AMU

Applied Meteorology Unit

Quarterly Report
Third Quarter FY-13
31 July 2013

Infusing Weather Technology Into Aerospace Operations

Contract NNK12MA53C/DRL-003 DRD-004

In this issue:

Antares test fight at Wallops Flight Facility on 21 April 2013 (http://spaceflightnow.com/antares/demo/aerials/, image credit: NASA Wallops Range Optics).

Launch Support

Dr. Watson and Dr. Huddleston supported the Atlas 5 launch on 15 May.

Dr. Bauman and Dr. Merceret supported the Delta 4 launch on 24 May.

This Quarter's Highlights

The AMU team worked on seven tasks for their customers:

- Ms. Crawford completed the objective lightning forecast tool for east-central Florida airports and delivered the tool and the final report to the customers.
- Ms. Shafer continued work for Vandenberg Air Force Base on an automated tool to relate pressure gradients to peak winds.
- Dr. Huddleston updated and delivered the tool that shows statistics on the timing of the first lightning strike of the day in the Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) area.
- Dr. Bauman continued work on a severe weather forecast tool focused on the Eastern Range (ER).
- Ms. Crawford acquired the software and radar data needed to create a dual-Doppler analysis over the east-central Florida and KSC/CCAFS areas.
- Mr. Decker continued developing a wind pairs database for the Launch Services Program to use when evaluating upper-level winds for launch vehicles.
- Dr. Watson continued work to assimilate observational data into the high-resolution model configurations she created for Wallops Flight Facility and the ER.

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 third quarter of Fiscal Year 2013 (April-June 2013). 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 6)

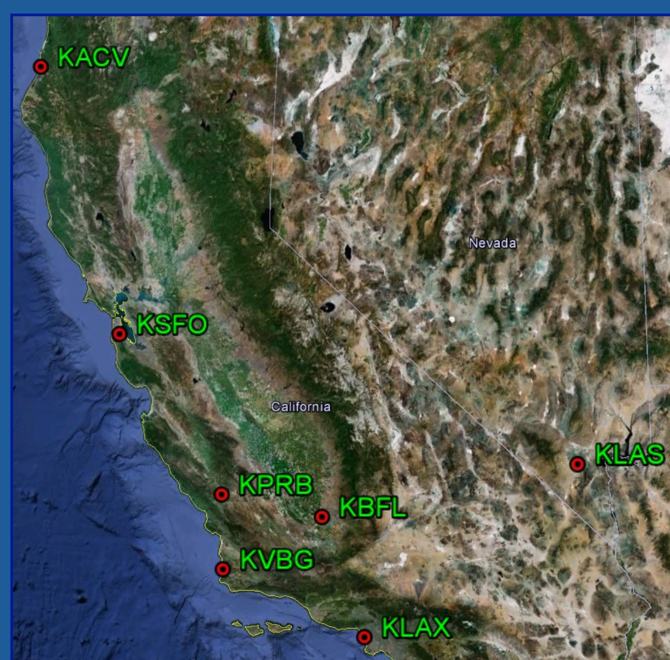
Right Brain Photography (http://www.flickr.com/photos/rightbrainphotography/480979176/sizes/z/in/photostream/)

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, FL (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: Delivered the final version of the tool as an Excel graphical user interface (GUI) and gave a briefing to the NWS MLB forecasters on how to use the tool and how it was developed. Completed the final report, delivered it to the customers, and submitted the forms for NASA approval in order to make the report available on the AMU website.

Vandenberg AFB Pressure Gradient Wind Study (Page 7)

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 (PG) across Vandenberg Air Force Base (VAFB). This will allow 30 OSS forecasters to evaluate PG 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 reviewing the relationship between pressure gradients and maximum peak wind at VAFB. Given the study did not yield a clear qualitative relationship, calculated correlation coefficients between the two variables for each station pair to determine quantitative relationship. Began organizing the climatology database to calculate statistics and deliver this information in a Microsoft Access or Excel GUI.

Quarterly Task Summaries
(continued)

First Cloud-to-Ground Lightning Timing Study (Page 10)

Purpose: Create a lightning timing forecast ability to assist 45 WS ER customers when planning potentially hazardous outdoor activities. The 45 WS provides a daily lightning forecast, then issues watches and warnings as needed. The ER customers would benefit from a forecast that provides expected times of lightning occurrence to adjust their outdoor operations planning. This tool provides the distribution of first cloud-to-ground (CG) lightning times in the KSC/CCAFS lightning warning circles to assist the 45 WS customers. 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: Completed a GUI using the Slicers feature in Excel 2010 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. Delivered the GUI to 45 WS and began writing the final report.

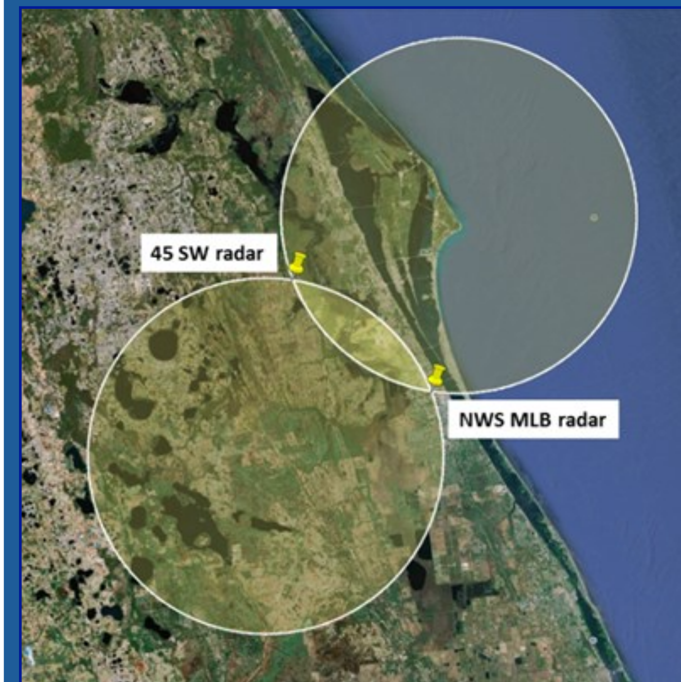
Severe Weather Tool using 1500 UTC CCAFS Sounding (Page 11)

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: Developed and began testing the real time severe weather tool in MIDDS. Developed a 1000 UTC sounding-based version of the 1500 UTC Severe Weather Tool and began testing it in MIDDS.

Quarterly Task Summaries
(continued)

Configuration and Evaluation of a Dual-Doppler 3-D Wind Field System (Page 14)



Purpose: Develop a dual-Doppler system using freely available software to create a three-dimensional (3-D) wind field over KSC/CCAFS using data from the three local Doppler radars. Space vehicle operations are halted when winds exceed defined thresholds and when lightning is a threat. A display of the wind field to reveal areas of high winds or convergence, especially over areas where no observations exist, would be useful to forecasters in predicting the onset of vehicle-critical weather phenomena, and can also be used to initialize a local mesoscale numerical weather prediction model to improve the model forecast of these phenomena. A dual-Doppler wind field display will aid in using ground processing and space launch resources more efficiently by stopping or starting work in a timelier manner.

Accomplished: Consulted with NWS MLB and chose the Warning Decision Support System Integrated Information (WDSS-II) software to conduct the dual-Doppler analysis. Downloaded and installed the software on an AMU Linux PC. Collected data from three local Doppler radars to use in testing the dual-Doppler procedure.

Wind Pairs Database for Persistence Modeling (Page 15)

Purpose: Develop upper-level (UL) wind profile temporal pair databases and conduct a statistical analysis of wind changes at the Eastern Range (ER), Western Range (WR) and Wallops Flight Facility (WFF) for use by NASA's Launch Services Program (LSP) space launch vehicle teams in their commit-to-launch decisions. Their current assessments are based on UL wind data obtained earlier in the launch count, which may not represent the winds the vehicle will ascend through. This uncertainty can be mitigated by a statistical analysis of wind change over time periods of interest using historical data from the launch range. The intent of these databases is to help LSP improve the accuracy of launch commit decisions by applying wind change statistics based on measured historical data, as opposed to modeled data, into UL wind assessments.

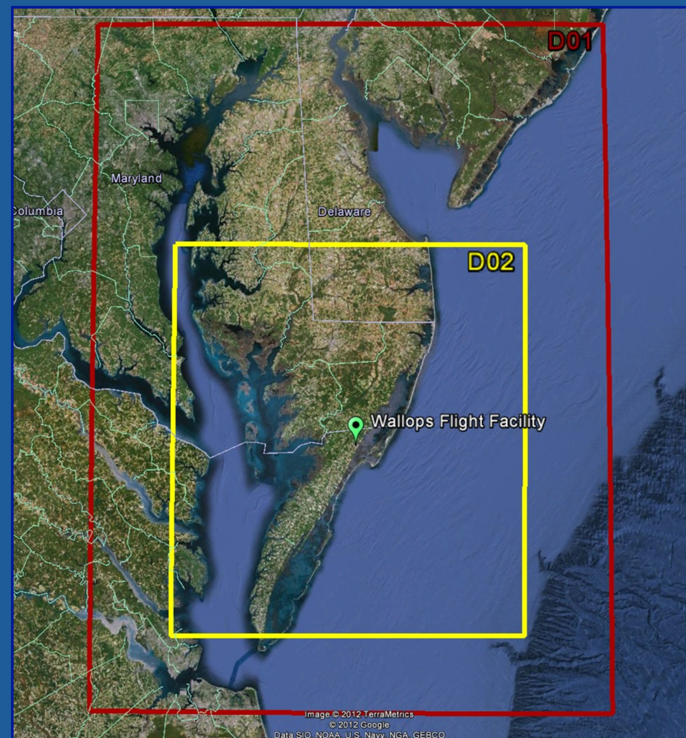
Accomplished: Applied quality control (QC) algorithms to remove suspect data from the WFF and ER databases. Analyzed wind pair samples from WFF to determine if the WFF sample size is suitable for UL wind assessments. Developed the ER wind profile pair database and determined the number of wind profile pairs for each time period.

Quarterly Task Summaries
(continued)

Range-Specific High-Resolution Mesoscale Model Setup (Page 18)

Purpose: Establish a high-resolution model with data assimilation (DA) for the ER and 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: Reinstalled the operating system on the old modeling cluster and continued to run test cases and learn about the Gridpoint Statistical Interpolation (GSI) software. Moved the new modeling clusters to their new location, established network connectivity, and implemented IT security for the clusters. Began installing and configuring needed software on the new clusters.



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 is similar to that developed by the AMU for the 45 WS in previous tasks (Lambert and Wheeler 2005, Lambert 2007). The lightning probability forecasts is valid for the time periods and areas needed by the NWS MLB forecasters in the warm season months, defined as May-September. Figure 1 shows the final output form of the GUI after the user inputs the required parameters (AMU Quarterly Report Q2 FY13).

Status

In early June, the Air Force reinstated the release of 1000 UTC rawinsondes from CCAFS due to their importance to the daily forecast. The forecasters at NWS MLB were informed, and they resumed using these data as input to the equations.

Ms. Crawford made some minor adjustments to the tool and delivered it to NWS MLB to use for the warm season lightning forecasts. She also visited NWS MLB and gave a presentation on how the tool was developed and how it works.

Ms. Crawford completed the final report after internal AMU and external customer reviews. She delivered it to the customers via email distribution. NASA approved the report for public distribution and it is now on the AMU website at science.ksc.nasa.gov/amu/final-reports/nws-obj-ltg-aprts.pdf.

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

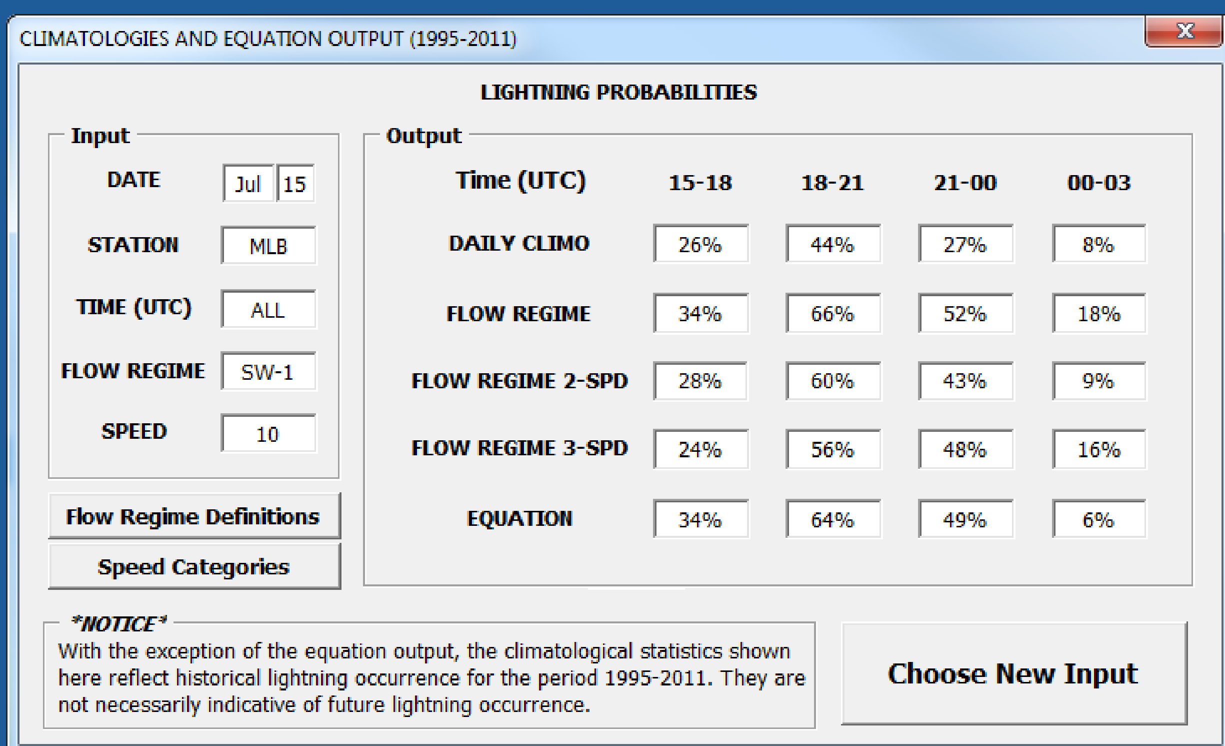


Figure 1. The GUI output form for all four time periods. The input choices are in the left panel and the climatological and computed probabilities for all four time periods are in the right panel. The "Choose New Input" button closes the form and returns control to the equation input form for the four time periods (Figure 4). The "Flow Regime Definitions" and "Speed Categories" buttons open message forms that provide definitions of these parameters.

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 (MSLP) from seven regional observing stations to determine the pressure difference (dP) 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 dP. 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. They also agreed to analyze PG as opposed to dP as it is a more accurate indicator of local wind speed. The 30 OSS has requested that the AMU develop an automated Excel GUI that includes PG thresholds between specific observing stations under different synoptic regimes to aid forecasters when issuing wind warnings.

Pressure Gradient Evaluation

In the previous quarter, Ms. Shafer created a series of graphs plotting PG and maximum peak wind (MPW) versus time for each of the synoptic regimes (See Tables 1 and 2 in AMU Quarterly Report Q2 FY13). The MPW was the maximum value of all peak wind speeds observed at the 26 VAFB towers in each hour. In order to better highlight potential trends and/or relationships between PG and MPW, Ms. Shafer also plotted the absolute value (ABS) of the PGs versus time. She created PG/MPW and ABS(PG)/MPW versus time graphs for four days in each synoptic regime, each day representing a different time of the year in order to have a diverse collection of case studies when evaluating PG and MPW. Ms. Shafer's initial review did not yield a clear relationship between the two variables. For the days selected, most PG and ABS (PG) trends did not follow the MPW trends as expected.

To further investigate the relationship between PG and MPW, Ms. Shafer divided VAFB into two sections: North Base (NB) and South Base (SB). The NB and SB towers are identified by the yellow and light blue diamonds in Figure 2, respectively. Ms. Shafer determined the NB-MPW and SB-MPW per hour for the same four days in each regime discussed previously, and then created ABS(PG)/MPW versus time graphs that included both NB-MPW and SB-MPW. She compared the NB-MPW and SB-MPW trends to those of the ABS(PG) to see if a stronger qualitative relationship could be found. For example, consider the ABS(PG) and MPW trends in Figures 3 and 4. Figure 3 is the ABS(PG)/MPW (all towers) versus time graph for 29 April 2008 with a Pacific High (PH) synoptic regime. The MPW is on the left y-axis, the ABS(PG) is on the right y-axis, and time is on the x-axis. Included in the graph are the ABS(PG) from each of the 14 station pairs used in the task (See Table 2 in AMU Quarterly Report Q2 FY13). Figure 4 shows the same ABS(PG) data, but

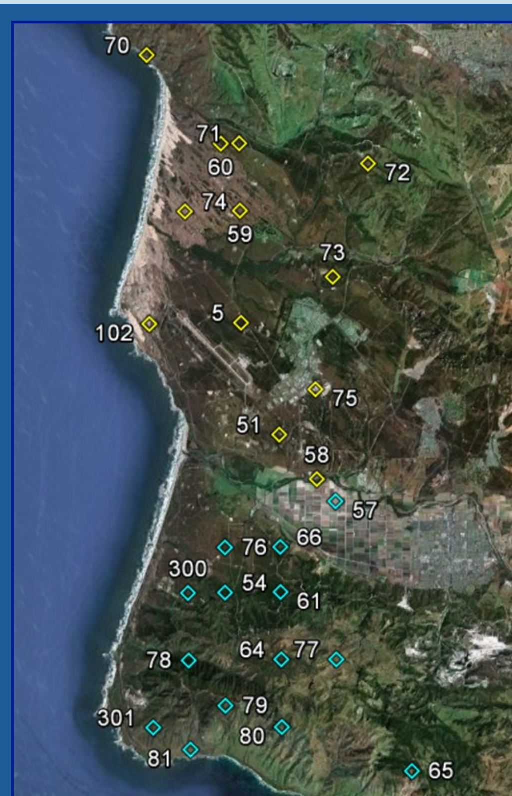


Figure 2. All VAFB wind towers designated as North Base (yellow) and South Base (light blue)

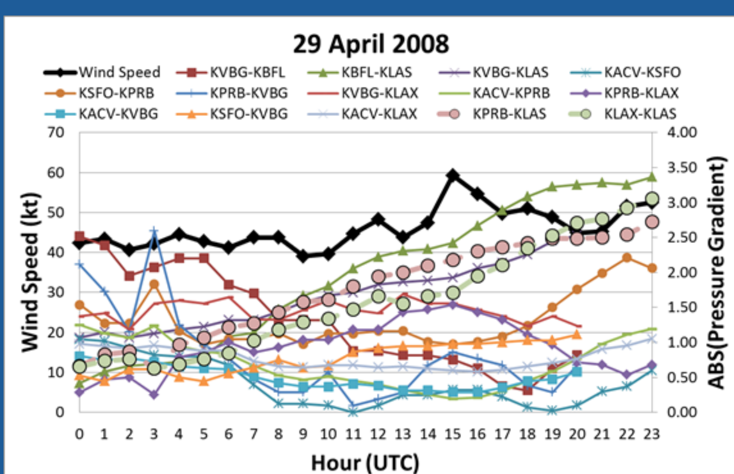


Figure 3. Example ABS(PG)/MPW versus time graph with PH synoptic regime.

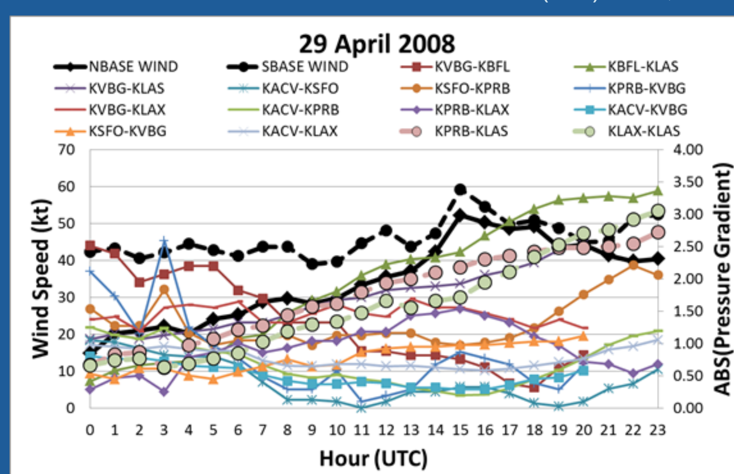


Figure 4. NB/SB ABS(PG)/MPW versus time graph for the PH synoptic regime. NB-MPW are the solid black line with diamonds, the SB-MPW are the dashed line with circles.

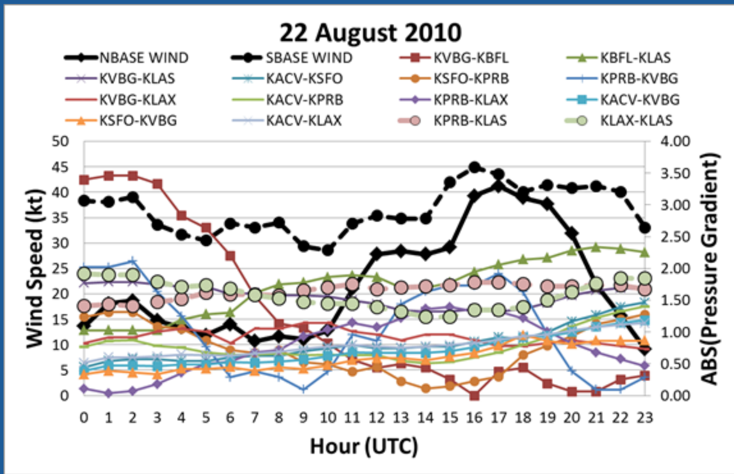


Figure 5. NB/SB ABS(PG)/MPW versus time graph for the PH synoptic regime. NB-MPW are the solid black line with diamonds, the SB-MPW are the dashed line with circles.

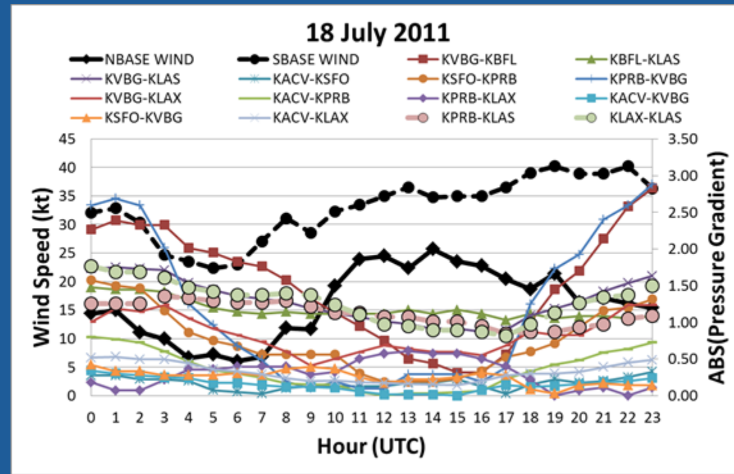


Figure 6. Same as Figure 5 except for the CL synoptic regime.

MPW is divided into NB-MPW and SB-MPW. Notice in Figure 3 the MPW remains between 40 and 45 kt during the time frame until 1000 UTC when it then begins a slight upward trend. This same upward trend is not evident in most of the ABS(PG) trends. For instance, the KBFL-KLAS (green line with triangles), KPRB-KLAS (pink line with large outlined circles), KVBG-KLAS (purple line with Xs), and KLAX-KLAS (green line with large outlined circles) ABS(PG)s gradually increased over the entire time period while the KVBG-KBFL ABS(PG) decreased. In Figure 4, it is clear the higher maximum winds on this day were observed on the SB towers. Ms. Shafer also noticed the NB-MPW followed the ABS(PG) trends more closely than the SB-MPW.

Unfortunately, Ms. Shafer did not find these matching trends in other test cases. For example, Figure 5 is an NB/SB ABS(PG)/MPW versus time graph for 22 August 2010 with a PH synoptic regime. Notice, similar to Figure 4, the highest maximum winds were again observed on the SB towers. However, neither the NB-MPW or SB-MPW follow the ABS(PG) trends this day. Another example is Figure 6 from 18 July 2011 with a California Low (CL) synoptic regime. The SB-MPW gradually increases during the time period while the NB-MPW increases from 0600-1400 UTC and then decreases. The ABS (PG)s from KVBG-KBFL (red line with squares) and KPRB-KVBG (blue line with +s) show an opposite trend where they decrease until 1500 UTC then show a steep increase through the rest of the time period. The remaining ABS(PG)s remain fairly constant or decrease in general. Overall, for the case studies selected, regardless of the time of year or synoptic regime, the NB-MPW and SB-MPW did not follow the same trends as the ABS(PG)s.

When creating the NB/SB ABS (PG)/MPW graphs, Ms. Shafer noticed most of the maximum winds were observed over the SB portion of VAFB. There were 28 case study days included in this task; 26 days showed SB-MPW values greater than NB-MPW for the majority of the 24-hour time period. The reason is likely due to the elevations of the towers on NB versus SB. At the start of this task, Mr. Brock of the 30 OSS provided Ms. Shafer an Excel sheet with detailed information about the VAFB tower network including NB/SB classification, latitude/longitude points and the elevation of each tower above sea level. The network has 26 towers: 12 on NB and 14 on SB. The elevations of the NB towers range from 64 to 920-ft while the SB towers range from 27 to 2,170 ft. Of the SB towers, five of them have elevations that exceed 1,200 ft. Since wind speeds tend to increase with altitude, the higher altitudes of the SB towers are more likely to observe higher wind speeds.

Correlations

As previously mentioned, regardless of the time of year or synoptic regime, the study did not yield a clear qualitative relationship between PG and MPW for the 28 selected case study days. Given this result, Mr. Roeder of the 45 WS suggested calculating the correlation coefficients between the two variables to quantitatively measure the relationship between them using the entire 2007-2012 database. Per this suggestion, Ms. Shafer used the PEARSON function in Microsoft Excel to determine the Pearson Correlation Coefficient (PCC). This value is a measure of the linear correlation between two variables ranging from -1 to +1. A value of zero indicates there is no relationship between the two datasets.

Ms. Shafer calculated this value for each station pair stratified by synoptic regime for the full VAFB, NB and SB. Figures 7, 8, and 9 show the ABS(PG) PCC versus synoptic regime for the full base, NB and SB, respectively. The PCC is on the y-axis and the synoptic regime on the x-axis. The “ALL” category on the x-axis includes all of the days in the 2007-2012 database regardless of flow regime and the solid black horizontal line highlights where PCC equals zero. When comparing the figures, the values in Figures 7 and 9 are nearly identical. This result was expected considering most of the MPWs were observed on SB towers. When comparing Figures 7 and 8, there are some minor differences among station pairs and corresponding synoptic regimes, but overall the patterns are very similar. These figures show most PCC values range between -0.1 and 0.4 with occasional outliers. Considering PCC indicates no relationship when it is equal to zero, these graphs show a very weak relationship between ABS(PG) and MPW at VAFB and should not be the lone data source when forecasting MPW.

One of the tools currently used at 30 OSS to predict MPW examines dP between the station pairs instead of PG. As a comparison, Ms. Shafer created a graph showing the dP PCC versus synoptic regime for the full base (Figure 10). Compared to the ABS(PG) PCC results, dP PCC has a smaller range per synoptic regime and values closer to zero. The North PH (NPH) and PH regimes show the highest PCC values, however they are mainly between zero and 0.5 with the exception of KVBG-KBFL in PH where PCC is -0.14. This graph confirms dP also performs poorly as a predictor for MPW at VAFB.

Climatology Database

In the previous quarter, Ms. Shafer completed processing the tower data from all 26 wind towers at VAFB for the climatology database. The database includes 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 6-, 12-, and 54-ft sensor levels. Ms. Shafer began exploring ways to develop a PivotTable to easily calculate and display climatology statistics as discussed at the November 2012 tasking meeting. She discovered Microsoft Excel is not capable of containing the entire database, so she is now starting to work with Microsoft Access.

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

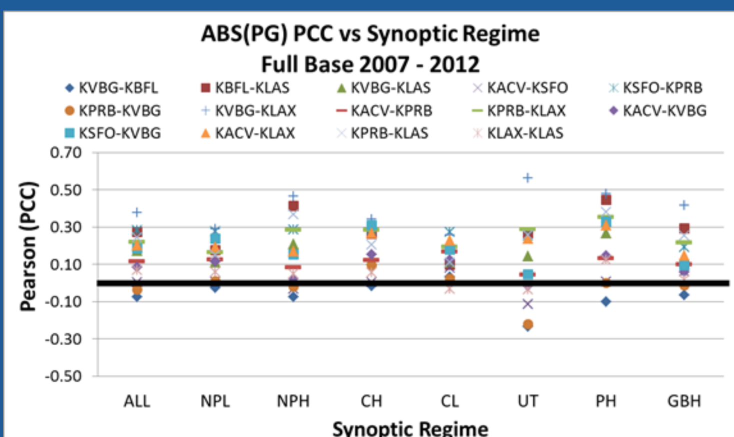


Figure 7. ABS(PG) PCC versus synoptic regime for the full base from 2007-2012. The solid black line highlights where PCC equals zero.

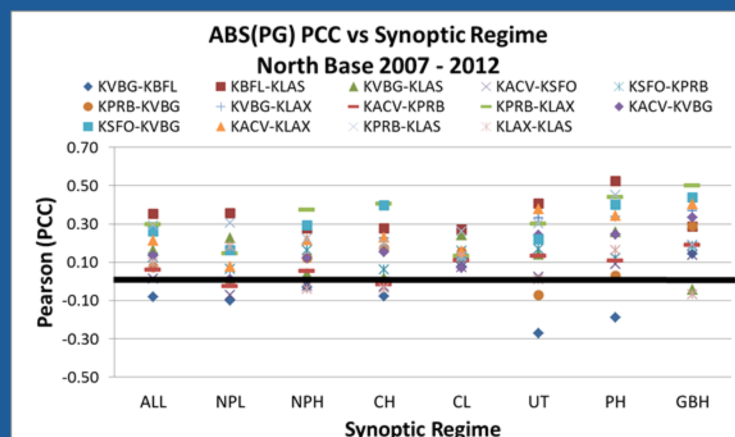


Figure 8. Same as Figure 7 except for NB instead of the full base.

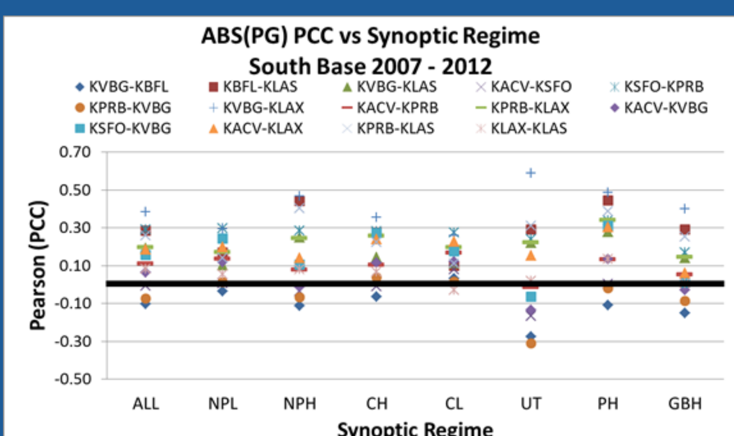


Figure 9. Same as Figure 7 except for SB instead of the full base.

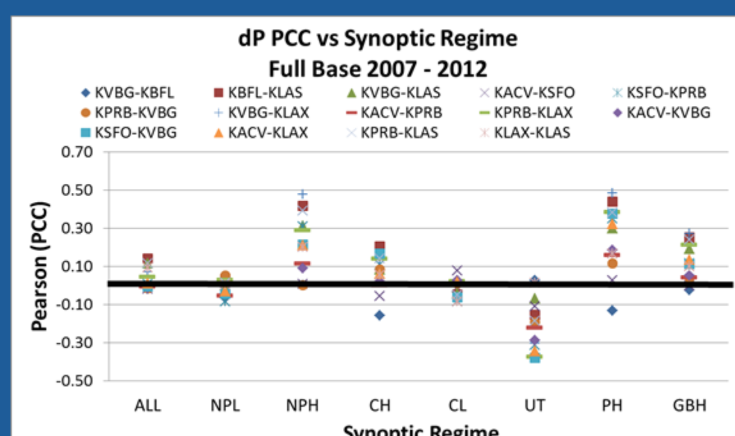


Figure 10. Same as Figure 7 except for dP instead of PG.

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 of this task was 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. Due to small data sample sizes, the AMU could not determine if there is a statistical relationship between speed-stratified flow regimes and the time of the first CG strike. However, the AMU developed a tool with input from the 45 WS that allows forecasters to visualize the climatological frequencies of the timing of the first lightning strike.

Table 1. Thompson Index (TI) thresholds (Vasquez 2006).

TI	Description
<25	No thunderstorm
25 to 34	Potential of thunderstorms
35 to 40	Potential of thunderstorms approaching severe
≥40	Potential of severe thunderstorms

Graphical User Interface

In previous quarters, the Dr. Huddleston stratified the lightning strike data into three sea breeze flow regimes and two wind speed categories defined by the 45 WS. Details on the stratification definitions are found in a previous report (AMU Quarterly Report Q1 FY13). She analyzed the stratified data and found there were not enough observations in each of the stratifications to determine statistical relationships between the stratifications and the time of the first lightning strike of the day (AMU Quarterly Report Q2 FY13).

With agreement from the 45 WS, she developed a GUI using the Slicers feature in Excel 2010 to display the climatological statistics for the times of the first lightning strike of the day in each stratification: month, flow regime direction, flow regime wind speed, and Thompson Index (TI) to account for stability (AMU Quarterly Report Q2 FY13). In previous AMU studies (Lambert 2005, Lambert 2007, Crawford 2010, Bauman and Crawford 2012), TI was an important predictor of lightning occurrence for most of the warm season months. Dr. Huddleston modified the first TI stratification thresholds in the GUI to thresholds adapted from Vasquez (2006) shown in Table 1.

Dr. Huddleston then updated the Slicers with the new TI thresholds for each of the five stratifications, three based on flow regime and two based on wind speed, and delivered the GUI to the 45 WS. Figure 11 shows an example of the GUI using Excel 2010 Slicers for the 45 WS Forecast Reference Notebook (FRN) sea

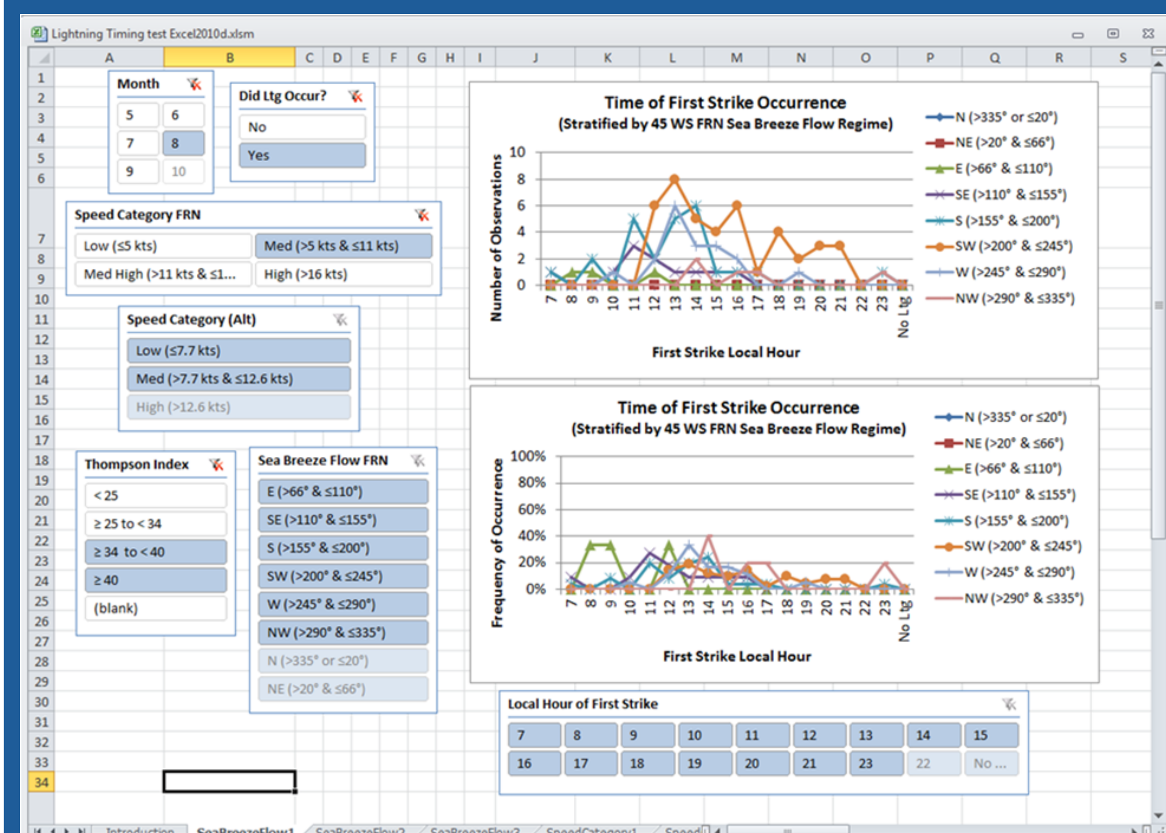


Figure 11. The GUI using Excel 2010 Slicers for the FRN flow regimes in August, days when lightning occurred, medium FRN speeds, and TI > 34. The top chart shows the number of times the first lightning strike occurred during each hour and the bottom chart shows the percentage of first lightning strike occurrences in each flow regime. After the user selects the filters from the menus, categories containing no data are grayed and moved to the end of the menu.

breeze flow regime stratification. In this particular stratification there were few lightning events (top chart) during easterly flow (E in the legend), but if lightning did occur it happened mostly before local noon (bottom chart).

Figure 12 shows the GUI for the FRN speed category stratification. There were fewer lightning strikes (top chart) in the low speed category, but if lightning did occur it happened at an earlier local time (peak at local noon) than in the other speed categories (bottom chart).

Final Report

Dr. Huddleston completed work on the task and started writing the final report.

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

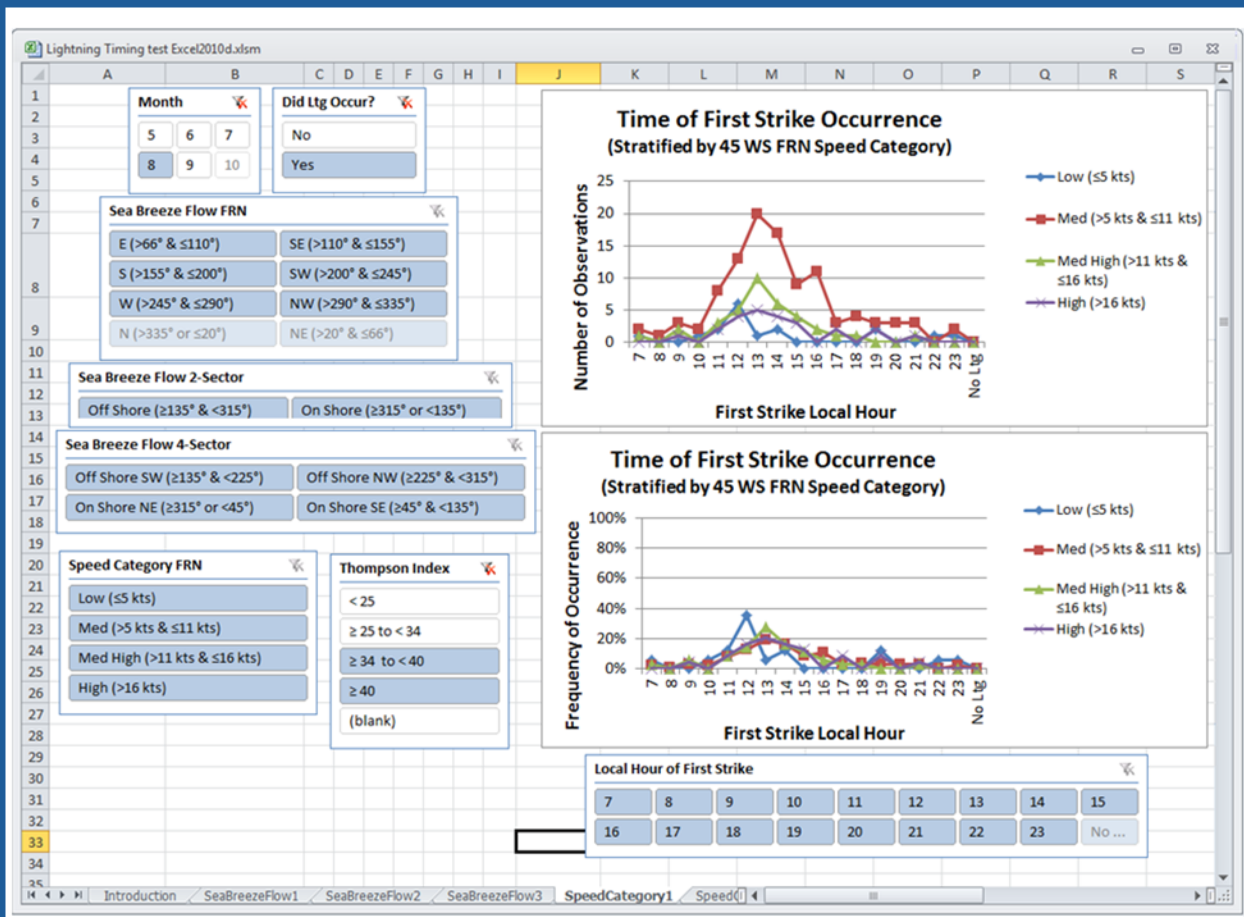


Figure 12. Same as Figure 11 except for the FRN speed category stratification.

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.

MIDDS Tool

Dr. Bauman developed the 1500 UTC (15Z) Severe Weather Tool in MIDDS using the Tool Command Language and its associated Tool Kit (Tcl/Tk). The user starts the tool from the main weather menu on MIDDS. The program executes the Tcl/Tk code to compute and retrieve sounding parameters and then presents the user with the GUI for manual input. Then the code computes a threat score for each parameter and the

Total Threat Score (TTS) for the day. The tool displays the output in two graphic windows for the user to view and saves two files in MIDDS for archive.

When the user executes the program in MIDDS, the message shown in Figure 13 is displayed while MIDDS accesses the sounding data and calculates the parameters.

Once the sounding parameters are ready, the GUI is displayed for the user to enter information about the 200 mb jet position and flow regime as shown in Figure 14. There is a Help button in the upper right of the GUI window that describes how to use the GUI and a description of the tool itself. The date is displayed in two formats just above the questions on the left: year and day-of-year, and calendar day in month/day/year. They gray buttons associated with each of the two questions provide a definition of each parameter via a pop-up window when the mouse is positioned over them. The user can also click one of the two white buttons associated with each question to display maps in the MIDDS graphics window of the phenomena they are assessing in order to answer the questions. Once the user clicks one of the gray buttons, the choice is displayed in the box at the far right of the window. After both choices are made, the user clicks the green box in the lower left to calculate the TTS. The GUI then closes and two other windows open with the results.

The TTS and associated data are shown in two windows in MIDDS. The first, shown in Figure 15, provides the user with a summary of the output from the tool. The first four lines of text display the climatological TTS categories and associated occurrences of reported severe weather. The fifth line of text displays the sounding time and date. The TTS is displayed as a large, bold number near the bottom of the window. The summary window was designed to give the user a quick look at the data output by the tool.

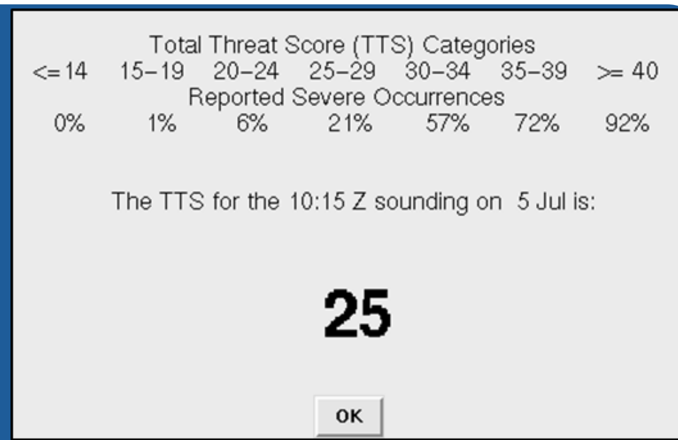


Figure 15. TTS summary window displayed in MIDDS provides a quick overview of the tool's output to the user.

The second window displayed, Figure 16, shows all of the sounding parameters and their values used to derive the TTS. The heading shows the Julian date and the month, day and year of the sounding. Below the heading is a table showing the index or parameter in the first (left) column. The next four columns show the low, medium, high and very high severe thresholds for each index or parameter to serve as a reference for the user. The last (right) column shows the value of the index or parameter from the sounding being evaluated. The next section of text below the table in this window duplicates the output from the summary window and includes the climatology-based TTS categories and their associated occurrences of reported severe weather, the time and date of the sounding, and the TTS. Finally, the last three lines of text at the bottom of the window serve as a reminder to the forecaster that they must consider the development and position of the sea breeze front and any outflow boundaries that could serve as triggers for convection and possibly lead to severe weather.

In addition to the two output windows, Dr. Bauman's code saves two files to MIDDS for archive purposes. One is a comma separated value (CSV) formatted file that displays the Julian date, month, day, year and time of the sounding plus the indices and parameters with their associated values from the sounding. A CSV file can be viewed in Microsoft Excel as shown in the example in Figure 17. The second file is saved in MIDDS as a text file that replicates the detailed TTS output window and can be viewed in any text viewer software. An example file is shown in NotePad++ software in Figure 18.

Figure 13. Message window in MIDDS notifying the user that the program is acquiring the sounding data.

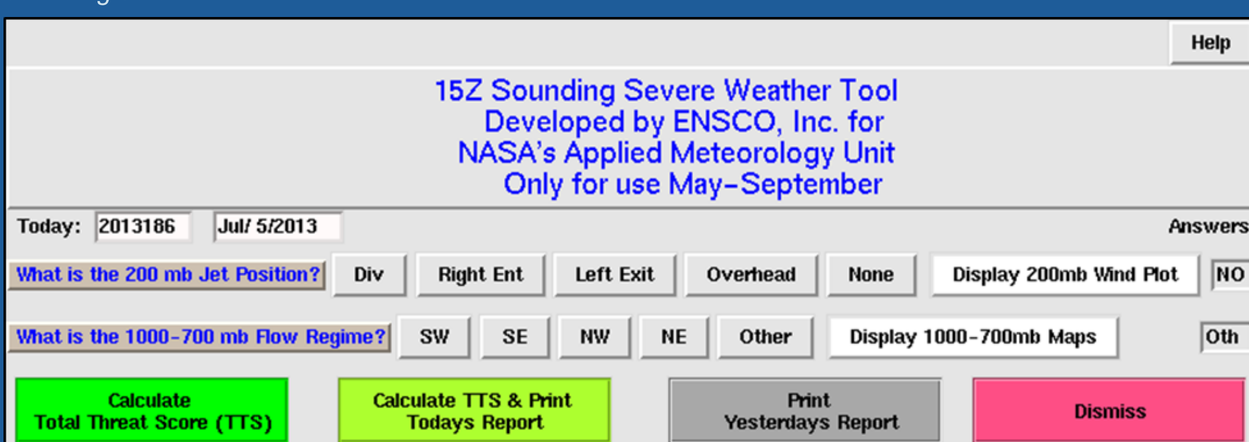
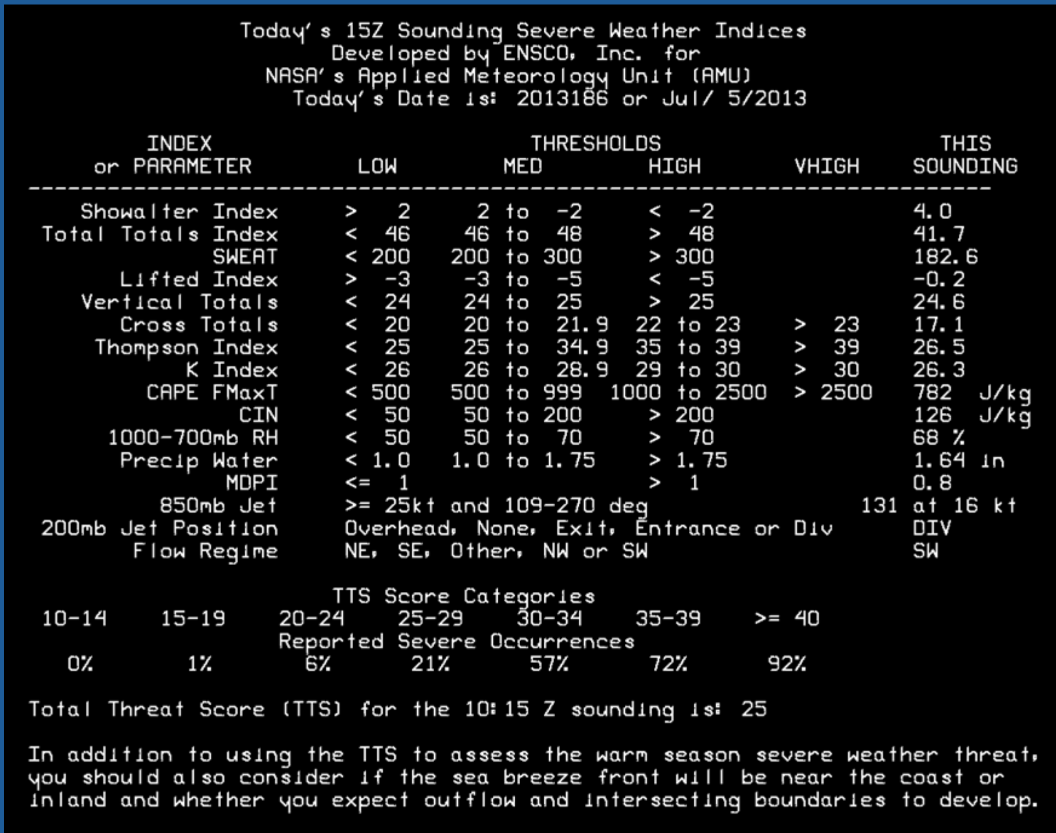


Figure 14. The 1500 UTC sounding-based Severe Weather Tool GUI.

MIDDS Tool Testing

Dr. Bauman began testing the tool by running it each day a



```
               Today's 15Z Sounding Severe Weather Indices
                      Developed by ENSCO, Inc. for
                 NASA's Applied Meteorology Unit (AMU)
                  Today's Date is: 2013186 or Jul/ 5/2013

        INDEX                        THRESHOLDS                       THIS
    or PARAMETER         LOW         MED         HIGH        VHIGH    SOUNDING
 ---------------------------------------------------------------------------
    Showalter Index     >   2      2 to  -2     <  -2                4.0
 Total Totals Index     <  46     46 to  48     >  48                41.7
              SWEAT     < 200    200 to 300     > 300                182.6
      Lifted Index      >  -3     -3 to  -5     <  -5                -0.2
    Vertical Totals     <  24     24 to  25     >  25                24.6
       Cross Totals     <  20     20 to  21.9   22 to 23   >  23     17.1
    Thompson Index      <  25     25 to  34.9   35 to 39   >  39     26.5
            K Index     <  26     26 to  28.9   29 to 30   >  30     26.3
         CAPE FMaxT     < 500    500 to 999   1000 to 2500 > 2500    782  J/kg
                CIN     <  50     50 to 200     > 200                126  J/kg
     1000-700mb RH      <  50     50 to  70     >  70                68 %
       Precip Water     < 1.0    1.0 to 1.75    > 1.75               1.64 in
               MDPI     <=  1                   >  1                 0.8
         850mb Jet      >= 25kt and 109-270 deg                 131 at 16 kt
 200mb Jet Position     Overhead, None, Exit, Entrance or Div        DIV
       Flow Regime      NE, SE, Other, NW or SW                      SW

                         TTS Score Categories
  10-14     15-19     20-24     25-29     30-34     35-39     >= 40
                     Reported Severe Occurrences
    0%        1%        6%       21%       57%       72%       92%

 Total Threat Score (TTS) for the 10:15 Z sounding is: 25

 In addition to using the TTS to assess the warm season severe weather threat,
 you should also consider if the sea breeze front will be near the coast or
 inland and whether you expect outflow and intersecting boundaries to develop.
```

Figure 16. Detailed TTS window displayed in MIDDS provides the user with index and parameter severe thresholds and the specific values derived from the current sounding used to generate the TTS.

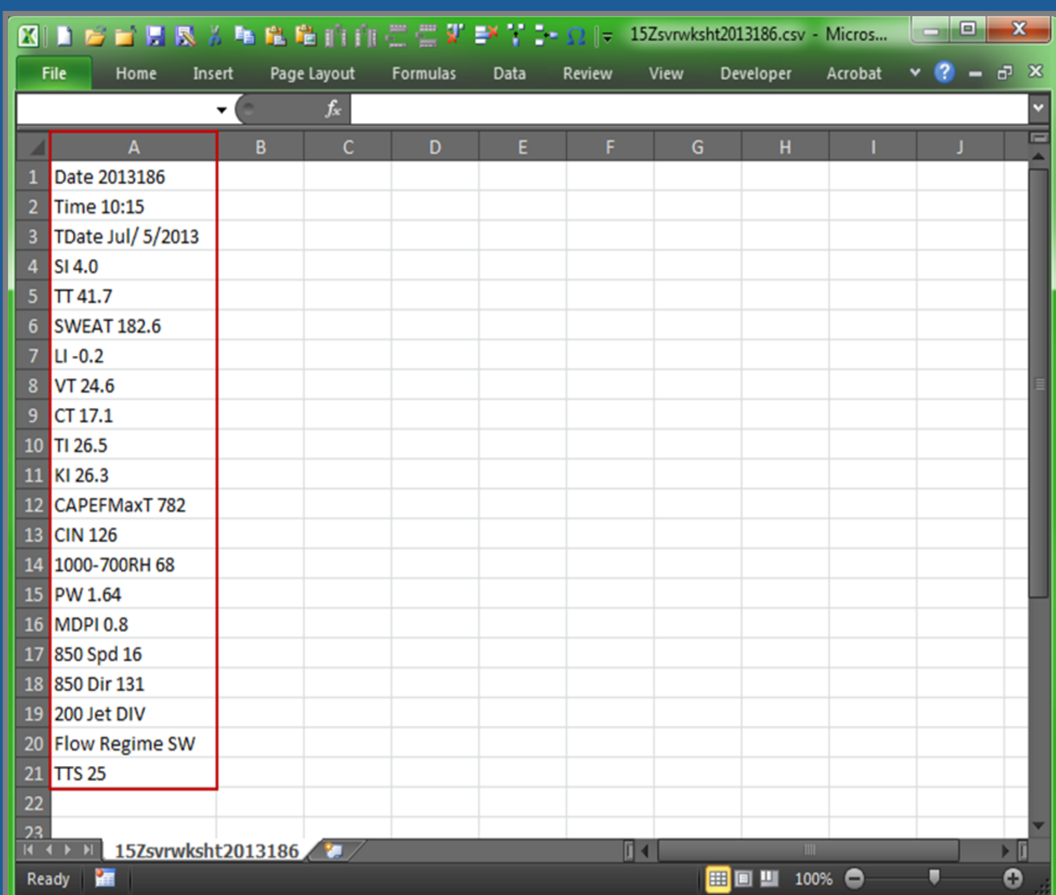


Figure 17. Example output from a CSV file saved in MIDDS and displayed in Microsoft Excel. All of the output from the file is shown within the red rectangle in Column A of the spreadsheet.

sounding was available to ensure MIDDS was calculating the correct values. He manually calculated each parameter's threat score and the resulting TTS to make sure they were identical to the corresponding threat scores calculated by the code in MIDDS for each sounding. To automate this process, he wrote code in Microsoft Excel Visual Basic for Applications that imported the MIDDS CSV files (Figure 17) and calculated each parameter's threat score and the TTS to compare to the manually calculated values. He tested this code on 14 soundings to make sure it worked before discontinuing manual calculation of the threat scores and TTS. Dr. Bauman continued testing by comparing values from the MIDDS CSV files to the Excel-calculated values.

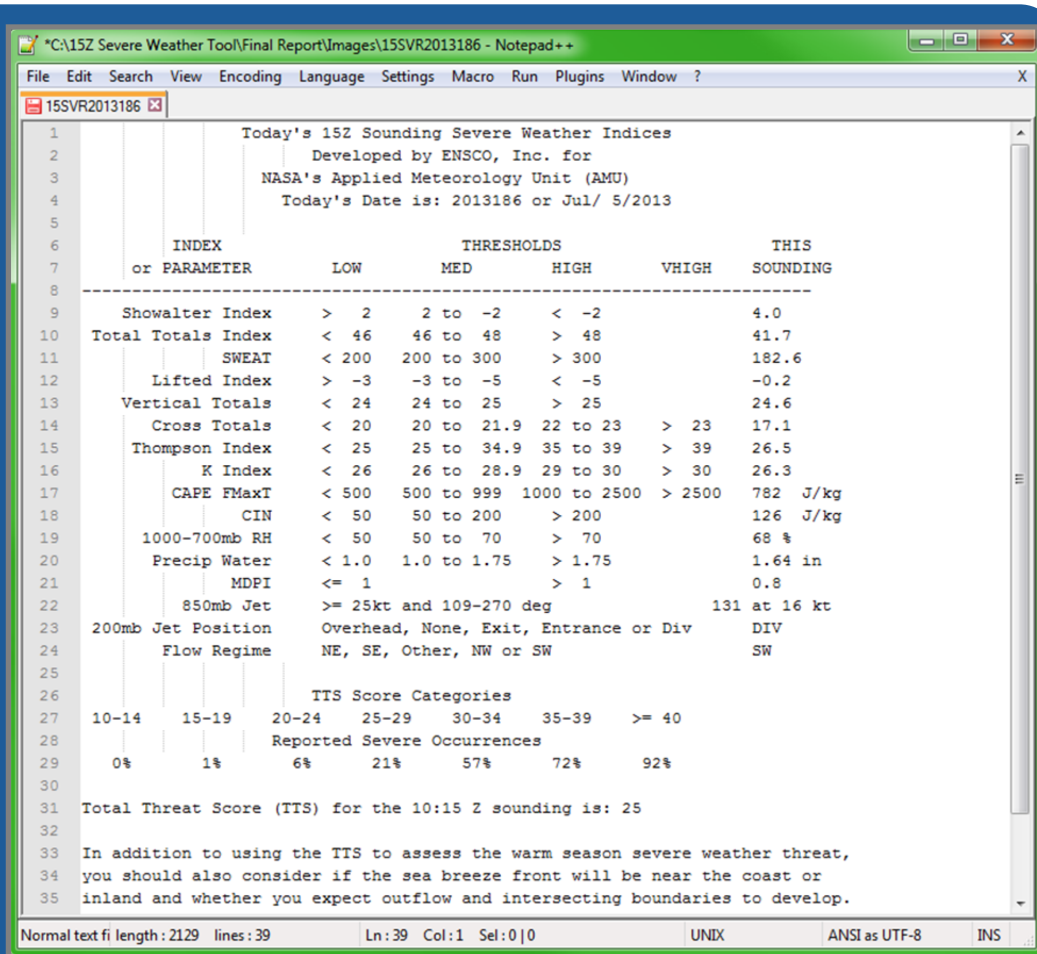
Current 1000 UTC Severe Weather Tool Update

Dr. Bauman presented a status briefing on the progress of the 1500 UTC Severe Weather Tool to the 45 WS staff in May. During the briefing, the 45 WS asked if the AMU could apply the same methodology into development of a new 1000 UTC tool. The existing 1000 UTC tool has a considerable amount of subjectivity built into it, but the 1500 UTC tool is much more objective and easier for the forecasters to use. The AMU stated that it would probably take only 2-3 weeks to implement this methodology in a MIDDS GUI using the 1000 UTC soundings because all of the stability parameters from the 1989-2012 1000 UTC soundings were previously calculated and readily available on the AMU server. During this status briefing, the KSC Weather Office authorized Dr. Bauman to undertake the work providing it did not delay the 1500 UTC sounding-based task. Since the 1500 UTC task was approximately two weeks ahead of schedule, Dr. Bauman imported the 1000 UTC sounding data into the Excel spreadsheets he developed for the1500 UTC tool and determined threat scores and a TTS for each sounding using the Excel Visual Basic for Applications scripts he wrote for the 1500 UTC tool. He then modified the Tcl/Tk code in MIDDS to process the 1000 UTC soundings and output the threat scores and TTS based on the 1000 UTC parameters. He began testing using the same methodology as for the 1500 UTC tool.

Training and Final Report

Dr. Bauman will work with 45 WS personnel to schedule an overview briefing of the task and provide hands-on training when the GUI is transitioned to the operational MIDDS. He will continue testing the MIDDS GUI code and solicit forecaster feedback through the rest of the 2012 warm season. Dr. Bauman started writing the final report.

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


*C:\15Z Severe Weather Tool\Final Report\Images\15SVR2013186 - Notepad++

```
                     Today's 15Z Sounding Severe Weather Indices
                              Developed by ENSCO, Inc. for
                         NASA's Applied Meteorology Unit (AMU)
                            Today's Date is: 2013186 or Jul/ 5/2013

           INDEX                           THRESHOLDS                    THIS
      or PARAMETER        LOW         MED         HIGH       VHIGH    SOUNDING
-------------------------------------------------------------------------
     Showalter Index     >   2      2 to  -2     <  -2               4.0
  Total Totals Index     <  46     46 to  48     >  48               41.7
               SWEAT     < 200    200 to 300     > 300               182.6
        Lifted Index     >  -3     -3 to  -5     <  -5               -0.2
     Vertical Totals     <  24     24 to  25     >  25               24.6
        Cross Totals     <  20     20 to  21.9  22 to 23    >  23    17.1
      Thompson Index     <  25     25 to  34.9  35 to 39    >  39    26.5
             K Index     <  26     26 to  28.9  29 to 30    >  30    26.3
          CAPE FMaxT     < 500    500 to 999   1000 to 2500  > 2500   782  J/kg
                 CIN     <  50     50 to 200     > 200               126  J/kg
       1000-700mb RH     <  50     50 to  70     >  70               68 %
         Precip Water    < 1.0    1.0 to 1.75    > 1.75              1.64 in
                 MDPI    <=  1                   >  1                0.8
           850mb Jet     >= 25kt and 109-270 deg                 131 at 16 kt
  200mb Jet Position     Overhead, None, Exit, Entrance or Div    DIV
         Flow Regime     NE, SE, Other, NW or SW                  SW

                               TTS Score Categories
  10-14    15-19    20-24    25-29    30-34    35-39    >= 40
                         Reported Severe Occurrences
    0%       1%       6%      21%      57%      72%      92%

Total Threat Score (TTS) for the 10:15 Z sounding is: 25

In addition to using the TTS to assess the warm season severe weather threat,
you should also consider if the sea breeze front will be near the coast or
inland and whether you expect outflow and intersecting boundaries to develop.
```

Figure 18. Example output from a text file saved in MIDDS and displayed in the NotePad++ software. This text file is identical to the output displayed in the detailed TTS window (Figure 16).

INSTRUMENTATION AND MEASURMENT

Configuration and Evaluation of a Dual-Doppler 3-D Wind Field System (Ms. Crawford)

Space vehicle ground and launch operations are halted when wind speeds from specific directions exceed defined thresholds and when lightning is a threat. Strong winds and lightning are difficult parameters for the 45 WS to forecast, yet are important in the protection of customer vehicle operations and the personnel that conduct them. A display of the low-level horizontal wind field to reveal areas of high winds or convergence would be a valuable tool for forecasters in assessing the timing of high winds impacting operations, or convection initiation (CI) and subsequent lightning occurrence. This is especially important for areas where no weather observation platforms exist. Developing a weather radar dual-Doppler capability would provide such a display to assist forecasters in predicting high winds and CI. The wind fields can also be used to initialize a local mesoscale numerical weather prediction model to help improve the model forecast winds, CI, and other phenomena. Finally, data combined from multiple radars will lessen radar geometry problems such as the cone of silence and beam blockage. This display will aid in using ground processing and space launch resources more efficiently by stopping or starting work in a timelier manner. The AMU was tasked by the 45 WS and NWS MLB to develop a dual-Doppler display using data from the 45 WS Doppler Radar, NWS MLB Weather Surveillance Radar 1988-Doppler (WSR-88D), and the Federal Aviation Administration Terminal Doppler Weather Radar (TDWR) at Orlando International Airport as input, and available software to derive the wind field over east-central Florida, especially over KSC/CCAFS to support the safety of ground and launch operations.

Software and Computing Resources

Dr. Bauman installed the Linux Community Enterprise Operating System (CentOS) Release 6.4 on an existing AMU computer that is capable of supporting both of the dual-Doppler software packages being considered for the task. The two packages were described in the previous AMU Quarterly Report (Q2 FY13). One is a set of software programs from the National Center for

Atmospheric Research (NCAR) that has been used in many research studies and one in which the programs were set up to run operationally (Dolan and Rutledge 2007). The other is WDSS-II from the National Severe Storms Laboratory (NSSL).

Ms. Crawford emailed descriptions of both software packages to Mr. Sharp of NWS MLB, who requested a meeting to discuss this task at the NWS MLB office in early May. At that meeting, Ms. Crawford briefed NWS MLB forecasters on the choices for dual-Doppler analysis software packages and recommended the WDSS-II package for several reasons. The NCAR software package is a set of several programs. They are currently being updated, and some of the programs are being merged together. The WDSS-II software is ready to install and use for research, with the possibility of transition to operational use. It is important to note that at this point in the task, this decision is not final. If issues arise that indicate WDSS-II is not the best package, Ms. Crawford will switch to the NCAR software, probably the most recent working version as opposed to the programs that are being modified.

Ms. Crawford downloaded and installed WDSS-II on the AMUI Linux PC after requesting a copy of the software from Dr. Lakshmanan, the WDSS-II lead scientist, through the WDSS-II website (http://www.cimms.ou.edu/~lakshman/WDSS2/index.shtml). She is currently looking for several missing library files needed to run the program.

Data

Ms. Crawford discussed possible test cases with Mr. McNamara of the 45 WS. He stated that more recent data from the 45th Space Wing (45 SW) WSR would be of better quality, and suggested data collected during a local tornadic event on 15 April 2013. He provided the WSR data for this date and for the time period 0000-0800 UTC. Ms. Crawford then downloaded the NWS MLB WSR-88D data for the same date and time from the National Climatic Data Center (NCDC) website. She also requested the MCO TDWR data from the FAA for this date and time.

WDSS-II ingests Level II radar data. The WSR-88D and TDWR data are in this format, but the WSR data are not. Dr. Carey of the University of Alabama Huntsville, who has worked with the WSR data, provided Ms. Crawford with a link to a program that will convert the WSR data to Level II format.

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

Wind Pairs Database for Persistence Modeling (Mr. Decker)

NASA LSP space launch teams include a UL wind assessment in their vehicle commit-to-launch decisions. Their assessments are based on wind measurements obtained earlier in the launch count, which may not represent the environment the vehicle will ascend through. Uncertainty in the UL winds over the time period between the assessment and launch can be mitigated by a statistical analysis of wind change over time periods of interest using historical data from the launch range. Without historical data, theoretical wind models must be used, which can result in inaccurate wind placards that misrepresent launch availability. This can result in over conservatism in vehicle wind placards and may reduce launch availability. Conversely, if the model is under-conservative it could result in launching into winds that might damage the vehicle. LSP tasked the AMU to calculate wind change statistics over specific time periods, also known as wind pairs, for each month from historical UL wind observations at the ER, WR and WFF. The wind pairs of interest are over the time periods of 45 and 90 minutes, and 2, 3 and 4 hours. The intent of these databases is to help LSP improve the accuracy of launch commit decisions based on UL wind assessments. Because of their experience in working with UL wind pair databases and statistical analysis of UL wind change, the Natural Environments (NE) group at Marshall Space Flight Center (MSFC) is working on this task under the AMU's direction.

WFF Data Processing and Analysis

Mr. Decker began the next steps in processing the wind pair database at WFF during this period. As noted in the previous quarterly report (AMU Quarterly Report Q2 FY13), the WFF wind profile database contained data spaced at inconsistent vertical intervals. All wind data in the databases delivered to LSP will be in 100-ft (30.4 m) intervals starting at the surface and have an ending altitude not exceeding 65,000 ft (19,811 m). This necessitated the use of data interpolation algorithms to fill in sections of wind profiles where data were not reported or to filter the wind data when reported at finer altitude spacing in order to remove smaller wavelength features while maintaining the same energy content. The WFF database does not contain any high-resolution wind profiles, so no data filtering was necessary.

Mr. Decker implemented the following QC algorithms on the data to remove wind profile pairs containing unacceptable wind profiles:

- Wind data with each profile in the pair had to reach a minimum of 20,000 ft.
- More than 50% of wind data must exist in both profiles.
- Wind component change between adjacent altitudes (vertical wind shear) must be less than or equal to 0.15 s^{-1}.
- Duplicate pairs will be removed.
- Manual inspection of each wind pair for erroneous data.

The minimum altitude requirement of 20,000 ft (6,095 m) was recommended by LSP as their customers need wind pairs to at least this height. Mr. Decker applied the remaining QC checks to address issues associated with using multiple wind profile sources to construct the wind pairs. When either wind profile in a pair did not contain at least 50% of possible data, the pair was rejected. This eliminated the potential of having an artificial large wind change exist between two profiles from a large interpolation. He applied the vertical wind shear check to remove profiles where unrealistic wind shears existed. Large wind shears can be an artifact of data interpolation over a large attitude interval.

Mr. Decker decided to manually inspect the data after reviewing the probability distributions of maximum wind component change, independent of altitude, for each pair time interval. His experience with temporal wind change analyses has shown that wind change extremes are typically correlated to time separation: the longer the time interval, the larger the extreme wind change magnitudes. However, the wind component change at probability levels greater than 95% in the 45- and 90-minute pairs were ~50% greater than the corresponding maximum wind change at the same probability level in the 2- 3- and 4-hour pairs. From the manual inspection of the WFF 45 - and 90-minute wind pairs, Mr. Decker noted these questionable wind change values associated with profile pairs occurring around 0000 UTC in data obtained from NOAA's Integrated Global Radiosonde Archive (IGRA) database (Imke et al. 2008). His manual review of the questionable profile pairs indicated that differences observed in the wind profiles seemed more characteristic of diurnal-scale wind change as opposed to short-time period wind change.

Mr. Decker decided to use an independent source to compare the winds at the altitude region where the maximum wind change occurred between the wind profiles. He reviewed the National Centers for Environmental Prediction (NCEP) North American Regional Reanalysis composite data for the time period of interest to determine if a large gradient in the winds occurred during the time period. The majority of these cases did not corroborate with the NCEP data and, as a result, he removed all the wind pairs occurring near 0000 UTC that contained wind profiles from the IGRA database. The resulting temporal wind change distributions were better correlated. Mr. Decker will apply the same process to the WR wind pairs.

After QC of the WFF database, the number of acceptable pairs was reduced by 30% from the initial record count (Table 2). The largest reductions in pairs were with the 45- and 90-minute intervals due to the manual QC process.

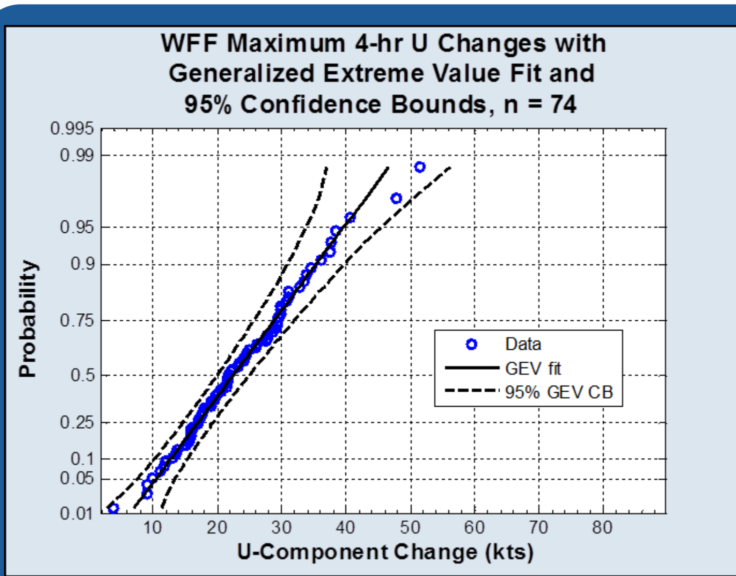
The small sample size for each time interval may not capture the range of wind change for each time period and also increases the uncertainty in characterizing wind change extremes. Mr. Decker applied a method to determine how well the sample population characterizes wind change extremes by applying a theoretical distribution function to the data in order to determine how much variability exists at specified percentile levels. Extreme wind change population distributions are usually non-Gaussian, so Mr. Decker applied a generalized extreme value (GEV) distribution function (Coles 2001) to fit the u- and v-component wind changes to a range of percentiles and calculated confidence bounds (CB) using the Asymptotic Distribution of Percentiles method (DasGupta 2008). The result of this analysis for both components of the 4 -hour wind pairs is shown in Figure 19. The cumulative probability, drawn from the probability density function (Wilks 2006), is along the y-axis and the magnitude of the component wind change is on the y-axis. Due to the small sample sizes for each time period, the 95% CBs for the observed wind change extremes (~ > 40 kt) have a large range of uncertainty as seen in Figure 19 for the 4-hour wind pairs. It is more pronounced for the meridional wind component (v-component) as the 95% CB for the 98th percentile v-component wind change ranged from 40.2 to 89.3 kt. Mr. Decker observed similar results for the other time intervals. Given the large range of component wind changes in Figure 19, it is unlikely that the observed extremes are representative of extreme temporal wind changes at WFF.

Table 2. Total count of wind pairs before and after QC in the WFF period of record (POR), January 1965-January 2013, for the five time intervals.

Pair Time Interval	Initial Count	Final Count after QC
45-minute	159	78
90-minute	86	54
2-hour	102	75
3-hour	146	127
4-hour	97	74
TOTAL	**590**	**409**

ER Data QC

Mr. BJ Barbré of Jacobs, in MSFC NE, developed the ER wind database from the KSC Doppler Radar Wind Profiler (DRWP) network to support other projects, and generated the wind pairs for this task not only because the pairs applied to those projects, but also because developing the pairs aided in the DRWP database QC process. Prior to this task, Mr. Barbré produced an archive of 50 -MHz DRWP (D-50) winds for the August 1997 to December 2009 POR (Barbré 2012), and had been performing QC assessments on 915-MHz DRWP (D-915) for the April 2000 to December 2010 POR, making the overlapping POR between the two archives April 2000 to December 2009. The algorithms and methodologies in Lambert et al. (2003) and Barbré (2012) were used in the D-915 QC process. Additional QC included removing profiles with duplicate timestamps, filling temporal data gaps greater than 15 minutes, and checking for correct altitude progression. Mr. Barbré completed QC of D-915 data for the POR during this quarter.



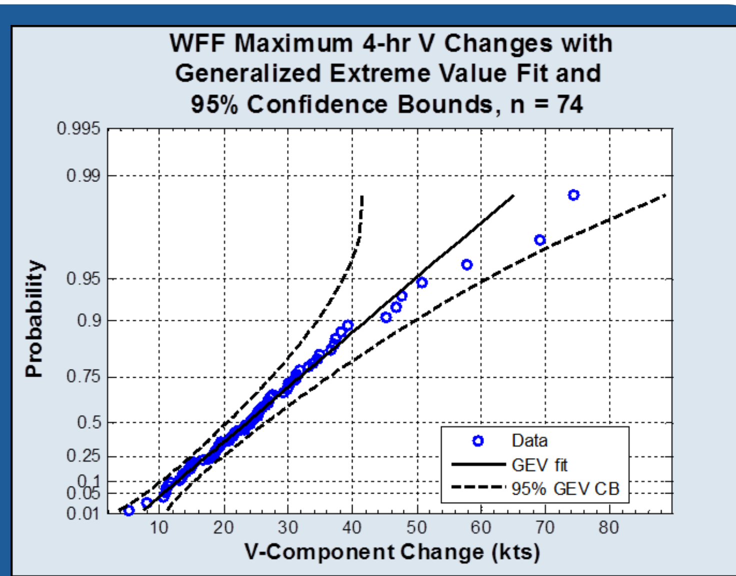


Figure 19. WFF maximum wind change from the 4-hour wind pairs with 95% CB for the U-(left) and V-component (right) wind changes. The magnitude of the wind component change is on the x-axis and probability is on the y-axis. The number (n) of pairs in the analysis is 74.

The next step after data QC entailed creating a single profile by splicing the two DRWP profiles at the altitude where the top of the D-915 profile (20,013 ft or 6,100 m at most) and the bottom of the D-50 profile (approximately 8,202 ft or 2,500 m) met or overlapped. Before generating the spliced DRWP profiles, Mr. Barbré determined and applied temporal and spatial (vertical) criteria to all DRWP profiles because the individual profiles had to match in both domains before splicing. The D-50 archive provides measurements at 492-ft (150-m) intervals every 5 minutes prior to an instrument upgrade in 2004 and 475-ft (145-m) intervals every 3 minutes thereafter. The D-915 archive provides measurements at 331-ft (101-m) intervals roughly every 15 minutes. Mr. Barbré chose 164 ft (50 m) as the spatial criterion and the D-50 measurement time intervals as the temporal criterion.

After determining the temporal and spatial criteria, Mr. Barbré developed an algorithm to splice the D-50 and D-915 profiles into one using each of the five D-915s. First, for each D-50 timestamp, the algorithm found the closest corresponding timestamp in each of the D-915 profiles. Next, the algorithm interpolated the D-50 and D-915 profiles to 164-ft (50-m) spacing in the altitude range 328-61,024 ft (100-18,600 m), the lowest observation of the D-915s to the highest observation of the D-50. Then, the algorithm counted the number of data gaps from each instrument, flagged excessively large gaps, and linearly interpolated wind components within unflagged gaps. Both profiles contained data placeholders at the same altitudes, with a transition region between the two profiles typically at altitudes around 6,562-9,843 ft (2,000-3000 m). The algorithm then spliced the two profiles using a methodology that varied slightly based on the data coverage of the two profiles within the transition region. If a D-915 profile overlapped the D-50 profile, then the algorithm combined the D-50 and D-915 wind components within the transition region using a weighting scheme that gave greater weight to the D-915 at lower altitudes and greater weight to the D-50 at higher altitudes. If a D-915 profile did not reach the D-50 profile, then the algorithm linearly interpolated the winds between the highest altitude of the D-915 profile and the lowest altitude of the D-50 profile provided the QC algorithm did not flag the gap. Each spliced profile contained winds exclusive to the D-915 below the transition region, derived winds within the transition region, and winds exclusive to the D-50 above the transition region. Splicing the D-50 and individual D-915 profiles produced up to five DRWP wind profiles at a given timestamp in the archive.

Mr. Barbré then combined the individual spliced profiles to generate a single composite DRWP profile representing the wind environment at a given timestamp. The individual spliced profiles only differed below the lowest altitude of the D-50 profile. Mr. Barbré developed an algorithm that generated composite winds at each altitude starting at 328 ft (100 m) and ending at 60,532 ft (18,450 m). He decided not to use data at the highest D-50 measurement altitude due to questionable shears. The algorithm first computed a mean reference wind using observations from D-915s with valid winds at each altitude. Next, vector differences between the winds from each of the individual D-915 profiles and the reference wind were used to derive weights corresponding to each of the profiles. Summing the product of the weights and wind components from all individual profiles produced the composite wind at each altitude. At altitudes above 328 ft (100 m), the algorithm computed the final composite wind as the mean of the reference wind described above and the composite wind at the previous altitude.

Mr. Barbré reduced the DRWP archive according to specific guidelines for this task. A wind profile must have contained data at all altitudes from 820-20,000 ft (250-6,096 m). He linearly reduced wind components below 820 ft (250 m) to no wind at 0 ft (0 m). Profile tops extended as high as 60,532 ft (18,450 m). Two profiles defined a pair if the desired time separation of the pair plus or minus two minutes separated the profiles' timestamps. For example, a 45-minute pair has two profiles spaced anywhere from 43-47 minutes apart. Mr. Barbré chose a two-minute window given the large number of profiles available, and generated pairs at 45-minute, 90-minute, 2-hour, 3-hour, and 4-hour time intervals over the POR. Table 3 displays the number of composite ER DRWP pairs for each time interval.

Continuing Work

Mr. Decker will discuss the results of the WFF wind pair database analysis with LSP and determine if there are any potential applications for the database. He will start to process and analyze the WR wind pair database and will perform an analysis of maximum wind changes over each time interval on the ER DRWP wind pairs database. He will deliver three sets of wind pair databases, one for each range, upon completion of the task.

Table 3. Number of ER DRWP pairs for each time interval during the POR.

Time Interval	Number of Pairs
45-minute	273,265
90-minute	260,878
2-hour	297,491
3-hour	273,189
4-hour	276,108

For more information contact Mr. Decker at 256-544-3068 or ryan.k.decker@nasa.gov

MESOSCALE MODELING

Range-Specific High-Resolution Mesoscale Model Setup: Data Assimilation (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 high resolution model would provide that capability. This is a continuation of a previously customer-approved task that began in FY12 in which the Weather Research and Forecasting (WRF) model was tuned for the ER and WFF. This task will provide a recommended local DA and numerical forecast model design optimized for the ER and WFF to support space launch activities. The model will be optimized for local weather challenges at both ranges.

Operating System Reinstallation

Dr. Watson asked Mr. Erik Magnuson, from ENSCO, Inc., to reinstall the operating system on the old modeling cluster due to the difficulties in running new software and due to the delay in getting the new AMU modeling clusters up and running. After the upgrade, Dr. Watson began installing and configuring updated versions of all the software needed to run the GSI data assimilation program. Dr. Watson then continued to run test cases and learn about GSI.

New Modeling Clusters Configuration

The two new AMU modeling clusters were moved to their new location in the KSC Data Center at the Central Instrumentation Facility (CIF) in May 2013. Mr. Magnuson installed the clusters in their racks, powered them up, and implemented basic network connectivity. Working with KSC Information Management and Communications Systems (IMCS) staff, he rebalanced power distribution to the two clusters to minimize load issues. Ms. Shafer, Mr. Magnuson, Dr. Bauman and Dr. Huddleston attended a meeting with KSC IT Security staff to determine the most efficient approach to conduct a risk assessment of the modeling clusters with the IMCS IT Security staff and then incorporate the assessment into the AMU System IT Security Plan. Mr. Magnuson, Ms. Shafer, and Dr. Bauman then conducted an IT Security vulnerability scan of the clusters. After the scans were completed, both modeling clusters were cleared for AMU staff use. Dr. Watson then began installing and configuring the software needed to conduct this task.

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

Modeling Clusters

Dr. Watson, Ms. Shafer and Dr. Bauman met with several people from the KSC Data Center on 25 April to assess the requirements to house the two AMU modeling clusters in their facility. Mr. Magnuson, ENSCO System and Software Engineer, installed the new AMU modeling clusters in their racks in the KSC Data Center at the CIF. He then powered them up and implemented basic network connectivity. Working with IMCS staff, he rebalanced power distribution to the two clusters to minimize load issues.

Ms. Shafer, Mr. Magnuson, Dr. Bauman and Dr. Huddleston supported a meeting with KSC IT Security to determine the most efficient approach to conduct a risk assessment of the new AMU modeling clusters with the IMCS IT Security staff in the KSC Data Center at the CIF and then incorporate the assessment into the AMU System IT Security Plan. Ms. Shafer coordinated a date to accomplish a vulnerability scan of the clusters that, when completed, will allow work to fully commence on the AMU Modeling Task on the new machines.

Mr. Magnuson, Ms. Shafer and Dr. Bauman met with Mr. Gary Peck and Mr. Eric Franco from IMCS to conduct an IT Security vulnerability scan of the new AMU modeling clusters. After the scans were completed, both modeling clusters were cleared for AMU staff use for current customer-directed modeling tasks.

IT

Ms. Shafer and Dr. Bauman completed the annual IT Security Requirements to conduct the AMU System's Continuous Monitoring assessment and update the AMU System Security Plan, the AMU Contingency Plan, the AMU Hurricane Preparedness Plan and AMU system diagrams in the SecureInfo Risk Management System. Mr. Magnuson upgraded the AMU Advanced Weather Information Processing System (AWIPS) to the latest available version.

Assistance to Range Weather Operations

During the 45 WS morning weather discussion on 22 May the forecaster mentioned that satellite imagery was lost overnight and thought there was an issue with MIDDS. They planned to contact CSR to see what could be done. After the briefing, Ms. Shafer researched the satellite imagery issue and discovered the Geostationary Operational Environmental Satellite 13 (GOES-13) was down and it was not a MIDDS problem. She notified the 45 WS Flight Commander, Capt. Sweat, who directed CSR to switch the local satellite feed from GOES-13 to GOES-14.

During the Delta IV launch operations in May, the Launch Weather Officer (LWO) asked for AMU assistance to display the AMU-developed Anvil Threat Corridor in AWIPS and at a lower altitude than the typical anvil cloud height in MIDDS. Dr. Bauman displayed the Anvil Threat Corridor in AWIPS and also showed the LWO how to display it. He also helped instruct the launch team on how to run the Anvil Threat Corridor in MIDDS to output the display at a lower altitude to match the height of the anvil clouds that could have potentially affected the launch.

Ms. Shafer assisted one of the 45 WS forecasters by providing training on use of the AWIPS warm season procedures developed by the AMU to help run the AMU-developed 1000 UTC sounding-based Severe Weather tool in MIDDS. She showed him where the procedures were located in the AWIPS menu system and opened all of them for him. He used the guidance from the AWIPS procedures when he ran the Severe Weather tool.

Ms. Shafer and Mr. Magnuson assisted one of the Launch Weather Officers during an Atlas V tanking test by helping them adjust the color tables on an AWIPS product he was using to support the operation.

Dr. Huddleston modified the code in the 45 WS lightning probability spreadsheet to add error ellipse axes adjustments to strokes with chi-squared values (location uncertainties) ≥ 3.

Meetings and Briefings

Dr. Bauman and Dr. Huddleston provided an overview of the AMU to the new AMU Contracting Officer's Representative, Ms. Janet Letchworth, on 4 April.

Dr. Watson and Ms. Crawford visited NWS MLB on 16 May to provide updates on the AMU's mesoscale modeling, lightning forecasting, and multi-Doppler radar analysis tasks.

Ms. Crawford, Dr. Bauman and Dr. Huddleston met with Mr. Michael Chambers, Chief of 45 SW Industrial Security, at the AMU for the annual review of the AMU Security Program. The AMU was found to be in compliance with all aspects of the National Industrial Security Program.

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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
ABS	Absolute Value
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
AWIPS	Advanced Weather Information Processing System
CB	Confidence Bounds
CCAFS	Cape Canaveral Air Force Station
CI	Convection Initiation
CIF	Central Instrumentation Facility
CG	Cloud-to-Ground
CL	California Low
CSR	Computer Sciences Raytheon
CSV	Comma Separated Value format
D-50	50-MHz DRWP
D-915	915-MHz DRWP
DA	Data Assimilation
dP	Pressure Difference
DRWP	Doppler Radar Wind Profiler
ER	Eastern Range
ESRL	Earth System Research Laboratory
FRN	Forecast Reference Notebook
FSU	Florida State University
GEV	Generalized Extreme Value Distribution
GSI	Gridpoint Statistical Interpolation
GOES	Geostationary Operational Environmental Satellite
GUI	Graphical User Interface
IGRA	Integrated Global Radiosonde Archive
IMCS	Information Management and Communications Systems
JSC	Johnson Space Center
KSC	Kennedy Space Center
LSP	Launch Services Program
LWO	Launch Weather Officer
MIDDS	Meteorological Interactive Data Display System
MPW	Maximum Peak Wind
MSFC	Marshall Space Flight Center
MSLP	Mean Sea Level Pressure
NB	North Base (at VAFB)
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NCEP	National Centers for Environmental Prediction
NE	Natural Environments Group at MSFC
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NPH	North PH
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service in Melbourne, FL
PCC	Pearson Correlation Coefficient
PG	Pressure Gradient
PH	Pacific High
POR	Period of Record
QC	Quality Control
SB	South Base (at VAFB)
SMC	Space and Missile Center
TI	Thompson Index
TTS	Total Threat Score
UL	Upper Level
USAF	United States Air Force
VAFB	Vandenberg Air Force Base
WDSS-II	Warning Decision Support System Integrated Information
WFF	Wallops Flight Facility
WR	Western Range
WRF	Weather Research and Forecasting Model
WSR	45 SW Weather Surveillance
WSR-88D	Weather Surveillance Radar 1988-Doppler
XMR	CCAFS 3-letter identifier

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

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