P3.1 UW-CIMSS SATELLITE WINDS ALGORITHM

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1. INTRODUCTION

Tracking cloud motions from geostationary meteorological satellites has become an important source of global tropospheric wind information. UW-CIMSS (University of Wisconsin-Madison, Cooperative Institute for Meteorological Satellite Studies) has pioneered the development of cloud and water vapor tracking algorithms, which have evolved from subjective, labor-intensive processes into a fully automated system. Today, winds from this system are produced operationally by NOAA NESDIS (National Environmental Satellite, Data, and Information Service) and the U.S. Air Force from GOES, GMS and Meteosat satellites (Velden et al. 1997, 1998; Nieman et al. 1997). This flexible software package can be used in applications and environments ranging from small research projects to large operational facilities, and algorithm derivatives are employed at operational and research satellite data centers around the world. Future development will be directed toward independence of the processing platform (computer host and operating system) and user-friendly interfaces, with a long range goal of standardizing international satellite feature-tracked winds production.

2. CURRENT STATUS

The UW-CIMSS winds algorithm currently exists in two forms; a mature 'operational' version written in Fortran, and a research and development version written in the C programming language. Both run under the Unix operating system. The C version is undergoing a rigorous testing and verification procedure, and it will eventually supplant the Fortran version (Olander, 2001).

Processing cloud and water vapor motions from successive satellite images into wind vectors is divided into modules. These include automated satellite image registration, initial target identification, calculation of target displacement vectors, wind vector production, quality control and editing.

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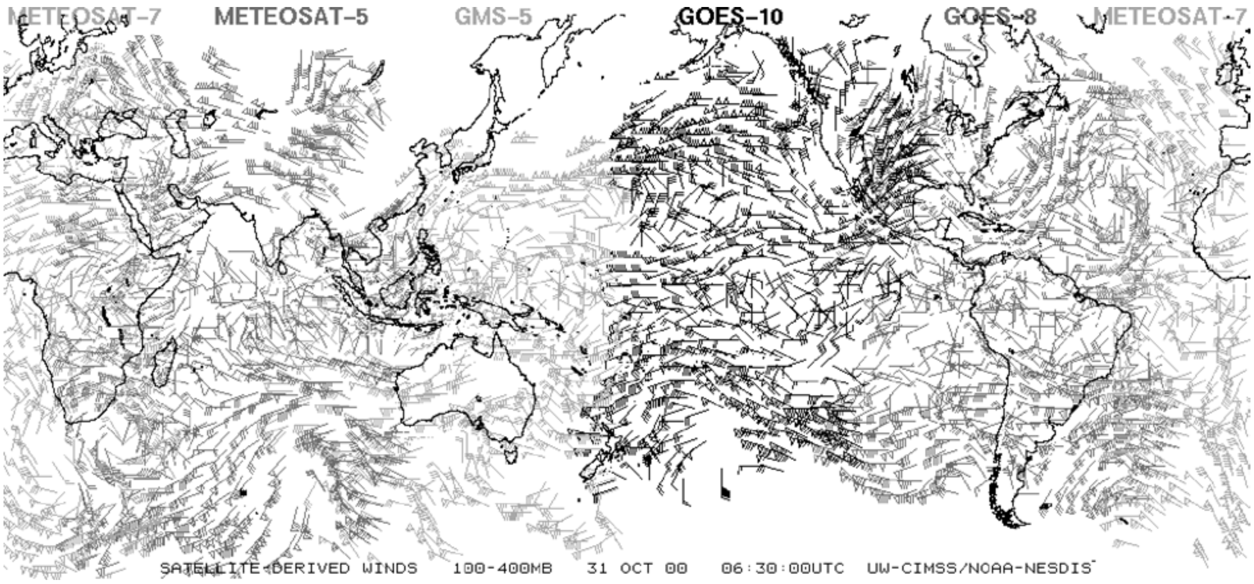
Registration is performed using an automated routine that employs cross correlation and minimum lag coefficient analysis at selected landmark points in the imagery to ensure proper alignment. In the targeting step, water vapor gradients or cloud edges are identified and assigned initial pressure heights. The vector derivation step computes direction and speed of target displacements between image pairs, which are then used to calculate time-averaged wind vectors. Three-dimensional postprocessing and quality assessment is performed on a data set containing vectors from all vertical levels. A series of checks are applied to identify misanalyzed vectors, adjust height assignments and flag anomalies. Remaining vectors are tagged with quality indicators based on their fit to the rest of the vector field. Recursive filter analysis is applied in the final editing step.

Input data requirements include a time series of three to five sequential satellite images for target tracking, images used for height assignment, and temperature, pressure and wind fields from numerical model grids. Images must be in McIDAS (Man computer Interactive Data Access System) Area format and the model data in GRIB format. The algorithm currently handles data from GOES, Meteosat and GMS, from visible, infrared, and water vapor sensors. Additional satellites and sensors can be incorporated when suitable geolocation (image line/element to earth latitude/longitude conversions) and calibration (raw count to brightness temperature conversion) modules are produced. Currently, the derived wind vector fields can be output in three file formats: McIDAS MD, ASCII text, and BUFR.

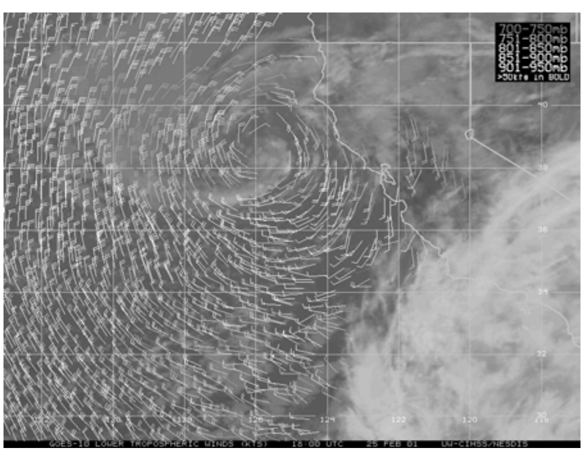
The Fortran version is currently in use at UW-CIMSS and NESDIS. Real-time wind sets are produced routinely from GOES-8 and -10, GMS, and Meteosat-5 and -7, incorporating data from visible, infrared, and water vapor bands. An example of a global composite upper tropospheric wind set comprising vectors from all five satellites is shown below.

In collaboration with the U.S. Navy and Air Force, the C version is being transitioned into operational use, and an additional cooperative effort is in progress with the Australian Bureau of Meteorology.

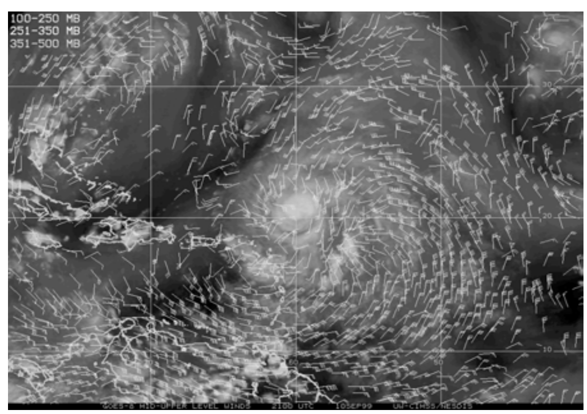


Global wind set composite from 5 geostationary satellites produced using UW-CIMSS tracking package.

Real-time field experiments provide excellent opportunities for testing the limits of the algorithm's capabilities. Most recently, this system played an important role in providing high-resolution winds from GOES rapid-scan imagery in support of *GWINDEX* (*G*OES rapid scan *WIND*s *EX*periment) and *CAMEX*-4 (*C*onvection *A*nd *M*oisture *EX*periment) (See paper by Velden et al., this volume). The following image is from the GOES-10 GWINDEX data set for 1800 UTC, 25 February 2001.


High-resolution, lower-tropospheric winds.

In addition to field experiments, the UW-CIMSS algorithm supports developing research projects and quasi-operational application demonstrations. For example, datasets are routinely derived at UW-CIMSS over tropical regions in support of tropical cyclone analysis at the National Hurricane Center and the Joint Typhoon Warning Center. An example of winds derived from GOES-8 during Hurricane Floyd in 1999 is shown below.



Hurricane Floyd mid-upper tropospheric winds derived from GOES-8 at 2100 UTC, 10 September 1999.

3. FUTURE OUTLOOK

Our vision is to create a user-friendly, state-of-the-art winds derivation system that can be universally used on different platforms and with any available satellite imagery. UW-CIMSS scientists play a prominent role in the WMO International Satellite Winds Working Group. It is a goal of this group to advance and standardize satellite feature-tracked winds production from all global satellite data centers. It is with this goal in mind that we plan to focus our future efforts, which include three primary themes.

The first is a continuation of research and development of the C version for major data production, with emphasis on operating platform/environment independence. Algorithm upgrades will be an ongoing process, and increased efficiency will reduce system requirements and processing time. Modular design enhancement will better facilitate the addition of new satellites and sensors, and generic data input and output formats will reduce dependency on McIDAS data structures. It is our intention to make the code available to the global user community.

The second development thread will be an optional winds algorithm add-on to McIDAS. This version will be more suitable for small-scale winds production or individual users. It will be available through the McIDAS User's Group (http://www.ssec.wisc.edu/mug/mug.html). A graphical user interface consistent with the McIDAS operating environment will be provided.

The third development path comprises research efforts aimed at taking feature-tracked winds production into new areas. These include deriving winds from new instruments currently in flight and planned in the near future. For example, preliminary experiments with successive-pass imagery over the polar regions from the MODIS instrument onboard the EOS (Earth Observing System) Terra polar-orbiting satellite are providing encouraging results (see paper by Key et al., this volume). Hyperspectral imaging from space-borne geostationary interferometers is just around the corner. The GIFTS (Geostationary Imaging Fourier Transform Spectrometer) instrument will provide hyperspectral images, multi-channel averaged 'superchannels' and moisture product retrievals. To be ready for these data, the UW-CIMSS algorithm is being adapted to run on simulated GIFTS datasets as part of a funded effort by NASA

4. REFERENCES

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5. ACKNOWLEDGMENTS

The authors wish to acknowledge the many UW-SSEC and CIMSS programmers/developers whom contributed to this state-of-the-art algorithm over the 20+ years of the effort. Jaime Daniels, Wayne Bresky and Ricky Irving contributed to the operational version at NOAA/NESDIS. Recent collaborations with Jeff Hawkins of NRL-MRY, Chuck Skupniewicz of FNMOC and Ken Holmlund of EUMETSAT have led to many advancements and proliferation of the code into the user community. Financial aid from NOAA/NESDIS (Grant NA07EC0676) and NRL (Grants N00173-98-C-6011 and N00173-01-C-2024) is responsible for supporting the research advances, and transition to operations.