2003 / 2004 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. Research and development activities involving new satellite-derived wind products or improvements to existing satellite-derived wind products 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 Geostationary Operational Environmental Satellite (GOES)-I/M series of satellites. Active areas of winds research include 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. Performance of Operational GOES Wind Products

Operational production of cloud-drift and water vapor winds from GOES-12 (GOES-E) and GOES-10 (GOES-W) continues every three hours at NOAA/NESDIS. The current operational wind products (plus frequency of production, GOES image sector covered, and image interval generated) at NOAA/NESDIS are shown in Table 1. All of the operational NESDIS wind products shown in Table 1 are encoded into the World Meteorological Organization (WMO)-sanctioned Binary Universal Form for the Representation (BUFR) of meteorological data and distributed over the Global Telecommunication System (GTS). NOAA/NESDIS continues to encode its operational AMV products into the SATOB format and distribute them over the GTS. Many, if not all of the Numerical Weather Prediction (NWP) centers have switched from using the SATOB products to the BUFR products given the wealth of additional information stored in the BUFR formatted product files. Dissemination of the AMV products to users is a key issue in regards to realizing user impacts from improvements in processing. The BUFR file format allows for additional data descriptors, which can be interrogated by AMV users to better integrate the information into analyses and data assimilation systems. NESDIS also disseminates the operational GOES AMVs to the NOAA/National Weather Service's (NWS) Advanced Weather Interactive Processing System (AWIPS). Once at the NWS field forecast offices, weather forecasters use AWIPS graphics tools and capabilities to integrate these products with other data sources including model output, rawinsondes, and aircraft reports.

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

Steady improvements in the GOES cloud-drift wind algorithms, processing schemes, and quality control algorithms continue to be realized. 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-12 winds and radiosonde winds for the period 6 May 1998 to 18 March 2004. There is a steady reduction in mean vector difference over this time period. Statistics for GOES-10, while not shown, show similar results.

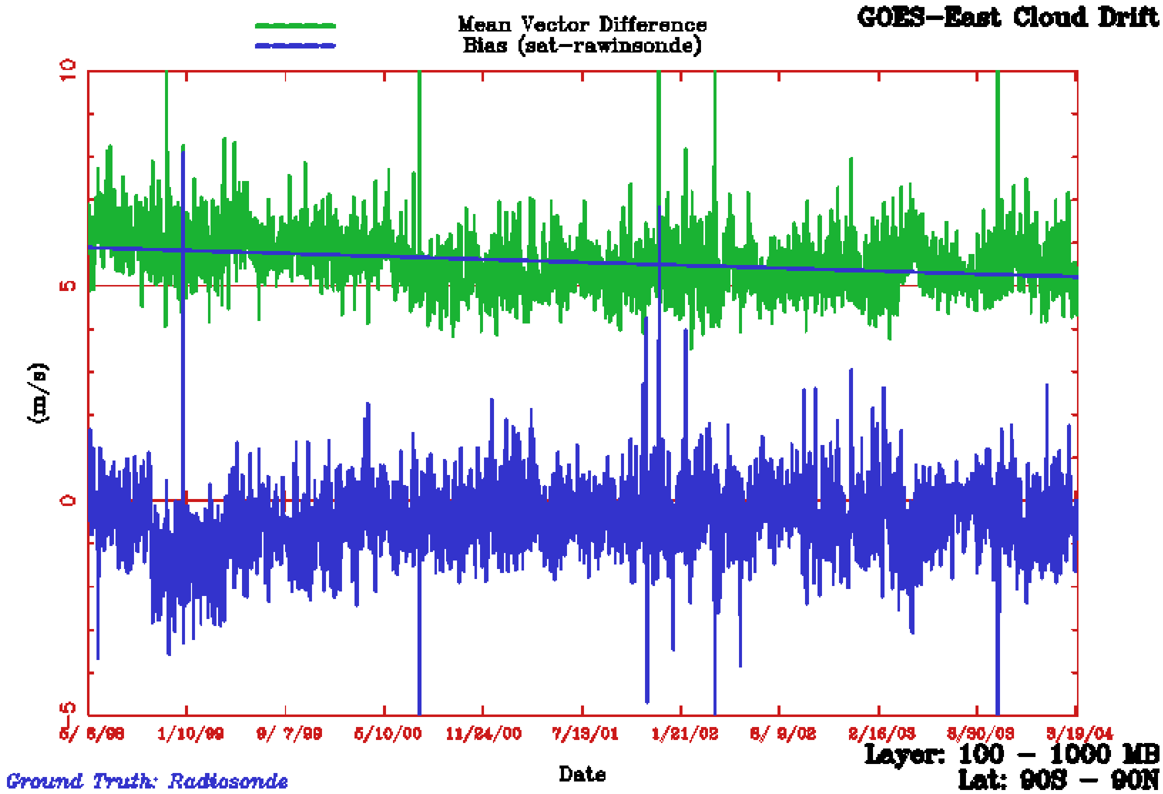

Figure 2. Time series (5/6/1998 – 3/18/2004) of mean vector difference and speed bias between GOES-12 IR cloud-drift winds and collocated radiosondes.

3. New Operational Wind Products

Operational production and distribution of low level (P > 600mb) cloud drift winds, derived from the 3.9 µm shortwave infrared (SWIR) channel on the GOES imagers, is scheduled to start on 27 July 2004. NOAA/NESDIS is currently generating this product on a routine basis in the operational environment. The usefulness of this channel for winds derivation is limited to nighttime applications because of its sensitivity to solar contamination. However, this is acceptable since tracking clouds using the visible channel is already very effective in daylight hours. Together, the SWIR cloud-drift winds, the traditional 10.7µm longwave infrared (LWIR) cloud drift winds, and the visible cloud drift winds provide a spatially and temporarly consistent set of wind observations in order to provide the best possible initial conditions for the NWP models and for the weather forecaster in the field to use. The SWIR AMVs from GOES provide significantly increased low-level wind information at night over that which is currently available with the routine operational LWIR techniques. This is illustrated in Figures 4 and 5 where the coverage of the SWIR AMVs (top) and LWIR AMVs (bottom) is shown.

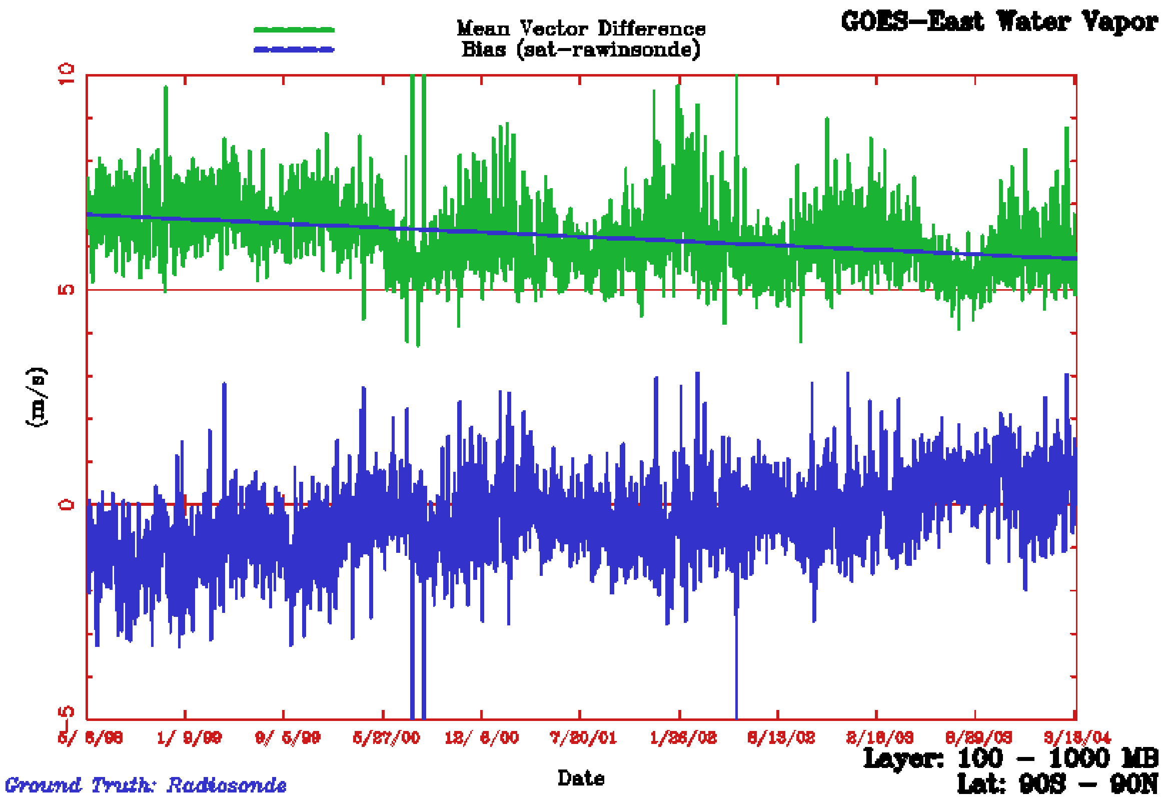

Figure 3. Time series (5/6/1998 – 3/18/2004) of mean vector difference and speed bias between GOES-12 Water Vapor winds and collocated radiosondes.

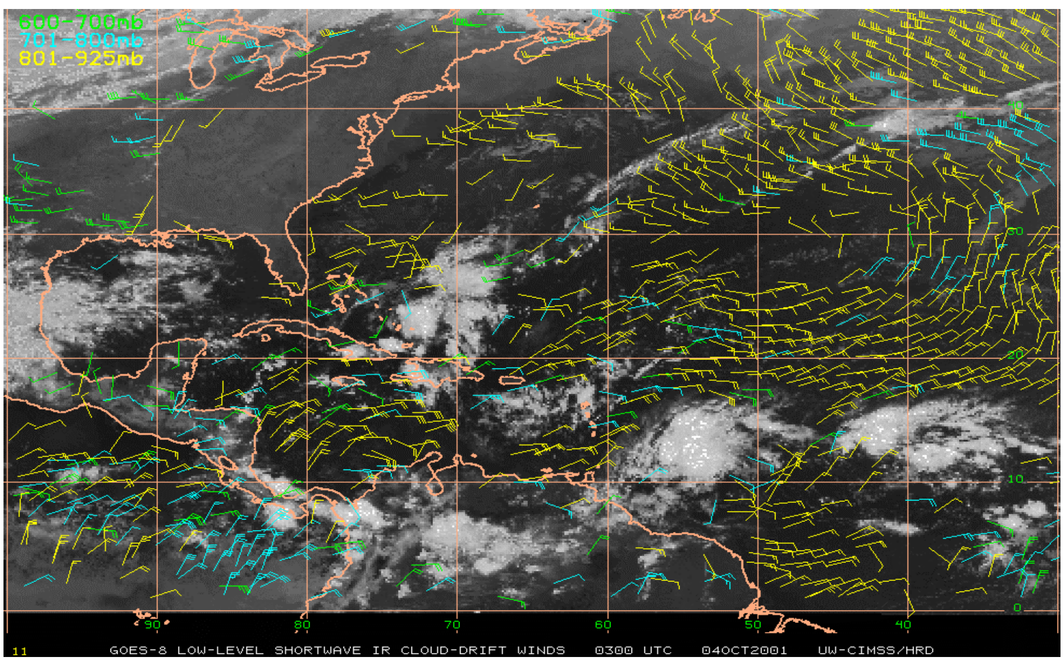

Figure 4. GOES-E nighttime SWIR AMVs over the western Atlantic Ocean on 3 October 2001.

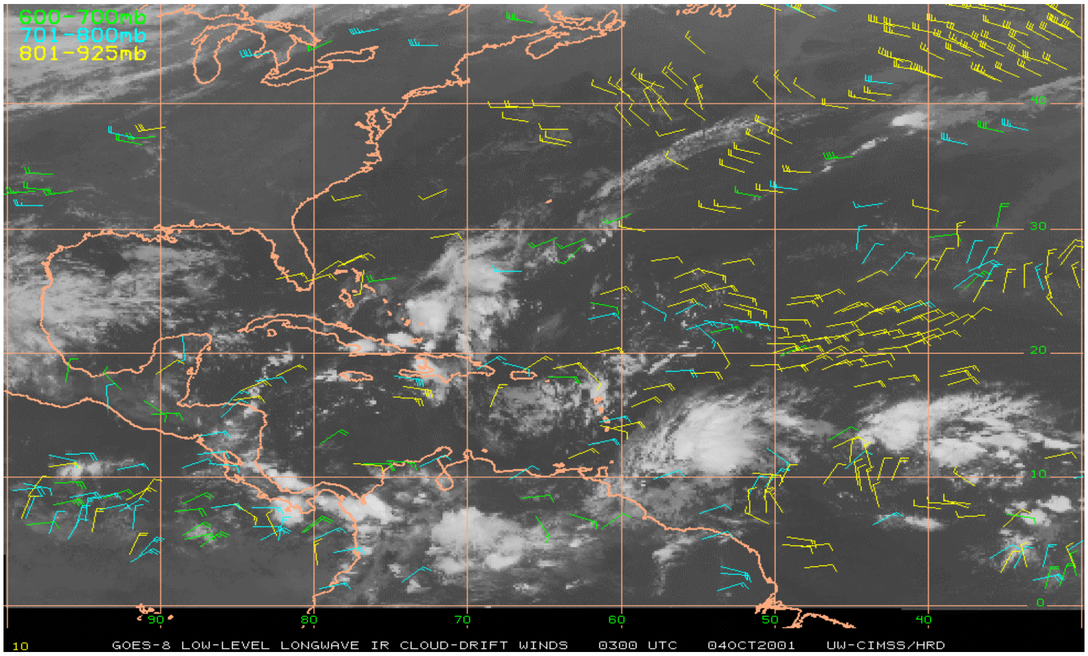

Figure 5. GOES-E nighttime LWIR AMVs over the western Atlantic Ocean on 3 October 2001.

4. Research and Development Activities

4.1 Winds from Rapid-Scan Imagery

GOES has been used in operational forecasting for quite some time in the United States. Forecasters recognize the additional detail that can be captured from more frequent imaging of events associated with rapidly changing cloud structures. This is evidenced by the recent inclusion of a 15-minute update cycle over the Continental United States (CONUS) sector in the current GOES schedule, and by the multitude of special National Weather Service (NWS) operational requests for more frequent sampling at 7.5 minute intervals (Rapid-Scan OPerations, RISOP). On occasion, special periods of Super-Rapid-Scan Operations (SRSO) have been requested by the research community. The SRSO allow limited-area coverage of one-minute interval sampling over meteorological events of interest.

Special GOES SRSO periods have been collected during several Atlantic hurricane events. The SRSO provides periods of continuous one-minute interval image sampling. Since hurricane cloud structures are characteristically fast-evolving, the advantages of super-rapid-scan imaging on resultant vector wind fields can showcase a prime application. A recent example of winds derived around Hurricane Isabel from SRSO imagery is shown in Figure 6. Routine use of the full 1-minute frequency for wind derivation, however, is not practical, due to the navigation/registration inaccuracies introduced at this high temporal frequency. However, sophisticated image pre-processing and tracking methodology and high-end computers can help overcome these limitations (Hasler et al. 1998). Applications of these rapid-scan data sets extend to hurricane genesis studies, and intensity change research (Knaff and Velden, 2000; Berger 2002).

The utility of GOES rapid-scan winds has been further demonstrated in field experiments designed to maximize observational abilities in regions of high-impact weather events. As an example, the GOES rapid-scan WINDs Experiment (GWINDEX) was carried out for two-month periods in each of the years 2001-2003 (Velden et al. 2001). The primary objective of GWINDEX was to demonstrate the improvement that could be gained in both quantity and quality of AMVs using GOES-10 RISOP imagery over the data-sparse northeast Pacific Ocean. The rapid-scan winds were produced in real time and provided mission-planning and forecast support to the coincident PACific landfalling JETs experiment (PACJET). An assessment of the GWINDEX datasets included a data impact study using the NWS Rapid Update Cycle (RUC) model.

Assimilation of the GWINDEX winds showed a positive impact on RUC analyses and short-term forecasts for the western U.S. coastal area (Weygandt et al. 2001).

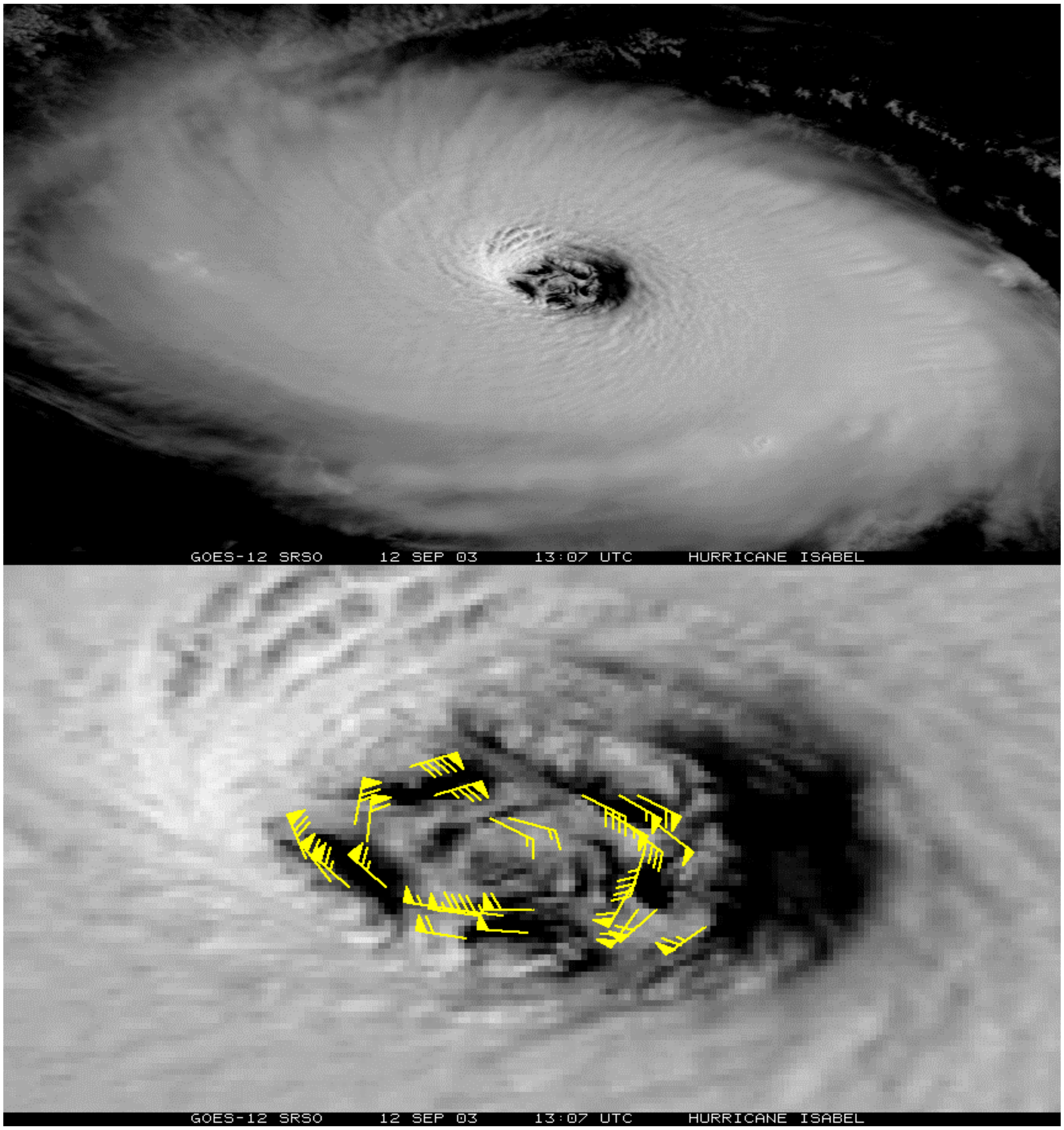

Figure 6. Hurricane Isabel in GOES-12 VIS imagery on 12 Sept. 2003 (top). Low-level AMVs in Isabel's eye derived from GOES-12 super-rapid-scan (3-minute intervals used) VIS imagery (bottom).

4.2 Polar Winds from MODerate Resolution Imaging Spectroradiometer (MODIS) data

The feasibility of deriving tropospheric wind information at high latitudes from the MODIS instrument aborad the Terra and Aqua satellites has been demonstrated by CIMSS (Santek et al, 2002; Key et al, 2003). Cloud and water vapor tracking with MODIS data is based on the established procedures used for GOES, which are essentially those described in Nieman et al. (1997) and Velden et al. (1997, 1998). With MODIS, cloud features are tracked in the IR window band at 11 µm and water vapor (WV) features are tracked using the 6.7 µm band. An example of typical MODIS AMV coverage is shown in Figure 7. Additional details are given in Key et al. , 2004

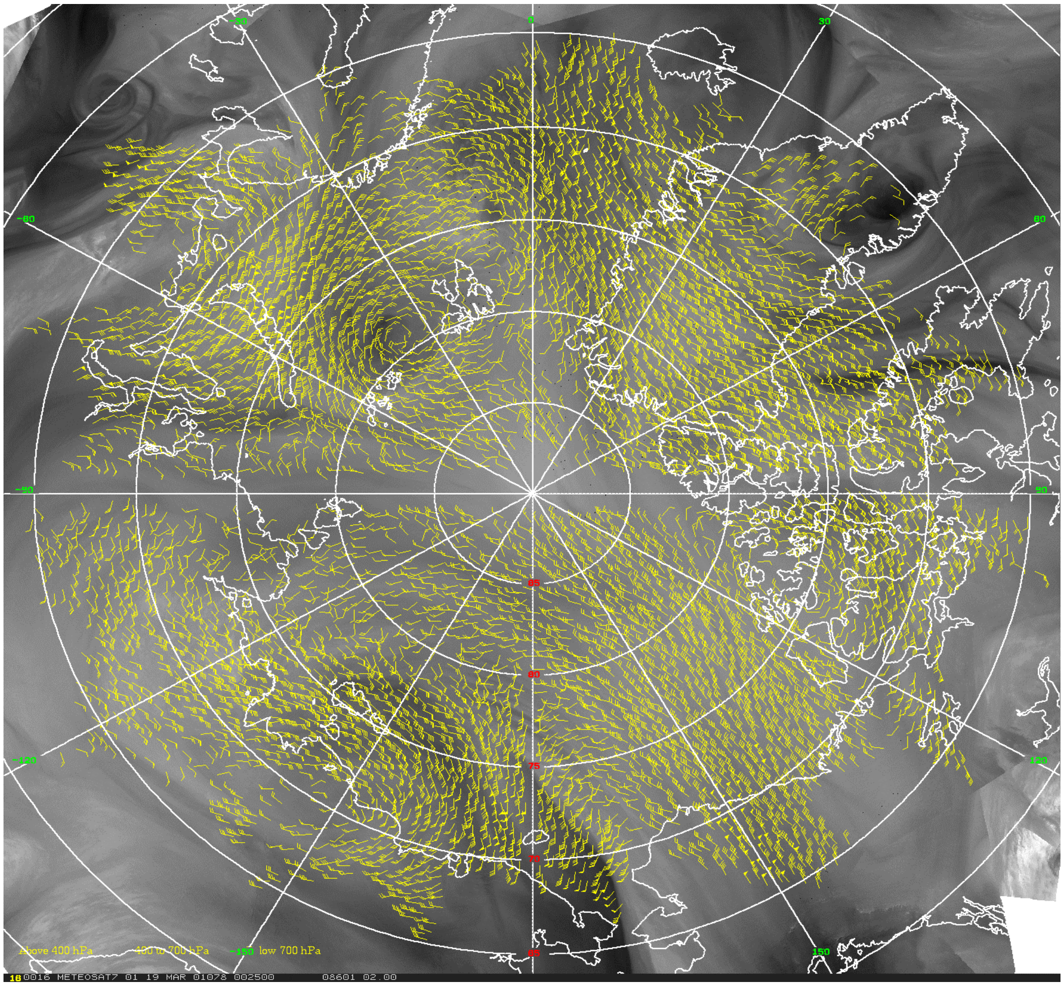

Figure 7. Wind vectors derived from infrared cloud and water vapor features of successive MODIS passes over the Arctic. This is the daily coverage of AMVs from Terra overlaid on a daily water vapor image composite.

Orbital characteristics, low water vapor amounts, a relatively high frequency of thin, low clouds, and complex surface features create some unique challenges for the retrieval of high-latitude AMV. Nevertheless, initial model impact studies with the MODIS polar AMVs conducted at the European Center for Medium Range Weather Forecasting (ECMWF) and the NASA Global Modeling and Assimilation Office (GMAO) were encouraging enough, such that these winds are now being assimilated on an operational basis at ECMWF.

For approximately the past three years, CIMSS has been processing the MODIS AMVs from the Terra satellite in near real time. The Aqua satellite AMVs were added in early 2003. The dataset processing success rate has been very good (>95%), with datasets normally available 3-8 hours after satellite overpass time. In mid 2003, NESDIS/ORA began processing the MODIS AMVs locally in a demonstration mode, in anticipation of transitioning to fully operational processing at NESDIS in late 2004.

Additional information regarding polar winds can also be found in CGMS XXXII NOAA-WP-25.

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