9.3 THE P-3 ERA OF AIRBORNE HURRICANE RESEARCH

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1. INTRODUCTION

In 1976 and 1977, NOAA commissioned two WP-3D research aircraft to conduct confirmatory replications of the apparently successful STORMFURY hurricane amelioration experiments of the 1960s. With their large fuselage volume, shirtsleeve cabin environment, substantial electrical generation capacity, relatively slow true airspeed, and long range and duration, these aircraft have proved to be nearly ideal platforms for hurricane research. The initial instrumentation suite included flight-level measurements, horizontally and vertically scanning radars, Omega dropwindsondes, hydrometeor imaging and replication systems, and expendable oceanographic probes (Jorgensen 1984a).

The P-3s were operated by NOAA's Research Flight Facility, now the Aircraft Operations Center (AOC). The primary users for the hurricane mission were scientists from the National Hurricane and Experimental Meteorology Laboratory, now the Hurricane Research Division (HRD) of NOAA's Atlantic Oceanographic and Meteorological Laboratory. Their first hurricane flights were on 1-2 September 1977 in Anita as it made landfall on the Mexican coast south of Brownsville, Texas.

2. STORMFURY

In the late 1970s, the STORMFURY investigators turned their attention to unmodified hurricanes as controls. The new observing platforms quickly showed that glaciogenic seeding of hurricane clouds was unpromising and that unmodified hurricanes frequently experienced eyewall replacements that exactly mimicked the expected result of cloud seeding. These considerations led NOAA to abandon hurricane-modification research (Willoughby et al. 1985).

3. THE 1980s AND 1990s

Studies of unmodified hurricanes revealed new paradigms for hurricane structure and dynamics. The P-3s were the platforms for

Fig. 1. *Formation flying with N42RF and N43RF, the NOAA WP-3D hurricane research airplalnes (NOAA Photograph).*

development of both airborne Doppler radar (Marks and Houze 1984) and microwave sensing of surface winds (Jones et al. 1981). The need to replace the STORMFURY mission led R. W. Burpee to initiate an effort to improve operational forecasting (Burpee et al. 1994) with special focus on synoptic surveillance to reduce track forecast errors through more detailed observation of the flow around the hurricane vortex, (Burpee et al. 1996, Aberson and Franklin 1999). Composites of airborne radar observations revealed the convective and mesoscale structure of hurricane vertical motions and hydrometeor distributions (Black et al. 2002). Operational highlights of the late 1980s were extrapolation of the lowest western-hemisphere sea-level pressure ever reported in Hurricane Gilbert (888 hPa) on 13 September 1988 (Willoughby et al. 1989) and the near loss of N42RF when it was damaged by an eyewall mesovortex during a low-level penetration of Hurricane Hugo a week before it passed onshore near Charleston, South Carolina, causing $7B in damage, the largest hurricane toll to that date.

Perhaps the greatest disappointment of the P-3's operational life was the decision by AOC management not to fly any research missions as Hurricane Andrew passed onshore in southern Miami-Dade County causing $25-30B in damage—the most expensive natural disaster in United States history. In the wake of Andrew, AOC and the P-3s moved from Miami International Airport to McDill Air Force Base near Tampa, Florida. Although the move complicated the logistics of hurricane research missions, it also resulted in much better aircraft maintenance

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and reliability through availability of hangers and generally improved facilities. A second positive outcome of Andrew was Congress' appropriation of funds to commission a Gulfstream IV jet airplane dedicated to synoptic surveillance, along with new dropsosndes based upon the Global Positioning System (GPS). The new dropsondes observed hurricanes' low-level wind structure in unprecedented detail, leading forecasters to adopt more accurate techniques for estimation of surface winds (Franklin et al 2003), and incidentally to reclassify Andrew from Category 4 to Category 5.

4. THE 21st CENTURY

Although synoptic surveillance, better assimilation of remotely sensed observations, and new generations of numerical models accelerated the improvement of track forecast errors, intensity forecasting remained a significant challenge---highlighted by the rapid intensifications of Andrew and of Hurricane Opal in 1995. Extensive, regrettably sparsely published, observations dating from the 1970s and results of a simple numerical model pointed to the importance of a warm ocean that stays warm and low vertical shear of the horizontal wind to rapid intensification. Additionally, sea-air interactions in the high wind regime are poorly understood. The dynamics of convection and Rossby waves in the highly rotational hurricane core and vortex interaction with environmental shear are of great theoretical and practical interest (Reasor et al. 2000). They are also ideal objects for observation by airborne dual-Doppler radar. Despite its addressing world–class scientific problems, HRD lost, and was unable to replace, a substantial fraction of its best scientists as a result of austere funding during the 1990s. After >35 seasons of hard flying, the WP-3Ds are becoming more expensive to maintain and operate. Nonetheless, they remain a unique and irreplaceable resource for airborne meteorological research.

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