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# Applied Meteorology Unit (AMU) Quarterly Report

Second Quarter FY-07 Contract NNK06MA70C 30 April 2007



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# Executive Summary

*This report summarizes the Applied Meteorology Unit (AMU) activities for the second quarter of Fiscal Year 2007 (January - March 2007). A detailed project schedule is included in the Appendix.*

Task: Objective Lightning Probability Tool: Phase II

*Goal* Update the lightning probability forecast equations used in 45th Weather Squadron (45 WS) operations with new data and create a graphical user interface (GUI) in the Meteorological Interactive Data Display System (MIDDS) that automatically gathers the data needed as input to the equations developed in Phase I of this task. The new data may improve the performance of the equations, and the automated tool will increase forecaster efficiency.

*Milestones* Created new lightning probability forecast equations and conducted four tests to determine their performance compared to the equations currently used in 45 WS operations.

*Discussion* The results from the four tests showed that the new equations outperform the current equations. The percent improvement in skill of the new equations over the warm season is 8%, they have better reliability, are able to distinguish lightning days more accurately, and have superior accuracy measures. Therefore, these new equations will replace the current operational equations before the 2007 warm season.

Task: Peak Wind Tool for General Forecasting

*Goal* Develop a tool to forecast the peak wind speed for the day from the surface to 300 ft on Kennedy Space Center (KSC)/Cape Canaveral Air Force Station (CCAFS) during the cool season (October – April). The tool should be able to forecast the timing of the peak wind speed and the background average wind speed, based on observational data available for the 45 WS 0700L weather briefing.

*Milestones* Briefed the 45 WS on the current status of the task; performed quality control on KSC/CCAFS wind tower data; and classified each cool season day from October 2002 to February 2007 into one of six categories based on the synoptic weather pattern in addition to the four categories based on the existence of an inversion and precipitation.

*Discussion* Composite wind speed and temperature profiles from the surface to 5000 feet aloft based on the six synoptic weather patterns, as well as the four categories based on inversions and precipitation revealed distinct differences in speeds. Days with an inversion and no precipitation had the lightest winds, while days with precipitation and no inversion had the strongest winds. Wind speeds aloft were similar for days with surface fronts approaching, over, or south of Central Florida. Winds were weakest aloft with surface high pressure over Florida.

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**Distribution (continued from Page 1)**

NWS Southern Region HQ/"W/SR"/ S. Cooper
NWS Southern Region HQ/"W/SR3" D. Billingsley
NWS/"W/OST1"/B. Saffle
NWS/"W/OST12"/D. Melendez
NSSL/D. Forsyth
30 WS/DO/J. Kurtz
30 WS/DOR/M. Barnhill
30 WS/DOR/S Storr
30 WS/SY/M. Schmeiser
30 WS/SYR/D Vorhees
30 SW/XPE/R. Ruecker
Det 3 AFWA/WXL/K. Lehneis
NASIC/FCTT/G. Marx
46 WS//DO/J. Mackey
46 WS/WST/C. Chase
412 OSS/OSWM/P. Harvey
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ENSCO, Inc./E. Lambert
ENSCO, Inc./A. Yersavich
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# Executive Summary, *continued*

Task Situational Lightning Climatologies for Central Florida, Phase II

Goal Create the climatological probability of lightning occurrence and mean number of strikes for each flow regime as in Phase I for the two 12-hour periods 0000–1200 and 1200–2400 UTC, and in 5-, 10-, 20-, and 30-n mi circles surrounding the Shuttle Landing Facility (SLF) in 1-, 3-, and 6-hour increments. The 12-hour climatologies will be used by the forecasters at the National Weather Service in Melbourne, FL (NWS MLB) to update their daily lightning threat index map. The SLF climatologies will aid in the aviation forecast requirements at NWS MLB, and provide a tool to the Spaceflight Meteorology Group (SMG) that will assist them in making forecasts for Flight Rule violations of lightning occurrence during a shuttle landing.

Milestones Modified the FORTRAN code to create 12-hour climatologies and delivered the updated code to NWS MLB.

Discussion The code that produced the 6-hour and 24-hour climatologies in Phase I was updated to the create 12-hour climatologies. The third and final part of this task to develop climatologies for 5-, 10-, 20- and 30-n mi range rings at the SLF was started at the end of this quarter.

Task Anvil Threat Corridor Forecast Tool in AWIPS

Goal Migrate the Anvil Threat Corridor Forecast Tool from MIDDS to the Advanced Weather Interactive Processing System (AWIPS). This tool is used in launch and landing operations to determine the threat from natural or triggered lightning due to flight through anvil cloud. The SMG is depending more on AWIPS for operations and the 45 WS plans to replace MIDDS with AWIPS. The 45 WS and SMG requested that the AMU transition the anvil tool to AWIPS to ensure it will remain available for operations.

Milestones Added several enhancements to the tool, and increased the accuracy of the layer-averaged wind and anvil threat corridor graphic calculations. Wrote a document describing all of the tests performed on the tool. Wrote draft copies of the User's Guide and the final report.

Discussion Based on extensive testing by SMG, the 45 WS, and the AMU, several changes were made to the software. These changes made the tool more accurate and easier to use. Draft copies of the User's Guide and the final report were written and given to SMG and the 45 WS for feedback.

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# Executive Summary, *continued*

Task — Volume Averaged Height Integrated Radar Reflectivity (VAHIRR)

*Goal* Transition the VAHIRR algorithm into operations using Weather Surveillance Radar 1988 Doppler (WSR-88D) data. The previous lightning launch commit criteria (LLCC) for anvil clouds to avoid triggered lightning were restrictive and lead to unnecessary launch delays and scrubs. The VAHIRR algorithm was developed as a result of the Airborne Field Mill program as part of 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 previous LLCC.

*Milestones* Determined that additional software development is necessary to modify the method of calculating the height and thickness of clouds. Completed a procedure by modifying an SMG script that allows VAHIRR radar products to be sent automatically to the AMU AWIPS. Created an AWIPS application that will plot launch trajectories over VAHIRR radar products.

*Discussion* The VAHIRR software will be modified to increase the accuracy of the cloud height and thickness calculations, account for the radar elevation above sea level, and address the radar cone-of-silence. The AMU AWIPS was modified so that the VAHIRR product can be displayed through the product menus.

Task — Tower Data Skew-t Tool

Goal The rapid reduction in visibility and ceiling associated with marine incursions is a concern to 30th Weather Squadron (30 WS) forecasters during launch operations at Vandenberg Air Force Base (VAFB). Such conditions are a launch safety concern for new launch vehicles that require they be viewable by remote cameras until radar lock-on. The 30 WS developed the Tower Data Skew-t Tool to help monitor the progress of marine-layer incursions. The AMU will evaluate the effectiveness of this tool for the 30 WS.

Milestones Reviewed the task plan and began collecting the data for the evaluation.

Discussion The 30 WS provided data from eight wind towers and the soundings at VAFB collected during August 2006. The tower data include temperature and humidity measurements at 6 ft, and wind direction and speed at 12 and 54 ft. The VAFB hourly surface observations for the same time period were also collected.

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# Executive Summary, *continued*

| | |
|---|---|
| <u>Task</u> | <u>Weather Research and Forecasting (WRF) Model Sensitivity Study</u> |
| *Goal* | Conduct several WRF sensitivity case studies to determine the best configuration to use operationally at SMG and NWS MLB for predicting warm season convective initiation. Determining the best model configuration will assist forecasters in their short-term thunderstorm forecasting for the general public and evaluating flight rules and launch commit criteria. |
| *Milestones* | Configured the Local Analysis and Prediction System (LAPS) software to initialize the WRF model. Completed all LAPS/Advanced Regional WRF (ARW) and LAPS/ Non-hydrostatic Mesoscale Model (NMM) runs within the WRF Environmental Modeling System (EMS) framework. Completed all local high-resolution 2-way and 1-way nested model runs using LAPS/ARW. Determined best objective precipitation verification technique for this study with customer input. |
| *Discussion* | The satellite data conversion issue was resolved and LAPS was able to be fully configured. The LAPS/ARW and LAPS/NMM 4-km models both forecast too much precipitation compared to the observations. The 2-way and 1-way nested model comparisons showed little difference between them. |

# 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 Tool: Phase II (Ms. Lambert)

The 45th Weather Squadron (45 WS) forecasters include a probability of lightning 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) and Cape Canaveral Air Force Station (CCAFS). The AMU developed a set of logistic regression equations that calculate the probability of lightning occurrence in Phase I of this task (Lambert and Wheeler 2005). These equations outperformed several standard forecast methods used in operations. The graphical user interface (GUI) developed in Phase I allows forecasters to interface with the equations by entering parameter values to output a probability of lightning occurrence. The forecasters must gather data from the morning sounding and other sources, then manually input that data into the GUI. The 45 WS requested that a tool be developed on the Meteorological Interactive Data Display System (MIDDS) that retrieves the required parameter values automatically for the equations to calculate the probability of lightning for the day. This will reduce the possibility of human error and increase efficiency, allowing forecasters to do other duties. The 45 WS requested the AMU to add the warm season data from the years 2004 and 2005 to the Phase I 15-year 1989–2003 data set. They also requested modifications to the predictors in the hope of improving equation accuracy.

#### *New Equations*

Ms. Lambert developed five new lightning probability forecast equations, one for each month in the warm season, using the development dataset that consisted of 14 warm seasons. She followed the same iterative procedure for choosing the predictors as outlined in Lambert and Wheeler (2005). The procedure involved adding one predictor at a time and checking the associated reduction in residual deviance. A large reduction in residual deviance meant that a predictor accounted for a large percentage of the variance in the predictand. Therefore, Ms. Lambert chose the predictors that effected the largest reduction. She stopped adding predictors as soon as a candidate predictor accounted for < 0.5% of the reduction in residual deviance.

Figure 1 shows the percent reduction in residual deviance from the NULL model as each predictor was added for the June equation. The Thompson Index (TI) reduced the residual deviance the most (19%) and was, therefore, the first predictor in the June equation. The second predictor was flow regime lightning probability (FRProb), which accounted for an additional 9% reduction. One-day persistence (Pers) was the third predictor, reducing the residual deviance by 1%, and so on. For June, the average relative humidity in the 825-525 mb layer (Avg.85.RH) reduced the residual deviance by 0.9%, but the daily climatology (Climo) reduced it by only 0.1%. Therefore, Climo was not chosen for the June equation, which consists of the predictors TI, FRProb, Pers, Vertical Total (VT), and Avg.85.RH.

Table 1 shows the final predictors for each of the monthly equations in rank order of their reduction in residual deviance. The second most important predictor in every month was FRProb. The FRProbs for each month are strong predictors on their own (Lambert 2006), so it was expected that they would account for a large part of the reduction in residual deviance. Adding the CCAFS sounding to determine the flow regime likely increased the accuracy in determining the correct flow regime for the day and, therefore, the value of the predictor.

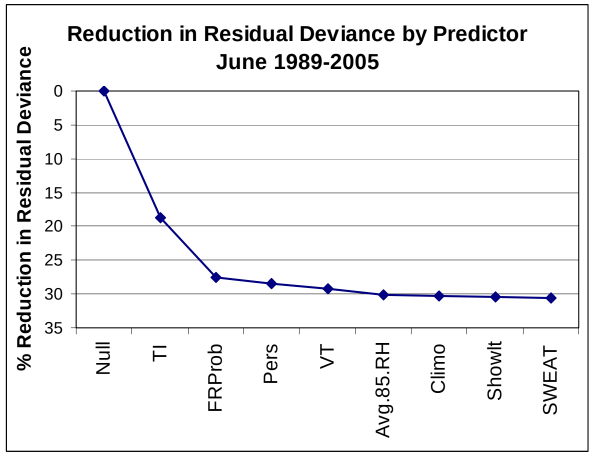


**Figure 1. The total percent reduction in residual deviance from that of the NULL model as each predictor was added to the equation using the June development dataset.**

The predictors Pers and VT were chosen for four of the five equations. It is possible to conclude that VT was chosen for all five equations since it is an element in the calculation of Total Totals, a predictor in July. A similar conclusion could be drawn for the K-Index (KI), which was only used explicitly in the May equation as the first predictor. The June, July, and August equations have TI as the most important predictor, but TI is calculated by subtracting the Lifted Index from KI.

**Table 1. The final predictors for each monthly equation, in rank order of their contribution to the reduction in residual deviance. The predictors in red font were in every equation, the predictors in blue font were in four of the five equations, the predictors in green were in three of the five equations, and the predictors in black were in only one equation.**

| ***May*** | ***June*** | ***July*** | ***August*** | ***September*** |
|---|---|---|---|---|
| K-Index | Thompson Index | Thompson Index | Thompson Index | 825–525 mb RH |
| Flow Regime | Flow Regime | Flow Regime | Flow Regime | Flow Regime |
| Vertical Total | Persistence | Total Totals | Daily Climatology | Persistence |
| Daily Climatology | Vertical Total | Persistence | 825–525 mb RH | Vertical Total |
| Persistence | 825–525 mb RH | | Vertical Total | Daily Climatology |

***Equation Testing***

Ms. Lambert tested the performance of the equations using the verification dataset, which consisted of three warm seasons. None of the days in the verification set were contained in the development set to allow for an independent evaluation of performance. The first step was to determine if the new equations showed improvement in skill over five forecast benchmarks. Four of the benchmarks were the same as those in the Phase I task: Pers, Climo, FRProb, and monthly climatology. The fifth was the forecasts produced by the equations developed in Lambert and Wheeler (2005) and currently used in operations, hereafter designated as the old equations.

The old equations were created using a larger valid area and flow regime probabilities that were determined from three, not four, Florida morning soundings. This made it difficult to calculate direct and fair differences in skill between the new and old equation sets. Ms. Lambert had several discussions with Mr. Roeder of the 45 WS to determine the best approach to ensure the fairest comparison in skill between the equation sets. They decided that the input parameters for the old equations should include data from the new POR and reflect the new area, since the new area represents the warning areas exactly. This included using the predictand, persistence, new daily climatology, and the flow regime lightning probabilities calculated for the new area. However, they decided to use flow regime lightning probabilities calculated with three soundings since that was the procedure employed to calculate the probabilities used in developing the old equations.

Ms. Lambert began the skill test by first calculating the mean squared error (MSE) between the forecasts and observations for all forecast methods. The MSE was calculated using the equation

$$\mathrm{MSE} = \frac{1}{n}\sum_{i=1}^{n}(p_i - o_i)^2 \quad \text{(Wilks 2006)},$$

where n is the number of forecast/observation pairs, $p_i$ is the probability associated with the forecast method, and $o_i$ is the corresponding binary lightning observation (Wilks 2006). She then calculated the skill of the new equations over the five forecast benchmarks using the equation for the Brier Skill Score (SS):

$$\mathrm{SS} = \left(\frac{\mathrm{MSE}_{eqn} - \mathrm{MSE}_{ref}}{\mathrm{MSE}_{perfect} - \mathrm{MSE}_{ref}}\right) * 100 \quad \text{(Wilks 2006)},$$

where $\mathrm{MSE}_{eqn}$ was the MSE of the new equations, $\mathrm{MSE}_{ref}$ was the forecast benchmark against which the new equations were tested, and $\mathrm{MSE}_{perfect}$ was the MSE of a perfect forecast, which is always 0. The SS represents a percent improvement or degradation in skill of the equation over the reference forecast when it is positive or negative, respectively.

The SS values for each of the monthly equations and a composite result for the entire warm season are shown in Table 2. The new equations show a double-digit improvement in skill for the first four benchmarks in the table, similar to the results for the old equations in Lambert and Wheeler (2005). They also show an 8% improvement in skill over the old equations for the entire warm season. For the individual months, the new equations show an improvement in skill for June, July, and September. The values of 0.2% for May and -0.8% for August are almost negligible and show similar skill between the new and old equations for these months. Ms. Lambert created and tested equations with varying sets of predictors for these two months in an attempt to improve the skill of the new equations. The predictors in the equations used to calculate the skill scores in Table 2 produced the best results with the verification dataset and were chosen using the method described in the previous section.

**Table 2. The percent (%) improvement (degradation) in skill of the new equations over the reference forecasts of persistence, daily and monthly climatologies, flow regime probabilities, and the 'old' equations developed in Lambert and Wheeler (2005). These scores were calculated using the verification data for each month and for the entire warm season (All).**

| *Forecast Method* | *May* | *Jun* | *Jul* | *Aug* | *Sep* | *All* |
|---|---|---|---|---|---|---|
| Persistence | 28 | 41 | 37 | 47 | 41 | 40 |
| Daily Climatology | 23 | 25 | 24 | 24 | 26 | 25 |
| Monthly Climatology | 29 | 27 | 34 | 30 | 25 | 29 |
| Flow Regime | 16 | 12 | 11 | 18 | 18 | 15 |
| Old Equations | 0.2 | 5 | 19 | (-0.8) | 12 | 8 |

Ms. Lambert stratified the old and new equation probability forecasts from all days in the verification dataset by lightning and non-lightning days, then created a probability distribution for each stratification. These distributions would show how well the equations distinguish between lightning and non-lightning days. Figure 2 shows the two probability distributions for lightning days, represented by the red curves, and non-lightning days, represented by the blue curves. For good performance, one would expect the blue curves to have a maximum in the lower probability values decreasing to a minimum at higher probability values, and the red curves to have a minimum in the lower probability values increasing to a maximum at the higher values.

Both blue curves for the non-lightning days in Figure 2 peak at a probability of 0.2, decrease rapidly through 0.4, and then decrease more slowly toward 1. This indicates good performance for both equation sets. However, the old equations distinguished non-lightning days with a bit more accuracy as evidenced by the higher peak of 59% versus 50% at 0.2 probability and the larger drop off to 21% versus 24% to 0.4. The percent occurrence for the old equations remained ~1% below those of the new equations from 0.4 to 1.

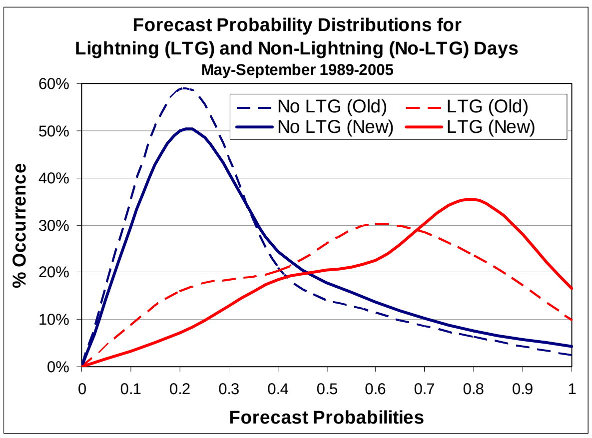


**Figure 2. Forecast probability distributions for lightning (red) and non-lightning (blue) days in the verification data. The solid lines represent the new equations and the dashed lines represent the old equations. The y-axis values are the frequency of occurrence of each probability value, and the x-axis values are the forecast probability values output by the equations.**

The red curve for the new equations indicates that they distinguish lightning days more accurately than the old equations. The percent occurrences of the new equation probabilities were lower than those for the old equations for all probability values less than 0.7, and higher for all probabilities greater than 0.7. The peak percent occurrence for the new equations was 36% at 0.8 probability, while the peak for the old equations was 30% at 0.6 probability.

The reliability diagrams for the old and new equations are shown in Figure 3. The black diagonal line represents perfect reliability, and the histogram in the lower right shows the number of observations in each probability bin for each method. Where the reliability curves are below the black line, the equations over-forecasted lightning occurrence, and where the curves are above the line, the equations under-forecasted lightning occurrence. The red curve for the new equations was closer to the perfect reliability diagonal than the blue curve for the old equations for all probabilities except fro 0.6 and 0.7. However, the frequency values for each forecast method at these probabilities were within 10% of each other. Overall, these curves demonstrate that the new equations have better reliability than the old.

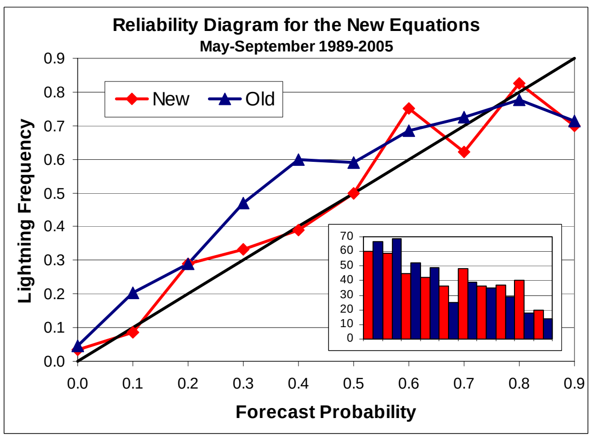


**Figure 3. Reliability diagram of the probability forecasts for all months. The black diagonal line represents perfect reliability, the blue curve represents the reliability of the old equations, and the red curve represents the reliability of the new equations. The histogram at the lower right shows the number of observations in each probability range for the old (blue) and new (red) forecast methods.**

The final test was to create contingency table statistics and determine a cutoff probability value for yes versus no lightning forecasts. Contingency table statistics are most appropriate for categorical forecasts in which a weather element is forecast to occur or not. It is less appropriate for probability forecasts that express levels of uncertainty in which no probability value in the range 0 – 1 is necessarily wrong or right (Wilks 2006). Nonetheless, it is a familiar method that can shed light on forecast performance provided an appropriate probability threshold value is defined above which the forecast will be 'yes' and below which the forecast will be 'no'. Wilks (2006) stated that the proper threshold to choose depends on the decision problem at hand. The original goal of Phase I was to create equations that perform better than persistence. Therefore, Ms. Lambert used the condition that the probability value chosen must outperform the Pers forecast for several contingency table values. This occurred at 0.47 for the new equations, and at 0.35 for the old equations. Using these as the cutoff values, Ms. Lambert found that the new equations outperformed one-day persistence and the old equations in every contingency-table statistic calculated. Table 3 shows the probability of detection (POD), false alarm rate (FAR) and HR for the old and new equations and their associated Pers forecasts.

**Table 3. A sample of the contingency table statistics for the new equations with a cutoff probability of 0.47, the old equations with a cutoff of 0.35, and the Pers forecasts.**

| ***Statistic*** | ***New (0.47)*** | ***Pers (New)*** | ***Old (0.35)*** | ***Pers (Old)*** |
|---|---|---|---|---|
| POD | 0.68 | 0.62 | 0.66 | 0.63 |
| FAR | 0.21 | 0.23 | 0.23 | 0.24 |
| HR | 0.74 | 0.71 | 0.73 | 0.71 |

The main goal for this task was to create new lightning probability forecast equations that would outperform the equations currently used in operations. The new equations did outperform the old equations, although not overwhelmingly, as evidenced by the four tests of SS, lightning/non-lightning day discrimination, reliability, and contingency table statistics. Given that most of the test indicated that the new equations exhibited superior performance, these new equations will replace those in current use before the start of the 2007 lightning season.

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

## Peak Wind Tool for General Forecasting (Mr. Barrett and Ms. Lambert)

The expected peak wind speed for the day is an important element in the daily morning forecast for ground and space launch operations at KSC and CCAFS. The 45 WS must issue forecast advisories for KSC/CCAFS when they expect peak gusts to exceed 35 kt, 50 kt, and 60 kt thresholds at any level from the surface to 300 ft. However, the 45 WS forecasters indicate that peak wind speeds are a challenging parameter to forecast, regardless of their value. They requested that the AMU develop a tool that will help them forecast the daily average and highest peak non-convective wind speed, and the timing of the peak speed, from the surface to 300 ft on KSC/CCAFS for the cool season (October-April). The AMU will use a 4-year database of high resolution soundings and other observational data available by the morning weather briefing at 0700 local time to develop a tool that provides a forecast of the peak wind speed for the day, its timing, and the average wind speed at the time of the peak.

### *Data Acquisition and Quality Control*

Mr. Barrett acquired additional KSC and CCAFS wind tower observations, morning CCAFS soundings (XMR) and Shuttle Landing Facility (SLF) observations. The database includes tower, upper-air, and surface observations during the cool seasons in the period October 2002 to February 2007. The tower data and upper-air soundings were provided by Mr. Paul Wahner of Computer Sciences Raytheon (CSR). The SLF observations between October 2002 and December 2006 were acquired from the Air Force Combat Climatology Center. The SLF hourly surface observations between January and February 2007 were acquired from the Plymouth State University Weather Center at the address http://vortex.plymouth.edu/statlog-u.html.

The SLF observations were used to determine if precipitation occurred at or near the SLF. The tower observations were reformatted and run through a quality control (QC) software program created by the AMU specifically for the KSC/CCAFS tower network data (Lambert 2002).

The AMU must still QC the tower observations from October 2006 to February 2007.

The tower wind observations Mr. Barrett will use to develop a forecast tool are those at and below 300 feet from the 32 towers that verify Weather Watches and Advisories (WW/WA) for winds issued by the 45 WS. As indicated in Figure 4, they use the yellow towers to verify WW/WA for KSC, and the red tower WW/WA for CCAFS. Analysis of upper-air sounding data is restricted to winds and temperatures at and below 5000 ft since it is unlikely that winds above this level would mix down to the surface.


**Figure 4. Map of the KSC/CCAFS area showing the locations of the wind towers in the network. The towers on CCAFS are represented by red triangles, those on KSC represented by yellow triangles, and those on the mainland represented by blue triangles.**

***Analysis of Data***

Based on input by the 45 WS, Dr. Short defined a day as the 24-hour period beginning at 1300 UTC on one day to 1300 UTC the next day (0800 – 0800 EST). He then stratified each day into one of four categories based on the existence or non-existence of a surface-based temperature inversion in the XMR morning sounding and the occurrence or non-occurrence of precipitation at the SLF. Originally, surface-based inversions were defined as an increase in temperature from the surface to 100 ft. After a discussion with the 45 WS, the definition was modified to an increase in temperature from the surface to 500 ft. There were 855 days with a morning XMR sounding and 852 days with both a morning sounding and SLF observations. Of those 852 days:

- 182 days had both a surface-based inversion and precipitation at or near the SLF,
- 374 days had a surface-based inversion and no precipitation at or near the SLF,
- 119 days had no surface-based inversion and precipitation at or near the SLF, and
- 177 days had no surface-based inversion and no precipitation at or near the SLF.

The wind profiles from the surface to 5000 ft for the four inversion/precipitation stratifications are shown in Figure 5. As expected, days with an inversion and no precipitation had the lightest winds, and days with precipitation and no inversion had the strongest winds. In general, wind speeds increased rapidly from the surface to about 500 ft on days with a surface-based inversion and to about 1000 feet on days without a surface-based inversion. The wind speeds remained nearly steady above these levels.

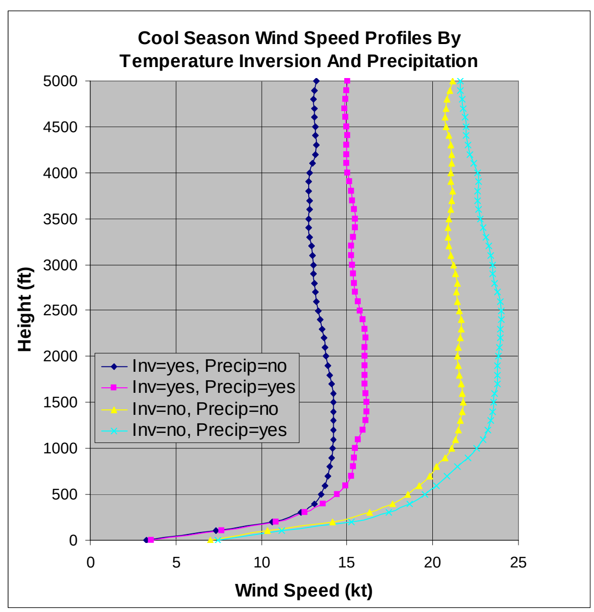


**Figure 5. Average profiles of wind speed (kt) versus height (ft) for four combinations of existence of a surface-based inversion (Inv) in the sounding and precipitation (Precip) at the SLF. The legend shows the colors and symbols used for each profile.**

Figure 6 shows the temperature profiles from the surface to 5000 ft for the same stratifications. Days with no inversion and no precipitation had the coolest temperatures aloft, which may be indicative of post-frontal cold-air advection. Days with precipitation had the warmest temperatures.

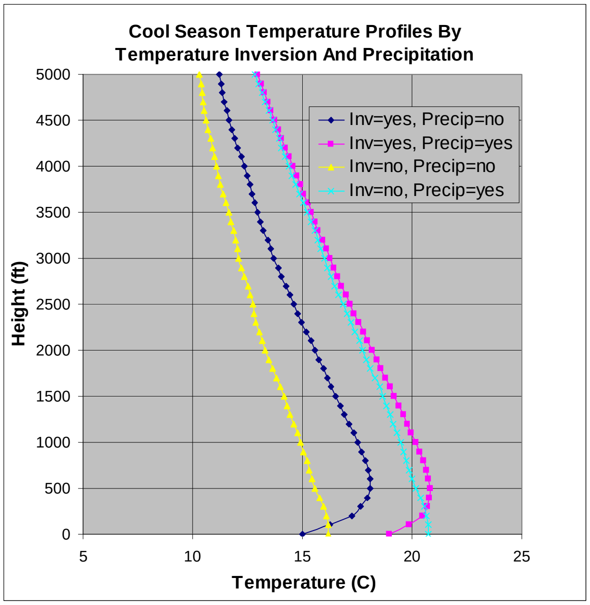


**Figure 6. Same as Figure 5 except that these are the average temperature profiles (C).**

The large-scale synoptic flow could have an effect on the local-scale peak wind speed. To explore this possible relationship, Mr. Wheeler and Mr. Barrett classified each cool-season day from October 2002 to February 2007 into one of six categories based on the synoptic weather pattern at 1200 UTC (number of days in parentheses):

- High pressure over or near Florida with variable winds across Central Florida (110),
- High pressure north or east of Florida with east winds across Central Florida (348),
- High pressure south or west of Florida with west winds across Central Florida (66),
- Front approaching Florida from the north (162),
- Front across Central Florida (131), and
- Front south of Central Florida (181).

There was a total of 998 days in the period stratified by synoptic pattern. These days will be filtered to only include the 852 days that had both an XMR morning sounding and SLF surface observations.

Figure 7 shows the wind profiles for these six synoptic weather patterns. Wind speeds aloft are similar for days with surface fronts north and approaching, over, or south of Central Florida. As expected, winds are weakest aloft when surface high pressure is over or near Florida. Days in which a front is approaching Florida from the north have the warmest temperature aloft, followed by days in which a front is across Central Florida. Figure 8 shows the average temperature profile for each synoptic pattern. Each weather pattern contains a surface-based temperature inversion, although the inversion is strongest when surface high pressure is over Florida.

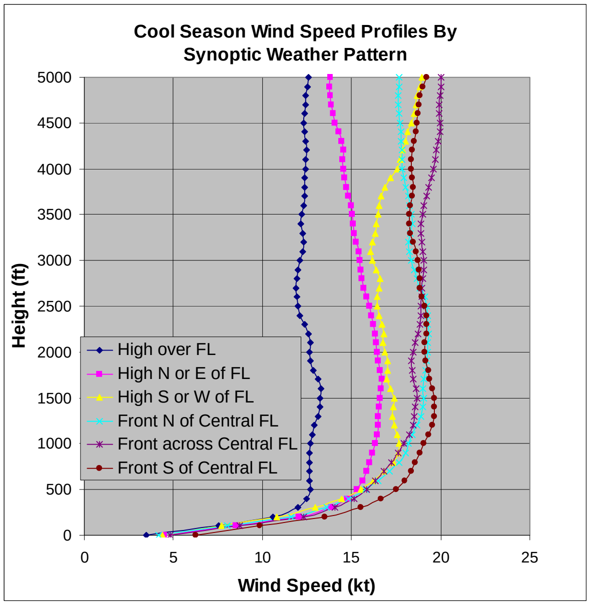


**Figure 7. Average profiles of wind speed (kt) versus height (ft) for six weather patterns across Florida. The legend in the lower left indicates the colors and symbols used for each profile.**

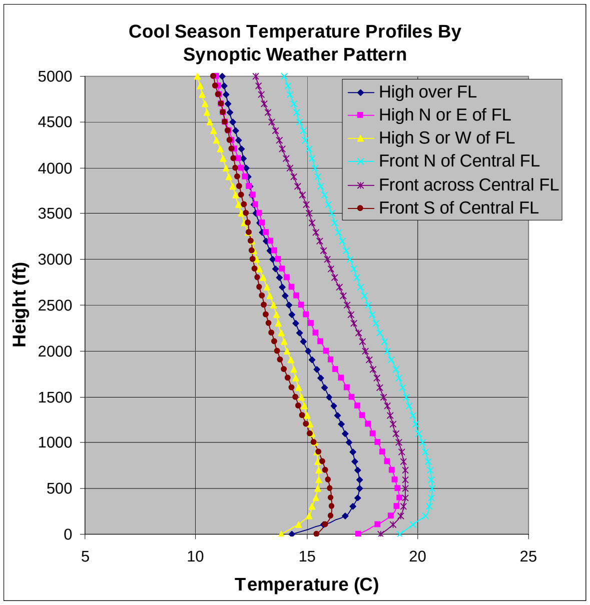


**Figure 8. Same as Figure 7 except that these are the average temperature profiles (C).**

### *Peak Wind Timing Forecast*

In addition to the tower peak wind-speed-of-the-day (TPWSD), the 45 WS needs to forecast the timing of the peak winds. Figure 9 shows the diurnal occurrence of peak wind speeds by time and wind speed for the cool season days in the period October 2002–April 2006. The figure shows that the TPWSD can occur at any hour of the day; however, occurrence is more frequent during the late morning and afternoon. Peak winds over 35 kt tended to happen between 1300 and 2400 UTC (0800 – 1900 EST).

### *Development of Forecast Tool*

In March, Dr. Short presented a briefing on the status of the task to the 45 WS. Mr. Barrett and Dr. Short met with Mr. Roeder of the 45 WS to determine the direction of the task, including the development of a forecast tool. Mr. Barrett took over as the task lead in the absence of Dr. Short, who left the AMU for a 4-month work sabbatical in Japan.

Mr. Barrett will QC the tower network data from October 2006 to February 2007 and add them to the database. He will then create equations to predict the time and speed of the TPWSD, as well as the background 5-minute average wind speed and direction at the time the peak wind speed occurred. The equations will likely be based on the relationship between the morning upper-air sounding data, synoptic weather pattern, observed precipitation at the SLF and observed TPWSD. A GUI will be created to predict the TPWSD and background average wind velocity, based on the equations and input from the 45 WS forecasters.

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

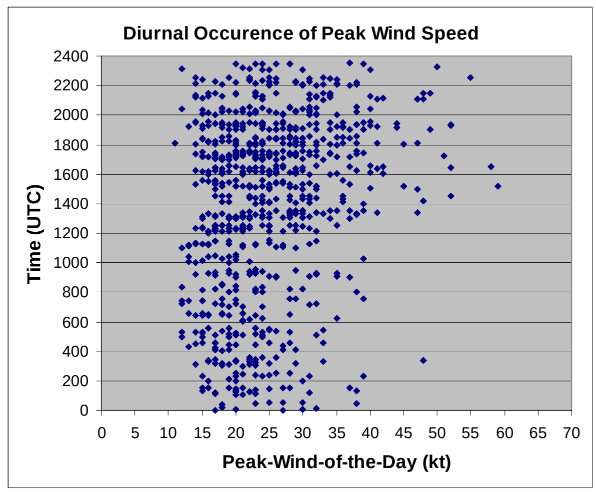


**Figure 9. Scatter diagram showing the cool season diurnal occurrence of the TPWSD during the period October 2002 – April 2006. The TPWSD is in knots and time is in UTC.**

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

The threat of lightning is a daily concern during the warm season in Florida. Recent research has revealed distinct spatial and temporal distributions of lightning occurrence that are strongly influenced by large-scale atmospheric flow regimes. In Phase I, Ms. Lambert created 6- and 24-hour gridded lightning density and frequency climatologies based on the flow regime that the forecasters at the National Weather Service in Melbourne, FL (NWS MLB) use to issue daily lightning threat maps for their county warning area (Lambert et al. 2006). Phase II of this work consists of three parts. In the first part, Dr. Short created climatological soundings of wind speed, wind direction, temperature, and dew point at Jacksonville, Tampa, Miami, and XMR for each of eight flow regimes from a 16 year database of soundings (Short 2006). In the second part of the Phase II work, Dr. Bauman calculated the same climatologies as in Phase I for the two 12-hour periods 0000–1200 UTC and 1200–2400 UTC. In the third part of the Phase II work, Dr. Bauman will create the flow regime climatologies for 5-, 10-, 20-, and 30-n mi circles around the SLF, as shown in Figure 10, in 1-, 3-, and 6-hour increments. The 5- and 10-n mi circles are consistent with the aviation forecast requirements at NWS MLB. The code from this task will be delivered to them so they can create the climatologies for the other airports at which they have forecast responsibilities. The 20- and 30-n mi circles at the SLF were chosen to create the climatologies that will assist the Spaceflight Meteorology Group (SMG) in making forecasts for FR violations of lightning occurrence during a shuttle landing.

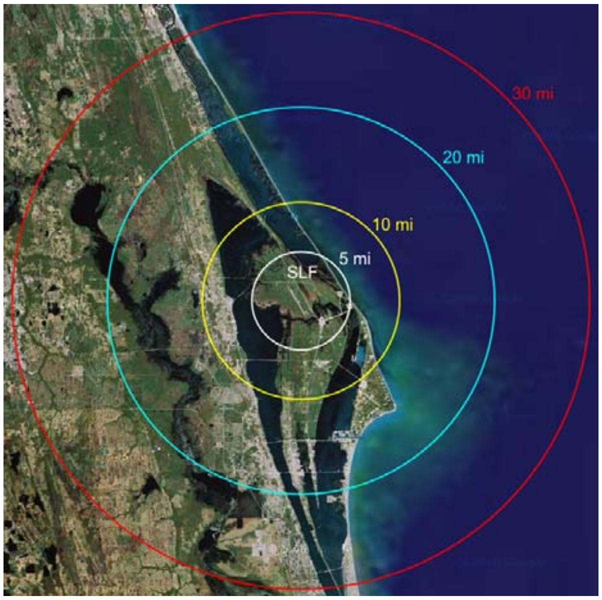


**Figure 10. Satellite image of KSC/CCAFS area with 5-, 10-, 20-, and 30- n mi range rings centered on the SLF.**

### *12-Hour Climatologies*

Dr. Bauman modified the FORTRAN code used in Phase I to stratify the gridded data into the 0000–1200 and 1200–2400 UTC periods. He then compiled and ran this code to create the gridded frequency and density lightning climatologies for each of the eight flow regimes identified in Phase I (Lambert et al. 2006). He also modified and ran the code to convert the gridded files to a format that can be read by the Graphical Forecast Editor (GFE) in the NWS MLB Advanced Weather Interactive Processing System (AWIPS). Dr. Bauman delivered the GFE files to NWS MLB.

### *SLF Climatologies*

Dr. Bauman started the third and last part of this task to modify the Phase I code to create the SLF climatologies mentioned previously. Before making the code modifications, he began working with the layout and geometry of the total grid that covers an area approximately 1000 km x 950 km as shown in Figure 11. There are 405 x 377 grid boxes in the domain that are 2.5 km on each side. Dr. Bauman identified the closest corresponding grid box to the latitude and longitude at the center point of the SLF runway (28.6150N, 80.6945W). He then determined the position of each grid box contained within each 5-, 10-, 20-, and 30-n mi range ring.

His next step will be to modify the Phase I code to create the algorithms that will determine the indices of the grid boxes comprising the requested range rings centered on the SLF. Once determined, the number of lightning strikes in all the boxes will be summed to create one value for the total number of lightning strikes in each range ring. The climatology calculations in the code will remain the same. Instead of a grid of values, one value each for the probability of lightning occurrence and the mean number of strikes per flow regime will be created for each range ring.

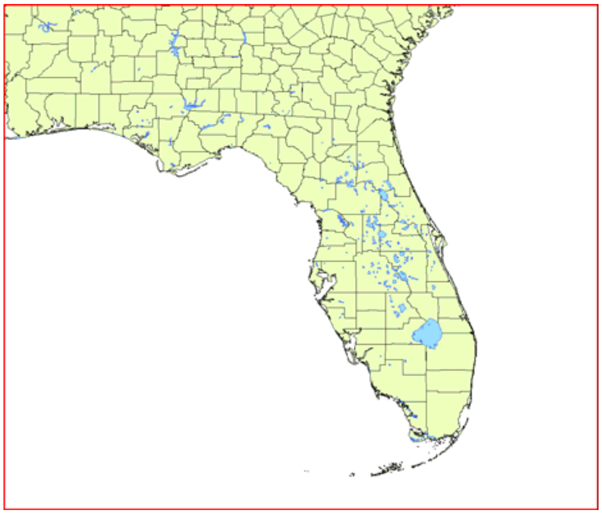

**Figure 11. Domain of the gridded lightning data, which covers approximately 950000 km$^2$.**

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

## *INSTRUMENTATION AND MEASUREMENT*

### Anvil Forecast Tool in AWIPS (Mr. Keen, Mr. Barrett, and Dr. Bauman)

The forecasters at SMG and 45 WS have identified anvil forecasting as one of their most challenging tasks when predicting the probability of LCC or FR violations due to the threat of natural or triggered lightning. In response, the AMU developed an anvil threat corridor graphic that can be overlaid on satellite imagery using the MIDDS. This tool helps forecasters estimate locations where thunderstorms might produce an anvil threat 1, 2, and 3 hours into the future. It has been used extensively in launch and landing operations. The SMG is depending more on AWIPS during operations and the 45 WS may replace their MIDDS with AWIPS. To ensure it will remain available for operations, the forecasters tasked the AMU to transition the anvil tool from MIDDS to AWIPS. The AMU will also create a GUI to ensure easy access to the tool.

The AMU, SMG, and 45 WS identified improvements that were needed after performing tests of the tool. These improvements were documented in a bug report that was updated with each new version of the tool. After the AMU performed final testing of the tool, the software was released for operational use. Software modifications included the following:

- The user can no longer create a new map until the 300- to 150-mb average wind has been calculated. This prevents run-time errors from occurring when variables are not initialized.
- The text output was modified to make it easier to read.
- A refresh-map feature was added. When enabled, the newly-created anvil threat corridor graphic is automatically displayed. The user does not need to clear the current graphic and load the new graphic.
- The labels on the graphic were modified to make them more useful and easier to read.
- The Date-Time and Site selections on the GUI were highlighted in red so that the user could see which selections were made (Figure 12).

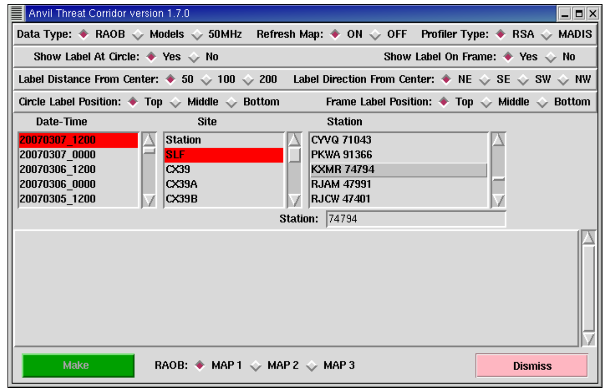


**Figure 12. The Anvil Forecast Tool GUI showing Date-Time and Site selections highlighted in red.**

- When using model data, the user will no longer receive an error message when data for a forecast hour is missing. Instead, the user will receive a dialog box stating that the forecast hour is not available.
- The Append Map function was removed because the label on the graphic only pertained to the last calculation performed by the tool. It was also difficult to differentiate between multiple graphics for the same Site. Instead, three graphics are available for each of the three input data types (rawinsonde, 50 MHz wind profiler, and numerical model forecasts). Up to nine graphics can be viewed together in one AWIPS display (Figure 13).

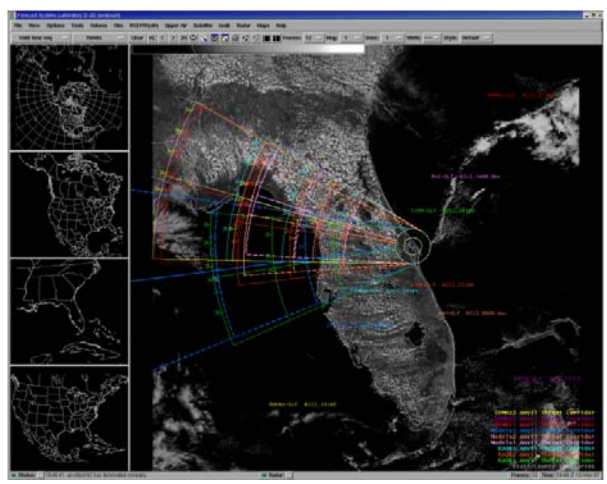

**Figure 13. An example of nine Anvil Forecast Tool graphics plotted in AWIPS, based on three different sounding, models and wind profiler times.**

- If there are multiple rawinsonde observations in a file for the selected station, the user will be prompted to select an observation time (Figure 14).

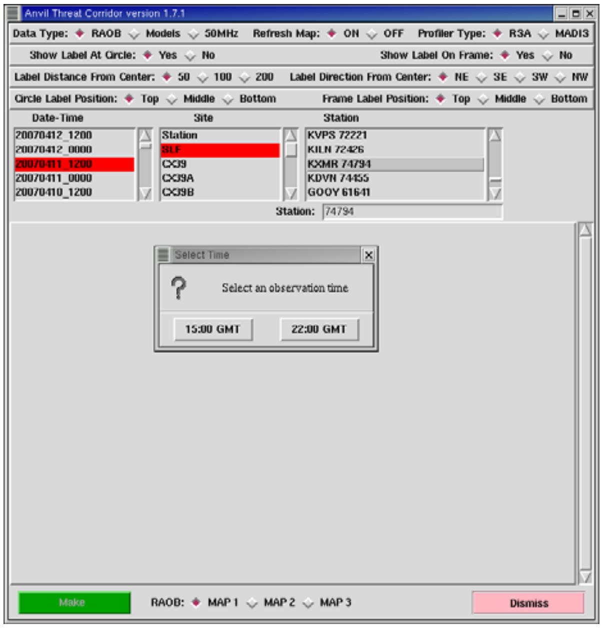


**Figure 14. There are multiple rawinsonde observations for station KXMR between 1200 and 2359 UTC on 11 April 2007. The message box prompts the user to select which observation time to use for the layer-average wind calculations.**

- The layer-average wind calculations with the 50 MHz profiler data now use the correct units. Previously, the 50 MHz profiler data calculations used meters per second; the data are in knots.
- The model grid points were adjusted so that the correct locations will be read from the model data.
- The vertical wind levels in the Global Forecast System (GFS) model forecasts are now read at the correct resolution.
- The tool now ignores missing wind data in the rawinsonde and 50 MHz profiler data.
- Double-clicking on a Station or Site with the left mouse button no longer creates an error.
- The radius of the inner circle centered at the Site was changed from 5 to 10 n mi.
- The maximum level of the winds in the rawinsonde and 50 MHz profiler observations was changed from 12,000 m to 14,000 m.
- The AMU AWIPS receives 50 MHz profiler data in Range Standardization and Automation (RSA) format, while the SMG AWIPS receives it data in Meteorological Assimilation Data Ingest System (MADIS) format. The Anvil Tool was modified to allow the use of both formats.
- The Anvil Tool can now display labels to the northeast, southeast, southwest, or northwest of the Site. The label can also be positioned 50, 100, or 200 n mi from the Site.
- The user now has the option of whether or not to display labels on the graphic.
- Wind calculations using model data were adjusted to take into effect the difference between grid-relative and north-relative winds.
- The calculations for locations on the graphic originally used a flat-earth approximation. This introduced errors in the locations of the one-, two-, and three-hour arcs in the graphic. The amount of error increased with latitude. A spherical-earth approximation replaced flat-earth approximation to create the graphics.
- The user now has the option of displaying labels at the top, middle, or bottom positions. This prevents labels from being overwritten.
- The Anvil Tool was developed to read GFS model data at the “CONUS211” projection, but the SMG AWIPS now receives these data at the “CONUS212” projection. Therefore, the tool was modified to read the data at the “CONUS212” projection

Dr. Bauman completed a draft of the User’s Guide describing the operation of the tool, and Mr. Barrett completed a draft of the final report. They gave the User’s Guide and final report to SMG and the 45 WS for their review. Dr. Bauman and Mr. Barrett expect to have both documents completed and ready for distribution by the end of April or beginning of May.

Contact Mr. Barrett at 321-853-8205 or barrett.joe@ensco.com, or Dr. Bauman at 321-853-8202 or bauman.bill@ensco.com for more information on this task.

## Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) Algorithm (Mr. Keen, Ms. Miller, 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 (Willett et al. 1999). These rules are designed to avoid 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 restrictive. 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 research program managed by KSC (Dye et al. 2006, 2007). Dr. Harry Koons of Aerospace Corporation conducted a performance analysis of the VAHIRR algorithm from a safety perspective. The results suggested that the LLCC based on this algorithm would assist forecasters in providing a lower rate of missed launch opportunities with no loss of safety compared with the previous LLCC.

In the previous Quarter, Mr. Barrett and Ms. Miller completed installing and configuring an Open Radar Product Generator (ORPG) clone machine at the AMU (AMU Quarterly Report Q1_FY07). The ORPG-clone is used to create VAHIRR radar products using a live feed of Level II data from the NWS MLB Weather Surveillance Radar 1988 Doppler (WSR-88D). Mr. Barrett, Ms. Miller, Dr. Merceret, and Dr. Bauman wrote a VAHIRR operational test plan that describes how the VAHIRR radar product will be tested for accuracy, reliability, and efficiency.

### *Operational Test Plan*

The AMU received feedback from SMG and the 45 WS on the operational test plan. Based on the feedback, the AMU determined that additional software development and testing are necessary. The following items must be performed before the VAHIRR operational test can be carried out:

- Address the cone of silence,
- Change how the cloud thickness is calculated by the VAHIRR radar product, and
- Account for the elevation of the radar when calculating the height and thickness of clouds.

### Cone of Silence

The cone of silence is a cone-shaped region, directly over the antenna of a radar transmitter in which no pulse is transmitted or signal detected. The software will be modified so all clouds and precipitation within the cone of silence will be reported as undefined. Figure 15 and Figure 16 show the cone-of-silence in two volume coverage patterns, VCP11 and VCP21, respectively, used by the WSR-88D when precipitation is occurring (OFCM 2006). The cone-of-silence in each figure is the yellow-shaded region to the left of the 19.5 degree elevation line (left-most red line).

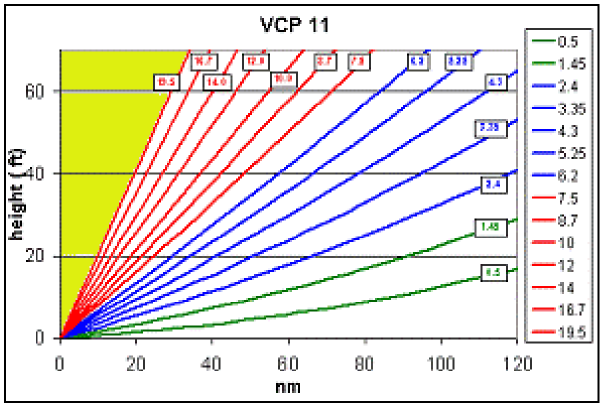


**Figure 15. VCP11 is used to sample severe and non-severe precipitation events. The legend at right shows the elevation angle values. The green, blue, and red colors represent different data collection and processing methods that are beyond the scope of this task. The area filled in yellow represents the cone of silence.**

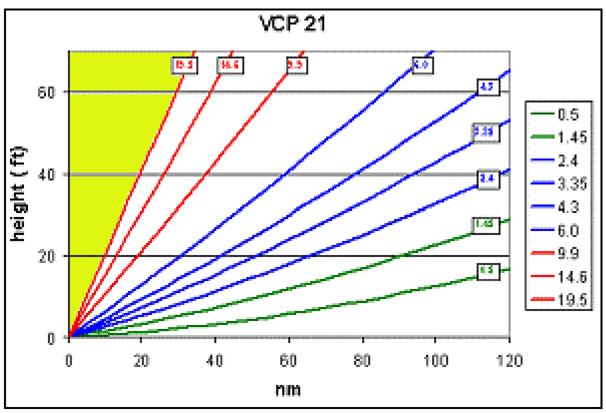


**Figure 16. Same as Figure 15 except this is VCP21, which is used to sample shallow precipitation. The area filled in yellow represents the cone of silence.**

### Cloud Thickness

The cloud thickness is derived by first calculating the difference between the height of the top and bottom elevation scans through the cloud. If the difference is less than 1 km, then the thickness is set to 1 km. If the cloud is detected in only one elevation scan, then the cloud thickness is set to 1 km. The software will be modified to eliminate the 1 km minimum for the cloud thickness. Instead, if a cloud is detected in only one elevation scan, then the cloud top will be calculated as the height of the elevation scan plus half the distance between the elevation scan and the adjacent elevation scan above it. The cloud bottom will be calculated as the height of the elevation scan minus half the distance between the elevation scan and the adjacent elevation scan below it.

### Radar Elevation

This modification will be important if the VAHIRR radar product is created with data from radars that are above mean sea-level. The software currently reports cloud heights in km above ground level (AGL), while the height of freezing level is reported in mean sea level (MSL). The software erroneously assumes that the freezing level is reported in km AGL. Assume, for example, that the elevation of the radar is 1 km MSL, the cloud bottom is reported at 2 km AGL, the cloud top is reported at 4 km AGL and the height of the freezing level is at 3 km MSL. The VAHIRR algorithm only considers clouds at or above the freezing level. In this case, the software will subtract the freezing level value of 3 from the cloud top value of 4 and report the cloud thickness as 1 km, but the cloud thickness is really 2 km.

### *VAHIRR in AWIPS*

With the assistance of SMG, Mr. Barrett created an automated procedure to send VAHIRR radar products to AWIPS (Q1_FY07). However, the VAHIRR radar product could not be viewed as a separate product in the AWIPS menu system. SMG and Mr. Barrett worked together to modify the AMU's AWIPS configuration in order to view the VAHIRR radar product. Mr. Barrett also wrote an AWIPS application to create launch trajectory graphics that can be overlaid onto radar products such as VAHIRR. The dialog box for this application is shown in Figure 17. Figure 18 shows an example of the VAHIRR radar product in AWIPS using live WSR-88D data. It also shows a launch trajectory extending northeastward from launch pad 39B inside the white circle. The left (north) edge of the track is shown by a green line, the nominal track is the red line in the center, and right (south) edge of the track is the blue line.

For more information on this task, contact Ms. Miller at miller.juli@ensco.com or 321-783-9735 ext. 221; Mr. Gillen at 321-783-9735 ext. 210 or gillen.robert@ensco.com; Mr. Barrett at 321-853-8205 or barrett.joe@ensco.com, or Dr. Merceret at Francis.J.Merceret@nasa.gov or 321-867-0818.

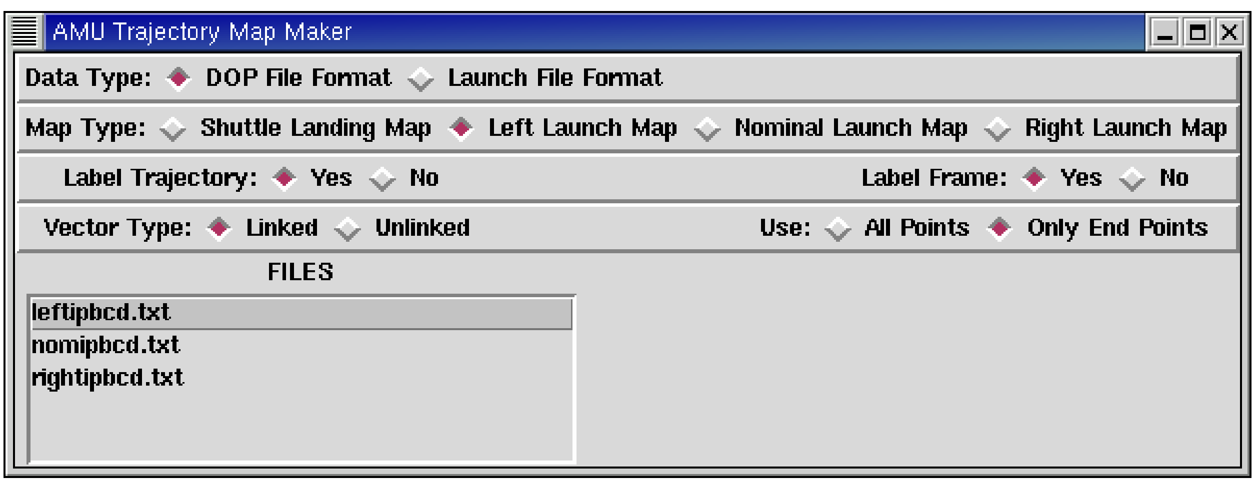


**Figure 17. AWIPS local application that will create graphics depicting launch trajectories.**

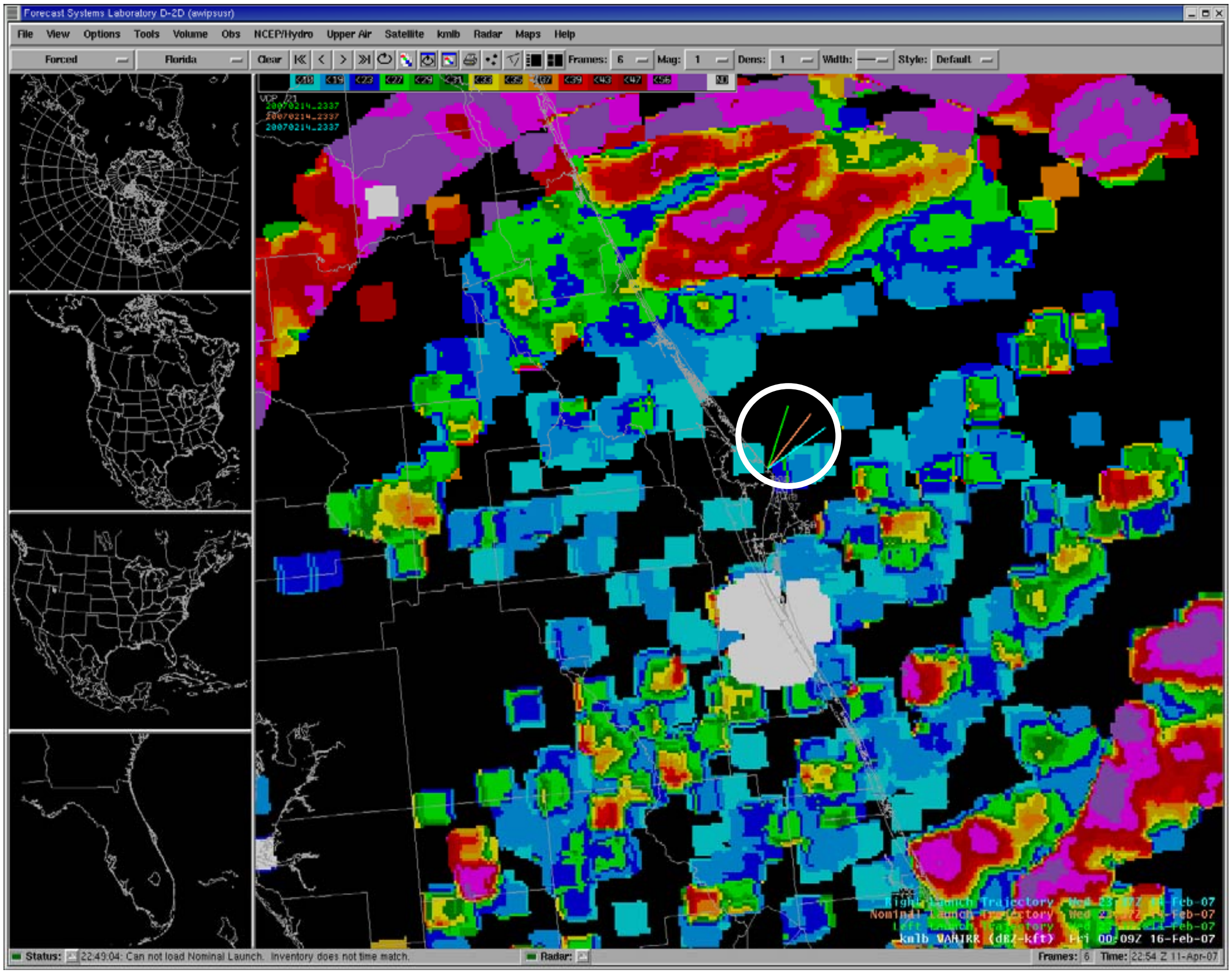


**Figure 18. The VAHIRR radar product in AWIPS created using a live data feed from 16 February 2007. A launch trajectory created with the GUI in Figure 17 can be seen inside the white circle.**

## Tower Data Skew-t Tool (Mr. Wheeler)

The rapid reduction in visibility and ceiling associated with marine incursions is a concern to 30th Weather Squadron (30 WS) forecasters during launch operations at Vandenberg Air Force Base (VAFB). Such conditions will become a launch safety concern with new launch vehicles that require they be viewable by remote cameras until radar lock-on. The incursion occurs when the marine layer (cooler/moist air) moves inland from the Pacific Ocean. The VAFB radiosonde is a critical data source in analyzing this phenomenon. To fill in for a temporary loss of radiosonde data due to software or sonde problems, the 30 WS developed the Tower Data Skew-t Tool to help monitor the progress of marine-layer incursions. The AMU will evaluate the effectiveness of this tool for the 30 WS using data collected during two previous marine-layer incursion events.

Mr. Wheeler reviewed the task plan and began collecting the data needed for the evaluation. Mr. Schmeiser of the 30 WS provided data from eight wind towers and the soundings at VAFB for August 2006. The tower data include temperature and humidity measurements at 6 ft, and wind direction and speed at 12 and 54 ft. Mr. Wheeler also contacted Mr. Schmeiser with questions on data format and other issues. The hourly surface observations for the period at VAFB were collected from the Plymouth State Weather Center at the website

http://vortex.plymouth.edu/sa_parse-u.html.

Once he collected all the data, Mr. Wheeler began decoding and filtering it into a common database.

Contact Mr. Wheeler at 321-853-8105 or wheeler.mark@ensco.com more information.

## MESOSCALE MODELING

### Weather Research and Forecasting (WRF) Model Sensitivity Study (Dr. Watson)

The WRF model is the next generation community mesoscale model designed to enhance collaboration between the research and operational sectors. The SMG and the NWS MLB are moving forward with implementing the WRF model operationally into their AWIPS systems. The WRF model has two dynamical cores – the Advanced Research WRF (ARW) and the Non-hydrostatic Mesoscale Model (NMM). There are also two options for the initialization of the WRF model – the Local Analysis and Prediction System (LAPS) and the Advanced Regional Prediction System (ARPS) Data Analysis System (ADAS). Having a series of initialization options and WRF cores, as well as many options within each core, provides SMG and NWS MLB with a lot of flexibility as well as challenges. This includes determining which configuration options are best to address specific forecast concerns. The goal of this task to assess the different configurations available and to determine which configuration will best predict warm season convective initiation. To accomplish this, the AMU was tasked to

- Compare the WRF model performance using ADAS versus LAPS for the ARW and NMM model cores,
- Compare the impact of using a high-resolution local forecast grid with 2-way, 1-way, and no nesting, and
- Examine the impact of assimilating soil moisture sensor data on WRF model performance.

#### *ADAS/NMM Model Configuration*

Although Dr. Watson installed the code fixes for the “hot-start” initialization of the WRF Environmental Modeling System (EMS), she has not been able to run a hot-start initialization of the ADAS/NMM. All microphysics continue to be set to 0. Dr. Watson corresponded with Dr. Robert Rozulmalski at COMET regarding this issue and he indicated that the WRF EMS software has not been tested using this configuration.

#### *LAPS/WRF Model Configuration*

Dr. Watson completed setting up and configuring the LAPS software. With assistance from Mr. Barrett, she was successful in resolving the satellite data conversion issue. The archived satellite files were available in Man Computer Interactive Data Access System (McIDAS) Area format, however, LAPS requires all data in Network Common Data Form (NetCDF) format. Using McIDAS, Dr. Watson and Mr. Barrett were able to remap the satellite files to the Lambert Conformal projection and then use the software McIDAStoNetCDF to reformat the McIDAS Area file to NetCDF format. She ingested these remapped and reformatted files into LAPS, and then completed all 4-km LAPS/ARW and LAPS/NMM model runs. Each model run was integrated 12 hours with three runs per day initialized at 0900, 1200, and 1500 UTC. Dr. Watson used data from the 40-km Rapid Update Cycle (RUC) model for the initial conditions and the 40-km North American Model (NAM) for boundary conditions.

Figure 19 and Figure 20 show the three-hourly composite reflectivity from the LAPS/ARW and LAPS/NMM simulations, respectively, at 1200 UTC 2 September 2006. Figure 21 shows the corresponding three-hourly images of observed composite reflectivity data. Comparison of the three figures reveals that both LAPS/ARW and LAPS/NMM spun up too much precipitation throughout the nine hours. Also, the model reflectivity values were 5 – 15 DbZ greater than the observed reflectivity values. The LAPS/NMM configuration produced too much rainfall in south Florida and failed to capture the convective initiation over land during forecast hours 6 and 9. The LAPS/ARW configuration did capture the convective initiation over land during hours 6 and 9; however, the areas of strong precipitation were displaced from their true locations.

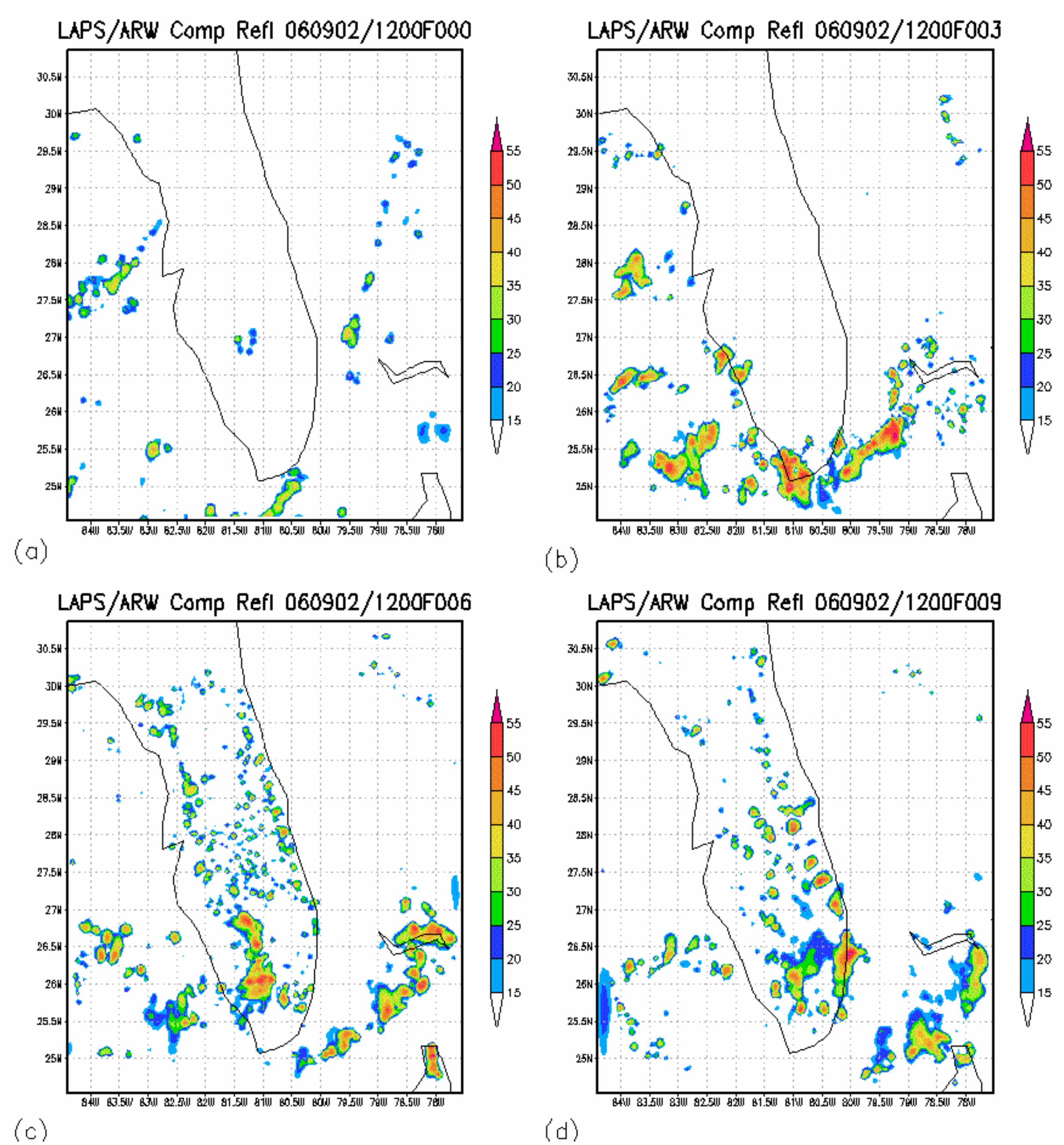


**Figure 19. LAPS/ARW composite reflectivity from the 1200 UTC 2 September model run, with valid times at (a) 1200 UTC, (b) 1500 UTC, (c) 1800 UTC, and (d) 2100 UTC. Units in DbZ.**

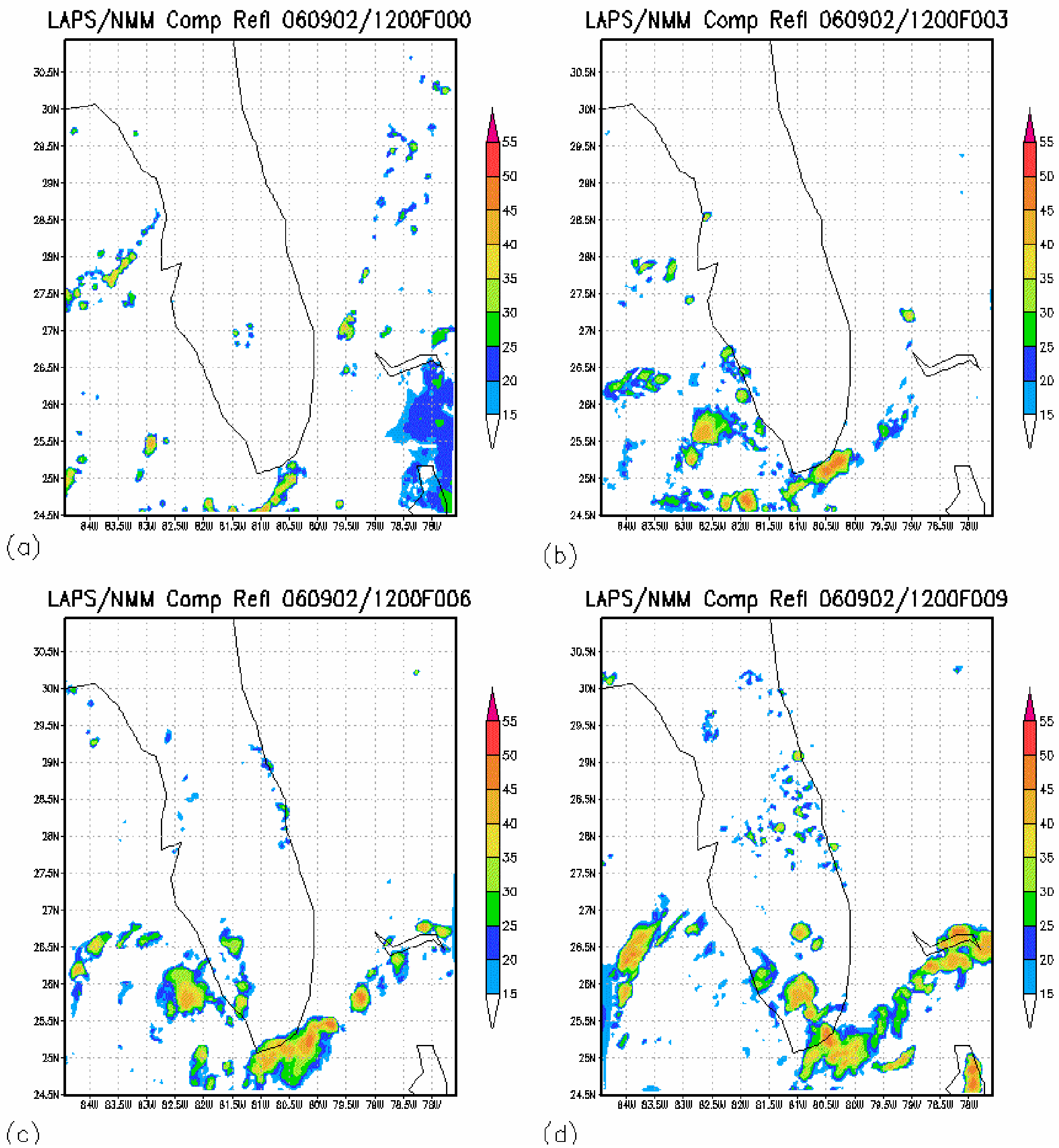


**Figure 20. LAPS/NMM composite reflectivity from the 1200 UTC 2 September model run, with valid times at (a) 1200 UTC, (b) 1500 UTC, (c) 1800 UTC, and (d) 2100 UTC. Units in DbZ.**

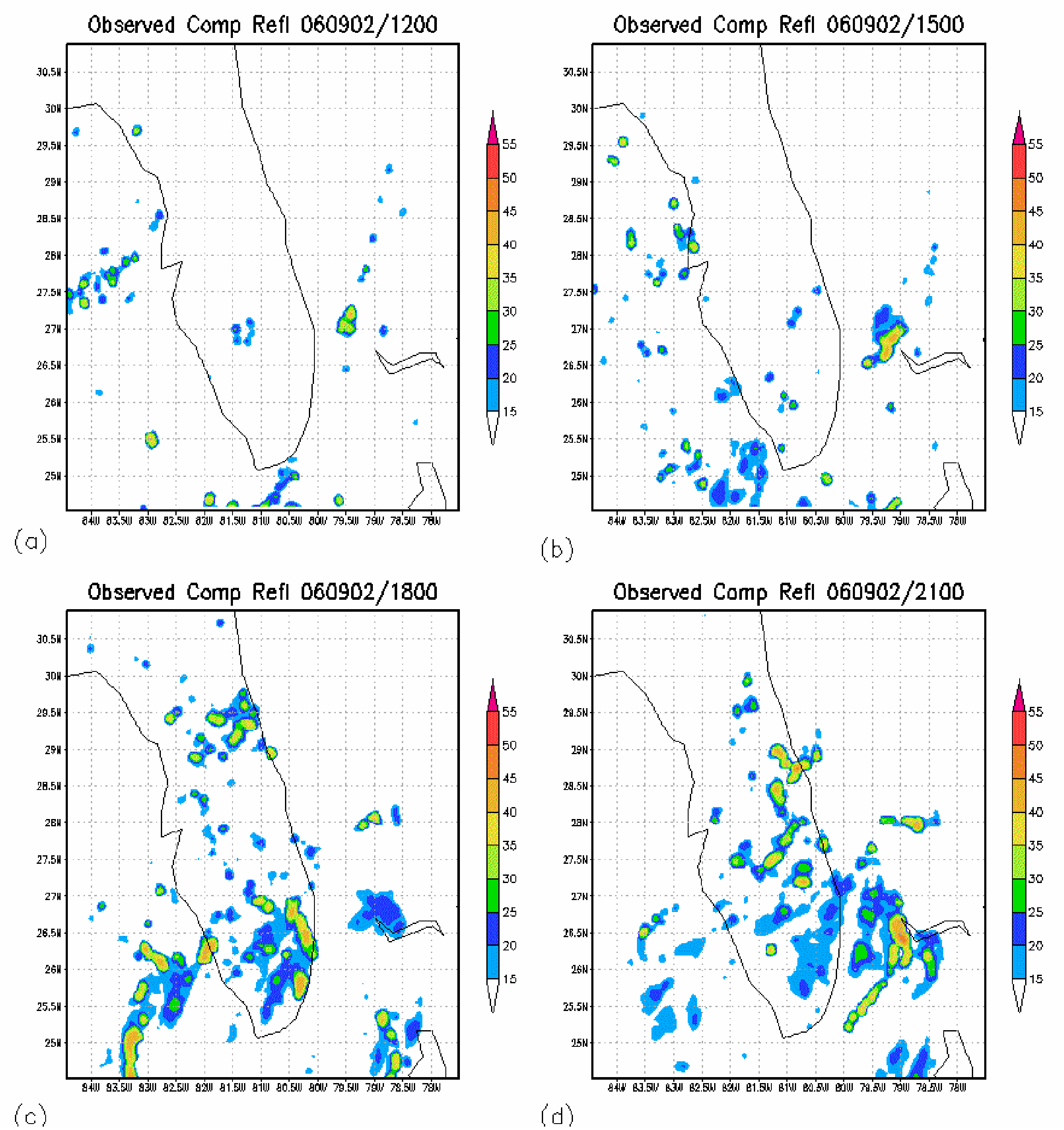


**Figure 21. Observed composite reflectivity from the 1200 UTC 2 September model run, with valid times at (a) 1200 UTC, (b) 1500 UTC, (c) 1800 UTC, and (d) 2100 UTC. Units in DbZ.**

### *Two-way and One-way Nested Model Runs*

Dr. Watson completed all local, high-resolution, 2-way and 1-way nested model runs using LAPS/ARW. Due to limitations of the NMM core, only the ARW core could be used for nested model runs. The LAPS/ARW configuration was chosen based on preliminary comparison of results from the 4-km ADAS/ARW and LAPS/ARW model runs. The inner nested grid was centered over East Central Florida such that it covered all of Brevard County, down to Martin County, and as far west as Lake County (Figure 22). Each model run was integrated 12 hours with three runs per day, initialized at 0900, 1200, and 1500 UTC. A comparison between the 2-way and 1-way nested runs (not shown) revealed very little difference in the timing, location, and intensity of the predicted composite reflectivity.

### *Model Verification*

Correspondence between Dr. Watson, SMG, and NWS MLB resulted in a decision to use an objective precipitation verification method instead of the originally proposed subjective method. Dr. Watson conducted a brief literature review in order to find the best objective precipitation verification technique for warm season convective initiation. After this review and through correspondence with Dr. Christopher Davis of the National Center for Atmospheric Research (NCAR), she decided to use a “fuzzy” method. Fuzzy methods attempt to define a skill score based on having the right precipitation rates within a neighborhood of a model grid point. However, most objective techniques, including fuzzy methods, compare forecast and model rainfall accumulation over some time period which is not amenable for using composite reflectivity. One method that Dr. Watson reviewed seemed the best fit for using composite reflectivity rather than rainfall accumulation. This method was the Fractions Skill Score based on work by Roberts (2005). This method answers the question of at what spatial scales the forecast most resembles the observations. This method could also be modified to look at the temporal scale as well.

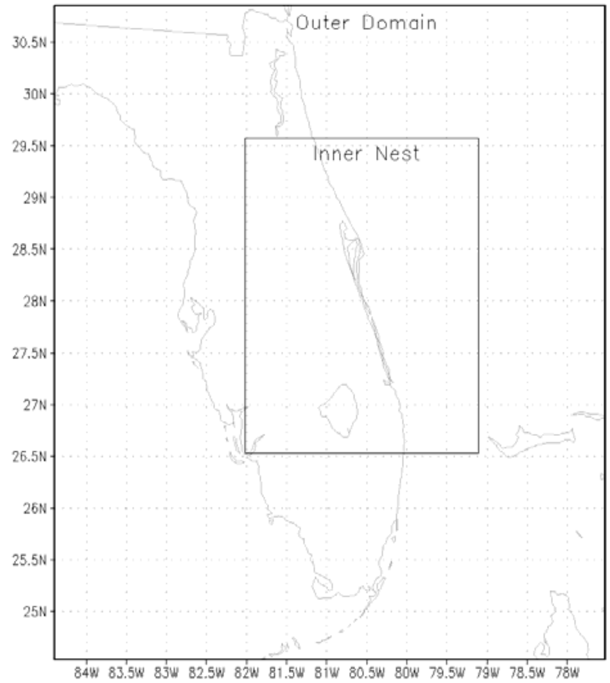


**Figure 22. The outer and inner nested grids used in the two- and one-way nested model comparisons.**

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

## *AMU CHIEF’S TECHNICAL ACTIVITIES (Dr. Merceret)*

Dr. Merceret provided technical guidance to the Constellation program in several areas including the design of weather sensor mounts to be installed on the new LC-39B lightning protection towers and technical reviews of the System Requirements Documents. He also assisted Barry Roberts at Marshall Space Flight Center in preparing the agenda for the February 6-8 Constellation Weather Operations Support Technical Interchange Meeting (TIM) and Day-of-Launch Working Group (DOLWG).

Dr. Merceret participated in an Integrated Product Team meeting for the acquisition of the radar replacement for the Patrick AFB WSR-74C, the GEMSTONE project's first tethered field deployment at KSC, and the Airborne Field Mill Experiment Phase-II data analysis kick-off teleconference. He drafted proposed revisions to the standoff distances in the anvil and debris cloud LLCC. He also prepared a risk analysis of the proposed revisions.

### *AMU OPERATIONS*

Dr. Bauman and Ms. Lambert attended the 87th AMS Annual Meeting held in San Antonio, TX from 14 – 18 January. Dr. Bauman presented results from the second phase of the stable low cloud task and Ms. Lambert presented results from the flow regime lightning climatology task in a poster at the 16th Conference on Applied Climatology. Ms. Lambert also presented results from Dr. Short's comparison of peak wind speeds between the RSA and Legacy wind sensors at the 14th Symposium on Meteorological Observations and Instrumentation. Dr. Bauman, Ms. Lambert, Mr. Barrett, and Dr. Watson attended the Constellation Weather Operations Support TIM and DOLWG on 6 – 8 February at KSC.

After powering-down the AMU cluster for building maintenance at ENSCO's Melbourne facility, several components failed to return to normal operating status upon power-up. Mr. Barrett, Dr. Watson, and ENSCO's IST Division personnel worked with the vendor, PSSC Labs, to trouble-shoot the hardware and acquire replacement parts that were still under warranty. The cluster was down for five business days.

Dr. Watson supported the Delta II THEMIS launch on 17 February. Dr. Bauman supported the launch of the Air Force's Atlas V Space Test Program 1 mission featuring six experimental satellites on 8 March.

Ms. Lambert was nominated for and won the Space Coast Section of the Society of Women Engineers 2006 Space Coast Woman Engineer Technical Achievement Award. Nominees for this award must meet the following requirements:

- Demonstrated a high level of competence, leadership, and personal integrity in her job;
- Contributed personally to her company's or organization's progress toward their mission;
- Has made significant lifetime achievements in the field of engineering;
- Resides or works in the Space Coast Area

Dr. Short began a four-month sabbatical to Japan on 16 March. He is working with Professor Kenji Nakamura, head of the Laboratory of Satellite Meteorology, part of the Hydrospheric Atmospheric Research Center at Nagoya University in Japan. Professor Nakamura has a group of seven researchers and several terabytes of data from the Precipitation Radar (PR) on board the Tropical Rainfall Measuring Mission satellite. The period of record for the data spans almost 10 years since TRMM was launched in late November 1997 from the Tanegashima Space Center in Japan. Dr. Short's project involves an examination of isolated shallow rain cells over the oceans. He will use statistical techniques to estimate ensemble properties of cells whose diameters are smaller or nearly equal to the PR resolution, 4.3 km in diameter. Improved knowledge of these features can contribute to a better understanding of heat and momentum fluxes in the boundary layer over the oceans, improved parameterizations for large-scale models, and validation of cumulus scale models that produce such features explicitly.

Mr. Wheeler joined the AMU on 19 March and will remain until Dr. Short's return in mid-August. While in the AMU, Mr. Wheeler will work on the Tower Data Skew-t Tool for the 30 WS at VAFB.

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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 |
| ADAS | ARPS Data Analysis System |
| AFSPC | Air Force Space Command |
| AFWA | Air Force Weather Agency |
| AGL | Above Ground Level |
| AMU | Applied Meteorology Unit |
| ARPS | Advanced Regional Prediction System |
| ARW | Advanced Research WRF |
| Avg.85.RH | Average RH in the 825-525 mb layer |
| AWIPS | Advanced Weather Interactive Processing System |
| CCAFS | Cape Canaveral Air Force Station |
| Climo | Daily Lightning Climatology |
| CSR | Computer Sciences Raytheon |
| DOLWG | Day-of-Launch Working Group |
| EMS | Environmental Modeling System |
| FAR | False Alarm Rate |
| FR | Flight Rules |
| FRProb | Flow Regime Lightning Probability |
| FSU | Florida State University |
| FY | Fiscal Year |
| GFE | Graphical Forecast Editor |
| GFS | Global Forecast System |
| GSD | Global Systems Division |
| GUI | Graphical User Interface |
| HR | Hit Rate |
| JSC | Johnson Space Center |
| KI | K-Index |
| KSC | Kennedy Space Center |
| LAPS | Local Analysis and Prediction System |
| LCC | Launch Commit Criteria |
| LLCC | Lightning LCC |
| MADIS | Meteorological Assimilation Data Ingest System |
| McBASI | McIDAS BASIC Language Interpreter |
| McIDAS | Man Computer Interactive Data Access System |
| MIDDS | Meteorological Interactive Data Display System |
| MSE | Mean Square Error |
| MSFC | Marshall Space Flight Center |
| MSL | Mean Sea Level |
| NAM | North American Mesoscale model |
| NASA | National Aeronautics and Space Administration |
| NCAR | National Center for Atmospheric Research |
| NetCDF | Network Common Data Form |
| NMM | Non-hydrostatic Mesoscale Model |
| NOAA | National Oceanic and Atmospheric Administration |
| NSSL | National Severe Storms Laboratory |
| NWS | National Weather Service |
| NWS MLB | NWS in Melbourne, FL |
| ORPG | Open Radar Product Generator |
| Pers | 1-Day Persistence Lightning Forecast |
| POD | Probability of Detection |
| QC | Quality Control |
| RH | Relative Humidity |
| RSA | Range Standardization and Automation |
| SLF | Shuttle Landing Facility |
| SMC | Space and Missile Center |
| SMG | Spaceflight Meteorology Group |
| SPoRT | Short-term Prediction Research and Transition |
| SS | Skill Score |
| TI | Thompson Index |
| TIM | Technical Interchange Meeting |
| TPWSD | Tower Peak Wind Speed of the Day |
| USAF | United States Air Force |
| UTC | Universal Coordinated Time |
| VAFB | Vandenberg Air Force Base |
| VAHIRR | Volume Averaged Height Integrated Radar Reflectivity |
| VT | Vertical Total |
| WRF | Weather Research and Forecasting Model |
| WSR-88D | Weather Surveillance Radar 1988 Doppler |
| WW/WA | Wind Warnings and Wind Advisories |
| XMR | CCAFS 3-letter identifier |

# Appendix A

AMU Project Schedule
30 April 2007

| AMU Projects | Milestones | Scheduled Begin Date | Scheduled End Date (*New End Date*) | Notes/Status |
|---|---|---|---|---|
| Objective Lightning Probability Phase II | Calculate new forecast parameters | Jan 06 | Feb 06 (*Oct06*) | Completed Delayed due to delays in Lightning Climatology task |
| | Develop and test new equations | Mar 06 | Apr 06 (*Feb 07*) | Completed Delayed as above |
| | Update the MIDDS tool with new equations | Apr 06 | Apr 06 (*Apr 07*) | Delayed as above |
| | Final report | Mar 06 | May 06 (*Jun 07*) | Delayed as above |
| Peak Wind Tool for General Forecasting | Data collection: wind towers, XMR 100-ft soundings, 915-MHz profilers | Sep 06 | Oct 06 (*Feb 07*) | Completed Delayed to obtain 915-MHz profiler data |
| | Software development: wind tower data QC, sounding inversion detection, 915 MHz total power display | Sep 06 | Dec 06 (*Mar 07*) | Completed Delayed to modify the AMU wind tower QC software |
| | Data analysis | Dec 06 | Feb 07 (*May 07*) | Delayed to add recent data sets |
| | Interim evaluation | Feb 07 | Mar 07 | Completed |
| | Forecast tool development, if approved | Mar 07 | May 07 | On Schedule |
| | Final report | Jun 07 | Jul 07 | On Schedule |
| Stable Low Cloud Phase II: Nocturnal Events | Data Collection: surface obs, soundings, IR satellite imagery | Apr 06 | July 06 (*Oct 06*) | Completed |
| | Data Analysis | May 06 | Aug 06 (*Oct 06*) | Completed |
| | Final report | Aug 06 | Sep 06 (*Jan 07*) | Completed Delayed to wait for NASA approval to distribute report |

AMU Project Schedule
30 April 2007

| AMU Projects | Milestones | Scheduled Begin Date | Scheduled End Date (*New End Date*) | Notes/Status |
|---|---|---|---|---|
| Situational Lightning Climatologies for Central Florida: Phase II | Modify code and develop algorithms needed to create climatologies | Nov 06 | Mar 07 | On Schedule |
| | Calculate number of lightning strikes in all boxes and output one value for each circle size for each flow regime | Mar 07 | May 07 | On Schedule |
| | Final memorandum | May 07 | Jun 07 | On Schedule |
| Anvil Forecast Tool in AWIPS | AWIPS training at GSD | Jul 05 | Nov 05 (*Jan 07*) | Completed Delayed due to funds transfer issues |
| | Develop software for calculation and display of anvil threat corridor | Dec 05 | Apr 06 (*Oct 06*) | Completed Delayed due to delay in training |
| | Test and evaluate performance of the software | Apr 06 | May 06 (*Mar 07*) | Completed Delayed as above |
| | Final memorandum | May 06 | June 06 (*Apr 07*) | Delayed as above |
| Volume-Averaged Height Integrated Radar Reflectivity (VAHIRR) | Acquisition and setup of development system and preparation for Technical Advisory Committee meeting | Mar 05 | Apr 05 | Completed |
| | Software Recommendation and Enhancement Committee meeting preparation | Apr 05 | Jun 05 | Completed |
| | VAHIRR algorithm development | May 05 | Oct 05 (*Jul 06*) | Completed – Delayed due to new code development made necessary by final product requirements |
| | ORPG documentation updates | Jun 05 | Oct 05 (*Sep 06*) | Completed Delayed as above |
| | Configure ORPG and AWIPS system in the AMU for live data testing. | Oct 05 | Jan 06 (*Aug 07*) | Delayed as above |
| | Preparation of products for delivery and memorandum | Oct 05 | Jan 06 (*Sep 07*) | Delayed as above |

AMU Project Schedule
30 April 2007

| AMU Projects | Milestones | Scheduled Begin Date | Scheduled End Date (*New End Date*) | Notes/Status |
|---|---|---|---|---|
| Subtask 26: Tower Data Skew-t Tool | Data collection: RSA wind towers, KVBG soundings, KVBG ASOS observations | Mar 07 | Apr 07 | On Schedule |
| | Data analysis, case study review using the 30 WS Tower Data Skew-t Tool | Apr 07 | Jul 07 | On Schedule |
| | Memorandum and presentation to 30 WS | Aug 07 | Aug 07 | On Schedule |
| WRF Model Sensitivity Tests | Identify candidate convective initiation days and archive data | Jul 06 | Sep 06 | Completed |
| | Configure LAPS to initialize WRF | Aug 06 | Oct 06 (*Feb 07*) | Completed Delayed due to satellite data conversion issues |
| | Compare LAPS-WRF vs. ADAS-WRF performance | Aug 06 | Jan 07 (*Apr 07*) | Delayed as above |
| | Compare use of high-resolution grid with 2-way, 1-way, and no nesting | Jan 07 | Mar 07 | Completed |
| | Assess impact of soil moisture data on WRF performance | Feb 07 | Apr 07 | On Schedule |
| | Final report and recommendations | Apr 07 | Jun 07 | On Schedule |

**NOTICE**