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Applied Meteorology Unit (AMU)

Quarterly Report

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EXECUTIVE SUMMARY

This report summarizes the Applied Meteorology Unit (AMU) activities for the second quarter of Fiscal Year 2002 (January − March 2002). A detailed project schedule is included in the Appendix. Significant progress was made on four main AMU tasks this quarter.

<u>Task</u> <u>Improved Anvil Forecasting Phase II</u>

Goal Develop an anvil-forecasting tool to aid forecasters in predicting the probability of violating the triggered lightning Launch Commit Criteria and Space Shuttle Flight Rules.

Milestones Completed refinement and testing of the forecast tool that graphically displays an anvil threat corridor on a satellite image.

Discussion Customer feedback during demonstration sessions led to changes that streamline the execution of the forecast tool and that will allow its transition to operations with minimal modifications.

<u>Task</u> <u>Statistical Short-Range Forecast Tools</u>

Goal Develop short-range peak winds forecast equations for use in support of launch and landing operations.

Milestones Developed a method for determining the probability of exceeding specified peak wind values given the average wind speed.

Discussion The distributions of the peak winds show a trend with increasing average wind. When the number of observations for a particular average wind is small the distributions no longer follow that trend. These errant distributions can be estimated properly by fitting a curve to the good distributions, then using the curve's equation to estimate the distributions for the smaller sample sizes. This would provide forecasters reasonable probabilities of peak wind events.

<u>Task</u> <u>Land Breeze Forecasting</u>

Goal Develop rules of thumb that will improve the reliability of the land-breeze occurrence forecasts and help determine land-breeze timing, direction, and strength.

Milestones Developed an objective, automated method to identify land-breeze boundaries from 5-minute wind tower observations.

Discussion The new method identified 257 land-breeze events in east-central Florida during the 1995 - 2002 cool seasons. A climatology of these events shows several aspects of the local land breeze such as: 1) land breezes were most common in the late winter and spring, 2) nights with land breezes had more fog reports at the Shuttle Landing Facility, and 3) the temperature and stability changes varied for land breezes moving in from different directions.

<u>Task</u> <u>AMPS Moisture Profiles</u>

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

Milestones Obtained 21 AMPS and MSS profiles collected in January and February 2002, and began conducting analyses on the humidity profiles.

Discussion AMPS is scheduled to replace MSS in the near future. Differences in the humidity profiles between the two systems may cause differences in the indices used to make thunderstorm forecasts. Because the local thunderstorm forecast rules of thumb are based on the indices computed from MSS data, it is important that forecasters are made aware of any changes that would impact their thunderstorm forecasts.

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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.merceret-1@ksc.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

STATISTICAL SHORT-RANGE FORECAST TOOLS (MS. LAMBERT)

The peak winds are an important forecast element for both the Space Shuttle and Expendable Launch Vehicle (ELV) programs. As defined in the Shuttle Flight Rules (FR) and the Launch Commit Criteria (LCC), 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 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast. The goal of this task is to develop short-range peak-wind forecast tools to be used in support of ELV/Shuttle launches and Shuttle landings. Ms. Lambert will use seven years (January 1995 – December 2001) of 5-min data from the Kennedy Space Center/Cape Canaveral Air Force Station (KSC/CCAFS) wind tower network and any other appropriate data sets to develop a statistical short-term forecast method for peak winds at the specific tower sites shown in Table 1.

Table 1. The towers and heights at which peak winds forecasts will be made, and their associated launch or landing operation.

Launch Operation	***Tower(s)***	***Primary Height (ft)***	***Backup Height (ft)***
Shuttle	0393/94, 0397/98	60	N/A
Shuttle (*landing*)	511 / 512 / 513 313	30 492	N/A N/A
Atlas	36	90	N/A
Delta	20 / 21	90	54
Titan	1101 / 1102	162	54

Climatology as a Predictor

As was shown in the previous AMU Quarterly Report (First Quarter FY-02), the monthly wind speed and direction climatologies provide valuable information about the average behavior of the winds at each of the towers and heights of interest. Therefore, the peak wind climatology and observed values at a single tower and height were examined for their utility in making short-term peak wind forecasts at that tower and height.

Figure 1 shows the 5-min peak wind observations over a 48-hour period from 1 - 3 January 1996 along with the January climatology for the same hours. Note the large variability in the time series of the peak wind observations and in the trends of the values. The climatology does show a diurnal variation in the speeds which can be useful to forecasters. However, it cannot capture the observed ranges of values and their trends on a given day because values have been smoothed out in the average calculation. Therefore, the climatological values would be of very limited use in the development of forecast equations. The variability in the observations also makes them less viable candidates for predictors of future values.

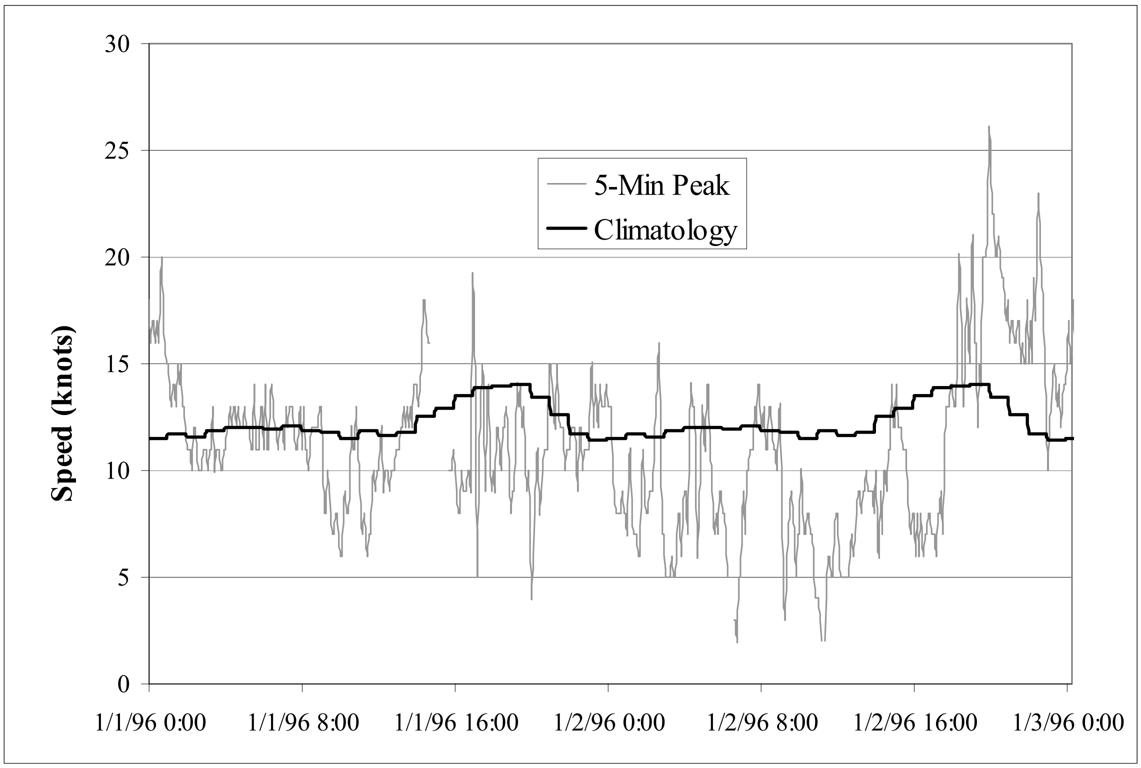

Figure 1. Time series of 5-min peak winds in the 48-hour period from 0000 UTC 1 January to 0000 UTC 3 January 1996 (gray line) overlaid with the hourly climatology values for January (black line) from Tower 36/90 ft.

After examining several time series and reaching similar conclusions, the plan to use single-station data to develop the forecast equations was dropped. More advanced techniques using data from multiple towers and levels, model point forecasts, surface observations, and other data types would be needed to develop a reliable peak wind forecast method.

Peak Wind Distributions

One of the goals of this task is to develop a method that will determine the probability of the peak wind speed exceeding a certain threshold value. Ms. Lambert began by determining these probabilities for the 5-min peak winds based on the 5-min average winds. Although purely diagnostic, it is an important first step in developing forecast methods to determine the behavior of peak winds with changes in wind speed. Currently, the gust factor method (McVehil and Camnitz 1969) estimates a single peak wind speed value based on the current average wind speed. The method described here goes one step further by determining the probability of reaching and exceeding specific peak wind speeds based on the current average wind speed.

Using the S-PLUS® software (Insightful Corp. 2000), Ms. Lambert created peak wind speed distributions for every 1 knot in the 5-min average wind speeds. She then calculated the probability density functions (PDFs) for each of the distributions. The PDFs for Tower 397 at 60 ft in January are shown in Figure 2. Each curve represents the range of peak wind values associated with a specific 5-min average value (legend in Figure 2). The value on the y-axis can be interpreted as the fraction of events with a particular peak speed for a given 5-min average speed. The sum of each value along the PDF curve is 1. To determine the probability of exceeding a certain peak value, one would simply integrate under the curve from the value of interest forward. Using the values in Figure 2, the probability of exceeding 15 knots when the average speed is 10 knots (solid line with solid diamonds) is 0.34, or 34%.

An obvious feature in Figure 2 is that the height and width of the PDFs decrease and increase, respectively, with increasing average speed in a consistent manner. When average speed reaches 19 knots, however, the PDFs no longer have a continuous shape nor continue the height/width trend of the previous PDFs. The number of observations used to calculate these PDFs was less than 600, with that number dropping quickly from 382 at 19 knots to 22 at 25 knots. This indicates that at least 600 samples are needed to develop representative distributions. The gray curves in Figure 2 show which PDFs were calculated with less than 600 samples. The maximum number of samples was 5100 for the 7-knot average speed. Clearly, the PDFs for the higher average winds must be estimated in order to calculate reliable probabilities of exceeding certain peak wind speed values.

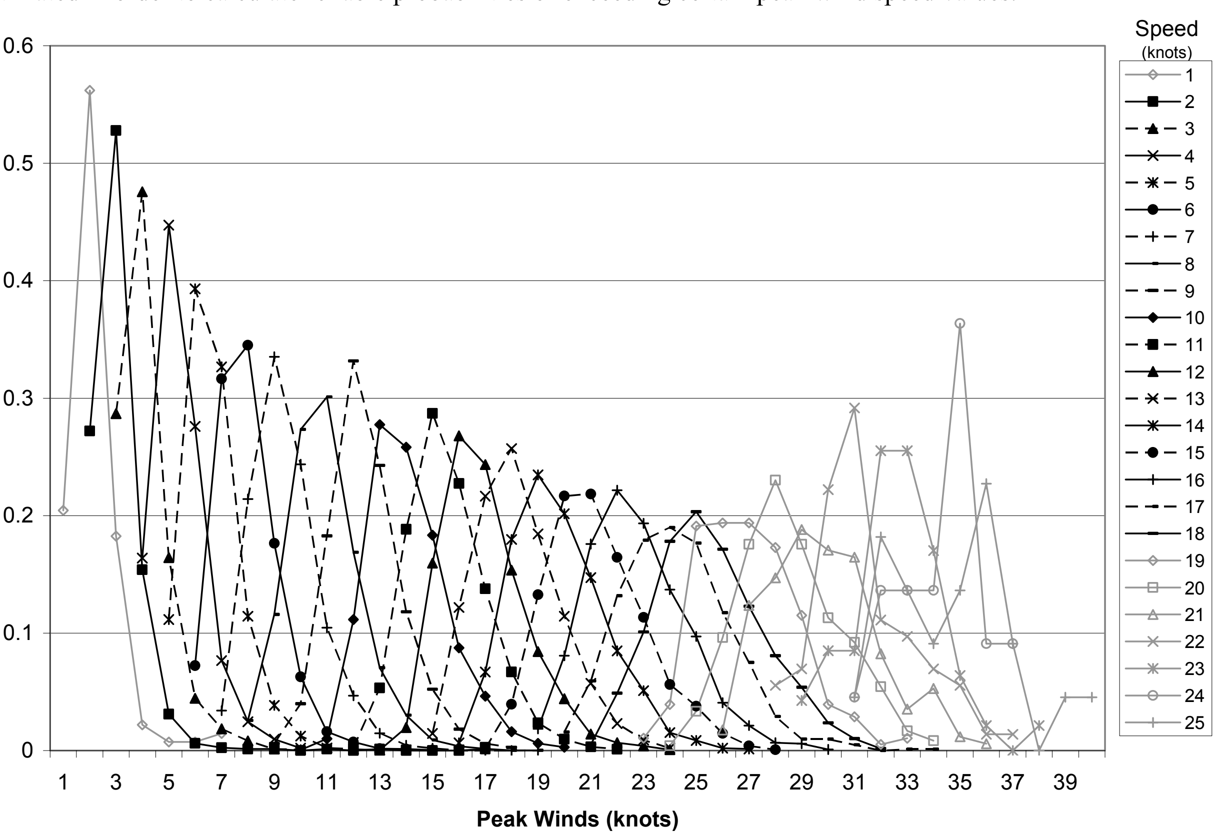

Figure 2. Probability density functions (PDFs) of the January peak wind speed distributions associated with each 5-min average wind speed (see legend) from 1-25 knots at Tower 397/60 ft. The gray PDFs were calculated from distributions with less than 600 observations. The legend shows the 5-min average speeds associated with each PDF. The black PDFs alternate solid and dashed lines to make them easier to distinguish. The value on the y-axis is the fraction of events for a particular peak speed.

The results of several tests indicate that the PDFs resemble the Weibull distribution (Wilks 1995). Just as the mean and standard deviation describe a Gaussian distribution, the shape and scale parameters describe a Weibull distribution. The shape parameter determines the location of the maximum probability in the distribution. As the shape increases the location of the maximum shifts to the right. The effect of the scale parameter is to stretch/compress the PDF horizontally, thereby also compressing/stretching it vertically. As the scale parameter goes to 0, the PDF appears as a spike, and as the scale parameter increases the PDF becomes more flat. Figure 3 shows the shape and scale parameter values for the PDFs in Figure 2. Both of these values increase with average speed, although the shape increases more slowly. These values are consistent with the PDF curves in Figure 2. The PDFs become shorter and wider as the scale increases, and the maximum PDF value shifts to the right in the distribution as the shape increases.

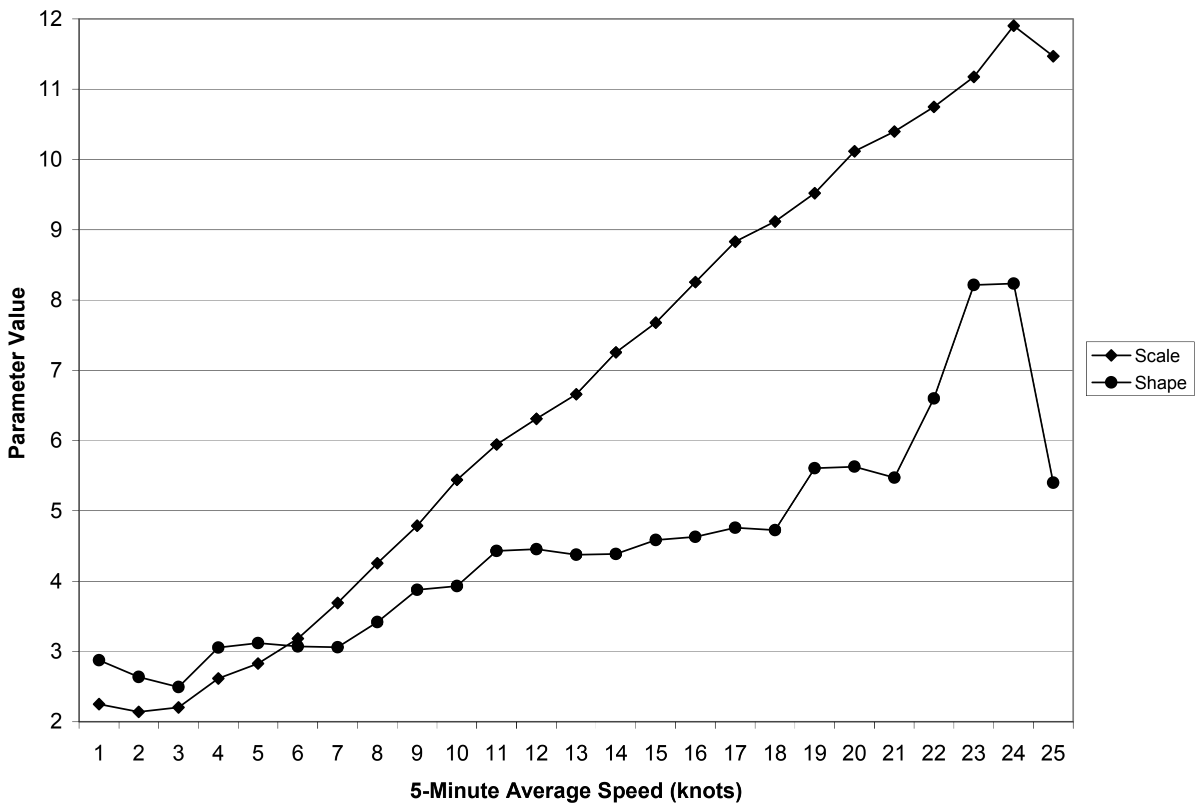

Figure 3. The Weibull scale and shape parameter values for the peak wind speed PDFs (see Figure 2) based on the January 5-min average wind speeds from 1-25 knots at Tower 397/60 ft.

The scale parameter curve in Figure 3 has a continuous and increasing trend with average wind speed that can be modeled easily by a linear or curvilinear regression technique. The scale values at 1 and 25 knots are questionable as they are inconsistent with this trend, but, as indicated in Figure 2, less than 600 observations were available to create the distributions at these speeds. As stated and shown previously, the PDFs for the average speeds 19 knots and higher do not follow the trends of the PDFs of lower speeds, probably due to small sample sizes. The trend in the scale parameter is continuous through these higher speed values and appears valid. However, an abrupt change in the trend of the shape parameter occurs at 19 knots and above. That this change occurs at the point where the sample size decreases below 600 could indicate that any parameter values for such sample sizes are not reliable. Another possibility is that the stronger winds are from different populations such as frontal passages, convective gust fronts, and high momentum air penetrating from above the inversion level. Their distributions may be something other than Weibull, but the sample sizes are too small to determine the actual distribution. Therefore, it is assumed that their distributions are Weibull, and only the parameter values whose underlying sample size is ≥ 600 will be used to create the regression equations. The parameters will be calculated as a function of 5-min average wind speed in the equations. The appropriate shape and scale parameters associated with each 5-min average speed, including those with small samples, can then be estimated from the equations. The new Weibull parameters will be used to create peak wind distributions for each average speed, from which probabilities of occurrence can be calculated.

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

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

The 45 WS Launch Weather Officers (LWOs) have identified anvil forecasting as one of their most challenging tasks when attempting to predict the probability of an LCC violation due to a threat of natural and triggered lightning. SMG forecasters have reiterated this difficulty when evaluating Space Shuttle FR. Phase I of this task (Lambert 2000) established the technical feasibility of developing an observations-based forecasting technique, given the promising relationships found by the 45 WS between anvil length and lifetime and the average wind speed/direction and moisture content in the anvil layer. The goals of Phase II are to 1) build upon the results of Phase I with data collection and analysis to increase the sample size of anvil cases and improve the reliability of resulting statistics, and 2) develop objective graphical tools for forecasting the occurrence of anvil clouds over the KSC/CCAFS area with lead times of 36 hours or less.

Testing and Refinement of Prototype Forecast Tool for Operational Use

Dr. Short and Mr. Wheeler developed a prototype graphical tool for short-term forecasting of anvil clouds. The tool overlays an anvil threat sector on a satellite image, indicating the direction and distance from which anvil clouds could threaten the station within the next three hours. Dr. Short and Mr. Wheeler accelerated the refinement and testing of the prototype forecast tool for operational use in response to customer input. The 45 WS, SMG and the National Weather Service in Melbourne, FL (NWS MLB) requested implementation of the short-term forecast tool in the operational environment for familiarization before further development in a Phase III task is considered.

Additional customer input was obtained from the 45 WS during demonstration sessions conducted on the Meteorological Interactive Data Display System (MIDDS) in the AMU. The prototype anvil forecast tool is executed on MIDDS by issuing a single-line command on the Man Computer Interactive Data Analysis System (McIDAS). The McIDAS command then automatically runs an AMU script file that analyzes current upper-wind data and plots the anvil threat sector for a user-selected station. The AMU MIDDS configuration is compatible with that in the Range Weather Operations (RWO), so that the script file that runs the forecast tool can be transitioned with minimal changes from the AMU to the RWO. In addition, the transitioning of the AMU script file onto the operational system will not require range certification.

In response to customer feedback obtained during the demonstration sessions, Dr. Short and Mr. Wheeler made modifications to the AMU script file that executes the prototype tool to streamline its execution on the MIDDS. Mr. Wheeler also added a data ingest section that handles the Automated Meteorological Profiling System (AMPS) format. AMPS is scheduled to replace the Meteorological Sounding System (MSS) in the near future. In order to obtain an independent test of the prototype forecast tool, Mr. Wheeler sent the AMU script file to Mr. Oram at SMG for testing on their MIDDS. Mr. Oram reported that the tool ran on their system with no difficulties encountered.

Reports

Dr. Short and Mr. Wheeler submitted an overview of the task to the 2002 KSC Research and Technology Report. The overview will be presented in a section that highlights Range Technologies currently in development at KSC. The Phase II Final Report has been reviewed internally by the AMU, revised and externally by the 45 WS, SMG and NWS MLB. The completed version is scheduled for distribution at the end of April 2002.

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.

LAND BREEZE FORECASTING (MR. CASE)

The onset of a nocturnal land breeze at KSC, CCAFS, and Patrick Air Force Base is an operationally significant event. The occurrence and timing of the land breeze at night affects low-temperature and fog forecasts, and is especially critical for toxic material dispersion forecasts during hazardous operations. With current tools, 45 WS forecasters are able to predict the occurrence of a land breeze for a particular night reasonably well, but find it challenging to forecast the timing. As a result, the 45 WS has tasked the AMU to develop rules of thumb that will improve the reliability of the occurrence forecasts, and help determine the timing of land-breeze occurrences. These rules of thumb will include guidance on the duration, speed, and approximate direction of the winds associated with the land breeze.

Land-Breeze Climatology

The first portion of this task involved developing a land-breeze climatology for east-central Florida to understand the characteristics of the land breeze. The initial effort towards building the climatology was a subjective classification of events from the 1999 – 2000 cool season, as discussed in the previous AMU Quarterly Report (First Quarter FY-02). The 1999 – 2000 cool season was chosen because the AMU had already documented all frontal/trough passages during these months as part of a previous model verification task.

The subjective, manual classification of all land-breeze events over several years is a labor-intensive task. Therefore, Mr. Case developed an objective, computer-based method that identifies land-breeze events while distinguishing them from other boundaries such as fronts or precipitation outflow. The following sub-sections describe the methodology used to develop the robust, objective land-breeze identification algorithm, and the preliminary 7-year climatology for the months of October to May. The results from this climatology will serve as a foundation for developing forecast rules to improve predictions of the onset time, strength, and movement of land breezes over KSC/CCAFS.

Methodology

The period of record for the climatology spans from February 1995 to January 2002 and excludes the peak convective months of June to September. The starting month of February 1995 was chosen based on a format change in the archived wind-tower data at that time. All KSC/CCAFS wind-tower data were quality controlled prior to processing for the land-breeze climatology, using the five routines described in the Statistical Short-Range Forecast Tools section of the previous AMU Quarterly Report (First Quarter FY-02).

The algorithm was designed to identify as many land-breeze events as possible with a near zero false alarm rate (FAR). The algorithm was developed using the 1999 – 2000 cool season data, attempting to match the results of the subjective land-breeze classification. The program was then tested on the 1995 – 1996 season data and results were validated by a subjective examination of each day that the program classified a land breeze. Additional adjustments to the algorithm were made to remove false alarms.

The algorithm identifies land-breeze boundaries from an analysis grid based on a distinct shift between onshore and offshore wind directions, and tracks the boundary features across the grid. First, the data were analyzed objectively to a grid with 1.25-km horizontal grid spacing using the Barnes (1964) technique and an average station spacing of 6 km. The temperature and dew point temperature at 6 ft, and temperature, and u-/v-wind components at 54 ft are analyzed to the grid every 5 minutes. Next, the program reads in the gridded data and computes the wind direction from the u-/v-wind components at each grid point in order to define a boundary separating onshore versus offshore winds.

Prior to identifying and analyzing the movement of boundaries, several rules are applied to remove from consideration any nights that experienced meteorological conditions unfavorable for land-breeze development, or had too much missing data. The computer program subsequently ignores nights in which any of the conditions listed in Table 2 occurred.

Table 2. A list of the meteorological and data conditions that warrant a night to be removed from consideration for a land breeze in the objective land-breeze identification program.	
Condition	***Reason(s) for Rejection***
1) Presence of a trough in archived mean sea level pressure (MSLP) data.	Prevent the identification of a wind shift associated with a frontal or trough passage.
2) Large MSLP changes (> 5.0 mb in 13 hours) at the Shuttle Landing Facility (TTS).	Prevent the identification of a wind shift associated with a frontal or trough passage.
3) Any report of precipitation at TTS between 0000 and 1300 UTC.	a) Avoid the identification of outflow boundaries. b) Occurrence of precipitation is highly unfavorable for land-breeze development.
4) More than 7 out of 14 hourly reports of cloud ceilings at TTS.	Insufficient radiational cooling for a land breeze to develop.
5) More than 5 out of a possible 14 TTS cloud reports missing.	Prevents the adequate determination of sufficiently clear skies, via condition 4.
6) Mean nighttime, domain-wide 54-ft wind greater than 3.8 m s^{-1}.	Wind speeds too strong for development of a land breeze. This upper threshold was determined from the subjective results of the 1999 – 2000 cool season, using the mean speed plus two standard deviations. This threshold exceeded the mean speed for all classified land-breeze events from the 1999 – 2000 cool season.
7) More than 4% of 5-minute wind-tower data missing between 0000 and 1300 UTC.	Too much missing data, preventing adequate temporal continuity for tracking boundaries in the program.

Boundary zones are identified according to wind-direction changes of at least 20° across a 2.5-km distance, where the wind direction is onshore (offshore) on the seaward (landward) side of the boundary. Onshore (offshore) winds are given by wind directions greater than 335° (180°) and less than or equal to 180°. These wind direction thresholds were chosen for two reasons. First, the coastline of east-central Florida is oriented approximately NNW to SSE (335° – 155°) north of the tip of Cape Canaveral. Second, 180° rather than 155° was used to accommodate for the change in the coastline orientation to the south of the tip and for the common inertial oscillation of winds (dominance of the Coriolis force) over central Florida. When subjectively analyzing land breezes during the 1999 – 2000 developmental season, many land-breeze nights had a gradual veering of the wind direction to southerly prior to the passage of the land-breeze front. This behavior is caused by the inertial oscillation, resulting in a nearly 360° clockwise turning of the wind direction in 24 hours under benign weather conditions (Zhong and Takle 1992).

Once the boundary points are flagged in the analysis grid, the land-breeze start and stop times are identified based on time and space continuity and a minimum mean eastward movement of at least 7.5 km. The start time is considered the onset time of the land breeze, or the time at which the program first identifies the boundary in the grid analysis domain. The stop time is the last time when the boundary is identified in the analysis domain. To ensure temporal continuity, the boundary must be present at every 5-minute analysis time between the start and stop times.

Finally, the meteorological data are archived for all identified land-breeze events at each individual wind tower location (see Table 3 for quantities archived). To determine which wind towers experienced a land-breeze passage, the program examines 5-minute time-series data at the analysis grid point nearest to each wind tower. If the algorithm identifies a shift and maintenance from onshore to offshore winds, along with a change in wind direction of at least 20°, then the wind tower is considered to have experienced a land-breeze passage. These data are then composited to determine the typical behavior of land breezes during this 7-year climatology.

Table 3. A list of the data archived for each land-breeze event to create a composite for the land-breeze climatology.	
Quantity	***Archive characteristics***
Date.*	Year, month, and day.
Start and stop times.	Time in UTC.
Percentage of towers experiencing the land-breeze event.	Ratio of the number of towers experiencing a land-breeze passage to the total number of towers available for the grid analysis.
Number of hourly TTS fog observations.*	Number of fog reports out of a possible 14.
6-ft and 54-ft temperatures.	5-minute time-series (±60 minutes) of all tower grid-point locations that experienced a land-breeze passage.
6-ft dew point temperature and relative humidity.	5-minute time-series (±60 minutes) of all tower grid-point locations that experienced a land-breeze passage.
Wind direction change (absolute value).	5-minute time-series (±60 minutes) of all tower grid-point locations that experienced a land-breeze passage.
Wind speed.	5-minute time-series (±60 minutes) of all tower grid-point locations that experienced a land-breeze passage.

*These parameters are archived for both land breeze and non-land breeze days.

Preliminary Results

The program generally underestimated the total number of land-breeze events on the test season [probability of detection (POD) of 68%] since it was designed to have a near zero FAR. However, the low POD for the 1999 – 2000 developmental season could have been caused by Range Standardization and Automation testing that was performed on the wind tower network leading to frequent periods of missing data at several sites throughout the season. The subsequent analyses experienced periodic discontinuities and coverage gaps due to this missing data. As a result, many land-breeze events identified subjectively could not be classified objectively due to the missing data.

The algorithm identified 257 land-breeze events during the 7-year period. The monthly distribution of these events is shown in Figure 4a. The monthly frequency peaks in April and reaches a minimum in December. The likely reasons why land-breeze frequency peaked in April is due to the prevalence of a surface high pressure ridge, the decreasing influence of synoptic-scale frontal systems and subsequent light surface winds, the increasing occurrence of daytime sea breezes, and the relatively large diurnal variation between the high and low temperatures. The smaller number of land breezes during December and January probably results from the greater frequency of synoptic-scale fronts and subsequent stronger winds, clouds, and precipitation, which preclude the development of a land breeze.

The strength of land breezes often varied substantially between events. Based on the subjective analysis prior to program development, "strong" land breezes were those events that had a distinct boundary passage and wind shift across most of the wind-tower network. "Weak" land-breeze events were often slow-moving, with a more subtle or gradual wind shift, and frequently affected only a portion of the wind-tower network. Thus, we used the percentage of the wind towers that experienced a land-breeze passage in the network as a proxy for the strength of an event. In Figure 4a, the frequency of stronger land-breeze events (> 56% of the tower network experiencing a land-breeze passage) is plotted as a function of month (dark gray bars). Note that the frequency of strongest land-breeze events also peaked in April with the broad maximum extending from February to May. Also note the small number of strong land breezes from October to December.

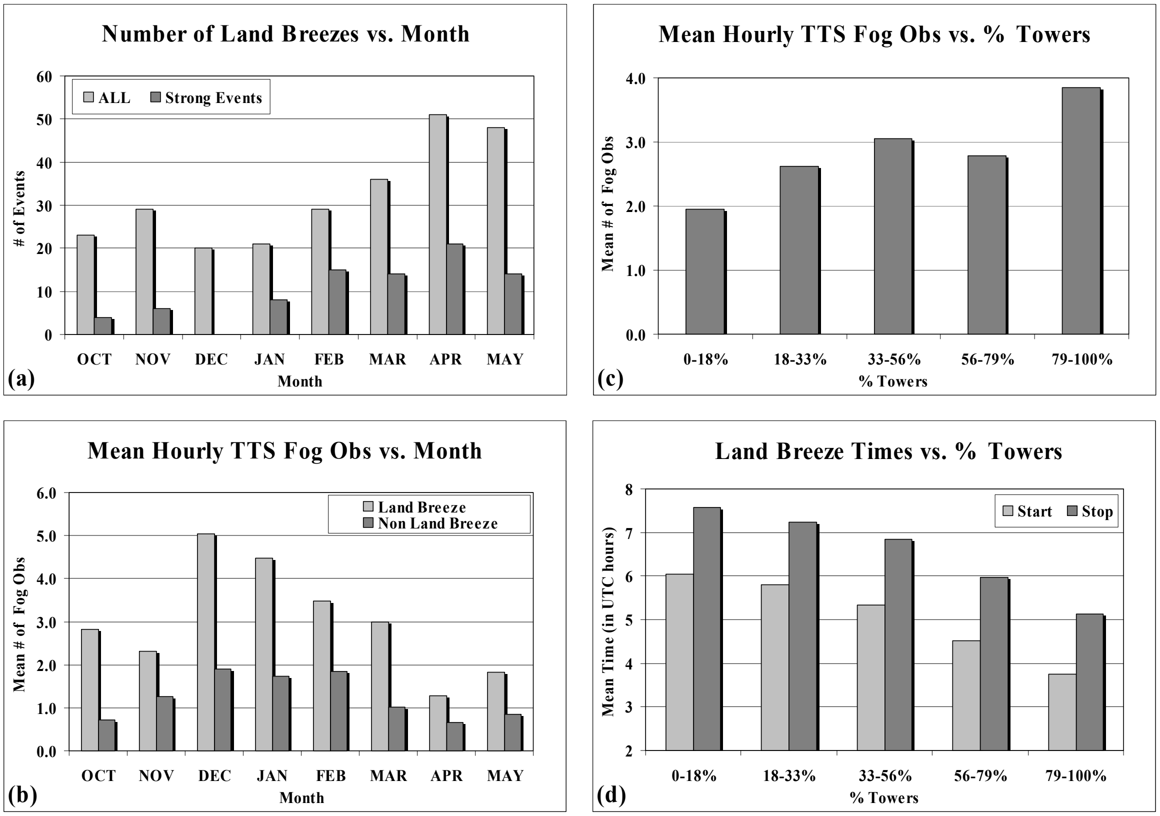

Figure 4. Summary statistics for the 257 land-breeze events from the automated identification program. (a) The frequency of land breezes as a function of month for all events (light gray), and for significant events (> 56% of towers, dark gray); (b) The mean number of TTS fog observations per night as a function of month for land breeze (light gray) versus non-land breeze events (dark gray); (c) The mean number of TTS fog observations per night as a function of the percentage of wind towers that experienced a land-breeze passage during an event; (d) The mean start (light gray) and stop times (dark gray) of the land breeze passage as a function of the percentage of towers that experienced a land-breeze passage during an event.

The weather conditions conducive to land-breeze development in east-central Florida are also favorable for fog development (Wheeler et al. 1993), and the results of this climatology clearly support this statement. The land breeze coincided with a much higher occurrence of fog over east-central Florida, as seen in Figure 4b. In every month, the mean number of fog observations at TTS associated with land breezes was approximately twice that of non-land breeze days. This amount of disparity could be a conservative estimate as well. Among the 12 land-breeze events that the algorithm did not capture from the 1999 – 2000 season, the mean number of hourly TTS fog reports on these days was 4.9 (not shown), considerably higher than most of the monthly means for land-breeze days. Figure 4c also shows that as the strength of a land-breeze event increased (higher percentage of towers experiencing a passage), the propensity to develop fog near TTS also increased. This result agrees well with the timing of the land breeze as shown in Figure 4d. As the strength of the land breeze increased, the onset time became earlier, thereby providing more time for fog to develop under the favorable offshore wind regime of a land breeze. These results have not yet been tested for statistical significance.

The land breeze also had an impact on the low-level temperatures at 6 ft and 54 ft. Figures 5a-b show the mean 6-ft and 54-ft temperature cooling rates within ± 60 minutes of land-breeze passages. Each event was categorized into northwest (NW), west (W), and southwest (SW) land breezes based on the mean wind direction for the hour after passage at all wind towers that experienced the particular land-breeze event. The mean cooling rate was then calculated for the NW, W, SW, and all land-breeze events (ALL).

At 6 ft, the land breeze tended to have warming effect particularly for land breezes with westerly winds (W) behind the boundary (Fig. 5a). For the hour prior to the land breeze (-60 to 0 minutes), the mean cooling rate at 6 ft was about -1°F h^{-1}. After the boundary passage (given by the bold line at t = 0 minutes), the W land breeze experiences a warming rate of about 0.5°F h^{-1} for approximately 30 minutes. The NW land breeze impact on 6-ft temperatures was slightly less as its passage only slowed the rate of cooling for the first 30 minutes, with a very slight warming rate thereafter. Meanwhile, the SW land breeze had the least impact on the mean cooling rate of the 6-ft temperatures.

At 54 ft, all land-breeze passages had a net cooling effect on the temperatures, with the W land breeze having the largest impact in the hour after passage (Fig. 5b). In fact, the mean 54-ft temperature change for each land breeze regime was nearly opposite to the 6-ft temperature change. The W (SW) land breeze had the greatest (least) warming influence at 6 ft, whereas the W (SW) land breeze had the greatest (least) cooling impact at 54 ft. At both heights, the NW land breeze aligned most closely with the overall mean cooling rates (ALL).

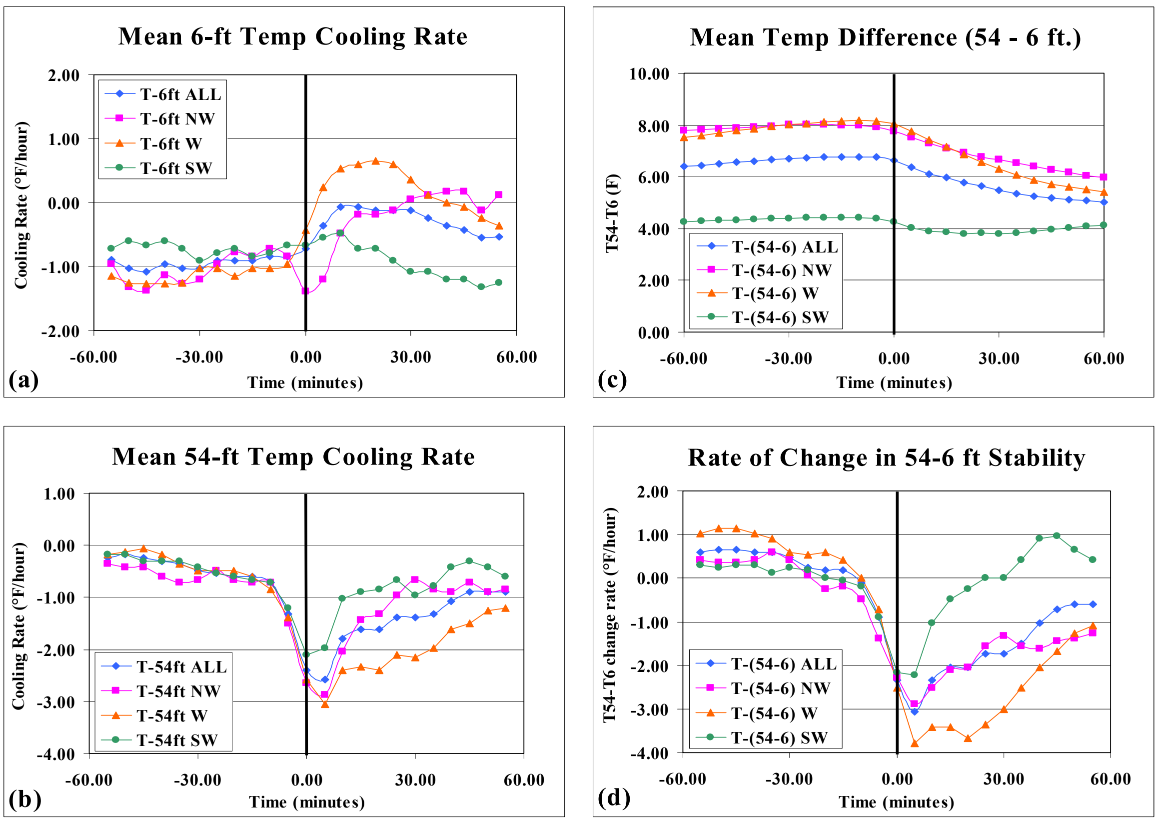

Figure 5. Five-minute mean temperature variations at ± 60 minutes of the land-breeze passage for all land breezes (ALL), and for events with post-land breeze winds from the northwest (NW), west (W), and southwest (SW). (a) 6-ft temperature cooling rate (°F h^{-1}), (b) 54-ft temperature cooling rate (°F h^{-1}), (c) the mean difference between the 54-ft and 6-ft temperatures (layer stability, $T_{54} - T_6$ in °F), and (d) the rate of change in the difference between the 54-ft and 6-ft temperatures (rate of change in 54–6 ft stability, °F h^{-1}). Instantaneous cooling and stability-change rates were computed every 5 minutes using centered differences. The bold vertical line at 0 minutes in each panel represents the time of the land-breeze passage.

The difference between the 54-ft and 6-ft temperatures ($T_{54} - T_6$, representing stability in this layer) also showed some interesting variations between the different land breezes. The near-surface layer was almost always stable during land-breeze events ($T_{54} > T_6$), due to light winds generating conditions favorable for development of a radiational inversion. In addition, the land-breeze passages acted to decrease the 6 to 54-ft stability due to the mechanical mixing associated with the leading edge of the land-breeze front. As seen in Figure 5c, the near-surface layer was the least stable during nights with SW land breezes, and the SW land-breeze passage also had the least impact on the rate of stability decrease (Fig. 5d). The W and NW land breezes had comparable low-level stability values (Fig. 5c); however, the W land breeze experienced the largest and most sustained rate of decrease in the stability (Fig. 5d). These results suggest that the W land breeze is strongest and that the SW land breeze is weakest across east-central Florida, but further categorizations and statistical significance tests are required to prove this hypothesis.

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

INSTRUMENTATION AND MEASUREMENT

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

At the request of Mr. Billie Boyd (45 WS), Dr. Manobianco provided information, FORTRAN source code, and AMU reports dealing with the Microburst Day Potential Index (MDPI)/Windex, Neumann-Pfeffer thunderstorm index, and total area divergence calculations used in the Meteorological and Range Safety Support (MARSS) system.

Table 4. AMU hours used in support of the I&M and RSA task in the second quarter of FY 2002 and total hours since July 1996.

Quarterly Task Support (hours)	***Total Task Support (hours)***
3	331.0

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 Automated Meteorological Profiling System (AMPS) at XMR in the near future. Humidity differences between the AMPS and MSS were noted by the 45 WS during a preliminary testing phase in 2001. In response, the 45 WS conducted a special data collection campaign at XMR during January and February 2002 to obtain approximately 26 pairs of humidity profiles from balloon flights that carried both AMPS and MSS sensors. The AMU will conduct a study of these dual-sensor profiles to determine if the humidity differences are random or systematic, and to evaluate the impact of the humidity differences on the diagnosis of atmospheric stability and thunderstorm indices.

MSS RAOBs have been launched operationally at XMR for many years and their data used by forecasters from the 45 WS and SMG. The vertical profile of humidity is a sensitive indicator of potential atmospheric instability. Systematic differences in humidity profiles between AMPS and MSS may introduce biases in thunderstorm indices used in thunderstorm forecasting. Because local experience and thunderstorm forecast rules of thumb are based on a long history of stability indices computed from MSS RAOBs, it is important that 45 WS forecasters become familiar with any changes in the humidity data that may accompany the transition to AMPS RAOBs and subsequently impact their analysis and forecasting of thunderstorms using stability indices.

The AMU will evaluate overall differences in relative humidity and differences level-by-level for the dual-sensor profiles to determine if they are random or systematic. The AMU will also examine humidity differences as a function of height, pressure and temperature to determine if any significant patterns appear. If a systematic pattern of differences in humidity is found, an additional estimate of the impact on thunderstorm forecasting indices will be made by applying the bias to a mean sounding for the warm season, since all profiles in the evaluation are from the cool season. An assessment will be made of the changes in thunderstorm forecasting indices (K-index, Lifted Index, Severe Weather Threat Index, Total Totals and MDPI) by comparing the mean and biased soundings.

AMU List of AMPS/MSS Dual-Sensor Profiles

Each dual sensor profile was obtained by tying an MSS sensor about 35 ft above the AMPS sensor on the cord that is suspended below the weather balloon. These dual-sensor RAOBs constitute the database for comparing humidity profiles from the two systems. Table 5 lists the current AMU list of dual-sensor profiles, acquired from the 45 WS.

Table 5. AMU list of dates and times of AMPS/MSS dual-sensor profiles used in the analysis.

Number	*Month*	*Day*	*Time(UTC)*
1	January	25	2315
2	January	26	1150
3	January	27	1100
4	January	28	1130
5	January	29	1140
6	January	30	1130
7	January	30	2300
8	January	31	1125
9	January	31	2308
10	February	6	2325
11	February	7	1120
12	February	10	1130
13	February	12	0008
14	February	12	2323
15	February	15	1700
16	February	21	1555
17	February	21	2315
18	February	22	1125
19	February	22	1535
20	February	25	2315
21	February	28	1511

Data Formats, Quality Control and Analysis

AMPS employs Global Positioning System (GPS) technology in order to determine altitude and wind information. Pressure for the AMPS profile is calculated from the altitude, temperature and humidity information, saving the weight and expense of a pressure transducer. Time, altitude, pressure, temperature and humidity are recorded every second in the raw AMPS data files. The MSS system requires radar tracking to determine height, winds and pressure. However, for dual sensor flights the tracking radar for MSS is turned off in order to avoid interference with the AMPS GPS function. As a result the MSS data stream does not have its normal radar telemetry information and the raw MSS files contain time, temperature and humidity measurements every six seconds, with no height or pressure information. The AMU will implement a subjective quality control process to identify and remove obvious outliers.

Figure 6 shows a comparison of AMPS and MSS humidity profiles observed on 31 January 2002 at 1125 UTC. The AMPS sensor indicated a higher relative humidity at pressures greater than 800 mb and a lower relative humidity at pressures lower than 760 mb. A subset of the AMPS data was created every six seconds to match the MSS data and pressure information was obtained from the AMPS subset. The vertical separation of consecutive data points is about 100 ft.

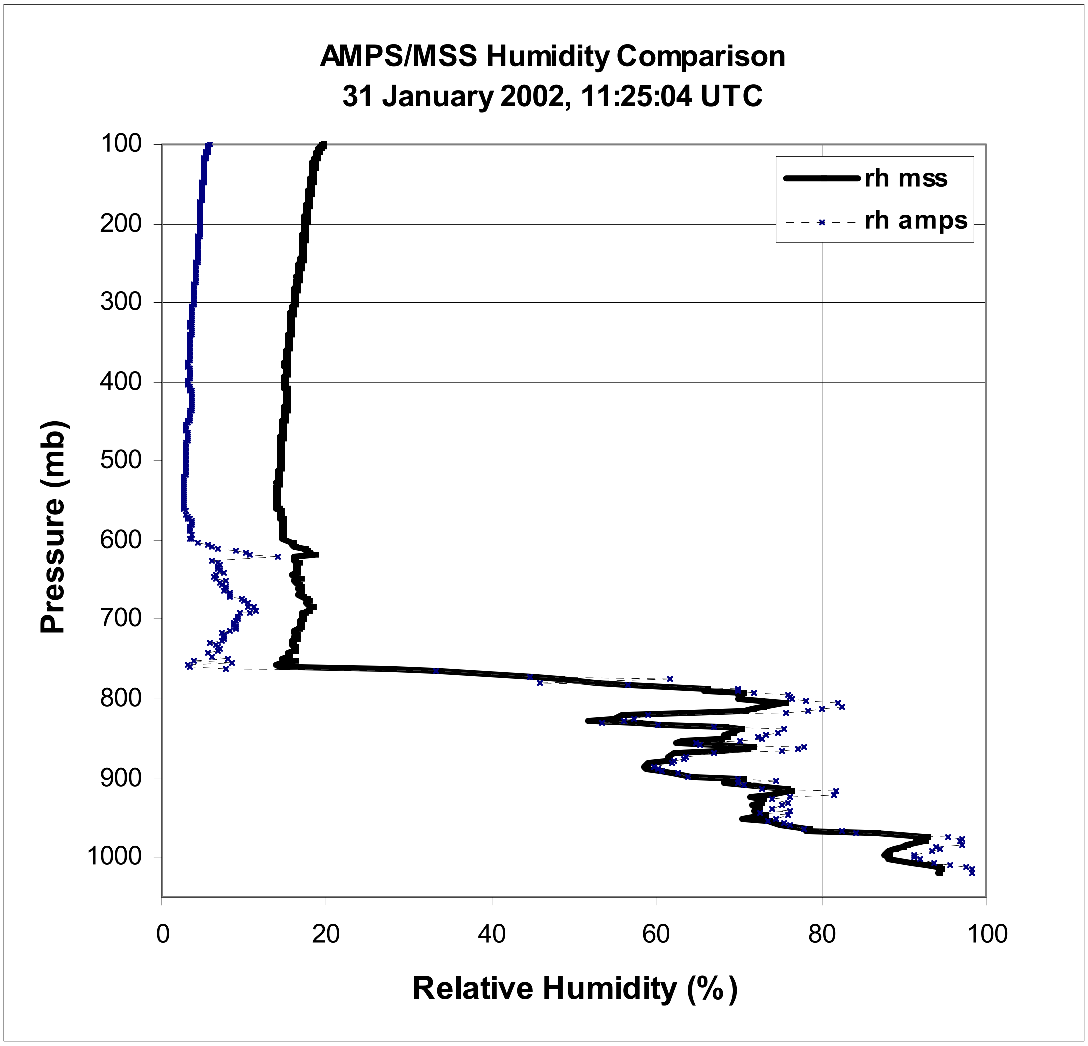

Figure 6. Relative humidity versus pressure for the dual-sensor rawinsonde flight taken at 11:25:04 UTC on 31 January 2002. MSS (dark line) and AMPS (thin dashed line) data are shown.

Vendor and Analyst Discussions and Literature Search

Dr. Short and Mr. Wheeler will contact the AMPS vendor and Computer Sciences Raytheon to find out what analysis and insights they have on the humidity sensors and algorithms. The AMU will also coordinate with Marshall Space Flight Center (MSFC) analysts who are assessing the impact of AMPS on wind and thermodynamic profiles, in order to avoid duplication of effort. They will perform a literature search to learn if other investigators may have published information about the AMPS humidity system that may be helpful in the present comparative study.

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 PHASE V (MR. CASE)

The Local Data Integration System (LDIS) task emerged out of the need to simplify short-term weather forecasting in support of launch, landing, and ground operations. The complexity of creating short-term forecasts has increased due to the variety and disparate characteristics of available weather observations. Therefore, the goal of the LDIS task is to generate high-resolution weather analysis products that may enhance the operational forecasters' understanding of the current state of the atmosphere, resulting in improved short-term forecasts.

Four phases of this task have been completed by the AMU. In Phase I, the AMU configured a prototype LDIS using the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS). In Phase II, the AMU simulated a real-time LDIS configuration using two weeks of archived data. In Phase III, the AMU provided assistance to SMG and NWS MLB to install a working real-time LDIS that routinely generates high-resolution products for operational guidance. In Phase IV, the AMU improved data ingest by including additional data sources, fine-tuned the analysis configuration, and assisted SMG and NWS MLB in improving real-time graphics capabilities. The Phase V portion of the LDIS task involves AMU assistance for SMG in upgrading the analysis software when version 5.0 of ARPS is officially released. Once SMG has fully upgraded and tested ARPS version 5.0, then the NWS MLB would upgrade their software as well. Only limited consultation was provided during this past quarter since ARPS version 5.0 has not yet been officially released to the public.

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

SMG and NWS MLB are running a real-time version of ADAS to integrate a wide-variety of national- and local-scale observational data. While the analyses have become more robust through the inclusion of additional local data sets as well as the modification of several adaptable parameters, further improvements are highly 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 including additional data sets and modifying the ingestion of selected data sets. The AMU will also investigate and recommend the steps required to implement additional features of ADAS that are not currently utilized, or features that are unavailable within the software. 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.

During this past quarter, the AMU provided limited assistance through remote consultation on several issues. Mr. Case provided SMG with the data-ingest programs that incorporate real-time aircraft data into the ADAS analyses. Mr. Case and Dr. Manobianco recently provided recommendations to SMG and NWS MLB on how to adjust the ADAS software in preparation for the upgrade and distribution of the 20-km version of the Rapid Update Cycle (RUC) model. Currently, both SMG and NWS MLB use the 40-km RUC forecasts as a background field for the 10-km analysis every 15 minutes. The 20-km RUC has the same areal coverage as the 40-km RUC, but contains more vertical levels and twice as many horizontal points. As a result, the data-ingest program and ARPS software need to be modified in preparation for the 20-km RUC data. Finally, in conjunction with Dr. Lazarus of FIT, Mr. Case assisted the NWS MLB in transporting the ADAS analyses into the Advanced Weather Interactive Processing System (AWIPS).

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

This is an option hours task funded by KSC under the Center Director's Discretionary Fund. It is a joint project with the KSC Engineering Support Contractor, Dynacs, Inc. A key to improving mesoscale Numerical Weather Prediction (NWP) models is the ability to evaluate effectively the performance of high-resolution model configurations. Traditional objective evaluation methodologies developed for large-scale models cannot adequately 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 is tasked to develop advanced techniques for objectively evaluating the performance of mesoscale NWP models currently employed or under development for Range use. For this project, 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 is chosen because the phenomenon is predicted fairly well by RAMS and the sea-breeze boundary is often nearly linear and narrow in width, making the geometry of the problem quite simple if a geometric technique is developed.

During this past quarter, the AMU conducted a literature search of all meteorological sources to determine if an objective technique has been applied to verify specific forecast phenomena. Only a small number of articles were applicable to the current problem, primarily in the areas of image processing and edge detection algorithms. These techniques may be useful for identifying features, but other methods will be explored to verify features in a mesoscale model forecast. In addition to the literature search, the AMU also prepared sample gridded observed and forecast data for Dynacs, Inc., who will be the primary developers of an objective verification algorithm.

AMU CHIEF'S TECHNICAL ACTIVITIES (DR. MERCERET)

Dr. Merceret continued developing software to analyze boundary-layer wind change characteristics measured by the 915-MHz profiler network. He and Ms. Jennifer Ward (co-op student) began processing the profiler data for dates selected by Mr. Case for the land breeze study. He completed a study of radar beam-filling effects for the Lightning Launch Commit Criteria program (Airborne Field Mill, ABFM). He and Ms. Ward also completed a study of wet-radome attenuation for the ABFM program.

AMU OPERATIONS

Mr. Wheeler researched possible solutions to the AMU Information Technology requirements, received quotes from vendors on several of the proposed hardware and software purchases and submitted the purchase requirements to the NASA Procurement office. New hard drives were delivered for the AMU's cluster. Mr. Wheeler installed them and reconfigured the cluster to work with the upgraded software.

Several AMU Team members attended conferences and training during the quarter. Four members attended conferences held during the American Meteorological Society (AMS) 82nd Annual Meeting in Orlando, FL. Dr. Short presented results on the Improved Anvil Forecasting study at the AMS 18th Conference on Interactive Information Processing Systems for Meteorology, Hydrology and Oceanography. Ms. Lambert traveled to Washington D.C. to attend an S-PLUS training seminar titled "Statistical Models in S-PLUS". The AMU also hosted a technical interchange visit by Dr. David Atlas, Distinguished Visiting Scientist from NASA Goddard Space Flight Center.

REFERENCES

Barnes, S. L., 1964: A technique for maximizing details in numerical weather map analysis. *J. Appl. Meteor.,* **3,** 396-409.

Insightful Corporation, 2000: *S-PLUS® 6 User's Guide*, Insightful Corp., Seattle, WA, 470 pp.

Lambert, W. C., 2000: Improved anvil forecasting: Phase I Final Report. NASA Contractor Report CR-2000-208573, Kennedy Space Center, FL, 24 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931.]

McVehil, G. E. and H. G. Camnitz, 1969: Ground Wind Characteristics at Kennedy Space Center. NASA Contractor Report CR-1418, Kennedy Space Center, FL, 102 pp.

Wheeler, M. M., M. K. Atchison, R. Schumann, G. E. Taylor, J. D. Warburton, and A. Yersavich, 1993: Analysis of rapidly developing fog at the Kennedy Space Center preliminary report, 56 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931.]

Wilks, D. S., 1995: *Statistical Methods in the Atmospheric Sciences*. Academic Press, Inc., San Diego, CA, 467 pp.

Zhong, S., and E. S. Takle, 1992: An observational study of sea- and land-breeze circulation in an area of complex coastal heating. *J. Appl. Meteor.*, **31,** 1426-1438.

NOTICE

List of Acronyms

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 LG	45th Logistics Group
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
AMS	American Meteorological Society
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
AWIPS	Advanced Weather Interactive Processing System
CCAFS	Cape Canaveral Air Force Station
CSR	Computer Sciences Raytheon
ELV	Expendable Launch Vehicle
FAR	False Alarm Rate
FR	Flight Rules
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GPS	Global Positioning System
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
LWO	Launch Weather Officer
MARSS	Meteorological and Range Safety Support
MDPI	Microburst Day Potential Index
MIDDS	Meteorological Interactive Data Display System
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
PDF	Probability Density Function
POD	Probability of Detection
QC	Quality Control
RAMS	Regional Atmospheric Modeling System
RAOB	Rawinsonde Observation
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle

RWO	Range Weather Operations
SLC	Space Launch Complex
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SRH	NWS Southern Region Headquarters
TTS	SLF 3-letter identifier
USAF	United States Air Force
UTC	Universal Coordinated Time
WWW	World Wide Web
XMR	CCAFS 3-letter identifier

Appendix A

AMU Project Schedule 30 April 2002				
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	Apr 02	Delay 1 Month due to Customer Request for Further Analysis
	Prepare products, final report for distribution	Apr 02	Jun 02	Delay 1 Month due to Customer Request for Further Analysis
Improved Anvil Forecasting Phase II	Collection and processing of data	May 01	Jan 02	Completed
	Algorithm formulation and testing	Aug 01	Feb 02	Completed
	Final report	Feb 02	Apr 02	On Schedule
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	On Schedule
	Development of forecast rules of thumb / automated tool	Apr 02	Jul 02	On Schedule
	Final report with forecasting rules of thumb	Jul 02	Sep 02	On Schedule
AMPS Moisture Profiles	Data collection, data reduction, and QC	Mar 02	Apr 02	On Schedule
	Analysis of humidity differences and impact on thunderstorm forecasting indices	Apr 02	May 02	On Schedule
	Memorandum	May 02	Jun 02	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	On Schedule
	Objective verification of RAMS sea-breeze boundaries	May 02	Dec 02	On Schedule
	Final report/Journal publications	Jan 03	Mar 03	On Schedule

AMU Project Schedule 30 April 2002				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
LDIS Extension: Phase V	Assistance in upgrading ADAS/ARPS to version 5.0 at SMG	Jan 02	Mar 02	Delayed: waiting release of ARPS 5.0
	Memorandum	Mar 02	Mar 02	Delayed: waiting release of ARPS 5.0
LDIS Optimization and Training	Revise data ingest programs	Jan 02	Sep 02	On Schedule
	Provide recommendations for implementing new features in ADAS	Jan 02	Sep 02	On Schedule
	Training to SMG and NWS MLB personnel	Jul 02	Sep 02	On Schedule
	Memorandum	Sep 02	Sep 02	On Schedule