Applied Meteorology Unit (AMU)
Quarterly Report
Third Quarter FY-98

Contract NAS10-96018

31 July 1998

ENSCO, Inc.
1980 N. Atlantic Ave., Suite 230
Cocoa Beach, FL 32931
(407) 853-8105 (AMU)
(407) 783-9735

Distribution:

NASA HQ/Q/F. Gregory
NASA HQ/AS/F. Cordova
NASA KSC/PH/R. Sieck
NASA KSC/PH/D. King
NASA KSC/PH/R. Roe
NASA KSC/AA-C/L. Shriver
NASA KSC/AA/R. Bridges
NASA KSC/MK/D. McMonagle
NASA KSC/PH-B/J. Oertel
NASA KSC/PH-B3/T. Greer
NASA KSC/AA-C-1/J. Madura
NASA KSC/AA-C-1/F. Merceret
NASA KSC/BL/J. Zysko
NASA KSC/DE-TPO/K. Riley
NASA JSC/MA/T. Holloway
NASA JSC/ZS8/F. Brody
NASA JSC/MS4/W. Ordway
NASA JSC/MS4/R. Adams
NASA JSC/DA8/J. Bantle
NASA MSFC/EL23/D. Johnson
NASA MSFC/SA0-1/A. McCool
NASA MSFC/EL23/S. Pearson
45 WS/CC/D. Urbanski
45 WS/DOR/W. Tasso
45 WS/SY/D. Harms
45 WS/SYA/B. Boyd
45 RANS/CC/S. Liburdi
45 OG/CC/P. Benjamin
45 MXS/CC/J. Hanigan
45 LG/LGQ/R. Fore
CSR 1300/M. Maier
CSR 4140/H. Herring
45 SW/SESL/D. Berlinrut
SMC/CWP/D. Carroll
SMC/CWP/J. Rodgers
SMC/CWP/T. Knox
SMC/CWP/R. Bailey
SMC/CWP (PRC)/P. Conant
Hq AFSPC/DDOR/G. Wittman
Hq AFSPC/DRSR/S. Heckman
Hq AFSPC/DORW/S. Carr
Hq AFMC/DOW/P. Yavosky
Hq AFWA/CC/J. Hayes
Hq AFWA/DNXT/R. Lefevre
Hq AFWA/DN/Freeman
Hq USAF/XOW/F. Lewis
Hq AFRL/DS/B. Bauman
Office of the Federal Coordinator for Meteorological Services and Supporting Research
SMC/SDEW/B. Hickel
SMC/MEEV/G. Sandall
NOAA "W/OM"/L. Uccellini
NOAA/OAR/SSMC-I/J. Golden
NOAA/ARL/J. McQueen

NOAA Office of Military Affairs/T. Adang
NWS Melbourne/B. Hagemeyer
NWS/SRHQ/H. Hassel
NWS "W/SR3"/D. Smith
NSSL/D. Forsyth
NWS/"W/OSD5"/B. Saffle
PSU Department of Meteorology/G. Forbes
FSU Department of Meteorology/P. Ray
NCAR/J. Wilson
NCAR/Y. H. Kuo
30 WS/CC/C. Davenport
30 WS/DOS/S. Sambol
30 SW/XP/R. Miller
NOAA/ERL/FSL/J. McGinley
SMC/CLNER/B. Kempf
Aerospace Corp./B. Lundblad
Tetratech/NUS Corp./H. Firstenberg
ENSCO ARS Div. V.P./J. Pitkethly
ENSCO Contracts/M. Penn

Executive Summary

This report summarizes AMU activities for the third quarter of FY 98 (April - June 1998). A detailed project schedule is included in the Appendix.

AMU personnel attended the annual AMU Tasking and Prioritization Meeting held at Patrick Air Force Base on 17 June. A draft version of the minutes describing the discussions and the tasks on which consensus was reached is currently being reviewed and will be distributed in late July. A summary of the tasks assigned to the AMU at this meeting is given in the following table.

Task Name	Primary Advocate	Product Sought	Operational Need	Target Begin Date	Target Completion Date
Local Data Integration System (LDIS) - Continuation	SMG	Final report detailing set-up, deficiencies and sensitivities of real-time configuration Possible assistance in setup and evaluation of real-time LDIS at SMG, NWS MLB, 45 WS	Produce timely, high resolution analyses of all available mesoscale data Optimize setup/operation of local data analysis/modeling systems	Oct 98	Jun 99
Evaluation of Meso-Models	NWS MLB	Final report comparing meso-models versus 32-km NCEP Eta model and assessing potential operational added value of meso-models	Improve specific short-term forecasts Determine added value of meso-models which will be delivered in future weather systems (e.g. AWIPS)	Sep 98	Jun 99
Statistical and L-1 Forecast Guidance	SMG 45 WS	Final report documenting the development and verification of statistical forecasting techniques Products and/or software suitable for operational use	Improve short-term forecasts for flight rules and launch commit criteria	Jul 98	Jun 99
Forecast Reviews, Case Studies & Radar Atlas	45 WS NWS MLB	Individual memorandums and possible utilities Hard and electronic copy of selected radar echo examples of operationally significant, non-meteorological and meteorological radar signatures	Improve short-term forecasting for flight rules and launch commit criteria	Jan 99	Jun 99
McIDAS-X GUI/Applications	45 WS	Technical expertise to assist CSR programmers in conversion of weather data display functionality to new system	Improve data retrieval, display and analysis in support of real-time operations	Jul 98	Jan 99

During this quarter, Ms. Lambert visited the Spaceflight Meteorology Group (SMG) at Johnson Space Center to observe their weather forecasting operations in preparation for the STS-91 landing from 10-12 June. These visits help maintain the two-way flow of information between SMG and the AMU by face to face discussions of work that is usually described only through written reports. From 17-19 June, Mr. Nutter attended a workshop in Boulder, CO to discuss real-time mesoscale modeling and model verification techniques. He documented his attendance in a memorandum that includes summaries of individual presentations and group discussions and an overall summary of lessons learned as applied to AMU efforts.

AMU personnel attended the 3rd annual Local Weather (LW) Technical Interchange Meeting (TIM) held at NWS Melbourne on 16 June. The goal of the LW TIM was to facilitate the exchange of applied research results, techniques, tools, training aids, etc. among meteorologists and others who perform and/or support operational weather forecasting for the central Florida Atlantic coast.

Mr. Wheeler distributed the report on the evaluation of WSR-88D thunderstorm cell attributes and trends in hail and high wind cases. Mr. Wheeler also continued work on the AMU's SIGMET/IRIS task. However, this task was deleted during the AMU Tasking and Prioritization meeting in favor of higher priority tasks.

Ms. Lambert completed and distributed the final report on the wind data quality assessment. Ms. Lambert and Dr. Taylor discovered issues with the current RASS data processing software that would make virtual temperature data quality control (QC) difficult. Ms. Lambert drafted a memorandum describing the current RASS data processing techniques and the problems created by it. As a result, the RASS data QC portion of the task was suspended. The contents of the memorandum are found in this report.

The Delta Explosion Analysis project, funded by NASA option hours, was put on hold in April while Mr. Evans was tasked by the NASA KSC Weather Office to work on the design of launch site climatologies. Mr. Evans also continued work on the U.S. Air Force's Model Validation Program (MVP) Data Analysis project. This program involves evaluation of Range Safety's modeling capability using controlled releases of tracers from both ground and aerial sources. The status of the analyses for each session is given in this report.

Reviews of the final report for the AMU's Extended 29-km Eta Model Objective Evaluation task were completed in May. Mr. Nutter began restructuring portions of the report in response to specific requests from the 45 WS to include a section summarizing objective results by station. These summary statements are provided in this report. The final report will be completed and distributed in July.

During April, Dr. Manobianco continued to develop and test software needed to reformat rawinsonde, ACARS, PIREP, and satellite-derived wind data into ADAS. He also completed testing of the complex-cloud analysis scheme in the latest version of ADAS. Preliminary examination of output from different configurations of the ADAS analysis cycle reveals that its utility may be limited by a lack of temporal continuity between analyses run at 15-minute intervals. In response, Mr. Nutter modified an existing ADAS/ARPS program to perform temporal blending of the data based on work done at MIT/Lincoln Laboratory.

Dr. Merceret began a study to determine the actual effective vertical resolution of the KSC 50-MHz Doppler radar wind profiler. He is also examining the temporal persistence of mid-tropospheric wind features as a function of the vertical wavelength.

SPECIAL NOTICE TO READERS

AMU Quarterly Reports are now published on the Wide World Web (WWW). The Universal Resource Locator for the AMU Home Page is:

http://technology.ksc.nasa.gov/WWWaccess/AMU/home.html

The AMU Home Page can also be accessed via links from the NASA KSC Internal Home Page alphabetical index. The AMU link is "CCAS Applied Meteorology Unit".

If anyone on the current distribution would like to be removed and instead rely on the WWW for information regarding the AMU's progress and accomplishments, please respond to Frank Merceret (407-867-2666, francis.merceret-1@ksc.nasa.gov) or Ann Yersavich (407-853-8203, anny@fl.ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. The progress being made in each task is discussed in Section 2 with the primary AMU point of contact reflected on each task and/or subtask.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

2.1 TASK 001 AMU OPERATIONS

AMU personnel attended the 3rd annual Local Weather (LW) Technical Interchange Meeting (TIM) held at NWS MLB on 16 June. The goal of the LW TIM was to facilitate the exchange of applied research results, techniques, tools, training aids, etc. among meteorologists and others who perform and/or support operational weather forecasting for the central Florida Atlantic coast. Participants included personnel from the 45 WS, SMG, NWS MLB, NASA KSC Weather Office, and AMU. Dr. Manobianco provided a status report on the Local Data Integration System (LDIS) task. In addition, Mr. Wheeler presented results from the AMU study on WSR-88D cell trends display utilization. Finally, Ms. Lambert described results from the AMU task on quality control of the 915-MHz wind profiler network data.

From 10-12 June, Ms. Lambert visited the Spaceflight Meteorology Group at Johnson Space Center to observe their weather forecasting operations in preparation for the STS-91 landing. She met with several of the forecasters to discuss SMG's responsibilities and procedures, and received an in-depth demonstration of their McIDAS-X system. Ms. Lambert also met with Mr. Frank Brody to discuss SMG operations including organization, responsibilities, and issues associated with forecasting Shuttle flight rules. While at JSC, she gave a presentation on the results of the AMU's 915 MHz boundary layer profiler data QC task. Members from SMG and the Descent Winds Group were present. These visits help maintain the two-way flow of information between SMG and the AMU by face_to_face discussions of work that is usually described only through written reports.

From 17-19 June, Mr. Nutter attended a workshop in Boulder, CO to discuss real-time mesoscale modeling and model verification techniques. More than 100 representatives from government, university, and private sector agencies attended the workshop. Results from the AMU's ongoing model verification efforts are consistent with many of the results presented for other modeling systems. The audience suggested that a minimum, universal set of objective verification measures is needed to facilitate mesoscale model comparison. However, local efforts to develop unique verification methodologies are encouraged. Other presentations demonstrated that objective (statistical) measures of forecast *quality* are different from subjective (phenomenological) measures of forecast *value*. Both methodologies are equally important in measuring the overall utility in mesoscale models. In general, the presentations and discussions at the workshop validated the AMU's assumption that enhanced initialization using local high-resolution data sets will help improve both the quality and value of local mesoscale models. Mr. Nutter documented his attendance at the workshop in a memorandum for record that includes summaries of individual presentations and group discussions and an overall summary of lessons learned as applied to AMU efforts.

During May, SMG, RWO, and NWS MLB submitted proposed tasks for the annual AMU tasking meeting to be held at PAFB on 17-18 June. AMU personnel exchanged electronic mail and participated in teleconferences with SMG, RWO, and NWS MLB to discuss and clarify both proposed and existing tasks in order to develop accurate resource requirement estimates. These estimates were used by representatives from SMG, RWO, and NWS MLB at the meeting to prioritize and select AMU tasks for the next six to twelve months.

AMU personnel attended the annual AMU Tasking and Prioritization Meeting held at Patrick Air Force Base on 17-18 June. Dr. Manobianco and Ms. Lambert recorded minutes from the meeting. A draft version of the minutes describing the discussions and the consensus that was reached was completed in June and will be circulated for review in early July.

AMU HARDWARE AND SOFTWARE MAINTENANCE

In April, one PC server and 4 PC workstations were received and installed by the AMU. Personal workstations were converted one at a time from Macintosh to the Windows NT operating system. All mail and work files were translated over to the Windows file system. This transition took several days. By the end of the month all AMU workstations had been converted and installed on the AMU LAN. The transition from Mac-based to PC-based systems will allow the AMU to easily communicate and transfer files/documents with both internal and external customers. During May and June additional software was received and installed. The AMU administrative system is now setup as 1 server and 6 clients with shared and individual software packages.

On 16-18 June, a major operating system (OS) upgrade was performed on the AMU's 3 IBM RS/6000 UNIX workstations. This upgrade included new versions of the FORTRAN and C compilers, mail software, and Common Desktop Environment (CDE).

2.2 TASK 004 INSTRUMENTATION AND MEASUREMENT

SUBTASK 1 NEXRAD EXPLOITATION (MR. WHEELER)

During this quarter, the report entitled, "WSR-88D Cell Trends Final Report" was distributed in May. If you would like to receive a copy of this report, please contact Mr. Wheeler at markw@fl.ensco.com.

SUBTASK 2 915 MHZ BOUNDARY LAYER PROFILERS (DR. TAYLOR)

Ms. Lambert completed and distributed copies of the wind data quality assessment final report to SMG, 45 WS, NWS Melbourne, and other interested parties. The report contains descriptions of the profiler network and the algorithms used, and a detailed discussion of their performance in both post-analysis and real-time modes. Summaries of the report can be found in the two previous AMU Quarterly Reports (First and Second Quarter FY-98). Copies of the report can be requested through Ms. Lambert at winnie@fl.ensco.com or 407-853-8130.

When analyzing the RASS data to determine the best QC techniques, Ms. Lambert and Dr. Taylor noticed large unrealistic changes in virtual temperature over short time periods. Further analysis by Ms. Lambert revealed issues with the current data processing software that would make RASS data QC difficult. Ms. Lambert drafted a memorandum describing the current RASS data processing techniques and the problems created by it. Dr. Merceret distributed that memorandum to the AMU tasking community for consideration. As a result of the memorandum, the RASS data QC portion of the task was suspended. Contents of the memorandum follow.

Current RASS Data

The RASS calculates virtual temperature (T_v) through the measurement of the speed of sound (C_a). A vertically propagating sound wave pattern is generated by the four acoustic horns surrounding the radar antenna. This wave pattern backscatters the transmitted radar signal in the same manner, as do changes in the index of refraction. Thus, the vertical radar beam measures the speed of propagation of this wave which corresponds to the local C_a.

The individual beam sample C_a values are consensus averaged over a 5-minute period. The consensus constraints are similar to those for the wind data: at least 60% of the samples must be within 2 m s^{-1} of each other before a consensus estimate is calculated. The consensus T_v is then calculated from the consensus C_a using the equation

$$T_v = [((C_a^2)*28.96)/(8314.3*1.4)] - 272.15$$

where T_v is in °C and C_a is in m s^{-1} (Radian 1994). It can be shown using the equation above that a speed difference of 2 m s^{-1} s corresponds to 6.1 °F. It follows, then, that the individual sample temperatures used in the consensus will be within 6.1 °F of each other.

Atmospheric vertical velocity (*w*) affects the measured C_a such that it will not represent the actual C_a. A data processing technique is used which allows *w* to be measured simultaneously with C_a. The value of the difference between the measured C_a and *w* is assumed to be the correct C_a. This new C_a can then be consensus averaged and used in the above equation to calculate a corrected T_v. It is important to note that T_v is highly sensitive to any changes in C_a and, therefore, *w*. Calculations using the equation above show that a 1 m s^{-1} change in *w* causes a 1.7 °C (~3 °F) error in T_v if its effect is not included. Confirmation of this vertical velocity error is found in the literature. Weber et al. (1993) found a similar error of 1.6 °C and Angevine et al. (1994) states that neglect of the vertical velocity is the largest source of error in RASS measurements.

In the current software implemented in the 915 MHz profiler network, the individual sample corrected T_v is calculated. However, the measured (uncorrected) individual sample C_a values are used in the consensus algorithm which produces an uncorrected T_v. It is this uncorrected T_v that is transmitted to the ROCC for display by operational personnel.

Case Study: 14 April 1998

A large increase in T_v over a 15-minute period occurred on 14 April 1998 at the False Cape profiler site between 1705 and 1720 UTC (1305 and 1320 EDT). This increase was evident at most of the gates in the later profile, and it was much more pronounced in the lower gates. In the subsequent profile at 1735 UTC the temperatures decreased to values similar to those in the 1705 UTC profile. The virtual temperatures and the virtual temperature differences between the 1705 and 1720 UTC profiles are shown in Table 1. The large increases in T_v over the short time period at most of the levels appeared suspicious. Analysis of data from other days showed other suspicious increases, therefore a more in-depth analysis using the individual sample RASS data for 14 April was undertaken to determine their cause.

The individual sample data in the spectra file were analyzed thoroughly for information that would lead to understanding the large change in virtual temperature. The spectra files for RASS data contain *w*, the uncorrected C_a, and the corrected T_v at each gate for each sample in the consensus time period. The corrected RASS C_a is the difference between the uncorrected C_a and *w*, both of which are in the spectra file. In order to determine if the virtual temperature rise was an error, new consensus T_v values for both profiles were calculated using the consensus of the corrected individual sample C_a values. The results are shown in Table 2.

The T_v values at 1705 UTC changed very little because the vertical velocities were small (< 1 m s^{-1}) during the 5- minute consensus period. However, the T_v values at 1720 UTC changed dramatically due to upward vertical velocities of 2-3 m s^{-1}. The new differences in T_v between the two profiles decreased to between –1 and 1 °F. This is a more reasonable change over a 15-minute time period.

Updraft regions occur over the Cape area in the form of thermals, convergence boundaries, or horizontal convective rolls (HCRs). Weckwerth et al. (1996) showed that vertical velocities in the updraft portion of HCRs are on the order of 1-3 m s^{-1}. This is consistent with the vertical velocity values in the 1720 UTC profile. A thorough meteorological analysis was not done to determine whether or not an HCR existed over the profile at 1720 UTC. However, it was obvious from the data that a local maximum in upward vertical velocity existed near or over the radar with values that were within the realm of possibility for the boundary layer. As updraft regions occur frequently over the Cape area, especially in the warm season, this is potentially a frequent contaminate of the current RASS data.

Table 1. The consensus virtual temperature profiles at 1705 and 1720 UTC 14 April 1998 and the differences in their values. A positive value in the fourth column indicates an increase in T_v with time. A '999.9' indicates that a consensus could not be reached, and a 'N/A' indicates a difference could not be calculated due to missing data.

Height (feet)	1705 UTC T_v (°F)	1720 UTC T_v (°F)	$T_{v\text{-}1720} - T_{v\text{-}1705}$ (°F)
368.9	69.4	77.4	8.0
713.2	68.4	75.6	7.2
1057.5	67.3	73.6	6.3
1401.8	64.9	74.3	9.4
1746.1	63.0	70.3	7.3
2090.4	61.7	68.5	6.8
2434.7	59.5	64.0	4.5
2779.0	57.7	62.8	5.1
3123.3	56.5	59.7	3.2
3467.6	55.4	57.9	2.5
3811.9	999.9	56.1	N/A
4156.2	999.9	54.7	N/A
4500.5	999.9	999.9	N/A
4844.8	59.2	999.9	N/A

Table 2. The corrected consensus virtual temperature profiles at 1705 and 1720 UTC 14 April 1998 and the differences in their values. A positive value in the fourth column indicates an increase in T_v with time. A '999.9' indicates that a consensus could not be reached, and a 'N/A' indicates a difference could not be calculated due to missing data.

Height (feet)	1705 UTC T_v (°F)	1720 UTC T_v (°F)	$T_{v\text{-}1720} - T_{v\text{-}1705}$ (°F)
368.9	70.4	71.3	0.9
713.2	69.6	69.4	-0.2
1057.5	68.8	68.2	-0.6
1401.8	66.2	67.3	1.1
1746.1	65.5	66.4	0.9
2090.4	63.4	63.5	0.1
2434.7	61.6	61.4	-0.2
2779.0	59.6	60.1	0.5
3123.3	57.6	58.3	0.7
3467.6	56.9	56.2	-0.7
3811.9	999.9	999.9	N/A
4156.2	999.9	999.9	N/A
4500.5	999.9	999.9	N/A

4844.8	999.9	999.9	N/A

Conclusions

This memorandum provides a case study that demonstrates the need to use the vertical velocity correction in the calculation of the consensus T_v. However, the corrected consensus T_v is not currently calculated. Instead, the uncorrected consensus T_v values are calculated and transmitted to the ROCC for display by operational personnel. Since small changes in vertical velocity can have a large effect on the resulting temperatures, it is likely that large amounts of the RASS data are contaminated.

The development of quality assessment routines for these data would be difficult at best. The consensus files only contain the uncorrected consensus T_v values and the number of individual beam samples used in the consensus. There is no information given about the atmospheric or sound wave vertical velocities. Since all profiles are potentially suspect, it will be difficult to determine which profile is contaminated when a large change in T_v occurs. Thus, any routines developed to QC the RASS data in their current form will most likely be ineffective.

A new profiler software package, called LAP-XM, will be used to calculate consensus values when the profilers are upgraded later this summer. This software will calculate the corrected consensus T_v along with the uncorrected consensus T_v. Both values will be available with the consensus-corrected speed of sound in the consensus files (John Neuschaeffer of Radian Corp., personal communication). With this additional information the presence of rain and other contaminates in the new data sets can be deduced with greater confidence than is currently possible. Thus, there will be a greater chance for success in developing quality assessment routines for the RASS data after the software upgrade is implemented.

References

Angevine, W. M., W. L. Ecklund, D. A. Carter, K. S. Gage, and K. P. Moran, 1994: Improved radio acoustic sounding techniques. *J. Atmos. Oceanic Tech.*, **11**, 42-49.

Radian Corporation, 1994: *Software Reference Document for the LAP™-3000*, 2990 Center Green Court, South, Boulder, CO 80301, Document Control No. 80010010, 184 pp.

Weber, B. L., D. B. Wuertz, D. C. Welsh, R. McPeek, 1993: Quality controls for profiler measurements of winds and RASS temperatures. *J. Atmos. Oceanic Tech.*, **10**, 452-464.

Weckwerth, T. M., J. W. Wilson, and R. M. Wakimoto, 1996: Thermodynamic variability within the convective boundary layer due to horizontal convective rolls. *Mon. Wea. Rev.*, **124**, 769-784.

SUBTASK 5 I&M AND RSA SUPPORT (DR. MANOBIANCO/MR. WHEELER)

In April, Dr. Manobianco participated in a videoconference with representatives from the US Air Force Space Command, Eastern and Western Range weather and safety, NASA KSC Weather Office, and CSR. The purpose of this conference was to reach consensus on range standard toxic hazard assessment hardware and software. Dr. Manobianco provided technical expertise regarding the configuration, use, and potential added value of local numerical weather prediction and dispersion models for assessing accidental release and/or abort scenarios. Based on group consensus reached during this videoconference, Major Scot Heckman said he would recommend to the SPO that the RSA proposed baseline include LAPS/RAMS for weather, OBDG/AFTOX and HYPACT for cold spills, and REEDM/LATRA and REEDM/HYPACT for launch risk management and hot spills.

SUBTASK 12 SIGMET/IRIS PROCESSOR EVALUATION (MR. WHEELER)

During this quarter, Mr. Wheeler continued to gain a better understanding of the SIGMET system. He was able to reload archived data from several earlier test cases and develop a full range of products from that data. The system has a much faster response time now that the memory has been increased to 256 MB. He attended a one-day training session on the system that was provided by SIGMET. Several case study days were archived for playback and analysis at a later date. This task was discussed at the annual AMU Tasking Meeting in June and by consensus of the 45 WS, SMG and NWS Melbourne, the SIGMET/IRIS processor evaluation was deleted in favor of other higher priority tasks.

2.3 TASK 005 MESOSCALE MODELING

SUBTASK 4 DELTA EXPLOSION ANALYSIS (MR. EVANS)

In early April, Mr. Evans produced graphs showing the comparison of observed versus predicted plume locations for the plume resulting from the Delta explosion. The HYPACT plume location data were determined by finding the peak predicted concentration in each HYPACT 100-meter layer. The peak concentrations were assumed to be at the center of the plume. The observed plume location was determined using data collected by the Melbourne WSR-88D radar. The Delta Explosion Analysis project will be completed during the next quarter and the final report will distributed at that time.

The Delta Explosion Analysis project, funded by NASA option hours, was put on hold in late April while Mr. Evans was tasked by the NASA KSC Weather Office, under the same funding, to work on the design of launch site climatologies. As part of this study, Mr. Evans met with Mr. Madura and Dr. Merceret to discuss the project. The NASA KSC Weather Office is considering advocating and seeking a source of funding for compiling a climatology of the violation of Launch Commit Criteria at selected current and potential launch facilities around the world. The study is to determine the feasibility, design criteria and rough estimate of cost for the climatology. The purpose of the climatology would be to provide an objective basis for comparative, vehicle specific evaluation of weather impacts to launch, landing and ground processing activities at the various launch and landing sites for both current and future space vehicles. The actual climatology would not be done by the AMU because it is not within the scope of the AMU charter. The design project is done under the AMU's charter to provide expert technical assistance on procurement of weather support.

The report on the launch site climatology was submitted to NASA in June. The report generated for this study includes lists of existing and potential launch sites and launch vehicles, lists of available climatological data (routine and launch-site unique), and lists of documents. The report also included a discussion of methodologies and assumptions that would be used to derive the Launch Commit Criteria from routine and available meteorological data.

SUBTASK 5 MODEL VALIDATION PROGRAM (MR. EVANS)

The primary purpose of the U.S. Air Force's Model Validation Program (MVP) Data Analysis project, which is being funded by option hours from the U.S. Air Force, is to produce RAMS and HYPACT data for the three MVP sessions conducted at Cape Canaveral in 1995-1996. This program involves evaluation of Range Safety's modeling capability using controlled releases of tracers from both ground and aerial sources.

The status of the MVP data analysis tasks is presented in Table 3.

Table 3. Status of MVP Data Analysis Tasks

MVP Data Analysis Task	Session I	Session II	Session III
Prepare Data	Completed	Completed	Completed
Run ERDAS-RAMS	Completed	Partially completed	Completed
Run ERDAS-HYPACT	In process	Partially completed	Completed
Run PROWESS-RAMS	Completed	Partially completed	Completed
Run PROWESS-HYPACT	Completed	Partially completed	Completed
Submit Data to NOAA-ATDD	To be done	To be done	Completed

The analysis of the MVP data for the three sessions is nearing completion. RAMS data has been produced for the days of all releases and HYPACT runs are being finalized. Session II RAMS data was produced using 2.5-

degree NCAR reanalysis data for initialization. Supplemental runs are being produced for Session II for 7 of the 16 days in which 80-km NGM data were available. HYPACT runs will be made for all of the releases using the available RAMS data.

The problem with the incompatibilities between the AMU and NOAA/ATDD tape drives has been solved and the remaining data will be sent to NOAA when completed.

SUBTASK 6 EXTEND 29-KM ETA MODEL OBJECTIVE EVALUATION (MR. NUTTER)

In March, Dr. Manobianco and Mr. Nutter submitted a two-part manuscript to *Weather and Forecasting*. The manuscript describes selected results from the subjective and objective portions of the Meso-Eta model evaluation. The manuscripts were accepted for publication pending revisions. Dr. Manobianco and Mr. Nutter began work on these revisions during the latter half of June.

In May, Representatives from 45 WS, SMG, and NWS MLB completed reviews on a draft of the final report entitled "An Extended Objective Evaluation of the 29-km Eta Model for Weather Support to the United States Space Program". During June, Mr. Nutter began restructuring portions of the report in response to specific requests from the 45 WS to include a section summarizing objective results by station. These summary statements are provided below and will appear in the final report when completed in July.

Introduction

From May 1996 through January 1998, the AMU conducted an objective verification of the NCEP 29-km Eta (Meso-Eta) numerical weather prediction model. The verification was designed to identify the model's error characteristics for surface and upper-air point forecasts at Cape Canaveral Air Station (XMR), FL, Tampa Bay (TBW), FL, and Edwards Air Force Base (EDW), CA. These stations are selected because they are important for 45 WS, SMG, and NWS Melbourne operational concerns.

Surface forecast accuracy

Error characteristics for surface parameter forecasts vary widely by location, season, and time of day. The statistics can be utilized most effectively by considering the model biases for each parameter separately. For example, the fact that Meso-Eta wind speed forecasts are too fast on average at XMR (Table 4) suggests that forecast accuracy might be improved by adjusting such guidance to lower speeds. Similar adjustments should be made to accommodate the biases identified for other parameters.

The random error component reveals substantial day-to-day variability in forecast accuracy. The random errors are caused primarily by the model's inability to resolve localized phenomena such as wind gusts, temperature gradients, or the effects of thunderstorms. While it is possible to partially adjust for model biases, it is much more difficult to accommodate the variability in forecast errors on any given day. It might help to compare current observations with the latest forecast guidance and make appropriate adjustments.

On average, the model provides useful guidance for time-averaged environmental parameters such as METAR observations. However, the model does not have sufficient resolution to forecast events such as peak wind gusts.

It is important that users maintain awareness of ongoing model changes. Such changes are likely to modify the basic error characteristics, particularly near the surface.

Table 4. Summary of Meso-Eta forecast biases (forecast – observed), RMS errors, and error standard deviations for surface parameters at XMR during the warm (May through Aug 1997) and cool (Oct 1997 through Jan 1998) seasons.

Variable	Season	RMS	Bias	Std Dev	Interpretation
Sea-level Pressure (mb)	Warm	1	–1 to 0	1	Forecasts tend to be slightly lower than observed.
	Cool	1	±0.5	1	Small, variable forecast bias with random errors of 1 mb.
Temp. (°C)	Warm	1 to 2	±1	1 to 2	Forecasts are slightly warm in afternoon, slightly cool at night. Large random error component.
	Cool	2	0 to 1	2	Slight warm bias throughout the forecast cycle. Random error contributes more than bias.
Dew Point (°C)	Warm	1 to 2	–1 to 0	1 to 2	Forecasts are slightly dry on average. Random error contributes more than bias.
	Cool	1 to 3	0 to 2	1 to 2	Forecasts are typically wetter than observed.
Wind Speed (m s^{-1})	Warm	2	0 to 2	1 to 2	Forecast winds are too fast on average.
	Cool	2 to 3	1 to 3	1.5	Forecast winds are too fast on average.
Wind Dir. (°)	Warm	50 to 70	±10	50 to 70	Forecasts are nearly unbiased although random errors are large.
	Cool	40 to 60	±10	40 to 60	Same as warm season except random errors are slightly smaller.

Table 5. Summary of Meso-Eta forecast biases (forecast – observed), RMS errors, and error standard deviations for surface parameters at TBW during the warm (May through Aug 1997) and cool (Oct 1997 through Jan 1998) seasons. A range of errors reveals fluctuations with time of day.

Variable	Season	RMS	Bias	Std Dev	Interpretation
Sea-level Pressure (mb)	Warm	1	–1 to 0	1	Forecasts tend to be slightly lower than observed.
	Cool	1	±0.5	1	Small, variable forecast bias with random errors of 1 mb.
Temp. (°C)	Warm	2.5	–3 to 1	1 to 2	Forecasts are too warm in the afternoon, too cool at night.
	Cool	1 to 3	–1 to 3	1 to 2	Forecasts are too warm in the afternoon, too cool at night.
Dew Point (°C)	Warm	1 to 2	–1 to 0	1 to 2	Forecasts are slightly dry on average. Random error contributes more than bias.
	Cool	1 to 3	0	1 to 3	Forecasts are unbiased but random errors reduce accuracy.
Wind Speed (m s^{-1})	Warm	1.5	±1	1 to 2	Small forecast bias. Random error contributes more than bias.
	Cool	2	0 to 1	1.5	Forecast winds are slightly fast on average.
Wind Dir. (°)	Warm	50 to 80	–30 to 0	50 to 80	Forecast winds should be backed slightly to better match the observations.
	Cool	30 to 50	–20 to 0	30 to 50	Same as warm season except random errors are smaller.

Table 6. Summary of Meso-Eta forecast biases (forecast – observed), RMS errors, and error standard deviations for surface parameters at EDW during the warm (May through Aug 1997) and cool (Oct 1997 through Jan 1998) seasons. A range of errors reveals fluctuations with time of day.

Variable	Season	RMS	Bias	Std Dev	Interpretation
Sea-level Pressure (mb)	Warm	1 to 3	–2 to 0	1.5	Forecasts tend to be lower than observed.
	Cool	2 to 3	0 to 3	2	Forecasts tend to be greater than observed.
Temp. (°C)	Warm	3 to 6	–6 to –2	1 to 3	Forecasts are too cold on average.
	Cool	3 to 5	–4 to 0	2 to 4	Forecasts are too cold on average, especially during the daytime.
Dew Point (°C)	Warm	3 to 9	0 to 8	3 to 5	Forecasts are too moist on average, especially during the daytime.
	Cool	3 to 6	–1 to 5	3.5	Forecasts are mostly wetter than observed, especially during the daytime.
Wind Speed ($m\ s^{-1}$)	Warm	2 to 6	–7 to –1	1.5 to 3	Forecasts too slow on average, especially during the daytime.
	Cool	2 to 3	–2 to 0	2	Forecasts too slow on average.
Wind Dir. (°)	Warm	20 to 90	0 to 30	20 to 90	Forecast winds should be veered slightly overnight to better match the observations.
	Cool	60 to 90	0 to 30	60 to 90	Same as warm season.

Upper-Air Forecasts

Since model biases do not significantly increase with time at upper-levels, the error characteristics outlined in Tables 7 and 8 apply at any time during the forecast period. This generality does not apply to surface forecasts where error characteristics vary with time of day.

Table 7. Summary of Meso-Eta upper-air forecast error characteristics at XMR and TBW during 1996 and 1997.	
Warm Season (May – Aug)	Cool Season (Oct – Jan)
On average, forecasts are about 1 °C too cold below 700 mb and 1 to 2 °C too warm above 700 mb. Forecasts are too dry below 800 mb and too moist above 500 mb. The temperature and moisture biases indicate that forecast soundings are too stable on average. This could be a consequence of the model's convective rainfall parameterization. Wind speed forecasts are nearly unbiased in the lower and middle troposphere, but are typically too fast above 400 mb. Wind direction forecast biases are less than ±10° but the random error component of 40 to 60° dominates the day-to-day variability.	The height of the lower tropospheric temperature inversion is often overforecast, thereby creating a 2 °C cold bias near the 700-mb level. Wind speed forecasts are about 1 m s^{-1} too slow in the middle troposphere and about 1 m s^{-1} too fast in the upper troposphere. Wind direction forecast biases are less than ±10°, but the random error component of 10 to 40° dominates the day-to-day variability.

Table 8. Summary of Meso-Eta upper-air forecast error characteristics at EDW during 1996 and 1997.	
Warm Season (May – Aug)	Cool Season (Oct – Jan)
Temperature biases are less than ±1 °C. Forecasts tend to retain greater amounts of moisture than observed except near the 600 mb level. Wind speed forecasts are 1 to 2 m s^{-1} too slow, but the random error component of 3 to 5 m s^{-1} dominates the day-to-day variability. On average, wind direction forecasts are backed about 10° relative to observations. The random error component of 30 to 60° dominates the day-to-day variability.	A strong cold bias exists in the forecasts below 700 mb. The bias exceeds –4 °C near the surface. Forecasts are too moist near the surface, and too dry above 800 mb. Wind speeds are 1 to 2 m s^{-1} too slow on average except near the tropopause. The random error component exceeds 6 m s^{-1}. On average, wind direction forecasts are backed about 10° relative to observations. The random error component of 30 to 90° dominates the day-to-day variability.

Table 9. Meso-Eta point forecast error characteristics for convective indices at XMR during the 1996 and 1997 warm seasons (May-Aug).	
Index	Forecast Error Characteristics
Precipitable Water	Forecasts have a slight dry bias, but are generally accurate across a wide range of values.
Lifted Index	Forecasts are more stable than observed. The forecasts tend to be most accurate when their values are around –3 to –4 °C but the day-to-day variations are not handled well.
K-index	Forecast biases are small but a large random error component limits their utility.
LCL	Forecast accuracy decreases at lower pressures (greater heights).
CAPE	Forecasts are too small (stable) on average and are susceptible to very large errors.
0-3 km Helicity	Forecasts tend to overestimate the magnitude of the vertically integrated wind shear.
MDPI	Forecasts are most reliable when values are near 1.0 but a large random error component limits their utility.

SUBTASK 7 DATA ASSIMILATION MODEL/CENTRAL FL DATA DEFICIENCY (DR. MANOBIANCO)

During April, Dr. Manobianco continued to develop and test software needed to reformat rawinsonde, ACARS, PIREP, and satellite-derived wind data into ADAS. In addition, he completed testing of the complex-cloud analysis scheme in the latest version of ADAS. Mr. Nutter and Dr. Manobianco continued data collection from 11-12 December 1997 for a cool season case study using ADAS. They also briefed SMG personnel via teleconference on the status of this work and discussed possible task proposals that might be submitted to extend and/or supplement current AMU efforts.

Preliminary examination of output from different configurations of the ADAS analysis cycle reveals that its utility may be limited by a lack of temporal continuity between analyses run at 15-min intervals. In a telephone conversation with Mr. Rodney Cole at MIT Lincoln Laboratory, Dr. Manobianco and Mr. Nutter learned that the Integrated Terminal Winds System (ITWS) achieves temporal continuity in wind analyses by blending the previous analysis with current first guess fields. In this manner, an objectively selected portion of the fine-scale detail added during the latest analysis cycle is preserved at the beginning of the next analysis cycle. Mr. Nutter modified an existing ADAS/ARPS program to perform blending following the ITWS methodology. Improvements in the temporal continuity between subsequent analyses should help users develop a better conceptual understanding of the analyzed weather event(s) using graphical animation.

Dr. Manobianco and Mr. Nutter will complete the case studies using the new version of ADAS and determine the impact of non-incorporation of specific data sources on the utility of the subsequent analyses.

2.4 AMU CHIEF'S TECHNICAL ACTIVITIES (DR. MERCERET)

In April, Dr. Merceret began a study to determine the actual effective vertical resolution of the KSC 50 MHz Doppler radar wind profiler (DRWP). The study will also examine the lifetime of mid-tropospheric wind features as a function of their vertical wavelength. Both analyses will use spectral techniques applied to the extensively quality controlled DRWP data set developed for the work published in the *Journal of Applied Meteorology,* November 1997 pp 1567 - 1575. The results will assist in the development of more effective concepts of operation for the profiler and other wind sounding systems including AMPS (which is scheduled to replace radar-tracked Jimspheres before FY 2000). The project design was discussed with technical personnel of the Shuttle and Titan programs, the AMU and the Aerospace Corporation (a USAF "think tank" with considerable expertise in the field). During May and June, Dr. Merceret completed writing the analysis software and continued processing the data and selected 93 days for analysis. Rawinsonde soundings were obtained for most of these days

Also during the past quarter, Dr. Merceret continued to advise John Lane on his Ph.D. dissertation for the University of Central Florida. The work is directed at improving rainfall estimates from radars such as the WSR-

88D and WSR-74C that are used to provide heavy rain advisories and accumulated rainfall estimates at KSC/CCAS. Dr. Merceret reviewed the first complete draft of the dissertation and provided comments to Mr. Lane.

NOTICE

Acronyms

45 MXS	45th Maintenance Squadron
45 WS	45th Weather Squadron
ACARS	Aeronautical Radio, Inc. (ARINC) Communications, Addressing & Reporting System
ADAS	ARPS Data Assimilation System
AFTOX	Air Force Toxic Chemical Dispersion Model
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
ATDD	Atmospheric Turbulence and Diffusion Division
AWIPS	Advanced Weather Interactive Processing System
CAPE	Convective Available Potential Energy
CAPS	Center for Analysis and Prediction of Storms
CCAS	Cape Canaveral Air Station
CDE	Common Desktop Environment
CSR	Computer Science Raytheon
DRWP	Doppler Radar Wind Profiler
EDW	Edwards Air Force Base Rawinsonde Station Identification
ERDAS	Emergency Response Dose Assessment System
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GOES	Geostationary Orbiting Environmental Satellite
GUI	Graphical User Interface
GVAR	GOES Variable
HCR	Horizontal Convective Roll
HYPACT	Hybrid Particle And Concentration Transport
I&M	Improvement and Modernization
IRIS	Integrated Radar Information System
ITWS	Integrated Terminal Winds System
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAN	Local Area Network
LAPS	Local Analysis and Prediction System
LCL	Lifted Condensation Level
LDIS	Local Data Integration System
LL	Lincoln Laboratory
LW	Local Weather
McIDAS	Man computer Interactive Data Access System
MDPI	Microburst Day Potential Index

Acronyms

METAR	Aviation Routine Weather Report
MIT	Massachusetts Institute of Technology
MSFC	Marshall Space Flight Center
MVP	Model Validation Program
NASA	National Aeronautics and Space Administration
NCAR	National Center for Atmospheric Research
NCEP	National Center for Environment Prediction
NEXRAD	NEXt-generation RADar
NGM	Nested Grid Model
NOAA	National Oceanic and Atmospheric Administration
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service Melbourne
OBDG	Ocean Breeze/Dry Gulch
OS	Operating System
PC	Personal Computer
PIREP	PIlot REport
PROWESS	Parallelized RAMS Operational Weather Simulation System
QC	Quality Control
RAMS	Regional Atmospheric Modeling System
RASS	Radio Acoustic Sounding Systems
REEDM	Rocket Exhaust Effluent Diffusion Model
RMS	Root Mean Square
ROCC	Range Operations Control Center
RSA	Range Standardization and Automation
RWO	Range Weather Operations
SMG	Spaceflight Meteorology Group
SPO	Space Program Office
STS	Space Transportation System
TBW	Tampa Bay area Rawinsonde Station Identification
TIM	Technical Interchange Meeting
USAF	United States Air Force
UUCP	UNIX to UNIX Copy Protocol
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web
XMR	Cape Canaveral Rawinsonde Station Identification

Appendix A

AMU Project Schedule

31 July 1998

AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
SIGMET/IRIS Processor Evaluation	Evaluate SIGMET radar data manipulation and display capabilities for operational use	Jan 98	Oct 98	Task deleted as a result of Tasking Meeting
	Final Report	Oct 98	Jan 99	Task deleted as a result of Tasking Meeting
Boundary Layer Profilers	Wind Data Quality Objective	May 97	Jan 98	Completed
	Interim Report	Jan 98	May 98	Completed
	Cool Season Data Collection	Nov 97	Mar 98	Completed
	Warm Season Data Collection	Mar 98	Sep 98	Ongoing
	RASS Data Quality Objective	Feb 98	June 98	Suspended due to RASS data processing issues
	Final Report	Apr 98	Jun 98	Completed
AF I&M and RSA Support	Review Document / Products, Attend Meetings / Reviews, Document Advice, Suggestions, and Comments	Jul 96	Ongoing	On schedule
Data Integration Model / Data Deficiency	Identify Mesoscale Data Sources in central Florida	May 97	May 98	Completed
	Identify / Install Prototype Analysis System	Aug 97	Nov 97	Completed
	Case Studies Including Data Non-incorporation	Nov 97	Jun 98	2-month delay - waiting for external data and software updates
	Final Report	Jul 98	Sep 98	2-month delay due to case studies delay
29-km Eta Model Evaluation Extension	Archive data for 1997/1998	May 97	Jan 98	Completed
	Perform Analysis	Sep 97	Feb 98	Completed
	Final Report	Mar 98	Jul 98	2-month delay for customer-requested revisions
GVAR Sounder Products Evaluation	Final Report	Jul 98	Feb 99	On schedule
Delta Explosion Analysis	Analyze Radar Imagery	Jun 97	Nov 97	Completed
	Run Models/Analyze Results	Jun 97	Jun 98	Completed

AMU Project Schedule 31 July 1998				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
	Final Report	Feb 98	Aug 98	
	Launch site climatology plan	Apr 98	May 98	Completed
Model Validation Program	Inventory and Conduct RAMS runs for Sessions I, II, and III	Jul 97	Jul 98	Session I and III completed
	Run HYPACT for all MVP releases	Aug 97	Aug 98	Session III completed; Session I & II PROWESS completed
	Deliver data to NOAA/ATDD	Oct 97	Aug 98	Delayed due to delay NOAA's tape read problems
	Acquire meteorological data for Titan launches	Jul 97	Sep 98	