3C.2 GATHERING IN-SITU DATA USING AIRCRAFT RECONNAISSANCE TO INVESTIGATE INCIPIENT TROPICAL CYCLOGENESIS

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1. INTRODUCTION

Gathering in-situ data within a tropical cyclone (TC) formation suspect area presents many challenges. Aircraft reconnaissance, while it is a vital diagnostic tool for operational forecasters, provides limited data sets for the purpose of detailed post-storm analysis and research. The inherent inability of a single, slow moving turboprop aircraft, to generate truly synoptic observations across a translating fluid vortex limits the utility of WC-130 flight-level data to researchers. One aircraft, flying at a standard storm penetration speed of less than 300 km/hr (180 knots), may take several hours to investigate a wave axis searching for incipient vortices. There is no way to effectively take a "snapshot" of winds, pressures, and temperatures, over such a spatial area, even using multiple aircraft or faster jet aircraft such as the NASA DC-8 or NOAA Gulfstream IV.

Even if there was a way to gather the data more synoptically, most operational reconnaissance of suspect areas is flown at altitudes less than 500 meters above the ocean surface. Much of the developing structure, as an easterly wave evolves into a TC, occurs between 650 and 850 millibars. While the teleconnection between the oceanic boundary layer and this structure above is best documented for operational purposes at the lowest possible flight level (surface winds providing the most crucial piece of the puzzle to NHC forecasters), in many cases, a cyclone is clearly seen developing on satellite imagery at levels above where the aircraft is operating.

Finally, while the temporal resolution of WC-130H reconnaissance data is excellent (data on wind, temperature, humidity, and pressure are measured each second for a given altitude and location, then averaged and archived in 10-second bins), and WC-130J data resolution will be even better, the missions may only be tasked to fly once every 12 to 24 hours. It is typically not until a disturbance reaches status as a tropical depression, storm or hurricane, or the system is an imminent threat to the U.S. coastline or territories, that aircraft reconnaissance coverage is tasked more continuously.

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2. IMPROVING DATA COLLECTION CAPABILITY

Incorporation of the Stepped Frequency Microwave Radiometer (SFMR) into operational reconnaissance onboard the WC-130J will greatly enhance the ability to gather data at higher flight levels (capturing the earlier stages of TC development at 850 millibars or higher) while still being able to accurately map the wind field in the boundary layer below.

Montgomery, Moeller, Kallenbach et al (several articles) have shown the complex processes of tropical cyclogenesis can be effectively and realistically modeled. A small insertion of in-situ verification data, whether gathered operationally during WC-130 missions, or during a field experiment by NOAA AOC/HRD or NASA CAMEX aircraft, would go a long way toward identifying the presence of recognizable mesoscale eigenmodes. Much of the recent work in this area focuses on characterizing the presence, and the role of, asymmetric potential vorticity (PV) anomalies that rotate around the larger scale, somewhat axisymetric, vortex. The process by which these PV anomalies feed barotropic intensification of the larger vortex feature is still a matter of much debate. Understanding how radially and vertically propagating convectively forced vortex Rossby waves transfer energy from smaller to larger scales is key to describing these events. The formation of "hot towers" during convective bursts is linked to thermodynamic changes in the developing vortex that appear more significant than simply increasing the core's equivalent potential temperature.

It has been noted in recent years that many non-developing cases can be tied to adverse external thermodynamic forcing (a prevailing low equivalent potential temperature layer at or near 700millibars associated with the Saharan Air Layer (SAL) (Dunion et al) invading the western Atlantic TC genesis region. It is still not clear whether this dry air ingestion curbs TC formation by inhibiting convection directly, or by disturbing the means by which energy from convective bursts is translated into barotropic wave development (or perhaps disrupting the positive feedback process whereby the two are linked and support each other).

Excess vertical shear is an obvious factor in many, if not most, disturbances not reaching the TC phase. The degree of vortex stretching and tilting, dictated by the nature of the shear environment in which the incipient vortices are embedded, often dictates how well the vortices are linked to supporting convection. Another question that needs to be explored is why suspect disturbances within African easterly waves transiting the deep tropics (below 20 degrees latitude) are so susceptible to shear and dry air intrusion, while disturbances at higher latitudes are seemingly more resistant, and tend to often develop in spite of adverse shear and thermodynamic conditions.

3. EXAMPLE CASES

Several cases of non-developing and developing tropical disturbances will be examined. Erin 1995 (see Figure 1) was investigated by WC-130 aircraft for several days (28, 29 and 30 July) as a wave moving toward the Bahamas. Its satellite signature, using Dvorak techniques, suggested a well defined depression was present with as much as a T2.5 rating. However, no circulation center could be found at the surface. It was not until approximately 0000z on 31 July, that a circulation center reached the surface and the reconnaissance crew was able to begin transmitting detailed vortex data messages to NHC (where advisories then began on TS Erin). Whether knowledge of a vortex at higher levels would have helped forecasters is a matter of debate, however, reconstructing such vortex formation, and the process by which it made its way down to the surface, would have been of great interest to those attempting to model such behavior.

Examples of non-development, including the 14 July 1998 disturbance shown in Figures 2 and 3, will be discussed. Methods of extracting useful research data sets from both field experiment flights as well as operational reconnaissance missions will be examined.

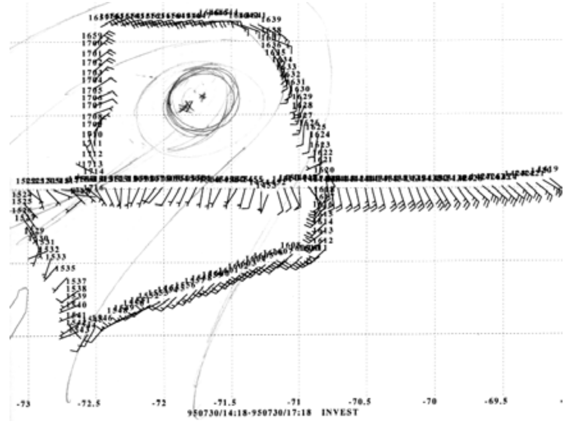

Figure 1. Plot of wind measurements made from 1418Z to 1718Z 30 July 1995 within the tropical wave that would become TS Erin about 12 hours later (from National Hurricane Center).

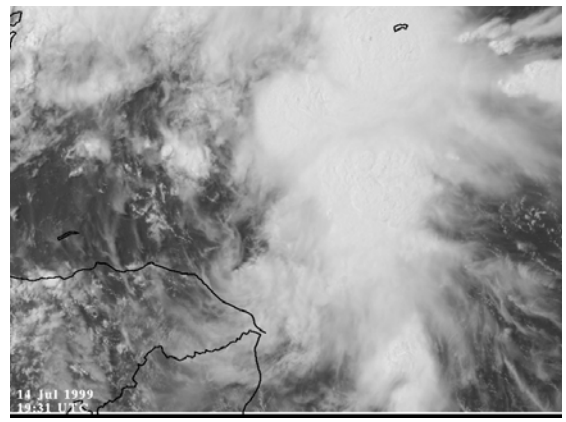

Figure 2. GOES image from 1931 UTC 14 July 1998 showing a very convectively active wave that never developed into an Atlantic tropical cyclone. (from NASA GHCC)

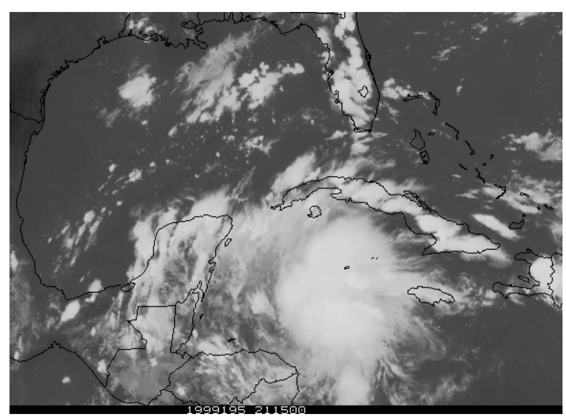

Figure 3. GOES imagery from 2115 UTC 14 July 1998 showing a wider view of the non-developing disturbance. (from University of Wisconsin CIMSS)