CGMS XXIX
USA-WP-31
AGENDA ITEM: III.1
DISCUSSED IN WG-3

2000/2001 REPORT ON NOAA/NESDIS SATELLITE-DERIVED WINDS

SUMMARY AND PURPOSE OF DOCUMENT

An overview of the 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. In addition research has begun on polar winds derived from MODIS.

ACTION REQUESTED: NONE

2000/2001 REPORT ON NOAA/NESDIS SATELLITE-DERIVED WINDS

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I. Introduction

The NOAA/NESDIS operational GOES-8/10 winds production has continued to evolve. Winds are being produced every three hours from IR window water vapor, and visible (when available) images with high spatial density; the quality of the wind product is being reported monthly in accordance with CGMS reporting procedures (Schmetz et al., 1999). Improvements in the winds product are being researched in several areas including 4 micron winds at night, improved motion vectors from rapid scan imagery, polar winds from multispectral MODIS data, and winds from hyperspectral GIFTS measurements.

II. NESDIS Operational Winds

NOAA/NESDIS, together with CIMSS, is continuing to improve the operational 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. Figure 1 shows the GOES cloud drift winds compared with radiosonde observations for the past 2 years; the root mean square is around 6 m/s and the bias is less than 1 m/s.

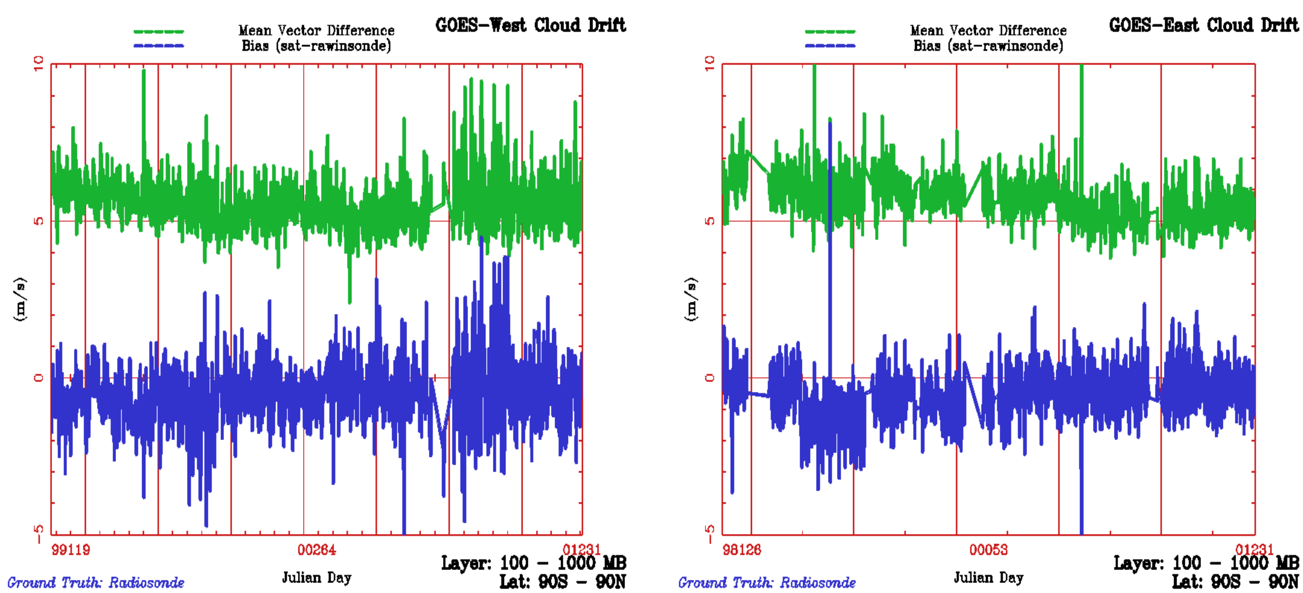

Figure 1. Statistics (bias and root mean square) of GOES-W (left) and GOES-E (right) cloud drift winds compared with radiosonde observations for May 1999 through August 2001.

III. NESDIS/CIMSS Satellite-Derived Winds Research

IIIa. Shortwave Infrared (3.9 µm) Cloud-Drift Winds

Low-level (600-925 hPa) cloud-drift winds are routinely generated by NOAA/NESDIS using the long wave IR (LWIR) and visible (VIS) channels on the GOES-8 and GOES-10 satellites. The visible channel greatly increases the coverage, but is only applicable in daylight imagery. Recent work using the 3.9 µm short wave infrared (SWIR) channel available on the GOES satellites is providing higher detectability of coherent low-level cloud tracers. The SWIR channel is a slightly cleaner window channel than the routinely used 10.7 µm LWIR channel for winds from GOES, and is more sensitive to warmer temperature clouds.

This channel must be limited to nighttime use, since the SWIR channel is sensitive to solar reflection by cirrus and especially low-level cumulus clouds which can adversely impact the accuracy of the wind vectors. To avoid solar contamination in the SWIR channel, any targets located in sunlit conditions or positioned within 30 min of local sunset (when utilizing 15 min. imagery) are excluded. To maximize the number of SWIR winds generated, the relatively flat gradients of 3.9 µm brightness temperatures must be stretched to enhance the warmer temperatures characteristic of the low-level gradients prior to their being used in the targeting/tracking algorithm. These improvements are producing low-level nighttime wind coverage that rivals that obtained using the visible channel during daylight hours. SWIR winds were compared to rawinsonde winds for two months over the CONUS region and found to exhibit accuracies similar to the LWIR winds.

SWIR cloud-drift winds are currently being developed to provide nighttime coverage in the tropical cyclone environment (Velden and Dunion 2001). Figure 2 clearly shows the improved coverage obtained by the SWIR winds over the current operational product. Figure 3 shows an impressive example from recent Tropical Storm Barry. This product was made available to the Tropical Prediction Center in real time as a demonstration, and was acknowledged as very useful to their wind analysis and advisories. Plans include the application of the NOAA/AOML/HRD surface adjustment algorithms on these nighttime SWIR winds for use in the HRD surface analysis.

These near infrared winds, while experimental, show promise for providing a substantial increase in the nighttime low-level wind information derived from geostationary satellites, particularly over oceanic regions such as the tropics or off the west coast of CONUS (Fig. 3). After a bit more testing, tuning and validation, the method will be transitioned into the NESDIS operational environment in the near future for routine production.

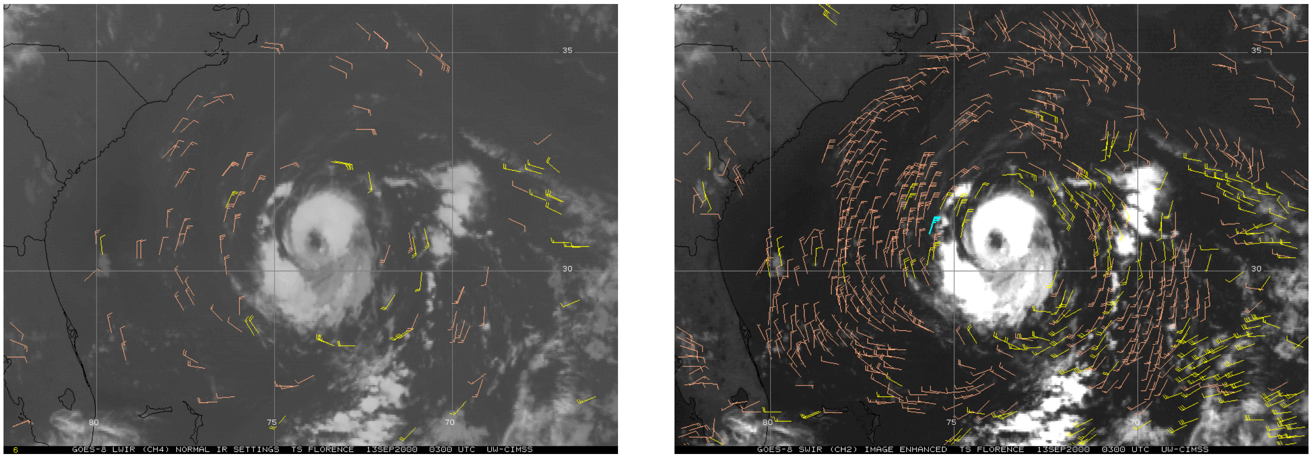

Figure 2: LWIR (left) and SWIR (right) cloud-drift winds with enhanced imagery/settings for Tropical Storm Florence on 13 Sep 2000 at 0300 UTC.

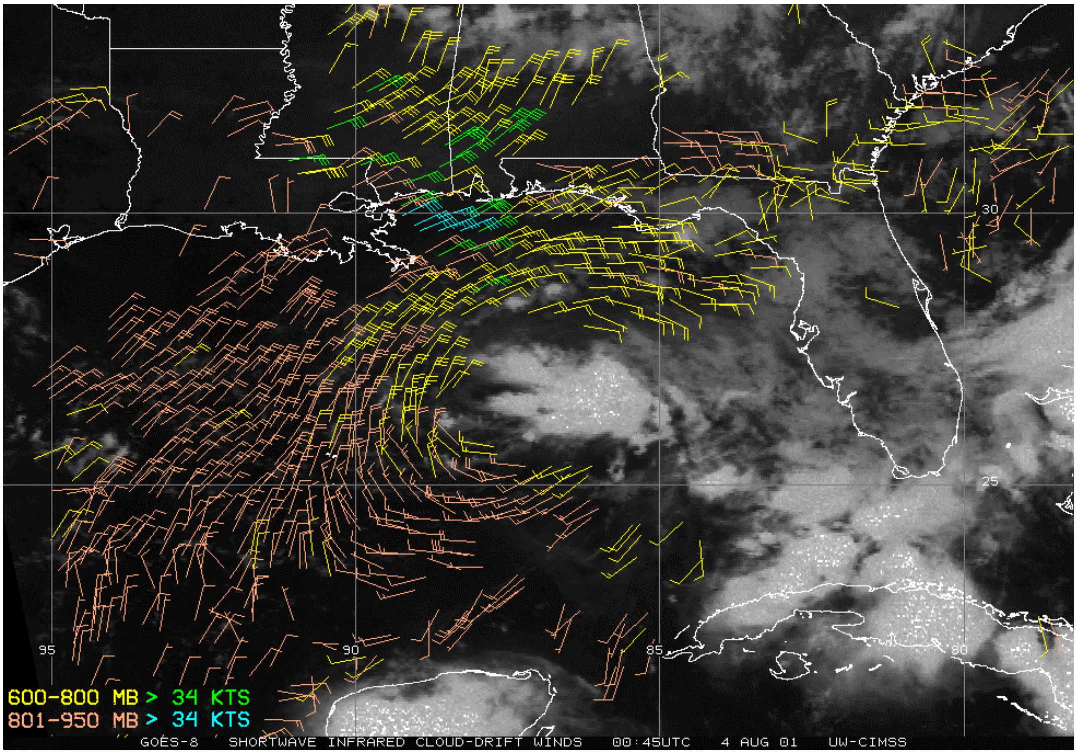

Figure 3: SWIR cloud-drift winds with enhanced imagery/settings for Tropical Storm Barry on 4 Aug 2001 at 0045 UTC.

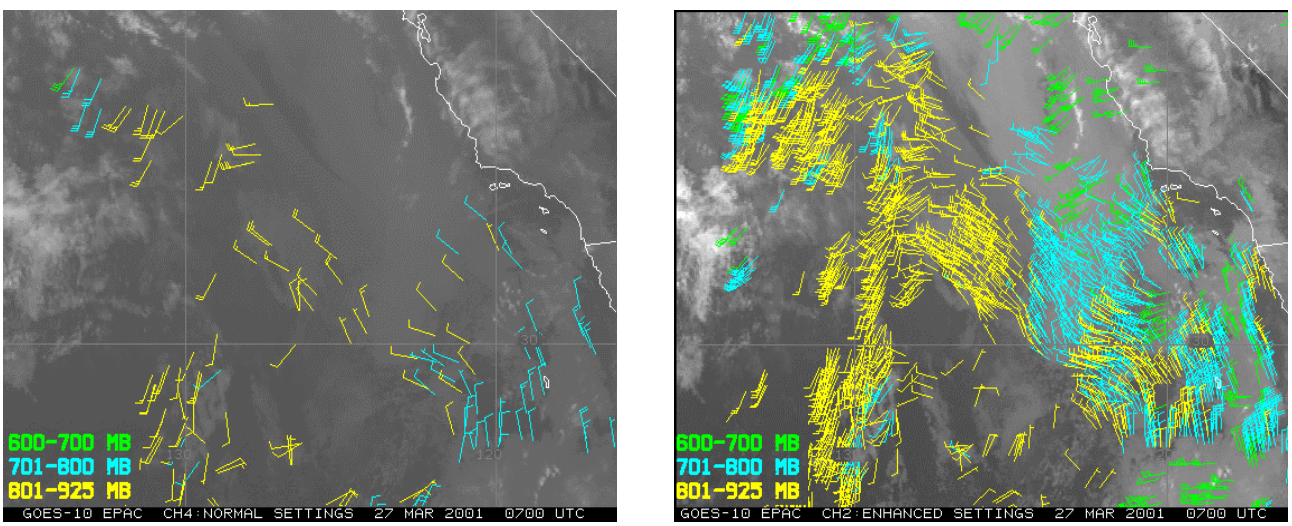

Figure 4: LWIR (left) and SWIR (right) cloud-drift winds with enhanced imagery/settings over the Eastern Pacific on 27 Mar 2001 at 0700 UTC.

IIIb. Rapid-Scan Studies with GOES

The GOES-10 rapid-scan WINDs EXperiment (GWINDEX), conducted January through March of 2001, demonstrated the improvement in both the quantity and quality of satellite-derived cloud-motion winds using 7.5 minute interval rapid-scan visible (0.65 µm channel, VIS) and infrared (10.7 µm channel, IR) imagery. The primary goal was to provide improved wind information over the data sparse northeast

Pacific Ocean; data was also provided to the coincident PACific landfalling JETs experiment (PACJET). The datasets were evaluated in real time by NWS forecasters and assessed through impact studies on the Rapid Update Cycle (RUC) model short-term forecasts.

Beginning in January through March 2001, NOAA implemented a special (and temporary) scanning schedule for GOES-10 that allowed three successive images approximately 7.5 minutes apart (with daily exceptions for routine satellite maintenance at 0400, 1600, and 2200 UTC). Special GWINDEX wind fields covered 15 to 60 N latitude and 115 to 175 W longitude. Satellite derived winds were generated by CIMSS on an hourly basis using the 7.5 minute interval VIS (from 1500 UTC through 0300 UTC) and IR image triplets. WV winds were produced at NOAA/NESDIS using one-hour interval image triplets. Very high-density vector plots each hour were focused on California and on Washington/Oregon providing close-ups on landfalling systems for the PACJET users. Three-hourly lower resolution plots provided synoptic scale perspectives for the entire northeastern Pacific Ocean region. All plots generated during GWINDEX are available at http://gale.ssec.wisc.edu/.

An example of the PACJET regional upper tropospheric winds plot from 2300 UTC on 18 March, 2001 is depicted in Figure 5. Winds included in this plot are derived from both GWINDEX rapid-scan IR and one-hour interval WV. Vector filtering was used to allow better interpretation of the data. The lower tropospheric winds for the same location and time are also shown in Figure 5. Since this time period was during daylight hours, most of the winds shown were derived from rapid-scan VIS images. Some rapid-scan IR winds are also included.

Initial evaluation of the impact of the GWINDEX datasets has been positive. The PACJET community used the data to help in mission planning and will evaluate the data with in situ observations taken during the experiment. An initial assessment on the impact of the datasets on RUC forecasts has been done (Weygandt et al. 2001), with the data showing a slight positive impact. Further data assimilation experiments are underway with the RUC, and planned with the MM5 (Mecikalski et al. 2001). A statistical analysis is being performed, but qualitative indications are that the rapid-scan data are coherent and the quantities produced vastly exceed those produced routinely using traditional image intervals.

A second experiment is being run in the summer/fall of 2001 using GOES-8 rapid-can schedules to observe Atlantic hurricane activity. It is hoped that these rapid scan demonstrations will lead to permanent operational 7.5-minute rapid scan schedules for GOES.

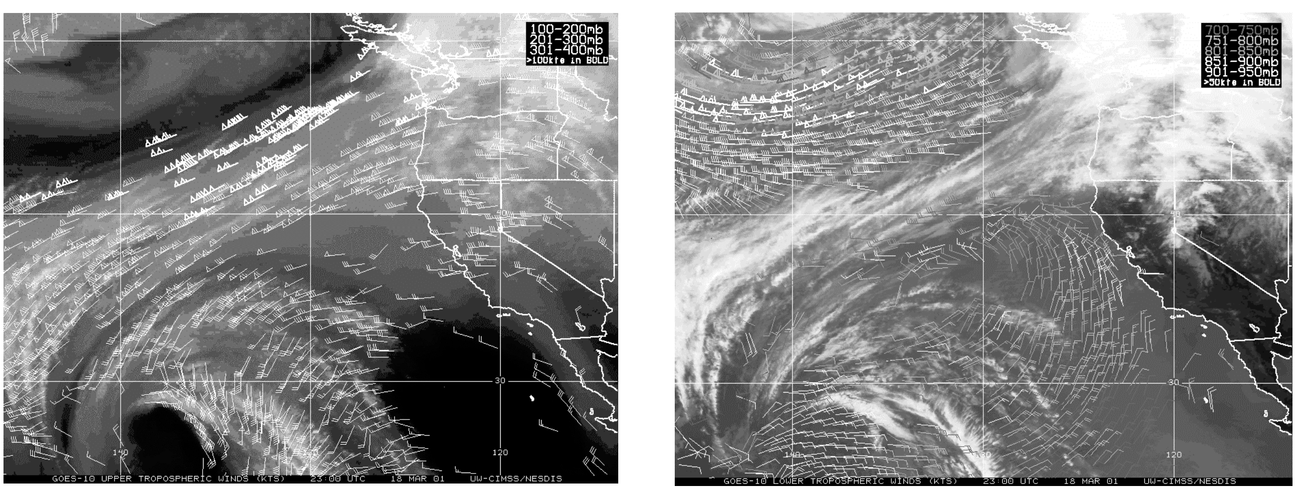

Figure 5: Upper-tropospheric (left) and lower-tropospheric (right) winds plotted over the GWINDEX region at 2300 UTC on 18 Mar 2001. Vectors have been filtered for plotting purposes.

IIIc. Polar Winds from MODIS

Polar regions also suffer from a lack of observational data. While there are land-based meteorological stations in the Arctic, and a small number of stations around the coast of Antarctica, there are no routine observations of winds over the Arctic Ocean and most of the Antarctic continent. Unfortunately, geostationary satellites are of little use at high latitudes due to the large view angles and poor spatial resolution, resulting in large uncertainties in the derived wind vectors. A new effort 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, which is essentially that described in Nieman et al. (1997). Height assignments are based on CO2 slicing with MODIS data (Menzel and Strabala, 1997). After wind vectors are determined and heights are assigned, the resulting data set is subject to a postprocessing, quality-control step. The purposes of this step are to determine the tropospheric level that best represents the motion vector being traced, to edit out vectors that are in obvious error, and to provide end users with vector quality information (Velden et al., 1998).

Figure 6 shows vectors derived from both cloud and water vapor tracking in three consecutive overpasses (separated by about 100 minutes) on 6 September 2000 over the western Arctic Ocean. Portions of the underlying infrared image are devoid of wind vectors because those areas were not observed in subsequent overpasses. Lower tropospheric wind estimates occur within the cyclonic system north of Siberia and also just east of 120 E longitude; mid-level, high velocity winds were measured in and around the frontal structure extending from the lower center portion of the image through the New Siberian Islands and also northeast of Wrangel Island in the bottom left portion of the image. Vectors for upper-level winds, primarily from the water vapor band, occur throughout the field. This preliminary work has demonstrated the feasibility of deriving tropospheric wind information at high latitudes from polar-orbiting satellites. Model impact studies are now planned.

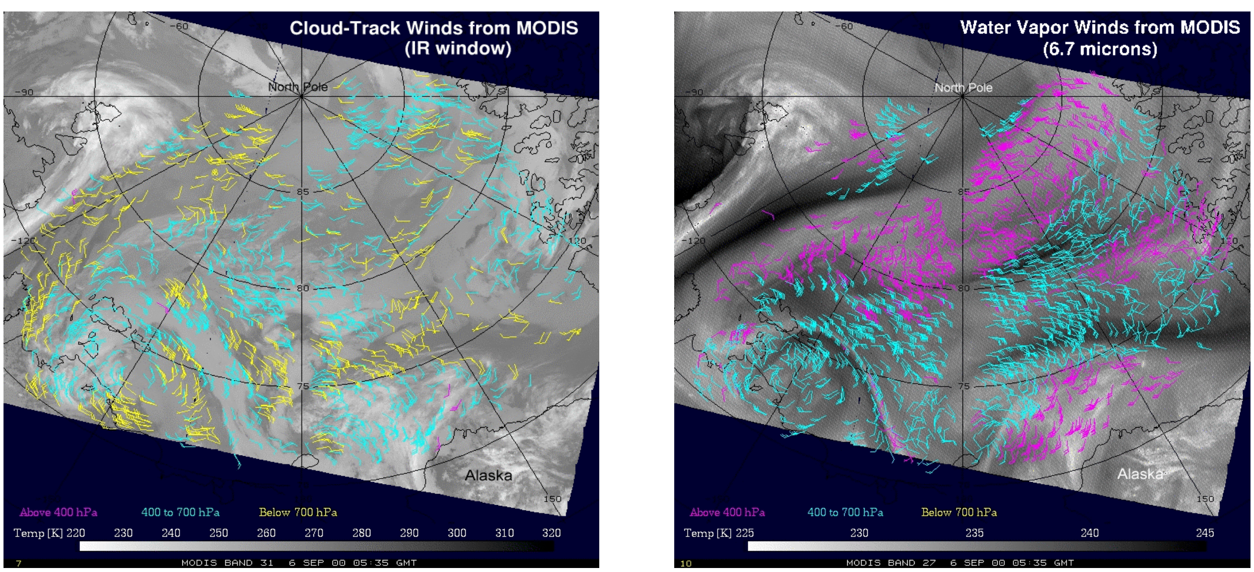

Figure 6: MODIS IRW (left) and water vapor winds (right) in the western Arctic on 8 Sep 2000. Vector heights are given in three broad categories: low (yellow), middle (blue), and high (purple).

IIId. Winds from Hyperspectral Imagery

The Geostationary Imaging Fourier Transform Spectrometer (GIFTS), selected for flight demonstration as NASA's New Millennium Program (NMP) Earth Observing-3 (EO-3) mission in 2005, will enable water-vapor winds to be altitude-resolved throughout the troposphere. The expected performance of wind retrievals and the justification is given in Figure 7a. Three different methods will be tried to derive wind vectors from the GIFTS fields. First, moisture feature tracking will be attempted in selected individual channels, much as we do now. Second, due to the plethora of spectral channels, feature tracking in "super-channels" will be explored; these super channels will be derived by combining selected individual channels to enhance the signal. Third, the retrieved moisture profiles will be analyzed onto constant pressure surfaces and the resulting fields will then be used to track features in time, and eliminate the ambiguity in vector height assignment.

In an attempt to get ready for the production of winds from this hyperspectral sampling, GIFTS data cubes have been simulated using a local mesoscale model. Successive moisture fields on constant pressure surfaces were tracked using the existing automated winds tracking software. A case from hurricane Bonnie in 1999 is used to illustrate the achievable vector distribution using simulated GIFTS moisture fields (Figure 7b). Extensive experimentation in this area is planned before launch.

References

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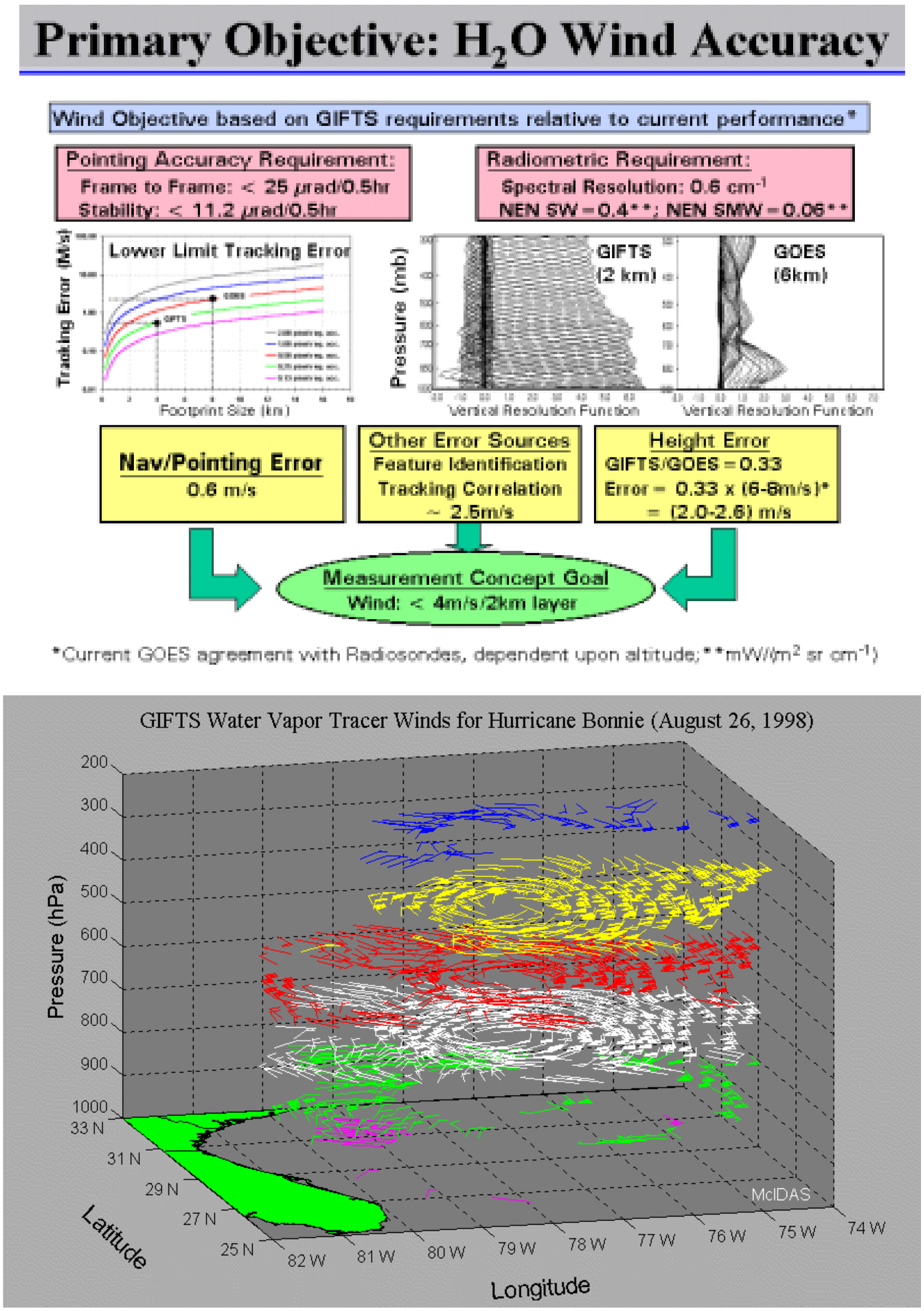

Figure 7a and 7b: The expected performance of wind retrievals from successive moisture fields on constant pressure surfaces was explored using the existing automated winds tracking software on simulated GIFTS data to produce this wind field for Hurricane Bonnie in 1999.