1B.7

ORIGIN AND PROPAGATION OF A DISTURBANCE ASSOCIATED WITH AN AFRICAN EASTERLY WAVE AS A PRECURSOR OF HURRICANE ALBERTO (2000)

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1. Introduction

A significant number of tropical cyclones that have occurred over the eastern Atlantic Ocean, particularly near the Cape Verde Islands, can be traced back to the African continent as mesoscale convective complexes (MCCs). In this study, we propose that a MCC and a mesovortex (MV), associated with a tropical disturbance that would become Hurricane Alberto (2000; see Hill and Lin 2003), were embedded within a wave-like disturbance over Northern Africa. The wave-like disturbance we observe may be classified as an African easterly wave (AEW). At the EH, there existed 2 modes of disturbance development: a stationary mode and a propagating mode. The stationary mode corresponded with the generation of new convective systems over the EH with a period of about 2 to 3 days. These convective systems then propagated westward within an AEW train at an average speed of 11.6 m s^{-1}. The average wavelength was roughly estimated to be about 2200 km.

For a recent 12-year period, a majority of tropical cyclones from the tropical eastern Atlantic Ocean began as a MCC in the vicinity of the EH. We analyzed the METEOSAT-7 IR imagery and ECMWF Operational Model (EOM) data from convective development of the first pre-Alberto MCC over the EH to the tropical cyclogenesis stage of Alberto over the eastern Atlantic Ocean. We investigated the characteristics of an associated AEW and determined the origin point of the AEW to be at the EH. Analysis of satellite imagery also reveals that the incipient disturbances for 23 of 34 eastern Atlantic tropical cyclones originated from the Ethiopian Highlands (EH) region. An idealized mesoscale model simulation enabled us to gain insight into the formation and propagation of AEWs and MVs from EH-like topography.

2. Results

Seven stages of the convective cycle for the pre-Alberto MCCs were identified (Fig. 1) from 28 July to 03 August, consisting of 4 genesis periods (G-I, G-II, G-III, G-IV) and 3 lysis periods (L-I, L-II, L-III). The locations of convective genesis and lysis generally agree with statistical study of Hodges and Thorncroft (1997), particularly east of 15°E. As was first alluded to by Hill and Lin (2003), the genesis and lysis of the individual African MCCs can be related to the propagation of an AEW and the eventual development of an Atlantic tropical cyclone.

Based on EOM and NCAR moisture datasets, we found that the availability of water vapor is the most essential factor controlling the convective cycle of the pre-Alberto disturbance over the African continent. The presence of significant topography contributes to the generation or decay of the associated MCCs through regulation of the water vapor supply. Four regions of mean $RH \geq 90\%$ along about 10°N were collocated with significant topography. Adiabatically warmed downslope flow from the Ruwenzori Mountains and Cameroon Highlands likely suppressed moist convection associated with the pre-Alberto disturbance. Based on this present study, orographic forcing led to the development of a pre-Alberto MCC at the EH during the G-I stage and at the range of the Darfur Mountains and Bongo Massif during the G-II stage. The presence of orography, therefore, affects the cycle of convective development within an AEW. This concept will be further investigated in a future study.

The pre-Alberto MCC was one of several MCSs observed over the African continent during the period of interest; one can identify 3 MCSs existing concurrently over the African continent. The stationary mode corresponded with the generation of new MCSs over the EH with a period of about 2 to 3 days. These MCSs then propagated westward with an AEW, with average characteristic values of λ = 2200 km and c = -11.6 m s^{-1}. COAMPS^{TM} simulations with uniform flow over idealized EH on a β plane show that AEW-like disturbances, with embedded MVs, can be generated through the sole influence of a mountain range (Fig. 2). The simulated AEW-like pattern was confined to the lowest 4 km of the vertical domain.

From our observational analysis and idealized modeling results, we present a conceptual model for the generation and propagation of an AEW and embedded MVs (Fig. 3). The lateral adjustment of partially blocked easterly flow at the north end of the EH can lead to the downstream development and propagation of an AEW across Africa along about 10°N. A lee mesoscale vortex (denoted as "V" in the figure) can develop within a cyclonic disturbance of the AEW. With the presence of abundant low-level moisture, significant topography, and possible other ingredients such as conditional instability, MCCs can develop and decay in a cyclic manner with the disturbance as it propagates westward within the AEW. Once the disturbance emerges over the eastern Atlantic Ocean, tropical cyclogenesis can ensue.

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4. References

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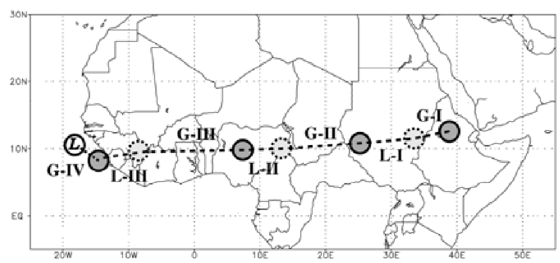

Figure 1: Track of pre-Alberto MCCs estimated from METEOSAT-7 satellite imagery, with genesis (G-I, G-II, G-III and G-IV) and lysis (L-I, L-II and L-III) stages denoted.

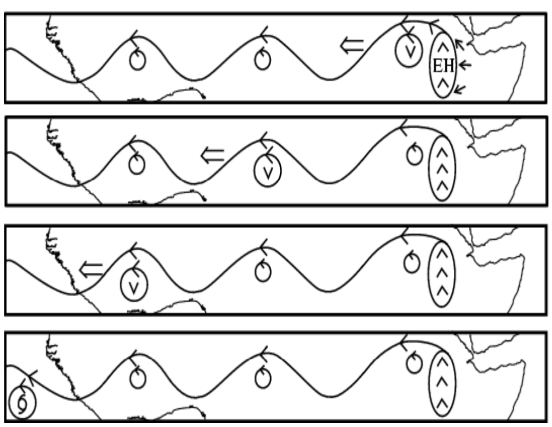

Figure 3: A conceptual model of the generation and propagation of an African Easterly Wave train originating at the Ethiopian Highlands.

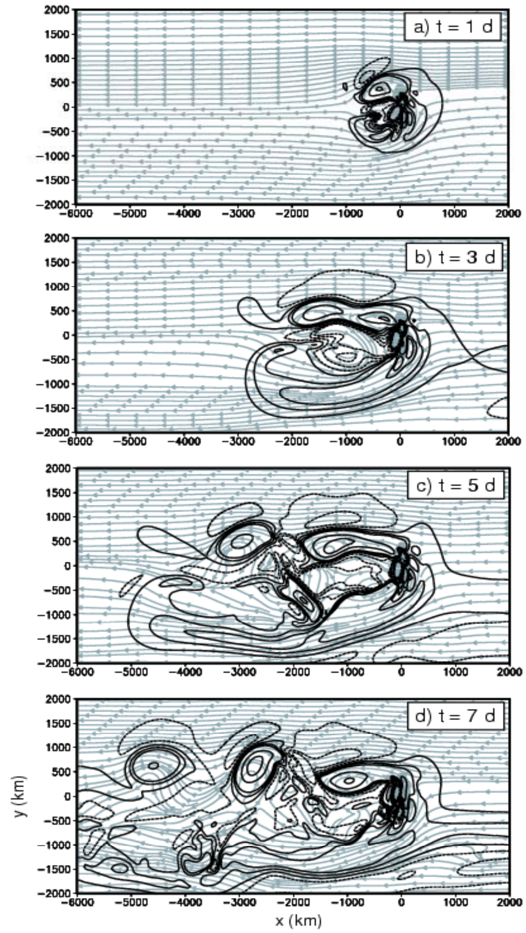

Figure 2: COAMPS streamline and potential vorticity (*PV*) fields for (a) t = 1 d, (b) t = 3 d, (c) t = 5 d, and (d) t = 7 d. Bell-shaped terrain higher than 0.5 km, centered at x = 0 km and y = 0 km, is shaded. *PV* is contoured every 0.04 pvu (PV unit) for -0.10 pvu ≤ PV ≤ 0.10 pvu and every 0.20 pvu for PV < -0.10 pvu and PV > 0.10 pvu. Positive (negative) PV is denoted by solid (dotted) contour.