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Agenda Item: III.2

2002/2003 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

2002/2003 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 collaborations aimed at improving the quality of Atmospheric Motion Vectors (AMVs) derived from the GOES-I/M series of satellites. Active areas of winds research include improved height assignment through use of the 13.3um channel aboard GOES-12 (NOAA's newest geostationary satellite) and the derivation of motion vectors from rapid scan GOES imagery, the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument, and from the Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS).

2. Wind Extraction Methods

Operational winds from GOES are derived from a sequence of three navigated and Earth located images. 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

The winds are calculated by a three-step objective procedure. The initial step selects targets from the middle image of the image triplet, the second step assigns pressure altitude, and the third step derives motion. Tracers are assigned heights based on a temperature/pressure derived from radiative transfer calculations in the environment of the target. Motion is derived by a pattern recognition algorithm that matches a feature within the "target area" in one image within a "search area" in the second image. For each target two winds are produced; one computed forward in time and the other computed backward in time. These two winds are then averaged to arrive at the wind vector for this target. An objective editing scheme is then employed to perform quality control: the first guess motion, the consistency of the two winds, the precision of the cloud height assignment, and the vector fit to an analysis are all used to assign a quality flag to the "vector" (which is actually the average of the two vectors). Two more quality flags are assigned to the satellite derived wind vector. These quality flags are based upon the EUMETSAT quality control scheme (Holmlund et al., 2000) and are computed with and without model forecast wind data.

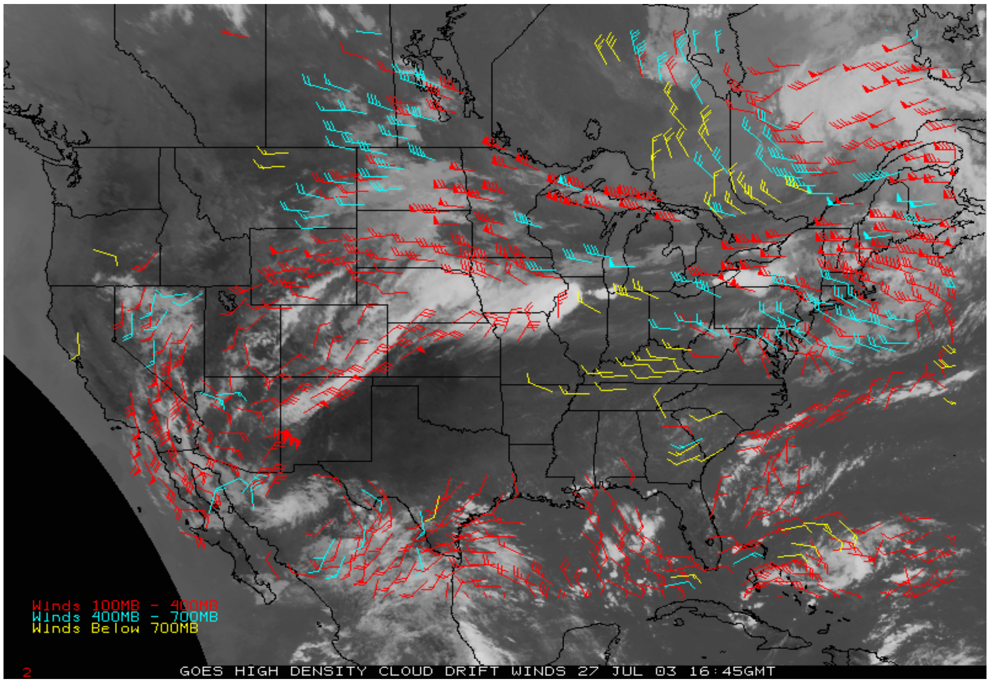

Figure 1. GOES-12 infrared cloud-drift wind product over the CONtinental United States (CONUS) at 16:45 UTC on July 27, 2003.

3. Product Dissemination to Users

All of the operational NESDIS wind products shown in Table 1 are encoded into Binary Universal Form for the Representation (BUFR) of meteorological data. All of the products, with the exception of the sounder water vapor winds, are encoded into the SATOB format and distributed over the Global Telecommunication System (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:

- Replacing local descriptors with WMO-sanctioned descriptors
- Using the latest version of the BUFR Tables
- Assuring that the quality control section contains Class 33 entries only
- Generating one BUFR message per file and increase the number of satellite wind observations per BUFR message. This eliminates file segmentation problems encountered by users, particularly when processing larger NESDIS wind files.
- Using newly defined WMO headers for GTS distribution

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 prepare improved weather forecasts.

4. Wind Evaluations

On April 1, 2003 GOES-12 replaced GOES-8 as the eastern satellite. The changes made to the GOES-12 imager offered benefits to the derivation of cloud-drift and water vapor motion winds. First, the addition of the 13.3um channel allowed, for the first time since GOES-7, cloud tracer height assignment to be accomplished with the well-known CO2-ratioing algorithm (Menzel, *et al*., 1983). Testing and validation of the GOES-12 wind products during the NOAA GOES-12 Science Test showed that the highest quality (as compared to collocated rawinsondes) high-level cloud-drift winds were those assigned CO2 heights. Based on this result, the height selection process was modified to follow a pre-determined order. For each tracer, a CO2 height is selected first (if available), then the H2O-intercept height (if the CO2 height is not available), and then the window height (if neither the CO2 height or H2O-intercept height is available). Second, the improved resolution (8km to 4km) of the water vapor channel has improved the water vapor motion wind product through improved tracking of water vapor features.

Steady improvements in the GOES cloud-drift wind algorithms, processing schemes, and quality control algorithms continue to be made. This is clearly evident in Figures 2 and 3, which illustrate the time series of mean vector difference and speed bias statistics between collocated GOES-E high level (100-400mb) cloud-drift winds and radiosonde winds in the Northern Hemisphere Extra-tropics (25N-90N) and the tropics (25N-25S) for the period May 6, 1998 to July 30, 2003. Note the steady reduction in mean vector difference over this time period.

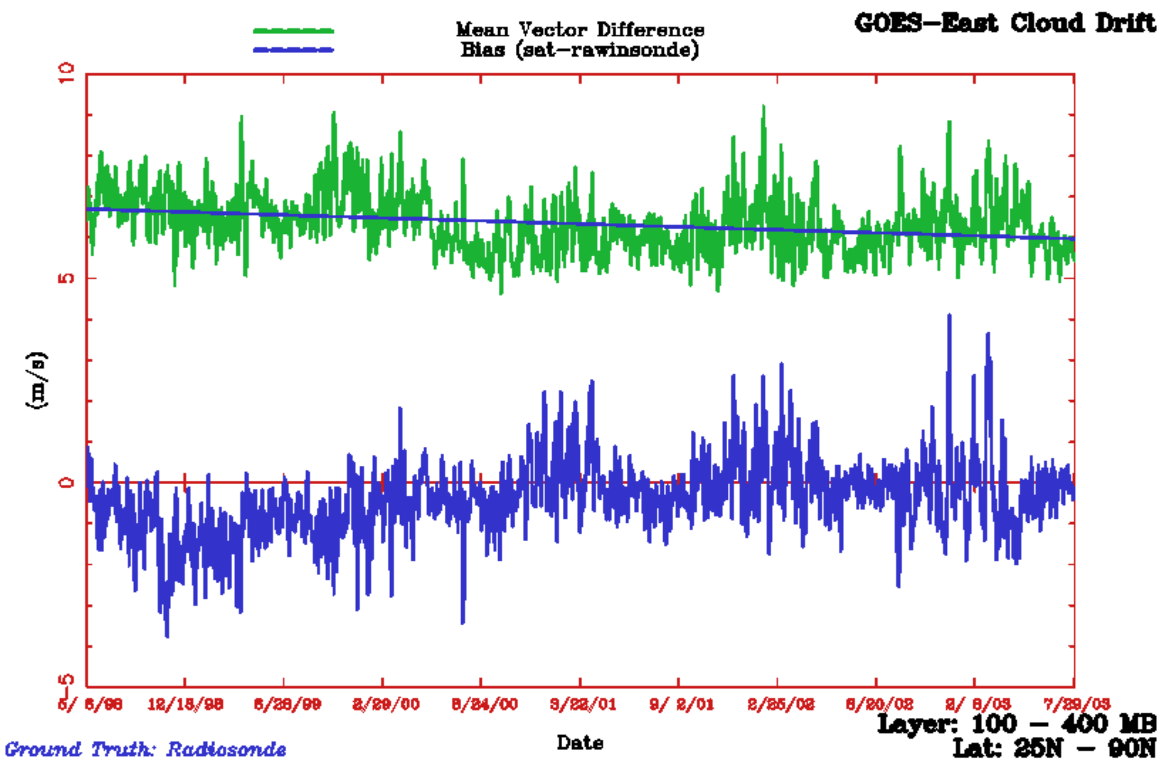

Figure 2. Time series (5/6/1998 – 7/29/2003) of mean vector difference and speed bias between high level (100-400mb) GOES-E IR cloud-drift winds and collocated radiosondes in the northern mid-latitudes.

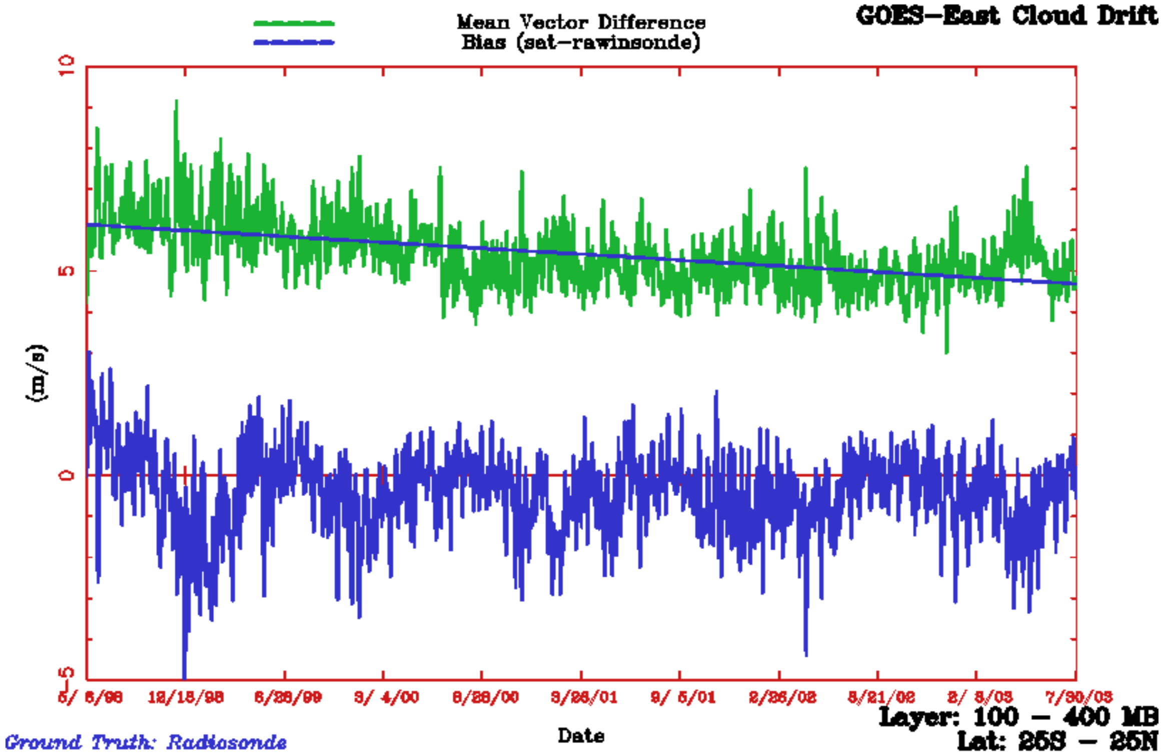

Figure 3. Time series (5/6/1998 – 7/29/2003) of mean vector difference and speed bias between high level (100-400mb) GOES-E IR cloud-drift winds and collocated radiosondes in the tropics.

On May 22, 2003, GOES-9 officially replaced Japan's ailing Geostationary Meteorological Satellite-5 (GMS-5), per a formal agreement between the United States and Japan. NESDIS began routine production of cloud-drift winds and water vapor motion winds every 6 hours from GOES-9. These are made available on a NOAA/NESDIS anonymous ftp server (gp12.wwb.noaa.gov) in BUFR format. The datasets can be found in /pub/bufrwinds/ where the dataset naming conventions are satwnd.bufrcdft.goesP* and satwnd.bufrwvap.goesP* for the cloud-drift winds and water vapor motion winds, respectively.

5. New Research

Real-time field experiments continue to provide excellent testing opportunities for deriving winds using rapid scan imagery. NOAA/NESDIS and CIMSS provided high-resolution winds from GOES-10 7.5 minute rapid scan visible and infrared imagery in support of the GWINDEX3/PACJET (GOES rapid scan WINDSs Experiment, PACific landfalling JETS experiment) which took place January-March, 2003. The rapid scan wind datasets are more coherent and contain a significantly larger number of wind vectors than those produced operationally using traditional image time intervals. Figure 4 is an example from the GOES-10 GWINDEX dataset for 1800 UTC on 29 January 2003.

Development of new approaches for obtaining estimates of high-latitude tropospheric winds continues using the MODerate Resolution Imaging Spectroradiometer (MODIS) on-board the NASA polar orbiting Terra and Aqua satellites. Areas of active research include determining the optimal mix of temporal resolution versus pixel resolution, determination of the optimal size of the target and search boxes, and understanding the inherent model guess dependency as it pertains to these choices. While this research is activity is ongoing, NOAA/NESDIS and CIMSS are working to transition the MODIS polar winds capability to the operational environment at NESDIS.

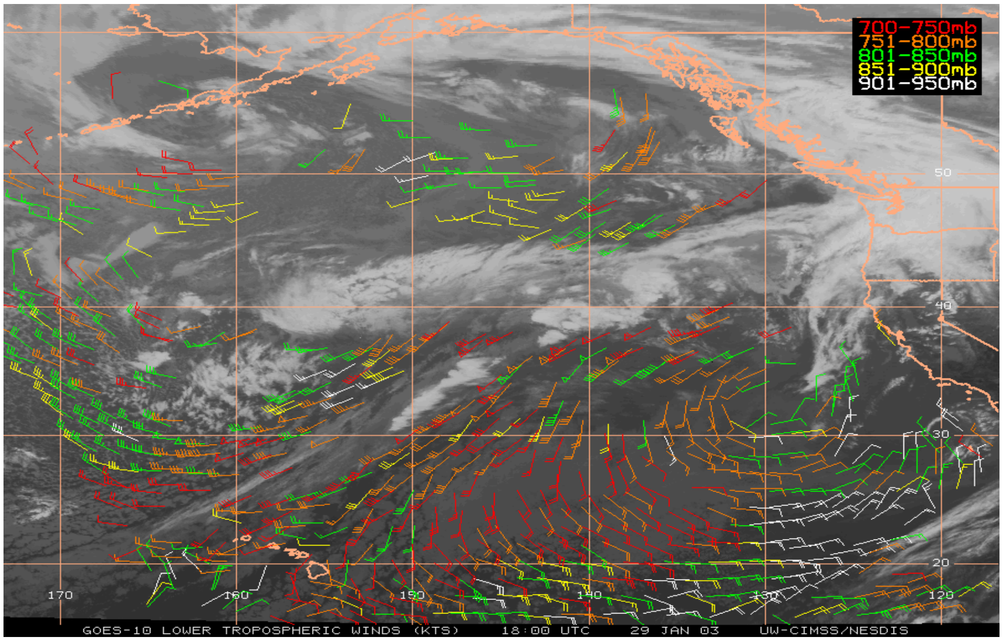

Figure 4. Lower tropospheric GOES-10 AMV from GWINDEX, 29 January 2003, 1800 UTC

CIMSS has started research in tracking features in hyperspectral moisture retrieval fields. Using simulated data from cases during the International H2O Project (IHOP) and THORPEX field programs, Geosynchronous Imaging Fourier Transform Spectrometer (GIFTS) retrievals were used to modify MM5 initial conditions. The resultant moisture fields (e.g., RH, mixing ratio on constant altitude surfaces) were used to track WV features with height assignments already dictated by the retrievals. These initial results proved that coherent vector fields could be achieved. However, a thorough validation of the vector field quality has not yet been completed. Another attempt utilized real data from a NPOESS Airborne Sounder Testbed Interferometer (NASTI) flight off the coast of California. This retrieval set was used to derive low-mid level moisture fields in a similar manner as above. While greatly restricted by the narrow viewing domain of the NASTI, the motion vectors that were retrieved agreed very well with the flow depicted in the nearby Vandenberg rawinsonde profile and the airborne wind lidar measurements. These studies are continuing at CIMSS.

References:

Holmlund, K., C.S. Velden, and M. Rohn, 2000: Improved quality estimates of atmospheric motion vectors utilizing the EUMETSAT quality indicators and the UW/CIMSS auto-editor. *Proc. Fifth Int. Winds Workshop*, Lorne, Australia, EUMETSAT, 73-80.

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