Applied Meteorology Unit (AMU)

Quarterly Report

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Executive Summary

This report summarizes the Applied Meteorology Unit (AMU) activities for the third quarter of Fiscal Year (FY) 00 (April – June 2000). A detailed project schedule is included in the Appendix.

All AMU personnel attended the AMU Tasking and Prioritization Meeting via teleconference on 12 May. Other participating agencies included the Spaceflight Meteorology Group (SMG), the 45th Weather Squadron (45 WS), the National Weather Service in Melbourne, FL (NWS MLB), the Kennedy Space Center (KSC) Weather Office, and Marshall Space Flight Center (MSFC). The Tasking Group unanimously accepted Dr. Manobianco's proposal to complete all new and current tasks over the next 18 months as the consensus tasking. A summary of the new tasks to be executed by the AMU is given in the following table.

Task Name	***Product Sought***	***Operational Benefit***	***Target Begin Date***	***Target Completion Date***
Neumann-Pfeffer Thunderstorm Probability Index (NPI)	– New NPI will produce thunderstorm occurrence and timing probabilities – Documentation and training on use of tool	– New NPI improvement over current NPI - will likely produce more reliable thunderstorm probabilities – Forecasters able to get probabilities of occurrence and timing in one step	Jul 00	May 01
Mini-SODAR Evaluation	– Periodic updates on SODAR performance – Final report describing SODAR performance and evaluation procedures – Training to explain SODAR parameters and performance	– Forecasters will have improved understanding of SODAR performance and data quality	Oct 00	Dec 01
RECCE Aircraft/Radar Discrepancy Case Studies	– Memorandum summarizing results from each analysis	– RECCE/Radar observation discrepancies may be better understood – Improve launch operation support	Oct 00	Sep 01
Core Aspect Ratio (CAR) Trends in Downburst/Hail Prediction	– Evaluation of predictive capabilities of CAR – Report describing results of CAR trends study – Training on use of CAR product – Results will be cross-fed to the WSR-74C Phase II Task	– Improved nowcasting of downburst and hail events	Jul 00	Sep 00
ARPS Phase I Configuration of Prototype	– Assistance in installation and configuration of ARPS numerical weather prediction (NWP) model at customer offices	– Improve short-range NWP guidance in support of space flight operations	Oct 00	Mar 01
ARPS Phase II Comparison to RAMS and Eta Models	– Final report summarizing comparison of point error statistics between the ARPS, RAMS, and Eta NWP models	– Improve short-range NWP forecast guidance in support of space flight operations – Better understanding of errors associated with each model	Jul 01	Dec 01

Ms. Lambert resumed work on the Statistical Short-Range Forecast Tools task. She began an exploratory data analysis (EDA) using a 20-year record of hourly surface observations (1973–1997) from stations in East-central Florida, and upper-air data collected at Cape Canaveral Air Force Station (CCAFS). The EDA centered on the ceiling thresholds defined by the Shuttle Flight Rules (FR). Ms. Lambert examined several aspects of the data including the number of occurrences of different ceiling categories by month, hour, and type of observed weather.

Dr. Short began Phase II of the Interactive Radar Information System (IRIS) SIGMET Processor Evaluation task in April. Phase II will develop new radar products to meet operational requirements of the 45 WS and SMG using SIGMET Inc.'s IRIS system on the Weather Surveillance Radar model 74C (WSR-74C) on Patrick Air Force Base (PAFB). Dr. Short presented results from the AMU Final Report on IRIS Product Recommendations at a working group (WG) meeting on 27 April. The purpose of the meeting was to develop a prioritized list of radar products to be generated by the IRIS software. Of the 18 recommended products listed in the Phase I report, the WG recommended that 7 be implemented immediately. The other 11 must be developed by the AMU. The WG also recommended implementation of a new scan strategy for the WSR-74C. The AMU developed the scan strategy to reduce vertical gaps in radar coverage over the KSC/CCAFS area by 37%, compared to the present scan strategy. The new scan strategy was put into operation on 6 June.

Mr. Wheeler and Mr. Dianic worked together with Mr. Tim Oram of SMG to develop an aircraft position overlay on WSR-74C SIGMET images in support of the Airborne Field Mill (ABFM) field experiment to improve lightning launch commit criteria (LCC). During the month of May, data displays were developed and tested and software to ingest and decode aircraft telemetry data was created. The needed display was completed on time to support the ABFM project at the beginning of June. AMU and SMG personnel were available during the project for consulting on use of the display software and troubleshooting.

Mr. Case submitted a paper to the Ninth Conference on Aviation, Range, and Aerospace Meteorology (11-15 September 2000, Orlando, FL). The paper focuses on the influence of horizontal resolution on the Regional Atmospheric Modeling System (RAMS) forecast errors, and compares these errors to those of the Eta model. RAMS is the meteorological forecasting component of the Eastern Range Dispersion Assessment System (ERDAS), and the Eta model is operated by the NWS. A portion of the conference paper is given in this report, highlighting the results that compare the RAMS and Eta model errors during the 1999 Florida warm season (May–August). The results indicate that the Eta model outperforms RAMS in temperature forecasts during the daylight hours. The RAMS and Eta models have a comparable dew point root mean square (RMS) error. The models also have comparable errors in wind direction and wind speed.

Mr. Wheeler continued to document suspected chaff returns in an effort to detect the source regions. Weather radar returns from chaff can mask meteorological signals, or at least complicate the job of interpreting meteorological returns for the 45 WS, SMG, and NWS MLB forecasters. He monitored products from the NWS Weather Surveillance Radar-1988 Doppler (WSR-88D) sites in the southeastern United States for chaff release signatures through April. A total of 47 events were documented since the data collection began in January 2000. Mr. Wheeler will complete and distribute the final report in the next quarter.

Mr. Case continued work on the Local Data Integration System (LDIS) Phase III task, which calls for AMU assistance to install a working LDIS at SMG and NWS MLB that generates routine high-resolution products for operational guidance. He acquired software from the National Severe Storms Laboratory (NSSL) that is needed by NWS MLB and tested it on an AMU workstation. He also performed system tests of the Advanced Regional Prediction System (ARPS) and ARPS Data Analysis System (ADAS) programs on a new AMU workstation.

Mr. Dianic began the Extension/Enhancement of the ERDAS RAMS Evaluation. He worked on three components of the task. The first component involves the generation of RAMS forecasts using Eta 0-hour forecasts rather than 12-hour forecasts for the RAMS initialization. The second component creates RAMS 3-grid forecasts for comparison to the full 4-grid configuration. In the third component, the graphical user interface (GUI) used to compare the RAMS forecasts to observational data will be modified and improved.

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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 (321-867-0818, francis.merceret-1@ksc.nasa.gov) or Winifred Lambert (321-853-8130, lambert.winifred@ensco.com).

1. BACKGROUND

The AMU has been in operation since September 1991. Tasking is reviewed annually with reviews at least semi-annually. 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. A list of acronyms used in this report immediately follows Section 2.

2. AMU ACCOMPLISHMENTS DURING THE PAST QUARTER

2.1 TASK 003 SHORT-TERM FORECAST IMPROVEMENT

SUBTASK 3 STATISTICAL SHORT-RANGE FORECAST TOOLS (MS. LAMBERT)

The goal of this task is to develop short-range ceiling forecast equations to be used in support of Space Shuttle landings. After attaining a basic proficiency with the AMU's new statistical software package, S-PLUS®, Ms. Lambert began an exploratory data analysis (EDA) using a 20-year record (1973–1997) of hourly surface observations from the Shuttle Landing Facility and several stations in East-central Florida, and the upper-air data collected at Cape Canaveral Air Force Station (CCAFS). The EDA centered on the ceiling thresholds defined by the Shuttle Flight Rules (FR) as defined in Table 1. Ms. Lambert examined several aspects of the data including the number of occurrences of different ceiling categories by month, hour, and type of observed weather. Figures 1 – 4 show some results from the surface data EDA.

Table 1. List of Flight Rules for ceiling thresholds at the Shuttle Landing Facility (SLF).

Ceiling Threshold	*Flight Rule*
< 5000 ft	Return to Launch Site (RTLS)
< 8000 ft	End of Mission (EOM)
< 10 000 ft	Navigation Aid Degradation

Figure 1 is a histogram showing the number of observed occurrences for all ceiling heights reported in the data. The ceiling heights in this data set are subjective human estimates, and were recorded by the observers discretely every 30 m up to 1500 m, every 300 m from 1500 m to 9000 m, and approximately every 1500 m above that. This histogram shows that there are preferred reporting heights above 900 m (~3000 ft). Three of those preferred heights correspond to the FR ceiling thresholds at 1500 m (~ 5000 ft), 2400 m (~ 8000 ft), and 3000 m (~ 10 000 ft).

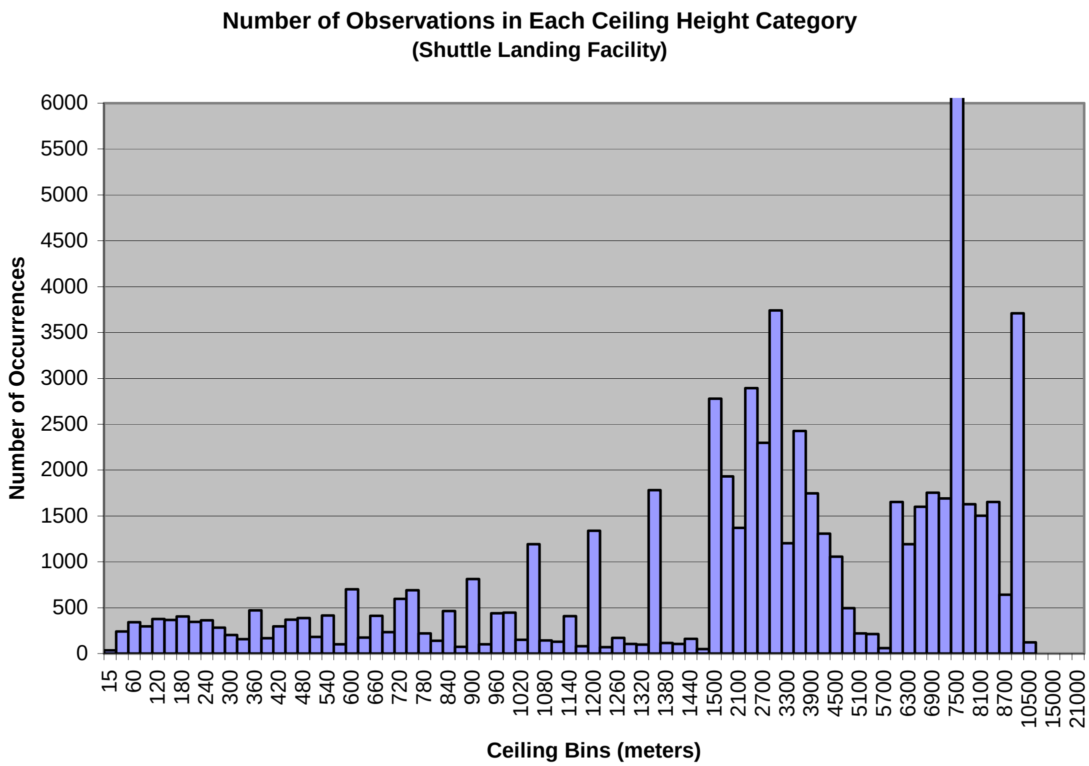

Figure 1. Histogram of the number of observations for all ceiling heights reported in 20 years (1978–1997) of hourly surface observations at the Shuttle Landing Facility. The total number of observations at 7500 m is 11 582. The scale of the vertical axis was truncated to emphasize the smaller number of observations at other heights.

Figure 2 is a color-fill contour plot of the percentage of occurrence of ceilings 5000 ft or below by month and hour of day (UTC). The months on the y-axis were ordered from July to June so that the cool season months would be in the middle of the plot. This produces a graph that clearly shows the maximum occurrences of low ceilings in the cool season. Figure 2 shows that the highest percentage of ceilings ≤ 5000 ft occurs during the cool season morning hours. For example, 25-30% of the time in December and January between the hours of 1100 and 1400 UTC, the ceiling is at 5000 ft or below.

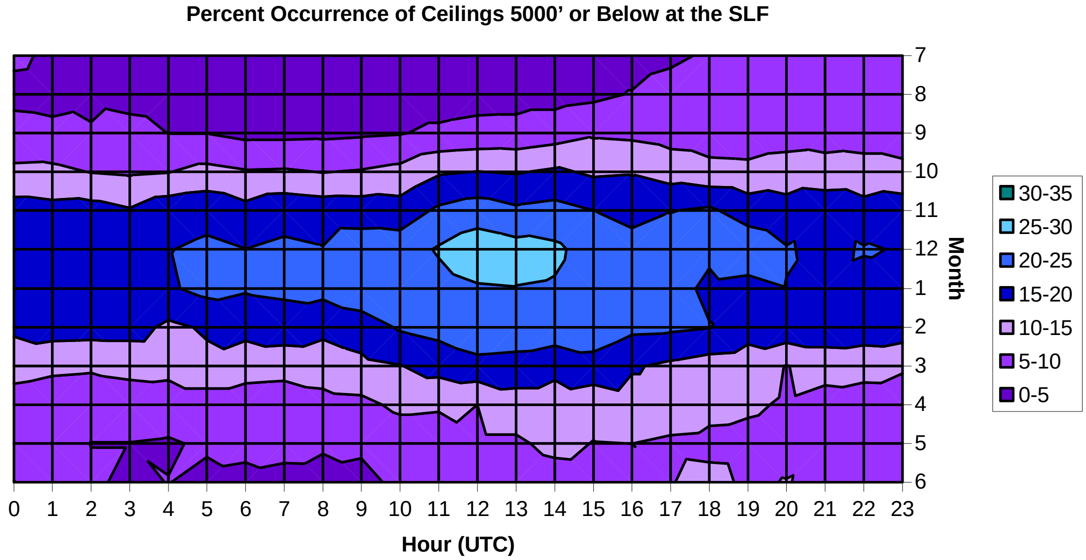

Figure 2. Contour plot of the percent occurrence of ceilings ≤ 5000 ft at the Shuttle Landing Facility by hour and month for the 20-year period 1978-1997. The legend at right shows the association of the colors with percentage ranges in intervals of 5%. The numbers on the y-axis represent the months of the year. The scale begins with July (7) at the top and ends with June (6) at the bottom.

In Figure 3, each line represents the hourly change in percent of occurrence of ceilings ≤ 5000 ft for a specific month. The cool months show a higher percent of occurrence at all hours with peaks in the morning (~ 1000 – 1500 UTC). There is a much lower percent of occurrence during the warm season, and the peaks occur later in the day.

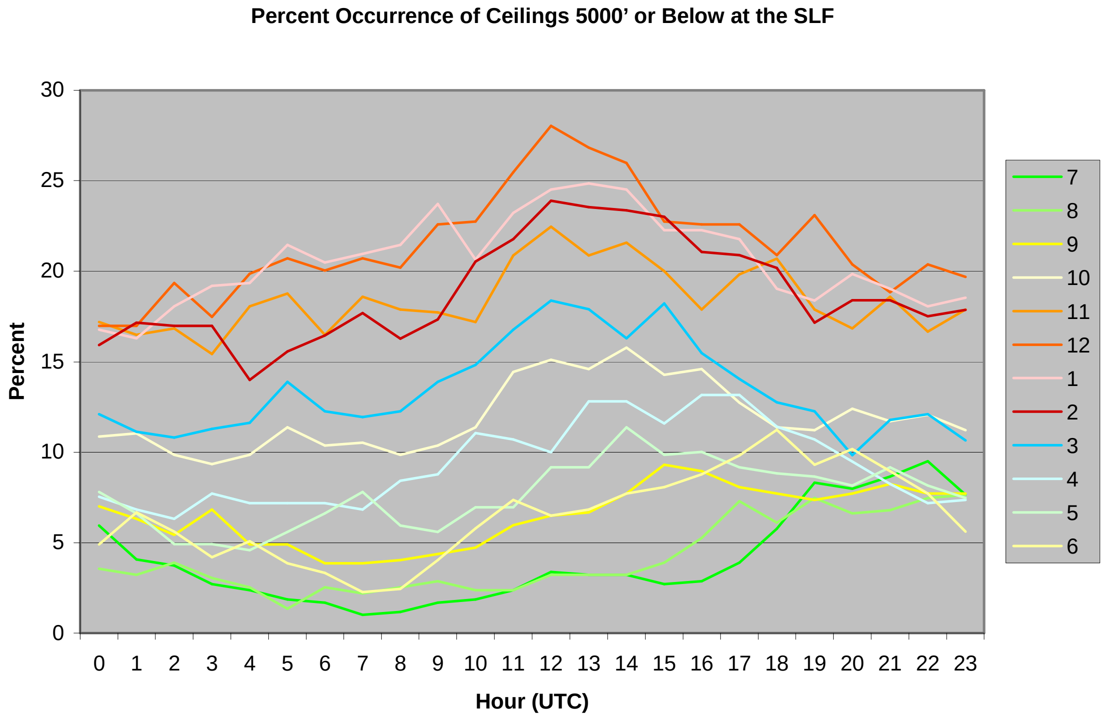

Figure 3. Graph showing the change in percent of occurrence of ceilings 5000 ft or below by hour of day for each month in the 20-year period 1978-1997. The legend at right shows the association of the colors with each month in the year. The numbers in the legend represent the months. The scale begins with July (7) at the top and ends with June (6) at the bottom.

Ms. Lambert also began an analysis of the 1200 UTC sounding data from CCAFS (XMR) over a 20-year period from 1978-1997. Figure 4 shows a color-fill contour plot of the number of occurrences of specific wind direction ranges by month at 700 mb. As in Figure 2, the months are ordered from July to June to emphasize the cool season maximum. The dominant wind direction for all months is west-southwest (WSW). However, WSW winds at 700 mb occur much more frequently in the cool months.

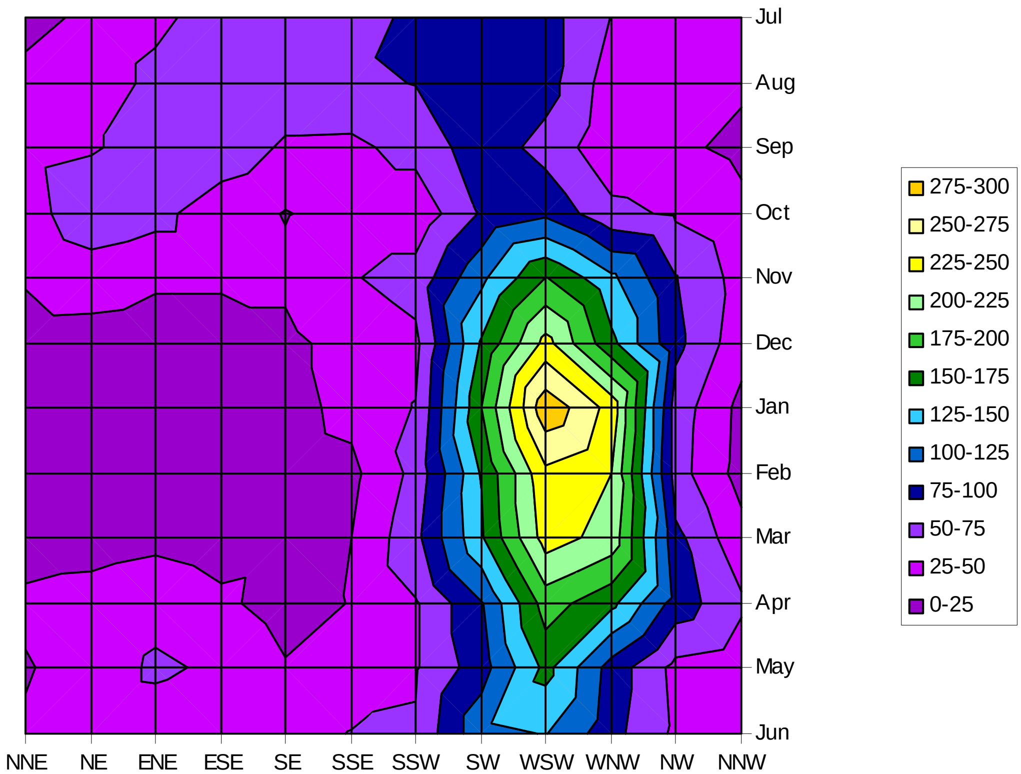

Figure 4. Contour plot of the number of occurrences of specific wind direction ranges at 700 mb for each month. The data are from 20 years of 1200 UTC rawinsonde data taken at Cape Canaveral Air Force Station (XMR). The colors represent ranges of 25 observations. The direction categories represent 30° direction ranges (e.g. NNE = 0° to 30°, NE = 30° to 60°, etc.).

Results thus far indicate that most low ceilings occur in the cool season morning hours. This was an expected result, but the EDA quantifies the temporal nature of the observations. Ms. Lambert will continue the EDA to help determine which variables will be the best predictors of ceiling at the SLF.

2.2 TASK 004 INSTRUMENTATION AND MEASUREMENT

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

In May, Mr. Wheeler and Dr. Manobianco attended a meeting with Mr. Tim Wilfong and other personnel from Lockheed Martin Raytheon (LMR). Representatives from the 45th Weather Squadron (45 WS), 45th Range Safety, and Kennedy Space Center (KSC) Weather Office were also present. The purpose of the meeting was to discuss AMU connectivity to the Range Standardization and Automation (RSA) weather systems, modeling with the Eastern Range Dispersion Assessment System (ERDAS) Regional Atmospheric Modeling System (RAMS), and other issues concerning the weather systems.

Table 2. AMU hours used in support of the I&M and RSA task in the third quarter of FY 2000 and total hours since July 1996.	
Quarterly Task Support (hours)	***Total Task Support (hours)***
4.5	247

SUBTASK 12 SIGMET IRIS/OPEN PROCESSOR EVALUATION (DR. SHORT)

Dr. Short began Phase II of the Interactive Radar Information System (IRIS) SIGMET Processor Evaluation task in April. IRIS provides display and analysis of radar reflectivity data from the Weather Surveillance Radar, model 74C, (WSR-74C) located at Patrick Air Force Base (PAFB). The purpose of the task is to develop new radar products for meeting operational requirements of the 45 WS and Spaceflight Meteorology Group (SMG) using SIGMET Inc.'s IRIS System. These requirements include evaluating launch commit criteria (LCC), FRs, and forecasting for ground operations.

The AMU Final Report on IRIS Product Recommendations includes recommendations for radar products emphasizing lightning and downburst tools for implementation on the IRIS System. The recommendations, based on discussions with weather support personnel from the 45 WS and SMG, provided the basis for discussions at a working group meeting attended by 45 WS, SMG and AMU personnel. Products and capabilities selected during the meeting will be designed, implemented and tested on the IRIS workstations during Phase II. It is important to note that the SIGMET IRIS software is proprietary and cannot be changed by the AMU. Therefore, it may not be possible to develop some of the recommended products using the current IRIS software. In this case, new algorithms, procedures or software modifications required to develop the recommended products will be forwarded to SIGMET, Inc. for possible implementation in future system builds.

Background Information

Forecasting of lightning and downbursts with the aid of radar reflectivity data requires detailed observations of the vertical structure of convective cells, anvils, and debris clouds. Updrafts in convective cells that penetrate the 0°C level can produce mixed (liquid and ice) phase processes. This can lead to cloud electrification, in-cloud, cloud-to-cloud and cloud-to-ground lightning, and an environment in which triggered lightning could be initiated. Local experience at KSC and CCAFS has shown that the reflectivity structure above the level of the -10°C isotherm and the amount of vertically integrated liquid (VIL) above the level of the 0°C isotherm are critically important for lightning forecasts (Pinder 1992; Pinder 1998; Roeder and Pinder 1998; Gremillion and Orville 1999). The "Pinder Principles" (Pinder 1992) emphasize the duration of high reflectivity layers above the level of the -10°C isotherm, with vertical extents greater than 3000 ft, for forecasting lightning.

Convective updrafts are also capable of suspending hydrometeors above the surface, possibly leading to downbursts generated and sustained by evaporative cooling of the air surrounding the hydrometeors and by precipitation loading. Recent AMU reports on cell trends (Lambert and Wheeler 1997; Wheeler 1998) have shown that temporal trends of VIL and reflectivity structure associated with convective cells are useful for forecasting downbursts and hail.

Working Group Meeting

Dr. Short presented results from the AMU Final Report on IRIS Product Recommendations at a working group (WG) meeting on 27 April. This meeting marked the transition from Phase I to Phase II, when new IRIS products will be developed. Mr. Roeder of the 45 WS conducted the meeting. Personnel from the 45 WS, SMG, and the National Weather Service in Melbourne, FL (NWS MLB) participated, either in person or by teleconference. The purpose of the meeting was for 45 WS, SMG and NWS MLB radar product users to develop a prioritized list of radar products to be generated by the IRIS software. The list of 18 recommended products from the report was divided into two parts. The first 7 products are sensitive to variations in the vertical temperature profile. The radar operator can implement these 7 products in the Range Weather Operations (RWO) using IRIS Graphical User Interface (GUI) tools. The WG recommended that these 7 products be implemented.

The remaining 11 products require development by the AMU on the AMU IRIS workstation using the IRIS programming feature known as the User Product Insert (UPI). The AMU rated the 11 products by technical complexity for further evaluation and recommendations by the WG. The three categories in Table 3 below are based on estimates of the amount and complexity of computer programming needed to develop the products.

Table 3. Technical complexity ranking of the 11 recommended IRIS products.
Low
Map of the ratio Vertically Integrated Liquid (VIL)/Storm Top
Map of the ratio VIL/Echo Top
Rain coverage within 20 nm of the Shuttle Landing Facility
Medium
Height of maximum dBZ map
Cell trend of maximum dBZ
Cell trend of Cell Top Height
High
Alarms for downburst and hail
Cell based VIL
Cell trend of cell based VIL
Core Aspect Ratio (CAR)
Cell trend of CAR

In addition, the WG recommended implementation of a revised scan strategy for the WSR-74C. The AMU developed the scan strategy to reduce vertical gaps in radar coverage over the KSC/CCAFS area by 37%, compared to the present scan strategy. The new scan strategy was put into operation on the WSR-74C on 6 June 2000.

References

Gremillion, M. S., and R. E. Orville, 1999: Thunderstorm Characteristics of Cloud-to-Ground Lightning at the Kennedy Space Center, Florida: A Study of Lightning Initiation Signatures as Indicated by the WSR-88D. *Wea. Forecasting*, **14**, 640 – 649.

Lambert, W. C., and M. M. Wheeler, 1997: Final Report on the AMU NEXRAD Exploitation Task. NASA Contractor Rep. CR-203009, 45 pp.

Pinder, C. S., 1992: The Pinder Principles, *Local Forecast Guidance Tool*, 45th Weather Squadron, 4 pp.

Pinder, C. S., 1998: IRIS VIL Lightning Forecasting Rules-of-Thumb. 45th Weather Squadron, 2 pp.

Roeder, W. P. and C. S. Pinder, 1998: Lightning Forecasting Empirical Techniques for Central Florida in Support of America’s Space Program. Preprints, *16th Conf. On Weather Analysis, and Forecasting*, Phoenix, AZ, Amer. Met. Soc., 475 – 477.

Wheeler, M., 1998: WSR-88D Cell Trends Final Report. NASA Contractor Rep. CR-207-904, 36 pp.

SUBTASK 12.1 AIRCRAFT POSITION RADAR OVERLAY (MR. WHEELER AND MR. DIANIC)

The aircraft position radar overlay task is funded by KSC under AMU option hours. The AMU was tasked to superimpose the location of the research aircraft from the Airborne Field Mill (ABFM) experiment on WSR-74C SIGMET radar images.

Given that NASA needed the overlay capability by 1 June 2000 to support the ABFM experiment, the AMU took advantage of efforts at SMG to develop an aircraft position radar overlay. Mr. Tim Oram of SMG was working to superimpose the position of the Shuttle Training Aircraft (STA) on SIGMET images using the Man-computer Interactive Data Access System (McIDAS-X). With approval from SMG Chief Mr. Frank Brody, Mr. Oram agreed to support the ABFM project with his expertise.

Mr. Oram developed the initial software to convert SIGMET images to McIDAS-X files and overlay the aircraft position and altitude on those images in real-time. In addition, he developed a GUI to simplify selection of user options such as radar product altitude and range, and center location of display. As Mr. Oram completed subsequent versions of the software, he sent them to Mr. Wheeler for implementation and testing on the AMU Hewlett Packard (HP) workstation running McIDAS-X. Mr. Wheeler configured the AMU IRIS SIGMET workstation to transfer real-time radar images to the HP workstation. Sample position data generated by Mr. Oram were used for initial system tests.

In parallel, Mr. Allan Dianic and Mr. Erik Magnuson of ENSCO, Inc. began developing software to decode, filter, and reformat aircraft position data. The ABFM committee decided that aircraft telemetry data would be transmitted from the aircraft via a range finder (RF) modem. An RF antenna was installed on the roof of the Range Operations Control Center (ROCC) and connected to an existing cable in the AMU. The aircraft position data were transferred to the HP workstation through a serial port.

The ABFM tracking and display development project was completed on time and ready to support the ABFM missions at the beginning of June. When the first real-time aircraft position data were transmitted, several format changes had to be made in the software. These changes were completed in a short time. Throughout the experiment, Mr. Dianic modified the software to make it more robust and AMU personnel were available to troubleshoot problems and provide guidance on using the software. With the help of Mr. Oram at SMG, Mr. Wheeler enhanced the ABFM GUI based on comments and feedback from the ABFM science team.

SUBTASK 15 DETECTING CHAFF SOURCE REGIONS (MR. WHEELER)

Mr. Wheeler documented 11 cases of possible chaff release signatures on the Weather Surveillance Radar-1988 Doppler (WSR-88D) Principle User Processor (PUP) in April. The signatures originated from both the northwest Gulf of Mexico and east of Jacksonville, Florida. A chaff release signature was also observed and documented during the STS-101 launch attempt on 26 April. The data collection period ended in April. A total of 47 chaff events were documented since the data collection began in January 2000. Work started on further analysis of the cases documenting the first detection point and arrival time into central Florida. Mr. Wheeler also began writing the final report. Distribution of the final report has been delayed until July due to Mr. Wheeler’s support of the ABFM option hours task.

2.3 TASK 005 MESOSCALE MODELING

SUBTASK 4 DELTA EXPLOSION ANALYSIS (MR. EVANS)

The Delta Explosion Analysis project is being funded by KSC under AMU option hours. The primary goal of this task is to conduct a case study of the explosion plume using the RAMS, Rocket Exhaust Effluent Dispersion Model (REEDM), and Hybrid Particle and Concentration Transport (HYPACT) model and compare the model results with available meteorological and plume observations. There are two reasons for the modeling exercise of comparing the observed and predicted plumes. The principal of the two reasons is to determine how well the modeled plume trajectories compare with the observed plume trajectories. The secondary reason is to determine how the REEDM-predicted source term compares with the actual source term. Mr. Evans continued to make revisions to the final report during the quarter.

SUBTASK 8 MESO-MODEL EVALUATION (MR. CASE)

This section summarizes the work performed this past quarter by the AMU in support of the evaluation of the RAMS component of ERDAS. During this past quarter, Mr. Case completed the interim report on the ERDAS RAMS evaluation, which summarizes the objective and subjective results from the 1999 Florida warm season. Mr. Case also submitted a paper for the preprint volume of the Ninth Conference on Aviation, Range, and Aerospace Meteorology, which will be held 11-15 September 2000 in Orlando, Florida. The conference paper focuses on the influence of horizontal resolution on the RAMS forecast errors, and compares the RAMS errors to those of the Eta model. A portion of this conference paper is given in the following sub-sections, highlighting the results that compare the RAMS and Eta model errors during the Florida warm season months of May–August 1999.

Background

ERDAS is designed to provide emergency response guidance for operations at the CCAFS and KSC in the event of an accidental hazardous material release or an aborted vehicle launch. The evaluation protocol is based on the needs of 45th Range Safety (45 SW/SE) and 45 WS personnel, and designed to provide specific information about the capabilities, limitations, and daily operational use of RAMS in ERDAS at KSC/CCAFS.

The goal of the evaluation is to determine the accuracy of RAMS forecasts during all seasons and under various weather regimes. The ERDAS RAMS evaluation concentrates on wind and temperature forecasts required for dispersion predictions. The prognostic data from RAMS is available to ERDAS for display and input to the HYPACT model. The HYPACT dispersion model provides three-dimensional dispersion predictions using RAMS forecast grids. Thus, the accuracy and sensitivities of the HYPACT model are contingent upon the prognostic data from the RAMS model.

RAMS Configuration in ERDAS

RAMS is run in three-dimensions over four nested grids with horizontal grid spacing of 60, 15, 5, and 1.25 km (Figure 5). The lateral boundary conditions on grid 1 are nudged (Davies 1983) by 12–36-hour forecasts from the National Centers for Environmental Prediction (NCEP) 32-km Eta model that have been interpolated onto an 80-km grid. Output from the Eta model is available every 6 hours for the boundary conditions in RAMS. Therefore, the timing and accuracy of weather features in RAMS are dependent on the timing and accuracy of features in the Eta model forecasts.

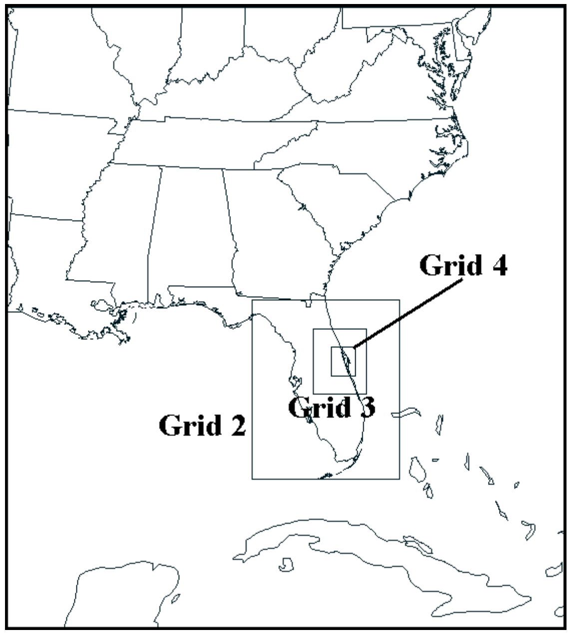

Figure 5. The real-time RAMS domains are shown for the 60-km mesh grid (grid 1) covering much of the southeastern United States and adjacent coastal waters, the 15-km mesh grid (grid 2) covering the Florida peninsula and adjacent coastal waters, the 5-km mesh grid (grid 3) covering east-central Florida and adjacent coastal waters, and the 1.25-km mesh grid (grid 4) covering the area immediately surrounding KSC/CCAFS.

RAMS is initialized twice-daily at 0000 and 1200 UTC using the Eta 12-h forecast grids and operationally-available data including the XMR rawinsonde, surface reporting stations (METAR), buoys, and KSC/CCAFS wind-towers, 915-MHz Doppler Radar Wind Profilers (DRWP), and 50-MHz DRWP data. RAMS is initialized from a cold start by simply integrating the model forward in time from an initial gridded field without any dynamic balancing or data assimilation steps. A more sophisticated model initialization scheme could be used to take advantage of all data sources available in east-central Florida, including WSR-88D data.

The operational cycle requires approximately 15 minutes to analyze observational data for the initial conditions and 10–12 hours to complete the 24-h forecast. When the model produces extensive precipitation, a 24-hour forecast takes longer than 12 hours to complete due to the calculations associated with the cloud scheme. In these instances, the RAMS run is terminated before the 24-h forecast is completed, and the new simulation begins. Consequently, RAMS data are occasionally missing from the 22–24-h forecasts. In the event of a premature termination, the forecast data from the previous forecast cycle are still available.

Methodology

The AMU evaluation of RAMS includes both an objective and a subjective component. The objective component is designed to present a representative set of model errors for winds, temperature, and moisture at both the surface and upper-levels. The goal of the subjective verification is to provide an assessment of the forecast timing and propagation of the east-central Florida East Coast Sea Breeze (ECSB) and daytime precipitation systems through an examination of RAMS forecast fields.

The objective evaluation focuses on point error statistics at many different observational locations on all four forecast grids. Zero to 24-h point forecasts of wind, temperature, and moisture were compared with surface METAR and buoy stations, the XMR rawinsonde, and KSC/CCAFS wind-tower, 915-MHz, and 50-MHz DRWP data at all available observational locations on grid 4, and selected surface and rawinsonde stations on grids 1–3. The locations of the grid-4 observations used for point verification are given in Figure 6.

As part of the objective component, the AMU performed a benchmark experiment consisting of a comparison between the NCEP Eta model and RAMS point forecasts at 14 selected stations across the southeastern United States. An algorithm extracted and interpolated RAMS forecasts to the locations of these 14 stations in order to generate surface and upper-air error statistics. The AMU computed point error statistics for temperature, wind, and moisture for comparison between RAMS and the Eta model. The benchmark experiment is an important component of the evaluation since it quantifies the potential added value of running RAMS on local workstations at much finer spatial resolution than the current national-scale operational Eta model. In this quarterly report, only error statistics from the 1200 UTC forecast cycle at the Shuttle Landing Facility (TTS) are shown for the RAMS/Eta comparison.

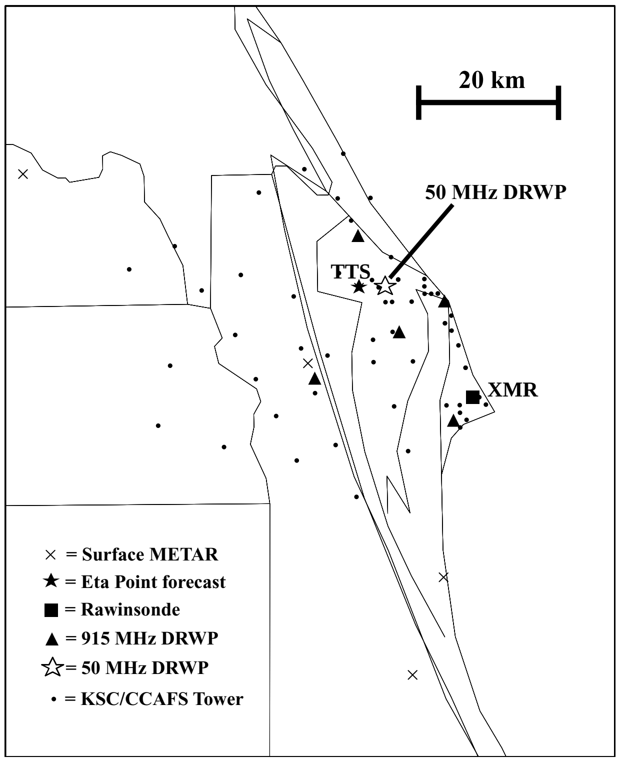

Figure 6. A display of the surface and upper-air stations used for point verification of RAMS forecasts on grid 4. The key in the lower left gives symbols for the observational data types.

Comparison of Surface Errors Between the RAMS and Eta Model

This section provides results from a small portion of the RAMS/Eta model comparison. The results are presented only for surface forecasts at TTS.

Temperature and Dew Point

For surface temperature forecasts from the 1200 UTC cycle at TTS, the Eta model outperforms RAMS during the daylight hours. The mean Eta forecast temperature follows the mean observed temperature closely during the 24-h period whereas the mean RAMS forecast temperature deviates by 2–3°C primarily during 6–15 h (Figure 7a). The Eta model root mean square (RMS) error is generally 2°C during the entire 24-h forecast period composed primarily of non-systematic error and little bias (Figs. 7b-d). Meanwhile, the RAMS RMS error is larger than that of the Eta model during the daytime, approaching 4°C at 10 h (Figure 7b). The RAMS temperature error is composed of a -2 to -3°C daytime cool bias (not found in the Eta model) in addition to a non-systematic error comparable to the Eta model (Figs. 7c-d).

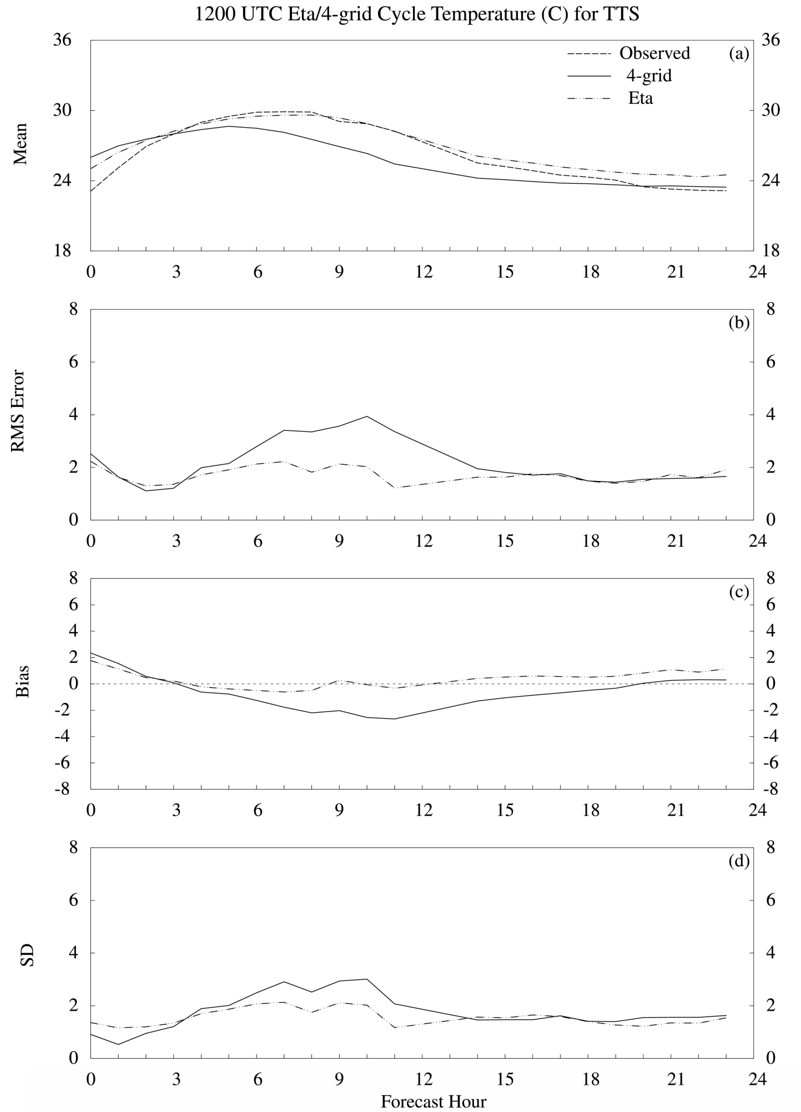

Figure 7. A meteogram plot that displays a comparison between the 1200 UTC forecast cycle surface temperature errors (°C) from the RAMS 4-grid configuration and the Eta model. Surface temperatures are verified at TTS since this is the only station on grid 4 where Eta point forecasts are available. Parameters plotted as a function of forecast hour for both RAMS and the Eta model include: a) mean observed temperature, mean RAMS forecast temperature, and mean Eta forecast temperature, b) RMS error, c) bias, and d) error standard deviation (SD). The plotting convention is a solid line for the RAMS 4-grid forecasts, dot-dashed line for the Eta model, and a dashed line for observed values.

The RAMS performance is nearly equivalent to the Eta model in dew point forecasts at TTS. The RMS error in both models is virtually the same despite RAMS being less biased than the Eta model (not shown). For a version of the Eta model run at 29-km resolution, Nutter and Manobianco (1999) identified a slight moist bias at TTS. In this study, the Eta model also exhibits a moist bias at TTS (~ 1°C), consistent with results found in Nutter and Manobianco (1999).

Wind Direction and Speed

With a few exceptions, the two models perform similarly in the wind direction and speed forecasts at TTS. The Eta model has a larger positive wind direction bias compared to RAMS, particularly during the afternoon and nighttime hours (Figure 8b). However, RAMS experiences at least as much non-systematic variability as the Eta model (not shown), thus the total RMS error in both models is comparable, generally 40–60° for most forecast hours (Figure 8a). The initial (0-hour) wind direction RMS error in RAMS is smaller than the Eta model because of the analysis of local mesoscale data sets, but the error quickly grows to that of the Eta model by 2 h. The wind speed forecasts are similar between 0 and 12 h; however, after 12 h the Eta model develops a +1.5 m s^{-1} bias whereas RAMS is virtually unbiased (not shown).

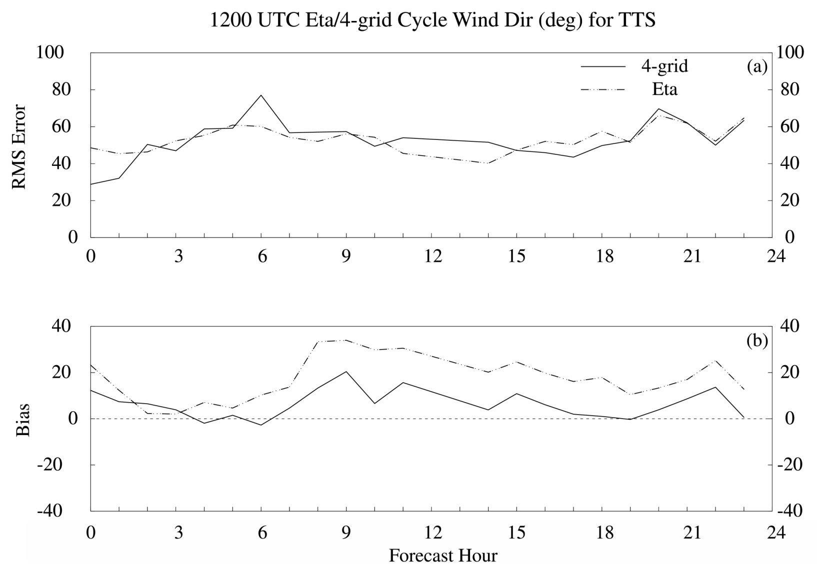

Figure 8. A meteogram plot that displays a comparison between the 1200 UTC forecast cycle surface wind direction errors (degrees) from the RAMS 4-grid configuration and the Eta model. Surface wind direction is verified at TTS since this is the only station on grid 4 where Eta point forecasts are available. Parameters plotted as a function of forecast hour for both RAMS and the Eta model include: a) RMS error and b) bias. The plotting convention is a solid line for the RAMS 4-grid errors and a dot-dashed line for the Eta model errors.

Summary and Future Work

This section presented a comparison between the RAMS and Eta model forecast errors at the Shuttle Landing Facility surface station during the 1999 Florida warm season. The results indicate that the Eta model outperforms RAMS in temperature forecasts during the daylight hours due to the prevailing cool bias in RAMS. The RAMS and Eta models have a comparable dew point RMS error at TTS. However, the Eta model exhibits a +1°C moist bias whereas RAMS is unbiased. The models have comparable errors in wind direction and wind speed. The only difference noted is that the Eta forecast wind direction experiences a larger positive bias, particularly during the post sea breeze (afternoon) and nocturnal hours. In addition, the Eta RMS error in wind speed is about 1 m s^{-1} larger than RAMS due to a larger positive bias, especially during the nocturnal hours.

The ERDAS RAMS evaluation will continue through the upcoming 2000 warm season. An evaluation of RAMS during the 1999-2000 Florida cool season will verify cold frontal timing and associated precipitation features. The extended warm season evaluation will include a verification of the first predicted thunderstorm of the day and a sea breeze verification that will include all available KSC/CCAFS wind towers. Objective statistics will also be computed for both the 1999-2000 cool season and the upcoming 2000 warm season. The additional components of the evaluation will be included in a final report by early 2001.

For more information or a copy of the interim report, contact Mr. Jonathan Case by phone at 321-853-8264 or by email at case.jonathan@ensco.com.

References

Davies, H. C., 1983: Limitations of some common lateral boundary schemes used in regional NWP models. *Mon. Wea. Rev.*, **111**, 1002-1012.

Nutter, P. A., and J. Manobianco, 1999: Evaluation of the 29-km Eta Model: Part I: Objective verification at three selected stations. *Wea. Forecasting*, **14**, 5-17.

SUBTASK 10 LOCAL DATA INTEGRATION SYSTEM PHASE III (MR. CASE)

The Local Data Integration System (LDIS) task emerged out of the need to simplify the generation of short-term weather forecasts in support of launch, landing, and ground operations. The complexity of creating short-term forecasts has increased due to the variety and disparate characteristics of the multitude of available weather observations. Therefore, the goal of the LDIS task is to generate high-resolution weather analysis products that may enhance a forecaster's understanding of the current state of the atmosphere, resulting in improved short-term forecasts. In Phase I, the AMU configured a prototype LDIS for east-central Florida that integrated all available weather observations into gridded analyses. In Phase II, the AMU simulated a real-time LDIS configuration using archived data. The LDIS Phase III task calls for AMU assistance to SMG and NWS MLB to install a working LDIS that generates routine high-resolution products for operational guidance.

NWS MLB and SMG will be running the LDIS in real-time on HP workstations. In order to access level II WSR-88D data, NWS MLB needs library files from the Radar Interface and Data Distribution System (RIDDS) software, which is distributed by the National Severe Storms Laboratory (NSSL). Currently, NSSL maintains the RIDDS software for a Sun platform, not an HP platform. During this past quarter, Mr. Case obtained a copy of the RIDDS source code from NSSL in order to compile and test the software on an AMU HP workstation. Most of the RIDDS files compiled successfully on the AMU HP workstation, with the exception of a few routines. Mr. Case will build the libraries files from the RIDDS routines that compiled successfully and test the real-time data access at the NWS MLB.

During this past quarter, Mr. Case continued to perform system tests of the Advanced Regional Prediction System (ARPS) and ARPS Data Analysis System (ADAS) programs on the AMU's new HP 4-processor workstation. He discovered that among the executable programs used in the LDIS analysis cycle, ADAS is the only one that cannot be compiled and run using optimization options. Since all other programs in the analysis cycle can be optimized, LDIS should run sufficiently fast in a real-time configuration, based on the hardware that will be used at SMG and the NWS MLB office. Further testing is required on the HP workstation in order to isolate the causes of the memory deficiencies when running ADAS in an optimized mode.

SUBTASK 11 EXTENSION / ENHANCEMENT OF THE ERDAS RAMS EVALUATION (MR. CASE AND MR. DIANIC)

The Extension / Enhancement of the ERDAS RAMS Evaluation is being funded by KSC under AMU option hours. During this past quarter, Mr. Dianic worked on three components of this task. The first component involves the generation of RAMS forecasts using Eta 0-hour forecasts rather than 12-hour forecasts as background fields for the initial condition of RAMS. The second component continues the RAMS 3-grid forecasts for comparison to the full 4-grid configuration. Finally, Mr. Dianic began modifying and improving the verification GUI used to compare the RAMS forecasts to observational data.

In order to generate the RAMS 4-grid forecasts using Eta 0-h forecasts for the initial condition, Mr. Dianic developed and implemented scripts and routines to manage the execution of these experimental RAMS forecasts. In addition, he improved the efficiency of data management on the workstation running these experiments. Finally, Mr. Dianic transferred data to an AMU disk for future analysis of these experiments. Once the experimental 4-grid forecasts are completed, the AMU will compare the error statistics to the standard 4-grid RAMS forecast errors to document improvements that may occur by using Eta 0-h rather than 12-h forecasts in the RAMS initial condition.

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

Dr. Merceret began writing two manuscripts for the Ninth Conference on Aviation, Range, and Aerospace Meteorology.

In June, Dr. Merceret supported the Lightning Launch Commit Criterion field program (also known as the ABFM program). He served as one of the primary ground control scientists and also as overall program manager.

2.5 TASK 001 AMU OPERATIONS

During April, SMG, 45 WS, and NWS MLB submitted proposed tasks for the annual AMU Tasking and Prioritization Meeting (T&P). AMU personnel exchanged electronic mail with SMG, 45 WS, and NWS MLB to discuss and clarify both proposed and existing tasks in order to develop accurate resource requirement estimates. Dr. Manobianco used these estimates to allocate AMU resources for the next 12 to 18 months. After meetings with AMU personnel, he determined that all current and proposed tasks could be completed over the next 18 months.

All AMU personnel attended the AMU T&P via teleconference on 12 May. Other participating agencies included the SMG, 45 WS, NWS MLB, KSC Weather Office, and Marshall Space Flight Center (MSFC). The Tasking Group unanimously accepted Dr. Manobianco's proposal to complete all tasks over the next 18 months as the consensus tasking for this meeting. All AMU personnel developed task plans for the new tasks that were accepted at the meeting. They also developed work schedules for the new and current tasks.

Mr. Wheeler completed and submitted the final purchase request to NASA for new equipment and services for this year. He also upgraded the AMU LAN to a two-hub 100mbs configuration. One hub is configured for the AMU UNIX systems and the other hub is for administration of the individual PC workstations. The two-hub configuration allows for faster data transfers between machines in the AMU and less traffic on the administrative LAN.

At the direction of the KSC Weather Office, Ms. Lambert selected a contractor to create a large sign containing the AMU logo to put on the wall in the AMU laboratory. The contractor created an acceptable version that is now hanging in the AMU. Ms. Lambert will now begin working with ENSCO graphic artists to develop an AMU storyboard.

NOTICE

List of Acronyms

30 SW	30th Space Wing
30 WS	30th Weather Squadron
45 LG	45th Logistics Group
45 OG	45th Operations Group
45 SE	45th Range Safety
45 SW	45th Space Wing
45 WS	45th Weather Squadron
ABFM	Airborne Field Mill
ADAS	ARPS Data Assimilation System
AFRL	Air Force Research Laboratory
AFSPC	Air Force Space Command
AFWA	Air Force Weather Agency
AMU	Applied Meteorology Unit
ARPS	Advanced Regional Prediction System
CAR	Core Aspect Ratio
CCAFS	Cape Canaveral Air Force Station
CSR	Computer Sciences Raytheon
DRWP	Doppler Radar Wind Profiler
ECSB	East Coast Sea Breeze
EDA	Exploratory Data Analysis
EOM	End of Mission
ERDAS	Eastern Range Dispersion Assessment System
FR	Shuttle Flight Rules
FSL	Forecast Systems Laboratory
FSU	Florida State University
FY	Fiscal Year
GUI	Graphical User Interface
HP	Hewlett Packard
HYPACT	Hybrid Particle and Concentration Transport
I&M	Improvement and Modernization
IRIS	SIGMET's Integrated Radar Information System
JSC	Johnson Space Center
KSC	Kennedy Space Center
LCC	Launch Commit Criteria
LDIS	Local Data Integration System
LMR	Lockheed Martin Raytheon
McIDAS	Man-computer Interactive Data Access System
METAR	Aviation Routine Weather Report
MHz	Mega-Hertz
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration

List of Acronyms

NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction
NOAA	National Oceanic and Atmospheric Administration
NPI	Neumann-Pfeffer Thunderstorm Probability Index
NSSL	National Severe Storms Laboratory
NWS MLB	National Weather Service in Melbourne Florida
PAFB	Patrick Air Force Base
RAMS	Regional Atmospheric Modeling System
REEDM	Rocket Exhaust Effluent Dispersion Model
RF	Range Finder
RIDDS	Radar Interface and Data Distribution System
RMS	Root Mean Square
ROCC	Range Operations Control Center
RSA	Range Standardization and Automation
RTLS	Return to Launch Site
RWO	Range Weather Operations
SD	Standard Deviation
SLF	Shuttle Landing Facility
SMC	Space and Missile Center
SMG	Spaceflight Meteorology Group
STA	Shuttle Training Aircraft
TTS	SLF 3-Letter Identifier
T&P	Tasking and Prioritization
UPI	User Product Insert
USAF	United States Air Force
UTC	Universal Coordinated Time
VIL	Vertically Integrated Liquid
WG	Working Group
WSR-74C	Weather Surveillance Radar, model 74C
WSR-88D	Weather Surveillance Radar - 88 Doppler
WWW	World Wide Web
XMR	CCAFS 3-Letter Identifier

Appendix A

AMU Project Schedule 31 July 2000				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
Statistical Forecast Guidance (Ceilings)	Determine Predictand(s)	Aug 98	Sep 98	Completed
	Data Collection, Formulation and Method Selection	Sep 98	Apr 99	Completed
	Equation Development, Tests with Independent Data, and Tests with Individual Cases	Apr 00	Nov 00	On Schedule
	Prepare Products, Final Report for Distribution	Nov 00	Feb 01	On Schedule
Statistical Forecast Guidance (Winds)	Determine Predictand(s)	Feb 01	Mar 01	On Schedule
	Data Reduction, Formulation and Method Selection	Mar 01	May 01	On Schedule
	Equation Development, Tests with Independent Data, and Tests with Individual Cases	May 01	Sep 01	On Schedule
	Prepare Products, Final Report for Distribution	Sep 01	Dec 01	On Schedule
Meso-Model Evaluation	Develop ERDAS/RAMS Evaluation Protocol	Feb 99	Mar 99	Completed
	Perform ERDAS/RAMS Evaluation	Apr 99	Sep 99	Completed
	Extend ERDAS/RAMS Evaluation	Oct 99	Sep 00	On Schedule
	Interim ERDAS/RAMS Report	Dec 99	Jun 00	Undergoing external review
	Final ERDAS/RAMS Report	Oct 00	Dec 00	On Schedule
Delta Explosion Analysis	Analyze Radar Imagery	Jun 97	Nov 97	Completed
	Run Models/Analyze Results	Jun 97	Jun 98	Completed
	Final Report	Feb 98	Jun 00	Undergoing final revisions
	Launch Site Climatology Plan	Apr 98	May 98	Completed
Detecting Chaff Source Regions	Detect and analyze chaff signatures for source region	Oct 99	Apr 00	Completed
	Final Report	Apr 00	Jun 00	Delayed 1 month to support ABFM option hours task

AMU Project Schedule 31 July 2000				
AMU Projects	Milestones	Actual / Projected Begin Date	Actual / Projected End Date	Notes/Status
SIGMET IRIS Processor Evaluation Phase I	Investigate current and possible new capabilities of product development software	Oct 99	Jan 00	Completed
	Phase I Interim Report	Feb 00	May 00	Completed
SIGMET IRIS Processor Evaluation Phase II	Develop and transition new products to 45 WS IRIS station	Apr 00	Feb 01	On Schedule
	Final Report	Mar 01	Apr 01	On Schedule
LDIS Extension: Phase III	Assistance in installation at NWS MLB	Jan 00	Jun 00	Delayed – waiting for setup of data connections
	Assistance in installation at SMG	Apr 00	Jul 00	Delayed for hardware and software setup
	Memorandum	Jul 00	Jul 00	Delayed to complete installation at SMG and NWS MLB
	Technical collaboration with SMG towards a conference paper	Aug 00	Sep 00	On Schedule
ERDAS RAMS Extension Task	Memorandum summarizing data transfer feasibility to SMG & NWS MLB	Jul 00	Aug 00	On Schedule
	Enhancement of verification Graphical User Interface	Apr 00	Feb 01	On Schedule
	Implement data transfer	Sep 00	Nov 00	On Schedule
	Input of methodology and results into ERDAS RAMS final report	Nov 00	Dec 00	On Schedule
Aircraft Position Radar Overlay	Develop aircraft position display for overlay on WSR-74C radar display	May 00	Jun 00	On Schedule