Applied Meteorology Unit (AMU) Quarterly Report

30 September 2011 Fourth Quarter FY-11 Contract NNK06MA70C

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Peak Wind Tool for User LCC, Phase IV

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MesoNAM Verification, Phase II

STS-135: The final launch of the Space Shuttle Program, Shuttle Atlantis lifts off on 8 July 2011 11:29 EDT (http://mediaarchive.ksc.nasa.gov/detail.cfm?mediaid=54505)

Launch Support

Dr. Bauman, Dr. Merceret and Dr. Huddleston supported the final launch of Shuttle Atlantis on 8 July.

Dr. Bauman and Ms. Wilson supported the Delta IV launch on 16 July.

Ms. Crawford and Dr. Merceret supported the Atlas V launch on 5 August.

Mr. Wheeler and Dr. Huddleston supported the Delta II launch on 10 September.

This Quarter's Highlights

The AMU Team completed work on all their tasks:

- Dr. Watson completed the second phase of verifying the performance of the MesoNAM weather model at Kennedy Space Center (KSC) and Cape Canaveral Air Force Station (CCAFS). She delivered the data to the 45th Weather Squadron (45 WS) and distributed the final report .
- Dr. Bauman completed modifying and updating lightning climatologies for KSC/CCAFS and other airfields around central Florida. He delivered the tool to the National Weather Service in Melbourne and 45 WS and distributed the final report
- Ms. Crawford completed modifying the AMU peak wind tool by analyzing wind tower data to determine peak wind behavior during times of onshore and offshore flow. She delivered the tool to the 45 WS and distributed the final report.
- All of the above reports are available on the AMU website: http://science.ksc.nasa.gov/amu/

The AMU Team was busy preparing for the end of the AMU contract on 30 September. The AMU functions will continue under a six-month contract extension through 31 March 2012.

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

Quarterly Task Summaries

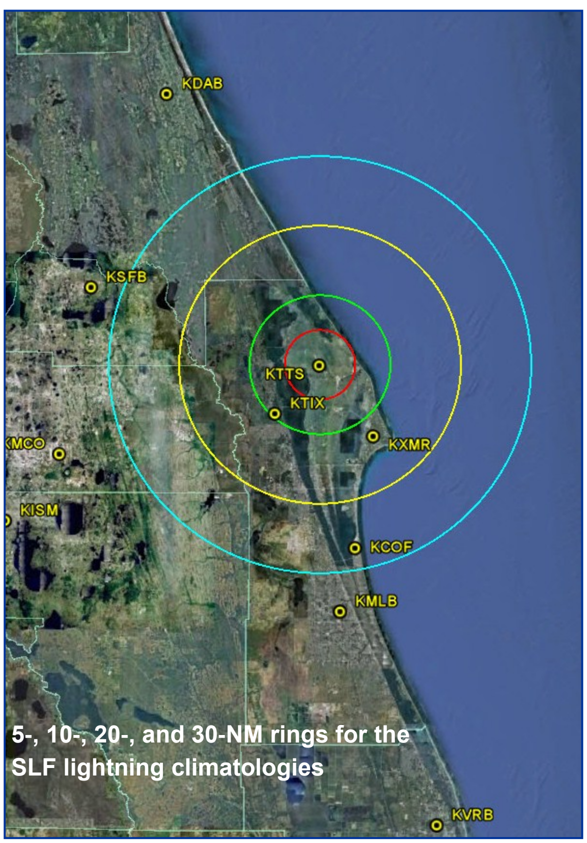
This section contains summaries of the AMU activities for the fourth quarter of Fiscal Year 2011 (July-September 2011). The accomplishments on each task are described in more detail in the body of the report starting on the page number next to the task name.

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

Purpose: Recalculate the Phase III cool season peak wind statistics using onshore and offshore flow as an added stratification. Peak winds are an important forecast element for launch vehicles, but the 45th Weather Squadron (45 WS) indicates that they are challenging to forecast. The forecasters have noticed a difference in behavior of tower winds between onshore and offshore flow. Recalculating the statistics after stratifying by these flows could make them more robust and useful to operations.

Accomplished: Created the 2- and 4-hour prognostic peak wind speed probabilities for onshore and offshore flow. The graphical user interface (GUI) was modified to display the new statistics and delivered to the 45 WS for testing. The final report was completed and distributed.

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



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

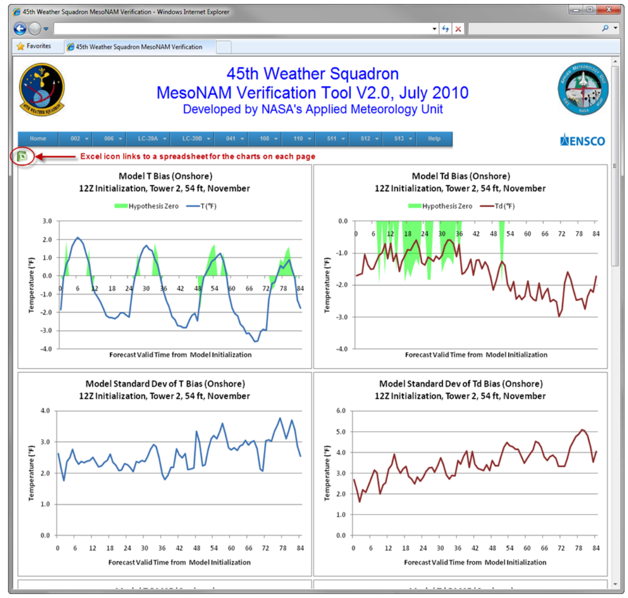
Purpose: Update the existing lightning climatology to improve operational weather support to Kennedy Space Center (KSC), Cape Canaveral Air Force Station (CCAFS), Patrick Air Force Base (PAFB), and commercial and general aviation across central Florida. The update includes adding more years of data to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

Accomplished: Completed the precipitable water (PWAT) stratification lightning climatologies for two additional backup sites as requested by the NWS and updated the GUI. Merged the Thompson Index (TI) stability parameter stratification with the PWAT stratified climatologies, completed the new GUI and finished the final report.

MesoNAM Verification Phase II
(Page 7)

Purpose: Update the current tool that provides objective verification statistics of the 12-km North American Mesoscale (NAM) model (MesoNAM) for CCAFS and KSC. This tool helps the Launch Weather Officers understand the model's performance when they use it to evaluate launch commit criteria (LCC) during launch operations. The modifications include adding a year of observations and model output data to the original database. The objective analysis consists of comparing the MesoNAM forecast winds, temperature and moisture to the observed values at the KSC/CCAFS wind towers used to evaluate LCC.

Accomplished: Updated the AMU-developed MesoNAM Verification Tool with statistics calculated after adding 15 months of new data to the period of record. The updated tool has the same structure as the original tool with an easy to use multi-level drop-down menu. The final report was written, distributed, and made available on the AMU website.



AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

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

SHORT-TERM FORECAST IMPROVEMENT

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

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

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

Prognostic Probabilities

Ms. Crawford modified the scripts used in Phase III to calculate the probabilities for onshore and offshore flow. Using the 2-hour onshore flow probabilities as an example, the modified algorithm checked to make sure that the onshore probabilities were created from only onshore data within the correct time periods. The result is that the onshore prognostic probabilities were created with only onshore values and the offshore probabilities created with only offshore values within the appropriate time periods.

Graphical User Interface

Ms. Crawford modified the GUI to access the new onshore/offshore stratifications for the hourly climatologies, diagnostic probabilities, and prognostic probabilities. Figure 2 shows the initial form of the GUI. It has two tabs, one for the climatologies (Figure 2a) and the other for the probabilities (Figure 2b). On both tabs, the user chooses the tower,

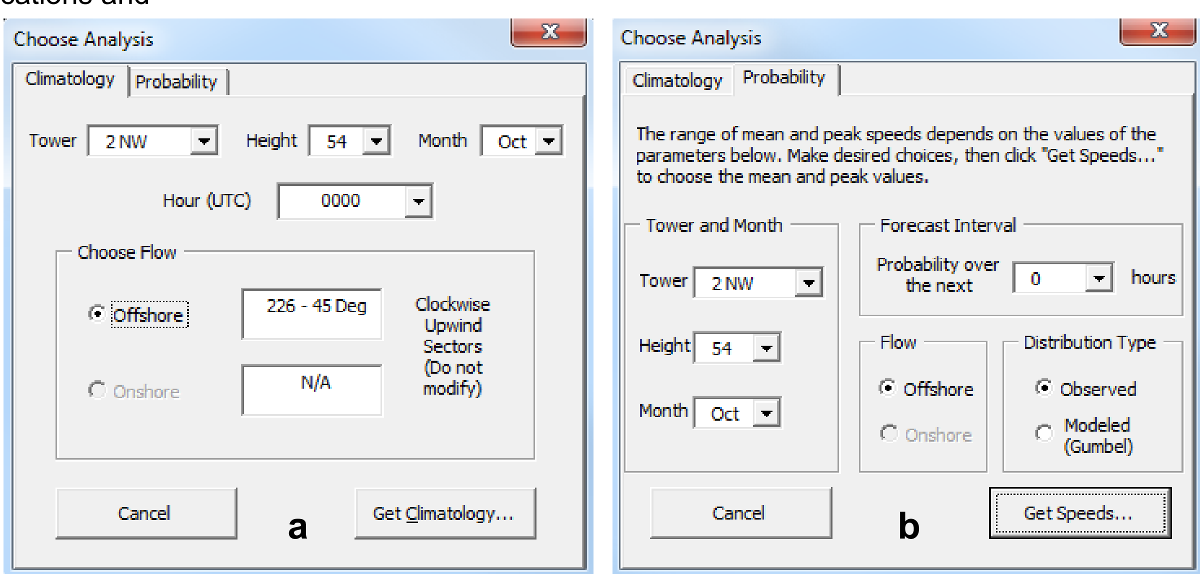


Figure 2. The Climatology a) and Probability b) tabs in the initial GUI form.

sensor height, month, and flow regime of interest. The tower must be chosen before the height because the choice of heights in the drop-down list is limited to the heights on the tower displayed in the "Tower" text box. The option button choice for onshore flow in both tabs is grayed out for the Tower 2 northwest sensors since onshore statistics were not calculated for this side. The same is true for offshore flow when the southeast side of Tower 2 is chosen. The boxes to the right of the Offshore and Onshore buttons in the Choose Flow box show the upwind sector for each flow pattern. This value cannot be changed.

Figure 3 shows the final output forms from the choices made in Figure 2a and b. Intervening steps after choosing the Probability tab (not shown) allow the user to choose the mean speed and the peak speed of interest for the probability. The output forms show all the choices made by the user to get the final values.

Final Report

Ms. Crawford wrote the final report and, after internal AMU and external customer reviews, acquired NASA approval and made the report available on the AMU website at http://science.ksc.nasa.gov/amu/.

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

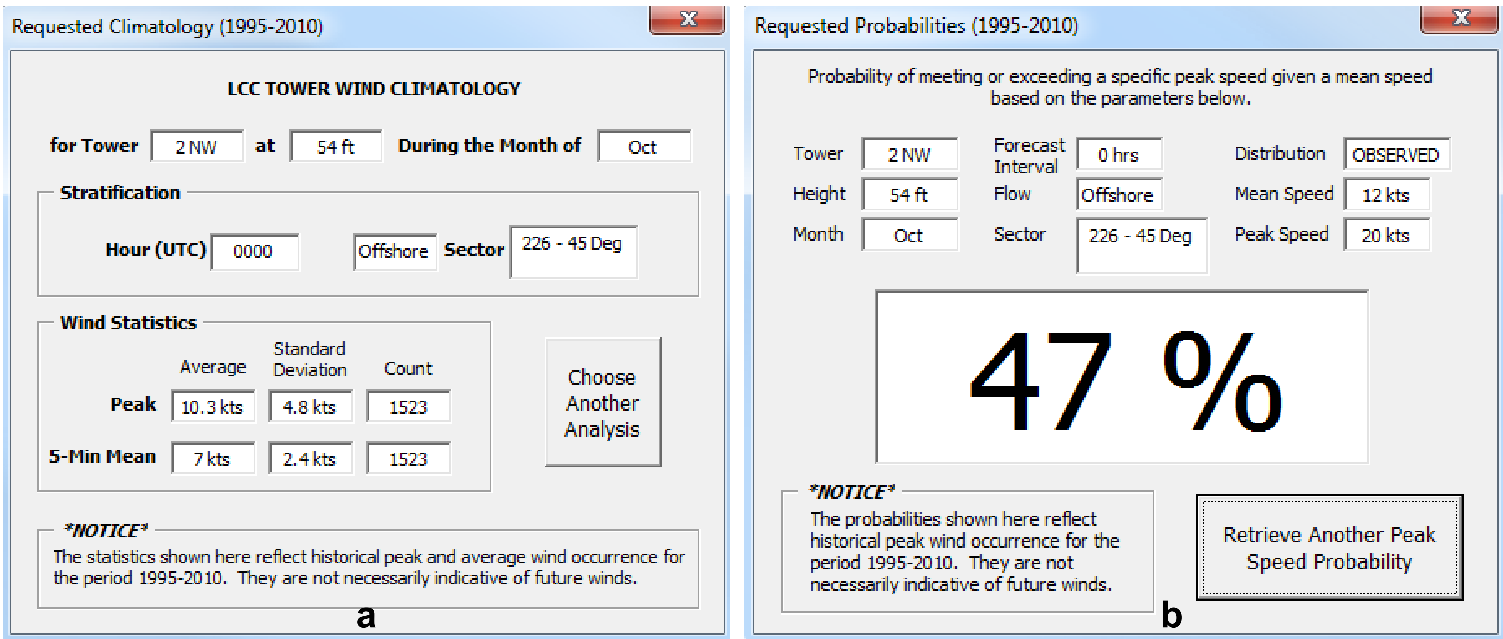


Figure 3. The final output forms for the a) Climatology tab with the choices shown in Figure 2a and b) Probability tab with the choices shown in Figure 2b.

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

The threat of lightning is a daily concern during the warm season in Florida. Research has revealed distinct spatial and temporal distributions of lightning occurrence that are strongly influenced by large-scale atmospheric flow regimes. The 45 WS, SMG and National Weather Service in Melbourne, Fla. (NWS MLB) have the responsibility of issuing weather forecasts for airfields located in central Florida. SMG and 45 WS share forecasting responsibility for the SLF depending on the mission. The 45 WS has forecasting responsibility for the CCAFS Skid Strip and Patrick Air Force Base (PAFB) while the NWS MLB is responsible for issuing terminal aerodrome forecasts (TAF) for airports throughout central Florida. In the previous phase (Bauman 2009), Dr. Bauman calculated lightning climatologies for the Shuttle Landing Facility (SLF) and eight other airfields in central Florida based on a 19-year record of cloud-to-ground lightning data from the National Lightning Detection Network (NLDN) for the warm season months of May through September (1989-2007). The climatologies included the probability of lightning at 5-, 10-, 20- and 30-NM distances from the center point of the runway at each site. The climatologies were stratified by flow regimes with probabilities depicted at 1-, 3-, and 6-hour intervals. This phase updates the previous work by adding 14 sites to the 9-site database including the CCAFS Skid Strip, PAFB and 12 commercial airports. It also adds three years of NLDN data resulting in a 22-year period of record (POR) for the warm season months from 1989-2010. In addition to the flow regime stratification, moisture and stability stratifications were added to separate more active from less active lighting days within the same flow regime.

Two New Sites

Dr. Bauman added the Lakeland (LAL) and Punta Gorda (PGD) airports (Figure 4) to the precipitable water (PWAT) stratification lightning climatology as requested by NWS MLB (see AMU Quarterly Report, Q3

FY11). He updated the GUI and made it available for NWS MLB to download via the AMU web site.

Stability Stratification

Dr. Bauman asked NWS MLB to review data for a test site, COF (PAFB), with the addition of the Thompson Index (TI) stratification to ensure the reduced sample size did not impact the operational utility of the tool. Upon verification that the sample size was sufficient, Dr. Bauman created the lightning climatologies by adding the TI stratification to the existing dataset for the 36 sites requested by the AMU customers. Figure 4 shows the 36 sites and their locations within each NWS weather forecast office (WFO) area of responsibility. There are six sites in the NWS Jacksonville region, eight sites within the NWS Tampa region, seven sites within the NWS Miami region and fifteen sites within the NWS MLB region. Within the NWS MLB region, the 45 WS and SMG share forecasting responsibility for TTS (SLF) and the 45 WS has forecasting responsibility for XMR (CCAFS) and COF.

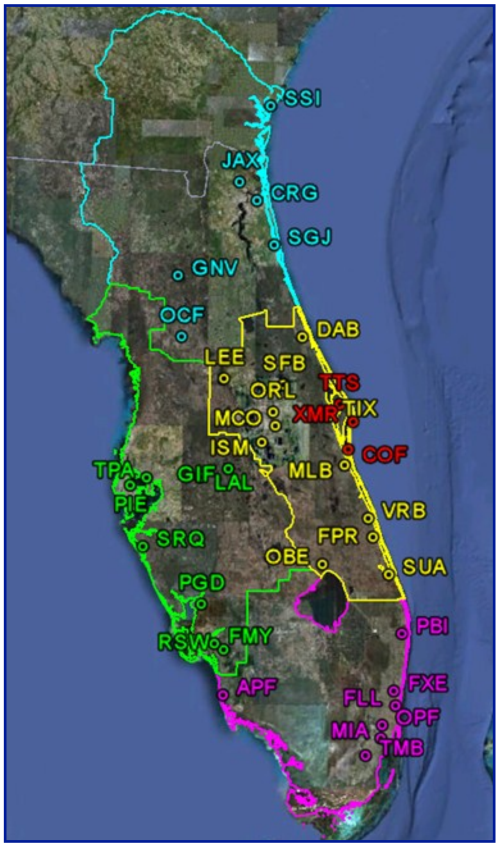


Figure 4. Map of Florida showing the locations of the 36 sites within each of the four NWS WFO regions included in this lightning climatology. From north to south, NWS Jacksonville (cyan), NWS Tampa (green), NWS MLB (yellow) and MWS Miami (magenta). The 45 WS and SMG sites located within the NWS MLB region are shown in red.

The TI threshold values were adopted from previous AMU work on the objective lightning tool (Lambert 2007) and the severe weather forecast tool (Bauman et al. 2005 and Watson 2011). These tasks revealed that TI was one of the best indicators of lightning occurrence and reported severe weather events during the warm season months. The 45 WS has also found TI to be one of the best thunderstorm predictors. However, the climatological TI stratification thresholds were not determined for each month like the PWAT values. Therefore, the TI thresholds were representative of the entire warm season based on the XMR sounding. The thresholds were adopted from the TI values in the severe weather forecast tool. The POR for the TI values was the warm season months from 1989-2010. The TI stratification thresholds were:

- Low: TI < 25
- Average: 25 ≤ TI ≥ 34
- High: TI > 35

Updated GUI

Dr. Bauman updated the GUI by adding the statistics calculated using the TI stratification. The only significant change to the GUI can be seen in the drop-down menu bar (Figure 5) and data bar (Figure 6). The TI stratification necessitated another drop-down menu highlighted in Figure 5 by the red ellipse. This allows the user to choose a low, average or high TI for the site of interest. Directly below the menu bar, the data bar (Figure 6) shows the user a summary of the selected stratifications. The TI range, highlighted by the red ellipse, was added to the data bar for the TI stratification.

Final Report

Dr. Bauman completed the final report and, after acquiring NASA approval, made the report available on the AMU website at http://science.ksc.nasa.gov/amu/.

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

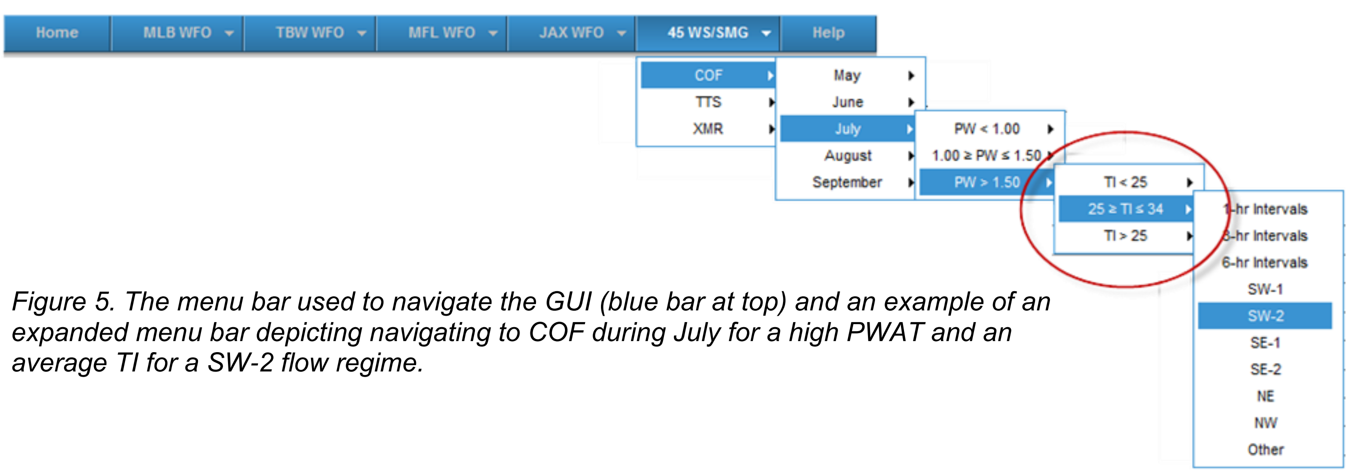


Figure 5. The menu bar used to navigate the GUI (blue bar at top) and an example of an expanded menu bar depicting navigating to COF during July for a high PWAT and an average TI for a SW-2 flow regime.

Figure 6. The data bar is located below the menu bar in the GUI and it shows (from left to right) the site, sounding location, month, PWAT range, TI range, time interval, flow regime and POR for the data.

MESOSCALE MODELING

MesoNAM Verification Phase II (Dr. Watson)

The 45 WS LWOs use the 12-km resolution North American Mesoscale (NAM) model (MesoNAM) text and graphical product forecasts extensively to support launch weather operations. In Phase I of this task (Bauman 2010), the AMU measured the actual performance of the model objectively by conducting a detailed statistical analysis of model output compared to observed values. The model products included hourly forecasts from 0 to 84 hours based on model initialization times of 00, 06, 12 and 18 UTC. The objective analysis compared 3.5 years of MesoNAM forecast winds, temperature and dew point, as well as the changes in these parameters over time, to the observed values from the sensors in the KSC/CCAFS wind tower network. For this task, the 45 WS requested the AMU modify the current tool by adding an additional year of model output to the database and recalculating the verification statistics. The AMU will also update the GUI with the new statistics. This tool helps the LWOs understand the model's performance when they use it to evaluate LCC during launch operations.

GUI Update

Dr. Watson updated the AMU-developed MesoNAM Verification Tool, a Hypertext Markup Language (HTML) GUI, with the statistics calculated after adding 15 months to the POR. The tool retains the same structure with a multi-level drop-down menu written in JavaScript embedded within the HTML code. The main page of the GUI is shown in Figure 7. The title at the top of the page defines the name, version, and date of the tool. The navigation menu allows the user to choose data by placing their mouse pointer over the desired tower/site to display a drop-down menu. Locations of the wind towers, MesoNAM model grid points, the CCAFS weather station (KXMR) and the MesoNAM land/sea mask are shown on the main page of the GUI. The updated GUI contains the charts showing the model bias, standard deviation of bias, and root mean square error of temperature, dew-point temperature, wind speed and wind direction for all towers, heights, months, initialization time, and stratifications for the entire POR (September 2006-April 2011).

Final Report

Dr. Watson completed the final report, delivered it to the customers, and, after obtaining NASA approval, made it available on the AMU website at http://science.ksc.nasa.gov/amu/.

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

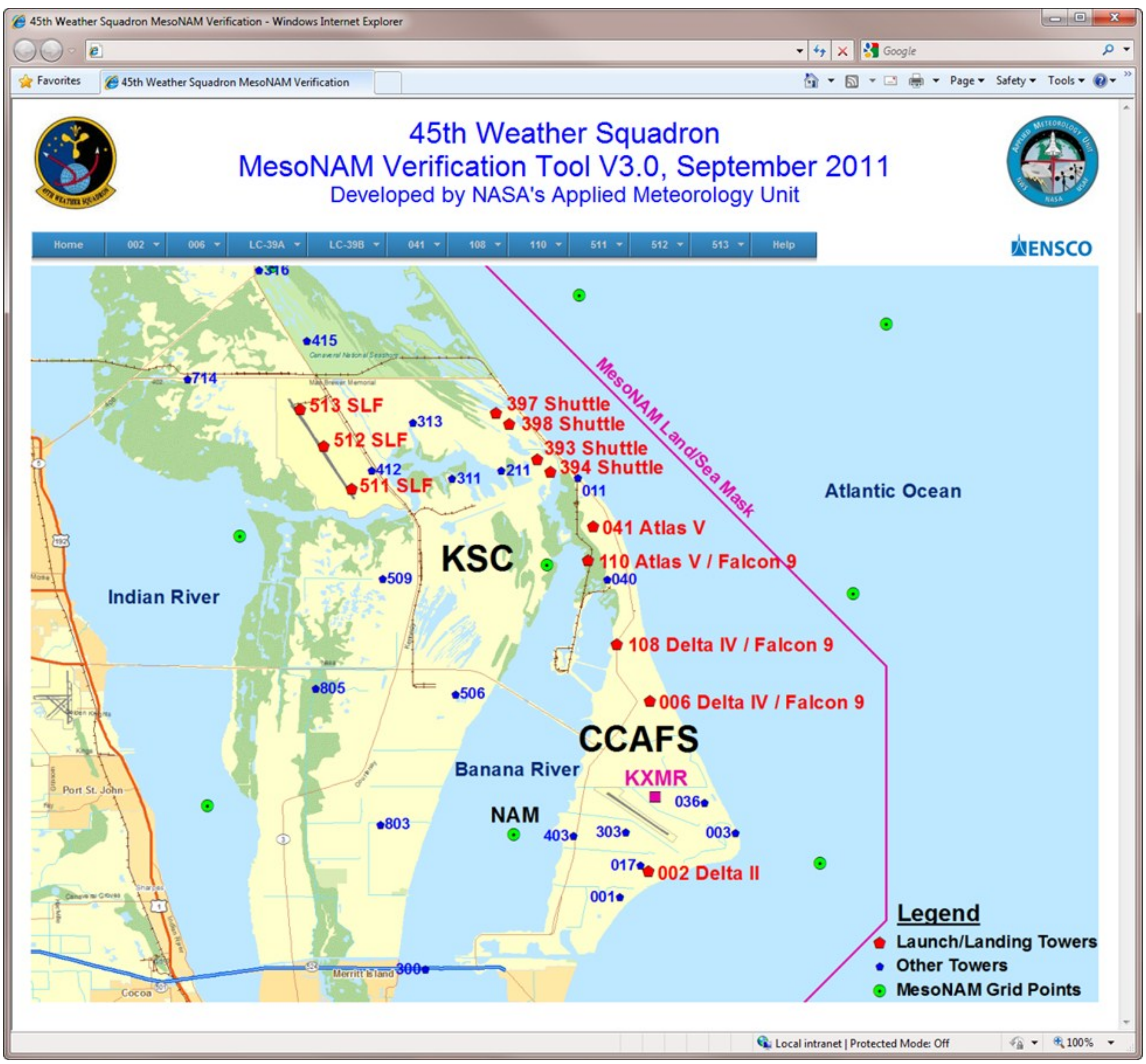


Figure 7. Main page of the GUI in a web browser showing the basic layout of the GUI.

AMU ACTIVITIES

AMU Operations

Mr. Wheeler worked on setting up a new Group Policy Object for the AMU Windows 7 computers. He also updated the FY 2012 IT Security Plan and worksheets and uploaded them for NASA IT review.

Mr. Wheeler conducted an inventory of all NASA AMU equipment and turned in several pieces that were not being used. He cleaned up files and directories on the shared file server by compressing them to free up storage space. He also continued updating the thunderstorm fire case training tool.

During the countdown of the 8 September Delta II launch, Ms. Winters of the 45 WS asked Ms. Crawford about the lifetime of the mature non-transparent stage of a thunderstorm anvil as documented by an earlier AMU study. Ms. Crawford read the final report on the development of the anvil forecast tool written by Dr. Short, and found that the average lifetime is two hours with a standard deviation of one hour. Ms. Winters used this information to analyze a thunderstorm anvil that had developed beyond the three-hour arc in the anvil tool display.

On the morning of 14 September, a forecaster asked Mr. Wheeler for assistance in running the objective lightning forecast tool on MIDDS. The tool would not display. Mr. Wheeler checked the MIDDS command in the text screen, reviewed the text output after issuing the command, and determined that the forecaster may have tried to run the tool before the morning sounding was complete. He deleted the information generated by running the command, waited for the sounding to complete, and then ran the tool successfully.

All AMU team members participated in preparations for the AMU Tasking meeting scheduled for 26 September. For the first time, the AMU was able to propose tasks for customers. The AMU team members wrote task proposals and responded to customer proposals.

Fifteen tasks were considered during the AMU tasking meeting. Of those, seven were approved for the AMU to work on in FY 2012: beginning on 3 October 2011:

- Calculate differences between model and observational upper-air data for the 45 WS LWOs;
- Develop a tool to calculate the probability of violating upper-air wind constraints at VAFB;
- Update and modify the current 45 WS objective lightning forecast tool;
- Determine the relationship between GPS precipitable water and lightning occurrence;
- Develop lightning forecast equations for airports in east-central Florida;
- Determine the logistics involved in creating a dual Doppler analysis with the two local radars;
- Configure a high-resolution mesoscale model for several U. S. launch ranges; and
- Set up a local data manager data retrieval system.

AMU Chief's Technical Activities (Dr. Huddleston)

Dr. Huddleston sent out the call for AMU tasking proposals for FY 2012 and distributed the proposals to all AMU tasking participants. She began working on AMU contract closeout activities and made preparations for the FY 2012 AMU tasking meeting that will occur on 26 September.

Dr. Huddleston wrote Visual Basic code for Mr. McAleenan and Mr. Roeder of the 45 WS to strip the precipitation and lightning probabilities from the Global Forecast System (GFS) Model Output Statistic (MOS) data for 2010. She then created an algorithm to blend the GFS MOS with climatology so that skill scores could be examined for precipitation and lightning probabilities obtained by each.

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LIST OF ACRONYMS

14 WS	14th Weather Squadron
30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 RMS	45th Range Management Squadron
45 OG	45th Operations Group
45 SW	45th Space Wing
45 SW/SE	45th Space Wing/Range Safety
45 WS	45th Weather Squadron
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground lightning
CSR	Computer Sciences Raytheon
FSU	Florida State University
FY	Fiscal Year
GFS	Global Forecast System
GSD	Global Systems Division
GUI	Graphical User Interface
HTML	Hypertext Markup Language
JSC	Johnson Space Center
KCOF (COF)	PAFB 4(3)-letter identifier
KSC	Kennedy Space Center
KTTS (TTS)	SLF 4(3)-letter identifier
KXMR (XMR)	CCAFS 4(3)-letter identifier
LAL	Lakeland, Fla. 3-letter identifier
LCC	Launch Commit Criteria
LWO	Launch Weather Officer
MesoNAM	12-km North American Mesoscale model
MOS	Model Output Statistics
MSFC	Marshall Space Flight Center
NCEP	National Centers for Environmental Prediction
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NWS MLB	National Weather Service in Melbourne, FL
PAFB	Patrick Air Force Base
PGD	Punta Gorda, Fla. 3-letter identifier
POR	Period of Record
PWAT	Precipitable Water
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
TAF	Terminal Aerodrome Forecast
TI	Thompson Index
USAF	United States Air Force
VAFB	Vandenberg Air Force Base
WFO	Weather Forecast Office

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

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

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45 SW/CD/G. Kraver
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45 OG/CC/D. Sleeth
45 OG/TD/C. Terry
CSR 4500/J. Osier
CSR 4500/T. Long
CSR 7000/M. Maier
SLRSC/ITT/L. Grier
SMC/RNP/M. Erdmann
SMC/RNP/T. Nguyen
SMC/RNP/R. Bailey
SMC/RNP(PRC)/K. Spencer
HQ AFSPC/A3FW/J. Carson
HQ AFWA/A3/M. Surmeier
HQ AFWA/A3T/S. Augustyn
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NWS Southern Region HQ/"W/ SR3"/D. Billingsley
NWS/"W/OST1"/B. Saffle
NWS/"W/OST12"/D. Melendez
NWS/OST/PPD/SPB/P. Roohr
NSSL/D. Forsyth
30 WS/DO/J. Roberts
30 WS/DOR/D. Vorhees
30 WS/OSS/OSWS/ M. Schmeiser
30 WS/OSS/OSWS/T. Brock
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FAA/K. Shelton-Mur
FSU Department of Meteorology/H. Fuelberg
ERAU/Applied Aviation Sciences/C. Herbster
ERAU/J. Lanicci
NCAR/J. Wilson
NCAR/Y. H. Kuo
NOAA/FRB/GSD/J. McGinley
Office of the Federal Coordinator for Meteorological Services and Supporting Research/ R. Dumont
Boeing Houston/S. Gonzalez
Aerospace Corp/T. Adang
ITT/G. Kennedy
Timothy Wilfong & Associates/ T. Wilfong
ENSCO, Inc/J. Clift
ENSCO, Inc./E. Lambert
ENSCO, Inc./A. Yersavich
ENSCO, Inc./S. Masters