CGMS

CGMS-39 WMO-WP-22
v1.0, 20 September 2011
Prepared by WMO
Agenda Item: II.10
Discussed in WG II

OUTCOME OF THE WMO INTERNATIONAL WORKSHOP ON SATELLITE ANALYSIS OF TROPICAL CYCLONES

WMO-WP-22 summarizes the results of the first WMO International Workshop on Satellite Analysis of Tropical Cyclones (IWSATC) organized by the WMO Tropical Cyclone Programme, in collaboration with the WMO World Weather Research Programme and the World Data Center for Meteorology at NOAA/NCDC.

The main purpose of the workshop was to increase the accuracy and reliability of satellite analyses of tropical cyclones (TCs) by sharing the latest knowledge and techniques amongst researchers and operational forecasters of the major warning centers. This included discussion on recent developments in satellite analysis of TCs, particularly the objective satellite-based TC analysis methods.

The workshop made a range of recommendations, including on how operational centres in common TC basins can better achieve consistent TC estimates for real-time warnings (and among all TC basins for improved continuity in Best Tracks), and on how centres can optimally blend the emerging objective guidance methods with existing subjective methods.

CGMS members are invited to take note of the workshop recommendations reported in this paper.

Action/Recommendation proposed:

Outcome of the WMO International Workshop on Satellite Analysis of Tropical Cyclones

1. OBJECTIVES

The first WMO International Workshop on the Satellite Analysis of Tropical Cyclones (IWSATC; Honolulu, Hawaii, USA, 13-16 April 2011) was organized by the WMO Tropical Cyclone Programme (TCP) in collaboration with the WMO World Weather Research Programme (WWRP), and the World Data Center for Meteorology at NOAA/NCDC. The workshop was attended by 28 experts from Regional Specialized Meteorological Centres (Miami, Honolulu, Tokyo, New Delhi, La Reunion and Nadi), Tropical Cyclone Warning Centres (TCWCs) in Australia, TCWCs (Jakarta, Port Moresby and Wellington), China Meteorological Administration, Hong Kong/China, WDC, US Naval Research Laboratory, CIMSS/University of Wisconsin of US, University of Guam (USA) and US Joint Typhoon Warning Center.

The main purpose of the workshop was to increase the accuracy and reliability of satellite analyses of tropical cyclones (TCs) by sharing the latest knowledge and techniques amongst operational forecasters of the major warning centres and researchers.

Specific objectives of the workshop were to:
a) Describe the operational procedures of satellite analysis of TCs (including the use of the Dvorak technique) in the participating TC warning centres;
b) Identify the differences in the procedures between the centres and their relevance to final TC intensity estimates (including spreads and biases) and resulting Best Track data;
c) Share recent developments in the satellite analysis of TCs, particularly the objective satellite-based TC analysis methods;
d) Make recommendations on 1) how operational centres in common TC basins can better reconcile Dvorak procedural differences to derive more consistent TC estimates for real-time warnings, and among all TC basins for improved continuity in Best Tracks, and 2) how operational centres can optimally blend the emerging objective guidance methods with existing subjective methods in order to improve the overall satellite analysis of TCs as it relates to both operational warnings and the Best Track data.

2. MAJOR FINDINGS

2.1 Satellite-based analysis of TCs: Current operational practices

Each TC operational centre presented a summary of their current satellite analysis procedures (see http://www.wmo.int/pages/prog/www/tcp/IWSATC.html for details).

Historically, the majority of reported TC maximum wind speed (*Vmax*) values by operational centres have been derived from application of the Dvorak analysis, by converting the Dvorak Current Intensity number (CI) directly to a maximum near-surface wind speed. Hence, the CI is commonly the primary original metric of intensity estimates. A degree of scatter in reported CI values between agencies is expected given the subjective nature of the Dvorak technique, and differences of +/-0.5 CI between analysts are common. While a reduction in the spread of CI is desirable, *biases* between agency estimates of *Vmax* is of greater concern. Referring back to the CI values for comparison of agency intensity estimates can be a first step towards reconciling analysis differences, since this circumvents the issues associated with use of different CI>*Vmax* tables (i.e. Koba et al. 1989) and different wind-averaging periods, as demonstrated in Nakazawa and Hoshino (2009).

The reports by TC centres showed that the Dvorak technique has been subject to a range of regional variations. Different wind speed averaging periods and conversion methods (i.e.., CI to

Vmax) have implications on the TC estimates. Some agencies use Visible imagery only while other use Enhanced Infrared imagery. Furthermore, differences in the use of ancillary satellite data (passive microwave and scatterometer winds) across the centres are also a likely source for discrepancies.

2.2 Summary of objective techniques that were presented at the workshop

Representatives from the TC research community were called upon to present their latest work on development of objective satellite-based TC intensity estimation techniques. The topics included: The Advanced Dvorak Technique (ADT), the Advanced Microwave Sounding Unit method (AMSU), the Automated Rotational Center Hurricane Eye Retrieval algorithm (ARCHER), the SATellite CONsensus approach (SATCON), passive microwave (PMW) applications, and the Multiplatform TC Surface Wind Analysis (MTCSWA). The following paragraphs summarize some of the findings:

Of all of the objective techniques briefed, by far the most familiar to the operational representatives is the ADT. In fact, many of the agencies are already employing the ADT in their operational assessments. While this is seen as progressive and encouraged, it does raise an additional complication to interpreting regional differences in TC estimates. Specifically, this stresses the fact that some TC agency estimates are increasingly being reflected by final intensities that are not purely subjective Dvorak based (besides the NHC, which has relied on aircraft recon estimates for quite some time). Further complicating the picture is that the ADT has evolved, and continues to evolve, so that any impacts on intensity estimates that may have been influenced in part by real-time ADT values will be difficult to trace.

Other objective techniques such as SATCON and AMSU-based intensity estimates are being utilized by some of the agencies, but generally to a lesser degree. The delegates commented that more information and confidence guidelines are necessary from the algorithm developers, since these methods are less familiar to them than the ADT. This is an action item for the CIMSS researchers. JMA reported that they are developing objective MTSAT, PMW and AMSU analysis techniques.

The MTCSWA (Knaff et al., 2011) is a recently developed technique for objectively estimating the surface wind ***structure*** of TCs (i.e. wind radii). Many of the delegates were aware of the product and some centres are already using the MTCSWA, particularly for estimating the gale radius. However there was evidence that further training is required to prevent misuse. The major misuse is the assumption that the MTCSWA outputs an independent estimate of *Vmax*. However, the displayed value is actually *input* to the MTCSWA from an external source, and should not be used as an independently-determined intensity estimate.

A new method developed at CIMSS to objectively fix the centres of TCs from both IR and PMW imagery (ARCHER) includes a component that also estimates TC intensity from PMW in certain situations (values are now fed to the ADT). The ARCHER is still a work in progress, but offers promise to those agencies looking for help/guidance in fixing TC centres to begin their analyses.

The Naval Research Laboratory (NRL) progresses in using computer vision and neural networks to derive TC intensities from passive microwave data. It is hoped that these efforts will eventually yield an objective estimate of TC intensity that is largely independent of the existing methods.

For reconciling Best Track discrepancies, the use of the ADT for an independent reanalysis seems plausible. Such efforts are underway at CIMSS.

The need for further training has been identified in the application of objective techniques, and also of PMW, particularly in the interpretation of method confidence levels, and ultimately for synthesis of the different estimates into a final intensity estimate. Documentation such as on-line references and perhaps even COMET modules was recommended.

There was general agreement that while the "pureness" of the Dvorak method and resulting derived CI values should be preserved on the record, the satellite analysts should be moving beyond the reliance on subjective Dvorak techniques towards a consensus approach utilizing all available intensity estimates. This is where the training and meeting together every so often as a community would pay dividends towards the goal of a global approach to satellite-based TC intensity analyses.

3. OUTCOMES AND RECOMMENDATIONS

3.1 General Outcomes

The workshop fostered much greater interagency understanding and provided significant documentation of some of the causes of interagency differences in intensity estimates. It allowed for important feedback from forecasters to developers of the emerging objective techniques. The event also initiated a dialogue between researchers and operational centres regarding the sharing of observational datasets.

3.2 Major Recommendations

Based on findings from the IWSATC, develop guidelines for the improvement of satellite analysis globally, with the idea to be presented by the co-Chairs at the Jakarta WMO Tropical Cyclone Centre (TCC) meeting.

Strongly encourage the sharing of national TC datasets to allow improved validation of existing satellite intensity estimation methods (to be followed-up by WMO).

Create and maintain a centralized web site hosted by WMO/TCP, with documentation summarizing regional differences in the satellite analysis of tropical cyclones, changes in local procedures, and availability/upgrades to advancing objective methods.

Expand training material focused on helping forecasters make optimal use of the available satellite-based intensity estimates.

Hold another WMO-sponsored IWSATC in two or three years, synchronized with the next IBTrACS meeting if possible, to measure progress and encourage further efforts towards consolidating reliability and accuracy in global satellite intensity estimates.

4. REFERENCES

Knaff, J.A., M. DeMaria, D. A. Molenar, C. R. Sampson and M. G. Seybold, 2011: An automated, objective, multi-satellite platform tropical cyclone surface wind analysis. Submitted to J. Appl. Meteor.

Koba, H., S. Osano, T. Hagiwara, S. Akashi, and T. Kikuchi, 1989: Determination of intensity of typhoons passing through the Philippine islands (in Japanese). J. Meteor. Res., 41, 157–162.

Nakazawa, T. and S. Hoshino, 2009: Intercomparison of Dvorak Parameters in the Tropical Cyclone Datasets over the Western North Pacific. SOLA, Vol.5, 033-036.