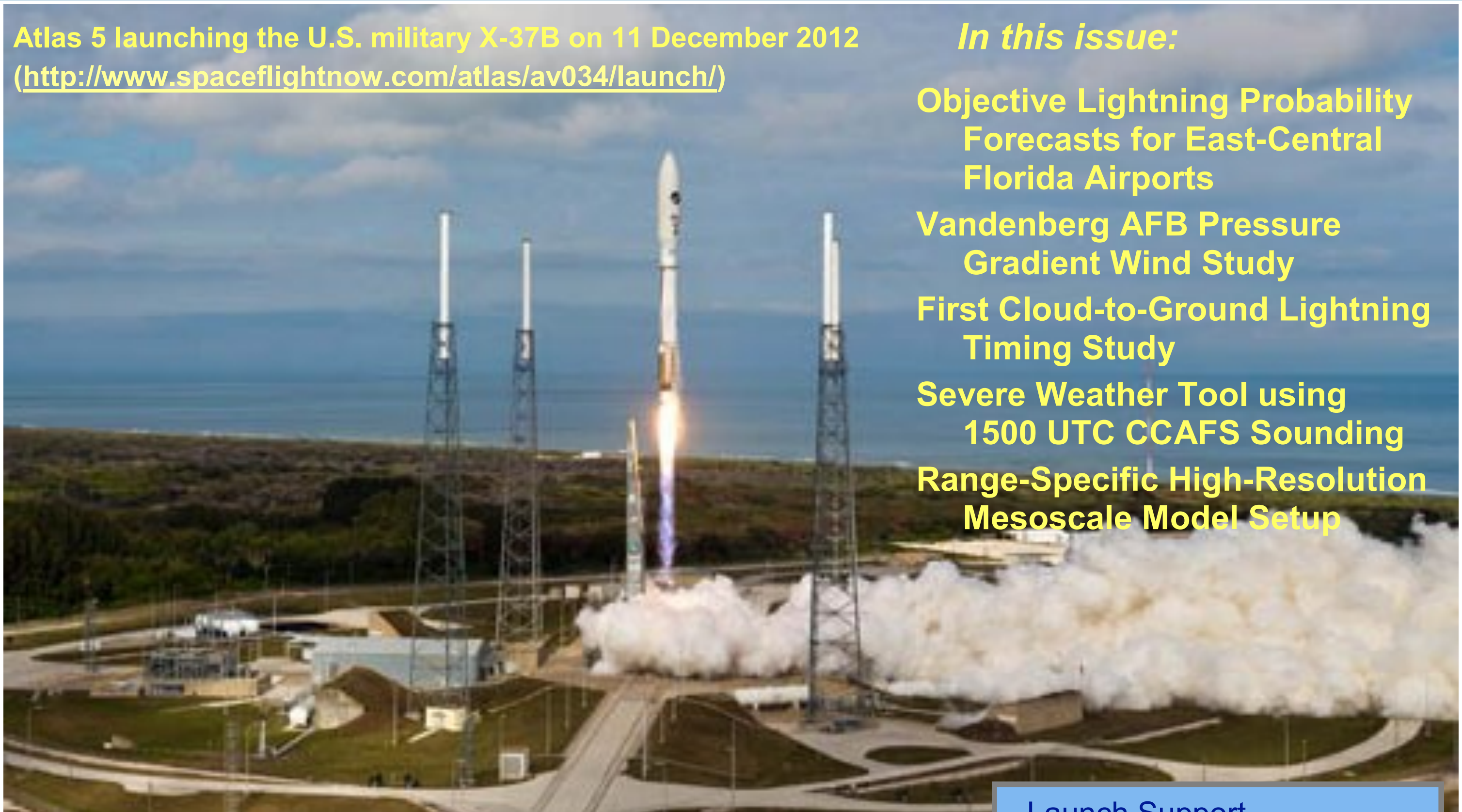
AMU Applied Meteorology Unit

Quarterly Report
First Quarter FY-13

31 January 2013

Infusing Weather Technology Into Aerospace Operations

Contract NNK12MA53C/DRL-003 DRD-004



Atlas 5 launching the U.S. military X-37B on 11 December 2012 (http://www.spaceflightnow.com/atlas/av034/launch/)

In this issue:

This Quarter's Highlights

The AMU team worked on five tasks for their customers:

- Ms. Crawford continued work on the objective lightning forecast task for airports in east-central Florida.
- Ms. Shafer continued work on the task for Vandenberg Air Force Base to create an automated tool that will help forecasters relate pressure gradients to peak wind values.
- Dr. Huddleston began work to develop a lightning timing forecast tool for the Kennedy Space Center/Cape Canaveral Air Force Station area.
- Dr. Bauman began work on a severe weather forecast tool focused on east-central Florida.
- Dr. Watson completed testing high-resolution model configurations for Wallops Flight Facility and the Eastern Range, and wrote the final report containing the AMU's recommendations for model configurations at both ranges.

Launch Support

Ms. Crawford, Ms. Wilson and Ms. Cummings supported the Delta 4 launch on 4 October.

Dr. Bauman, Ms. Wilson and Ms. Cummings supported the Falcon 9 launch on 7 October.

Ms. Shafer, Dr. Huddleston and Ms. Cummings supported the Atlas 5 launch on 11 December.

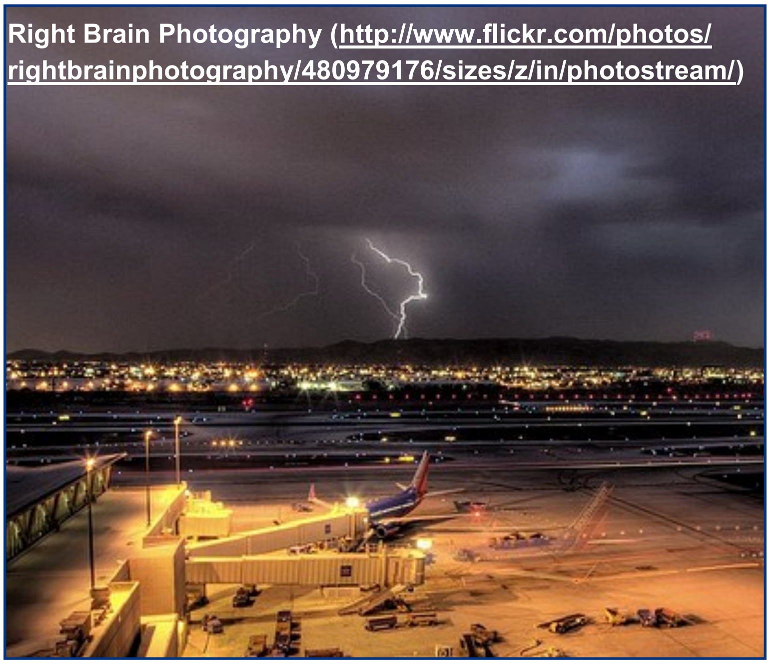
ENSCO

1980 N. Atlantic Ave., Suite 830
Cocoa Beach, FL 32931
(321) 783-9735, (321) 853-8203 (AMU)

Quarterly Task Summaries

This section contains summaries of the AMU activities for the first quarter of Fiscal Year 2013 (October-December 2012). 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.

Objective Lightning Probability Forecasts for East-Central Florida Airports (Page 5)



Right Brain Photography (http://www.flickr.com/photos/rightbrainphotography/480979176/sizes/z/in/photostream/)

Purpose: Develop an objective lightning probability forecast tool for commercial airports in east-central Florida to help improve the lightning forecasts in the warm season. The forecasters at the National Weather Service in Melbourne, Fla. (NWS MLB) are responsible for issuing forecasts for airfields in central Florida, and need to make more accurate lightning forecasts to help alleviate delays due to thunderstorms in the vicinity of an airport. The AMU will develop a forecast tool similar to that developed for the 45th Weather Squadron (45 WS) in previous AMU tasks. The probabilities will be valid for the areas around the airports and time periods needed for the NWS MLB forecast.

Accomplished: Created a graphical user interface (GUI) to output the climatological lightning probabilities for each station, month and time period stratification. Developed lightning probability forecast equations for all stratifications.

Vandenberg AFB Pressure Gradient Wind Study (Page 6)

Purpose: Provide a wind forecasting capability that will improve wind warning forecasts and enhance the safety of the 30th Operational Support Squadron (30 OSS) customers' operations. This capability will be an Excel GUI that ingests surface pressure data automatically and determine the likelihood of reaching warning-level winds based on the pressure gradient across Vandenberg Air Force Base (VAFB). This will allow 30 OSS forecasters to evaluate pressure gradient thresholds between specific pairs of regional observing stations under different synoptic regimes to help determine the onset and duration of warning category winds.

Accomplished: Completed processing the VAFB tower data and developed a database containing maximum hourly peak winds for each day from October 2007-November 2012. Submitted a request to the 14th Weather Squadron (14 WS) for weather station data from the seven 30 OSS-identified synoptic weather stations to evaluate the pressure gradients between them when peak winds ≥ 30kt were observed.

Quarterly Task Summaries
(continued)

First Cloud-to-Ground Lightning Timing Study (Page 8)

Purpose: Develop a tool that provides the distribution of first cloud-to-ground (CG) lightning times in the Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) lightning warning circles to assist the 45 WS customers when planning potentially hazardous outdoor activities. The AMU will determine if there is a relationship between speed-stratified flow regimes and the time of the first CG strike. This relationship, if it exists, would be used in a final tool to assist forecasters in determining when the first CG lightning will occur on KSC/ CCAFS .

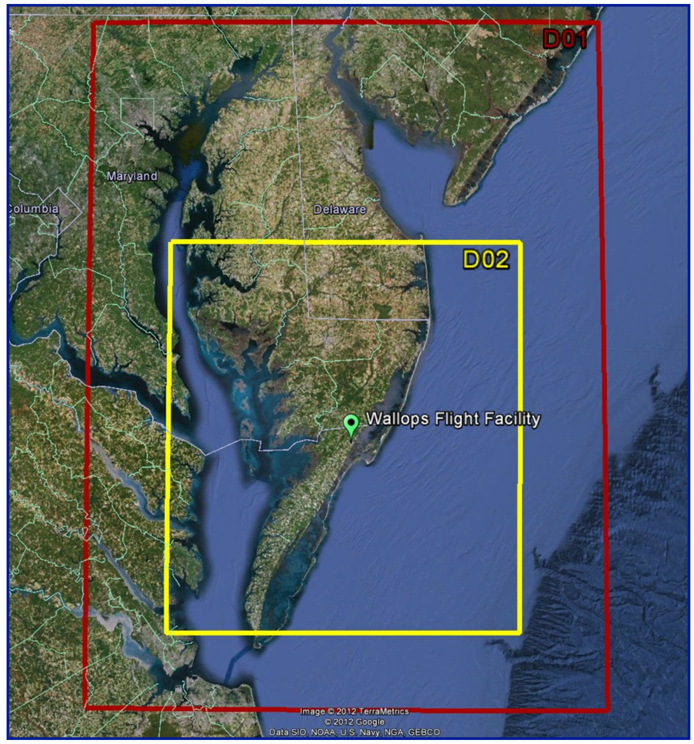
Accomplished: Collected and processed the lightning and sounding data needed to create associations between the first CG strike and the speed-stratified flow regime of the day. Created pivot charts showing the number of times the first strike occurred in each hour for any combination of stratifications, including the sea breeze flow regime, speed, month, and whether lightning occurred.

Severe Weather Tool using 1500 UTC CCAFS Sounding (Page 10)

Purpose: Develop a Meteorological Interactive Data Display System (MIDDS) capability to assess the daily severe weather threat during the warm season months of May-September at KSC/CCAFS based on the late morning, 1500 UTC, CCAFS (XMR) sounding. Using the late morning sounding for this capability instead of the early morning, 1000 UTC, sounding will provide a the 45 WS forecasters with a more accurate assessment of the atmospheric instability each day leading to a better assessment of the severe weather threat.

Accomplished: Generated, downloaded and analyzed upper-level maps for jet stream position. Downloaded the May -September 2011 and May-August 2012 storm reports and added them to the existing AMU storm report database. The Sep 2012 reports will be added to the database when they become available. Wrote Visual Basic for Applications (VBA) scripts in Excel to extract all 1430-1530 UTC May-September 1989-2012 XMR soundings, perform quality control checks, and create a 1500 UTC sounding database.

Range-Specific High-Resolution Mesoscale Model Setup (Page 11)



Purpose: Establish a high-resolution model for the Eastern Range (ER) and Wallops Flight Facility (WFF) to better forecast a variety of unique weather phenomena. Global and national scale models cannot properly resolve important local-scale weather features due to their coarse horizontal resolutions. A properly tuned model at a high resolution would provide that capability and provide forecasters with more accurate depictions of the future state of the atmosphere.

Accomplished: Completed all additional model test cases for the ER using three more Weather Research and Forecasting (WRF) model domain configurations, and validated and compared the output against local observations. Completed writing the first draft of the final report in which model configuration recommendations are made for both the ER and WFF.

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

Objective Lightning Probability Forecasts for East-Central Florida Airports (Ms. Crawford)

The forecasters at NWS MLB are responsible for issuing weather forecasts to several airfields in central Florida. They identified a need to make more accurate lightning forecasts to help alleviate delays due to thunderstorms in the vicinity of an airport. Such forecasts would also provide safer ground operations around terminals, and would be of value to Center Weather Service Units serving air traffic controllers in Florida. To improve the forecast, the AMU was tasked to develop an objective lightning probability forecast tool for the commercial airports in east-central Florida for which NWS MLB has forecast responsibility using data from the National Lightning Detection Network (NLDN). The resulting forecast tool will be similar to that developed by the AMU for the 45 WS in previous tasks (Lambert and Wheeler 2005, Lambert 2007). The lightning probability forecasts will be valid for the time periods and areas needed by the NWS MLB forecasters in the warm season months, defined in this task as May-September.

Graphical User Interface

Ms. Crawford and Mr. Volkmer of NWS MLB discussed how to proceed with the task given the mediocre performance of the forecast equations (AMU Quarterly Report Q4 FY12). They decided to create a GUI to output the climatological values, and then to develop the equations and add them to the GUI when complete.

Even though the equations did not outperform the climatologies, Mr. Volkmer stated that forecasters would still be interested in seeing the equation output since it is calculated using parameters from the current sounding. Ms. Crawford designed the GUI to output the daily climatology and flow regime values for each stratification using Microsoft Excel VBA. The input form is shown in Figure 1. The user chooses the month, day, station, time period, flow regime, and mean speed in the flow regime layer through the drop-down lists, then clicks the "Continue…" button to get the desired output. Figure 2 shows the output from the choices made in Figure 1. The left panel repeats the information from the input form and the daily climatology and flow regime probabilities are shown in the right panel. The Equation box shows -999 as a space holder until Ms. Crawford incorporates the equations. Ms. Crawford delivered the GUI to Mr. Volkmer for testing and design suggestions. Mr. Volkmer's tests were successful and he approved the design.

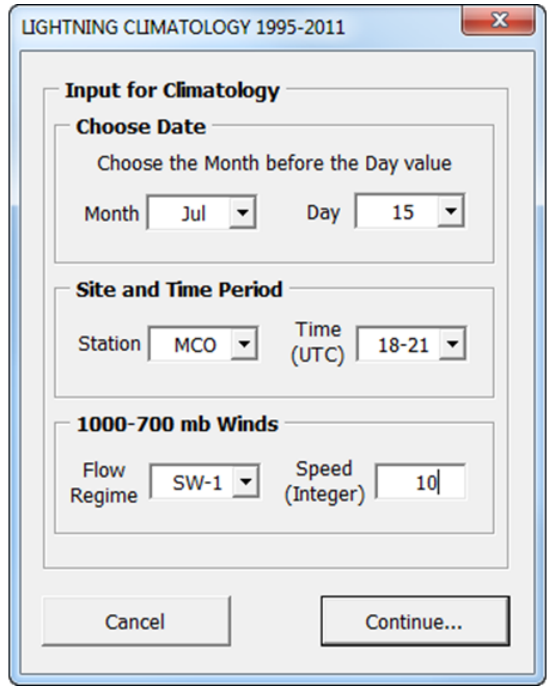


Figure 1. The GUI input form. The user makes choices in each box and then clicks the "Continue…" button to get the output.

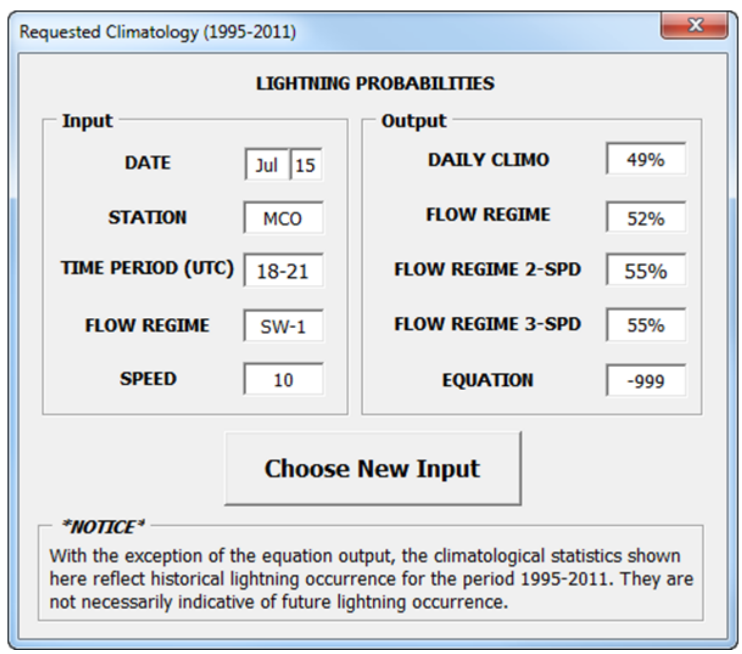


Figure 2. The GUI output form. The input choices are in the left panel and the climatological and computed probabilities are in the right panel. The "Choose New Input" button closes the form and returns control to the input form (Figure 1).

Equation Development

Ms. Crawford developed and tested the Orlando International Airport (MCO) and Melbourne International Airport (MLB) equations, one for each station, month and time period stratification. She developed and tested the equations using the same method described in Lambert (2007), in which the predictors are chosen in rank order of importance. Two stations, five months in the warm season (May-September), and four 3-hour time periods resulted in 40 equations. The number of predictors in the equations ranges from two to five, with an average of three. Thirty-nine equations have either the standard or speed-stratified flow regime probabilities (AMU Quarterly Report Q3 FY12) as one of the first three predictors: 3 have the standard flow regime probabilities, 10 have the two-speed stratified flow regime probabilities, and 26 have the three-speed stratified flow regime probabilities. Representing stability and moisture, 19 equations have Thompson Index, 7 have Total Totals, 6 have precipitable water, and a few of the other parameters as one of the first three predictors.

As part of development and testing, Ms. Crawford created a base equation and then added and eliminated predictors from it to find the combination that performs best using the verification data. She calculated the percent improvement or degradation in skill of the final equations over five forecast benchmarks using the Brier Skill Score (SS) defined in Wilks (2006) and Lambert (2007). Table 1 contains the SS values showing the skill of the July MCO and MLB equations relative to the other forecast methods using the verification data.

The positive values in Table 1 indicate the equations had more skill than the corresponding forecast method, and negative values indicate less skill. As in all previous tests, the equations outperformed 1-day persistence by a wide margin, but the results for the daily climatology and flow regime probabilities were mixed. Values with magnitudes within 10% of 0, positive or negative, likely indicate that the equations performed similarly to the corresponding forecast method. With the exception of the values for 2100-0000 UTC at MCO, most of the values in each time period in Table 1 are > -10% and < 10%.

Status

Ms. Crawford will modify the GUI to incorporate the equations and develop a form to allow forecasters to enter the input parameters for the equations. Ms. Crawford also began writing the final report.

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

Table 1. The percent improvement (positive, black font) or degradation (negative, red font) in skill of the MCO and MLB July equations over the forecast benchmarks of 1-day persistence, daily climatology and three flow regime probabilities. The times in the four column headings to the right are in hours UTC, each time period is three hours. Cells shaded in yellow contain values within 10% of 0.

Station	***Forecast Benchmark***	***15-18***	***18-21***	***21-00***	***00-03***
MCO	1-Day Persistence	49	51	50	48
	Daily Climatology	-4	7	28	4
	Flow Regime Probability	-6	5	23	-2
	Flow Regime 2-Speed	2	5	20	-5
	Flow Regime 3-Speed	-1	4	12	-6
MLB	1-Day Persistence	54	47	55	52
	Daily Climatology	-1	-4	12	3
	Flow Regime Probability	-2	-4	5	-1
	Flow Regime 2-Speed	-1	-3	4	0
	Flow Regime 3-Speed	-2	-6	1	-2

Vandenberg AFB Pressure Gradient Wind Study (Ms. Shafer)

Warning category winds can adversely impact day-to-day space lift operations at VAFB. For example, winds ≥ 30 kt can affect Delta II vehicle transport to the launch pad, Delta IV stage II attitude control system tank load, and other critical operations. The 30 OSS forecasters at VAFB use the mean sea level pressure from seven regional observing stations to determine the magnitude of the pressure gradient as a guide to forecast surface wind speed at VAFB. Their current method uses an Excel-based tool that is manually intensive and does not contain an objective relationship between peak wind and pressure gradient. They require a more objective and automated capability to help them forecast the onset and duration of warning category winds to enhance the safety of their customers' operations. The 30 OSS has requested that the AMU develop an automated Excel GUI that includes pressure gradient thresholds between specific observing stations under different synoptic regimes to aid forecasters when issuing wind warnings.

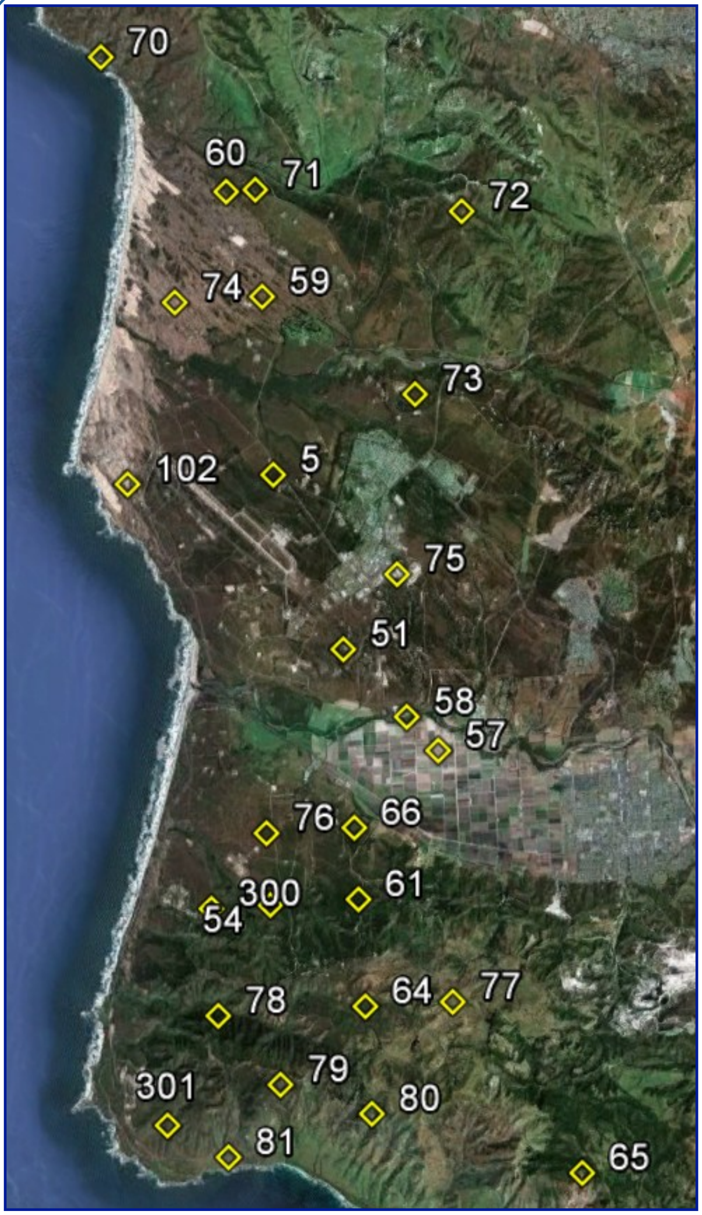


Figure 3. Locations of the 26 wind towers in the VAFB network (KVBG in Figure 4).

Figure 4. Locations of the seven observing stations included in the pressure gradient assessment. KVBG is VAFB.

Data Acquisition and Processing

Part of this task is to determine past high wind events in the wind tower network on VAFB and compare the local pressure gradients at the time. The 30 OSS delivered historical wind data from the 26 VAFB wind towers (Figure 3) in their network to the AMU. Ms. Shafer quality controlled and processed the observations and developed a database containing maximum hourly peak winds for each day from October 2007-November 2012. Ms. Shafer then determined all days where winds ≥ 30 kt were observed and provided Mr. Brock of the 30 OSS with a list of these dates. Mr. Brock will organize these dates by synoptic regime as agreed in the task proposal. Meanwhile, Mr. Roeder of the 45 WS submitted a request to the 14 WS for mean sea level pressure observations from the seven weather stations identified by 30 OSS for calculating pressure gradients (Figure 4). Once received, Ms. Shafer will organize the observations by flow regime and determine pressure gradients by station pair.

Climatology Database

As discussed in the November 2012 tasking meeting, the AMU agreed to use the VAFB wind tower data to build a master climatology database for each of the 26 wind towers. The database will include temperature (F), dewpoint (F), relative humidity (%), average 1 minute sustained wind speed (kt) and direction (degrees), and peak wind speed (kt) and direction (degrees) at the 2, 4, and 16 m sensor levels. Ms. Shafer wrote Perl scripts and began processing the tower data for this climatology database.

Contact Ms. Shafer at 321-853-8200 or shafer.jaclyn@ensco.com for more information.

First Cloud-to-Ground Lightning Timing Study (Dr. Huddleston)

The probability of CG lightning occurrence is included in the daily and weekly lightning probability forecasts issued by the 45 WS. These forecasts are important in the warm season months, May-October, when the area is most affected by lightning. Many KSC and CCAFS organizations use this information when planning potentially hazardous outdoor activities, such as working with fuels or rolling a vehicle to a launch pad. These organizations would benefit greatly if the 45 WS could provide more accurate timing of the first CG lightning of the day in addition to the probability of lightning occurrence. The AMU has made significant improvements in forecasting the probability of lightning for the day. However, forecasting the time of the first CG lightning with confidence has remained a challenge. The ultimate goal is to develop a tool that provides the distribution of first CG lightning times in the KSC/CCAFS lightning warning circles to assist the 45 WS customers to plan for activities prone to disruption due to lightning activity. In this task, the AMU will determine if there is a relationship between speed -stratified flow regimes and the time of the first CG strike. This relationship, if it exists, would be used in a final tool to assist forecasters in determining when the first CG lightning will occur on KSC/CCAFS.

Data Preparation

The data to be used in this task are from the Cloud-to-Ground Lightning Surveillance System (CGLSS) and 1000 UTC XMR soundings. The period of record is the warm season months in the years 1989-2011. The AMU has the processed XMR and CGLSS data from previous tasks and will use them to create distributions of time of the first CG strike in the KSC/CCAFS 5 NM lightning warning circles (Figure 5). These data are stratified by month and were provided to Dr. Huddleston by Ms. Crawford.

CGLSS

In addition to being stratified by month, the CGLSS data were filtered to capture the hour of the first lightning strike of the day that occurred in the KSC/CCAFS warning circles for which the 45 WS has forecasting responsibility and for times between 7:00 a.m. and midnight local time (Lambert 2007).,The area does not include Haulover, Astrotech, and Patrick Air Force Base.

XMR Soundings

The AMU's 1000 UTC XMR data were filtered to only include observations between the surface and 700 mb. According to the 45 WS Forecast Reference Notebook (FRN), the forecasters use the average direction in a sea breeze layer from the surface to 5,000 ft. Dr. Huddleston used Microsoft Access to filter the data further to include only data in this sea breeze layer. She then calculated the average surface to 5,000-ft winds and used them to determine the sea breeze flow regime of the day.

Stratification

The AMU and 45 WS held a meeting to discuss ways of stratifying the data into sea breeze flow regimes and speed categories. They decided to follow the sea breeze flow regime direction sectors and speed categories defined in the FRN. They also discussed some simplified stratification methods in case there were not enough data in one or more stratifications to create robust statistics in determining a relationship between the flow regime/speed stratifications and the time of the first CG strike.

Table 2 shows the eight sea breeze flow regimes as defined in the FRN. Table 3 shows the alternate two- and four-sector sea breeze flow regimes that will be used if there are not enough data in the eight-sector stratifications. Table 4 shows the four-speed stratifications defined by the 45 WS during the meeting, and the alternate three-speed stratifications that will be used if there are not enough data in the four-speed stratifications. These speed ranges are based on the values in the FRN that define different speed stratifications for each sea breeze flow regime.

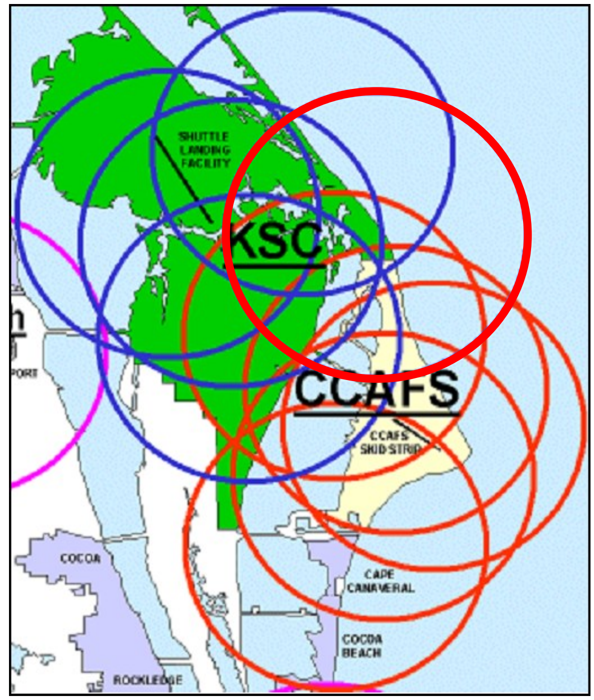


Figure 5. The 5-NM lightning warning circles on KSC (blue) and CCAFS (red) (Crawford 2010).

Table 2. The eight 45 WS sea breeze flow regime sectors for the surface to 5,000-ft layer as outlined in the FRN.

Sea Breeze Flow Regime	Direction Sector
E	>66° and ≤110°
SE	>110° and ≤155°
S	>155° and ≤200°
SW	>200° and ≤245°
W	>245° and ≤290°
NW	>290° and ≤335°
N	>335° or ≤20°
NE	>20° and ≤66°

Dr. Huddleston stratified the data by flow regime and then by speed range. With two, four and eight flow regime categories, and three and four speed categories, the data could be divided into a minimum of six to a maximum of 24 stratifications. Dr. Huddleston will choose the categories that provide enough observations in each stratification to derive meaningful statistics.

Exploratory Data Analysis

Dr. Huddleston imported the CGLSS and XMR sounding data into Microsoft Access for processing. She filtered out the time of the first strike of the day from the CGLSS data, and filtered the sounding data to contain only observations from the surface to 5,000 ft. She then calculated the average speed and direction in the 5,000-ft layer from the sounding observations in order to determine the flow regime and speed classification for each day.

Dr. Huddleston imported the processed data into Microsoft Excel to create PivotTables, an Excel feature that allows the user to display data in different configurations with point-click-drag techniques. These PivotTables allow creation of PivotCharts to assist in visualizing the number of times the first strike occurred in each hour for any combination of stratifications, including the sea breeze flow regime, speed, month, and whether lightning occurred or not. Figure 6 shows the number of first CG strikes in each local hour by the FRN flow regimes (Table 2). Figure 7 shows the number of strikes in July for the FRN medium speed category and the FRN flow regimes.

Continuing Work

Dr. Huddleston will meet with the 45 WS to discuss which flow regime/speed stratification produces enough observations to make robust probability density functions (PDFs) showing the probability of a first lightning strike occurring at a specified local hour of the day. Based on the results of the discussion, Dr. Huddleston will select the desired sea breeze flow regime and speed categories to generate PDFs. She will analyze the PDFs to determine if there is a relationship between the flow regime/speed stratifications and the time of the first CG strike of the day.

For more information contact Dr. Lisa Huddleston at 321-853-8217 or lisa.l.huddleston@nasa.gov.

Table 3. The alternate two- and four-sector sea breeze flow regime sectors for the surface to 5,000-ft layer.

Stratification	Sea Breeze Flow Regime	Direction Sector
Two-Sector	Off-Shore	≥135° and <315°
	On-Shore	≥315° or <135°
Four-Sector	Off-Shore SW	≥135° and <225°
	Off-Shore NW	≥225° and <315°
	On-Shore NE	≥315° or <45°
	On-Shore SE	≥45° and <135°

Table 4. The mean surface to 5,000-ft layer four-speed stratifications and alternate three-speed stratifications.

# Speed Stratifications	Stratification Name	Wind Speed Range
Four	Low	≤5 kts
	Medium	>5 kts and ≤11 kts
	Medium High	>11 kts and ≤16 kts
	High	>16 kts
Three (alternate)	Low	≤7.7 kts
	Med	>7.7 kts and ≤12.6 kts
	High	>12.6 kts

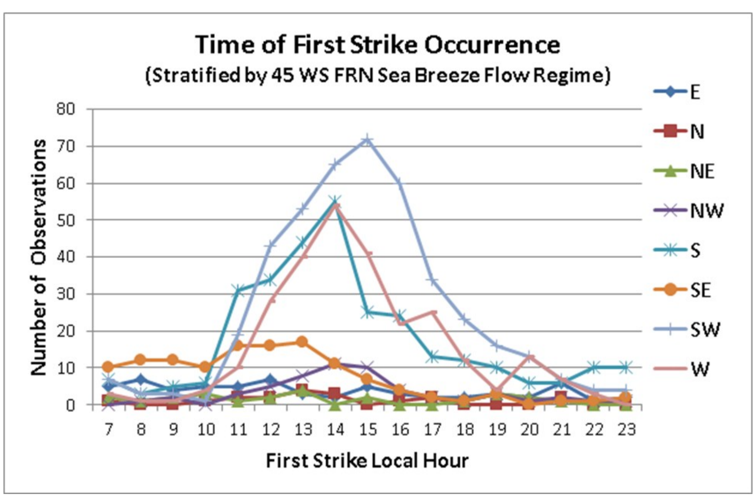


Figure 6. Lines showing the number of times the first strike occurred in each local hour stratified by the FRN sea breeze flow regime (legend at right) described in Table 2. All months and all speed categories are included in the values.

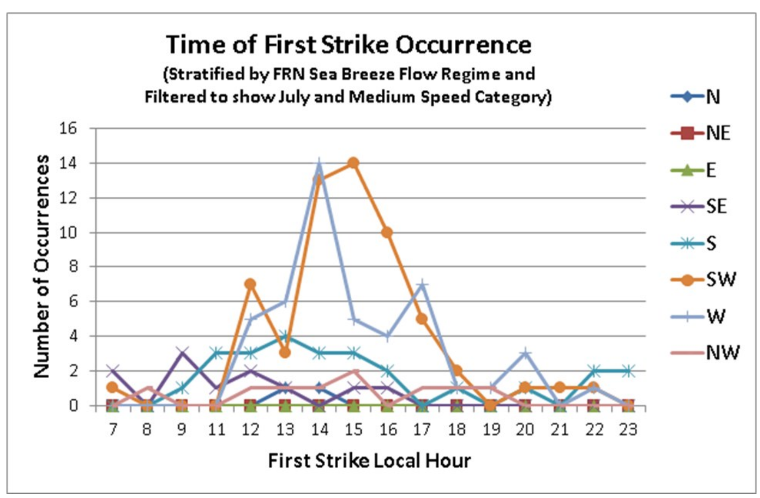


Figure 7. Lines showing the number of times the first strike occurred in each local hour stratified by the FRN sea breeze flow regime (legend at right) described in Table 2. The data are filtered to show the values for July and the FRN medium speed category (>5 kts and ≤11 kts) described in Table 4.

Severe Weather Tool Using 1500 UTC CCAFS Soundings (Dr. Bauman)

People and property at KSC and CCAFS are at risk when severe weather occurs. Strong winds, hail and tornadoes can injure individuals and cause costly damage to structures if not properly protected. The ER customers at KSC and CCAFS use the daily and weekly severe weather forecasts issued by the 45 WS to determine if they need to limit an activity such as working on gantries, or protect property such as a vehicle on a pad. Missed lead-times and false alarm rates have shown that severe weather in east-central Florida is difficult to forecast during the warm season (May-September). Due to the threat severe weather poses to life and property at the ER and the difficulty in making the forecast, the 45 WS requested the AMU develop a warm season severe weather tool based on the late morning, 1500 UTC (1100 local time), XMR sounding. The 45 WS frequently makes decisions to issue a severe weather watch and other severe weather warning support products to NASA and the 45th Space Wing in the late morning, after the 1500 UTC sounding, which is more representative of the atmospheric instability than the early morning, 1000 UTC, sounding. A tool using the 1500 UTC sounding should provide improved accuracy for severe weather notifications and better allow decision makers to implement appropriate mitigation efforts.

Existing Data Sets

The AMU has three existing data sets that were compiled during several previous tasks that will be used in this task after they are updated with 2011 and 2012 data. They include upper-level jet stream analyses, severe storm reports and daily flow regimes.

To update the existing data sets, Dr. Bauman generated and downloaded the 200 mb wind and streamline maps from the Plymouth State University Weather Center (http://vortex.plymouth.edu/u-make.html) for the 2011 and 2012 warm season months. He analyzed the maps for the jet stream position and entered the results into the existing 1989-2010 AMU jet stream analysis database. Next, Dr. Bauman downloaded the 2011 and 2012 warm season months severe storm reports from the National Climatic Data Center Storm Events Database (ftp.ncdc.noaa.gov/pub/data/swdi/stormevents) and then added the severe events for Brevard, Volusia, Indian River, Seminole, Osceola and Orange counties to the existing 1989-2010 AMU severe storm reports database. Finally, Dr. Bauman added the 2011 daily flow regimes to the 1989-2010 AMU flow regime database. He will create and add the 2012 flow regimes to the database later in this task.

New Data Set

The one new data set required for this task is the stability parameters from the 1500 UTC sounding database. To create this database, Ms. Crawford provided sounding files that she reformatted from the original raw soundings the AMU received for previous tasks from Computer Sciences Raytheon (CSR) personnel. The reformatted files contained data from all radiosondes released from May-September 1989-2011. Upon inspection, Dr. Bauman discovered the 1991 files only contained 1000 UTC soundings. Since the AMU did not have the 1500 UTC 1991 soundings, he requested all soundings from May-September 1991 from Mr. Kulow at the CCAFS Weather Station. These data have not yet been delivered.

The sounding files reformatted by Ms. Crawford were in ASCII text format and were parsed into files containing mandatory, significant and 1,000-ft levels for multiple years and months. Dr. Bauman reorganized these files into three files per year containing data from all soundings in May-September of each year: one mandatory, one significant and one 1,000-ft. He also reformatted the raw 2012 soundings in the same manner as Ms. Crawford did for the other years. Dr. Bauman wrote scripts using VBA in Excel to process the sounding files as follows:

- extract the 1430-1530 UTC mandatory, significant and 1,000-ft level sounding data,
- merge the extracted data into individual daily sounding files and save them as Excel spreadsheets,
- format the files to be processed by TIBCO Spotfire S+ (TIBCO 2010) scripts created by Ms. Crawford to generate the sounding stability parameters, and
- automatically quality control (QC) the soundings to remove duplicate levels, check for heights in meters instead of feet and check for multiple daily soundings between 1430-1530 UTC.

After running the scripts, Dr. Bauman manually QC'd the data in the Excel spreadsheets flagged by the automated QC. For any days with multiple soundings between 1430-1530 UTC, he assessed each sounding and kept the one released closest to 1500 UTC or the most complete sounding. For any soundings with heights in both meters and feet, he deleted the rows with heights in meters, leaving complete soundings containing only heights in feet. Finally, he wrote a VBA script that merged each daily sounding file for each year into one Excel file per year. Not including 1991, 22 years of warm season soundings resulted in a total of 2,776 days with one sounding released between 1430-1530 UTC out of a possible 3,366. The total number of soundings will increase after Dr. Bauman processes the 1991 data.

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

Range-Specific High-Resolution Mesoscale Model Setup (Dr. Watson)

The ER and WFF would benefit greatly from high-resolution mesoscale model output to better forecast a variety of unique weather phenomena. Global and national scale models cannot properly resolve important local-scale weather features at each location due to their horizontal resolutions being much too coarse. A properly tuned model at a high resolution would provide that capability. This is the first phase in a multi-phase study in which the WRF model will be tuned individually for each range. The goal of this phase is to tune the WRF model based on the best model resolution and run time while using reasonable computing capabilities. The ER and WFF supported tasking the AMU to perform a number of sensitivity tests in order to determine the best model configuration for operational use at each of the ranges.

Additional ER Test Cases

At the request of the 45 WS, Dr. Watson compared three additional WRF configurations for the ER with varying horizontal grid spacing to determine if a slightly coarser or finer resolution would have an impact on the results. The additional model configurations are listed below:

- Configuration 1: Advanced Research WRF (ARW) core, 2 km outer domain and 0.67 km inner domain, Lin microphysics scheme, Yonsei University (YSU) planetary boundary layer (PBL) scheme (Lin-YSU 2/0.6),
- Configuration 2: ARW core, 3 km outer domain and 1 km inner domain, Lin microphysics scheme, YSU PBL scheme (Lin-YSU 3/1), and
- Configuration 3: ARW core, 1 km outer domain and 0.3 km inner domain, Lin microphysics scheme, YSU PBL scheme (Lin-YSU 1/0.3).

Dr. Watson initiated the three configurations at 1500 UTC and integrated them 9 hours once per day from 1-7 August 2011. She computed the verification statistics for each configuration at seven KSC/CCAFS wind towers. She then used the mean error (ME) and root mean square error (RMSE) values to populate the color-coded Good-Bad-Neutral (GBN) tables. The GBN tables show which model configuration performed the best and worst. A good rating is colored green and indicates that the model configuration had the lowest, or best, ME or RMSE values among the different configurations. A bad rating is colored red and had the highest, or worst, ME or RMSE values, and neutral is yellow and fell in between. Table 5 shows the 7-day ME and RMSE values for the three configurations for wind direction, wind speed, temperature, and dewpoint temperature. The results indicate that the two higher resolution model configurations slightly outperformed the coarser resolution for wind speed, temperature, and dewpoint temperature. The Lin-YSU 3/1 km outperformed the both the 2/0.67 and 1/0.3 km configurations for wind direction.

Final Report

Dr. Watson completed a first draft of the final report containing details of the work done and the AMU's model configuration recommendations for both ranges. It is currently in AMU internal review.

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

Table 5. GBN chart of the average ME and RMSE for 1-7 August 2011 for seven KSC/CCAFS wind towers for three ARW configurations with varying horizontal resolutions. The best values are green, the worst are red, and the yellow are in between.

7-day: Mean Error - All Towers				
Configuration	*Wind Dir*	*Wind Spd*	*Temp*	*Dewpt*
Lin-YSU (2/0.6)	47.4	-0.086	-0.880	-1.950
Lin-YSU (3/1)	43.0	0.143	-2.240	-1.950
Lin-YSU (1/0.3)	49.6	-0.097	-0.942	-1.879
7 day: RMSE - All Towers				
Configuration	*Wind Dir*	*Wind Spd*	*Temp*	*Dewpt*
Lin-YSU (2/0.6)	63.1	1.400	2.369	3.224
Lin-YSU (3/1)	62.1	1.534	3.161	3.353
Lin-YSU (1/0.3)	65.9	1.335	2.632	3.039

AMU ACTIVITIES

AMU Operations

AMU Tasking

In preparation for the AMU Tasking Meeting, the AMU team completed the task proposal responses and each team member reviewed each response before they were prepared for the customers. Dr. Huddleston distributed the AMU responses to the customers on 10 October. The AMU Tasking Meeting was held on 16 November at KSC. Six new tasks were approved for the AMU to work on in FY 2013. The AMU team updated the Task Plans with the new task descriptions. Dr. Bauman submitted the updated AMU Task Plans to the AMU COTR for review and approval on 7 December.

Visitors

Ms. Shafer presented the AMU General Briefing to visiting Embry-Riddle Aeronautical University students as part of their tour of the 45 WS weather operations center.

Conferences and Training

Ms. Crawford attended the 37th National Weather Association (NWA) Annual Meeting in Madison, Wis., 8-11 October. She attended several meetings as a member of the NWA Communications and Publications Committees.

Ms. Shafer and Dr. Bauman presented dry-runs of their briefings for the 93rd American Meteorological Society Annual Meeting to the AMU staff, KSC Weather Office and 45 WS personnel.

General

Dr. Bauman met with Mr. Jeff Kohler and Ms. Hetal Miranda from the KSC Technology Transfer Office to discuss the New Technology Report (NTR) submitted by Dr. Bauman for the Upper Air Changes Through Launch Count task. Mr. Kohler indicated they would move forward to approve the NTR and he also indicated he would like to feature the AMU in an upcoming issue of Tech Transfer Magazine.

The AMU team worked with ENSCO's Art Director and Senior Web Designer/Front-end Developer to design a new AMU logo. The old logo prominently portrayed a space shuttle, which is no longer representative of the AMU mission since the Shuttle Program ended. AMU customers were asked to vote on several new logo designs. Once chosen, the KSC Weather Office and KSC Public Affairs approved the new AMU logo, which is at the top left on the front page of this report.

Dr. Bauman participated in a teleconference with Mr. Madura, Dr. Merceret and Mr. Roeder led by Dr. Paul O'Brien of The Aerospace Corporation to develop a strategy for writing a feature article to appear in the journal *Space Weather*. This article will describe how the space weather community could benefit from an AMU-type organization.

AMU Chief's Technical Activities (Dr. Huddleston)

Dr. Huddleston attended the kick-off meeting for the KSC 50 MHz Doppler Radar Wind Profiler (DRWP) acquisition project on 19 October. She attended a "walk through" of the 50 MHz DRWP on 28 November. She is also reviewing the KSC 50 MHz DRWP replacement proposal to prepare for the preliminary design review scheduled for 17-18 January 2013.

Dr. Huddleston resumed collecting infrared thermometer sky temperature data for comparison with Global Positioning System (GPS) integrated precipitable water data.

Dr. Huddleston reviewed a proposal for the NASA Experimental Program to Stimulate Competitive Research (EPSCoR) program titled "Research Portfolio for Inaugural Aerospace Science Doctoral Program."

Dr. Huddleston completed a Princeton University online statistics course to learn the R statistical software package for possible use in future AMU tasks. She accessed the course through Coursera, a company that offers free online courses from several universities.

REFERENCES

Crawford, W., 2010: Objective Lightning Probability Forecasting for Kennedy Space Center and Cape Canaveral Air Force Station, Phase III. NASA Contractor Report CR-2010-216292, Kennedy Space Center, FL, 34 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 830, Cocoa Beach, FL, 32931, and http://science.ksc.nasa.gov/amu/final-reports/objective-ltg-fcst-phase3.pdf.]

Lambert, W., 2007: Objective Lightning Probability Forecasting for Kennedy Space Center and Cape Canaveral Air Force Station, Phase II. NASA Contractor Report CR-2005-214732, Kennedy Space Center, FL, 57 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 830, Cocoa Beach, FL, 32931, and http://science.ksc.nasa.gov/amu/final-reports/objective-ltg-fcst-phase2.pdf.]

TIBCO, 2010: TIBCO Spotfire S+® 8.2 Programmer's Guide, TIBCO Software Inc., Seattle, WA, 532 pp.

Wilks, D. S., 2006: *Statistical Methods in the Atmospheric Sciences*. Academic Press, 627 pp.

LIST OF ACRONYMS

14 WS	14th Weather Squadron
30 SW	30th Space Wing
30 OSS	30th Operational Support 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
AMPS	Automated Meteorological Profiling System
AMU	Applied Meteorology Unit
ARW	Advanced Research WRF
AUC	Area Under the Curve
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground
CGLSS	CG Lightning Surveillance System
CSR	Computer Sciences Raytheon
DRWP	Doppler Radar Wind Profiler
ER	Eastern Range
ESRL	Earth System Research Laboratory
FRN	Forecast Reference Notebook
FSU	Florida State University
GBN	Good Bad Neutral
GPS	Global Positioning System
GUI	Graphical User Interface
JSC	Johnson Space Center
KSC	Kennedy Space Center
MCO	Orlando International Airport
ME	Mean Error
MIDDS	Meteorological Interactive Data Display System
MLB	Melbourne International Airport
MSFC	Marshall Space Flight Center
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NTR	New Technology Report
NWS MLB	National Weather Service in Melbourne, Fla.
PDF	Probability Density Function
QC	Quality Control
RMSE	Root Mean Square Error
SMC	Space and Missile Center
SS	Brier Skill Score
URL	Uniform Resource Locator
USAF	United States Air Force
VAFB	Vandenberg Air Force Base
VBA	Visual Basic for Applications
WFF	Wallops Flight Facility
WRF	Weather Research and Forecasting Model
XMR	CCAFS 3-letter identifier

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

AMU Quarterly Reports are available on the Internet at http://science.ksc.nasa.gov/amu/.

They are also available in electronic format via email. If you would like to be added to the email distribution list, please contact Ms. Winifred Crawford (321-853-8130, crawford.winnie@ensco.com).

If your mailing information changes or if you would like to be removed from the distribution list, please notify Ms. Crawford or Dr. Lisa Huddleston (321-861-4952, Lisa.L.Huddleston@nasa.gov).

Distribution

NASA HQ/AA/ W. Gerstenmaier
NASA KSC/AA/R. Cabana
NASA KSC/KT-C/J. Perotti
NASA KSC/LX/P. Phillips
NASA KSC/LX/S. Quinn
NASA KSC/LX-52/J. Amador
NASA KSC/NESC-1/S. Minute
NASA KSC/GP/S. Kerr
NASA KSC/GP/D. Lyons
NASA KSC/GP/R. Mizell
NASA KSC/GP/P. Nickolenko
NASA KSC/GP-B/J. Madura
NASA KSC/GP-B/F. Merceret
NASA KSC/GP-B/ L. Huddleston
NASA KSC/GP-B/J. Wilson
NASA KSC/GP-B/K. Cummings
NASA KSC/GP-G4/R. Brown
NASA KSC/LX-D1/M. Galeano
NASA KSC/LX-S1/P. Nicoli
NASA KSC/SA/R. Romanella
NASA KSC/SA/B. Braden
NASA KSC/VA/A. Mitskevich
NASA KSC/VA-H/M. Carney
NASA KSC/VA-H1/B. Beaver
NASA KSC/VA-H3/ P. Schallhorn
NASA KSC/VA-H3/D. Trout
NASA KSC/VA-2/C. Dovale
NASA KSC/VA-2/O. Baez
NASA KSC/VA-2/T. Dunn
NASA KSC/OP-MS/K. Boos
Analex Corp/Analex-20/ M. Hametz
NASA JSC/WS8/F. Brody
NASA MSFC/EV44/B. Roberts
NASA MSFC/EV44/R. Decker
NASA MSFC/EV44/H. Justh
NASA MSFC/ZP11/ G. Jedlovec
NASA MSFC/VP61/J. Case
NASA MFSC/VP61/G. Stano
NASA WFF/840.0/A. Thomas
NASA WFF/840.0/T. Wilz
NASA WFF/840.0/N. Kyper
NASA WFF/840.0/E. Thomas
NASA DFRC/RA/E. Teets
NASA LaRC/M. Kavaya
45 WS/CC/S. Cahanin
45 WS/DO/B. Belson
45 WS/DOR/M. McAleenan
45 WS/DOR/J. Smith
45 WS/DOR/M. Howard
45 WS/DOR/F. Flinn
45 WS/DOR/ T. McNamara
45 WS/DOR/J. Tumbiolo
45 WS/DOR/K. Winters
45 WS/DOR/D. Craft
45 WS/DOU/K. Schubeck
45 WS/SY/J. Fenlason
45 WS/SYA/J. Saul
45 WS/SYR/W. Roeder
45 RMS/CC/V. Beard
45 RMS/RMRA/R. Avvampato
45 SW/CD/G. Kraver
45 SW/SELR/K. Womble
45 SW/XPR/R. Hillyer
45 OG/CC/D. Schiess
45 OG/TD/C. Terry
CSC/M. Maier
CSR 1000/S. Griffin
CSR 3410/C. Adams
CSR 3410/R. Crawford
CSR 3410/D. Pinter
CSR 3410/M Wilson
CSR 4500/J. Osier
CSR 4500/T. Long
SLRSC/ITT/L. Grier
SMC/OL-U/M. Erdmann
SMC/OL-U/T. Nguyen
SMC/OL-U/R. Bailey
SMC/CON/J. Gertsch
HQ AFSPC/A3FW/J. Carson
HQ AFWA/A3/M. Surmeier
HQ AFWA/A3T/S. Augustyn
HQ AFWA/A3T/D. Harper
HQ AFWA/16 WS/WXE/ J. Cetola
HQ AFWA/16 WS/WXE/ G. Brooks
HQ AFWA/16 WS/WXP/ D. Keller
HQ USAF/A30-W/R. Stoffler
HQ USAF/A30-WX/T. Moore
HQ USAF/Integration, Plans, and Requirements Div/ Directorate of Weather/ A30-WX
NOAA “W/NP”/L. Uccellini
NOAA/OAR/SSMC-I/J. Golden
NOAA/NWS/OST12/SSMC2/ J. McQueen
NOAA Office of Military Affairs/ M. Babcock
NWS Melbourne/B. Hagemeyer
NWS Melbourne/D. Sharp
NWS Melbourne/S. Spratt
NWS Melbourne/P. Blottman
NWS Melbourne/M. Volkmer
NWS Southern Region HQ/“W/ SR”/S. Cooper
NWS/SR/SSD/STB/B. Meisner
NWS/“W/OST1”/B. Saffle
NWS/”W/OST12”/D. Melendez
NWS/OST/PPD/SPB/P. Roohr
NSSL/D. Forsyth
30 OSS/OSWS/DO/B. Lisko
30 OSS/OSWS/M. Schmeiser
30 OSS/OSWS/T. Brock
30 SW/XPE/R. Ruecker
Det 3 AFWA/WXL/K. Lehneis
NASIC/FCTT/G. Marx
46 WS//DO/J. Mackey
46 WS/WST/E. Harris
412 OSS/OSW/P. Harvey
412 OSS/OSWM/G. Davis
UAH/NSSTC/W. Vaughan
FAA/K. Shelton-Mur
FSU Department of Meteorology/H. Fuelberg
ERAU/Applied Aviation Sciences/C. Herbster
ERAU/J. Lanicci
NCAR/J. Wilson
NCAR/Y. H. Kuo
NOAA/ESRL/GSD/S. Benjamin
Office of the Federal Coordinator for Meteorological Services and Supporting Research/ R. Dumont
Aerospace Corp/T. Adang
ITT/G. Kennedy
Timothy Wilfong & Associates/ T. Wilfong
ENSCO, Inc./J. Stobie
ENSCO, Inc./R. Gillen
ENSCO, Inc./E. Lambert
ENSCO, Inc./A. Yersavich
ENSCO, Inc./S. Masters

NOTICE: Mention of a copyrighted, trademarked, or proprietary product, service, or document does not constitute endorsement thereof by the author, ENSCO, Inc., the AMU, the National Aeronautics and Space Administration, or the United States Government. Any such mention is solely for the purpose of fully informing the reader of the resources used to conduct the work reported herein.