CREATION OF A PLATFORM-INDEPENDENT VERSION OF THE UW-CIMSS GEOSTATIONARY, HIGH-DENSITY WIND DERIVATION ALGORITHM

Timothy Olander, Christopher Velden, and Connie Spinoso

University of Wisconsin - Cooperative Institute for Meteorological Satellite Studies
1225 West Dayton Street, Madison, WI 53706
USA

ABSTRACT

In response to the widespread use of geostationary satellite-derived winds in the meteorological community, a portable, platform-independent version of the UW-CIMSS winds processing algorithm has been developed. The incentive for this development derives from the desire to allow flexibility to satellite wind processing and research centers around the world to be able to locally create site-specific data sets tailored to suit their forecast, NWP or research needs using the latest advances and techniques. The prototype version of the CIMSS winds algorithm must be executed within a McIDAS environment, utilizing specific McIDAS formatted satellite data and model forecast “guess” fields. The revised algorithm will run within either McIDAS or UNIX shell environments, allowing utilization and processing of other geostationary satellite data and model guess field formats in addition to McIDAS.

This revised edition is currently being implemented and evaluated at the U.S. Naval Fleet Numerical Meteorology and Oceanography Center, and the Air Force Global Weather Center. Transfer of the new software to NOAA/NESDIS for operational testing and evaluation is also planned. The new CIMSS winds processing algorithm will soon be released and available to other interested data processing centers or research institutes. The updated algorithm includes the latest post-processing quality-control module that combines the objective-editor/recursive filter (RF) analysis developed at CIMSS with the quality indicator (QI) scheme developed by EUMETSAT. Future versions of the algorithm will continue to be advanced and supported by UW-CIMSS. Further expansion of I/O interfacing will allow easier portability to various operating systems utilizing a wide variety of input data sets. A generic X-Windows and/or IDL graphical display capability will be added to allow easier data entry, and visualization tools now supplied with the McIDAS version of the code.

1. Introduction

Wind algorithms using geostationary satellite imagery have been developed and distributed by the University of Wisconsin-Madison Cooperative Institute for Meteorological Satellite Studies (UW-CIMSS) in collaboration with NOAA/NESDIS for many years. The algorithm architecture is housed within McIDAS, a software package developed at the University of Wisconsin-Madison, and relies on McIDAS for accessing, manipulating, and displaying the required input satellite and meteorological data. While highly successful, the potential users of the algorithm are limited to sites that utilize McIDAS.

Traditionally, the latest in advanced winds processing from GOES and other geostationary satellites is demonstrated at UW-CIMSS before being transitioned to NOAA/NESDIS (Velden et al. 1998). Many other sites around the world rely on UW-CIMSS and NOAA/NESDIS to derive and distribute various real-time satellite wind sets. This arrangement has been proven to be successful a great majority of the time, but remote users are still limited by many factors outside their control in their ability to receive data, such as internet connectivity problems. These problems could be alleviated by local production of the data sets at each site. Direct operation of the winds algorithm would also allow each site to individually tailor the algorithm to meet their respective requirements and needs. The derivation of winds by sites around the world from multiple satellite platforms using a common algorithm is also a desirable goal.

During the past few years, UW-CIMSS has received queries about obtaining the winds algorithm for use at local sites around the world. Potential applications range from research to operational support. These requests provided the impetus for developing a platform-independent version of the UW-CIMSS wind processing algorithm. This goal has been achieved during the past year and has resulted in modifications and upgrades to the prototype version.

2. Motivation

The prototype wind processing algorithm was written in the FORTRAN programming language over a period of approximately 20 years. A multitude of programmers have worked on this code both at UW-CIMSS and NOAA/NESDIS in Washington, DC. Many sections have become outdated as computer resources improved, satellite instruments/sensors evolved, and as changes were made to code logic and structure over many years (including McIDAS library functions). In order to provide a manageable algorithm for potential remote users, many sections of the code needed to be rewritten or eliminated entirely. Also, several new processing routines needed to be added to the increasingly large amount of code comprising the winds derivation package.

In addition to cleaning up the algorithm, a desire to increase compatibility with remote site-specific needs was taken into consideration during this process. Discussions with potential users indicated that a visualization package may be required with the algorithm. McIDAS users possess an interactive display platform, however many sites must either rely on visualization packages already in place or do not have such capability at the current time. Visualization tools such as X-Windows, IDL, JAVA, and TeraScan are easily compatible with or already written in the C programming language (McIDAS is also being converted to C for compatibility reasons). The C language also possesses many inherent advantages over FORTRAN, such as internal data storage (structures and global variables) and the availability of a universal C compiler, gcc, which is independent of UNIX operating systems. Therefore, the new version has been written in the C language.

By converting the algorithm into a portable, platform-independent algorithm, the user base can be increased. Remote sites around the world can have access to the latest advances in satellite wind processing. With on-site processing, users can customize wind data sets for individual needs, such as tailoring the wind set space/time resolution for targeting specific meteorological phenomena.

3. Current status

Clean-up and conversion of the primary satellite wind derivation routines have been completed. These routines comprise targeting (including height assignment procedures), vector displacement, objective Recursive Filter (RF) analysis wind editing, automatic image registration/navigation, and the newly-implemented EUMETSAT Quality Indicator (QI) routine. In addition, many ancillary routines have been converted.

Input file formats required for operation of the winds algorithm have been modified during the conversion process. Numerical model guess parameters can be ingested either directly from GRIB-format files or from McIDAS MD-format files. Satellite imagery is still required to be in McIDAS AREA-format, due to the use of McIDAS-based internal navigation and calibration routines within the winds algorithm. Future versions will convert various formats internally, eliminating the need for the user to pre-process the image data.

Various output data file formats are available. The default output wind file format is McIDAS MD-format. Routines are provided with the new winds package to convert these files to ASCII and/or BUFR format. Also, the grid analyses from the RF editor can be output in McIDAS GRID-format, with a conversion program from GRID-format to GRIB-format being developed.

It is emphasized that all of these routines can still be utilized within the McIDAS environment for users who wish to process and display wind vectors with this system. A number of supplemental McIDAS visualization and editing routines will be converted and supplied with future wind package upgrades.

Preliminary comparisons of data sets derived by the new C version with the prototype FORTRAN version have yielded near-exact agreement. The comparisons were conducted on several UNIX platforms to check for any platform specific dependencies. Any such dependencies were eliminated, including those found within the compilation makefiles used to create the executable files. A more extensive comparison is being conducted for GOES-8 and GMS-5 wind data sets. Both versions are automated with UNIX shell scripts utilizing an identical sequence of processing commands. A sample shell script will be provided to future users as a guide for automated wind processing.

A comprehensive User's Guide is also being written. This guide will thoroughly document all procedures within the winds processing package. Flowcharts of all routines will be diagrammed in order to outline the logic comprising each procedure. All command line control keywords utilized with the procedures will be catalogued and explained, with all valid options and default values listed for each keyword. Numerous examples and current operational settings will be presented for clarity.

4. Integration of EUMETSAT Quality Indicator (QI)

In an effort to further improve the objective wind vector editing procedure, the EUMETSAT Quality Indicator procedure (Holmlund et al. 2000) has been added prior to the RF analysis routine (Velden et al. 1998). In effect, the QI acts as a pre-filter of erroneous vectors. Model forecast impact studies have documented the positive influence of the combined QI/RF procedures (Holmlund et al. 2000). Initial testing of the combined approach at UW-CIMSS is also yielding positive results. The most important issue regarding use of the QI algorithm as a pre-filter is in setting the threshold. It has been found that the QI behaves differently for each geostationary satellite. A precise definition of these properties is necessary for optimal utilization of the QI/RF for numerical modeling and research applications. Therefore, a thorough statistical analysis using rawinsonde verification is underway.

Preliminary results of this study are shown in Figure 1. Normalized root mean square (NRMS) errors for different QI value ranges are displayed for wind vectors derived using GMS-5 and GOES-10 data, as verified against collocated rawinsonde observations. Fig. 1 displays the NRMS errors for the QI-only stage, and for the QI/RF combination. A significant NRMS error reduction is achieved for each satellite after the QI/RF analysis has been performed. Most notably, the QI/RF combination leads to a large reduction in the NRMS error for wind vectors carrying lower QI values, with less editing on the higher-quality vectors. This is clearly shown in the reduction of sample size between the two comparison data sets, with a greater percentage of higher quality (high QI) winds being retained by the RF analysis.

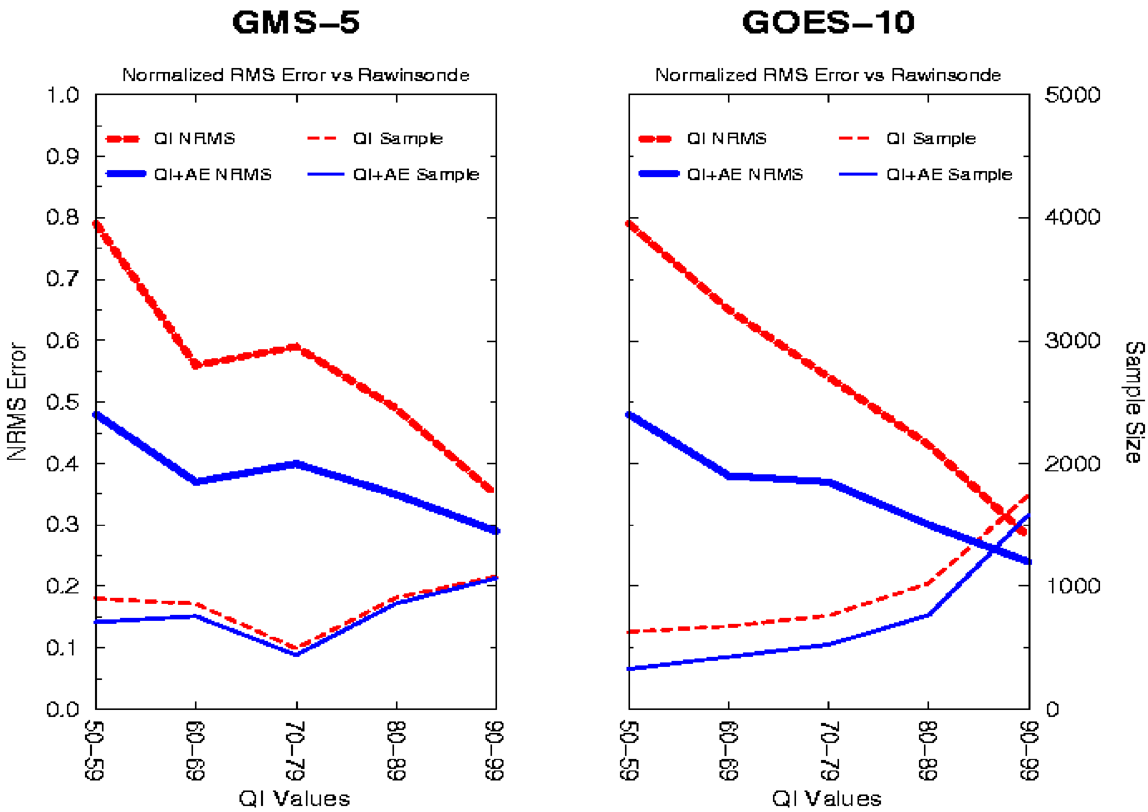

Figure 1. Normalized RMS Error versus rawinsonde observations for GMS-5 and GOES-10 satellite wind vectors prior to (red) and after RF analysis (blue) for various QI value bins (higher values of QI are considered higher quality).

One interesting feature we have noted is that the behavior of the QI routine appears to be satellite dependent. We have found the QI threshold value needs to be set about one category higher for GOES relative to GMS in order to achieve equal editing percentages. For GOES-10, there are a greater percentage of wind vectors retained by the QI=50 threshold vs. GMS-5. This is currently unexplained, and will be further examined. Other satellites will also be investigated.

5. Future plans

As mentioned previously, a generalized visualization interface will be developed for potential users not possessing McIDAS visualization tools. A generic X-Windows graphical user interface (GUI) will be provided for these users since X-Windows software is available to all UNIX-based platforms. For remote users who wish to utilize site-specific GUI software packages for visualization purposes (e.g. IDL, TeraScan), detailed explanations of pertinent input and output file formats will be provided for data file access. For McIDAS users, visualization tools/commands currently used in the FORTRAN version of the winds derivation code will be converted to C and released in future versions.

A significant goal for future UW-CIMSS wind algorithm packages is to reduce the influence of numerical model forecast guess fields. Entirely eliminating the need for model forecast fields is not likely given the reliance of the height assignment methodologies on model temperature profiles. However, studies on several new "model-independent" targeting, tracking and objective editing schemes will be performed to assess their strengths and weaknesses

6. Summary

A platform-independent version of the UW-CIMSS satellite-derived wind processing algorithm is in development. A preliminary version has been completed, with the main procedures rewritten from FORTRAN to C language to allow for greater compatibility with remote site platforms. This version retains many features distinct to the McIDAS environment, such as input and output file formats and internal navigation/calibration of the satellite imagery data, but can now be run either inside or outside of the McIDAS environment. This capability will expand the user-base of satellite-derived winds by allowing local processing, and reduce the reliance upon UW-CIMSS for distributed real-time or post-processed wind sets.

The UW-CIMSS algorithm is currently in the process of being ported to platforms for use by the U.S. Navy, and should be available for general distribution during the coming year. The algorithm will be fully supported by UW-CIMSS, with all new upgrades and additions to the software package available as warranted. A comprehensive User's Guide is being composed and will be made available to all users. This guide will fully document all methodologies utilized in the new wind algorithm. A web site is also under development.

A new addition to the objective quality control module (the EUMETSAT Quality Indicator) has been integrated into the winds processing code and is being evaluated. Preliminary indications on the impact of using a combined QI and RF wind editing approach are positive, with a significant reduction in NRMSE vs. collocated rawinsondes supporting earlier numerical model impact studies (Holmlund et al. 2000).

REFERENCES

Holmlund, K., C. S. Velden and M. Rohn, 2000: Enhanced automated quality control applied to high-density GOES winds derived during NORPEX. Conditionally accepted in *Mon. Wea. Rev.*

Velden, C. S., T. Olander and S. Wanzong, 1998: The impact of multispectral GOES-8 data wind information on Atlantic tropical cyclone track forecasts in 1995. Part 1: Data set methodology, description and case analysis. *Mon. Wea. Rev.*, **126**, 1202-1218.