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Applied Meteorology Unit (AMU) Quarterly Report

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NWS Melbourne/S. Spratt
NWS Melbourne/P. Blottman
NWS Melbourne/M. Volkmer

Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the first quarter of Fiscal Year 2009 (October - December 2008). A detailed project schedule is included in the Appendix.

Task: Peak Wind Tool for User Launch Commit Criteria (LCC)

Goal: Update the Phase I cool season climatologies and distributions of 5-minute average and peak wind speeds. The peak winds are an important forecast element for the Expendable Launch Vehicle and Space Shuttle programs. The 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast. The Phase I climatologies and distributions helped alleviate this forecast difficulty. Updating the statistics with more data and new time stratifications will make them more robust and useful to operations.

Milestones: Determined criteria to define the highest average speed modeled with the Gumbel distribution, wrote a memorandum describing the Graphical User Interface (GUI), created 2-hour probabilities for each hour, and continued running scripts for the 4-hour prognostic probabilities.

Discussion: The highest average speed distribution that can be modeled is defined by the largest change in the Gumbel location and/or scale parameter values for distributions with ≥ 100 and ≤ 400 observations. The different criteria and the longer period of record allow the modeling of higher wind speeds than in Lambert (2002). The 2-hour probabilities for each hour were not smooth and created a large Excel file. Options for combining the hourly data into groups will be discussed in January.

Task: Peak Wind Tool for General Forecasting, Phase II

Goal: Update the tool used by the 45 WS to forecast the peak wind speed for the day on Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) during the cool season months October-April. The tool forecasts the timing of the peak wind speed for the day, the associated average speed, and provides the probability of issuing wind warnings in the KSC/CCAFS area using observational data available for the 45 WS morning weather briefing. The period of record will be expanded to increase the size of the data set used to create the forecast equations, new predictors will be evaluated, and the performance of the Phase I and Phase II tools will be compared to determine if the updates improved the forecast.

Milestones: Compared interpolated sounding data to 100-ft data for the period October 2002 to April 2008.

Discussion: The 1000-ft sounding data were linearly interpolated to 100-ft increments up to 15,000 ft MSL and then compared to the 100-ft data for the period October 2002 to April 2008. No significant differences were found between the interpolated and 100-ft sounding data. A recommendation was made to use interpolated sounding data for October 1996 to April 2002, and use 100-ft sounding data for October 2002 to April 2008.

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Distribution (continued from Page 1)

NWS Southern Region HQ/"W/SR"/ S. Cooper
NWS Southern Region HQ/"W/SR3" D. Billingsley
NWS/"W/OST1"/B. Saffle
NWS/"W/OST12"/D. Melendez
NSSL/D. Forsyth
30 WS/DO/J. Kurtz
30 WS/DOR/D. Vorhees
30 WS/SY/M. Schmeiser
30 WS/SYR/G. Davis
30 WS/SYS/J. Mason
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/C. Donohue
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ENSCO, Inc./E. Lambert
ENSCO, Inc./A. Yersavich
ENSCO, Inc./S. Masters

Executive Summary, *continued*

Task: Situational Lightning Climatologies for Central Florida: Phase IV

Goal Recalculate lightning climatologies for the Shuttle Landing Facility (SLF) and eight other airfields in the National Weather Service at Melbourne (NWS MLB) county warning area using individual lightning strike data to improve the accuracy of the climatologies, and update the GUI. In a previous task, lightning climatologies were calculated using gridded lightning data providing less accurate results. As in the previous task, stratify the climatologies for each location by flow regime and, new for this task, not stratified by flow regime.

Milestones Created and ran scripts to stratify the lightning data by 1-, 3- and 6-hr time periods and then stratified them at 5-, 10- and 20-NM distances from the center of the runway of each site.

Discussion Dr. Bauman reviewed the work started by Mr. Dreher and Ms. Crawford in September, and then created and ran scripts in S-PLUS software to sort the lightning data files for each site by 1-, 3- and 6-hr time periods and 5-, 10- and 20-NM radii from the center of each runway.

Task: VAHIRR Cost Benefit Analysis

Goal Conduct a cost-benefit analysis to assess the value of using Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) in support of launch operations at the Eastern Range and Western Range. VAHIRR was developed from the Airborne Field Mill program to correlate operational weather observations with in-cloud electric fields capable of rocket triggered lightning in anvil clouds. It has been used as an input to assess lightning LCC (LLCC) since 2005. If the analysis reveals positive results, funding for development of an automated algorithm may be sought.

Milestones Refined preliminary results and completed final report.

Discussion The preliminary results reported in the previous Quarterly Report indicated VAHIRR provided relief from the anvil cloud LLCC 28.6% of the time, allowing a launch to proceed that was otherwise "NO GO" due to the anvil cloud LLCC. However, taking into account the amount of time a decision maker has to evaluate the change from "NO GO" to "GO" resulted in VAHIRR providing relief 15.1-18.0% of the time. The final report was completed, distributed and posted on the AMU web site.

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Executive Summary, *continued*

Task	Severe Weather and Weak Waterspout Checklist in MIDDS
Goal	Migrate the functionality of the web-based Severe Weather Forecast Decision Aid and the Weak Waterspout Checklist to the Meteorological Interactive Data Display System (MIDDS). The likelihood of severe weather occurrence is included in the 45 WS morning weather briefing, but is a difficult parameter to forecast. This information is used by range customers to protect personnel and other assets of the 45th Space Wing, CCAFS, and KSC. In the current program, the forecasters enter values manually to output a threat index. Making these tools more automatic in MIDDS will reduce human errors and increase efficiency, allowing forecasters to do other duties.
Milestones	Created the programs in MIDDS to automatically access the real-time data for the severe weather and weak waterspout worksheets, created a user-interface in MIDDS for forecaster input, and demonstrated the programs to the 45 WS.
Discussion	The code was tested to ensure the calculations were done correctly, and that the correct weights were being applied in order to calculate an appropriate threat index value. After testing revealed correct output, the MIDDS tool was demonstrated to 45 WS personnel. Their suggested changes to formats and graphics were made to the code.

Task	WRF Wind Sensitivity Study at Edwards Air Force Base (EAFB)
Goal	Assess different high-resolution Weather Research and Forecasting (WRF) model configurations to determine which is best to assist SMG in their short-term wind forecasts at EAFB for shuttle landings. The focus will be on “wind cycling” cases, in which the wind speed and direction oscillate over a period of time. Accurate forecasts are needed for EAFB in cases where the Shuttle cannot land at KSC due to adverse weather conditions.
Milestones	Completed identification and collection of data for candidate wind cycling days. Finished configuring the latest version of the Local Analysis and Prediction System (LAPS) for the EAFB area and began configuring the latest version of the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS). Completed the objective and subjective analyses, and wrote the final report. The final report was distributed and posted on the AMU web site.
Discussion	After completing the data collection for candidate wind cycling days, six WRF model configurations were run with varying dynamical cores, initializations, and physics for each candidate day. Subjective and objective analyses were done comparing wind tower observations to model output. In both analyses, the AMU found the Advanced Research WRF (ARW) dynamical core performed the best among all model configurations. The model was able to differentiate between wind cycling days and null cases, which would provide added value to the Shuttle landing forecast

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Executive Summary, *continued*

Task	HYSPLIT/WRF-EMS
Goal	Configure the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model on a NWS MLB Linux machine. The HYSPLIT model is used by NWS MLB for computing trajectories, dispersion, and deposition of atmospheric pollutants to assist local emergency managers. HYSPLIT will be modified to ingest output from operational models in near-real time. This will assist NWS MLB forecasters in the event of any incident involving toxic substances dispersed into the atmosphere. A comparable version of HYSPLIT will support SMG forecasters for Space Shuttle landing attempts during scenarios involving low-altitude smoke and high-altitude anvil clouds from thunderstorms.
Milestones	Completed installing and configuring HYSPLIT on an NWS MLB Linux machine. Wrote automated scripts to download and ingest several operational model products into HYSPLIT and began testing them on the AMU Linux cluster in real-time. Modified existing software to convert local NWS MLB WRF output into HYSPLIT format. Ran several test HYSPLIT trajectories using NWS MLB WRF output.
Discussion	Existing code was modified to covert the local NWS MLB WRF output into HYSPLIT format and is currently being tested in the AMU. The new HYSPLIT WRF software utility will be tested on the NWS MLB Linux system in the near future.

Special Notice to Readers

Applied Meteorology Unit (AMU) Quarterly Reports are now available on the Wide World Web (www) at Hhttp://science.ksc.nasa.gov/amu/H.

The AMU Quarterly Reports are also available in electronic format via email. If you would like to be added to the email distribution list, please contact Ms. Winifred Crawford (321-853-8130, Hcrawford.winifred@ensco.comH). If your mailing information changes or if you would like to be removed from the distribution list, please notify Ms. Crawford or Dr. Francis Merceret (321-867-0818, HFrancis.J.Merceret@nasa.govH).

Background

The AMU has been in operation since September 1991. Tasking is determined annually with reviews at least semi-annually. The progress being made in each task is discussed in this report with the primary AMU point of contact reflected on each task.

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

SHORT-TERM FORECAST IMPROVEMENT

Peak Wind Tool for User LCC (Ms. Crawford)

The peak winds are an important forecast element for the Expendable Launch Vehicle and Space Shuttle programs. As defined in the Launch Commit Criteria (LCC) and Shuttle Flight Rules (FR), each vehicle has peak wind thresholds that cannot be exceeded in order to ensure safe launch and landing operations. The 45th Weather Squadron (45 WS) and the Spaceflight Meteorology Group (SMG) indicate that peak winds are a challenging parameter to forecast, particularly in the cool season. To alleviate some of the difficulty in making this forecast, the AMU calculated cool season climatologies and distributions of 5-minute average and peak winds in Phase I (Lambert 2002). The 45 WS requested that the AMU update these statistics with more data collected over the last five years, using new time-period stratifications, and a new parametric distribution. These modifications will likely make the statistics more robust and useful to operations. They also requested a graphical user interface (GUI) similar to that developed in Phase II (Lambert 2003) to display the wind speed climatologies and probabilities of meeting or exceeding certain peak speeds based on the average speed.

Gumbel Distributions

Ms. Crawford calculated the Gumbel parameters using the observed peak speed distributions for all mean speeds in the database. She then examined the values and conducted tests to determine what criteria should be used to establish an upper mean speed limit when calculating the Gumbel distributions. In Lambert (2002), the upper limit was defined by distributions that had 600 observations or less. That criterion was too conservative for the Gumbel method, which was able to model peak speed distributions of higher mean speeds with less than 600 observations.

Ms. Crawford examined the Gumbel location (θ) and scale (β) parameters along with the number of observations in each distribution. She found that the observation number threshold varied between 400 and 100. Typically, there were three to five mean speeds within this range. To narrow the choices down to one speed, she found the changes in θ and β from consecutive mean speeds to be useful as a second threshold. The final algorithm checked the changes in θ and β for distributions with ≥ 100 and ≤ 400 observations. The lowest speed with the highest change in θ or β from the previous speed was chosen as the cutoff. Gumbel distributions were calculated for all speeds less than the cutoff speed.

Figure 1 shows an example of how this method was used. For the 54 ft sensor on Tower 0020 in December, there were 428 observations of 16-kt mean winds, 224 17-kt mean winds, 122 18-kt mean winds, and 69 19-kt mean winds. This put 17 and 18 kt within the 100 – 400 observation range, indicated by the black vertical lines. The highest change in θ and β occurred at 18 kt, highlighted by the red ellipse. Therefore, Gumbel distributions were calculated for all mean speeds ≤ 17 kt. Above 18 kt, the slope of the parameter curves becomes erratic. This is likely due to the small number of observations for these higher speeds.

In Lambert (2002), the highest speed modeled for this tower/height/month stratification was 14 kt. The combination of more observations due to a longer period of record and the ability of the Gumbel formulation to model observed distributions with < 600 observations allowed higher speeds to be modeled. This is significant as the higher speeds are important to operations.

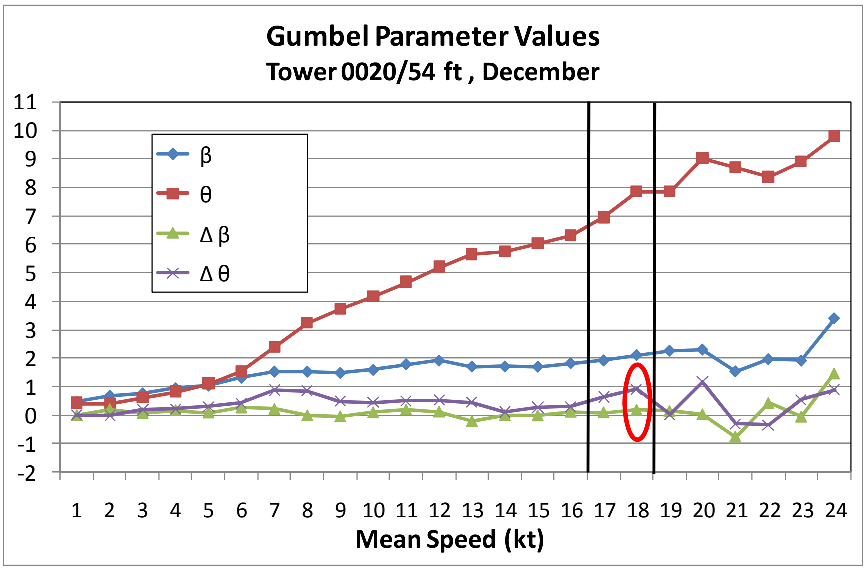


Figure 1. The Gumbel parameters, θ and β, for each mean wind speed and their change in value ($\Delta\theta$ and $\Delta\beta$) from the previous mean wind speed. The mean speeds are in kt on the x-axis and the parameter values (dimensionless) are on the y-axis. The black vertical lines outline the range of speeds with 100 – 400 observations, and the red ellipse outlines the largest $\Delta\theta$ and $\Delta\beta$ within the vertical lines.

Graphical User Interface

Ms. Crawford incorporated the Gumbel probabilities into the GUI and delivered the GUI to the 45 WS for review. Mr. Roeder requested that the GUI be used in upcoming operations scheduled during the remainder of the 2008-2009 cool season. Communications with Dr. Merceret and Mr. Roeder resulted in Ms. Crawford writing a memo describing the GUI and how to use it. Once approved, this memo will be distributed with the GUI so that it can be used officially in operations. The two previous versions of the AMU Quarterly Report, Q3 and Q4 FY-08, have examples of forms in the GUI.

Prognostic Probability Status

Ms. Crawford calculated the observed 2-hr prognostic probabilities at Tower 0020/21 for each hour. The PDF and CDF curves were not smooth, with some curves crossing each other. Increasing the observations for each hour through the re-sampling technique (AMU Quarterly Report Q1 FY-08) did not appear to assist in creating distributions that could be modeled, even for lower speeds. In general, the CDF curves for mean speeds higher than 11 kt were erratic. The Excel 2007 file containing the Tower 0020/21 data, which included values for four sensors, was 32 MB. The Excel 2007 file containing the GUI with the diagnostic data for all towers and sensors is only 17 MB. Using hourly values for all towers, all prognostic periods, and both observed and

Gumbel distributions would make the GUI file very large and affect its performance. Ms. Crawford asked Mr. Roeder to consider combining the hourly values into 3-, 6-, 12- or even 24-hour groups to alleviate these two issues. They will discuss it in January. Ms. Crawford continued running the 4-hr scripts and is close to completion. If the issues with the 2-hr data can be resolved in early January, the 4-hr probabilities will be created on time next Quarter.

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

Peak Wind Tool for General Forecasting, Phase II (Mr. Barrett)

The expected peak wind speed for the day is an important element in the daily morning forecast for ground and space launch operations at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS). The 45 WS must issue forecast advisories for KSC/CCAFS when they expect peak gusts to exceed 35 kt, 50 kt, and 60 kt thresholds at any level from the surface to 300 ft. In Phase I of this task (Barrett and Short 2008), the AMU developed a tool to help forecast the highest peak non-convective wind speed, the timing of the peak speed, and the average wind speed at the time of the peak wind from the surface to 300 ft on KSC/CCAFS for the cool season (October – April). For Phase II, the 45 WS requested that additional observations be used in the creation of the forecast equations by expanding the period of record (POR). In Phase I, the data set included observations from October 2002 to February 2007. In Phase II, observations from March and April 2007 and October 2007 to April 2008 will be added. To increase the size of the data set even further, the AMU will consider adding data prior to October 2002. Additional predictors will be evaluated, including wind speeds between 500 ft and 3000 ft, static stability classification, Bulk Richardson Number, mixing depth, vertical wind shear, inversion strength and depth, wind direction, synoptic weather pattern and precipitation. Using an independent data set, the AMU will compare the performance of the Phase I and II tools for peak wind speed forecasts. The final tool will be a user-friendly GUI to output the forecast values.

In Phase I, the tool was delivered as a GUI in Microsoft Excel. The tool will be delivered as a Microsoft Excel GUI in Phase II. In addition, at the request of the 45 WS, the AMU will make the tool available in the Meteorological Interactive Data Display System (MIDDS), their main weather display system. This will allow the tool to ingest observational and model data automatically and produce 5-day forecasts quickly.

Sounding Data

The sounding data must be in 100-ft increments in order to calculate the new predictors requested by the 45 WS. The data between October 1996 and April 2002 are only available in 1000-ft increments, while data between October 2002 and April 2008 are available in both 1000-ft and 100-ft increments. In order to increase the POR by including the data prior to October 2002, Mr. Barrett needed to determine if there were significant differences between 1000-ft data interpolated to 100-ft and the observed 100-ft data. He interpolated the 1000-ft sounding data from October 1996 to April 2008 to 100-ft increments up to 15,000 ft above mean sea-level (MSL), using two different methods. In Method1, the 1000-ft, significant, and mandatory levels were linearly interpolated to 100-ft increments. In Method2, only the significant and mandatory levels were linearly interpolated to 100-ft increments. A significant level occurs when there is a significant change in temperature or wind with height. Therefore, the number and heights of the significant levels are variable. Up through 15,000 ft MSL, mandatory levels in Automated Meteorological Profiling System (AMPS) sounding data format are at 1000 mb, 950 mb, 900 mb, 850 mb, 800 mb, 750 mb, 700 mb, 650 mb, and 600 mb. In July 2002, another mandatory level was added at 925 mb.

Mr. Barrett compared the interpolated data to the 100-ft sounding data in the period October 2002 to April 2008. First, he compared individual soundings for a small sample of seven days in the 2002/2003 cool season, with the following conclusions:

- The 100-ft data values were usually close to the interpolated data (Methods 1 and 2),
- The interpolated data were usually closer to each other than to the 100-ft data,
- The differences between the Method1 and Method2 interpolated data were largest at multiples of 1000 ft MSL,
- At multiples of 1000 ft MSL, the Method1 interpolated and 100-ft data were usually exactly the same, especially for temperature, dew point, and relative humidity,

- Due to the high vertical variability in dew point, there were occasionally large (on the order of 5 °C) differences between the interpolated and 100-ft data, and
- There were occasionally large differences between the interpolated and 100-ft data in wind speed and direction (on the order of 5 kt and 90°).

Next, he made comparisons between the interpolated and 100-ft data monthly averages in the POR. As expected, there were differences among the months, for example October had the highest average temperatures and dew points. However, the monthly averages for the interpolated and 100-ft data were practically equal, indicating no significant biases in the interpolated data. As an example, Figure 2 compares the u-wind component in the 100-ft and interpolated data for each month in the POR. The figure shows that there are no differences between the interpolated and 100-ft data in the monthly averages.

Finally, Mr. Barrett compared the interpolated and 100-ft data using mean absolute error (MAE). The MAE is the mean of the absolute value of the differences between the interpolated and 100-ft data. The MAE differences were small between the months averaged over the POR. Figure 3 shows the monthly averages of the u-wind component MAE versus height. The graph shows very little scatter in the monthly averages. However, the MAE differed for each year within individual months. Figure 4 shows a large amount of scatter among the December monthly plots for each year in the POR of height versus the u-wind component MAE. Figure 5 and Figure 6 show the monthly averages for temperature and dew point, respectively.

Mr. Barrett made the following conclusions after analyzing the monthly averages:

- For all of the meteorological variables except pressure, a minimum in MAE occurred at the mandatory pressure levels,
- For all of the meteorological variables except pressure, a maximum in MAE occurred halfway between mandatory levels,
- A secondary minimum in MAE at multiples of 1000 ft MSL occurred in the Method1 interpolated data,
- At multiples of 1000 ft MSL, the MAE in the Method1 interpolated data was very close to zero for all meteorological variables except wind,
- For pressure, the maximum in MAE occurred at mandatory levels and the minimum occurred halfway between the mandatory levels, and
- For all meteorological variables, the Method1 interpolated data's MAE was lower than in the Method2 interpolated data.

Since he found no significant differences between the interpolated and 100-ft sounding data, Mr. Barrett recommended interpolated sounding data should be used for October 1996 to April 2002, and 100-ft data should be used for October 2002 to April 2008. Method1 should be used to interpolate the data since it had the lowest MAE values. He reported these findings to Mr. Roeder of the 45 WS.

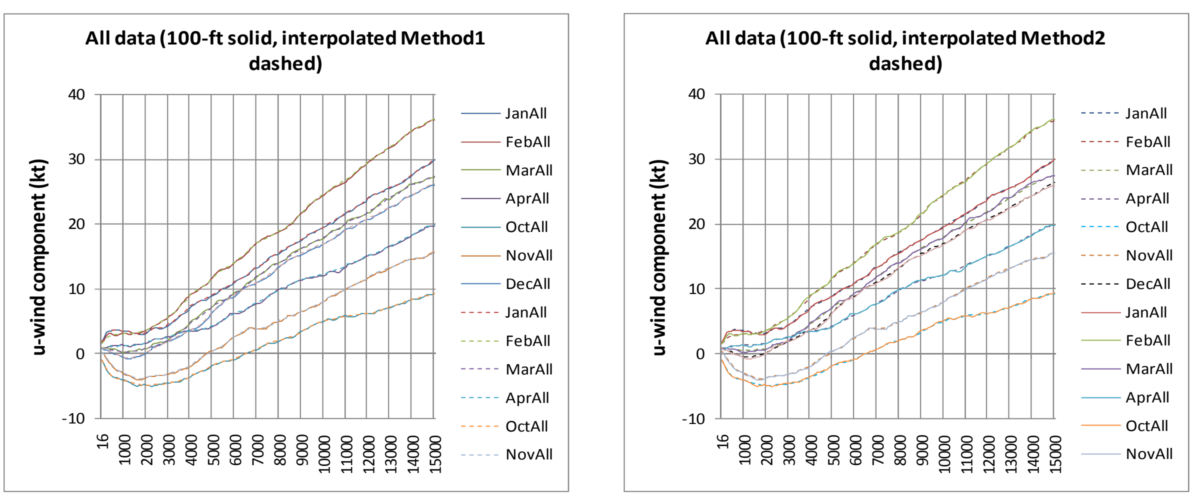


Figure 2. Monthly averages of height versus u-wind component, using interpolated and 100-ft data. The data were interpolated using Method1 (left) and Method2 (right).

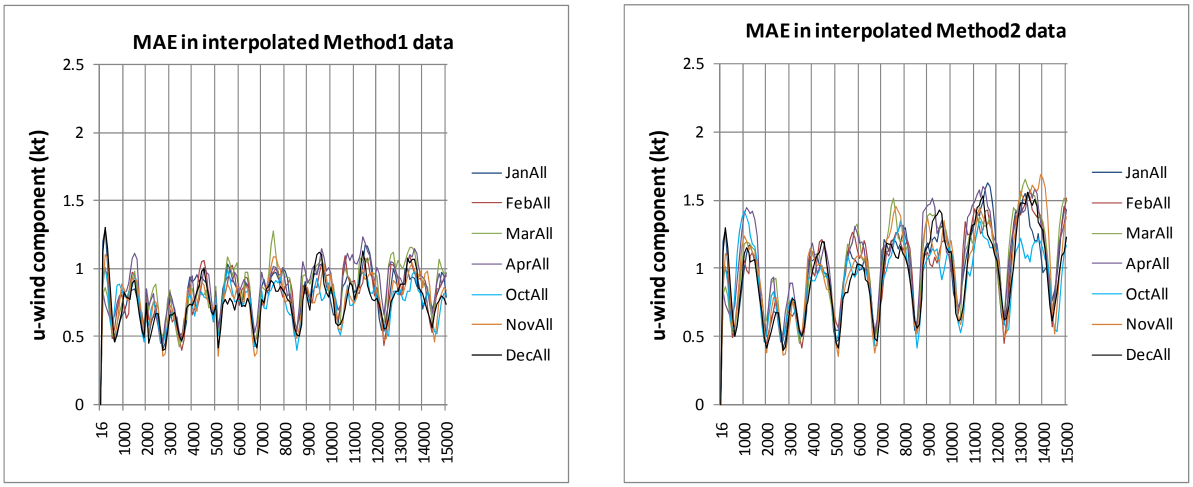


Figure 3. Monthly averages of height versus MAE in u-wind component, using interpolated and 100-ft data. The data were interpolated using Method1 (left) and Method2 (right).

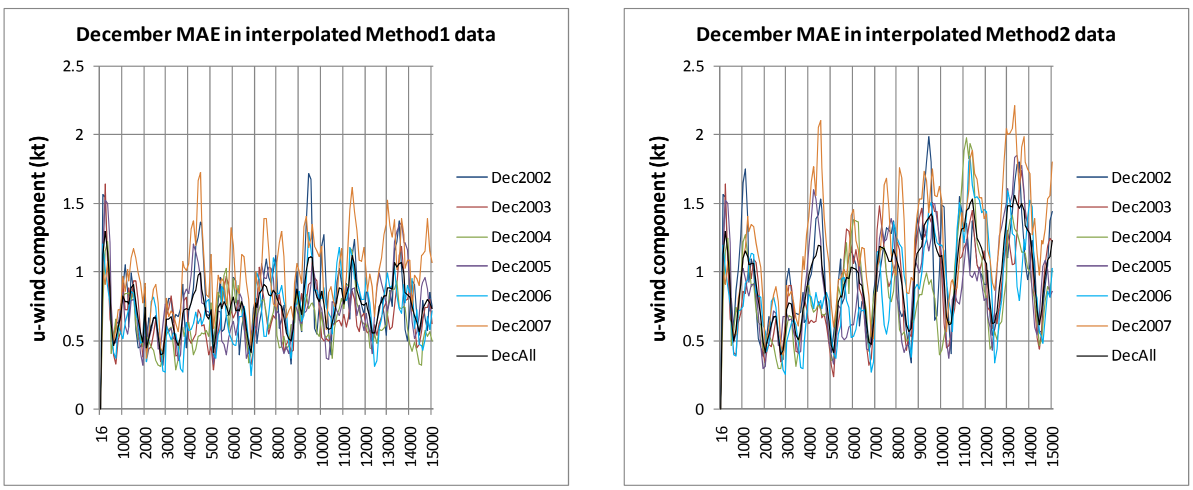


Figure 4. The December plots of height versus MAE in u-wind component, using interpolated and 100-ft data. The data were interpolated using Method1 (left) and Method2 (right).

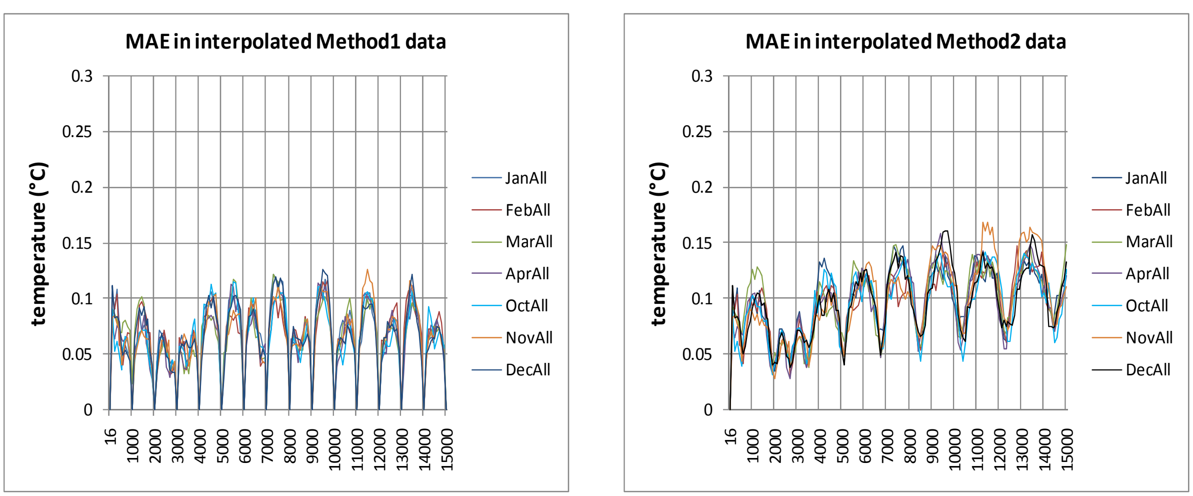


Figure 5. Monthly averages of height versus MAE in temperature, using interpolated and 100-ft data. The data were interpolated using Method1 (left) and Method2 (right).

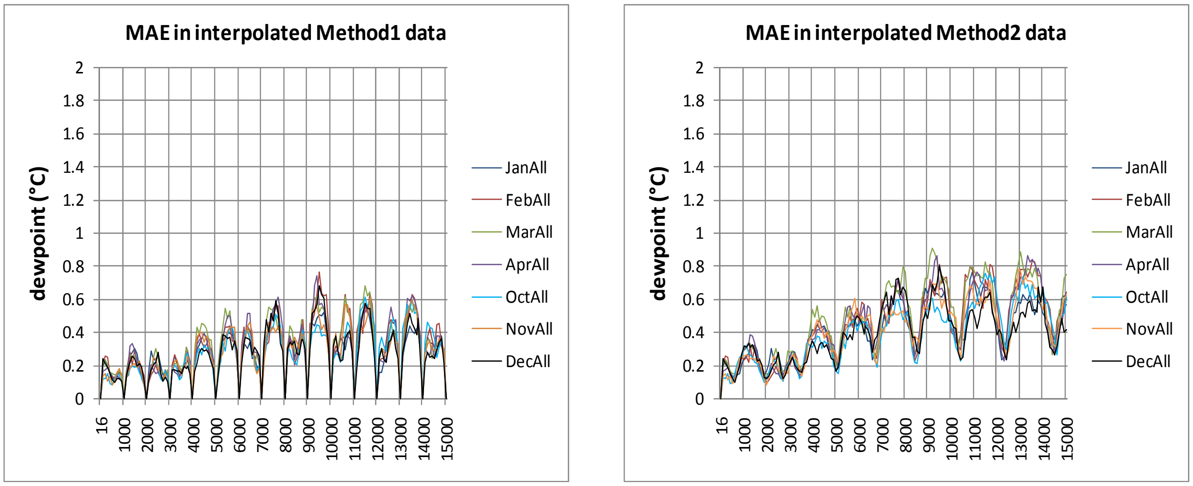


Figure 6. Monthly averages of height versus MAE in dew point, using interpolated and 100-ft data. The data were interpolated using Method1 (left) and Method2 (right).

Wind Tower Data Quality Control (QC)

Mr. Barrett began rewriting the software program that performs QC on the KSC/CCAFS wind tower data. The original version was written in the Fortran programming language, while the new version is in the Java language. Using Java makes the program more portable because it does not need to be recompiled in order to run on multiple operating systems. The new version uses a configuration text file to store values that were previously hard-coded in the source code, such as the years in the POR and the list of wind tower identifiers. This allows the user to easily change the program's parameters by modifying the configuration file. Previously, the user had to edit the source code and recompile the program.

Contact Mr. Barrett at 321-853-8205 or barrett.joe@ensco.com, for more information.

Situational Lightning Climatologies for Central Florida: Phase IV (Dr. Bauman)

The threat of lightning is a daily concern during the warm season in Florida. Research has revealed distinct spatial and temporal distributions of lightning occurrence that are strongly influenced by large-scale atmospheric flow regimes. In the previous phase, Dr. Bauman calculated the gridded lightning density and frequency climatologies based on the flow regime as in Lambert et al. (2006) for 1-, 3- and 6-hr intervals in 5-, 10-, 20-, and 30-NM range rings around the Shuttle Landing Facility (TTS) and eight other airfields in the National Weather Service in Melbourne (NWS MLB) county warning area. The 5- and 10-NM range rings are consistent with the aviation forecast requirements at NWS MLB, while the 20- and 30-NM range rings at TTS assist SMG in making forecasts for FR violations of lightning occurrence during a shuttle landing. For this phase, Dr. Bauman will use individual strike data from the National Lightning Detection Network (NLDN) to create more accurate climatological values for each range ring than was possible with the gridded data set. Also, the size of the range rings around each site will be corrected since the range ring distances in the last phase were calculated as diameters, but should have been radii. The 10- and 20-NM diameter range rings were still useful for NWS MLB since they represented 5- and 10-NM radius range rings, but they were not useful for SMG. Also, using gridded lightning data required estimating circular range rings from square grids. This resulted in over- and underestimating the lightning climatologies at each site, depending on the size of the range ring.

Site Locations and Data Processing

The sites in this task are the same as in the previous work and include TTS, Daytona Beach (DAB), Leesburg (LEE), Sanford (SFB), Orlando International (MCO), Kissimmee (ISM), Melbourne (MLB), Vero Beach (VRB) and Fort Pierce (FPR) in east-central Florida. Figure 7 shows the locations of the nine sites with 5-, 10-, 20- and 30-NM radius range rings extending outward from the center of the runway. Dr. Bauman will calculate the climatological probability of lightning within each range ring at each site based on flow regime and independent of the flow regimes.

The POR includes the warm season months, May-September, for the years 1989-2007. For this phase, the AMU was able to obtain individual NLDN lightning strike data with assistance from SMG and the 45 WS. The NLDN data were provided to the 45 WS by the 14th Weather Squadron (14 WS) and contain the date, time, latitude and longitude of every cloud-to-ground (CG) lighting strike within a 30 NM radius of each site for the entire POR. Having lightning data in this format will simplify the data processing and provide more accurate climatologies.

The 14 WS provided the 45 WS with nine data files (one for each site) in comma delimited (.csv) format ranging in size from 80 to 134 MB per file. Each file contained all NLDN CG lightning strikes within 30 NM of each site for all months of all years from 1989-2007. The files were too large to open in Microsoft Excel 2007 but could be opened and processed by S-PLUS. Using S-PLUS, Mr. Dreher and Ms. Crawford first removed the non-warm season months from each file. With assistance from Ms. Crawford, Dr. Bauman wrote scripts in S-PLUS to create individual files for each site broken down by 1-, 3- and 6-hr time intervals and then by 5-, 10- and 20-NM range rings. Next, Dr. Bauman will calculate probabilities of lightning climatologies for each site for the total data set (not flow-regime based) and then separate the individual data files by flow regime.

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

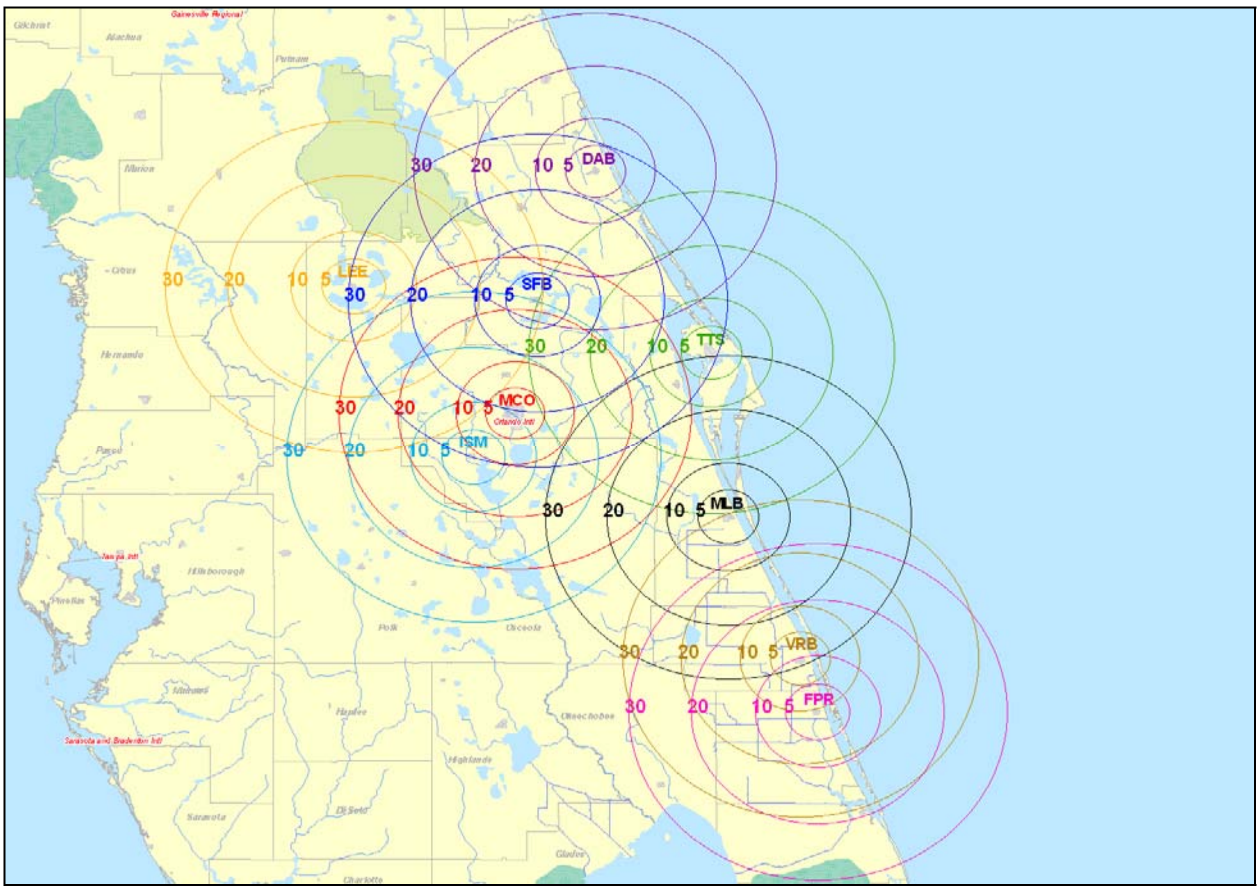


Figure 7. Map of central Florida showing locations of nine sites with 5-, 10-, 20- and 30-NM range rings.

INSTRUMENTATION AND MEASUREMENT

VAHIRR Cost-Benefit Analysis (Dr. Bauman)

The lightning LCC (LLCC) are designed to prevent space launch vehicles from flight through environments conducive to natural or triggered lightning. To assure avoidance of a triggered lightning event, the LLCC are extremely conservative. Some of these rules have had such high safety margins that they prohibited flight under conditions that are now thought to be safe 90% of the time (Merceret et al. 2006). The LLCC for anvil clouds was upgraded in the summer of 2005 to incorporate results from the Airborne Field Mill (ABFM) experiment at the Eastern Range. Numerous combinations of parameters were considered to develop the best correlation of operational weather observations to in-cloud electric fields capable of rocket triggered lightning in anvil clouds. The Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) was the best metric found. The KSC Weather Office is considering seeking funding for development of an automated VAHIRR algorithm for the new 45 WS RadTec 43/250 weather radar and Weather Surveillance Radar–1988 Doppler (WSR-88D) radars. Before developing an automated algorithm, the AMU was tasked to determine the frequency with which VAHIRR would have allowed a launch to safely proceed during weather conditions otherwise deemed “red” by the Launch Weather Officer. To do this, Dr. Bauman calculated VAHIRR values manually based on candidate cases from past launches with known LLCC violations. An automated algorithm may be cost-effective if the analyses from past launches show VAHIRR can provide a significant cost benefit by allowing a significant fraction of launches to proceed that otherwise would have to be scrubbed.

Final Results

The 45 WS launch weather summaries from the six launch operations with usable data identified LLCC as red for anvil cloud for 2,314 minutes. All necessary data required to calculate VAHIRR were available 74% of that time. This included 344 usable 5-minute volume scans of WSR-88D data. Of the 344 usable radar volume scans, VAHIRR was not calculated for 95 scans due to radar reflectivity values > 35 dBZ above 13,123 ft within 10.8 NM of the flight path, and for 32 scans due to lightning within 10.8 NM of the flight path. Under these conditions, VAHIRR could not provide relief from the anvil cloud LLCC rule. Therefore, VAHIRR was calculated for 217 radar volume scans of which 155 indicated VAHIRR values were too large to provide relief from the anvil cloud LLCC violations.

For the remaining 62 volume scans, VAHIRR values were small enough to provide relief from the anvil cloud LLCC violations. However, these 62 events contained combinations of single 5-minute periods and multiple 5-minute periods. This raised the question how much time launch directors and flight directors require to make a decision from “NO-GO” for anvil cloud LLCC violations to “GO” based on VAHIRR. Figure 8 shows the number of consecutive 5-minute periods that VAHIRR provided relief for an observed red anvil cloud LLCC condition. The figure shows that

- 18.0% of the time (62 out of 344) VAHIRR provided relief for at least one 5-minute period,
- 16.3% of the time (56 out of 344) VAHIRR provided relief for least two consecutive 5-minute periods,
- 15.7% of the time (54 out of 344) VAHIRR provided relief for least three consecutive 5-minute periods,
- 15.4% of the time (53 out of 344) VAHIRR provided relief for least four consecutive 5-minute periods, and
- 15.1% of the time (52 out of 344) VAHIRR provided relief for five or more consecutive 5-minute periods.

The results of these calculations indicated VAHIRR would have provided relief from the anvil cloud LLCC between 15.1% and 18.0% of the time, depending on the number of consecutive 5-minute periods, during the six launch attempts in this study. Had the launch T-0 time occurred during the anvil cloud LLCC violations, VAHIRR would have allowed launches to proceed that were otherwise “NO GO” due to the anvil cloud LLCC alone. The AMU did not take into account whether or not other weather LCC violations were occurring at the same time since the goal of this task was to determine how often VAHIRR provided relief to the anvil cloud LLCC. Therefore, in the statistics presented here, it is possible that, even though VAHIRR provided relief to the anvil cloud LLCC, other weather LCC could have been violated, not permitting the launch to proceed.

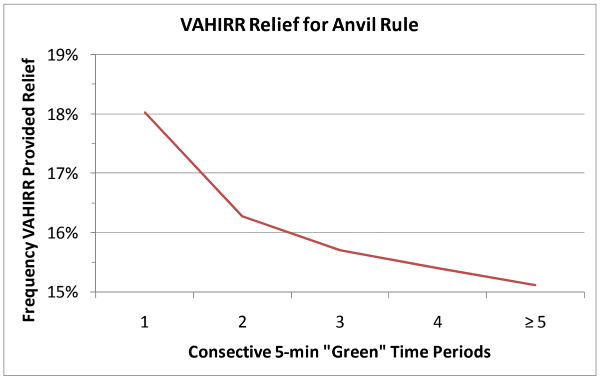


Figure 8. The frequency at which VAHIRR provided relief to the anvil cloud LLCC rule based on the number of consecutive 5-minute periods when VAHIRR would have allowed a launch to proceed.

Calculating VAHIRR manually is time consuming and not suited for fast-paced operations. It took Dr. Bauman 7-8 minutes to calculate VAHIRR manually for each radar volume scan. Given that the WSR-88D volume scans are 5 minutes in length, this would not allow a real-time VAHIRR calculation for each volume scan. Additionally, the new 45 WS radar will produce a volume scan every 2-3 minutes, making it even more difficult to manually calculate VAHIRR in real time. An automated algorithm would assist Launch Weather Officers in making this critical decision.

Dr. Bauman completed the final report and distributed it to the customer. It is now posted on the AMU web site.

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

Severe Weather and Weak Waterspouts Checklists in MIDDS (Mr. Wheeler)

The 45 WS Commander's morning weather briefing includes an assessment of the likelihood of local convective severe weather for the day in order to enhance protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC. The severe weather elements produced by thunderstorms include tornadoes, wind gusts ≥ 50 kt, and/or hail with a diameter ≥ 0.75 in. Forecasting the occurrence and timing of these phenomena is challenging for 45 WS operational personnel. In a previous task, the AMU developed the web-based Severe Weather Forecast Decision Aid worksheet to assist forecasters in determining the probability of issuing severe weather watches and warnings for the day. The forecasters enter values into the worksheet manually to output a threat index. For the current task, the 45 WS requested the AMU to migrate the functionality of the worksheet to MIDDS. MIDDS is able retrieve many of the needed parameter values for the worksheet automatically. They also requested the AMU to transfer the functionality of their Weak Waterspout Checklist, if time permits. Making these tools more automatic will reduce the possibility of human error and increase efficiency, allowing forecasters to do other duties.

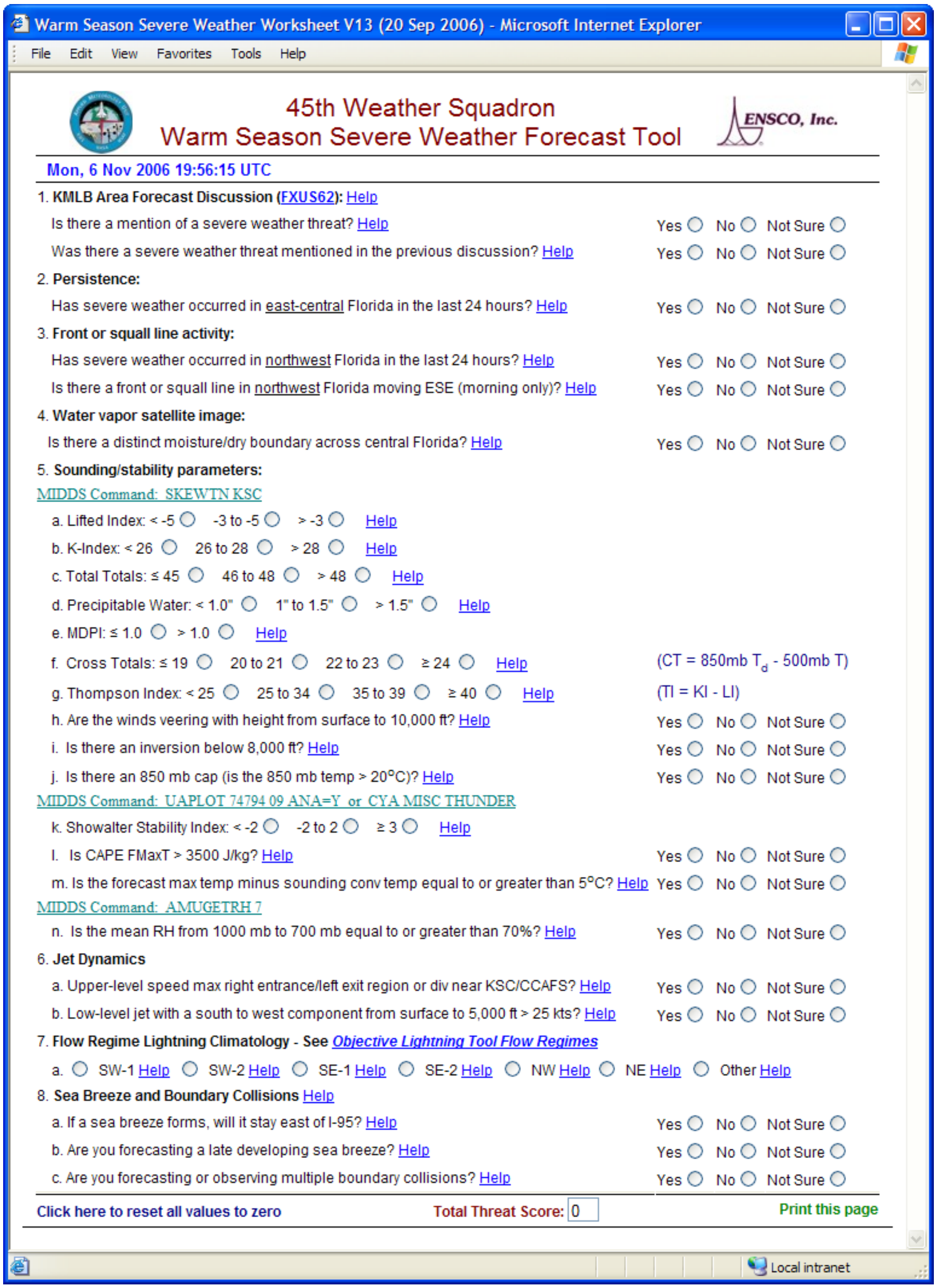
Previous Work

In the Severe Weather Forecast Decision Aid task final report (Bauman et al., 2005), Dr. Bauman and Mr. Wheeler presented a 15-year climatological study of severe weather events and related severe weather atmospheric parameters. The POR for the analysis was May – September, 1989 – 2003. The data sources included local forecast rules, archived soundings, Cloud-to-Ground Lightning Surveillance System (CGLSS) data, surface and upper air maps, and two severe weather event databases covering east-central Florida. They used the local forecast rules to set threat-assessment thresholds for stability parameters that were derived from the sounding data. The severe event databases were used to identify days with reported severe weather and the CGLSS data were used to differentiate between lightning and non-lightning days. These data sets provided the foundation for analyzing stability parameters and synoptic patterns with the goal of developing an objective tool to aid in forecasting severe weather events.

Dr. Bauman developed an interactive web-based Severe Weather Forecast Decision Aid (Figure 9) to assist the duty forecaster by providing a level of objective guidance based on the stability parameters from the CCAFS (XMR) sounding, CGLSS data, and synoptic-scale dynamics. Dr. Bauman tested and evaluated the Decision Aid during the 2006 warm season to verify the values chosen for each parameter based on the climatological study were consistent with the Total Threat Score. An additional objective was to determine if there was a Total Threat Score threshold at which reported severe weather did or did not occur.

MIDDS

The primary advantage of using MIDDS is the ability to automatically populate values available in the MIDDS databases without forecaster intervention. The forecaster will still need to answer subjective questions that MIDDS will assign the appropriate values to using criteria from the existing severe weather worksheet climatology before calculating a total threat score for the day. Mr. Wheeler used the initial MIDDS code developed by Ms. Winters of the 45 WS as a starting point for this MIDDS Severe Weather Forecast Decision Aid.



Warm Season Severe Weather Worksheet V13 (20 Sep 2006) - Microsoft Internet Explorer

File Edit View Favorites Tools Help

45th Weather Squadron
Warm Season Severe Weather Forecast Tool

ENSCO, Inc.

Mon, 6 Nov 2006 19:56:15 UTC

1. KMLB Area Forecast Discussion (FXUS62): Help
   - Is there a mention of a severe weather threat? Help — Yes No Not Sure
   - Was there a severe weather threat mentioned in the previous discussion? Help — Yes No Not Sure
2. Persistence:
   - Has severe weather occurred in east-central Florida in the last 24 hours? Help — Yes No Not Sure
3. Front or squall line activity:
   - Has severe weather occurred in northwest Florida in the last 24 hours? Help — Yes No Not Sure
   - Is there a front or squall line in northwest Florida moving ESE (morning only)? Help — Yes No Not Sure
4. Water vapor satellite image:
   - Is there a distinct moisture/dry boundary across central Florida? Help — Yes No Not Sure
5. Sounding/stability parameters:

MIDDS Command: SKEWTN KSC

   - a. Lifted Index: < -5 -3 to -5 > -3 Help
   - b. K-Index: < 26 26 to 28 > 28 Help
   - c. Total Totals: ≤ 45 46 to 48 > 48 Help
   - d. Precipitable Water: < 1.0" 1" to 1.5" > 1.5" Help
   - e. MDPI: ≤ 1.0 > 1.0 Help
   - f. Cross Totals: ≤ 19 20 to 21 22 to 23 ≥ 24 Help — (CT = 850mb T_d - 500mb T)
   - g. Thompson Index: < 25 25 to 34 35 to 39 ≥ 40 Help — (TI = KI - LI)
   - h. Are the winds veering with height from surface to 10,000 ft? Help — Yes No Not Sure
   - i. Is there an inversion below 8,000 ft? Help — Yes No Not Sure
   - j. Is there an 850 mb cap (is the 850 mb temp > 20°C)? Help — Yes No Not Sure

MIDDS Command: UAPLOT 74794 09 ANA=Y or CYA MISC THUNDER

   - k. Showalter Stability Index: < -2 -2 to 2 ≥ 3 Help
   - l. Is CAPE FMaxT > 3500 J/kg? Help — Yes No Not Sure
   - m. Is the forecast max temp minus sounding conv temp equal to or greater than 5°C? Help — Yes No Not Sure

MIDDS Command: AMUGETRH 7

   - n. Is the mean RH from 1000 mb to 700 mb equal to or greater than 70%? Help — Yes No Not Sure
6. Jet Dynamics
   - a. Upper-level speed max right entrance/left exit region or div near KSC/CCAFS? Help — Yes No Not Sure
   - b. Low-level jet with a south to west component from surface to 5,000 ft > 25 kts? Help — Yes No Not Sure
7. Flow Regime Lightning Climatology - See *Objective Lightning Tool Flow Regimes*
   - a. SW-1 Help SW-2 Help SE-1 Help SE-2 Help NW Help NE Help Other Help
8. Sea Breeze and Boundary Collisions Help
   - a. If a sea breeze forms, will it stay east of I-95? Help — Yes No Not Sure
   - b. Are you forecasting a late developing sea breeze? Help — Yes No Not Sure
   - c. Are you forecasting or observing multiple boundary collisions? Help — Yes No Not Sure

Click here to reset all values to zero Total Threat Score: 0 Print this page

Local intranet

Figure 9. The Severe Weather Forecast Decision Aid worksheet.

Software Development and Testing

Mr. Wheeler developed and tested the functionality of the Severe Weather Forecast Decision Aid automatic data input and the subjective questions into a MIDDS program using the Man-computer Interactive Data Analysis System (McIDAS) BASIC (McBASI) language Interpreter code in MIDDS, a language similar to BASIC. McBASI allows the flexibility of coding different modules to retrieve, process, and apply functions to data in the weather data database.

Development

MIDDS stores local data sets, model output and other gridded data, radar and satellite images in fixed areas on a server. McIDAS commands and McBASI programs can access and manipulate different data formats based on gridded, point or textual data structure. The following features of MIDDS were used in the development of the different modules and routines needed to migrate the Severe Weather Forecast Decision Aid's functionality into a single forecaster routine:

- **McBASI**: A programming language similar to the original BASIC language that allows users to group commands and/or parameters into a single file, which can then be entered as a single McIDAS command;
- **ASK**: An interface utility that can be programmed to query the user for specified parameter values and then enter a McIDAS command with the user's responses as the command parameters; and
- **String Tables**: User- or code-defined strings that can be assigned to commands and/or parameters lists and then used as a short cut for entering commands and/or providing a parameter list.

The XMR 1000 UTC morning sounding was the primary focus of the data retrieval routines. Automatic values and threat scores were computed for 14 out of the 26 total questions in the worksheet. The rest of the questions are subjective and need to be answered by the forecaster. These questions are displayed along with text or a graphic product that would help the forecaster answer the question, and then, based on the response, compute a weighted value. The McBASI programs use the sounding data to calculate the stability indices needed by the worksheet, and then store these values for other calculations in the subjective answer portions of the module. All the sounding information, including stability indices and the Threat Score for the day, is displayed on the MIDDS text screen (Figure 10) and also saved into a daily text file. This file can be viewed or printed later.

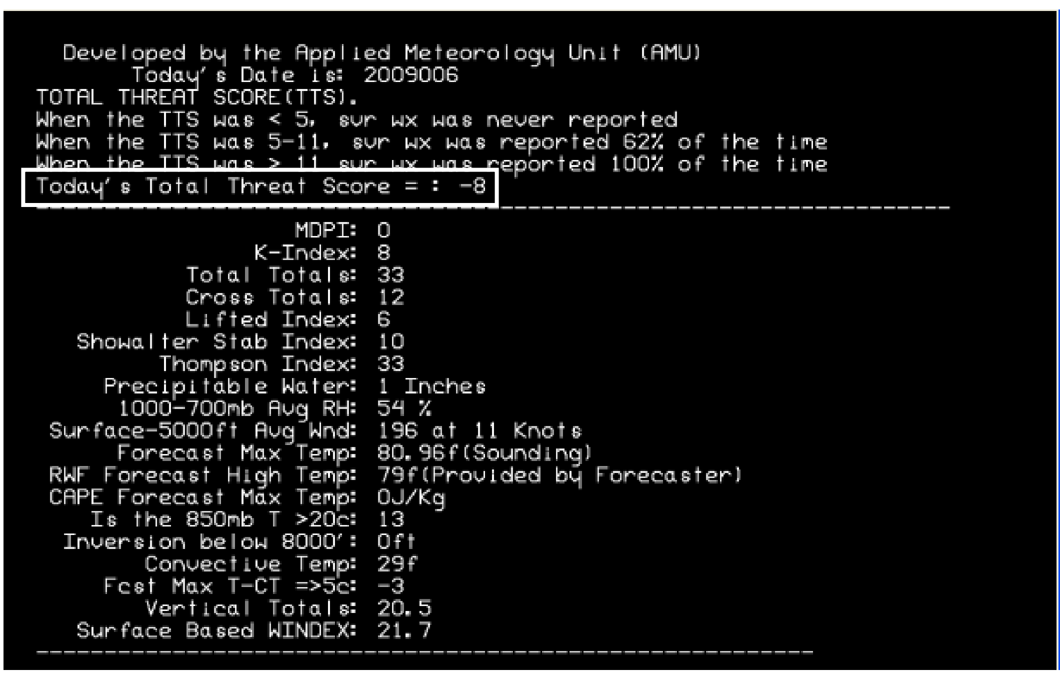


Figure 10. Example of the Severe Weather Forecast Decision Aid output screen in MIDDS. The location of the Total Threat Score is surrounded by the white box.

Mr. Roeder of the 45 WS provided the Weak Waterspout checklist to the AMU, and Mr. Wheeler wrote MIDDS code to retrieve and compute the necessary values to migrate this checklist into MIDDS. The program automatically calculates most of the parameters on the checklist except one: it asks the forecaster to answer a question about the previous day's waterspout occurrences. Once all information is gathered, the checklist calculates and displays a weak waterspout threat score.

Testing

Once the code development was completed, Mr. Wheeler developed several ways to test the code. He developed an additional module of the code so all variables and weights would be listed to the screen. After running the code, he compared these output values to the sounding variables to make sure the calculations were done correctly. Also, the weighted values were compared with those on the original study worksheet to make sure the proper weights were applied. Both tests produced the expected values in all cases. Once initial testing was completed, Mr. Wheeler demonstrated the programs to 45 WS personnel. They offered several suggestions on formatting the questions asked and displaying of certain graphics. Mr. Wheeler incorporated these changes into the MIDDS programs. In the next Quarter, Mr. Wheeler will provide a briefing and training on the programs to the 45 WS.

For more information contact Mr. Wheeler at wheeler.mark@ensco.com or 321-853-8264.

MESOSCALE MODELING

WRF Wind Sensitivity Study at EAFB (Dr. Watson and Dr. Bauman)

Occasionally, the Shuttle must land at Edwards Air Force Base (EAFB) in Southern California when weather conditions at KSC violate the FR. However, the complex terrain in and around EAFB makes forecasting surface winds a challenge for SMG. In particular, wind "cycling cases", in which the wind speeds and directions oscillate among towers near the EAFB runway, present a challenging forecast problem for Shuttle landings. An accurate depiction of the winds along the runway is crucial in making the landing decision. Global and national scale models cannot properly resolve the wind field due to their coarse horizontal resolutions, so a properly tuned high-resolution mesoscale model is needed. The Weather Research and Forecasting (WRF) model meets this requirement. It has two dynamical cores and two options for initialization, as well as a number of different model parameterizations within each core. This provides SMG with a lot of flexibility as well as challenges. The goal of this task is to assess the different configurations available and determine which will best predict surface wind speed and direction at EAFB. Specifically, the AMU was tasked to 1) compare the model performance among different combinations of the dynamical cores and initializations, and 2) compare model performance while varying the physics options.

Subjective Analysis

Dr. Bauman completed the subjective analysis of the WRF forecasts for all candidate days. The goals of the subjective analysis were to determine

- If the model was able to predict the timing and/or magnitude of the wind cycling events at the concrete runway towers by comparing the observed wind speed to the forecast wind speed, and
- If the model could provide the forecasters with an indication of whether or not a wind cycling event was likely to occur by assessing the model forecasts on wind cycling days and null case days.

Using the Grid Analysis and Display System software, Dr. Watson extracted the model forecast winds from every model run at each grid point nearest to each of the three concrete runway towers for comparison. Dr. Bauman overlaid the forecast steady-state wind speed provided by Dr. Watson from each of the three model configurations on the observed steady-state wind speed at all three towers and for 42 wind cycling and 14 null case model runs.

An example of a cycling event at Tower 224 on 7 June 2008 is shown in Figure 11. The event began at 0200 UTC and indicates a wave-like behavior in the wind speed time series that ended at 1300 UTC (denoted by the blue shaded box). During this time there were six oscillations in wind speed indicated by a change of 3 to 6 ms^{-1}

(6 to 12 kt) approximately every 45 minutes. All of the model configurations correctly forecast the general trend of the wind speeds with the strongest occurring from 0000 to 0200 UTC, decreasing until 0800 UTC, then increasing again until the end of the cycling event. Only the Advanced Regional Prediction System (ARPS) Data Assimilation System (ADAS) Advanced Research WRF (ARW) configurations (Figure 11c) showed any indication of the wind speed cycling within the general trend. The ADAS ARW Mellor-Yamada-Janjic (MYJ) Eta configuration indicated four to five oscillations whereas the ADAS ARW Yonsei Fifth-Generation NCAR / Penn State Mesoscale Model (MM5) configuration indicated three oscillations within the event timeline. The MYJ Eta configuration also had larger magnitudes in the wind speed oscillation compared to the Yonsei MM5. This result was consistent for the other two towers for this event.

Objective Analysis

Dr. Watson completed the objective analysis and compared observed wind speed to forecast wind speed using the latest version of the Model Evaluation Tools (MET) software. Each statistic computed for this task compared the gridded WRF model data, available every 15 minutes, to the observations from the 12 wind towers at EAFB. In addition, the observed wind direction from the 12 wind towers was compared to forecast wind direction from the WRF model data. However, the MET software does not currently support objective analysis of wind direction. Therefore, the forecast wind direction was manually pulled from the model data and all statistics were computed using Microsoft Excel.

Of the many statistics available in MET, Dr. Watson looked at three for wind speed: the forecast vs. the observed mean, the mean error, and the Pearson Correlation Coefficient (PCC); and two for wind direction: the mean error and the PCC. The statistics compared data from all 12 towers combined to the corresponding locations in the model forecast. Towers indicating wind cycling were not separated from those that did not. Thus, the objective analysis does not indicate whether the wind cycling phenomena were captured, rather it only shows how well the model performed overall. The subjective analysis was used to determine if the model captured the wind cycling events. However, comparison of the null cases to the wind cycling cases may help to determine whether the model is adept at forecasting a mesoscale process, such as wind cycling.

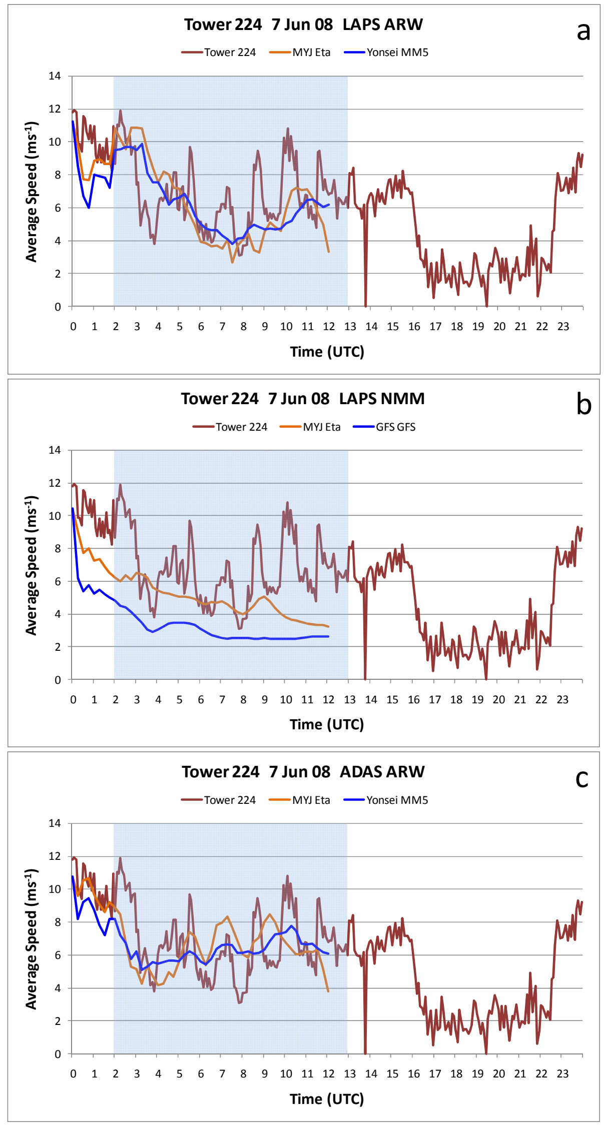


Figure 11. Graphs of a wind cycling case from Tower 224 on 7 June 2008. The observed steady-state wind speed is shown by the dark red line and the forecast steady-state wind speed is shown by the orange and blue lines representing various model configurations as identified by the graph legends. The light blue shaded box indicates the duration of the wind cycling event.

The mean forecast vs. observed wind speed comparison shows how well the forecast wind speed corresponded to the observed wind speed. The PCC ranges between -1 and 1; 1 indicates a perfect correlation, -1 indicates a perfect negative correlation, and 0 indicates no correlation between the forecast and observations. Specifically, the PCC for wind speed measures whether large values of forecast wind speed tend to be associated with large values of observed wind speed (positive correlation), whether small values of forecast wind speed tend to be associated with large values of observed wind speed or vice versa (negative correlation), or whether values of both variables are unrelated (correlation near 0). For wind direction, the PCC measures the rotation of the wind with a perfect positive correlation indicating that the winds are shifting in the same direction with the same magnitude and a perfect negative correlation indicating that the winds are shifting in opposite directions with the same magnitude.

All WRF model configurations under-predicted the wind speed throughout the forecasts for all wind cycling case days, except for 30/31 July 2008, which was the marginal wind cycling case day. Overall, no one model configuration was the best or worst performer for a majority of the cases. The mean error is a measure of the overall bias of the wind speed or direction. The discrepancies between model configurations for mean error of wind direction were smaller than for the wind speed, indicating that the model may have been better at forecasting wind direction than speed.

The PCC can indicate whether the model configurations caught the overall trend of the wind speed (Figure 12). That is, it answers the question of whether the model winds were in phase with the observed winds. When comparing forecast vs. observed wind speed, only positive coefficients indicate any value in the model forecasts. Figure 12 shows the PCC for wind speed from the 12-hour forecasts of all wind cycling and null cases simulated with the six model configurations. The most obvious feature is that on both 30 January 2008 and 4 June 2008 each model configuration did a poor job at capturing the trends in the observed winds. The best model forecast days were 4/5 March 2008 and 30/31 July 2008. Both days had correlation coefficients of 0.6 or above for all model configurations. The best performer for 4/5 March was the Local Analysis and Prediction System (LAPS) Non-hydrostatic Mesoscale Model (NMM)_MYJ and the LAPS-NMM_Global Forecast System (GFS) for 30/31 July; however, the bias for these two configurations was poor compared to the other configurations for the same day. This indicates that although the model forecast wind speeds were too low, the model configuration was able to capture the fluctuations in wind speed maximums and minimums. Disregarding the PCCs for the two worst days (30 January and 4 June 2008), the LAPS-ARW_Yonsei and LAPS-NMM_MYJ configurations performed consistently well.

For wind direction, the PCC can indicate whether the model configurations caught the overall shifts in wind direction (Figure 13). That is, it answers the question of whether the model wind direction was in phase with the observed wind direction. Figure 13 shows the PCC of wind direction for the 12-hour forecasts of all wind cycling and null cases from the six model configurations. Unlike the PCC for the wind speed forecasts, each model configuration did a poor job at capturing any of the trends in the observed directions on 30/31 July 2008. In fact, the average PCC for this day for all model configurations combined was 0, or no correlation. The model configurations did well capturing the shifts in wind direction for the rest of the wind cycling case days. Overall, the model was better able to capture shifts in wind direction for the wind cycling days than for the null cases. The best model forecast day was 7 June 2008, which had a correlation coefficient of 0.6 or above for all model configurations. As was found with the mean error calculations, there was no indication of one model configuration as the best or worst performer.

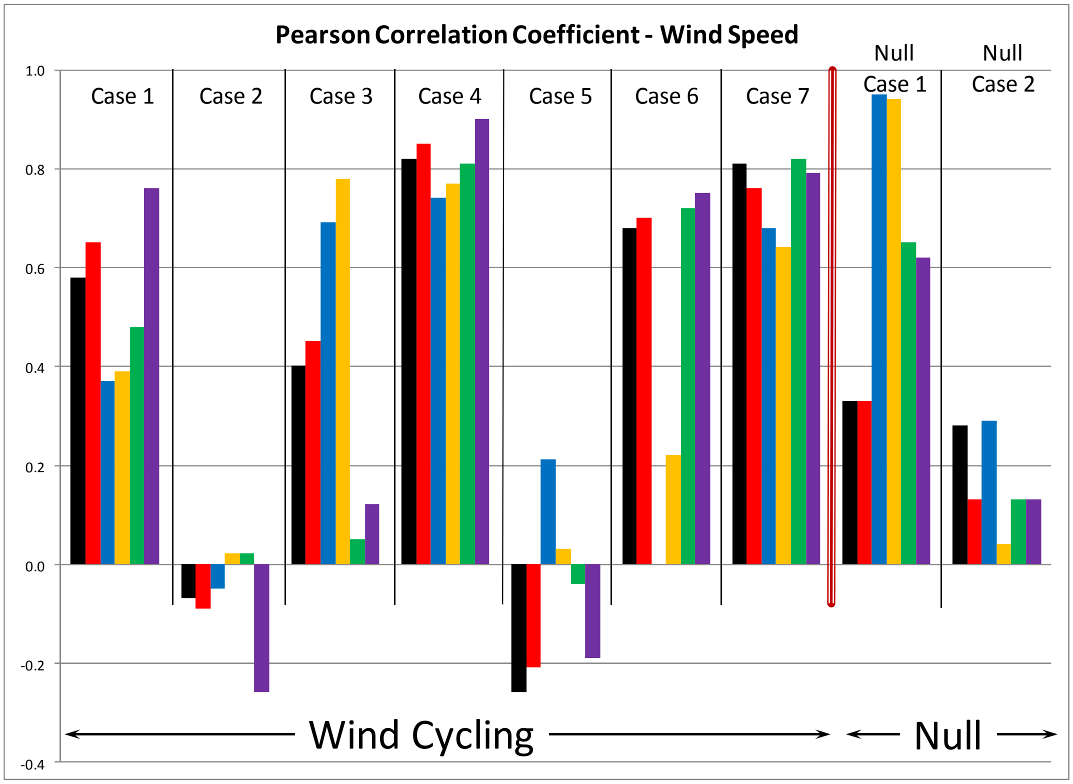


Figure 12. Chart showing the Pearson Correlation Coefficient for wind speed for the 12-hour forecasts for all wind cycling and null cases for the six model configurations.

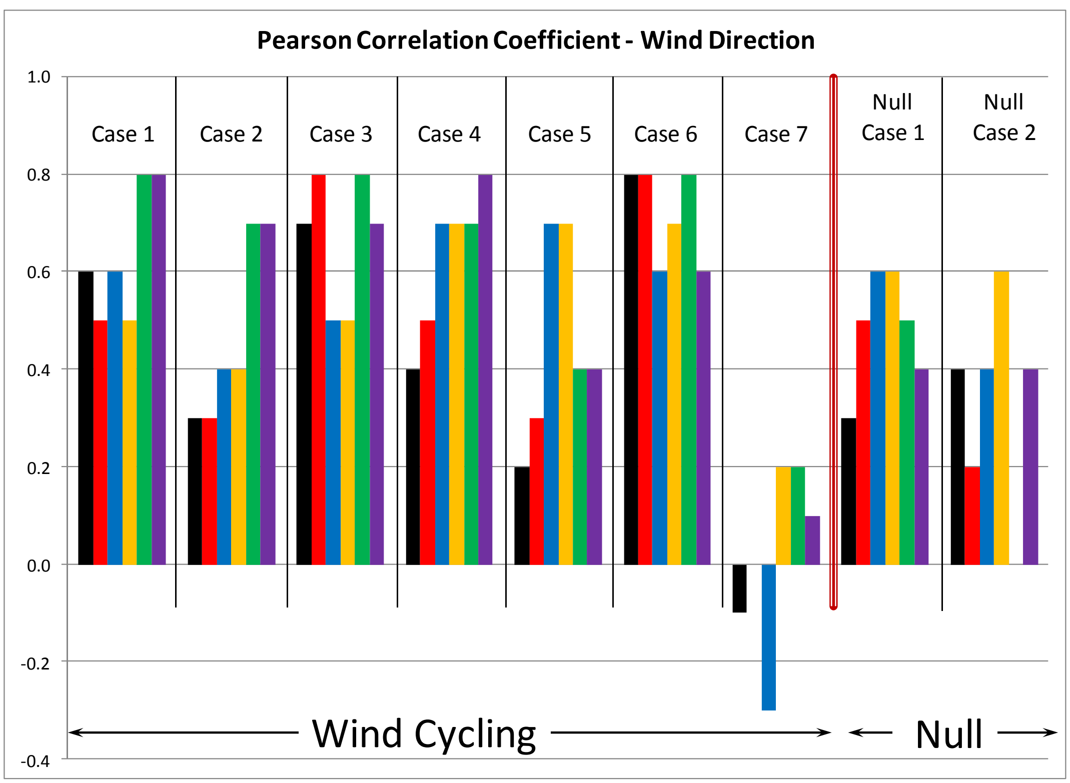


Figure 13. Chart showing the Pearson Correlation Coefficient for wind direction for the 12-hour forecasts for all wind cycling and null cases for the six model configurations

Results

The major results from the evaluation show the following:

- Subjective analysis,
  - Overall, the ARW runs outperformed the NMM runs.
  - Changing the model core seemed to have the biggest impact on the forecasts, while changing the model physics seemed to have the least impact.
  - Model configurations that used the MYJ PBL scheme seemed to slightly outperform other PBL schemes.
  - The model was able to differentiate between wind cycling days and null cases.
- Objective analysis,
  - Overall the ARW runs outperformed the NMM runs.
  - The NMM core was more successful in matching the increasing and decreasing trends in wind speed with the observations, but did a poor job at capturing the magnitude of the wind and consistently under-predicted wind speeds by the largest margin.
  - As was found in the subjective analysis, changing the model core seemed to have the biggest impact on the forecasts, while changing the model physics seemed to have the least impact.
  - It does not appear that the model did any better forecasting wind speeds for the null days vs. the wind cycling days.
  - Model configurations that used the MYJ PBL scheme seemed to slightly outperform other PBL schemes.

In both the subjective and objective analyses, the AMU found the ARW core and MYJ PBL scheme performed better than the other model configurations. The model did not produce a better wind forecast on null days vs. wind cycling days. The model was able to differentiate between wind cycling days and null cases, which would provide added value to the shuttle landing forecast.

Recommendations

Of the six model configurations tested, the AMU recommends either the ADAS ARW MYJ or LAPS ARW MYJ configuration for operational forecasting of wind cycling events at EAFB for the following reasons:

- Both configurations consistently had the lowest bias for wind speed compared to the other model configurations,
- Both configurations best captured wind speed oscillations when compared to the observed wind speeds at the concrete runway towers, and
- The NMM core produced wind speed forecasts well below those observed and did not capture the wind direction changes well on the cycling days.

Future Work

The goal of this work was to run different WRF model options, assess how well they could predict surface wind speed and direction at EAFB, and determine if one model configuration performed better than the others. While that goal was met, the data suggested further investigations outside the scope of this task that may lead to discoveries of why the winds cycle as they do and how that relates to model configuration and performance. Such studies could include sophisticated signal analysis and/or rotating the model coordinate system orthogonal or parallel to the prevailing wind flow, and comparing the observed and forecast wind speed cycles to direction cycles.

For more information contact Dr. Watson at watson.leela@ensco.com or 321-853-8264 or Dr. Bauman at bauman.bill@ensco.com or 321-853-8202.

HYSPLIT WRF/EMS Task (Mr. Dreher)

NWS MLB is responsible for providing support to county emergency managers across central Florida in the event of any incident involving the release of harmful chemicals, radiation, and smoke from fires and/or toxic plumes into the atmosphere. NWS MLB uses the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model to provide trajectory, concentration, and deposition guidance during such events. In addition, forecasters at SMG have expressed interest in using HYSPLIT to support airborne particle and anvil trajectory forecasts that may have situational implications during a Shuttle landing attempt. Currently, NWS MLB and SMG rely on a PC-based version of the HYSPLIT model that is difficult to run and manage in an operational environment. The first goal of this task is to install and configure a version of HYSPLIT on a Linux-based computer able to routinely ingest the

National Centers for Environmental Prediction (NCEP) model guidance such as output from the GFS, North American Model (NAM) and the Rapid Update Cycle (RUC). Since NWS MLB and SMG also run locally configured versions of the WRF model, the second goal of this task is to develop a software utility that converts WRF output into HYSPLIT format. This will allow forecasters to automatically provide trajectory and concentration guidance on a scheduled basis using either NCEP products or from a locally configured WRF model and, therefore, provide timely information on hazardous conditions to their customers.

HYSPLIT Model Description

The HYSPLIT model uses gridded meteorological data to compute trajectories, complex dispersion, and deposition simulations using either puff or particle approaches (Draxler 2007) at regular time intervals. The HYSPLIT model software is written mainly in Fortran with several modules in C code. A complete description of the model, code, and structure can be found in Draxler (1997, 2007).

HYSPLIT model dispersion of a pollutant is calculated by assuming either puff or particle dispersion. In the puff model, puffs expand until they exceed the size of a pre-defined meteorological grid cell and then split into several new puffs, each with a share of the pollutant mass. In the particle model, a fixed number of particles are moved by the mean horizontal and vertical wind field including a turbulent component. For default simulations, HYSPLIT assumes a puff distribution in the horizontal and particle dispersion in the vertical. This allows for greater accuracy of the vertical dispersion parameterization combined with the advantage of having an ever-expanding number of particles to represent the pollutant distribution. HYSPLIT trajectories are calculated by running the model without dispersion, thus computing the advection of a single pollutant particle within the mean wind. For both trajectory and concentration computations, the model can be run forward or backward in time in order to locate an unidentified pollutant source location.

The meteorological data fields required to run HYSPLIT can be obtained from archived data sources or forecast model output available from NCEP. Fortran preprocessors are required to convert the model output fields into HYSPLIT's own binary format. The HYSPLIT input data structure is a compressed binary direct-access format where multiple time-periods can be contained in each file for quick read access at model run time. Each time period contains a separate index record that includes grid definition, quality control flags, variable identification and vertical level information. The model can accept gridded meteorological data from multiple grid configurations including polar, global latitude/longitude such as in the GFS model, and Lambert conformal such as in the NAM model. The input meteorological data are interpolated to an internal sub-grid chosen by the user to reduce memory requirements and increase computational speed. In addition, HYSPIT calculations can be performed on nested multiple grids, usually specified from fine to coarse resolution, which allows users the flexibility of using their own locally configured model.

The model can be run interactively on the internet through the National Atmospheric and Oceanic Administration (NOAA) website (http://www.arl.noaa.gov/HYSPLIT.php) with appropriate permissions, or the source code can be downloaded and built on the user's own system. HYSPLIT contains a GUI for ease in setting up a trajectory, concentration, or deposition simulation. The GUI includes capabilities to download model input data from a defined File Transfer Protocol (FTP) server, convert the data to HSYPLIT binary format, run the trajectory or concentration model, and post-process the output graphically. The GUI is convenient for managing and configuring single use simulations; however NWS MLB forecasters require HYSPLIT simulations to be made on a regularly-scheduled basis, so they requested a Linux version that can be automated for real-time simulations.

HYSPLIT Linux Configuration

Mr. Dreher obtained the latest version of the HYSPLIT model from the developer, Dr. Roland Draxler of NOAA. This version of the model is flexible enough to either be run on the PC or built with a Fortran and/or C compiler for use on UNIX or Linux. Mr. Dreher originally configured the code on the AMU Linux cluster with the system default Portland Group Compiler. However, NWS MLB requested the code be compiled using the GNU compiler since many of their other software programs were built using that compiler. Therefore, Mr. Dreher obtained a pre-compiled version of the GNU Fortran compiler (http://gcc.gnu.org) to build the model and pre-processors on the AMU Linux cluster. After testing HYSPLIT on the AMU Linux cluster, he configured the model on the NWS MLB Linux system.

Mr. Dreher obtained and configured the gribmaster utility program from Dr. Robert Rozumalski at the NOAA NWS Science and Training Research Center. This program automatically downloads operational forecast products, including the GFS and NAM guidance, from the NCEP FTP servers. In addition, Mr. Dreher modified the gribmaster program to download GFS data already in the HYSPLIT binary format from the NOAA HYSPLIT FTP server. Downloading the GFS data already in HYSPLIT binary format alleviates the time and steps required to convert data from the NCEP gridded binary (GRIB) format.

Mr. Dreher configured several Linux cron job scripts to automatically download the NCEP NAM model products, convert the meteorological grids into HYSPLIT binary format, run the model from several pre-selected latitude/longitude sites, and post-process the data to create output graphics. Cron jobs enable users to execute commands or scripts automatically at specified times and dates. Mr. Dreher configured the HYSPLIT cron jobs to run four times per day using meteorological grids supplied by the NCEP GFS and NAM 12-km grids. Figure 14 shows an example of 10 different 24-h forecast HYSPLIT trajectories initialized in real-time by the NAM 12-km model. Figure 15 depicts an example of output from the HYSPLIT concentration model for a single source release of a “test” pollutant initialized in real-time by the NAM 12-km model. This guidance is similar to what will be output at the NWS MLB for their automated HYSPLIT system.

With the assistance of Mr. Blottman of NWS MLB, Mr. Dreher modified the gribmaster program to download NCEP NAM 12-km forecast tiles over Florida instead of the entire Continental United States. This will save NWS MLB download time along with significant space on their Linux system. The NAM 12-km grid is NWS MLB’s preferred forecast guidance for running the HYSPLIT model since it supplies them with better spatial resolution than the global GFS grids. At the request of NWS MLB, Mr. Dreher is currently investigating whether the NCEP RUC 13-km grid configuration can be converted into HYSPLIT format. The RUC is an operational model updated hourly that assimilates many types of observations, including surface and aircraft data, at a higher temporal resolution than the NAM and GFS models.

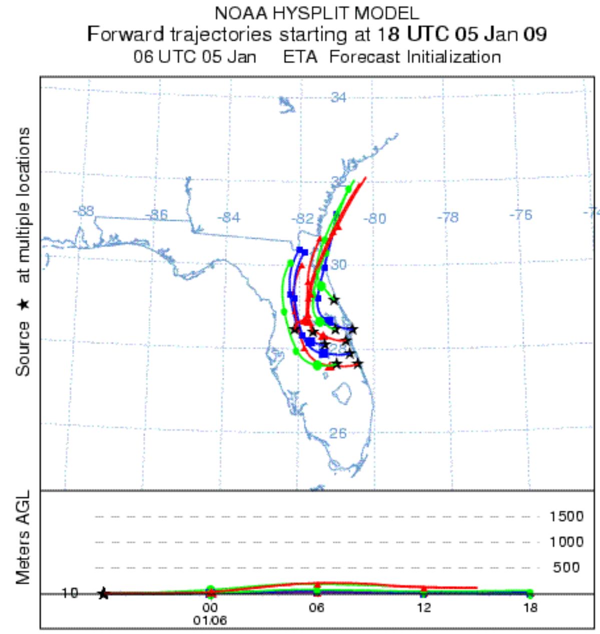


Figure 14. Example HYSPLIT output showing 24 h forecast trajectories from 10 different source locations within the NWS MLB forecast area. The HYSPLIT trajectories began at 0600 UTC 5 January 2009 and initialized using real-time NAM 12 km forecast data. The elevation in meters of each trajectory is shown on the bottom.

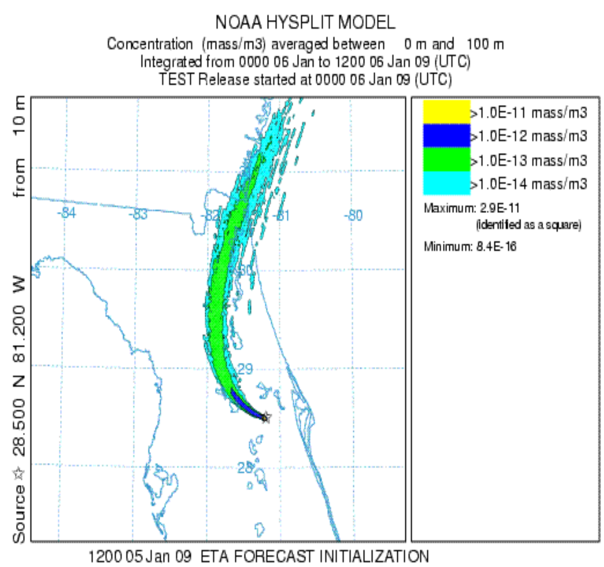


Figure 15. Example HYSPLIT concentration model output showing a “test” pollutant release of time integrated air concentrations from 0000 UTC through 1200 UTC 6 January 2009. HYSPLIT was initialized using real-time NAM 12 km forecast data. The pollutant mass units are shown on the top right.

HYSPLIT and WRF EMS

The HYSPLIT model normally relies on output from operational synoptic and mesoscale models provided by NCEP; however, recent modifications to the model have allowed users the flexibility of using their own data including guidance from locally configured WRF simulations. There are conversion utilities currently included within the HYSPLIT package that allow GRIB files from the GFS, NAM, and versions of MM5 to be converted into HYSPLIT format. In addition, recent source code was made available to convert ARW model output in NetCDF format to HYSPLIT format. Most of these conversion codes are specific to the model being run in terms of resolution, domain size, and output variables. However, NWS MLB is running the NMM version of the WRF within the Environmental Modeling System (EMS) software package. The EMS is a complete, full-physics, and numerical weather prediction package that incorporates dynamical cores from both the WRF-ARW and NCEP WRF-NMM models into a single end-to-end forecasting system. The EMS includes all the pre-compiled binaries necessary to run all pre- and post-processing programs as well as both dynamical cores of WRF. More details on the WRF EMS can be found at this URL: http://strc.comet.ucar.edu/wrf/index.htm. The HYSPLIT conversion program already developed for the WRF-ARW core could not be used as is to convert NWS MLB WRF output because of the different horizontal and vertical coordinate systems so modifications needed to be made to the NWS MLB EMS software.

Mr. Dreher modified the existing HYSPLIT Fortran code used to convert the NAM operational guidance to ingest WRF NMM output. The modifications included changing the horizontal and vertical grid structure within the code to match the grid configuration of the WRF EMS at NWS MLB. Mr. Dreher also modified the WRF EMS Perl scripts within the model post-processing (WRFPOST) program to write out meteorological variables on vertical model levels in addition to the normal pressure level output. The newly modified routine that converts the NAM model output into the HYSPLIT binary format required the variables on the native model coordinate system. He ran several HYSPLIT trajectory forecasts using WRF EMS model output obtained from the NWS MLB. Mr. Dreher also began discussions with Dr. Rozumalski, developer of the WRF EMS, about how to make HYSPLIT compatible with the WRF EMS. Mr. Dreher will soon configure the modified HYSPLIT conversion program on the NWS MLB Linux system and make the necessary changes to their WRF EMS software.

Status

Mr. Dreher completed installing the HYSPLIT model on the NWS MLB Linux system. He configured the model to ingest several NCEP forecast products including output from the GFS and NAM models. He is currently investigating whether HYSPLIT can ingest meteorological grids from the RUC model. Mr. Dreher is also working with Mr. Blottman of NWS MLB to test these procedures in real-time.

Mr. Dreher modified an existing software utility to convert the output from the local WRF EMS model into HYSPLIT format. He tested the utility to ensure it functioned properly by creating several HYSPLIT trajectories using WRF EMS output obtained from the NWS MLB. He will install and test the new software on the NWS MLB Linux system in the near future.

SMG forecasters have also expressed interest in a Linux configuration of HYSPLIT that integrates output from their own locally-configured WRF EMS. They currently use the WRF-ARW model core in operations. A HYSPLIT version that supports SMG forecasters for Space Shuttle landing attempts during scenarios involving low-altitude smoke and high-altitude anvil clouds from thunderstorms is needed. Mr. Dreher will work with SMG to assess the availability of a Linux HYSPLIT version that ingests their local WRF configurations.

For more information contact Mr. Dreher at dreher.joe@ensco.com or 321-853-8105.

AMU CHIEF'S TECHNICAL ACTIVITIES (Dr. Merceret)

Dr. Merceret submitted a manuscript to the National Weather Digest describing the hurricane gust factor tool. He received comments from reviewers, which he addressed in a revision to the manuscript. He will re-submit the manuscript to the Digest in January.

In other work, Dr. Merceret also advised the Constellation program on weather instrumentation for the new LC-39 lightning protection towers.

AMU OPERATIONS

IT

The AMU switched the computer antivirus software on the Windows-based PCs from AVG to Norton Antivirus 2009.

Conferences and Meetings

Dr. Bauman, Ms. Crawford, and Mr. Barrett attended the National Weather Association 33rd Annual Meeting in Louisville, KY. They presented the following:

- Dr. Bauman presented a poster titled "Performance of a Local Mesoscale Model with Data Denial" he co-authored with Dr. Watson,
- Mr. Barrett presented a poster titled "Displaying Composite and Archived Soundings in the Advanced Weather Interactive Processing System", and
- Ms. Crawford gave an oral presentation titled "Developing a Peak Wind Probability Forecast Tool for Kennedy Space Center and Cape Canaveral Air Force Station".

Three AMU team members prepared material to be presented at conferences during the 89th Annual American Meteorological Society meeting to be held 11-15 January 2009 in Phoenix, AZ:

- Mr Dreher prepared a manuscript titled "Statistical Short-Range Guidance for Peak Wind Speeds at Edwards Air Force Base, CA" for the 25th Conference on International Interactive Information and Processing Systems (IIPS) for Meteorology, Oceanography, and Hydrology. He also completed slides for an oral presentation. His co-authors are Ms. Crawford, Mr. Lafosse and Mr. Hoeth of SMG, and Dr. Burns of MSFC.
- Dr. Bauman completed two manuscripts for the 13th Symposium on Integrated Observing and Assimilation Systems for the Atmosphere, Oceans, and Land Surface (IOAS-AOLS). The first manuscript, co-authored with Dr. Watson, is titled "Observation Denial and Performance of a Local Mesoscale Model". The second manuscript, co-authored with Dr. Watson and Mr. Hoeth of SMG, is titled "Weather Research and Forecasting Model Wind Sensitivity Study at Edwards Air Force Base, CA". Dr. Bauman also completed briefing slides for both manuscripts.
- Mr. Barrett completed a manuscript and poster for the 25th Conference on IIPS for Meteorology, Oceanography, and Hydrology, co-authored with Ms. Hood of SMG, titled "Anvil Forecast Tool in the Advanced Weather Interactive Processing System".

General

Dr. Watson began maternity leave on October 27 and will return to the AMU in late Jan 2009. Mr Wheeler began working at the AMU in November. He will be in the AMU until late Jan 2009 when Dr. Watson returns. He is working on the Severe Weather and Weak Waterspouts Checklists in MIDDS task.

Dr. Bauman supported the launch of STS-126 on 14 November.

REFERENCES

Barrett, J. H. and D. A. Short, 2008: Peak Wind Tool for General Forecasting Final Report. NASA Contractor Report CR-2008-214743, Kennedy Space Center, FL, 59 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931 and http://science.ksc.nasa.gov/amu/final.html]

Bauman, W., M. Wheeler and D. Short, 2005: Severe Weather Forecast Decision Aid: Final Report. NASA Contractor Report CR-2005-212563, Kennedy Space Center, FL, 50 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL, 32931.]

Draxler, R.R., 2007, HYSPLIT 4 User's Guide, NOAA Technical Memorandum [Available from http://www.arl.noaa.gov/HYSPLIT.php.]

Draxler, R.R., and G.D. Hess, 1997, Description of the HYSPLIT 4 modeling system, NOAA Technical Memorandum ERL ARL-224, December, 24p.

Lambert, W., 2002: Statistical Short-Range Guidance for Peak Wind Speed Forecasts on Kennedy Space Center/Cape Canaveral Air Force Station: Phase I Results. NASA Contractor Report CR-2002-211180, Kennedy Space Center, FL, 39 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931 and http://science.ksc.nasa.gov/amu/final.html.]

Lambert, W., 2003: Extended Statistical Short-Range Guidance for Peak Wind Speed Analyses at the Shuttle Landing Facility: Phase II Results. NASA Contractor Report CR-2003-211188, Kennedy Space Center, FL, 27 pp. [Available from ENSCO, Inc., 1980 N. Atlantic Ave., Suite 230, Cocoa Beach, FL 32931 and

http://science.ksc.nasa.gov/amu/final.html.]

Lambert, W., D. Sharp, S. Spratt, and M. Volkmer, 2006: Using cloud-to-ground climatologies to initialize gridded lightning threat forecasts for East Central Florida. Preprints, *Second Conf. on Meteorological Applications of Lightning Data*. Atlanta, GA, Amer. Meteor. Soc., 4 pp.

Merceret, F. J., M. McAleenan, T. M. McNamara, J. W. Weems, and W. P. Roeder, 2006: Implementing the VAHIRR Launch Commit Criteria Using Existing Radar Products. Preprints, *12th Conf. on Aviation, Range and Aerospace Meteorology*, Atlanta, GA, Amer. Meteor. Soc., 8 pp. [Available online at: http://ams.confex.com/ams/pdfpapers/98076.pdf]

LIST OF ACRONYMS

14 WS	14th Weather Squadron
30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
ABFM	Airborne Field Mill Program
ADAS	ARPS Data Analysis System
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMPS	Automated Meteorological Profiling System
AMS	American Meteorological Society
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
ARW	Advanced Research WRF
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground
CGLSS	CG Lightning Surveillance System
CSR	Computer Sciences Raytheon
EAFB	Edwards Air Force Base, CA
EMS	Environmental Modeling System
FR	Flight Rules
FSU	Florida State University
FTP	File Transfer Protocol
FY	Fiscal Year
GFS	Global Forecast System
GSD	Global Systems Division
GUI	Graphical User Interface
HYSPLIT	Hybrid Single-Particle Lagrangian Integrated Trajectory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAPS	Local Analysis and Prediction System
LCC	Launch Commit Criteria
LLCC	Lightning LCC
MAE	Mean Absolute Error
McIDAS	Man-computer Interactive Data Analysis System
McBASI	McIDAS BASIC
MET	Model Evaluation Tools
MIDDS	Meteorological Interactive Data Display System
MM5	Penn State/NCAR Mesoscale Model V5
MSFC	Marshall Space Flight Center
MSL	Mean Sea Level
MYJ	Mellor-Yamada-Janjic
NAM	North American Model
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NLDN	National Lightning Detection Network
NM	Nautical Miles
NMM	Non-hydrostatic Mesoscale Model
NOAA	National Oceanic and Atmospheric Administration
NWS	National Weather Service
PC	Personal Computer
PCC	Pearson Correlation Coefficient
POR	Period of Record
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SPoRT	Short-term Prediction Research and Transition
TTS	Shuttle Landing Facility 3-letter Identifier
USAF	United States Air Force
UTC	Universal Coordinated Time
VAHIRR	Volume Averaged Height Integrated Radar Reflectivity
WRF	Weather Research and Forecasting Model
WR	Western Range
WSR-88D	Weather Surveillance Radar 1988 Doppler
XMR	CCAFS Sounding 3-letter Identifier

Appendix A

AMU Project Schedule
31 January 2009

AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Peak Wind Tool for User LCC Phase II	Collect and QC wind tower data for specified LCC towers, input to S-PLUS for analysis	Jul 07	Sep 07 (*Nov 07*)	Delayed due to need for manual QC
	Stratify mean and peak winds by hour and direction, calculate statistics	Sep 07	Oct 07 (*Nov 07*)	Delayed as above
	Stratify peak speed by month and mean speed, determine parametric distribution for peak	Oct 07	Nov 07	Completed
	Create distributions for 2-hour prognostic peak probabilities, and develop GUI to show climatologies, diagnostic and 2-hour peak speed probabilities	Nov 07	Oct 08	Delayed due to need to re-run scripts for some sensors
	Create distributions for 4-hour prognostic peak probabilities and incorporate into GUI	Oct 08	Jan 09	On Schedule
	Create distributions for 8-hour prognostic peak probabilities and incorporate into GUI	Jan 09	Apr 09	On Schedule
	Create distributions for 12-hour prognostic peak probabilities and incorporate into GUI	Apr 09	Jul 09	On Schedule
	Final report	Jul 09	Sep 09	On Schedule
EAFB Statistical Guidance Wind Tool	Acquire, examine, and format data obtained from MSFC into Excel	May 08	May 08	Completed
	Create Excel PivotTables and modify PC-based GUI code	May 08	Sep 08	Completed
	Test PC-based GUI	Sep 08	Sep 08	Completed
	Final Report	Oct 08	Nov 08	Completed

AMU Project Schedule 31 January 2009				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Peak Wind Tool for General Forecasting - Phase II	Collect wind tower data, CCAFS soundings, and SLF observations	Sep 08	Sep 08	Completed
	Interpolate 1000-ft sounding data to 100-ft increments for October 1996 to April 2008. Compare interpolated data to 100-ft sounding data for October 2002 to April 2008.	Sep 08	Oct 08 (*Nov 08*)	Completed
	QC SLF observations	Oct 08	Nov 08	Completed
	QC wind tower data	Nov 08	Jan 09	On Schedule
	Create prediction equations for peak winds	Feb 09	Apr 09	On Schedule
	Create and test Excel GUI application	May 09	Jun 09	On Schedule
	Compare Phase I and II tools using 2 cool-seasons of 45 WS-issued wind warnings/advisories	Jul 09	Aug 09	On Schedule
	Compare Phase I and II tools to either MOS or model forecast winds	Sep 09	Oct 09	On Schedule
	Compare Phase I and II tools to wind tower climatology from AMU's Peak Wind for User LCC task	Nov 09	Dec 09	On Schedule
	Transition tool to MIDDS to provide 5-day peak wind forecasts, using model data	Jan 10	Jun 10	On Schedule
	Final Report and training	Jul 10	Sep 10	On Schedule
Situational Lightning Climatologies for Central Florida: Phase IV	Develop and run scripts in S-Plus to create lightning data files broken down by time period, distance from location and flow regime	Jan 09	Feb 09	On Schedule
	Develop HTML GUI	Mar 09	Apr 09	On Schedule
	Write Final Report	Apr 09	May 09	On Schedule
VAHIRR Cost-Benefit Analysis	Identify Potential Cases and Acquire Data	Jun 08	Jul 08	Completed
	Calculate VAHIRR for Cases	Jul 08	Aug 08	Completed
	Compile and Analyze Results	Aug 08	Sep 08	Completed
	Final Report	Sep 08	Oct 08	Completed

AMU Project Schedule 31 January 2009				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date (*New End Date*)	Notes/Status
Severe Weather and Weak Waterspouts Checklists in MIDDS	Develop MIDDS utilities to extract sounding parameters	Nov 08	Dec 08	Completed
	Transfer functionality of question-and-answer decision aids into MIDDS code	Dec 08	Jan 09	Completed
	Weak Waterspout Checklist	Dec 08	Jan 09	On Schedule
	Final Report and Training	Jan 09	Jan 09	On schedule
WRF Wind Sensitivity Study at Edwards AFB (EAFB)	Identify wind cycling cases at EAFB and archive data	Jan 08	Jun 08	Completed
	Compare multiple model configurations and physical parameterization settings to predict wind speed and direction at EAFB	Mar 08	Nov 08	On Schedule
	Final report and recommendations	Nov 08	Dec 08	On Schedule
HYSPLIT/WRF-EMS	Acquire and configure HYSPLIT on NWS MLB Linux machine	Oct 08	Dec 08	Completed
	Configure HYSPLIT to ingest NCEP model products	Oct 08	Dec 08	Completed
	Develop utility to convert WRF EMS output into HYSPLIT	Oct 08	Jan 09	On Schedule
	Final report and training	Feb 09	Apr 09	On Schedule

NOTICE