7A.2 TROPICAL CYCLONE INTENSITY ESTIMATES USING SATELLITE DATA: THE EARLY YEARS

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In the 1960s and 70s advances in space technology resulted in an increasing number of weather satellites being placed in orbit. As the ability to provide weather pictures from space developed, meteorologists began to take advantage of these new data sources and come up with practical applications. This was particularly true with regard to the Joint Typhoon Warning Center (JTWC) where satellite reconnaissance of tropical cyclones was needed to augment the information provided by dedicated weather reconnaissance aircraft.

The development of weather satellites followed closely the first successful man made satellite, Sputnik, launch in 1957. The first successful weather satellite, TIROS I, launched in 1960, provided automatic picture transmission (APT) television camera visible and low resolution infrared (LRIR)(Berkowitz 1984) (Eikelman 1970). Improvements continued and in the early 1970s, the Data Acquisition and Processing Program (DAPP) and later Defense Meteorological Satellite Program (DMSP) polar orbiters (DAPP/DMSP history: web site) began supplying improved high resolution visible/infrared plus low light nighttime visible to Department of Defense (DoD) activities. It soon became evident that the science of building and orbiting spacecraft was outpacing the ability of meteorologists to understand and apply weather satellite pictures to operations.

In an effort to increase meteorological understanding in support of the tropical cyclone mission, an Air Force DAPP/DMSP tactical weather satellite terminal and a Technique Development cell were collocated with the JTWC on Guam in 1971. The development charter of the cell, that started with two officers and grew to four in 1973, was to develop techniques, using satellite data to provide tropical cyclone position, intensity and wind distribution information. Due to the high quality DMSP imagery, steady headway was being made with positioning and position code numbers (PCN). However, intensity estimation was proving to be a more difficult problem. Earlier papers by Fett (1966), Fritz, Hubert and Timchalk (1966) and, Hubert and Timchalk (1969) were studied, but it wasn't until Mr. Vern Dvorak (1973, 1975) shared his empirical technique, conceptual model, code and T numbers, that progress was realized.

Operational evaluation of the Dvorak technique by the Technique Development cell at JTWC described in 1WWP 105-10 (1974), stated the following, "…while it [the Dvorak technique] produces more representative intensity estimates than past methods several problems remain."

1) "…because DMSP data have better resolution than the data used by Dvorak in developing the technique…it is necessary to mentally smooth the finer details observed…"
2) "…while the use of the technique with visual data has proven successful, its use with infrared data has not."
3) "There has been no satisfactory theoretical basis developed to explain intensity changes predicted by the [Dvorak] model, or departures from expected changes which are observed in rapidly developing or weakening storms."

To satisfy problem 1, DoD satellite analysts learned to "squint". In answer to problem 2, Dvorak (1977, 1984) later adapted the pattern recognition technique to infrared pictures and developed the enhanced Infrared (EIR) technique, using his "BD curve" and gray scale code. As Dvorak was improving his (T-number) technique, Hebert and Poteat (1975) crafted a pattern recognition technique for subtropical (ST-numbers) cyclones.

The operational impact of tropical cyclone positioning and the Dvorak intensity estimation, using satellite data, on the JTWC warnings in the western North Pacific is shown in Figure 1 (Guard, etal 1992). For a 16-year period from 1972 to 1987, the gradual draw down of dedicated aircraft reconnaissance assets was roughly balanced by an increased operational reliance on satellite reconnaissance. Thus, for more than a decade, satellite reconnaissance techniques matured and stabilized in an environment where aircraft reconnaissance was available to provide a

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measure of ground truth. (Note: In 1988 the aircraft reconnaissance trace in the graph goes to zero due to the inactivation of the 54th Weather Reconnaissance Squadron, based at Andersen AFB, Guam, in the summer of 1987. The reason that neither aircraft nor satellite reconnaissance captured 100% of the JTWC warnings is related the fact that there are always a small number of warnings based on radar, synoptic fixes or extrapolation.)

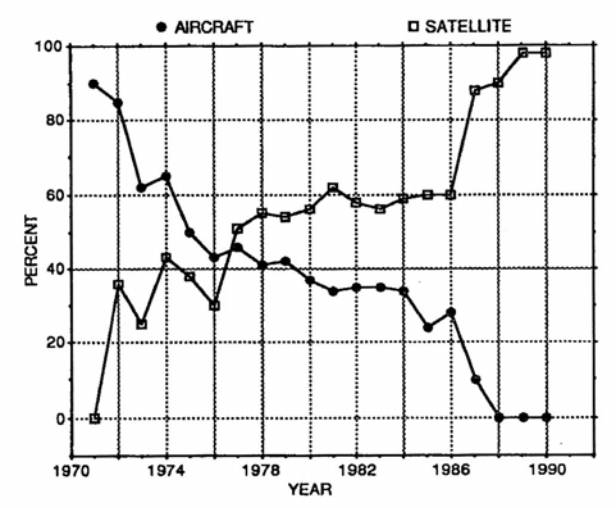

Figure 1. Reconnaissance platforms used for JTWC warnings in the western North Pacific.

In summary, Mr. Vern Dvorak's technique progressed from an empirical study to a conceptual model where it is shown that tropical cyclone development passes through certain recognizable classes that can be described by central and banding features. A key to the longevity of the Dvorak technique is contained in the quote from the 1WWP 105-10. "The [Dvorak] model will provide reliable estimates with data of poor quality, with conflicting evidence, inexperience on the part of the analyst, and variations in satellite camera system." For the past thirty years, Mr. Dvorak's practical insights and tools for estimating tropical cyclone intensity have proven invaluable operationally. Of interest, from the evaluation in 1974 (1WWP 105-10), the third problem remains. "There has been no satisfactory theoretical basis developed to explain intensity changes predicted by the [Dvorak] model, or departures from expected changes which are observed in rapidly developing or weakening storms." In the meantime, what Vern Dvorak has provided works.

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