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Applied Meteorology Unit (AMU) Quarterly Report

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Continued on Page 2

Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the second quarter of Fiscal Year 2010 (January - March 2010). 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 Completed running the scripts for the 12-hour probabilities, incorporated them into the graphical user interface (GUI), and delivered the GUI to the 45 WS. Completed a first draft of the final report

Discussion The final report was submitted for internal AMU review. It will be sent to the customers for their review after the internal review is complete.

Task: Objective Lightning Probability Tool, Phase III

Goal Update the lightning probability forecast equations used in 45 WS operations with new data and new stratification based on the progression of the lightning season. Update the Microsoft Excel and Meteorological Interactive Data Display System (MIDDS) GUIs with the new equations. The new data and stratifications are likely to improve the performance of the equations used to make the daily lightning probability forecasts for operations on Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS).

Milestones Found and fixed an error in the 2004 flow regime data, and calculated stability parameters from the 1000 UTC CCAFS morning soundings.

Discussion The flow regime data for 2004 were associated with the wrong dates. The sounding data were re-processed and checked thoroughly to ensure the flow regime days were correct. The stability parameters will be used to develop an objective method for determining the start and end date of the lightning sub-seasons for each year.

Distribution (continued from Page 1)

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Executive Summary, *continued*

Task <u>Peak Wind Tool for General Forecasting, Phase II</u>

Goal Update the tool used by the 45 WS to forecast the peak wind speed for the day on KSC/CCAFS during the cool season months October-April. The tool forecasts the timing of the peak wind speed for the day, the associated average speed, and provides the probability of issuing wind warnings in the KSC/CCAFS area using observational data available for the 45 WS morning weather briefing. The period of record will be expanded to increase the size of the data set used to create the forecast equations, new predictors will be evaluated, and the performance of the Phase I and Phase II tools will be compared to determine if the updates improved the forecast.

Milestones Created linear regression equations for the Day-1 to Day-3 forecasts using 12-km North American Mesoscale model (MesoNAM) cool-season forecasts from March 2007 to April 2009. Completed development of the Phase II Microsoft Excel Tool.

Discussion Separate equations were developed for the 0000 and 1200 UTC model runs, and for days with and without precipitation over KSC/CCAFS. The 45 WS evaluated the Microsoft Excel Tool and gave several suggestions for improvement. The tool was then updated and delivered to the 45 WS for operational use.

Task <u>Upgrade Summer Severe Weather Tool in MIDDS</u>

Goal Upgrade the Severe Weather Tool by adding weather observations from the years 2004-2009, re-analyzing the data to determine the important parameters, and update the tool with the new information. The likelihood of severe weather occurrence for the day is included in the morning weather briefing. 45 WS forecasters use the Severe Weather Tool, developed by the AMU, to assist in making this forecast. Updating the database and MIDDS GUI will likely improve the performance of the tool and will increase forecaster confidence in the output.

Milestones Completed updating the severe weather database with data from 2004-2009. Computed the stability threshold values for the full database 1989-2009. Verified the daily severe weather Total Threat Score (TTS) with the observed severe weather events. Completed updating and adding functionality to the Severe Weather Worksheet GUI. Verified tool performance.

Discussion Severe weather-related data from the Storm Prediction Center and the CCAFS morning sounding were added to the existing database, increasing it from 15 to 21 years (1989-2009). After completing analysis of the data and computing the parameter verification scores, the Severe Weather Worksheet GUI was updated with additional functionality. The verification scores show the tool performed well during the 2009 warm season.

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Executive Summary, *continued*

Task	ADAS Update and Maintainability
Goal	Acquire the latest version of the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) for the local data integration system (LDIS) at the National Weather Service in Melbourne, FL (NWS MLB) and SMG, and update the AMU-developed shell scripts that were written to govern the LDIS so that it can be easily maintained. In addition, the AMU will update the previously developed ADAS GUI.
Milestones	Learned the Tool Command Language / Tool Kit (Tcl/Tk) programming language. Installed the existing GUI on the local cluster. Began updating the existing GUI to take into account new data assimilated into ADAS. Created a new map background for the GUI.
Discussion	The Tcl/Tk programming language will be used to update the existing ADAS GUI software code. An existing shell script was updated using the Perl programming language. This script extracts information about the number of observations analyzed by ADAS and passes it to the GUI.

Task	Verify MesoNAM Performance
Goal	Verify the performance of the MesoNAM forecasts for CCAFS and KSC. Verification will be accomplished by an objective statistical analysis consisting of comparing the MesoNAM forecast winds, temperature and moisture, as well as the changes in these parameters over time, to the observed values at customer selected KSC/CCAFS mesonet wind towers. The objective analysis will give the forecasters knowledge of the model's strength and weaknesses, resulting in improved forecasts for operations.
Milestones	Completed calculating model verification statistics for all towers. Completed and delivered the MesoNAM Verification Tool to the 45 WS.
Discussion	The bias, standard deviation of bias and root mean square error statistics were completed for all towers. The hypothesis zero test, which shows the forecasters where the model bias is statistically 0, was run and completed for all towers. A sample GUI was developed for the MesoNAM Verification Tool and approved by the 45 WS. Subsequently an updated GUI with an improved user interface for the tool was developed and delivered to the 45 WS for operational use.

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.winnie@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 at the end of each task summary.

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 a new 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 developed in Phase II (Lambert 2003) to display the wind speed climatologies and probabilities of meeting or exceeding certain peak speeds based on the average speed.

Prognostic Probability and GUI Status

Ms. Crawford completed running scripts to create the 12-hour probabilities. She incorporated the values into the GUI and delivered it to the 45 WS for testing. Ms. Crawford completed a first draft of the final report and submitted it for internal AMU review.

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

Objective Lightning Probability Tool, Phase III (Ms. Crawford)

The 45 WS includes the probability of lightning occurrence in their daily morning briefings. This information is used by forecasters when evaluating LCC and FR, and planning for daily ground operations on Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS). In Phase I, the AMU developed a set of equations that calculate the probability of lightning occurrence for the day (Lambert and Wheeler 2005) and a GUI to display the output. These equations outperformed several forecast methods used in operations. The GUI allowed forecasters to interface with the equations by entering predictor values to output a probability of lightning occurrence. In Phase II (Lambert 2007), two warm seasons were added to the period of record (POR), the equations redeveloped with the new data, and the GUI transitioned to the Meteorological Interactive Data Display System (MIDDS). The MIDDS GUI retrieves the required predictor values automatically, reducing the possibility of human error. In this phase, three warm seasons (May–September) will be added to the POR, increasing it to 20 years (1989–2008), and data for October will be included. The goal of this phase is to create equations based on the progression of the lightning season instead of creating an equation for each month. These equations will capture the physical attributes that contribute to thunderstorm formation more so than a date on a calendar.

Data Quality Check

Ms. Crawford found an error in the processed 2004 flow regime data that she traced back to the raw Tampa and Jacksonville, Fla data downloaded from the Global Systems Division (GSD) site. At some point between downloading and processing the data, the order of the month column in the yearly file became alphabetical but the data remained chronological by day in the season, i.e. data from May were associated with the month of August. She downloaded the data again, checked it at every step in the process to make sure the data and dates stayed together, then re-calculated the 2004 flow regime days. She provided the new flow regime data to Mr. Wheeler for his work on the Severe Weather Tool task.

Determining Stratifications

After determining that sounding data will be needed to develop an objective method for choosing the start/end dates of the lightning sub-seasons, Ms. Crawford calculated the 12 stability parameters below from the 1000 UTC CCAFS soundings. She also provided these data to Mr. Wheeler for the Severe Weather Tool task.

- K Index
- Thompson Index
- Cross Totals
- Total Totals
- Showalter Index
- SWEAT Index
- Lifted Index
- Precipitable water
- Vertical Totals
- T at 500 mb
- 825-525 mb Mean RH
- 800-600 mb Mean RH

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

Peak Wind Tool for General Forecasting, Phase II (Mr. Barrett)

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 25, 35, and 50 kt thresholds at any level from the surface to 300 ft. In Phase I of this task (Barrett and Short 2008), the AMU developed a tool to help forecast the highest peak non-convective wind speed, the timing of the peak speed, and the average wind speed at the time of the peak wind from the surface to 300 ft on KSC/CCAFS for the cool season (October – April). For Phase II, the 45 WS requested that additional observations be used in the creation of the forecast equations by expanding the POR. In Phase I, the data set included observations from October 2002 to February 2007. In Phase II, observations from March and April 2007 and October 2007 to April 2008 will be added. To increase the size of the data set even further, the AMU will consider adding data prior to October 2002. Additional predictors will be evaluated, including wind speeds between 500 ft and 3000 ft, static stability classification, Bulk Richardson Number, mixing depth, vertical wind shear, inversion strength and depth, wind direction, synoptic weather pattern and precipitation. Using an independent data set, the AMU will compare the performance of the Phase I and II tools for peak wind speed forecasts. The final tool will be a user-friendly GUI to output the forecast values.

As in Phase I, the tool will be delivered as a Microsoft Excel GUI. In addition, at the request of the 45 WS, the AMU will make the tool available in MIDDS, their main weather display system. This will allow the tool to ingest observational and model data automatically and produce 5-day forecasts quickly.

Development of Phase II Microsoft Excel Tool

Mr. Barrett created linear regression equations for the Day-1 to Day-3 forecasts using the 12-km North American Mesoscale model (MesoNAM) cool-season forecasts from March 2007 to April 2009. He first stratified the data by precipitation and non-precipitation days across KSC and CCAFS, then developed equations to predict peak wind speed, as well as the average speed at the time of the peak wind. The strongest peak speeds during a 24-hour period at vertical levels 2 (~ 200 ft AGL) to 18 (~ 3100 ft AGL) of the

MesoNAM were used as the predictors in the equations. In addition, he developed equations using the 24-hour peak speeds in the lowest 1000-, 2000-, and 3000-ft of the MesoNAM forecasts. Mr. Barrett selected the most accurate equations for the tool, based on the lowest Mean Absolute Error.

After Mr. Barrett completed the first version of the Microsoft Excel tool, forecasters from the 45 WS evaluated it. The second version of the tool incorporated suggestions from the 45 WS and fixed one programming bug. Forecasters again evaluated the tool and had no further comments. The tool was then delivered to the 45 WS for operational use.

Using the Phase II Microsoft Excel Tool

To use the tool, the forecaster opens the Excel file to the “Intro” worksheet (Figure 1). This worksheet contains instructions on how to use the tool. Common user questions are answered in the “FAQs” (Frequently Asked Questions) worksheet. To start the tool, the forecaster selects the “Start Cool-Season Peak Wind Calculation” button.

The tool will then display a “Browse” dialog box containing a list of MesoNAM text and graphical forecast files. These files are sent to the 45 WS by ACTA, Inc. via e-mail. The dialog box first opens to the directory that was last used. The forecaster may need to navigate to the directory containing the MesoNAM files and then selects one of the files (Figure 2).

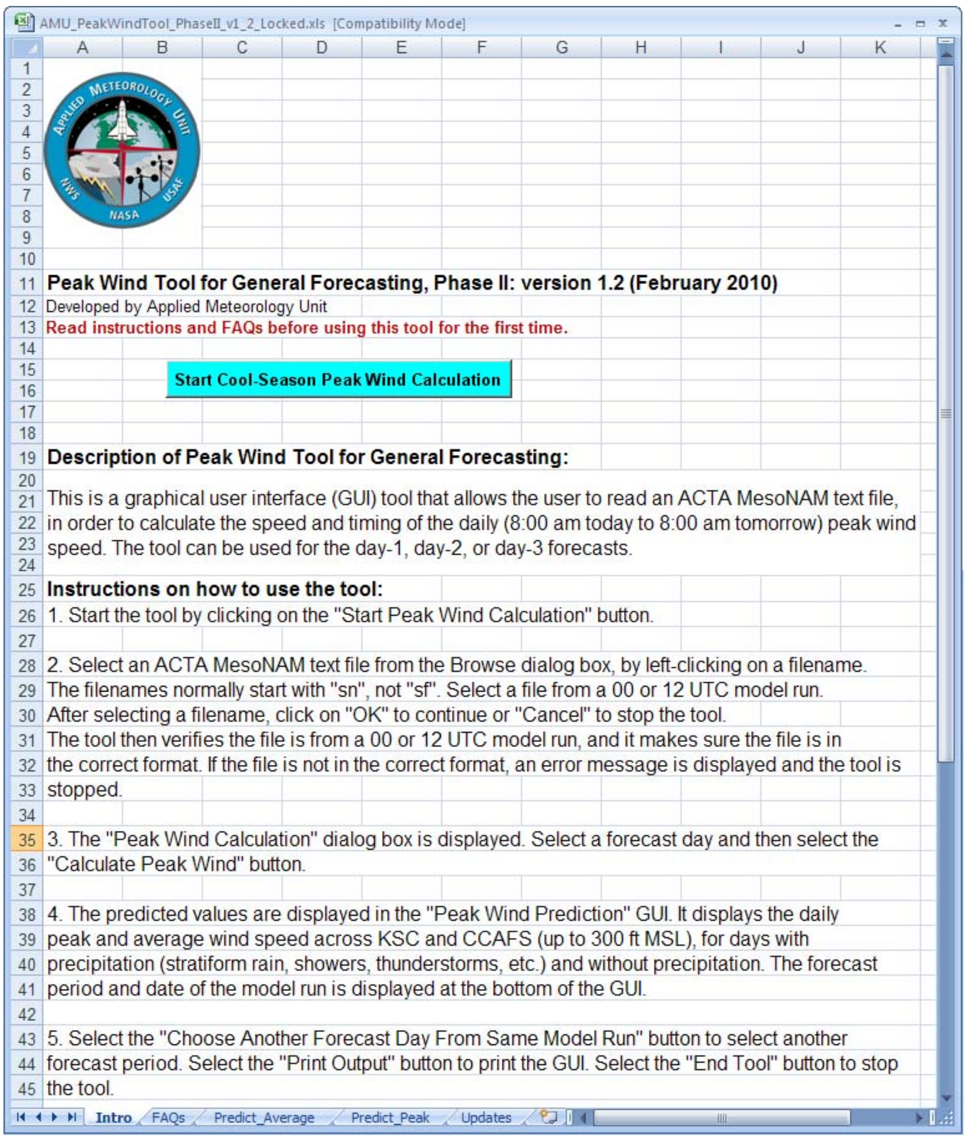

Figure 1. Intro worksheet to start the Peak Wind Tool.

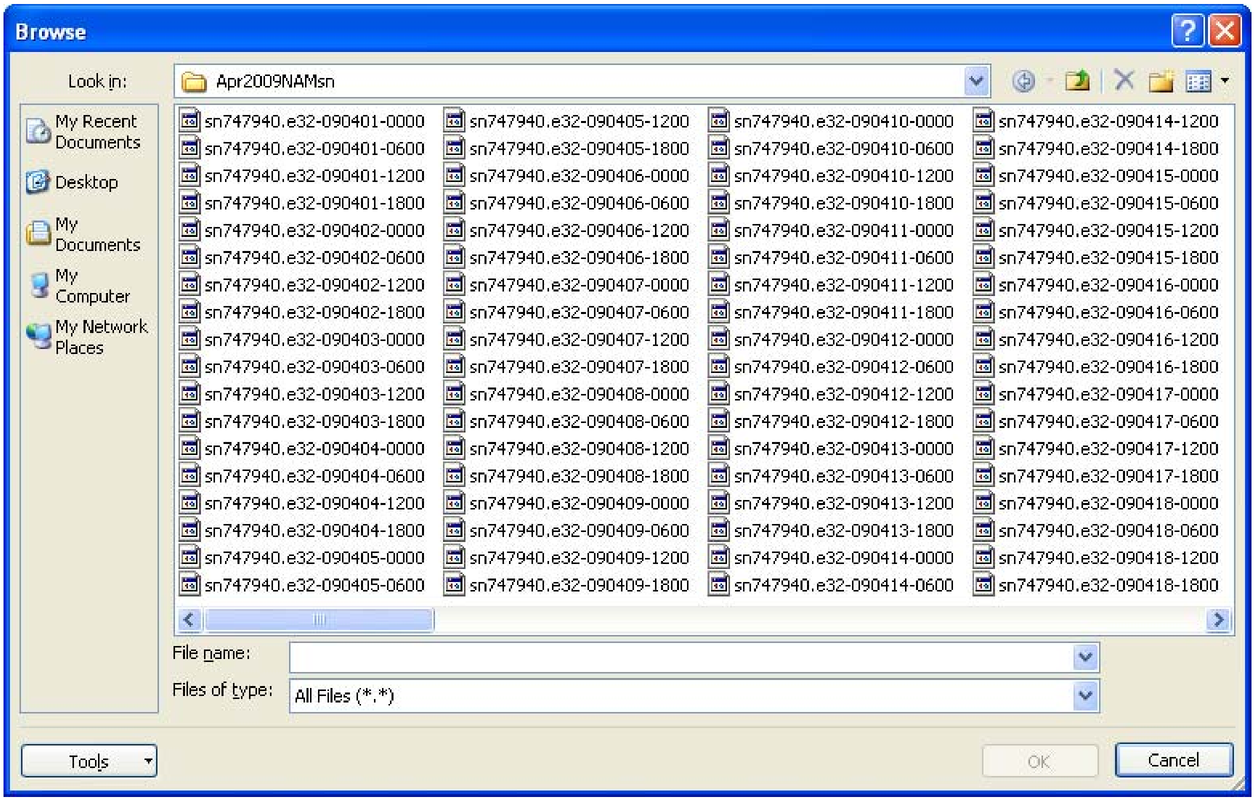

Figure 2. Dialog box used to select a MesoNAM input file.

The tool verifies the file chosen by the forecaster is in the correct format and is from a 0000 or 1200 UTC run of the MesoNAM. If the file is invalid, the tool displays an error message and exits. Otherwise, the “Peak Wind Calculation” dialog box is displayed (Figure 3). The dialog box shows the date and time of the model run. In this example, it is the 0000 UTC run on 1 April 2009. The forecaster selects a forecast day and then clicks the “Calculate Peak Wind” button. The Peak Wind Prediction GUI with the desired output is then displayed (Figure 4). This GUI shows the forecasts for peak wind speed, average speed at the time of the peak wind, and the probability that the peak wind will meet or exceed 35, 50, and 60 kt. The left/right side of the GUI shows the forecasts for precipitation events/non-events. Unlike the Phase I version of the tool, this version does not forecast the timing of the peak wind. Based on the independent verification performed in the previous quarter (AMU Quarterly Report Q1 FY10), no methods could forecast the timing of the peak wind significantly better than climatology. Therefore, the GUI contains the following note: “The peak wind speed of the day usually occurs during the afternoon or evening. The climatological timing of the peak speed is 2248 UTC. Adjust the time of peak wind, based on expected movement of fronts, wind surges, changes in pressure gradient, etc.” The forecast period is displayed at the bottom of the GUI. In this example, the forecast period is from 1 April 2009 (0800 EST) to 2 April 2009 (0800 EST). The forecaster can now select one of three options: “Print Output”, “Choose Another Forecast Day From Same Model Run”, and “End Tool”.

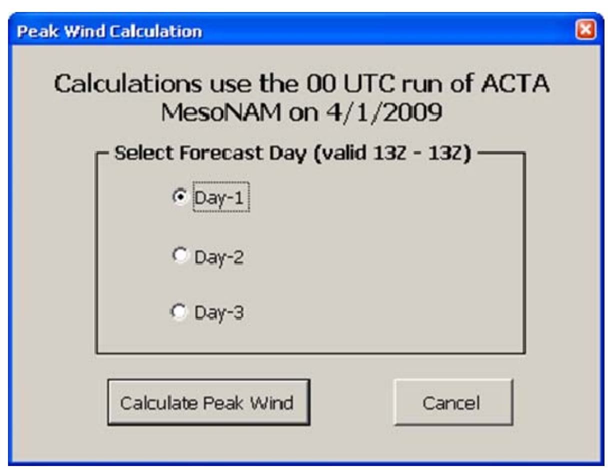

Figure 3. Dialog box used to select a forecast day. The model run is displayed at the top.

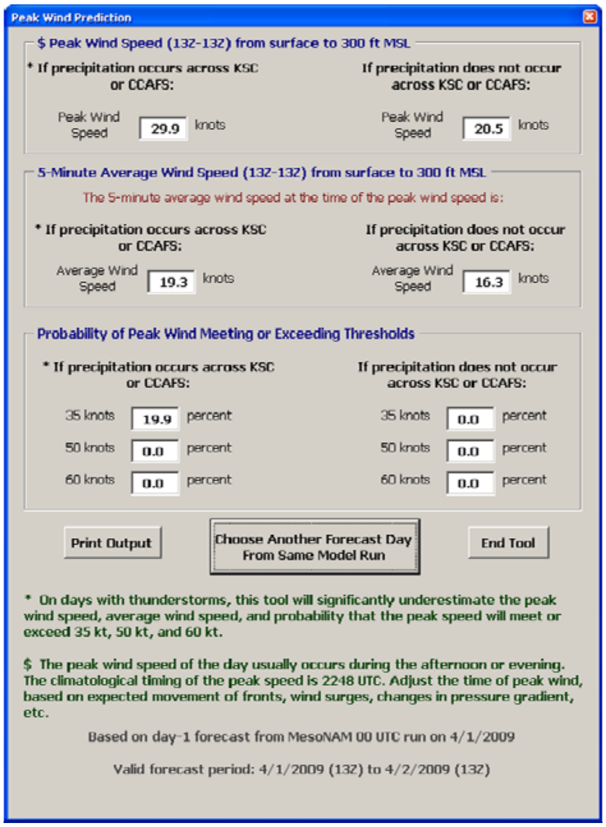

Figure 4. GUI displaying the tool's output. The top section shows the predicted peak wind speed, the middle section shows the average wind speed at the time of the peak wind, and the bottom section shows the probability the peak speed will be greater than or equal to 35 kt, 50 kt, and 60 kt.

The 45 WS recently changed the wind advisory thresholds to 25, 35, and 50 kt, and no longer issues forecast advisories for winds in excess of 60 kt. The output GUI in Figure 4 shows the probabilities for 35, 50, and 60 kt. Mr. Barrett learned of this change very recently and will update the tool so it calculates and displays the probability the peak wind will meet or exceed 25, 35, and 50 kt.

Development of the MIDDS Tool

The MIDDS tool will use gridded model data as input, instead of the ACTA MesoNAM text files. The tool will use the closest grid point to the CCAFS sounding (XMR). MIDDS contains the 0000 and 1200 UTC model runs from the North American Meso (NAM) and Global Forecast System (GFS). Both models have a horizontal grid spacing of 80 km. The MIDDS tool will use the same prediction equations developed from the archived ACTA MesoNAM forecasts described above. While the ACTA MesoNAM contains hourly forecasts out to 84 hours, the NAM and GFS data include 6-hourly forecasts out to 60 hours and 240 hours, respectively. The MIDDS tool will generate NAM forecasts for Day-1 and Day-2 and GFS forecasts for Day-1 to Day-5. Since the MIDDS gridded model data are only available every six hours, Mr. Barrett had to update the linear regression equations to take this into account. Otherwise, the MIDDS tool would have a low bias in predicting wind speeds. Since the ACTA MesoNAM forecasts are available out to 84 hours, or 3.5 days, the MIDDS tool will use the Day-3 equations for the Day-4 and Day-5 predictions. After the equations were updated, Mr. Barrett began writing source code for the MIDDS tool in the Tool Command Language/Tool Kit (Tcl/Tk) programming language.

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

INSTRUMENTATION AND MEASUREMENT

Upgrade Summer Severe Weather Tool in MIDDS (Mr. Wheeler)

The 45 WS Commander's morning weather briefing includes an assessment of the likelihood of local convective severe weather for the day in order to enhance protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC. Forecasting the occurrence and timing of severe weather is challenging for 45 WS operational personnel. In Phase I, the AMU analyzed stability parameters and synoptic patterns from Central-Florida severe weather days in the years 1989-2003 to determine which were important to severe weather development. The AMU then created an objective Hyper-Text Markup Language (HTML) tool using the important predictors to assist forecasters in determining the probability of issuing severe weather watches and warnings for the day. Work in a follow-on task resulted in a MIDDS-based GUI to replace the HTML tool. This new tool retrieved stability parameters and other information from MIDDS automatically, minimizing the forecaster's interaction with the tool. The result was a reduction in the possibility of human error and increased efficiency, giving forecasters more confidence in the tool output and allowing them more time to do other duties. For this task, the 45 WS requested the AMU upgrade the severe weather database by adding weather observations from the years 2004-2009, re-analyzing the data to determine the important parameters, make adjustments to the index weights depending on the analysis results, and update the MIDDS GUI. Updating the database and MIDDS GUI will likely improve the tool's performance and increase forecaster confidence in the output.

Severe Weather Database

Mr. Wheeler received the 1000 UTC CCAFS sounding stability parameters for the 2004–2009 warm season months (May–September) from Ms. Crawford, who created them for the Objective Lightning Probability Tool task (see parameter list on Page 5 of this report). He added them to the data base that includes severe weather reports from the Storm Prediction Center, data collected on the severe weather days from the National Climatic Data Center, and the large-scale flow regimes for each day in the POR. With this update, there is now a 21-year record of severe weather reports and associated surface, sounding and upper air weather data for the warm season.

Mr. Wheeler analyzed 200 mb charts to identify the location of the upper-level jet relative to Central Florida and its characteristics and added this information to the database. He then stratified the severe and non-severe days into the Low, Medium, and High threat categories for each stability parameter as defined in Phase I. This allowed him to determine what the parameter threat values were on each day with reports of severe hail, wind and tornadoes.

Data Analysis

Several of the sounding stability parameters showed increased severe weather forecast potential after including the data from 2004-2009, which increased the tool's overall severe weather predicting capability. When the Total Totals (TT) index was > 48 (High threat), a severe weather event was reported in 45% of the new 2004–2009 days. This increased the overall 21-year value to 34% from 28% for 15 years in Phase I. Figure 5 displays the threat levels of Low, Medium and High with the occurrence/non-occurrence of severe weather for all 21 years. The Thompson Index (TI) continued to be a valuable high threat predictor for severe weather. When the TI value was > 40 (Very High threat), severe weather was reported 94% of the time in the new six-year data set. It increased the occurrence to 91% for the 21-year data base over the Phase I value of 88%. Figure 6 displays the TI threat levels with the associated occurrence/non-occurrence of severe weather. Because of this increase, the weighted value for TI will be increased by 1 to a weight of 3, making it one of the highest weighted values for severe weather prediction.

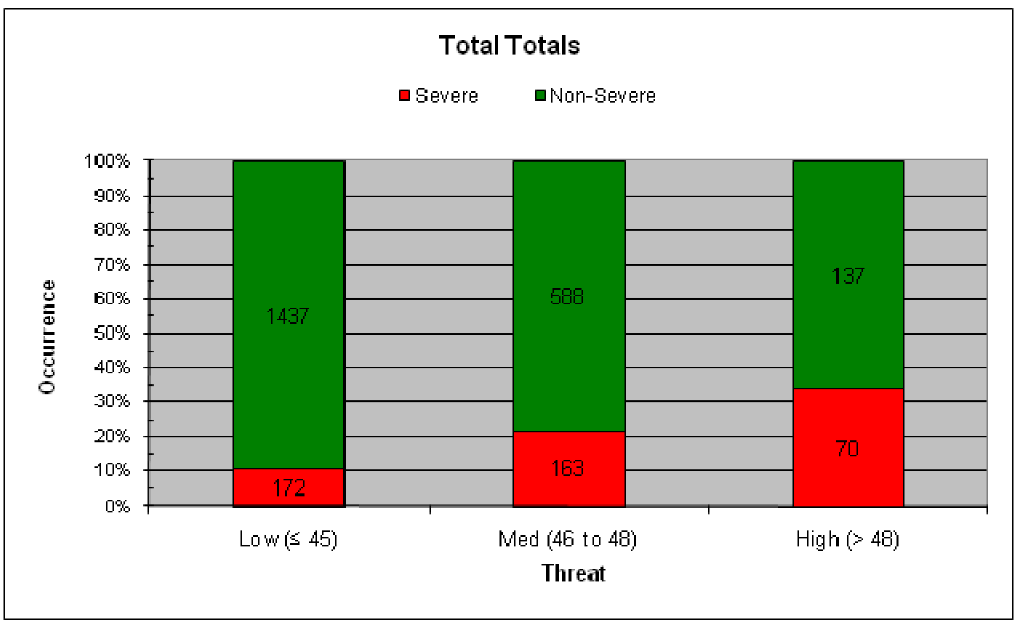

Figure 5 The number of severe/non-severe occurrences for the TT Low, Medium and High threat thresholds for all years in the severe weather database.

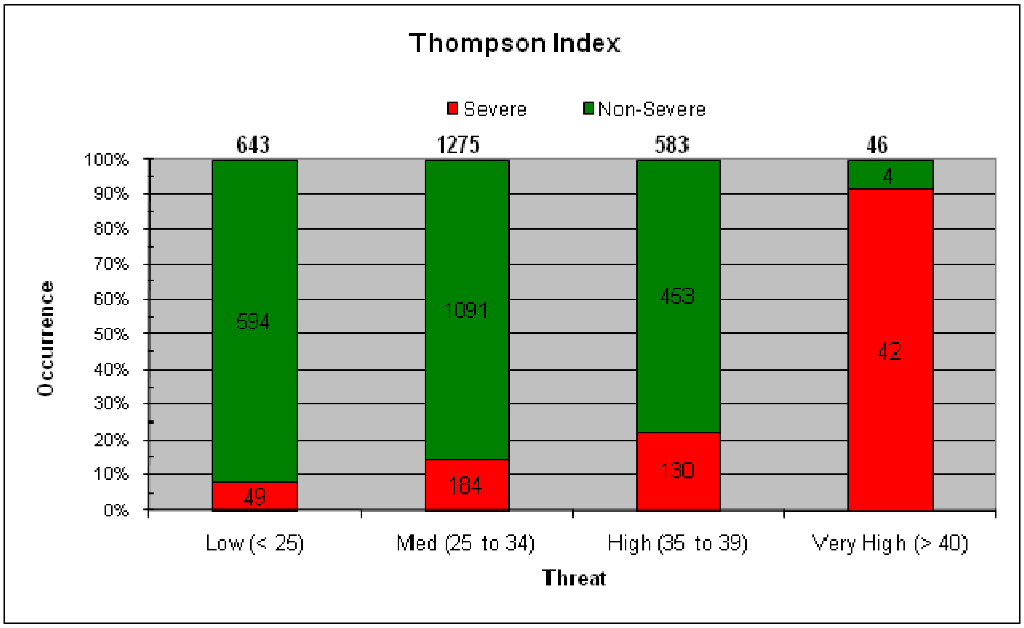

Figure 6 The number of severe/non-severe occurrences for the TI with Low, Medium, High and Very High threat thresholds for all years in the severe weather database.

Other morning sounding stability parameters also showed improved severe weather forecast potential. When the Lifted Index was < -5 (High threat), severe weather was reported 50% of the time in the new 6-year data set. This increased the severe weather occurrence in the 21-year data set to 32% over the 25% in Phase I. When the Showalter Stability Index was < -2 (High threat) severe weather was reported in central Florida 37% of the time, an increase over the 31% in Phase I.

TTS Verification for 2009

Mr. Wheeler calculated verification statistics for the Total Threat Score (TTS) determined by the 45 WS forecasters in the 2009 warm season. When the forecasters completed the Severe Weather Worksheet and computed the daily TTS, a file was saved that contained their inputs and the stability parameters for the day. This allowed Mr. Wheeler to compare the daily TTS with reported severe weather events in 2009. He used the standard 2x2 contingency table shown in Table 1 and calculated the statistics and scores shown in the last row of Table 1.

Table 2 shows the contingency table statistics for the 2009 warm season. The 45 WS forecasters completed the severe weather worksheet and calculated a TTS for 94 of the 153 days. The TTS forecast threshold value for the contingency table was 5: if < 5 it was a No forecast and if ≥ 5 it was a Yes forecast. If severe weather was reported across east-central Florida, that was classified as observed Yes. The Severe Weather Worksheet TTS verified well in the 2009 warm season, with a low FAR and high values for POD, CSI and HSS.

Table 1. The standard contingency table used for forecast verification.		**Observed Event** Yes	**Observed Event** No
Forecast Event	Yes	a	b
	No	c	d
N = a + b + c + d False Alarm Rate (FAR) = b/(a+b) Probability of Detection (POD) = a/(a+c)		Critical Success Index (CSI) = a/(a+b+c) Heidke Skill Score (HSS) = [(a+d) - E]/(N-E) E = [(a+c)(a+b)+(b+d)(c+d)]/N	

Table 2. Warm season 2009 TTS Verification Statistics		Observed Severe: Yes	Observed Severe: No	
Forecast Severe	Yes	**23**	**2**	FAR = 0.08
	No	**3**	**66**	POD = 0.88
				CSI = 0.82
				HSS = 0.94

Severe Weather Forecast GUI

Mr. Wheeler updated the functionality of the MIDDS Severe Weather Forecast GUI (Figure 3) using the Tcl/Tk language Interpreter. Tcl/Tk allows the flexibility of coding to retrieve, process, and apply functions to MIDDS data in the weather data database and then display output into the GUI.

The GUI retrieves and calculates most of the severe weather parameters from the XMR 1000 UTC morning sounding. It calculates values and threat score weights for 14 out of the 26 questions in the worksheet. Twelve of the questions are more subjective and need to be answered by the forecaster. These questions were handled by displaying the question for the forecaster, having mouse-over help to display a descriptive text, and a View Graphic button. The View Graphic button displays a MIDDS graphic image of the parameter to help the forecaster answer the question. The GUI calculates an index value based on the forecaster response. When the forecaster selects the button marked "Calculate Total Threat Score (TTS)", the GUI adds all the index values and displays the total, the TTS, to the forecaster. The magnitude of the TTS represents the severe weather threat for the day. All of the calculated values and parameters are written and stored in a text file that can be viewed later. The forecasters have the option to make a hard copy print of the TTS along with the stability parameters. They can also print the previous day's values, if the worksheet was filled out.

For more information contact Mr. Wheeler at wheeler.mark@ensco.com or 321-853-8105.

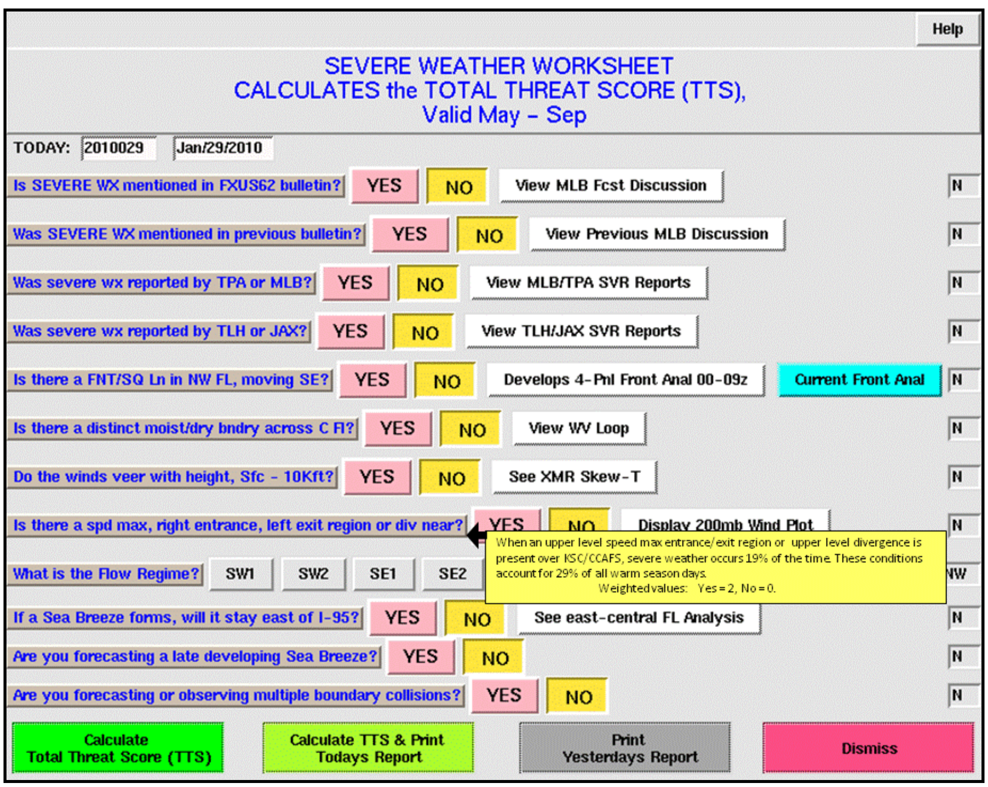

Figure 7. The Severe Weather Worksheet GUI with mouse-over help displayed in the yellow box toward the bottom of the GUI with a black arrow on the upper left.

MESOSCALE MODELING

ADAS Update and Maintainability (Dr. Watson)

Both the National Weather Service in Melbourne, FL (NWS MLB) and SMG have used a local data integration system (LDIS) since 2000 and routinely benefit from the frequent analyses. The LDIS uses the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) package as its core, which integrates a wide variety of national and local-scale observational data. The LDIS provides accurate depictions of the current local environment that help with short-term hazardous weather applications and aid in initializing the local Weather Research and Forecasting (WRF) model. However, over the years the LDIS has become problematic to maintain since it depends on AMU-developed shell scripts that were written for an earlier version of the ADAS software. The goal of this task is to update the NWS MLB/SMG LDIS with the latest version of ADAS and upgrade and modify the AMU-developed shell scripts written to govern the system. In addition, the previously developed ADAS GUI will be updated.

Modification of ADAS GUI

One of the goals of this task is to update the previously developed ADAS GUI. The original GUI was developed by the AMU in 2004 to allow forecasters to quickly and easily interact with ADAS to maintain or improve the integrity of each 15-minute analysis cycle. The intent was to offer forecasters the means to monitor and manage the observational data streams ingested by ADAS without having prior ADAS expertise. The GUI was created using the Tcl/Tk.

During this quarter, Dr. Watson began learning the Tcl/Tk programming language in order to update the existing ADAS GUI software. She installed the existing GUI on the local cluster and began familiarizing herself with the content.

Information about the data ingested by ADAS is passed to the GUI from the output of the ADAS analysis. Unique files are created by a script that extracts information from the ADAS output file about the numbers of each observation type that are analyzed by ADAS. Dr. Watson rewrote the previous shell script that extracted this information using the Perl programming language. The script now takes into account the new Meteorological Assimilation Data Ingest System (MADIS) data now assimilated by ADAS.

Dr. Watson also created a new map background for the ADAS GUI to replace the existing one using the MapServer software. The new map includes state and county boundaries, and significant lakes and rivers in Florida. Figure 8 shows the existing and new map backgrounds for Florida and the surrounding areas.

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

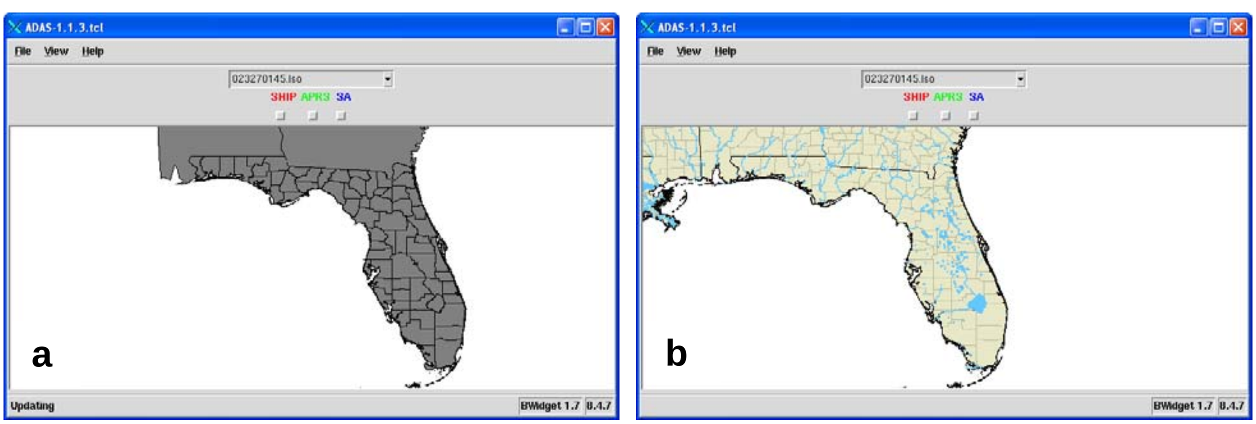

Figure 8. (a) Existing ADAS GUI map background and (b) newly developed map background of Florida and the surrounding areas.

Verify MesoNAM Performance (Dr. Bauman)

The 45 WS LWOs use the MesoNAM text and graphical product forecasts extensively to support launch weather operations. However, the actual performance of the model has not been measured objectively. In order to have tangible evidence of model performance, the 45 WS tasked the AMU to conduct a detailed statistical analysis of model output compared to observed values. The model products are provided to the 45 WS by ACTA, Inc. and include hourly forecasts from 0 to 84 hours based on model initialization times of 00, 06, 12 and 18 UTC. The objective analysis will compare the MesoNAM forecast winds, temperature and dew point, as well as the changes in these parameters over time, to the observed values from the sensors in the KSC/CCAFS wind tower network shown in Table 3. Objective statistics will give the forecasters knowledge of the model's strength and weaknesses, which will result in improved forecasts for operations.

Table 3. Towers, launch activities and sensor heights at KSC and CCAFS that will be used in the objective analysis to verify the MesoNAM forecasts.

Tower Number	***Supported Activity and Facility***	***Sensor Heights***
0002	Delta II (LC-17)	6 ft, 54 ft, 90 ft
0006	Delta IV (LC-37)/ Falcon 9 (LC-40)	54 ft
0108	Delta IV (LC-40)/Falcon 9 (LC-40)	54 ft
0110	Atlas V (LC-41)/Falcon 9 (LC-40)	54 ft, 162 ft, 204 ft
0041	Atlas V (LC-41)	230 ft
393 / 394	Shuttle/Constellation (LC-39A)	60 ft
397 / 398	Shuttle/Constellation (LC-39B)	60 ft
511 / 512 / 513	Shuttle Landing Facility	6 ft, 30 ft

Data Stratification

Dr. Bauman completed calculating the bias, standard deviation of bias and root mean square error of the MesoNAM verification statistics for all towers. The results confirmed the preliminary assessment presented in a previous AMU Quarterly Report (Q4 FY09) that indicated a diurnal signal in the bias of temperature (T) and weaker but discernable diurnal signal in the bias of dewpoint temperature (T_d) (Figure 9) in the MesoNAM forecasts. Also, as reported in a previous AMU Quarterly Report (Q4 FY09), the standard deviation of the bias of T and T_d indicated the model error increased with the forecast period for both parameters (Figure 10).

Statistics calculated for the remaining towers supported the preliminary findings that the bias of wind speed and wind direction did not show the same diurnal fluctuation as the T and T_d. However, the standard deviation of the bias for wind speed and direction showed similar trends as the T and T_d for the entire data set. As shown in Figure 11 for wind speed and direction the trend of the model error increased during the forecast period.

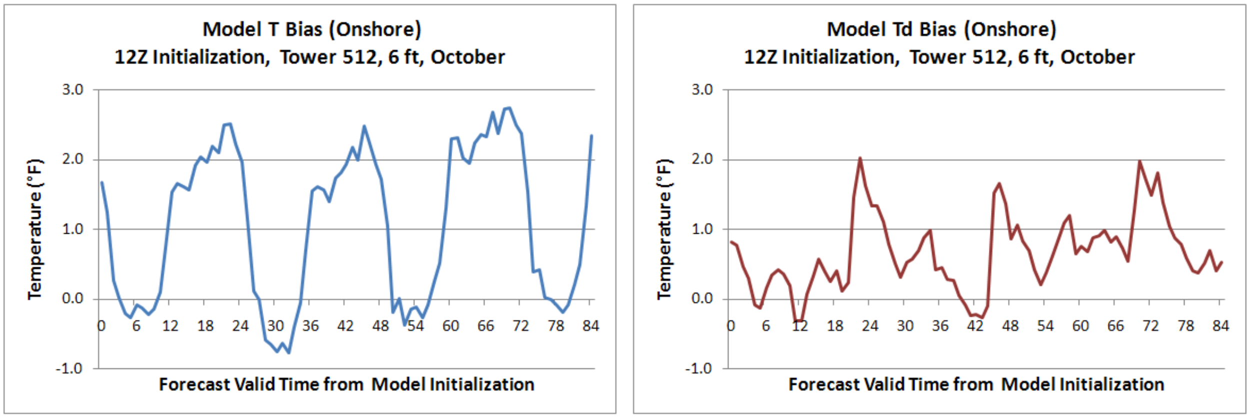

Figure 9. An example of verification charts showing model bias of T (left) and T_d (right) from a 1200 UTC model initialization using observations from Tower 512 at 6 ft for October.

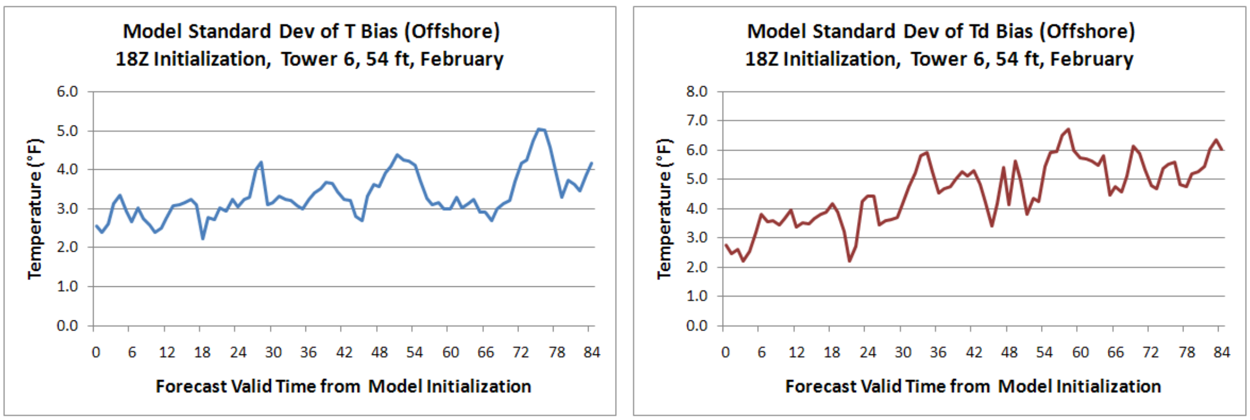

Figure 10. As in Figure 9 except for standard deviation of bias and an 1800 UTC model initialization using observations from Tower 6 at 54 ft for February.

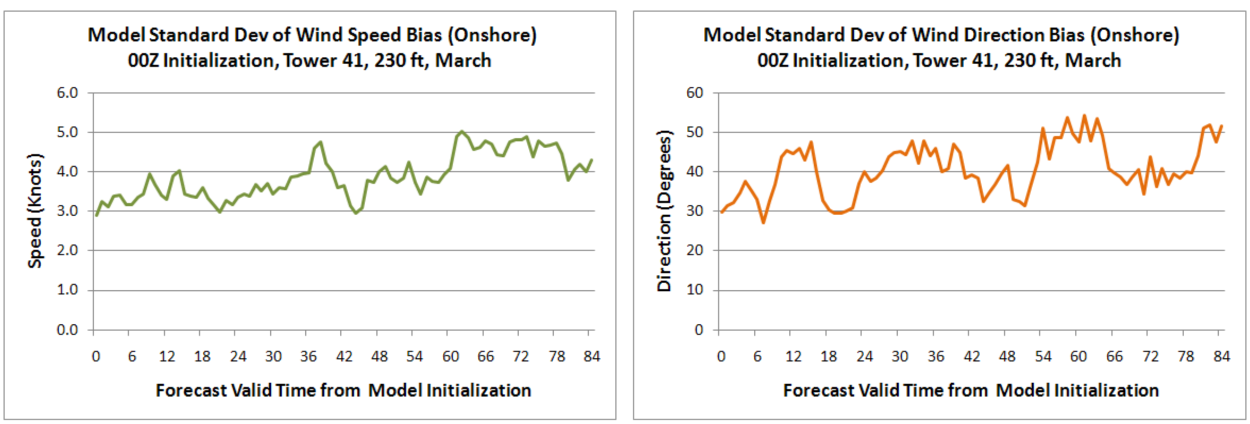

Figure 11. An example of verification charts showing model standard deviation of bias of wind speed (left) and wind direction (right) from an 1800 UTC model initialization using observations from Tower 41 at 230 ft for March.

Hypothesis Zero Test

Hypothesis testing uses statistics to determine the probability that a given hypothesis is true. Dr. Bauman worked with Mr. Roeder of the 45 WS to determine the best way to setup the test. The goal was to determine if the model bias of any of the parameters assessed throughout the model forecast period was statistically zero. Mr. Roeder recommended the test statistic for this data set would be to divide the mean bias of a given parameter by the mean standard deviation of that parameter divided by the square root of the number of observations within a given stratification (onshore or offshore) as shown by:

$$\frac{Mean\ Bias}{\frac{Mean\ STDEV}{\sqrt{n}}}$$

where n = number of observations. If this equation produced a value ≥ -1.96 or ≤ 1.96 for a data point, then the bias at that point was effectively 0 and the model forecast for that point was considered to have no error (Mr. Roeder, personal communication).

Dr. Bauman worked with Mr. Roeder and the 45 WS Launch Weather Officers (LWOs) to determine the best way to display the results of the hypothesis zero test graphically so it would be useful for operations. The group agreed to have the hypothesis zero test displayed on the model bias charts as shaded regions only when the test was true (-1.96 ≤ test value ≤ 1.96). When the hypothesis zero test was true, it indicated that even though the bias may not have been zero at any given data point, statistically the bias was zero. In Figure 12, there are several time periods when the hypothesis zero test was true as indicated by the green shading. For an operational example, consider the forecast valid time period 73–83 hr indicated by a red ellipse in Figure 12. Even though the model temperature bias (blue line) was not 0, the hypothesis zero test indicated that statistically, the temperature bias was 0 and the LWO would not have to adjust the model temperature forecast for this time period.

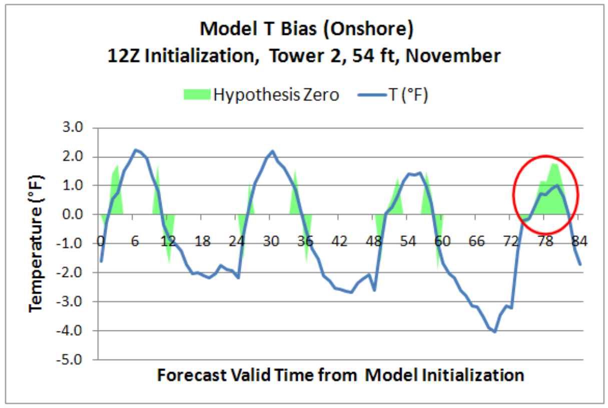

Figure 12. An example of a verification chart showing model bias of T (blue line) and hypothesis zero test = true (light green shaded regions) from a 1200 UTC model initialization using observations from Tower 2 at 54 ft for November The red ellipse highlights the region of the chart in the example discussed in the text.

Graphical User Interface

A GUI is needed so the LWOs have an operational tool at their disposal that is easy to navigate among the multiple stratifications of information to include tower locations, month, model initialization times, sensor heights and onshore/offshore flow. Dr. Bauman developed a "mockup" of a proposed GUI and presented it to Mr. Roeder and the LWOs (Figure 13). He developed the GUI using HTML so the tool could be used in most popular web browsers with computers running different operating systems such as Microsoft Windows and Linux. The 45 WS approved the basic GUI design and use of HTML. When Dr. Bauman began to develop the MesoNAM Verification Tool, he discovered the navigation menu and supporting code was extremely cumbersome to work with from both a programming and a user perspective. The navigation menu code created many unneeded files to handle all of the stratifications and required the user to make up to five mouse-clicks just to display the desired data.

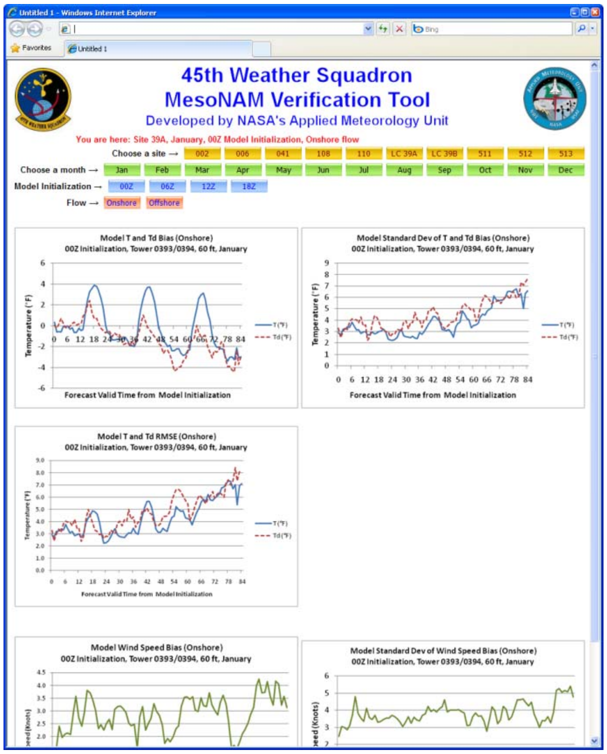

Figure 13. Mockup of the original GUI for the operational MesoNAM Verification Tool.

Dr. Bauman found that a better solution was to implement a multi level drop-down menu written in JavaScript embedded within the HTML code. The new GUI for the MesoNAM Verification tool is shown in Figure 14. The navigation menu now uses a smaller space above the charts and allows the user to choose data by placing their mouse pointer over the desired tower/site resulting in a drop-down menu being displayed as shown in Figure 15. In this example, the user placed their mouse pointer over the menu item for Tower 2. This displayed the first level of the drop-down menu, the months January- December. The user then moved the mouse pointer over November, the 1200 UTC (12Z) model initialization time, 54 ft sensor height, and then clicked "Onshore" for the flow.

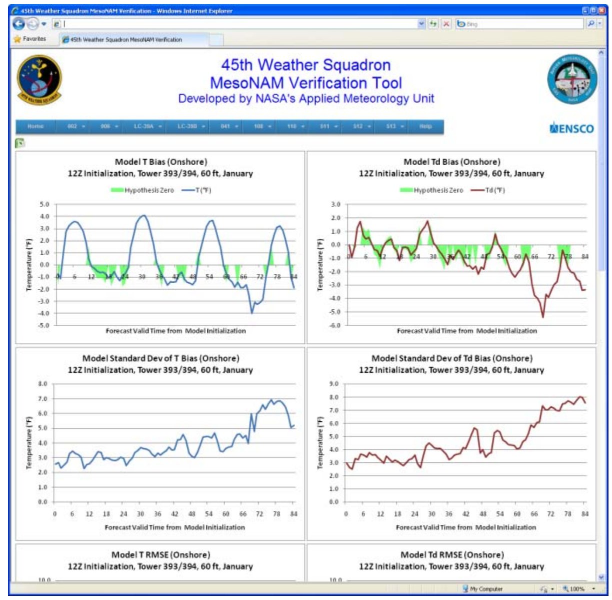

Figure 14. Redesigned GUI for the operational MesoNAM Verification Tool with the new navigation menu (light blue bar above the charts).

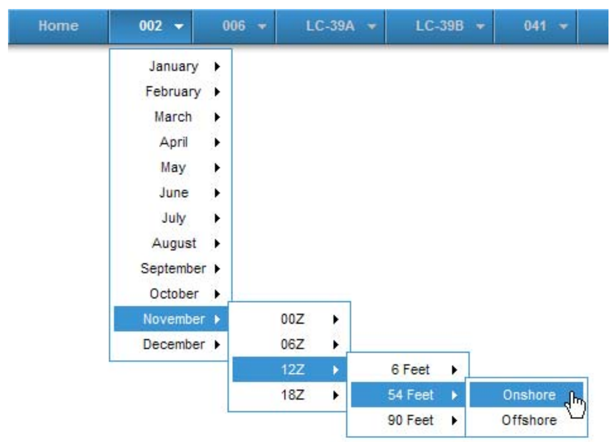

Figure 15. Example of the multi-level drop-down menu functionality.

On each page in the tool, Dr. Bauman added a link to the corresponding Excel file that produced the charts on that page. This feature allows the user to interrogate and view the spreadsheets from which the charts were derived. As shown in Figure 16, there is an Excel icon just under the "Home" link on the navigation menu. When the user clicks the link, Excel opens the file associated with the charts on that web page.

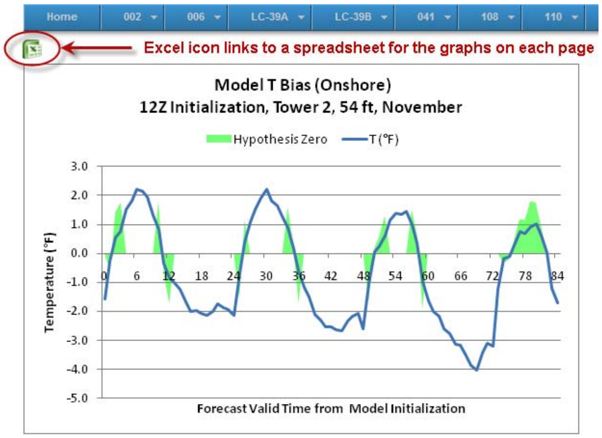

Figure 16. Location of the Excel icon that links the user to the Excel file associated with the charts on a given web page is shown by the red ellipse.

Dr. Bauman included a "Help" page as part of the GUI that briefly explains why the tool was developed, how to use it, sensor configuration and a description of the data. Dr. Bauman delivered the tool to the 45 WS on 22 March.

Noisy Statistics

As discussed in a previous AMU Quarterly Report (Q3 FY09), data from a total of three cool seasons (2006-2007, 2007-2008 and 2008-2009) and two warm seasons (2007 and 2008) would be used for this task. Upon visual inspection of the results, Dr. Bauman realized that two years worth of warm season data stratified by onshore and offshore flow produced "noisy statistics" due to the lack of observations, especially with an offshore stratification during the summer months. Figure 17 shows an example of this noisiness in the T bias for Towers 393 and 394 at 60 ft. Some offshore stratifications during warm season months had less than 1,000 observations out of a possible 5,208 for a given month and some model initialization times had zero observations available for verification over a monthly stratification during warm season months. Therefore, additional observations from Sep 2006 and May 2009-Jan 2010 will be added to the data set and the statistics will be reevaluated. Dr. Bauman requested and acquired MesoNAM forecasts for these time periods from ACTA, Inc. and will begin to infuse the new data into the existing data set in April.

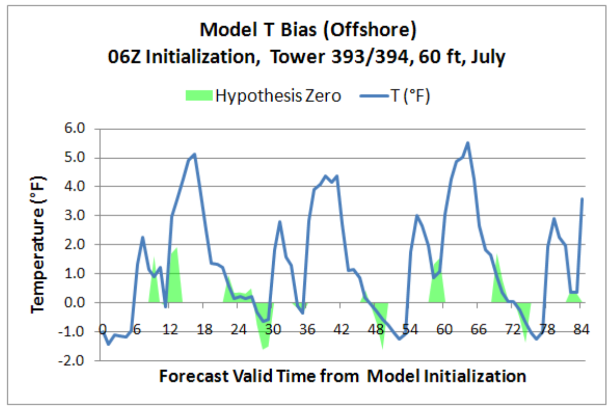

Figure 17. The verification chart showing model bias of T from a 0600 UTC model initialization using observations from Towers 393 and 394 at LC-39A at 60 ft for July.

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

AMU CHIEF'S TECHNICAL ACTIVITIES (Dr. Merceret)

Comparison of Tropical Storm (TS) and Non-TS Peak Winds (Dr. Merceret and Ms. Crawford)

Early in the Quarter, Dr. Merceret was appointed by the Chairman of the Lightning Advisory Panel (LAP) as Associate Editor to assist the Chief Editor, Dr. John Willett, with the compilation of a history of the LAP and the lightning launch commit criteria (LLCC). At a meeting of the LAP in mid-March, those roles were switched with Dr. Merceret re-designated as Editor because his level of effort in preparing the document had grown substantially from what was originally planned. Dr. Willett was given the role of Associate Editor. Dr. Merceret and the members of the LAP began submitting contributions to the document and Dr. Merceret began assembling these disparate inputs into a single, coherent history. With the support of the LAP, and especially Associate Editor Dr. Willett, he was able to submit a first draft to the customer, KSC's Safety and Mission Assurance Directorate, on 31 March. The document contains the technical rationale for the LLCC as the history. The work is funded by the NASA Safety and Mission Assurance organization to provide permanent written documentation supporting the origin and validity of the LLCC.

Dr. Merceret and Ms. Crawford submitted a manuscript titled "A Comparison of Tropical Storm (TS) and Non-TS Gust Factors for Assessing Peak Wind Probabilities at the Eastern Range" to the 14th Aviation, Range, and Aerospace Conference held in conjunction with the 90th American Meteorological Society (AMS) Annual Meeting in Atlanta, GA, 17-21 January 2010. They also created presentation slides that Ms. Crawford presented at the conference. The abstract, manuscript, and slides are available online at http://ams.confex.com/ams/90annual/techprogram/paper_156464.htm.

AMU OPERATIONS

Conferences, Meetings, and Training

Three AMU team members presented at conferences during the 90th Annual American Meteorological Society meeting held 17-21 January 2010 in Atlanta, Ga.:

- Dr. Bauman gave an oral presentation titled “An Objective Verification of the North American Mesoscale Model for Kennedy Space Center and Cape Canaveral Air Force Station” at the 14th Aviation, Range and Aerospace Meteorology (ARAM) Conference. The abstract, manuscript and slides are online at http://ams.confex.com/ams/90annual/techprogram/paper_162253.htm.
- Ms. Crawford gave an oral presentation titled “A Comparison of Tropical Storm (TS) and Non-TS Gust Factors for Assessing Peak Wind Probabilities at the Eastern Range" at the 14th ARAM Conference. The abstract, manuscript and slides are online at http://ams.confex.com/ams/90annual/techprogram/paper_156464.htm.
- Dr. Watson gave an oral presenation titled “Maintaining a Local Data Integration System in Support of Weather Forecast Operations" at the 14th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS) Conference. The abstract, manuscript and slides for this presentation are available online at http://ams.confex.com/ams/90annual/techprogram/paper_164799.htm.

The AMU staff attended the Day-of-Launch Working Group held at KSC on 24 March.

Launch Support

- Mr. Wheeler supported the launch attempt of STS-130 on 7 February and Mr. Barrett supported the successful launch of STS-130 on 8 February.
- Dr. Watson and Dr. Merceret supported the launch attempt of the Atlas 5 (AV-021) on 9 February and the successful launch of Atlas 5 on 10 February.
- Ms. Crawford supported the Delta IV launch of GOES-P on 4 March.

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Barrett, J. H. and D. A. Short, 2008: Peak Wind Tool for General Forecasting Final Report. NASA Contractor Report CR-2008-214743, Kennedy Space Center, FL, 59 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 830, Cocoa Beach, FL, 32931 and http://science.ksc.nasa.gov/amu/final-stfi.html] http://science.ksc.nasa.gov/amu/final-mm.html]

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 830, Cocoa Beach, FL 32931 and http://science.ksc.nasa.gov/amu/final-stfi.html]

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LIST OF ACRONYMS

14 WS	14th Weather Squadron
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
ADAS	ARPS Data Analysis System
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AGL	Above Ground Level
AMU	Applied Meteorology Unit
ARAM	Aviation, Range, and Aerospace Meteorology
ARPS	Advanced Regional Prediction System
CCAFS	Cape Canaveral Air Force Station
CSI	Critical Success Index
CSR	Computer Sciences Raytheon
FAR	False Alarm Rate
FR	Flight Rules
FSU	Florida State University
FY	Fiscal Year
GFS	Global Forecast System
GSD	Global Systems Division
GUI	Graphical User Interface
HSS	Heidke Skill Score
HTML	Hyper-Text Markup Language
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAP	Lightning Advisory Panel
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
LLCC	Lightning LCC
LWO	Launch Weather Officer
MADIS	Meteorological Assimilation Data Ingest System
MesoNAM	12-km resolution NAM
MIDDS	Meteorological Interactive Data Display System
MSFC	Marshall Space Flight Center
NAM	North American Model
NOAA	National Oceanic and Atmospheric Administration
NWS MLB	National Weather Service in Melbourne, FL
POD	Probability of Detection
POR	Period of Record
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
T	Temperature
T_d	Dewpoint Temperature
Tcl/Tk	Tool Command Language / Tool Kit
TI	Thomson Index
TS	Tropical Storm
TT	Total Totals
TTS	Total Threat Score
USAF	United States Air Force
UTC	Universal Coordinated Time
WRF	Weather Research and Forecasting Model
XMR	CCAFS 3-letter Identifier

Appendix A

AMU Project Schedule 30 April 2010				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled 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	Completed
	Stratify mean and peak winds by hour and direction, calculate statistics	Sep 07	Oct 07	Completed Nov 07
	Stratify peak speed by month and mean speed, determine parametric distribution for peak	Oct 07	Nov 07	Completed
	Create distributions for 2-hour prognostic peak probabilities, and develop GUI to show climatologies, diagnostic and 2-hour peak speed probabilities	Nov 07	Oct 08	Completed Feb 09
	Create distributions for 4-hour prognostic peak probabilities and incorporate into GUI	Oct 08	Jan 09	Completed Mar 09
	Create distributions for 8-hour prognostic peak probabilities and incorporate into GUI	Jan 09	Apr 09	Completed in Jul 09
	Create distributions for 12-hour prognostic peak probabilities and incorporate into GUI	Apr 09	Jul 09	Completed in Feb 10
	Final report	Jul 09	Sep 09	Delayed
Objective Lightning Probability Tool – Phase III	Collect CGLSS data for May–Sep 2006–2008 and Oct 1989–2008, analyze to determine if Oct data are needed	Mar 09	May 09	Completed
	Determine dates for lightning season stratifications	Jun 09	Sep 09	Reprogrammed
	Collect sounding data for May–Sep 2006–2008, and Oct 1989–2008 if needed, create candidate predictors for each stratification.	Jul 09	Nov 09	Completed in Feb 10
	Create and test new equations; compare performance with previous equations	Dec 09	Mar 10	Delayed
	Incorporate equations in Excel GUI	Apr 10	Apr 10	Delayed
	Final Report	May 10	Jul 10	Delayed

AMU Project Schedule 30 April 2010				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Peak Wind Tool for General Forecasting - Phase II	Collect wind tower data, CCAFS soundings, and SLF observations	Sep 08	Sep 08	Completed
	Interpolate 1000-ft sounding data to 100-ft increments for October 1996 to April 2008. Compare interpolated data to 100-ft sounding data for October 2002 to April 2008.	Sep 08	Oct 08	Completed Nov 08
	QC SLF observations	Oct 08	Nov 08	Completed
	QC wind tower data	Nov 08	Jan 09	Completed
	Create prediction equations for peak winds	Feb 09	Apr 09	Completed Jun 09
	Compare Phase I and II tools: • Using 2 cool-seasons of 45 WS-issued wind warnings/advisories; • To either MOS or model forecast winds; and • To wind tower climatology from the Peak Wind for User LCC task.	Jun 09	Nov 09	Completed
	Create and test Excel GUI application	Dec 09	Jan 10	Completed
	Transition tool to MIDDS to provide 5-day peak wind forecasts, using model data	Jan 10	Jun 10	On Schedule
	Final Report and training	Jul 10	Sep 10	On Schedule
Upgrade Summer Severe Weather Tool in MIDDS	Acquire and update the severe weather database and adjust weights	Nov 09	Feb10	Completed
	Update GUI software code	Feb 10	Mar 10	Completed
	Final Report and training	Apr 10	May 10	On Schedule
ADAS Update and Maintainability Task	Install and configure LDM on amu-cluster and retrieve real-time date	Jan 09	Feb 09	Completed
	Install and configure latest version of ADAS code	Feb 09	Mar 09	Completed
	Modify and upgrade AMU-developed scripts	Feb 09	Nov 09	Completed
	Update GUI software code	Dec 09	Feb 10	Delayed
	Split ADAS data sources into multiple files	May 10	May 10	New Milestone
	Optimize error statistics for MADIS data	Jun 10	Jul 10	New Milestone

AMU Project Schedule 30 April 2010				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
	Update GUI with new source data	Aug 10	Aug 10	New Milestone
	Final Report and training	Aug 10	Sep 10	Reprogrammed
Verify MesoNAM Performance Task	Acquire ACTA MesoNAM forecasts and KSC/CCAFS wind tower observations	Jun 09	Jun 09	Completed
	QC wind tower observations, stratify by month, season and wind direction	Jun 09	Sep 09	Completed
	Objectively verify model forecasts against wind tower observations	Oct 09	Mar 10	Completed
	Add wind tower observations and MesoNAM forecasts from May 09-Feb 10 and process the data to prepare for updated verification	Mar 10	May 10	New Milestone
	Update objective model verification with additional May 09-Feb 10 data	May 10	Jun 10	New Milestone
	Update GUI	Jun 10	Jul 10	New Milestone
	Final report	Jul 10	Sep 10	Reprogrammed

NOTICE