ENSCO, Inc.

1980 N. Atlantic Ave., Suite 230
Coca Beach, FL 32931
(321) 783-9735, (321) 853-8202 (AMU)

Applied Meteorology Unit (AMU) Quarterly Report

Third Quarter FY-08 Contract NNK06MA70C 31 July 2008

Distribution:

NASA HQ/M/AA/W. Gerstenmaier
NASA KSC/AA/W. Parsons
NASA KSC/MK/L. Cain
NASA KSC/LX/J. Talone
NASA KSC/PH/ R. Willcoxon
NASA KSC/PH-A2/D. Lyons
NASA KSC/PH/M. Leinbach
NASA KSC/PH/S. Minute
NASA KSC/VA/S. Francois
NASA KSC/VA-2/C. Dovale
NASA KSC/KT/D. Bartine
NASA KSC/KT-C/R. Nelson
NASA KSC/KT-C-H/J. Madura
NASA KSC/KT-C-H/F. Merceret
NASA KSC/KT-C-H/J. Wilson
NASA JSC/MA/W. Hale
NASA JSC/WS8/F. Brody
NASA JSC/WS8/R. Lafosse
NASA JSC/WS8/B. Hoeth
NASA MSFC/EV44/D. Edwards
NASA MSFC/EV44/B. Roberts
NASA MSFC/EV44/R. Decker
NASA MSFC/EV44/H. Justh
NASA MSFC/MP71/G. Overbey
NASA MSFC/SPoRT/W. Lapenta
NASA DFRC/RA/E. Teets
NASA LaRC/M. Kavaya
45 WS/CC/A. Boerlage
45 WS/DO/J. Alexander
45 WS/DOU/M. McAleenan
45 WS/DOR/K. Nordgren
45 WS/DOR/M. Buchanan
45 WS/DOR/P. Phan
45 WS/DOR/F. Flinn
45 WS/DOR/ T. McNamara
45 WS/DOR/J. Tumbiolo
45 WS/DOR/K. Winters
45 WS/SYA/B. Boyd
45 WS/SYR/W. Roeder
45 RMS/CC/M. Wasson
45 SW/CD/G. Kraver
45 SW/SESL/D. Berlinrut
45 SW/XPR/R. Hillyer
45 OG/CC/B. Gruber
45 OG/TD/C. Olive
CSR 4500/J. Saul
CSR 7000/M. Maier
SMC/RNP/S. Exum
SMC/RNP/T. Knox
SMC/RNP/R. Bailey
SMC/RNP (PRC)/K. Spencer
HQ AFSPC/A3FW/J. Carson
HQ AFWA/A3/5/M. Surmeier
HQ AFWA/A8TP/G. Brooks
HQ AFWA/A5R/M. Gremillion
HQ USAF/A30-W/R. Stoffler
HQ USAF/A30-WX/M. Zettlemoyer
HQ USAF/A30-WX/L. Zuccarello
NOAA "W/NP"/L. Uccellini
NOAA/OAR/SSMC-I/J. Golden
NOAA/NWS/OST12/SSMC2/J. McQueen
NOAA Office of Military Affairs/M. Babcock
NWS Melbourne/B. Hagemeyer
NWS Melbourne/D. Sharp
NWS Melbourne/S. Spratt
NWS Melbourne/P. Blottman
NWS Melbourne/M. Volkmer

Continued on Page 2

Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the third quarter of Fiscal Year 2008 (April - June 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 Tested the maximum likelihood estimation (MLE) and Chi-squared (X^2) goodness-of-fit (GOF) methods to determine which produced the best-fit parameters for the Gumbel distribution. Modified the graphical user interface (GUI) to output the climatology values.

Discussion Testing revealed that the X^2 GOF method produced Gumbel parameters that fit the observed distributions better than those from MLE. The GUI was coded to display the climatologies and probabilities for all the towers instead of having separate GUIs for each launch program.

Task Anvil Forecast Tool in AWIPS Phase II

Goal Update the Anvil Forecast Tool in the Advanced Weather Interactive Processing System (AWIPS) to make it faster and more user-configurable. The tool is used by SMG during shuttle launch and landing operations to determine the threat from natural or triggered lightning due to flight through anvil cloud. SMG requested that the tool be modified to allow user-defined atmospheric pressure levels and model gridded data files.

Milestones Added "User Profiles" to the tool so that parameters do not have to be hard-coded into the software source code. Updated the tool to use the National Weather Service's AGRID software to read model gridded data files. Delivered the software, User's Guide, and installation instructions to SMG for their evaluation.

Discussion User Profiles allow the user to change the values of several parameters in the tool, such as data filenames, pressure levels, and the names of locations of interest. The AGRID software gives the tool more flexibility in accessing model gridded data. In addition, model gridded data can now be read significantly faster than before.

Continued on Page 2

Distribution (continued from Page 1)

NWS Southern Region HQ/"W/SR"/
S. Cooper
NWS Southern Region HQ/"W/SR3"
D. Billingsley
NWS/"W/OST1"/B. Saffle
NWS/"W/OST12"/D. Melendez
NSSL/D. Forsyth
30 WS/DO/J. Kurtz
30 WS/DOR/D. Vorhees
30 WS/SY/M. Schmeiser
30 WS/SYR/G. Davis
30 WS/SYS/J. Mason
30 SW/XPE/R. Ruecker
Det 3 AFWA/WXL/K. Lehneis
NASIC/FCTT/G. Marx
46 WS//DO/J. Mackey
46 WS/WST/E. Harris
412 OSS/OSW/P. Harvey
412 OSS/OSWM/C. Donohue
UAH/NSSTC/W. Vaughan
FAA/K. Shelton-Mur
FSU Department of Meteorology/H.
Fuelberg
ERAU/Applied Aviation Sciences/
C. Herbster
ERAU/CAAR/I. Wilson
NCAR/J. Wilson
NCAR/Y. H. Kuo
NOAA/FRB/GSD/J. McGinley
Office of the Federal Coordinator for Meteorological Services and Supporting Research/R. Dumont
Boeing Houston/S. Gonzalez
Aerospace Corp/T. Adang
ACTA, Inc./B. Parks
ITT/G. Kennedy
Timothy Wilfong & Associates./T. Wilfong
ENSCO, Inc/J. Clift
ENSCO, Inc./E. Lambert
ENSCO, Inc./A. Yersavich
ENSCO, Inc./S. Masters

Executive Summary, *continued*

Task: Completion of the Edward Air Force Base (EAFB) Statistical Guidance Wind Tool

Goal: Develop a GUI, similar to that used by SMG for Kennedy Space Center (KSC) landing forecasts, using the Edwards Air Force Base (EAFB) wind tower data already quality-controlled and analyzed at Marshall Space Flight Center (MSFC). SMG forecasters indicate that peak winds are a challenging parameter to forecast at EAFB. The development of a GUI that displays peak wind climatology and likelihood will help forecasters evaluate Flight Rules when the shuttle lands at EAFB.

Milestones: Obtained and formatted EAFB wind tower data from MSFC. Created Microsoft Excel PivotTables from the peak wind data. Finished a prototype version of the GUI and delivered it to SMG for an initial review.

Discussion: The initial version of the GUI is similar to the tool used for the KSC landing forecasts. It allows users to display both climatologies and probabilities of exceeding peak-wind thresholds for all months at the runway towers on EAFB. The prototype GUI was submitted to the forecasters at SMG for review. Any SMG feedback will be incorporated into the GUI to ensure it will be useful for operations.

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 lightning 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 internal AMU review of the final report. Submitted the report for review to Dr. Jim Dye of the Airborne Field Mill II program team, SMG, and 45 WS.

Discussion: Dr. Dye found an error in the AMU's VAHIRR data set that affected the analysis. The final report was updated based on Dr. Dye's comments.

Continued on Page 3

Executive Summary, *continued*

<u>Task</u>	<u>Impact of Local Sensors</u>
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/Cape Canaveral Air Force Station (CCAFS). Loss of these data may affect output from local weather prediction models. Forecasters at the 45 WS, The National Weather Service in Melbourne, Florida (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	Completed the objective analysis of all warm and cool season candidate days and completed the final report.
Discussion	The objective analysis found minimal difference between the model runs with and without wind tower and CCAFS rawinsonde data. The average difference in the four Weather Research and Forecasting (WRF) model scenarios for the entire 12-hr forecast period was 1.91 kt for the warm season and 1.38 kt for the cool season. The root mean square error was computed and indicated WRF performance was worse in the warm season. The model also under-forecast peak wind events in both seasons.

<u>Task</u>	<u>Radar Scan Strategies for the PAFB WSR-74C Replacement</u>
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	Completed and distributed the final report.
Discussion	The final report was reviewed by the AMU and the AMU customers. When the review was completed, the report was distributed.

Continued on Page 4

Executive Summary, *continued*

TABLE of CONTENTS

Task — VAHIRR Cost Benefit Analysis

Goal Conduct a cost-benefit analysis to assess the value of using VAHIRR in support of launch operations at the Eastern Range and Western Range. VAHIRR was developed from the Airborne Field Mill program to correlate operational weather observations with in-cloud electric fields capable of rocket triggered lightning in anvil clouds. It has been used as an input to assess LLCC since 2005. If the analysis reveals positive results, funding for development of an automated algorithm may be sought.

Milestones Obtained weather summaries from previous launches for several candidate cases from the 30th Weather Squadron (30 WS) and 45 WS. Ordered radar and satellite data. Purchased GR2Analyst radar display software and RAOB sounding analysis software.

Discussion Began reviewing the launch weather summaries for the candidate cases while organizing and formatting the radar, satellite and sounding data for use in the new software. The GR2Analyst software can display multiple radar beam elevation angles as well as a 3-D view of all elevation angles. It will be very useful in identifying anvil clouds and creating cross-sections.

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 EAFB 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 EAFB in cases where the shuttle cannot land at KSC due to adverse weather conditions.

Milestones Continued to identify and collect data for candidate wind cycling days from April 2008 to present. Finished configuring the latest version of the Local Analysis and Prediction System (LAPS) for the EAFB area and began configuring the latest version of the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS).

Discussion Two more wind cycling case days were identified. The latest version of LAPS was configured to ingest all available high-resolution datasets in the EAFB area including the local wind tower data. The latest version of ADAS is being currently being configured to ingest the same high-resolution datasets used in the LAPS analyses. Six WRF model configurations with varying dynamical cores, initializations, and physics will be run for each candidate day.

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)

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

Ms. Crawford tested two methods to determine the parameter values for the Gumbel distribution of peak winds for each mean speed. As discussed in the previous AMU Quarterly Report (FY 08 Q2), the Gumbel cumulative distribution function (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. Ms. Crawford first estimated the location and scale parameters using the Method of Moments:

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

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 first estimate values are usually not optimal. Therefore, Ms. Crawford tested two methods that iterate to find parameters values that are closer to optimal. The first method was the

X^2 (chi-squared) goodness-of-fit (GOF) test that determines the optimal values 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. If the Gumbel distribution is fitted perfectly to the observed, $X^2 = 0$. In Initial tests, Ms. Crawford observed X^2 values indicating that the Gumbel distribution produced a good fit to the observations. The second method was the maximum likelihood estimation (MLE). Dr Rick Katz of the National Center for Atmospheric Research (NCAR) suggested that this was a better way to estimate the parameters and sent S-PLUS functions to Ms. Crawford that contain MLE calculations for the Gumbel distribution. The parameter values calculated with MLE produced Gumbel distributions that fit the data well, but not as well as the X^2 GOF. Therefore, Ms. Crawford used the X^2 GOF method to calculate the Gumbel parameters for all peak speed distributions.

Graphical User Interface

Ms. Lambert continued modifying the Excel GUI created for SMG to display climatology values for the LCC towers. Instead of creating a GUI for each launch program, she will include the statistics for all LCC towers in one GUI. Figure 1 shows the Tower drop-down list that allows the user to choose the tower of interest. The choice of heights in the height drop-down list depends on the chosen tower. Figure 2 shows the choice of heights for the southeast side of Tower 110 (1102), used for Atlas operations. Clicking the "Get Climatology…" button outputs the Requested Climatology shown in Figure 3. Ms. Crawford completed code modifications for the climatology tab and began modifications to include the peak speed probabilities in the GUI. She is making the modifications using Excel 2007 since the 45 WS is transitioning to this version in July.

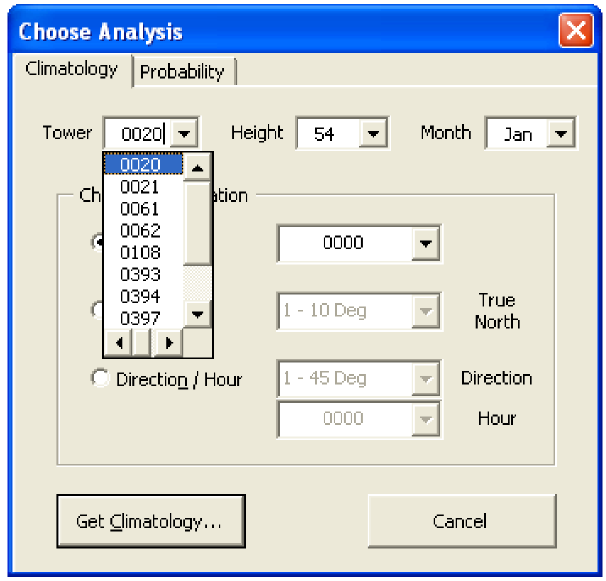


Figure 1. The Climatology tab of the GUI with the tower drop-down list displayed.

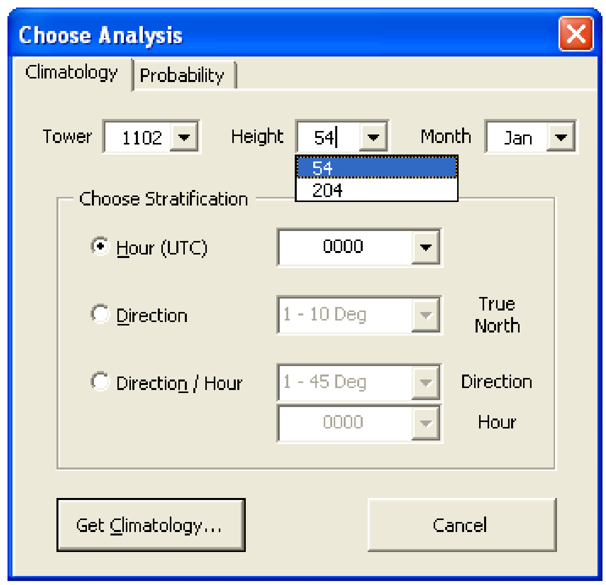


Figure 2. The Climatology tab of the GUI with the height drop-down list for Tower 1102 displayed.

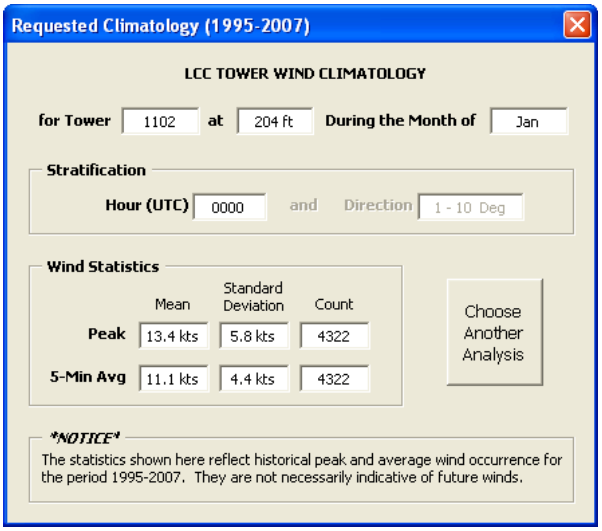


Figure 3. The mean and peak wind speed climatology at 204 ft on Tower 1102 at 0000 UTC in January.

Status

Ms. Crawford completed 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. She began modifying the scripts to calculate the 4-hour probabilities

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

Anvil Forecast Tool in AWIPS Phase II (Mr. Barrett)

The forecasters at SMG and 45 WS have identified anvil forecasting as one of their most challenging tasks when predicting the probability of LCC or FR violations due to the threat of natural or triggered lightning. In response, the AMU developed an anvil threat corridor graphic that can be overlaid on satellite imagery using the Meteorological Interactive Data Display System (MIDDS). This tool helps forecasters estimate the location of thunderstorms that might produce an anvil threat one, two, and three hours into the future. It has been used extensively in launch and landing operations. The SMG is depending more on the Advanced Weather Interactive Processing System (AWIPS) during operations. In Phase I of this task (Barrett et al. 2007), the AMU transitioned the anvil tool from MIDDS to AWIPS. For Phase II, SMG requested the AMU modify the tool to read model gridded data from user-defined files instead of hard-coded files, and to allow the user to modify the atmospheric pressure levels used in the tool.

User Profiles

Mr. Barrett added “User Profiles” so that users can define the model data files, atmospheric pressure levels, and other parameters used in the tool. Previously, these parameters were hard-coded into the software source code. He created a default User Profile and included it in the installation files. User Profiles are text files with a filename extension of .profile. User Profiles can be added through the tool’s GUI or by creating a new file with a text editor. The tool must be restarted to change the current User Profile. User Profiles can only be modified with a text editor. The default User Profile is displayed in Figure 4.

Model Data

SMG requested the tool be modified to use a National Weather Service (NWS) local AWIPS application called AGRID to read model gridded data. The AGRID software makes it easier to adjust which pressure levels and latitude/longitude points are read from the gridded model data. Mr. Barrett installed AGRID on the AMU AWIPS system, and then modified the tool’s source code to use AGRID for reading model gridded data. The AGRID software has significantly increased the speed at which gridded data can be read with the tool. For example, it took the previous version around 10 seconds to read and calculate the layer-average wind from the North American Mesoscale (NAM) model, while it only takes 1 second for the current version.

Running the Anvil Forecast Tool

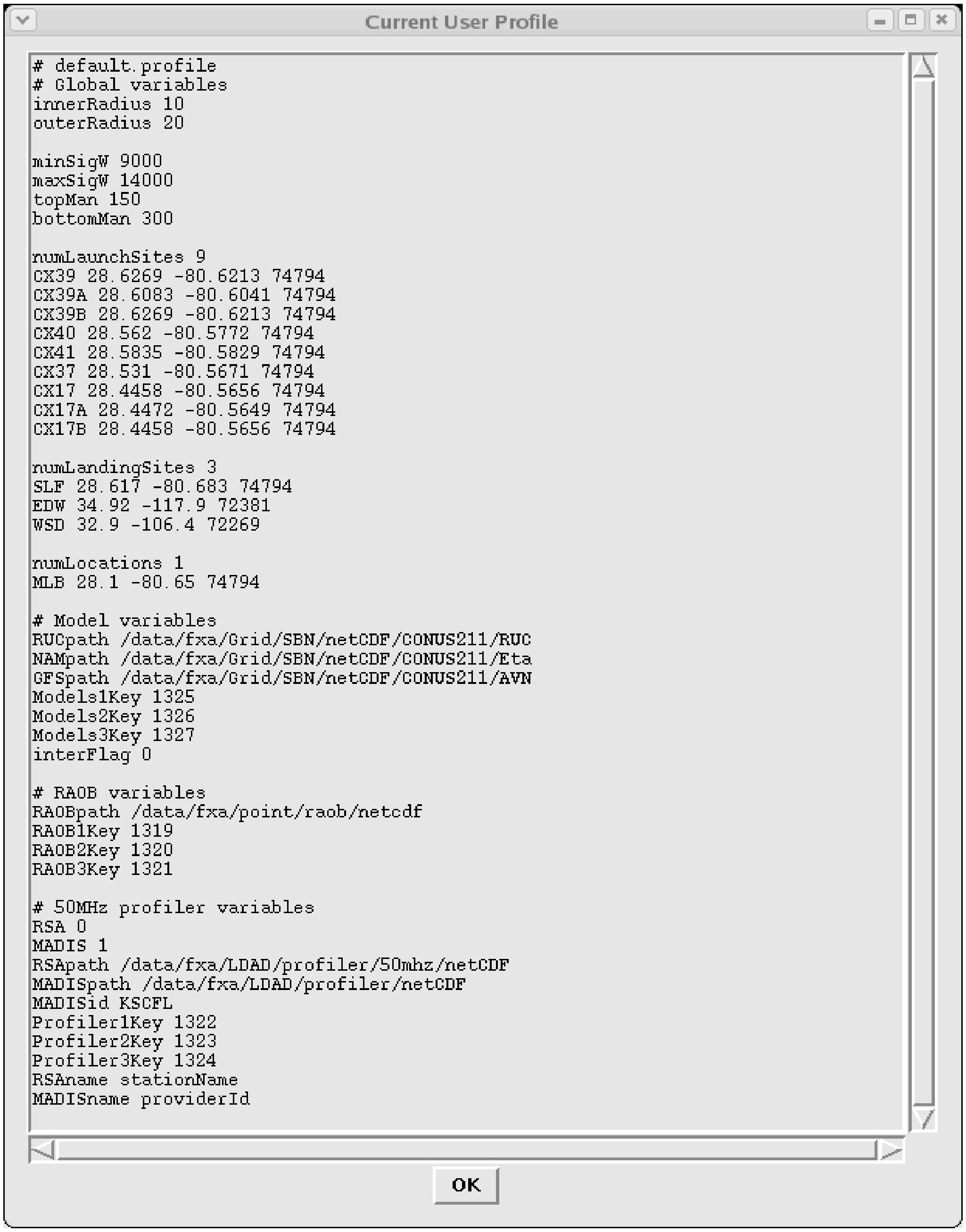
To start the tool, the user first selects the Tools dropdown menu from the AWIPS Main Menu and selects “Anvil Tool Phase II...”. A dialog box opens and prompts the user to select a User Profile. After selecting a profile, the GUI starts up. Figure 5 shows the GUI after the Center of Plot and Station listboxes have been populated. Initially, these listboxes are empty. The User Profiles menu is used to display the current User Profile or add a new User Profile. The Circle and Frame Label Options menus control the display of labels on the anvil threat corridor graphic. The user can change the type of data with the Data Type radiobuttons. The Refresh Map radiobutton controls whether the graphic is automatically displayed on the screen after it is calculated. The Profiler Type radiobuttons determine what profiler data formats are available.

In order to create a graphic, the user first makes a selection from the Date-Time listbox (Figure 5), and then selects the central location of the graphic from the Center of Plot listbox. If the data type is “RAOB” (rawinsonde observation) or “50MHz” (profiler observation), the user selects the observation site from the Station listbox (not shown). If the data type is “Models”, the user selects a forecast hour (Figure 6). After the observation site or forecast hour has been selected, the layer-average wind is calculated. To create the graphic for display in AWIPS, the user selects the button labeled “Make”. Figure 7 shows an example graphic in AWIPS.

Installation at SMG

Mr. Barrett delivered the software, User’s Guide, and installation instructions to SMG. They will evaluate the software and User’s Guide, and provide feedback to the AMU.

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




```
# default.profile
# Global variables
innerRadius 10
outerRadius 20

minSigW 9000
maxSigW 14000
topMan 150
bottomMan 300

numLaunchSites 9
CX39 28.6269 -80.6213 74794
CX39A 28.6083 -80.6041 74794
CX39B 28.6269 -80.6213 74794
CX40 28.562 -80.5772 74794
CX41 28.5835 -80.5829 74794
CX37 28.531 -80.5671 74794
CX17 28.4458 -80.5656 74794
CX17A 28.4472 -80.5649 74794
CX17B 28.4458 -80.5656 74794

numLandingSites 3
SLF 28.617 -80.683 74794
EDW 34.92 -117.9 72381
WSD 32.9 -106.4 72269

numLocations 1
MLB 28.1 -80.65 74794

# Model variables
RUCpath /data/fxa/Grid/SBN/netCDF/CONUS211/RUC
NAMpath /data/fxa/Grid/SBN/netCDF/CONUS211/Eta
GFSpath /data/fxa/Grid/SBN/netCDF/CONUS211/AVN
Models1Key 1325
Models2Key 1326
Models3Key 1327
interFlag 0

# RAOB variables
RAOBpath /data/fxa/point/raob/netcdf
RAOB1Key 1319
RAOB2Key 1320
RAOB3Key 1321

# 50MHz profiler variables
RSA 0
MADIS 1
RSApath /data/fxa/LDAD/profiler/50mhz/netCDF
MADISpath /data/fxa/LDAD/profiler/netCDF
MADISid KSCFL
Profiler1Key 1322
Profiler2Key 1323
Profiler3Key 1324
RSAname stationName
MADISname providerId
```

Figure 4. The default User Profile used in the anvil forecast tool.

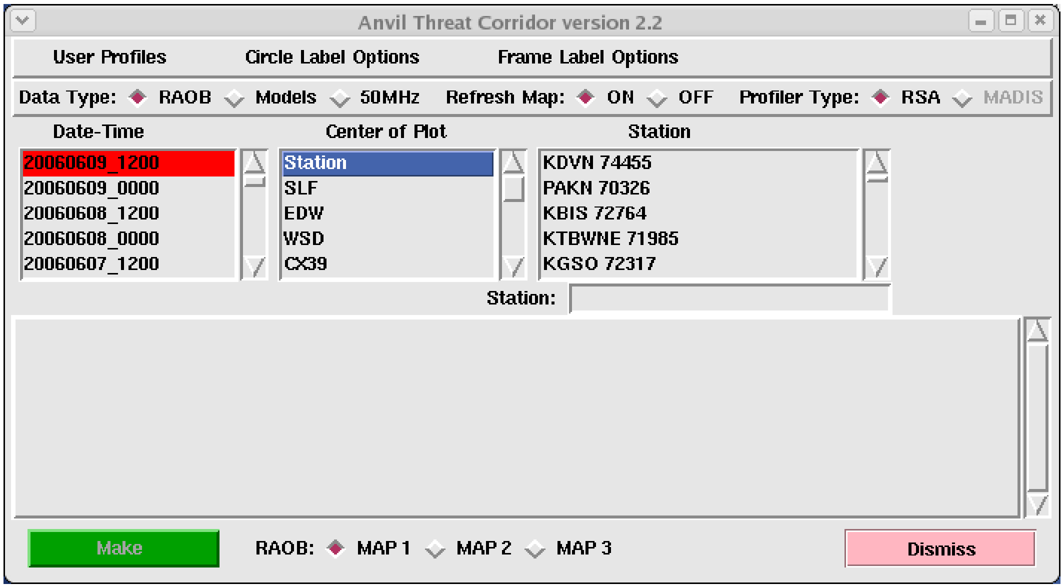


Figure 5. A date/time of 1200 UTC on 9 June 2006 was selected from the Date-Time listbox in the GUI.

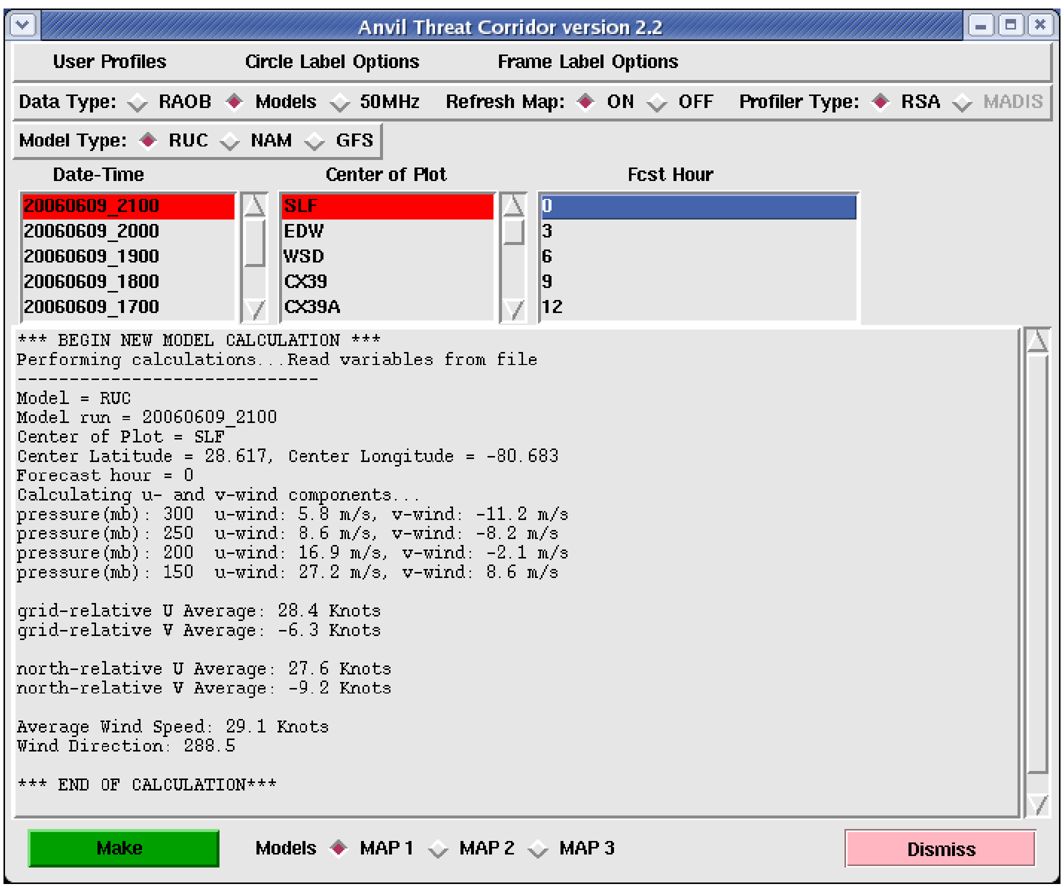


Figure 6. Data from the Rapid Update Cycle model 2100 UTC run on 9 June 2006 was selected. The model initialization time will be used, since the selected forecast hour is “0”. The graphic will be centered over “SLF”, so the grid point closest to Shuttle Landing Facility (SLF) will be used to calculate the layer-average wind. The layer-average wind speed and wind direction are displayed at the bottom of the text box.

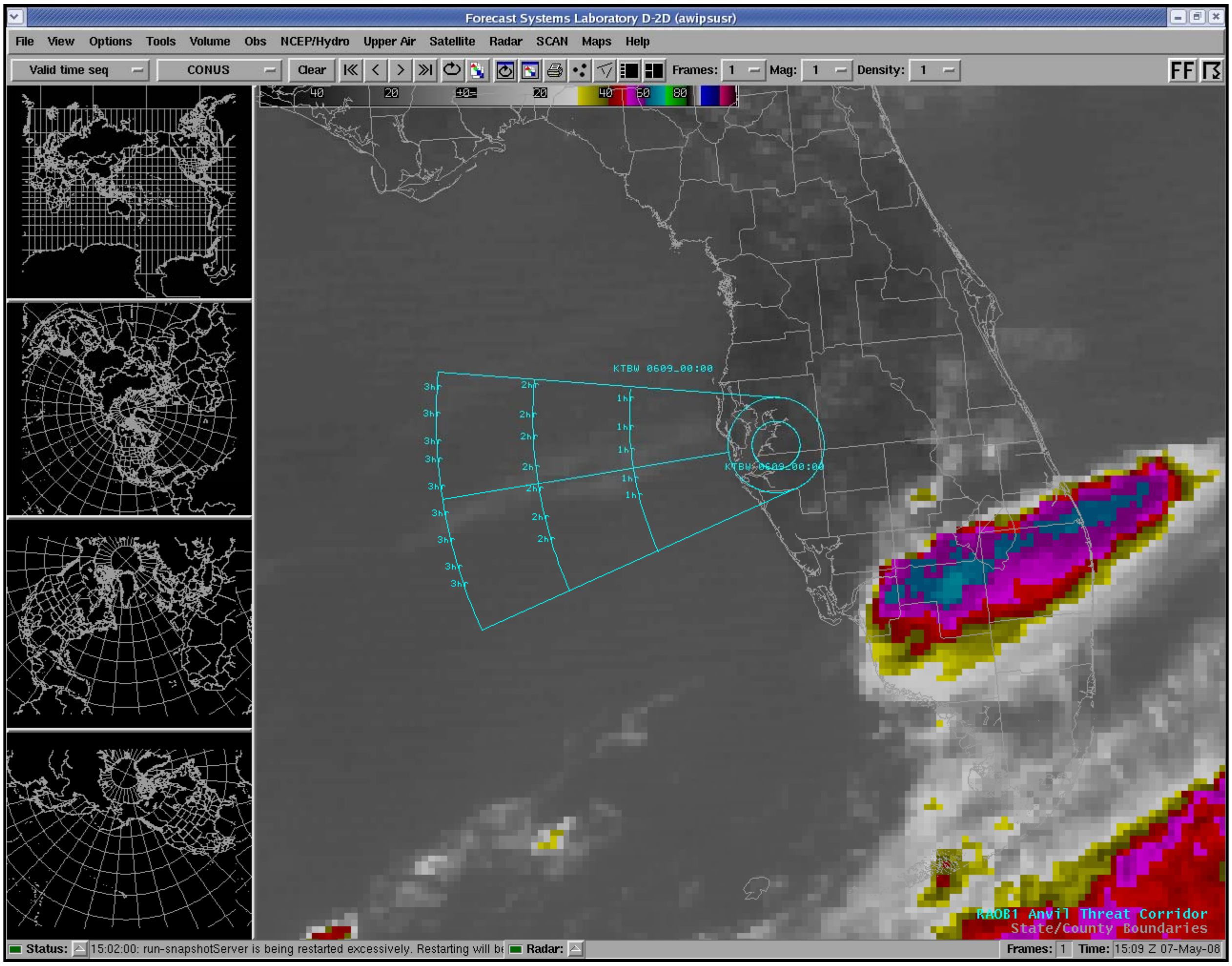


Figure 7. An anvil threat corridor graphic is displayed in AWIPS over Tampa, Florida (KTBW). The data source was the KTBW rawinsonde observation at 0000 UTC on 9 June 2006.

Completion of the Edward Air Force Base (EAFB) Statistical Guidance Wind Tool (Mr. Dreher)

The peak winds near the surface are an important forecast element for Space Shuttle landings. As defined in the Shuttle FR, there are peak wind thresholds that cannot be exceeded in order to ensure the safety of the shuttle during landing operations. Occasionally, the shuttle must land at EAFB in southern California when weather conditions at Kennedy Space Center (KSC) violate the FR. Peak winds are a challenging parameter to forecast for SMG, especially due to the complex topography in and around EAFB. To alleviate the difficulty in making such wind forecasts, the AMU developed a PC-based GUI for displaying peak wind climatology and probabilities of exceeding peak-wind thresholds for the Shuttle Landing Facility (SLF) at KSC (Lambert 2003). In 2004 Marshall Space Flight Center (MSFC) began work to replicate the AMU tool using the wind towers at EAFB. They completed the analysis and quality control of the data, but due to higher priority work did not start development of the GUI. The goal of this task is to create a GUI using the EAFB wind tower data that have already been quality-controlled and analyzed by MSFC personnel.

MSFC Data

Mr. Dreher reformatted the EAFB peak wind statistics obtained from MSFC, and wrote a FORTRAN program in order to speed up the reformatting process and ensure there were no issues with the data. He compiled the 5- and 10-minute peak wind data for all months in the period 1997-2004 from Towers 44, 220, 224 (adjacent to the shuttle landing runway) and 350 within EAFB (Figure 8). For all towers, the wind observations were recorded at 30 feet. Since SMG only uses the 10-minute peak from the EAFB wind towers in evaluating FR, the 5-minute data were not included in the PC-based GUI.

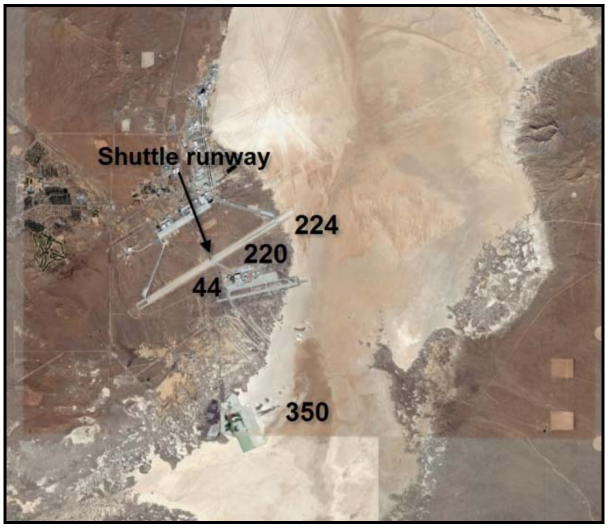


Figure 8. Wind tower network at EAFB. The background image is from Google Earth.

For each of the towers and months, MSFC calculated wind climatologies and probabilities of average peak wind occurrence based on the average speed. The climatologies were calculated for each tower and month, and consisted of peak and average wind speed means and standard deviations stratified by hour, direction, and direction/hour. The number of observations for each of the climatologies was also included in the MSFC calculations.

For the probabilities of peak wind occurrence, MSFC calculated empirical and modeled probabilities of meeting or exceeding specific 10-minute peak wind speeds using probability density functions (PDFs). The empirical distributions were created from the observed peak wind values and used to determine the climatological probability of meeting or exceeding a given 10-minute peak wind speed based on the average wind speed. Empirical PDFs were created from the individual peak wind speeds based on the actual number observed for each average 2-minute wind speed.

Based on previous work done in Lambert (2003), MSFC fit a parametric distribution to the observed peak wind speed data. This was done in order to smooth and interpolate over variations in the observed values due to possible under-sampling of certain peak winds and to estimate probabilities associated with average winds outside the observed range (Wilks 2006). The PDFs calculated by MSFC were asymmetrical (i.e. not Gaussian) and bounded on the left by the average wind speed. They determined that a generalized extreme value (GEV) distribution fit the empirical distributions best. It provided a much better fit for the EAFB wind tower data than either the Weibull or Gumbell distributions, which are the two most often mentioned distributions in the literature for modeling peak wind speeds. The PDF for the GEV distribution is given by:

$$F(x)=\frac{1}{\sigma}\left[1+\xi\left(\frac{X-\mu}{\sigma}\right)\right]^{1-\frac{1}{\xi}} EXP\left\{-\left[1+\xi\left(\frac{X-\mu}{\sigma}\right)^{-\frac{1}{\xi}}\right]\right\}$$

where X is the variable of interest (in this case peak wind speed), μ is the location parameter that determines where the origin will be located, ξ is the shape parameter that governs the tail behavior of the distribution, and σ is the scale parameter that determines the width or spread of the distribution.

Graphical User Interface

Mr. Dreher imported the statistics obtained from MSFC into Microsoft Excel format and then created PivotTables, an Excel feature that allows the user to display different values with point-click-drag techniques. While reformatting the data into the desired format, he noted several missing parametric wind values for given towers and months, especially for Tower 350. Dr. Lee Burns of MSFC said the values were missing because they did not fit the GEV distribution well and were subsequently discarded. Mr. Dreher notified SMG about the missing values and they recommended not including data from Tower 350 in the GUI since many of the missing modeled peak wind speeds were at that tower. In addition, due to Tower 350's location well south of the main runway, SMG forecasters rarely use the data for evaluating FR. Mr. Dreher inserted the number "-99" into the PivotTables to indicate missing data at the other towers.

Mr. Dreher created a PC-based GUI by modifying the Microsoft Visual Basic for Applications (VBA) code developed in Lambert (2003). The EAFB GUI allows the user to display both climatological data and probabilities of exceeding peak wind values given a specified average wind speed at each tower.

The GUI is run through a macro within Microsoft Excel. Once the macro is executed, the input GUI is displayed on the screen where the user can select the Climatology (left side of Figure 9) or Probability tab (right side of Figure 9). On both tabs, the user can select the tower and month for the requested climatology or probability. Towers 44, 220, and 224 for all 12 months are available via drop-down lists on both tabs. On the Climatology tab, the user selects to output an hourly, direction, or direction/hourly stratification for the chosen tower and month. After the choices are made, the user can click the "Get Climatology…" button and a separate output page will display the requested information. The VBA code populates the output GUI through the information contained in the PivotTables. The Probability tab is similar except that the user can choose to output empirical or modeled distributions for a given tower and month (right side of Figure 9). For both of these distributions, the user can select the 2-minute average wind speed for a given tower. The empirical drop-down list contains all 2-minute wind speeds observed for that selected month and tower, whereas the modeled drop-down list includes the 2-minute wind speeds fit to the GEV distribution model described above. Once the user has selected a tower, month, and distribution, clicking the "Get Probabilities…" button will display a separate window with the requested peak wind speeds and their probabilities of occurrence.

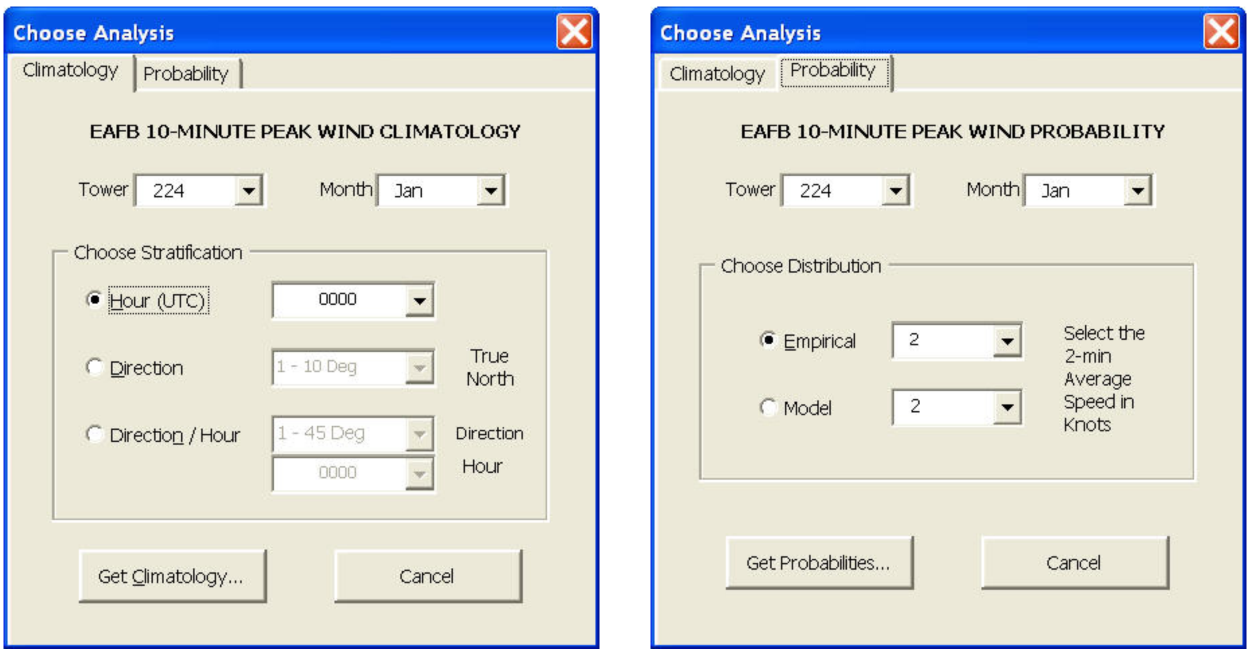


Figure 9. EAFB peak wind input GUI. The left panel is used to retrieve climatology data, and the right panel is used to retrieve probability data for a given month and tower. The "Climatology" and "Probability" tabs located at the top of the GUI allows the user to toggle between panels.

Requested Climatology

After the user clicks the "Get Climatology" button, an output window is displayed with wind climatologies. Figure 10 illustrates the hourly peak wind climatology for 0400 UTC in the period of record 1997-2004 at Tower 224 for the month of March. Similar output windows are created for the direction and direction/hour climatologies. A summary of the selected tower number and height, month, and stratification method is displayed at the top of the window. The statistics section of the window displays the mean, standard deviation, and number of observations for the peak and average wind speeds for the desired tower and month. The "Choose Another Analysis" button in Figure 10 allows the user to return to the main input GUI.

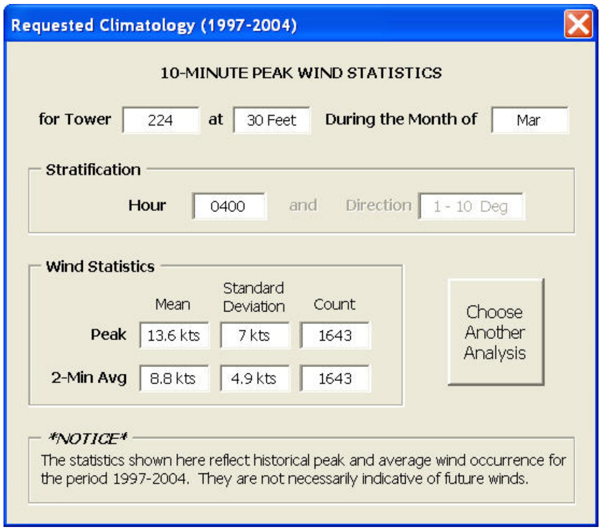


Figure 10. Requested climatology output GUI. The requested tower number, height, and month are displayed at the top, and selected stratification parameters are displayed in the middle. The observed average and peak wind climatology including mean, standard deviation, and count are displayed in the "Wind Statistics" section.

Requested Probabilities

The output window in Figure 11 is displayed when the user clicks the "Get Probabilities" button. The distribution type, tower number and height, month, and selected 2-minute average wind speed are displayed at the top of the window. The "Peaks and Probabilities" section contains three rows. The first row contains the peak wind speeds associated with the chosen empirical or modeled average 2-minute wind speed shown at the top of Figure 11. The second row contains the empirical or modeled probabilities in percent of meeting or exceeding each peak wind speed; and the last row contains the probability of occurrence in percent for that peak wind speed. The letters "N/A" are displayed in the probability boxes where empirical data are missing or in the case of modeled data where they did not fit the GEV distribution. The "Retrieve Another Probability Range" button in Figure 11 allows the user to go back to the main input GUI in order to choose another analysis or close the GUI.

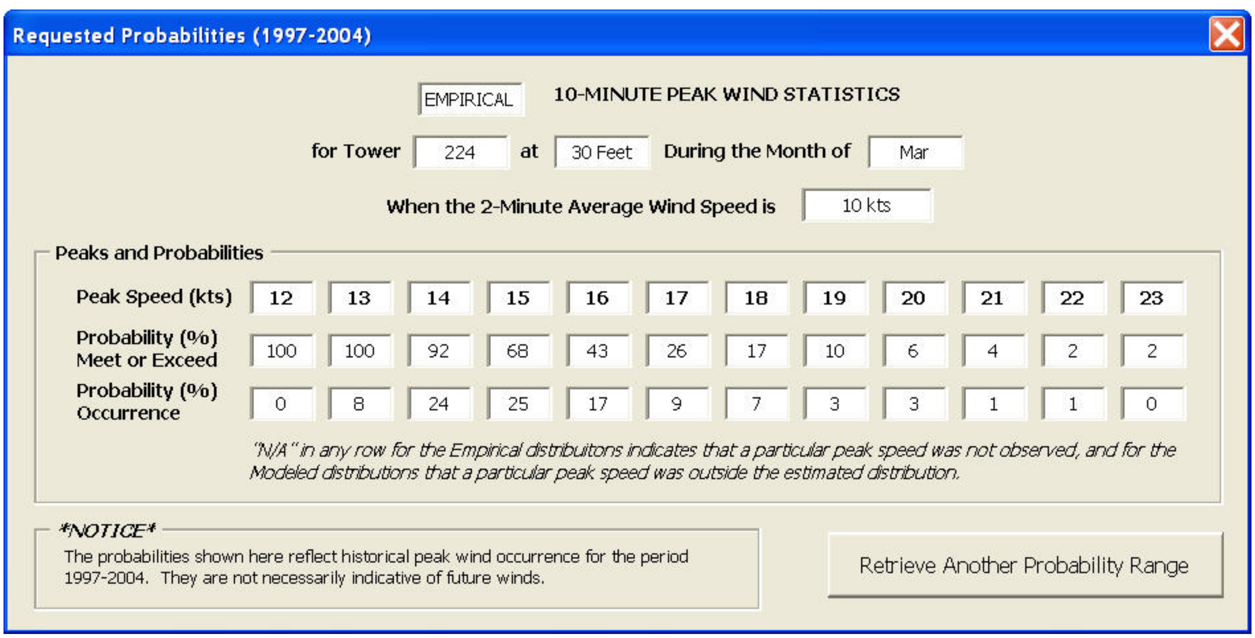


Figure 11. Requested probabilities output GUI. The requested distribution, tower number and height, month, and 2-minute average wind speed are displayed at the top. The probabilities for each peak wind speed are displayed in the "Peaks and Probabilities" section.

Status

Mr. Dreher submitted the initial version of this GUI to the forecasters at SMG. He will include any feedback they may have into future versions of the GUI. This will ensure that the end product meets their needs. He will continue to test and examine the GUI by comparing the output to the completed Microsoft Excel PivotTables to make sure the data are correct. In addition, he will begin analysis of the data needed for the final report.

For more information contact Mr. Dreher at dreher.joe@ensco.com or 321-853-8105.

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.

The internal AMU review of the final report was completed. Dr. Jim Dye, a member of the ABFM Science Team and Lightning Advisory Panel, reviewed the report and found an error in the AMU's data set. The final report stated the ABFM calculated several VAHIRR values incorrectly. The VAHIRR should be equal to the product of average cloud thickness and average radar reflectivity, although this was not the case for all ABFM VAHIRR values. Dr. Dye found that erroneous data were the cause of most of the incorrect calculations. The erroneous data were caused by errors in copying the data to Microsoft Excel spreadsheets. After the data points were corrected, only one ABFM VAHIRR value was incorrect. Dr. Dye also revealed that there is an apparent error in the ABFM software code when the cloud top is slightly above 5 km. Figure 12 compares the AMU and ABFM VAHIRR values before the data points were corrected. Figure 13 compares the same values after the data points were corrected. Mr. Barrett updated the final report after receiving Dr. Dye's comments and submitted the report to SMG and the 45 WS for their review.

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.

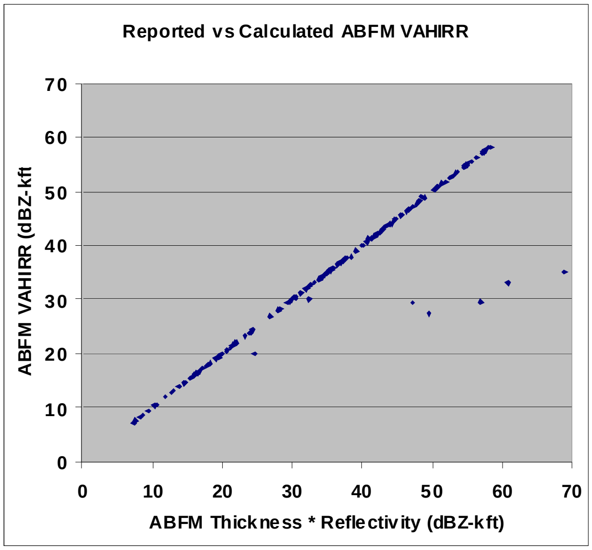


Figure 12. ABFM VAHIRR versus the product of cloud thickness and reflectivity, before the data set was corrected. Note the several large outliers.

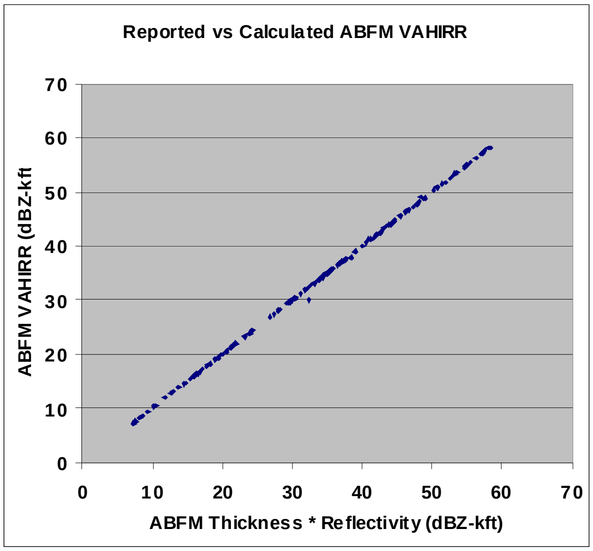


Figure 13. ABFM VAHIRR versus the product of cloud thickness and reflectivity, after the data set was corrected. There is now only one outlier.

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

Forecasters at the 45 WS use observations from the KSC/Cape Canaveral Air Force Station (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 SLF. Due to impending budget cuts, some or all of the mainland wind towers (Figure 14) 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 and CCAFS RAOB data. 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.

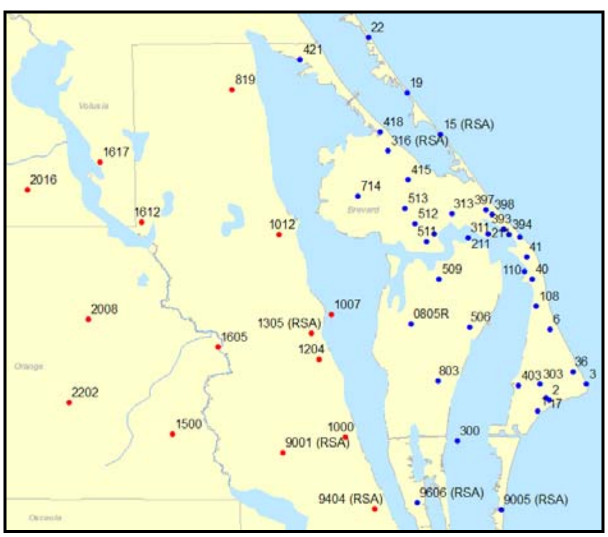


Figure 14. Map of the KSC/CCAFS area showing mainland tower locations (red dots) and island/cape tower locations (blue dots).

Objective Peak Wind Analysis

Dr. Bauman completed the objective analysis for all 20 days by comparing the WRF forecast maximum peak wind speed to the observed maximum peak wind speed, and then evaluating how well the four model scenarios performed against each other. The first question to answer was whether one of the four scenarios forecast the maximum peak wind better than the other three. To do this, Dr. Bauman computed the average difference between the maximum and minimum WRF peak wind speeds for each forecast hour in each case. The results are shown in Table 1. During the warm season, the four scenarios were within 2 kt of each other through the 7-hr forecast and then diverged to over 3 kt at the 11-hr forecast. The cool season results indicate the four scenarios tracked better after the 4-hr forecast than before, remaining within 1.4 kt of each other. The data from Table 1 are shown in the chart in Figure 15. The average difference among the four WRF scenarios for the entire 12-hr forecast period was 1.91 kt for the warm season and 1.38 kt for the cool season. This indicates the data-denial scenarios performed comparably to the data-rich scenarios.

Table 1. Differences in the WRF maximum peak wind speed forecasts among the four “with and without” data scenarios for the warm and cool season cases and each forecast hour.

Warm Season		**Cool Season**	
WRF Forecast Hour	**Avg Difference Among the Four Scenarios (kt)**	**WRF Forecast Hour**	**Avg Difference Among the Four Scenarios (kt)**
0	1.05	0	1.08
1	1.44	1	1.89
2	1.83	2	2.09
3	1.59	3	2.63
4	1.19	4	1.25
5	1.30	5	1.38
6	1.10	6	1.22
7	1.94	7	1.04
8	2.72	8	1.15
9	2.46	9	1.14
10	2.43	10	0.87
11	3.27	11	1.11
12	2.51	12	1.08

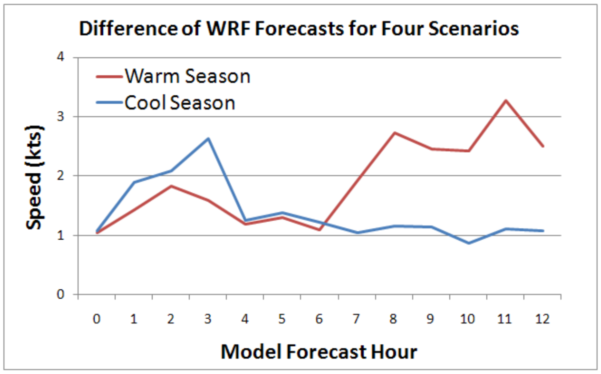


Figure 15. Chart showing the differences in WRF forecasts of maximum peak wind speed among the four scenarios for each model forecast hour in the warm season (red line) and cool season (blue line).

Dr. Bauman also computed the root mean square error (RMSE) between the WRF forecast and observed maximum peak wind speeds using the equations

$$MSE = \frac{1}{n}\sum_{i=1}^{n}\left(f_i - o_i\right)^2 \text{ and}$$

$$RMSE = \sqrt{MSE},$$

where:

n = 12 for the warm season and 8 for the cool season,

f = average of four WRF forecast scenario maximum peak wind speeds for each WRF forecast interval, and

o = average of the observed maximum peak wind speeds for each WRF forecast interval.

The results are shown in Table 2 and the corresponding chart is in Figure 16. During the warm season, the WRF RMSE decreased from 4.7 kt at the 0-hr forecast to 2.3 kt at the 3-hr forecast, a reduction of just over 2 kt. It then generally increased throughout the remaining 12-hr forecast period to a maximum RMSE of 13.87 kt at the 11-hr forecast. During the cool season, the WRF RMSE was consistent throughout most of the forecast intervals at about 5-7 kt, with a maximum RMSE of 7.77 kt at the 2-hr forecast. These data indicate WRF performance is worse in the warm season.

The RMSE provides an overall indication of model performance for the cases investigated in this work. However, on certain days the RMSE was as large as 30 kt during the warm season and 16 kt during the cool season. Sometimes the error was due to WRF incorrectly forecasting the magnitude of the peak wind speed for the day while at other times WRF forecast the magnitude correctly but error was due to timing. The bias of the model compared to the observations for the warm season was -3.27 kt and for the cool season -3.40 kt. This indicates a tendency for WRF to under-forecast peak wind events in both seasons.

Table 2. The RMSE of the WRF maximum peak wind speed forecasts among the four “with and without” data scenarios compared to the observations for the warm and cool season cases and each forecast hour.

Warm Season		Cool Season	
WRF Forecast Hour	**RMSE (kt)**	**WRF Forecast Hour**	**RMSE (kt)**
0	4.71	0	5.93
1	3.45	1	6.33
2	3.34	2	7.77
3	2.33	3	5.68
4	6.27	4	7.04
5	7.17	5	5.69
6	4.82	6	5.05
7	7.35	7	4.36
8	7.75	8	5.21
9	9.56	9	4.75
10	9.23	10	6.13
11	13.87	11	5.82
12	10.89	12	4.97

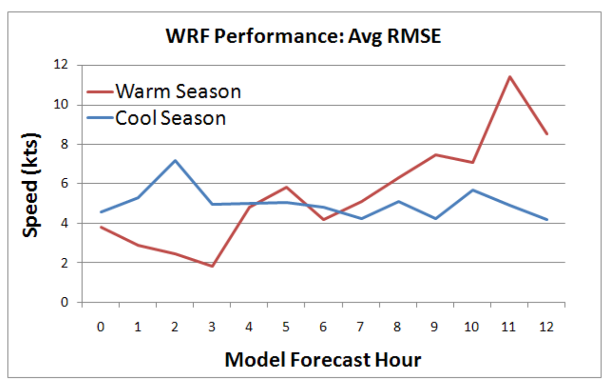


Figure 16. Chart showing the RMSE among the four WRF forecasts of maximum peak wind speed and the observations for each model forecast hour in the warm season (red line) and cool season (blue line).

Conclusions

In both the subjective and objective analyses, Drs. Watson and Bauman found little difference among the four WRF model scenarios. The WRF model did perform better in the cool season during prevailing synoptic forcing regimes and was also a good indicator of the threat of advisory or warning criteria wind speeds over each 12-hr forecast model run. This would provide added value to the forecaster's daily planning forecast.

Drs. Bauman and Watson wrote a final report describing the work and results. After it was reviewed and approved, Dr. Watson distributed the final report to AMU customers.

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.

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 three minutes 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 in Melbourne, Florida (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 submitted a draft of the final report for internal AMU and external customer reviews. He made modifications to the report based on those reviews, distributed the report to AMU customers, and then submitted a DAA for NASA approval to make the report available to the public on the AMU website.

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

VAHIRR Cost-Benefit Analysis (Dr. Bauman)

The LLCC are designed to prevent space launch vehicles from flight through environments conducive to natural or triggered lightning. To assure avoidance of a triggered lightning event, the LLCC are extremely conservative. Some of these rules have had such high safety margins that they prohibited flight under conditions that are now thought to be safe 90% of the time. The LLCC for anvil clouds was upgraded in the summer of 2005 to incorporate results from the ABFM experiment at the Eastern Range. Numerous combinations of parameters were considered to develop the best correlation of operational weather observations to in-cloud electric fields capable of rocket triggered lightning in anvil clouds. VAHIRR was the best metric found. The KSC Weather Office is considering seeking funding for development of an automated VAHIRR algorithm for the new 45 WS RadTec 43/250 weather radar and Weather Surveillance Radar–1988 Doppler (WSR-88D) radars. Before developing an automated algorithm, the AMU was tasked to determine the frequency with which VAHIRR would have allowed a launch to safely proceed during weather conditions otherwise deemed "red" by the Launch Weather Officer. To do this, Dr. Bauman will manually calculate VAHIRR values based on candidate cases from past launches with known LLCC violations. An automated algorithm may be developed if the analyses from past launches show VAHIRR would have provided a significant cost benefit by allowing a launch to proceed.

Dr. Bauman requested candidate cases from previous launches and received three from the 30 WS and four from the 45 WS. The 45 WS will provide several additional cases. He reviewed the launch summaries provided by both weather squadrons and ordered radar and satellite data for the seven cases. Dr. Bauman received archived Level II and Level III WSR-88D data from the Melbourne, Florida radar for the Eastern Range and from the Vandenberg AFB (VAFB), California radar for the Western Range. Due to limited archived data from the VAFB radar, Dr. Bauman also ordered data from the Los Angeles, California radar. The archived data were ordered and obtained from the National Climatic Data Center via ftp download. Dr. Bauman also ordered satellite data from the National Oceanic and Atmospheric Administration's Comprehensive Large Array-data Stewardship System and obtained it via ftp download. He began formatting sounding data obtained from the Range Technical Services Contractor into RAOB software format.

Dr. Bauman tested the GR2Analyst software with real time Level II radar data. The benefit from this software is that it can display multiple radar beam elevation angles, such as the 0.5° angle as shown in Figure 17 as well as a 3-D view of all elevation angles as shown in Figure 18. Figure 17 shows precipitation falling over the mainland but not at KSC or CCAFS. The 3-D view in Figure 18 is at the same time as Figure 17. It shows the precipitation over the mainland and also shows anvil cloud over KSC and CCAFS. This capability will make it easier to identify the location of anvil clouds in the archived radar data as well as create 2-D cross sections of the data to calculate VAHIRR.

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

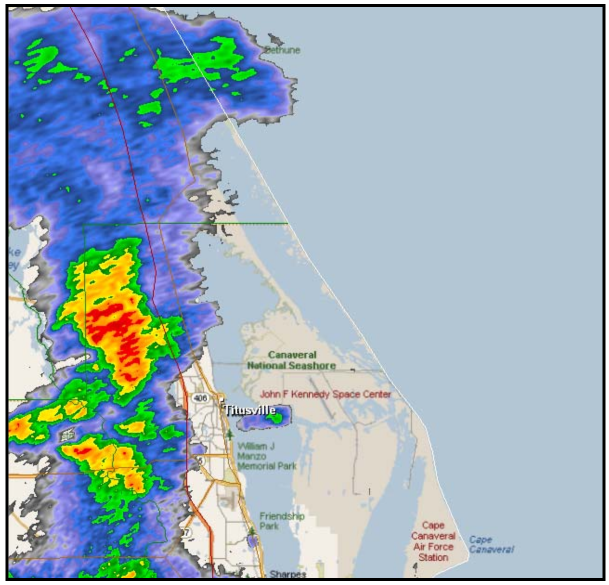


Figure 17. GR2Analyst software display of 0.5° elevation angle reflectivity from the Melbourne, Florida radar at 1845 UTC 8 July 2008.

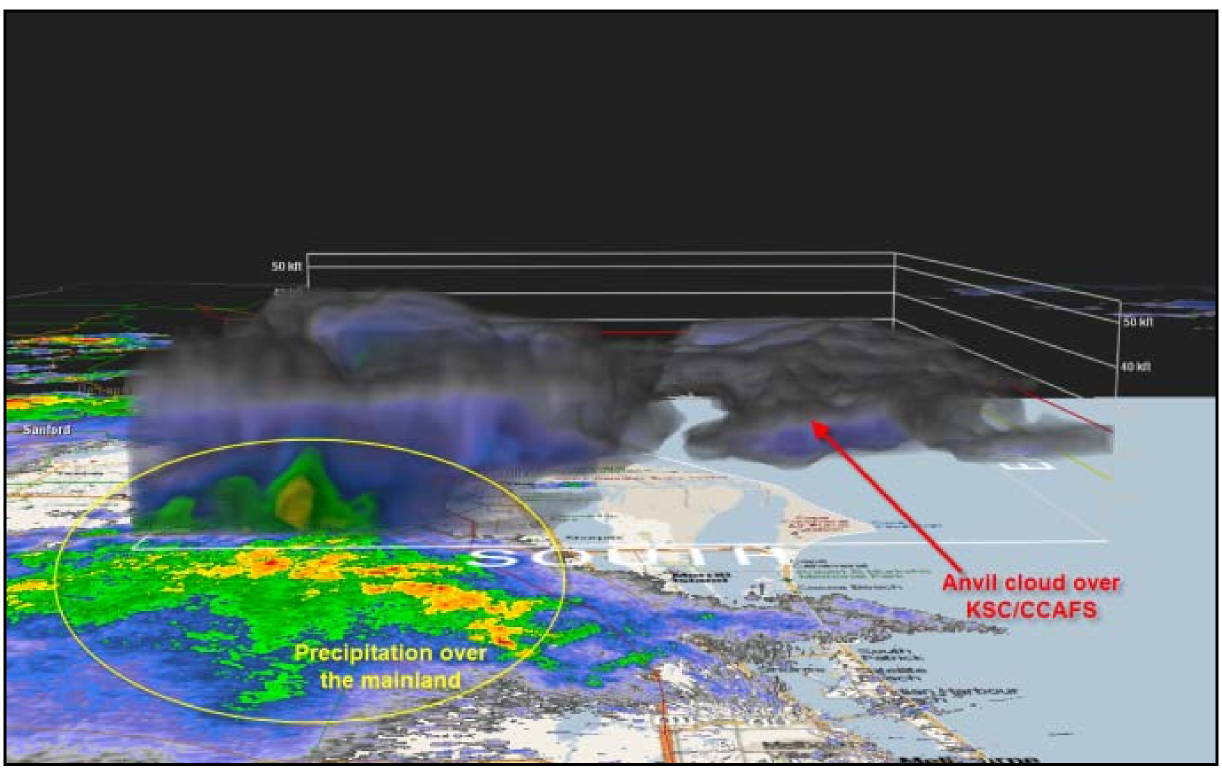


Figure 18. GR2Analyst software display of 3-D reflectivity from the Melbourne, Florida radar at 1845 UTC 8 July 2008.

MESOSCALE MODELING

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

Occasionally, the shuttle must land at EAFB in Southern California when weather conditions at KSC violate the FR. However, the complex terrain in and around EAFB 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 EAFB 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 EAFB. Specifically, the AMU was tasked to 1) compare the model performance among different combinations of the dynamical cores and initializations, 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 tower network near the EAFB runway complex. Figure 19 shows the approximate locations of the towers along the EAFB 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 that reported from towers near the lakebed runway (Towers 154, 230, 234). These events usually occur from 90 minutes up to a 4 hour or longer period and most often occur when the prevailing wind is from the northwest or west-northwest. Four wind cycling case days have already been identified. Mr. Brian Hoeth of SMG provided Dr. Watson with two more wind cycling case days in the April to June 2008 time frame: 4 June and 7 June 2008.

LAPS- & ADAS-WRF Model Configuration

Dr. Watson downloaded and configured the latest version of LAPS to ingest all available high-resolution datasets in the EAFB area and wrote a script to ingest the local EAFB wind tower data. After running LAPS for one of the candidate days, she noticed that LAPS was not initializing precipitation. She contacted Mr. Chris Anderson of the Global Research Division (GSD) to ask what the cause could be and for possible solutions. He stated that at a 1-km grid spacing, initializing WRF with hydrometeors could create a large outflow that would degrade the forecasts. Consequently, GSD zeroed out the precipitation particles in the initialization, but left the cloud particles. He recommended keeping the precipitation initialization turned off if it was not an essential component of the research. Dr. Watson decided to not initialize precipitation since this study is not focused on convective forecasting.

Dr. Watson began configuring the latest version of ADAS to ingest all available high-resolution datasets in the EAFB area, including visible and infrared satellite imagery, WSR-88D data, and data from the Meteorological Assimilation Data Ingest System (MADIS). Wind tower data from EAFB will also be included in the ADAS analysis.

Dr. Watson based the choice of background data for both LAPS and ADAS on what is currently supported in the latest versions of both analysis packages. The latest version of LAPS allows the use of the Rapid Update Cycle (RUC) 20-km model as background data. Dr. Watson decided to use this instead of the WRF cold-start since the RUC data incorporates many observations in a 1-hour assimilation cycle and could provide a more robust background for LAPS. However, the latest version of ADAS does not support RUC 20-km data, but does support NAM 12-km data, which cannot be used in LAPS. NAM 12-km data will be used as background data in the ADAS portion of the task.

Dr. Watson will run six different model configurations for each candidate day:

- LAPS-ARW with the Yonsei University planetary boundary layer (PBL) scheme and MM5 similarity surface layer scheme,
- LAPS-ARW with the Mellor-Yamada-Janjic PBL scheme and ETA similarity surface layer scheme,
- LAPS-NMM with the National Center for Environmental Prediction (NCEP) Global Forecast Systems (GFS) PBL scheme and NCEP GFS surface layer scheme,
- LAPS-NMM with the Mellor-Yamada-Janjic PBL scheme and ETA similarity surface layer scheme,
- ADAS-ARW with the Yonsei University PBL scheme and MM5 similarity surface layer scheme, and
- ADAS-ARW with the Mellor-Yamada-Janjic PBL scheme and ETA similarity surface layer scheme.

All other physics parameters were the same for each model run.

Problems Encountered

After a scheduled power shutdown on 7 June at the Melbourne, FL ENSCO facility that houses the AMU cluster, the cluster failed to come back up and had to be rebuilt. Dr. Watson and ENSCO's Information Systems and Technology (IST) division worked to restore the AMU cluster and fixed the major bugs in the system by the end of June. There are still some minor bugs that are being addressed.

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.

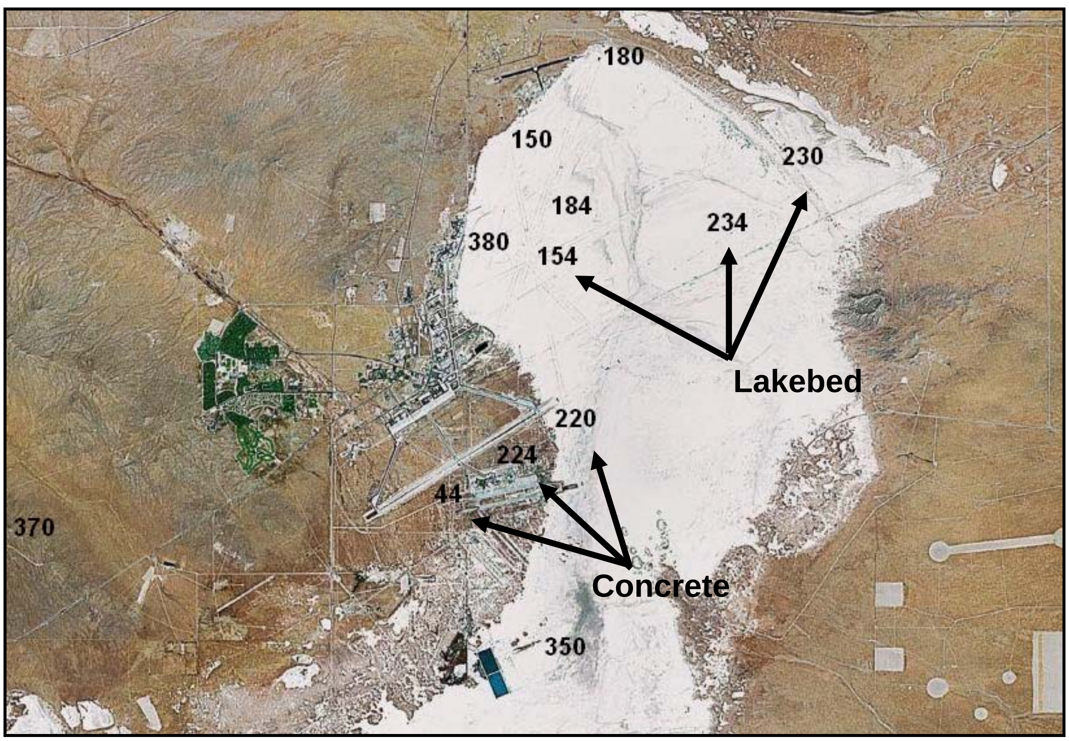


Figure 19. Wind tower locations on EAFB. The towers along the concrete and lakebed runways are indicated by arrows. The wind tower locations are approximate. Background image from Google maps.

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 presented a paper on the work to date at the 28th AMS Conference on Hurricanes and Tropical Meteorology in Orlando on 30 April. He is now working on the more difficult task of characterizing the upper tail of the distributions by treating the quantity (GF-1) as a lognormal distribution.

AMU OPERATIONS

IT Communications

The NASA network was activated in the AMU on 19 May by JBOSC network technicians. Mr. Barrett and Mr. Manning of NASA/KSC/KT monitored and tested the connection. The AMU remained connected to the ENSCO network until all issues with the NASA network were resolved. On 18 June, Mr. Barrett and Dr. Bauman switched the AMU from the ENSCO corporate network to the NASA network. Mr. Rhoades, of ENSCO IST, and Mr. Manning assisted with the switchover. Mr. Barrett continued working on various issues related to the switchover, such as Windows group policy, computer security, and backups.

Launch Support

Dr. Watson supported the Atlas V launch on 14 April; Dr. Watson, Mr. Dreher, and Dr. Merceret supported the launch of STS-124 on 31 May; and Dr. Bauman and Mr. Dreher supported the NASA Delta II GLAST launch on 11 June.

Conferences and Meetings

Ms. Crawford attended the 20th International Lightning Data Conference and the Second International Lightning Meteorology Conference in Tucson AZ, both sponsored by Vaisala. She presented the results from the Objective Lightning Probability Forecast Tool, Phase II task.

General

Mr. Joe Dreher joined the AMU Team in the Meteorologist position on 28 April.

REFERENCES

Barrett, J. H., W. H. Bauman, and J. Keen: Anvil Tool in the Advanced Weather Interactive Processing System: Phase I Final Report. NASA Contractor Report CR-2007-214729, Kennedy Space Center, FL, 26 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931, and on the AMU website at http://science.ksc.nasa.gov/amu/final.html]

Dye, J. E., M. G. Bateman, D. M. Mach, C. A. Grainger, H. J. Christian, H. C. Koons, E. P. Krider, F. J. Merceret, and J. C. Willett, 2006: The scientific basis for a radar-based lightning launch commit criterion for anvil clouds. Preprint 8.4, 12th Conf. on Aviation, Range, and Aerospace Meteorology, Atlanta, GA, Amer. Meteor. Soc., 4 pp. [Available online at: http://ams.confex.com/ams/pdfpapers/100563.pdf]

Dye, J. E., M. G. Bateman, H. J. Christian, E. Defer, C. A. Grainger, W. D. Hall, E. P. Krider, S. A. Lewis, D. M. Mach, F. J. Merceret, J. C. Willett, and P. T. Willis, 2007: Electric fields, cloud microphysics and reflectivity in anvils of Florida thunderstorms, *J. Geophys. Res.*, **112**, D11215, doi10.1029/2006JD007550.

Lambert, W., 2002: Statistical Short-Range Guidance for Peak Wind Speed Forecasts on Kennedy Space Center/Cape Canaveral Air Force Station: Phase I Results. NASA Contractor Report CR-2002-211180, Kennedy Space Center, FL, 39 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931 and http://science.ksc.nasa.gov/amu/final.html.]

Lambert, W., 2003: Extended Statistical Short-Range Guidance for Peak Wind Speed Analyses at the Shuttle Landing Facility: Phase II Results. NASA Contractor Report CR-2003-211188, Kennedy Space Center, FL, 27 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931 and http://science.ksc.nasa.gov/amu/final.html.]

Wilks, D. S., 2006: *Statistical Methods in the Atmospheric Sciences*. 2d ed. Academic Press, Inc., San Diego, CA, 467 pp.

Willett, J. C., H. C. Koons, E. P. Krider, R. L. Walterscheid, and W. D. Rust, 1999: Natural and Triggered Lightning Launch Commit Criteria (LLCC), Aerospace Report A923563, Aerospace Corp., El Segundo, CA, 23 pp.

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
CSR	Computer Sciences Raytheon
EAFB	Edwards Air Force Base, CA
FR	Flight Rules
FSU	Florida State University
FY	Fiscal Year
GEV	Generalized Extreme Value
GF	Gust Factor
GOF	Goodness of Fit
GSD	Global Systems Division
GUI	Graphical User Interface
JSC	Johnson Space Center
KSC	Kennedy Space Center
KTBW	Tampa, FL identifier
LAPS	Local Analysis and Prediction System
LCC	Launch Commit Criteria
LLCC	Lightning LCC
MADIS	Meteorological Assimilation Data Ingest System
MIDDS	Meteorological Interactive Data Display System
MLB	Melbourne, FL 3-letter identifier
MLE	Maximum Likelihood Estimation
MSE	Mean Square Error
MSFC	Marshall Space Flight Center
NCAR	National Center for Atmospheric Research
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
PC	Personal Computer
PDF	Probability Density Function
QC	Quality Control
RAOB	Rawinsonde Observation
RMSE	Root MSE
RUC	Rapid Update Cycle
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SPoRT	Short-term Prediction Research and Transition
USAF	United States Air Force
UTC	Universal Coordinated Time
VAFB	Vandenberg Air Force Base, CA
VAHIRR	Volume Averaged Height Integrated Radar Reflectivity
VBA	Visual Basic for Applications
WRF	Weather Research and Forecasting Model
WSR-74C	Weather Surveillance Radar Model 74C
WSR-88D	Weather Surveillance Radar 1988 Doppler

Appendix A

AMU Project Schedule
31 July 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 (*Sep 08*)	Delayed due to computational intensive script
	Develop a GUI that shows climatologies, probabilities of exceeding peak	Dec 07	Feb 08 (*Jul 08*)	Delayed as above
	Final report	Feb 08	Apr 08 (*Nov 08*)	Delayed as above
Peak Wind Tool for General Forecasting	Data collection: wind towers, CCAFS 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 (*Apr 08*)	Completed Delayed as above

AMU Project Schedule 31 July 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 (*Apr 08*)	Completed Delayed as above
Anvil Forecast Tool in AWIPS, Phase II	Install the AGRID Perl module to read gridded model data	Apr 08	May 08	Completed
	Add user profiles to make software more configurable	Apr 08	May 08	Completed
	Update software to use AGRID	May 08	Jun 08	Completed
	Test tool performance	May 08	Jun 08	Delayed waiting for customer feedback
	Update User’s Guide and installation instructions	May 08	Jun 08	Delayed as above
	Final Report	Jul 08	Aug 08	On Schedule
EAFB Statistical Guidance Wind Tool	Acquire, examine, and format data obtained from MSFC into Excel	May 08	May 08	Completed
	Create Excel PivotTables and modify PC-based GUI code	May 08	Sep 08	On Schedule
	Test PC-based GUI	Sep 08	Sep 08	On Schedule
	Final Report	Oct 08	Nov 08	On Schedule

AMU Project Schedule 31 July 2008				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
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 (*Jul 08*)	Delayed as above
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	Completed
	Final Report	May 08	Jun 08	Completed

AMU Project Schedule 31 July 2008				
AMU Projects	**Milestones**	**Scheduled Begin Date**	**Scheduled End Date (*New End Date*)**	**Notes/Status**
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 (*Jun 08*)	Completed
VAHIRR Cost-Benefit Analysis	Identify Potential Cases and Acquire Data	Jun 08	Jul 08	On Schedule
	Calculate VAHIRR for Cases	Jul 08	Aug 08	On Schedule
	Compile and Analyze Results	Aug 08	Sep 08	On Schedule
	Final Report	Sep 08	Oct 08	On Schedule
WRF Wind Sensitivity Study at Edwards AFB (EAFB)	Identify wind cycling cases at EAFB and archive data	Jan 08	Jun 08	Completed
	Compare multiple model configurations and physical parameterization settings to predict wind speed and direction at EAFB	Mar 08	Nov 08	On Schedule
	Final report and recommendations	Nov 08	Dec 08	On Schedule

NOTICE