Technical Attachment

Florida Tropical Cyclone Workshop Summary

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Purpose and Logistics

A two-day training workshop was organized and hosted by the authors during mid April 2001 at the National Hurricane Center in Miami. The workshop focused on specific tropical cyclone (TC) operational issues of recent concern, including:

- Exploiting new data sets and display platforms to improve TC-related forecasts and warnings.
- Examining new technology-based methods to improve severe weather diagnostics.
- Improving the communication of hazardous weather information to NWS customers in a consistent format using innovative graphical methods.

Operational personnel from all Florida WFOs attended - Tallahassee, Jacksonville, Tampa Bay, Melbourne, Miami, and Key West - along with meteorologists from WFOs San Juan and Wakefield, Virginia. Local attendees included several hurricane specialists, as well as forecasters from the Tropical Analysis and Forecast Branch (TAFB) of the Tropical Prediction Center (TPC). Participants totaled between 20 and 25 individuals.

The NHC was chosen as the location for the workshop to draw from the expertise of hurricane specialists and NOAA/Hurricane Research Division (HRD) meteorologists. This setting also allowed WFO attendees to become familiar with the NHC environment, and it stimulated dialogue between the WFO and TPC/HRD communities. Two additional participants were Dr. Steve Lyons, the tropical weather expert from The Weather Channel and Jack Parrish, a NOAA Aircraft Operations Center (AOC) flight director and the project manager for the G-IV high altitude jet.

A Web-based version of this summary is available on the WFO Melbourne home page, http://www.srh.noaa.gov/mlb/tcworkshop_2001.html. Included are links to the available complete workshop presentations.

Day One Summary

Graphical Hurricane Local Statement (HLS). Scott Spratt (WFO Melbourne) provided an overview of the WFO's local suite of experimental hazard graphics, specific to east-central Florida TC situations. The graphical package, available on the Internet, provides an interactive environment encompassing wind, surge, marine, flood, and tornado threats. Each hazard category includes a "Degree of Threat" bar chart and an accompanying "Threat Area Map" which geographically depicts threat areas and/or delineates timing of particular hazards. The product was first used operationally during tropical storm Gordon (2000). Examples were shown of how graphics could have enhanced the official HLS text products during several recent TC events. A graphical HLS demo can be viewed at: http://www.srh.noaa.gov/MLB/hlsfiles/hlsmain.html.

Improving Public Response to TC Flooding. Jim Lushine (WFO Miami WCM) described his compilation of flood information from past TC events and stratification into various degrees of flood risk. Given the nearly homogenous geography of south Florida, heavy widespread rainfall often produces similar flooding effects from event to event, thus distinct degrees of flooding with respect to structures, roadways and agriculture can be quantified. Historical data also helped quantify average flood durations for both rural and urban areas given certain rainfall accumulations. Local procedures incorporate this information by comparing expected flooding to past events to provide the public with a better appreciation of impact and danger associated with TC flooding. Future plans may involve pairing each level of flooding with Web-based images from past events to help the public visualize the degree of flooding forecast and thus improve public response.

TWC Graphical Forecasts & Expected Public Response. Steve Lyons (TWC) discussed the recent expansion of on-air graphics by TWC during tropical cyclones situations, including the use of animations, ocean/coastal/inland impact maps, wave/surge impact maps, and sea surface temperature analyses. In addition to relaying basic hurricane information, the depiction of impacts and simple scientific relationships have been stressed over recent seasons. To produce the expected public response, the graphics must be simple and clear, have a useful purpose, and they must tell a story. The on-air specialist must translate the situational meteorology to meet public needs and thus provide information to allow them to take the necessary actions. Steve stressed that expected *"impact(s)"* to life and property are much more useful to the majority of the general public as compared to quantitative information (e.g., precipitation totals, storm surge heights, or maximum sustained wind speeds).

Graphical HLS Standardization Project. Dave Sharp (WFO Melbourne SOO) explained how the WFO has joined with WFO Wakefield to informally evaluate expanded use of threat graphics by WFOs during TC watch/warning situations. WFO Melbourne will use their experience with PC-based graphical product production, together with customer and coastal WFO feedback, to develop and standardize a suite of hazard graphics which could be applicable to all coastal WFOs. Meanwhile, WFO Wakefield will examine graphical product development on AWIPS using the IFPS Graphical Forecast Editor, and the eventual incorporation of the full graphical HLS package. John Billet (WFO Wakefield) explained how his WFO has begun to experiment with AWIPS development applications and he highlighted their future plans for base map and hazard depiction production.

Requirements for peripheral applications will be examined, as well as potential dissemination schemes (e.g., LDAD, FTP, Internet). A final "development and standardization" plan proposal will be submitted to Southern and Eastern Region Headquarters for approval. Final project completion is targeted for the 2002 hurricane season.

Open Discussion: The Future of WFO Graphical TC Products & AWIPS Requirements. The above presentations set the stage for a discussion of future graphical product needs. Overall, there was strong agreement graphical hurricane threat products can provide a useful and increasingly necessary supplement to text products. Issues still to be addressed include the need for some threat localization versus full standardization, workload concerns, product composition training requirements (we need to simplify composition as much as possible), adjustment of threat categories to incorporate "coastal threats" (e.g., coastal flooding, beach erosion, storm surge), a means to survey and assess the needs of potential product users, making the product as useful as possible for local media (a primary voice to get the message out). In addition, especially at longer time scales the need exists to imply inherent forecast

uncertainty (related to track, wind radii, etc.), but NHC emphasized that too much detail in graphic products can be misleading at times, implying more forecast skill than may actually exist. .

Day Two Summary

Emergency Management Display System (EMDS) Demo. Pablo Santos (WFO Miami SOO) demonstrated a prototype data display system developed by NOAA's Forecast Systems Laboratory. Information from a local AWIPS data base can be fed to area emergency managers through the local LDAD, via the Southern Region server. The data transfer system frequently compares index files on the Webserver and the local PC hard drive, and immediately sends any new files to the PC. The WFO can choose which products to place in the index files (e.g., Miami WSR-88D images). The system currently allows only one-way communication (from local AWIPS to an emergency manager's PC), but testing is underway to allow for possible two-way exchanges. For example, hurricane evacuation information could be sent from the EM to the WFO for incorporation into an HLS. WFO Miami is currently beta-testing the system, which is proceeding favorably, although communications have been slow at times due to problems with the regional server. EMDS will likely be expanded to other WFOs in the near future.

Realtime Multi-platform Hurricane Wind Analysis System. Mark Powell (HRD) explained the need for accurate hurricane wind radii measurements for both real-time monitoring and post-storm surveys. The HRD system incorporates all available observations over a 4-6 hr period in a storm-relative coordinate system, applies quality control, and extrapolates to a common platform equivalent (maximum 1-min wind at a 10 m height for open terrain). In addition to standard surface observations, data from GPS dropsondes, satellite radiometers/sounder/cloud-drift derived winds, and reconnaissance flights are incorporated. An improvement of surface roughness parameters will be applied this season, specific to each surveyed ASOS, to better reduce winds to the common platform. Compared with the previous wind analysis system (used mainly for post-event modeling), the new system results in a smaller and more realistic radius of maximum wind and provides better asymmetric features. The system has provided analyses to hurricane specialists in near real-time over the past several seasons and it is expected to be incorporated into NCEP operations within two years.

Realtime WSR-88D Hurricane Wind Analyses - GBVTD. Colin McAdie (NHC/TDAU) discussed how an algorithm was developed at NCAR to provide an estimate of the horizontal wind from single or multiple radars. The ground-based velocity track display (GBVTD) algorithm uses WSR-88D radial velocity fields to obtain the total horizontal wind and wind maxima (which often are obscured by the WSR-88D radial wind zero isodop). Current configurations use Level-IV radar data, as Level-II data are not yet available operationally. Although the total wind field is retrieved, caution must be used as each analysis is valid for a selected elevation tilt, and therefore increasing altitude with distance. An example of the 0.5 deg tilt from the San Juan radar during hurricane Debby (2000) showed the retrieved wind fields within eyewall convection compared well with reconnaissance observations along the flight track northeast and southeast of the center. Eventual integration into AWIPS is planned, with access to the Level-II base data expected once the Open RPG architecture is fielded.

Satellite Remote Sensing for Surface Wind Analyses. Stacey Stewart (NHC hurricane specialist) discussed the strengths of satellite wind sensing technology. The purposes are to provide supplemental information over data-sparse regions to help determine the strength of disturbances and circulations, to

improve wind radii analyses, and to improve model initializations. The satellite platforms include "passive" sensors such as DMSP and the Tropical Rainfall Measuring Mission (TRMM), and "active" sensors such as the ERS-2 and QuickSCAT scatterometers. The passive sensors do not provide wind directions, but give estimates of speeds near the 20 m elevation, often with a low speed bias. The active sensors provide wind speed and direction estimates near 10 m, but the direction can be 180 deg out of phase at times. The QuickSCAT scatterometer provides a wider data footprint than the ERS-2, however it suffers from significant rain contamination which results in a limited amount of useful data near the TC center. NHC has used the scatterometers to help define closed circulations at the surface and to ascertain tropical depression and tropical storm 34 kt wind radii. It was also noted the scatterometers often have difficulty with center positioning and can produce erroneous wind speeds near coastlines and in areas of shallow water (the Bahama Banks, for example).

An Update to the GFDL Model. Richard Pasch (NHC hurricane specialist) explained the latest changes to the GFDL hurricane model. It was stressed the model requires accurate initializations of TC position, size distribution, strength, and background environmental wind fields. A recent improvement in the model resulted from a new TC vortex relocation scheme, which filters the original model vortex, then inserts a new "target" vortex (specified by NHC and spun-up by a separate model). This season the GFDL will be coupled with the Princeton Ocean Model, which allows the sea surface temperature to evolve throughout a forecast integration. Results have indicated the ocean coupling has a positive influence on the skill of intensity forecasts. The greatest improvement is expected for slow moving TCs, with no improvement likely of the over-intensification bias within strongly sheared environments. Fewer "boguscanes" are expected, however a negative track impact may result for weak TCs. Additionally, a boundary layer upgrade should result in a more realistic surface wind field. Storm structure modifications will also occur, as well as better moisture initialization, which should improve intensity forecasts within the 12-24 hr period and produce a more realistic (smaller) system size. A rerun of year 2000 TCs resulted in a significant track improvement overall (approximately 20%), although not all individual tracks were improved. A summary of the changes can be viewed at: http://sgi76.wwb.noaa.gov:8080/emchurr/gfdl/gfdl.2001.html.

TRMM-based Rainfall Climatology. Frank Marks (HRD) began his presentation by reminding everyone that rainfall is a function of rain rate and duration, thus TC size and motion are critical for producing a reasonable precipitation forecast. Orographics and mesoscale-to-synoptic scale forcing can also significantly enhance accumulations. Climatological studies have shown nearly 90% of tropical rainfall is stratiform, consisting of small/weak updrafts. The greatest rainfall totals occur from embedded convection contained within small, intense cores and occurring over brief time periods due to rapid cell motion. TC rainfall events can be thought of as "closed systems" since the widespread nature of the precipitation pattern tends to average out detail compared to diurnal warm season convection.

A climatological TC rainfall data base was initiated in 1998, using data from the TRMM microwave imager. Over 800 "events" were seen by the satellite in 1998 alone, accounting for nearly one in eight orbits "seeing" part of a TC. The data base will continue to be expanded as additional years are added. The data have been divided into four quadrants and 100 10 km wide bands to determine TC rainfall climatologies. The results may eventually be used to develop a forecast model with precipitation swaths over the ocean leading to downstream probabilistic forecasts over land.

Ensemble TC Track Forecasting. Sim Aberson (HRD) discussed a simple ensemble scheme using a barotropic hurricane model (VICBAR). The ensemble consists of a series of perturbations encompassing 41 members, twice a day. Verification over recent years show the ensemble spread encompasses the TC best-track nearly 90% of the time for cross-track errors, and nearly 70% of the time for along-track errors, through 120 hours. The ensemble mean performs better than just about all the individual members on average. Some specific ensemble members produce better forecasts more often than the others, suggesting that a weighting factor might be employed. The increasing importance of ensemble forecasts for TC forecasting was discussed.

Using Real-time SLOSH Model Output. Brain Jarvinen (TPC Storm Surge Unit) described that SLOSH modeling in the past had normally been run at the time of landfall, primarily to provide estimates for resource and recovery placement to FEMA. During 2000, SLOSH forecasts were made available over the Internet to WFOs near landfall to assist with surge estimates. For 2001, the runs will be made routinely for WFOs, beginning about 12 hr before landfall. The forecasts will be made for "pure" storm surge (i.e., height above normal tide level) and will normally be available 1-1.5 hr after synoptic times. A single value is input to the model for radius of maximum wind and that value is usually not changed through landfall. It was stressed that evacuation decisions should not be based primarily on a single SLOSH run, but instead trends should be assessed and areas of greatest "relative" threat may be determined.

Improving Wave & Swell Forecasts. Steve Lyons (TWC) noted the best possible short-term wind forecast must be used to produce a good TC wave/swell forecast (i.e., incorporate all surface observations, satellite wind observations, etc.). Next, incorporate NHC surface wind radii, while remaining cautious of numerical wave forecasts of TC's. It was stressed that the public understands and responds better to the perceived "impact" of breaking waves, erosion, and rip currents, rather than a quantitative expression of the hazard. Swell blockage and/or refraction (around the Bahama Banks, for example) must be accounted for, with wave periods above ~10 sec often causing refraction around obstructions. The right-front quadrant of the TC often produces the greatest waves, mainly due to the largest fetch area. It was also pointed out that wave setup is not related to surge, and beach erosion is maximized when breaking wave heights are the largest and when the wind produces a significant along-shore current.

Tailoring NHC Wind Guidance for Inland Locations. Ron Morales (WFO Tampa Bay) offered a premise that a uniform wind reduction (surface roughness) factor could be determined for non-coastal counties not covered by a NHC watch/warning. Ron noted local wind forecasts for inland counties often are over-forecast due to projected large wind radii (especially for areas removed from the over land path). Since a common reduction factor could not be immediately determined, it was suggested this item should be formally introduced at the 2002 NOAA Hurricane Conference. An ongoing HRD study examining wind reductions for inland ASOS sites may be able assist with this effort. An example of a new FSL AWIPS application currently being tested at WFO Tampa Bay was also shown. The IFPS GFE allows creation of detailed graphical depictions, while at the same time creating a numerical data base of forecast grids. Office-to-office coordination will become increasingly important to keep these new products consistent, especially over the marine area during TC situations.

NHC 5-Day Forecast Plan. Jack Beven (NHC hurricane specialist) explained that internal (NHC) track and intensity forecasts will be generated out to five days, beginning this season. The need for extended

forecasts is being driven by the expansion of the NWS marine/public forecasts to 5-7 days, and additional requirements requested by the DOD, as well as emergency managers and mariners. Currently, an external survey is underway to help formulate precise user requirements. Given favorable verification of the forecast parameters over the next two hurricane seasons the forecasts will be officially extended. Estimates suggest an average position error for the 120-hr forecast will be near 360 nm, similar to the average 72-hr forecast for the 1974-83 period. With limited intensity skill at extended periods, it is expected that the 4-5 day strength forecasts will be categorical (TD, TS, hurricane) rather than quantitative. Some important caveats were mentioned: occasional very large errors will occur in the 4-5 day forecasts, and it is possible that an intense hurricane could make landfall *less than* five days after classification as a TD (for example, hurricane Camille).

Real-time NOAA Airborne Observations. Jack Parrish (NOAA Aircraft Operations Center at McDill AFB, Tampa) discussed aircraft surveillance and reconnaissance operations. Generic and in-situ flight patterns and rationales were described. The NOAA aircraft recently acquired new satellite telephone technology (Inmarsat) and tests are underway to download real-time data to the ground (NHC). The data can range from routine reconnaissance and dropsonde text messages to detailed digital radar images. In the past, messages (text and voice) had to be relayed through one or more communication gateways, resulting in significant delays for receipt at NHC and WFOs. Examples were shown of data types collected during hurricane Irene (1999) surveillance missions over south Florida, including radar imagery of the precipitation-free southwest quadrant and accompanying extremely dry dropsonde profiles. Additional experiments with real-time voice and data exchange will continue this hurricane season.

NOAA Aircraft-to-Ground Satellite Data Transfer Capabilities. Frank Marks (HRD) continued the discussion begun by Jack Parrish concerning the newly obtained Inmarsat technology. Greater collaboration among HRD and the WFOs will help identify and remedy forecast limitations in the field. It was suggested a protocol be established to expand the opportunity for WFO forecasters to take part in NOAA aircraft missions, with the dual goal of exposing them to the tropical cyclone environment and assisting with data exchange to promote the transition of research to operations. NOAA surveillance operations this season will run from August 10 through September 30, with additional reconnaissance missions tasked as necessary by NHC.

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