Applied Meteorology Unit (AMU) Quarterly Report

31 January 2011 First Quarter FY-11 Contract NNK06MA70C

Falcon 9 launch photo by SpaceX/Chris Thompson (http://spaceflightnow.com/falcon9/002/remotes/)

In this issue:

Launch Support

Dr. Watson supported the Delta 4-Heavy launch on 21 November

Ms. Wilson and Mr. Wheeler supported the Falcon 9 launch on 8 December

The AMU Team began four new tasks in this quarter:

- Ms. Crawford began work to improve the AMU-developed tool that provides the launch weather officers information on peak wind speeds that helps them assess their launch commit criteria;
- Dr. Bauman began updating lightning climatologies for airfields around central Florida. These climatologies help National Weather Service and Air Force forecasters determine the probability of lightning occurrence at these sites;
- Mr. Wheeler began a study for the 30th Weather Squadron at Vandenberg Air Force Base in California to determine if precursors can be found in weather observations to help the forecasters determine when they will get strong wind gusts in their northern towers; and
- Dr. Watson began work to update the AMU-developed severe weather tool with more data and possibly improve its performance using a new statistical technique.

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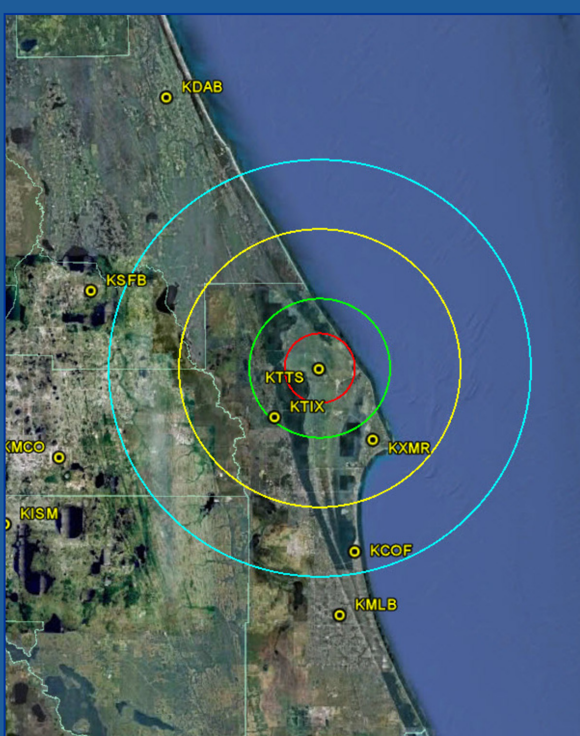
Quarterly Task Summaries

This section contains summarizes of the AMU activities for the first quarter of Fiscal Year 2011 (October - December 2010). The accomplishments on each task are described in more detail in the body of the report starting on the page number next to the task name.

Peak Wind Tool for User LCC, Phase IV (Page 4)

Purpose: Recalculate the Phase III cool season peak wind statistics using stability as an added stratification. Although peak winds are an important forecast element for launch vehicles, the 45th Weather Squadron (45 WS) and Spaceflight Meteorology Group (SMG) indicate that they are a challenging to forecast. The Phase III tool helped alleviate this forecast difficulty. Stability has long been known to have a strong affect on surface wind speeds. Recalculating the statistics after stratifying by stability will make them more robust and useful to operations.

Accomplished: The wind tower and sounding data needed for this task were provided by Computer Sciences Raytheon (CSR). These data were quality-checked (QC'd) and processed for analysis. The Richardson number will be used to determine the stability stratification, which is calculated using virtual potential temperature and u/v wind components. The wind tower data were formatted to begin calculating these values for each level on each tower.



5-, 10-, 20-, and 30-NM rings for the SLF lightning climatologies

Situational Lightning Climatologies for Central Florida, Phase V (Page 5)

Purpose: Update the existing lightning climatology to improve operational weather support to Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), and commercial and general aviation across central Florida. The update includes adding more years of data to the database, adding more sites and adding stratifications for moisture and stability parameters. These updates will provide climatologies for new sites for which the 45 WS and National Weather Service have forecast responsibility, and to help forecasters distinguish lightning days that are more active from those that are less active within the same flow regime.

Accomplished: Received National Lightning Detection Network (NLDN) data (May-September 1989-2010) from the 14 WS and downloaded NWS sounding data from the NOAA Earth System Research Laboratory. Updated and tested S-PLUS scripts to create the warm season 2010 flow regime files and merged the flow regime data with the NLDN data. Generated lightning climatologies for all sites. Updated and delivered the graphical user interface (GUI) to the customers. Began incorporating the precipitable water observations from soundings at CCAFS, Jacksonville, Tampa and Miami into the sounding database.

Quarterly Task Summaries
(continued)


Delta II at VAFB
Photo by Thom Baur/Boeing

Vandenberg Air Force Base North Base Wind Study (Page 7)

Purpose: Analyze local wind tower, surface, upper air and sounding data from Vandenberg Air Force Base (VAFB) to find precursors to high wind events in the north base towers. The 30 Weather Squadron (30 WS) states that terrain influences the unpredicted strong northeast winds that have been measured on several of the north base wind towers and exceed their 35 kt warning criteria. This study will look into those influences and document any precursors that may be found that will assist forecasters in analyzing their wind warning criteria.

Accomplished: VAFB data for the years 2004 to April 2010 to include wind towers and soundings were requested from the 30 WS in September 2010. Due to 30 WS workload issues, the tower data were not received until mid-October. Excel scripts were developed to decode the raw tower data. Once decoded, the data were input to Excel spreadsheets. The other data sets required for the task, upper air and surface maps along with VAFB sounding data were retrieved from other data archives.

Upgrade Summer Severe Weather Tool Phase III (Page 8)

Purpose: Upgrade the Summer Severe Weather Tool by adding another warm season and testing another statistical technique to determine if its performance can be improved. This task increases the period of record from 21 to 22 years and uses logistic regression to determine the appropriate predictors and provide a probability forecast. The performance of the logistic regression equations will be compared with the previous tool.

Accomplished: The severe weather database was updated with data from the 2010 warm season, increasing the period of record from 21 to 22 years. The verification statistics for the 2010 warm season Total Threat Scores (TTS) showed the tool did not perform well during that season. The data were stratified and predictor selection began for the statistical logistic regression analysis.

Tornado on KSC
Photo by anonymous USA employee

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

The progress being made in each task is provided in this section, organized by topic, with the primary AMU point of contact given at the end of the task discussion.

SHORT-TERM FORECAST IMPROVEMENT

Peak Wind Tool for User LCC, Phase IV (Ms. Crawford)

The peak winds are an important forecast element for the Expendable Launch Vehicle and Space Shuttle programs. As defined in the Launch Commit Criteria (LCC) and Shuttle Weather Flight Rules, each vehicle has peak wind thresholds that cannot be exceeded in order to ensure safe launch and landing operations. The 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast, particularly in the cool season. To alleviate some of the difficulty in making this forecast, the AMU calculated cool season wind climatologies and peak speed probabilities for each of the towers used to evaluate LCC (Figure 1) in Phase I (Lambert 2002). In Phase III (Crawford 2010), the AMU updated these statistics with six more years of data, added a new time-period stratifications and created a graphical user interface (GUI) to display the desired values similar to that developed for SMG in Phase II (Lambert 2003). Based on recommendations from Phase III and observations by the launch weather officers (LWOs), the 45 WS tasked the AMU to stratify the data by stability and onshore/offshore flow and recalculate the climatologies and probabilities. These modifications will likely make the statistics more robust and useful to operations.

Data

The AMU archive contained most of the 5-minute wind tower and sounding data needed for this work, but was missing data from the recent 3 years. Ms. Crawford collected these data from Mr. Madison of CSR. The data are from the cool season months October through April 1995—2010, resulting in 16 cool seasons in the period of record (POR). Ms. Crawford quality checked (QC'd) all tower and sounding data except for December 2010. Mr. Madison of CSR will deliver those data in January. She also determined that the hourly Shuttle Landing Facility (SLF) sea level pressure (SLP) data are needed to calculate the stability values for the stratification. She requested the values from the 14 WS, who will deliver the data in early January.

Stability Stratification

Ms. Crawford researched several stability parameters and discussed them with Dr. Merceret. They determined the gradient and bulk Richardson numbers (Ri and R_B; Stull 1988) using tower and sounding data, respectively, will be used to determine the stability stratifications. The equation is similar for both:

$$Ri = \frac{\dfrac{g}{\overline{\Theta}_v}\dfrac{\partial\overline{\Theta}_v}{\partial z}}{\left[\left(\dfrac{\partial\overline{U}}{\partial z}\right)^2 + \left(\dfrac{\partial\overline{V}}{\partial z}\right)^2\right]}$$

where g is gravity, z is height, Θ_v is the virtual potential tem-

Figure 1. Map showing the locations of the launch pads and LCC wind towers described in Table 1.

Table 1. Towers, and sensor heights that will be analyzed in this task with their associated launch vehicles.

Launch Vehicle	*Tower(s)*	*Primary Height*	*Backup Height*
Shuttle	393/394 (39A) 397/398 (39B)	60 ft	N/A
Atlas	41: primary 110: backup	230 ft 204 ft	54 ft
Delta II	2	90 ft	54 ft
Delta IV	6: primary 108: backup	54 ft	12 ft

perature, and U/V are the horizontal wind components. The horizontal bar over Θ_v, U, and V indicate a time-averaged value, in this case 5 minutes. For the towers, Ms. Crawford will calculate Ri at each level, and R_B will be calculated using data from the surface and boundary layer top levels in the soundings.

Ms. Crawford began creating the Θ_v values and u/v wind components needed to calculate Ri at the towers.

Virtual Potential Temperature

The tower data needed to calculate Θ_v are temperature (T) and dew point temperature (T_d). Ms. Crawford is using a standard set of thermodynamic equations to derive Θ_v from T and T_d. The first step is to calculate vapor pressure, e, using T_d (Rogers and Yau 1989):

$$e = 6.112\exp\left[\frac{17.67(T_d)}{T_d + 243.5}\right]$$

Next, the mixing ratio, w is calculated using e and pressure (p):

$$w = \frac{0.622(e)}{p - e}$$

The potential temperature, Θ, is calculated using Poisson's Equation:

$$\Theta = T\left(\frac{1000\,\text{mb}}{p}\right)^{0.286}$$

This value and w are used to calculate Θ_v:

$$\Theta_v = \Theta\left[1 + 0.61(w)\right]$$

The wind towers do not have barometers to measure pressure, so the pressure at each level of the tower must be estimated. These pressures will be calculated using a derivation of the hydrostatic equation in which the lapse rate along the tower is constant (Hess 1959):

$$p = p_0\left(\frac{T}{T_0}\right)^{\frac{g}{R\gamma}}$$

where p is the pressure at a tower level, p_0 is the surface pressure, T is the tower level temperature, T_0 is the surface temperature, g is gravity, R is the gas constant for dry air, and γ is the lapse rate. The hourly SLF sea level pressure will be p_0 and the 6-ft temperature will be T_0.

Wind Components

The wind data are provided as speed in knots and direction in degrees. Ms. Crawford converted these values to u and v components using

$$u = \text{spd} \times \cos\left[(270 - \text{dir}) \times \frac{\pi}{180}\right]$$

$$v = \text{spd} \times \sin\left[(270 - \text{dir}) \times \frac{\pi}{180}\right]$$

where spd is the speed in m/s and dir is the direction in degrees. Ms. Crawford converted the speed from knots to m/s with the relation

$$\text{spd} = \text{speed}\ (\text{kt}) \times 0.5175\ .$$

Other Stratifications

Ms. Crawford will also stratify the data by month, hour, and onshore/offshore flow. In the previous phases, she stratified the data by direction in 10° sectors, and by hour and direction in 45° sectors. With the added stability and onshore/offshore stratifications it may not be possible to stratify by higher resolution direction sectors. As the data are processed and analyzed, Ms. Crawford will assess whether the data can support more directional stratifications.

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

Situational Lightning Climatologies for Central Florida, Phase V (Dr. Bauman)

The threat of lightning is a daily concern during the warm season in Florida. Research has revealed distinct spatial and temporal distributions of lightning occurrence that are strongly influenced by large-scale atmospheric flow regimes. The 45 WS, SMG and National Weather Service in Melbourne, Fla. (NWS MLB) have the responsibility of issuing weather forecasts for airfields located in central Florida. SMG and 45 WS share forecasting responsibility for the SLF depending on the mission. The 45 WS has forecasting responsibility for the Cape Canaveral Air Force Station (CCAFS) Skid Strip and Patrick Air Force Base (PAFB) while the NWS MLB is responsible for issuing terminal aerodrome forecasts (TAF) for airports throughout central Florida. In the previous phase (Bauman 2009), Dr. Bauman calculated lightning climatologies for the SLF and eight other airfields in central Florida based on a 19-year record of cloud-to-ground (CG) lightning data from the National Lightning Detection Network (NLDN) for the warm season months of May through September (1989-2007). The climatologies included the probability of lightning at 5-, 10-, 20- and 30-NM distances from the center point of the runway at each site. The climatologies were stratified by flow regimes with probabilities depicted at 1-, 3-, and 6-hr intervals. This phase updates the previous work by adding 14 sites to the 9-site database including the CCAFS Skid Strip, PAFB and 12 commercial airports. It also adds three years of NLDN data resulting in a POR for the warm season months from 1989-2010. In addition to the flow regime stratification, moisture and stability stratifications will be added to separate more active from less active lighting days within the same flow regime.

Data Acquisition and Processing

Dr. Bauman requested the NLDN data for May-September 1989-2010 from Mr. Roeder of the 45 WS for the 23 sites. The 14 WS prepared the NLDN data files and Dr. Bauman downloaded them from their servers. He then processed the NLDN data using existing S-PLUS scripts to remove the cool season months from the data. He needed to create 2010 flow regime files and did so by first downloading NWS sounding data from the NOAA Earth System Research Laboratory for Jacksonville (JAX), Tampa (TBW), Miami (MFL) and CCAFS. Then he updated and tested S-PLUS scripts to create the warm season 2010 flow regime files and merged the flow regime data with the NLDN data.

Generate Lightning Climatologies

The goal of the first part of this task is to provide updated lightning climatologies using the longer POR and additional sites prior to the beginning of the 2011 warm season. This does not include the additional stratifications by moisture or stability parameters. Dr. Bauman created S-PLUS scripts for the 14 additional sites to process the merged NLDN and flow regime data. These scripts separated the data into files containing NLDN data at 5-, 10-, 20- and 30-NM distances from the center point of the runway at each site at 1-, 3-, and 6-hr intervals stratified by flow regimes. He then generated the lightning climatologies for all 23 primary and backup sites for the 21-year period of record.

GUI Update

By more than doubling the number of sites in this phase of the work, Dr. Bauman needed to find a more efficient way for the users to navigate through the stratifications in the GUI. He implemented a JavaScript drop-down menu for the GUI (Figure 2) that, at the top level, separates the sites by NWS forecast region and 45 WS/SMG sites. When the user rolls the mouse pointer over one of the menu items, subsequent drop-down menus are shown for the different stratifications allowing the user to choose the site, month or entire warm season and time interval or flow regime segregation. Dr. Bauman delivered the updated GUI to the customers for evaluation.

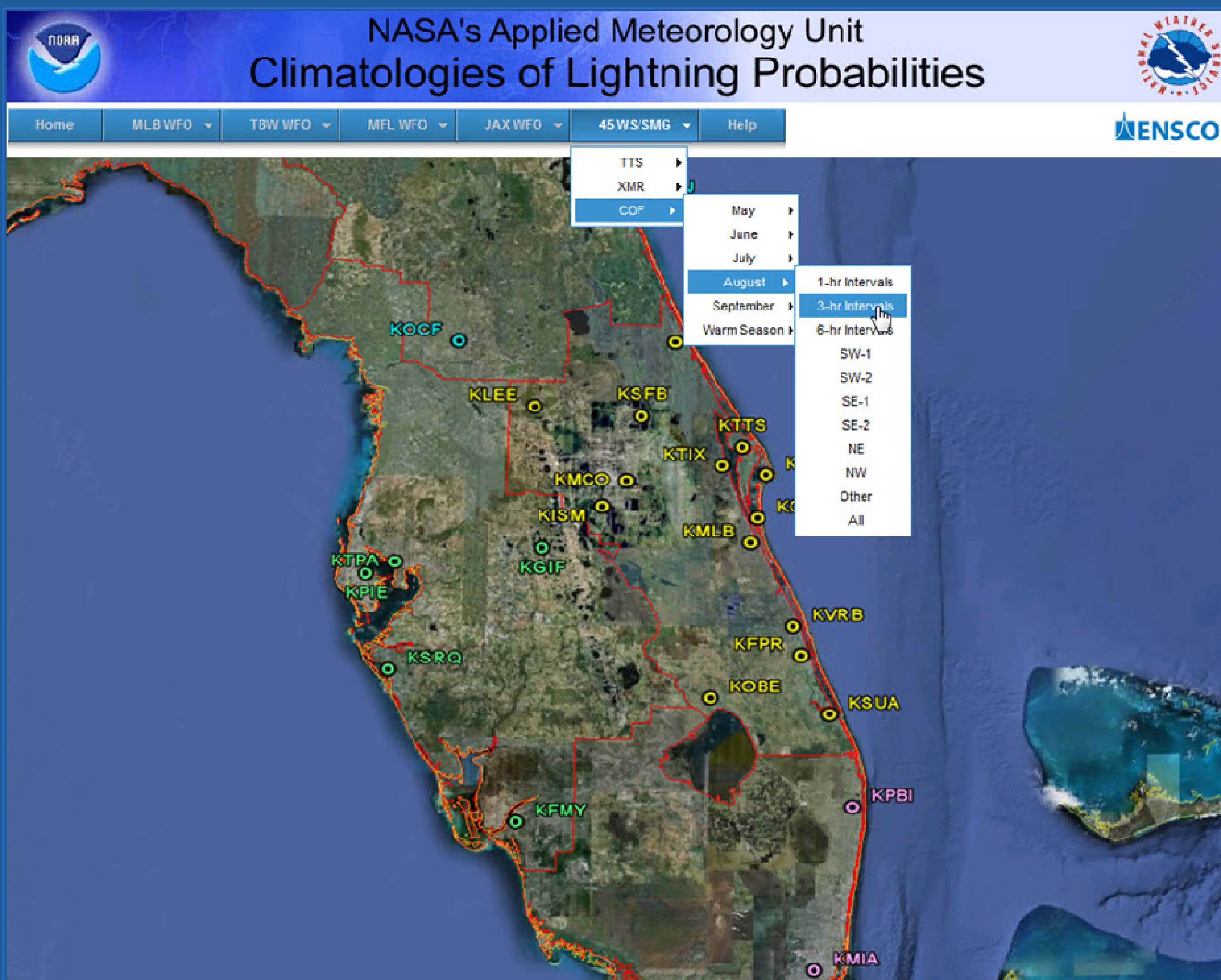


Figure 2. First page of the Hyper Text Markup Language (HTML)-based GUI shows a map of the sites color-coded by NWS forecast office region. The drop-down menu is located under the banner image at the top and depicts an example of a user choosing the PAFB site (COF) for August at 3-hr intervals.

New Stratifications

Dr. Bauman began incorporating the precipitable water (PWAT) observations from soundings at CCAFS, JAX, TBW and MFL into the sounding database. Ms. Crawford provided Dr. Bauman with code from existing S-PLUS scripts she wrote for other AMU tasks to first compute mixing ratio and then PWAT values. Ms. Crawford had previously calculated the PWAT values for the CCAFS soundings, so Dr. Bauman incorporated and modified the existing code to process the observations from the NWS sounding sites. He had to import the NWS sounding data from each of the three sites into S-PLUS, calculate mixing ratios and then PWAT for each warm season month, year and site.

After calculating the PWAT values, Dr. Bauman wrote scripts to verify the number of days and their associated PWAT values were correct. He manually spot-checked the data for several sites against the verification scripts for the entire warm season and then for each warm season month. Once he knew the calculations were correct, he began generating new lightning climatologies for all of the sites using the PWAT stratification.

Table 2 shows the PWAT stratification from the CCAFS sounding data for the warm season months. The PWAT values for the JAX, TBW and MFL soundings are not shown. The values were derived from precipitable water plots created by Mr. Matthew Bunkers, the Science and Operations Officer at the Rapid City, S.D. NWS Forecast Office (http://www.crh.noaa.gov/unr/?n=pw). Based on discussions with Mr. Sharp at NWS MLB, values below the 25th percentile will be considered low, values above the 75th percentile will be considered high, and the values between them and inclusive will be considered medium.

Table 2. The PWAT stratification thresholds for the warm season months from the CCAFS sounding data from 1950-2009. The low values represent the 25th percentile and the high values the 75th percentile from the dataset with the medium values falling between the two.

Month	*Low*	*Medium*	*High*
May	< 1.00”	1.01” to 1.49”	> 1.50”
June	< 1.45”	1.46” to 1.89”	> 1.90”
July	< 1.60”	1.61” to 1.94”	> 1.95”
August	< 1.65”	1.66” to 2.04”	> 2.05”
September	< 1.55”	1.56” to 1.99”	> 2.00”

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

Vandenberg Air Force Base North Base Wind Study (Mr. Wheeler)

The 30 WS states that terrain influences along the extreme northern fringes of Vandenberg Air Force Base (VAFB) make it difficult for forecasters to issue timely and accurate high wind warnings for that particular part of the base during northeasterly wind events. These events tend to occur during the winter or early spring when they are under the influence of the Great Basin high pressure weather regime. The LWOs have seen these rapid wind increases in the current Towers 60, 70 and 71 along the northern edge of VAFB in excess of the 35 kt warning threshold. For this task, the 30 WS requested the AMU analyze data from days when these towers reported winds in excess of 35 kt and determine if there are any precursors in the observations that would allow the LWOs to better forecast and warn their operational customers for these wind events.

VAFB Wind Tower Database

Figure 3 is a Google Earth map showing the locations of the wind towers on VAFB. Towers 60, 70 and 71 along the northern part of VAFB are the primary wind towers Mr. Wheeler will use for this study.

Mr. Wheeler requested the VAFB weather data prior to September 2010, but due to a heavy workload and an Operational Readiness Inspection at the 30 WS, he received the tower data in mid-October on several compact discs (CDs). He also received a list of the suspected 35-kt wind event days from 2004 through the spring of 2010. The wind tower data from 2004 to October 2007 was from the legacy mechanical wind sensors and the data from November 2007 through March 2010 was from the ultrasonic sensors. The legacy wind data were obtained from a cup-and-vane system with the vane (direction) and cups (speed) mounted separately, but at the same level. The ultrasonic sensor derives wind speed and direction from the

Figure 3. Google Earth map of the VAFB tower locations as yellow circles with white tower numbers. The towers for this task are surrounded by the yellow ellipse.

effect of wind on the transit time of ultrasonic pulses between three electro-acoustic transducers configured in an equilateral triangle.

Mr. Wheeler copied the wind tower data files from the CDs and moved them to yearly and monthly folders. The tower data files were compressed, so he had to uncompress and extract the monthly and daily data. He then ran Excel scripts developed by Dr. Bauman to extract the the 6, 12 and 54 foot wind direction and speed along with temperature and humidity from the data files . Mr. Wheeler used several computers to do this extraction process as the data from 2007 through 2010 was in 1-minute Network Common Data Form (NetCDF) format and took a long time to extract each day's data set. While this was being done he retrieved surface, 500 and 850 mb upper air weather maps of the Southwest US on another computer, and also retrieved VAFB sounding data for each of the event days from Plymouth State University and the National Centers for Environmental Prediction weather data archives.

For more information contact Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com.

INSTRUMENTATION AND MEASUREMENT

Upgrade Summer Severe Weather Tool Phase III (Dr. Watson)

The 45 WS Commander's morning weather briefing includes an assessment of the likelihood of local convective severe weather for the day. This forecast is provided in order to enhance protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC. The severe weather elements produced by thunderstorms include tornadoes, convective surface winds of 50 knots, and/or hail with a diameter of 0.75 inches. Forecasting the occurrence and timing of these phenomena during the warm season (May – September) is challenging for 45 WS operational personnel. In previous tasks, the AMU analyzed stability parameters and synoptic patterns from Central Florida severe weather days during 1989-2003 to determine which were important to severe weather development (Bauman et al. 2005). The AMU then created an HTML-based tool using the important parameters and patterns to help determine the probability of issuing severe weather watches and warnings for the day. The HTML tool was replaced with a Meteorological Interactive Data Display System (MIDDS)-based GUI in a follow-on task (Wheeler 2009) that retrieved stability parameters and other information from MIDDS automatically, minimizing the forecaster's interaction with the tool. Later, the AMU updated the severe weather database with data from the years 2004-2009, re-analyzed the data to determine the important parameters, made appropriate adjustments to the index weights depending on the results of the analysis, and updated the MIDDS GUI (Wheeler 2010). For this task, the 45 WS requested the AMU upgrade the severe weather database by adding weather observations from 2010, update the verification data set with results from the summer of 2010, use statistical logistic regression analysis on the database and develop a new forecast tool if appropriate, and update the MIDDS GUI, if necessary.

Severe Weather Database

Dr. Watson retrieved the May – September 2010 severe weather reports from the Storm Prediction Center and the National Climatic Data Center databases and integrated the reports into the existing severe weather database. She included stability indices calculated from the local rawindsondes as well as the Florida large-scale flow regime data provided by Ms. Crawford. She also used archived upper air data from Plymouth State University to plot and analyze the jet stream characteristics over Florida. Inclusion of these data increases the period of record from 21 to 22 years (1989 – 2010).

2010 Verification Results

Dr. Watson computed verification statistics for the 2010 warm season using the Total Threat Score (TTS) computed from the MIDDS GUI (Table 3). The AMU and 45 WS forecasters computed the TTS for 132 days during May – September 2010 with values ranging from -23 to 20. Severe weather was reported in east-central Florida on 15 days during the warm season. The TTS forecast threshold value for computing the statistics was 5: if < 5 it was a No forecast and if ≥ 5 it was a Yes forecast. If severe weather was reported across these Florida counties, that was classified as an observed Yes. The Severe Weather Worksheet TTS did not verify well in the 2010 warm season, with a high False Alarm Rate

Table 3. Warm season 2010 TTS Verification Statistics		**Observed Severe**		FAR = 0.54
		Yes	No	POD = 0.43
Forecast Severe	Yes	**6**	**7**	CSI = 0.29
	No	**8**	**111**	HSS = 0.37
				TSS = 0.37

(FAR) and low values for Probability of Detection (POD), Critical Success Index (CSI), Heidke Skill Score (HSS), and True Skill Statistic (TSS) (Wheeler 2010).

Logistic Regression Analysis

Dr. Watson installed and began learning the S-PLUS statistical software that is used to perform the statistical logistic regression analysis. She stratified the data into equation development and verification datasets. The development dataset requires enough samples so that the resulting set of equations is stable. Therefore, data from 1989 to 2008 were chosen as the development dataset. This dataset included 380 severe weather days out of 2742 total days.

She began predictor selection using the development dataset and the procedure outlined in Lambert and Wheeler (2005). The predictand is 0 or 1 depending on whether severe weather occurred (1) or not (0). The eight candidate predictors included the

- Total Totals,
- K-Index,
- Lifted Index,
- Thompson Index,
- Showalter Stability Index,
- Precipitable Water,
- Flow Regime, and
- Jet stream characteristics.

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

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AMU ACTIVITIES

AMU Chief's Technical Activities (Dr. Merceret)

Dr. Merceret completed final processing of the Lightning Launch Commit Criteria Rationale for formal public release (Merceret and Willett, 2010). The document will be available after 10 January 2011.

Dr. Merceret contributed as a co-author with Dr. Lisa Huddleston and Mr. Roeder on a paper to be submitted to the Journal of Atmospheric and Oceanic Technology describing a new methodology for using CGLSS and NLDN data to assess the probability that lightning struck within a defined distance of a specified target, such as LC39. He also prepared an extended abstract about the AMU to be presented at the 91st Annual Meeting of the American Meteorological Society (AMS) in January. After it was reviewed by his co-authors John Madura, Bill Bauman, Bill Roeder, Frank Brody and Bart Hagemeyer, he submitted the document to the AMS. Dr. Bauman, Dr. Merceret and Mr. Roeder developed a PowerPoint presentation for review by the other co-authors.

AMU OPERATIONS (AMU Team)

Launch Support

Dr. Watson supported the Delta 4-Heavy launch on 21 November. Ms. Wilson and Mr. Wheeler supported the Falcon 9 launch on 8 December.

LIST OF ACRONYMS

14 WS	14th Weather Squadron
30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
CCAFS	Cape Canaveral Air Force Station
CD	Compact Disc
CG	Cloud-to-Ground lightning
CSI	Critical Success Index
CSR	Computer Sciences Raytheon
FAR	False Alarm Rate
FSU	Florida State University
FY	Fiscal Year
GSD	Global Systems Division
GUI	Graphical User Interface
HSS	Heidke Skill Score
HTML	Hyper Text Markup Language
JAX	Jacksonville, Fla. 3-letter identifier
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LWO	Launch Weather Officer
MFL	Miami, Fla. 3-letter identifier
MIDDS	Meteorological Interactive Data Display System
MSFC	Marshall Space Flight Center
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NWS MLB	National Weather Service in Melbourne, FL
PAFB	Patrick Air Force Base
POD	Probability of Detection
POR	Period of Record
PWAT	Precipitable Water
QC	Quality Control
SLF	Shuttle Landing Facility
SLP	Sea Level Pressure
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
TAF	Terminal Aerodrome Forecast
TBW	Tampa, Fla. 3-letter identifier
TSS	True Skill Statistic
TTS	Total Threat Score
USAF	United States Air Force
VAFB	Vandenberg Air Force Base

The AMU has been in operation since September 1991. Tasking is determined annually with reviews at least semi-annually.

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