ENSCO, Inc.

Applied Meteorology Unit (AMU) Quarterly Report

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Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the first quarter of Fiscal Year 2005 (October – December 2005). A detailed project schedule is included in the Appendix.

Task Objective Lightning Probability Forecast: Phase I

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

Milestones A graphical user interface (GUI) was developed to allow forecasters user-friendly access to the equations. The GUI was developed through consultations with the 45th Weather Squadron (45 WS) to ensure the final product meets their operational needs.

Discussion The GUI allows the user to input values that are readily available to operational forecasters from the morning sounding, then calculates the probability of lightning occurrence for the day and displays the value quickly in an easy-to-read format.

Task Severe Weather Forecast Decision Aid

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

Milestones The analysis to separate lightning vs. non-lightning days was completed. The stability indices were stratified by severe weather, lightning but no severe weather, and no lightning days, then analyzed to determine if there were significant differences in their values between severe and non-severe weather on lightning days only.

Discussion While the analysis of the stability indices is not complete, initial results still show that no significant differences in values exist that will help forecasters discern between a severe/non-severe weather day.

Task Hail Index

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

Milestones The AMU obtained a copy of the software used to generate the current hail size forecasts from sounding data. The computed forecasts were compared to observations, revealing a large discrepancy in the values forecast vs. those observed. Two major errors were found in the software and reported to Computer Sciences Raytheon personnel.

Discussion The errors in the code were modified in the AMU copy of the software and new forecasts were computed. The results showed a closer association between the number of hail events forecast and the number observed.

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Executive Summary, *continued*

Task	<u>Stable Low Cloud Evaluation</u>
Goal	Examine archived data collected during rapid stable cloud development events resulting in cloud ceilings below 8,000 ft at the Shuttle Landing Facility (SLF). Document the atmospheric conditions favoring this type of cloud development to improve the ceiling forecast issued by the Spaceflight Meteorology Group (SMG) for Shuttle landings at KSC.
Milestones	Used local rawinsonde and hourly surface observations at the SLF to develop a database of days with low-level temperature inversions and cloud ceilings below 8,000 ft using data from 10 cool seasons (November-March) from the years 1993–2003.
Discussion	An objective analysis was done first by using software to choose days with low-level inversions and days with ceilings below 8000 ft. A subjective analysis was then performed to match days that had both attributes and moisture near the inversion level. These days will be compared to satellite data to build a database of rapidly developing ceiling events.
Task	<u>Shuttle Ascent Camera Cloud Obstruction Forecast</u>
Goal	In response to a Shuttle Program request to implement a Columbia Accident Investigation Board recommendation, develop a model to forecast the probability that at least three of the shuttle ascent imaging cameras will have a view of the shuttle launch vehicle unobstructed by cloud at any time from launch to Solid Rocket Booster separation.
Milestones	Completed the customer-recommended revisions to the final report. The AMU remains on standby to present briefings to the Shuttle Launch Director and Integration Control Boards as required.
Discussion	Results from this work were presented at the American Meteorological Society's 11th Conference on Aerospace, Range, and Aviation Meteorology.
Task	<u>RSA and Legacy Wind Sensor Evaluation</u>
Goal	Compare wind speed and direction statistics from legacy and RSA sensors on the Eastern and Western Ranges (ER and WR) to quantify the impact of sensor technology changes on wind measurements. The 45 WS and 30th Weather Squadron (30 WS) use these winds to issue weather advisories for operations and, therefore, need to know if there are significant differences in the wind measurements between the systems.
Milestones	Began archiving ER legacy data and received samples of ER RSA sonic wind data for preliminary analysis. Software to ingest and reformat the data was developed and tested.
Discussion	A preliminary analysis of the 1-second wind speed data from the ER RSA sensors on Tower 313 did not show the degree of variability expected. The data capture protocol and data transfer interfaces are being examined to answer questions resulting from the preliminary analysis.

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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) at the National Weather Service (NWS) in Melbourne (MLB) and SMG forecast offices.
Milestones	Completed the upgrade of the ARPS numerical weather prediction model to software version 5.1.2 at the NWS MLB.
Discussion	The new version of ARPS has many improvements and features that will make maintenance much easier. The ADAS upgrade requires additional work to install the necessary supportive software components on the new Linux system.

Task	User Control Interface for ADAS Data Ingest
Goal	Develop a GUI to help forecasters manage the data sets assimilated into the operational ADAS run at NWS MLB and SMG.
Milestones	Added two components to the GUI that allow the user to determine which groups of observations are analyzed by ADAS, and have the ability to modify the display of observation data logs.
Discussion	One new feature gives the user power to choose which groups of observations are used in the ADAS analysis by turning them on or off. The second feature allows the user to see a data log of the number of observations being ingested into ADAS at a particular time or a flag indicating whether a data type was used.

Special Notice to Readers

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

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

Background

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

AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

SHORT-TERM FORECAST IMPROVEMENT

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

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

The results of the equation development and testing were shown in the previous AMU Quarterly Report (Q4 FY04). All of the equations showed an increase in skill over the benchmark forecasts of daily and monthly climatology, persistence, and the flow regime lightning probabilities. As a result, the new equations will be added to the current set of tools and procedures used by the 45 WS forecasters to make the daily lightning probability forecast.

Graphical User Interface

In order to use these equations, the forecasters need an interface that will facilitate user-friendly input and fast output. In cooperation with Mr. Roeder of the 45 WS, Ms. Lambert developed a graphical user interface (GUI) using Microsoft® Excel© Visual Basic®. The 45 WS was involved in the GUI development by providing comments and suggestions on the design. This will ensure that the final product will address their operational needs.

The GUI begins with a dialog box that queries the user for the current month and day, shown in Figure 1. A drop-down list is shown for each parameter by clicking on the arrow to the right of the text box. The user must choose a value from the Month drop-down list, but has the option of entering a day value manually or through the Day drop-down list. Choosing the month determines which equation will be used, as there is one equation for each month. Choosing the day will determine the Daily Climatology value used as a predictor in the equation.

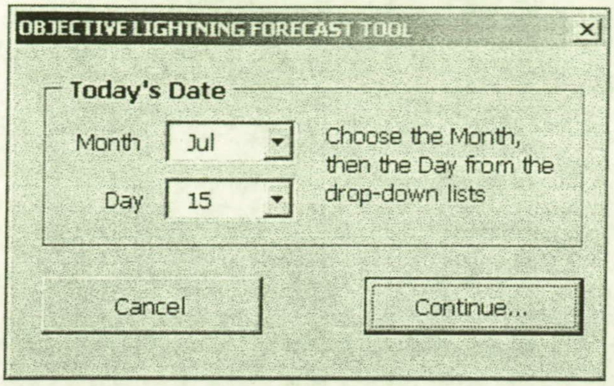


Figure 1. The first dialog box in the GUI that queries the user for the month and day. Month and Day are chosen by clicking on the down arrows and choosing from the drop-down lists. The Cancel button exits from the GUI, the Continue button brings up the next dialog box.

Once the Month and Day are chosen, the user clicks on the "Continue…" button. This executes a second dialog box that contains choices for predictor values based on the month. The dialog box in Figure 2 contains the predictor choices for July, following the choices in Figure 1. The predictors for the daily lighting probability in July are 1-day persistence, flow regime, Total Totals (TT), and the average relative humidity in the 800-600 mb layer (RH). The GUI allows the user to choose only one item under Persistence and only one item under Flow Regime. The values for TT and RH from the morning 1000 UTC sounding can be input manually or by using the up/down arrows to the right of the text box. The initial values for the sounding parameters in all months (TT and RH in July) are set to -999 when the predictor dialog box is first displayed. If the user forgets to input values for any of the sounding parameters, the -999 value will trigger an error dialog box that tells the user to input a value for the parameter. The GUI code contains upper and lower limits on the parameter values to ensure realistic values are entered.

After making all the choices in the predictor dialog box, the user clicks on the "Calculate Probability…" button. This executes the third and final dialog box that displays the lightning probability for the day as calculated by the equation for the month. Figure 3 shows the lightning probability for the values shown in Figures 1 and 2. When the user clicks the "Calculate Another Probability" button, this dialog box is closed and control is returned to the second dialog box containing the predictor choices. At this point the user can make new choices for the predictors and calculate a new probability, or click the "New Date" button and return control to the first dialog box. At this point the user can choose a new date and start the process over, or click the "Cancel" button and close the GUI.

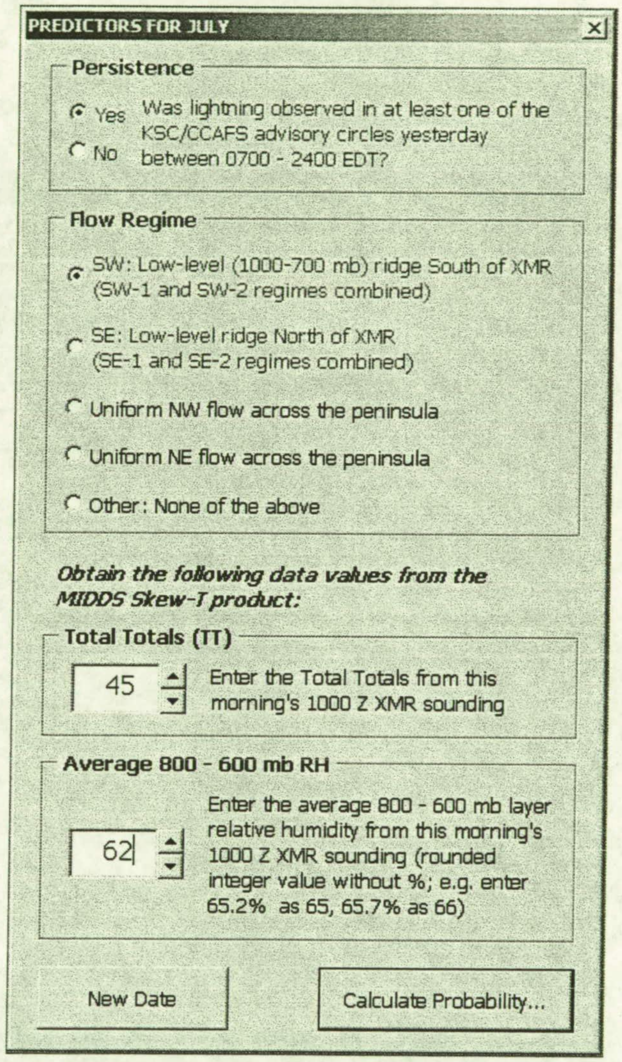


Figure 2. The second dialog box that contains choices for the predictors in the July equation. Persistence and Flow Regime are chosen by clicking one of the option buttons in each section. TT and RH are chosen by entering the values manually or using the up/down arrows. The "New Date" button closes this dialog box and returns control to the first dialog box (Figure 1). The "Calculate Probability…" button brings up the next dialog box.

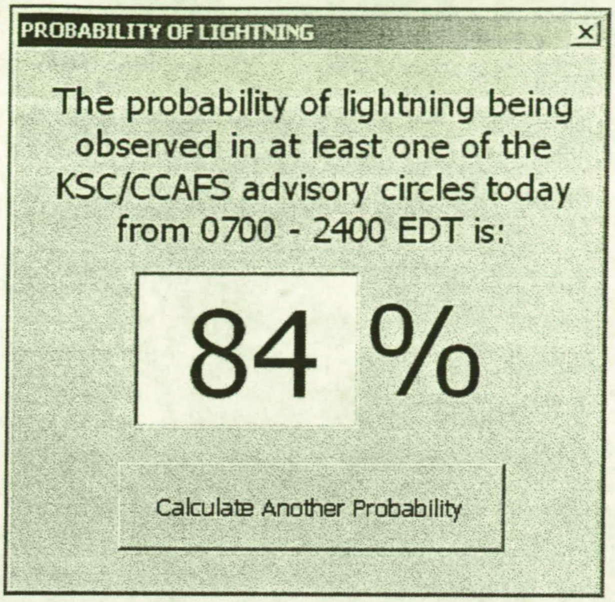


Figure 3. The third and final dialog box in the GUI containing the probability of lighting for the day based on the inputs shown in Figures 1 and 2.

Excel Workbook

The GUI described in the previous section is executed from an Excel© workbook containing six worksheets. The first worksheet contains brief instructions on how to start and use the GUI, and the other five pages contain information for each individual month. The information for each month includes the

- Predictor names and their coefficients in the equations,
- Flow regime names and their probabilities of lightning occurrence,
- Climatological lightning probability for each day,
- Minimum, maximum, median, mean, and first and third quartile values of the observed sounding stability indices,
- Range of valid values in the GUI for the stability indices, and
- Stability index values associated with convection.

After choosing a month and day in the first dialog box and continuing, the worksheet corresponding to the chosen month is displayed in the workbook along with the second GUI. This allows the user to view all the possible parameter values for use in a particular month's equation.

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

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

The 45 WS Commander's morning weather briefing includes an assessment of the likelihood of local convective severe weather for the day in order to enhance protection of personnel and material assets of the 45th Space Wing, CCAFS, and KSC. The severe weather elements produced by thunderstorms include tornadoes, wind gusts ≥ 50 kts, and/or hail with a diameter ≥ 0.75 in. Forecasting the occurrence and timing of these phenomena is challenging for 45 WS operational personnel. The AMU has been tasked with the creation of a new severe weather forecast decision aid, such as a flow chart or nomogram, to improve the various 45 WS severe weather watches and warnings. The tool will provide severe weather guidance for the day by 1100 UTC (0700 EDT).

Dr. Bauman created a lightning strike database using Cloud-to-Ground Lightning Surveillance System (CGLSS) data for May-September 1989-2003. The CGLSS data was obtained from Mr. Paul Wahner of CSR in the form of text files containing the date, time, latitude, longitude, strength, and polarity of individual cloud-to-ground lightning strikes. The ArcView® Graphical Information System (GIS) software package was used to display the data on a map background in order to confirm the existence of thunderstorms in the area of interest. In order to import the data into the GIS package, they were reformatted into a single file for each day, then converted to Excel© files, and finally saved in dBase IV format files. The displays were used to distinguish between thunderstorm and non-thunderstorm days. A previous analysis using stability indices from all days was unable to produce any correlations between index values and severe weather. Dr. Bauman and Mr. Wheeler thought an analysis using only days with lightning may find a distinction between severe and non-severe thunderstorm days.

The database of all stability indices was stratified into three categories:

- Severe weather days,
- Lightning but no severe weather days, and
- Non-lightning days.

There are three important caveats to note in this stratification. First, a day with no severe weather does not mean severe weather did not occur in the area of interest, but that no severe weather was reported. There is no other way to verify severe weather. Second, a non-lightning day only means there was no cloud-to-ground lightning. There could have been in-cloud or cloud-to-cloud lightning that the CGLSS sensors cannot detect.

The 14 stability parameters listed below were examined in each of the three categories:

- Total Totals (TT),
- K-Index,
- Lifted Index,
- Thompson Index,
- SWEAT Index,
- Precipitable water,
- Showalter Stability Index,
- Cross Totals,
- Convective Available Potential Energy (CAPE),
- CAPE Max θ_e (CAPE based on layer with maximum equivalent potential temperature),
- CAPE FMaxT (CAPE based on forecast maximum surface temperature),
- Convective Inhibition (CIN),
- T_{500} (500 mb temperature), and
- T_{d500} (500 mb dew point temperature).

Scatter plots of each stability parameter were created for each individual day-stratification and for all days combined. These scatter plots for each stability parameter were used to try and discern if the morning CCAFS sounding was a good tool to help objectively differentiate among reported severe weather days, thunderstorm days with no reported severe weather, and days with no lightning. The ultimate goal was to determine if a signal was present in any of the stability parameters to help the 45 WS forecaster analyze the thunderstorm and severe weather threat. Examples of the scatter plots are shown using the TT values for each day-stratification in Figures 4 through 6. For comparison of values between the three stratifications, Figure 7 shows the TT for all days combined.

In each figure there are two horizontal lines showing the current 45 WS values for distinguishing between low, medium and high risk for severe weather. Figure 4 shows the TT values as red dots on days in which severe weather was reported. The physical expectation was that the dots would be clustered toward high TT values and in or near the risk category. In fact, the scatter in the plot is large with TT covering the range of values. The same analysis can be made for Figure 5, which shows the TT values as green dots on days with lightning but no severe weather. The analysis for non-lightning days, shown by blue dots in Figure 6, is quite different. Most of the values are clustered in the low risk category. However, when all values are combined in the scatter plot shown in Figure 7, one can see that a low TT value does not necessarily reduce the risk of lightning or severe weather occurrence.

It is clear from the TT examples that this stability parameter is not a good indicator to discern among the three types of days. The other stability parameters do not appear to be good objective indicators of severe weather occurrence but they are being studied in detail. In addition to testing the feasibility of using the individual stability parameters as stand-alone discriminators, other criteria such as surface high pressure ridge position, persistence, and upper level dynamics are being studied individually and in combination with the stability parameters.

Finally, Dr. Bauman and Mr. Wheeler continued working on their proposed Severe Weather Decision Aid, essentially an update to the current 45 WS severe weather checklist, and began writing the final report.

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

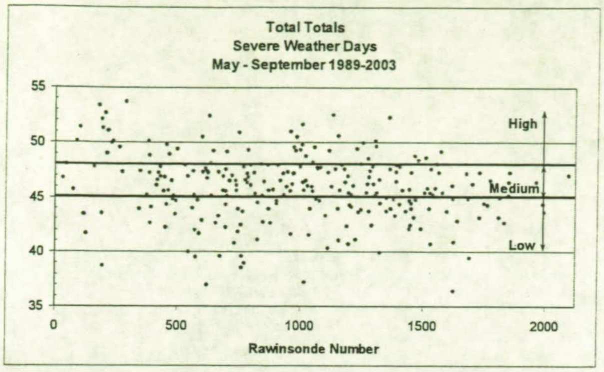


Figure 4. Scatter plot of TT (red dots) for all days with reported severe weather. The rawinsonde number is shown along the x-axis and represents soundings in the months May–September, 1989–2003. The heavy black lines sub-divide the severe weather threat categories of low, medium, and high TT values based on the current 45 WS severe weather checklist.

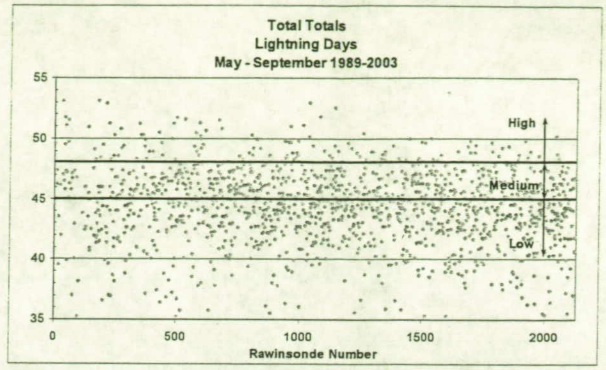


Figure 5. Scatter plot of TT (green dots) for all days with lightning but no severe weather. The rawinsonde number is shown along the x-axis and represents soundings in the months May–September, 1989–2003. The heavy black lines sub-divide the severe weather threat categories of low, medium, and high TT values based on the current 45 WS severe weather checklist.

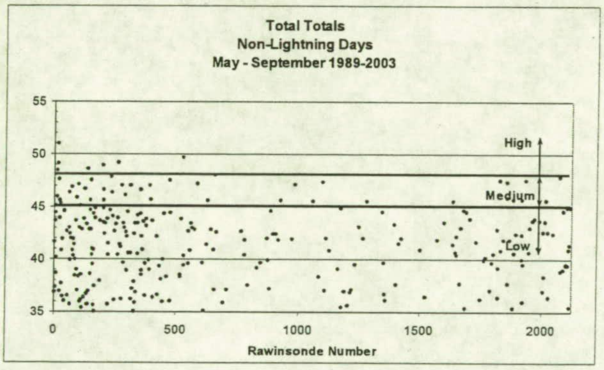


Figure 6. Scatter plot of TT (blue dots) for all days with no lightning. The rawinsonde number is shown along the x-axis and represents soundings in the months May–September, 1989–2003. The heavy black lines sub-divide the severe weather threat categories of low, medium, and high TT values based on the current 45 WS severe weather checklist.

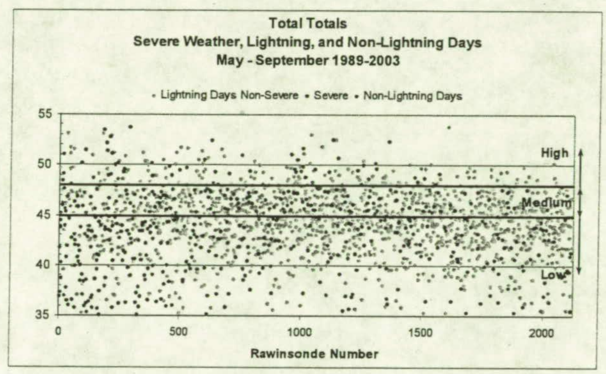


Figure 7. Combination of the TT scatter plots for the three stratifications. The rawinsonde number is shown along the x-axis and represents soundings in the months May–September, 1989–2003. The heavy black lines sub-divide the severe weather threat categories of low, medium, and high TT values based on the current 45 WS severe weather checklist.

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

Forecasters at the Space 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 is 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.

The forecasters at SMG indicated that these events typically take place in the cool season during daylight hours. Therefore, Mr. Case and Mr. Wheeler collected the morning CCAFS rawinsondes (XMR) and hourly surface observations at the SLF (TTS) between 1100-2300 UTC during the cool season months of November-March 1993-2003, for a total of 10 cool seasons. Mr. Case developed software to identify inversions below 8000 ft in the XMR data and ceilings less than 8000 ft in the TTS surface observations. The software provided daily output of the low-level inversions and cloud ceilings, as well as reports of precipitation and fog at TTS for all 10 cool seasons.

Mr. Wheeler then conducted a subjective analysis of the output in order to identify potential case days. Through this subjective analysis, the database was narrowed further to exclude precipitation events and days with ceilings below 8000 ft all day, since the goal of the task is to study the ceiling development. Days were identified as potential events if they exhibited each of the following three elements:

- A low level inversion,
- Moisture near the inversion, and
- A ceiling below 8000 ft.

Mr. Wheeler and Mr. Case will obtain and examine satellite data for the potential case days to determine the actual events for which there were rapidly developing ceilings below 8000 ft. One of the requirements of this task is to examine only events when the low ceilings occurred as a result of development or formation, not advection from another location. The satellite imagery will be important in determining whether the low cloud ceilings were caused by formation or advection. The final database will contain only days with low cloud ceiling development, excluding days when clouds advected over central Florida.

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.

Hail Index
(Dr. Short and Mr. Wheeler)

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

Dr. Short and Mr. Wheeler evaluated the operational technique used by the 45 WS to forecast hail. The Neumann-Pfeffer index (Neumann 1971) for forecasting thunderstorm probability is combined with the Fawbush-Miller hail graph (Reymann et al. 1998) for forecasting hail size. Dr. Short and Mr. Wheeler generated hail forecasts for the 14-year period 1989–2002 using an archive of XMR rawinsonde data and the operational computer programs run by CSR personnel at the CCAFS weather station. Results of the comparison between hail size forecasts and hail size reports in Brevard County, Florida are presented below.

Climatology of Forecast Hail Sizes from the 45 WS "Thunderstorm Probability Study"

The probability of thunderstorm activity for the day and the expected size of associated hail is determined each morning by 45 WS forecasters through analyses of the local and large-scale weather patterns as well as data from rawinsonde observations (RAOBs) taken at XMR. The CSR personnel at XMR use a computer program named WVTHUV1.f to analyze vertical profiles of temperature, humidity and wind from the RAOBs to generate a bulletin titled "Thunderstorm Probability Study." The bulletin includes a yes/no indicator for thunderstorm activity and a forecast hail size. The bulletin is transmitted to the Meteorological Interactive Data Display System (MIDDS) in the Weather Operations Center and can be displayed by entering the MIDDS command "CYA MISC THUNDER". The Thunderstorm Probability Study bulletin is generated during the warm season months of May-September. The areas of forecast responsibility lie within Brevard County on Florida's east-central coast.

Dr. Short generated the Thunderstorm Probability Study bulletin using 14 years of RAOBs from XMR and the operational computer code WVTHUV1.f. The RAOB with a time closest to 1000 UTC between 0800-1200 UTC was selected for analysis for each day of the potential 2142-day database. The climatology of forecast hail sizes was based on 697 days with a thunderstorm probability of "yes" and is shown in Table 1. Also shown is the number of large hail size reports on 42 hail days in Brevard County during the same reporting period. The large hail size reports were obtained from the National Climatic Data Center's Storm Reports website.

Table 1. Climatology of hail sizes forecast from the XMR morning RAOB and observed in Brevard County for May-September for the years 1989-2002.

Description	*Approximate Size (inches)*	*# Forecast*	*# Observed*
> Golfball	≥ 2	1	1
Ping Pong/Golfball	1.5 - 1.75	1	7
Quarter to Half Dollar	1 - 1.25	2	13
Dime/Nickel	0.75 - 0.88	0	21
Marble	0.5	0	N/A
Pea	0.25	575	N/A
< Pea	< 0.25	118	N/A

Corrected Climatology of Forecast Hail Sizes from the 45 WS "Thunderstorm Probability Study"

Table 1 reveals a significant discrepancy between the number of forecast days with large hail (4 ≥ 0.75 in) and the number of observed days(42 ≥ 0.75 in). The occurrence of large hail is under-forecast by a factor of 10. Because the forecast hail size depends on a computerized analysis of the temperature and humidity profiles from the morning RAOB, Dr. Short examined the WVTHUV1.f computer code in an effort to determine the source of the discrepancies between the forecast and observed hail sizes. He found the following two coding errors: 1) The temperature of the convective condensation level (CCL) was much too high; and 2) the computed height of the wet-bulb zero temperature was actually the height of the zero degree isotherm. Mr. Kulow of CSR, who runs the program, concurred with the error analysis and forwarded remedial recommendations to CSR.

Dr. Short made changes to the AMU version of WVTHUV1.f to correct for the CCL and the height of the wet-bulb zero temperature and regenerated the climatology of forecast hail sizes. Table 2 shows the resulting corrected climatology of forecast hail sizes.

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.

Table 2. Climatology of corrected hail sizes forecast from the XMR morning RAOB and observed in Brevard County for May-September for the years 1989-2002.

Description	*Approximate Size (inches)*	*# Forecast*	*# Observed*
> Golfball	≥ 2	29	1
Ping Pong/Golfball	1.5 - 1.75	7	7
Quarter to Half Dollar	1 - 1.25	28	13
Dime/Nickel	0.75 - 0.88	24	21
Marble	0.5	38	N/A
Pea	0.25	454	N/A
< Pea	< 0.25	117	N/A

Shuttle Ascent Camera Cloud Obstruction Forecast (Dr. Short and Mr. Lane)

Optical imaging of the Space Shuttle launch vehicle (hereinafter the Shuttle) from ground-based and airborne cameras is susceptible to obstruction by clouds. The Columbia Accident Investigation Board (CAIB) recommended that the Shuttle ascent imaging network be upgraded to have the capability of providing at least "three useful views" of the Shuttle from lift-off to Solid Rocket Booster (SRB) separation. In response, the NASA/KSC Weather Office tasked the AMU to develop a model to forecast the probability that, at any time from launch to SRB separation, at least three of the Shuttle ascent imaging cameras will have a view of the Shuttle unobstructed by cloud. The resulting model was based on computer simulations of 1) idealized, random cloud coverage scenarios, 2) the optical lines-of-sight from cameras to the Shuttle using the camera network before and after upgrades for Return to Flight and 3) a Shuttle ascent trajectory for a launch from Pad 39B to the International Space Station (ISS).

During this past quarter Dr. Short presented a briefing on the model results to the KSC Director, Mr. Kennedy. A paper on the model results was presented by Dr. Bauman at the 11th Conference on Aerospace, Range and Aviation Meteorology in Hyannis, MA (Short et al. 2004). Dr. Short completed customer recommended revisions to the Final Report and remains on stand-by for further briefings at the request of the Launch Director, Mr. Leinbach.

Contact Dr. Short at 321-853-8105 or short.david@ensco.com, or Mr. Lane at 321-783-9735 Ext. 245 or lane.bob@ensco.com for more information on this work.

INSTRUMENTATION AND MEASUREMENT

I&M and RSA Support (Dr. Bauman and Mr. Wheeler)

Mr. Wheeler and Dr. Merceret attended a working group meeting to discuss a possible turn-over of the AMU's Advanced Weather Interactive Processing System (AWIPS) from the Range Standardization and Automation (RSA) program to the Eastern Range (ER). The turn-over was not approved and the AMU's AWIPS will be transitioned at the same time as the other ER assets. They also discussed how the AMU will be able to retrieve and archive all local and national weather datasets.

Mr. Wheeler also worked with Mr. Johnny Weems and Mr. Clay Flinn of the 45 WS on several AWIPS weather display issues, and continued to work with Lockheed Martin (LM) personnel on a solution to import all weather data to the AMU for use in required tasks and archiving. He installed software and configured a PC that will be used for archiving AWIPS data.

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 Launch Commit Criteria forecasts and evaluations, and toxic dispersion support. This is especially true for changes in weather tower wind instruments, such as is occurring with the switch from cup-and-vane legacy sensors to sonic RSA sensors. Because legacy sensors respond to wind speed and direction mechanically, while the sonic RSA sensors have no moving parts, there is a possibility that the statistics of peak wind speed and wind direction variability may differ between the two systems. 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.

The RSA and legacy wind sensors will be co-located on the following towers:

- ER: 403, 313, 110, 108, 006 and 002,
- WR: 301, 300, 102, 74, 71, 70, 60 and 54.

Dr. Short and Mr. Wheeler will perform an objective comparison of wind speed and direction data from the two systems at each tower listed above. Wind data for the comparison will include mean wind speed and direction, peak wind speed and direction, and wind direction variability (sigma theta). The AMU will also calculate higher order measures of the wind data such as u and v component means and variances, u and v component power spectra, and u and v component cross coherence. Special attention will be required for sensors that are physically separated vertically, and/or horizontally, and/or on different sides of the tower, and/or with different sheltering. For example, the averaging periods required to get representative results will vary depending on the separation of the sensors. If Dr. Short and Mr. Wheeler have any subjective impressions about the data during the evaluation, such as the impact of rain on the sensors, data noisiness, reliability, etc., they will report these issues as well.

Mr. Wheeler began collecting the legacy data from the ER and obtained samples of 1-second RSA data at Tower 313 from LM personnel. Dr. Short developed and tested data ingest and reformatting software. A preliminary analysis of the 1-second RSA wind speed data showed less variability than expected. Mr. Wheeler and Dr. Short are coordinating with LM personnel to understand data capture and data transfer interfaces that may affect the nature of the RSA wind data.

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

MESOSCALE MODELING

ARPS Optimization and Training Extension (Mr. Case)

As the Advanced Regional Prediction System (ARPS) prognostics and ARPS Data Analysis System (ADAS) diagnostics mature for increased operational use, the National Weather Service at Melbourne, FL (NWS MLB) and SMG require increased accessibility to AMU resources to ensure the most beneficial evolution of these systems. There are plans to ingest several new data sets into ADAS, and to port the operational configuration a Linux workstation. In addition, AMU assistance is required to upgrade the ARPS system to the latest version. The plans also include a switch from the Rapid Update Cycle (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 assistance in making the upgrades and improvements described above.

Mr. Case upgraded the operational ARPS forecast cycle software at Melbourne to version 5.1.2 in early December. He has not yet completed the upgrade and transition of the operational ADAS analysis cycle to the new Linux workstation. The primary reason is due to difficulties with building the Hierarchical Data Format (HDF) software on the Linux workstation as it contains a different operating system than the Linux cluster that runs the ARPS forecast cycle. The HDF utility is an important component required by the ARPS software, especially for mapping satellite data onto the analysis grid. Additional effort is still needed to resolve this problem.

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

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

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

Mr. Keen developed additional core components of the prototype GUI this past quarter. The new features he added include the capability to control which groups of observations are analyzed by ADAS, and the ability to modify the display of observation data logs.

Figure 8a shows an example of accessing the PIREP group of observations (pilot reports) and turning it on/off for the analysis. By accessing a data group in this manner, the user only has the ability to include or exclude all observations within the data group from the analysis. The data types are grouped according to the average spacing of the instruments, and the groups are analyzed in ADAS in a user-specified order. In the NWS MLB ADAS configuration, there are four such groups. In Figure 8b, each individual data type has five option buttons of which only one can be chosen. The "Off" choice removes the data from the analysis, and the first four choices indicate the order in which a data group should be analyzed. The name of each data type is at the top of each box. Access to this feature should be reserved for an experienced ADAS user, and could be limited or password protected to avoid inadvertent changes by inexperienced users.

An example of the ADAS observational data log display is given in Figure 9. The data log shows the user either the number of observations used in the analysis or a flag indicating whether or not the data from a particular source are being used in the analysis (1) or not (0). The display of possible observation types is shown in Figure 9a. The horizontal row of check boxes at the top of the display allows the user to choose which data type is shown. Since many data types are not analyzed in real time, it would increase the readability of the display to show only those observations groups that are in current use by the operational ADAS. In Figure 9b, the data log table displays only those data types with a checked box.

Future capabilities to be added include user modification of the data influence ranges for selected observation groups, the ability to include or exclude individual observations (and/or variables) within a group, and the ability to reset all parameters to a default configuration. Additional modifications could be requested by the customer after the prototype GUI is installed and tested onsite.

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

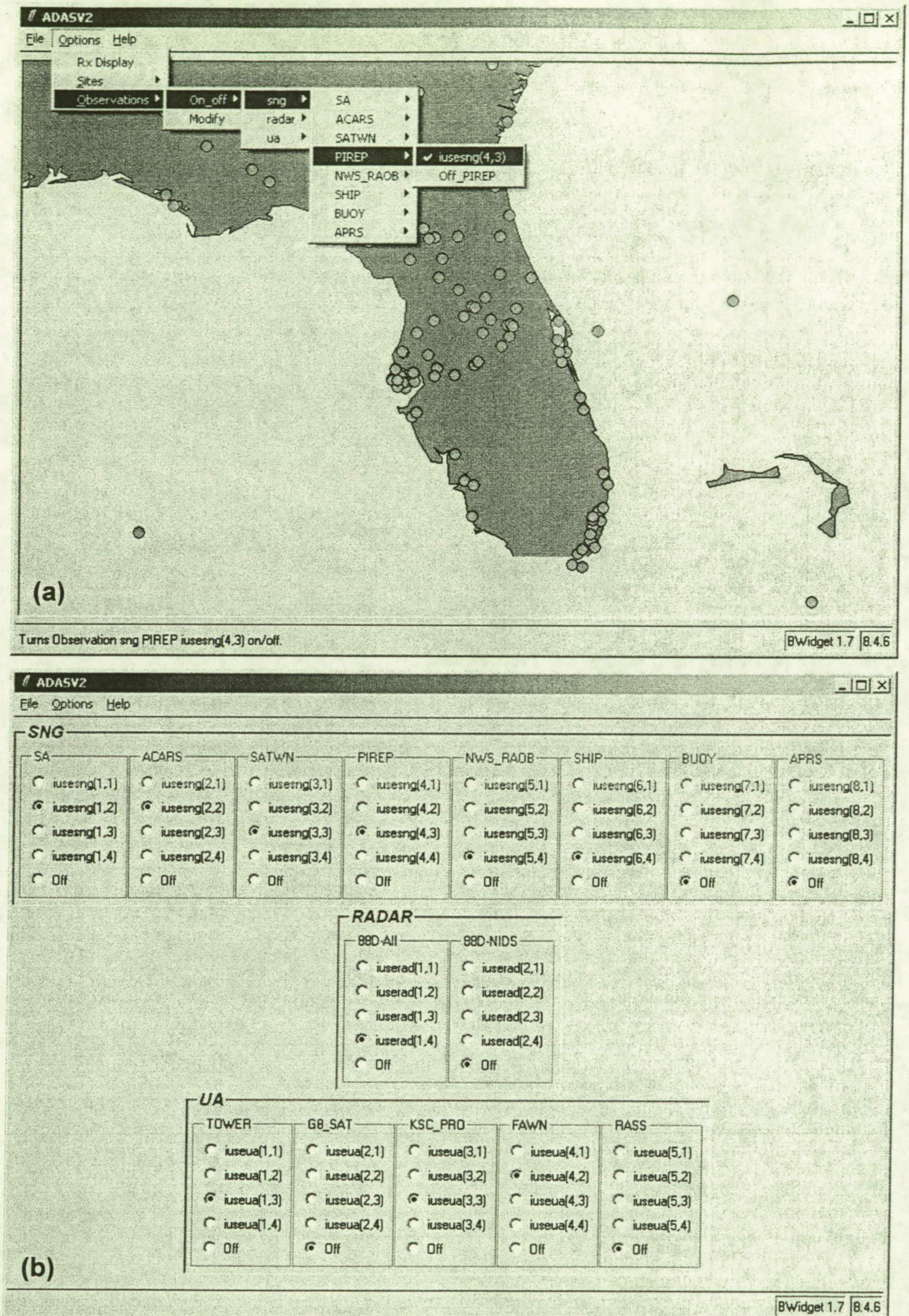
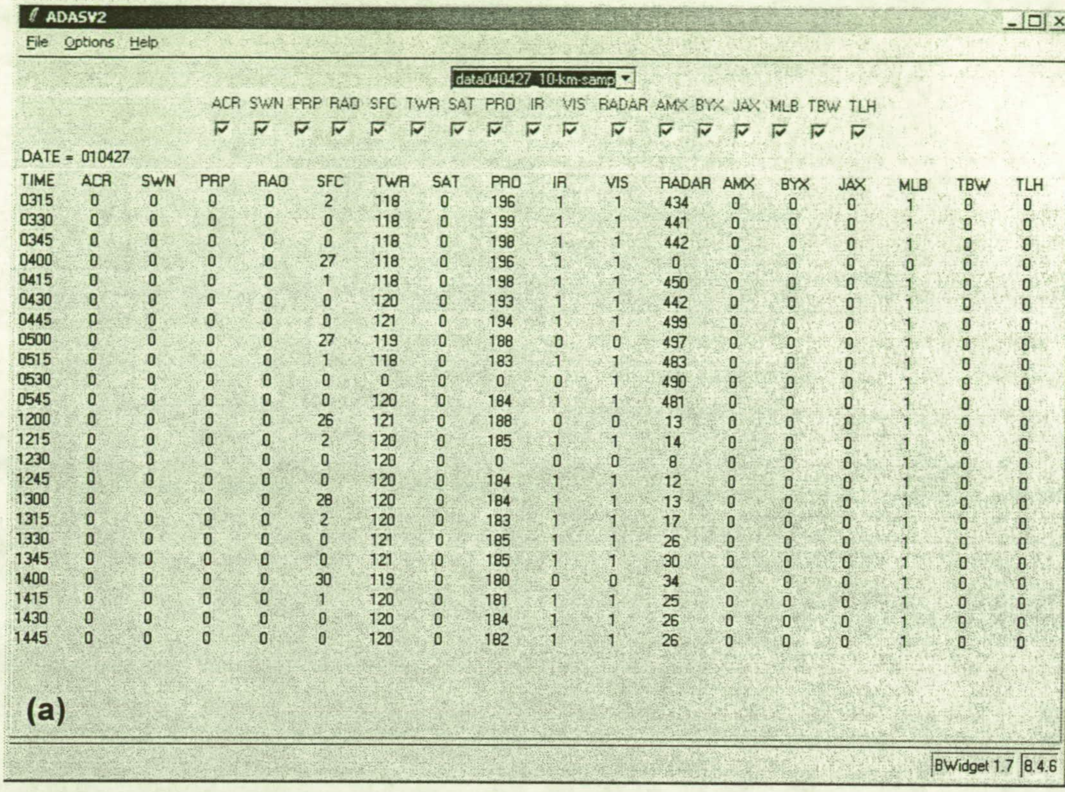


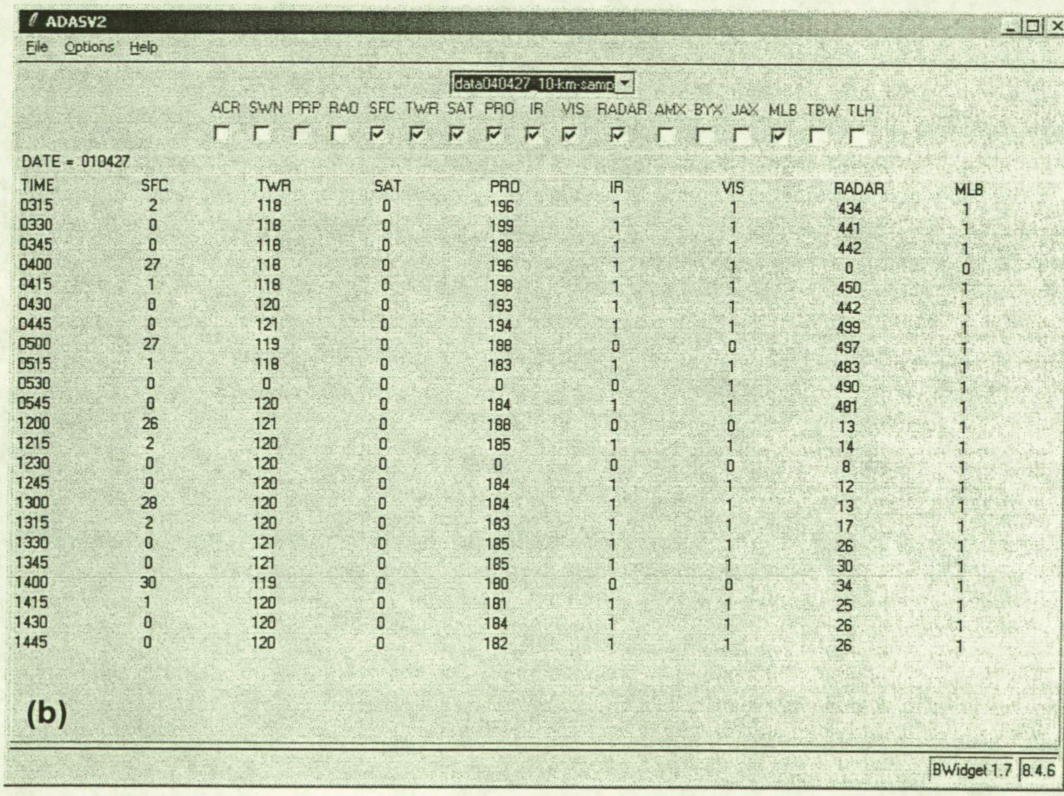
Figure 8. The control GUI capability to control how groups of observations are analyzed by ADAS. (a) An example of how to turn on/off a specific observation group. (b) Interface that allows the user to modify the ADAS computational pass of (or turn off) observation groups.



DATE = 010427

TIME	ACR	SWN	PRP	RAO	SFC	TWR	SAT	PRO	IR	VIS	RADAR	AMX	BYX	JAX	MLB	TBW	TLH
0315	0	0	0	0	2	118	0	196	1	1	434	0	0	0	1	0	0
0330	0	0	0	0	0	118	0	199	1	1	441	0	0	0	1	0	0
0345	0	0	0	0	0	118	0	198	1	1	442	0	0	0	1	0	0
0400	0	0	0	0	27	118	0	196	1	1	0	0	0	0	0	0	0
0415	0	0	0	0	1	118	0	198	1	1	450	0	0	0	1	0	0
0430	0	0	0	0	0	120	0	193	1	1	442	0	0	0	1	0	0
0445	0	0	0	0	0	121	0	194	1	1	499	0	0	0	1	0	0
0500	0	0	0	0	27	119	0	188	0	0	497	0	0	0	1	0	0
0515	0	0	0	0	1	118	0	183	1	1	483	0	0	0	1	0	0
0530	0	0	0	0	0	0	0	0	0	1	490	0	0	0	1	0	0
0545	0	0	0	0	0	120	0	184	1	1	481	0	0	0	1	0	0
1200	0	0	0	0	26	121	0	188	0	0	13	0	0	0	1	0	0
1215	0	0	0	0	2	120	0	185	1	1	14	0	0	0	1	0	0
1230	0	0	0	0	0	120	0	0	0	0	8	0	0	0	1	0	0
1245	0	0	0	0	0	120	0	184	1	1	12	0	0	0	1	0	0
1300	0	0	0	0	28	120	0	184	1	1	13	0	0	0	1	0	0
1315	0	0	0	0	2	120	0	183	1	1	17	0	0	0	1	0	0
1330	0	0	0	0	0	121	0	185	1	1	26	0	0	0	1	0	0
1345	0	0	0	0	0	121	0	185	1	1	30	0	0	0	1	0	0
1400	0	0	0	0	30	119	0	180	0	0	34	0	0	0	1	0	0
1415	0	0	0	0	1	120	0	181	1	1	25	0	0	0	1	0	0
1430	0	0	0	0	0	120	0	184	1	1	26	0	0	0	1	0	0
1445	0	0	0	0	0	120	0	182	1	1	26	0	0	0	1	0	0

(a)



DATE = 010427

TIME	SFC	TWR	SAT	PRO	IR	VIS	RADAR	MLB
0315	2	118	0	196	1	1	434	1
0330	0	118	0	199	1	1	441	1
0345	0	118	0	198	1	1	442	1
0400	27	118	0	196	1	1	0	0
0415	1	118	0	198	1	1	450	1
0430	0	120	0	193	1	1	442	1
0445	0	121	0	194	1	1	499	1
0500	27	119	0	188	0	0	497	1
0515	1	118	0	183	1	1	483	1
0530	0	0	0	0	0	1	490	1
0545	0	120	0	184	1	1	481	1
1200	26	121	0	188	0	0	13	1
1215	2	120	0	185	1	1	14	1
1230	0	120	0	0	0	0	8	1
1245	0	120	0	184	1	1	12	1
1300	28	120	0	184	1	1	13	1
1315	2	120	0	183	1	1	17	1
1330	0	121	0	185	1	1	26	1
1345	0	121	0	185	1	1	30	1
1400	30	119	0	180	0	0	34	1
1415	1	120	0	181	1	1	25	1
1430	0	120	0	184	1	1	26	1
1445	0	120	0	182	1	1	26	1

(b)

Figure 9. The control GUI display of the number of observations analyzed by ADAS at all analysis times on a given day. (a) Display of all observation groups. (b) Display of user-selected observation groups.

AMU CHIEF'S TECHNICAL ACTIVITIES (Dr. Merceret)

Dr. Merceret supported Shuttle program discussions of both ground and ascent winds. At the request of the Lightning Advisory Panel (LAP), he drafted implementation instructions for using existing infrastructure to evaluate new lightning LCC (LLCC) being prepared by the LAP. The new LLCC will require specialized software for the WSR-74C and WSR-88D radars for complete implementation, but Dr. Merceret designed a method through which the new LLCC could be temporarily implemented using existing radar products. The temporary implementation will be more conservative than the complete implementation, but should still provide some safe relief from the more restrictive LLCC currently in effect.

Dr. Merceret participated extensively as a member of the YA Directorate's "Future Roles and Missions" team. The team is examining the Directorate's planned and potential research and development programs over the next 15 years as NASA transitions from the Shuttle and Station in low earth orbit to a new vehicle in an exploration program featuring a return to the moon as a first step to manned missions to Mars and beyond.

Dr. Merceret participated in discussions defining the AMU tasking to compare the RSA sonic anemometers with the legacy cup anemometers and wind vanes at the Eastern and Western Ranges. He began writing software to perform some of the comparison analyses. Dr. Merceret also participated in Shuttle Technical Interchange Meetings relating to wind persistence effects on Shuttle ascent loads constraints.

AMU OPERATIONS

Mr. Wheeler continued to work with the NASA procurement office on several purchase requests (PRs). He tracked two PRs that were delayed in the NASA procurement office. He consulted with the office personnel to help them understand the PRs and send the orders through. He also configured and cleaned some items for turn-in.

Mr. Wheeler began migrating the systems in the AMU lab to the Linux operating system. He also continued tracking the request to upgrade the AMU's internet communications line.

Dr. Bauman traveled to Hyannis, MA to attend the Aviation, Range and Aerospace Meteorology conference from 4-8 October. Dr. Bauman co-chaired 1 session and presented 3 papers and 1 poster.

Ms. Lambert visited SMG at Johnson Space Center in Houston TX to attend the Weather User's Forum and present results from the AMU task to determine a relationship between radar data and anvil transparency. She also presented the results from the objective lightning probability forecasting task.

The AMU supported the Delta II Swift and Delta IV Heavy Demo launches.

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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
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
AWIPS	Advanced Weather Interactive Processing System
CAIB	Columbia Accident Investigation Board
CCAFS	Cape Canaveral Air Force Station
CCL	Convective Condensation Level
CGLSS	Cloud-to-Ground Lightning Surveillance System
CSR	Computer Sciences Raytheon
EDT	Eastern Daylight Time
ER	Eastern Range
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GIS	Geographic Information System
GUI	Graphical User Interface
HDF	Hierarchical Data Format
ISS	International Space Station
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LLCC	Lightning LLC
LM	Lockheed Martin
MIDDS	Meteorological Interactive Data Display System
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service in Melbourne, FL
PC	Personal Computer
QC	Quality Control
RAOB	RAwinsonde Observation
RH	Average 800-600 mb Relative Humidity
RSA	Range Standardization and Automation
RUC	Rapid Update Cycle
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
SRB	Solid Rocket Booster
SRH	NWS Southern Region Headquarters
SWEAT	Severe WEAther Threat
TT	Total Totals
TTS	SLF 3-Letter Identifier
USAF	United States Air Force
UTC	Universal Coordinated Time
WR	Western Range
WSR-74C	Weather Surveillance Radar Model 74C
WSR-88D	Weather Surveillance Radar 1988 Doppler
WWW	World Wide Web
XMR	CCAFS 3-Letter Identifier

Appendix A

AMU Project Schedule 31 January 2005				
AMU Projects	**Milestones**	**Scheduled Begin Date**	**Scheduled End Date**	**Notes/Status**
Objective Lightning Probability Phase I	Literature review and data collection/QC	Feb 03	Jun 03	Completed
	Statistical formulation and method selection	Jun 03	Oct 03	Completed, but delayed due to errors found in COTS software
	Equation development, tests with verification data and other forecast methods	Aug 03	Nov 03	Completed, but delayed as above
	Develop operational products	Nov 03	Jan 04	Completed, but delayed as above and due to hurricane evacuations
	Prepare products, final report for distribution	Jan 04	Mar 04	Delayed as above
Severe Weather Forecast Tool	Local and national NWS research, discussions with local weather offices on forecasting techniques	Apr 03	Sep 03	Completed
	Develop database, develop decision aid, fine tune	Oct 03	Apr 04	Delayed due to higher priority Shuttle Ascent Camera Cloud Obstruction Forecast Task
	Final report	May 04	Jun 04	Delayed as above
Stable Low Cloud Evaluation	Gather data, develop database	Oct 04	Jan 05	On Schedule
	Identify, classify weather characteristics of events	Jan 05	Jul 05	On Schedule
	Gather data, develop database	Oct 04	Jan 05	On Schedule
Hail Index	Evaluate Current Techniques	Aug 04	Feb 05	On Schedule
	Memorandum	Mar 05	May 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

AMU Project Schedule 31 January 2005				
AMU Projects	Milestones	Scheduled Begin Date	Scheduled End Date	Notes/Status
	Analyze optical viewing conditions for representative cloud distributions and develop viewing probability tables	Feb 04	Feb 04	Completed
	Memorandum	Feb 04	Jun 04	Delayed to provide support for additional briefings and to complete the Final Report.
RSA/Legacy Sensor Comparison	Data Collection and Pre-Processing	Dec 04	May 05	On Schedule
	Data Evaluation	Dec 04	Jun 05	On Schedule
	Final Report	July 05	Sep 05	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	Delayed due to completion of other tasks
	Determine operational feasibility of techniques found in the literature	Jul 04	Jan 05	Delayed as above
	Final Report	Jan 05	Mar 05	Delayed as above
ARPS/ADAS Optimization and Training Extension	Provide the NWS Melbourne with assistance in upgrading to ARPS version 5.x.	Aug 04	Oct 04	Completed
	Provide the NWS Melbourne with assistance in porting the operational ADAS to a Linux workstation	Oct 04	Dec 04	Delayed due to problems in building supporting software.
	Assist the NWS Melbourne in upgrading to the 20-km RUC pressure coordinate background fields	Oct 04	Dec 04	Delayed due to ADAS Linux workstation transition delay.
	Develop routines for incorporating new data sets into ADAS	Dec 04	May 05	On Schedule
	Examine a limited number of warm-season convective cases	May 05	Jul 05	On Schedule
User Control Interface for ADAS Data Ingest	Develop control graphical user interface (GUI)	Apr 04	Jan 05	On Schedule
	Installation assistance and documentation	Jan 05	Mar 05	On Schedule

NOTICE