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Applied Meteorology Unit (AMU) Quarterly Report

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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 (July - September 2005). A detailed project schedule is included in the Appendix.

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 Kennedy Space Center (KSC).

Milestones Developed a database of days in which rapid, stable low cloud formation occurred. The meteorological characteristics of event and non-event days were compared, revealing a vertical wind profile that likely favors rapid stable cloud development.

Discussion Visible satellite imagery revealed 68 days that had low cloud ceilings at the Shuttle Landing Facility, 20 of which were due to rapid stable cloud formation. The meteorological conditions for these 20 events were analyzed and compared to the conditions on the 48 non-event days. The wind direction change with height was found to be a key factor in determining days that might have a rapid formation of low cloud ceilings.

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. 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 Examined the data and code files provided by the Florida State University (FSU) and NWS Tallahassee, FL (TAE). Determined the dates on which each flow regime occurred and sent the information to NWS MLB.

Discussion NWS MLB requested a list of dates on which each flow regime occurred in the period of record. These dates were extracted from the files provided by FSU and NWS TAE, as well as the days that had valid sounding data but could not be classified in a flow regime.

Distribution (continued from Page 1)

NWS Southern Region HQ/"W/SRH"/ X. W. Proenza
NWS Southern Region HQ/"W/SR3" D. Billingsley
NWS/"W/OST1"/B. Saffle
NWS/"W/OST12"/D. Melendez
NSSL/D. Forsyth
NSSL/C. Crisp
30 WS/DO/M. Fitzgerald
30 WS/DOR/R. Benz
30 WS/DOR/M. Barnhill
30 WS/SY/M. Schmeiser
30 WS/SYR/L. Wells
30 SW/XPE/R. Ruecker
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88 WS/WES/G. Marx
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Executive Summary, *continued*

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 KSC/Cape Canaveral Air Force Station.

Milestones Developed two data analysis and display tools for working with and viewing the graphical data sets in the archive.

Discussion Data from 11 southeast flow days were collected between 7 July and 28 September, bringing the total number of case days to 25. The data sets are being incorporated into the display and analysis tools to begin evaluation of the case days.

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 three weeks of RSA and Legacy wind data from Tower 301 on the WR and Tower 0002 on the ER from the period May–June 2005.

Discussion The average wind speeds were generally within 0.5 kts for the Legacy and RSA data, and the RSA peak speeds averaged about 1 kt higher than the Legacy peak speeds on both towers. An unexpected positive bias of 2-to-4 kts was found in afternoon RSA average and peak wind speeds at the 12 ft level on ER Tower 0002.

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 Launch Commit Criteria (LCC) and Flight Rule 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 development of the anvil threat corridor GUI was completed.

Discussion The initial layout of the GUI was modified through several iterations until an intuitive easy-to-use format was created. At the same time the scripts and code to do the computations and plotting of the threat corridor were completed. The GUI and code were integrated into the MIDDS and tested with success.

Continued on Page 3

TABLE of CONTENTS

Executive Summary, *continued*

Task	Volume Averaged Height Integrated Radar Reflectivity (VAHIRR)
Goal	Transition the VAHIRR algorithm into operations on the Weather Surveillance Radar 1988 Doppler. 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 results are computed in a timely manner and the data encoding and orientation of the VAHIRR output are being tested and modified.
Discussion	ENSCO's software engineers designed a two-pass approach for computing VAHIRR values. The first pass compiled parameters for each grid point based on data above a point. For the second pass, a simple iterative technique was used to calculate VAHIRR using the first-pass inputs. This method proved to take minimal processing time.
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	Completed a first draft of the final report and submitted it for internal AMU review.
Discussion	There were 10 phenomenological verification techniques found in the literature: 7 were developed to verify precipitation forecasts, 2 were developed to verify forecasts of multiple phenomena, and 1 was developed to verify wind forecasts. All techniques were at various stages of development, but none were determined to be ready for use in operations.

Continued on Page 4

Executive Summary, *continued*

Task	ARPS Optimization and Training Extension
Goal	Provide assistance and support for upgrading and improving the operational Advanced Regional Prediction System (ARPS) and ARPS Data Analysis System (ADAS) that is used to make operational forecasts at the NWS MLB and SMG forecast offices.
Milestones	Developed a method for performing convective sensitivity tests using different configurations of ARPS, and completed a draft of the final task memorandum.
Discussion	Several sensitivity experiments were run with ARPS to see how the physics packages, model resolution, and initial conditions may affect the quality of convective forecasts across the Florida peninsula. These experiments helped formulate a methodology that can be used to conduct more numerous sensitivity tests to determine the most robust configuration of ARPS.
Task	Operational Weather Research and Forecasting (WRF) Model Implementation
Goal	Test and implement an appropriate configuration of the WRF model over the Florida peninsula for forecasting operations at SMG and NWS MLB to assist in the WRF transition effort taking place at both locations.
Milestones	Attended tutorials for both versions of WRF model. Conducted software performance benchmark on a 16-node, dual-processor cluster system. Configured and ran a WRF simulation using archived data.
Discussion	The WRF model was run on a 16-node Linux cluster with 3.0 GHz processor speeds. Based on the results, a 9-hour WRF forecast is estimated take slightly more than 4 hours to complete on the current NWS MLB hardware, and slightly less than 1.5 hours to complete on the new hardware at SMG.

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

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 (SLF) 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 continued to analyze 68 days that were flagged as possible rapid, stable low cloud development days. Based on analysis of visible satellite imagery, they confirmed 20 of these days as rapid development cases. The remaining 48 days were non-events characterized by advection of clouds and/or widespread cloudiness for much of the day, neither of which are a concern to shuttle landing operations. The next two sections present the meteorological characteristics of the 20 rapid, stable low cloud development days, and compare the characteristics between the 20 event and 48 non-event days.

Summary of Rapid Cloud Development Events

By definition, the rapid, stable low cloud development days consisted of a stable low level sounding with an inversion present below 8000 ft. Other characteristics included development times between 1200–1800 UTC, a relatively moist mean boundary layer, and a veering vertical wind profile from the surface to the middle troposphere. Also, the mean wind flow beneath the inversion tended to have a southerly and/or easterly component, but varied quite substantially from case to case. A summary of the meteorological characteristics of the 20 rapid, stable low cloud development events is given in Table 1.

Table 1. Summary of the 20 rapid low cloud development events and accompanying meteorological characteristics. The mean quantities (relative humidity, wind direction and wind speed) are given for all levels at and below the base of the inversion. The wind direction change with height was determined by examining the sounding data from the surface to mid levels (~ 500 mb).

Event Date	Onset Time (UTC)	Dissipation Time (UTC)	Highest Inversion Height (ft)	Inversion Strength (°C)	Mean RH (%)	Mean Flow (dirn@spd in kts)	∆ Wind Direction w/ Height
12/20/93	1500	after 1800	surface	7.1	91	0°@ 4	veering
11/4/94	1445	advected	4000	4.2	85	95°@ 13	slight veering
1/6/95	1745	1915	4000	2.2	85	135°@ 15	veering
3/10/95	1715	N/A	5000	2.6	75	39°@ 19	backing
11/13/95	1345	advected	5000	1.4	80	104°@ 3	slight veering
1/7/96	1345	1415	surface	2.6	94	213°@ 21	veering
2/21/96	1415	1745	surface	7.4	91	251°@ 9	veering
3/2/97	1415	1715	6000	6.3	94	177°@ 18	slight veering
3/30/97	1245	1545	surface	5.6	94	260°@ 2	slight backing
12/19/98	1345	1515	6000	4.7	84	153°@ 16	veering
1/30/99	1345	1445	6000	1.4	72	144°@ 9	veering
3/31/99	1215	1445	7000	1.1	90	127°@ 20	veering
1/30/01	1445	advected	6000	6.9	89	199°@ 31	veering
2/15/01	1300	1600	5000	1.6	81	211°@ 12	slight veering
12/4/01	1615	advected	6000	1.6	92	57°@ 13	negligible
2/26/03	1330	1430	surface	5.3	100	10°@ 2	veering
3/6/03	1245	1315	5000	3.7	78	198°@ 20	veering
2/20/04	1300	1400	4000	4.3	86	195°@ 11	veering
3/3/04	1215	1530	5000	4.6	86	125°@ 14	slight veering
1/6/05	1515	1715	6000	2.8	97	187°@ 14	slight veering

Comparison of Event/Non-Event Day Characteristics

Since all 68 days had both low cloud ceilings at the SLF and a stable, capped thermodynamic environment, one would expect that many meteorological characteristics were similar between the 20 event days and the 48 non-event days. Figures 1–3 illustrate these common characteristics. Both event and non-event days had wide ranging inversion heights (Figure 1), inversion strengths (Figure 2), and generally had mean relative humidities (RH) above 70% (Figure 3). No distinguishable differences existed in these criteria. These conditions are simply the fundamental criterion needed for days that experience low cloud ceilings in east-central Florida under a stable regime.

Many of the 48 non-event days were classified as such after examining the visible satellite imagery. Most had an obvious advection signature, typically from the Atlantic Ocean, or else had widespread cloud ceilings that could be forecast easily as a “No-Go” condition. As stated earlier, advection scenarios are not a concern to forecasters since they can monitor the continuity of the low cloud ceilings with sufficient lead-time for landing forecasts. The real challenge comes in discerning whether low cloud ceilings will develop when ceilings do not already exist in the type of environment described by Figures 1–3. The cloud development in the 20 event days was typically rapid, in 30 minutes or less, with no prior extensive cloud decks present.

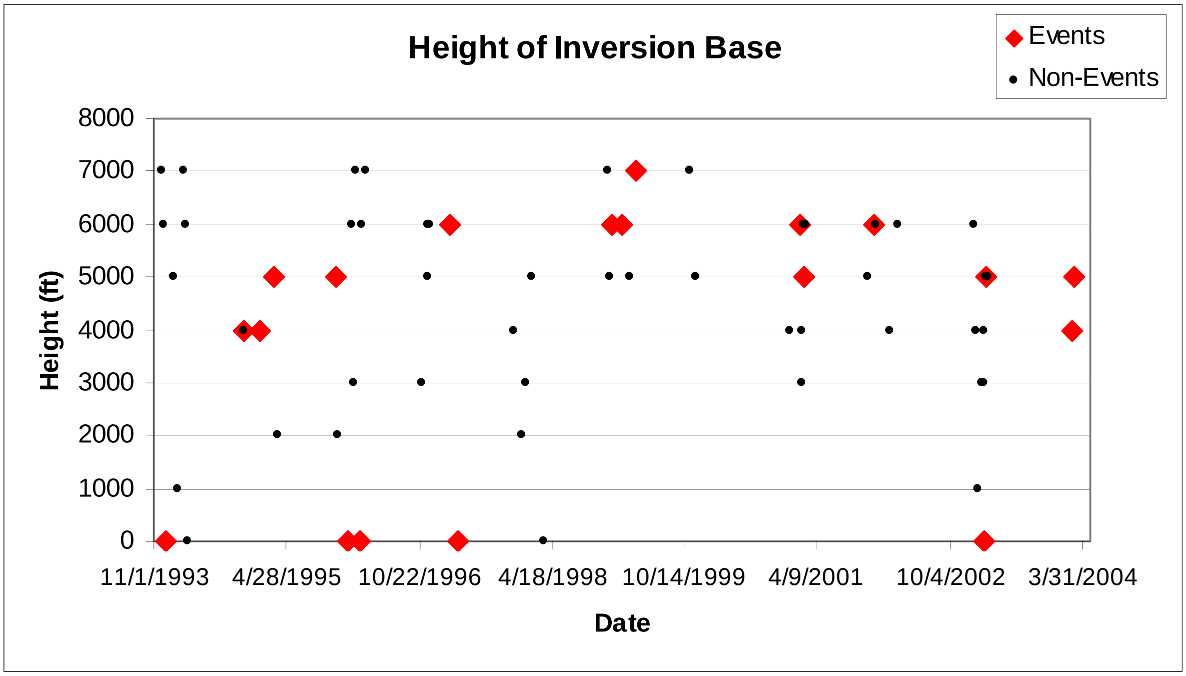

Figure 1. Scatter plot of the highest inversion heights (in ft) during event (large diamond) and non-event days (small circle).

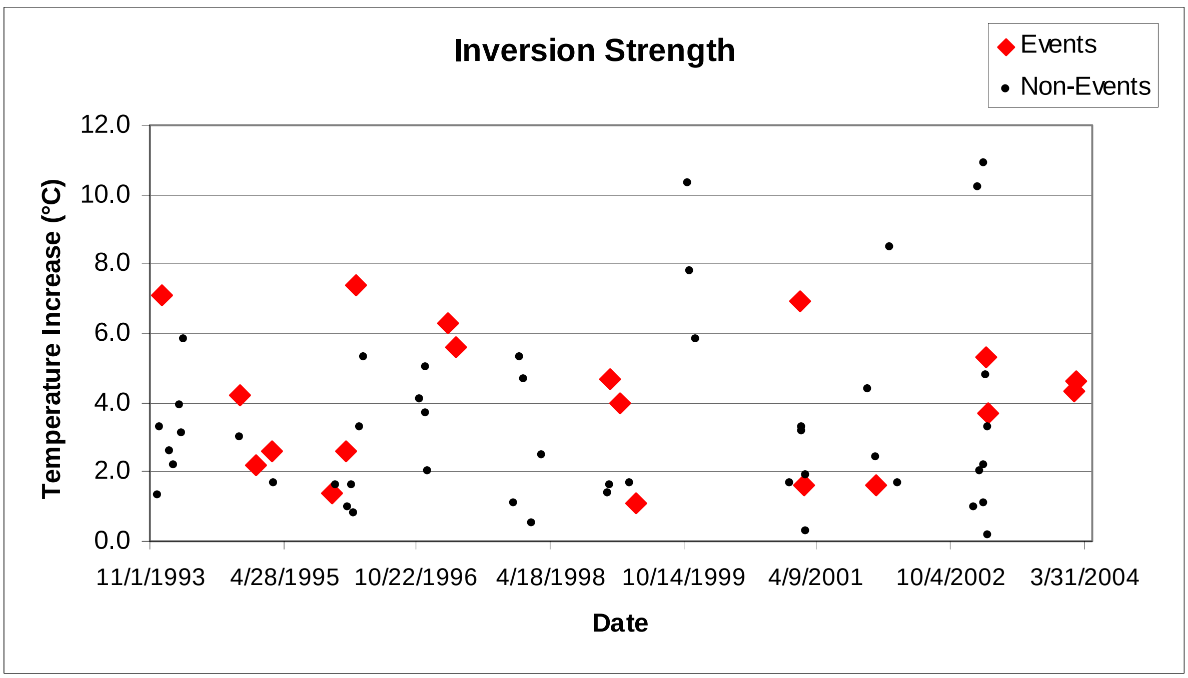

Figure 2. Scatter plot of the inversion strength (in °C) during event (large diamond) and non-event days (small circle).

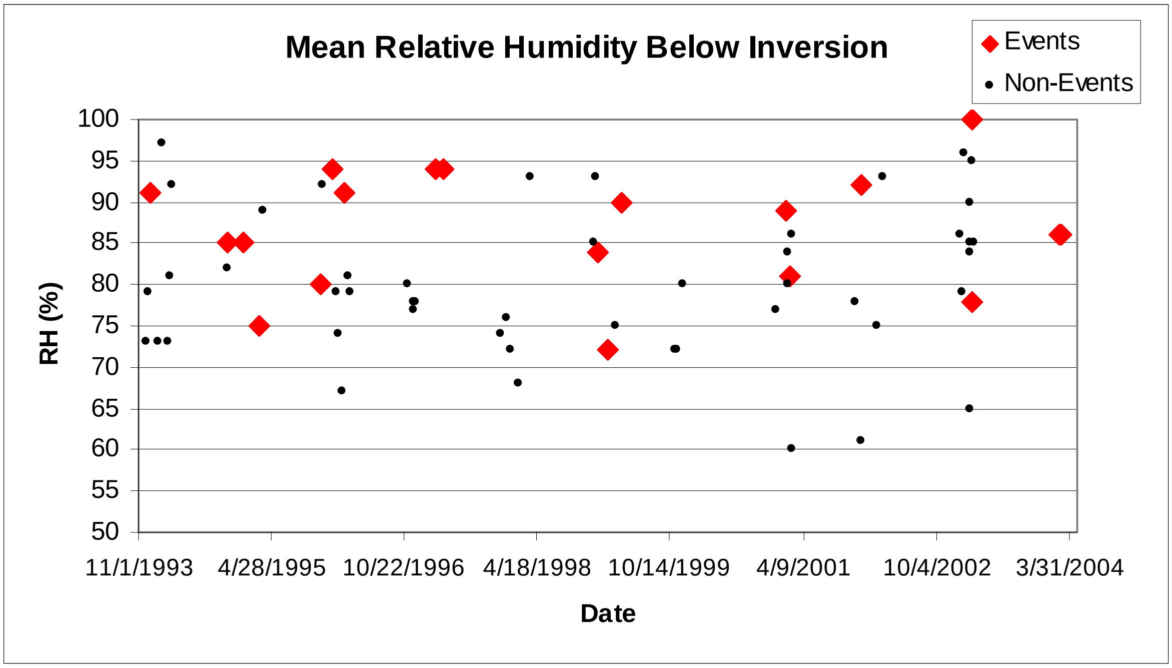

Figure 3. Scatter plot of the mean relative humidity (in %) below the inversion during event (large diamond) and non-event days (small circle).

Table 2 shows a summary of meteorological parameters for the 20 event days versus the 48 non-event days. The most distinguishing characteristic between them is the vertical wind profile in the lower to middle troposphere. A veering wind was present in 17 of the 20 event days indicating a warm advection pattern that favored rising motion and, thus, cloud development in a moist environment. Meanwhile, 40 of the 48 non-events had a backing vertical wind profile or negligible wind direction change with height, suggesting a post-frontal cold-advection pattern that would favor advection of cloud ceilings rather than development.

The mean inversion height and strength were similar between the event and non-event days, while the mean RH was slightly higher in the event days (87% vs. 80%). The statistical significance of the differences between event and non-event days was not tested for any of the parameters. However, the differences in the vertical wind profile for events versus non-events looks quite promising as a discerning factor. The veering wind profile also makes physical sense since veering winds contribute to large-scale rising motion and cloud development.

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.

Table 2. Summary of meteorological parameters associated with events/non-events.

Parameter	Event days	Non-Event Days
# of days with winds backing with height or negligible directional shear	3 days (15%)	40 days (83%)
# of days with winds veering with height	17 days (85%)	8 days (17%)
Mean inversion height	4000 ft	4521 ft
Mean inversion strength	3.9°C	3.4°C
Mean RH below inversion	87%	80%

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.

Ms. Lambert examined the data and code files provided by Mr. Shafer and Mr. Watson of the NWS in Tallahassee, FL. From these files she was able to extract the days on which each flow regime occurred, and determined which days had valid data but could not be classified in a flow regime. Ms. Lambert provided these data to the personnel at NWS MLB. She also met with them at the NWS MLB office to observe how the lightning threat index map is created and to discuss details of how the work on this task will be conducted.

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 45th Weather Squadron (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 Launch Commit Criteria (LCC) and Flight Rules (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, Cape Canaveral Air Force Station (CCAFS), and Kennedy Space Center (KSC).

Dr. Bauman continued to archive data, adding 11 more southeast flow event days for a total of 25 thus far. The dates of the event days are shown in the following table:

Apr	*May*	*Jun*	*Jul*	*Aug*	*Sep*
5	12	9	7	15	19
11	13	14	20	16	26
12	16	27	25	18	28
	17	28		23	
	18			24	
	19				
	20				

Dr. Bauman also developed a software analysis and display tool (Figure 4) to organize and view graphics for the data collected for this task. This will permit easy navigation among the cases for inter-comparison as well as a controlled looping capability for satellite, radar, and model graphics. This web-based tool includes a navigation menu for each graphics data set collected for each case as well as a link to a similar tool (Figure 5) to view and analyze high resolution Advanced Regional Prediction System (ARPS) model data.

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

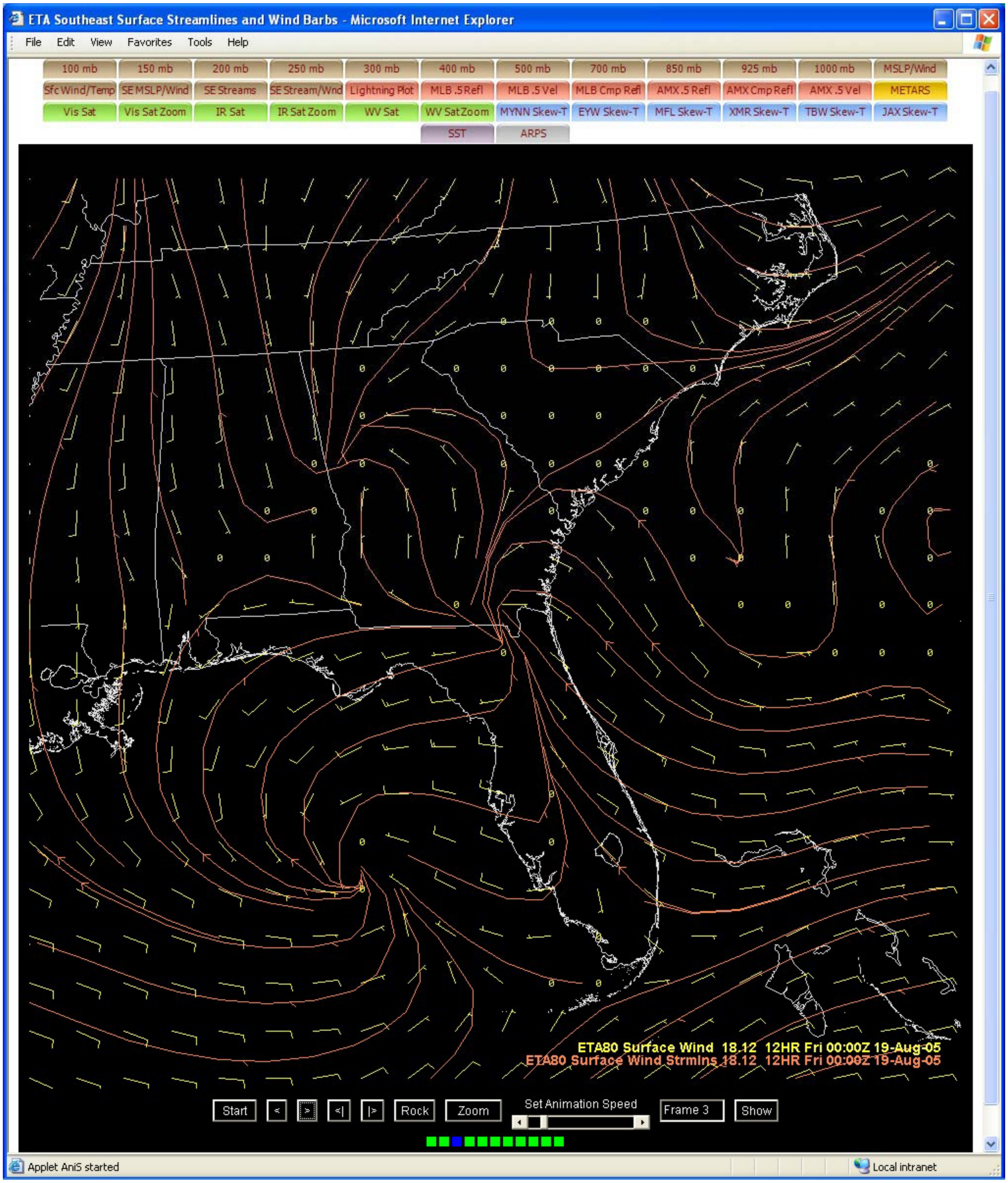

Figure 4. **Analysis and display tool showing navigation buttons at the top with a single image from a loop of surface streamlines and wind barbs from the North American Mesoscale (NAM) model. The looping controls are shown at the bottom of the image.**

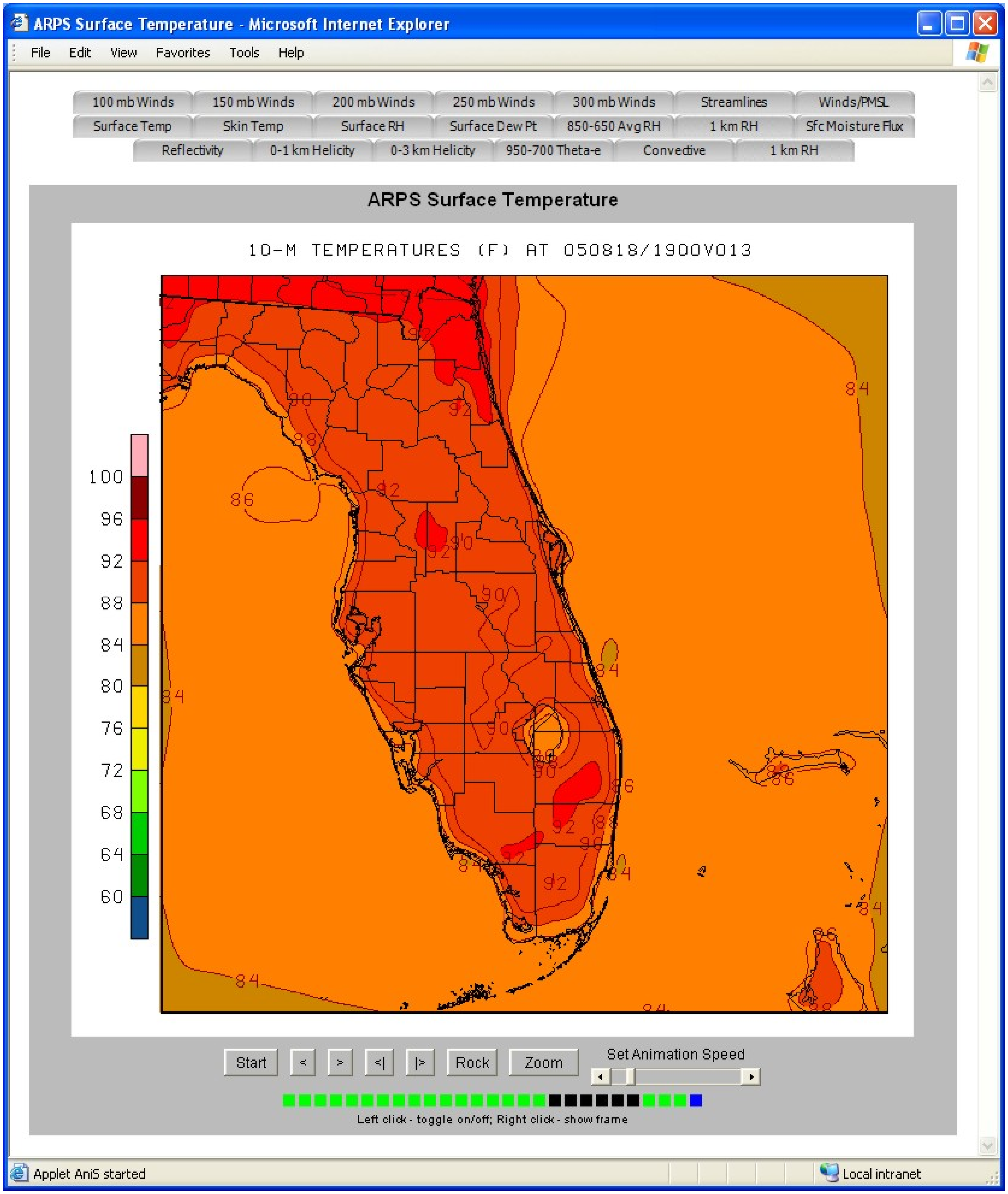

Figure 5. Analysis and display tool for ARPS images showing navigation buttons at the top with a single image from a loop of surface temperature. The looping controls are shown at the bottom of the image.

INSTRUMENTATION AND MEASUREMENT

I&M and RSA Support (Mr. Wheeler)

Mr. Wheeler continued documenting and analyzing an Advanced Weather Interactive Processing System (AWIPS) display problem and consulting with Lockheed Martin personnel. At times, certain display windows will freeze and a re-start of the AWIPS system is required to solve the problem. He also reviewed and commented on the Eastern Range (ER) Weather Legacy Shutdown Plan.

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 ER and Western Range (WR) 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. They also obtained 18 days of 1-minute Legacy and RSA wind speed and direction data from five towers on the ER: 0002, 0006, 0108, 0313 and 0403. The ER data covers 24 hours per day and includes the peak wind speed used to evaluate LCC during operations.

The 1-minute wind speed data were recorded in discreet intervals.

- ER Legacy average: approximately 0.5 m/s (1 kt) intervals,
- ER Legacy peak, 1 kt intervals,
- ER RSA average and peak, 0.2 m/s (0.4 kt) intervals,
- WR Legacy average and peak, 1 kt intervals, and
- WR RSA average and peak, 0.2 m/s (0.4 kt) intervals.

This report shows a comparative analysis of the 1-minute data from the highest and lowest levels on WR Tower 301 (300 ft and 12 ft) and ER Tower 0002 (204 ft and 12 ft). For each pair of collocated sensors, Dr. Short matched time series of 1-minute data minute-by-minute. He then ordered the matched time series from lowest to highest average wind speeds from the Legacy sensors. For each discreet value of Legacy 1-minute average wind speed, he averaged all corresponding RSA 1-minute average wind speeds. Dr. Short followed the same procedure with the peak wind speed data. This method produced a comparison of sensor performance over the full range of 1-minute wind speed data observed during the period of record.

WR Tower 301

Figure 6 shows the comparison of average and peak wind speed from the Legacy and RSA sensors on the highest level of WR Tower 301 at 300 ft and 298.5 ft (91 m), respectively. The number of hours of data for each wind speed is also shown. The analysis was truncated at the higher wind speeds where the number of minutes of available data was less than 30. When the average Legacy wind speed was 15 kts, there were about 6 hours of 1-minute data and an average RSA wind speed of 15.7 kts. There were also about 5 hours of Legacy peak wind speed data at 15 kts, with an average RSA peak wind speed of 16.5 kts. The chart in Figure 6 shows that the RSA average and peak wind speeds tend to be higher than the Legacy speeds, with the difference increasing as the Legacy wind speed increases. An overall comparison of the average wind speed at the highest level on Tower 301 gives a Legacy/RSA ratio of 12.4/13.2 (kts). For the peak wind speed data the Legacy/RSA ratio is 15.1/16.4 (kts).

Figure 7 shows the comparison of average and peak wind speed data from the Legacy and RSA sensors on the lowest level of WR Tower 301 at 12 ft and 13.1 ft (4 m), respectively. As in

Figure 6, the number of hours of data for each wind speed is also shown. For example, when the average legacy wind speed was 5 kts, there were about 8 hours of 1-minute data with an average RSA wind speed of 5 kts. There were also about 4 hours of legacy peak wind speed data at 5 kts, with an average RSA peak wind speed of 5.9 kts. Figure 7 indicates excellent agreement between legacy and RSA average wind speeds at the lowest level of Tower 301. The average difference between legacy and RSA peak wind speeds was 1.1 kts.

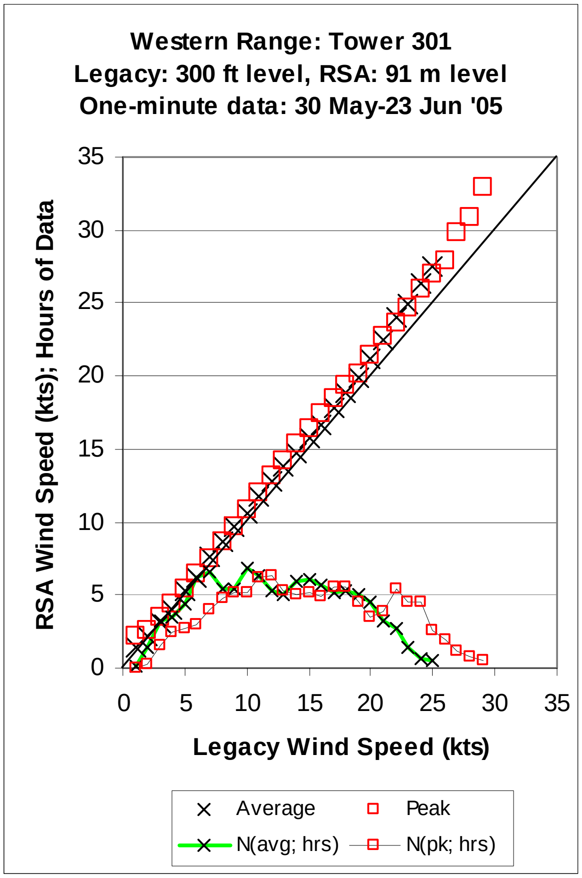

Figure 6. The Legacy vs. RSA wind speed data at 300 ft and 91 m (298.5 ft) on WR Tower 301 during 1600–2200 UTC 30 May to 23 June 2005. Average (X) and peak (□) wind speeds are shown with the number of hours of data for each wind speed. The solid diagonal line represents the 1:1 correspondence between the Legacy and RSA wind speeds.

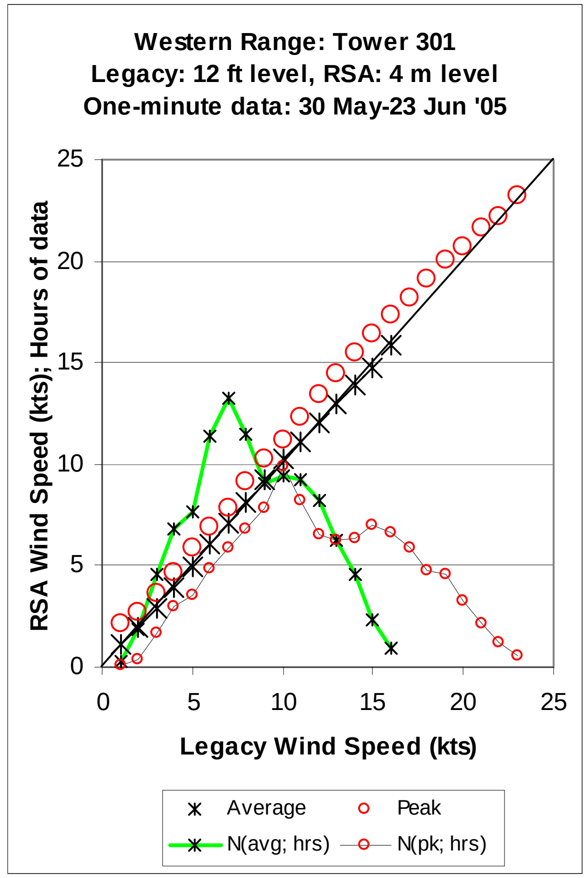

Figure 7. The Legacy vs. RSA wind speed data at 12 ft and 4 m (13.1 ft) on WR Tower 301 during 1600–2200 UTC 30 May to 23 June 2005. Average (∗) and peak (○) wind speeds are shown along with the number of hours of data for each wind speed. The solid diagonal line represents the 1:1 correspondence between the Legacy and RSA wind speeds.

ER Tower 0002

Figure 8 shows a comparison of average and peak wind speed data from the Legacy and RSA sensors on the highest level of ER Tower 0002 at 204 ft and 210 ft (64 m), respectively. The number of hours of data for each wind speed is also shown. For example, when the average Legacy wind speed was 15 kts, there were about 9 hours of 1-minute data with an average RSA wind speed of 15.8 kts. There were about 17 hours of legacy peak wind speed data at 15 knots, with an average RSA peak wind speed of 16.5 kts. The chart in Figure 8 shows that the RSA average and peak wind speeds tend to be slightly higher than the Legacy speeds, with the difference decreasing as the Legacy wind speed increases. An overall comparison of the average wind speed data at the highest level on Tower 0002 gives a Legacy/RSA ratio of 9.7/10.5 (kts). For the peak wind speed the Legacy/RSA ratio is 11.2/12.4 (kts).

Figure 9 shows a comparison of the diurnal cycle of average wind speeds from the Legacy and RSA sensors on lowest level of ER Tower 0002 for the period 12–30 May 2005. From 0000 to about 1100 UTC (8 PM to 7 AM local time) the RSA average wind speed was 0.5 kts higher than the Legacy average wind speed, consistent with the other Legacy/RSA comparisons above. However, after 1100 UTC the RSA-Legacy difference increased to 2 kts. A similar pattern was found in the diurnal cycle of peak winds, with the RSA-Legacy difference of 4 kts during the afternoon. This pattern was observed from day-to-day. Dr. Short will continue investigating the RSA and Legacy wind speed data from the other towers and conduct similar comparisons to those shown here.

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.

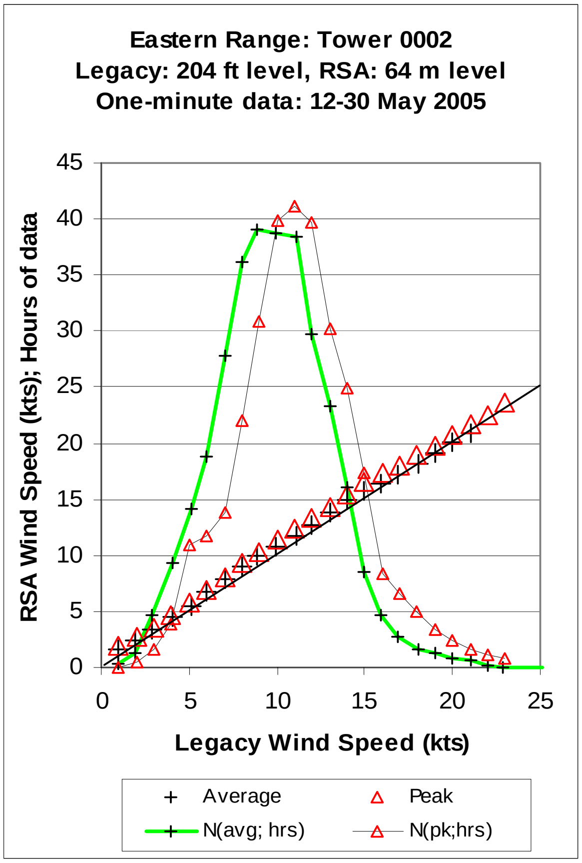

Figure 8. The Legacy vs. RSA wind speed data at 204 ft and 64 m (210 ft) on ER Tower 0002 during 12–30 May 2005. Average (+) and peak (Δ) wind speeds are shown with the number of hours of data for each wind speed. The solid diagonal line represents the 1:1 correspondence between the Legacy and RSA wind speeds.

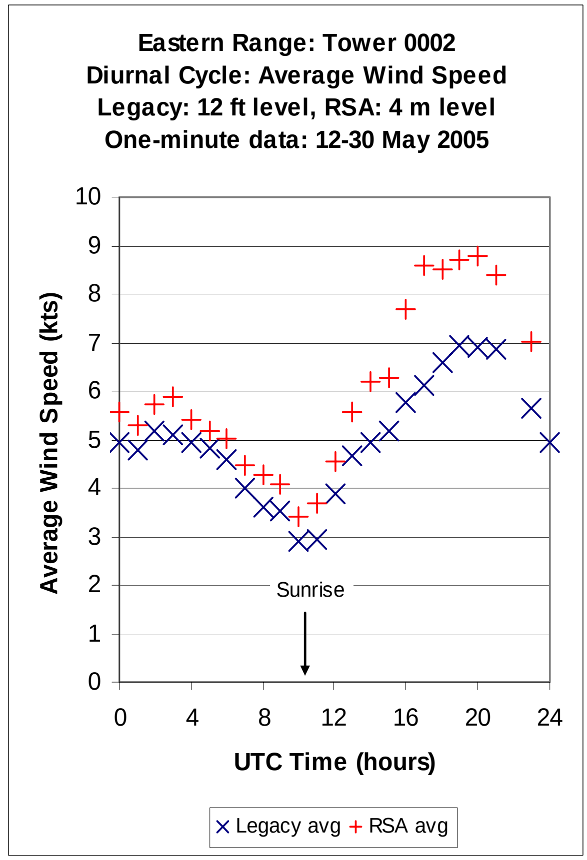

Figure 9. The diurnal cycle of average wind speed from the Legacy (×) sensor at 12 ft and the RSA (+) sensor at 4 m (13.1 ft) on ER Tower 0002 during 12–30 May 2005. Sunrise occurred at approximately 10:30 UTC.

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 the Meteorological Interactive Data Display System (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 graphical user interface (GUI) to allow for easier and faster access to the anvil tool.

Mr. Wheeler designed a phased approach in the development of the GUI. He first created a flow diagram to determine the layout of the GUI and how the different modules would be attached. He then began work on the Man Computer Interactive Data Access System (McIDAS) BASIC Language Interpreter (McBASI) program that would do the computations and graphics plotting.

Mr. Paul Wahner of CSR provided assistance in developing the McIDAS Anvil GUI. The code he used to create the GUI is a scripting language called Tool Command Language (TCL) and its associated GUI toolkit, TK. Mr. Wahner designed the GUI based on Mr. Wheeler's flow diagram and other GUI examples he had researched. The GUI has a main menu (Figure 10) that allows the user to select the line position for the label, launch complex or other site on which to center the graphic, color, graphic frame for the plotting, and the date and time. The tabs allow the user to choose the data source for the calculations (rawinsonde, model, or 50MHz).

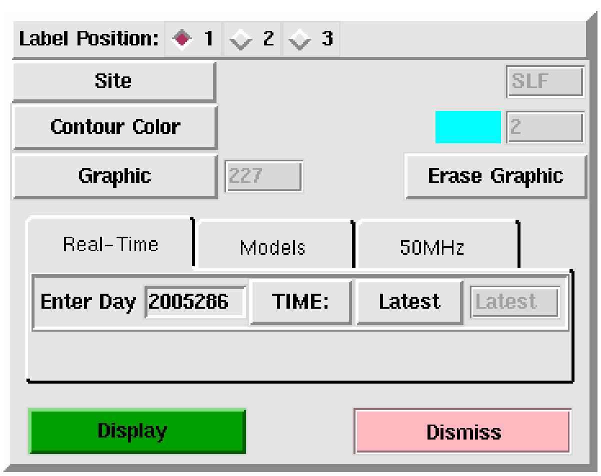

Figure 10. The anvil threat corridor GUI main menu.

Once the site, color, graphic frame and time have been selected, the user selects the data set to use for the anvil threat corridor calculation. Figure 11 shows the sub-menu to select model data. This is initiated when the middle tab "Models" in the main menu is chosen. At this level the user chooses a model, the model initialization time, and the forecast hour.

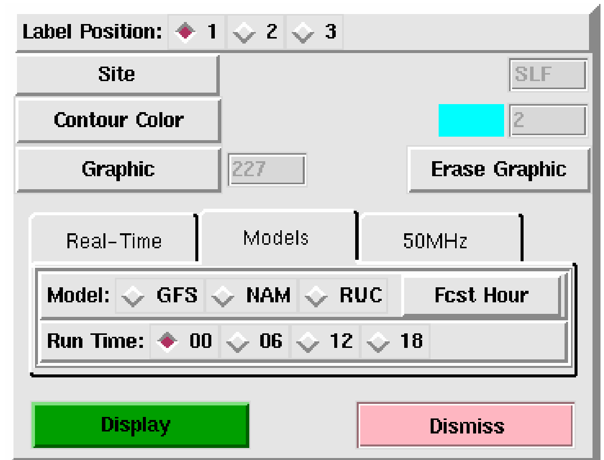

Figure 11. The anvil threat corridor model selection sub-menu.

Figure 12 shows the sites that are available for selection. They include all KSC/CCAFS launch complexes, Melbourne, FL, Edwards AFB, CA and White Sands Missile Range, NM. The site selected will be the focal point for the anvil threat corridor plot.

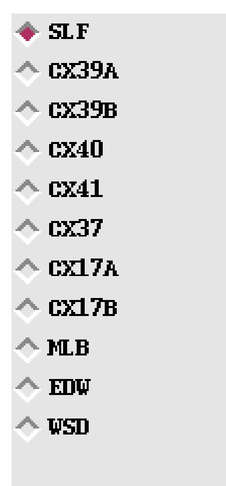

Figure 12. Anvil Threat Corridor site selection sub-menu.

After the GUI was created, Mr. Wheeler developed the McIDAS code needed to retrieve the data, make the calculations, and plot the results on a McIDAS graphic frame. He found that the model point data were in a non-standard format for McIDAS, NetCDF (Network Common Data Format). He designed a TCL script to be called from the McBASI code when the user selects model data to retrieve the needed values from the NetCDF database. The other data types were compatible with the McBASI code.

Once he completed the GUI and McBASI code, Mr. Wheeler tested each dataset and made minor changes to how the data were displayed in the graphics frame. He then delivered the GUI and McBASI code to Computer Sciences Raytheon (CSR) for installation onto the 45 WS MIDDS and also sent the programs to SMG for installation onto their system

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

Volume Averaged Height Integrated Radar Reflectivity (VAHIRR) Algorithm (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. 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 Weather Surveillance Radar 1988 Doppler (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.

ENSCO’s software engineers designed a two-pass approach for computing the VAHIRR values. The first pass creates parameters for each grid point, based on vertically related data above each point: cloud bottom, cloud top, average reflectivity, and number of reflectivity samples. For the second pass, Ms. Miller selected a simple iterative calculation that computes VAHIRR using first-pass inputs for each grid point whose surrounding horizontal 11 x 11 km grid point set has qualifying parameters. This method proved to take minimal processing time, calculating VAHIRR results in less than a minute following receipt of a test volume scan from the NWS MLB WSR-88D.

A meeting was held in October with the Launch Weather Officers, Mr. Roeder, Mr. Gillen, and Ms. Miller to establish a consensus for the VAHIRR color scheme. The group determined VAHIRR values for 16 levels and discussed additional information about desired launch overlays. Mr. Keen began work on identifying data file changes needed to display the VAHIRR results on AWIPS consoles and on creating a tool for generating the launch overlays.

Ms. Miller began debugging the data encoding and orientation of the VAHIRR output. Mr. Steve Smith of the ROC was instrumental in providing technical assistance to Ms. Miller on integrating the VAHIRR task into the RPG environment, formatting the output data, and the use of development tools.

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

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, Rapid Update Cycle (RUC), NAM, and Global Forecast System (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 were 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 was assessed.

Ms. Lambert found 10 techniques in the literature: 7 were developed to verify precipitation forecasts, 2 were developed to verify forecasts of multiple phenomena, and 1 was developed to verify wind forecasts. All techniques were at various stages of development, but none were determined to be ready for use in operations.

Ms. Lambert completed a first draft of the final report and submitted it for internal AMU review. The report contains detailed summaries of each technique and associated references in the literature. It also contains a table that ranks each technique according to its readiness for use in the operational AWIPS.

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 developed a methodology for conducting convective sensitivity tests to determine possible improvements to the ARPS configuration over the Florida peninsula. To enable the sensitivity experiments, he established a real-time data feed and configured ARPS to run in real-time on the AMU's Linux cluster, as discussed in the previous AMU quarterly report. The model ran throughout the summer months, creating and archiving graphics each day for identifying potential convective sensitivity case days, in addition to supporting the AMU task Forecasting Low-Level Convergent Bands Under Southeast Flow. Due to resource constraints, the convective sensitivity tests focused mainly on one event.

Mr. Case found that higher horizontal and vertical resolution may provide improved cellular structure and slightly earlier convection initiation in the model; however, modest increases in resolution lead to much larger computational requirements for a given domain and time integration window. The relatively minor improvements realized by increased resolution may not be feasible or practical given the existing computational resources at SMG and NWS MLB.

A few experiments revealed ways to improve the forecast configuration in terms of faster run-time performance and increased integration time. The model's run-time performance improved by ~15% when only the vertical component of the sub-grid scale turbulent mixing was calculated instead of all three dimensions. The computation time saved could be used to improve the vertical resolution by increasing the number of levels by ~15%, as an example. In addition, a longer time integration beyond 9 hours can be realized by using the NAM instead of the RUC as boundary conditions. The AMU recommends that additional tests be conducted in order to measure the impact of the configuration changes (as discussed in the memorandum) on convective initiation and evolution under a variety of weather regimes.

For more information or a copy of the task memorandum containing the results of the sensitivity experiments, contact Mr. Case at 321-853-8264 or case.jonathan@ensco.com.

Operational Weather Research and Forecasting (WRF) Model Implementation (Mr. Case)

The WRF model is the next generation community mesoscale model designed to enhance collaboration between the research and operational sectors. The NWS as a whole has begun a transition toward WRF as the mesoscale model of choice to use as a tool in making local forecasts. AMU customers have derived great benefit from the maturity of the ADAS in support of its varied forecast programs, and would like to use ADAS for providing initial conditions for WRF. To assist in the WRF transition effort, the AMU has been tasked to conduct preliminary work towards testing and implementing an appropriate configuration of the WRF model over the Florida peninsula. This includes conducting a hardware performance comparison study, configuring and testing an ADAS/WRF setup, and modifying the ADAS GUI for controlling the tunable initialization and parameterization settings for ADAS/WRF.

Mr. Case began familiarizing himself with the WRF model and its infrastructure this past quarter. He attended two tutorial classes, each providing background and practical information on the two different versions of the WRF model. He also downloaded and installed the latest community version of WRF and ran some performance benchmark tests. Finally, Mr. Case downloaded sample grid data and ran a WRF simulation using real-time data. The upcoming sections describe the WRF tutorial classes, WRF run-time performance estimates, and various necessary components of the WRF system.

WRF Tutorial Classes

Mr. Case attended two tutorials in Boulder, CO, one in July and the other in September, which provided background information and hands-on practice sessions in setting up and running the WRF model. The July tutorial provided a description of the Advanced Research WRF (ARW), which is the version of WRF primarily designed and written by the National Center for Atmospheric Research (NCAR). The September tutorial provided a description of the Non-hydrostatic Mesoscale Model (NMM) version of WRF, which is primarily designed and written by the National Centers for Environmental Prediction (NCEP). These versions of WRF are referred to as the WRF-ARW and WRF-NMM, respectively. The two versions of WRF are both supported by the Developmental Testbed Center and will eventually be merged into one modeling system that can run each separate framework.

WRF-ARW

The WRF-ARW was designed for research and operational applications. Its dynamical “core” consists of fully-compressible, Eulerian non-hydrostatic equations of motion (conservative for scalar quantities), a terrain-following hydrostatic pressure vertical coordinate, up to 6th ordered horizontal and vertical advection schemes, an advanced time-split integration method using a 3rd-order Runge-Kutta scheme that provides more stability at larger time steps than the Leap Frog scheme, and smaller time steps for acoustic and gravity-wave modes (Skamarock et al. 2005). In addition to this dynamical core, numerous physics schemes are available for predicting cloud microphysics, sub-grid scale cumulus parameterization, surface and planetary boundary layer physics, atmospheric radiation, and turbulence parameterization. Many of the physics schemes from the Penn State/NCAR Mesoscale Model Version 5 are found in the WRF-ARW, along with more sophisticated packages.

WRF-NMM

The WRF-NMM is designed primarily for operational applications only. Its core consists of fully-compressible, non-hydrostatic dynamics (Janjic et al. 2001; Janjic 2003a; Janjic 2003b), a terrain-following hybrid sigma-pressure vertical coordinate, a forward-backward time integration scheme that uses the same time step for all computations, second-order horizontal and vertical scalar advection, and energy and enstrophy conservation (Janjic 1984).

Due to the significant differences between the WRF-ARW and WRF-NMM dynamics, time integration, and advection schemes, most physics packages available to the WRF-ARW have not been tested with the WRF-NMM (and vice versa). Therefore, the number of physics schemes available to the WRF-NMM is currently more limited than the WRF-ARW; however, the same general suite of physics is available. Additional physics packages will be made available to the WRF-NMM as progress is made in combining the two dynamical cores into the same common WRF framework.

Description of WRF Modeling System

The WRF model is only the numerical weather prediction (NWP) portion of the entire WRF system. An operational WRF modeling system includes the following components:

WRF Standard Initialization (WRFSI). The WRFSI provides the means to establish a grid domain, initialize fixed field data such as terrain height, soil and vegetation type, etc., and interpolate initial and boundary condition grids to the WRF grid. A special GUI was designed to help interface with the various WRFSI programs (Figure 13).

Data Integration. The data integration can be performed by a variety of applications. The WRF-ARW tutorial focused on the WRF 3D Variational (WRF-VAR) application, which minimizes the analysis errors using an iterative technique. The WRF-VAR can be challenging to tune correctly because observational and background error covariances need to be specified properly for the technique to work correctly. Other applications such as the ADAS or the Local Analysis and Prediction System (LAPS) can use output from WRFSI to generate a high-resolution analysis for input into WRF. This task will utilize AMU knowledge of ADAS to generate analyses for input into the WRF model.

WRF Initialization. Output from WRFSI, WRF-VAR, ADAS, or LAPS are input into a program called "real", which ensures that all data conform to the WRF framework.

WRF NWP model (ARW/NMM). This step is the actual numerical prediction.

Graphical Post-Processing. A variety of software conversion routines were presented in the WRF-ARW and WRF-NMM tutorials using output mechanisms such as NCAR graphics, GrADS, and GEMPAK.

WRF Run-Time Performance Benchmark

Mr. Case ran the WRF-ARW on a parallel cluster owned by ENSCO, Inc. with sample data from an archived weather event provided by NCAR. Based on the grid configuration, resolution, and time steps used for the sample case, he scaled the run-time performance to estimate how long WRF would take to complete a 9-hour forecast over the same Florida domain currently run at NWS MLB with the ARPS NWP model. The ARPS at NWS MLB uses a domain with 4-km grid spacing and 177 points in both horizontal directions, resulting in a domain size of ~700 km x 700 km. The run-time performance was scaled assuming 35 vertical levels in WRF.

The scaled WRF run-time performance estimates based on this grid configuration are given in Table 3. The estimated performance of a 4-km WRF forecast on the cluster is ~1.6 hours, given 32 processors, each rated at 3.0 GHz. This performance is also scaled to the current and future hardware at NWS MLB and SMG. Based on these estimates, it appears that SMG could run a rapid refresh cycle, where 9-hour WRF forecasts could be run 8 times per day. As long as the run time is less than 3 hours, the forecast cycle could be updated every 3 hours. SMG could also explore WRF configurations that yield longer forecast times beyond 9 hours at less frequent update intervals, if desired.

Given the current and expected hardware at NWS MLB, the WRF model can be updated four times per day, since the time to completion is slightly more than 3 hours. However, Mr. Case could examine different configurations of WRF to find one that reduces the time it takes to complete a forecast. Also, these benchmarks were done using the WRF-ARW. The WRF-NMM is advertised to run faster than the WRF-ARW given the same approximate physical schemes. Once a community version of WRF-NMM is made available, Mr. Case will perform additional benchmark tests to compare the run-time performance of WRF-NMM to WRF-ARW.

For more information, contact Mr. Case at (321)-853-8264 or case.jonathan@ensco.com.

Table 3. Summary of estimated WRF run-time performance on various hardware configurations, based on the current 4-km ARPS grid configuration run at NWS MLB.

Hardware Description	Estimated Run Time
ENSCO Inc., 3.0 GHz cluster, 32 processors	1.6 hours
NWS MLB 2.2 GHz cluster, 18 processors (current)	4.2 hours
NWS MLB 2.2 GHz cluster, 24 processors (future)	3.2 hours
SMG 3.4 GHz cluster, 32 processors (future)	1.5 hours

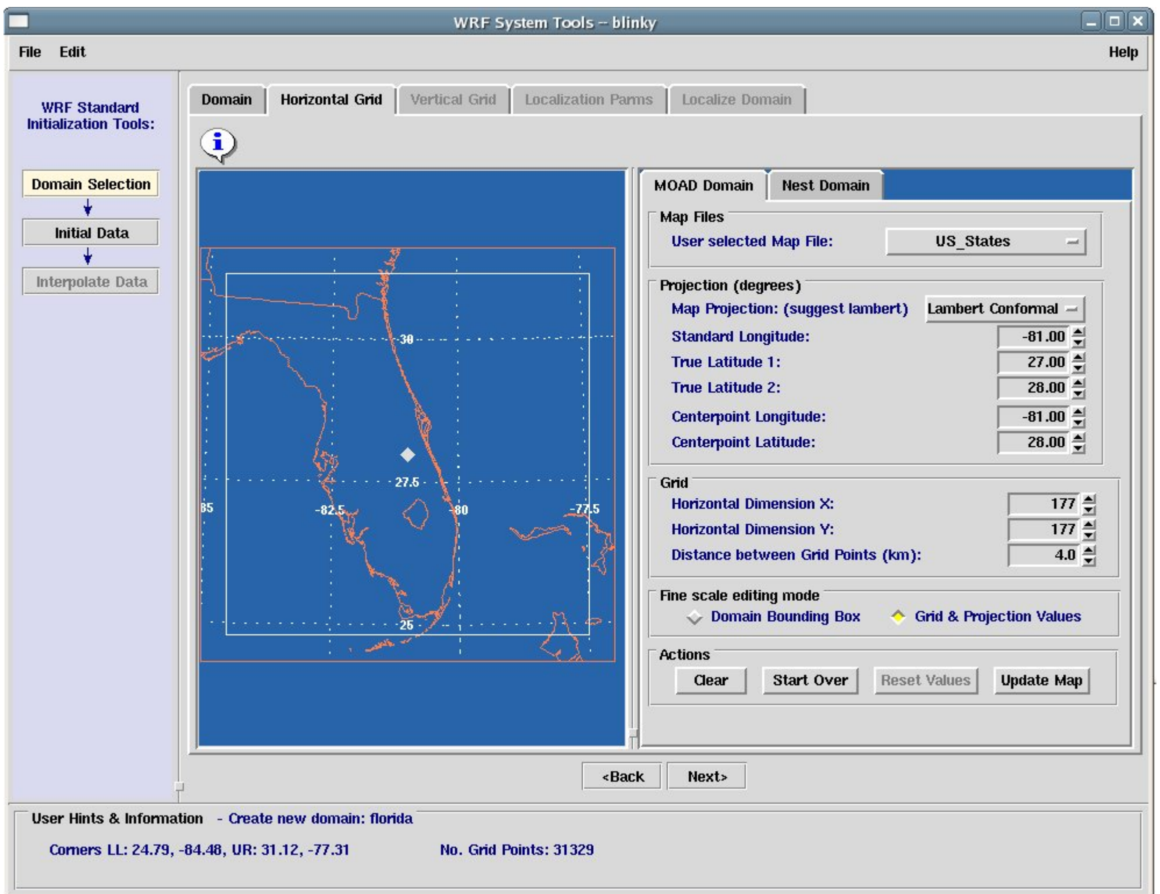

Figure 13. The WRF Standard Initialization graphical user interface allowing the users to set up a forecast grid and initialize all parameters for a WRF model run.

METEORLOGICAL TECHNIQUES AND STATE OF THE SCIENCE RESEARCH

Ms. Lambert attended the Southern Thunder Project (formerly the Total Lightning Applications, Transition, Evaluation, Science and Technology or LaTEST) Workshop, convened jointly by NASA's Short-term Prediction Research and Transition Center (SPoRT), the NWS, and Vaisala, Inc. The workshop was held in Fort Worth, TX on 25-27 July 2005, and was a follow-up to the LaTEST workshops held in Huntsville, AL on 1-2 April 2004 and at the January 2005 AMS Annual Meeting in San Diego. She summarized of the meeting in an AMU Memorandum (Lambert 2005).

All total lightning networks in use and in development were described in the first few presentations. The rest of the workshop involved discussion of different ways of displaying the data and using it in operational forecasting. Most displays used some form of lightning density in which the raw data were discretized into grids. This greatly reduced the size of the data sets but still allowed for meaningful and useful displays of the lightning observations.

Upon returning to the AMU, Ms. Lambert discussed with Dr. Merceret the possibility of transforming the local Lightning Detection and Ranging (LDAR) archive of ~11 years into a gridded database that would be much less cumbersome to use in AMU tasks and could be shared more easily with the research community. The main issues would be determining appropriate space and time resolutions for the grids and how to quality control the data. This could be a topic for future AMU Tasking Meetings.

For a copy of the AMU Memorandum describing the workshop, contact Ms. Lambert at lambert.winnie@ensco.com or 321-853-8130.

AMU CHIEF’S TECHNICAL ACTIVITIES (Dr. Merceret)

Dr. Merceret completed 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, and provided them with a preliminary report for their review

Dr. Merceret and Ms. Ward began writing software to do spectral and coherence processing of the 915-MHz wind profiler data that MSFC Natural Environments Branch has been using for examination of winds in the Shuttle roll maneuver region. This will compliment the structure function analysis of the same data recently completed by Dr. Merceret. He also revised several manuscripts that are being prepared for conferences or journals.

VISITING SCIENTISTS

Dr. James Koermer and Mr. Andrew Loconto from Plymouth State University completed their work on convective winds and left the AMU in August. During their time in the AMU, they created an updated warm-season convective wind climatology using KSC/CCAFS wind tower data from May–September of 1995-2003. The resulting climatology includes stratifications of convective wind events by year, month, hour, elevation, and tower. They chose five strong convective wind events and five weaker events that each occurred on days of negligible synoptic-scale pressure gradient at random for case-study comparisons. They then derived a number of thermodynamic parameters from Skew-T/Log P diagrams and calculated statistics to determine which parameters differentiated the best between the strong and weak events. Preliminary results from these tests indicate that the lapse rate of equivalent potential temperature may be a useful in forecasting microbursts. Their work was supported by NASA Space Grant Workforce Development Funds.

Ms. Angel Bennett, a senior in the Pennsylvania State University (PSU) meteorology program, arrived in July and departed in August. She was a summer intern in PSU’s KSC Internship Development Program. Her project involved statistical analysis of CG Lightning Surveillance System (CGLSS) data and updating the daily lightning climatology found in Lambert and Wheeler (2005) to include 2004 data and a smaller area that no longer includes the Astrotech 5 n mi circle at Titusville Airport. She also wrote a final report and gave a final presentation.

AMU OPERATIONS

All AMU personnel participated in a teleconference discussing the contents of the AMU Quarterly Report for the Third Quarter of FY 2005. Other teleconference participants included personnel from the 45 WS, SMG, NWS MLB, 30 WS, and the KSC Weather Office.

Mr. Wheeler converted two AMU UNIX systems to the Linux operating system and transferred most of the data from the UNIX external hard drives to the Linux system. This will allow the AMU to turn in six external hard drives. He tested the AMU's new cluster head node, which will be installed in the cluster in November. He created and installed an additional data back-up solution for individual workstations. Now all full and incremental backups are synchronized to a large external hard drive that can be taken off-site if necessary. Mr. Wheeler also started developing the FY06 IT requirements and budget.

AMU personnel supported both Shuttle landing attempts, two Delta IV launch attempts, the Atlas V launch, and the Delta II launch.

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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
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
ARW	Advanced Research WRF
AWIPS	Advanced Weather Interactive Processing System
CCAFS	Cape Canaveral Air Force Station
CG	Cloud-to-Ground
CGLSS	CG Lightning Surveillance System
CSR	Computer Sciences Raytheon
CWA	County Warning Area
ER	Eastern Range
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
KSC	Kennedy Space Center
LAPS	Local Analysis and Prediction System
LaTEST	Lightning Applications, Transition, Evaluation, Science and Technology
LCC	Launch Commit Criteria
LDAR	Lightning Detection and Ranging
LLCC	Lightning LCC
McBASI	McIDAS BASIC Language Interpreter
McIDAS	Man Computer Interactive Data Access System
MIDDS	Meteorological Interactive Data Display System
MSFC	Marshall Space Flight Center
NAM	North American Model
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NetCDF	Network Common Data Format
NLDN	National Lightning Detection Network
NMM	Non-hydrostatic Mesoscale Model
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWP	Numerical Weather Prediction
NWS	National Weather Service
NWS MLB	National Weather Service in Melbourne, FL
NWS TAE	National Weather Service in Tallahassee, FL
QC	Quality Control
RH	Relative Humidity
ROC	Radar Operations Center
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SREC	Software Recommendation and Enhancement Committee
SRH	NWS Southern Region Headquarters
TAC	Technical Advisory Committee
TCL	Tool Command Language
USAF	United States Air Force
UTC	Universal Coordinated Time
VAHIRR	Volume Averaged Height Integrated Radar Reflectivity
WR	Western Range
WRF	Weather Research and Forecasting Model
WRFSI	WRF Standard Initialization
WRF-VAR	WRF 3D Variational Integration
WSR-88D	Weather Surveillance Radar 1988 Doppler
WWW	World Wide Web

Appendix A

AMU Project Schedule 31 October 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
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
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	Completed
	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

AMU Project Schedule 31 October 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
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	Delayed for analysis of new data.
Updated Anvil Threat Corridor Forecast Tool	Software Requirements Review and Graphical User Interface Development	Jun 05	Jul 05	Completed
	Testing and Memorandum	Aug 05	Sep 05	Completed
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	Delayed due to new code development deemed necessary by requirement
	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

AMU Project Schedule 31 October 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
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	Completed
	Final Memorandum	Aug 05	Sep 05	Completed, pending customer review
Operational Weather Research and Forecasting (WRF) Model Implementation	Hardware performance comparison study	Jul 05	Aug 05	Completed
	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

NOTICE