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2001/2002 Report on NOAA/NESDIS Satellite-Derived Winds

SUMMARY AND PURPOSE OF DOCUMENT

This paper summarizes the current NOAA/NESDIS operational wind product suite that includes the high density cloud-drift winds from the GOES imager, water vapor motion winds derived from the GOES sounder. Anticipated improvements under study are also summarized

ACTION REQUESTED: NONE

2001/2002 REPORT ON NOAA/NESDIS SATELLITE-DERIVED WINDS

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1. Introduction

NOAA/NESDIS and the Cooperative Institute for Meteorological Satellite Studies (CIMSS) continue a fruitful collaboration aimed at improving the quality of Atmospheric Motion Vectors (AMVs) derived from the GOES-I/M series of satellites. The NOAA/NESDIS operational winds processing system continues to be incrementally upgraded with updated wind algorithms, new wind products, and new processing strategies. Active areas of winds research include derivation of motion vectors from rapid scan imagery and their utilization and impact on forecast accuracy, improved height assignment through use of the 13.3um channel aboard GOES-12 (NOAA's newest geostationary satellite), and polar winds from multispectral MODIS data.

2. NESDIS Operational Winds

NOAA/NESDIS, together with CIMSS, is continuing to improve the operational GOES wind product suite. Wind products operationally supported include the high-density visible cloud-drift winds from the GOES imager and water vapor-motion winds derived from the GOES sounder 7.0um and 7.4um moisture channels. All of the NOAA/NESDIS wind products continue to be encoded into the unified BUFR template. NOAA/NESDIS processing strategies utilize available 15-minute and 7.5-minute image loops for the derivation of visible cloud-drift winds. The quality of the wind products continues to look good.

2a. Status of GOES Satellites

NOAA/NESDIS currently maintains a continuous stream of data from two geostationary environmental operational satellites. At the present time, these two operational satellites include GOES-8 at 75^{o}W and GOES-10 at 135^{o}W. To reduce the risk of a break in operational service, NOAA uses the on-orbit spare concept. To this end, the GOES constellation also includes GOES-9, a limited-capability on-orbit spare, and GOES-11 and GOES-12, which are two fully capable on-orbit spares. GOES-11 and GOES-12 were successfully launched on May 3, 2000 and July 23, 2001, respectively. Plans call for GOES-12 to replace GOES-8 in April 2003.

GOES-11 carries the same instrumentation as the previous three GOES satellites. GOES-12 carries redesigned instrument motors and carries the same instrument complement as the previous satellites, with two primary changes. Imager instrument changes made include the replacement of the 12.0um channel (4km resolution) with a 13.3um channel (8km resolution) and a spectrally modified water vapor channel with improved resolution. The water vapor channel is spectrally wider then its counterparts on the previous GOES satellites where its central wavelength is 6.5um instead of 6.7um. The resolution of the water vapor channel has improved from 8km to 4km at the sub-satellite point.

2b. Operational GOES Wind Products and Dissemination Plans

The current operational wind products being generated at NOAA/NESDIS are shown in Table 1. The frequency at which each product is produced, together with the GOES image sector used, and image interval is presented in this table.

Wind Product	*Frequency (Hours)*	*Image Sector(s)*	*Image Interval (minutes)*
IR Cloud-drift	3	RISOP	7.5
	3	CONUS	15
	3	Extended NH: SH	30
Water Vapor	3	Extended NH; SH	30
Vis Cloud-drift	3	RISOP	7.5
	3	PACU/CONUS	15
	3	Extended NH; SH	30
Sounder WV (7.4um)	3,6	CONUS/Tropical	60
Sounder WV (7.0um)	3,6	CONUS/Tropical	60

Table 1. NOAA/NESDIS Operational Satellite Wind Products

All of the operational NESDIS wind products shown in Table 1 are encoded into the unified BUFR format and available on a NESDIS server. All of the products, with the exception of the sounder water vapor winds, will continue to be encoded into the SATOB format and distributed over the GTS.

NESDIS has updated its operational GOES satellite wind BUFR encoder to correct deficiencies noted by users of these data. A summary of changes made to the BUFR encoder include:

- Replace use of local descriptors with WMO-sanctioned descriptors
- Use of Version 10 of the BUFR Tables
- Quality control section contains Class 33 entries only
- Generate one BUFR message per file and increase the number of satellite wind observations per BUFR message. This will eliminate file segmentation problems encountered by users, particularly when processing larger NESDIS wind files.
- Newly defined WMO headers for GTS distribution

The newly encoded GOES wind BUFR datasets are currently being distributed out over the GTS with new WMO bulletin headers. These dataset are also available via an anonymous ftp server. The current NESDIS wind BUFR products will continue to be distributed over the GTS until the user community has fully tested their systems to ingest the updated datasets.

In addition to transmitting the GOES wind products over the GTS, NESDIS will also be transmitting these products to the NOAA/National Weather Service's (NWS) Advanced Weather Interactive Processing System (AWIPS). This represents a significant milestone for NOAA, as this is the first time these products will be distributed via an operationally supported network to NWS field forecast offices. Once at the NWS field forecast offices, weather forecasters will be able to use existing AWIPS graphics capabilities to easily integrate these products with other data sources (model output, rawinsondes, aircraft reports) which, ultimately, will help them in preparing a better forecast.

The NESDIS operational winds continue to perform well. The quality of these wind products is being tracked according to CGMS guidelines. Figures 1 and 2 present the CGMS wind statistics over the past twelve months for all wind types (at all levels) for GOES-8 and GOES-10, respectively.

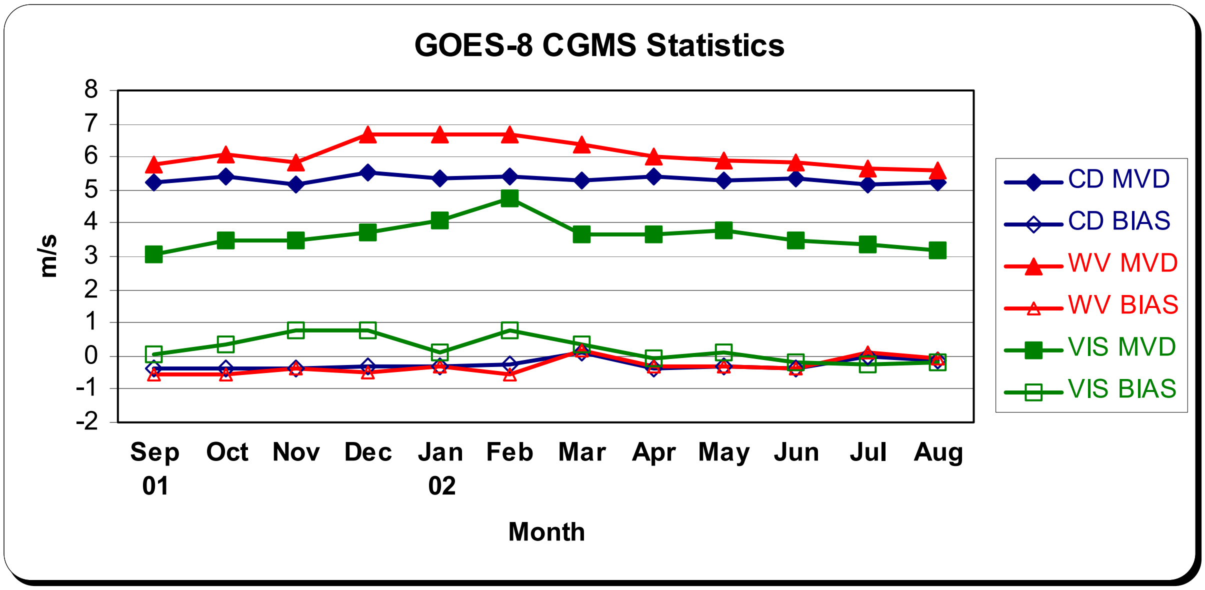

Figure 1. CGMS statistics (Mean Vector Difference and Speed Bias) for GOES-8 IR cloud-drift (CD), water vapor (WV), and visible (VIS) cloud-drift winds (all levels) for September 2001 – August 2002

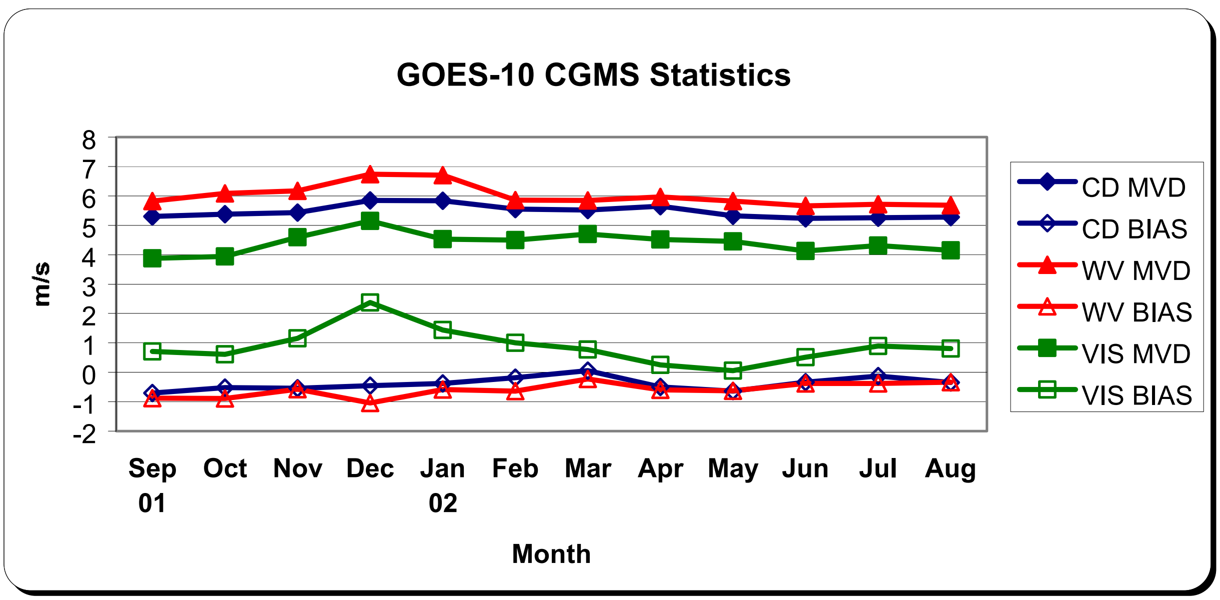

Figure 2. CGMS statistics (Mean Vector Difference and Speed Bias) for GOES-10 IR cloud-drift (CD), water vapor (WV), and visible (VIS) cloud-drift winds (all levels) for September 2001 – August 2002

2c. Recent Operational Implementations

A number of updates have been made to the operational GOES winds processing system. These are described below:

- Use of rapid scan imagery for IR cloud-drift winds
- Middle image targeting

The middle image of the image triplet is now used for target selection and height assignment for all wind product types. Winds vectors are computed forward and backward in time and averaged in this approach. A larger percentage of targets are selected and produce higher quality winds as a result of this approach.

- Speed bias correction limited to fast, high-level cloud-drift winds poleward of 25^{o} latitude

- Quality control changes

Numerous changes relating to quality control of the GOES wind products were made. First, the EUMETSAT quality control indicator (Holmlund et al., 2000) has been implemented and passed into the final BUFR wind product datasets. The second change involved correcting tracer height assignments placed above the tropopause. The correction involved placing the tracer height at the tropopause level. The third change involves a small, but important change to the operational procedure used to reassign heights to thin cirrus tracers. The water vapor intercept height technique fails at times for thin cirrus tracers. In these cases, the IR window method must be relied on to provide an estimate of the tracer height, and due to emissivity problems is often erroneous (heights assigned too low). The procedure involves checking neighboring vectors where the water vapor intercept method was successful. If a neighboring vector is found, and is in general agreement with the vector in question, then the vector in question is assumed to be tracing undetected thin cirrus and its height is reassigned to the water vapor intercept of its neighbor. The change made to this procedure was to pass on the target temperature from the neighboring vector so that it would be consistent with the reassigned pressure. The final change made involved the reinstatement of fast (> 60m/s) cloud-drift winds at high levels (100-300mb) in jet streak regimes that may not agree with the guess wind speed. An example of reinstated winds is illustrated in Figure 3.

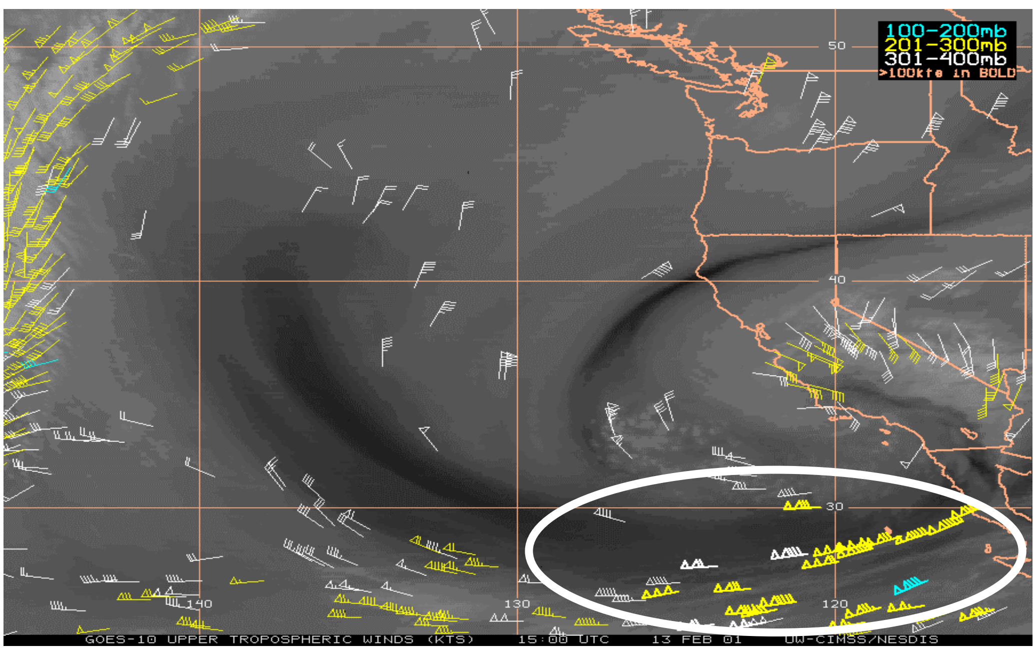

Figure 3. Reinstating high (100-300mb), fast (> 60m/s) cloud-drift winds (BOLD) that do not agree with the model forecast in the data-processing quality control step can provide useful information to weather forecasters in the field.

- Cloud-drift Winds Derived from 3.9um Measurements

The operational NESDIS winds software package has been updated to allow for the generation of low-level cloud-drift winds in non-sunlit areas using the 3.9um channel. While this capability is now present in operations, the actual production of these wind datasets will not occur until the end of 2002. The coverage offered by 3.9um winds rivals that obtained using the visible channel during daylight hours. This new product, then, will supplement the low-level visible and 10.7um cloud-drift wind products being generated operationally. The Tropical Prediction Center (TPC) has found this product extremely useful for analyzing the low-level wind field in the tropical cyclone environment (Dunion and Velden, 2001).

3. NESDIS/CIMSS Satellite-Derived Winds Research

3a. Rapid Scan Winds

Several field experiments afforded NESDIS and CIMSS the opportunity to further demonstrate improvements in both the quantity and quality of satellite cloud drift winds using 7.5 minute rapid-scan imagery. These field experiments included the 2001 and 2002 Pacific Landfalling Jets Experiments (PACJET) and the 2001 Convection and Moisture Experiment (CAMEX). Special GOES schedules were coordinated for each of these experiments that provided an hourly rapid-scan (7.5 minute) image triplet. Hourly rapid-scan wind datasets were generated in real-time and made available to participants in the various experiments. An example of the high spatial and temporal resolution cloud-drift wind products generated is shown in Figure 4. Inclusion of these hourly rapid-scan winds into the Rapid Update Cycle (RUC) mesoscale model has resulted in improved short-range (0-12 hour) wind predictions by up to 10% (Weygandt, et al., 2001).

While such experiments have allowed for the creation of special GOES schedules that provide routine rapid-scan imagery, operational implementation of such schedules in a two GOES satellite operation is more difficult because of the limited time budget offered by the current GOES schedules and the competing requirements for the GOES imagery which is available. A possible solution would be a three GOES satellite operation where one satellite is dedicated to providing routine rapid-scan imagery.

3b. New Capabilities with GOES-12

NOAA/NESDIS conducted a GOES-12 Science Test which allowed for the characterization of the quality of GOES-12 measurements and routine generation and validation of derived products including winds. The official time period of the science test was September 23, 2000 - October 27, 2001, but the GOES-12 data continued to be available until December 16, 2001.

The changes made to the GOES-12 imager offer potential benefits to the derivation of cloud-drift and water vapor motion winds. First, the addition of the 13.3um channel will allow, for the first time since GOES-7, the use of the well-known CO2 slicing algorithm (Menzel, et al., 1983) to assign heights to viable cloud tracers. The resultant CO2 slicing algorithm height assignments will supplement the height assignments provided by the water vapor intercept algorithm (Schmetz et al., 1992). Second, the improved resolution of the water vapor channel is expected to aid and improve the water vapor-motion wind product through improved tracking of water vapor features.

The GOES high-density winds software has been significantly modified to prepare it for the GOES-12 imager instrument changes and for the adoption and use of a new radiative transfer model. The RTTOVS radiative transfer model, which has been used since the launch of GOES-8, was successfully replaced with the Pressure-Layer Optical Depth (PLOD) radiative transfer model. Wind verification statistics, for high-level tracers whose primary height assignment method is the water vapor intercept method, indicate no significant differences in wind quality when switching from the RTTOVS to PLOD radiative transfer model.

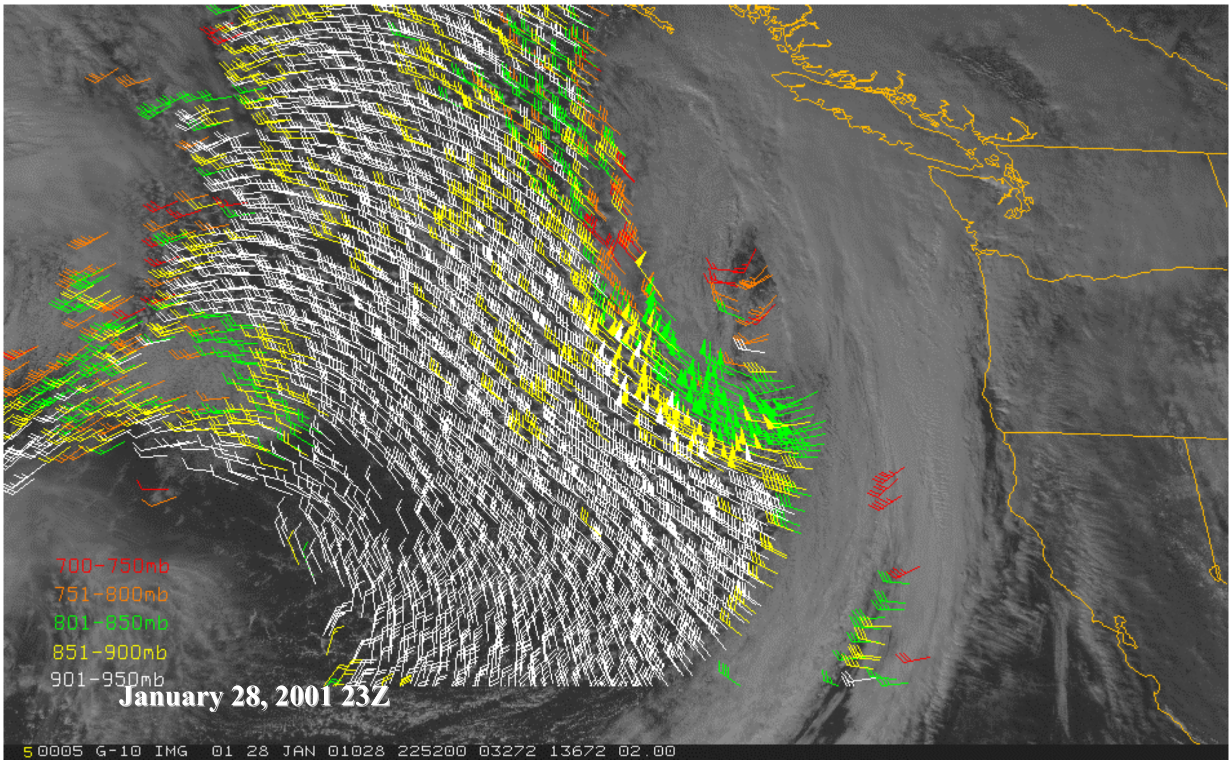

Figure 4. GOES-10 low-level cloud-drift winds generated from rapid-scan imagery during the 2001 PACJET Experiment

3c. Effects of First Guess Model Fields Used in the Derivation and Quality Control of Satellite-Derived Winds

A study was undertaken at CIMSS to investigate the effects of the first guess used in the derivation and quality control of the NESDIS satellite-derived cloud-drift winds. For a period of just over a month in the summer of 2002, cloud-drift winds were generated two times a day (near 00 and 12 GMT) over the US continental region. For each processing time, two sets of cloud-drift winds were generated; once using the NCEP Aviation model 12-hr forecast and once using the USNAVY NOGAPS global model 12-hr forecast as our first guess. A total of 74 cases were processed and rawindsondes were used to develop a statistical match file with collocated winds vectors (match radius of 1 degree, 50mb in height, and less than one hour time difference. Preliminary statistical analysis indicate that there appears to be very little impact on the overall quantity or quality of the satellite-derived winds using the operational NESDIS winds processing algorithm and different first guess fields. The overall wind counts (NOGAPS vs AVN) are within 1.5% of each other, and the root mean square differences are virtually identical. There is an indication of differences in vertical height distributions (vector height assignments) between the mid and upper-level bins. However, these differences are not large. This is being investigated further to determine the mean height differences between the two datasets.

While this study does not preclude local analysis differences that may result from the use of different first guess fields in the satellite wind processing, the overall effects are minimal. This conclusion could be a result of a convergence in the quality of global model analyses from different Centers, and also the steps taken to minimize the influence of the first guess in the satellite wind processing system. It is possible the differences may be greater over oceanic regions where the model analyses may exhibit larger differences. With these caveats, we believe the outcome of this preliminary study demonstrate a positive step towards addressing the concerns of the global modeling community over the processing of satellite winds using locally-selected first guess model fields for input into other global models.

3d. Polar Winds from MODIS

A new effort being demonstrated at CIMSS has been started to obtain estimates of high-latitude tropospheric winds using the MODerate Resolution Imaging Spectroradiometer (MODIS) on-board the National Aeronautics and Space Administration's (NASA) polar orbiting Terra satellite. Polar wind derivation presents some unique challenges, including the irregularity of temporal sampling, different viewing geometries from one image to the next, large uncertainties in the model forecast profiles used in height assignment and quality control, and the complexity of surface albedo. Cloud and water vapor tracking with MODIS data is based on the established procedure used for GOES. USA-WP-32 describes the recent developments in polar winds.

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