

JP8.3 ESTIMATING HURRICANE STRENGTH USING MULTIPLE INTEGRATED SATELLITE DATA SOURCES

Christopher Velden, Derrick Herndon, Tony Wimmers, Timothy Olander, and Jeff Hawkins¹

University of Wisconsin – Cooperative Institute for Meteorological Satellite Studies

¹Naval Research Lab, Monterey, CA

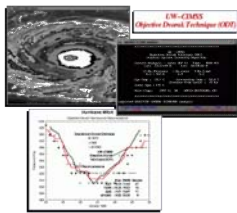
Introduction and Motivation

Several existing or promising satellite-based methods to estimate tropical cyclone (TC) intensity are available to forecasters today. Some of these, such as the IR-based Dvorak Technique, have been utilized operationally for over 30 years. Others, such as those based on microwave data, are experimental. Each of the methods by themselves represents or promises significant contributions to TC intensity analysis. However, each technique (or instrument that it is based on) also has its limitations. An effort is underway at CIMSS to build an integrated satellite-based algorithm that is fully automated and objective, and utilizes a multispectral approach. This system builds on, and takes advantage of, the latest science advances in existing (and emerging) methods.

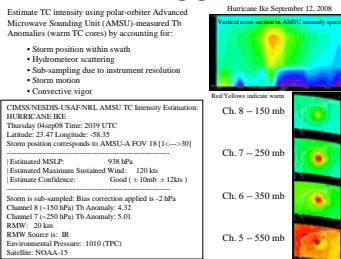
Corresponding author: Chrisv@ssec.wisc.edu

Current Satellite-Based TC Intensity Estimation Methods Developed at CIMSS

ADT



AMSU



For a complete description of the objective and fully automated Advanced Dvorak Technique (ADT), see the Web site and paper by Olander and Velden: <http://cimss.ssec.wisc.edu/tropic2/misc/adf/info.html>

For more information visit amsu.ssec.wisc.edu

Overall Performance

ADT Validation Statistics

Independent test data sample of 190 cases in 2006 vs. recon aircraft reports

MSLP (hPa)	Bias	RMSE	Mean Err.
ADT (auto/objective)	-2.77	8.21	6.10
Op Center (manual)	-3.16	9.01	6.54

CIMSS AMSU algorithm performance for storms for 2007-2008 using latest algorithm logic

MSLP (hPa)	CIMSS AMSU	Dvorak
Bias	-0.1	-2.7
Mean Error	4.9	6.0
RMSE	6.6	7.9
N	225	225

Situational Performance

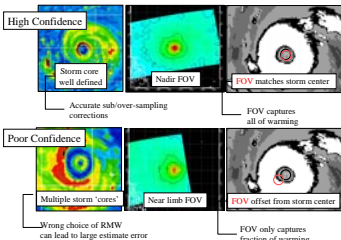
- Info can be employed by integrated algorithm through weighting -

ADT Statistics Stratified by Scene Type (Large sample of cases 1996-2006)

MSLP (hPa)	Bias	RMSE	MeanErr	N
All Scenes	-4.38	13.08	9.67	2022
All Eye Scenes	-3.52	15.12	10.57	623
All No Eye Scenes	-4.83	12.01	9.13	1399
CDO	-5.78	14.19	10.71	521
Curved Band	-3.77	10.80	7.61	559
Shear	-2.72	9.21	7.28	319

These statistics are given in hPa to assess the performance in familiar intensity units. However, for situational weighting purposes, the use of the Dvorak T-Number units to discriminate performance is superior, since T-Number increments account for the nonlinear relationship between MSLP and Vmax at different intensity bins.

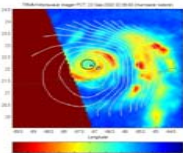
AMSU Confidence Scenarios



Multi-Sensor Information Sharing

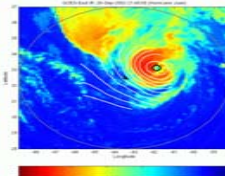
Improved TC Center-Fix Methods

Important for the initialization of the ADT and AMSU intensity estimation methods



Two methods based on the study summarized in Wimmers and Velden, 26th AMS Hurr. Conf.

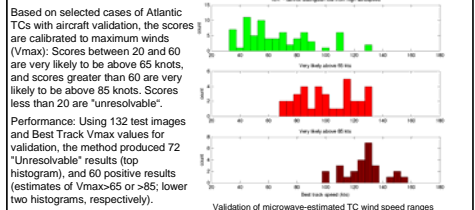
Using passive microwave. Example: TRMM Microwave Imager (TMI) overpass of Hurricane Isidore (2002). "PCT" is a weighted difference between vertical and horizontal polarizations that indicates scattering by ice crystals and is a proxy for precipitation. Forecast center, triangle; spiral-fitting score field, white contours; optimum spiral center, square. The ring is final selection of the eye, with center of this ring the final TC center fix location.



Using IR data. Example: GOES IR image of Hurricane Juan; initial guess of TC center based on a short-term track forecast, black triangle; spiral-fitting score field, white contours; area used in calculating the score field, gray circle; optimum eye ring, black circle.

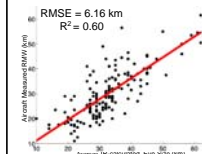
Eye/Eyewall Structure Parameterization

An automated passive microwave image analysis scheme has been parameterized to enhance the ADT, especially designed for central dense overcast scenes in situations with developing TC eyes, where the IR-based ADT has difficulties. The scheme uses two separate discriminators to estimate maximum winds from 85-92 GHz imagery: 1) The "completeness" of the eyewall (determined by either absolute Tb or relative Tb), and 2) The Tb difference between the eye and eyewall. Using these, the scheme assigns an intensity score between 0 and 100 to the image.



Estimates of Radius of Maximum Wind (RMW)

IR-Based - Objective - Used by ADT - Results fed to AMSU Method



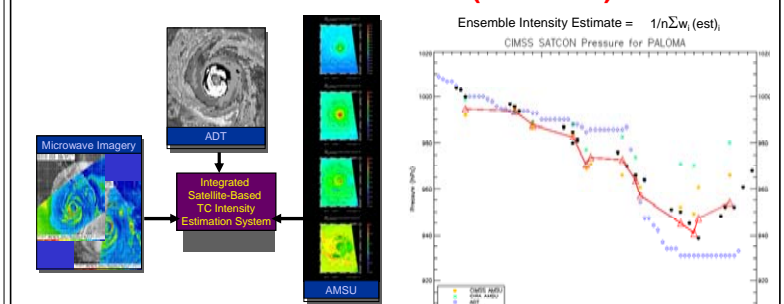
Relationship between eye size, as measured by IR, and aircraft-measured RMW, for clear-eye Atlantic TC cases (ADT provides these RMW estimates for clear-eye scenes).

MSLP (hPa)	IR Estimate (subjective best guess)	IR Estimate (objective from ADT)	Oper.
Bias	1.6	-0.5	5.1
Absolute Error	5.4	6.8	8.3
RMSE	7.5	8.7	10.6
N	50	50	50

AMSU intensity estimates using IR RMW values perform better than using operationally-verified RMW on independent cases verified against Atlantic recon.

TC Intensity Estimation: Integrated Approach

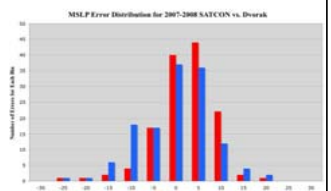
SATellite CONsensus (SATCON)



Results

N = 145	SATCON	SIMPLE	ADT	CIMSS AMSU	CIRA AMSU	Oper. Dvorak
Bias	-0.3	-2.6	-3.7	-0.3	-4.5	-1.9
Avg Error	4.7	5.1	7.4	5.3	8.1	6.2
RMSE	6.3	7.1	9.9	7.1	12.1	8.3

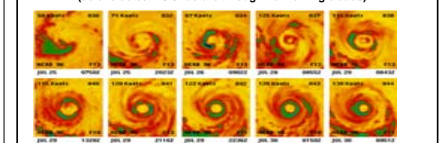
Independent validation for 2007-2008 cases, compared to reconnaissance-measured MSLP. All units in hPa. SIMPLE is a straight average of ADT, CIMSS AMSU and CIRA AMSU (a second AMSU-based method developed at CIRA). SATCON is a consensus of the 3 objective methods weighted by their individual situational errors. Oper. Dvorak is an average of operational subjective Dvorak estimates produced at TAFB (NHC) and SAB (NESDIS).



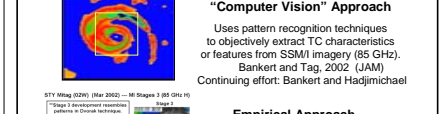
Other Potential SATCON Members?

SSMI, SSMIS, TMI, AMSR-E

Automated intensity estimates from passive microwave imagery (able to detect TC structure through non-raining clouds)



Example: SSMI 85 GHz and Rain Rate features



Continuing effort: Bankert and Hadjimichael

Summary

As part of an R&D effort at CIMSS to develop improved TC intensity estimation from satellites, existing methods to estimate intensity from different satellite platforms/sensors are being employed to create a more robust and reliable integrated approach. Taking advantage of the single method characteristics and situational tendencies, the final TC intensity estimate at a given analysis time is obtained by employing a weighted consensus approach to blend/resolve the independent estimates. The algorithm outputs both MSLP and Vmax (maximum sustained wind) TC intensity parameters, and future versions will include estimate confidence indicators.

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