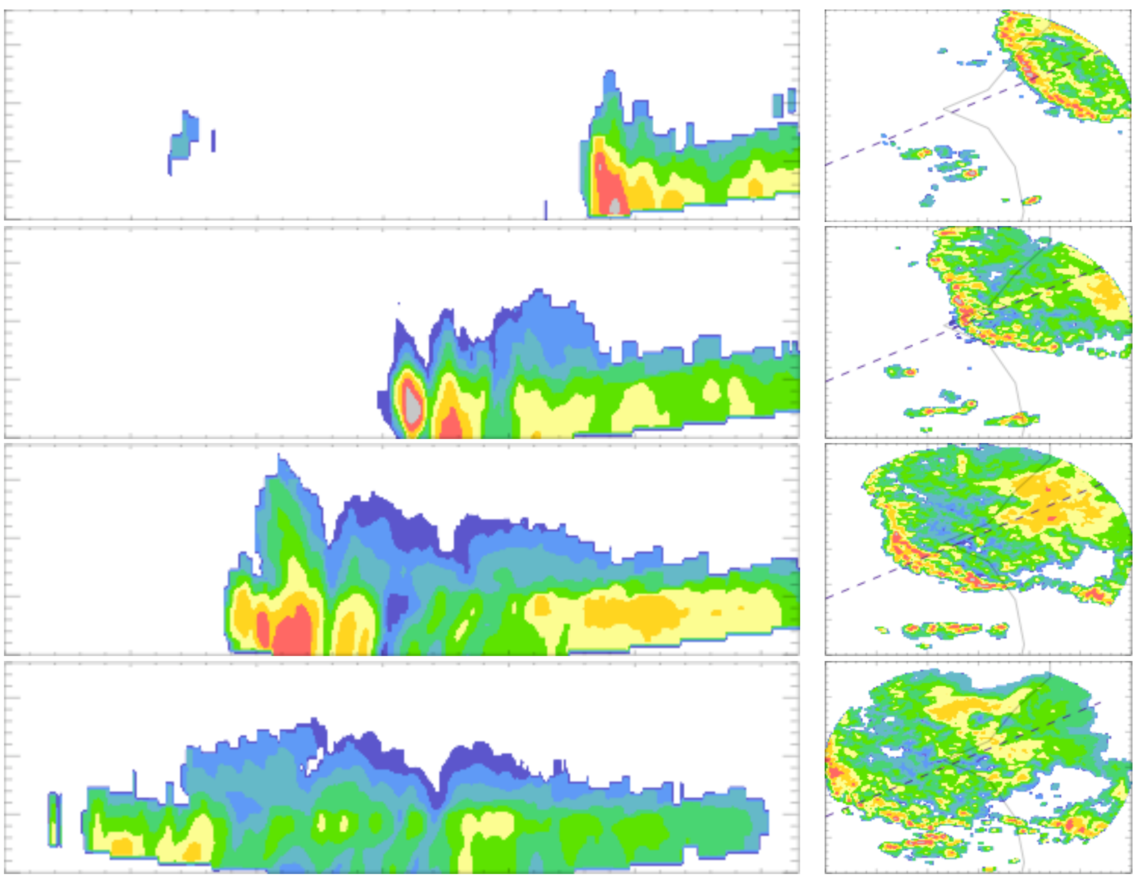

**Figure 1.** Evolution of 31 August 2006 case from 0700 to 1000 UTC in hour increments. The coast of Senegal is indicated by a thin black line in the 4.0 km altitude horizontal cross-sections shown in the right column. The dashed black line is the average storm motion vector along which the vertical cross-sections of the MCS were plotted as seen in the left column.

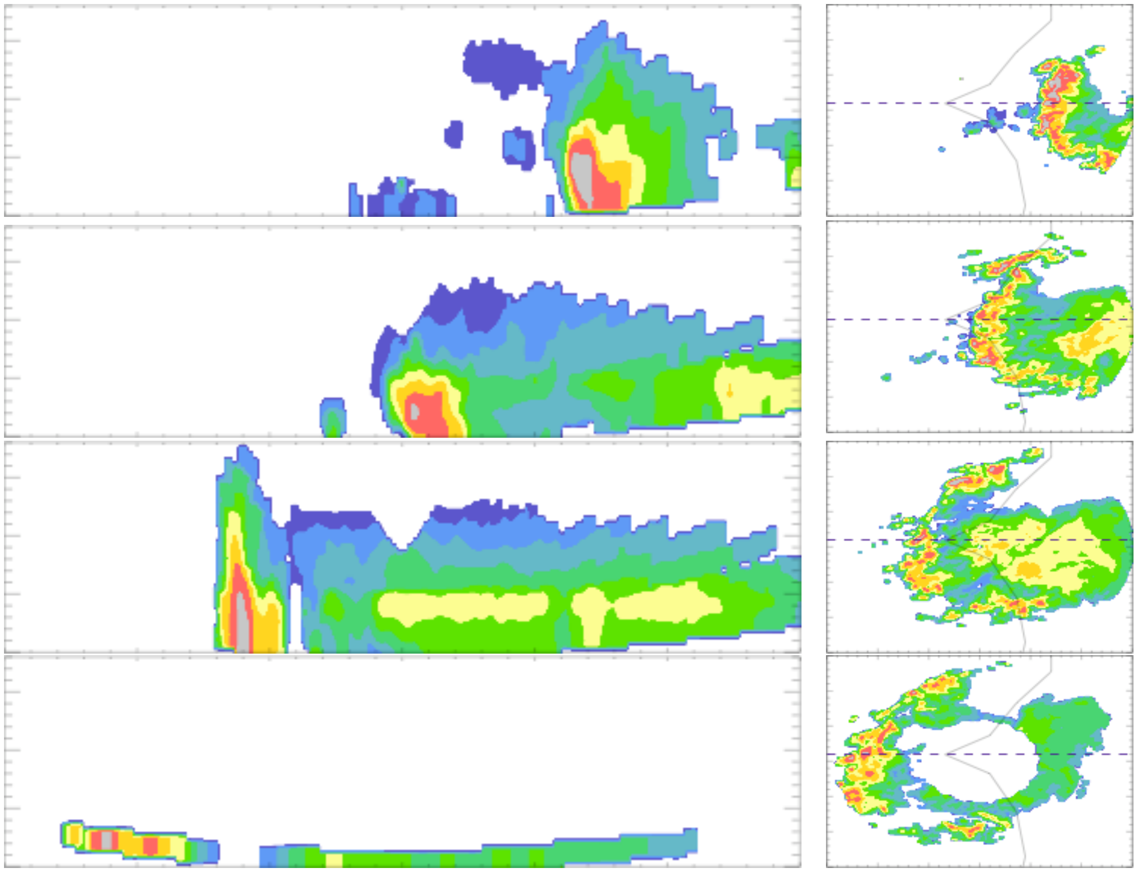

**Figure 2.** Same as Figure 1, except for 0000 to 0300 UTC 2 September 2006.

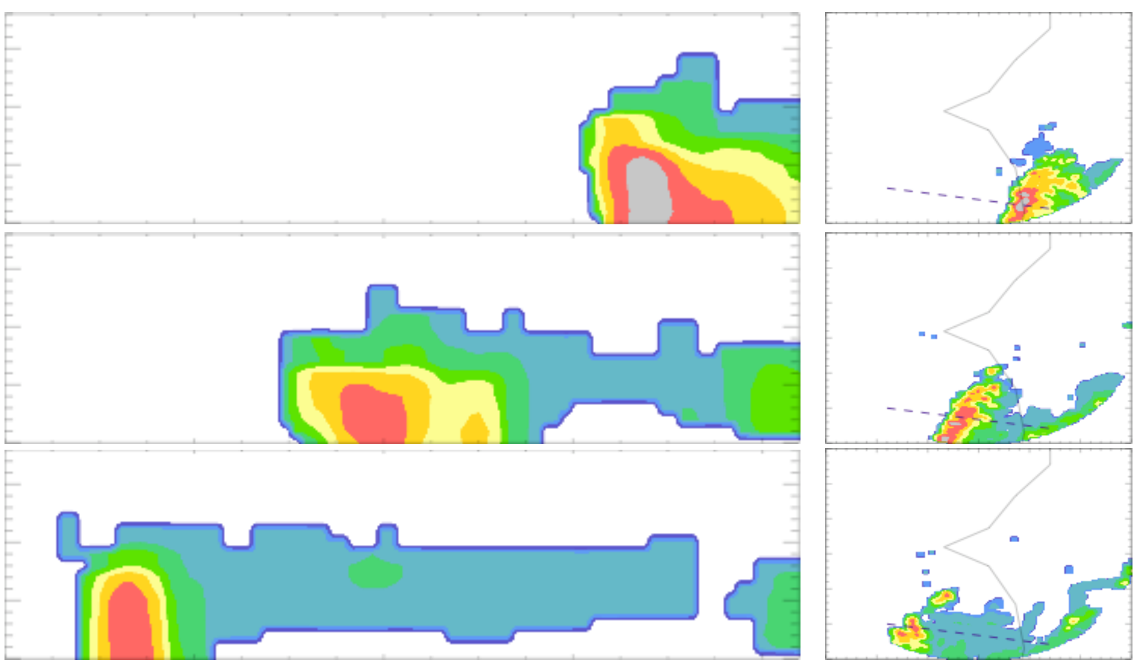

**Figure 3.** Same as Figure 1, except for 0900 to 1100 UTC 11 September 2006.

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