

The H*Wind Real-time Hurricane Wind Analysis System

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Final Report on the Joint Hurricane Testbed Project

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Summary:

Through several years of research and development, HRD has developed an interactive, real-time hurricane wind analysis system (called H*Wind) which allows scientific users to select a storm, graphically examine and quality control the real-time or retrospective data collected during the time period of interest, analyze and archive the wind field, and create a variety of graphical analysis products or data sets derived from the wind field. HRD has continually improved and field-tested H*Wind by conducting real-time wind analyses on an experimental basis and delivering products to NHC forecasters on a 3-6h operational cycle.

The goal of this JHT project is to complete development of H*Wind and, over a 2 year period, transition the technology to the National Hurricane Center for operational use. We began the JHT project under the original requirements: A) converting software to existing TPC IT architecture, or if not possible obtain/install native h/w and s/w. B) user support-staff training, C) user analysis time ≤ 20 min, D) user-specified sfc. reduction factors, E) export of wind radii to ATCF, F) manual override of objective analysis contours, G) internet delivery to end users as stand alone product. Over two years, these activities have changed as a result of numerous meetings to set prioritized requirements based on feedback from actual user experiences and trade offs between what would be nice to have vs. what is really needed subject to the available resources. Never-the-less, most of the original activities have been achieved and over 80% of the analyses in 2003 were conducted by TPC forecasters. Once H*Wind is set up for a particular storm, we have proven demonstrated that an operational forecaster is able to conduct real-time wind field analyses while in the midst of other activities.

Major accomplishments for FY 2002:

- We conducted training sessions with Miles Lawrence and James Franklin, which started the compilation of numerous suggestions and improvements in terms of program behavior and display.
- 64 real-time analyses conducted by HRD, 4 by NHC for the 2001 season.
- Data timeliness issues are raised.
- H*Wind received the "Best Technology Transfer to Operations" award at the NOAA Tech 2002 conference.
- An extended list of TPC personnel were trained.

In the latter half of 2002, we reached consensus with NHC hurricane specialists on a prioritized list of requirements for operational use. This was the most valuable part of the JHT process whereby researchers and forecasters interacted to produce a realistic implementation schedule and to tailor H*Wind to fit TPC needs.

Included in the implementation were:

- Automated annotation on the graphical wind field image products published on the web, saving time in delivery of wind analysis products.
- Establishment of a 5-mesh generic analysis, eliminating the ambiguous decision of storm size (small, medium, large). Expert parametrization was also made available.
- HRD database software was upgraded from Oracle8i to Oracle9i, to overcome limitations with precision, editions and queries. The database was reorganized to accommodate new storage and query requirements.
- Database query performance was improved by restricting data retrieval to a 10x10-degree region around a storm center position.
- New platforms were incorporated into H*Wind data stream including: GPS WL 150m and GOES short-wave IR cloud drift winds.
- We collected and stored Vortex messages in the database.
- We simplified the graphical user interface into one main window. This has greatly improved overall user interaction.

- An improved flight-level surface adjustment algorithms was implemented. This gps-sonde based method corrects 700 mb data to a mean boundary layer wind and then adjusts that wind to the surface.
- New tools: (un)flagg by platform, individual (un)flagg, estimate center position, auto-pilot mode.
- Installation of Oracle9i on a JHT server at NHC.
- WMO Training, training at Central Pacific Hurricane Center (Sam Houston) and Joint Typhoon Warning Center (Shirley Murillo, Chris Cantrell), in Hawaii.
- Training at UCAR/COMET for NWS Science Operations Officers in Boulder, CO. Shirley Murillo conducted a half day lab session using H*Wind.
- Papers were presented at the 2002 National Hurricane Conference in Orlando and AMS Conference on Hurricanes and Tropical Meteorology in San Diego.
- 104 Real-time analyses were completed mostly by HRD personnel, but many were also conducted by TPC personnel (e. g. Laura Salvador).

Major accomplishments for 2003:

- Release of a complete User Guide (on PDF) on H*Wind's web site.
- Distribution of gridded files, shapefiles, ATCF files.
- We modified analysis FORTRAN code to allow larger domain analyses to be able to better contain large storms like Isidore from 2002.
- Comprehensive TPC presentation/training.
- Much greater involvement of TPC personnel on conducting analyses since June 1, accounting for 80% (21/26) of the real-time analyses.
- Greater contribution from the JHT liason in terms of application errors and suggestions.

Summary of most recent period (March to July 2003):

H*Wind activities for the second half of 2003 have focused on TPC training to provide the capability for TPC to evaluate H*Wind during operations. Several TPC forecasters have been able to conduct H*Wind analyses during their normal duties, even when answering phones, producing radar center fixes, and helping to prepare advisories (e.g. Robert Molleda and Dan

Brown conducted wind field analyses during Tropical Storm Bill and Hurricane Claudette's respective landfalls while performing these duties). The analyses are readily viewable on the TPC intranet, and each forecaster can easily review the analyses they have conducted throughout the season. In light of the controversy and allegations generated by AccuWeather following Claudette's landfall, the H*Wind analyses provide instant documentation on the strength of the wind field at landfall, consistent with the advisories issued by NHC. As of 5 August 2003, over 80% of H*Wind analyses were conducted by TPC personnel. This is an important metric on the potential of H*Wind for operations. This information should be sufficient to support the TPC director's decision on whether to make H*Wind operational.

1. Interdepartmental Hurricane Conference: March 13, IHC conference with Panel on H*Wind

Drs. Powell and Knabb organized a panel discussion on future applications of real-time wind analyses. Dr. Powell, Dr. Steve Lyons of the Weather Channel, Ed Laatsch of the Department of Homeland Security (FEMA), Bryan Norcross of CBS, James Franklin of TPC, Jeff Sciadone of the Institute for Business and Home Safety, and Scott Kiser of the Office of Meteorology participated. Dr. Powell gave an introduction to H*Wind and mentioned the limitations of H*Wind, that the analysis is only as good as the data available and would naturally vary depending on data coverage, type, and timeliness. Steve Lyons and Bryan Norcross indicated that the graphical H*Wind analysis product would help them convey to the public the extent of damaging winds, Ed Laatsch discussed how wind swaths from H*Wind would be used as input to the HAZUS model to conduct real-time estimates of losses due to wind damage, and James Franklin discussed how the H*Wind peak winds differed from the official estimates. There was clear customer-driven demand for real-time H*Wind analysis information.

2. March 25, WMO Course on Tropical Meteorology

For the second year, tropical meteorologists from several developing countries attended an H*Wind lab during the WMO course at NHC. Shirley Murillo and Jason Dunion developed a session built upon observations from Hurricane Lili. We much appreciate the help of Salim Leyva and Douglas Gaer for restoring connectivity to our database (chac.nhc.noaa.gov). Network connections had been disrupted since the installation of a firewall at NHC in February. The course attendees were able to perform their H*Wind training individually.

3. Forecaster Training:

On May 8-9, at TPC, an H*Wind presentation/training session was organized with two sessions repeated each day to allow forecasters to best fit the training in among their regular work duties. This included brief presentations on several observing platforms (Aircraft, SFMR, GOES, C-MAN) and how they are adjusted to H*Wind's common framework. Following the presentations, a hands-on H*Wind training session was given based on the training lab developed for the WMO course. Individual database accounts were given to all users. The list of attendees: Jorge Aguirre-Echevarria, Waldemar "Wally" Barnes, Eric Blake, Chris Burr, Dan

Brown, Hugh Cobb, Mike Formosa, Eric Holweg, Rick Knabb, Alison Krautkramer, Michelle Mainelli, Rob Molleda, Jaime Rhome, Dave Roberts, Chris Sisko, Patrica Wallace, and Krissy Williams.

2. Real time analysis

Our focus for this hurricane season is that all analyses be completed by TPC personnel. For events with named storms within reconnaissance aircraft range, HRD scientists are available during daytime hours to assist TPC forecasters with using H*Wind to perform surface wind field analyses. With active tropics early in this hurricane season, we were pleased to report that TPC staff were involved in performing real-time wind analyses, achieving a certain degree of comfort. So far, this is the tally of operational analyses:

Atlantic basin:

al03 Bill

Analyst	Number of analyses
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Brown	1
Molleda	2
Powell	1

al04 Claudette

Brown	2
Droberts	3
Molleda	2
Murillo	1
Nelson	2
Powell	3
Rhome	4
Sitkowski	4

al06

Sitkowski	1
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3. User Guide

H*Wind's User Guide was released on March 3, 2003 <http://cat5.nhc.noaa.gov>. It is currently being updated due to changes on the program's user interface. The updated version will be released shortly.

4. Data Collection

Decoders and scripts of data platforms used in H*Wind, have been streamlined and tested for

transitioning to NHC. We have contacted Brian Maher regarding the possibility of a testing environment in situ. We are awaiting details on that.

5. Progress on the prioritized list of NHC requirements

Many of the transition issues that we had hoped to implement and test in order to transition H*Wind during the project budget period, have been delayed on the TPC side, to await management decisions on which JHT projects will become operational. Most of the User requirements have been satisfied with the exception of minor nagging issues on how the version of JAVA on HP-UX treats the flagging cursor and zooming.

A. Transition Issues:

Regarding the transition of the Oracle9i database, we have not yet received information that the storage space requested is available. Therefore, we have not been able to make any progress in this direction. As discussed in the excerpt from our previous report (below) this was seen to be an important milestone but without the storage space this is out of our hands.

Excerpt from previous report on February 2003: "In November we met with TPC to discuss progress on the prioritized list and to discuss revisions based on feedback received during the 2002 season. Agreement was reached that most of the items on the list had been achieved and some others were now deemed to be of lower priority relative to others. "

Status of JHT based on revised priorities stemmed from the meeting on Nov. 21, 2002. Going over the list provided by Dr. Richard Knabb at the time:

JHT: Over and above all items listed below, of highest priority is the need to install the H*Wind database on the JHT server, the first step toward testing a fully functional version of H*Wind on the JHT server prior to possible operational implementation. The current target for completion of testing the H*Wind application on the JHT server is April 2003.

HRD: Oracle 9i database software was successfully installed on the JHT server in December 2002. However, the server did not have enough space in order to properly setup the schema, and consequently, test the data collection process. Dr. Jiing and Brian Maher were informed then of what is needed. As soon as we know that the JHT server is ready, we will continue. Equally vital is to compile analysis FORTRAN code on HP architecture. Sonia will work on this with the necessary parties.

Regarding the transition of the FORTRAN analysis code, results of failed compilation attempts with HP FORTRAN 90 and information conveyed by Sim Aberson confirmed that the analysis code can only compile with FORTRAN 77. The code contains obsolete FORTRAN 66 source code that it is accepted by FORTRAN 77, but not by FORTRAN 90. Sonia also tried to compile with GNU's FORTRAN 77, but that was unsuccessful as well. Native compilers seem to be the only suitable ones. On March 19, Sonia informed Brian Maher of these conclusions for the basis

of requesting FORTRAN 77 on the JHT server (running HP-UX). After searching for a while, Brian informed Sonia on June 8 the good news he had secured a copy, and that he will get it loaded that week. Also, on the message of March 19, Sonia requested Brian the software IDL version 5.5 or higher. This software is vital for the analysis image generation. Jiing was informed as well. Representatives from IDL made presentations at NHC in June, so there is some interest in obtaining the software.

On April 4th, we asked Dr. Jiing about the status of our requests, due to the impending need of having these resources at NHC for H*Wind to be ready or at least well on its way to be ready to become operational on August 1, 2003. Based on our agreed time-line, we relied on the last 3 months, May, June and July to advance on these transition issues and their testing, since the software requirements of H*Wind's client user interface had been mostly met. A brief e-mail exchange that day raised the fact that the decision by management on whether to establish H*Wind or not operationally was still in the air. Nevertheless, Dr. Jiing thought that it would be nice to make H*Wind available to the forecasters quasi-operationally from the JHT project angle. On June 25th, we answered Alison Krautkramer's request for a summary list of all computer and data resources that are needed for NHC to independently support HWIND. On August 4, Brian spoke to Sonia and confirmed the status of unavailability of disk space on JHT database server, of IDL software, and of FORTRAN 77 for lack of installation.

B. User Requirements

Regarding progress on the itemized list of requirements dated in November 2002, these are the outstanding items (same item numbers retained):

Item 8. Output results (radii, max wind) to ATCF fix format message. Output text files can be placed on the JHT server version of H*Wind. HRD is asked to contact Jiann-Gwo Jiing to coordinate where the text output will be placed, for him to then consider an approach for possibly testing its use in ATCF.

HRD on 2/28/2003: The actual production of the file following the latest format is done. Sonia sent Dr. James Gross on 1/24/2003 a sample ATCF file for his review.

HRD (current): On June 3rd, Sonia sent Chris Sisko a sample of ATCF file with the correct spacing as had been specified by him previously. His program is unable to read the final section of the file, the 'ANAL' section, but that section is valid based on the latest agreed ATCF format that James Gross provided in June 2002. Chris' latest update on the situation (July 31st, 2003) states that nothing has been resolved regarding the inclusion of the analysis part into the ATCF. During the annual ATCF working group meeting in November, he plans to consult with NAVY developers Buck Sampson and Ann Schrader on how they would like to handle the analysis portion within the F-deck and then they can fully put that on the 2004 ATCF task list. Under these circumstances, the ATCF files H*Wind generates are published on the FTP site of cat5.nhc.noaa.gov.

Item 9. Restatement of old item 7. Output display to N-AWIPS.

Real-time access to the gridded version of each analysis output (generated by the primary operational user, see previous item above), is required for conversion to gempak gridded format. Also needed, for each analysis run by the primary operational user, is real-time access to a text file with all of the information used to annotate the graphical analysis output (i.e., top header with storm name, analysis time, list of data upon which analysis was based; wind radii table at top left of graphic; and max surface wind information below graphic).

HRD (on 2/28/2003): We will provide Alison with the location of gridded files and their format. We will discuss how to provide the annotation text file. On a related note, JHT/TPC staff may in January demonstrate H*Wind to the NCEP/NCO Computer Development Branch (NAWIPS/GEMPAK developers), so that they are aware of its capabilities. However, such interaction is not required to complete this enhancement item. Contents of requested annotation file are approximately included in ATCF fix format contents, already implemented (request #8). We should discuss exactly what is needed and try not to duplicate. Sonia will contact Alison.

HRD (current): We have provided Alison access to the gridded files and their format. With respect to the annotation file, Sonia has not addressed this thoroughly because of its closely related contents to the ATCF file. Alison and Sonia spoke on August 1st, concluding that Alison will ask around at NHC whether the information provided in the ATCF file is good enough or an extra special file with an annotation similar to the one provided in the image output is necessary.

Item 20. On a monitor, the observations are hard to see against the white background of the map. Have you tried using a black background? We may also want to change the default colors for the most important data types (recon, in particular, is hard to see against white background). (For printing, though, white background is obviously better.)

HRD (on 2/28/2003): This is not feasible given the resources. As an alternative, TPC will provide a list of default colors for each platform, such that the appearance of the observations is optimal against the white background.

HRD (current): We have not received a list of default colors for platforms from TPC. This is an easy and quick modification to H*Wind once the platform colors are known. On July 31st, Sonia contacted Alison to check if this request is still valid. Alison replied to leave it pending until she can talk to hurricane specialists about it. It is currently somewhat difficult given their different work shifts.

Item 25. Rephrased previous item. QC Client window, Tools menu, Group Flag: Modify or replace the flag and unflag icons/pointers such that they have a more definitive point, as with an arrow.

HRD (on 2/28/2003): Right now this happens only on HPs. We will evaluate possible solutions.

This issue will be addressed on three fronts: For the problem of oversized/distorted icons on HPs, Sonia Otero will contact Brian Maher at TPC with a description of the problem, so that he may forward it to HP support.

HRD (current): After further researching on Java specialized websites or newsgroups, Sonia has not been able to explain the nature of this problem, which appears related to HP's implementation of the JAVA virtual machine. Loading the same image at different resolutions or sizes does not modify the outcome of an oversized cursor image and the fact that the "business end" of the cursor is located at the upper left side rather than the center. Given other higher pressing needs related to Brian, Sonia did not pursue this issue with him. This is the only item that is left unfulfilled on our part (not forgotten though).

C. Enhancements and bugs fixed:

- Correct basin maps conforming to the areas specified by ATCF.
- Modified FORTRAN analysis code to allow for larger domains. This was a standing request due to certain storm size cases larger than usual. Basically, the maximum limits of nodal intervals in both x and y directions were increased from 45 to 65. This parameter can be changed under "Operations -> Change Meshes -> Expert" menu. An increase on the number of nodes from 40 to 60 increases analysis execution time by 3-4 times (2-3 minutes to 8-9 minutes), because calculations become more intensive per mesh. In general, a default-mesh analysis executed on our Sun Ultra 10 server takes an average of around 6.5 minutes, which includes: ~ 3 minutes for the execution of the FORTRAN code, ~2 minutes of IDL scripts and ~2 minutes of annotation scripts.
- Alison Krautkramer reported a QCSet with a consistent 4-hour time difference between a storm track center position's time and the time posted on the web page, when performing analyses on moray.nhc.noaa.gov. Java's Date formatter method turned out be unreliable when sending dates across machines in different timezones: moray is on GMT, cat5 is on EST. The problem was easily solved, but it is one we are glad we encountered because of the implications for potential users on timezones around the world.
- On the analysis output, we discovered the cause of certain inconsistencies between the location of the arrow and explanation of maximum winds in the output.
- With helpful assistance from Doug Marcy and Russell Jackson at NOAA's Coastal Services Center in Charleston, shapefiles are now generated with every analysis, and placed on the FTP site of cat5.nhc.noaa.gov. These files can be readily imported to GIS software for mapping infrastructure and population information in regions receiving high winds. This was not a JHT requirement but is a feature some of our public customers have long requested so we decided to make it available in H*Wind.
- On certain cases, namely poorly organized or developing tropical storms (e. g. Tropical Storm

Bill) we observed that the analysis output generation process was taking longer than normal. Our investigation revealed that in cases where the mesoscale and the observed radius of maximum wind are substantially different, no enhancement should be performed. We have implemented this change. The result is that the analysis will tend to over smooth the peak winds in these weak systems with wind maxima far from the storm center. The analyst may overcome this limitation by using the expert mode to shorten the filter wavelength in the mesh that comprises the peak winds.

- We eliminated undesirable effects on a storm track when the source position of an interpolation or extrapolation is edited. Whenever a storm center position is edited, the program detects whether the original position has interpolations or extrapolations associated with it. Those interpolations and/or extrapolations calculated based on original values of that position are no longer valid on the track. Therefore, if this happens, the program will prompt the user with a warning/question message, and ask whether to continue or not with the operation. If the answer is YES, all interpolations/extrapolations associated with the position will be removed, and your modifications will be recorded. If the answer is NO, the track remains unchanged.

- Per Alison Krautkramer's suggestion, we modified the software behavior when flagging an edited observation: whenever a height-adjusted observation is flagged, it will retain the adjustment as opposed to going back to the flight-level or original values. Also, if an adjusted observation is flagged, the original observation associated with it will also change its status to flagged, and vice-versa. This will help keep consistency and reduce confusion.

Near Future (1 month):

Auto Pilot: Calculate extrapolations considering the motion between previous positions having at least one hour difference. When using the auto-pilot, this will prevent cases of erroneously calculating extrapolation positions using large motion values caused by the fact the previous two positions happen to be close in time.

Saving data sets: We will make changes to automatically save a QCSet after every successful operational analysis. Currently, by observing NHC users, it seems that it is easy to forget to save a QCSet to the database after an analysis. This will also save time by eliminating another step from the analysis process.

Additional future plans depend on whether H*Wind becomes operational. Our recent 2004 JHT proposal listed many exciting features and capabilities that could enhance H*Wind. If H*Wind becomes operational, with TPC support our team will be available to assist with implementation of these capabilities and improvements.