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Applied Meteorology Unit (AMU) Quarterly Report

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Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the second quarter of Fiscal Year 2008 (January - March 2008). A detailed project schedule is included in the Appendix.

Task Peak Wind Tool for User Launch Commit Criteria (LCC)

Goal Update the Phase I cool season climatologies and distributions of 5-minute average and peak wind speeds. The peak winds are an important forecast element for the Expendable Launch Vehicle and Space Shuttle programs. The 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast. The Phase I climatologies and distributions helped alleviate this forecast difficulty. Updating the statistics with more data and new time stratifications will make them more robust and useful to operations.

Milestones Wrote a script to calculate the Gumbel distribution using the observed data, and began working on the graphical user interface to display the climatologies and probabilities.

Discussion Using a parametric distribution, such as Gumbel, to model the observed distributions helps smooth and interpolate over variations in the observations due to under-sampling of certain peak speeds. It can also estimate probabilities for peak speeds outside the range of observations. Tests showed that the Gumbel distribution fit the observed data well.

Task Peak Wind Tool for General Forecasting

Goal Develop a tool to forecast the peak wind speed for the day from the surface to 300 ft on Kennedy Space Center (KSC) / Cape Canaveral Air Force Station (CCAFS) during the cool season months October – April. The tool should be able to forecast the timing of the peak wind speed and the background average wind speed, based on observational data available for the 45 WS 0700L weather briefing.

Milestones Completed testing the tool and writing the user instructions. Wrote the first draft of the final report.

Discussion Several tests confirmed that the software implemented the prediction equations correctly. The first draft of the final report was submitted for internal AMU review. After the internal review is completed, it will be submitted for review by the 45 WS and SMG.

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Distribution (continued from Page 1)

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Executive Summary, *continued*

Task	Situational Lightning Climatologies for Central Florida, Phase III
Goal	Customize the Advanced Weather Interactive Processing System (AWIPS) to allow display of the composite soundings created in Phase II. This will give forecasters at the National Weather Service in Melbourne, FL (NWS MLB) the capability to compare the current state of the atmosphere with climatology. After comparing current soundings to composite soundings, forecasters can make appropriate adjustments to their lightning forecast for the day.
Milestones	Wrote a software program to convert soundings in National Skew-T Hodograph Analysis and Research Program (NSHARP) Archive format into a Network Common Data Form (NetCDF) file that can be displayed in AWIPS. Delivered software, NetCDF file, and installation instructions to NWS MLB. Completed the first draft of the final report.
Discussion	A software program was written to convert the 32 composite soundings from NSHARP to NetCDF format, and it was able to display the composite soundings successfully in the AMU. Personnel at NWS MLB installed the soundings into their AWIPS. The final report is currently being reviewed internally by the AMU.
Task	Volume Averaged Height Integrated Radar Reflectivity (VAHIRR)
Goal	Develop an automated algorithm to create the VAHIRR product for the Weather Surveillance Radar 1988 Doppler (WSR-88D) weather radar. The Launch Commit Criteria (LLCC) for anvil clouds have incorporated the VAHIRR quantity to safely reduce unnecessary launch delays and scrubs. VAHIRR is expected to be included in the debris cloud LLCC soon. The VAHIRR provisions of the LLCC must currently be evaluated manually. The automated product will reduce the Launch Weather Officer's workload and chances for error in evaluating the LLCC.
Milestones	Completed the first draft of the final report.
Discussion	The AMU VAHIRR product failed a critical test during its final acceptance testing and, as a result, an operational product will not be delivered at this time. However, the final report captures the valuable lessons learned that should enable a subsequent similar task to succeed. The final report describes the development and testing of the AMU VAHIRR product, contains the source code and installation instructions, and shows the test results. It is currently being reviewed internally by the AMU.

Executive Summary, *continued*

Task — Impact of Local Sensors

Goal Determine the impact to high resolution model forecasts due to denial of local observations. Impending budget cuts may result in the elimination of some weather observation systems on KSC/CCAFS. Loss of these data may affect output from local weather prediction models. Forecasters at the 45 WS, NWS MLB and SMG use such model output for their operational forecasts. To determine the effects of losing these data sources, the model will be run using four different data ingest configurations, including and excluding the data. The results will help determine the importance of the measurements that may be eliminated.

Milestones Finished running the Local Analysis and Prediction System (LAPS) Weather Research and Forecasting (WRF) model (LAPS-WRF) "with and without" tests for all warm and cool season candidate days. Completed a subjective analysis of all warm and cool season candidate days and began an objective analysis.

Discussion The LAPS-WRF simulations of several warm and cool season days from June 2007 to January 2008 were compared to observations. The subjective analysis found no difference between the model runs with and without wind tower and CCAFS rawinsonde (RAOB) data. For the warm season days, the model showed little skill in correct placement of the radar reflectivity and, therefore, placement of the peak winds. The objective evaluation will be done to determine if the model forecast peak winds showed skill in "with and without" scenarios.

Task — Radar Scan Strategies for the PAFB WSR-74C Replacement

Goal Develop a scan strategy for the new radar that will replace the 45 WS WSR Model 74C (WSR-74C). A new scan strategy is needed to provide high vertical resolution data over the KSC and CCAFS launch pads while still taking advantage of the radar's advanced capabilities. Data from the new radar will be used by forecasters at the 45 WS, SMG, and NWS MLB to issue weather warnings and watches. The new radar will also aid in detecting cloud electrification to improve the timeliness of lightning advisories, and maintain the capability to evaluate LLCC.

Milestones Developed a plan for evaluating scan strategies and began writing the final report.

Discussion Critical elements of a scan-strategy evaluation include the vertical resolution, volume scan timing, timely generation and delivery of products to operations, and interpretation of the reflectivity, Doppler, and dual polarization products by the radar operator.

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Task — WRF Wind Sensitivity Study at Edwards Air Force Base

Goal — Assess different high-resolution model configurations to determine which is best to assist SMG in their short-term wind forecasts at Edwards Air Force Base, CA (EDW) for shuttle landings. The focus will be on "wind cycling" cases, in which the wind speed and direction oscillate over a period of time. Accurate forecasts are needed for EDW in cases where the shuttle cannot land at KSC due to adverse weather conditions.

Milestones — Identified and archived data for candidate wind cycling case days from January 2007 to present. Began configuring the LAPS-WRF model for the EDW domain.

Discussion — Four definite and three possible wind cycling case days were identified using data from the EDW wind tower network. The LAPS was configured to ingest all available high-resolution datasets in the EDW area. A comparison of forecasts helped determine that a cold-start WRF model run will be used as background data for all LAPS analyses.

Special Notice to Readers

Applied Meteorology Unit (AMU) Quarterly Reports are now available on the Wide World Web (www) at http://science.ksc.nasa.gov/amu/.

The AMU Quarterly Reports are also available in electronic format via email. If you would like to be added to the email distribution list, please contact Ms. Winifred Crawford (321-853-8130, crawford.winifred@ensco.com). If your mailing information changes or if you would like to be removed from the distribution list, please notify Ms. Crawford or Dr. Francis Merceret (321-867-0818, Francis.J.Merceret@nasa.gov).

Background

The AMU has been in operation since September 1991. Tasking is determined annually with reviews at least semi-annually. The progress being made in each task is discussed in this report with the primary AMU point of contact reflected on each task.

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

SHORT-TERM FORECAST IMPROVEMENT

Peak Wind Tool for User LCC (Ms. Crawford, formerly Lambert)

The peak winds are an important forecast element for the Expendable Launch Vehicle and Space Shuttle programs. As defined in the Launch Commit Criteria (LCC) and Shuttle Flight Rules (FR), each vehicle has peak wind thresholds that cannot be exceeded in order to ensure safe launch and landing operations. The 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast, particularly in the cool season. To alleviate some of the difficulty in making this forecast, the AMU calculated cool season climatologies and distributions of 5-minute average and peak winds in Phase I (Lambert 2002). The 45 WS requested that the AMU update these statistics with more data collected over the last five years, using new time-period stratifications, and test another parametric distribution. These modifications will likely make the statistics more robust and useful to operations. They also requested a graphical user interface (GUI) similar to that from Phase II (Lambert 2003) that will display the mean and peak speed climatologies and probabilities of meeting or exceeding certain peak speeds based on the average speed.

Probability Calculations

One of the goals of this task is to calculate the probability of meeting or exceeding a given peak wind speed depending on the specific LCC. To calculate these probabilities, Ms. Crawford stratified the peak winds by 5-minute mean wind speed in 1-kt (0.514 m s^{-1}) intervals and created empirical probability density functions (PDFs) of the peak winds. To help determine the probability of meeting or exceeding each peak speed given a mean speed, she calculated complementary cumulative distribution functions (C-CDFs), given by 1 – CDF, from the PDFs. A CDF displays the probability that a peak speed will not exceed a certain value. The 45 WS forecasters need to know the opposite as shown by a complementary CDF (C-CDF): the probability of the peak speed meeting or exceeding a certain LCC value. The peak speed C-CDFs for each 5-minute mean speed from Tower 6 at 54 ft in December are displayed in Figure 1. Only C-CDFs for the even mean speeds are shown for chart clarity. Each symbol on a mean speed curve corresponds to a peak speed on the horizontal axis and a probability of meeting or exceeding that peak speed on the vertical axis.

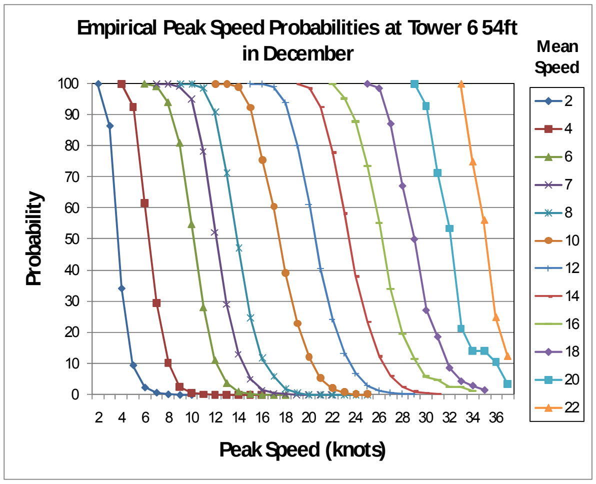

Figure 1. The empirical C-CDFs for the even 5-minute mean winds from Tower 6 at 54 ft in December. The legend shows the symbols and colors for each mean speed.

Note in Figure 1 that the C-CDFs for the lower mean speeds are smooth, but the tails become noisy for mean speeds higher than 14 kt. For 17 kt and higher, the entire curve becomes noisy. The number of 5-minute mean speed observations of 15 kt and higher drops below 200 and goes to just two observations at 24 kt. Fitting a parametric distribution to the data will help smooth and interpolate over variations in the empirical CDFs due to under-sampling of certain peak speeds and possibly estimate probabilities for peak speeds outside the range of observations in the POR.

Fitting the C-CDFs with the proper parametric distribution is necessary for calculating the appropriate probability values, especially for extreme values that are observed only occasionally. The Gumbel distribution will be used in this work since it has been proven as the best distribution for winds at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS) in studies conducted at Marshall Space Flight Center. Ms. Crawford created an S-PLUS script to calculate the Gumbel distribution of peak winds for each mean speed. Wilks (2006) identifies the Gumbel as an often-used extreme value distribution and, as such, is appropriate for peak winds. The Gumbel CDF is defined by the following equation in Wilks (2006):

$$GumbelCDF = exp\left\{-exp\left[-\frac{x-\theta}{\beta}\right]\right\}$$

where x is the peak speed variable, θ is the location parameter, and β is the scale parameter. The location and scale parameters will be determined using two methods. The Method of Moments will be used first to calculate first-guess values

$$\hat{\beta} = \frac{s\sqrt{6}}{\pi} \text{ and } \hat{\theta} = \bar{x} - \gamma\hat{\beta}$$

where s is the standard deviation of the peaks, $\bar{x}$ is the mean of the peaks, and γ is Euler's Constant (0.57721…). The Chi-squared (X^2) goodness-of-fit test will be used to find the optimal values for these parameters by minimizing X^2 in the equation

$$X^2 = \sum \frac{(\#Observed - \#Expected)^2}{\#Expected}$$

Where *#Observed* is the number of observations for a peak value, and *#Expected* is the number of observations for that peak based on the fitted distribution. When the parametric distribution is fitted perfectly to the observed, X^2 = 0. In Initial tests with the script, Ms. Crawford observed X^2 values indicating that the Gumbel distribution produced a good fit to the empirical C-CDFs.

Graphical User Interface

Ms. Crawford provided a copy of the Excel GUI (Lambert 2003) to Mr. Roeder for him to determine which aspects of the GUI will be useful to 45 WS forecasters and which must be changed. She began modifying the Excel GUI to display climatology values for the LCC towers. Ms. Crawford will create an interim GUI for the climatologies and diagnostic probabilities, and will add the prognostic probabilities at a later date when they can be created.

Status

Ms. Crawford continued running the S-PLUS scripts to stratify the data for the 2-hour probabilities for each hour of the day in each month and each tower. Due to the large amount of data I/O the procedure requires, it takes over 20 minutes to process the data for one hour/one sensor/one month/all years. There is not enough memory available on a Windows XP computer to run the script for more than two sensors at a time. The AMU discussed the issue with Mr. Roeder, and they decided to continue processing the data on Ms. Crawford's and two other PCs in the AMU. With concurrence from Mr. Roeder, this will delay the start on the Objective Lightning Probability Phase III task.

Conference Presentation

Ms. Crawford presented the status and results thus far for this task at the 19th Conference on Probability and Statistics, part of the 88th American Meteorological Society (AMS) Annual Meeting in January 2008.

Contact Ms Crawford at 321-853-8130 or crawford.winnie@ensco.com for more information.

Peak Wind Tool for General Forecasting (Mr. Barrett and Dr. Short)

The expected peak wind speed for the day is an important element in the daily morning forecast for ground and space launch operations at KSC and CCAFS. The 45 WS must issue forecast advisories for KSC/CCAFS when they expect peak gusts to exceed 35 kt, 50 kt, and 60 kt thresholds at any level from the surface to 300 ft. However, the 45 WS forecasters indicate that peak wind speeds are a challenging parameter to forecast, regardless of their value. They requested that the AMU develop a tool to help them forecast the daily average and highest peak non-convective wind speed, and the timing of the peak speed, from the surface to 300 ft on KSC/CCAFS for the cool season (October-April). The AMU used a 4-year database of high resolution soundings and other observational data available by the morning weather briefing at 0700 local time to develop a tool that provides a forecast of the peak wind speed for the day, its timing, and the average wind speed at the time of the peak.

Software Test

Mr. Barrett conducted a series of tests that verified the software in the tool implemented the prediction equations correctly. He accomplished this by comparing the output to manual calculations. He also verified that the tool handled invalid input values correctly.

Final Report

Mr. Barrett completed the user instructions for the tool and the first draft of the final report. The report is currently being reviewed internally by the AMU. After the internal review is completed, it will be submitted to the 45 WS and SMG for their review.

Contact Mr. Barrett at 321-853-8205 or barrett.joe@ensco.com, for more information.

Situational Lightning Climatologies for Central Florida, Phase III (Mr. Barrett)

The threat of lightning is a daily concern during the warm season in Florida. Recent research has revealed distinct spatial and temporal distributions of lightning occurrence that are strongly influenced by large-scale atmospheric flow regimes in Florida. The first two phases of this work involved developing spatial and temporal climatologies of lightning occurrence based on the flow regime. In the first part of Phase II, Dr. Short created climatological, or composite, soundings of wind speed and direction, temperature, and dew point temperature at Jacksonville (JAX), Tampa (TBW), Miami (MFL), and CCAFS (XMR), Florida for each of eight flow regimes, resulting in 32 soundings (Short 2006). These soundings could only be displayed using the National version of the Skew-T Hodograph Analysis and Research Program (NSHARP). For Phase III, the National Weather Service in Melbourne, FL (NWS MLB) requested that the AMU make these composite soundings available for display in the Advanced Weather Interactive Processing System (AWIPS) so that they can be overlaid onto current soundings. This will allow the forecasters to compare the current state of the atmosphere with climatology. After comparing current soundings to composite soundings, the NWS MLB forecasters can make adjustments to the forecast of lightning in their Hazardous Weather Outlook and lightning threat index products.

AWIPS Display

Mr. Barrett wrote a software program called “NSHARP to AWIPS” in the Tool Command Language/Tool Kit (Tcl/Tk) language. He used this program to convert the 32 composite soundings in NSHARP Archive format into a single Network Common Data Form (NetCDF) file. In AWIPS, soundings must be stored in NetCDF format. Figure 2 shows the “NSHARP to AWIPS” GUI. After the program is started, the filenames of the NSHARP composite files are displayed in the listbox on the left. The user selects the time and date for the NetCDF file at the top of the GUI. When the user selects an NSHARP file, the filename is moved to the listbox on the right. After the desired NSHARP filenames have been selected, the user selects the “Create CDL File” button. This creates a file in the network Common data form Description Language (CDL). Finally, the user exits the program and converts the CDL file to a NetCDF file with the ncgen utility.

Mr Barrett succeeded in displaying the composite soundings on the AMU AWIPS. The NetCDF file containing the composite soundings, GUI software, and installation instructions were delivered to NWS MLB. Figures 3 and 4 show how the composite soundings can be displayed in AWIPS. Figure 3 shows the MFL, TBW, JAX, and XMR soundings for the Northeast (NE) flow regime. Figure 4 compares an observed XMR sounding to the XMR sounding for the Southeast (SE-1) flow regime.

Final Report

Mr. Barrett completed the first draft of the final report. The report is currently being reviewed internally by the AMU. After the internal review is completed, it will be submitted for review by NWS MLB, SMG, and the 45 WS.

Contact Mr. Barrett at 321-853-8205 or barrett.joe@ensco.com for more information.

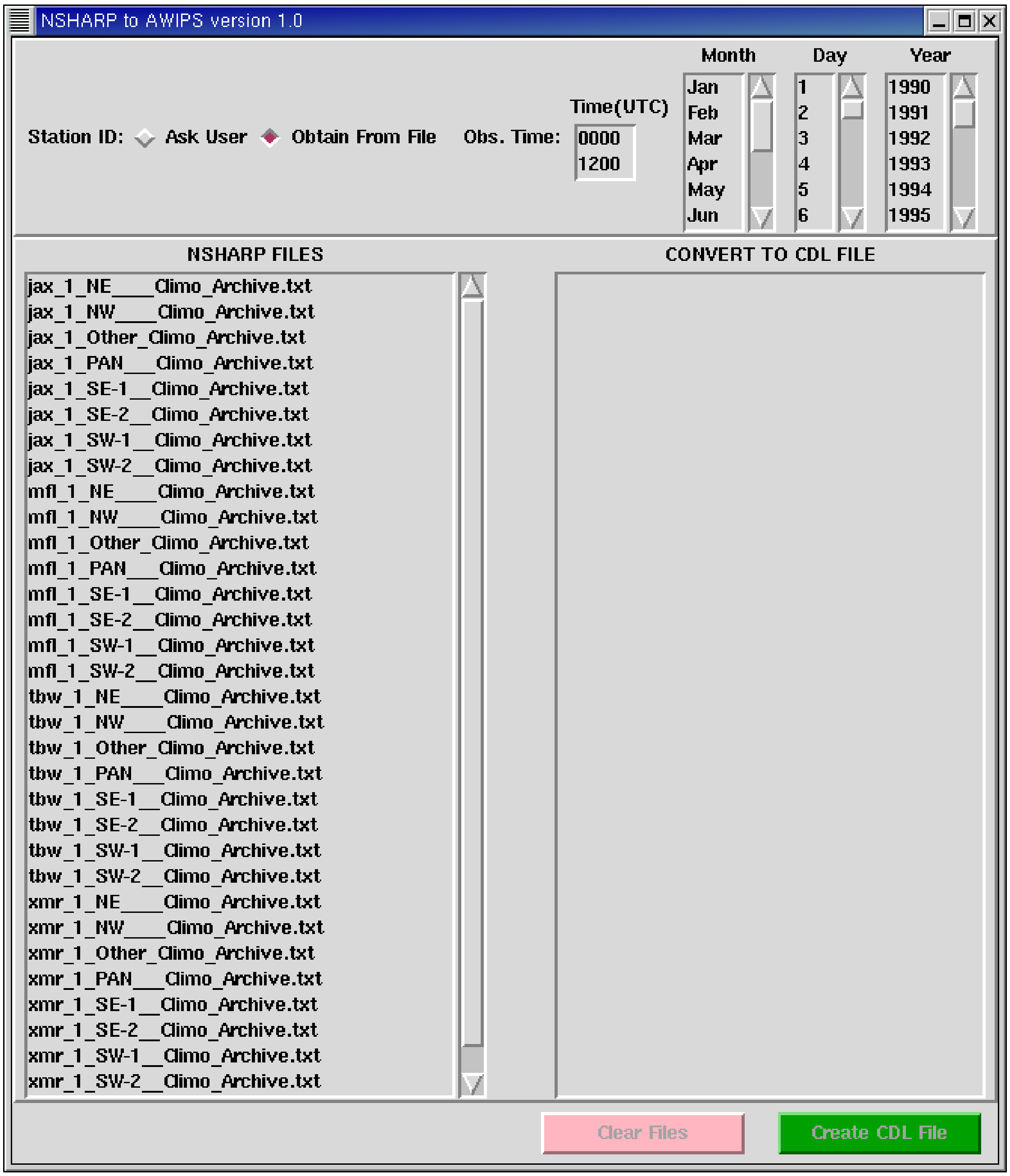

Figure 2. The NSHARP-to-AWIPS GUI at start-up.

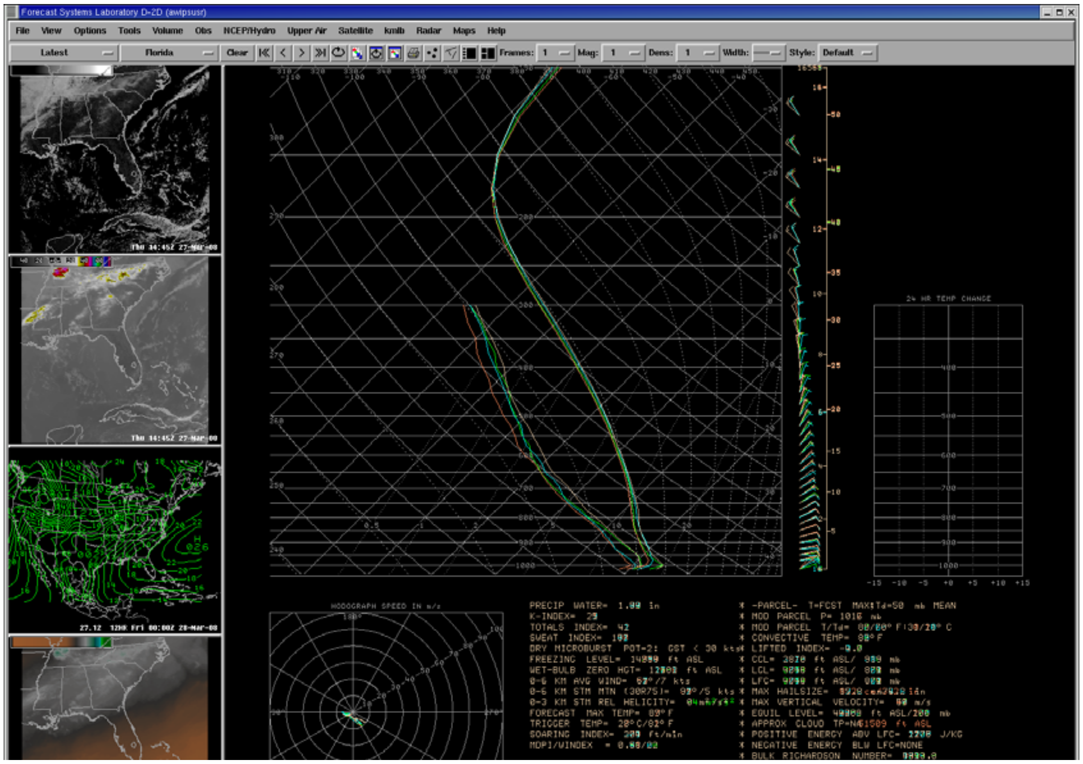

Figure 3. The AWIPS display of the MFL, TBW, JAX, and XMR composite soundings for the NE flow regime.

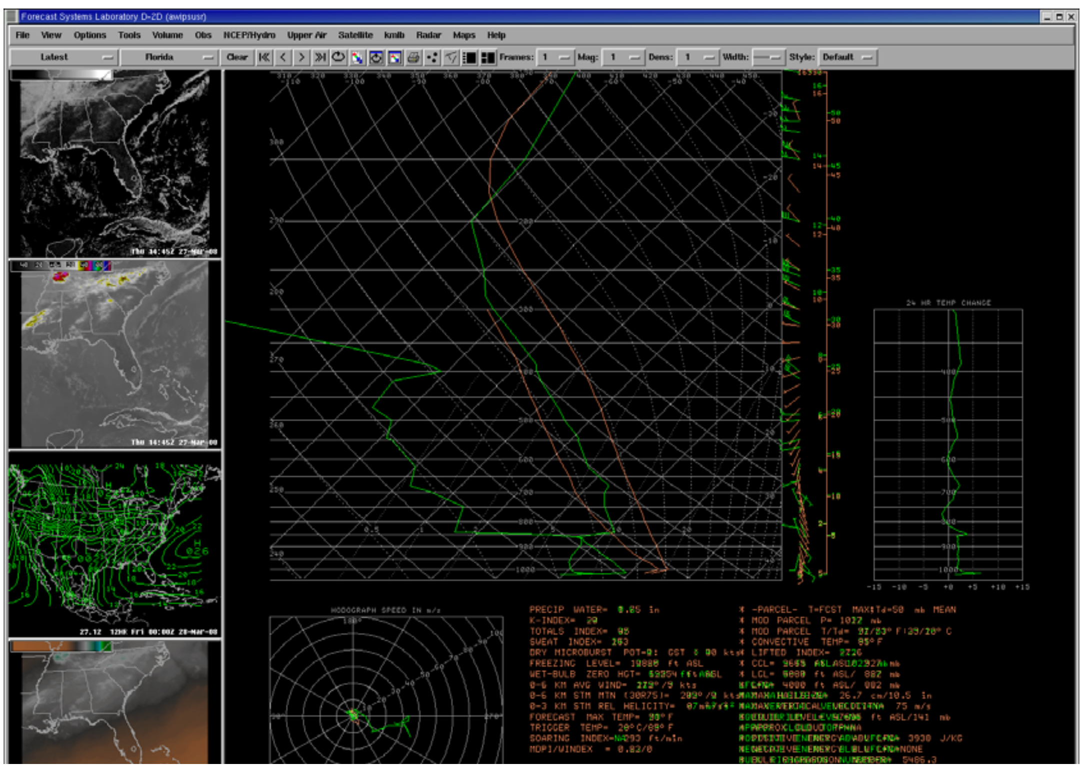

Figure 4. The AWIPS display of the XMR observed sounding at 1000 UTC 27 March 2008 (green) and the XMR composite sounding for the SE-1 flow regime (orange). The observed sounding is cooler and drier because the composite sounding was created with warm season (May - September) data.

INSTRUMENTATION AND MEASUREMENT

Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) Algorithm (Mr. Barrett, Ms. Miller, Ms. Charnasky, Dr. Merceret, and Mr. Gillen)

Lightning LCC (LLCC) are used for all launches, whether Government or commercial, using a Government or civilian range (Willett et al. 1999). Shuttle lightning FR are also used for all landings. These rules are designed to avoid natural and triggered lightning strikes to space vehicles, which can endanger the vehicle, payload, and general public. The current LLCC for anvil clouds, meant to avoid triggered lightning, have been shown to be overly restrictive. They ensure safety, but falsely warn of danger and lead to costly launch delays and scrubs. A new LLCC for anvil clouds, and an associated radar-derived quantity (VAHIRR) needed to evaluate that new LLCC, were developed using data collected by the Airborne Field Mill (ABFM) research program managed by KSC (Dye et al. 2006, 2007). Dr. Harry Koons of Aerospace Corporation conducted a risk analysis of the VAHIRR parameter. The results indicated that relaxation of the LLCC based on VAHIRR would pose a negligible risk of flying through hazardous electric fields.

The comparison between the AMU and ABFM VAHIRR products (AMU Quarterly Report Q4 FY07) revealed large differences between them. The AMU analyzed the differences, but could not determine the causes of the differences. Therefore, the AMU VAHIRR software was not released for operational use.

Mr. Barrett completed the first draft of the final report describing the development and testing of the AMU VAHIRR software. The final report consists of four volumes: a main report, source code, installation guide, and test results. The final report is currently being reviewed internally by the AMU. After the internal review is completed, it will be submitted for review by the 45 WS and SMG.

For more information, contact Mr. Barrett at barrett.joe@ensco.com or 321-853-8205, or Dr. Merceret at Francis.J.Merceret@nasa.gov or 321-867-0818.

Impact of Local Sensors (Dr. Watson and Dr. Bauman)

Forecasters at the 45 WS use observations from the KSC/CCAFS wind tower network and daily rawinsonde observations (RAOB) to issue and verify wind advisories, watches, and warnings for operations. They are also used by SMG to support shuttle landings at the KSC Shuttle Landing Facility. Due to impending budget cuts, some or all of the mainland wind towers (Figure 5) and RAOBs may be eliminated. The loss of these data may significantly impact the forecast capability of the 45 WS and SMG. The AMU was tasked to conduct an objective independent modeling study to determine how important these observations are to the accuracy of the model output used by the forecasters as input to their forecasts. To accomplish this, the AMU will perform a sensitivity study using the Weather Research and Forecasting (WRF) model run with and without KSC/CCAFS wind tower XMR RAOB observations. The AMU will assess the accuracy of model forecasts by comparing operationally significant model output parameters with advisory and warning criteria forecast by the 45 WS. The model forecasts will be displayed graphically with the observations overlaid for comparison to determine the model performance when initialized with and without wind tower and RAOB observations. These analyses will help the 45 WS determine the importance of the measurements slated for elimination.

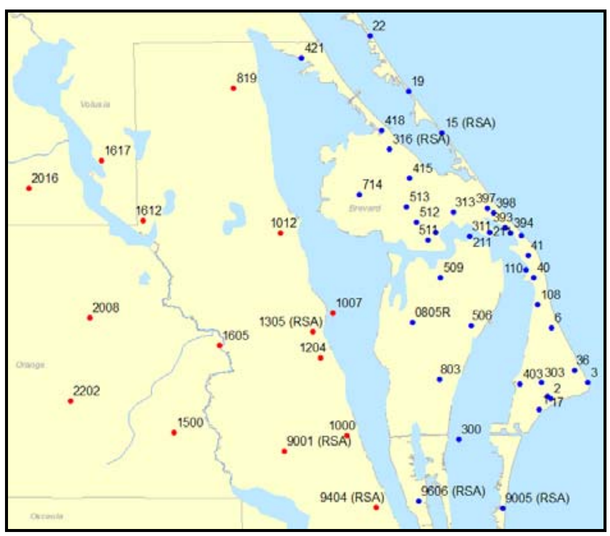

Figure 5. Map of the KSC/CCAFS area showing mainland tower locations (red dots) and island/cape tower locations (blue dots).

Subjective Data Analysis

Dr. Bauman completed a subjective analysis of the WRF forecasts for 12 warm season and eight cool season days. The forecasts were valid near the time of wind events in the wind tower network based on 45 WS advisories and warnings. The goal was to determine

1) If the model could provide an indicator to the forecaster that there may be winds meeting advisory or warning criteria for the day, and
2) If including or excluding mainland wind towers and/or the XMR RAOB made a difference in the model wind forecast.

During the warm season, WRF peak wind forecasts were highly correlated with the location and strength of the forecast radar reflectivity. On most days, WRF misplaced the convection but did well with the coverage and intensity. Figure 6 shows the observed radar reflectivity from the Melbourne Weather Surveillance Radar – 1988 Doppler (WSR-88D) (shaded) at 1756 UTC 12 June 2007 and the WRF forecast radar reflectivity (contours) at 1800 UTC 12 June 2007. The WSR-88D reflectivity shows a line of convection extending northeast-to-southwest from the Atlantic Ocean across KSC/CCAFS and then over the mainland. The WRF forecast reflectivity shows a line of convection extending over the mainland west of KSC extending north-to-south. Although the observed and forecast reflectivity lines were almost perpendicular to each other, the WRF forecast of coverage and intensity was similar to the observed. The WRF forecast peak winds of 30-35 kts near the strongest forecast reflectivity values ≥ 54 dBz southwest of KSC while the observed peak wind was 40 kts at Tower 1007 on the eastern shore of the mainland west of KSC. There was no discernable difference in the WRF reflectivity or peak wind forecasts among the four “with and without” cases.

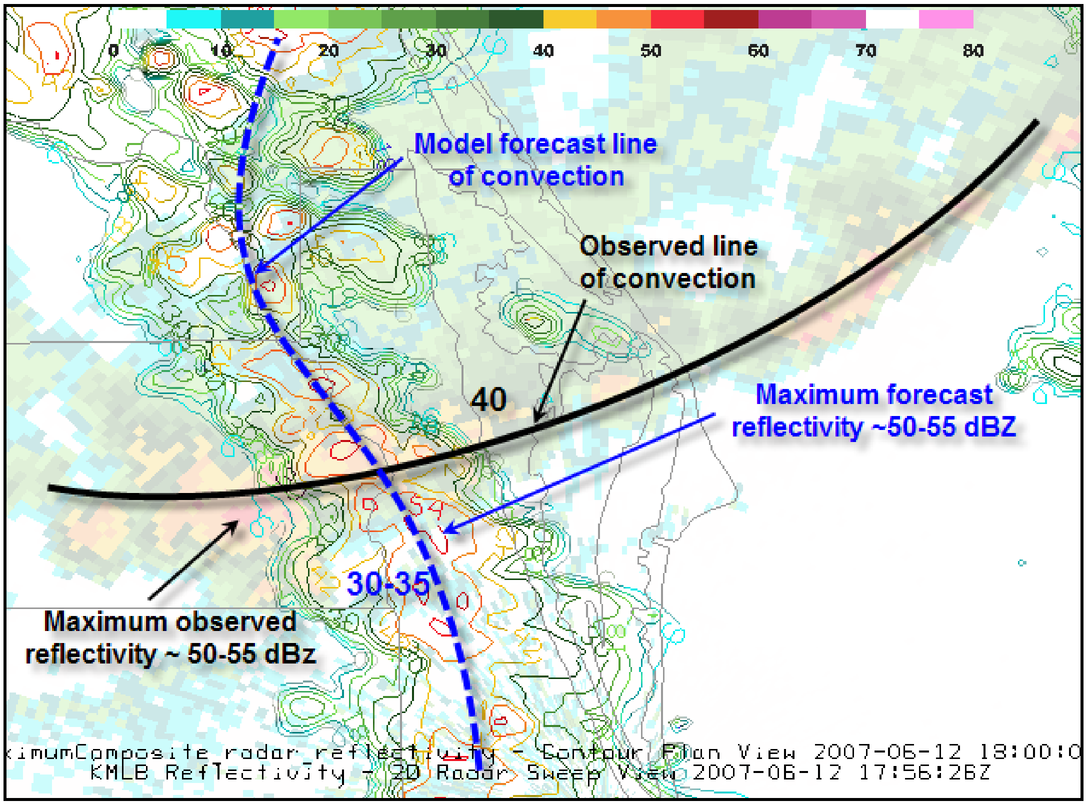

Figure 6. WRF model forecast of radar reflectivity (contours) valid 1800 UTC 12 June 2007 overlaid on Melbourne WSR-88D observed radar reflectivity (shaded) valid 1756 UTC 12 June 2007. The reflectivity scale is shown at the top. The solid black line indicates the location of the observed line of convection. The dashed blue line indicates the location of the forecast line of convection. The black number “40” shows the location of the observed peak wind of 40 kts. The blue numbers “30-35” show the location of the model forecast peak winds of 30-35 kts.

Figure 7 shows the radar reflectivity observed by the Melbourne WSR-88D (shaded) at 1701 UTC 10 July 2007 and the WRF forecast radar reflectivity (contours) at 1700 UTC 10 July 2007. Both the observed and forecast reflectivity indicated isolated convection over the region. The WRF forecast produced a few convective cells with maximum reflectivity values of 45-50 dBZ while the observed maximum reflectivity values were 50-55 dBZ. The highest observed peak wind of 29 kts was at Tower 9404 on the eastern shore of the mainland southwest of KSC, but the highest forecast peak winds were just south of the observed highest peak wind.

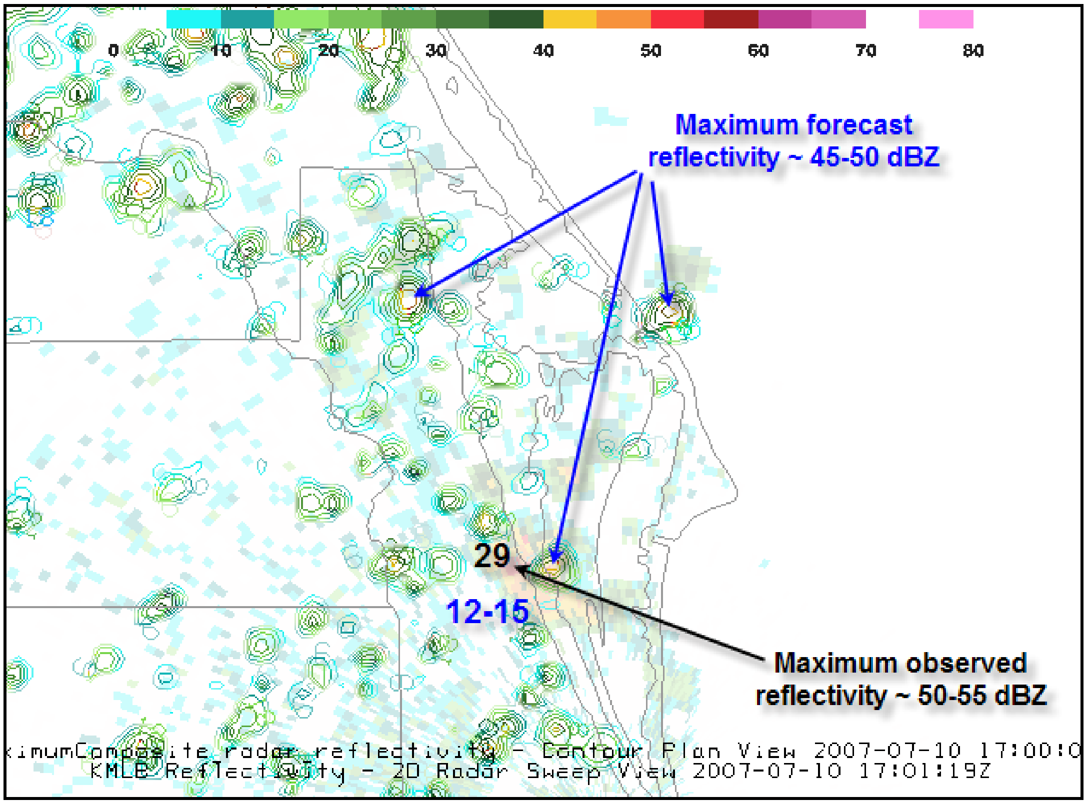

Figure 7. WRF model forecast of radar reflectivity (contours) valid 1700 UTC 10 July 2007 overlaid on Melbourne WSR-88D observed radar reflectivity (shaded) valid 1701 UTC 10 July 2007. The reflectivity scale is shown at the top. The black number "29" shows the location of the observed peak wind of 29 kts. The blue numbers "12-15" show the location of the model forecast peak winds of 12-15 kts.

During the cool season, synoptic scale gradient flow was the primary cause of high wind events that warranted 45 WS advisories and warnings. Convection was rarely the driver. Based on the subjective analysis, the WRF peak wind forecasts were better during the cool season in both timing and location compared with the warm season forecasts. Figure 8 shows the WRF peak wind forecast (shaded) at ~ 33 ft for 1500 UTC 17 January 2008 with a plot of the observed winds at 54 ft from the KSC/CCAFS mesonet towers and 295 ft from Tower 313 at 1500 UTC 17 January 2008. The WRF forecast indicated stronger peak winds over KSC/CCAFS and offshore than inland, with peak speeds of ~ 20-25 kts inland increasing to ~ 27-31 kts along the coast. The observed winds were lower than forecast, but the trend was the same with the strongest winds at the coastal towers.

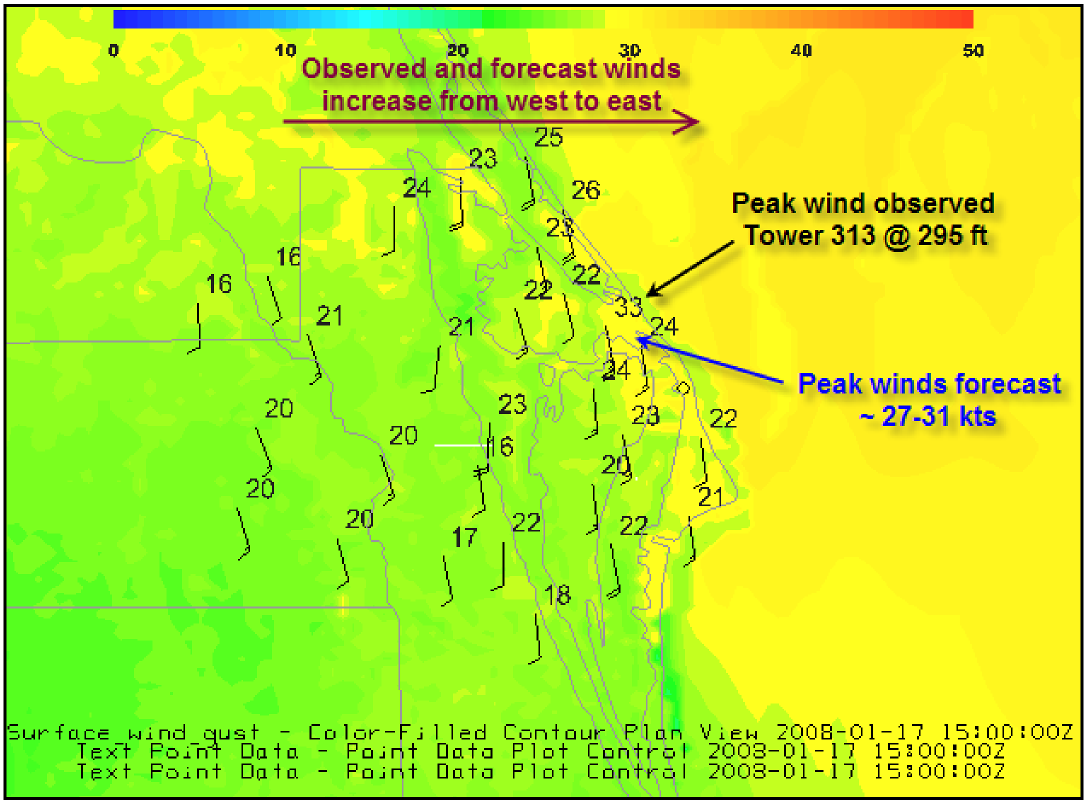

Figure 8. WRF model forecast of peak winds at ~ 33 ft (shaded) valid 1500 UTC 17 January 2008 with a plot of the observed winds at 54 ft from the KSC/CCAFS mesonet towers and 295 ft from tower 313 at the same time. Both the forecast and observed winds increase from west to east.

Objective Peak Wind Analysis

Upon reviewing the results of the subjective analysis, Mr. Roeder asked the AMU to conduct a more objective analysis of the peak wind comparisons to determine the magnitude of the differences among the four model runs. The analysis would also determine if the model runs provide value to the forecaster for their daily planning forecast when indicating the possibility of wind advisory or warning criteria occurrence. To do this, Dr. Watson identified model-domain peak wind speeds for each forecast output time using the Grid Analysis and Display System (GrADS). The max() function in GrADS allows the user to identify the maximum value of a variable within a user specified domain. Dr. Watson used this function to return the maximum wind speed within the domain pictured in Figure 8. Using Dr. Watson's results, Dr. Bauman began comparing the observed maximum wind speed to the WRF-forecast maximum wind speed. An example of the objective analysis is shown in Figure 9, which plots the maximum wind speed observed from the tower network and the model forecast maximum wind speed for the four "with and without" scenarios. He will complete the objective analysis for all 20 days during the next quarter.

For more information contact Dr. Watson at watson.leela@ensco.com or 321-853-8264 or Dr. Bauman at bauman.bill@ensco.com or 321-853-8202.

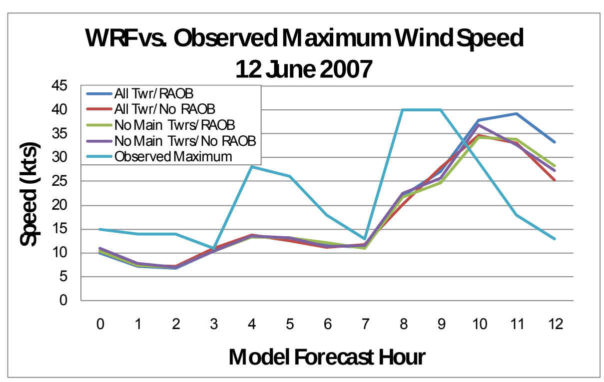

Figure 9. Chart of the observed maximum wind speed from the KSC/CCAFS towers and the model forecast maximum wind speed for each "with and without" scenario on 12 June 2007 for all 12 1-hour forecast periods.

Radar Scan Strategies for the PAFB WSR-74C Replacement (Dr. Short)

The Eastern Range is replacing the WSR, Model 74C (WSR-74C) at Patrick Air Force Base (PAFB) with a Doppler, Dual Polarization radar, the RadTec 43/250. This new radar is being installed 20 n mi northwest of PAFB. A new scan strategy is needed to take advantage of the new radar's advanced capabilities for detecting severe weather phenomena associated with convection within the 45 WS area of responsibility, while providing high vertical resolution data over the KSC and CCAFS launch pads. Rapid updates of 3 min or less are required for evaluating LLCC and monitoring the growth and electrification of convective clouds. Radar products generated by the new data processing system will be used by forecasters of the 45 WS, SMG and NWS MLB to provide weather warnings and watches for convective wind events such as downbursts and mesoscale vortices which can spawn tornadoes. The new radar will also provide capabilities to detect cloud electrification, improving the timeliness of lightning advisories, while maintaining the capability for evaluation of LLCC. The AMU will evaluate the capabilities of the new weather radar and develop several scan strategies customized for the operational needs of the 45 WS. The AMU will also develop a plan for evaluating the scan strategies in the period prior to operational acceptance, planned for November 2008. The 45 WS will use the results of the evaluation to choose one or more of the scan strategies developed by the AMU.

Dr. Short completed development of a plan for evaluating scan strategies. The critical elements of such an evaluation include effects of vertical resolution on radar products, the timing of a complete volume scan, timely generation and delivery of radar products to the operational display system, and timely interpretation of the reflectivity, Doppler, and dual polarization products by the radar operator. He also began writing a draft of the final report.

Contact Dr. Short at short.dave@ensco.com for more information.

MESOSCALE MODELING

WRF Wind Sensitivity Study at EDW (Dr. Watson and Dr. Bauman)

Occasionally, the shuttle must land at Edwards Air Force Base (EDW) in Southern California when weather conditions at KSC violate the FR. However, the complex terrain in and around EDW makes forecasting surface winds a challenge for SMG. In particular, wind "cycling cases", in which the wind speeds and directions oscillate among towers near the EDW runway, present a challenging forecast problem for shuttle landings. An accurate depiction of the winds along the runway is crucial in making the landing decision. Global and national scale models cannot properly resolve the wind field due to their coarse horizontal resolutions, so a properly tuned high-resolution mesoscale model is needed. The WRF model meets this requirement. It has two dynamical cores and two options for initialization, as well as a number of different model parameterizations within each core. This provides SMG with a lot of flexibility as well as challenges. The goal of this task to assess the different configurations available and determine which will best predict surface wind speed and direction at EDW. Specifically, the AMU was tasked to 1) compare the model performance among different combinations of the dynamical cores and intializations, and 2) compare model performance while varying the physics options.

The Modeling System

The WRF model is the next generation community mesoscale model designed to enhance collaboration between the research and operational sectors. The WRF model has two dynamical cores -- the Advanced Research WRF (ARW) and the Non-hydrostatic Mesoscale Model (NMM). There are also two options for a "hot-start" initialization of the WRF model – the Local Analysis and Prediction System (LAPS) and the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS). Both LAPS and ADAS are three-dimensional weather analysis systems that integrate multiple meteorological data sources into one analysis over the user's domain of interest. These analysis systems allow mesoscale models to benefit from the addition of high-resolution data sources in their initial conditions.

Wind Cycling Case Days

Wind cycling events occur when there is an oscillation in wind direction and/or wind speed among the wind towers in the network near the EDW runway complex. Figure 10 shows the approximate locations of the towers along the EDW runway complex. During these cycling events, the wind speed and direction reported from the towers near the concrete runway (Towers 44, 220, 224) are noticeably different than those reported from towers near the lakebed runway (Towers 154, 230, 234). These events usually last 90 minutes to 4 hours or longer and most often occur when the prevailing wind is from the northwest or west-northwest. Mr. Brian Hoeth of SMG provided Dr. Watson with four wind cycling case days: 22 December 2006, 30 January 2008, 14 February 2008, and 5 March 2008. In addition, Dr. Watson identified three more possible wind cycling case days: 17 April 2007, 20 October 2007, and 26 December 2007. Dr. Watson is continuing to identify candidate case days.

Figure 11 shows a time series of wind speed and direction from a wind cycling event that occurred on 14 February 2008 for Towers 44 and 234. Inspection of Figure 11 reveals a wave-like behavior in the time series for wind speed and direction at Tower 44, which is located near the concrete runway. Between 0300 and 0700 UTC (denoted by the yellow vertical lines) there was a wind direction oscillation between southwesterly and northwesterly, as well as a 5 to 15 kt change in wind speed, that occurred approximately every half hour. The wind at Tower 234, near the lakebed runway, did not exhibit this wave-like behavior.

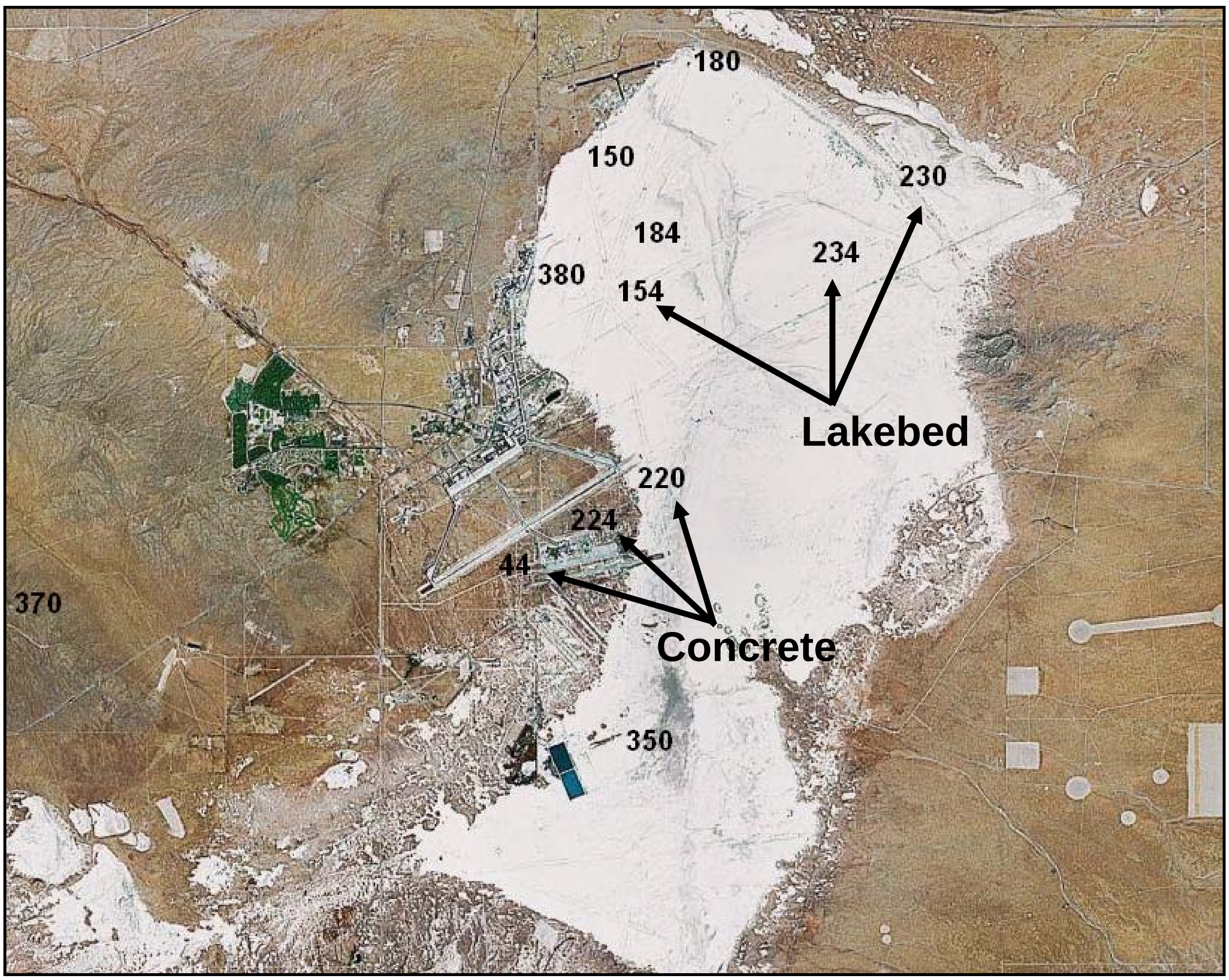

Figure 10. Wind tower locations on EDW. The towers along the concrete and lakebed runways are indicated by arrows. The wind tower locations are approximate. Background image from Google maps.

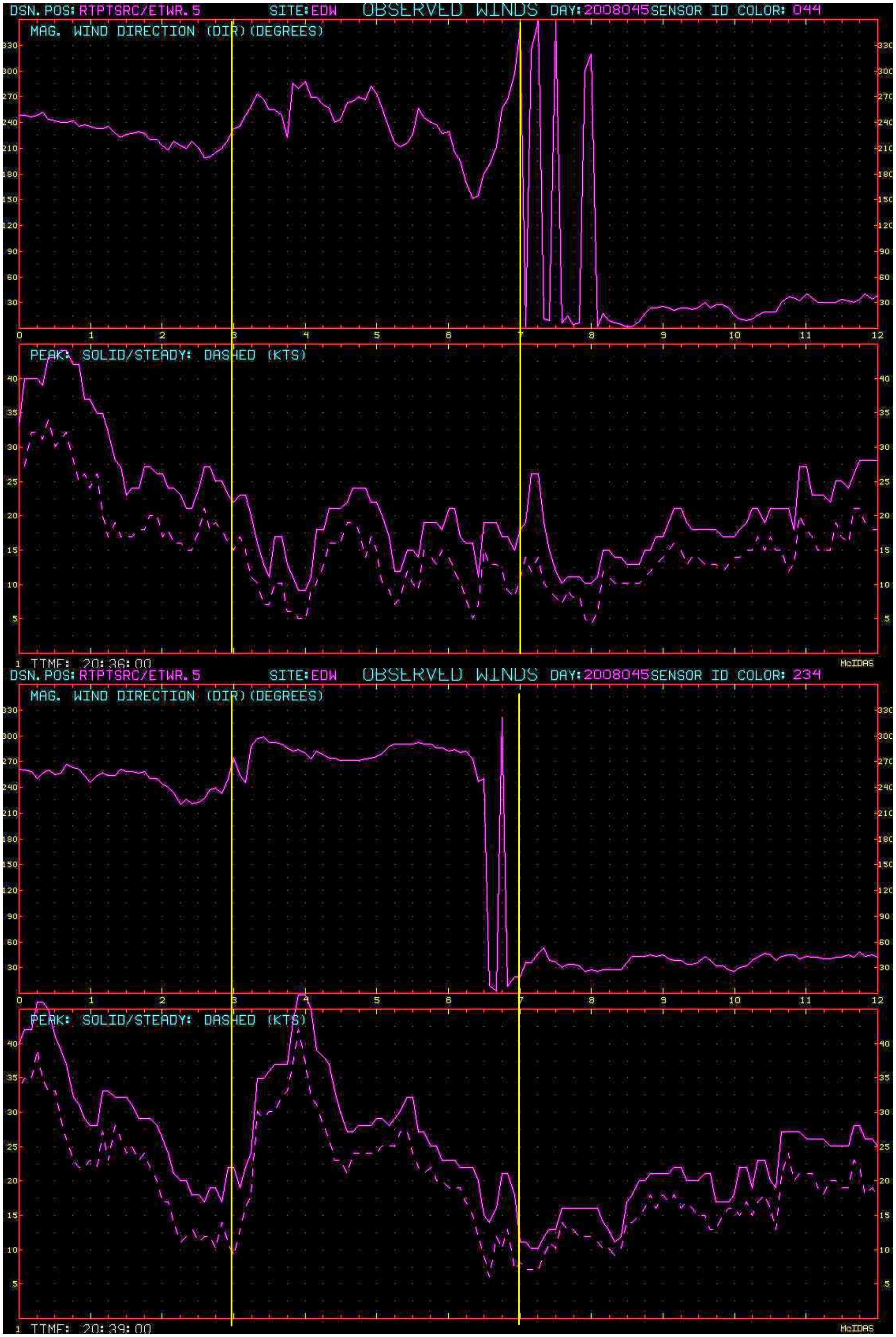

Figure 11. Wind direction (degrees) and wind speed (kts) for Tower 44 (top) and Tower 234 (bottom) on 14 February 2008 from 0000 to 12000 UTC. The solid line is the peak wind, the dashed line is the mean wind. Images provided by Brian Hoeth of SMG.

LAPS-WRF Model Configuration

Dr. Watson began configuring LAPS to ingest all available high-resolution datasets in the EDW area. These included visible and infrared satellite imagery, WSR-88D data from the Las Vegas, NV (KESX), Yuma, AZ (KYUX), Santa Ana Mountains, CA (KSOX), San Joaquin Valley, CA (KHNX), San Diego, CA (KNKX), and Los Angeles, CA (KVTX) radars (see Figure 12), and Meteorological Assimilation Data Ingest System (MADIS) data. She compared the 40-km Rapid Update Cycle (RUC) versus a 4-km cold-start WRF model as background data for the LAPS analyses to determine which model produced a better forecast. Dr. Watson determined that both backgrounds produced nearly identical results. However, since RUC 40km data is not available for all candidate days and the WRF data is at a higher resolution she will use a cold-start WRF run as background data for the LAPS analyses.

For more information contact Dr. Watson at watson.leela@ensco.com or 321-853-8264 or Dr. Bauman at bauman.bill@ensco.com or 321-853-8202.

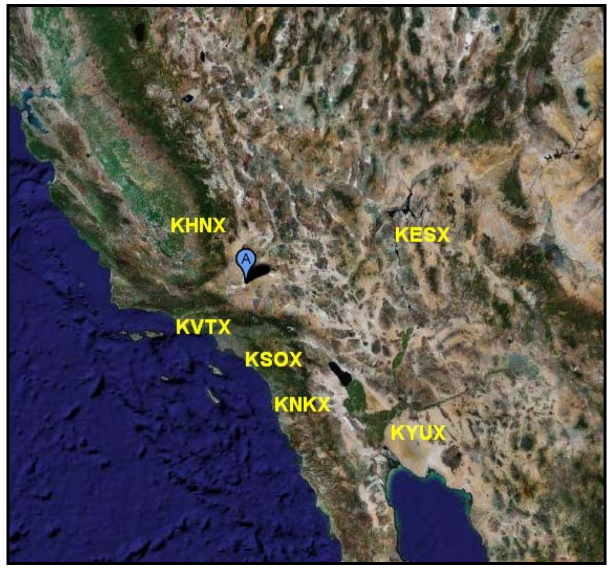

Figure 12. Locations of WSR-88D sites used in creating the high-resolution LAPS analyses. The blue “A” shows the location of EDW.

AMU CHIEF’S TECHNICAL ACTIVITIES (Dr. Merceret)

Dr. Merceret continued studying the probability distribution of gust factors (GF) in hurricanes Frances and Jeanne (2004). He circulated a draft of a report describing empirical models for the first and second moments of the distribution of gust factors as a function of height and wind speed to the 45WS and Ms. Crawford for internal review. The reviews indicated that the models for the mean and standard deviation of the gust factor as a function of height and wind speed will be useful operationally. He also finalized a paper for the 28th AMS Conference on Hurricanes and Tropical Meteorology based on the reviews. He is now working on the more difficult task of characterizing the upper tail of the distributions. Treating the quantity (GF-1) as a lognormal distribution looks promising.

AMU OPERATIONS

IT Communications

Dr. Bauman continued to work on switching the AMU from the ENSCO to the NASA communications network in the Morrell Operations Center (MOC). He and Dr. Merceret attended a meeting on 11 January with KSC and 45th Space Wing (45 SW) networking personnel to discuss combining efforts in switching the AMU from the ENSCO to the NASA communications network and adding the capability for the 45 WS Shuttle Launch Weather Officer, Ms. Winters. The 45 SW completed their work to receive the NASA network on CCAFS, and KSC made progress for connectivity and expected to be complete within several weeks. Mr. Josh Manning (KSC/KT) will lead the effort to make the network change until the task is finished.

Mr. Manning informed Dr. Bauman that KSC ordered the equipment needed to connect the AMU to the NASA communications network on 22 February. He could not provide an estimated date when the equipment would be delivered and installed.

Network administrators at KSC conducted a "30% Design Review" on 13 March to determine the status of switching the AMU from the ENSCO network to the NASA network. During the review, NASA discussed the option of using an existing JBOSC network already in the MOC and work began to move in this direction. Dr. Bauman provided KSC personnel with the AMU floor plan showing equipment and network locations. This was followed-up by a site survey from Mr. Rob Serfozo at KSC JBOSC - Network Operations. The KSC network administrators estimated the switch to the NASA network will occur by 30 April 2008.

Launch Support

Dr. Short supported the launch of STS-122 on 7 February and Mr. Barrett supported landing on 20 February. Ms. Crawford supported the launch of STS-123 on 11 March and Mr. Barrett supported the landing on 26 March. Dr. Bauman observed SMG operations at JSC during the launch of STS-123. Ms. Ward of the KSC Weather Office supported both launches and landings.

Conferences and Meetings

Three AMU team members attended the 88th Annual Meeting of the AMS, 20-24 January 2008 in New Orleans, LA and presented the following papers:

- Ms. Crawford gave an oral presentation titled "Developing a Peak Wind Forecasting Tool for Kennedy Space Center and Cape Canaveral Air Force Station" at the 19th Conference on Probability and Statistics;
- Mr. Barrett gave a poster presentation titled "Forecasting Cool Season Daily Peak Winds at Kennedy Space Center and Cape Canaveral Air Force Station" and an oral presentation titled "Development and Testing of the VAHIRR Product", both at the 13th Conference on Aviation, Range and Aerospace Meteorology; and
- Dr. Bauman gave a poster presentation titled "Flow Regime Based Climatologies of Lightning Probabilities for Spaceports and Airports" at the Third Conference on Meteorological Applications of Lightning Data.

Ms. Crawford wrote and submitted a manuscript to accompany her presentation at the 2008 International Lightning Data Conference in April. Prior to submission, the 45 WS and NASA approved the document, titled "Update to the Lightning Probability Forecast Equations at Kennedy Space Center/Cape Canaveral Air Force Station, Florida."

General

Mr. Barrett submitted the FY2008 IT purchase requests to Ms. Ward at the KSC Weather Office. Dr. Jim Stobie, ENSCO's Director of Aviation Weather Programs, visited the KSC Weather Office and the AMU.

Dr. Dave Short, the AMU Senior Scientist, left the AMU on 22 February to accept a Research Fellow position at the Hydrologic Atmospheric Research Center of Nagoya University in Japan. Dr. Bauman became the Senior Scientist, and Ms. Crawford became the Senior Meteorologist. The AMU reviewed applicants for the Meteorologist position.

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List of Acronyms

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
ABFM	Airborne Field Mill Program
ADAS	ARPS Data Analysis System
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMS	American Meteorological Society
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
ARW	Advanced Research WRF
AWIPS	Advanced Weather Interactive Processing System
CCAFS	Cape Canaveral Air Force Station
CDF	Cumulative Distribution Function
C-CDF	Complementary CDF
CDL	Common data form Description Language
CSR	Computer Sciences Raytheon
FR	Flight Rules
FSU	Florida State University
FY	Fiscal Year
GrADS	Grid Analysis and Display System
GSD	Global Systems Division
GUI	Graphical User Interface
JAX	Jacksonville, FL 3-letter identifier
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAPS	Local Analysis and Prediction System
LCC	Launch Commit Criteria
LLCC	Lightning LCC
MFL	Miami, FL 3-letter identifier
MLB	Melbourne, FL 3-letter identifier
MSFC	Marshall Space Flight Center
NCAR	National Center for Atmospheric Research
NE	Northeast Flow Regime
NetCDF	Network Common Data Form
NMM	Non-hydrostatic Mesoscale Model
NOAA	National Oceanic and Atmospheric Administration
NSHARP	National Skew-T Hodograph analysis and Research Program
NSSL	National Severe Storms Laboratory
NWS	National Weather Service
NWS MLB	NWS in Melbourne, FL
ORPG	Open Radar Product Generator
PAFB	Patrick Air Force Base, FL
QC	Quality Control
RAOB	Rawinsonde Observation
SE-1	Southeast-1 Flow Regime
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SPoRT	Short-term Prediction Research and Transition
TBW	Tampa, FL 3-letter identifier
Tcl/Tk	Tool Command Language/Tool Kit
USAF	United States Air Force
UTC	Universal Coordinated Time
VAHIRR	Volume Averaged Height Integrated Radar Reflectivity
WRF	Weather Research and Forecasting Model
WSR-74C	Weather Surveillance Radar Model 74C
WSR-88D	Weather Surveillance Radar 1988 Doppler
XMR	CCAFS 3-letter identifier

Appendix A

AMU Project Schedule
31 January 2008

AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Peak Wind Tool for User LCC Phase II	Collect and QC wind tower data for specified LCC towers, input to S-PLUS for analysis	Jul 07	Sep 07 (*Nov 07*)	Delayed due to need for manual QC
	Stratify mean and peak winds by hour and direction, calculate statistics	Sep 07	Oct 07 (*Nov 07*)	Delayed as above
	Stratify peak speed by month and mean speed, determine parametric distribution for peak	Oct 07	Nov 07	Completed
	Create distributions for peak winds 2, 4, 8, and 12 hours	Nov 07	Dec 07 (*Feb 08*)	Delayed due to computational intensive script
	Develop a GUI that shows climatologies, probabilities of exceeding peak	Dec 07	Feb 08	Delayed as above
	Final report	Feb 08	Apr 08	Delayed as above
Peak Wind Tool for General Forecasting	Data collection: wind towers, XMR 100-ft soundings, 915-MHz profilers	Sep 06	Oct 06 (*Feb 07*)	Completed Delayed to obtain 915-MHz profiler data
	Software development: wind tower data QC, sounding inversion detection, 915 MHz total power display	Sep 06	Dec 06 (*Mar 07*)	Completed Delayed to modify the AMU wind tower QC software
	Data analysis	Dec 06	Feb 07 (*Jun 07*)	Completed Delayed to add recent data sets
	Interim evaluation	Feb 07	Mar 07	Completed
	Forecast tool development, if approved	Mar 07	May 07 (*Jan 08*)	Completed Delayed due to work on VAHIRR
	Final report	Jun 07	Jul 07 (*Feb 08*)	Delayed as above

AMU Project Schedule 31 January 2008				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Situational Lightning Climatologies for Central Florida, Phase III	Customize AWIPS so that the composite soundings can be viewed in the D2D application	Jul 07	Sep 07 (*Oct 07*)	Completed Delayed due to work on VAHIRR task
	Develop application to create NetCDF files from NSHARP upper-air sounding files	Nov 07	Dec 07 (*Feb 08*)	Completed Delayed due to work on VAHIRR
	Add NetCDF files to AWIPS	Dec 07	Feb 08	Completed
	Final Report	Jan 08	Feb 08	Delayed as above
Volume-Averaged Height Integrated Radar Reflectivity (VAHIRR)	Acquisition and setup of development system and preparation for Technical Advisory Committee meeting	Mar 05	Apr 05	Completed
	Software Recommendation and Enhancement Committee meeting preparation	Apr 05	Jun 05	Completed
	VAHIRR algorithm development	May 05	Oct 05 (*Jul 06*)	Completed – Delayed due to new code development made necessary by final product requirements
	ORPG documentation updates	Jun 05	Oct 05 (*Sep 06*)	Completed Delayed as above
	Configure ORPG and AWIPS system in the AMU for live data testing.	Oct 05	Jan 06 (*Apr 07*)	Completed Delayed as above
	Conduct Acceptance Test Procedures	May 07	Aug 07 (*Jan 08*)	Completed – Failed, testing to find reason for failure
	Preparation of products for delivery and memorandum	Oct 05	Jan 06 (*Feb 08*)	Delayed as above

AMU Project Schedule 31 January 2008				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Impact of Local Sensors	Identify candidate warm and cool season days and archive data	Jul 07	Jan 08	Completed
	Configure LAPS to ingest all data and write scripts to ingest all Eastern Range wind tower and RAOB data	Aug 07	Sep 07	Completed
	Run LAPS-ARW "with and without" tests for all warm and cool season candidate days	Sep 07	Jan 08	Completed
	Validate and compare forecast results	Sep 07	May 08	On Schedule
	Final Report	May 08	Jun 08	On Schedule
Radar Scan Strategies for PAFB WSR-74C Replacement	Development and analysis of scan strategies based on vendor suggestions, radar characteristics and 45 WS requirements	Aug 07	Nov 08	Completed
	Develop plan for evaluating scan strategies	Dec 08	Jan 08	Completed
	Develop training on implementation of new scan strategy into the radar's configuration files	Feb 08	Mar 08	Removed with Customer Concurrence
	Final Report	Mar 08	May 08	On Schedule
WRF Wind Sensitivity Study at Edwards AFB (EDW)	Identify wind cycling cases at EDW and archive data	Jan 08	Jun 08	On Schedule
	Compare multiple model configurations and physical parameterization settings to predict wind speed and direction at EDW	Mar 08	Nov 08	On Schedule
	Final report and recommendations	Nov 08	Dec 08	On Schedule

NOTICE