8A.2 USES OF MICROWAVE IMAGERY AS A SUPPLEMENT TO THE DVORAK TECHNIQUE, AN INTEGRATED TECHNIQUE

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1. INTRODUCTION

The Dvorak tropical cyclone (TC) intensity technique (Dvorak 1975, 1984) has been successfully used over the data sparse regions of the tropical oceans for over 30 years. In most regions of the world it is the only method for assessing TC intensity. Even in the western Atlantic basin, where there is routine access to aircraft reconnaissance, the Dvorak analysis is performed for almost every forecast cycle. The Dvorak technique is still used today because 1) it can be used wherever visual (VIS) and infrared (IR) imagery are routinely available and 2) it is highly reproducible and relatively easy to apply. Special Sensor Microwave Imager (SSM/I) polar-orbiting data have been available to TC forecasters for almost 15 years; however, the low resolution (15 km at 85 GHz) and lack of continuous coverage make it an unlikely candidate as a replacement for the VIS/IR technique. With the launch of the Tropical Rainfall Measuring Mission (TRMM) Microwave Imager in 1997 both the number of available overhead passes and the resolution (7km at 85 GHz) have greatly improved. This now increases the viability of a microwave technique to serve as (at least) a supplement to the Dvorak technique. The microwave imagery (MI) has the ability to see rain and ice particle patterns within TC rain bands that are normally blocked by mid- to upper- level clouds in the IR and VIS imagery. This gives forecasters the ability to more directly deduce the three physical properties related to TC intensity as inferred by the empirical Dvorak patterns (see Guard, 2004): vorticity (and the related circulation position); shear; and convective vigor. In works such as Cocks et al. (1999), and Edson and Lander (2002), MI patterns are compared with similar Dvorak patterns and to the entire TC life cycle; however, a complete replacement scheme is unlikely from these less frequent polar-orbiting data sources. This presentation suggests several ways where the MI data can either supplement or help calibrate the Dvorak intensity technique and perhaps eventually lead to a combined satellite-based remote sensing technique.

2. EXAMPLES OF MI AS A SUPPLEMENT TO THE DVORAK TECHNIQUE

a) Improvement in positioning and identification of a low level circulation. The first important evaluation that a TC analyst makes is to determine whether a suspect area has a distinct surface circulation. When the lower cloud structure is not readily apparent, as at night or when obscured by higher clouds, there is often a disagreement between analysts as to whether a surface circulation exists, and if so, where it is located. The MI and scatterometer data more easily addresses this issue and also helps reveal the best pattern (e.g. banding versus shear) to use in the Dvorak classification.

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b) TC genesis and help with initial classification of T number 1.0 (T1.0). Today, with more detailed satellite-based information than ever before, there is often some confusion about when to start the Dvorak classification process since some features are evident well before the TC begins to intensify. This is less of a factor when using only VIS/IR imagery since convective organization meeting the initial T1.0 classification normally is seen just prior to intensification. Hence, the current process expects the TC to reach a classification of T2.0 (30kts) in 24 hours (based on a 'normal' trend). With scatterometer and MI data it is possible to see evidence of TC genesis and structure well before intensification begins. Procedures can be developed in the microwave data to identify early TC features that would pre-exist the T1.0 phase without being forced to T2.0 in 24 hours. This, in turn, would help with continuity and the understanding of the incipient TC. Examples such as an early appearance of a low-level circulation or trough axis or an increase in moisture and low level cloudiness in the boundary layer are readily identifiable in the MI and scatterometer data (Fig. 1).

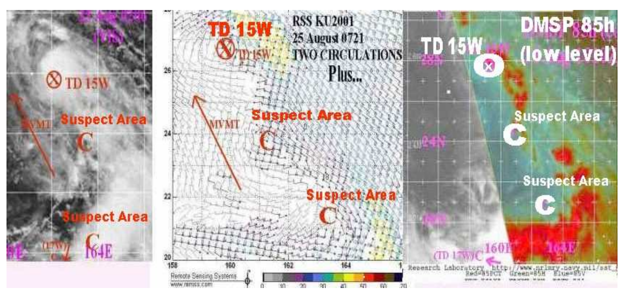
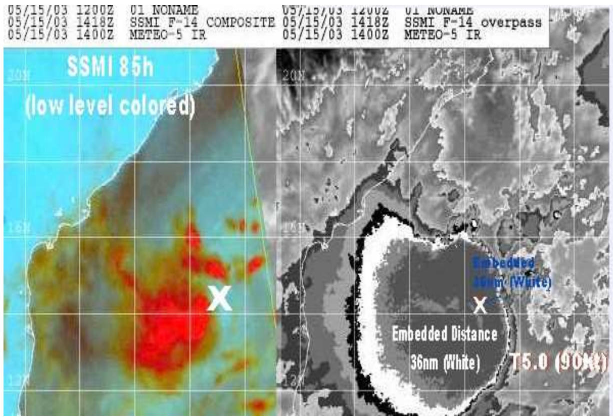


Fig 1. Combinations of data (visual, scatterometer and MI) offer more detailed information on the character of the pre-classifiable suspect area.

c) Determination of rapid development conditions. Dvorak has identified several environmental conditions that are precursors to rapid development (such as the shape of the outflow jet), but little discussion on the character of the convective organization during the crucial upper- tropical storm intensity (~50-55kts) time period when rapid intensification often begins. These features are normally obscured under the central dense overcast (CDO) in the VIS and IR. Patterns, however, exists in the MI that show increased organization and early eye development during this period that can be included into the current IR/VIS technique as signs that the three physical parameters of the TC (vorticity, shear and convective vigor) are quickly improving.

d) Improved positioning with the embedded IR technique. One of the most difficult periods of assessment of the TC with the (IR) Dvorak technique is the period when the low level center has moved under the CDO. In the embedded IR technique a T number can change from T3.5 (55kts) to T5.0 (90kts) with only a very small change in the low level center position (which is often just a guess in the IR/VIS). Precise positioning during this period with a combination of data, including scatterometer, MI and VIS will greatly increase the accuracy of the intensity assessment (Fig. 2).

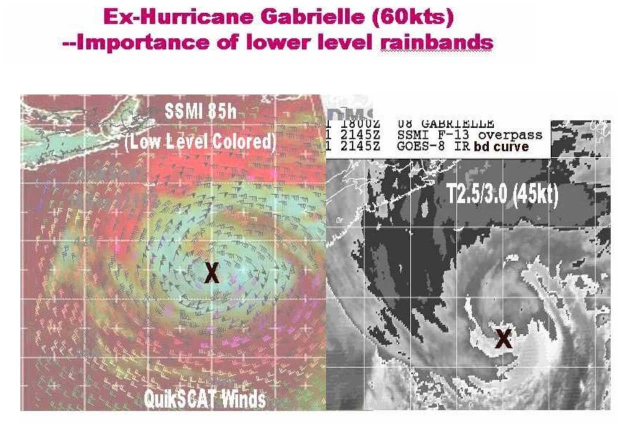


(Embedded Distance 36nm – T5.0, 90kt)

Fig. 2 Comparison between MI and IR data for TC01B provides for a greater degree of accuracy in measurements of the embedded distances.

e) Identification of peaking period, changes to the meteorological trend (MET), and initial weakening stage. Studies have shown that most satellite assessments tend to be too low during the intensification period and too high during the initial phase of the deintensificaiton period. The Dvorak technique allows for a change in the MET through a plus/minus indicator; however, this is rarely used since most changes under the convective canopy are not readily seen. The MI imagery has shown to be a good candidate to signal these changes. Prior to evidence in either the IR or VIS imagery (besides the disappearance of the eye) the MI often shows the loss of the deep convection in the 85GHz while still showing a strong circulation in the 37GHz imagery. In addition, the MI partially clarifies the source of a change in trend such as when an eyewall cycle occurs (versus a loss in deep convection due to SST, shear or dry air intrusion).

f) Dissipation and extratropical transition (ET). Another difficult assessment for the satellite analyst is the estimation of the surface winds during the TC dissipation or ET phase. During this period the deep convection often dissipates and moves away from the center quickly allowing for little objective assessment in the Dvorak technique. However, the effect on the surface winds is dependent upon the wind structure prior to the initial ET phase, the speed of movement of the TC, and the ability of the remaining weaker convection to push the stronger winds down into the boundary layer. Scatterometer data and MI (especially at 37GHz) show promise of indicating when the stronger winds still exist at the ocean surface (see Fig 3).



(T2.5/3.0 (45kt)

Fig. 3 Scatterometer winds overlayed over MI imagery provide an effective picture to enhance the Dvorak technique during extratropical transition.

3. FUTURE WORK AND REMARKS

This paper has offered some suggestions for where the addition of microwave data can best supplement the current Dvorak intensity technique. These procedures offer almost immediate improvement in the consistency and accuracy of results among different analyst. However until more development is performed (and with even more extended MI coverage), the Dvorak technique is likely to remain the primary satellite-based remote sensing technique for TC intensity determination for a while longer.

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