ENSCO, Inc.

1980 N. Atlantic Ave., Suite 230
Coca Beach, FL 32931
(321) 783-9735, (321) 853-8202 (AMU)

Applied Meteorology Unit (AMU) Quarterly Report

Third Quarter FY-05 Contract NAS10-01052 31 July 2005

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NOAA "W/NP"/L. Uccellini
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Continued on Page 2

Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the third quarter of Fiscal Year 2005 (April - June 2005). A detailed project schedule is included in the Appendix.

Task — Objective Lightning Probability Forecast: Phase I

Goal Develop a set of statistical equations to forecast the probability of lightning occurrence for the day. This will aid forecasters in evaluating flight rules (FR) and determining the probability of launch commit criteria (LCC) violations, as well as preparing forecasts for ground operations.

Milestones A draft of the final report was completed, reviewed internally by the AMU, and distributed to the customers for an external review.

Discussion The customers received a draft of the final report that had undergone revisions after an internal AMU review. They were asked to respond with comments by early July.

Task — Severe Weather Forecast Decision Aid

Goal Create a new forecast aid to improve the severe weather watches and warnings for the protection of Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) personnel and property.

Milestones The stability indices were examined in greater detail, resulting in new relationships being found between the indices and severe weather occurrence. The web-based Severe Weather Decision Aid was updated and provided to the forecasters for more testing during operations.

Discussion The usefulness of the stability indices was determined based on severe weather occurrence within given threat level thresholds. Based on this analysis, the severe weather threat values in the Severe Weather Decision Aid worksheet were reevaluated and updated. Forecaster testing of the worksheet began in May and will go through September.

Task — Stable Low Cloud Evaluation

Goal Examine archived data collected during rapid stable cloud development events resulting in cloud ceilings below 8000 ft at the Shuttle Landing Facility. Document the atmospheric conditions favoring this type of cloud development to improve the ceiling forecast issued by the Spaceflight Meteorology Group (SMG) for Shuttle landings at KSC.

Milestones There were 68 possible rapid stable cloud development events identified through the use of CCAFS sounding data and local area hourly surface observations. Satellite data from these 68 event days were analyzed, reducing the number of possible events to 20.

Discussion The 68 possible event days were identified based on the existence of low-level temperature inversions in the CCAFS soundings and low cloud ceilings reported in the local area hourly surface observations. Visible satellite images were analyzed in 30-minute increments for each of the 68 days to identify cases with rapid low cloud development, resulting in a dataset of 20 events.

Continued on Page 2

Distribution (continued from Page 1)

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Executive Summary, *continued*

Task — Hail Index

Goal Evaluate current techniques used by the 45th Weather Squadron (45 WS) to forecast the probability of hail occurrence and size. Hail forecasts are required to protect personnel and material assets at KSC, CCAFS, Patrick Air Force Base and the Melbourne International Airport. The evaluation results will be used by the 45 WS to determine if a new technique is needed.

Milestones The continued analysis of the software used to generate the current hail size forecasts from sounding data revealed a third error. This error was corrected and reported to Computer Sciences Raytheon personnel, and a comparison of the corrected forecasts to observations was completed.

Discussion The results of the comparison using the corrected forecasts showed a closer association between the number of forecast and observed hail events. However, the correction for melting of hail as it falls was shown to be excessive, reducing the accuracy of the forecast hail size.

Task — Climatology of Cloud-to-Ground (CG) Lightning

Goal Develop a climatology of gridded CG lightning densities and frequencies of occurrence for the Melbourne, FL National Weather Service (NWS MLB) county warning area (CWA). These grids will be used by the forecasters as a first-guess field when creating the lightning threat index map that is available on the NWS MLB website. Forecasters currently create this map from scratch. Having the climatologies as a background field will increase consistency between forecasters and decrease their workload, ultimately benefiting all end-users of the product.

Milestones Acquired gridded CG lightning densities and associated software for processing from the Florida State University (FSU) and NWS Tallahassee, FL (TAE).

Discussion FSU and NWS TAE provided density grids for every hour of every day in the warm seasons 1989-2004. The grids were created with National Lightning Detection Network data at a grid resolution of 2.5 km X 2.5 km. The grids encompass the entire state of Florida, adjacent Atlantic and Gulf of Mexico waters, and southern Georgia and Alabama.

Task — Forecasting Low-Level Convergent Bands Under Southeast Flow

Goal Provide guidance that will help improve forecasting of convergent bands under synoptic southeast flow. When these convergent bands occur, they can lead to missed cloud, rain, and thunderstorm forecasts that adversely affect operations at CCAFS and KSC.

Milestones Developed data acquisition and archive procedures and began collecting data during days with southeast flow.

Discussion The data types collected include Doppler radar, visible/infrared/water vapor satellite imagery, hourly surface observations, sounding plots, sea surface temperatures, CG lightning data, and numerical weather prediction output from the North American Mesoscale model and Advanced Regional Prediction System (ARPS) model. Data from 14 southeast flow days were collected between 5 April and 30 June.

Continued on Page 3

TABLE of CONTENTS

Executive Summary, *continued*

Task — RSA and Legacy Wind Sensor Evaluation

Goal — Compare wind speed and direction statistics from the Legacy and RSA sensors on the Eastern (ER) and Western (WR) Ranges to determine the impact of the sensor changes on wind measurements. The 45 WS and 30th Weather Squadron need to know of any differences in the measurements between the two systems as they use these winds to issue weather advisories for operations.

Milestones — Analyzed five days of RSA and Legacy wind data from Towers 300 and 301 on the WR for the period 29 May – 02 June 2005.

Discussion — The average wind speeds were within 0.5 kts for the Legacy and RSA data, and the RSA peak speeds averaged about 1 knot higher than the Legacy peak speeds on both towers.

Task — Updated Anvil Threat Corridor Forecast Tool

Goal — The anvil threat corridor forecast tool is used to help forecasters determine whether thunderstorm anvils will be a threat when forecasting LCC and FR violations. The current software that creates the anvil threat corridor graphic must be modified to accommodate changes in the data sources. A drop-down menu on the Meteorological Interactive Data Display System (MIDDS) graphical user interface (GUI) will also be developed to allow quick and easy access to the tool.

Milestones — The current anvil tool script was acquired to review the required data and user inputs. Another script was acquired that accesses the new data sources. References describing the Tool Command Language, the language used to create the drop-down menu in the MIDDS GUI, were reviewed.

Discussion — The script that creates the anvil tool was modified to ingest the new data sources and tests began to ensure that it works properly. Creation of the design of the drop-down menu began to determine the best format that will allow quick access to the tool.

Task — Volume Averaged Height Integrated Radar Reflectivity (VAHIRR)

Goal — Transition the VAHIRR algorithm into operations on the Weather Surveillance Radar 1988 Doppler (WSR-88D). The current lightning LCC (LLCC) for anvil clouds to avoid triggered lightning are overly conservative and lead to costly launch delays and scrubs. The VAHIRR algorithm was developed as a result of the Airborne Field Mill program to evaluate a new LLCC for anvil clouds. This algorithm will assist forecasters in providing fewer missed launch opportunities with no loss of safety compared with the current LLCC.

Milestones — The VAHIRR algorithm was acquired from the National Center for Atmospheric Research.

Discussion — The VAHIRR algorithm was received and installed on a local computer for development. There were also several discussions with Mr. Tim Crum and Mr. Randy George of the Radar Operations Center in Norman, OK on the process of integrating new algorithms into the WSR-88D operational system.

Continued on Page 4

Executive Summary, *continued*

Task	Mesoscale Model Phenomenological Verification Evaluation
Goal	Find model weather-phenomena verification tools in the literature that could be transitioned into operations. Forecasters use models to aid in forecasting weather phenomena important to launch, landing, and daily ground operations. Methods that verify model performance are needed to help forecasters determine the model skill in predicting certain phenomena.
Milestones	Collected more journal articles describing the development and/or use of new phenomenological verification techniques and began writing the final report.
Discussion	A model verification expert at the NOAA Forecast Systems Laboratory stated that a reliable operational phenomenological verification technique does not currently exist. At the current rate of advancement in the science, a technique may be available in 5-10 years.
Task	ARPS Optimization and Training Extension
Goal	Provide assistance and support for upgrading and improving the operational ARPS and ARPS Data Analysis System (ADAS) that is used to make operational forecasts at the NWS MLB and SMG forecast offices.
Milestones	Corrected a bug that affected derived reflectivity products. Configured ARPS for real-time prediction at the AMU. Established real-time connectivity with the Marshall Space Flight Center and SMG to obtain the necessary initialization data for ARPS.
Discussion	A bug was identified and corrected in which the derived reflectivity in ARPS/ADAS was not using both liquid and ice particles, leading to a low bias in the coverage of reflectivity. The AMU began running real-time ARPS predictions initialized with radar, satellite, and surface observations in late May. All data were archived in order to perform future sensitivity tests.
Task	User Control Interface for ADAS Data Ingest
Goal	Develop a GUI to help forecasters at NWS MLB and SMG manage the data sets assimilated into the operational ADAS at those offices.
Milestones	Made several improvements and incorporated additional features into the control GUI.
Discussion	Based on feedback from the forecasters at NWS MLB, several improvements and new features were added to the GUI. The modifications based on the suggestions will be completed in July.

Special Notice to Readers

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

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 Lambert (321-853-8130, lambert.winifred@ensco.com). If your mailing information changes or if you would like to be removed from the distribution list, please notify Ms. Lambert or Dr. Francis Merceret (321-867-0818, Francis.J.Merceret@nasa.gov).

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

Objective Lightning Probability (Ms. Lambert and Mr. Wheeler)

The 45th Weather Squadron (45 WS) forecasters include a probability of thunderstorm occurrence in their daily morning briefings. This information is used by personnel involved in determining the possibility of violating Launch Commit Criteria (LCC), evaluating Flight Rules (FR), and planning for daily ground operation activities on Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS). Much of the current lightning probability forecast is based on a subjective analysis of model and observational data. The forecasters requested that a lightning probability forecast tool based on statistical analysis of historical warm-season data be developed. Such a tool would increase the objectivity of the daily thunderstorm probability forecast. The AMU developed statistical lightning forecast equations that provide a lightning occurrence probability for the day by 1100 UTC (0700 Eastern Daylight Time (EDT)) during the months May – September (warm season). The equation development was based on the results from several research projects. Tests of the equations showed that they improve the daily lightning forecast, therefore the AMU developed a PC-based tool from which the daily probabilities can be displayed by the forecasters. The three data types used in this task were:

- Cloud-to-Ground Lightning Surveillance System (CGLSS) data,
- 1200 UTC sounding data from synoptic sites in Florida, and
- 1000 UTC CCAFS sounding (XMR) data.

Ms. Lambert used the S-PLUS® software package (Insightful Corporation 2000) to process and analyze the data, and to develop the lightning forecast equations. She developed the PC-based tool using Microsoft® Excel© Visual Basic®.

Final Report

Ms. Lambert completed a draft of the final report and circulated it within the AMU for internal review. After making modifications based on suggestions during the internal review, she distributed the revised draft to the customers for their review. They were asked to provide comments by early July.

For more information contact Ms. Lambert at lambert.winifred@ensco.com or 321-853-8130.

Severe Weather Forecast Decision Aid (Mr. Wheeler and Dr. Bauman)

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 kts, and/or hail with a diameter ≥ 0.75 in. Forecasting the occurrence and timing of these phenomena is challenging for 45 WS operational personnel. The AMU has been tasked with the creation of a new severe weather forecast decision aid, such as a flow chart or nomogram, to improve the various 45 WS severe weather watches and warnings. The tool will provide severe weather guidance for the day by 1100 UTC (0700 EDT).

Dr. Bauman continued to analyze the stability parameters from the 1000 UTC XMR sounding to determine relationships between their threat level frequency and severe weather frequency of occurrence. The threat level frequency was based on the threshold criteria provided by the

- 45 WS Severe Weather Worksheet,
- National Weather Service Jacksonville, FL Severe Weather Checklist,
- Forecaster experience, or
- National criteria if local criteria were not available.

As discussed in the previous AMU Quarterly Report (Q2 FY05), 6 of the 14 stability parameters examined showed potential as guidance to forecasters when considering severe weather potential in their morning forecast. The six parameters were the

- K Index (KI),
- Total Totals (TT),
- Lifted Index (LI),
- Thompson Index (TI),
- Precipitable Water (PW), and
- Cross Totals (CT).

After further examination, two additional stability parameters showed potential as severe weather predictors, bringing the total to eight. The two additional stability parameters are the

- Showalter Stability Index (SSI) and
- Convective Available Potential Energy (CAPE) based on the forecast maximum surface temperature (FMaxT).

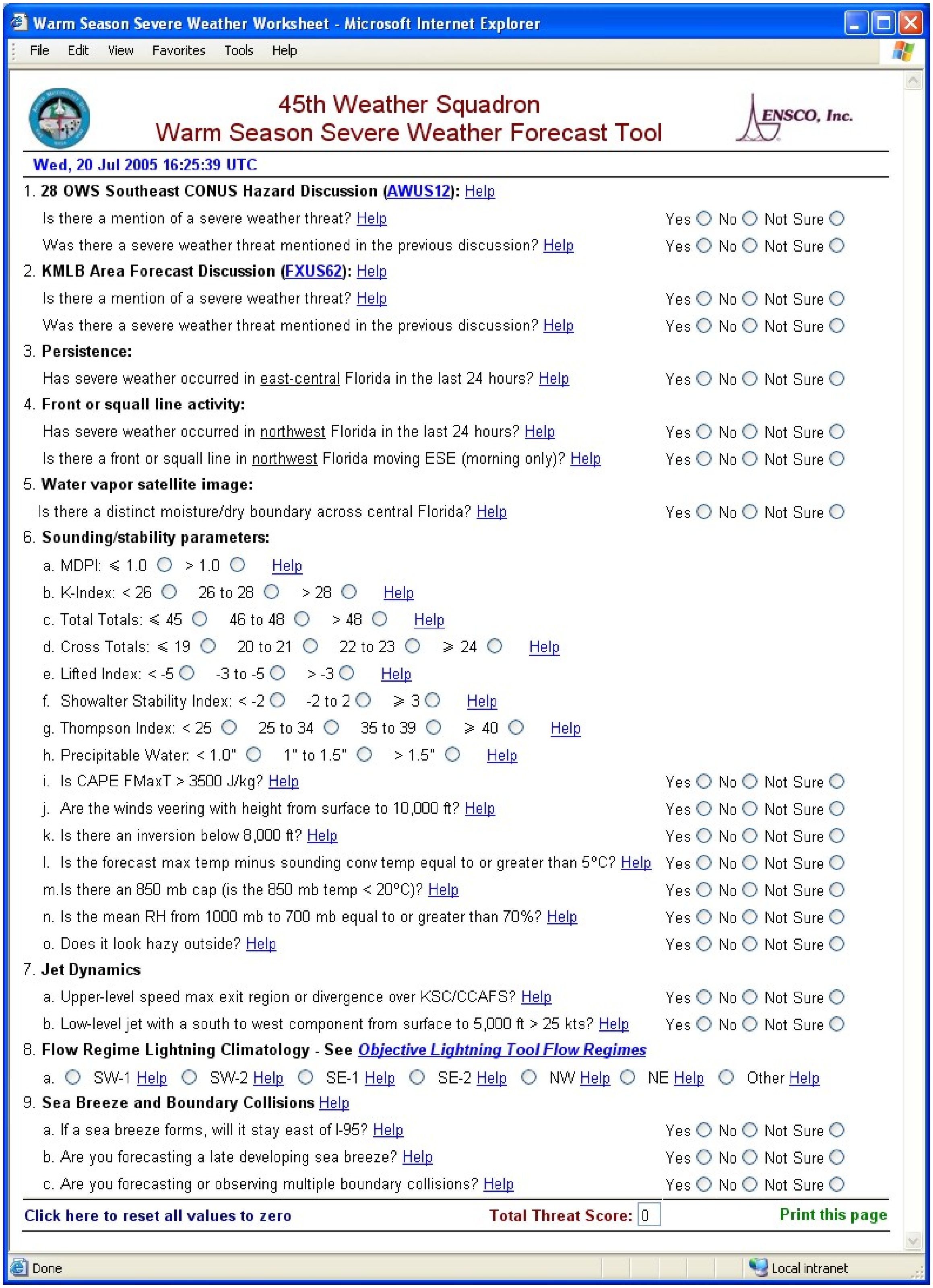
Table 1 shows the threat level and severe weather occurrence frequencies for the eight stability parameters. In general, severe weather occurrence was less than 18% when the parameter values were in the low-medium threat ranges. But when the values were in the high, very high, or extreme threat ranges the frequency of severe weather was generally 25% or higher. Note in the Threat Level Frequency rows, however, that the occurrence of parameter values in the high, very high, or extreme threat ranges was rare. Additionally, KI and PW showed the possibility of providing guidance in forecasting non-severe and non-lightning days.

Table 1. The threat level and severe weather occurrence frequencies for the eight stability parameters used in the Severe Weather Decision Aid. The most significant threat category and associated threat level and severe weather frequencies of occurrence are shaded in light yellow.

Stability Parameter	Low Threat	Medium Threat	High Threat	Very High Threat	Extreme Threat
Total Totals					
Threat Level Frequency	64%	28%	8%		
Severe Weather Frequency	9%	18%	29%		
Lifted Index					
Threat Level Frequency	57%	40%	3%		
Severe Weather Frequency	10%	16%	25%		
Thompson Index					
Threat Level Frequency	31%	37%	26%	6%	
Severe Weather Frequency	6%	16%	16%	21%	
Showalter Stability Index					
Threat Level Frequency	40%	58%	2%		
Severe Weather Frequency	7%	16%	32%		
Cross Totals					
Threat Level Frequency	43%	30%	21%	6%	
Severe Weather Frequency	10%	14%	13%	27%	
CAPE FMaxT					
Threat Level Frequency	13%	20%	59%	8%	.04%
Severe Weather Frequency	7%	12%	14%	16%	67%
K Index					
Threat Level Frequency	36%	10%	54%		
Severe Weather Frequency	8%	18%	16%		
Precipitable Water					
Threat Level Frequency	4%	28%	68%		
Severe Weather Frequency	3%	9%	15%		

Dr. Bauman and Mr. Wheeler modified the Severe Weather Decision Aid worksheet, shown in the previous AMU Quarterly Report (Q2 FY05), based on initial feedback from the forecasters and the addition of the SSI and CAPE FMaxT stability parameters. The worksheet, shown in Figure 1, is a JavaScript-based tool that forecasters can access from any computer with a Java-enabled web browser. The forecaster will click on the appropriate radio button for each question or parameter in the list. Each answer has an assigned value that was determined through discussions with experienced forecasters and/or the occurrence of severe weather related to the stability parameters. Dr. Bauman also added a help link to each question that provides more information about the question and brief rationale for the choice of answer values. An unchecked item or an answer of “Not Sure” will retain the default value of zero. The values range from a low of -2 to a high of +3, proportional to increase or decrease in the probability of severe weather occurrence. The worksheet automatically adds the values based on the responses and provides a Total Threat Score at the bottom. The higher the Total Threat Score, the more likely severe weather will occur. As of the writing of this report, the relationship between the Total Threat Score value and the occurrence of severe weather is not known. During the 2005 warm season, the 45 WS will conduct a qualitative assessment of the worksheet by keeping daily records of Total Threat Score and severe weather events. Then the AMU can make a quantitative assessment of the relationship between Total Threat Score and severe weather occurrence.

Contact Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com, or Dr. Bauman at 321-853-8202 or bauman.bill@ensco.com for more information on this work.



Warm Season Severe Weather Worksheet - Microsoft Internet Explorer

File Edit View Favorites Tools Help

45th Weather Squadron
Warm Season Severe Weather Forecast Tool

ENSCO, Inc.

Wed, 20 Jul 2005 16:25:39 UTC

1. **28 OWS Southeast CONUS Hazard Discussion (AWUS12):** 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. **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
3. **Persistence:**
   - Has severe weather occurred in east-central Florida in the last 24 hours? Help — Yes No Not Sure
4. **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
5. **Water vapor satellite image:**
   - Is there a distinct moisture/dry boundary across central Florida? Help — Yes No Not Sure
6. **Sounding/stability parameters:**
   - a. MDPI: ≤ 1.0 > 1.0 Help
   - b. K-Index: < 26 26 to 28 > 28 Help
   - c. Total Totals: ≤ 45 46 to 48 > 48 Help
   - d. Cross Totals: ≤ 19 20 to 21 22 to 23 ≥ 24 Help
   - e. Lifted Index: < -5 -3 to -5 > -3 Help
   - f. Showalter Stability Index: < -2 -2 to 2 ≥ 3 Help
   - g. Thompson Index: < 25 25 to 34 35 to 39 ≥ 40 Help
   - h. Precipitable Water: < 1.0" 1" to 1.5" > 1.5" Help
   - i. Is CAPE FMaxT > 3500 J/kg? Help — Yes No Not Sure
   - j. Are the winds veering with height from surface to 10,000 ft? Help — Yes No Not Sure
   - k. Is there an inversion below 8,000 ft? Help — Yes No Not Sure
   - l. Is the forecast max temp minus sounding conv temp equal to or greater than 5°C? Help — Yes No Not Sure
   - m. Is there an 850 mb cap (is the 850 mb temp < 20°C)? Help — Yes No Not Sure
   - n. Is the mean RH from 1000 mb to 700 mb equal to or greater than 70%? Help — Yes No Not Sure
   - o. Does it look hazy outside? Help — Yes No Not Sure
7. **Jet Dynamics**
   - a. Upper-level speed max exit region or divergence over 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
8. **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
9. **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**

Done Local intranet

Figure 1. The updated interactive web-based Severe Weather Decision Aid worksheet. Users choose only one radio button next to each question. The Total Threat Score is displayed at the bottom of the worksheet.

Stable Low Cloud Evaluation (Mr. Wheeler and Mr. Case)

Forecasters at the Spaceflight Meteorology Group (SMG) issue 30 to 90 minute forecasts for low cloud ceilings at the Shuttle Landing Facility for all Space Shuttle missions. Mission verification statistics have shown cloud ceilings to be the biggest forecast challenge. Forecasters at SMG are especially concerned with rapidly developing clouds/ceilings below 8000 ft in a stable, capped thermodynamic environment, since these events are the most challenging to predict accurately. The AMU was tasked to develop a database of these cases, identify the onset, location, and if possible, dissipation times, and document the atmospheric regimes favoring this type of cloud development.

Mr. Case and Mr. Wheeler developed and analyzed a 10-year database of possible stable low cloud development event days. They examined the corresponding XMR sounding data, identifying days that had high boundary layer relative humidity associated with a thermally-capped environment below 8000 ft. From this analysis, they identified 68 days listed in Table 2 as containing potential stable low cloud development events.

Mr. Case and Mr. Wheeler examined the hourly surface observations from the Shuttle Landing Facility and Melbourne, Orlando, Sanford, and Ocala, FL taken during the 68 days for the onset of cloud ceilings below 8000 ft between 1100 and 2000 UTC. Once they supplemented the database with the hourly surface cloud observations, they analyzed the associated visible satellite images in 30-minute intervals to confirm event occurrences. Based on the satellite analysis, they identified 20 rapidly developing low cloud event days, indicated by bold font in Table 2. Mr. Case and Mr. Wheeler will analyze the prevailing sounding and meteorological conditions on these 20 case days for potential pre-curser information that would help improve the prediction of these events.

Table 2. Dates of possible rapid low cloud development cases. The twenty dates in bold font indicate events confirmed with visible satellite imagery. The dates are listed chronologically top to bottom, left to right with horizontal lines between years.

12/2/93	1/29/96	12/15/98	12/5001
12/15/93	2/9/96	**12/19/98**	2/5/02
12/20/93	**2/21/96**	**1/30/99**	3/6/02
1/20/94	3/5/96	3/8/99	1/13/03
2/7/94	3/20/96	**3/31/99**	1/24/03
3/3/94	11/3/96	11/5/99	2/1/03
3/12/94	11/28/96	11/9/99	2/18/03
3/20/94	11/29/96	12/3/99	2/19/03
11/3/94	12/5/96	12/23/00	2/23/03
11/4/94	**3/2/97**	**1/30/01**	2/24/03
1/6/95	**3/30/97**	2/8/01	**2/26/03**
3/10/95	11/19/97	2/9/01	3/5/03
3/24/95	12/16/97	**2/15/01**	**3/6/03**
11/13/95	1/1/98	2/20/01	3/11/03
11/25/95	2/1/98	2/21/01	**2/20/04**
1/7/96	3/20/98	11/6/01	**3/3/04**
1/18/96	12/10/98	**12/4/01**	**1/6/05**

Figures 2 and 3 depict a rapid low cloud development event from 13 November 1995. Figure 2 shows only widely scattered clouds at 1315 UTC across central Florida, with higher coverage of low clouds farther to the north. By 1345 UTC (Figure 3), low clouds formed rapidly across central Florida in the corridor that was mostly clear just 30 minutes earlier.

Contact Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com, or Mr. Case at 321-853-8264 or case.jonathan@ensco.com for more information on this work.

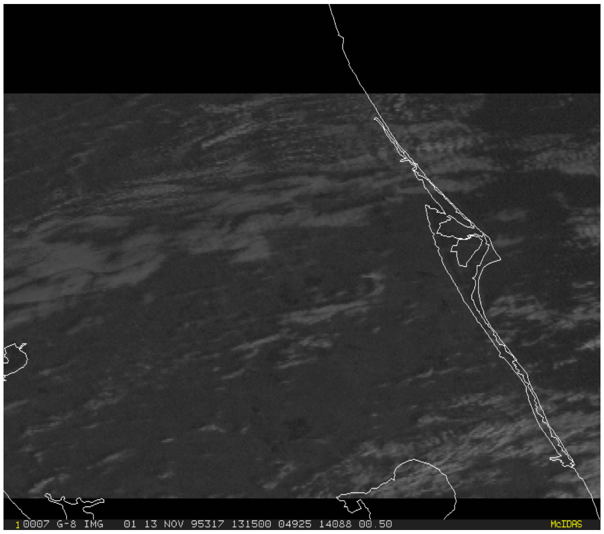


Figure 2. Visible satellite image from 13 November 1995 at 1315 UTC.

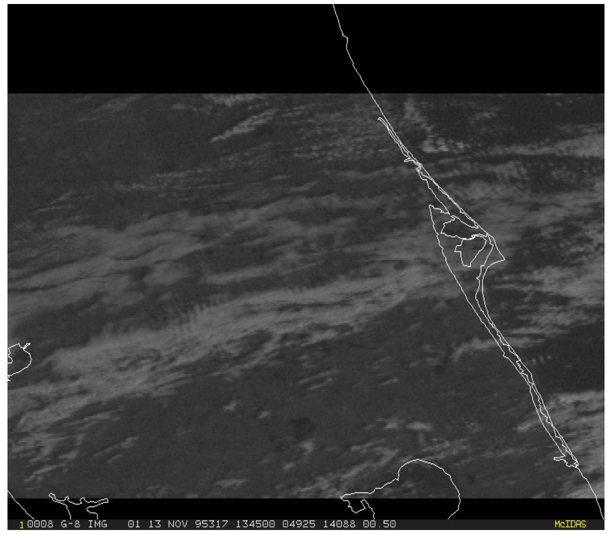


Figure 3. Same as Figure 2 except the time is 1345 UTC.

Hail Index (Dr. Short and Mr. Wheeler)

The 45 WS has an operational requirement to issue weather advisories for hail of any size, including severe hail with a diameter ≥ 0.75 in. These advisories are issued for KSC, CCAFS, Patrick Air Force Base, and the Melbourne International Airport to protect personnel and material assets. The forecasters must also provide the probability of hail at any of these locations for the day at the 0700L weather briefing. The 45 WS tasked the AMU to evaluate the current operational tools used to make daily hail forecasts and, if needed, to develop a new tool tuned to the local area.

Dr. Short and Mr. Wheeler evaluated a computerized version of the Fawbush-Miller (FM) hail graph (Reymann et al. 1998). The FM outputs the Potential Maximum Hail Size (PMHS) that is used operationally by the 45 WS as hail size forecast guidance. Dr. Short and Mr. Wheeler generated PMHS output for the warm season months of May – September in the 13-year period-of-record (POR) 1989–2001 using XMR sounding data and an AMU-corrected version of the operational FM computer program run by Computer Sciences Raytheon (CSR) personnel at XMR. Results of the comparison between PMHS output and hail size reports in Brevard County and east-central Florida are presented in the following sections.

AMU Corrections to the Computerized Fawbush-Miller Hail Graph

Forecast guidance for hail size is determined each morning by 45 WS forecasters through analyses of the local and large-scale weather data. The CSR personnel at XMR use a computer program named WVTHUV1.f to analyze vertical profiles of temperature, humidity and wind from the XMR soundings to generate a bulletin titled "Thunderstorm Probability Study" (TPS). The TPS bulletin includes a yes/no indicator for thunderstorm activity and a forecast PMHS based on the FM technique if the thunderstorm forecast is "yes." The TPS bulletin is transmitted to the Meteorological Interactive Data Display System (MIDDS) and can be displayed by entering the MIDDS command "CYA MISC THUNDER". The TPS bulletin is generated during the warm season.

Dr. Short found and corrected errors in three variables calculated in WVTHUV1.f, which affected the calculation of PMHS:

- The temperature of the convective condensation level,
- The height of the wet-bulb zero temperature (WB0), and
- The parameterization of the pseudo-adiabatic lapse rate.

The impact of the first two errors was reported in previous AMU Quarterly Reports (Q1 and Q2 FY05). The third error was uncovered by a comparison of manual and computerized analyses of XMR soundings using the FM technique. Dr. Short corrected the AMU computer code to produce results consistent with manual analyses. He then regenerated the TPS bulletin to produce a climatology of forecast PMHS and compared it to observations of hail obtained from the National Climatic Data Center (NCDC).

Corrected Climatology of Forecast Hail Sizes

Table 3 shows a comparison of the original and corrected PMHS and observed maximum hail sizes in Brevard County. The data from NCDC did not contain observations of hail size smaller than 0.75 in, therefore an 'N/A' appears for the small hail categories in the '# Observed Days' column. Table 3 shows that the overall number of days with forecast and observed severe hail (diameter ≥ 0.75 in) agree reasonably well, with 28 versus 30, respectively. However, severe hail was observed in Brevard County on only 2 of the days with a PMHS forecast of severe hail. On days when severe hail was observed and the thunderstorm forecast indicated "yes," the PMHS was 0.25 in or less on 23 out of 30 hail days.

Table 3. Number of days with PMHS hail size forecasts from the revised WVTHUV1.f code, and the original WVTHUV1.f code. Also shown are the number of days with observed hail in Brevard County during May-September in the years 1989-2001.

Description	*Approximate Size (inches)*	*# Corrected PMHS Days*	*# Original PMHS Days*	*# Observed Days*
> Golf ball	≥ 2	2	1	0
Ping Pong/Golf ball	1.5 - 1.75	1	1	5
Quarter to Half Dollar	1 - 1.25	7	2	10
Dime/Nickel	0.75 - 0.88	18	0	15
Marble	0.5	28	0	N/A
Pea	0.25	50	556	N/A
< Pea	< 0.25	564	117	N/A
Missing		7	0	

Effect of Melting Correction on PMHS

The final PMHS value was calculated from a preliminary PMHS and an empirical correction for melting that increases with the WB0 height. To help analyze the effect of the melting algorithm, Dr. Short revised the code to produce two changes in the TPS Bulletin output:

- It always calculated PMHS even when the thunderstorm forecast was "no", and
- The preliminary and final PMHS were output to document the effect of the FM correction for melting.

In this analysis, Dr. Short used hail reports from all six counties in east-central Florida (Brevard, Indian River, Orange, Seminole, St. Lucie, and Volusia) and the PMHS from all days on which severe hail was reported, independent of the thunderstorm forecast. This procedure assumed that the XMR sounding characterized the general air mass over east-central Florida.

During the POR there were 1843 days with XMR morning soundings and 112 days with severe hail reported to NCDC in the six-county area. The preliminary and final PMHS values and the reported maximum hail size for each of those 112 days are plotted in Figure 4, versus the height of the WB0. Figure 4 shows that the final PMHS forecasts were systematically less than the observed hail sizes when the WB0 was > 10,500 ft. This result is consistent with the findings of Moore and Pino (1990) that the FM correction for melting results in hail < 0.25 in for all cases with a WB0 height of 12,300 ft. They noted that the FM preliminary hail size was closer to observed hail size than the final PMHS, also consistent with the results in Figure 4.

Contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com for more information on this work.

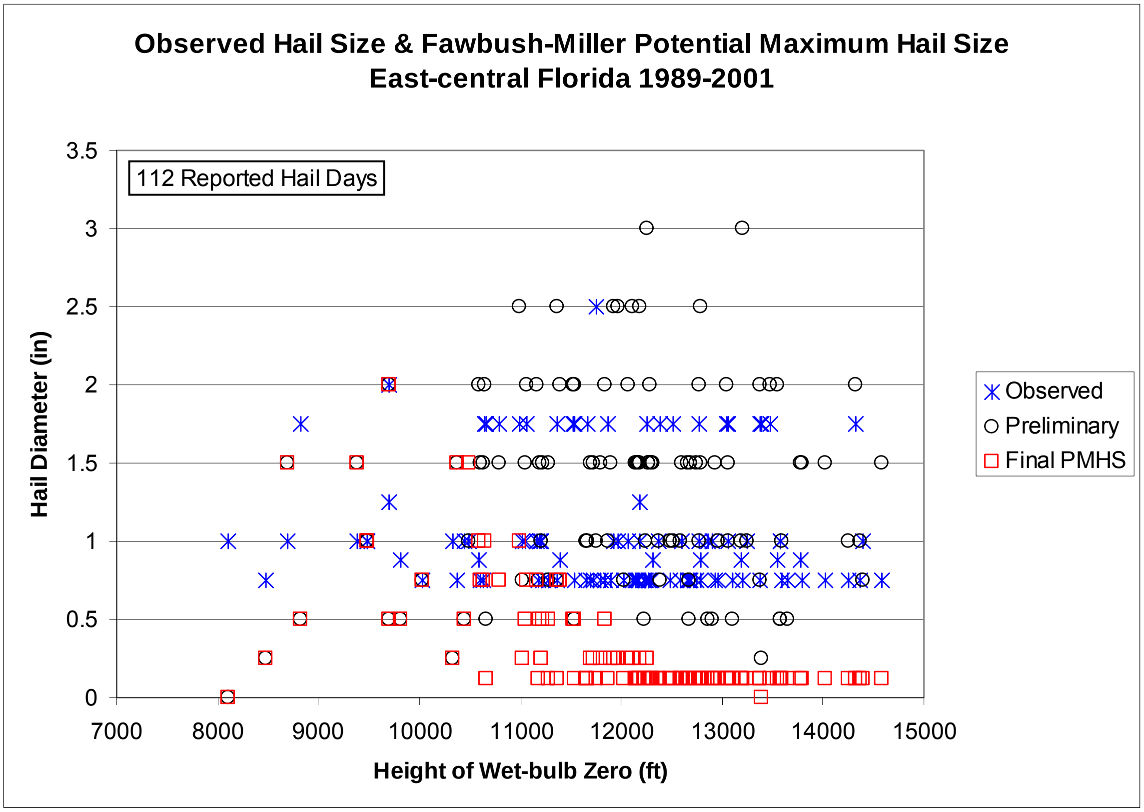


Figure 4. Height of WB0 versus observed and forecast hail diameter for 112 days during the warm seasons of the years 1989 – 2001. The NCDC severe hail reports are shown as blue asterisks, preliminary PMHS forecasts are shown as black circles, and final PMHS forecasts with the FM correction for melting are shown as red squares.

Climatology of Cloud-to-Ground Lightning (Ms. Lambert)

The forecasters at the National Weather Service in Melbourne, FL (NWS MLB) produce a daily cloud-to-ground (CG) lightning threat index map for their county warning area (CWA) that is available on their web site. Given the hazardous nature of frequent lightning in central Florida, especially during the warm season months of May – September, this map helps users discern the probable lightning threat for the day at any location of interest. The map is color-coded in five levels from Very Low to Extreme threat. The placement of the different threat levels in the CWA depend on the location of the low-level ridge, forecast sea breeze propagation, and other factors that influence the spatial distribution of thunderstorms over the CWA. The forecasters create each threat index map manually from a blank map using considerable time and effort. As a result, the NWS MLB forecasters requested the AMU to create gridded warm-season CG lightning climatologies that could be used as a first-guess starting point when creating the lightning threat index map. This would increase consistency between forecasters and decrease workload, ultimately benefiting the end-users of the product. It would also provide forecasters the ability to extend the lightning threat forecast into Day-2 and beyond during the warm season.

Lightning Threat Index Map

The lighting threat index map from 2 August 2005 is shown in Figure 5 as an example. The map is issued for the 24-hour period beginning at 1200 UTC (0700 AM EST) each day with a grid resolution of 5 X 5 km. To provide a climatological first-guess background for creating this map, NWS MLB requested warm season CG strike densities and frequencies of occurrence in 1-, 3-, 6-, 12-, and 24-hour increments based on the flow regime (Lericos et al. 2002). The new time increments will allow forecasters to update the map during the day.

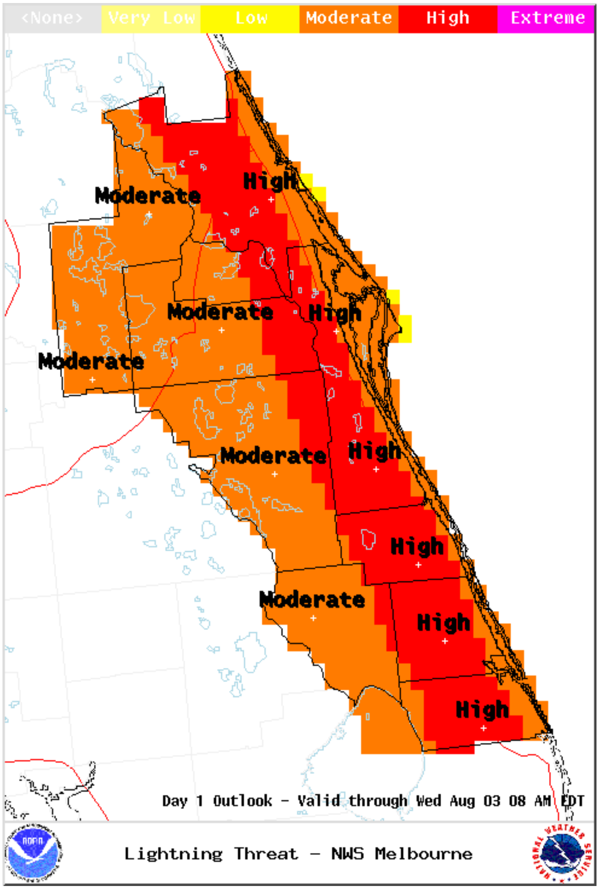


Figure 5. The NWS MLB Lightning Threat map for 2 August 2005. The color legend for each threat level is shown at the top of the image.

Data

The Florida 1200 UTC synoptic soundings are needed to determine the daily flow regimes, and data from the National Lightning Detection Network (NLDN) are needed to determine the times and locations of CG strikes. Data from NLDN are the most appropriate for this work since it can detect strikes over the entire CWA. The detection and location accuracy of the CGLSS becomes questionable beyond the local area of the network, situated in the north-central area of the CWA. The time period for the climatology is all warm seasons in the years 1989–2004. Ms Lambert has an archive of warm season Florida soundings from 1989–2003 and can access the 2004 soundings easily from the Forecast Systems Laboratory (FSL) website. However, neither she nor any AMU team member has direct access to an NLDN archive.

Several studies took place at the Florida State University (FSU) and NWS Tallahassee (TAE) in which similar lightning and flow regime information were needed. They created lightning densities using NLDN data on a 2.5 X 2.5 km grid for every hour of every day during the warm seasons in the years 1989–2004 for their work. Ms. Lambert convened a teleconference between Mr. Dave Sharp of NWS MLB, Dr. Henry Fuelberg of FSU, and Mr. Phil Shafer and Mr. Irv Watson of NWS TAE to discuss the needs of the AMU task and discern what data FSU and NWS TAE could provide. Dr. Shafer and Mr. Watson made their gridded lightning density data available on an FSU ftp site, as well as FORTRAN code to process the gridded data and to create flow regimes from the sounding data. Ms. Lambert downloaded all files on the ftp site and checked the gridded data for completeness.

The lightning density grids encompass the area from 24°–32.5° North latitude and 78°–88° West longitude, which covers the entire state of Florida, adjacent Atlantic and Gulf of Mexico waters, and southern Georgia and Alabama. The NWS MLB forecasters prefer to have the densities and frequencies calculated for the entire area rather than just their CWA. These data will provide improved spatial resolution and expansion of the lightning threat area to include adjacent coastal waters.

For more information on this work, contact Ms. Lambert at lambert.winnie@ensco.com or 321-853-8130.

Forecasting Low-Level Convergent Bands Under Southeast Flow (Dr. Bauman)

Forecasting the occurrence and timing of convergent bands under synoptic southeast flow is challenging for 45 WS operational personnel. When the convergent bands occur, they are sometimes associated with rain, gusty winds and thunderstorm activity. Such weather could cause suspension of daily ground operations as well as violations of LCC and FR during operations. At other times the convergent bands only produce benign clouds. There have also been cases of southeast flow with no clouds present. Southeast flow leading to the production of convergent bands has occurred in every month of the year, though the forecast precursors may vary seasonally. The 45 WS requested that the AMU study convergent band formation under southeast flow and attempt to determine precursors to convergent band formation during southeast flow regimes. The ability of the 45 WS to predict weather caused by these convergent bands would work toward enhancing protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC.

Dr. Bauman developed data collection and archive procedures using the ENSCO, Inc. MetWise™ Net data display software. MetWise Net is a Java-based graphical user interface (GUI) tool based on the NOAA Advanced Weather Information Processing System (AWIPS). A significant feature of MetWise Net is the ability to archive all frames of any product displayed as individual JPEG or GIF files for later interrogation. An example of the MetWise Net screen is shown in Figure 6. Like AWIPS, the GUI consists of pull-down menus for product selection and five product display windows.

The data types Dr. Bauman is collecting include Weather Surveillance Radar 1988 Doppler (WSR-88D) radar observations of reflectivity and velocity from the Melbourne and Miami, FL radars; visible, infrared and water vapor satellite imagery; Florida and Bahamas surface observations including nearby buoy and ship reports; Florida and Bahamas sounding data; satellite-derived sea surface temperatures; NLDN lightning data; and numerical weather prediction output from the North American Mesoscale (NAM) model and Advanced Regional Prediction System (ARPS) model.

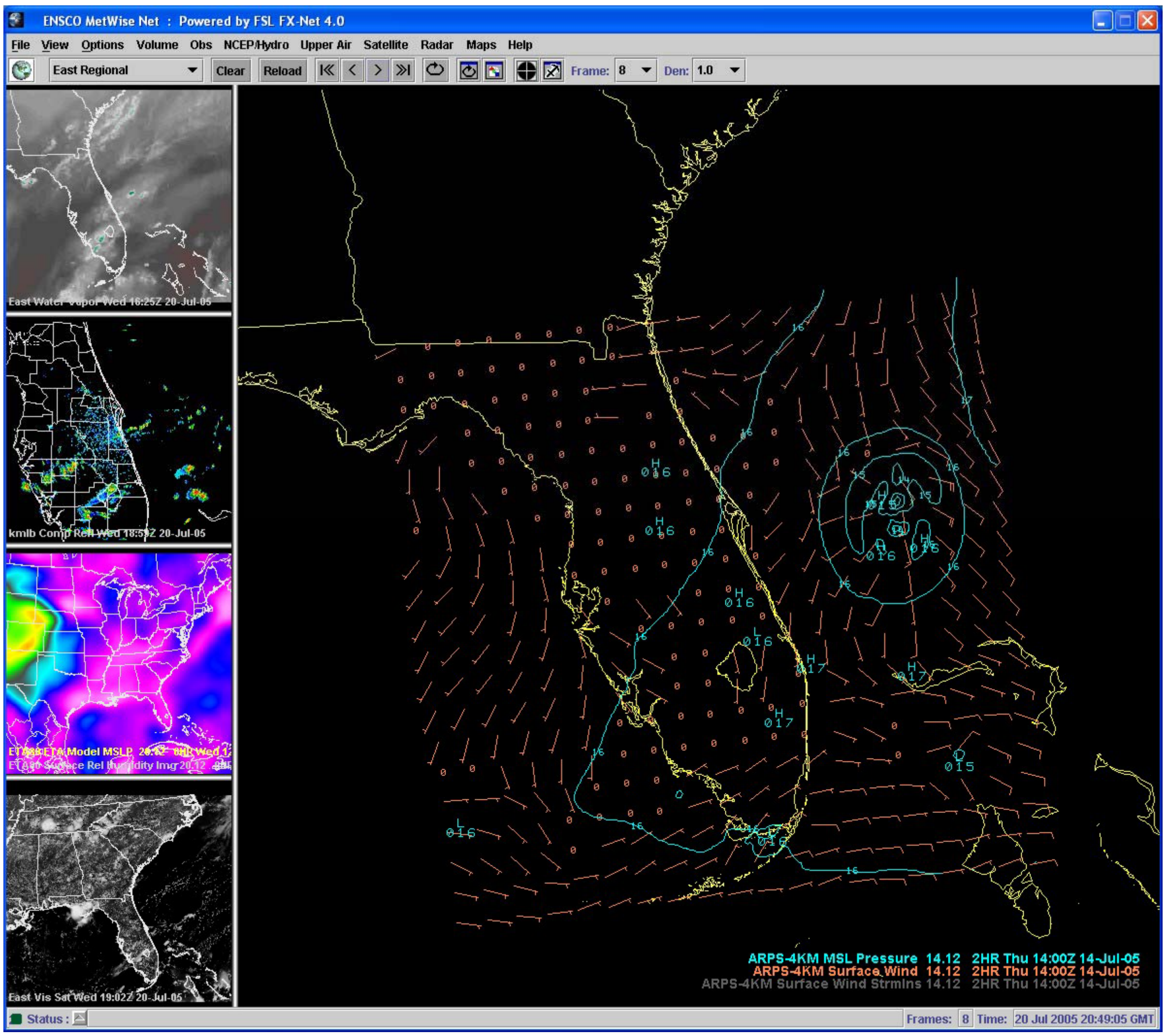


Figure 6. Example of the MetWise Net GUI showing the forecast mean sea level pressure and surface winds from the ARPS mesoscale model in the primary (large) window and in the storage (small) windows (top down) a water vapor satellite image, WSR-88D composite reflectivity image, NAM model surface relative humidity image, and a visible satellite image.

Data collection began with the first southeast flow day on 5 April 2005. Dr. Bauman has archived data from 14 case days so far. The dates of the case days are shown in the following table:

April	May	June
5	12	9
11	13	14
12	16	27
	17	28
	18	
	19	
	20	

A sample of an archived visible satellite image collected during the southeast flow case on 11 April is shown in Figure 7.

Contact Dr. Bauman at 321-853-8202 or bauman.bill@ensco.com for more information on this work.

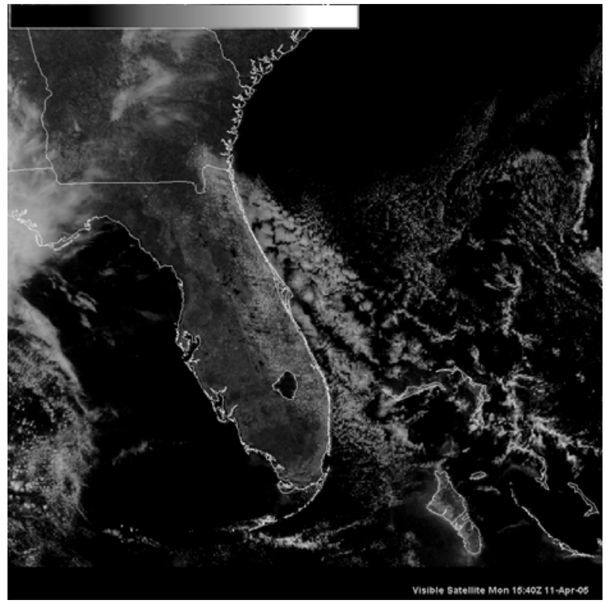


Figure 7. Visible satellite image archived using MetWise Net showing clouds offshore the east coast of Florida moving northeast from the Bahamas at 1500 UTC, 11 April 2005.

INSTRUMENTATION AND MEASUREMENT

I&M and RSA Support (Mr. Wheeler)

Mr. Wheeler began documenting and analyzing an AWIPS display problem. At times, certain display windows will freeze and a re-start of the AWIPS system is required to solve the problem.

RSA and Legacy Wind Sensor Evaluation (Dr. Short and Mr. Wheeler)

Launch Weather Officers, forecasters, and Range Safety analysts need to understand the performance of wind sensors at the Eastern (ER) and Western (WR) Ranges for weather warnings, watches, and advisories, special ground processing operations, launch pad exposure forecasts, user LCC forecasts and evaluations, and toxic dispersion support. Through the Range Standardization and Automation (RSA) program, the current weather tower wind instruments are being switched from the Legacy cup-and-vane sensors to sonic sensors. The Legacy sensors measure wind speed and direction mechanically, but the sonic RSA sensors have no moving parts. These differences in wind measuring techniques could cause differences in the statistics of peak wind speed and wind direction variability. The 45 WS and the 30 WS requested that the AMU compare the data between RSA and Legacy sensors to determine if there are significant differences between the systems.

Dr. Short and Mr. Wheeler obtained 23 days of 1-minute Legacy and RSA wind speed and direction data collected during 29 May–23 June 2005 from five towers on the WR: 301, 300, 102, 60 and 54. The WR Legacy data covers a 6-hour interval 1600–2200 UTC each day and includes the peak wind speed used to evaluate LCC during operations.

Figure 8 shows a schematic representation of a horizontal cross-section through Tower 300, which is also representative of Tower 301. There are two RSA instrument booms and one Legacy instrument boom at each of five wind sensor levels (12, 54, 102, 204, and 300 ft). The RSA booms are labeled NW and SE in Figure 8. The RSA and Legacy wind sensors output wind speed and direction data every second to an intermediary data processing system. The algorithms for computing the 1-minute average wind speeds and directions, and peak wind speeds and directions from the 1-second data are the same for the two sensors.

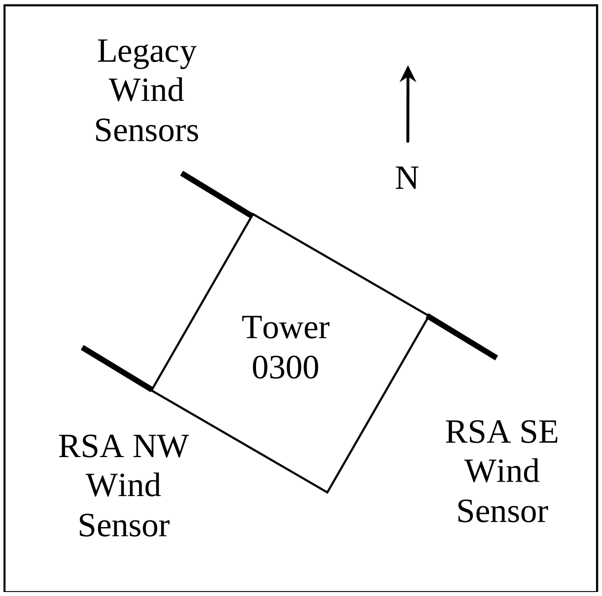


Figure 8. Schematic of the horizontal cross-sectional view of WR Tower 300. The Legacy and RSA wind sensors are located at 5 levels: 12, 54, 102, 204, and 300 ft.

Dr. Short performed a comparison of the Legacy and RSA wind speed data obtained from Towers 300 and 301 for the 5-day period of record (POR) 29 May–2 June 2005. Wind direction was generally from the NW during the period, giving the Legacy and RSA NW sensors exposures unobstructed by the tower.

Figure 9 shows a comparison of the average wind speeds from the Legacy and RSA sensors on Tower 301 for the 5-day POR. Each point represents the 6-hour period 1600–2200 UTC on one day from one of the five levels on the tower. Values from the Legacy sensor are plotted versus values from the NW and SE RSA sensors, for a total of 50 data points. Average wind speeds varied from 5 to 16 knots with the RSA values following the 1:1 diagonal quite closely. The average wind speeds for all five levels for all five days were 10.01 kts (Legacy), 10.30 kts (RSA NW), and 10.44 kts (RSA SE). The two highest points on Figure 9 are from the NW and SE RSA sensors on the 300 ft level. For those two measurements the RSA average wind speed was about 1.22 (NW) and 1.52 (SE) knots higher than the Legacy average wind speed.

Figure 10 shows a comparison of peak wind speeds from Legacy and RSA sensors on Tower 301 for the 5-day POR. Each point represents an average of peak wind speeds over the 6-hour period 1600–2200 UTC on one day from one of the five levels on the tower. Average peak wind speeds from the Legacy sensor are plotted versus average peak wind speeds from the NW and SE RSA sensors. Average values varied from 7 to 19 knots with the RSA values mostly above the 1:1 diagonal by 1 or 2 knots. The average peak wind speeds for all five levels for all five days were 12.72 kts (Legacy), 13.66 kts (RSA NW), and 13.97 kts (RSA SE).

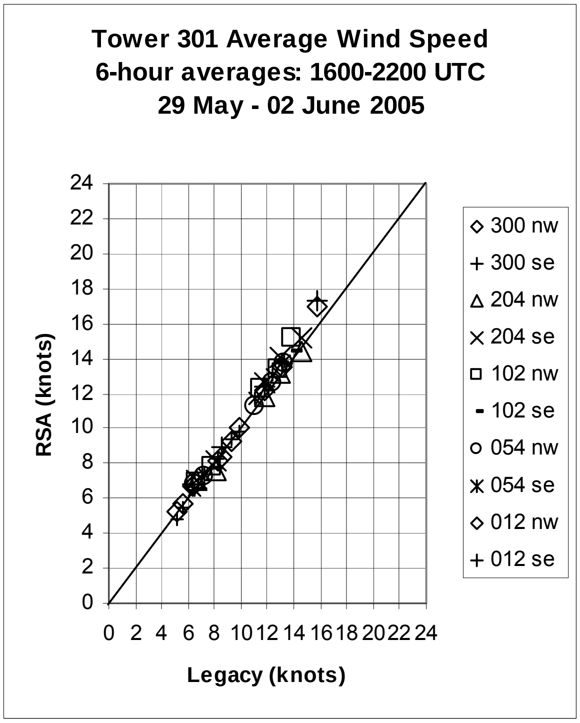


Figure 9. The Legacy versus RSA average wind speed data from NW and SE sensors on five levels (300, 204, 102, 54, and 12 ft) of WR Tower 301 from the 6-hour interval 1600 – 2200 UTC on 29 May to 2 June 2005.

Figure 11 shows a comparison of the average wind speeds from Legacy and RSA sensors on Tower 300 for the 5-day POR. Each point represents the 6-hour period 1600–2200 UTC on one day from one of the five levels on the tower. Values from the Legacy sensor are plotted versus values from the NW and SE RSA sensors, for a total of 50 data points. Average wind speeds varied from 4 to 10 knots with the RSA values mostly along the 1:1 diagonal, but with a larger dispersion than shown in Figure 9 for Tower 301. The average wind speeds for all five levels and all five days were 6.60 kts (Legacy), 6.27 kts (RSA NW), and 5.88 kts (RSA SE). The RSA SE sensor at 204 ft showed consistently lower values than the Legacy sensor, whereas the RSA SE sensor at 12 ft showed the highest positive departure from the Legacy sensor. This suggests that instrument calibration may be partly responsible for the differences, because the wind directions at 204 and 12 ft were similar throughout the POR, giving the sensors similar exposure to the wind.

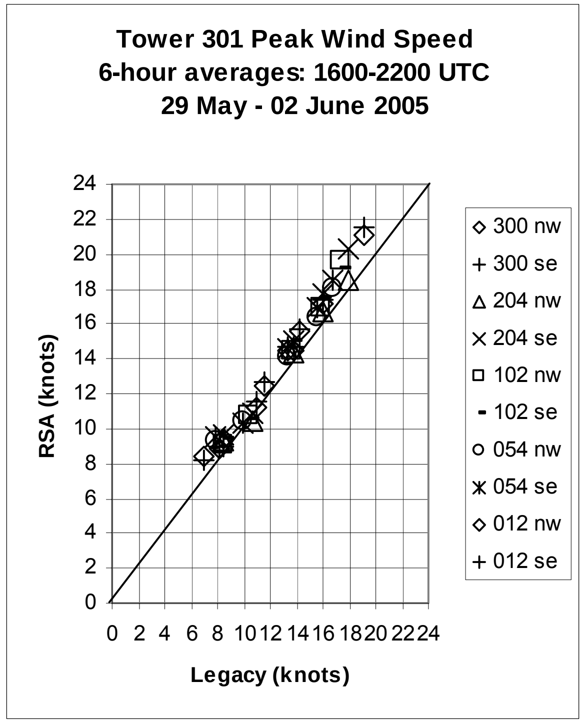


Figure 10. The Legacy versus RSA peak wind speed data from NW and SE sensors on five levels (300, 204, 102, 54, and 12 ft) of WR Tower 301 from the 6-hour interval 1600 – 2200 UTC on 29 May to 2 June 2005.

Figure 12 shows a comparison of peak wind speeds from Legacy and RSA sensors on Tower 300 for the 5-day POR. Each point represents an average of peak wind speeds over the 6-hour period 1600–2200 UTC on one day from one of the five levels on the tower. Average peak wind speeds from the Legacy sensor are plotted versus average peak wind speeds from the NW and SE RSA sensors. Average peak wind speeds varied from 6 to 14 knots with the RSA values mostly above the 1:1 diagonal by about 1 knot. The RSA sensor at 204 ft showed consistently lower values than the Legacy sensor, as in Figure 10. The average peak wind speeds for all five levels and all five days were 9.08 kts (Legacy), 9.38 kts (RSA NW), and 9.09 kts (RSA SE).

Contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Wheeler at 321-853-8205 or wheeler.mark@ensco.com for more information on this work.

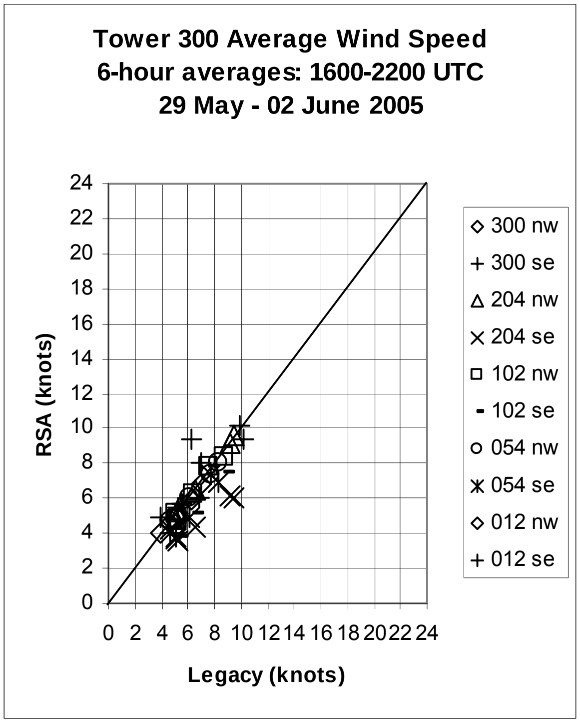


Figure 11. The Legacy versus RSA average wind speed data from NW and SE sensors on five levels (300, 204, 102, 54, and 12 ft) of WR Tower 300 from the 6-hour interval 1600 – 2200 UTC on 29 May to 02 June 2005.

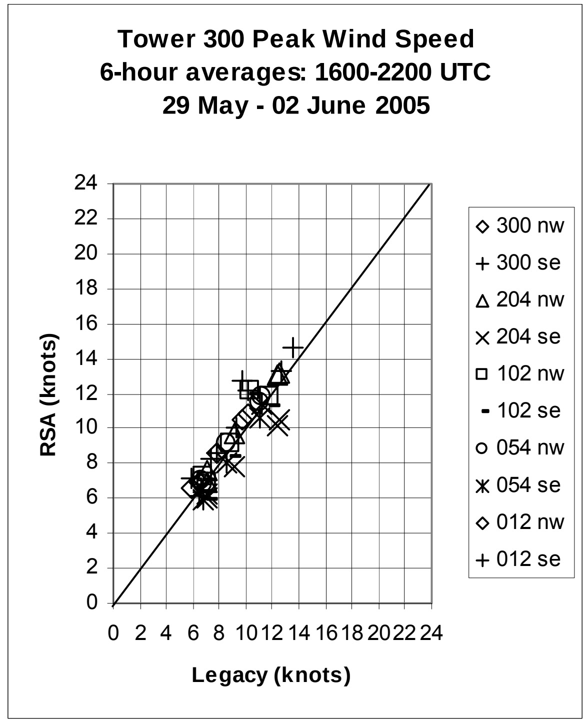


Figure 12. The Legacy versus RSA peak wind speed data from NW and SE sensors on five levels (300, 204, 102, 54, and 12 ft) of WR Tower 300 from the 6-hour interval 1600 – 2200 UTC on 29 May to 02 June 2005.

Updated Anvil Threat Corridor Forecast Tool (Mr. Wheeler)

The SMG forecasters and 45 WS launch weather officers identified anvil forecasting as one of their most challenging tasks when attempting to predict the probability of LCC or FR violations due to the threat of natural and triggered lightning. The work in Phase II (Short and Wheeler 2002) of the anvil forecasting effort resulted in the implementation of an operational anvil nowcasting tool in MIDDS that uses sounding data to estimate the length and orientation of anvils that might form during the day. The tool itself is a graphical overlay of an anvil threat sector on a weather satellite image centered over a user-selectable station. In Phase III (Wheeler and Short 2003), the tool was enhanced with the capability to use model forecast winds in addition to observed winds to create anvil threat sectors with lead times from 1 to 72 hours. Since these two tasks were completed, the operational sounding data processing system, the available model data, and the file format of the model data have all changed. As a result, the AMU was tasked to modify the existing software that creates the anvil tool to accommodate these changes and allow continued use of the tool. Once completed, the AMU will add the capability to run the anvil tool through a drop-down menu on the MIDDS GUI to allow for easier and faster access to the anvil tool.

The anvil tool developed in Phases II and III consists of a Man Computer Interactive Data Access System (McIDAS) BASIC Language Interpreter (McBASI) script that computes the average upper-level wind speed between 300 and 150 mb. The wind speed is calculated from the most current sounding or from either the Eta or Medium Range Forecast (MRF) models. Three major changes have since taken place in the data used to calculate the anvil threat sector:

- The operational sounding analysis system changed from the Meteorological Sounding System to the Automated Meteorological Profiling System (AMPS),
- The model names changed from Eta and MRF to the North American Model (NAM) and Global Forecast System (GFS), respectively, and

- The model data file format changed from Meteorological Data to Network Common Data Format (NetCDF).

These issues have an effect on the operation of the tool and modifications are needed in the script to accommodate them. The customers also requested that Rapid Update Cycle (RUC) model data be made available for use in the tool.

Mr. Wheeler began reviewing the McBASI code and documenting the required user inputs and data flow. He also reviewed several Tool Command Language (TCL) programming books and existing TCL scripts to get a better understanding of what is needed to develop the drop-down menu to provide access to running the anvil tool through the MIDDS GUI. He made a sketch of a possible user parameter selection screen for the drop-down menu that included items such as site, model, and forecast hour.

Mr. Paul Wahner of CSR provided a script that ingests the new NetCDF model data format. It searches the GFS, NAM or RUC model database and retrieves an index number that identifies the starting point of the model and station data within the data structure. Mr. Wheeler modified the anvil tool McBASI script to use this index number and new model data format and began tests to ensure the script works properly after the changes.

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

Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) Algorithm (Mr. Gillen and Dr. Merceret)

Lightning LCC (LLCC) and FR are used for all launches and landings, whether Government or commercial, using a Government or civilian range. These rules prevent natural and triggered lightning strikes to space vehicles, which can endanger the vehicle, payload, and general public. The current LLCC for anvil clouds, meant to avoid triggered lightning, have been shown to be overly conservative. They ensure safety, but falsely warn of danger and lead to costly launch delays and scrubs. A new LLCC for anvil clouds, and an associated radar algorithm needed to evaluate that new LLCC, were developed using data collected by the Airborne Field Mill (ABFM) research program managed by KSC which conducted a performance analysis of the VAHIRR algorithm from a safety perspective. The results suggested that this algorithm would assist forecasters in providing a lower rate of missed launch opportunities with no loss of safety compared with current LLCC. The VAHIRR algorithm, needed to evaluate the new LLCC, should be implemented on the WSR-88D as it is the only radar available to most current and future users. The AMU will develop the new VAHIRR algorithm for implementation in the WSR-88D system under Option Hours funding. Mr. Gillen and software engineers of ENSCO, Inc. will work closely with key personnel at the Radar Operations Center (ROC) in Norman, OK and NASA to ensure smooth and proper transition of this product into operations.

Algorithms to be included in the software baseline for WSR-88D radar systems must undergo a formal approval process. The first step in this process is approval from the Technical Advisory Committee (TAC), followed by approval from the Software Requirements Evaluation Committee (SREC). Prior to the TAC meeting, Mr. Gillen and Dr. Merceret held discussions with ROC personnel to identify the required presentation materials for the TAC. These included a formal request-for-change document to identify product requirements and completion of the TAC Template. Mr. Crum drafted the initial request-for-change form that was then revised by Dr. Merceret and Mr. Madura representing NASA, Mr. Lafosse representing the NWS, Mr. Roeder representing the 45 WS, and Ms. Shelton-Mur representing the Federal Aviation Administration. Dr. Merceret and Mr. Gillen completed the template and a presentation summarizing the template for the meeting. The TAC meeting was held on 29 April 2005. Attending via teleconference were Dr. Merceret, Dr. Bauman, and Mr. Gillen. Points of emphasis at the meeting included a summary of the ABFM program, which led to the development of the VAHIRR algorithm, reasons why the algorithm should be included in the WSR-88D software baseline, and a schedule of the development effort. Although there was some reservation by TAC members on the need to include the algorithm in the WSR-88D baseline, the TAC approved the VAHIRR algorithm for the SREC meeting in June.

The SREC meeting also required the submission of a template and presenting the material to the SREC. Dr. Merceret and Mr. Gillen generated the SREC material and Mr. Gillen attended the meeting on 15 June 2005 in Norman, OK with support from Dr. Merceret and Mr. Madura via teleconference. Prior to the meeting, Dr Merceret and Mr. Gillen agreed not to push for the VAHIRR to be included to Build 9 (Spring 2006 release) but rather wait for Build 10. The reasons were uncertainty regarding the resource load on the WSR-88D hardware for the VAHIRR algorithm and to allow for time to address concerns raised by the TAC regarding the concept of operations for use of the VAHIRR algorithm.

The development of the VAHIRR algorithm will proceed using a WSR-88D Radar Product Generator clone to generate the VAHIRR product using the Level-II radar data from the Melbourne WSR-88D site. The development team completed the initial software in preparation for code review in mid-July. The development environment provided by the ROC provided extensive documentation for use by the team but did require a longer than expected learning curve. Ms. Miller consulted with the with ROC developers to overcome the learning curve issues. The VAHIRR algorithm generates a value for each grid-point in a horizontal plane based on an 11x11 km column above that and adjacent grid points. To calculate the values, the development team opted for a two-pass approach to compute the final VAHIRR values. The first pass will calculate the required parameters; bottom of cloud, top of cloud, average reflectivity, and number of reflectivity samples, at each grid point. The second pass will use these parameters to calculate the VAHIRR values based on the grid points in the 11 x 11 km column. Several methods to calculate the VAHIRR in the second pass are being considered to reduce computation time.

Contact Mr. Gillen at 321-783-9735 ext. 210 or gillen.robert@ensco.com, or Dr. Merceret at 321-867-0818 or Francis.J.Merceret@nasa.gov for more information on this work.

MESOSCALE MODELING

Mesoscale Model Phenomenological Verification Evaluation (Ms. Lambert)

Forecasters at SMG, 45 WS, and NWS MLB use model output data on a daily basis to make their operational forecasts. Models such as ARPS, RUC, NAM, and GFS aid in forecasting such phenomena as low- and upper-level winds, cloud cover, timing and strength of the sea breeze, and precipitation. Given the importance of these model forecasts to operations, methods are needed to verify model performance. Recent studies have indicated that traditional objective point statistics are insufficient in representing the skill of mesoscale models, and manual subjective analyses are costly and time-consuming. They also concluded that verification of local mesoscale models should be more phenomenologically-based. The AMU was tasked to determine if objective phenomenological verification tools exist in the literature that can be transitioned into operations. Candidate techniques will be identified through a literature search, and then the feasibility of implementing the techniques operationally in the AWIPS at SMG, NWS MLB, and the 45 WS will be assessed.

Ms. Lambert found four more articles that provide descriptions of objective verification techniques at various stages of development. None were developed or were ready for use in operations. She also spoke with Ms. Jennifer Mahoney of FSL about current operational verification techniques and whether any of them are phenomenologically-based. She stated that, while there is much research being conducted in this area, no one phenomenological-based verification technique has proven robust or reliable enough to verify operational or archived model data. Many issues still remain, such as how to identify a specific phenomenon objectively, what parameters should be used, and what threshold values are appropriate. Ms. Mahoney estimated that such a reliable technique may be available in 5–10 years given the current rate of scientific advancements in the research. She also stated that one particular technique described in Ebert and McBride (2000) is gaining favor among several researchers. This article is included in the set collected by Ms. Lambert.

For more information on this work, contact Ms. Lambert at lambert.winnie@ensco.com or 321-853-8130.

ARPS Optimization and Training Extension (Mr. Case)

As the ARPS prognostics and ARPS Data Analysis System (ADAS) diagnostics mature for increased operational use, the NWS MLB and SMG require increased accessibility to AMU resources to ensure the most beneficial evolution of these systems. The NWS MLB plans to ingest several new data sets into ADAS, and the operational configuration will be ported to a Linux workstation. In addition, the NWS MLB requires assistance to upgrade the ARPS system to the latest version. The NWS MLB also desires to switch from the RUC 40-km hybrid coordinate fields to the RUC 20-km pressure coordinate fields to use as background fields for ARPS simulations. Finally, a limited examination of several ARPS warm-season convective cases will be necessary to offer suggestions for adaptable parameter modifications leading to improved forecasts of convective initiation and coverage. Therefore, the AMU was tasked to develop routines for incorporating new observational data sets into the operational ADAS and provide the NWS MLB with assistance in making the upgrades and improvements described above.

Mr. Case identified and corrected a significant bug in the post-processing of ARPS/ADAS that affected the derived radar reflectivity product. The reflectivity should be derived from liquid and ice precipitation particles, but the ice particles were not being diagnosed. As a result, the reflectivity aloft was underrepresented and the overall composite reflectivity field had too little coverage, particularly with respect to thunderstorm anvils. By correcting this bug, the composite reflectivity fields now have a more accurate depiction of the liquid and ice fields in ARPS/ADAS.

Mr. Case also completed a real-time configuration of ARPS in the AMU computer lab to support work on convective forecast sensitivity tests for this task. To mimic the NWS MLB and SMG configurations, he obtained many of the same real-time data sets that are analyzed by ADAS at the customer offices. To acquire these data sets, Mr. Case set up the Local Data Manager software on an AMU workstation and coordinated with SMG, Marshall Space Flight Center (MSFC), and ENSCO IT personnel. Once data sharing permissions and utilities were established, the AMU began receiving real-time Level II Doppler radar data for all Florida radar sites from MSFC, and surface observations and satellite data from SMG. These data are currently being assimilated into real-time ARPS model runs on the AMU Linux cluster.

Mr. Case ran the real-time ARPS and archived the data during the last two days of May and all of June. Many different convective scenarios occurred during this time period, including a tropical cyclone. These data will be beneficial in performing additional simulations to examine the sensitivity of ARPS to different input parameters and boundary conditions.

Contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com for more information on this work.

User Control Interface for ADAS Data Ingest (Mr. Keen and Mr. Case)

The integrity of real-time, continuous diagnostic grids from the operational ADAS has become very important, with a requirement to be operationally managed at the forecaster level. Forecasters at NWS MLB and SMG have the need for a user-friendly GUI in order to quickly and easily interact with ADAS to maintain or improve the integrity of each 15-minute analysis cycle. The intent is to offer operational forecasters the means to manage and quality control the observational data streams ingested by ADAS without any prior expertise of ADAS required. Therefore, the AMU was tasked to develop a GUI tool to help forecasters manage the data sets assimilated into ADAS.

Mr. Keen installed a fully-functional version of the control GUI in April. Based on customer feedback, several new features were incorporated as well as modifications to existing capabilities. The new features include an orderly start/stop of the ADAS cycle, control over the super observation parameter, color-coding of different observation types, symbol changes for stations that are quality-controlled, and the capability to include or exclude a variable for an entire observation group. Mr. Keen will complete the GUI modifications and install a new version in July.

Contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com, or Mr. Keen at 321-783-9735 x248, or keen.jeremy@ensco.com for more information on this work.

AMU CHIEF'S TECHNICAL ACTIVITIES (Dr. Merceret)

Dr. Merceret and Mr. Gillen prepared and presented a briefing on the VAHIRR to the NEXRAD TAC (see VAHIRR section above). Dr. Merceret is preparing a manuscript for submission to the Journal of Applied Meteorology reporting the results of the recent boundary layer wind climatologies that were prepared for MSFC. He also began work on developing structure function software for analysis of the Shuttle roll maneuver regime from 915-MHz wind profiler data as requested by the Natural Environments Group at MSFC.

AMU VISITING SCIENTISTS

Dr. James Koermer and Mr. Andrew Loconto arrived at the AMU in June as visiting scientists to spend the summer working on convective winds. Dr. Koermer is a Professor of Meteorology and the Director of the Judd Gregg Meteorology Institute at Plymouth State University (PSU) in Plymouth, NH and Mr. Loconto is a graduate student in the PSU MS program in Applied Meteorology. Winds from thunderstorms require the second most frequent warning products (after lightning) issued by the 45 WS for CCAFS and KSC areas. The long lead-times and precise speed thresholds of these convective wind warnings make them an extreme challenge. The initial focus of the PSU team was on updating the warm season convective wind climatology for the area by analyzing 9 years of observations from over 40 towers on or near the KSC/CCAFS complex. During this process, they manually reviewed all cases of wind reports greater than or equal to 35 knots in order to separate out probable bad reports and pressure gradient induced events from the convectively driven events. They will continue developing a more complete climatology and then identifying possible forecast indicators for strong convective wind outbreaks versus weaker events. Their work is supported by NASA Space Grant Workforce Development Funds.

AMU OPERATIONS

Mr. Wheeler setup two cubicles and configured and installed new software on two desktop PCs in support of visiting scientists during the summer. He continued configuring and installing Linux workstations that will replace the AMU's UNIX workstations. He repaired a node on the AMU Model cluster and updated the workstation and Linux backup procedures. He also received all IT equipment and software that was ordered for FY 05.

Mr. Case conducted the annual industrial security review of the AMU contract with Mrs. Kathleen Futch of the 45th Space Wing. All areas reviewed were in compliance with the National Industrial Security Program Operating Manual and a rating of Satisfactory was assigned.

All AMU personnel participated in a teleconference discussing the contents of the AMU Quarterly Report for the Second Quarter of FY 2005. Other teleconference participants included personnel from the 45 WS, SMG, NWS MLB, 30 WS, and the KSC Weather Office. All AMU personnel also participated in a June tasking meeting. This meeting was called after the AMU's Lightning Cessation task was transferred to a student at FSU, requiring another task to be chosen to replace it. The new task involves updating the Anvil Tool on the AWIPS.

Mr. Case attended a Florida mesonet conference/workshop in Jacksonville, FL on 5–6 April, hosted by the University of North Florida, and the annual Weather Research and Forecasting (WRF) model workshop in Boulder, CO from 27–30 June. Mr. Wheeler attended the RSA Technical Interchange Meeting in Boulder, CO from 8–9 June.

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List of Acronyms

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
ADAS	ARPS Data Analysis System
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMPS	Automated Meteorological Profiling System
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
AWIPS	Advanced Weather Interactive Processing System
CAPE	Convective Available Potential Energy
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground
CGLSS	CG Lightning Surveillance System
CSR	Computer Sciences Raytheon
CT	Cross Totals
CWA	County Warning Area
EDT	Eastern Daylight Time
ER	Eastern Range
EST	Eastern Standard Time
FM	Fawbush-Miller
FMaxT	Forecast Maximum Temperature
FR	Flight Rules
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GFS	Global Forecast System
GUI	Graphical User Interface
JSC	Johnson Space Center
KI	K-Index
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LLCC	Lightning LCC
LI	Lifted Index
McBASI	McIDAS BASIC Language Interpreter
McIDAS	Man Computer Interactive Data Access System
MIDDS	Meteorological Interactive Data Display System
MRF	Medium Range Forecast
MSFC	Marshall Space Flight Center
NAM	North American Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCDC	National Climatic Data Center
NetCDF	Network Common Data Format
NLDN	National Lightning Detection Network
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NW	Northwest
NWS MLB	National Weather Service in Melbourne, FL
NWS TAE	National Weather Service in Tallahassee, FL
PC	Personal Computer
PMHS	Potential Maximum Hail Size
POR	Period of Record
PW	Precipitable Water
QC	Quality Control
ROC	Radar Operations Center
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
SE	Southeast
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SREC	Software Recommendation and Enhancement Committee
SRH	NWS Southern Region Headquarters
SSI	Showalter Stability Index
TAC	Technical Advisory Committee
TCL	Tool Command Language
TI	Thompson Index
TPS	Thunderstorm Probability Study
TT	Total Totals
USAF	United States Air Force
UTC	Universal Coordinated Time
VAHIRR	Volume Averaged Height Integrated Radar Reflectivity
WB0	Wet-Bulb Zero Temperature
WR	Western Range
WRF	Weather Research and Forecasting Model
WSR-88D	Weather Surveillance Radar 1988 Doppler
WWW	World Wide Web
XMR	CCAFS Sounding 3-letter Identifier

Appendix A

AMU Project Schedule
31 July 2005

AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Objective Lightning Probability Phase I	Literature review and data collection/QC	Feb 03	Jun 03	Completed
	Statistical formulation and method selection	Jun 03	Oct 03	Completed, but delayed due to errors found in COTS software
	Equation development, tests with verification data and other forecast methods	Aug 03	Nov 03	Completed, but delayed due to errors found in COTS software
	Develop operational products	Nov 03	Jan 04	Completed, but delayed as above and due to hurricane evacuations
	Prepare products, final report for distribution	Jan 04	Mar 04	External review of final report completed
Severe Weather Forecast Tool	Local and national NWS research, discussions with local weather offices on forecasting techniques	Apr 03	Sep 03	Completed
	Develop database, develop decision aid, fine tune	Oct 03	Apr 04	Completed, but delayed due to higher priority Shuttle Ascent Camera Cloud Obstruction Forecast Task
	Final report	May 04	Jun 04	External review of final report completed
Stable Low Cloud Evaluation	Gather data, develop database	Oct 04	Jan 05	Completed
	Identify, classify weather characteristics of events	Jan 05	Jul 05	On Schedule
	Gather data, develop database	Aug 05	Oct 05	On Schedule
Hail Index	Evaluate Current Techniques	Aug 04	Feb 05	Completed
	Memorandum	Mar 05	May 05	Delayed to complete memorandum

AMU Project Schedule 31 July 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Shuttle Ascent Camera Cloud Obstruction Forecast	Develop 3-D random cloud model and calculate yes/no viewing conditions from optical sites for a shuttle ascent	Jan 04	Jan 04	Completed
	Analyze optical viewing conditions for representative cloud distributions and develop viewing probability tables	Feb 04	Feb 04	Completed
	Memorandum	Feb 04	Jan 05	On stand-by for additional work at Launch Director's request
Situational Climatology of CG Lightning Flash Counts	Collect NLDN data and FORTRAN code from Florida State University and NWS Tallahassee	Apr 05	Jun 05	Completed
	Analyze and test code on AMU or NWS system	Jul 05	Aug 05	On Schedule
	Modify code to produce desired gridded output, deliver code and output to NWS MLB	Aug 05	Oct 05	On Schedule
	Memorandum	Nov 05	Dec 05	On Schedule
Forecasting Low-Level Convergent Bands Under Southeast Flow	Develop standard data/graphics archive procedures to collect real-time case study data	Apr 05	Apr 05	Completed
	Collect data real-time during southeast flow days	Apr 05	Jan 06	On Schedule
	Data analysis	Jul 05	Feb 06	On Schedule
	Final report	Feb 06	Mar 06	On Schedule
RSA/Legacy Sensor Comparison	Data Collection and Pre-Processing	Dec 04	May 05	Completed, but delayed due to request for more data
	Data Evaluation	Dec 04	Jun 05	Delayed for analysis of new data
	Final Report	July 05	Sep 05	On Schedule
Updated Anvil Threat Corridor Forecast Tool	Software Requirements Review and Graphical User Interface Development	Jun 05	Jul 05	On Schedule
	Testing and Memorandum	Aug 05	Sep 05	On Schedule

AMU Project Schedule 31 July 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Volume-Averaged Height Integrated Radar Reflectivity (VAHIRR)	Acquisition and setup of development system and preparation for Technical Advisory Committee (TAC) meeting	Mar 05	Apr 05	Completed
	Software Recommendation and Enhancement Committee (SREC) meeting preparation	Apr 05	Jun 05	Completed
	VAHIRR algorithm development	May 05	Oct 05	On Schedule
	ORPG documentation updates	Jun 05	Oct 05	On Schedule
	Preparation of products for delivery and memorandum	Oct 05	Jan 06	On Schedule
Mesoscale Model Phenomenological Verification Evaluation	Literature search for studies in which phenomenological or event-based verification methods have been developed	Jun 04	Jan 05	Completed, but delayed due to COTS software issues found in the Objective Lightning task
	Determine operational feasibility of techniques found in the literature	Jul 04	Jan 05	Completed
	Final Report	Jan 05	Mar 05	Delayed as above
ARPS/ADAS Optimization and Training Extension	Provide the NWS Melbourne with assistance in upgrading to ARPS version 5.x.	Aug 04	Dec 04	Completed
	Provide the NWS Melbourne with assistance in porting the operational ADAS to a Linux workstation	Oct 04	Jan 05	Completed
	Assist the NWS Melbourne in upgrading to the 20-km RUC pressure coordinate background fields	Oct 04	Jan 05	Withdrawn
	Develop routines for incorporating new data sets into ADAS	Dec 04	May 05	Completed
	Examine a limited number of warm-season convective cases	May 05	Jul 05	On Schedule
User Control Interface for ADAS Data Ingest	Develop control graphical user interface (GUI)	Apr 04	Jan 05	Completed
	Installation assistance and documentation	Jan 05	Mar 05	Delayed to implement necessary modifications

AMU Project Schedule 31 July 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
Operational Weather Research and Forecasting (WRF) Model Implementation	Hardware performance comparison study	Jul 05	Aug 05	On Schedule
	Configure and test WRF with ADAS initialization	Aug 05	Apr 06	On Schedule
	Modify ADAS GUI to Control WRF Initialization and Run-Time	Jan 06	Apr 06	On Schedule
	Operational Implementation and Memorandum	Apr 06	Jun 06	On Schedule

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