Current Methods of Tropical Cyclone Analysis using Microwave Imagery and Data

(Why Can’t Operational Forecasters Supplement this into the Dvorak Technique?)

by

Roger T. Edson
Science and Operations Officer
NOAA/NWS WFO Guam, USA

31st Conference on Hurricane and Tropical Meteorology
American Meteorological Society
31 March – 4 April 2014
San Diego, California
Satellite-based Analysis of Tropical Cyclone Outside of the Atlantic Basin:
(No aircraft reconnaissance)

Primary means of evaluating tropical cyclones

--Synoptic data (scarce)
--Radar (localized)

(and so, still!)

**Dominated by visual and infrared satellite imagery AND the (IR) Dvorak Technique that is over 30 years old**
Outline of Talk

Where can Dvorak be supplemented with Microwave Data

(from Peter Black, “Roger, It has already been done”
   Roger, “Uh? Then why do operational agencies have such different positions and intensities and make so many ‘mistakes’”)

-- Position

-- Genesis (plus dissipation)

-- Intensity/Change of Intensity

-- Structure and Structure Change

p.s. See Anthony Salemi and Mike Turk’s work 9C.5**
Reasons for non-use of these data in operational setting

- Timing of Availability
- Failure to go back and 're-best track'
- Too many tasks
- Not working as a 'team' with the forecaster/analyst (afraid to offer something different: culture???)
- NOT advocated and championed by experienced Middle Managers (OJT)
Comparison between JTWC and JMA (non-agreement between TC centers)

• 1’ vs. 10’
• Modification to high end scale (based on an observation study by Koba, et al. 1991)
• See T# correspondence (however, satellite interpretation of definition of T# is the same)
• However, (except for the intensities of high-end TCs) this is NOT the primary reason for the differences
<table>
<thead>
<tr>
<th>T Number</th>
<th>JTWC (1min)</th>
<th>JMA (10min)</th>
<th>10’ to 1’</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>30</td>
<td>30</td>
<td>33.6</td>
</tr>
<tr>
<td>2.5</td>
<td>35</td>
<td>35</td>
<td>39.2</td>
</tr>
<tr>
<td>3</td>
<td>45</td>
<td>45</td>
<td>50.4</td>
</tr>
<tr>
<td>3.5</td>
<td>55</td>
<td>55</td>
<td>61.6</td>
</tr>
<tr>
<td>4</td>
<td>65</td>
<td>65</td>
<td>72.8</td>
</tr>
<tr>
<td>4.5</td>
<td>77</td>
<td>70</td>
<td>78.4</td>
</tr>
<tr>
<td>5</td>
<td>90</td>
<td>77</td>
<td>86.2</td>
</tr>
<tr>
<td>5.5</td>
<td>102</td>
<td>85</td>
<td>95.2</td>
</tr>
<tr>
<td>6</td>
<td>115</td>
<td>93</td>
<td>104.7**</td>
</tr>
<tr>
<td>6.5</td>
<td>127</td>
<td>100</td>
<td>112.0</td>
</tr>
<tr>
<td>7</td>
<td>140</td>
<td>107</td>
<td>119.8</td>
</tr>
<tr>
<td>7.5</td>
<td>155</td>
<td>115</td>
<td>128.8</td>
</tr>
<tr>
<td>8</td>
<td>170</td>
<td>122</td>
<td>136.6</td>
</tr>
</tbody>
</table>
Break Down of the Dvorak Technique

- Unwilling to accept/supplement (even repetitive) scatterometer data
  - (clearly not a 1' to 10' scenario)
Many MI instruments (and many coming on line)
Possible ways to Supplement the Dvorak Analysis with Microwave Imagery
(this is not the first time that I presented this)

- Provide for an integrated positioning technique (spiral band curvature and shear)—Don’t need automated techniques
- Precision in use of embedded IR technique (MI eye)
- TC life cycle supplement (in MI)—PATTERN T#
- Early genesis identification (pre-T#1)
- Identifying both potential ‘rapid’ and ‘delayed’ intensification scenarios (‘MET’), Use of PLUS/MINUS
- Identification of ‘peaking’ and ‘MET’ changes MINUS
- Intensities during Extratropical Transition and dissipation scenarios (MUST use other data)
- Integration with ‘other’ techniques, including use of AMSU, Scatterometer, AODT, SATCON, etc.
Positioning

- STILL using (1) IR
  
  (2) “Multi-spectral” (IR/VIS)
  
  Really should mean, “MULTI-spectral”: IR/VIS/MI/SCAT! (animated)
  
  (Even Archer method goes back and finds the highest confident fix!)

Simple Rules: STOP using (only) IR...SYSTEMATIC POSITIONING

- Meteorological Training (automated techniques be aware)!!!

-- MUST position in the surface trough (light wind and cyclonic curvature...NOT in the strong winds, may look for weakening tendency of winds, though): MI and Scatterometer, VIS animation

-- Avoid putting UNDER the convection
  
  (Low pressure falls within the warming subsidence in-between CBs)

-- Keep your eye on the surface center

-- (Don’t be swayed by mid-atmospheric ‘twirls’ in the vorticity)
Animated 36Ghz Imagery
(Tropical Depression Sudal – 4 April 2004)
Where do you look for the center?
Combine MI with Scatterometer
Rules for using Scatterometer Data

TC Genesis

- Position the center in the low wind/light rain region
- Look along trough axis and examine ambiguities
- Place along (meridional) axis closest to strongest wind gradient and curvature
- In NRCS, look for broad 'dark' area
- Must coincide with other data (expect one (1) center...and if 'others' must be also in trough axis)
Pre-Typhoon Yutu South of Chuuk
(“Typical TC Genesis”)
Finding Centers and Development in a Monsoon Gyre
TD developing from Monsoon Circulation 16W (Man-yi)

Scatterometer Winds and TRMM 85h
TD developing from Monsoon Circulation 16W (Man-yi)
TD developing from Monsoon Circulation 16W (Man-yi)
PSN 13.9N 136.7E

Strong Wind region

Light Wind region

trough axis
Pre-Genesis....No Surface Moistening
Surface Moistening (Pre-Typhoon Francesco)
Microwave 85 and 37GHz

You can see the low Level CU line in the MI through the cirrus
Scatterometer shows development just like the IR
Not all rain contamination!
Structure and Pre-existing Wind Field
How to handle pre-existing wind field

- Describe it in the warning as ‘away from the center’
-- Expect some influence once wrap-around occurs
Intensification

Super Typhoon Utor (11W)
August 2013
Tropical Cyclone Lifecycle in Microwave Imagery (Pattern MI T#)

I. TC Genesis Stage ~25-30kt
II. Early Intensification and Development ~30-45kt
III. Continued Intensification and Mature Stage
IV. Peaking and Initial Weakening Stage
V. Dissipation and Extratropical Transition
Comparison of Dvorak patterns with first 3 MI Stages in a TC Life Cycle

<table>
<thead>
<tr>
<th>MI Stages</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEVELOPMENTAL PATTERN TYPES</td>
<td>PRE STORM</td>
<td>TROPICAL STORM</td>
<td>HURRICANE PATTERN TYPES</td>
</tr>
<tr>
<td></td>
<td>PRE STORM</td>
<td>TROPICAL STORM</td>
<td>HURRICANE PATTERN TYPES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MINIMAL</td>
<td>STRONG</td>
</tr>
<tr>
<td>CURVED BAND</td>
<td>T1.5</td>
<td>T2.5</td>
<td>T3.5</td>
</tr>
<tr>
<td>PRIMARY PATTERN TYPE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CURVED BAND</td>
<td>PRE ONLY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EIR ONLY</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CDO PATTERN TYPE</td>
<td>VIS ONLY</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SHEAR PATTERN TYPE</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Stages 4 and 5 not in Dvorak
Too much Spiral Band Curvature (SBC)

We should be able to improve on this part of the Dvorak Technique.
Stage 2 – Shear pattern (35kts)

Each system may require a varied set of microwave imagery to best bring out the best features.
Pattern ‘C’: LLCC present and convection < 250 K forms hooks, claws or broken rings: AVG INTENSITY = 57 kts
**there may be many other quantitative measurements**

(From Cock et al.)
Identifying CCC Pattern with MI data

Review of a 'Hot Tower' under a Central Cold Cover (CCC) Burst
Tropical Cyclone Lehar (05B), 27 Nov 2013 - 0230 UTC

Note: CCC usually occur at T3.5 (55kt) and under the Dvorak technique, this is a (temporary) arrested development, or a 'hold' on a T# per day. Quite often intensification occurs within 12 hours at a equal or greater rate of intensification.

Visual

(CCC)

(overshooting tops)

SSMIS 91h

(Hot Tower or Burst)

SSMIS 36color

(Hot Tower or Burst)
Nice View in the 37Ghz Imagery
EVALUATIONS OF CAT5/SUPER TYPHOONS (85h)

VIEWS: Time changes in red inner eyes

TC Susan 70kt - 26hr

TC Susan 95kt - 13hr

TC Susan 120kt - 06hr

STY Zeb 95kt - 24hr

STY Zeb 140kt - 00hr
Eye-Wall Replacement Cycle

12hr Trend of Hurricane Katrina (85h and IRbd)
~28/12Z to 29/00Z

Weakening

Last 3hrs

IRbd

Overnak Curve
Note: Above 35kt, 30kt/24hr is not rapid!!
Examples of TC Rapid Intensification - Early

Rapid Intensification of Hurricane Frances
August 2004 (early stage)

37 GHz 60-65kt

85h GHz 26Aug1049Z

25Aug2321Z

25Aug1959Z

35kt
ASCAT and Extra-Tropical Transition Winds ‘ok’ 50-60kts
BTW: Critical Need for WMO to require reporting of ‘peak wind’ since the last reporting time!
TC Centers and TC Forecasters

IR Dvorak CANNOT (should not) work by itself

Initial Stages should be ‘modernized’

Only an integrated/combined satellite analysis will improve TC Analysis (and Forecasting)

Now is the time!
Questions?