

On the Application of the Dvorak Technique in the Satellite Analysis Branch



66th Interdepartmental Hurricane Conference
Charleston, South Carolina
March 6, 2012

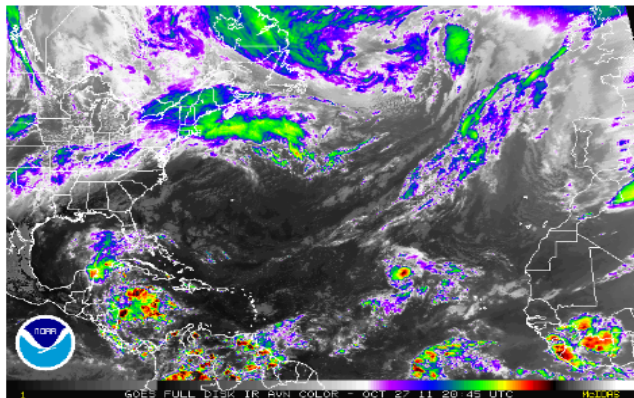
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Satellite Products & Services Division
NOAA/NESDIS

<http://www.ssd.noaa.gov/PS/TROP/>

North Atlantic Tropical Products

Active Storms:

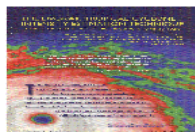
Storm Name	Storm ID	Dvorak Intensity	Last Classified	Basin
RINA	18L	T3.0/4.0	27/1745Z	Atlantic



World | Atlantic | East Pacific | Central Pacific | West Pacific
North Indian | South Indian | South Pacific | South Atlantic | Med Sea

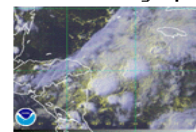
SPSD Tropical Program Products:

Dvorak Classifications



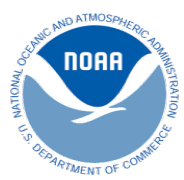
Subjective position and intensity estimates of tropical disturbances and cyclones across the globe using the internationally recognized Dvorak technique.

Satellite Imagery



Static and animated imagery of tropical disturbances, tropical cyclones and Atlantic areas of interest. Users have the ability to overlay a variety of data on animated imagery loops of tropical storms.

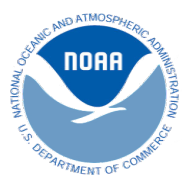
[Storm Floaters](#) | [Atlantic Imagery](#)



Core Dvorak Docs Used at SAB



- Dvorak (1984)
- Notes on the Dvorak Technique
(Andrew Burton, Bureau of Meteorology)



SAB Pre-2006: Experience Reigns



- As recently as 2006, SAB was unaware of how the PT was to be determined.
 1. The requirement that the PT must be within 0.5 T of the MET was violated on numerous occasions and sometimes to a ridiculous degree.
 2. The PT was, at best, a match between the patterns in Dvorak (1984) and what appeared in current imagery; at worst, it was the “gut” feeling of the analyst

- Nor was there an appreciation for determining the FT based on:
 1. The DT when cloud features are clear cut;
 2. The PT when cloud features are not clear and adjustment to the MET is made;
 3. Otherwise the MET

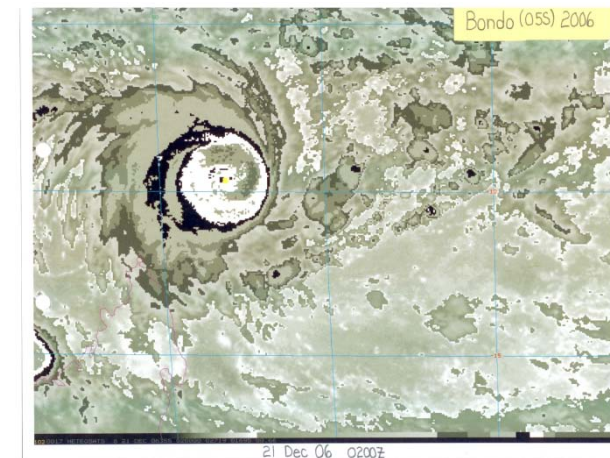
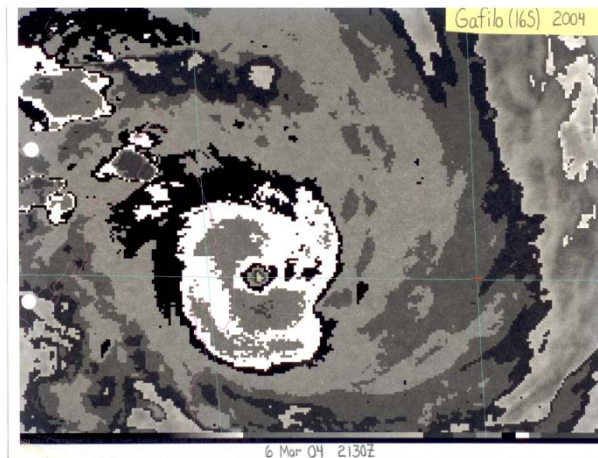
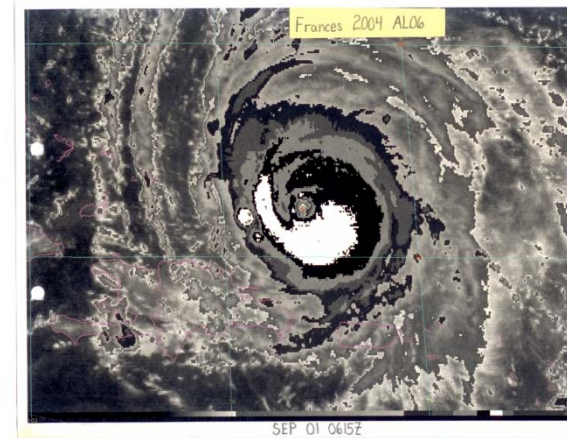
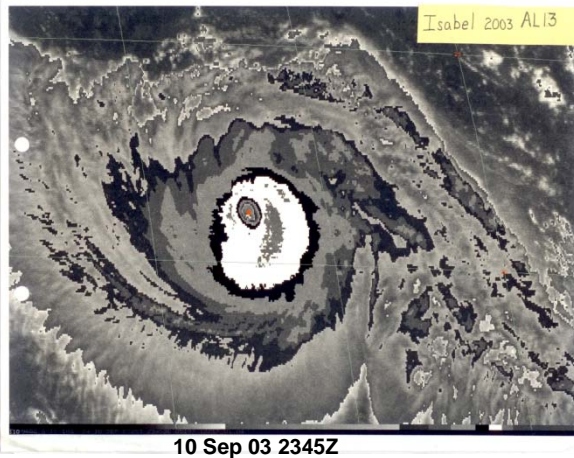
- CI rules for weakening systems were applied inconsistently
 1. Hold CI to the highest FT during the preceding 12 hour period
 2. But never more than 1 above the current FT

- The analyst felt “pressure” to ensure that the DT=FT regardless of how clear cut the cloud features were.
 1. “Experienced” analysts could look at an image
 2. “Know” the DT and only then
 3. Determine, for example, the amount of banding that was (or must) be present

- Banding features (BF) added indiscriminately, even in the absence of actual banding, to ensure the DT could serve as the basis for the FT

Erroneous Banding Additions

0.5 T-no was added as a BF in each of these nighttime cases...



...even though no clear-cut comma tail band existed



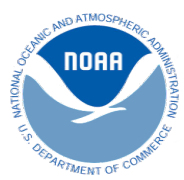
Errors in CI Number During Weakening

Ivan (AL09) 2004		
Date/Time	FT	CI
14/1745Z	5.5	6.5
14/2345Z	5.5	6.0
15/0645Z	5.5	6.0 5.5
15/1145Z	5.0	6.0 5.5

Ivan (AL09) 2004		
Date/Time	FT	CI
09/1145Z	6.5	7.0
09/1745Z	6.5	7.0
09/2345Z	6.5	7.0 6.5
10/0645Z	6.5	7.0 6.5

Beryl (AL02) 2006		
Date/Time	FT	CI
20/0545Z	3.5	3.5
20/1145Z	3.5	3.5
20/1745Z	3.0	3.5
20/2345Z	2.5	3.0 3.5

Florence (AL06) 2006		
Date/Time	FT	CI
11/1145Z	4.0	4.5
11/1745Z	3.5	4.0
11/2345Z	3.0	4.0
12/0645Z	3.0	4.0 3.5



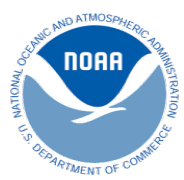
SAB Post-2007:



Increased Awareness/Uniformity

Analysts now have a good sense of:

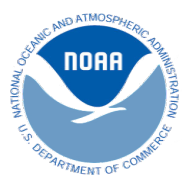
- How to determine the PT
- The proper basis for the FT considering the DT, PT and MET
- Requirements for achieving DT of 2.5 or greater using shear pattern
 1. LLC defined by parallel, circularly curved low cloud lines near or under...
 2. An overcast with a diameter greater than or equal to 1.5 degrees latitude.
- When a banding feature addition may be used when only EIR is available:
 1. CF is 4 or more;
 2. T-number estimate w/o BF is lower than the MET;
 3. System contains a clear cut comma tail band that...
 4. Curves $\frac{1}{4}$ or more of the distance around the CF or comma head,
 5. Is cold (MG or colder), and
 6. Has a warm edge (DG or warmer) between the tail and the CF that cuts at least half to $\frac{2}{3}$ of the way through the pattern
- No “plus” eye adjustment for large eyes or elongated eyes
- For elongated eyes, if no previous subtraction has been made, subtract 0.5 for Eno greater than or equal to 4.5



Experience vs Technique?

Years	RMS Psn Error (nm)	RMS Int Err (kt)
2001-2	20.5	19.8
2003-4	19.7	10.3
2005-6	17.4	10.7
2007-8	15.6	10.5
2009-10	23.0	10.4
2001-5	18.9	10.2
2006-10	19.5	10.7

- SAB position and fix errors for tropical cyclones made within an hour of synoptic time and within an hour of a recon fix
- Intensity errors are up since 2006 (but increases may not be statistically significant)
- NHC also noted a low bias of 2.9 kt over the 2009-10 period
- Do these results suggest that the loss of experience trumps stricter adherence to the Dvorak technique? Might the intensity errors have been greater since 2006 without the stricter adherence to the Dvorak technique? Would the combination of experience and stricter adherence to the technique provide better results than experience alone?



SAB Local Variations



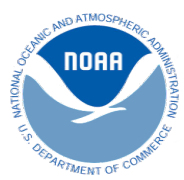
- Maximum allowable change of FT for (developing) storms above T1.5 and 24 hours or more after the initial T1.0:
 1. 1.0 in 6 hrs; 1.5 in 12 hrs; 2.0 in 18 hrs; 2.5 in 24 hrs
 2. These rules are considered to be an allowance, not a requirement
 3. Traditional rules (0.5 in 6 hrs; 1.0 in 12 hrs; 1.5 in 18 hrs; 2.0 in 24 hrs) encouraged for disturbances, depressions and weak tropical storms to account for diurnal effects

- Managing Land Interaction—what to do upon emergence back over water?
 1. FT and CI may be set to the DT when a system has spent a considerable amount of time over land or an even shorter time over very mountainous terrain
 2. MET is undefined

- For weakening systems, hold the CI to the highest FT during the preceding 12 hr period, but never more than 1.0 above the current FT. CI never constrains the FT.

- Managing Extreme Intensification Rates
 1. Rules governing changes in T-no should be broken when the average DT calculated once each hour for the 6-hr period ending at the classification time is in excess of the constraints governing changes in FT over time.
 2. Same logic may be applied to extreme weakening rates
 3. ADT initial raw (e.g., *Ini Raw*) T-nos may be averaged over 6-hr intensification period ending at classification time if the ADT is successfully resolving the eye throughout the period

- Terminate Dvorak classifications once extratropical transition *begins*



SAB Uncertainties

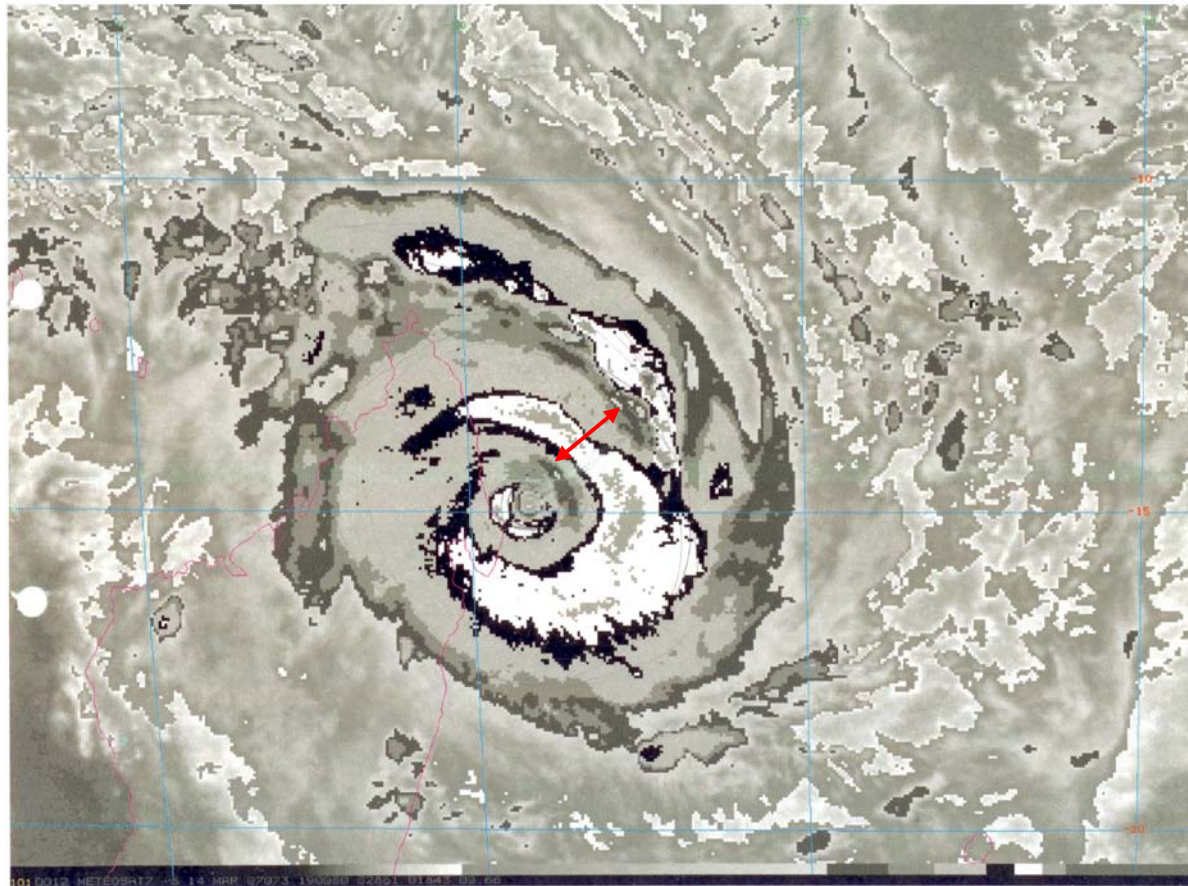


- Subtropical Cyclones (Hebert-Poteat method)
 1. Analysts have much less experience
 2. Technique is more descriptive than quantitative
 3. Uncertain on rules of weakening and how to codify
 - SAB provides a single ST number (e.g., ST2.5 not ST2.5/2.5) based on maximum wind speed (MWS)
 - SAB does not apply any rules of weakening/changes in ST number over time—ST number is based solely on best estimate of MWS at classification time

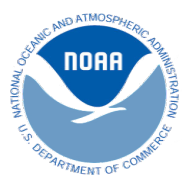
- Eyewall Replacement Cycles (ERC) or Concentric Eyewalls
 1. Presents challenges to Dvorak due to presence of warm moats
 2. SAB accepts coldest grey shade that meets min width requirements regardless of its location relative to the eye (i.e., min width might be met in outer ring at radius beyond warm moat)

- Monsoon Depressions
 1. Dvorak cannot accurately depict intensity since it was designed to identify TC intensity based on a convective pattern around the central features of the TC
 2. Pre-existing background winds are not well described

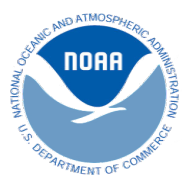
How Best to Handle ERC?



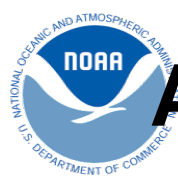
- Look outside the warm moat for the surrounding gray shade that satisfies the minimum width criteria.
- LG in the case above for Eno of 5.0. WMG eye surrounded by LG gives Eadj of 0.5.
- DT=5.5



Questions?



Additional Information



Ancillary Data Used in SAB: Positioning

1. Microwave Data

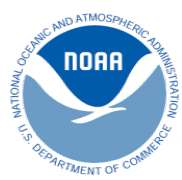
- Must be analyzed just prior to performing Dvorak analysis *except when*:
 1. Eye is apparent in conventional satellite imagery at classification time
 2. Circulation center is completely exposed in VIS/EIR at classification time
 3. Analyst does not feel MW can be fixed accurately
- Correction issued to Dvorak fix when subsequent MW data within 90 min of subjective Dvorak suggests position is outside analyst's stated accuracy

2. Shortwave Infrared Imagery

3. Scatterometer data

4. Advanced Dvorak Technique (ADT)

- Provides fix positions based on 1 of 4 methodologies: interpolation of RSMC (NESDIS version only) or JTWC forecast (FCST), spiral analysis (SPRL), combination of spiral and ring analysis (COMBO) or extrapolation of ADT history file (EXTRP)
- ADT FCST positions may be used by analysts
- ADT positions derived from EXTRP should NOT be used



Ancillary Data Used in SAB: Intensity



1. CIMSS Satellite Consensus (SatCon) Estimates

- SAB evaluation has shown SatCon estimates to be superior to SAB's subjective Dvorak estimates in the Atlantic
- Use with caution when TC eye is smaller than AMSU FOV
- SatCon estimated pressure is converted to a T-no using P/T-number conversion found in Dvorak (1984)
- SatCon estimate used to inform future Dvorak intensity estimates

2. ADT

- Examination of raw T-no can signal rapid intensification provided the eye is resolved which may require suspension of Dvorak rules...
- ...when avg ADT raw T-no over the 6 hr period leading up to and including current classification time breaks constraints

3. Microwave Imagery

- Banding type eyes appear in MW imagery at a CI of 3.0
- Bona fide eyes appear in MW imagery at a CI of 3.5 and greater

4. Polar IR Data

- Used to assess temperatures of small (generally < 10 nmi wide) eyes
- Larger eyes when TC is on edge of a geostationary satellite's FOV