2005 Semiannual Report on Second Year of JHT Project entitled:

Real-Time Dissemination of Hurricane Wind Fields Determined from Airborne Doppler Radar Data

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Accomplishments since Year 1 Report:

1) Real-time quality-control, interpolation, and synthesis software installed aboard NOAA P-3 for 2004 hurricane season
2) Wind fields developed onboard aircraft in "real time" during flights in Hurricanes Frances and Ivan
3) Quality-controlled files of Doppler-velocity radials produced aboard the aircraft
4) Completion of debugging and optimization of code, both needs becoming apparent during the 2004 tests onboard the P-3
5) Evaluation of output wind fields using GPS dropsondes begun
6) Discussions with TPC hurricane specialists were held to determine the kinds of displays of data they think might help them to "nowcast" wind structure.

Overall goals of project:

The goal of this JHT project is to provide information to the National Weather Service regarding winds in three dimensions near the core of the storm using the airborne Doppler radar. The expertise to synthesize quality-controlled Doppler measurements into three-dimensional analyses is already well developed at HRD; however, the means to quality control has always been from using "black box" software from NCAR, and doing much of the quality control manually, using people qualified to make judgments about which data are actually artifacts or will contribute to errors in the analysis. The analyses are also completed over a period that may span months or years, affording the analyst the luxury to mull over the data. Thus the analyses are performed in a laboratory using computers on the ground. Consequently, the major tasks to be accomplished to provide real-time data are 1) automatic quality control, 2) production of analyses aboard the aircraft, 3) successfully transmitting Doppler radial observations (in the form which the PI and those receiving the data at EMC agree are most useful and practical) from the aircraft, and 4) transmitting and depicting the analyses conveniently for the very busy hurricane specialist.

Discussion:

As of the time of the first year annual report in mid-May of 2004, major task (1) above was nearing completion, except for modifications that might be necessitated after testing the software during the hurricane season. It was hoped that during the 2004 hurricane season, major task (2) would be accomplished and major task (3) would be tested. During flights of NOAA 43 in Hurricane Frances and Ivan, analyses were produced. Unfortunately, the complete networking needed to send the test transmission of data to EMC had not been completed, so no SATCOM transmissions of data off the aircraft occurred during the 2004 Hurricane Season.

Major task (2), the production of wind analyses in real time aboard the aircraft, was successfully accomplished during the flights of NOAA 43 on 12 and 15 September, and with more limited success on 13 September. The software on these three flights was operated by the PI. On 31 August in Hurricane Frances, the software was operated with limited success by, Mr. Peter Dodge, an HRD co-investigator on this project. The major obstacles to more successful completion of the analyses jobs on 31 August and 13 September resulted from testing the software on the ground in debug mode, but neglected to test it thoroughly in optimized mode. Such tests were conducted immediately following the flight season, and several uninitialized variables were found in the code. These bugs were corrected and the code appears to run to completion in over 90% of the cases it is now applied to. Photographs of the display of the onboard HRD workstation on 12 September, 2004, in Hurricane Ivan are shown in Figure 1. The upper

photograph shows the wave-number 0 and 1 components of wind speed at the 1-km altitude. The low-wave-number Fourier analysis was applied to the automatically de-aliased Doppler radar data. Such an analysis tends to reduce the local effect of an error in de-aliasing. The low-wavenumber wind analysis was then used to "seed" the radial de-aliasing scheme, wherever there was a radial gap in Doppler-velocity data greater than 1 km. Otherwise, within contiguous segments of data along the radial, Bargen-Brown de-aliasing was still applied, followed by an azimuthal de-aliasing. To prevent whole scans from being improperly de-aliased by 1 or more Nyquist intervals (2 times the Nyquist velocity), the resulting scans were compared with the projection of the low-wavenumber analysis upon the scan, and the mean differences were forced to be within in Nyquist velocity, by increasing or decreasing all radial velocities on the scans by integer multiples of the Nyquist interval. From the Doppler radials that resulted from this second-pass de-aliasing, a fully three-dimensional analysis was produced, as well as the vertical profiles such as the one shown in the lower photograph of Figure 1. During these flights, a set of trimmed, corrected Doppler radials were stored in the form they would have had for transmission from the aircraft. Since the hurricane season, further trimming has been applied to the files, since early use of the data will be in models with horizontal resolutions of ~10 km, and the SATCOM bandwidth is limited presently to several hundred bytes per second.

An evaluation of the Doppler analyses by comparing with GPS sondes has just begun. Thus far, only comparisons for 12 September have been done. Two of the more encouraging comparisons for data on 12 September are shown in Figure 2. The comparison is between the radial vertical profiles with 150-m vertical resolution, and the GPS sondes. No attempt has been made to filter the GPS profile to give it the same vertical resolution as the Doppler profiles, but the match between the overall shapes of the profiles is very good. For the top profile the mean difference of the Doppler profile from the GPS profile was –0.8, -0.8, and –1.4 m/s for the wind speed, radial, and tangential winds, respectively, while the corresponding rms differences were, 2.3, 4.8, and 3.0 m/s. The corresponding values for the bottom profile were 0.0, -2.5, -0.3, 4.0, 4.7, and 3.9 m/s. Summed over all 11 sondes dropped within the Doppler analysis domain, the corresponding values are 0.6, -1.0, 0.3, 3.4, 5.2, and 3.5 m/s. Thus the rms differences for wind speed and vector difference were 3.4 and 6.3 m/s, respectively, and the vector difference is dominated by differences in the radial wind. These comparisons will eventually be made for all the analyses of hurricane penetrations in 2004.

Discussions with hurricane specialists at TPC recently began concerning products that could be tested during the hurricane season. The first choice was a horizontal wind field at 500 m (1600 ft). The next choice would be vertical profiles that extend out to minimal-tropical-storm-force winds (in practice this will mean out to the end of the radial flight leg). Software will be modified to make these analyses available to TPC, and the data files will be used to develop display products for the NWS NMAP2 software.

Remaining tasks:

1) Cooperate with TPC to develop display products that will use analyses sent from the NOAA P-3 aircraft in real time
2) Compare Doppler analyses performed with real-time software to GPS sonde winds
3) Develop users guides for software
4) Complete final report
5) Send analysis products to TPC during the 2005 hurricane season (probably after final report)
6) Send a test file of quality-controlled Doppler radials to EMC (probably after final report)

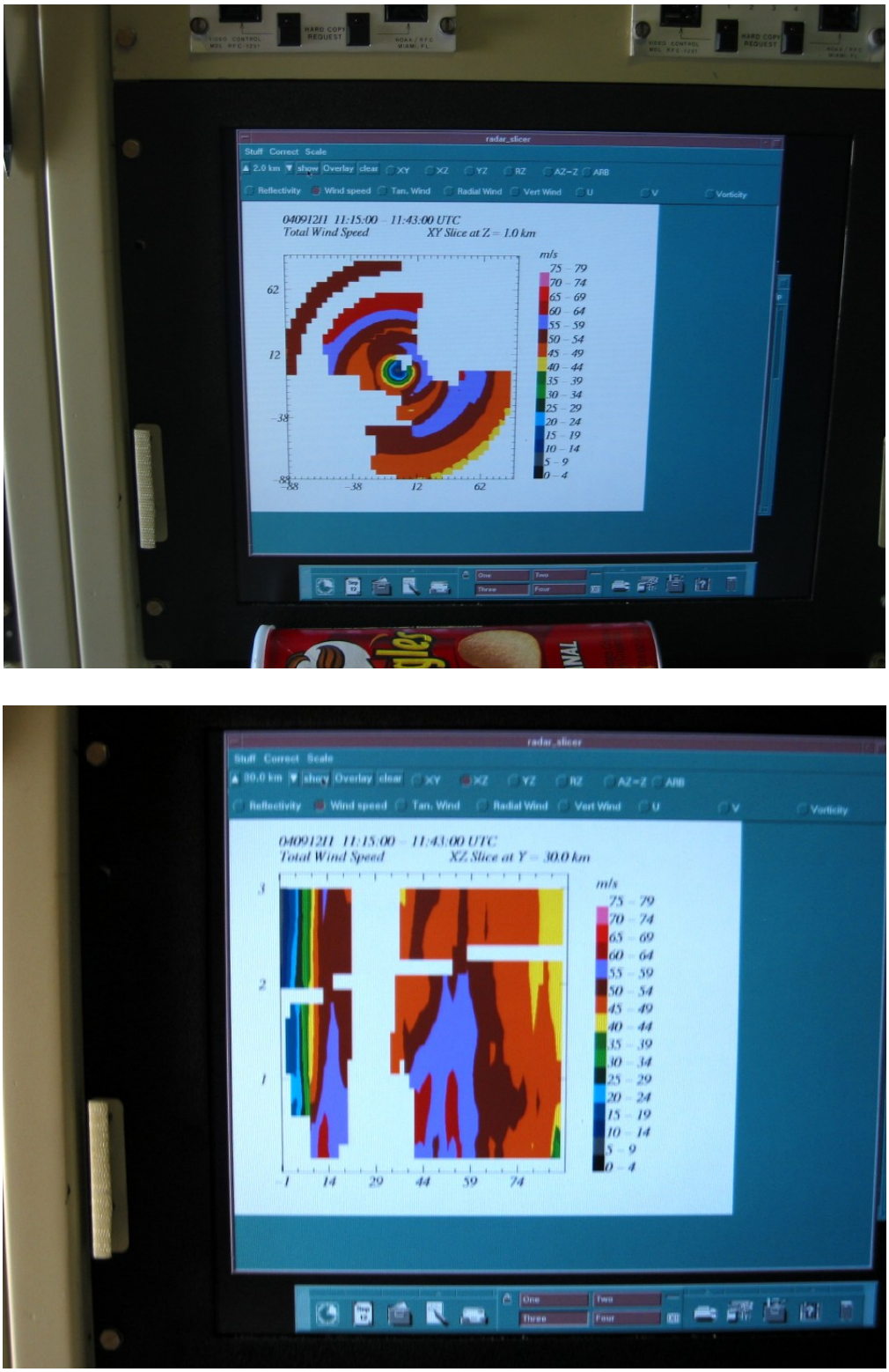
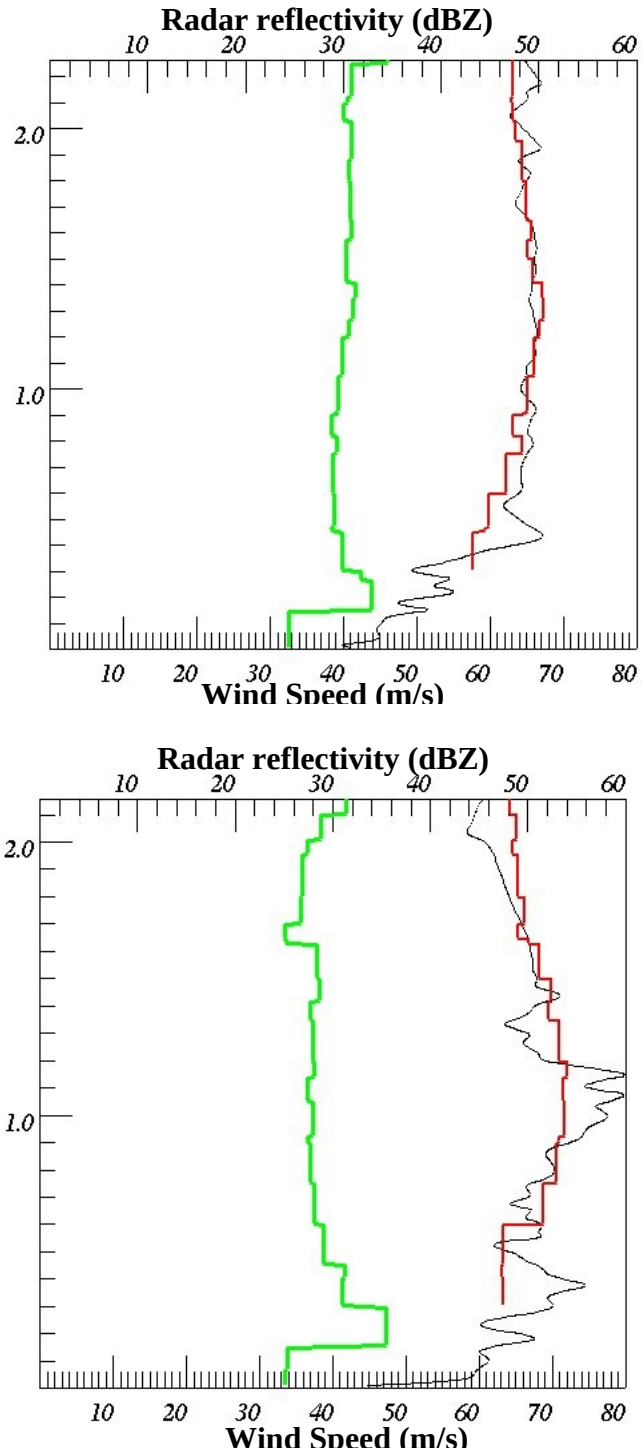


Figure 1. Digital photographs taken of HRD workstation display during the flight of NOAA 43 on 12 September 2004 in Hurricane Ivan. Top analysis shows the horizontal wind speed in m/s extending radially outward to 88 km, including wavenumbers 0 and 1 only, at 1 km flight level. Bottom analysis shows vertical cross-section of wind speed from 0.15 to 3 km in height and from 4.0 to 88 km in radius. Since these analyses were performed the radial resolution of the vertical cross-sections has been increased to 1.5 km, the resolution of the radar scans.



Comparisons of dropsondes dropped at 1310 (top) and 1503 (bottom) UTC on 12 September 2004 in Hurricane Ivan. Black curve is dropsonde wind speed, and red and green curves are wind speed and radar reflectivity, respectively, interpolated from Doppler vertical profile. Note that scale on top of plots is radar reflectivity and scale at bottom is wind speed.