The UW- CIMSS
Advanced Dvorak Technique (ADT):
An Automated IR Method to Estimate Tropical Cyclone Intensity

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**Motivation**

The ADT was developed to provide tropical cyclone (TC) forecasters with a purely objective tool to estimate TC intensity using geostationary satellite imagery in regions where aircraft reconnaissance and other data are not available.

The ADT is based upon the Dvorak Technique (DT), a “decision tree” methodology, which primarily relies upon human interpretation of cloud patterns in satellite imagery to derive TC intensity. The major drawbacks of the DT are its inherent subjectivity and time required to master its regional subtleties.

The ADT represents an attempt to advance beyond the limits of the DT while still retaining its basic philosophy. The ultimate goal is to provide an objective tool that yields reliable TC intensity and structure information to help improve forecasts.
### Background

The original/subjective DT is a “top-down” flow chart methodology which guides the TC analyst to an estimated storm intensity through a series of steps focusing on:

- **The current storm presentation** (“scene type”) in the satellite image
- **Recent storm history** (and model “expected” current intensity)
- **Various constraints** regarding the allowable strengthening/ weakening rates.

### The Advanced Dvorak Technique

**Background**

- **The Dvorak Technique**
  - A subjective DT
  - A series of steps focusing on:
    - The current storm presentation (scene type) in the satellite image
    - Recent storm history (and model “expected” current intensity)
    - Various constraints regarding the allowable strengthening/ weakening rates.

### Procedure

1. **Start**
   - Locate the “CCW” at the front of all curved cloud lines or bands.
   - For initial development (ID), see Step 1a.

2. **Analyze using pattern**
   - Follow when possible, then go to Step 3.

3. **Current Band Pattern**
   - Features located along 10° (long spin).

4. **Eye Pattern**
   - Center definition in the eye.

5. **Center and Core” Pattern**
   - Core location within the convective core.

6. **Center Core Cover” Pattern**
   - When post 24-hr (25) maintain model forecast.
     - When post 12-hr, hold 12. 12-hr forecast.
     - When post 1-hr, hold 24. Use as fast tem, then go to Step 3.

7. **Top Determination**
   - Use data in one from Step 2 when cloud features are clear.
   - Use pattern when BT is not clear and adjustment to MET is made.
   - For other cases, use the MET.

8. **Current Intensity**
   - Unit C or “final” TBT, except when final TBT should change to weakening trend or when rapid development is indicated.
   - For other cases, use the BBT. To determine the 1-hr forecast, add 12-hr forecast to the initial deviation to the increments equation.
This enhancement is known as the "Dvorak Hurricane IR Curve for Tropical Cyclone Classification" and is applied to infrared (11μm) imagery. Each different black/white/gray shade corresponds to a specific cloud-top temperature range and represents different intensity classifications in the Subjective Dvorak Intensity Classification Technique. (NOAA Technical Report NESDIS 11, 1984)

The ADT utilizes this “BD Curve” but has modified the relationships between the cloud-top temperatures and TC intensity using statistical regression analysis and additional/new cloud characteristic parameters.
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ADT Development Timeline

1980s
Dvorak objective EIR technique outlined (Dvorak, 1984)

Late 1980s – 1990’s
Digital Dvorak (DD) technique (Zehr, 1989)

1995 - 2001
Objective Dvorak Technique (ODT)
(Velden et al., 1998)

2001 - 2004
Advanced Objective Dvorak Technique (AODT)
(Olander et al., 2002)

2004 - present
Advanced Dvorak Technique (ADT)
(Olander and Velden, 2007)
The ADT utilizes imagery from the longwave infrared window channel (~11µm) from most of the current, operational geostationary satellites available. The algorithm is constantly updated to utilize any new satellites as they come online, and the data is made available. In addition, a current NESDIS/ CIMSS/ CIRA study is underway using simulated data to determine the potential impact of the upcoming GOES-R Advanced Baseline Imager (ABI) imagery on the ADT algorithm.
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ADT Information

- The ADT retains many of the qualities of the original Dvorak Technique, such as scene type determination and various intensity time constraints.

- A completely automated and objective TC storm center determination scheme has been implemented to remove all subjectivity from the ADT analysis. However, an ADT user has the option to modify/over-ride the objectively-chosen location, or scene type determination (e.g. ‘pinhole’ eyes are difficult).

- The ADT code can be installed within a McIDAS environment (now a core McIDAS routine) or integrated within a separate satellite analysis platform (e.g., a version now operates in the NWS N- AWIPS system).
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ADT Flowchart - Overview

Get User Inputs

Intensity Analysis? Yes
   Center Positioning?
   Automated
       Read Forecast
       SC/RF Analysis
       Select Center Fix

TC Over Land? Yes
   Perform Scene Analysis
   Calculate Intensity Estimates

No
   List/Graph History File

Manual
   Read Cursor Location

Manual Scene Override?

Yes
   Output ADT Analysis

Write History File
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ADT Flowchart – Scene Type Determination

1. Perform Scene Analysis
2. Determine Eye and Cloud Region Temperatures
3. Perform FFT Analysis on Eye and Cloud Regions
4. Calculate Convective Symmetry and Eye Region Std Deviation Values
5. Derive Eye and Cloud Region “Scene Scores” (based on various environmental analysis parameters)

- **Cloud Scenes**
  - Shear: Calculate Distance to Convection
  - Curved Band: Perform 10° Log Spiral Analysis

- **Eye Scenes**
  - CDO: Measure CDO Size
  - Embedded Center Check: Pinhole Eye Check
  - Eye: Determine Eye Size

- **Determine Scene Type From Scene Scores**
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ADT Flowchart – Intensity Estimation

[Diagram]

1. Calculate Intensity Estimates
2. Derive Raw T# Value (based on analysis of current image)
   - Regression Analysis for CDO/Eye Scenes
   - Convective Curvature for Curved Band
   - Distance to Convection for Shear
3. History File Utilized? (Yes or No)
   - Yes: Apply Dvorak Technique “Rule 8” Constraints (to limit growth/decay of Raw T# over time)
     - Adj Raw T#
     - Calculate Time Averaged Final T# Values
     - 6-hr Weighted Average and 3-hr Average
     - Determine Current Intensity CI# Value
     - Apply Dvorak Technique “Rule 9” Weakening Rule
     - Implement East Pacific Rapid Dissipation Rule
4. Output Intensity Estimate Values

Compute MSLP Latitude Bias Adjustment
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**Validation**

*Homogeneous comparison between ADT and Operational Forecast Center (OFC) DT estimates of TC Central MSL Pressure (in hPa)*

*Ground Truth: Coincident aircraft reconnaissance reports*

**Atlantic TCs - - 2006**

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*(Negative bias = ADT over-estimate)*
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Hurricane Ioke/Super Typhoon 01C

ADT v7.1 and v7.2 versus JTWC Best Track MSLP intensity estimates

Pressure (hPa)

August/September 2006
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Hurricane Felix

ADT versus Reconnaissance MSLP/Wind Speed

Legend
- ADT Wind
- Recon Wind
- ADT MSLP
- Recon MSLP

Mean Sea Level Pressure (hPa)

September 2007
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Future Directions

➢ Continue improving scene identification scheme
  ◦ Utilize auto-centering techniques in (pinhole) eye identification

➢ Explore regression analysis for other scene types
  ◦ Target shear and curved band scenes

➢ Examine methods to improve intensity estimates
  ◦ Multi-channel methods such as WV/IR difference (see poster)
  ◦ Possible microwave imager “Dvorak-type” analysis
  ◦ Explore TC stage breakdowns (formation, mature, dissipation)

➢ Continue ADT integration within UW-CIMSS Satellite Consensus (SATCON) TC Intensity Algorithm (see poster)
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Current ADT User Sites

Operational Usage
- NOAA/Tropical Prediction Center
- NOAA/Satellite Analysis Branch
- NOAA/Central Pacific Hurricane Center
- Joint Typhoon Warning Center
- Australian Bureau of Meteorology (Melbourne and Perth Regional Offices)

Experimental or Research Usage
- Japan Meteorological Agency
- Shanghai Typhoon Institute of China
- National Typhoon and Marine Forecast Center - China Met. Adm.
- The Meteorologist Department - Thailand
- Cooperative Institute for Meteorological Satellite Studies


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