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Applied Meteorology Unit (AMU)

Quarterly Report

First Quarter FY-03

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NOAA/NWS/OST12/SSMC2/J. McQueen
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EXECUTIVE SUMMARY

This report summarizes the Applied Meteorology Unit (AMU) activities for the First Quarter of Fiscal Year 2003 (October – December 2002). A detailed project schedule is included in the Appendix.

Task MiniSODAR Evaluation

Goal Compare wind data from the Doppler miniSODAR™ System (DmSS) near SLC-37 to wind data from the nearest tall tower, and determine the reliability and quality of the DmSS data.

Milestones Continued acquisition and analysis of data from the DmSS and Towers 6 and 108.

Discussion Peak wind observations from the DmSS, now used for launch decisions at SLC-37, caused the launch weather officer to call a No Go for the 19 November Delta IV launch. The 45 WS requested a comparison of DmSS and tower speeds to determine if they were similar. Within 24 hours, Dr. Short showed that the DmSS and tower observations were in good agreement.

Task Extend Automated Meteorological Profiling System (AMPS) Moisture Profiles

Goal Evaluate the differences in moisture profiles between the AMPS and Meteorological Sounding System (MSS), and determine their impact on thunderstorm forecasting indices.

Milestones Completed analysis of the 20 dual-sensor AMPS/MSS profiles taken in July and August 2002.

Discussion Dr. Short's comparison of the AMPS and MSS stability indices showed no significant differences in the values of these important parameters used to help forecast thunderstorms.

Task Improve Anvil Forecasting Phase III

Goal Develop a utility to create and display the anvil threat sector using forecast upper-level wind data from the Eta or MRF model point data.

Milestones Completed the final report on the anvil threat sector utility development and implementation.

Discussion The new utility is now available for use by SMG and 45 WS forecasters, giving them an improved capability to assess the anvil threat.

Task Local Data Integration System (LDIS) Optimization and Training

Goal Improve the operational configuration and data ingest of the real-time LDIS at NWS MLB and SMG, and provide limited training and documentation for maintenance of the system.

Milestones Improved first-guess fields for the analysis, modified data ingest algorithms, and prepared a draft training and maintenance document.

Discussion The revised first-guess fields provide the analyses with greater time continuity and reduced interpolation errors. The modified data-ingest for the FAWN data gives the user the ability to quality control observation sites so that questionable data can be removed prior to the analysis.

Task Near-Storm Environment

Goal Provide assistance to NWS MLB in transferring graphics generation to a separate dedicated workstation, and develop an enhanced suite of severe weather graphics.

Milestones Assisted NWS MLB in transferring all graphics generation to a workstation separate from the LDIS workstation, and provided NWS MLB with enhanced severe weather parameters.

Discussion Once all graphics generation was moved to a separate workstation, more system resources were available to create more sophisticated graphics and enhance the analysis configuration on the LDIS workstation. The additional graphical parameters provide forecasters with diagnostic fields critical for assessing severe weather and tornado threats.

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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 Lambert (321-853-8130, lambert.winifred@ensco.com). If your mailing information changes or if you would like to be removed from the distribution list, please notify Ms. Lambert 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 and/or subtask.

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

SHORT-TERM FORECAST IMPROVEMENT

IMPROVED ANVIL FORECASTING PHASE III (DR. SHORT AND MR. WHEELER)

The 45th Weather Squadron (45 WS) Launch Weather Officers (LWOs) have identified anvil forecasting as one of their most challenging tasks when attempting to predicting the probability of a Launch Commit Criteria (LCC) violation due to the threat of natural and triggered lightning. Spaceflight Meteorology Group (SMG) forecasters have reiterated this difficulty when evaluating Space Shuttle Flight Rules (FRs). Phase II of this task resulted in the operational implementation of an observations-based nowcasting tool, due to the high correlation found between anvil propagation characteristics and the observed wind speed/direction in the anvil layer, between 300 and 150 mb (Short and Wheeler 2002a). The anvil threat sector tool graphically overlays an anvil threat corridor sector for a user-selected station on a weather satellite image. The goals of Phase III are to build upon the results of Phase II by enhancing the anvil threat corridor sector tool with the capability to use model forecast winds for depiction of potential anvil lengths and orientations over the Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) area with lead times from 1 to 72 hours.

The Anvil Threat Sector tool developed in Phase III consists of a Man Computer Interactive Data Access System (McIDAS) BASIC Language Interpreter (McBASI) script that computes the average upper-level wind speed between 300 and 150 mb from the most current Eta or Medium Range Forecast (MRF) model data to plot the anvil threat sector. The anvil threat sector forecast can be displayed with lead times at every hour from 3 – 60 hours using the Eta point data and every 12 hours from 72 to 168 hours using MRF point data. Figure 1 shows an example of the forecast anvil threat sector. Input from the user centered the plot on Space Launch Complex 37 (SLC-37) and specified a forecast of 26 hours using upper-level winds from the Eta model point data. The legend on the top right shows the model used, the model initialization time in Julian date and UTC, the number of forecast hours from the initialization, the mean 300 to 150 mb forecast wind direction and speed, and a code for the center point location.

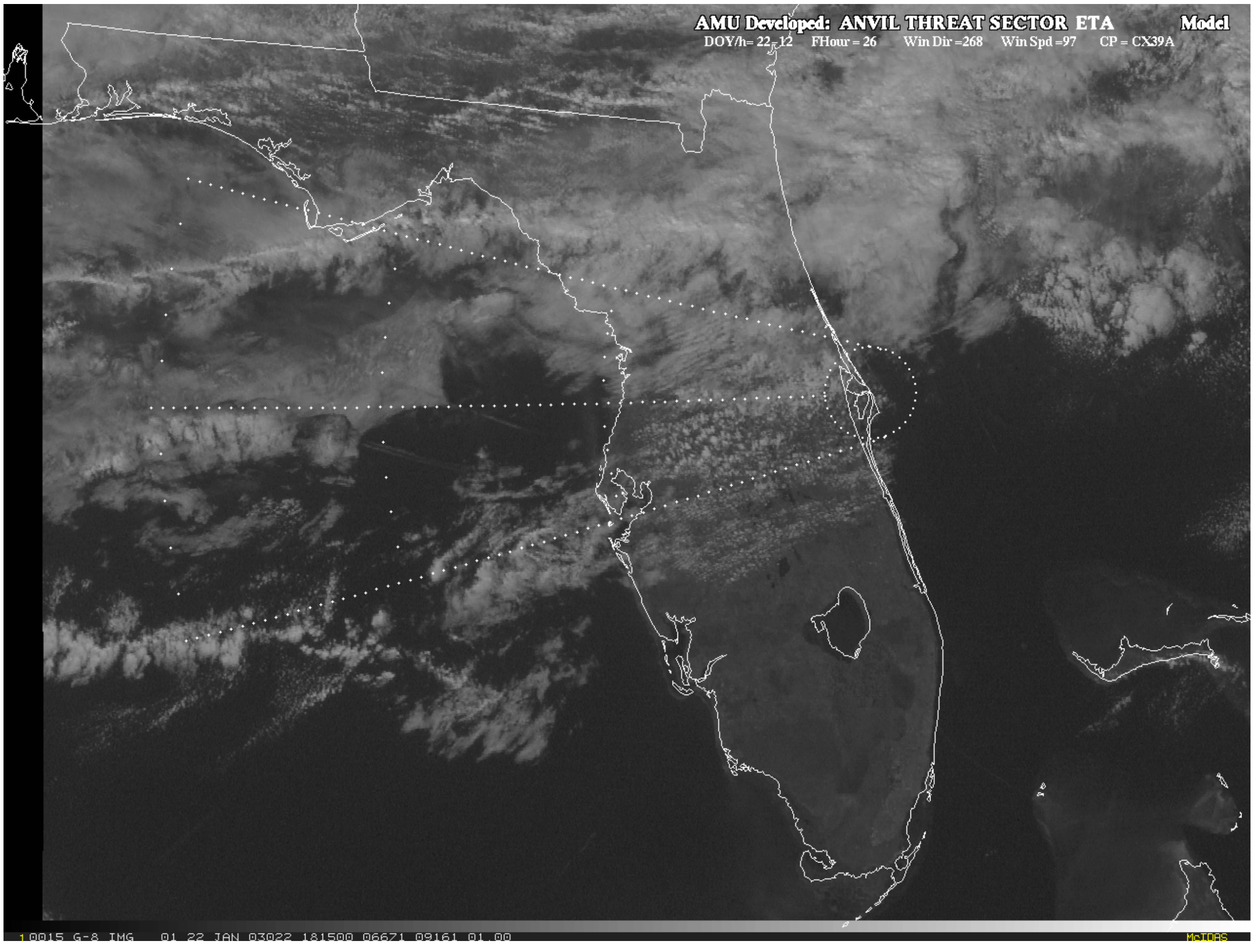

Figure 1. Example of an anvil threat sector using the Phase III anvil forecast plotting utility. The white dots highlight the anvil threat sector using SLC-37 as the center point, and a 26-hour forecast using upper-level winds from the Eta model point data.

The tools developed in Phase II and III can be displayed together to view the threat sector for the current day created from the most recent rawinsonde data, and forecast threat sectors using model forecast data. As shown in Figure 2, the forecasters can display the current anvil threat sector and then view the forecast changes based on input from either the Eta or MRF point data. This tool could help improve the 24- and 36-hour launch and landing forecasts if convection is a concern.

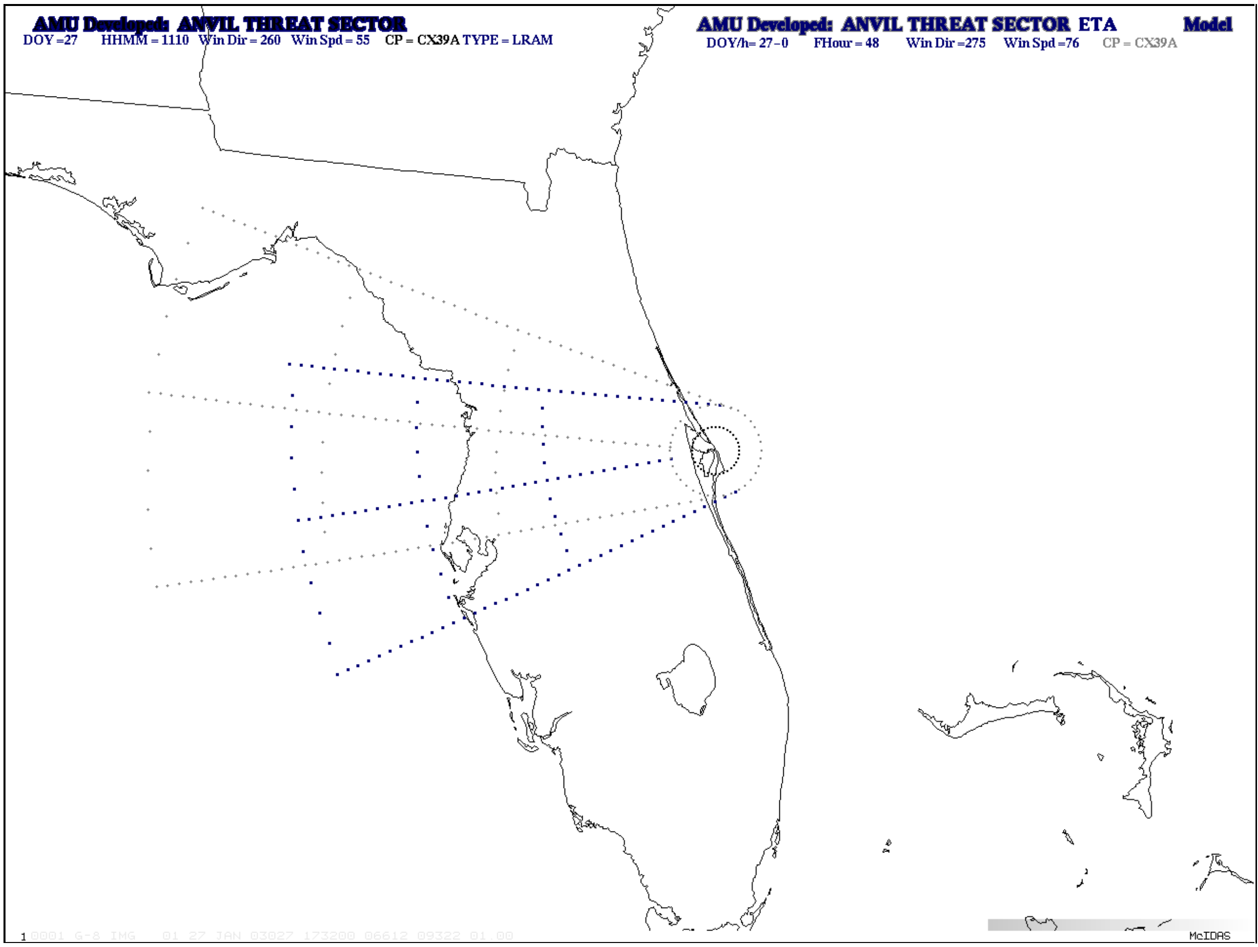

Figure 2. Example of overlaying the anvil threat sector utilities developed in Phase II and III. The black dots highlight the Phase II anvil threat sector, and the light gray dots are a 48-hour anvil forecast threat sector using upper level winds from the Eta point data.

For more information on this work, contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com.

Extend Statistical Forecast Guidance for the SLF Towers (Ms. Lambert)

The peak winds near the surface are an important forecast element for both the Space Shuttle and Expendable Launch Vehicle (ELV) programs. As defined in the LCC and the Shuttle FRs, each vehicle has certain peak wind thresholds that cannot be exceeded in order to ensure the safety of that vehicle during launch and landing operations. The 45 WS and the SMG indicate that peak winds are a challenging parameter to forecast. In Phase I of this task, climatologies and distributions of the 5-minute average and peak winds were created for the towers used in evaluating LCC and FRs. However, SMG uses a 10-minute peak as the standard for determining and verifying wind speed FRs. The goal of this phase of the task is to re-calculate the distributions and resulting probabilities of exceeding peak-wind thresholds using a 10- instead of 5-minute peak for the Shuttle Landing Facility (SLF) towers for all months. A tool will also be developed that can be used on a personal computer (PC) to display the desired information quickly and easily.

PC-Based Tool

Ms. Lambert began development of a PC-based tool to display the 5- and 10-minute peak wind speed climatologies and probabilities that were created in the previous quarter and in Phase I of this task. She is using Visual Basic for Applications in Microsoft® Excel 2002 (hereafter Excel) to develop the tool as a graphical user interface (GUI). The tool will consist of separate input and output GUIs. The GUI that prompts the user for input needed to retrieve data for output was completed during the quarter and is shown in Figure 3.

The input GUI has separate pages for climatology and probability analyses, with tabs at the top for the user to select which analysis is desired. In Figure 3, the page for input to retrieve climatology data is on the left and the page for input to retrieve probability data is on the right. For climatology data, the user first chooses the peak speed time interval. The 5-minute peak speed climatologies for the SLF towers (Towers 511, 512, and 513) and Tower 313 were calculated in Phase I. The 10-minute peak wind climatologies for the SLF towers were calculated the previous quarter (AMU Quarterly Report Fourth Quarter FY-02). After choosing the peak speed time interval of interest, the user chooses the tower and month of interest from the appropriate drop-down lists. The final step is to choose one of the three stratifications and the desired hour and/or direction sector in the associated drop-down box(es).

After all choices are made, the user will click on the Get Climatology command button and an output GUI with the retrieved information will be displayed. The climatology output GUI is currently in development. The inputs are the same on the probability page, except that the user chooses the empirical or theoretical distribution of the time interval/tower/month combination of interest instead of an hourly and/or directional stratification. The user must then select the 5-minute average wind speed of interest, most likely the currently observed or forecast value. The Get Probabilities command button will display an output GUI with the range of peak speeds associated with the input average speed and their probabilities of occurrence. The probability output GUI will be created when the climatology output GUI is complete.

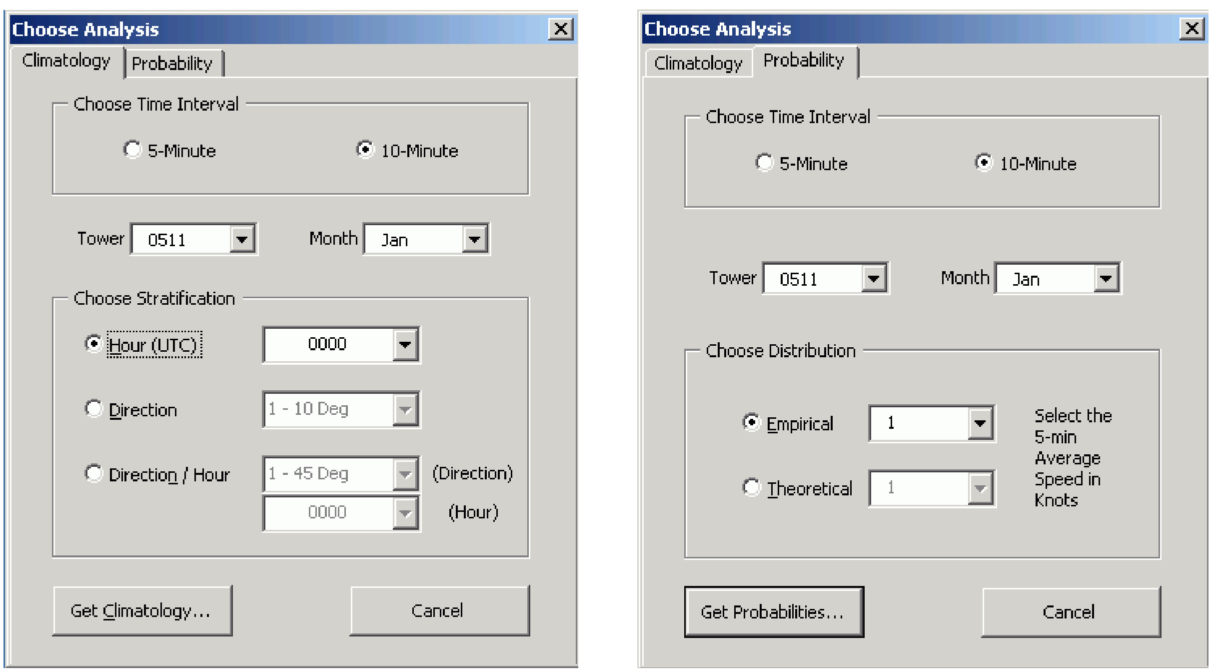

Figure 3. The two pages in the input GUI used to retrieve the requested climatological or probability of occurrence data. The left panel inputs the information needed to retrieve the climatology data, and the right panel inputs the information needed to retrieve the probability data.

The input GUI shown in Figure 3 is the final result of consultations between Ms. Lambert and forecasters at SMG. They were given the Excel file with the GUI algorithm to test and make suggestions for modifications, all of which were incorporated. Similar consultations will occur during development of the output GUIs. This will ensure that the end product will be easy to use and produce useful information in a readable format.

For more information on this work, contact Ms. Lambert at 321-853-8130 or lambert.winifred@ensco.com.

INSTRUMENTATION AND MEASUREMENT

I&M AND RSA SUPPORT (DR. MANOBIANCO AND MR. WHEELER)

Mr. Wheeler reviewed and provided comments on the AMU equipment and console setup plans submitted by Lockheed Martin. He also attended the NOAA Satellite Direct Readout Conference of the Americas in Miami, FL. Dr. Manobianco attended a meeting with representatives from NASA, 45 WS, 45 Range Management Squadron (RMS), Lockheed Martin and the USAF System Program Office to discuss the ownership and maintenance responsibilities for the AMU RSA equipment.

Table 1. AMU hours used in support of the I&M and RSA task in the First Quarter of FY 2003 and total hours since July 1996.

Quarterly Task Support (hours)	***Total Task Support (hours)***
51.5	400.0

EXTEND AMPS MOISTURE PROFILES (DR. SHORT AND MR. WHEELER)

The 45 WS utilizes vertical profiles of humidity and temperature from balloon-borne rawinsonde observations (RAOBs) to assess atmospheric stability and the potential for thunderstorm activity. Operational RAOBs from the Meteorological Sounding System (MSS) will be replaced by the Low Resolution Flight Element (LRFE) of the Automated Meteorological Profiling System (AMPS) at the balloon facility (XMR) on CCAFS in the near future. Testing of the AMPS LRFE (hereafter AMPS) and earlier comparisons with MSS revealed significant differences in relative humidity (RH) between the two systems (Leahy 2002; Short and Wheeler 2002b). Because local experience and thunderstorm forecast rules of thumb are based on a long history of stability indices computed from MSS RAOBs, and because the vertical profile of RH is a sensitive indicator of atmospheric stability, it is important that forecasters become familiar with any changes in humidity data that accompany the transition to AMPS RAOBs. The AMU was tasked to examine the RH differences in detail to evaluate the impact of the humidity differences on the diagnosis of atmospheric stability and thunderstorm indices.

A special data collection campaign was conducted at XMR during July and August 2002, resulting in 20 pairs of humidity and temperature profiles from balloon flights that carried both AMPS and MSS sensors. This warm-season campaign was designed to supplement the cool-season campaign that had been carried out earlier in the year and reported in Short and Wheeler (2002b). For the present task extension, Dr Short and Mr. Wheeler are performing a study of the 20 warm-season dual-sensor profiles to determine if the humidity differences seen during the cool season also occurred in the warm season. Dr. Short will also evaluate the impact of the observed humidity differences on thunderstorm forecasting indices used operationally by the 45 WS, SMG, and the National Weather Service Office at Melbourne, FL (NWS MLB).

Background

In the previous quarterly report (AMU Quarterly Report Fourth Quarter FY-02), Dr. Short and Mr. Wheeler reported that the pattern of RH differences in the dual-sensor profiles from July and August 2002 was similar to that in the January, February and April 2002 dual-sensor profiles. The AMPS RH averaged 5% greater than the MSS RH when the MSS RH was above 50%. Conversely, the AMPS RH averaged 10% lower for MSS values lower than 30%.

Comparison of Stability Indices

Individual profiles of temperature and humidity from the AMPS and MSS sensors were formatted for analysis by the GEneralized Meteorological PAcKage (GEMPAK). Pressure derived from AMPS height, temperature and humidity was used for both profiles, due to the lack of MSS derived pressure information in the dual-sensor configuration. Four stability indices that are used for thunderstorm forecasting by the 45 WS, SMG, and NWS MLB were computed for each profile: Showalter Index, Lifted Index, K-Index and Total Totals. Figure 4 shows scatter diagrams of the stability indices computed from the MSS and AMPS profiles of temperature and humidity. Cool and warm season data are included in each scatter diagram with triangles denoting July and August 2002 data (warm season) and Xs denoting January, February and April 2002 data (cool season).

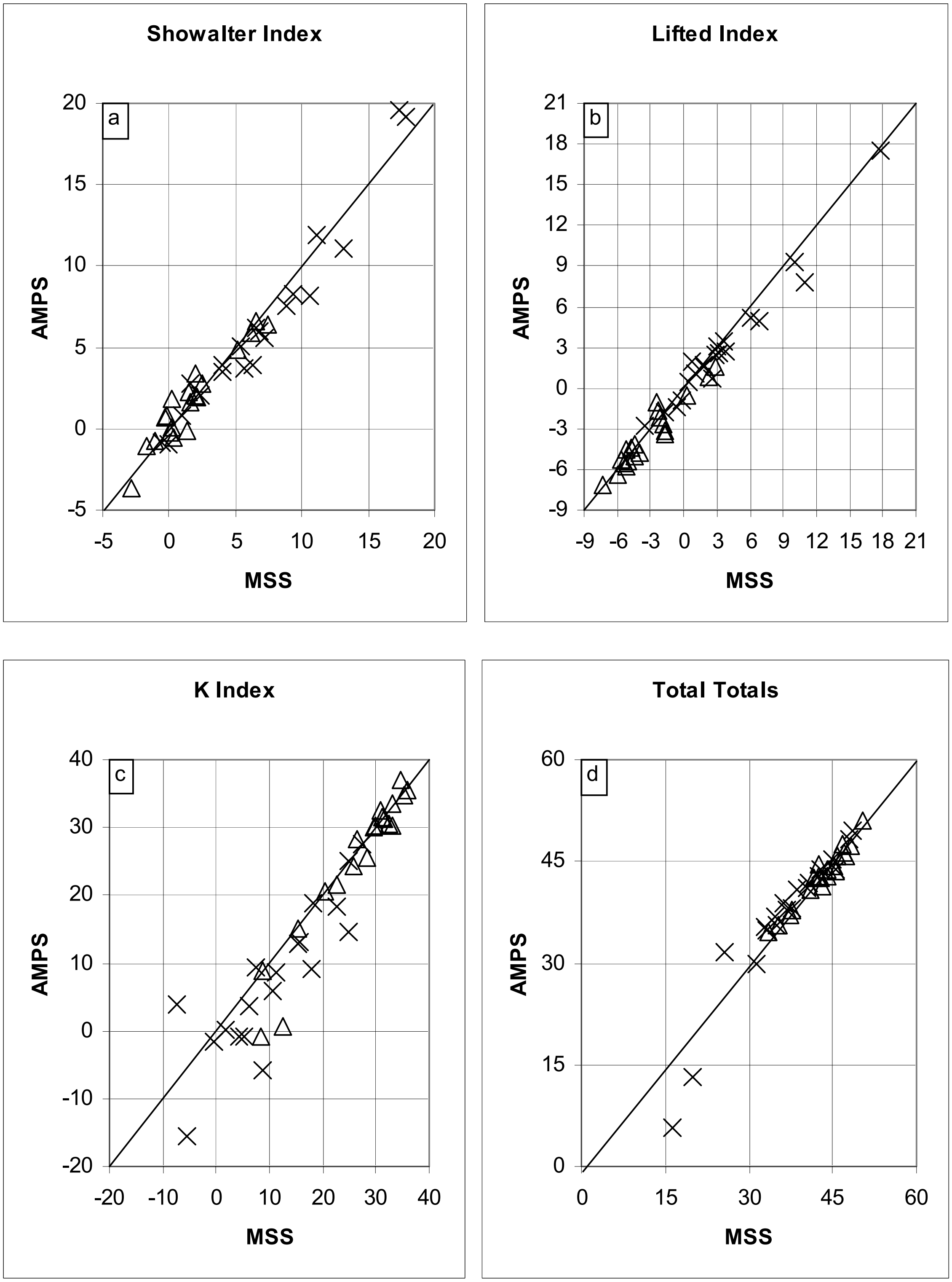

Figure 4. MSS thunderstorm forecasting indices versus AMPS indices for twenty dual-sensor profiles from July and August 2002 (Δ), and twenty dual-sensor profiles from January, February and April 2002 (X): a) Showalter Index; b) Lifted Index; c) K-Index; and d) Total Totals. A 1:1 ratio is indicated by the solid diagonal line in each panel.

The correlation between stability indices from the MSS and AMPS profiles is very high for all four panels shown in Figure 4: a) 0.97; b) 0.98; c) 0.95; d) 0.96. Points clustered near the 1:1 lines in the lower left-hand corners of Figure 4a and b indicate the prevalence of unstable conditions during the warm season (triangles) and an overall consistency between the Showalter and Lifted stability indices computed from AMPS and MSS RAOBs. Points clustered near the 1:1 lines in the upper right-hand corners of Figure 4c and d also indicate the prevalence of unstable conditions during the warm season (triangles) and an overall consistency between the K- and Total Totals stability indices computed from AMPS and MSS RAOBs.

The MSS and AMPS stability indices for the warm season display no clear evidence of small systematic biases that had been expected on the basis of projections from the cool season comparison. Bias adjustments of the following magnitude had been recommended on an interim basis, pending analysis of the warm season dual-sensor profiles: a) Add 1 to the Showalter Index; b) Add 1 to the Lifted Index; c) Subtract 2 from the K-Index; d) Subtract 1 from the Total Totals. However, the stability indices derived from the AMPS and MSS dual-sensor profiles during the warm season are virtually indistinguishable despite the systematic differences found in relative humidity and documented in the previous quarterly report. The following section presents additional insight into this unexpected and apparently paradoxical result by an analysis of temperature data from the two sensors.

Comparison of Temperature Differences Between MSS and AMPS

Initial analyses of cool season temperature differences between MSS and AMPS sensors had revealed apparent random deviations with a mean near zero and a standard deviation of about 0.3°C. However, a detailed analysis of warm season temperature differences has revealed a weak, but systematic, positive temperature difference that increases with increasing temperature. Figure 5 shows histograms of temperature differences between MSS and AMPS (MSS – AMPS) for three MSS temperature intervals ranging from –20°C to 40°C, each with a width of 20C°. It is apparent that MSS reads slightly higher than AMPS, on average, as the temperature increases above 0°C. The temperature differences affect stability indices through their influence on absolute humidity.

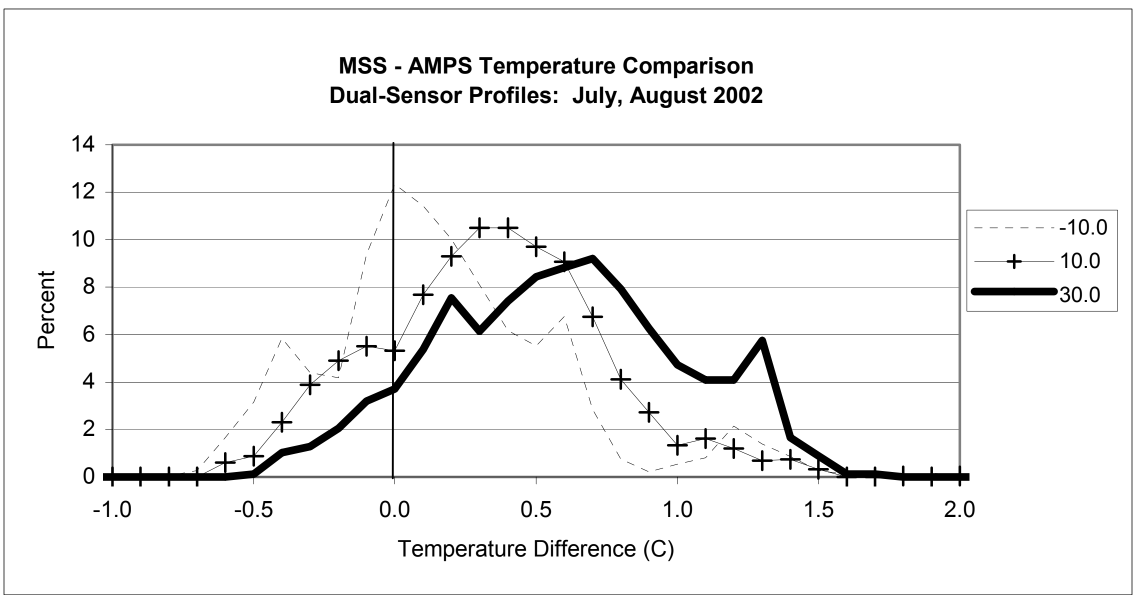

Figure 5. Histograms of temperature difference between the MSS and AMPS sensors (MSS – AMPS) as a function of MSS temperature. The dashed line is for MSS temperatures in the range of –20°C to 0°C. The thin solid line (+) is for MSS temperatures in the range of 0°C to 20°C. The heavy solid line is for MSS temperatures in the range from 20°C to 40°C. The legend shows the value on which each interval is centered.

Although relative humidity is measured directly by the MSS and AMPS sensors, measures of absolute humidity are actually required in the calculations of stability indices. Absolute humidity accounts for the mass of water vapor per unit mass of air and the latent heat of vaporization stored in the air. It is convective processes that lead to condensation, release of latent heat and destabilization of the atmosphere. Absolute humidity depends on a combination of relative humidity and temperature and is quite sensitive to small changes in temperature. For example, with a fixed RH, a 1C° increase in temperature from 30°C to 31°C increases the absolute humidity by 5.9% (Bolton 1980). As a result, with the AMPS RH reporting about 5% higher than MSS and the AMPS temperature reporting about 1C° lower than MSS, their absolute humidity and resulting atmospheric stability are about the same. This combination of factors has been observed in the dual-sensor profiles in the lower atmosphere, where humidity effects on atmospheric stability are most pronounced.

The analysis of warm season stability indices from dual-sensor flights of the MSS and AMPS sensors has shown no significant differences between them, even though systematic relative humidity differences exist, consistent with the analysis of cool season data. This apparent paradox is resolved by a weak temperature difference with the MSS reading slightly warmer than AMPS as the temperature increases. The weak positive temperature difference makes up for the relative humidity difference by its impact on absolute humidity, the more physically-based measure of potential atmospheric instability.

Because of these results, the AMU will revise its interim operational recommendations (Short and Wheeler 2002b) accordingly.

For more information on this work, contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com.

MINISODAR EVALUATION (DR. SHORT AND MR. WHEELER)

The Doppler miniSODAR™ System (DmSS) is an acoustic wind profiler from AeroVironment, Inc., that provides vertical profiles of wind speed and direction with high temporal and spatial resolution. The DmSS in this evaluation is a model 4000 system, configured to provide wind estimates every minute at 23 height levels from 15 to 125 m, or 49.2 to 410.1 ft, every 5 m, or 16.4 ft. The DmSS is a phased array system with 32 speaker elements that are used to form 3 beams for measuring orthogonal components of the wind field, 2 horizontal and 1 vertical. The Boeing Company installed a DmSS at SLC-37 as a substitute for a tall wind tower. It will be used to evaluate the launch pad winds for the new Evolved ELV during ground operations and to evaluate LCC during launch operations. In order to make critical Go/No Go launch decisions, the 45 WS LWOs and forecasters need to know the quality and reliability of DmSS data. The AMU was tasked to perform an objective comparison between the DmSS wind observations near SLC-37 and those from the nearest tall (≥ 204 ft) wind tower. The tall wind tower that is nearest to SLC-37 is Tower 6, a distance of 0.95 n mi to the south-southeast.

Effect of Maintenance on Data Availability

In mid-October 2002 the DmSS was checked out by the vendor to determine the cause of frequent anomalous peak wind speeds that had been noted by the 45 WS and the AMU. Several speaker elements in the phased array were replaced. Figure 6 shows a comparison of data availability before and after the maintenance. The fraction of missing observations near the 200-ft level improved from 18% to 3%. At the 98-ft level that the Delta LWO monitors during operations, the fraction of missing data improved from 3.9% to 0.8%. The general decreasing trend of data availability with height is characteristic of acoustic wind profiling systems (Crescenti 1997) as echo returns become weaker with increasing distance from the speaker array.

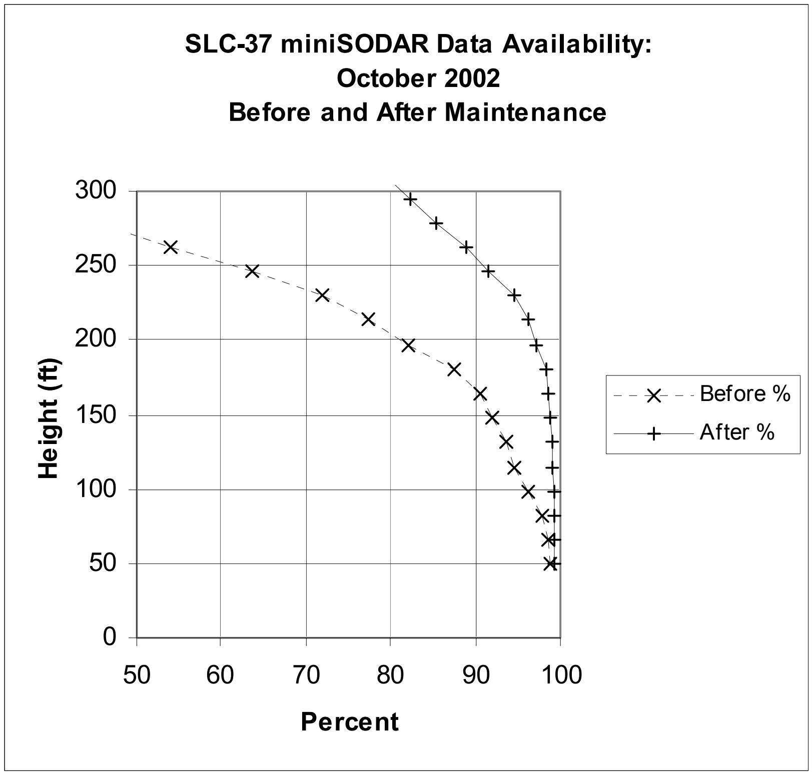

Figure 6. Vertical profile of data availability from the DmSS before (x) and after (+) maintenance in mid-October 2002. The minimum wind retrieval height is 49.2 ft (15 m).

Mission Immediate Analysis

During the Delta IV launch window on 19 November, the LWO called a No Go due to the peak wind speed observations in the DmSS exceeding the operational constraint. The 45 WS requested that the AMU conduct a Mission Immediate analysis of the DmSS and wind tower network wind speed data to determine if they were similar. The graphics of DmSS and nearby wind tower data shown in this section were prepared by Dr. Short and Mr. Wheeler within 24 hours after the event, allowing a timely analysis by the launch team.

Figure 7 shows a two-hour time series of 1-minute average wind speeds at the 98-ft level from the DmSS along with 1-minute average wind speeds from Tower 6 at the 54-ft and 162-ft levels of the northwest side (designated TWR61 in Figure 7). The northwest tower sensors were chosen by the LWO over the southeast sensors to be most representative because prevailing winds were from the north. The DmSS data were consistent with the wind tower data in terms of overall averages and degree of variability. Tower 6 shows an increase in average wind speed with height, consistent with the general trend of wind speed near the surface. Localized maxima and minima are poorly correlated, as expected, due to the distance between the sensors (about 0.95 n mi) and the turbulent nature of short-term wind speed variations.

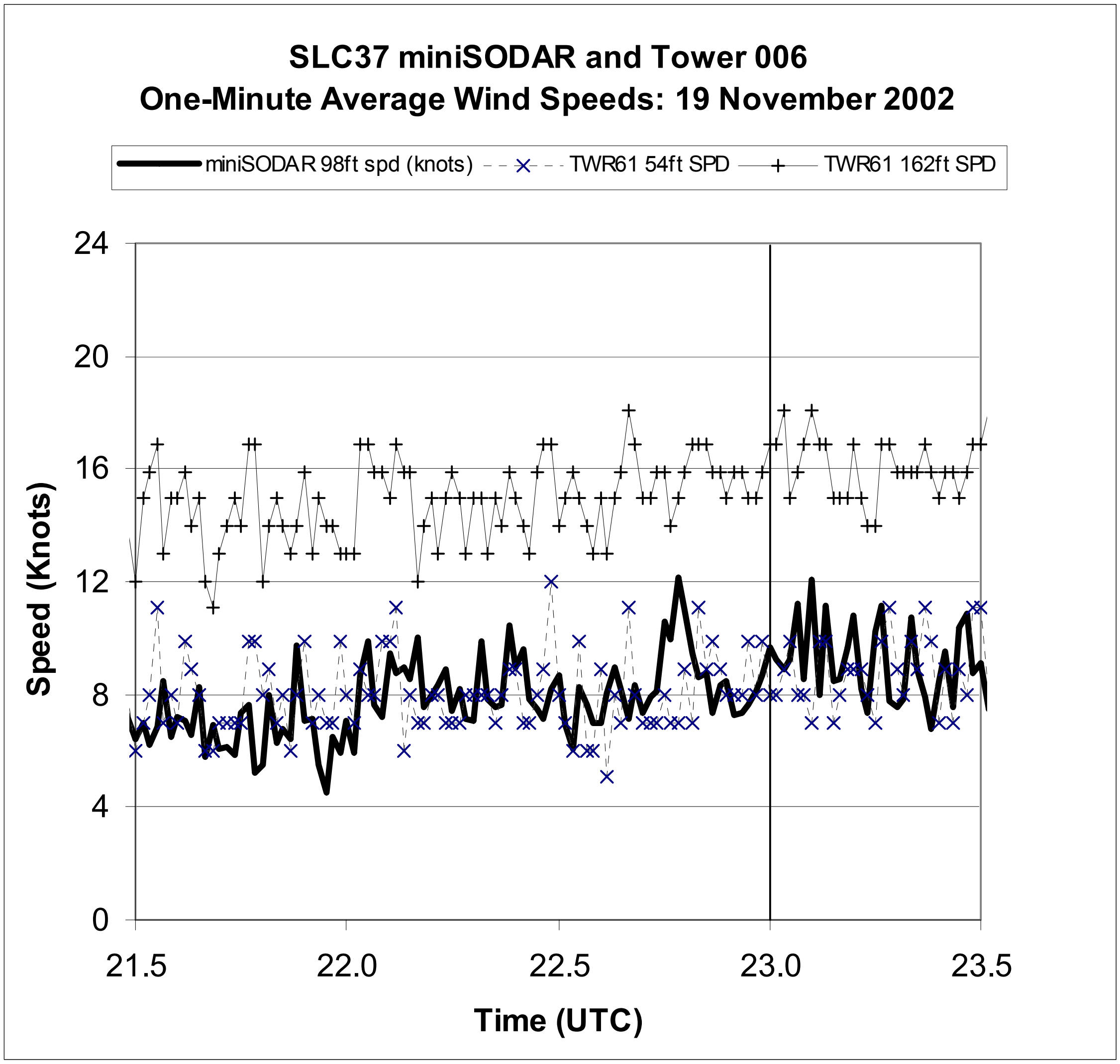

Figure 7. A two-hour time series of 1-minute average wind speeds from the 98-ft level of the DmSS (heavy solid line) and the 54-ft (X) and 162-ft (+) levels on the northwest side of Tower 6 (designated TWR61).

Figure 8 shows a two-hour time series of 1-minute peak wind speeds from the 98-ft level of the DmSS and the 54-ft and 162-ft levels on the northwest side of Tower 6. Weather launch constraints for this maiden flight of the new Delta IV launch vehicle required peak wind speeds less than 16 kts at the 98-ft level. The DmSS peak wind speeds were consistent with the tower data. Several DmSS peaks exceeding 16 knots occurred at and just after 2300 UTC. These peaks occurred within the launch window, resulting in a No Go call by the LWO.

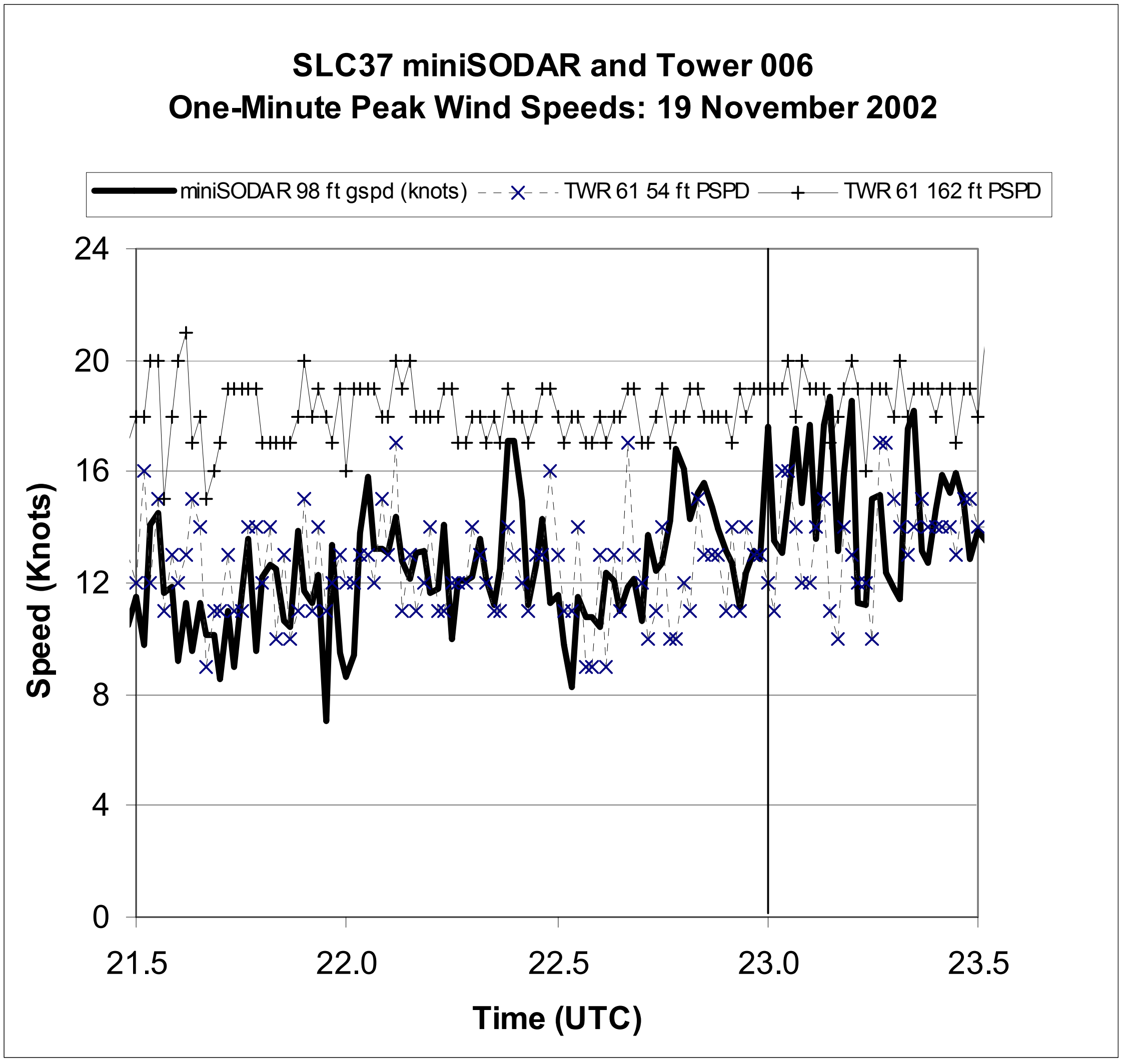

Figure 8. A two-hour time series of peak wind speeds within each minute from the 98-ft level of the DmSS (heavy solid line) and the 54-ft (X) and 162-ft (+) levels on the northwest side of Tower 6 (designated TWR61).

Table 2 presents a quantitative summary of wind speed statistics for the two-hour time series shown in Figures 7 and 8. The mean value of the DmSS average wind speed at the 98-ft level was 8.3 kts, identical to the value for the 54-ft level on Tower 6. The mean values of the peak wind speeds from the 98-ft level of the DmSS and the 54-ft level of the tower were nearly identical, at 13.0 and 12.9 kts, respectively. The standard deviations of average wind speeds were similar for the DmSS and tower, whereas the standard deviation of the peak wind speeds from the DmSS was somewhat higher. The higher degree of variability in the DmSS peak wind speed is visually evident in Figure 8. However, analysis of more data will be required to determine if this difference persists and if it is significant. Table 2 includes values of skewness and kurtosis, the 3rd and 4th moments respectively, further indicating indicate that the DmSS wind speed data were consistent with the tower data for this small sample.

Table 2. The 1-minute wind statistical moments for the average and peak wind speeds during 21:30 to 23:30 UTC, 19 November 2002.

Statistical Moment	***Tower 006 54 ft***		***Tower 006 162 ft***		***minSODAR 98 ft***	
	Average	*Peak*	*Average*	*Peak*	*Average*	*Peak*
Mean	8.3	12.9	15.4	18.4	8.3	13.0
StDev	1.5	1.8	1.5	1.1	1.6	2.4
Skewness	0.4	0.1	-0.3	-0.3	0.5	0.5
Kurtosis	-0.4	-0.3	-0.1	0.3	0.3	0.1

Despite the agreement between DmSS and tower data shown above, the AMU and 45 WS have noticed occasional high-speed outliers in the DmSS data, requiring the LWO to visually crosscheck for consistency with wind towers during operations. The AMU has relayed examples of high-speed outliers to the vendor and continues routine acquisition and detailed analysis of the DmSS database to improve understanding of their origin and to develop possible quality control procedures for removing them.

For more information on this work, contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com.

MESOSCALE MODELING

LOCAL DATA INTEGRATION SYSTEM OPTIMIZATION AND TRAINING EXTENSION (MR. CASE)

Both SMG and NWS MLB are running a real-time version of the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS) to integrate a wide variety of national- and local-scale observational data (Case et al. 2002). While the analyses have become more robust through the inclusion of additional local data sets and the modification of several adaptable parameters, further improvements are desired prior to configuring and initializing the ARPS model with ADAS analyses in future AMU tasks. In addition, limited training would facilitate the transfer of the ARPS/ADAS software configuration and maintenance responsibilities to the NWS MLB and SMG. As a result, the AMU is tasked to improve the real-time data ingest by improving the background fields, expanding the analysis domain, including additional data sets, and modifying the ingestion of selected data sets. Finally, the AMU will provide limited training to NWS MLB and SMG forecasters regarding the maintenance of data-ingest programs and adjustments to the local ADAS configuration.

Several modifications and improvements were made to the real-time ADAS configuration at NWS MLB. Specifically, these modifications consist of:

- Improvement in the configuration of the Rapid Update Cycle (RUC) model forecasts used as first-guess fields for the ADAS analyses,
- Changes in the usage and incorporation of Florida Automated Weather Network (FAWN) observations within ADAS, and
- Consolidation of the two nested analysis grids into a single, expanded grid to provide coverage across the entire Florida peninsula and to provide a configuration that will run the ARPS numerical weather prediction (NWP) model in real time, commensurate with the hardware acquired by NWS MLB.

In addition, Mr. Case began to prepare a training and reference document designed to assist NWS MLB and SMG with the maintenance and trouble-shooting of the real-time ADAS.

Improvements in the Usage of RUC First-Guess Forecasts

The prior real-time configuration at NWS MLB used 40-km RUC 3- to 6-hour forecasts, interpolated in both time and space and updated every 3 hours, as background or first-guess fields for the outer ADAS analysis grid with 10-km horizontal grid spacing (Figure 9a). The 10-km analysis grid was then interpolated to an inner nested grid over east-central Florida with 2-km grid spacing (Figure 9b), and served as the background field for the 2-km analysis. Both analyses were generated every 15 minutes by linearly interpolating in time the 40-km RUC 3- to 6-hour forecasts to the 10-km grid, at the valid time of the ADAS analysis. The NWS MLB requested two improvements to the configuration with respect to RUC data:

- Use 1- to 2-hour forecasts updated hourly rather than 3- to 6-hour forecasts updated every 3 hours to improve the quality of the background fields and reduce the errors associated with linear time interpolation of forecast fields,
- Use the full-resolution 20-km RUC grids rather than the RUC forecasts interpolated to the old 40-km RUC grid.

The limiting factor behind the feasibility of these changes was the available internet bandwidth at NWS MLB for downloading the full-resolution grids at more frequent time intervals. Based on the available bandwidth, it was determined that NWS MLB could not obtain the full-resolution 20-km RUC data every hour in a timely fashion; however, the 40-km RUC 1- to 2-hour forecasts could be obtained at the desired hourly interval. Therefore, Mr. Case assisted NWS MLB in transitioning the real-time ADAS configuration to the RUC 1- to 2-hour forecasts. The full-resolution RUC data will be acquired once NWS MLB obtains additional bandwidth necessary for downloading the larger 20-km RUC files.

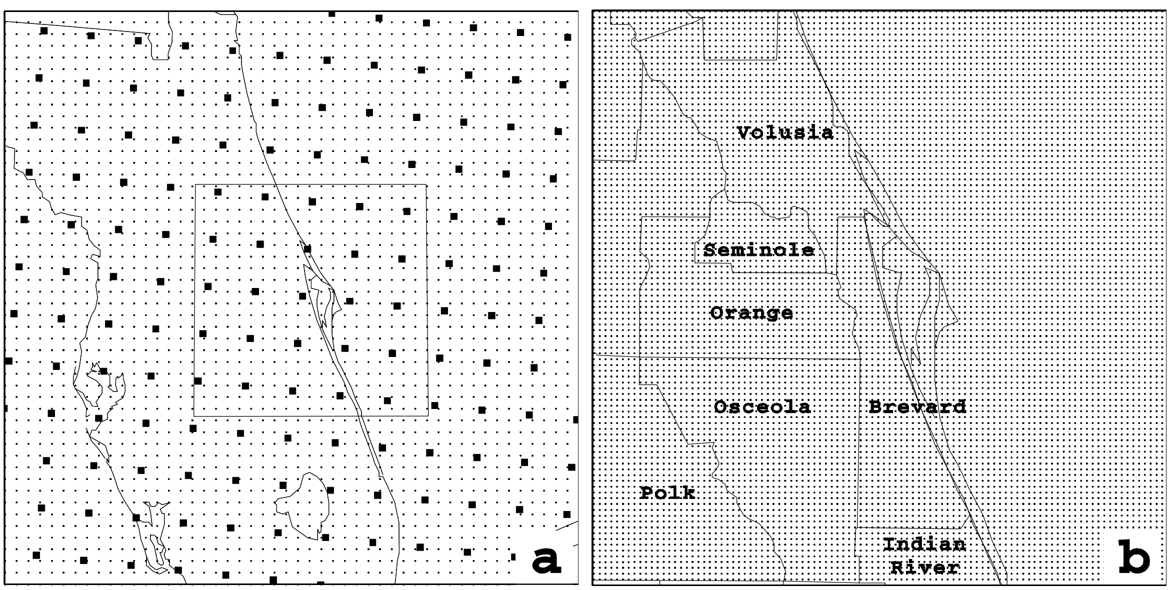

Figure 9. The ADAS domains for the 10-km grid and 2-km grid are depicted in panels a) and b), respectively. The 10-km grid point (small dots) and 40-km RUC grid point locations (solid squares) are shown in panel a) while the 2-km grid point locations (small dots) and county labels are shown in panel b). The boxed region in panel a) denotes the 2-km domain.

Changes in FAWN Data Ingest

The FAWN is a special network of automated weather instruments across Florida maintained by the University of Florida Institute of Food and Agricultural Sciences (see http://fawn.ifas.ufl.edu/). The FAWN currently consists of 26 surface stations that measure temperature, dew point, and winds; however, the instruments do not provide any surface pressure readings. The lack of pressure measurement is important because ADAS requires the conversion of temperature to potential temperature prior to analyzing surface observations, thus necessitating a surface pressure reading.

Due to this limitation, the AMU initially wrote the FAWN data-ingest program to treat the observations as mini soundings, in the same manner as the KSC/CCAFS tower observations, which also do not have near-surface pressure readings (except for two sites). Code was modified within ADAS to obtain first-guess pressure values at the sensor locations for sounding data in order to calculate potential temperature from the temperature measurements. The limitation in treating the FAWN observations as mini-soundings is that NWS MLB and SMG cannot manually exclude specific variables at sites that may consistently have data-quality problems — a feature of ADAS that is only available with surface-formatted observations.

Therefore, Mr. Case modified the FAWN data-ingest program to re-format FAWN observations as surface observations rather than mini-soundings. To overcome the missing pressure readings, Mr. Case developed a technique in the data converter to extract surface pressure estimates from the short-range RUC forecasts that provide first-guess information to ADAS. The RUC pressure estimates are then used to calculate potential temperatures at each observational site, allowing the analysis of FAWN surface temperature and moisture measurements. As discussed in the Local Data Integration System Phase IV memorandum, the resulting errors in potential temperature and specific humidity will be less than 1%, even in the most extreme instances. For example, a 5-mb error in the RUC forecast surface pressure (a very high estimate for 1- to 2-hour forecasts) would result in only a 0.14% error in potential temperature and a 0.50% error in specific humidity, using a temperature of 27°C at a pressure of 1010 mb.

Consolidation of Analysis Grids into a Single Expanded Grid

In preparation for running the ARPS NWP model in real-time at NWS MLB and to expand the analysis domain over the entire Florida peninsula, the AMU developed an expanded grid configuration for ADAS. The consensus between NWS MLB and the AMU was to transition to a single expanded analysis grid with 4-km horizontal grid spacing and increased vertical levels necessary for running the ARPS NWP model. The new grid configuration and resolution was designed to run the ARPS NWP model in real time, given the capabilities of the PC Linux cluster hardware recently acquired by NWS MLB. The run-time performance of the ARPS NWP model on the NWS MLB cluster was estimated based on ARPS benchmarks simulations conducted on the AMU's cluster, and a scaling comparison between the floating-point computation rates of each cluster. The domain of the expanded 4-km analysis grid is shown in Figure 10.

Figure 10. The NWS MLB 4-km ADAS domain with each grid point denoted by a small dot.

For more information on this work, contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com.

NEAR-STORM ENVIRONMENT TASK (MR. CASE)

The NWS MLB and SMG are running a real-time version of ADAS to integrate a wide-variety of national and local-scale observational data. Part of the analysis cycle generates graphical products that are used by forecasters and posted to the NWS MLB web page. To assist short-term severe-weather threat assessments across central Florida, the NWS MLB sought enhanced graphical products that include a suite of severe weather parameters in the GIF file format used by their web page. In addition, the NWS MLB requested assistance to transfer the graphical product generation onto a separate dedicated workstation to increase the number of graphical products generated, as well as to free up resources on the current workstation running the ADAS cycle.

Transfer of Graphics Generation to Dedicated Workstation

Part of the real-time ADAS analysis cycle at NWS MLB includes the generation of graphical products using the GEMPAK software. The GEMPAK software is used to contour, analyze, and animate primary and derived meteorological quantities and generate graphical products in GIF format that can be used by forecasters and posted to the NWS MLB web site. The system resources required to run GEMPAK and generate the products require processor time that is needed for the expanded ADAS 4-km domain.

The former ADAS analysis cycle at NWS MLB was run on a single dedicated workstation, which included all pre- and post-processing, as well as graphical generation using GEMPAK. Considering that a new ADAS analysis cycle starts every 15 minutes, this time constraint placed a restriction on the amount of graphics that could be generated each cycle. In some instances when extensive radar echoes were present, the ADAS analysis and graphics cycle could not complete within 15 minutes, preventing the subsequent analysis cycle from running. To prevent skipped analyses and to improve the run-time performance of the entire analysis/graphics cycle, the NWS MLB decided to transition the graphics generation to a separate dedicated workstation.

The AMU provided onsite technical assistance to the NWS MLB when transferring the graphical scripts to a separate workstation. The AMU and NWS MLB developed a technique to trigger graphics generation on the new workstation as soon as the analysis computations were completed on the ADAS workstation. This new workstation is currently devoted to only graphical generation so more system resources are available on the current ADAS operational workstation. As a result, the analysis cycle and graphics generation processes each have up to 15 minutes to complete, instead of 15 minutes for both procedures.

Severe Weather Assessment Fields

The AMU developed several UNIX shell scripts that currently run GEMPAK programs within the real-time analysis cycle in order to generate a suite of specific graphical products. These scripts can be tuned such that the NWS MLB can generate a wide variety of specific products based on their forecast requirements.

Severe weather parameters such as helicity, the bulk Richardson number, and moisture convergence are helpful to forecasters when generating short-range forecasts and severe weather threat assessments. Currently, several severe weather parameters are not available in the ADAS/GEMPAK files and/or cannot be readily derived by the GEMPAK software, particularly parameters such as helicity that depend on vertical shear calculations. However, as part of a recent collaborative effort to study the atmospheric features associated with Tropical Storm Gabrielle, the AMU modified code to compute shear-dependent fields during the ADAS post-processing conversion to GEMPAK format. The AMU provided this modified source code, assisted in the real-time implementation, and modified existing shell scripts to incorporate these fields and many new parameters for posting to the NWS MLB website.

For more information on this work, contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com.

VERIFICATION OF NUMERICAL WEATHER PREDICTION MODELS (DR. MANOBIANCO AND MR. CASE)

This project is an option-hours task funded by KSC under the Center Director's Discretionary Fund. It is a joint effort between the KSC Engineering Support Contractor, Dynacs, Inc., and the AMU. A key to improving mesoscale NWP models is the ability to evaluate the performance of high-resolution model configurations. Traditional objective evaluation methodologies developed for large-scale models cannot verify phenomenological forecasts from mesoscale models, and subjective manual alternatives are lengthy and expensive. New objective quantitative techniques are required for evaluating high-resolution, mesoscale NWP models. Therefore, in coordination with personnel from Dynacs, Inc., the AMU was tasked to develop advanced techniques for the objective evaluation of mesoscale NWP models currently employed or under development for Range use. Archived Regional Atmospheric Modeling System (RAMS) forecasts and KSC/CCAFS wind-tower observations will be used to develop the objective verification algorithms for the sea-breeze phenomenon. The verification of sea breezes was chosen because this phenomenon is predicted fairly well by RAMS and the sea-breeze boundary is often nearly linear and narrow in width, making the geometry simple.

Dr. Manobianco and Mr. Case continued to meet periodically with Dynacs Inc. representatives and the principle investigator, Dr. Merceret, to discuss progress on the Dynacs objective software and technique, named the Contour Error Map (CEM). Mr. Dianic and Mr. Case re-ran all daily RAMS forecasts, initialized at 1200 UTC, for the months of July and August 2000. These forecasts were re-generated in order to obtain a superior database that contained forecast output every 5 minutes, consistent with the temporal resolution of the KSC/CCAFS tower observations. The original RAMS output was archived only once per hour for these months, thereby limiting the precision of the CEM technique developed by Dynacs representatives. Mr. Case processed all 5-minute data for both months and sent the data to Dynacs for continued development of CEM and processing of results. Finally, Mr. Case began developing scripts to generate graphical images of the CEM results, including sea-breeze transition times and horizontal distributions of timing biases associated with the sea-breeze transition zones identified by CEM in the observed and forecast wind fields.

For more information on this work, contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com.

AMU CHIEF'S TECHNICAL ACTIVITIES (DR. MERCERET)

Dr. Merceret developed software to analyze the coherence length of electric field, radar, and cloud particle concentration measurements for the Airborne Field Mill (ABFM - Lightning Launch Commit Criteria) program. He participated in a joint meeting of the ABFM program science team and the Lightning Advisory Panel (LAP), where he presented his analyses of radar attenuation due to rainfall and discussed the coherence scales of radar, cloud physics and electric field data. Dr. Merceret also obtained information on the performance degradation of the hydrophobic coating on WSR-88D radomes as a function of time and on the maintenance procedures for renewing these coatings. The information was requested by the LAP.

AMU OPERATIONS

Mr. Wheeler began developing the Fiscal Year 2003 AMU equipment and software procurement plans. He researched equipment and software that would meet AMU requirements and requested quotes from several vendors. He then submitted a purchase request to the NASA procurement for the equipment. Mr. Wheeler also attended the annual McIDAS Users Group Meeting in Madison, WI.

Ms. Lambert attended the National Weather Association 27th Annual Meeting in Fort Worth, TX and presented two posters describing the results of the peak winds and land breeze forecasting tasks. She also began modifications to the AMU website to improve the appearance and make it easier to navigate the site.

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List of Acronyms

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
ABFM	Airborne Field Mill
ADAS	ARPS Data Analysis System
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMPS	Automated Meteorological Profiling System
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
CCAFS	Cape Canaveral Air Force Station
CEM	Contour Error Map
CSR	Computer Sciences Raytheon
DmSS	Doppler miniSODAR
ELV	Expendable Launch Vehicle
FAWN	Florida Automated Weather Network
FR	Flight Rule
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GEMPAK	Generalized Meteorological Package
GUI	Graphical User Interface
ITSS	Information Technology and Scientific Services
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAP	Lightning Advisory Panel
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
LRFE	Low Resolution Flight Element
LWO	Launch Weather Officer
McIDAS	Man Computer Interactive Data Access System
McBASI	McIDAS BASIC Language Interpreter
MRF	Medium Range Forecast
MSFC	Marshall Space Flight Center
MSS	Meteorological Sounding System
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWP	Numerical Weather Prediction
NWS MLB	National Weather Service in Melbourne, FL
PC	Personal Computer
QC	Quality Control
RAMS	Regional Atmospheric Modeling System

RAOB	Rawinsonde Observation
RH	Relative Humidity
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
SLC-37	Space Launch Complex 37
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SRH	NWS Southern Region Headquarters
USAF	United States Air Force
UTC	Universal Coordinated Time
WWW	World Wide Web
XMR	CCAFS 3-letter identifier

Appendix A

AMU Project Schedule 31 January 2003				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Statistical Forecast Guidance (Peak Winds)	Determine predictand(s)	Aug 01	Aug 01	Completed
	Data reduction, formulation and method selection	Sep 01	Mar 02	Completed
	Equation development, tests with independent data and individual cases	Mar 02	May 02	Completed
	Prepare products, final report for distribution	May 02	Oct 02	Completed
Land Breeze Forecasting	Data collection, data reduction, and QC	Aug 01	Nov 01	Completed
	Identification and analysis of case studies	Sep 01	Nov 01	Completed
	Development of land-breeze climatology	Dec 01	Apr 02 Sep 02	Completed Completed
	Development of forecast rules of thumb / automated tool	Apr 02	Jul 02	Completed
	Final report with forecasting rules of thumb	Jul 02	Oct 02	Completed
Improved Anvil Forecasting Phase III	Algorithm formulation and testing	Aug 02	Nov 02	Completed
	Memorandum	Dec 02	Dec 02	Completed
Extend Statistical Forecast Guidance to the SLF Towers	Create climatologies / determine theoretical distribution for 10-min peaks	Sep 02	Oct 02	Completed
	Develop PC-based tool to display climatologies and probabilities	Oct 02	Mar 03	On Schedule
	Prepare products, final report for distribution	Mar 03	May 03	On Schedule
Extend AMPS Moisture Analysis	Data collection, data reduction, and QC	Aug 02	Sep 02	Completed
	Analysis of humidity differences and impact on thunderstorm forecasting indices	Sep 02	Jan 03	On Schedule
	Memorandum	Feb 03	Apr 03	On Schedule

AMU Project Schedule 31 January 2003				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
MiniSODAR Evaluation	Data collection, data reduction, and QC	Aug 02	Jul 03	On Schedule
	Comparative analysis of miniSODAR and nearby wind tower observations	Sep 02	Jul 03	On Schedule
	Final Report	Jul 03	Sep 03	On Schedule
KSC-Funded Verification of Mesoscale NWP Models	Literature review	Mar 02	Mar 02	Completed
	Develop objective sea-breeze boundary detection algorithm	Apr 02	Aug 02	Completed
	Objective verification of RAMS sea-breeze boundaries	May 02	Jan 03	Delayed 1 Month to Finalize Method
	Final report/Journal publications	Jan 03	Mar 03	On Schedule
LDIS Optimization and Training Extension	Expand outer analysis grid at NWS MLB	Aug 02	Jan 03	Delayed 1 Month to Address Expanded Grid Problems
	Revise data ingest programs	Sep 02	Dec 02	Completed
	Training to SMG and NWS MLB personnel	Oct 02	Jan 03	Delayed 1 Month to Address Expanded Grid Problems
	Provide recommendations for implementing new features in ADAS	Oct 02	Jan 03	Delayed 1 Month to Address Expanded Grid Problems
	Memorandum	Dec 02	Jan 03	Delayed 1 Month to Address Expanded Grid Problems
Near-Storm Environment	Transfer graphics generation to a separate workstation at NWS MLB	Sep 02	Oct 02	Completed
	Develop enhanced severe-weather graphics scripts	Oct 02	Dec 02	Completed
	Memorandum	Dec 02	Dec 02	Completed

NOTICE